Draft

PROGRAMMATIC ENVIRONMENTAL ASSESSMENT FOR TRAINING WITH DEFENSIVE COUNTERMEASURES

United States Department of the Air Force

March 2023

Letters or other written comments provided may be published in the Final EA. As required by law, substantive comments will be addressed in the Final EA and made available to the public. Any personal information provided will be kept confidential. Private addresses will be compiled to develop a mailing list for those requesting copies of the Final EA. However, only the names of the individuals making comments and their specific comments will be disclosed. Personal home addresses and phone numbers will not be published in the Final EA.

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ABSTRACT

Designation: Programmatic Environmental Assessment

Title of Proposed Action: Testing and Training with Defensive Countermeasures

Project Location: Air Force Training Airspace

Lead Agency: Department of the Air Force

Affected Region: Continental United States

Action Proponent: Air Force Civil Engineering Center (AFCEC)

Point of Contact: Nolan Swick AFCEC/CZN
2261 Hughes Avenue, Suite 155 JBSA
Lackland, TX 78236-9853
nolan.swick@us.af.mil

Date: March 2023

The Department of the Air Force (DAF) has prepared this Programmatic Environmental Assessment (PEA) in accordance with the National Environmental Policy Act (NEPA), as implemented by the Council on Environmental Quality regulations and DAF regulations for implementing NEPA. The Proposed Action would continue the use of legacy defensive countermeasures in testing and routine flight training in the DAF training airspace where their use is approved across the continental United States and implement the use of new countermeasures designed to defend against advanced weapon system threats. Under the Proposed Action, the DAF would continue to deploy countermeasures at current levels and in accordance with DAF policy and restrictions, including those that are currently in place for specific airspace units. Implementation of the Proposed Action would provide for realistic testing and training with legacy defensive countermeasures and implement the use of direct replacements and new defensive countermeasures to increase pilot's and aircrew's ability to succeed in real combat situations.

This PEA for testing and training with defensive countermeasures evaluates the potential environmental impacts associated with the Proposed Action Alternative (Preferred) and the No Action Alternative to the following resource areas: safety, air quality, cultural resources, biological resources, soil and water resources, land use and visual, and socioeconomics.

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PROGRAMMATIC ENVIRONMENTAL ASSESSMENT
FOR
TESTING AND TRAINING WITH DEFENSIVE COUNTERMEASURES

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Acronyms and Abbreviations

Acronym	Definition
AFB	Air Force Base
AFI	Air Force Instruction
AFLCMC	Air Force Life Cycle Management Center
AGL	above ground level
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
DAF	Department of the Air Force
DoD	Department of Defense
EA	Environmental Assessment
EIAP	Environmental Impact Analysis Process
EIS	Environmental Impact Statement
°F	degrees Fahrenheit
FAA	Federal Aviation Administration
IR	infrared
MAJCOM	major command
MOA	Military Operations Area
mph	miles per hour
MSL	mean sea level
MTR	military training route
MTV	magnesium, Teflon, and Viton
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
PEA	Programmatic Environmental Assessment
PFAS	per- and polyfluoroalkyl substances
Proposed Action	Proposed Action Alternative
ppt	parts per trillion
U.S.	United States
USEPA	United States Environmental Protection Agency

1. PURPOSE AND NEED FOR THE ACTION

1.1 INTRODUCTION

The United States (U.S.) Department of the Air Force (DAF) is preparing this Programmatic Environmental Assessment (PEA) to assess the continued use of legacy defensive countermeasures, their replacements, and the use of new defensive countermeasures in DAF testing and military training programs. Chaff and flares are the principal defensive countermeasures dispensed by military aircraft to avoid detection or targeting by enemy air defense systems or enemy aircraft. The DAF and other components of the Department of Defense (DoD) have been deploying defensive countermeasures since as early as the 1950s as part of their training for combat readiness and to improve the survivability of the aircraft and pilot. While this activity was initially associated with bomber type aircraft, in today's military, this training activity extends to almost all types of aircraft. Air Force Manual 13-212V1, *Range Planning and Operations,* provides guidance for commanders to operate assigned ranges safely, effectively, and efficiently to meet training and test requirements while minimizing potential effects on the environment and the surrounding communities. It provides general guidance for the use of flares and chaff, stating that flares are employed in accordance with Air Force Instruction (AFI) 11-214, while chaff is employed in accordance with the latest version of the Chairman of the Joint Chiefs of Staff Manual 3212.02D, *Performing Electronic Attack in the United States and Canada for Tests, Training, and Exercises*, and AFI 11-2MDS series instructions, unless further restricted by Major Command (MAJCOM) or local supplements.

Defensive Countermeasure Definitions

Chaff – aluminum-coated silica fibers dispersed from an aircraft to form an electronic cloud that temporarily obscures an aircraft from radar detection.

Flare – a pellet cartridge ejected from an aircraft that ignites and burns, producing a high-temperature heat source that misleads heat-seeking targeting systems**.**

Legacy Items – chaff and flare units deployed during the past 40 years and evaluated in previous technical studies and environmental analyses.

New Items – includes (1) replacements for legacy countermeasure items that do not introduce any meaningful difference in the potential for environmental impacts and (2) advanced types of units for aircraft systems, which could introduce differences in the potential for environmental impacts.

Testing – includes the verification of operational capabilities of defensive countermeasures and explores the capabilities of the aircraft and pilots in realistic combat training situations with other aircraft and against adversary aircraft.

Training – includes aircrew's completing the handling, loading, and unloading of defensive countermeasures and the pilot's deployment during air-to-air, air-to-ground, and electronic combat flight training operations.

This PEA is being prepared to evaluate the potential environmental consequences of the Proposed Action in compliance with the National Environmental Policy Act (NEPA) of 1969 (42 United States Code 4331 et seq.); the regulations of the President's Council on Environmental Quality (CEQ) that implement NEPA procedures (40 Code of Federal Regulations [CFR] Parts 1500–1508), as amended; and the DAF Environmental Impact Analysis Process (EIAP) promulgated at 32 CFR Part 989.

Programmatic NEPA analyses provide the basis for broad, high-level or sequenced decisions and allows the DAF to subsequently tier in order to analyze narrower, site- or proposal-specific issues. The contrast between a programmatic and a project- or site-specific NEPA analysis is most strongly reflected in how environmental impacts are analyzed. Impacts in a programmatic NEPA review typically concern environmental effects over a large geographic and/or time horizon;

therefore, the depth and detail in programmatic analyses will reflect the major broad and general impacts that might result from making broad programmatic decisions. The context of the decision made should be clear, as well as how it relates to the potentially affected environment and degree of any potential impacts. By identifying potential program impacts early, particularly reasonably foreseeable future impacts/trends, programmatic NEPA reviews provide opportunities to modify program components in order to avoid or mitigate adverse impacts when developing subsequent proposals.

This PEA is being completed through the Air Force Civil Engineer Center NEPA Division in San Antonio, Texas, coordinating with the DAF Air Combat Command at Joint Base Langley Eustis, Virginia; the Air Force Life Cycle Management Center (AFLCMC) at Hill Air Force Base (AFB), Utah; and the Air Force Installation and Mission Support Center – Detachment 6 at Wright-Patterson AFB, Ohio.

1.2 BACKGROUND

The primary defensive countermeasures used by the military aircraft are chaff and flares. Chaff has been used in test, training, and combat operations for more than 60 years. Chaff consists of small, extremely fine fibers of aluminum-coated silica glass with an anti-clumping Neofat coating composed of 90 percent stearic acid and 10 percent palmitic acid, which degrades when exposed to light and air. When deployed by an aircraft, chaff forms a temporary electronic cloud that reflects radar signals in various bands, depending on the length of the chaff fibers. Chaff is made as small and light as possible so it will remain in the air long enough to confuse enemy radar. Individual chaff fibers are approximately one-thousandth of an inch in diameter, or one-half as thick as a very fine human hair. Trace amounts of iron, copper, magnesium, and zinc have also been detected in the controlled combustion of chaff (DAF, 1997). Figure 1.2-1 shows the type of chaff most commonly used by the DAF in training.

Self-protection flares traditionally are primarily mixtures of magnesium, Teflon, and Viton (MTV) molded into rectangular shapes that burn for a short period of time (less than 10 seconds) at temperatures exceeding 2,000 degrees Fahrenheit (°F). The burn temperature is hotter than the exhaust of an aircraft and, therefore, attracts and decoys heat-seeking weapons targeted on the aircraft. Figure 1.2-2 shows a type of flare commonly used by the DAF, the MJU-7A/B.

As aircraft design and capabilities are advanced, there are also advances in adversary weapons systems designed to defeat the defensive countermeasures, including the proliferation of legacy infrared (IR) heat-seeking shoulder-launched missiles and technological advancements in IR seeker missile warheads. In response to the changing threat environment, the DAF has updated chaff and flare capabilities to provide defensive countermeasures for pilots and aircraft to defend against the more advanced adversary weapons systems. Training with those defensive countermeasures is essential to pilot and aircrew survivability in combat theatres.

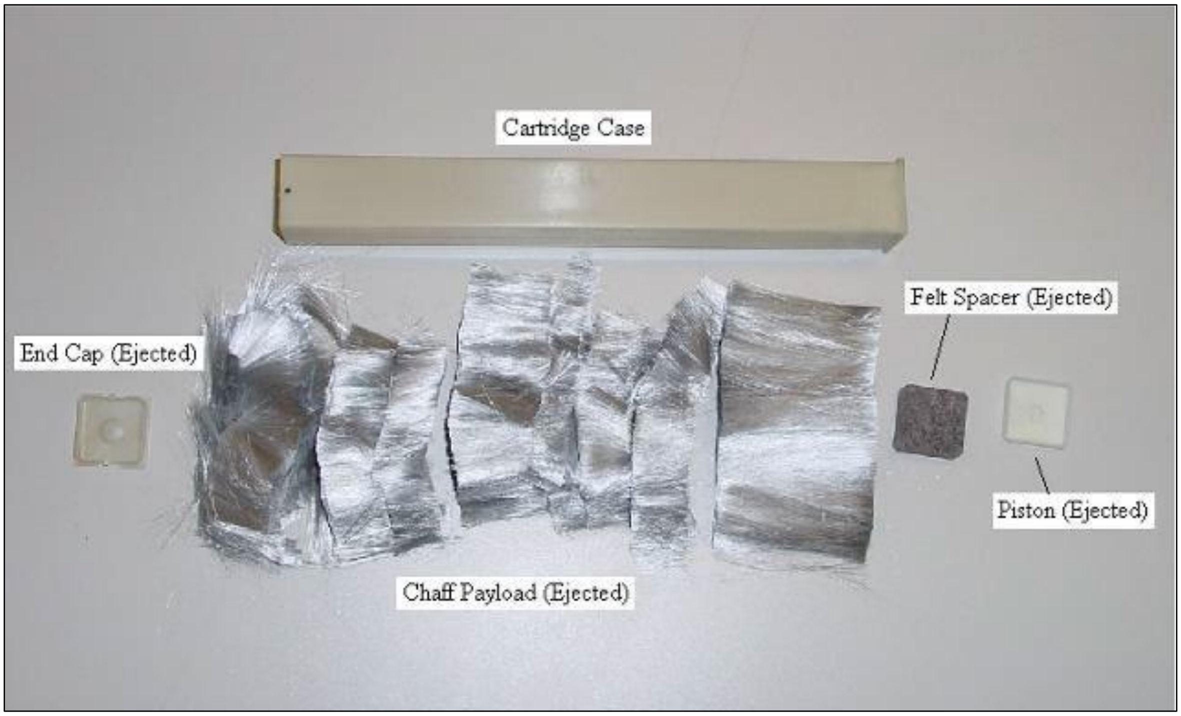


Figure 1.2-1. Photograph of Example Chaff Cartridge (RR-188/AL)

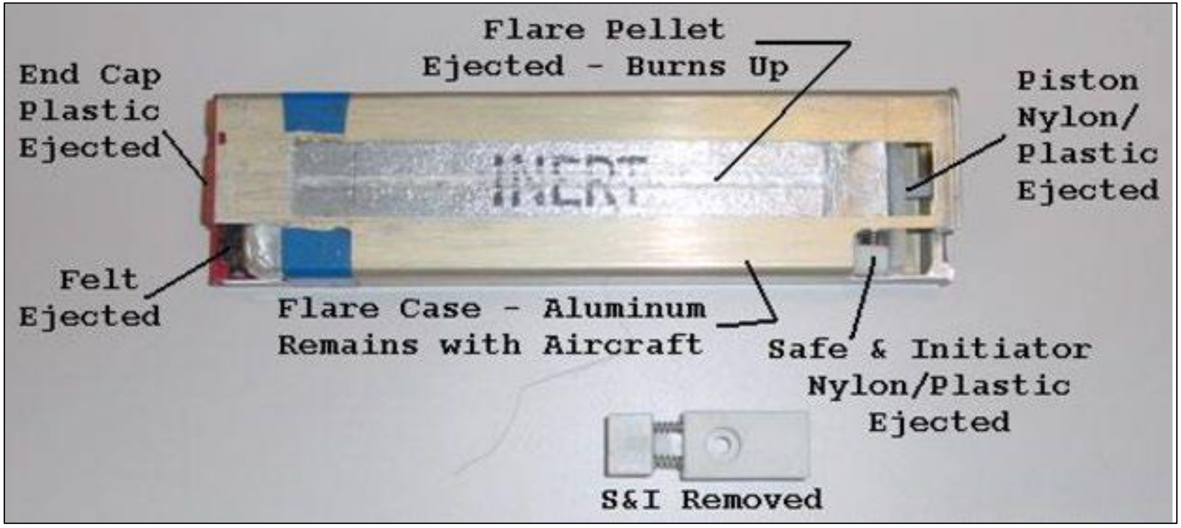


Figure 1.2-2. Photograph of Example Flare

The testing of defensive countermeasures is performed over DoD weapons ranges and electronic combat ranges (see Figure 1.2-3) where the use of ordnance is approved. Training with defensive countermeasures is performed in Military Operations Areas (MOAs) / Air Traffic Control Assigned Airspaces, overwater warning areas, and on military training routes (MTRs) over public and private lands after completion of environmental analysis.

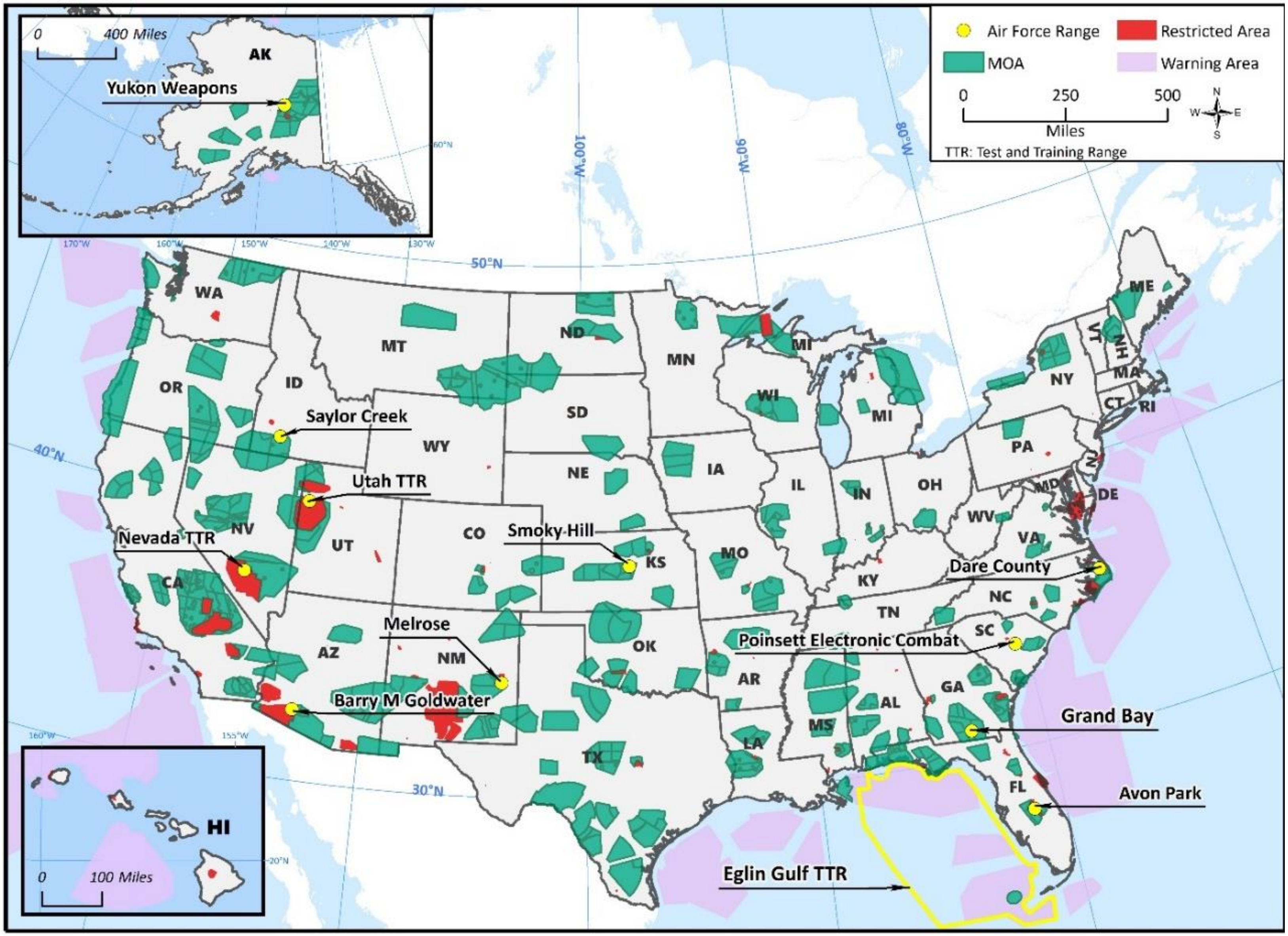


Figure 1.2-3. Military Training Airspace Used by the DAF

1.3 PURPOSE OF AND NEED FOR THE ACTION

The purpose of the Proposed Action is to provide for realistic testing and training with legacy defensive countermeasures and to implement the use of direct replacements and new defensive countermeasures to increase pilot's and aircrew's ability to succeed in real combat situations. Defensive countermeasures are used by military aircraft during training in response to simulated threats. The simulated threats are representative of the current and future threats from radar-guided missiles, which are defended against by chaff, and from IR missiles, which are defended against by flares.

The Proposed Action is needed to ensure that the DAF is able to conduct tests of and train with defensive countermeasures designed for advanced military aircraft that are capable of defending against modern air-to-air and surface-to-air missile systems. Pilots need to train with the legacy and new, more advanced, defensive countermeasures to provide realistic training in order to survive in combat. To be able to deploy defensive countermeasures in a combat situation, DAF pilots must "train as they will fight." This type of training consists of deploying defensive countermeasures in approved military training airspace to replicate combat conditions. Training with defensive countermeasures provides pilots with the opportunity to develop instinctive reactions for threat avoidance and become proficient in masking their aircraft in highly contested environments.

1.4 SCOPE OF THIS PEA

The DAF has prepared this analysis as a broad program-wide evaluation of the use of defensive countermeasures and the potential environmental consequences. As a programmatic analysis, it is intended to support DAF installation-level programs by streamlining coordination and analysis. When a DAF installation has determined that NEPA analysis is required for a specific action involving the use of defensive countermeasures, the action would be evaluated for coverage under this PEA by initiating an environmental sensitivity review documented on the Air Force Form 813. If the review determines that a specific defensive countermeasure use is outside the scope of this PEA or is expected to create impacts greater in magnitude, extent, or duration than those described in this PEA, then tiered NEPA documentation such as a separate Environmental Assessment (EA), Environmental Impact Statement (EIS), or a categorical exclusion would be prepared for that action.

This PEA builds on the previously completed technical studies and environmental analyses which addressed various environmental conditions in sensitive environments that are representative of the range of environmental settings under all DAF test and training airspaces, including woodlands, desert, agricultural areas, oceans, grasslands, and wetlands. The PEA uses the past agency and government-to-government consultations to guide the analysis and, since the analysis in this PEA is programmatic in nature, no consultations specific to this study are conducted. If an installation conducts a separate tiered NEPA analysis for a specific action involving training with defensive countermeasures, then specific agency and government-to-government consultations may be necessary. The diverse training areas for analysis of environmental effects of chaff and flares included in the PEA is based on training airspaces for which there is prior EIAP documentation analyzing the use of legacy defensive countermeasure items.

As part of the effort to complete this PEA, the DAF has included in Appendix A the update to the 1997 and 2011 reports on defensive countermeasures (DAF, 1997; DAF, 2011a). This report update describes the legacy and new defensive countermeasures in the DAF inventory and addresses primary environmental issues associated with chaff and flare deployment. Primary environmental issues with chaff include potential effects of chaff particles on humans, wildlife, livestock, and health; radio frequency effects on air traffic; and potential injury from falling residual materials. Primary environmental issues with flare deployment include fire risk, including malfunctioning flares or deployment at too low altitudes; dud flare frequency and potential ignition upon impacting the ground; potential injury or damage from residual materials; and persistence and fate of flare residual materials.

1.5 COOPERATING AGENCIES AND INTERAGENCY COORDINATION AND PUBLIC INVOLVEMENT

The DAF is the lead agency for this PEA. Past environmental studies have not identified any other federal, state, or local agency having jurisdiction by law or having a special expertise needed for the evaluation of the use of defensive countermeasures. As defined in 40 CFR 1508.5, a Cooperating Agency:

> *"…means any Federal agency other than a lead agency which has jurisdiction by law or special expertise with respect to any environmental impact involved in a proposal (or a reasonable alternative) for legislation or other major Federal action significantly affecting the quality of the human environment. The selection and responsibilities of a cooperating agency are described in § 1501.6. A State or local agency of similar qualifications or, when the effects are on a reservation, an Indian Tribe, may by agreement with the lead agency become a cooperating agency."*

The DAF initiated interagency coordination during the scoping phase of this PEA in accordance with the requirements of NEPA (40 CFR 1501.7(a)(1)). Scoping letters that provided a description of the Proposed Action and No Action Alternative were sent to the national headquarters of the U.S. Environmental Protection Agency (USEPA); the U.S. Department of Interior, Bureau of Indian Affairs, Bureau of Land Management, U.S. Fish and Wildlife Service; the U.S. Department of Agriculture, National Park Service; the U.S. Department of Transportation Federal Aviation Administration (FAA), and the Department of Commerce National Ocean and Atmospheric Administration National Marine Fisheries Service. Appendix B provides copies of the correspondence. CEQ regulations direct agencies to involve the public in preparing and implementing their NEPA procedures. The DAF will publish a Notice of Availability of the Draft PEA indicating the availability of the Draft PEA for a 30-day review and comment period (TBD to TBD, 2023). Comments received from the public and agencies will be provided in Appendix B.

1.6 KEY DOCUMENTS

Key documents are sources of information incorporated into this PEA. Documents are considered to be key because of long-standing, demonstrated guidance and analyses that apply to this Proposed Action. CEQ guidance encourages incorporating documents by reference. Details on documents incorporated by reference in part or in whole are presented in Table 1.6-1. Several NEPA documents and special scientific studies have been conducted regarding the use and potential impacts of chaff and flares, including the following, which are incorporated by reference to support the environmental analysis in this document.

Table 1.6-1. Key Documents Incorporated by Reference

Date	Title	Citation	Type
1997	Environmental Effects of Self-Protection Chaff and Flares: Final Report	(DAF, 1997)	Technical Study - Chaff & Flares
1998	Environmental Protection: DOD Management Issues Related to Chaff. GAO Report GAO/NSIAD-98-219.	(GAO, 1998)	Technical Study - Chaff
1999	Environmental Effects of RF Chaff: A Select Panel Report to the Undersecretary of Defense for Environmental Security. Naval Research Laboratory/PU/6110-99-389	(Spargo, 1999)	Technical Study - Chaff
2000	Environmental Assessment of the Expansion of the Use of Self-Protection Chaff and Flares at the Utah Test and Training Range, Hill Air Force Base, Utah	(DAF, 2000)	NEPA Analysis - Desert, Wetland
2007	Environmental Assessment for the Replacement of F-15 Aircraft with F-22A Aircraft at Hickam Air Force Base, Hawaii	(DAF, 2007)	NEPA Analysis - Ocean
2010	Final EIS for the Airspace Training Initiative, Shaw Air Force Base, South Carolina	(DAF, 2010)	NEPA Analysis - Southern Woodlands, Agriculture, Wetlands
2011	Supplemental Report for Environmental Effects of Training with Defensive Countermeasures	(DAF, 2011a)	Technical Study - Chaff & Flares
2011	Environmental Assessment (for) Recapitalization of the 49th WG Combat Capabilities and Capacities, Holloman Air Force Base, New Mexico	(DAF, 2011b)	NEPA Analysis - Desert, Wetlands
2013	EIS for the Modernization and Enhancement of Ranges, Airspace and Training Areas in the Joint Pacific Alaska Range Complex in Alaska	(DAF and Army, 2013)	NEPA Analysis - Arctic Woodlands
2014	Powder River Training Complex, Ellsworth Air Force Base, South Dakota EIS	(DAF, 2014)	NEPA Analysis – Grasslands, Agriculture, Woodlands
2020	Final Environmental Assessment Combat Air Forces Contracted Adversary Air Temporary Operations From Tyndall AFB, Florida	(DAF, 2020a)	NEPA Analysis - Southern Woodlands, Wetlands
2020	Draft EIS for Moody AFB Comprehensive Airspace Initiative – Draft	(DAF, 2020b)	NEPA Analysis - Southern Woodlands
2021	EIS for Special Use Airspace Optimization to support Existing Aircraft at Holloman AFB, New Mexico	(DAF, 2021)	NEPA Analysis - Desert

Key: AFB = Air Force Base; DOD = Department of Defense; EIS = Environmental Impact Statement; GAO = General Accounting Office; NEPA = National Environmental Policy Act; NSIAD = National Security and International Affairs Division; RF = Radio Frequency

1.7 RELEVANT LAWS AND REGULATIONS

This PEA has been prepared based upon federal and state laws, statutes, regulations, and policies pertinent to the implementation of the Proposed Action, including, but not limited to, those presented in Table 1.7-1.

Table 1.7-1. Relevant Laws and Regulations Pertinent to the Proposed Action

NEPA (42 U.S.C. Sections 4321–4370h)
CEQ Regulations for Implementing the Procedural Provisions of NEPA (85 FR 43359, July 16, 2020, as amended by 87 FR 23453, April 20, 2022)
Air Force Regulations for Implementing NEPA (32 CFR Part 989)
Clean Air Act (42 U.S.C. Section 7401 et seq.)
Clean Water Act (33 U.S.C. Section 1251 et seq.)
Coastal Zone Management Act (16 U.S.C. Sections 1451–1465)
Endangered Species Act (16 U.S.C. Section 1531 et seq.)
Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. Sections 1801–1882)
Marine Mammal Protection Act (16 U.S.C. Section 1361–1362)
National Historic Preservation Act (54 U.S.C. Section 300101 et seq.)
Resource Conservation and Recovery Act (40 CFR Parts 239–282)
EO 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations
EO 13045, Protection of Children from Environmental Health Risks and Safety Risks
AFMAN 32-7003, Environmental Conservation
AFMAN 13-212V1, Range Planning and Operations
AFI 11-214, Air Operations Rules and Procedures
DAF Manual 13-201, Airspace Management
Chairman of the Joint Chiefs of Staff Manual 3212.02D, Performing Electronic Attack in the United States and Canada for Tests, Training, and Exercises
AFI 11-2MDS series instructions
FAA Regulations 14 CFR 91.15, Dropping Objects

Key: AFI = Air Force Instruction; AFMAN = Air Force Manual; CEQ = Council on Environmental Quality; CFR = Code of Federal Regulations; DAF = Department of the Air Force; EO = Executive Order; FAA = Federal Aviation Administration; FR = Federal Register; NEPA = National Environmental Policy Act; U.S.C. = United States Code

2. DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

2.1 PROPOSED ACTION

The DAF proposes to continue the use of legacy defensive countermeasures in testing and routine flight training in the DAF training airspace where their use is approved. The Proposed Action also includes use of the replacements to the legacy countermeasures that have been identified for replacement and new defensive countermeasures. Under the Proposed Action, the DAF would continue to deploy countermeasures at current levels and in accordance with DAF policy and restrictions, including those that are currently in place for specific airspace units.

2.2 SCREENING CRITERIA

NEPA and CEQ regulations require consideration of reasonable alternatives before undertaking any proposed action. “Reasonable alternatives” are those that could meet the purpose of and need for the proposed action. Per the requirements of 32 CFR 989.8(b), the DAF EIAP regulations, selection standards are used to identify alternatives that meet the purpose of and need for the proposed action. The potential alternatives that meet the purpose and need as identified in Section 1.3 were evaluated against the following screening criteria:

- Supports unique DAF-specific military defensive countermeasure test requirements
- Supports DAF-specific flight training requirements with defensive countermeasures

In addition to the above criteria, all alternatives carried forward for analysis would have to be in accordance with all applicable federal and state laws and all relevant permitting requirements.

When a DAF installation prepares a NEPA analysis tiered from this PEA, screening criteria applicable to the site-specific action will be developed to identify alternatives that meet the purpose and need of that specific action.

2.3 ALTERNATIVES CARRIED FORWARD FOR ANALYSIS

Only the Proposed Action meets the purpose and need for the action and is carried forward for analysis in this PEA. In addition, CEQ regulations specify that an EA include a no action alternative against which potential impacts can be compared. The No Action Alternative represents the baseline, or existing, conditions which would continue if the testing and training use of new defensive countermeasures did not occur at this time. While the No Action Alternative would not satisfy the purpose of or need for the Proposed Action, the No Action Alternative is carried forward for analysis in this PEA in accordance with CEQ regulations.

2.3.1 Proposed Action Alternative: Train with Legacy and New Defensive Countermeasures

The DAF proposes to continue the use of the legacy defensive countermeasures used by the DAF in test and training operations across the continental United States and the new countermeasures designed to defend against advanced weapon system threats. The timeframe for the Proposed Action is 10 years, and the proposed quantities of chaff and flares are specified in Table 2.3-1 through Table 2.3-6. The defensive countermeasures included in the Proposed Action Alternative (Proposed Action) described below have been grouped into five different defensive countermeasure categories: chaff, standard MTV flares, standard spectral flares, thrusted flares, and spectral decoys.

Chaff: Modern chaff used during training consists of extremely small strands (or dipoles) of aluminum-coated, crystalline silica core fibers. Modern chaff is often called “angel hair” chaff, since it is very fine and is cut to lengths that effectively counter specific radars. Training chaff dipoles are cut in lengths that are designed to not interfere with FAA radars. When deployed by an aircraft, modern chaff forms a brief electronic cloud that reflects radar signals in various bands, depending on the length of the chaff fibers. Dispersed chaff forms an image of reflected signals on an enemy radar screen. The pilot maneuvers his or her aircraft while it is momentarily obscured or masked from precise radar detection by the electronic cloud to avoid or break the radar-guided threat. Chaff is made as small and light as possible so that it will remain dispersed in the air long enough to confuse enemy radar.

Standard MTV Flare: This flare uses the initial defensive flare technology to create a heat source that is hotter than an aircraft engine and is designed to draw the IR missile toward the flare or series of flares. The MTV flare successfully defends an aircraft from legacy IR missiles. Furthermore, since many man-portable air-defense systems in different countries still use legacy technology in their missiles, the MTV flares remain a useful countermeasure against low technology IR threats.

Standard Spectral Flares: Standard spectral flares represent the second family of flare countermeasures that present multiple spectral bands to the IR missile advanced seeker heads. These improved spectral flares cause the seeker head to momentarily lose a target among the deployed defensive flares, emitting multiple spectral bands comparable to those emitted by a target aircraft. The pilot would typically maneuver as flares were deployed to further distract the IR missile. Spectral flares have made it more difficult for the missile seeker head to distinguish a spectral flare with diverse IR signatures from the target aircraft with diverse IR signatures.

Thrusted Flares: A thrusted flare essentially functions as a small rocket, with the flare nozzle using the magnesium “fuel” to propel the flare within a finned body made of carbon fiber, steel, or aluminum. As mini-rockets, thrusted flares are used for testing and limited training on established ranges where munitions are deployed and in combat.

Spectral Decoys: These countermeasures present an entirely different heat signature from that of the pyrotechnic flares in the first three families of flare countermeasures considered in this report. The magnesium pellets in MTV, standard spectral, and thrusted flares were all combusting and creating an IR signature to interfere with the specific IR missile’s seeker head. Spectral decoys are not pyrotechnic flares, but they are pyrophoric flares comprised of thin iron foils with an oxidizing coating. When exposed to air, the thin foils, which can be differently coated and packed, create a myriad of IR signatures.

For the Proposed Action, these five categories (chaff, standard MTV flares, standard spectral flares, thrusted flares, and spectral decoys) each contain between five to nine specific defensive countermeasure items as identified in Table 2.3-1 through Table 2.3-5. Of the 35 items included in the Proposed Action, 13 items were evaluated in the prior 1997 and 2011 defensive countermeasure reports (DAF, 1997; DAF, 2011a), and the other 22 items are new (see Table 2.3-1 through Table 2.3-5).

Table 2.3-1. Chaff Annual Use and Projected Use for the Proposed Action

Chaff Item	Included in 1997 or 2011 Reports	12-Month Training[1]	12-Month Test[1]	Comments and/or Expected Change in Use	Potential Future Annual Training	Potential Future Annual Test
RR-170A/AL	Both	53	868	Standard Single-Shot Combat Chaff	70	90
RR-180/AL	Both	2,675	4,810	Standard Dual-Shot Combat Chaff	3,000	4,300
RR-188/AL	Both	404,073	10,515	Standard Single-Shot Training Chaff	340,000	1,000
RR-196(T-1)/AL	2011	40,742	2,370	Parchment Paper-Wrapped Bundles - Delayed Opening Training Chaff	46,000	1,000
RR-196/AL	2011	0	0	Kapton-Wrapped Bundles - Delayed Opening Combat Chaff	250	1,700
RR-198/AL	No	0	0	Delayed Opening Combat Chaff Kapton-Wrapped Bundles	350	3300
RR-199/AL	No	0	0	Delayed Opening Training Chaff, Parchment Paper-Wrapped Bundles	75,000	5500
Totals		**447,544**	**18,562**		**464,670**	**16,890**

Note:
[1] Average 12-month training and testing usage is calculated from 27 months of data.

Table 2.3-1 lists the self-protection chaff currently in use or proposed for future use, the calculated quantities used annually during 2020, and the proposed annual use for the next 10 years. The self-protection flares and decoys currently in use or proposed for future use, the calculated quantities used during 2020, and the proposed annual use for the next 10 years are listed in Table 2.3-2 through Table 2.3-5. The comments column in Table 2.3-1 through Table 2.3-5 provides notes on the chaff and flares, respectively, including upgrades to respond to increasing threats. Table 2.3-6 summarizes the annual allocation of defensive countermeasures currently in use and proposed for future use, grouped by the five different defensive countermeasure categories.

Based on records kept by the AFLCMC, specific information on each item listed in Table 2.3-1 through Table 2.3-5 can be found in the Final Supplemental Report Update: Environmental Effects of Training with Defensive Countermeasures (hereafter referred to as the "Supplemental Report Update") provided in Appendix A.

Table 2.3-2. Standard MTV Flares Annual Use and Projected Use for the Proposed Action

Flare Type	Included in 1997 or 2011 Reports	12-Month Training[1]	12-Month Test[1]	Comments and/or Expected Change in Use	Potential Future Annual Training	Potential Future Annual Test
ALA-17C	2011	733	0	Limited Inventory for Combat	0	0
M206	Both	557,346	7,794	Training to transfer to MJU-61A/B	20,000	1,000
MJU-7A/B	Both	151,075	3,714	Training to transfer to MJU-53/B, MJU-61A/B, or MJU-75/B	10,000	500
MJU-10/B	Both	9,086	583	Training to transfer to MJU-53/B, MJU-61A/B, or MJU-75/B	2,300	50
MJU-23A/B	Both	257	0	B-1B only	0	0
MJU-53/B	No	2,417	50	Same as MJU-75/B with a different impulse cartridge	50,000	500
MJU-61A/B	2011	40,032	1,028	Same as MJU-77/B, except different IR signature	490,000	4,500
MJU-75/B	No	0	267	Same as MJU-53/B, except different (updated) impulse cartridge	150,000	4,000
MJU-77/B	No	0	0	Same as MJU-61A/B, except different IR signature	36,000	3,000
Totals		**760,946**	**13,436**		**758,300**	**13,550**

Key: IR = infrared; MTV = magnesium, Teflon, and Viton
Note:
[1] Average 12-month training and testing usage is calculated from 27 months of data.

Table 2.3-3. Standard Spectral Flares Annual Use and Projected Use for the Proposed Action

Flare Type	Included in 1997 or 2011 Reports	12-Month Training[1]	12-Month Test[1]	Comments and/or Expected Change in Use	Potential Future Annual Training	Potential Future Annual Test
M212	No	0	47	Expected to be replaced as supplies of MJU-73/B become available starting in 2023	0	0
XM216E5	No	0	0	Expect to be updated by MJU-78/B with improved impulse cartridge	0	100
MJU-62/B or MJU-62A/B	2011	1,751	79	MJU-62A/B has an updated pellet. Both versions are to be used.	0	200

Table 2.3-3. Standard Spectral Flares Annual Use and Projected Use for the Proposed Action (continued)

Flare Type	Included in 1997 or 2011 Reports	12-Month Training[1]	12-Month Test[1]	Comments and/or Expected Change in Use	Potential Future Annual Training	Potential Future Annual Test
MJU-73/B	No	0	3	Updated design to replace M212 starting in 2023	1,700	200
MJU-78/B	No	0	0	Updated XM216E5 with different ignition cartridge	100	200
Totals		**1,751**	**129**		**1,800**	**700**

Note:

[1] Average 12-month training and testing usage is calculated from 27 months of data.

Table 2.3-4. Thrusted Flares Annual Use and Projected Use for the Proposed Action

Flare Type	Included in 1997 or 2011 Reports	12-Month Training[1]	12-Month Test[1]	Comments and/or Expected Change in Use	Potential Future Annual Training	Potential Future Annual Test
MJU-39A/B and MJU-40A/B	No	0	28	Combat flare	0	0
MJU-68/B	2011	0	67	Very limited training use	25	3,000
MJU-71/B	No	0	997	Very limited training use; expected to be replaced by MJU-76/B in future	25	100
MJU-76/B	No	0	0	Undergoing testing in 2022; expected to replace MJU-71/B; very limited training use	25	1,000
Totals		**0**	**1,092**		**75**	**4,100**

Note:

[1] Average 12-month training and testing usage is calculated from 27 months of data.

Table 2.3-5. Spectral Decoys Annual Use and Projected Use for the Proposed Action

Flare Type	Included in 1997 or 2011 Reports	12-Month Training[1]	12-Month Test[1]	Comments and/or Expected Change in Use	Potential Future Annual Training	Potential Future Annual Test
M211	No	0	45	Replaced by MJU-64/B as of 2022 and later to MJU-66/B	0	0
XM219	No	0	27	Strapped bundle design	0	50
MJU-50/B MJU-50A/B	No	8,717	204	Primarily 50/B; 50A/B for any future production	8,500	400
MJU-51A/B	No	1,489	12	For larger aircraft	2,500	200

Table 2.3-5. Spectral Decoys Annual Use and Projected Use for the Proposed Action (continued)

Flare Type	Included in 1997 or 2011 Reports	12-Month Training[1]	12-Month Test[1]	Comments and/or Expected Change in Use	Potential Future Annual Training	Potential Future Annual Test
MJU-52A/B	No	0	0	Special dispenser required; limited applications	2,000	1,000
MJU-64/B	No	7,862	408	Being replaced by MJU-66	1,000	2,000
MJU-66/B	No	15,334	1,412	Improved version of the MJU-64	15,000	3,000
Total		**33,402**	**2,108**		**29,000**	**6,650**

Note:

[1] Average 12-month training and testing usage is calculated from 27 months of data.

Table 2.3-6. Annual Allocation of Defensive Countermeasures

Defensive Countermeasure Categories[1]	Current Use (No Action Alternative)			Proposed Use (Proposed Action)		
	Test	Training	Total	Test	Training	Total
Chaff	18,562	447,544	466,106	16,890	464,670	481,560
Standard MTV Flares	13,436	760,946	774,382	13,550	758,300	771,850
Standard Spectral Flares	129	1751	1,880	700	1,800	2,500
Thrusted Flares	1,092	0	1,092	4,100	75	4,175
Spectral Decoys	2,108	33,402	35,510	6,650	29,000	35,650

Key: MTV = magnesium, Teflon, and Viton

Note:

[1] For a more detailed listing of types of defensive countermeasures included in these categories, please see the Supplemental Report Update in Appendix A.

The DAF routinely implements a variety of management strategies to reduce and/or minimize the potential environmental effects from the use of defensive countermeasures, which have been identified in the previous NEPA analyses for their use. These management strategies would apply to any alternative of this PEA selected for implementation. The DAF has established these strategies in past referenced environmental analysis when operating near areas sensitive to the use of defensive countermeasures:

- Altitude restrictions on deployment of flares over specific land uses
- Restrictions on flare use and altitude of deployment based on local and regional fire conditions
- Seasonal restrictions on deployment of flares in consideration of ranching, recreational, cultural/tribal, and biological resource issues
- Distance setbacks from airports for the release of training chaff
- Development of briefing procedures and informational materials to provide users of the training airspace and landowners beneath these airspaces on the use of chaff and flares within the airspace and the potential for residual materials
- Continue research on the potential for biodegradable materials used in flare and chaff manufacture, and subsequent deposition and degradation of residual materials following deployment

When a DAF installation prepares a NEPA analysis tiered from this PEA, the application of these strategies would be considered along with any additional strategies that are specific to the installation's action.

2.3.2 No Action Alternative

CEQ regulations require that an agency "include the alternative of no action" as one of the alternatives it considers (40 CFR 1502.14(c)). Under the No Action Alternative, defensive countermeasure use in testing and training by the DAF would continue with legacy chaff and flare units at levels identified in Table 2.3-1 through Table 2.3-4, in currently approved airspace and under current management strategies. The use of legacy chaff and flares with agreed-to deployment conditions to reduce the potential for environmental effects would continue, such as the use of Kapton-wrapped combat chaff only for test and very limited training and the use of parchment-wrapped chaff for required training. There would be very limited training and testing of flares with a weighted nose by deploying such flares over ranges approved for live or inert munitions. While current management strategies would continue, the No Action Alternative would not ensure use of replacements for legacy countermeasures and the incorporation of new defensive countermeasures into DAF test and training programs. The No Action Alternative does not meet the purpose of and the need for the Proposed Action. However, the No Action Alternative is carried forward for analysis consistent with CEQ guidelines to provide a baseline against which to measure the impacts of the Proposed Action.

2.4 ALTERNATIVES CONSIDERED BUT NOT CARRIED FORWARD

2.4.1 Cease Training with Defensive Countermeasures

Stopping the use of chaff and flares altogether is not a reasonable alternative because of ongoing DAF training and readiness requirements, which include training to ensure aircrew proficiency in the use of these defensive measures. Stopping the use of chaff or flares in training would result in DAF units being required to use methods in combat for which they have never been trained, which is unacceptable.

2.4.2 Replacement of Training with Complete or Partial Virtual Training

The use of virtual training as a partial or whole replacement for the realistic training with chaff and flares was considered as an alternative to the Proposed Action. Realistic training for the deployment of defensive countermeasures requires that training occur under conditions that replicate actual combat situations with opposing forces and changing atmospheric and topographic elements. The pilot/aircrew must coordinate monitoring and responding to sensor warnings, maneuvering an aircraft at high speeds while under extensive g-forces, and deploying countermeasures. Additionally, aircraft maintainers need the practice of loading actual chaff and flares versus doing it on an infrequent basis. Virtual training does not replace the realistic training (train-like-we-fight); therefore, the alternative was not carried forward for analysis.

2.5 SCOPE OF RESOURCE ANALYSIS

The Proposed Action has the potential to affect certain environmental resources. These potentially affected resources have been identified through review of past environmental documentation and public input. Specific environmental resources with the potential for environmental consequences include safety, air quality, biological resources, cultural resources, land use and visual resources, and socioeconomics.

CEQ regulations (40 CFR 1501.9(f)) require that the lead agency for an action identify and eliminate from detailed study the issues that are not significant or have been covered by prior environmental review(s), narrowing the discussion of these issues to a brief presentation of why they will not have a significant effect on the human environment or providing a reference to their coverage elsewhere. The following resource areas have been eliminated from detailed analysis: airspace, hazardous materials and waste management, noise, infrastructure/utilities, and socioeconomics.

Airspace Management. Airspace management would not be affected by the Proposed Action. Operations within the training airspace would remain unchanged, and no modifications to the size or manner of use of these airspace units would occur. Chaff used for training in the United States has been modified so that current FAA and weather radars are able to differentiate training chaff from weather events. Proposed use of chaff and flares would not affect civil aviation or FAA operations in the areas around the training airspace. Under the current DAF restrictions to not use chaff within 60 nautical miles of airport control radars, the type of chaff to be deployed would not affect FAA radars. Therefore, no impacts would occur to airspace if the Proposed Action were implemented.

Hazardous Materials and Waste Management. Effects from hazardous materials and waste would be negligible to nonexistent. The components in chaff and flares do not comprise hazardous materials or waste. Thus, any residues contacting the ground after deployment would not introduce hazardous materials or waste into the environment. Adherence to existing policies relating to hazardous materials management, storage, and use would continue to be undertaken and monitored under the DAF's environmental management programs. Given the enforced requirement to ensure safe handling of materials, the minimal amounts of materials likely to be used, and the lack of impacts from residues, the probability for an effect on the environment would be so negligible that further analysis in this EA is unwarranted.

Infrastructure/Utilities: The Proposed Action would be limited to airspace only, and its implementation would not require or result in any facility construction or modification, infrastructure upgrades, or demolition. Training with defensive countermeasures over DAF-owned lands when there is fire risk would occur at or greater than 500 feet above ground level (AGL). Training with defensive countermeasures over non-DAF-owned lands (e.g., tribal, federal, private, etc.) would occur at over 2,000 feet AGL (AFI 11-214). Residual materials from deployed flares or angel hair chaff would not be of the size or shape to disrupt electrical transmission systems and would not impact any ground utilities or structures. These residual materials are also not considered a solid waste as defined by Subpart M, Section 266.202 of the Resource Conservation and Recovery Act, as they have been used for their intended purpose. As a result, the DAF anticipates no short- or long-term impacts; therefore, this resource area, including solid waste, is not carried forward for detailed analysis.

Noise. There is no change in aircraft operations, and implementation of the Proposed Action would not result in any change in the acoustic environment. As a result, the DAF anticipates no short- or long-term impacts; therefore, this resource area is not carried forward for detailed analysis.

Greenhouse Gasses. There is no change in aircraft operations, and implementation of the Proposed Action would not result in any increase of aircraft-related emissions in the atmosphere. Emissions from countermeasure use would remain effectively the same because there is no proposed increase in the overall quantity to be used. As a result, the DAF anticipates no short- or long-term impacts; therefore, this resource area is not carried forward for detailed analysis.

Environmental Justice. This resource would not be affected by implementation of the Proposed Action. Chaff and flare deployment throughout all DAF training airspace would not have a disproportionate effect on minority and low-income populations. Therefore, further analysis of this resource is not undertaken.

2.6 COMPARISON OF ENVIRONMENTAL IMPACTS

Table 2.6-1 provides a summary of the potential environmental impacts associated with the Proposed Action and the No Action Alternative.

Table 2.6-1. Comparison of Environmental Impacts

Resource	Proposed Action	No Action Alternative
Safety	*Legacy Countermeasure Items* • No significant impacts. Previous technical reports and NEPA analyses incorporated by reference, and the updated technical report (Appendix A), have shown that the safety risks of injury from falling residual materials is negligible and that current DAF regulations and procedures, including altitude restrictions on flare deployment, effectively reduce the risk for starting wildland fires from burning flares. *New Countermeasure Items* • No significant impacts. Potential impacts to safety from testing and training use of the new chaff and flare (MTV, standard spectral, and thrusted) items, as proposed, would be similar to legacy items with continuation of legacy item management strategies. Training use of spectral decoys has less potential to impact safety than other countermeasures, with no potential for dud items, lighter residual materials, and a lower risk of causing fire due to lower temperature of the pyrophoric oxidation.	No significant impacts. Continued testing and training use of legacy chaff and flare items would have no significant impacts to safety with continuation of current management strategies.
Air Quality (includes GHG)	*Legacy Countermeasure Items* • No significant impacts. Previous technical reports and NEPA analyses incorporated by reference, and the updated technical report (Appendix A), have shown that chaff fibers do not release respirable particulate matter into the atmosphere, and all emissions associated with flares have no significant impact on air quality. *New Countermeasure Items* • No significant impacts. Potential impacts to air quality from testing and training use of the new chaff and flare (MTV, standard spectral, and thrusted) items, as proposed, would be similar to legacy items with continuation of legacy item management strategies. Training use of spectral decoys has even less potential to impact air quality than other countermeasures, with no pyrotechnic burning flare material and only pyrophoric oxidation of coating on iron foils.	No significant impacts. Continued testing and training use of legacy chaff and flare items would have no significant impacts to air quality.
Cultural Resources	*Legacy Countermeasure Items* • No significant impacts. Previous technical reports and NEPA analyses incorporated by reference, and the updated technical report (Appendix A), have shown that residual materials from testing and training use of legacy chaff and flares result in no adverse impacts to cultural resources with continuation of current management strategies. *New Countermeasure Items* • No significant impacts. Potential impacts to cultural resources from testing and training use of the new chaff and flare (MTV, standard spectral, and thrusted) items, as proposed, would be similar to legacy items with continuation of legacy item management strategies. Training use of spectral decoys has the potential to impact cultural resources by depositing the residual oxidized foils that could be more visible on the surface than the residual materials of chaff and flares. The	No significant impacts. Continued testing and training use of legacy chaff and flare items would have no adverse impacts to cultural resources with continuation of current management strategies.

Table 2.6-1. Comparison of Environmental Impacts (continued)

Resource	Proposed Action	No Action Alternative
	degree of potential impact would vary with the potential for foils to concentrate at a site, which is related to altitude and frequency of deployment over the same area.	
Biological Resources	*Legacy Defensive Countermeasures* - No significant impacts. Previous technical reports and NEPA analyses incorporated by reference, and the updated technical report (Appendix A), have shown that residual materials from testing and training with legacy chaff and flare countermeasures, when deployed with the continuation of current management strategies, either have no significant impact or continue to result in a “may affect, but not likely to adversely affect” determination for biological resources, including sensitive species, under DAF training airspace. *New Defensive Countermeasures* - Potential impacts to biological resources from training and testing use of new delayed deployment chaff and flares (MTV, standard spectral, and thrusted), with the continuation of current management strategies for legacy countermeasures, would either have no significant impact or be expected to result in a “may affect, but not likely to adversely affect” determination for biological resources, including sensitive species, under DAF training airspace. Training with spectral decoys in DAF airspace as described in the Proposed Action would release thousands of light, durable iron foils with each decoy deployed. Introducing metal foils into woodlands, wetlands, or oceans could affect but would not be expected to have a significant impact to biological resources. Foils in grasslands used for grazing could affect domestic species through inadvertent consumption of foils suspended in grass. Use of spectral decoys for testing and limited training exercises on the DAF ranges has the potential to result in a “may affect, but not likely to adversely affect” determination for sensitive biological species.	No significant impacts. Continued testing and training use of legacy chaff and flare items with application of current management strategies would be expected to either have no significant impact or result in a “may affect, but not likely to adversely affect” determination for biological resources, including sensitive species, under DAF training airspace.
Soil and Water Resources	*Legacy Countermeasure Items* - No significant impacts. Previous technical reports and NEPA analyses incorporated by reference, and the updated technical report (Appendix A), have shown that residual materials from testing and training use of legacy chaff and flares result in no adverse impacts to soil and water resources with continuation of current management strategies. *New Countermeasure Items* - No significant impacts. Potential impacts to soil and water resources from testing and training use of the new chaff and flare (MTV, standard spectral, and thrusted) items, as proposed, would be similar to legacy items with continuation of legacy item management strategies. Training use of spectral decoys has the potential to impact soil and water resources by depositing the residual oxidized foils, which could be more numerous than the residual materials of chaff and standard flares. Until further studies are conducted, it is anticipated that seasonal weathering and vegetative litter will reduce the oxidized foils to iron and iron oxide particles, which would not significantly impact soil components. It is calculated that it would take four completely dissolved 0.25-gram foils per cubic meter of	No significant impacts. Continued testing and training use of legacy chaff and flare items would have no adverse impacts to soil and water resources with continuation of current management strategies.

Table 2.6-1. Comparison of Environmental Impacts (continued)

Resource	Proposed Action	No Action Alternative
	water to reach USEPA's National Recommended Water Quality Criteria – Aquatic Life Criteria water quality cleanup standard of 1,000 µg/l. Impacts to surface waters would not be significant.	
Land Use and Visual Resources	*Legacy Countermeasure Items* • No significant impacts. Previous technical reports and NEPA analyses incorporated by reference, and the updated technical report (Appendix A), have shown that impacts could result from wildfires from flare deployment and flare residual materials being visible in recreational or pristine environments. Testing and training use of legacy chaff and flares result in no significant impacts to land use and visual resources with continuation of current management strategies. *New Countermeasure Items* • No significant impacts. Testing and training use of the new chaff and flare (MTV, standard spectral, and thrusted) items similar to legacy items, as proposed, would result in similar minor impacts to land use and visual resources with continuation of legacy item management strategies. Training use of spectral decoys has the potential to result in impacts to visual resources by depositing the residual oxidized foils that could be more numerous and/or visible on the surface in recreational or pristine environments than the residual materials of chaff and flares. The degree of potential impact would vary with the potential for foils to concentrate in a given area, which is related to altitude and frequency of deployment over the same area.	No significant impacts. Continued testing and training use of legacy chaff and flare items would have no adverse impacts to land use and visual resources with continuation of current management strategies.
Socioeconomics	*Legacy Defensive Countermeasures* • No significant impacts. Previous technical reports and NEPA analyses incorporated by reference, and the updated technical report (Appendix A), have shown that residual materials from training and testing with legacy chaff and flare countermeasures, when deployed with the continuation of current management strategies, have no significant impact upon socioeconomic resources, although individuals encountering a residual piece of chaff or flare material may be annoyed. *New Defensive Countermeasures* • No significant impacts. Testing and training use of the new chaff and flare (MTV, standard spectral, and thrusted) items similar to legacy items, as proposed, would have no significant impact upon socioeconomic resources with continuation of legacy item management strategies. DAF training with spectral decoys in MOAs over agricultural land at low altitude would release thousands of light, durable iron foils with each decoy deployed. These foils have the potential to impact socioeconomic resources, specifically agricultural activities associated with livestock feed crops and silage and other crops that could be seen as adverse by farmers and ranchers.	No significant impacts. Continued testing and training use of legacy chaff and flare items with application of current management strategies would not significantly impact socioeconomic resources.

Key: µg/l = microgram per liter; DAF = Department of the Air Force; GHG = greenhouse gas; MTV = magnesium, Teflon, and Viton; NEPA = National Environmental Policy Act; USEPA = United States Environmental Protection Agency

3. AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

This PEA addresses the potential environmental consequences to natural and human environments beneath the airspaces approved for DAF deployment of defensive countermeasures for test or training (see Figure 1.2-3). Military testing and training with defensive countermeasures occur in MOAs, Air Traffic Control Assigned Airspace, MTRs, and Restricted Airspaces over land, and in Warning Areas over offshore waters. The land surfaces under the airspaces are managed by either the military, federal government agencies, other government agencies, federally recognized tribes, or private landowners. The lands and waters beneath these airspaces include a diverse array of arid and temperate environmental settings.

3.1 OVERALL PROGRAMMATIC APPROACH AND SECTION ORGANIZATION

For this programmatic approach, the DAF has consolidated the analyses to address the environmental effects of defensive countermeasure use. The representative environmental settings under DAF training airspace include woodlands, desert, agricultural areas, oceans, wetlands, and grasslands. Table 3.1-1 identifies, by environmental setting and by airspace, the prior NEPA analysis documents incorporated by reference in this PEA. Figure 3.1-1 identifies the airspace units/complexes that the prior NEPA documents analyzed. Incorporating by reference publicly available information facilitates a more efficient, effective, and timely NEPA review and thereby avoids duplication of information that is available elsewhere.

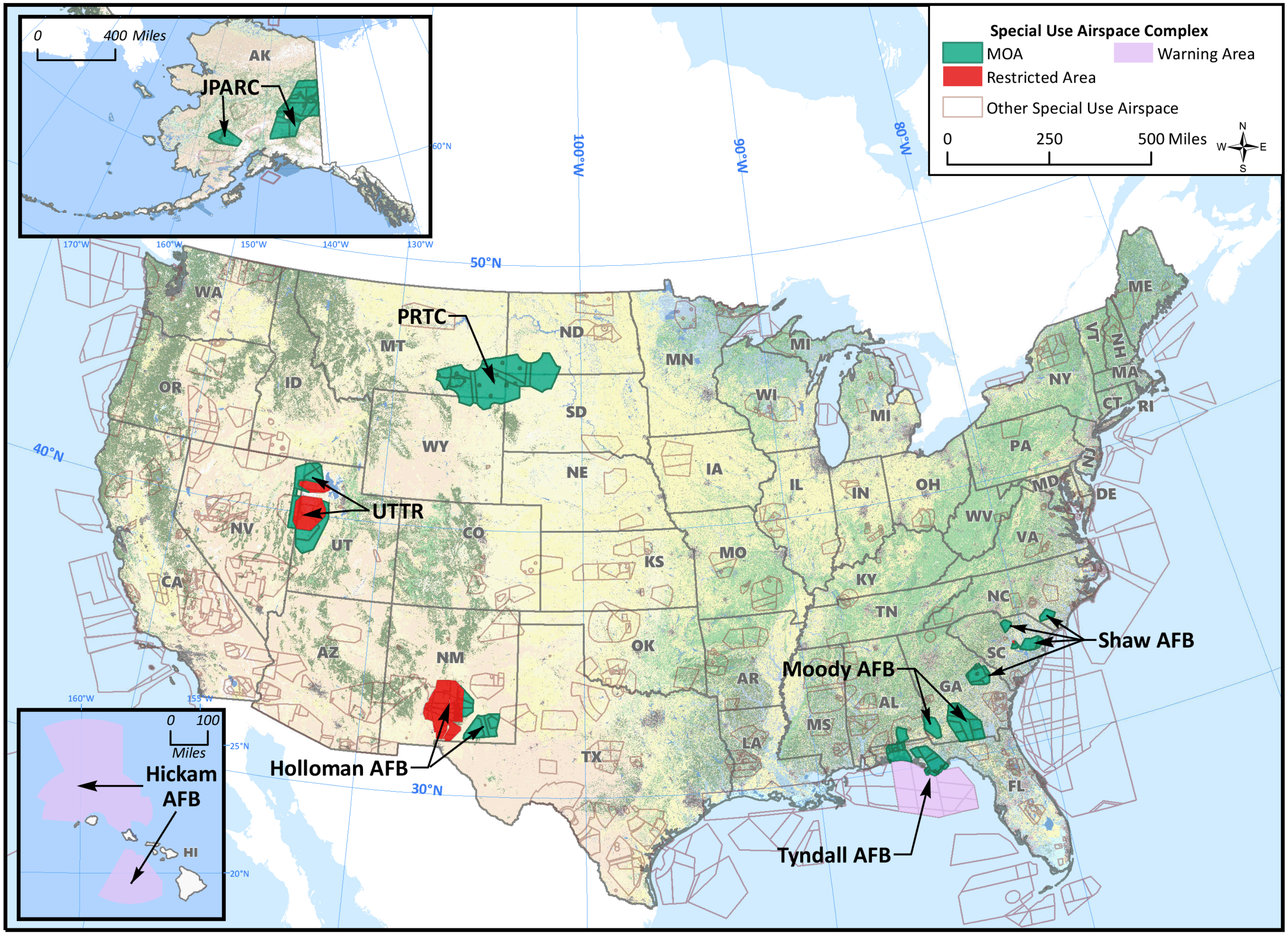
The scope of environmental effects analysis in this PEA focuses on those environmental resources that have the potential to be affected by either the Proposed Action or No Action Alternative as per CEQ guidance (40 CFR 1501.9(f)). Those resource areas that could be affected are analyzed for environmental effects. Those resources that would not be not expected to be impacted, and the reasoning, are identified in Section 2.5.

As stated in Section 1.2, the testing of defensive countermeasures is performed over DoD weapons ranges and electronic combat ranges (see Figure 1.2-3) where the use of ordnance is approved. For this reason, the environmental effects analysis of the Proposed Action and No Action Alternatives in this PEA focuses on the potential impacts from countermeasure use during training. While environmental effects from countermeasure testing is possible, the potential for effects is lower, primarily due to the disturbed nature of ranges caused by ordnance use. There exists potential for environmental impacts to resources outside the Range boundaries from testing, but any potential for impacts would be expected to be lower than the potential impacts to resources outside MOA boundaries from training, because of the higher quantities (for all but one type [see Table 2.3-6]) used during training. Overall, the potential for environmental impacts of countermeasure use is considered to be higher for training than for testing, which is why the focus of the impacts analysis is on training.

Table 3.1-1. Representative Training Airspace and Prior NEPA Documents Incorporated by Reference for Analysis in the PEA

Environmental Setting	Airspace Location	NEPA Document Reference
Woodlands	Joint Pacific Alaska Range Complex, Alaska	Environmental Impact Statement for the Modernization and Enhancement of Ranges, Airspace, and Training Areas in the Joint Pacific Alaska Range Complex in Alaska (DAF and Army, 2013) (the JPARC EIS)
Woodlands	Tyndall AFB, Florida	Combat Air Forces Contracted Adversary Air Temporary Operations From Tyndall AFB, Florida (DAF, 2020a) (the ADAIR EA)
Woodlands	Powder River Training Complex (PRTC), Ellsworth AFB, South Dakota	Powder River Training Complex, Ellsworth Air Force Base EIS (DAF, 2014) (the PRTC EIS)
Woodlands	Moody AFB, Georgia	Draft Environmental Impact Statement for the Comprehensive Airspace Initiative for Moody Air Force Base, Georgia (DAF, 2020b) (the Moody AFB EIS)
Woodlands	Shaw AFB, South Carolina	Final Environmental Impact Statement (EIS) for the Airspace Training Initiative, Shaw AFB, South Carolina (DAF, 2010) (the Shaw ATI EIS)
Desert and Arid Regions	Holloman AFB, New Mexico	Environmental Assessment (for) Recapitalization of the 49th WG Combat Capabilities and Capacities, Holloman Air Force Base, New Mexico (DAF, 2011b) (the Holloman AFB EA)
Desert and Arid Regions	Holloman AFB, New Mexico	Environmental Impact Statement for Special Use Airspace Optimization to Support Existing Aircraft at Holloman Air Force Base (DAF, 2021) (the Holloman AFB EIS)
Desert and Arid Regions	Utah Test and Training Range (UTTR), Hill AFB, Utah	Expansion Of The Use Of Self-Protection Chaff And Flares At The UTTR, Hill AFB, Utah (DAF, 2000) (the UTTR EA)
Agricultural Areas (includes crops & livestock)	PRTC, Ellsworth AFB, South Dakota	Powder River Training Complex, Ellsworth Air Force Base EIS (DAF, 2014) (the PRTC EIS)
Oceans	Hickam AFB, Hawaii	Replacement of F-15 Aircraft with F-22A Aircraft, Hickam Air Force Base, Hawaii (DAF, 2007) (the Hickam AFB EA)
	Tyndall AFB, Florida	Combat Air Forces Contracted Adversary Air Temporary Operations From Tyndall AFB, Florida (DAF, 2020a) (the ADAIR EA)
Wetlands	Holloman AFB, New Mexico	Environmental Assessment (for) Recapitalization of the 49th WG Combat Capabilities and Capacities, Holloman Air Force Base, New Mexico (DAF, 2011b) (the Holloman AFB EA)
	UTTR, Hill AFB, Utah	Expansion Of The Use Of Self-Protection Chaff And Flares At The UTTR, Hill AFB, Utah (DAF, 2000) (the UTTR EA)
Grasslands	PRTC, Ellsworth AFB, South Dakota	Powder River Training Complex, Ellsworth Air Force Base EIS (DAF, 2014) (the PRTC EIS)

Key: ADAIR = adversary air; AFB = Air Force Base; EA = Environmental Assessment; EIS = Environmental Impact Statement; JPARC = Joint Pacific Alaska Range Complex; PEA = Programmatic Environmental Assessment; PRTC = Powder River Training Complex; UTTR = Utah Test and Training Range



Key: AFB = Air Force Base; JPARC = Joint Pacific Alaska Range Complex; MOA = Military Operations Area; PRTC = Powder River Training Complex; UTTR = Utah Test and Training Range

Figure 3.1-1. Representative Training Airspace Included in Prior NEPA Documents Incorporated by Reference for Analysis in the PEA

3.1.1 Section Organization and Environmental Analysis Inputs

For each resource area carried forward in Section 3, specific tables (one each for affected environment and environmental consequences) are included within the respective resource subsection that list the NEPA documents incorporated by reference, along with the sections of the NEPA documents that analyze the resource for those representative environmental settings and training airspaces. Resource definitions, as well as the regulatory setting and methodology of analysis, are found in Appendix C. The environmental consequences analysis for each resource is further divided into two subsections: (1) legacy defensive countermeasure items and (2) new defensive countermeasure items.

3.1.1.1 Legacy Defensive Countermeasure Items

Legacy defensive countermeasure items are identified in Table 3.1-2. These commonly used defensive countermeasures were previously evaluated in the 1997 report, *Environmental Effects of Self-Protection Chaff and Flares* (DAF, 1997) and/or the 2011 supplement to the 1997 Report (DAF, 2011a). Environmental effects of continued use of legacy defensive countermeasures would be as previously identified in the cited documents (Table 3.1-1), which relied upon the 1997 and 2011 Reports and have been updated for this PEA and included as Appendix A. Any previously adopted management strategies implemented to reduce potential for impacts would continue to be applied during DAF training. The residual materials that are deposited on the surface include plastic, rubber, felt, and, in some cases, wrapping materials. The Supplemental Report Update, provided in Appendix A, includes illustrations and photographs of the residual materials identified in Table 3.1-2.

Table 3.1-2. Legacy Defensive Countermeasure Items Evaluated in Previous Technical Studies and Environmental Analyses

Defensive Countermeasure	Included in 1997 or 2011 Reports	Cartridge Dimensions	Comments and Use	Residual Materials
Chaff				
RR-170A/AL	Both	1”x1”x8”	Single-shot test and combat chaff	Plastic or rubber end cap, felt spacer, plastic piston
RR-180/AL	Both	1”x1”x8”	Dual-shot test and combat chaff	Plastic or rubber end cap, felt spacer, plastic piston, 7 pieces of thin plastic I beam
RR-188/AL	Both	1”x1”x8”	Extensively used single-shot training chaff	Plastic or rubber end cap, felt spacer, plastic piston
RR-196/AL	2011	1”x1”x8”	Kapton-wrapped bundles - delayed opening combat chaff used over existing land ranges only to avoid significant impact to marine environments	Plastic or rubber end caps (2), 2 felt spacer glued to plastic piston; 12 approximately 2-inch x 7-inch and 6 approximately 1/2-inch x 18-inch pieces of Kapton plastic film

Table 3.1 2. Legacy Defensive Countermeasure Items Evaluated in Previous Technical Studies and Environmental Analyses (continued)

Defensive Countermeasure	Included in 1997 or 2011 Reports	Cartridge Dimensions	Comments and Use	Residual Materials
RR-196(T-1)/AL	2011	1”x1”x8”	Parchment Paper-wrapped bundles delayed opening training chaff developed for training use to avoid potential significant impacts	Plastic or rubber end cap, felt spacer glued to plastic piston; 12 approximately 2-inch x 7-inch and (6) approximately 1/2-inch x 18-inch pieces of parchment paper
MTV Flares				
ALA-17C	2011	2.75” diameter x 11.75”	Limited inventory for B-52 combat	Plastic or rubber end cap, 4 felt spacers, 2 S&I devices, plastic or nylon piston; spent BBU cartridge, 2 aluminum foil wrapping tapes, center divider, wires, end cap
M206	Both	1”x1”x8”	Extensive use in training; to be replaced by MJU-61A/B	Aluminum foil wrapping tape, felt spacer, piston, plastic or nylon end cap
MJU-7A/B	Both	1”x2”x8”	Extensive use in training; to be replaced by MJU-53/B, MJU-61A/B, or MJU-75/B	Aluminum end cap, rubber cushion, felt spacer, S&I device, plastic or nylon piston, aluminum foil wrapping tape
MJU-10/B	Both	2”x2.5”x8”	Training to be replaced by MJU-53/B, MJU-61A/B, or MJU-75/B	Plastic or nylon end cap, felt spacer, S&I device, plastic or nylon piston, aluminum foil wrapping tape
MJU-23A/B	Both	2.85” diameter x 10.6”	Limited inventory for B-1B training or combat	Plastic end cap and disc closure, 3 felt spacers, S&I device, plastic or nylon piston, aluminum foil wrapping tape
MJU-61A/B	2011	1”x1”x8”	Training test and combat to replace M206 parasitic flare.	Plastic or nylon end cap, felt spacer, combined plastic piston and S&I device, compression pad and seal, aluminum foil wrapping tape and foil strip
Standard Spectral Flare				
MJU-62/B or MJU-62A/B	2011	1”x2”x8”	Training and combat. Comparable to MJU-7A/B with advanced features.	Nylon piston, S&I device, aluminum foil wrapping tape, felt spacer, plastic or nylon end cap with o ring
Thrusted Flare				
MJU-68/B	2011	1.5”x1.5” x15.75”	Test and combat flare with MTV components encased in finned body. Very limited training use	Carbon fiber flight body and shroud, S&I device, plastic or nylon piston, aluminum end cap, tungsten nose

Key: “ = inch; MTV = magnesium, Teflon, and Viton; S&I = Safe and Initiation

3.1.1.2 New Defensive Countermeasure Items

New defensive countermeasure items are those that were not evaluated in previous technical studies and environmental analyses. New chaff items are listed in Table 3.1-3, and new flare items are listed in Table 3.1-4, the content of which is based on Table 2.3-1 through Table 2.3-5, augmented with information from the Supplemental Report Update (Appendix A). As identified in Table 3.1-3 and Table 3.1-4, certain new defensive countermeasures are very similar in design and materials to legacy items, and environmental consequences would be anticipated to be comparable.

Some of the new countermeasure types, specifically the thrusted flares and spectral decoys, were not evaluated for environmental effects in previous DAF environmental documentation. Table 3.1-4 lists these new countermeasures and includes a summary of the potential for environmental effects from their use in training and testing. More detailed information and illustrations of residual materials for both the legacy and new defensive countermeasure items can be found in the Supplemental Report Update, included as Appendix A.

Table 3.1-3. New Chaff Items not Evaluated in Previous Technical Studies and NEPA Analyses and Comparison of Environmental Consequences with Legacy Items

New Chaff	Chaff Type	Primary Use	Residual Materials	Comparison with Legacy Chaff	Environmental Consequences
RR-198/AL	Kapton-wrapped bundles of delayed opening combat chaff	Test and combat	Plastic or rubber end cap, felt spacer glued to plastic piston; 12 approximately 2-inch x 7-inch and 6 approximately 1/2-inch x 18-inch pieces of Kapton plastic film	Comparable to RR-196/AL in 2011 Report	Kapton has potential for significant impact to marine species. This combat delayed opening chaff would be used for testing and very limited training over existing land ranges only to avoid significant impact to marine environments.
RR-199/AL	Parchment paper-wrapped bundles of delayed opening training chaff	Training with some testing	Plastic or rubber end cap, felt spacer glued to plastic piston; 12 approximately 2-inch x 7-inch and (6) approximately 1/2-inch x 18-inch pieces of parchment paper	Comparable to RR-196(T-1)/AL in 2011 Report; developed to avoid potential significant impacts	Training with delayed opening chaff incorporating biodegradable paper wrapping materials would not be expected to result in significant environmental impacts.

Key: NEPA = National Environmental Policy Act

Table 3.1-4. New Flares not Evaluated in Previous Technical Studies and NEPA Analyses and Comparison of Environmental Consequences with Legacy Items

New Flare	Primary Use	Residual Materials	Comparison with Legacy Flare	Potential for Environmental Consequences
Legacy MJU-7A/B (included for comparison)	Training, testing, and combat	Plastic Safe & Ignition (S&I) assembly; duct tape foil wrapping; felt cushion, piston and end cap	1"x2"x8" Legacy flare previously addressed for environmental effects	Representative training and combat flare for environmental effects comparison with new flares
MTV Flares				
MJU-53/B	Training and test; replacement for MJU-7A/B	Plastic closure cap and end cap, rubber spacer, S&I assembly with slider and piston, aluminum foil wrapping tape	1"x2"x8" Same size and comparable residual materials as Legacy MJU-7A/B	Deployment of MJU-53/B would have no different effect on environmental resources under any airspace than an MJU-7A/B flare.
MJU-75/B	Replaces MJU-7A/B, MJU-10/B, and MJU-75/B with extensive use in test, training, and combat	Plastic or nylon end cap with glued rubber pad, combined piston and S&I assembly, no wrapping or other residual materials	1"x2"x8" Same size as Legacy MJU-7A/B, no wrapping or separate S&I assembly	Deployment of MJU-75/B would have a reduced effect on environmental resources under any airspace than an MJU-7A/B flare.
MJU-77/B	Use in training, test, and combat; to replace MJU-61A/B	Plastic or nylon end cap with square seal, compression pad, combined piston, S&I assembly, aluminum foil wrapping tape, and foil strip	1"x1"x8" Size of M206 legacy flare. one-half size of MJU-7A/B with similar and smaller residual materials	MJU-53/B has residual materials comparable to MJU-7A/B and increased when compared with M206. No different effect on environmental resources under any airspace compared with an MJU-7A/B flare.
Standard Spectral Flares				
M212	Limited testing; being replaced by MJU-73/B	Brass nose for momentum, rubber cushion, S&I device, plastic or nylon piston, aluminum foil wrapping tape	1"x1"x8" One-half size of MJU-7A/B with smaller residual materials and weighted nose	Deployment of M212 with weighted nose could cause damage from a strike and have a potentially greater effect than a legacy flare. Limited testing over established ranges would not be expected to adversely affect environmental resources on the ranges.
XM216E5	Developmental flare to test multiple components for other flares	Piston/S&I assembly; wrapping, Aluminum strip, slices, rubber pad, tungsten nose, end cap	1"x1"x8" One-half size of MJU-7A/B with more and smaller residual materials and weighted nose	Deployment of XM216ES with weighted nose could cause damage from a strike and have a potentially greater effect than a legacy flare. Limited testing over established ranges would not be expected to adversely affect environmental resources on the ranges.

Table 3.1-4. New Flares not Evaluated in Previous Technical Studies and NEPA Analyses and Comparison of Environmental Consequences with Legacy Items (continued)

New Flare	Primary Use	Residual Materials	Comparison with Legacy Flare	Potential for Environmental Consequences
MJU-73/B	Test, training, and combat to replace M212	Brass nose with rubber O ring seal, plastic piston, S&I device, aluminum foil wrapping tape	1"x1"x8" One-half size of MJU-7A/B with smaller residual materials and weighted nose	Deployment of MJU-73/B with brass nose could cause damage from a strike and have a potentially greater effect than a legacy flare. Very limited training and testing over established ranges would not be expected to adversely affect environmental resources on the ranges.
MJU-78/B	Test and combat developmental flare to incorporate XM216E5 components	Plastic or nylon end cap with rubber seal, foam pad cushion, tungsten nose, aluminum slices and strip, combined plastic piston and S&I device, aluminum foil wrapping tape	1"x1"x8" One-half size of MJU-7A/B with more small residual materials and weighted nose	Deployment of MJU-73/B with brass nose could cause damage from a strike and have a potentially greater effect that a legacy flare. Testing over established ranges would not be expected to adversely affect environmental resources on the ranges.
Thrusted Flares				
MJU-39A/B and MJU-40A/B	Test and combat. MTV flare encased in finned flight body	Carbon fiber 10.5" flight body, shroud, S&I assembly, piston and end cap, tungsten nose	2"x2.5"x10.5" Larger than the MJU-7A/B with more and larger residual materials, a flight body, and a weighted nose	Deployment of MJU-39A/B or MJU-40A/B would result in heavy residual materials which could cause substantial damage. Limited testing over established munitions deployment areas on ranges would not be expected to adversely affect environmental resources on the ranges.
MJU-68/B	Test and combat. MTV flare encased in finned flight body; very limited training	Carbon fiber 10.5" flight body with weighted nose, sequencer assembly, piston, end cap/vibration damper	1.5"x1.5"x10.5" Different shape compared to the MJU-7A/B with more residual materials, a flight body, and a weighted nose	Deployment of MJU-68/B would result in heavy residual materials which could cause substantial damage. Limited testing over established munitions deployment areas on ranges would not be expected to adversely affect environmental resources on the ranges.
MJU-71/B	Test and combat flare with MTV components in a fin assembly and flight body; very limited training	Flight body with a separate fin assembly, tungsten weighted nose with O ring, tape, nylon translating slider (similar to piston) sequencer assembly	1"x1"x8" One-half the size of the MJU-7A/B with more residual materials, a flight body, and a weighted nose	Deployment of MJU-71/B would result in heavy residual materials which could cause substantial damage. Limited testing and very limited training over established munitions deployment areas on ranges would not be expected to adversely affect environmental resources on the ranges.

Table 3.1-4. New Flares not Evaluated in Previous Technical Studies and NEPA Analyses and Comparison of Environmental Consequences with Legacy Items (continued)

New Flare	Primary Use	Residual Materials	Comparison with Legacy Flare	Potential for Environmental Consequences
MJU-76/B	Test and combat finned body flare planned to replace MJU-68/B and MJU-71/B; very limited training	Carbon fiber flight body, weighted tungsten end cap with rubber seal, S&I piston and igniter assembly, compression pad	1”x1”x8” One-half the size of the MJU-7A/B with smaller residual materials and a flight body with a weighted nose	Deployment of MJU-76/B would result in heavy residual materials which could cause substantial damage. Limited testing and very limited training over established munitions deployment areas on ranges would not be expected to adversely affect environmental resources on the ranges.
Spectral Decoys				
M211	Limited test decoy sealed to prevent pyrophoric foils from reacting with air; to be replaced by MJU-66/B	Plastic piston, aluminum end cap, 1,500 to 3.000 0.75"x0.75"x 0.00125" to 0.00188" iron foils	1”x1”x8” One-half the size of the MJU-7A/B with two plastic pieces and 1,500 to 3,000 very light and durable iron foils	Durable, light, long-lasting foils can drift for miles from the deploying aircraft. See individual resource sections below for a discussion of potential impacts.
XM219	Delayed opening test and combat decoy with two bundles of foils	Plastic, acrylic or aluminum piston, 2 plates, bundle spacer, sealed end cap, and payload separator; vibration film assembly and approximately 3,500 0.75”x0.75”x 0.00125” iron foils	1”x1”x8” One-half the size of the MJU-7A/B with 6 plastic pieces and up to 3,500 very light, and durable iron foils	Durable, light, long-lasting foils can drift for miles from the deploying aircraft. See individual resource sections below for a discussion of potential impacts.
MJU-50/B MJU-50A/B	Training, test, and combat decoy; same as M211 with different foil payload mix	Plastic piston, sealed aluminum end cap, and a 0.5-inch diameter disc; approximately 1,500 to 3,000 0.75”x0.75”x 0.00125” iron foils	1”x1”x8” One-half the size of the MJU-7A/B with two caps and up to 3,000 very light, and durable iron foils	Durable, light, long-lasting foils can drift for miles from the deploying aircraft. See individual resource sections below for a discussion of potential impacts.
MJU-51A/B	Training, test, and combat decoy to be replaced by MJU-66B	Crimped plastic end caps with O ring, (MJU-51/B has aluminum end cap), plastic piston, 0.5” disc, approximately 1,600 0.75”x1.75”x 0.0025” iron foils	1”x2”x8” Same size as the MJU-7A/B with two caps and up to 1,600 very light, and durable iron foils	Durable, light, long-lasting foils can drift for miles from the deploying aircraft. See individual resource sections below for a discussion of potential impacts.

Table 3.1-4. New Flares not Evaluated in Previous Technical Studies and NEPA Analyses and Comparison of Environmental Consequences with Legacy Items (continued)

New Flare	Primary Use	Residual Materials	Comparison with Legacy Flare	Potential for Environmental Consequences
MJU-52A/B	Training, test, and combat decoy	2.83"x0.375" plastic frame, payload tray, sail, heat seal, and 150 0.75"x1.75"x 0.00125 to 0.00188" iron foils	3"x2.5"x0.375" plastic cassette frame with multiple plastic pieces and 150 very light, and durable iron foils	Durable, light, long-lasting foils can drift for miles from the deploying aircraft. See individual resource sections below for a discussion of potential impacts.
MJU-64/B	Training, test, and combat decoy; same as M211 with different foil payload mix and end cap	Plastic sealed and crimped end cap with O ring, piston, 0.5" diameter disc, approximately 2,000 0.75"x0.75"x 0.002" iron foils	1"x1"x8" One-half the size of the MJU-7A/B with two caps and 2,000 very light, and durable iron foils	Durable, light, long-lasting foils can drift for miles from the deploying aircraft. See individual resource sections below for a discussion of potential impacts.
MJU-66/B	Training, test, and combat decoy; same as M211 with different foil payload mix and end cap	Plastic sealed and crimped end cap with O ring, piston, 0.5" diameter disc, approximately 2,000 0.75"x0.75"x 0.002" iron foils	1"x1"x8" One-half the size of the MJU-7A/B with two caps and 2,000 very light, and durable iron foils	Durable, light, long-lasting foils can drift for miles from the deploying aircraft. See individual resource sections below for a discussion of potential impacts.

Key: " = inch; MTV = magnesium, Teflon, and Viton; NEPA = National Environmental Policy Act; S&I = Safe and Ignition

3.1.1.2.1 *New Chaff*

As identified in Table 3.1-3, there are two new chaff items. RR-198/AL is delayed opening combat chaff that has durable plastic Kapton wrapping materials and which is used in very limited quantities for testing and minimal training (see Table 2.3-1) over land ranges only and not over marine environments. The new RR-198/AL is comparable to previously analyzed RR-196/AL, and both are used for testing and very limited training over land ranges only. The new RR-199/AL chaff is delayed opening training chaff made with biodegradable parchment paper wrapping materials comparable to previously analyzed RR-196(T-1)/AL chaff. Both the new RR-199/AL and legacy RR-196(T-1)/AL chaff with parchment paper wrapping would be used for training (see Table 2.3-1).

3.1.1.2.2 *New MTV, Standard Spectral, and Thrusted Flares*

The new MTV, standard spectral, and thrusted flares listed in Table 3.1-4 are described in detail in Sections 7.3 through 7.5 of the Supplemental Report Update, included as Appendix A. The new MTV flares are comparable to legacy flares and, in some cases, have smaller or fewer components that fall to the ground as residual materials. Standard spectral flares are primarily combat flares; those with a weighted nose would be used for testing and very limited training over ranges approved for deploying live or inert munitions. Thrusted flares are combat flares primarily used during testing, with very limited training use over ranges suitable for munitions deployment. Thrusted flares can be an MTV flare or a standard spectral flare encased in a light body and fitted with aerodynamic fins, designed to use the magnesium flare as a fuel to propel it.

3.1.1.2.3 *Spectral Decoys*

The new spectral decoys listed in Table 3.1-4 are described in detail in Section 7.6 of the Supplemental Report Update, included as Appendix A. Spectral decoys present a pyrophoric IR signature that is different from that of the three types of pyrotechnic flares described above. The magnesium pellets in MTV, standard spectral, and thrusted flares all combust to create an IR signature that interferes with the specific IR missile’s seeker head. Spectral decoys are not pyrotechnic flares but are decoys with payloads comprised of thin iron foils with chemical pyrophoric coatings that oxidize when exposed to air, rather than a block of magnesium (see Figure 1.2-2). A spectral decoy is deployed by an electrical pulse passing through the countermeasure dispenser system to the impulse cartridge, which generates gasses and pushes the piston. The sealed end cap then releases, and the decoy assembly of pyrophoric coated foils is ejected from the aluminum case. When exposed to air, the thin foils react with the air to rapidly oxidize, generating an IR signature. After the reaction is completed, the oxidized foils, end cap, and piston fall to the ground. The foil oxidization generates heat of approximately 700 °F to 1,500 °F for a few seconds. The iron foils reach ambient temperature before they have drifted approximately 500 feet. The foils, which can be approximately 0.75 inches by 0.75 inches by 0.00125 inches or thicker, can be stacked in groups, and the total number of coated iron foils in a standard-size (1-inch by 1-inch by 8-inch) aluminum case varies from 1,500 to 3,000 foils.

Appendix A, Section 7.6.4.8, explains that after a spectral decoy is deployed the light foils are distributed by the wind in a manner similar to chaff. Foils deployed at 2,000 feet AGL in a 5-miles per hour (mph) wind would have a forward momentum based on the aircraft speed that, in the case of an aircraft flying at 500 mph, could result in the foils reaching the surface in an ellipse approximately 0.22 miles wide and 0.33 miles long (approximately 38 acres) some distance from the deployment point. A typical rapid deployment of 3 spectral decoys with a total of 6,000 foils is calculated to result in an estimated 159 foils per acre distributed within a 38-acre ellipse. Deployment of spectral decoys at different altitudes and different wind speeds would result in different concentrations of foils. For example, 3 spectral decoys deployed in a 25-mph wind at 30,000 feet AGL are calculated to result in 6,000 foils being distributed over nearly 1 million acres and have a concentration of 1 foil per 100 acres. Different combinations of spectral decoy numbers, deployment altitudes, and wind speeds are presented in Appendix A, Section 7.6.4.8.

As of 2022, there have not been extensive laboratory tests or controlled experiment studies of spectral decoy iron foils comparable to those performed on chaff to ascertain how the foils behave in the air after deployment or after landing on the ground or how long they take to corrode to the point they are no longer visible to the casual observer. In order to have some indication of what would happen to the residual foils after spectral decoy deployment, a simple wind drift test and an informal 3-month weathering test were performed to inform the environmental impact analysis. The methodology of the tests and results are discussed in the Supplemental Report Update, included as Appendix A and are summarized in the environmental impact analyses below, as applicable. The 3-month weathering test found that spent foils on the surface in an arid setting were blown by wind to settle on the downwind side of a 2-inch change in the surface height and showed little deterioration after 3 months; they displayed minor rusting around the edges but did not lose their shape or become brittle. Foils that were dropped on grasses became enmeshed in the grasses and did not descend to the soil, and when exposed to two showers weekly, displayed rust on the edges, became more fragile than foils in an arid environment, and started to break down into smaller iron pieces in the 3-month test. Results of the wind drift test confirmed assumptions that the foils from a spectral decoy would disperse over a larger area and farther from the point of release as the altitude of deployment and the wind speed at the time of deployment increase (see Appendix A, Section 7.6.4.8).

3.2 SAFETY

3.2.1 Affected Environment

The affected environment for safety under the Proposed Action includes the area underlying the DAF training airspace where defensive countermeasure use is approved (Figure 1.2-3). Table 3.2-1 summarizes the affected environment for safety under the representative DAF training airspaces for this programmatic analysis, which is introduced in Table 1.6-1 and Table 3.1-1. The affected environment for safety is described by summarizing extracted quotes from the relevant NEPA documents that are incorporated by reference and listed in Table 3.1-1 for all the representative environmental settings.

Table 3.2-1. Safety Affected Environment - NEPA Document Section References Pertaining to the Representative Training Airspace

Environmental Setting	Representative Airspace Location	Safety Section References for NEPA Documents in Table 3.1-1
Woodlands	Joint Pacific Alaska Range Complex, Alaska	**Safety Affected Environment, Section 3.13.1** (DAF and Army, 2013) “Chaff and defensive flares are managed as ordnance. Chaff and flares are authorized … in existing MOAs and ATCAAs. Use is governed by detailed operating procedures to ensure safety. Air Force altitude restrictions for flare use in Alaskan airspace are above 5,000 feet AGL from June through September and above 2,000 feet AGL for the rest of the year. These altitude restrictions substantially reduce any risk of a fire from training with defensive flares.”
Woodlands	Tyndall AFB, Florida	Chaff and flare use was not analyzed for safety (DAF, 2020a).
Woodlands	PRTC, Ellsworth AFB, South Dakota	**Safety Affected Environment, Section 4.1.3.1, Appendices C & D** (DAF, 2014) “The Air Force would implement standing instructions to brief pilots training in the proposed PRTC airspace that only RR-188, RR-112, RR-179 chaff or MJU-23, M206, MJU-7, and MJU-10 flares would be permitted (with limitations) for training use within the [airspace].”
Woodlands	Moody AFB, Georgia	**Safety Affected Environment, Section 3.4.4.2;** (DAF, 2020b) “Current annual chaff and flare use in the Moody Airspace Complex is … 8,780 chaff and 10,000 flares [annually].”
Woodlands	Shaw AFB, South Carolina	**Safety Affected Environment, Section 3.3.3** (DAF, 2010) “Chaff and defensive flares are managed as ordnance. Flares and chaff are authorized for use in the existing MOAs and on Poinsett ECR. Use is governed by detailed operating procedures to ensure safety. Chaff used in

Table 3.2-1. Safety Affected Environment - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Representative Airspace Location	Safety Section References for NEPA Documents in Table 3.1-1
		the existing Shaw AFB airspace is specifically designed to not interfere with FAA [Federal Aviation Administration] radars." "Flare use in Shaw AFB-managed airspace is governed by a minimum release altitude restriction of 5,000 feet MSL (approximately 4,500 AGL)." "Flares may be deployed at lower altitudes above Poinsett ECR and in offshore Warning Areas."
Desert and Arid Regions	Holloman AFB, New Mexico	**Safety Affected Environment, Section 4.3.2.1** (DAF, 2011b) "Flare use in Holloman AFB-managed airspace has a minimum release altitude of 5,000 feet MSL (approximately 4,500 AGL)." "Flares may be deployed at lower altitudes above Oscura, Rio, and/or Centennial Ranges [and] may be dropped from a minimum altitude of 2,000 feet AGL within WSMR airspace. The minimum release altitude over Red Rio and Oscura Bombing Ranges is 500 feet AGL. Flares may not be deployed in WSMR airspace during very high or extreme fire danger conditions to limit the potential for a flare fire incident."
Desert and Arid Regions	Holloman AFB, New Mexico	**Safety Affected Environment, Section 3.10.2.3** (DAF, 2021) "Defensive flares typically burn out in 3.5 to 5 seconds, during which time the flare will fall between 200 and 400 feet…. The best way to reduce the risk of fires caused by flares is to establish and enforce minimum altitudes for flare release. ...the minimum altitude for flare release would be 2,000 feet AGL which would result in flare burnout by 1,600 feet AGL." "Holloman AFB restricts flare use during "Very High" or "Extreme" fire danger and this restriction…" "In addition to restricting flare use during times of elevated fire danger, flares may not be dropped below an altitude of 2,000 feet AGL within the existing or proposed airspace. This ensures that the flare has had ample time to exhaust itself and further prevents the chances of fires from flare use. There have been no reported flare caused fires beneath the MOAs or ATCAAs as a result of Holloman AFB pilot training."
Desert and Arid Regions	Hill AFB, Utah	**Safety Affected Environment, Section 3.3.1** (DAF, 2000) "Historic mishaps involving chaff systems have occurred." "From January 1983 through February 1993… there were 53 [High Accident Potential] occurrences" "None of the recorded mishaps resulted in significant damage to aircraft." "Dud flares pose several safety concerns. If flares are ejected from the aircraft and do not ignite, or ignite and burn improperly, risks may arise from accidental ignition on the ground, improper handling, or the possibility of striking a person on the ground." "No incidences of injuries from falling flares or debris have ever been recorded."
Agricultural	PRTC, Ellsworth AFB, South Dakota	**Safety Resource Affected Environment, Section 4.1.3.1, Appendices C & D** (DAF, 2014) Safety issues are not specifically identified as occurring in agricultural areas in the prior NEPA documents; please see the PRTC Ellsworth AFB Woodlands row of this table for a summary description of safety issues, some of which could be in or near an agricultural environment.

Table 3.2-1. Safety Affected Environment - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Representative Airspace Location	Safety Section References for NEPA Documents in Table 3.1-1
Oceans	Hickam AFB, Hawaii	**Safety Affected Environment, Section 3.3.3.2 Appendices A & B** (DAF, 2007) “Ordnance are handled and stored in accordance with Air Force explosive safety directives (AFI [Air Force Instruction] 91-201), and all maintenance is carried out by trained, qualified personnel using Air Force approved technical procedures.” “System malfunctions or material failures could result in either an accidental release of ordnance or the release of a dud component that fails to operate properly. Studies have shown that the probability of such an accidental release occurring, the probability of it occurring where person or property could be affected, and the possibility of injury to a person or damage to property on the ground is so infinitesimally small that the risk associated with the occurrence can be essentially discounted”
Oceans	Tyndall AFB, Florida	**Safety Affected Environment, Section 3.4.2** (DAF, 2020a) Chaff and flare use was not discussed in the affected environment for safety.
Wetlands	Holloman AFB, New Mexico	**Safety Affected Environment, Section 4.3.2.1** (DAF, 2011b) Safety issues are not specifically identified as occurring in wetland areas in the prior NEPA documents; please see the Holloman AFB Desert and Arid Regions row of this table for a summary description of safety issues, some of which could be in or near a wetlands environment.
Wetlands	Hill AFB, Utah	**Safety Affected Environment, Section 3.3.1** (DAF, 2000) Safety issues are not specifically identified as occurring in Wetlands in the prior NEPA documents; please see the Hill AFB Desert and Arid Regions row of this table for a summary description of safety issues, some of which could be in or near a Wetlands environment.
Grasslands	PRTC, Ellsworth AFB, South Dakota	**Safety Affected Environment, Section 4.1.3.1, Appendices C & D** (DAF, 2014) Safety issues are not specifically identified as occurring in Grasslands in the prior NEPA documents; please see the PRTC, Ellsworth AFB Woodlands row of this table for a summary description of safety issues, some of which could be in or near a Grasslands environment.

Key: AFB = Air Force Base; AGL = above ground level; ATCAA = Air Traffic Control Assigned Airspace; ECR = Electronic Combat Range; MOA = Military Operations Area; MSL = mean sea level; NEPA = National Environmental Policy Act; PRTC = Powder River Training Complex; UTTR = Utah Test and Training Range; WSMR = White Sands Missile Range

3.2.2 Environmental Consequences of the Proposed Action

3.2.2.1 Continued Use of Legacy Defensive Countermeasure Items

The deployment of legacy chaff and flares in DAF training airspace, as described above, results in the determination of no significant impacts to ground, explosive, and flight safety in DAF training airspaces, as summarized from prior NEPA documentation (incorporated by reference and listed in Table 3.1-1) in Table 3.2-2. The table summarizes the environmental consequences from deploying legacy defensive countermeasures in the different environmental settings where the DAF conducts testing and training. The overall summary from the existing environmental documents is that the continued use of legacy chaff and flares results in residual materials falling to the ground in a dispersed fashion, posing very low risk of striking a person or animal.

Additionally, DAF regulations and procedures, including establishing altitude restrictions on flare deployment, reduce the risk for starting wildland fires from burning flares.

Table 3.2-2. Safety Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace

Environmental Setting	Representative Airspace Location	Safety Section References for NEPA Documents in Table 3.1-1
Woodlands	Joint Pacific Alaska Range Complex, Alaska	**Safety Environmental Consequences, Section 3.1.3.3.1** (DAF and Army, 2013) “The proposed use of chaff in the MOAs results in small plastic, nylon, and aluminum-coated Mylar pieces falling to the ground. With flares, residual materials are also generally light with a high surface-to-weight ratio…” “This results in essentially no likelihood of a flare end cap, piston, or wrapper causing injury in the highly unlikely event residual material from a flare struck a person or an animal.” “The only exception could be the flare safe and initiation device, which falls with the force of a medium -sized hailstone.” “it is extremely unlikely that anyone would be struck with the force of a medium-sized hailstone as a result of existing or proposed training with flares in the airspace.” “The use of defensive flares in the MOAs may also be expected to have impacts associated with the potential for starting wildland fires from burning flares.” “Three primary management actions are used to prevent wildfires. First, a fire danger rating system is used to reduce the likelihood of a fire by limiting military activities. Certain military activities are restricted when thresholds of wildfire risk are reached. Second, wildfire danger is reduced through the removal of accumulated fuels.… Third, an Initial Attack Response Team remains available during military training activities during high and extreme fire danger to provide a rapid initial response to wildfires in the area.” “Therefore, the use of chaff and flares would result in no significant impacts to ground safety.”
Woodlands	Tyndall AFB, Florida	**Safety Environmental Consequences, Sections 4.3.2, 4.5.2.2** (DAF, 2020a) “The 325 MXS would support contract ADAIR daily training operations with the maintenance and delivery of countermeasure chaff and flares. This support would be provided by trained and certified personnel following Air Force safety guidance and technical orders. Trained and certified contract ADAIR personnel would be responsible for the loading and unloading of countermeasures on contract ADAIR aircraft and would follow approved safety measures outlined in the Performance Work Statement.” “The loading and unloading of countermeasure chaff and flares would occur on the aircraft parking ramp. The proposed ramp area for contract ADAIR aircraft is authorized for chaff and flare operations (Hazard Class 1.3) in accordance with AFMAN [Air Force Manual] 91-201 para 12.47.2 and 12.47.3. No significant impacts on explosive safety are anticipated to occur under the Proposed Action provided contract ADAIR personnel are trained and all applicable safety guidelines are implemented.” “The potential of being struck by debris, or by a dud flare, given … such a large area over Eglin E and Rose Hill MOAs… is remote.”
Woodlands	Powder River Training Complex (PRTC), Ellsworth AFB, South Dakota	**Safety Environmental Consequences, Section 4.3.3.1.3; Appendices C & D, 3.13.1** (DAF, 2014) Safety effects are not specifically identified as occurring in Woodlands in the PRTC Environmental Impact Statement.

Table 3.2-2. Safety Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Representative Airspace Location	Safety Section References for NEPA Documents in Table 3.1-1
Woodlands	Moody AFB, Georgia	**Safety Environmental Consequences, Section 3.4.4.2** (DAF, 2020b) "Flares would be employed in all of the proposed new low-altitude MOAs…." "… there would be an introduced risk in areas where there is currently no risk of wildland fires from flares. Because the occurrence of wildfire associated with flares is inherently low, the use of flares would be limited to altitudes above 2,000 feet AGL, the use of flares is suspended when conditions are conducive to wildfires (i.e., drought periods), and Moody AFB has never had a fire caused by flares and has never had a fire outside a training area on the installation, the increase in risk would be negligible."
Woodlands	Shaw AFB, South Carolina	**Safety Environmental Consequences, Section 3.3.3.1** (DAF, 2010) "Use of Multi Jettison Unit (MJU)-7 A/B flares and M-206 flares in the MOA/ATCAA [Air Traffic Control Assigned Airspace] airspace would continue …with 20 FW established minimum release altitudes of 5,000 feet MSL [mean sea level] … Considering the short burn-time of the flare (approximately 3.5 to 5 seconds), all combustible material is consumed approximately 400 feet from the release altitude. This provides a margin of safety of approximately 4,000 feet and ensures that no burning material from a functioning flare contacts the ground." "Residual components of the M-206 and MJU-7 A/B flares fall to the ground following the ignition/ejection process.… The MJU-7 A/B S&I device … Could result in a bruise-like injury similar to that of a large hailstone if it struck an unprotected person.… The S&I would not be expected to damage a structure. An S&I impact could cause a cosmetic dent to a vehicle. A strike to the windshield of a moving vehicle could result in an impact comparable to a small stone kicked up by a truck tire.… "These residual materials which are currently deposited on the ground under the airspace are not expected to be a safety risk."
Desert and Arid Regions	Holloman AFB, New Mexico	**Safety Environmental Consequences, Section 4.3.2.1** (DAF, 2011b) "The composition of chaff is similar to those components found in the Earth's crust, and do not present health or safety risks to humans or animals." "A flare failure can occur if a flare does not ignite and remains in the aircraft, does not burn the prescribed duration or temperature, is ignited but is not dispersed, or does not ignite after ejection (a dud flare). Historically, range clean-up where flare use is intensive in a relatively constrained geographic area (such as Melrose Range in New Mexico and the Utah Test and Training Range) indicates that of all flares expended only an estimated 0.01 percent were actually found on the ground as duds." "…overall reliability data indicates that approximately two dud flares per year could impact the ground under the airspace." "Holloman AFB provides instructions to fire departments and other organizations on how to identify a dud flare and who to contact at Holloman AFB if a suspected dud flare is found." "The likelihood of a person being struck by flare parts is remote given the large size of airspace, the small area occupied by individuals, and the relatively low density of persons in the area, but, anyone incurring damage or injury that results from Holloman AFB training activities should contact Holloman AFB directly to inquire about the Air Force damage claims process."

Table 3.2-2. Safety Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Representative Airspace Location	Safety Section References for NEPA Documents in Table 3.1-1
Desert and Arid Regions	Holloman AFB, New Mexico	**Safety Environmental Consequences, Sections 2.8.1.2, 4.10.1.3** (DAF, 2021) "Safety issues for people underneath or immediately adjacent to the [airspace] would stem from the probability of chaff residual material striking an individual on the ground." "…there have been no reports of any person being injured from falling chaff residual material." "If an [flare] end cap struck a person on the ground, the momentum generated would be far below that required to cause serious injury." "…wide distribution of the residual materials would make the probability of these materials impacting a person on the ground extremely unlikely. Therefore, safety risks related to residual flare material would be negligible."
Desert and Arid Regions	Hill AFB, Utah	**Safety Environmental Consequences, Section 3.3.1** (DAF, 2000) "There is little safety risk to aircrews, aircraft, or the public anticipated from the use of chaff. There is no safety risk as a result of falling chaff debris." The 1997 ACC Report concluded that it would be reasonable to consider flare reliability to be at least 99 percent, although it is probably higher [*see Appendix A for an updated reliability discussion*]. Most safety risks associated with flare use are either low in probability or manageable through corrective action. Civilian impacts are minimal or nonexistent. The relatively low number of incidents involving aircraft indicate that there is a minimal risk to aircrews, aircraft, and the public from an aircraft Mishap being caused by a malfunction involving flares or the flare dispensing system.
Agricultural	PRTC, Ellsworth AFB, South Dakota	**Safety Environmental Consequences, Section 4.3.3.1.3** (DAF, 2014) "The Safe & Initiation device … could cause injury in the extremely unlikely event an individual were struck on an unprotected head with no hat. With the frequency of flare use and the average population density of fewer than two persons per square mile, such an event would be immeasurably unlikely. The residual materials would not be expected to result in a safety impact."
Ocean	Hickam AFB, Hawaii	**Safety Environmental Consequences, Section 3.3.3.2 Appendices A & B** (DAF, 2007) "Chaff and flares would continue to be expended in the overwater training airspace…. The same safety procedures for handling chaff and flares currently enforced would continue in effect. Implementation of the Proposed Action would not result in adverse impacts to safety."
Ocean	Tyndall AFB, Florida	**Safety Environmental Consequences, Sections 4.3.2, 4.5.2.2** (DAF, 2020a) "The potential of being struck by debris, or by a dud flare, given the small increase in chaff and flare use in such a large area over … the Gulf of Mexico is remote"
Wetlands	Holloman AFB, New Mexico	**Safety Environmental Consequences, Sections 2.8.1.2, 4.10.1.3** (DAF, 2021) Safety effects are not specifically identified as occurring in Wetlands in the prior NEPA documents; please see the Holloman AFB Desert and Arid Regions row of this table for a summary analysis of safety effects, some of which could be in or near a Wetlands environment.

Table 3.2-2. Safety Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Representative Airspace Location	Safety Section References for NEPA Documents in Table 3.1-1
Wetlands	Hill AFB, Utah	**Safety Environmental Consequences, Section 3.3.1** (DAF, 2000) Safety effects are not specifically identified as occurring in Wetlands in the prior NEPA documents; please see the Hill AFB Desert and Arid Regions row of this table for a summary analysis of safety effects, some of which could be in or near a Wetlands environment.
Grasslands	PRTC, Ellsworth AFB, South Dakota	**Safety Environmental Consequences, Section 4.3.3.1.3, Appendices C & D** (DAF, 2014) Safety effects are not specifically identified as occurring in Grasslands in the prior NEPA documents; please see the PRTC, Ellsworth AFB Agricultural row of this table for a summary analysis of safety effects, some of which could be in or near a Grasslands environment.

Key: ACC = Air Combat Command; ADAIR = adversary air; AFB = Air Force Base; MOA = Military Operations Area; NEPA = National Environmental Policy Act; PRTC = Powder River Training Complex; S&I = Safe and Initiation; UTTR = Utah Test and Training Range

3.2.2.1.1 *Chaff*

Potential impacts to safety from the use of the legacy chaff items identified in Table 3.1-2 could result from chaff residual materials striking persons or property and have been addressed in the prior NEPA documents identified in Table 3.2-1. These extremely low probability events would not be anticipated to result in significant environmental impacts.

3.2.2.1.2 *Flares*

Potential impacts to safety from the use of the legacy flare items identified in Table 3.1-2 could result from wildfires from flare deployment and flare residual materials striking persons or property and have been addressed in the prior NEPA documents identified in Table 3.2-1. The types of flares deployed and the adopted management strategies for use of flares in the airspaces are primarily related to altitude restrictions for deployment and ensure complete consumption of the flare before contact with the ground surface. Training with defensive countermeasures over DAF-owned lands when there is fire risk would occur at or greater than 500 feet AGL or down to the aircraft minimum operating altitude if there is no fire hazard (AFI 11-214). Training with defensive countermeasures over non-DAF-owned lands (e.g., tribal, federal, private, etc.) would occur at over 2,000 feet AGL, unless a higher altitude is specified in range regulations (AFI 11-214). Fire risk conditions can determine whether flare use would be limited to above a specific altitude or discontinued. As an example, the Holloman AFB EIS (DAF, 2021) specifies that "during periods of 'High' fire danger, aircraft would not use flares below 18,000 feet [mean sea level] MSL." Furthermore, the risk of potential for injury or damage to personnel or property beneath the training airspace from residual materials striking a person on the ground has been found to have an extremely low probability. The conclusion of effects to safety resources is that legacy flares and residual materials from their deployment would not result in significant impacts to safety under the DAF airspace.

3.2.2.2 Use of New Defensive Countermeasure Items

3.2.2.2.1 *Chaff*

Table 3.1-3 compares new chaff with previously assessed legacy chaff based on the technical description/analysis of the items included in Appendix A and concludes that the new chaff items (RR-198/AL and RR-199/AL) are comparable to previously analyzed chaff items (RR-196/AL and RR-196(T-1)/AL, respectively). The environmental consequences from the proposed training and testing use of the new chaff items as described in Table 2.3-1 would be expected to result in no significant safety impacts, similar to the comparable legacy chaff items summarized in Table 3.2-2.

3.2.2.2.2 *Flares*

Table 2.3-2 through Table 2.3-5 and Table 3.1-4 list the new flares that have not been previously evaluated in existing environmental documents. Table 3.1-4 compares the new flares with legacy flare components based on the technical description/analysis of the items included in Appendix A. The new MTV flares are comparable to legacy flares and would have no significant safety impacts, as with the comparable legacy flares summarized in Table 3.1-4 and Table 3.2-2. Standard spectral flares are primarily combat flares with a weighted nose and would be used for testing and very limited training over ranges approved for deploying live or inert munitions. The limited use of standard spectral flares would be expected to have no significant environmental effects to safety resources. Thrusted flares are combat flares; their use during testing and limited training over ranges suitable for munitions deployment would be expected to have no significant environmental effects to safety.

The risk of fire from the deployment of countermeasure flares remains the same as analyzed in prior NEPA documents, as identified in Table 3.2-1. The primary fire risk from a defensive flare is where one were deployed at too low an altitude and reached combustible material on the surface while still burning. A defensive flare is designed to burn out within approximately 500 feet of deployment. DAF regulations reduce the risk of too-low deployment of a flare by establishing altitude restrictions on flare deployment in AFI 11-214. In training areas over non-government-owned or -controlled property, the minimum flare deployment altitude is 2,000 feet AGL unless specified otherwise in governing regulations. Defensive flares are permitted to be deployed down to 500 feet AGL over DAF-owned or -controlled property if there is a fire hazard, or down to the aircraft minimum operating altitude if there is no fire hazard, unless a higher altitude is specified in range regulations (AFI 11-214). On active military ranges, firebreaks reduce the risk of fires spreading off the range, although windblown flames can move very rapidly and jump firebreaks. Additional restrictions on flare use based on fire conditions may be established by MAJCOM policy, the Base Commander, or the airspace manager to reduce the risk of flare-caused fires. Human error is still possible, and the risk is that, under intense combat-like training conditions, a pilot could inadvertently deploy a flare at too low an altitude (e.g., below that prescribed) during changes in aircraft altitude and/or over rapidly changing terrain.

There is a minor risk of a fire being caused by a dud flare (a flare that did not ignite on being ejected from the aircraft) striking a hard rock surface upon landing and causing a spark and igniting. There is one known and one suspected instance of a dud flare starting a fire in this manner.

However, the potential for a dud flare landing on the surface is very small (calculated in Appendix A as 0.004 [0.4 percent] of all flares deployed annually), and the potential for a dud flare striking a hard surface at a specific angle and igniting is much smaller. The primary way to ensure that flares do not reach combustible materials on the surface is the establishment and strict adherence to deployment altitude restrictions, which would result in very few, if any, countermeasure flare-caused fires. The environmental consequences from use of the new flares as described in Table 3.1-4 would be expected to result in no significant safety impacts.

3.2.2.2.3 *Spectral Decoys*

As described in Section 7.6 of the Supplemental Report Update (Appendix A), each decoy deploys from 1,500 to 3,000 iron foils, which measure either 0.75 by 1.75 by 0.00125 inches or 0.75 by 0.75 by 0.00125 inches thick. Similar to chaff fibers, these extremely light foils would be dispersed by atmospheric conditions over a wide region, depending on the altitude of deployment, thus reducing the potential for the foils or residual decoy materials to cause personal or property damage upon impact. As described in Section 3.1.1.2.3, there is no injury or property damage risk associated with the use of spectral decoys, because the method of deployment of a spectral decoy precludes the possibility of a dud decoy ejecting from the aircraft and falling to the ground. The iron foil oxidization generates heat of approximately 700 °F to 1,500 °F for a few seconds, which is a lower temperature than MTV or other flares. The foils reach ambient temperature before they have drifted for approximately 500 feet, and the risk of causing a wildland fire is less than a standard MTV flare. DAF munitions maintenance personnel would need to be trained to handle these new countermeasures to ensure that proper explosive safety standards are followed. Deployment of spectral decoys would be expected to have no significant impacts to safety.

3.2.3 Environmental Consequences of No Action

Under the No Action Alternative, defensive countermeasure use during testing and training operations by the DAF would continue with legacy chaff and flare units included in the 1997 or 2011 Reports (DAF, 1997; DAF, 2011a), at levels identified in Table 2.3-1 through Table 2.3-5, in currently approved airspace. Training with legacy chaff has incorporated management strategies to reduce the potential for environmental effects, such as interference with FAA radar. Training with legacy flares has incorporated specifications on the altitudes for flare deployment and management strategies limiting or stopping the use of flares when warranted by airspace fire conditions. With continued adherence to the current management strategies for their use, there would be no significant impacts to safety from legacy chaff and flare use, as described in Section 3.2.2.1.

3.3 AIR QUALITY

3.3.1 Affected Environment

The affected environment for criteria pollutant emissions under the Proposed Action includes the area underlying the DAF training airspace where defensive countermeasure use is approved (Figure 1.2-3). Table 3.3-1 summarizes the air quality affected environment under the representative DAF training airspaces for this programmatic analysis, which is introduced in

Table 1.6-1 and Table 3.1-1. The air quality affected environment is described by summarizing extracted quotes from the relevant NEPA documents that are incorporated by reference and listed in Table 3.1-1 for all the representative environmental settings. For some of the NEPA documents, the training use with chaff and flares was not analyzed for air quality; therefore, no affected environment information from those documents is presented, as noted in Table 3.3-1.

Table 3.3-1. Air Quality Affected Environment - NEPA Document Section References Pertaining to the Representative Training Airspace

Environmental Setting	Representative Airspace Location	Air Quality Section References for NEPA Documents in Table 3.1-1
Woodlands	Joint Pacific Alaska Range Complex, Alaska	**Air Quality Affected Environment, Section 3.1.4.1, 3.3.4.1** (DAF and Army, 2013) "The … [airspace is over] four adjacent [Alaska] boroughs and census areas: Denali, Matanuska-Susitna, Southeast Fairbanks, and Valdez-Cordova … [which] are all in attainment of the National Ambient Air Quality Standards (NAAQS)"
Woodlands	Tyndall AFB, Florida	**Air Quality Affected Environment, Section 3.5.1** (DAF, 2020a) "Tyndall AFB and the nearby MOAs (Eglin E, Tyndall E, B, and C/H) are located in an attainment area for all criteria pollutants …. Counties bordering W-151 and W-470 are also in attainment for all criteria pollutants."
Woodlands	Moody AFB, Georgia	Chaff and flare use was not analyzed for air quality (DAF, 2020b).
Woodlands	Shaw AFB, South Carolina	**Air Quality Affected Environment, Section 3.4.2** (DAF, 2010) "[The area under the airspace] is designated attainment for all criteria pollutants."
Desert and Arid Regions	Holloman AFB, New Mexico	**Air Quality Affected Environment, Section 3.4.2** (DAF, 2021) "The areas [under the airspace] … are in attainment for all criteria pollutants…. A small portion of Grant County…. [and a] small portion of … Greenlee County in Arizona [were] maintenance areas for SO_2 … due to emissions from copper smelting operations that are no longer operational." "[Proximate] National Parks and Wilderness Areas are categorized as Class I Areas … protected from impairment of visibility resulting from manmade air pollution."
Desert and Arid Regions	Holloman AFB, New Mexico	Chaff and flare use was not analyzed for air quality (DAF, 2011b).
Desert and Arid Regions	Hill AFB, Utah	**Air Quality Affected Environment, Section 3.3.2** (DAF, 2000) "All of the counties underlying the UTTR are in attainment for all criteria pollutants…"
Agricultural Areas	Shaw AFB, South Carolina	**Air Quality Affected Environment, Section 3.4.2** (DAF, 2010) "[The area under the airspace] is designated attainment for all criteria pollutants."
Oceans	Tyndall AFB, Florida	Air Quality was not analyzed for the Warning Areas over the Gulf of Mexico (DAF, 2020a).
Oceans	Hickam AFB, Hawaii	Air Quality was not analyzed for the Warning Areas over the Pacific Ocean (DAF, 2007).
Wetlands	Shaw AFB, South Carolina	**Air Quality Affected Environment, Section 3.4.2** (DAF, 2010) "[The area under the airspace] is designated attainment for all criteria pollutants."
Grasslands	Powder River Training Complex,	**Air Quality Affected Environment, Section 3.4.3** (DAF, 2014) "Most of the [rural areas under the airspace] … are considered as unclassified … [or] attain all national and state ambient air quality

Table 3.3-1. Air Quality Affected Environment - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Representative Airspace Location	Air Quality Section References for NEPA Documents in Table 3.1-1
	Ellsworth AFB, South Dakota	standards. Lame Deer, MT, [under the airspace], is nonattainment for PM_{10}…. Outside the airspace [a portion of] Yellowstone County, MT is nonattainment for SO_2 and [a] portion of Sheridan County, WY is nonattainment for PM_{10}."

Key: AFB = Air Force Base; MOA = Military Operations Area; NEPA = National Environmental Policy Act; PM_{10} = particulate matter with a diameter of 10 micrometers or less; SO_2 = sulfur dioxide; UTTR = Utah Test and Training Range

3.3.2 Environmental Consequences of the Proposed Action

3.3.2.1 Continued Use of Legacy Defensive Countermeasure Items

Table 3.3-2 summarizes the environmental consequences from deploying legacy defensive countermeasures in the different environmental settings where the DAF conducts testing and training. The environmental consequences column quotes or draws from prior NEPA documents incorporated by reference (listed in Table 3.1-1) with analysis of deployment of legacy chaff and flares in the representative environmental settings. The overall summary from the existing environmental documents is that legacy chaff and flare use does not generate sufficient emissions to adversely affect air quality within or beneath DAF training airspaces.

Table 3.3-2. Air Quality Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace

Environmental Setting	Representative Airspace Location	Air Quality Section References for NEPA Documents in Table 3.1-1
Woodlands	Joint Pacific Alaska Range Complex, Alaska	**Air Quality Environmental Consequences, Section 3.1.4.3** (DAF and Army, 2013) The air quality impacts of chaff were evaluated by the Air Force… "[and] the study concluded that …although some fibers may fracture during ejection, … this fracturing does not release particulate matter (Air Force 1997-2).… The use of chaff … would not result in significant adverse air quality impacts."
Woodlands	Tyndall AFB, Florida	**Air Quality Environmental Consequences, Section 4.4.2** (DAF, 2020a) "The deployment of chaff would not contribute to an exceedance of the NAAQS [National Ambient Air Quality Standards] … Emission from M206 Countermeasure Flares were estimated [and] no significant short-term or long-term effects to air quality would be expected [from flares]…"
Woodlands	Moody AFB, Georgia	Chaff and flare use was not analyzed for air quality (DAF, 2020b).
Woodlands	Shaw AFB, South Carolina	**Air Quality Environmental Consequences, Section 3.4.3.1** (DAF, 2010) "Training chaff and flares, used exclusively at altitudes greater than 4,500 feet AGL … are not expected to affect the air quality at ground level nor within the mixing layer of the atmosphere below 3,000 feet AGL…. [There would be no effect]"
Desert and Arid Regions	Holloman AFB, New Mexico	**Air Quality Environmental Consequences, Section 4.4.1** (DAF, 2021) "To provide the most conservative estimate for air quality impacts, the total number of flares was estimated to be released between 2,000 and

Table 3.3-2. Air Quality Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Representative Airspace Location	Air Quality Section References for NEPA Documents in Table 3.1-1
		3,000 feet AGL…. [Even under this extremely conservative assumption] the proposed net increases for all pollutants would be less than significant."
Desert and Arid Regions	Holloman AFB, New Mexico	Chaff and flare use was not analyzed for air quality (DAF, 2011b).
Desert and Arid Regions	Hill AFB, Utah	**Air Quality Environmental Consequences, Section 3.3.2** (DAF, 2000) "The potential for release of hazardous air pollutants is not an issue with chaff deployment … chaff dipoles settle to the ground quickly and … would not impact [air quality standards] … No significant adverse impacts to air quality would be expected as a result of … chaff deployment throughout the entire UTTR …. [Fewer than 40 thousand flares are released annually and] approximately 234 million flares could be deployed within the UTTR airspace annually without significantly increasing short- and long-term [air quality] effects … [There would be no air quality effects]"
Agricultural	PRTC, Ellsworth AFB, South Dakota	**Air Quality Environmental Consequences, Section 4.4.3.1** (DAF, 2014) "Flare emissions are not now, nor is it feasible that they could become, a health hazard… [there would be no air quality effect]"
Oceans	Hickam AFB, Hawaii	Air Quality was not analyzed for the Warning Areas over the Pacific Ocean (DAF, 2007).
Oceans	Tyndall AFB, Florida	Air Quality was not analyzed for the Warning Areas over the Gulf of Mexico (DAF, 2020a).
Wetlands	Shaw AFB, South Carolina	**Air Quality Environmental Consequences, Section 3.4.3.1** (DAF, 2010) "Training chaff and flares, used exclusively at altitudes greater than 4,500 feet AGL … are not expected to affect the air quality [over wetlands] nor within the mixing layer of the atmosphere below 3,000 feet AGL."
Wetlands	Hill AFB, Utah	**Air Quality Environmental Consequences, Section 3.3.2** (DAF, 2000) "No significant adverse impacts to air quality would be expected as a result of … chaff deployment throughout the entire UTTR…. [Fewer than 40 thousand flares are released annually and] approximately 234 million flares could be deployed within the UTTR airspace annually without significantly increasing short- and long-term [air quality] effects …"
Grasslands	PRTC, Ellsworth AFB, South Dakota	**Air Quality Environmental Consequences, Section 4.4.3.1** (DAF, 2014) "Flare emissions are not now, nor is it feasible that they could become, a health hazard …"

Key: AFB = Air Force Base; AGL = above ground level; NEPA = National Environmental Policy Act; PEA = Programmatic Environmental Assessment; PRTC = Powder River Training Complex; UTTR = Utah Test and Training Range

3.3.2.1.1 *Chaff*

Potential impacts to air quality from the continued use of the legacy chaff items identified in Table 3.1-2 would be negligible, as chaff material would not affect PM_{10} (particulate matter less than or equal to 10 microns) National Ambient Air Quality Standards (NAAQS) or impact prevention of significant deterioration Class I standards in test and training airspaces. These conclusions have been addressed in the prior NEPA documents summarized in Table 3.3-2. The conclusion of effects to air quality from the continued use of legacy chaff is that no significant adverse impacts to air quality would be expected as a result of chaff deployment during testing and training operations in DAF airspace.

3.3.2.1.2 *Flares*

Potential impacts to air quality from the continued use of the legacy flare items identified in Table 3.1-2 would be associated with the limited use of flares below 3,000 feet AGL. Previous analysis addressed in the prior NEPA documents summarized in Table 3.3-2 has shown that even if the total number of flares used in the airspace were deployed below 3,000 feet AGL, emission effects to the NAAQS would result in no adverse impacts to air quality. Future use of legacy defensive countermeasures would take place at higher altitudes, as fifth-generation aircraft fly a higher proportion of training operations above 3,000 feet AGL. A typical legacy MJU-7A/B MTV flare is comprised of 5.28 ounces of magnesium, 3.08 ounces of Teflon, and 0.44 ounces of Viton weight (Koch et al., 2012). Teflon is a per- and polyfluoroalkyl substances (PFAS) composition (see Appendix A, Section 7.3.2). An MTV flare burns at a temperature in excess of 2,000 °F. EPA tested PFAS destruction temperatures, and a temperature of 1,830 °F was found to destroy 99.99 percent of the PFAS, or effectively all of the Teflon (Winchell et al., 2021). During the flare burn, the magnesium, Teflon, and Viton are totally consumed. The conclusion of effects to air quality from the continued use of legacy flares is that no significant adverse impacts to air quality would result from flare use during testing and training operations in DAF airspace.

3.3.2.2 Use of New Defensive Countermeasure Items

3.3.2.2.1 *Chaff*

Table 3.1-3 compares new chaff with previously assessed legacy chaff based on the technical description/analysis of the items included in Appendix A and concludes that the new chaff items (RR-198/AL and RR-199/AL) are comparable to previously analyzed chaff items (RR-196/AL and RR-196(T-1)/AL, respectively). The environmental consequences from proposed training and testing use of the new chaff items as described in Table 2.3-1 would result in no significant impacts to air quality, similar to the comparable legacy chaff items summarized in Table 3.3-2.

3.3.2.2.2 *Flares*

Table 2.3-2 through Table 2.3-5 and Table 3.1-4 list the new flares that have not been previously evaluated in existing environmental documents and compares the new flares with legacy flare components based on the technical description/analysis of the items included in Appendix A. The new MTV flares are comparable to legacy flares and would have no significant impacts to air quality, as summarized in Table 3.3-2. Standard spectral flares and thrusted flares use the same basic flare cartridge and emissions as legacy flares, with some flares adding a weighted nose or body. Standard spectral flare or thrusted flare emissions would be comparable to legacy flares and would be expected to result in no significant impacts to air quality.

3.3.2.2.3 *Spectral Decoys*

As described in Section 7.6 of the Supplemental Report Update (Appendix A), each decoy releases from 1,500 to 3,000 iron foils, which are extremely light and would be dispersed by atmospheric conditions over a broad area. The air emissions from these foils would result from the oxidization of the foil pyrophoric coating upon contact with air. The emissions from the oxidization process would not be measurable within a few feet from deployment and would not result in adverse effects to air quality, even if they were all deployed below 3,000 AGL, which would not occur. Deployment of spectral decoys would be expected to have no significant impacts to air quality.

3.3.3 Environmental Consequences of No Action

Under the No Action Alternative, defensive countermeasure use during training and testing operations by the DAF would continue with legacy chaff and flare units included in the 1997 or 2011 Reports (DAF, 1997; DAF, 2011a), at levels identified in Table 2.3-1 through Table 2.3-4, in currently approved airspace. With continued adherence to the current management strategies for their use, there would be no significant impacts to air quality, as described in Section 3.3.2.1.

3.4 CULTURAL RESOURCES

3.4.1 Affected Environment

The affected environment for cultural resources under the Proposed Action includes the area underlying the DAF training airspace where defensive countermeasure use is approved (Figure 1.2-3). Table 3.4-1 summarizes the cultural resources affected environment under the representative DAF training airspaces for this programmatic analysis, which is introduced in Table 1.6-1 and Table 3.1-1. The cultural resources affected environment is described by summarizing extracted quotes from the relevant NEPA documents that are incorporated by reference and listed in Table 3.1-1 for all the representative environmental settings. For some of the NEPA documents, the training use of chaff and flares was not analyzed for cultural resources; therefore, no affected environment information from those documents is presented, as noted in Table 3.4-1.

Table 3.4-1. Cultural Resources Affected Environment - NEPA Document Section References Pertaining to the Representative Training Airspace

Environmental Setting	Representative Airspace Location	Cultural Resources Section References for NEPA Documents in Table 3.1-1
Woodlands	Joint Pacific Alaska Range Complex, Alaska	Chaff and flare use was not analyzed for cultural resources (DAF and Army, 2013).
Woodlands	Tyndall AFB, Florida	Chaff and flare use was not analyzed for cultural resources (DAF, 2020a).
Woodlands	Moody AFB, Georgia	Chaff and flare use was not analyzed for cultural resources (DAF, 2020b).
Woodlands	Shaw AFB, South Carolina	**Cultural Resources Affected Environment, Section 3.7.1.2** (DAF, 2010) "Directly beneath the … airspace in Georgia, there are 36 properties listed on the NRHP [including] ... homes and plantations to churches and schools and include six historic districts ... beneath the airspace [in] South Carolina [are] 29 NRHP listed properties [including] … four districts, a battle site, houses and commercial buildings, Fort Watson, and the Santee Indian Mound."

Table 3.4-1. Cultural Resources Affected Environment - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Representative Airspace Location	Cultural Resources Section References for NEPA Documents in Table 3.1-1
Desert and Arid Regions	Holloman AFB, New Mexico	**Cultural Resources Affected Environment, Section 4.6.1.1.1** (DAF, 2021) "Information on cultural resources … was derived from … background research to identify National Register and the State Register of Historic Places properties beneath the affected airspace; national historic landmarks; national battlefields; national historic trails; any cultural landscapes, historic forts, or historic ranches … and American Indian Reservations, sacred areas, or traditional use areas. …. archaeological sites primarily consist of ruins, artifact scatters, and historic ranches. The architectural sites consist of one trail marker, one historic district, one bank, and multiple houses."
Desert and Arid Regions	Holloman AFB, New Mexico	**Cultural Resources Affected Environment, Section 4.7.1** (DAF, 2011b) "Archaeological sites under the airspace include native burial sites, village and settlement sites, historic trails, battle sites, and historic mining sites.... Architectural resources … include structures relating to mining, ranching, settlement, the railroad, and the military…."
Desert and Arid Regions	UTTR, Hill AFB, Utah	**Cultural Resources Affected Environment, Section 3.3.6** (DAF, 2000) "A wide range of prehistoric and historic resources occur within the area underlying the UTTR airspace boundaries.…surveys…have…[identified] more than 130 archeological sites within 30 miles of the boundaries of the ranges.... Two Native American Reservations underlie the UTTR ..."
Agricultural Areas	Shaw AFB, South Carolina	**Cultural Resources Affected Environment, Section 3.7.1.2** (DAF, 2010) Cultural resources are not specifically identified as occurring in agricultural areas in the prior NEPA documents. Please see the Woodlands row of this table for summary description of cultural resources, some of which could be in or near agricultural areas.
Oceans	N/A	Any cultural resources in ocean environments would be submerged and not impacted by defensive countermeasures residual materials. There is no prior analysis of potential impacts to cultural resources in marine environments in the technical and NEPA documents incorporated by reference to this PEA.
Wetlands	Shaw AFB, South Carolina	**Cultural Resources Affected Environment, Section 3.7.1.2** (DAF, 2010) Cultural resources are not specifically identified as occurring in wetland areas in the prior NEPA documents. Please see the Woodlands row for this EIS in this table for summary description of cultural resources, some of which could be in or near a wetlands environment.
Grasslands	PRTC, Ellsworth AFB, South Dakota	**Cultural Resources Affected Environment, Sections 3.7.3, 3.7.3.2** (DAF, 2014) "… [cultural resources] included historic battlefields, trails, and ranches…. National Monuments, ghost towns, and places of traditional religious and cultural significance within the proposed PRTC APE [Area of Potential Effects]…. In general, archaeological sites … were not considered … as they will not incur any effects …. However, rock art sites were included, as they may be part of indigenous traditional ceremonies, or sacred landscapes, or TCPs [traditional cultural properties]."

Table 3.4-1. Cultural Resources Affected Environment - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Representative Airspace Location	Cultural Resources Section References for NEPA Documents in Table 3.1-1

Key: AFB = Air Force Base; EIS = Environmental Impact Statement; N/A = not applicable; NEPA = National Environmental Policy Act; NRHP = National Register of Historic Places; PEA = Programmatic Environmental Assessment; PRTC = Powder River Training Complex; UTTR = Utah Test and Training Range

3.4.2 Environmental Consequences of the Proposed Action

Since the analysis of legacy and new defensive countermeasures in this PEA is programmatic in nature, no National Historic Preservation Act Section 106 consultations or tribal government-to-government consultations specific to this study have been conducted. If an installation has a future specific action involving training with defensive countermeasures and identifies the need to conduct a separate tiered NEPA analysis (see Section 1.4), then any specific agency and government-to-government consultations necessary would be conducted at that time.

3.4.2.1 Continued Use of Legacy Defensive Countermeasure Items

The deployment of legacy chaff and flares in DAF training airspace, as described above, results in the determination of no significant impacts to cultural resources in DAF training airspaces, as summarized from prior NEPA documentation (incorporated by reference and listed in Table 3.1-1) in Table 3.4-2. The table summarizes the environmental consequences from deploying legacy defensive countermeasures in the different environmental settings where the DAF conducts testing and training. The overall summary from the existing environmental documents is that the use of legacy chaff and flares results in residual materials that fall to the ground in a dispersed fashion. As detailed in Sections 6.1 and 9.0 of the Supplemental Report Update, provided in Appendix A, the residual materials from chaff and flares do not collect in quantities great enough to adversely affect the National Register of Historic Places status of archaeological or historic resources.

Table 3.4-2. Cultural Resources Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace

Environmental Setting	Representative Airspace Location	Cultural Resources Section References for NEPA Documents in Table 3.1-1
Woodlands	Joint Pacific Alaska Range Complex, Alaska	Chaff and flare use was not analyzed for cultural resources (DAF and Army, 2013).
Woodlands	Tyndall AFB, Florida	Chaff and flare use was not analyzed for cultural resources (DAF, 2020a).
Woodlands	Moody AFB, Georgia	Chaff and flare use was not analyzed for cultural resources (DAF, 2020b).
Woodlands	Shaw AFB, South Carolina	**Cultural Resources Environmental Consequences, Section 4.7.1.2** (DAF, 2010) "The material residue from both training chaff and flares … does not collect in quantities great enough to adversely affect the NRHP status of archaeological or historic [architectural] resources.… there is a remote possibility that [a flare] S&I [Safe and Initiation] device [strike of] a historic building in poor repair, [it] could be damaged…similar to that

Table 3.4-2. Cultural Resources Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Representative Airspace Location	Cultural Resources Section References for NEPA Documents in Table 3.1-1
		from a large hailstone…. [but] is extremely unlikely in view of the distribution of flares and historic structures.”
Desert and Arid Regions	Holloman AFB, New Mexico	**Cultural Resources Environmental Consequences, Section 4.11.1.1** (DAF, 2021) “Chaff and flares deployed from the aircraft would not pose a visual intrusion … [because] they are small in size …, burn only for a few seconds (flares only), and the relatively high altitude … when deployed would make them virtually undetectable to observers on the ground. The likelihood of residual chaff and flare material to land at archaeological or architectural sites would be very rare and would not have an adverse effect on these resources.”
Desert and Arid Regions	Holloman AFB, New Mexico	**Cultural Resources Environmental Consequences, Section 4.7.2.1.1** (DAF, 2011b) “The material residue from both training chaff and flares … does not collect in quantities great enough to adversely affect the NRHP status of archaeological or historic [architectural] resources. Existing use of flares by legacy aircraft is not known to have impacted these resources and their [continued] use … is not expected to result in impacts.”
Desert and Arid Regions	UTTR, Hill AFB, Utah	**Cultural Resources Environmental Consequences, Section 3.3.6** (DAF, 2000) “The use of chaff during training operations within the UTTR would not be expected to adversely impact cultural resources.” “Chaff debris has low visibility and little effect on the aesthetic quality of [cultural resources]…. it would be unlikely that [it] would accumulate in significant objectionable quantities. Potential minor adverse impacts could occur ... [from fire associated with] … [low probability of] …inadvertent low releases of flares….”
Agricultural Areas	Shaw AFB, South Carolina	**Cultural Resources Environmental Consequences, Section 4.7.1.2** (DAF, 2010) Cultural resources are not specifically identified as occurring in agricultural areas in the prior NEPA documents; please see the Shaw AFB Woodlands row of this table for summary analysis of cultural resources, some of which could be in or near agricultural areas.
Oceans	N/A	Any cultural resources in ocean environments would be submerged and not impacted by defensive countermeasures residual materials. There is no prior analysis of potential impacts to cultural resources in marine environments in the technical and NEPA documents incorporated by reference to this PEA.
Wetlands	Shaw AFB, South Carolina	**Cultural Resources Environmental Consequences, Section 4.7.1.2** (DAF, 2010) Cultural resources are not specifically identified as occurring in wetland areas in the prior NEPA documents; please see the Shaw AFB Woodlands row of this table for summary analysis of cultural resources, some of which could be in or near a wetlands environment.
Grasslands	Powder River Training Complex, Ellsworth AFB, South Dakota	**Cultural Resources Environmental Consequences, Sections 4.7.3, 4.7.3.1** (DAF, 2014) “Studies have shown that chaff and its residual materials do not pose a significant threat to the visual integrity of archaeological and architectural resources (GAO, 1998).... The residual materials from chaff and flares … do not collect in quantities great enough to adversely affect … archaeological or architectural resources....no studies have been

Table 3.4-2. Cultural Resources Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Representative Airspace Location	Cultural Resources Section References for NEPA Documents in Table 3.1-1
		conducted on traditional cultural resources … [and] residual materials.... When a plastic chaff or flare piece is found and identified … [at] a cultural resource, the individual … may be annoyed.”

Key: AFB = Air Force Base; N/A = not applicable; NEPA = National Environmental Policy Act; NRHP = National Register of Historic Places; PEA = Programmatic Environmental Assessment; PRTC = Powder River Training Complex; UTTR = Utah Test and Training Range

3.4.2.1.1 *Chaff*

Potential impacts to cultural resources from the use of the legacy chaff items identified in Table 3.1-2 could result from visual intrusion of the chaff deployment (temporary) or chaff residual material on the surface of the resource and have been addressed in the prior NEPA documents summarized in Table 3.4-2. The conclusion of effects to cultural resources from the use of legacy chaff is that chaff fibers and residual materials from chaff deployment would not collect in quantities great enough to adversely affect archaeological or historic resources (see Section 6.1 of the Supplemental Report Update, provided in Appendix A, for calculations of chaff dispersal). No significant adverse impacts to cultural resources would be expected as a result of continued chaff deployment during testing and training operations in DAF airspace.

3.4.2.1.2 *Flares*

Potential impacts to cultural resources from the use of the legacy flare items identified in Table 3.1-2 could result from visual intrusion of the flare deployment (temporary); flare residual materials on the surface of the resource; the unlikely possibility of a flare Safe and Initiation device striking a historic building in poor repair, causing damage similar to that from a large hailstone; or the unlikely possibility of a flare-caused fire. Table 3.4-2 summarizes the potential impacts to cultural resources from the use of legacy flares for the different environments under DAF training airspace. The types of flares deployed and the adopted management strategies for use of flares in the airspaces are primarily related to altitude restrictions for deployment and ensure complete consumption of the flare before contact with the ground surface. The conclusion of effects to cultural resources is that legacy flares and residual materials from their deployment would not result in significant impacts to cultural resources under the DAF airspace.

3.4.2.2 Use of New Defensive Countermeasure Items

3.4.2.2.1 *Chaff*

Table 3.1-3 compares new chaff with previously assessed legacy chaff based on the technical description/analysis of the items included in Appendix A and concludes that the new chaff items (RR-198/AL and RR-199/AL) are comparable to previously analyzed chaff items (RR-196/AL and RR-196(T-1)/AL, respectively). The environmental consequences from proposed training and testing use of the new chaff items as described in Table 2.3-1 would be expected to result in no significant impacts to cultural resources, similar to the comparable legacy chaff items summarized in Table 3.4-2.

3.4.2.2.2 *Flares*

Table 2.3-2 through Table 2.3-5 and Table 3.1-4 list the new flares that have not been previously evaluated in existing environmental documents. Table 3.1-4 compares the new flares with legacy flare components based on the technical description/analysis of the items included in Appendix A. The new MTV flares are comparable to legacy flares and would have no significant impacts to cultural resources, similar to the comparable legacy flares summarized in Table 3.4-2. Standard spectral flares are primarily combat flares with a weighted nose and would be used for testing and very limited training over ranges approved for deploying live or inert munitions. The limited use of standard spectral flares would be expected to have no significant impacts to cultural resources. Thrusted flares are combat flares; their use during testing and limited training over ranges suitable for munitions deployment would be expected to have no significant impacts to cultural resources. The environmental consequences from use of the new flares as described in Table 3.1-4 would be expected to result in no significant impacts to cultural resources.

3.4.2.2.3 *Spectral Decoys*

As described in Section 7.6 of the Supplemental Report Update (Appendix A), each decoy releases from 1,500 to 3,000 iron foils, which measure either 0.75 by 1.75 by 0.00125 inches or 0.75 by 0.75 by 0.00125 inches thick and weigh 0.0046 to 0.009 ounces (0.13 to 0.25 grams). The potential for environmental effects of the residual foils is the result of the potential quantity deposited at any given site during each deployment and the potential to accumulate due to their relative durability. Similar to the dispersal of chaff fibers, although chaff are deployed in far greater numbers (see Table 2.3-6), the extremely light foils would be dispersed by atmospheric conditions over a wide region, depending on the altitude of deployment, thus reducing the potential for the foils or residual decoy materials to land on any individual historic property or site of traditional, religious, or cultural value (see Section 3.1.1.2.3 and Table 7-11 of Appendix A). The potential to accumulate at any given site also depends, in part, on the likelihood that a spectral decoy would be deployed over the same site more than once before any previously deposited foils are disintegrated or obscured by natural processes. Due to their size and relative durability, the foils or residual materials could have a noticeable presence on a site and be a visual annoyance to any visitor to the site; however, they would not be expected to collect and/or accumulate at any given site in quantities great enough to adversely affect archaeological or historic resources. Deployment of spectral decoys would be expected to have no significant impacts to cultural resources.

3.4.3 Environmental Consequences of No Action

Under the No Action Alternative, defensive countermeasure use during testing and training operations by the DAF would continue with legacy chaff and flare units included in the 1997 or 2011 Reports (DAF, 1997; DAF, 2011a), at levels identified in Table 2.3-1 through Table 2.3-4, in currently approved airspace. With continued adherence to the current management strategies for their use, there would be no significant impacts to cultural resources, as described in Section 3.4.2.1.

3.5 BIOLOGICAL RESOURCES

3.5.1 Affected Environment

The affected environment for biological resources under the Proposed Action includes the area underlying the DAF training airspace where defensive countermeasure use is approved (Figure 1.2-3). Table 3.5-1 summarizes the biological resources affected environment under the representative DAF training airspaces for this programmatic analysis, which is introduced in Table 1.6-1 and Table 3.1-1. The biological resources affected environment is described by summarizing extracting quotes from the relevant NEPA documents that are incorporated by reference and listed in Table 3.1-1 for all the representative environmental settings.

Table 3.5-1. Biological Resources Affected Environment - NEPA Document Section References Pertaining to the Representative Training Airspace

Environmental Setting	Airspace Location	Biological Resources Section References for NEPA Documents in Table 3.1-1
Woodlands	Joint Pacific Alaska Range Complex, Alaska	**Biological Resources Affected Environment, Sections 3.1.8, 3.1.8.1** (DAF and Army, 2013) "Habitat under the propose [airspace] expansion areas ranges from alpine tundra to marshy lowlands and supports populations of big game species, waterfowl, and anadromous fish…. The combined … MOAs cover more than 2 million acres of nationally significant waterfowl nesting habitat. Raptors, including bald eagles and golden eagles can be relatively common in the region."
Woodlands	Tyndall AFB, Florida	**Biological Resources Affected Environment, Section 3.6.1.1 Florida** (DAF, 2020a) "The Southeastern Plains…. consist of a mosaic of cropland, pasture, woodland, and forest. and Southern Coastal Plain … is comprised of mostly flat plains containing swamps, marshes and lakes … 22 cetacean species, [6] Federally endangered and threatened bird [species, 2 mice, 2] fish, and the West Indian manatee … can occur [under the Tyndall airspace]"
Woodlands	PRTC, Ellsworth AFB, South Dakota	**Biological Resources Affected Environment, Sections 3.6.3, 3.6.3.1, 3.6.3.2, 3.6.3.3** (DAF, 2014)**:** "The area under the … airspace is … is primarily flat, [with] valleys and foothills that support woodlands … and riparian woodlands…. … [4] birds, [3] mammals, [2] fish and [2] plant species are listed under the ESA [Endangered Species Act] as threatened or endangered and [3] candidate bird species have been documented or have the potential to occur in suitable habitats within or near the [airspace]"
Woodlands	Moody AFB, Georgia	**Biological Resources Affected Environment, Section 3.6.4.2** (DAF, 2020b) Much of the … areas under the [airspace] have been converted to agricultural uses…. Remaining natural habitats … include pine and hardwood forests and wetlands … [4 bird, 3 reptile, and 1 tortoise species] are Federally listed [or proposed for listing and] could potentially be found [under the airspace] There are also numerous state listed mammal, bird, reptile, and amphibian species. No designated critical habitat for listed birds, mammals, reptiles, or amphibians occurs beneath the airspace."
Woodlands	Shaw AFB, South Carolina	**Biological Resources Affected Environment, Section 3.6.1.2, ROD** (DAF, 2010) "[Approximately] 60 percent of the area is classified as forested with…cropland and pasture comprising [the remaining area]…. Natural

Table 3.5-1. Biological Resources Affected Environment - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Airspace Location	Biological Resources Section References for NEPA Documents in Table 3.1-1
		vegetation is dominated by the southern evergreen forest [with common] bottomland swamps and marshes… Carolina Bays … support different community types…. [19] special-status species have the potential to occur (under the airspace) [7] species are federally endangered and [4] are federally threatened…. There is no designated critical habitat [under the airspace…. 7] additional … state endangered or threatened and [20] special-status species may be found under the airspace.”
Desert and Arid Regions	Holloman AFB, New Mexico	**Biological Resources Affected Environment, Section 4.6.1.1.1** (DAF, 2011b)**:** “Vegetation … [under the airspace] begins with grasslands mixed with shrubs at lower elevations, transitions to shrubland mixed with forest stands at mid-elevations, and becomes denser forest cover at higher elevations…. [8] listed, proposed, or candidate bird special status species, [2] mammals, [8] fish species and amphibians, [9] invertebrates, and [8] plants which are listed, proposed, or candidate (occur under the airspace)”
Desert and Arid Regions	Holloman AFB, New Mexico	**Biological Resources Affected Environment, Section 3.6.1.2, ROD** (DAF, 2021) “Most of the land beneath the airspace consists of Chihuahuan Basins and Playas…. Vegetative cover is predominantly desert grassland and arid shrubland, except for high elevation islands of woodland…. [6] bird and [2] mammal special-status species [are residents or migratory].”
Desert and Arid Regions	UTTR, Hill AFB, Utah	**Biological Resources Affected Environment, Section 3.3.4** (DAF, 2000) “The UTTR [airspace] is … characterized by the presence of broad, low basins, numerous small mountain ranges, alkaline soils, and predominately shadscale-vegetated valleys … Over 60…percent … of the land represent barrens [with the remainder] sparse salt-tolerant vegetation and shadscale/kochia…. There were [1] fish, [1] bird, [1] mammal, [1] clam, and [1] plant…listed as threatened and endangered species (under the airspace in 2000).”
Agricultural Areas	PRTC, Ellsworth AFB, South Dakota	**Biological Resources Affected Environment, Section 3.9, 3.8.2.2, 3.6.3.3** (DAF, 2014) “Ranching and farming … define the regional character and economy [under the airspace]…. Beef cattle, with some milk cows…and sheep and lambs represent the greatest proportion of livestock.… Cultivated agricultural areas include hay/pastureland, irrigated, and other cultivated cropland. game species and birds occur throughout the area.”
Ocean	Hickam AFB, Hawaii	**Biological Resources Affected Environment 3.5.3.1** (DAF, 2007) “Biological resources [under the Warning Areas] include … the Insular Pacific-Hawaiian Large Marine Ecosystem … characterized by limited ocean nutrients, leading to high biodiversity but low sustainable yields for fisheries…. There are 25 cetacean and 1 pinniped species that could occur within the Warning Areas. Some cetacean species are resident … while others … migrate through the area.”
Ocean	Tyndall AFB, Florida	**Biological Resources Affected Environment, Section 3.6.1.1, Table 2.7-1** (DAF, 2020a)**:** “Approximately half of the Warning Areas overlie the continental shelf and half overlie the continental slope…. There are 22 marine mammal species that could occur within the Warning Areas…. Some cetacean species are resident … others … migrate through the area. Federally endangered and threatened marine species could occur in the Warning Areas.”

Table 3.5-1. Biological Resources Affected Environment - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Airspace Location	Biological Resources Section References for NEPA Documents in Table 3.1-1
Wetlands	Holloman AFB, New Mexico	**Biological Resources Affected Environment, Sections 4.6.1.2.1, 4.6.1.4.1** (DAF, 2011b)**:** "Wetlands and aquatic habitat include springs and seeps in mountainous areas and wetland marshes and creeks in the Tularosa Basin. Other regional wetland … playas form in undrained or poorly drained basins with seasonal rainfall….Wetlands and riparian areas are important for food, water, cover, breeding, brood rearing, and shade for most animal species, particularly migratory birds…. Federally listed, proposed, and candidate species … include [2] mammals, [8] birds, [1] frog, [1] lizard, [6] fish, [9] invertebrates, and [8] plants
Wetlands	Moody AFB, Georgia	**Biological Resources Affected Environment, Section 3.6.1** (DAF, 2020b) "Biological resources include native or invasive plants and animals, sensitive and protected floral and faunal species, and the habitats, such as wetlands … in which they exist…. Mammal, bird, and reptile … species typically associated with open water areas … can be found in these areas."
Wetlands	UTRR, Hill AFB, Utah	**Biological Resources Affected Environment, Section 3.3.4** (DAF, 2000) "The predominant cover type … is mudflat that is either barren or covered by water…. The vegetation types … [are] sparse salt-tolerant vegetation, desert brush mixes, and sand barrens…. Biological resources include wetlands [which] provide essential breeding, spawning, nesting, and wintering habitats for … fish and wildlife species."
Grasslands	PRTC, Ellsworth AFB, South Dakota	**Biological Resources Affected Environment, Section 3.6.3.2** (DAF, 2014) "The most extensive vegetation type [under the airspace] is grasslands…. [which] are composed of species that can and do recover quickly from fires…. Ungulate game species [and] a variety of birds occur throughout the area. The diversity of species crossing under the proposed airspace during migratory periods is large."

Key: AFB = Air Force Base; ESA = Endangered Species Act; MOA = Military Operations Area; NEPA = National Environmental Policy Act; PRTC = Powder River Training Complex; ROD = Record of Decision; UTTR = Utah Test and Training Range

3.5.2 Environmental Consequences of the Proposed Action

Since the analysis of legacy and new defensive countermeasures in this PEA is programmatic in nature, no Endangered Species Act Section 7 consultations specific to this study have been conducted. If an installation has a future specific action involving training with defensive countermeasures and identifies the need to conduct a separate tiered NEPA analysis (see Section 1.4), then any specific agency consultations necessary would be conducted at that time.

3.5.2.1 Continued Use of Legacy Defensive Countermeasure Items

The deployment of legacy chaff and flares in DAF training airspace, as described above, results in the determination of no significant impacts to biological resources in DAF training airspaces, as summarized from prior NEPA documentation (incorporated by reference and listed in Table 3.1-1), in Table 3.5-2. The table summarizes the environmental consequences from deploying legacy defensive countermeasures in the different environmental settings where the DAF conducts testing and training. The overall summary from the existing environmental documents is that legacy chaff and flare residual materials may affect but would not be likely to adversely affect any of the biological resources under DAF training airspaces.

Table 3.5-2. Biological Resources Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace

Environmental Setting	Airspace Location	Biological Resources Section References for NEPA Documents in Table 3.1-1
Woodlands	Joint Pacific Alaska Range Complex, Alaska	**Biological Resources Environmental Consequences, Section 3.1.8.3, 3.1.8.3.1** (DAF and Army, 2013) "Extensive studies of chaff particles and defensive flare constituents have found no negative impacts on biological resources…. Mitigations in place to restrict altitude deployment of flares … have successfully avoided fire impacts [to biological resources] from training with defensive flares."
Woodlands	Tyndall AFB, Florida	**Biological Resources Environmental Consequences, Section 4.5.2, FONSI** (DAF, 2020a) "Although unlikely due to the large training space within the Warning Areas, [federally listed species] could ingest residual plastic chaff and flare components. The Air Force has made a 'may affect but not likely to adversely affect' determination for the [listed species' and coordinated with] the National Marine Fisheries Service and United States Fish and Wildlife Service."
Woodlands	PRTC, Ellsworth AFB, South Dakota	**Biological Resources Environmental Consequences, Sections 4.6.3, 4.6.3.1** (DAF, 2014) "Ingestion of chaff by either ranch animals or wildlife is expected to … be negligible.... The Air Force received concurrence from USFWS in 2010 on their determination of 'may affect, not likely to adversely affect, federally listed threatened and endangered species.'"
Woodlands	Moody AFB, Georgia	**Biological Resources Environmental Consequences, Sections 4.6.2, 4.6.2.1, Table 2.7-1** (DAF, 2020b) "It is highly unlikely that small amounts of lightweight material ejected during [chaff or flare] deployment would have an adverse impact on birds or that the material would … have an impact on mammals…. Flares would have a negligible … risk of wildland fires.… Flare use is limited to altitudes above 2,000 feet AGL [above ground level] and the use of flares is suspended when conditions are conducive to wildfires."
Woodlands	Shaw AFB, South Carolina	**Biological Resources Environmental Consequences, Section 4.6.1.2, ROD** (DAF, 2010) "Previous studies have documented that wildlife and domestic animals would not be harmed by residual chaff or flare materials There are no recorded cases of domestic or wild animals ingesting end caps [or other residual materials]…. That USFWS concurred with the Air Force's determination of 'may affect, not likely to adversely affect' wood storks [and] no effects were found on other listed species. Neither wildlife nor domestic animals would be harmed by residual chaff or flare materials."
Desert and Arid Regions	Holloman AFB, New Mexico	**Biological Resources Environmental Consequences, Section 4.6.1.1.1** (DAF, 2011b)**:** "Concentrations of chaff and flare [residual materials] would not result in conditions that affect biological resources…. Species are not likely to be affected by continued deployment of chaff and flares in approved airspace…. no adverse impacts are anticipated for the sensitive … species … or their associated habitats that may occur

Table 3.5-2. Biological Resources Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Airspace Location	Biological Resources Section References for NEPA Documents in Table 3.1-1
		(under the airspace)…. USFWS findings [were] that potential impacts 'may affect,… but would not likely adversely affect' (listed species)."
Desert and Arid Regions	Holloman AFB, New Mexico	**Biological Resources Environmental Consequences, Sections 4.5.1.1, 4.5.1.2, 4.5.1.3, Table 2.9-1** (DAF, 2021) "Based on toxicological studies on chaff and flare residual materials, impacts to biological resources are not expected…. Wildlife do not use chaff fibers for food or nesting material and chaff is not known to be toxic to animals if ingested…. The possibility of a wildfire from flare usage impacting wildlife habitat would be remote [and] would be mitigated by operational constraints, including the prohibition of flares during periods of "Very High" or "Extreme" National Fire Danger Ratings…. The … USFWS concurred with the DAF [and issued a determination] 'may affect, is not likely to adversely affect' listed species and 'may affect, is not likely to jeopardize the continued existence of' proposed species."
Desert and Arid Regions	UTTR, Hill AFB, Utah	**Biological Resources Environmental Consequences, Section 4.6.1, Table 2.7-1** (DAF, 2000) "In arid areas, the slow chemical decomposition of chaff is expected to have no adverse effects on soil chemistry and plant growth…. The trace amounts of … chemicals in the chaff fibers would be released in such small quantities that no effects would be anticipated…. Use of self-protection chaff and flares within the UTTR would have no significant, adverse impacts to biological resources."
Agricultural Areas	PRTC, Ellsworth AFB, South Dakota	**Biological Resources Environmental Consequences, Section 4.9.3, 4.9.3.1, 4.3.3.1.3** (DAF, 2014) "Ingestion of chaff by either ranch animals or wildlife is expected to…be negligible…. Inhalation of chaff fibers is not expected to have negative effects on…livestock…. Flare fire risk would remain extremely low throughout the airspace…. Any potential loss of forage, livestock, or infrastructure due to fire could result in economic impacts to affected landowners. The Air Force follows established procedures for claims in the unlikely event that an Air Force-caused fire should occur and subsequently damage livestock or infrastructure. [Chaff and flare] residual pieces could be an annoyance if such a plastic piece were found on the ground and identified."
Ocean	Hickam AFB, Hawaii	**Biological Resources Environmental Consequences, Section 4.5.2.1, FONSI** (DAF, 2007) "In the very unlikely event that chaff and flare [residual] components were encountered and ingested by a marine mammal, the small size of chaff and flare end-caps and pistons … would pass through the digestive tract of marine mammals…. The use of defensive countermeasures during training activities in the Warning Areas may affect but is not likely to adversely affect…federally listed birds,…marine mammals,…sea turtles…or [fish]… There is no designated critical habitat … in the Warning Areas…. No potential for significant cumulative effects on biological resources is expected."

Table 3.5-2. Biological Resources Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Airspace Location	Biological Resources Section References for NEPA Documents in Table 3.1-1
Ocean	Tyndall AFB, Florida	**Biological Resources Environmental Consequences, Sections 4.6.1. 2.7.1, Table 2.6, FONSI** (DAF, 2020a) "Within the Warning Areas, …RR-188 chaff and M206 flares [or similar] result in residual components [that] could be ingested by federally listed species…. The Air Force has made a 'may affect but not likely to adversely affect' determination for federally listed birds, mammals, sea turtles, giant manta ray, [and fish].,… There would be no impact on Essential Fish Habitat."
Wetlands	Holloman AFB, New Mexico	**Biological Resources Environmental Consequences, Section 4.6.2.1.1** (DAF, 2011b) "Wildlife and domestic animals would have little opportunity to be exposed to chaff fibers and flare residual materials…. [Toxicity could only result from] repeated and concentrated use in localized areas, which would not occur because of the widely dispersed nature of flare deployment…. There would be a very low probability that an unburned flare or material from a flare would reach an aquatic or wetland environment. …No adverse impacts on wetlands and water bodies have been observed from the use of chaff and flares."
Wetlands	Moody AFB, Georgia	**Biological Resources Environmental Consequences, Section 4.6.1, Table 2.7-1** (DAF, 2020b) "It is highly unlikely that wood storks [or other species] would ever encounter chaff and flare components in aquatic environments …where they forage…. The use of chaff and flares in the…training airspace may affect but is not likely to adversely affect the wood stork (or any other listed species)."
Wetlands	UTTR, Hill AFB, Utah	**Biological Resources Environmental Consequences, Section 3.3.4** (DAF, 2000) "In wet, acidic environments, chemical decomposition is more rapid, but no adverse effects are expected (because) the small quantity of chaff …would release minute amounts of chemicals, primarily aluminum and silicon dioxide, that are abundant in the soil… No effects would be anticipated… Use of self-protection chaff and flares within the UTTR would have no significant, adverse impacts to biological resources."
Grasslands	PRTC, Ellsworth AFB, South Dakota	**Biological Resources Environmental Consequences, Sections 4.6.3.1, 4.8.3.1, 4.9.3, 2.8.5.2** (DAF, 2014) "Chaff and flare plastic and wrapper residual materials are typically inert and not expected to impact soils or water bodies. … No known deaths of waterfowl [or any other animal] have occurred from ingesting chaff. Given the [very small] chaff deposition in annual ounces per acre … adverse effects from ingestion are not expected and impacts would be less than significant."

Key: AFB = Air Force Base; FONSI = Finding of No Significant Impact; PRTC = Powder River Training Complex; ROD = Record of Decision; USFWS = United States Fish and Wildlife Service; UTTR = Utah Test and Training Range

3.5.2.1.1 *Chaff*

Potential impacts to biological resources from the use of the legacy chaff items identified in Table 3.1-2 could result from ingestion of chaff by either wildlife or ranch animals, which have been addressed in the prior NEPA documents summarized in Table 3.5-2. The conclusion of effects to biological resources from the use of legacy chaff is that no significant adverse impacts to biological resources would be expected as a result of chaff deployment during testing and training operations in DAF airspace.

3.5.2.1.2 *Flares*

Table 3.5-2 summarizes the potential impacts to biological resources from the use of legacy flares for the different environments under DAF training airspace. The determination of no significant impact is based on the types of flares deployed and the adopted management strategies implemented to reduce potential for impacts from use of flares in the airspaces. The conclusion of effects to biological resources is that legacy flares and residual materials from their deployment would not result in significant impacts to biological resources under the DAF airspace.

3.5.2.2 Use of New Defensive Countermeasure Items

3.5.2.2.1 *Chaff*

Table 3.1-3 compares new chaff with previously assessed legacy chaff based on the technical description/analysis of the items included in Appendix A and concludes that the new chaff items (RR-198/AL and RR-199/AL) are comparable to previously analyzed chaff items (RR-196/AL and RR-196(T-1)/AL, respectively). The environmental consequences from proposed training and testing use of the new chaff items as described in Table 2.3-1, when applicable management actions are incorporated for new countermeasures, would result in no significant impacts to biological resources, similar to the comparable legacy chaff items summarized in Table 3.3-2 and Section 3.1.1.2.1.

3.5.2.2.2 *Flares*

Table 2.3-2 through Table 2.3-5 and Table 3.1-4 lists the new flares that have not been previously evaluated in existing environmental documents and compares the new flares with legacy flare components based on the technical description/analysis of the items included in Appendix A. The new MTV flares are comparable to legacy flares and would have no significant impacts to biological resources as, summarized in Table 3.5-2. Standard spectral flares are primarily combat flares with a weighted nose and would be used for testing and very limited training over ranges approved for deploying live or inert munitions. This limited training over ranges would be expected to have no significant environmental effects to biological resources. Thrusted flares are combat flares, and their use during testing and limited training over ranges suitable for munitions deployment would be expected to have no significant environmental effects to biological resources.

3.5.2.2.3 *Spectral Decoys*

Spectral decoys have fewer plastic pieces than legacy flares, and the large number of pyrophoric foils oxidize when exposed to air, so there would be no dud spectral decoys on the on the surface. Training and testing with spectral decoys would result in a large number of light, durable iron foils potentially being concentrated as the result of low altitude deployment or distributed 30 to 50 miles from the point of high altitude deployment (see Appendix A, Section 7.6.4.8). Training and testing with the annual quantity of spectral decoys identified in Table 2.3-5, resulting in a large number of iron foils being released throughout DAF training airspace in the United States, would not be expected to have a significant environmental effect and would be expected to result in “may affect, but is not likely to adversely affect” sensitive biological resources in woodlands, wetlands, or oceans. There would be the potential for domestic species in grasslands, specifically agricultural areas used for grazing, to be impacted by concentrations of foils, should they accumulate and concentrate in a given area. Spectral decoys are described and the environmental effects are presented in detail in the Supplemental Report Update (Appendix A, Sections 7.6.4.8 and 8.11). This section applies the results of the brief foil weathering and drift tests (see Appendix A, Section 7.6.4.8) to summarize the potential environmental effects for each environment setting under DAF training airspaces (see Table 3.1-1).

Woodlands: Foils are as light as leaves and would be expected to settle in a forest canopy until being redistributed by rain or wind to the ground and becoming covered by woodlands litter. Widely distributed iron foils would not be expected to affect the growth of vegetation or break down to such an extent that they would alter soil chemistry. Foils were found to not be attractive to common terrestrial bird or mammal species during a 3-month weathering test. Significant woodlands biological impacts would not be anticipated.

Desert and Arid Regions: Foils on an arid surface, such as a desert, would take a year or years to weather and fragment to iron particles. Testing and training with spectral decoys could result in large numbers of exposed durable iron foils on the surface and potentially have a minor effect on surface water flow similar to naturally occurring desert pavement.

Sources of water for species are infrequent in an arid environment and, with a lack of laboratory tests or controlled experiment studies, it is not known precisely what effect the weathering of a few iron foils would have on a small desert water source or natural pool. In a simple informal experiment, foils placed in a freshwater container were found to rust and break down to particles smaller than one-half of a foil in a 3-month period. Training with the quantity of spectral decoys identified in Table 2.3-6 would increase the potential for foils to be deposited in a desert water source. The potential concentration of foils would be a high of 159 foils per acre (in 38 acres) from 3 decoys deployed at 2,000 feet AGL in a 5-mph wind (see Appendix A, Section 7.6.4.8). A small desert water source with a surface area of 0.02 acre beneath such a spectral decoy deployment could receive approximately four iron foils (up to 1.0 gram total weight). Four iron foils in a small water source would be expected to disintegrate emitting oxidized material from the surface of the foil to produce a minor increase in the iron content as a result of rusting. The solid particles would remain settled on the bottom unless perturbed and would eventually be covered by the natural sedimentation processes of lake/pond water bodies. As explained in Section 3.6.2.2.3, four iron foils in a small water source such as this would have a negligible effect on the water quality.

Agriculture: Training and testing with spectral decoys at altitude or in wind conditions where the foils were deployed at a 2,000 feet AGL or where foils could drift to agricultural operations has the potential to impact domestic species (see Appendix A, Section 7.6.4.6). The 3-month weathering test found that bird and most mammal species did not see the foils as useful for food or nesting and basically ignored the foils in an arid and grassland environment (see Appendix A, Section 8.7). Migrating species would be expected to react to the foils in a comparable way and not be impacted by iron foils or iron particles. Foils could settle on a variety of crops such as alfalfa, hay, other standing crops, or row crops. Migrating species regularly forage on agricultural lands during migration. Residual iron foils or iron particles could affect the availability of forage or result in inadvertent ingestion, with detriment to individuals. Such inadvertent consumption would not be expected to be extensive and would be expected to result in "may affect, but is not likely to adversely affect" determination for sensitive species.

Appendix A, Section 7.6.4.8, explains that foil concentrations from low altitude deployment or overlapping higher altitude deployment could result in 159 iron foils per acre or 32 foils per large hay roll or a comparably sized large hay bale. Farmers and ranchers could be expected to see such concentrations as having an adverse impact on their agricultural operations (see Appendix A, Section 8.11). Ranchers at public hearings have explained that parts of a nail, screw, or piece of wire can cause bovine hardware disease or bovine traumatic reticuloperitonitis. The pieces of metal settle in the compartment of the cattle's stomach called the reticulum and can irritate or penetrate the lining. These conditions most commonly occur in a feed lot where cattle are fed hay containing small residual iron materials, but they can also occur if grazing animals indiscriminately forage on grasses in which a metal object is enmeshed. In cases of bovine hardware disease, the metallic object can penetrate the stomach lining and have mild, severe, or even fatal consequences. Training and testing with spectral decoys at low altitude or in wind conditions where the foils could concentrate on agricultural operations has the potential to impact domestic species, which could be seen by ranchers as an adverse impact.

Ocean Environment: The effects of spectral decoy foils on marine species have not been studied. Based on informal freshwater tests, foils were dropped from a height of 6 inches on a slowly moving surface subject to a 1-mph wind. Thirty-three percent of the foils that landed on the water surface on edge or at an angle were found to immediately begin to sink. An additional 20 percent of the foils remained on the surface for 10 to 30 seconds. Forty-six percent of the foils landed in a relatively flat trajectory and remained on the surface due to water surface tension for 10 minutes or more. One-half of the foils on the surface resisted sinking until there was substantial agitation of the water. In a marine environment, wave or wind action would be expected to cause foils to remain on the surface a short time and then sink. Foils on a marine surface or descending in the water column could be seen as a potential prey item and detrimentally affect marine predators or could be ingested by species that consume large quantities of krill-like animals. Use of spectral decoys for DAF training over a marine environment, or where drifting into a marine environment could occur, would introduce large numbers of foils into the environment. The foils would be distributed over very large ocean surfaces and would descend to the ocean floor. There could be impacts on individual marine animals inadvertently ingesting foils, and because the foils would be transient in the water column during descent to the sea floor, the number of individual animals affected would be expected to be small. The overall effects on native species populations would be expected to be sufficiently low to result in a "may affect, but not likely to adversely affect" biological determination for sensitive species.

Wetlands: There have been no studies for the spectral decoy foils comparable to the earlier studies conducted with chaff and flare residual materials (DAF, 1997; DAF, 2011a) that would inform assessment of potential effects on wetland species. Foils in regularly agitated fresh water were found to oxidize and begin to break down in 2 weeks. DAF training or testing that results in the deposition of iron foils in slowly flowing wetlands would have a negligible effect on water quality. Foils which remain on the surface or slowly descend in the water column, as described under the marine discussion above, could be seen as a potential prey item and would detrimentally affect freshwater predators. DAF training or testing with spectral decoys over a wetlands environment, or where numbers of foils could drift into a wetlands environment, would introduce a foreign material to predators and could result in repeated deposits of foils in the wetland. Over a period of weeks, the iron foils would be expected to be covered by natural materials in a wetland and the oxidization process would be expected to accelerate rusting. Use of spectral decoys over wetlands would introduce quantities of iron foils and particles and could impact wetlands and wetland species, but the impact would not be expected to be significant.

Grasslands: Foils deployed over a grassland would introduce an iron residual material that would be anticipated to remain suspended in the grasses until the foils fragmented into smaller iron particles and fell to the soil surface over an estimated several months, up to a year. Foils deposited in grasslands would not be expected to be of sufficient quantity to affect plant growth. As described in the agriculture discussion above, grazing animals, which are indiscriminate in their consumption of grasses, could ingest suspended iron foils. Birds and animals were not found to use legacy chaff or flare plastic, wrapping, or chaff materials in dens or nests and would not be expected to use a foreign iron foil material in dens or nests. Common birds and animals, including crows, scrub jays, towhees, white-crowned sparrows, woodpeckers, skunks, ground squirrels, possums, and a racoon (which experimented with tasting a foil) generally ignored the foils during the 3-month weathering tests. Extensive low altitude or higher altitude overlapping training with spectral decoys over grasslands could result in the buildup of durable iron foils in the environment and affect grazing animals.

Summary of Spectral Decoy Biological Effects: The primary source of spectral decoy impacts is the large number of light and relatively durable iron foils distributed with each decoy deployed, which with repeated use over the same location could result in the residual foils accumulating in one place (see Table 3.1-4). DAF training and testing with the quantity of spectral decoys identified in Table 2.3-6 could have environmental impacts to biological resources in agricultural areas, oceans, wetlands, and grasslands. Testing and training with spectral decoys over DAF ranges with specified altitude and wind conditions during the tests would be expected to result in a much lower level of impacts to individual species within a confined area. Spectral decoy deployment at low altitude in MOAs off DAF ranges could concentrate foils. Although specific individual animals could be adversely affected, the overall effects on native species populations in woodlands, wetlands, oceans, and grasslands would be expected to be sufficiently low to result in a “may affect, but not likely to adversely affect” biological determination for sensitive species.

3.5.3 Environmental Consequences of No Action

Under the No Action Alternative, defensive countermeasure use during testing and training by the DAF would continue with legacy chaff and flare units included in the 1997 or 2011 Reports (DAF, 1997; DAF, 2011a) at levels identified in Table 2.3-1 through Table 2.3-4, in currently approved airspace. With continued adherence to the current management strategies for their use, there would be no significant impacts to biological resources, as described in Section 3.5.2.1.

3.6 SOIL AND WATER RESOURCES

3.6.1 Affected Environment

The affected environment for soil and water resources under the Proposed Action includes the area underlying the DAF training airspace where defensive countermeasure use is approved (Figure 1.2-3). Table 3.6-1 summarizes the soil and water resources affected environment under the representative DAF training airspaces for this programmatic analysis, which is introduced in Table 1.6-1 and Table 3.1-1. The soil and water resources affected environment is described by summarizing extracted quotes from the relevant NEPA documents that are incorporated by reference and listed in Table 3.1-1 for all the representative environmental settings.

Table 3.6-1. Soil and Water Resources Affected Environment - NEPA Document Section References Pertaining to the Representative Training Airspace

Environmental Setting	Representative Airspace Location	Soil and Water Resources Section References for NEPA Documents in Table 3.1-1
Woodlands	Joint Pacific Alaska Range Complex, Alaska	Chaff and flare use was not analyzed for soil and water resources (DAF and Army, 2013).
Woodlands	Tyndall AFB, Florida	Chaff and flare use was not discussed in the affected environment for soil and water resources (DAF, 2020a).
Woodlands	Moody AFB, Georgia	Chaff and flare use was not discussed in the affected environment for soil and water resources (DAF, 2020b).
Woodlands	Shaw AFB, South Carolina	**Soil and Water Resource Affected Environment, Section 3.5.2** (DAF, 2010) "The … airspace overlie the Vidalia Upland District of the Southern Coastal Plain … [and] … Middle Atlantic Coastal Plain and the Atlantic Coast Flatwoods Land Resource Area. The Vidalia Uplands is a moderately dissected area with a well-developed dendritic stream pattern on gravelly, clayey sands." "… upland soils are acidic, deep, and well or moderately well drained…" The predominant landform [of the Middle Atlantic Coastal Plain] is a flat, weakly dissected alluvial plain ... Soils are deep, medium texture, and have adequate to excessive water supplies for use by vegetation. Soils throughout the affected environment range from strongly acidic to moderately acidic with a pH ranging from 4.5 to 6.0." "Surface water resources underlying the … airspace include portions of the Santee, Pocotaligo, Black, and Great Pee Dee Rivers … [and] the Ogeechee, Ohoopee and Little Ohoopee, and Brier Creek. The water table is high in many areas, resulting in poor natural drainage and abundance of wetlands. In addition, numerous pocosins and Carolina Bays exist under the [airspace]. Pocosins are evergreen shrub bogs found between coastal freshwater marshes and deepwater swamp forests. Pocosins, like bogs, have lots of sphagnum moss and nutrient-poor acidic soil and water. Carolina Bays are ovate shaped shallow depressions and represent a type of bog or bog-lake complex unique to the southeastern coastal plain."
Desert and Arid Regions	Holloman AFB, New Mexico	**Soil and Water Resource Affected Environment, Sections 4.5.1.1, 4.5.1.2** (DAF, 2011b) "Centennial, Oscura, and Red Rio Ranges are located in the Southern Desertic Basins, Plain, and Mountains Major Land Resource Area (MLRA) as defined by the USDA [U.S. Department of Agriculture]. Soils in this MLRA are generally moderately deep to very deep, well drained,

Table 3.6-1. Soil and Water Resources Affected Environment - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Representative Airspace Location	Soil and Water Resources Section References for NEPA Documents in Table 3.1-1
		and loamy or clay rich. Some soils are shallow or very shallow over a calcium carbonate hardpan or overlie a shallow bedrock layer." "Centennial Range is located on the northwestern edge of the Salt Basin, a hydrologic basin with its upper portion in southeast New Mexico … [which] covers approximately 2,400 square miles and includes the western portion of Otero Mesa and the southern slopes of the Sacramento foothills. The Sacramento River is the primary surface water feature in the area of the Centennial Range. Some surface waters derived from the river are captured and diverted to pipelines running through McGregor Range. Oscura and Red Rio Ranges are located on the northwestern flank of the Tularosa Basin, a closed hydrologic basin that comprises an area of approximately 6,500 square miles in south-central New Mexico."
Desert and Arid Regions	Holloman AFB, New Mexico	Chaff and flare use was not analyzed for soil and water resources in the Holloman AFB EIS (DAF, 2021).
Desert and Arid Regions	UTTR, Hill AFB, Utah	**Soil and Water Resource Affected Environment, Section 3.3.3** (DAF, 2000) "The land underlying the UTTR airspace boundaries is primarily covered by Playa and Playa-Saltair Complex soils. These soils are found primarily in the low-lying, flat portions of the ranges. The playas consist of barren undrained basins that are subject to repeated inundation by salt water and salinization by evaporation of the accumulated water. The surfaces of playas are often thinly covered by salt crystals and patterned by cracks when dry. The soil materials are strongly calcareous, stratified lacustrine sediments of silt, clay, and sand containing sufficient amounts of salt to prohibit the growth of vegetation." "No perennial streams originate on the Hill and Wendover Air Force Ranges, although there are perennial streams in the Deep Creek Mountains to the southwest. The only flows in the stream channels… are found just below perennial springs and generally infiltrate within a short distance." "Groundwater occurs in both the unconsolidated and consolidated rocks beneath Hill Air Force Range and Wendover Air Force Range. The major groundwater reservoir is the unconsolidated to partially consolidated basin fill. This material is more than 1,000 feet thick, possibly ranging up to 2,000 feet thick beneath some areas of Hill and Wendover Air Force Ranges."
Agricultural	PRTC, Ellsworth AFB, South Dakota	**Soil and Water Resource Affected Environment, Sections 3.5.3.3, 3.5.3.4** (DAF, 2014) "The soils … consist of five soil orders: Mollisols, Entisols, Inceptisols, Alfisols, and Vertisols." "…the major surface water features … include…: the Bighorn, Tongue, Powder, Little Powder, Little Missouri, Belle Fourche, Cheyenne, Moreau, Grand, and Cannonball rivers. The rivers and their associated tributaries … serve as an important source of water for both domestic and commercial public-supply, agricultural, and industrial uses. Much of the surface water has been largely appropriated for agricultural use, primarily irrigation, and for compliance with downstream water pacts. Reservoirs store some of the surface water for flood control, irrigation, power generation, and recreational purposes." "… PRTC … [airspace] lie within the Northern Great Plains aquifer system … [and] … there are 4 major aquifers within the Northern Great Plains aquifer system in the ROI [region of influence] (from shallowest to

Table 3.6-1. Soil and Water Resources Affected Environment - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Representative Airspace Location	Soil and Water Resources Section References for NEPA Documents in Table 3.1-1
		deepest): Lower Tertiary, Upper Cretaceous, Lower Cretaceous, and Paleozoic…”
Oceans	Hickam AFB, Hawaii	**Soil and Water Resource Affected Environment, Section 3.5.3.1** (DAF, 2007) Chaff and flare use in the airspace was not analyzed for soil resources as training takes place over water. “Waters of the Pacific Ocean north of the Equator generally swirl in a clockwise direction.” “In the middle of this giant swirl (at about 30° N Lat) is an area of still water called the North Pacific Gyre. Floating material (both natural planktonic materials and human) in the Pacific Ocean eventually gathers in the gyre. Non-degrading materials, like plastics, will persist on the surface in the gyre indefinitely. Periodically, stochastic processes cause masses of floating debris to escape the gyre and re-enter circulating currents. Sometimes mobilized debris is then deposited along the mainland coasts or the north shores of the Hawaiian Islands. The North Pacific Gyre lies to the north of Hawaii.”
Oceans	Tyndall AFB, Florida	Chaff and flare use was not analyzed for soil and water resources (DAF, 2020a).
Wetlands	N/A	Wetlands are discussed under Biological Resources, Section 3.5.
Grasslands	PRTC, Ellsworth AFB, South Dakota	**Soil and Water Resource Affected Environment, Sections 3.5.3.3; 3.5.3.4** (DAF, 2014) Soil and water resources are not specifically identified as occurring in Grasslands in the prior NEPA documents; please see the PRTC, Ellsworth AFB Agricultural row of this table for a summary description of soil and water resources, some of which could be in or near a Grasslands environment

Key: AFB = Air Force Base; EIS = Environmental Impact Statement; MLRA = Major Land Resource Area; N/A = not applicable; NEPA = National Environmental Policy Act; PRTC = Powder River Training Complex; UTTR = Utah Test and Training Range

3.6.2 Environmental Consequences of the Proposed Action

3.6.2.1 Continued Use of Legacy Defensive Countermeasure Items

The deployment of legacy chaff and flares in DAF training airspace, as described above, results in the determination of no significant impacts to soil and water resources in DAF training airspaces, as summarized from prior NEPA documentation (incorporated by reference and listed in Table 3.1-1), in Table 3.6-2. The table summarizes the environmental consequences from deploying legacy defensive countermeasures in the different environmental settings where the DAF conducts testing and training. The overall summary from the existing environmental documents is that the use of legacy chaff and flares have no significant impact on soil and water resources.

3.6.2.1.1 *Chaff*

Potential impacts to soil and water resources from the use of the legacy chaff items identified in Table 3.1-2 could result from the breakdown of chaff fibers and chaff residual materials in soils and waters and have been addressed in the prior NEPA documents identified in Table 3.6-2. The conclusion of effects to soil and water resources from the use of legacy chaff is that chaff fibers and residual materials from chaff deployment would not result in significant environmental impacts.

Table 3.6-2. Soil and Water Resources Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace

Environmental Setting	Representative Airspace Location	Soil and Water Resources Section References for NEPA Documents in Table 3.1-1
Woodlands	Joint Pacific Alaska Range Complex, Alaska	Chaff and flare use was not analyzed for soil and water resources (DAF and Army, 2013).
Woodlands	Tyndall AFB, Florida	**Soil and Water Resource Environmental Consequences, Sections 1.4.1.5, 1.4.1.7** (DAF, 2020a) "Under the airspace, the use of defensive countermeasures (i.e., chaff and flares) has been found to be nontoxic and would not adversely affect soil resources; therefore, soil resources are not carried forward for detailed analysis."
Woodlands	Moody AFB, Georgia	**Soil and Water Resource Environmental Consequences, Section 3.1.2** (DAF, 2020b) "The Proposed Action would not increase any expendables used during training operations in the Moody Airspace Complex, but chaff and flare use would be redistributed. Residual materials of chaff and flares could collect on the soil surface; however, the probability of such residual materials being deposited in any one location would be minuscule due to the dispersal of chaff and flares. Therefore, impacts on soils would be insignificant." "Depending on the altitude of release and wind speed and direction, the chaff from a single bundle can be spread over distances ranging from less than a 0.25 mile to over 100 miles. Chaff and flares do not contain materials that would degrade water quality or pose a human health risk."
Woodlands	Shaw AFB, South Carolina	**Soil and Water Resource Environmental Consequences, Section 3.5.3.1** (DAF, 2010) "Chaff disperses widely when deployed and ultimate disposition depends upon the altitude of release and the prevailing winds at different altitudes at the time of release. Based on the quantity of chaff bundles proposed for deployment … chaff would not accumulate to a point where it could create an impact." Flare residual materials would not be expected to discernibly or measurably affect water or soil resources. Given the large size of the [airspace] and the annual number of flares that are used in the airspace, no substantive impact would occur to soils or water resources.
Desert and Arid Regions	Holloman AFB, New Mexico	**Soil and Water Resource Environmental Consequences, Section 4.5.2.1** (DAF, 2011b) "Chaff and flares are authorized for use in the existing MOAs and … [the] Ranges.... Use of flares is approved at a minimum altitude [of] 2,000 feet AGL over WSMR airspace and 500 feet AGL over Red Rio and Oscura Ranges. Deployment of flares is not permitted in WSMR airspace during very high or extreme fire conditions." "No impact to soil or water resources would be anticipated from chaff, even in the case of a highly unlikely event such as an entire clump of undispersed chaff falling on the ground or into a small, confined water body." "Once ejected from an aircraft, the magnesium flare pellet is designed to be fully consumed before reaching the ground (there are also other components, which similar to those found in the chaff package). A

Table 3.6-2. Soil and Water Resources Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Representative Airspace Location	Soil and Water Resources Section References for NEPA Documents in Table 3.1-1
		flare failure that results in a dud on the ground is estimated to occur in 0.01 percent of flares used… There would be no significant impacts to physical [soil and water] resources due to the chemical composition of flare materials that reach the ground.”
Desert and Arid Regions	Holloman AFB, New Mexico	**Soil and Water Resource Environmental Consequences, Section 3.1.3** (DAF, 2021) “There is a possibility that chaff fibers or residual material from chaff and flares could collect on water surfaces; however, the probability of a substantial amount of residues being deposited in any one location, specifically within a small, confined waterbody, would be minuscule due to the large area within which flight operations would occur.” “Residual materials of chaff and flare could collect on the soil surface; however, the probability of such residual materials being deposited in any one location would be minuscule due to the dispersal of chaff and flares….” Therefore, impacts to soils would be insignificant.
Desert and Arid Regions	UTTR, Hill AFB, Utah	**Soil and Water Resource Environmental Consequences, Sections 3.3.3, 3.3.4** (DAF, 2000) “Chaff is approximately 60 percent glass fibers and 40 percent aluminum by weight. The comparison to desert dust is relevant because the composition of dust is dominated by silicon dioxide (SiO_2) and aluminum oxide (Al_2O_3), which are the most common minerals in the Earth’s crust.” “In arid areas, the slow chemical decomposition of chaff is expected to have no adverse effects on soil chemistry and plant growth. In wet, acidic environments, chemical decomposition is more rapid, but no adverse effects are expected for several reasons. The small quantity of chaff accumulating on the ground would release minute amounts of chemicals, primarily aluminum and silicon dioxide, that are abundant in the soil. The trace amounts of the other chemicals in the chaff fibers would be released in such small quantities that no effects would be anticipated.” “The 1997 ACC [Air Combat Command] Report presented the findings of a 13-day experiment in which salt water from the Chesapeake Bay was spiked with chaff. No appreciable increases in aluminum, cadmium, iron, or zinc levels were detected. Therefore, the expansion of the use of self-protection chaff within the UTTR would not have any significant, adverse affects [sic] on soil and water resources.” “The effects of dud flares and flare ash on the soil and water resources depend on the quantity of material deposited in a particular environment, the characteristics of the receiving environment (e.g., pH), and the sensitivity of the environment to the contaminants of concern. Dud flares are rare and incidental events, so it is extremely unlikely that any given location would experience long-term cumulative effects from a buildup of flare material. Flare ash is widely distributed by wind, and the likelihood that a sufficient quantity would accumulate in a particular water body to measurably affect its chemical makeup is also remote. Therefore, the use of self-protection flares within the UTTR, especially the lowering of the allowable release altitude, would not have any significant, adverse affects [sic] on soil and water resources.”

Table 3.6-2. Soil and Water Resources Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Representative Airspace Location	Soil and Water Resources Section References for NEPA Documents in Table 3.1-1
Agricultural Areas	Powder River Training Complex (PRTC), Ellsworth AFB, South Dakota	**Soil and Water Resource Environmental Consequences, Section 4.5.3.1** (DAF, 2014) "The primary constituents of chaff are silica and aluminum. The component of chaff that has the potential to affect soil or water chemistry is aluminum, which tends to break down in acidic and highly alkaline environments. Analysis to detect chaff concentration in aquatic and soil environments, where chaff has been deployed for decades, was unable to detect any but a few chaff particles. This is because chaff on the ground rapidly breaks down to silica and aluminum, the two most common elements of the earth's crust, and becomes indistinguishable from native soils…" "Given the small amount of diffuse or aggregate chaff material that could possibly reach water bodies and the moderate pH of regional water bodies, water chemistry would not be expected to be affected." "Chaff and flare plastic and wrapper residual materials are typically inert and not expected to impact soils or water bodies.… Overall, no significant impacts to soil and water resources in the ROI [region of influence] are expected…"
Oceans	Hickam AFB, Hawaii	**Soil and Water Resource Environmental Consequences, Section 4.5.1** (DAF, 2007) "… chaff would be expected to be widely dispersed per year for each square mile of open ocean area under training airspace. Upon initial contact with sea surfaces chaff would be expected to be briefly supported by surface tension. Wave action would quickly cause vitreous chaff fibers to enter the water column where their negative buoyancy would carry them to the seafloor. No studies characterize transit time of chaff fibers through the deep sea water column." "In most environments, chaff rapidly breaks up to become indistinguishable from native substrates. Chaff use would be difficult to detect in the environment and would not produce a significant effect upon ocean waters under the airspace." "Plastic, nylon, and Mylar pieces that fall when chaff is deployed are inert. These pieces are similar to the plastic pieces that come from current chaff use. The Mylar wrapping is similar to the aluminum-coated Mylar that falls when flares are deployed. These materials are inert and are not expected to be concentrated in any way under any specific airspace. Plastic debris of any type is a serious and increasingly high profile issue in marine environments. The persistence and accumulation of waste plastic materials from a variety of sources is well-studied in many ocean basins, including the North Pacific. This volume of plastics is a statistically insignificant amount of plastic, compared to other sources of plastic waste in the North Pacific. Quantifiable, predictable, and avoidable sources of plastic debris should be noted. Any inert plastics have the potential to enter the plankton food chain and interfere with normal food web function and therefore water chemistry. Flare debris consist of 1-inch by 1-inch plastic or nylon parts, aluminum-coated Mylar wrapping materials, and a medium hailstone-sized plastic safe and initiation device."
Oceans	Tyndall AFB, Florida	Chaff and flare use was not analyzed for soil and water resources in the ADAIR EA (DAF, 2020a).
Wetlands	Holloman AFB, New Mexico	Wetlands are discussed under Biological Resources, Section 3.5.

Table 3.6-2. Soil and Water Resources Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Representative Airspace Location	Soil and Water Resources Section References for NEPA Documents in Table 3.1-1
Grasslands	PRTC, Ellsworth AFB, South Dakota	**Soil and Water Resource Environmental Consequences, Section 4.3.3.1.3, Appendices C & D** (DAF, 2014) Soil and water resources are not specifically identified as occurring for Grasslands in the prior NEPA documents; please see the PRTC, Ellsworth AFB Agricultural row of this table for a summary analysis of soil and water resources, some of which could be in or near a Grasslands environment.

Key: AFB = Air Force Base; AGL = above ground level; EA = Environmental Assessment; MOA = Military Operations Area; NEPA = National Environmental Policy Act; PRTC = Powder River Training Complex; UTTR = Utah Test and Training Range; WSMR = White Sands Missile Range

3.6.2.1.2 *Flares*

Potential impacts to soil and water resources from the use of the legacy flare items identified in Table 3.1-2 could result from wildfires from flare deployment and the resulting residual materials on the surface, including duds, which have been addressed in the prior NEPA documents identified in Table 3.6-1. The types of flare deployed and the adopted management strategies for use of flares in the airspaces are primarily related to altitude restrictions for deployment and ensure complete consumption of the flare before contact with the ground surface. A typical legacy MJU-7A/B MTV flare is comprised of 5.28 ounces of magnesium, 3.08 ounces of Teflon, and 0.44 ounces of Viton (Koch et al., 2012). Teflon is a PFAS composition, and on June 15, 2022, the EPA issued a drinking water health advisory for different types of PFAS which ranged from not exceeding 0.004 parts per trillion (ppt) to not exceeding 2,000 ppt depending on the type of PFAS compound (USEPA, 2022). The exact type of PFAS in an MTV flare is not known. A representative 1.0 ppt of PFAS has been considered to generally not exceed historic EPA drinking water health advisories (Evans et al., 2020). A 1.0 ppt concentration of water soluble PFAS could result from one dud MJU-7A/B flare with 3.08 ounces of Teflon falling in a 5.5-square mile or smaller lake with an average depth of 20 feet, with the conservative assumptions that the Teflon in the flare pellet would be water soluble and completely dissolve. Given that the entire surface area of the U.S. lower 48 states is just 3 percent surface water (USDA, 2020), the opportunity for the deposition of a dud flare in a water body located beneath military training airspace would be much less than on land. Since not all surface water in the U.S. is used as a source for domestic drinking water, the likelihood of a dud flare landing in a drinking water source would be even lower.

As discussed in Section 7.7.3 of Appendix A, there are very few dud flares, and it would be nearly impossible for multiple dud flares to accumulate in one small area; it is calculated that a representative 2,000-square mile MOA would have one dud flare per 25 square miles. The conclusion of effects to soil and water resources is that legacy flares and residual materials from their deployment would not result in significant impacts to soil and water resources under the airspace.

3.6.2.2 Use of New Defensive Countermeasure Items

3.6.2.2.1 *Chaff*

Table 3.1-3 compares new chaff with previously assessed legacy chaff based on the technical description/analysis of the items included in Appendix A and concludes that the new chaff items (RR-198/AL and RR-199/AL) are comparable to previously analyzed chaff items (RR-196/AL and RR-196(T-1)/AL, respectively). The environmental consequences from proposed training and testing use of the new chaff items as described in Table 2.3-1 would be expected to result in no significant impacts to soil and water resources, similar to the comparable legacy chaff items summarized in Table 3.6-2.

3.6.2.2.2 *Flares*

Table 2.3-2 through Table 2.3-5 and Table 3.1-4 list the new flares that have not been previously evaluated in existing environmental documents. Table 3.1-4 compares the new flares with legacy flare components based on the technical description/analysis of the items included in Appendix A. The new MTV flares are comparable to legacy flares and would have no significant impacts to soil and water resources, similar to the comparable legacy flares summarized in Table 3.6-2. Standard spectral flares are primarily combat flares with a weighted nose and would be used for testing and very limited training over ranges approved for deploying live or inert munitions. This limited use of standard spectral flares would be expected to have no significant environmental effects to soil and water resources. Thrusted flares are combat flares; their use during testing and limited training over ranges suitable for munitions deployment would be expected to have no significant impacts to soil and water resources. The environmental consequences from use of the new flares as described in Table 3.1-4 would be expected to result in no significant impacts to soil and water resources.

3.6.2.2.3 *Spectral Decoys*

As described in Section 7.6 of the Supplemental Report Update (Appendix A), each decoy deploys from 1,500 to 3,000 iron foils, which measure either 0.75 by 1.75 by 0.00125 inches thick or 0.75 by 0.75 by 0.00125 inches thick. Similar to chaff fibers, these extremely light (0,0046- to 0.009-ounce or 0.13- to 0.25-gram) foils would be dispersed by atmospheric conditions over a wide region, depending upon the altitude of release and the prevailing winds at different altitudes at the time of release, thus reducing the potential for the iron foils to have a concentrated effect on a soil resource or water body. The potential widespread distribution of the foils into water bodies has not been the subject of any special studies; however, degradation of the very thin foils would be similar to the degradation of nails, reinforcing bar, or other ferrous materials found in water bodies but would be faster due to their extreme thinness. It is calculated that it would take four completely dissolved 0.25-gram foils per cubic meter of water to reach USEPA’s National Recommended Water Quality Criteria – Aquatic Life Criteria water quality cleanup standard of 1,000 µg/l. Thus, it would take the deposition and complete degradation of approximately 647 of the larger foils in a pond with a surface area of 0.02 acre to reach the USEPA’s water quality cleanup standard. With iron as the fourth most common element of the Earth’s crust, and it not being considered hazardous in aquatic environments, it is anticipated that there would be negligible effects on surface waters from the use of spectral decoys.

During an informal 3-month weathering test, oxidized foils from spectral decoys placed in an arid setting did not noticeably weather on the surface from exposure to heat in excess of 100 °F or cold below 40 °F. The foils were found to not substantially change in weight or shape and are expected to remain intact in an arid environment longer than in a moist environment, but for an unknown time period, up to a year or more. In a pecan nursery in Georgia, a farmer found deteriorating (rusting) residual spectral decoy iron foils distributed on the ground in his nursery and was able to trace the source of the foils to the DAF. The DAF response included collecting and analyzing soil samples to determine if the rusting foils had any impact on the soil chemistry. Soil samples from where the foils were found, as well as outside the nursery where no foils were found, showed no statistical difference in chemistry, specifically iron and iron oxides. The results indicated no discernible impact on the surface soils at the nursery property from the residual iron foils. Until further laboratory and in-situ studies are conducted that evaluate the long-term degradation of the foils in both acidic and alkaline soil environments, it is anticipated that seasonal weathering and vegetative litter will reduce these foils to particles indistinguishable from soils components. Deployment of spectral decoys would be expected to have no significant impacts to soil and water resources.

3.6.3 Environmental Consequences of No Action

Under the No Action Alternative, defensive countermeasure use during testing and training operations by the DAF would continue with legacy chaff and flare units included in the 1997 or 2011 Reports (DAF, 1997; DAF, 2011a), at levels identified in Table 2.3-1 through Table 2.3-4, in currently approved airspace. With continued adherence to the current management strategies for their use, there would be no significant impacts to soil and water resources, as described in Section 3.6.2.1.

3.7 LAND USE AND VISUAL RESOURCES

3.7.1 Affected Environment

The affected environment for land use and visual resources under the Proposed Action includes the area underlying the DAF training airspace where defensive countermeasure use is approved (Figure 1.2-3). Table 3.7-1 summarizes the land use and visual resources affected environment under the representative DAF training airspaces for this programmatic analysis, which is introduced in Table 1.6-1 and Table 3.1-1. The land use and visual resources affected environment is described by summarizing extracted quotes from the relevant NEPA documents that are incorporated by reference and listed in Table 3.1-1 for all the representative environmental settings.

Table 3.7-1. Land Use and Visual Resources Affected Environment – NEPA Document Section References Pertaining to the Representative Training Airspace

Environmental Setting	Airspace Location	Land Use and Visual Resource Section References for NEPA Documents in Table 3.1-1
Woodlands	Joint Pacific Alaska Range Complex, Alaska	**Land Use and Visual Resource Affected Environment, Section 3.1.10.1** (DAF and Army, 2013) “Land ownership … is a mixture of Federal, State, local borough, and private land (including Native regional and village corporation land)…” “Plans

Table 3.7-1. Land Use and Visual Resources Affected Environment – NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Airspace Location	Land Use and Visual Resource Section References for NEPA Documents in Table 3.1-1
		developed by the Federal government, the State, local boroughs, municipalities, and Native corporations describe the management intent and priorities for lands within their jurisdictions." "The State of Alaska and BLM manage the vast majority of lands…in the area.… Recreation, subsistence activities and mining are primary uses." "Federal and State lands with legislatively designated protection … includes 10 areas with special purposes and management based on particular resource values, including refuges, parks, preserves, sanctuaries, critical habitat areas, ranges, and special management areas."
Woodlands	Tyndall AFB, Florida	**Land Use and Visual Resource Affected Environment, Section 1.4.1.6** (DAF, 2020a) "…. The Proposed Action would not affect the aesthetic qualities of the lands and Gulf of Mexico beneath the MOAs and Warning Areas; therefore, this resource is not carried forward for further detailed analysis in this EA [Environmental Assessment]."
Woodlands	Moody AFB, Georgia	**Land Use and Visual Resource Affected Environment, Sections 3.8.4.1, 3.8.4.2** (DAF, 2020b) "The majority (97 percent) of the land underlying the Moody Airspace Complex is owned and managed by private individuals. Most of the land … is undeveloped and is classified as forested or agricultural with some woody wetlands. A total of seven urban clusters (i.e., areas with populations between 2,500 and 50,000) …[and] 13 recreational areas … underlie the Moody Airspace Complex. Recreational areas include state parks, areas, natural areas, national forests, NWRs [National Wildlife Refuges], and WMAs [Wildlife Management Areas]…"
Woodlands	Airspace Training Initiative, Shaw AFB, South Carolina	**Land Use and Visual Resource Affected Environment, Section 3.8.3** (DAF, 2010) "Agriculture, forestry, and rural communities are the primary land uses [with over] 96 percent … privately owned land. Numerous, sparsely populated communities are scattered throughout … the affected [airspace]" "Special use areas provide recreational opportunities and/or provide solitude or wilderness experiences. These areas may include public land area such as national forests or state and local parks."
Desert and Arid Regions	Holloman AFB, New Mexico	**Land Use and Visual Resource Affected Environment, Section 4.8.1.1** (DAF, 2011b) "The majority of federal land under the airspace is administered by BLM, followed by DoD, and then by the United States Forest Service (USFS). Training ranges include DoD lands requiring special management for conservation. The SULMAs [Special Use Land Management Areas] include wilderness and Wilderness Study Areas (WSAs), national forests, national wildlife refuges, experimental ranges, national monuments, reservoirs, Native American reservation lands, and state parks."
Desert and Arid Regions	Holloman AFB, New Mexico	**Land Use and Visual Resource Affected Environment, Sections 3.6.2, 3.7.2** (DAF, 2021) "The area beneath SUA [Special Use Area] in southern New Mexico is predominantly rural with areas of higher population density in Artesia, Carlsbad, Socorro, and Silver City. Extractive industries including oil production, forestry, and grazing operations are common in the region." "Common types of recreation that occur on the land beneath all the proposed airspace areas include hiking; viewing natural features, wildlife, and historic sites; camping; fishing; hunting; driving for pleasure; bicycling; horseback riding; water activities; and skiing. Recreational activities can occur on both

Table 3.7-1. Land Use and Visual Resources Affected Environment – NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Airspace Location	Land Use and Visual Resource Section References for NEPA Documents in Table 3.1-1
		public and private lands. The majority of lands under the proposed airspace are public. Land management is undertaken by multiple Federal and state agencies, including the USFS, BLM [Bureau of Land Management], NPS [National Park Service], USFWS [U.S. Fish and Wildlife Service], USDA [U.S. Department of Agriculture], BOR [Bureau of Reclamation], and New Mexico State Parks."
Desert and Arid Regions	UTTR, Hill AFB, Utah	**Land Use and Visual Resource Affected Environment, Section 3.3.5** (DAF, 2000) "The land base of Hill and Wendover Air Force Ranges is approximately 928,000 acres… and are managed primarily by BLM….for multiple use, … and include livestock grazing, support of wildlife, dispersed and developed recreation, and mining. Some industrial uses on lands adjacent to the ranges include mineral extraction and processing, mining, landfills/waste incineration, and brine shrimp collection. The only significant commercial development … is … Casinos, hotels and motels, service stations, stores, recreational vehicle camps, and related tourist facilities are found "at Wendover UT/NV." "The visual resources of the lands within the UTTR airspace boundaries are … one of isolation, remoteness, expansive open space, and dramatic basin and range landforms."
Agricultural Areas	PRTC, Ellsworth AFB, South Dakota	**Land Use and Visual Resource Affected Environment, Sections 3.8.2.1, 3.8.2.2** (DAF, 2014) "[PRTC] land[(s)] consists of about 34,000 square miles…26,540 square miles rangeland … 4279 square miles agricultural." "Ranching and farming are well-established activities that define the regional character and economy since settlement by Americans of European descent … and … have become important activities of Native Americans…"
Oceans	Hickam AFB, Hawaii	Chaff and flare use was not analyzed for land use and visual resources (DAF, 2007).
Oceans	Tyndall AFB, Florida	Chaff and flare use was not analyzed for land use and visual resources (DAF, 2020a).
Wetlands	UTTR, Hill AFB, Utah	**Land Use and Visual Resource Affected Environment, Section 3.3.4** (DAF, 2000) "Three wetland types have been identified on Hill and Wendover Ranges: a pickleweed-saltgrass-glasswort community, a saltgrass (or rabbitfoot beardgrass) community, and a bulrush-phragmites community." "At Hill Air Force Range, … 22,576 acres categorized as jurisdictional wetland… At Wendover Air Force Range, … 22,425 acres categorized as jurisdictional wetland"
Wetlands	Moody AFB, Georgia	**Land Use and Visual Resource Affected Environment, Section 3.8.4.1** (DAF, 2020b) "Most of the land underlying the [airspace] is undeveloped and is classified as forested or agricultural with [558,476 acres of woody wetlands and 20,552 acres of emergent herbaceous wetlands] from a total of 2.35 million acres."
Grasslands	PRTC, Ellsworth AFB, South Dakota	**Land Use and Visual Resource Affected Environment, Section 3.8.2.3** (DAF, 2014) "Some federal land … is managed and protected for particular resource values or attributes such as wilderness or wildlife preserves. The area also has units of the National Park system, State Parks, and National Monuments [and] … includes portions of the Custer and Black Hills National Forests, Thunder Basin National Grassland, Cedar River and Grand River National Grasslands."

Table 3.7-1. Land Use and Visual Resources Affected Environment – NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Airspace Location	Land Use and Visual Resource Section References for NEPA Documents in Table 3.1-1

Key: AFB = Air Force Base; BLM = Bureau of Land Management; DoD = Department of Defense; MOA = Military Operations Area; NEPA = National Environmental Policy Act; PRTC = Powder River Training Complex; USFS = United States Forest Service; UTTR = Utah Test and Training Range

3.7.2 Environmental Consequences of the Proposed Action

3.7.2.1 Continued Use of Legacy Defensive Countermeasure Items

The deployment of legacy chaff and flares in DAF training airspace, as described above, results in the determination of no significant impacts to land use and visual resources in DAF training airspaces, as summarized from prior NEPA documentation (incorporated by reference and listed in Table 3.1-1), in Table 3.7-2. The table summarizes the environmental consequences from deploying legacy defensive countermeasures in the different environmental settings where the DAF conducts testing and training. The overall summary from the existing environmental documents is that the use of legacy chaff and flares could have minimal impact on land use and visual resources.

Table 3.7-2. Land Use and Visual Resources Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace

Environmental Setting	Representative Airspace Location	Land Use and Visual Resources Section References for NEPA Documents in Table 3.1-1
Woodlands	Joint Pacific Alaska Range Complex, Alaska	**Land Use and Visual Resource Environmental Consequences, Section 3.1.10.3.1** (DAF and Army, 2013) "Minimal impact on land use from chaff and flare use is expected. Fox 3 MOA and Paxon ATCAA [Air Traffic Control Assigned Airspace] have historically supported chaff and flare use with little or no impact on land use, recreation, or natural settings. Under this proposal…chaff and flares … would have minimal effect on land use ... The potential for fires from flares can affect vegetation and wildlife, and fires can indirectly change visual qualities of an area for many years. The risk of flare-caused fire, compared to other sources, is extremely low. Dispersed over an extremely large area, the likelihood of noticing residual materials deposited on the ground, such as small plastic, felt end caps, or wrapping material, is very low. Residual materials, if found and identified in a pristine setting, could annoy some persons, but would not change the overall visual qualities of an area."
Woodlands	Tyndall AFB, Florida	Chaff and flare use was not analyzed for land use and visual resources (DAF, 2020a).
Woodlands	PRTC, Ellsworth AFB, South Dakota	**Land Use and Visual Resource Environmental Consequences, Section 4.8.3.1** (DAF, 2014) "… chaff and flares deposit residual materials in the ground. Such residual materials consist of wrappers and plastic or felt caps which are small and widely dispersed. At the rate of use described in Section 2.5, an estimated chaff or flare residual plastic, paper, or wrapper piece would be deposited an average of one piece per 149 acres per year. An estimated average of 0.0049 ounces per acre of chaff would be deposited annually. The visibility or effect of this plastic, felt, or wrapping material would be negligible given the patterns of human activity in the underlying areas. Residual

Table 3.7-2. Land Use and Visual Resources Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Representative Airspace Location	Land Use and Visual Resources Section References for NEPA Documents in Table 3.1-1
		materials, if found and identified, could be seen as an annoyance by a rancher, recreationist, or other persons finding the materials. Overall, chaff and flare use, given altitude restrictions proposed and the distribution of use, would not be expected to impact land use.”
Woodlands	Moody AFB, Georgia	**Land Use and Visual Resource Environmental Consequences, Section 3.1.2** (DAF, 2020b) “The use of flares would be dispersed across large areas and would be at altitudes that would not be visible during the daytime and visible at night only with very clear night skies. Flare releases would be at very low altitudes (between 2,000 and 4,000 feet AGL) and would not be visible unless the individual observing the flare was proximate to the training event at the time of the release of defensive countermeasures. Therefore, the use of flares in the Moody Airspace Complex under the Proposed Action would not create an annoyance or detract from the visual characteristics of the environment.”
Woodlands	Shaw AFB, South Carolina	**Land Use and Visual Resource Environmental Consequences, Section 3.5.3.1** (DAF, 2010) “If chaff and flare expended plastic, felt, and wrapping materials were distributed evenly throughout the airspace, it would result in approximately one piece of residual material per 5 acres under [the airspace]. Residual materials do not appear to accumulate in quantities that would result in a significant visual effect, although spent flare materials could be intrusive and unwanted to private landowners in the area. Flare residual materials could be undesirable in areas specifically protected to preserve naturalness and pristine qualities. These areas include Wilderness Areas, Wild and Scenic Rivers, wildlife and habitat project areas, and areas designated to have outstanding visual quality, where any human-made object would be incongruous and unexpected, and where people walking, camping, and hiking would be within viewing distance of flare materials on the ground.”
Desert and Arid Regions	Holloman AFB, New Mexico	Chaff and flare use was not analyzed for land use and visual resources in the Holloman AFB EA (DAF, 2011b).
Desert and Arid Regions	Holloman AFB, New Mexico	**Land Use and Visual Resource Environmental Consequences, Section 3.1.3** (DAF, 2021) Chaff and flare use was not analyzed for land use resources. “Flares … would be a temporary source of light emissions (flares burn for approximately 3 to 5 seconds).” “Aircraft operations and the use of flares in the training airspace would be dispersed through the horizontal limits of the airspace. As such, no one location would receive a consistent distribution of flares and flare usage would not create a consistent source of light.”
Desert and Arid Regions	UTTR, Hill AFB, Utah	**Land Use and Visual Resource Environmental Consequences, Section 3.3.5** (DAF, 2000) “Chaff fibers and debris may be noticed occasionally by outdoor recreationists but would not attract attention due to their small size or to their similarity to other familiar natural or manmade objects. However, in areas specifically protected to preserve naturalness and pristine qualities, such as WSAs [Wilderness Study Areas] or National Wildlife Refuges, users (both the public and land managers) are more likely to perceive chaff debris as undesirable and unattractive since it conflicts with the expectations of primeval character and management objectives to preserve naturalness.”

Table 3.7-2. Land Use and Visual Resources Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Representative Airspace Location	Land Use and Visual Resources Section References for NEPA Documents in Table 3.1-1
		"Flare debris, such as end caps, are not easily detected and would not affect the overall scenic quality or outdoor experiences." "Flare debris would not accumulate in quantities that would result in significant visual impacts. However, it could be more noticeable and undesirable in areas specifically protected to preserve naturalness and pristine qualities…." "The visual illumination of flares would be short term and temporary and would not be expected to significantly affect sensitive visual resources, unless large numbers of flares were dispensed over scenic areas on a frequent basis. Impacts to scenic resources are not generally a concern at night. However, flares dispensed at night could be perceived as an intrusion and disturbing to people in recreation areas."
Agricultural Areas	PRTC, Ellsworth AFB, South Dakota	**Land Use and Visual Resource Environmental Consequences, Section 4.3.3.1.3** (DAF, 2014) "If a rancher or recreationist were to find a piece of residual flare material on the ground, and identified it as a piece of plastic or material from a deployed flare, the individual could be annoyed."
Oceans	Hickam AFB, Hawaii	Chaff and flare use was not analyzed for land use and visual resources (DAF, 2007).
Oceans	Tyndall AFB, Florida	Chaff and flare use was not analyzed for land use and visual resources (DAF, 2020a).
Wetlands	UTTR, Hill AFB, Utah	**Land Use and Visual Resource Environmental Consequences, Section 3.3.5** (DAF, 2000) Land Use and Visual resources are not specifically identified as occurring for Wetlands in the prior NEPA documents; please see the UTTR Hill AFB Desert and Arid Regions row of this table for a summary analysis of Land Use and Visual resources, some of which could be in or near a Wetlands environment.
Wetlands	Moody AFB, Georgia	**Land Use and Visual Resource Environmental Consequences, Section 3.1.2** (DAF, 2020b) Land Use and Visual resources are not specifically identified as occurring for Wetlands in the prior NEPA documents; please see the Moody AFB Woodlands row of this table for a summary analysis of Land Use and Visual resources, some of which could be in or near a Wetlands environment.
Grasslands	PRTC, Ellsworth AFB, South Dakota	**Land Use and Visual Resource Environmental Consequences, Section 4.8.3.1** (DAF, 2014) "One public concern for range land use is any potential for flare-caused fires. Fire can damage crops, rangelands, timber, and/or ranch or other infrastructure. National grasslands, forests, and agricultural areas under the airspace are vulnerable to fire." "Altitude restrictions on flare release above 2,000 feet AGL are designed to have flares burn out a minimum of 1,500 feet above the ground surface. Flare use would be discontinued in a MOA where an extreme fire danger existed. The possibility of a flare-caused fire is remote."

Key: AFB = Air Force Base; AGL = above ground level; EA = Environmental Assessment; MOA = Military Operations Area; NEPA = National Environmental Policy Act; PRTC = Powder River Training Complex; UTTR = Utah Test and Training Range

3.7.2.1.1 *Chaff*

Potential impacts to land use and visual resources from the use of the legacy chaff items identified in Table 3.1-2 could result from the presence of chaff fibers and chaff residual materials and have been addressed in the prior NEPA documents summarized in

Table 3.7-2. The conclusion of effects to land use and visual resources from the use of legacy chaff is that chaff fibers and residual materials from chaff deployment would not result in significant environmental impacts.

3.7.2.1.2 *Flares*

Potential impacts to land use and water resources from the use of the legacy flare items identified in Table 3.1-2 could result from wildfires from flare deployment and flare residual materials being visible in recreational or pristine environments. Table 3.7-2 summarizes the potential impacts to land use and visual resources from the use of legacy flares for the different environments under DAF training airspace. The types of flare deployed and the adopted management strategies for use of flares in the airspaces are primarily related to altitude restrictions for deployment and ensure complete consumption of the flare before contact with the ground surface. The conclusion of effects to land use and visual resources is that legacy flares and residual materials from their deployment would not result in significant impacts to land use and visual resources under the DAF airspace.

3.7.2.2 Use of New Defensive Countermeasure Items

3.7.2.2.1 *Chaff*

Table 3.1-3 compares new chaff with previously assessed legacy chaff based on the technical description/analysis of the items included in Appendix A and concludes that the new chaff items (RR-198/AL and RR-199/AL) are comparable to previously analyzed chaff items (RR-196/AL and RR-196(T-1)/AL, respectively). The environmental consequences from proposed training and testing use of the new chaff items as described in Table 2.3-1 would be expected to result in no significant impacts to land use and visual resources, similar to the comparable legacy chaff items summarized in Table 3.7-2.

3.7.2.2.2 *Flares*

Table 2.3-2 through Table 2.3-5 and Table 3.1-4 list the new flares which have not been previously evaluated in existing environmental documents. Table 3.1-4 compares the new flares with legacy flare components based on the technical description/analysis of the items included in Appendix A. The new MTV flares are comparable to legacy flares and would have no significant impacts to land use and visual resources, similar to the comparable legacy flares summarized in Table 3.7-2. Standard spectral flares are primarily combat flares with a weighted nose and would be used for testing and very limited training over ranges approved for deploying live or inert munitions. This limited use of standard spectral flares would be expected to have no significant environmental effects to land use and visual resources. Thrusted flares are combat flares; their use during testing and limited training over ranges suitable for munitions deployment would be expected to have no significant impacts to land use and visual resources. The environmental consequences from use of the new flares as described in Table 3.1-4 would be expected to result in no significant impacts to land use and visual resources.

3.7.2.2.3 *Spectral Decoys*

Use of spectral decoys in test and training operations started about 2010 and had increased to an annual use of approximately 35,510 decoys by 2020 (see Table 2.3-5 and Table 2.3-6). Projected annual use is anticipated to be 35,650 decoys over the next 10 years. As described in Section 7.6 of the Supplemental Report Update (Appendix A), each decoy releases from 1,500 to 3,000 iron foils, which measure either 0.75 by 1.75 by 0.00125 inches or 0.75 by 0.75 by 0.00125 inches thick and weigh 0.0046 to 0.009 ounces (0.13 to 0.25 grams). The potential for environmental effects of the residual foils is related to the potential quantity deposited during each deployment and the potential to accumulate due to their relative durability. Similar to the dispersal of chaff fibers, although chaff are deployed in far greater numbers (see Table 2.3-6), the extremely light foils would be dispersed by atmospheric conditions over a wide region, depending on the release altitude, thus reducing the potential for the foils or residual decoy materials to accumulate on any sensitive land use or visual resource (see Section 3.1.1.2.3 and Table 7-11 of Appendix A). The potential to accumulate also depends, in part, on the unlikely event that a spectral decoy would be deployed over the same location more than once before any previously deposited foils are disintegrated or obscured by natural processes (see Appendix A, Section 7.6.4.8). Due to their size and relative durability, the foils or residual materials could accumulate on the ground surface and may be noticed occasionally by outdoor recreationists and be a visual annoyance to any visitor in areas specifically protected to preserve naturalness and pristine qualities (i.e., Wilderness Study Areas or National Wildlife Refuges). Both the public and land managers are more likely to perceive the foils as undesirable and unattractive since it conflicts with the expectations of primeval character and management objectives to preserve naturalness. However, they would not be expected to accumulate in quantities great enough to change any land uses or adversely affect visual resources. Deployment of spectral decoys would be expected to result in no significant impacts to land use and visual resources.

3.7.3 Environmental Consequences of No Action

Under the No Action Alternative, defensive countermeasure use during testing and training operations by the DAF would continue with legacy chaff and flare units included in the 1997 or 2011 Reports (DAF, 1997; DAF, 2011a), at levels identified in Table 2.3-1 through Table 2.3-4, in currently approved airspace. With continued adherence to the current management strategies for their use, there would be no significant impacts to land use and visual resources, as described in Section 3.7.2.1.

3.8 SOCIOECONOMICS

3.8.1 Affected Environment

The affected environment for socioeconomic resources under the Proposed Action includes the area underlying the DAF training airspace where defensive countermeasure use is approved (Figure 1.2-3). Table 3.8-1 summarizes the socioeconomic affected environment under the representative DAF training airspaces for this programmatic analysis, which is introduced in Table 1.6-1 and Table 3.1-1. The socioeconomic affected environment is described by summarizing extracted quotes from the relevant NEPA documents that are incorporated by reference and listed in Table 3.1-1 for all the representative environmental settings. The affected environment section references and quotes in the table are often obtained from other resources, such as land use, because the potential socioeconomic effects of defensive countermeasure use have not always been independently assessed. Each affected environment is specific to the potentially affected socioeconomic resource under the DAF training airspace.

Table 3.8-1. Socioeconomic Affected Environment - NEPA Document Section References Pertaining to the Representative Training Airspace

Environmental Setting	Airspace Location	Socioeconomic Section References for NEPA Documents in Table 3.1-1
Woodlands	Joint Pacific Alaska Range Complex, Alaska	**Affected Environment, Sections 3.1.12, 3.1.12.1** (DAF and Army, 2013) "Population concentrated in a few communities in the southwest portion of the airspace with remote smaller communities under the airspace. The primary potential consequences are associated with subsistence and other hunting."
Woodlands	Tyndall AFB, Florida	Socioeconomics was not analyzed in this Environmental Assessment (DAF, 2020a).
Woodlands	PRTC, Ellsworth AFB, South Dakota	**Affected Environment, Section 3.6.3.1** (DAF, 2014) "The region under the airspace…has occasional valleys and foothills that support woodlands…. [which] … are vulnerable to fire…. Woodlands and shrubland communities recover over long time periods depending on severity of the fire and climatic conditions [especially precipitation and temperature regimes] available following fire."
Woodlands	Moody AFB, Georgia	**Affected Environment, Section 3.9.1** (DAF, 2020b) "[There is] a mosaic of agriculture, pasture, and some mixed pine and hardwood forests … under the airspace…. These include row crops such as cotton, corn, soybeans, and peanuts as well as pine plantations for forest products."
Woodlands	Shaw AFB, South Carolina	**Affected Environment, Sections 3.6.2.1, 3.9.3.1** (DAF, 2010) "[Under the airspace, 60] percent is forest land and the [remainder] is cropland and pasture.... Airfields … support agricultural aviation [and] apply to any low-level airspace."
Desert and Arid Regions	Holloman AFB, New Mexico	**Affected Environment, Section 3.8.1.1 (Land Use), 4.8.1.1** (DAF, 2011b) "Semidesert Grasslands … cover approximately 50 percent of the lands under the … airspace…. BLM-owned, state-owned, and private lands … are used primarily for grazing…. The BLM and Air Force deconflict schedules to accommodate one another's activities."
Desert and Arid Regions	Holloman AFB, New Mexico	**Affected Environment** (DAF, 2021) "Agriculture, including beef and dairy cattle ranching, is an important economic activity in this area. Other important industries are oil [and]

Table 3.8-1. Socioeconomic Affected Environment - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Airspace Location	Socioeconomic Section References for NEPA Documents in Table 3.1-1
		gas…. Visitor spending … below the … airspace [is related to the] … National Forests.”
Desert and Arid Regions	UTTR, Hill AFB, Utah	**Affected Environment, Sections 3.3.3, 3.3.5** (DAF, 2000) “Soils are poorly suited to livestock grazing, rangeland seeding, recreational uses, or homesite development due to low forage quality, alkalinity, and frequent flooding.…. Several ranches and agricultural and mining operations may be found in small communities near the airspace.”
Agricultural Areas	PRTC, Ellsworth AFB, South Dakota	**Affected Environment, Section 3.9** (DAF, 2014) “Agriculture, represented by farm, forestry, and related activities, is an important component of the economy in the region…. Cultivated agricultural areas (encompassing hay/pastureland, irrigated, and other cultivated cropland) have major crops including wheat, sunflowers, alfalfa, hay, barley, and soybean fields…. Beef cattle, with some milk cows…and sheep and lambs represent the greatest proportion of livestock [under the airspace].... “[There are] large reserves of…oil, natural gas, and coal … [and] wind energy is … common.”
Ocean	Hickam AFB, Hawaii	**Affected Environment, Section 3.5.3.1** (DAF, 2007) “The Insular Pacific-Hawaiian Large Marine Ecosystem [under the Warning Areas] is characterized by limited ocean nutrients, leading to high biodiversity but low sustainable yields for fisheries.”
Ocean	Tyndall AFB, Florida	**Affected Environment, Section 3.6.1.1** (DAF, 2020a) “The zooplankton and phytoplankton…in the marine environment … are critical to supporting fisheries health and abundance…. Hard and intermediate bottom structure…in the Warning Areas…support … 22 commercial/recreational fishes.”
Wetlands	Holloman AFB, New Mexico	**Affected Environment, Section 4.6.1.2.1** (DAF, 2011b) “BLM-owned, state-owned, and private lands…are used primarily for grazing…. Despite their limited geographic area in this arid region, wetlands and riparian areas are of extremely high importance for food, water, cover, breeding, brood rearing, and shade for most animal species, particularly migratory birds.” [Recreation includes hunting.]
Wetlands	UTTR, Hill AFB, Utah	**Affected Environment, Sections 3.3.4, 3.3.5** (DAF, 2000) “There are no well-developed aquatic ecosystems along the eastern shore of the lake…. [Accessible] areas are used … during hunting season…. Marshes, sloughs, and wetlands near the Great Salt Lake and the boundaries of Hill Air Force Range offer opportunities to waterfowl hunters…. Cattle and sheep are grazed over much of the public land in the vicinity.”
Grasslands	PRTC, Ellsworth AFB, South Dakota	**Affected Environment, Section 3.6.3.1** (DAF, 2014) “The majority of the grasslands (under the airspace) The majority of agricultural use … is for livestock grazing. [and] agriculture.” “Recreational activities such as four-wheeling, horseback riding, fishing, hunting, hiking, and climbing typically occur in remote landscapes, including national grasslands.”

Key: AFB = Air Force Base; BLM = Bureau of Land Management; NEPA = National Environmental Policy Act; PRTC = Powder River Training Complex; UTTR = Utah Test and Training Range

3.8.2 Environmental Consequences of the Proposed Action

3.8.2.1 Continued Use of Legacy Defensive Countermeasure Items

Table 3.8-2 summarizes the environmental consequences from deploying legacy defensive countermeasures in the different environmental settings where the DAF conducts testing and training. The environmental consequences column quotes or draws from prior NEPA documents incorporated by reference (Table 3.1-1) with analysis of deployment of legacy chaff and flares in the representative environmental settings. The overall summary from the existing environmental documents is that legacy chaff and flare use would not result in significant impacts to socioeconomic resources.

Table 3.8-2. Socioeconomic Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace

Environmental Setting	Airspace Location	Socioeconomic Section References for NEPA Documents in Table 3.1-1
Woodlands	Joint Pacific Alaska Range Complex, Alaska	**Environmental Consequences, Section 3.1.12.3** (DAF and Army, 2013) "Chaff and flare residual materials are not expected to have adverse impacts on wildlife, either birds, fish, or vegetation. Chaff and flare residual materials are not expected to adversely affect the population of subsistence wildlife or vegetation."
Woodlands	Tyndall AFB, Florida	Socioeconomics was not analyzed in the Tyndall AFB Environmental Assessment (DAF, 2020a).
Woodlands	PRTC, Ellsworth AFB, South Dakota	**Environmental Consequences, Sections 3.1.3.5.2, 4.8.3.1, 4.9.3, 4.6.3.1, 2.8.5.2** (DAF, 2014) "Chaff and flare plastic and wrapper residual materials are typically inert and not expected to impact soils or water bodies … [and would not affect] … recreational hunting … [which supports] … ranchers [and] local service industries…. The risk of fire as a result of flare use is minimal due to the low failure rate of flares and procedures that require flare use above 2,000 feet AGL. Flares would not be authorized [in an area of] extreme fire conditions…. Chaff and flare use, given altitude restrictions proposed and the distribution of use, would not be expected to impact land use [which includes ranching and agriculture]."
Woodlands	Moody AFB, Georgia	**Environmental Consequences, Sections 2.0, 3.1.2, 3.4.4.2, 4.8.2.1, Table 2.7.1** (DAF, 2020b) "There are no … activities … associated with this … airspace … that would interact with farmlands or soils…. Flare deployment would be restricted to an altitude of 2,000 feet above ground level (AGL) in all … airspace…. There have been no reported flare-caused fires under the airspace as a result of training operations…. Chaff and flares [would] not be toxic to humans and wildlife…. The use of defensive countermeasures … in the airspace would not be incompatible with any existing land uses, including agricultural... livestock and poultry."
Woodlands	Shaw AFB, South Carolina	**Environmental Consequences, Section 4.2.2, ROD** (DAF, 2010) "Extensive previous research has shown little to no negative effects of chaff or flares residual material on soil or water quality [used for agriculture]…. Flare release would continue to be authorized only above 5,000 feet MSL… Flares have a low dud rate and are designed to bum out within … creating a very low probability of a flare-caused

Table 3.8-2. Socioeconomic Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Airspace Location	Socioeconomic Section References for NEPA Documents in Table 3.1-1
		fire…. While any fire can affect agricultural resources…the increased risk of fire … is very low.”
Desert and Arid Regions	Holloman AFB, New Mexico	**Environmental Consequences, Table 2-12** (DAF, 2011b) “[To reduce any risks to ranching or agriculture], flare use would continue to be subject to existing fire safety restrictions based on the National Fire Danger Rating employed by Holloman AFB….Neither chaff nor flares would be released below 2,000 feet AGL. Residual material from chaff [and flares] has been found on private property… [but residual material] would not produce a significant effect on water or soils under the airspace…. Materials are inert and are not expected to be concentrated in any way that could impact soil or water resources.”
Desert and Arid Regions	Holloman AFB, New Mexico	**Environmental Consequences, Sections 4.10.1, 4.10.1.3** (DAF, 2021) RR-188 training chaff … has dipole fibers removed thereby eliminating interference with FAA radar tracking systems and has been approved for use by the FAA…. Any fires … may adversely affect vegetation, injure wildlife or livestock, and destroy property such as fences or buildings…. Flares would not be used [below 2,000 feet AGL or] at altitudes less than 18,000 feet MSL under “High” fire conditions, and flares would not be used at all under “Very High” or “Extreme” fire conditions…. No significant fire-related impacts would be expected.”
Desert and Arid Regions	UTTR, Hill AFB, Utah	**Environmental Consequences, Sections 3.3.1, 3.3.5, 4.2** (DAF, 2000) “Chaff use is not expected to affect agricultural, industrial, or commercial land uses (or economics)…. The vast majority of flares deployed within the UTTR are done so over DoD-controlled lands.… Fires can cause significant economic damage and pose a safety hazard in agricultural and residential areas…. Under conditions when a fire would be expected to spread rapidly and/or burn with high intensity, any risk of ignition may be deemed unacceptable, leading to a “no flare release” constraint…. No significant adverse effects would be expected as a result of … the minimum altitude allowable for flare deployment of [2,000 feet AGL over non-DoD land]…. There would be no significant long-term impact on socioeconomic resources.”
Agricultural Areas	PRTC, Ellsworth AFB, South Dakota	**Environmental Consequences, Sections 4.9., 2.8.5.2** (DAF, 2014) “Chaff is highly unlikely to accumulate … in sufficient quantities to affect property values or land uses, including agriculture, ranching, or energy development]…. Any fires of a natural or non-natural source may adversely affect vegetation, injure wildlife or livestock, and destroy property such as fences or buildings…. The risk of fire as a result of flare use is minimal due to the low failure rate of flares and procedures that require flare use above 2,000 feet AGL. During extreme fire conditions, flares would not be authorized in an airspace…. The AFB has the personnel and facilities to handle dud flares should they be encountered…. Some individuals could express annoyance if a chaff or flare end cap or other residual material were found on their property or at a recreation location, but this is not expected to affect land values or regional economics.’
Ocean	Hickam AFB, Hawaii	**Environmental Consequences FONSI, Section 4.5.2** (DAF, 2007) “The … use of defensive countermeasures would have no impact on Essential Fish Habitat…. Potential impacts on avian species…or marine mammals … from the use of chaff and flares would be limited

Table 3.8-2. Socioeconomic Environmental Consequences - NEPA Document Section References Pertaining to the Representative Training Airspace (continued)

Environmental Setting	Airspace Location	Socioeconomic Section References for NEPA Documents in Table 3.1-1
		to a startle effect from chaff and flare deployment, inhalation of chaff fibers or flare combustion products, and, in some species, the potential to digest residual plastic caps if mistaken for prey….the use of defensive countermeasures … in the Warning Areas may affect but is not likely to adversely affect the giant manta ray and oceanic whitetip shark.”
Ocean	Tyndall AFB, Florida	**Environmental Consequences, Sections 4.5.2, 4.5.2.3** (DAF, 2020a) “The use of… RR-188 chaff and M206 flares or similar … would have a potential minor, adverse impact on fish species that are large enough to ingest plastic pieces that fall to the Gulf floor … the likelihood of any large fish species encountering plastic caps from chaff and flares is extremely low.… The Air Force made a may affect but not likely to adversely affect determination for … federally listed species…. Defensive countermeasures would have no impact on Essential Fish Habitat.”
Wetlands	Holloman AFB, New Mexico	**Environmental Consequences, Sections 3.6.2.1.2, 4.6.1.2, 4.6.2.1.1** (DAF, 2011b) “No adverse impacts on wetlands and water bodies have been observed from the use of chaff and flares…. Flare use during periods of very high or extreme fire danger are restricted to minimize the potential for a burning flare to reach the ground … impacts on vegetation and wildlife [or domestic animals] would be less than significant.”
Wetlands	UTTR, Hill AFB, Utah	**Environmental Consequences, Section 3.3.4** (DAF, 2000) “The dispersal and decomposition of chaff fibers on land would limit the exposure of grazing animals to chaff…. In arid areas, the slow chemical decomposition of chaff is expected to have no adverse effects on soil chemistry and plant growth…. Plastic caps and cartridges are not likely to be eaten by wildlife [or domestic animals] and would have no effect on them. Startle effects of flares … are expected to be negligible.”
Grasslands	PRTC, Ellsworth AFB, South Dakota	**Environmental Consequences, Sections 4.8.3.1, 4.9.3, 2.8.5.2** (DAF, 2014) “Chaff and flare plastic and wrapper residual materials are …inert and not expected to impact soils or water bodies [important to agricultural use or grazing] … National grasslands, forests, and agricultural areas under the airspace are vulnerable to fire…. Altitude restrictions [have] flare release above 2,000 feet AGL… Flare use [is] discontinued … where an extreme fire danger existed. The possibility of a flare-caused fire is remote…. The extremely rare case of a dud flare falling to the ground could constitute a safety risk [and the] AFB has the personnel … to handle dud flares should they be encountered…. [Although not a socioeconomic impact], some individuals could express annoyance if a chaff or flare end cap or other residual material were found.”

Key: AFB = Air Force Base; AGL = above ground level; NEPA = National Environmental Policy Act; PRTC = Powder River Training Complex; ROD = Record of Decision; UTTR = Utah Test and Training Range

3.8.2.1.1 *Chaff*

The environmental consequences to socioeconomics from the continued use of legacy chaff items (identified in Table 3.1-2) are summarized in Table 3.8-2. The consequences are presented for each of the representative environmental settings under training airspace as described in prior NEPA documents identified in Table 3.8-1. Use of legacy chaff in training or testing does not result in significant environmental impacts to socioeconomics.

3.8.2.1.2 *Flares*

The environmental consequences to socioeconomics from the continued use of legacy flare items (identified in Table 3.1-2) are summarized in Table 3.8-2. The consequences are presented for each of the representative environmental settings under training airspace as described in prior NEPA documents identified in Table 3.8-1. The conclusion of effects to socioeconomics is that legacy flares and residual materials from their deployment would not result in significant impacts to socioeconomics under the DAF airspace, with continuation of current management strategies.

3.8.2.2 Use of New Defensive Countermeasure Items

3.8.2.2.1 *Chaff*

Table 3.1-3 compares new chaff with previously assessed legacy chaff based on the technical description/analysis of the items included in Appendix A and concludes that the new chaff items (RR-198/AL and RR-199/AL) are comparable to previously analyzed chaff items (RR-196/AL and RR-196(T-1)/AL, respectively). The environmental consequences from proposed training and testing use of the new chaff items as described in Table 2.3-1 would be expected to result in no significant impacts to socioeconomics, similar to the comparable legacy chaff items summarized in Table 3.8-2.

3.8.2.2.2 *Flares*

Table 2.3-2 through Table 2.3-5 and Table 3.1-4 list the new flares that have not been previously evaluated in existing environmental documents. Table 3.1-4 compares the new flares with legacy flare components based on the technical description/analysis of the items included in Appendix A. The new MTV flares are comparable to legacy flares and would have no significant socioeconomic impacts. Standard spectral flares are primarily combat flares with a weighted nose and would be used for testing and very limited training over ranges approved for deploying live or inert munitions. This limited use of standard spectral flares would be expected to have no significant socioeconomic environmental effects. Thrusted flares are combat flares; their continued use during testing and limited training over ranges suitable for munitions deployment would be expected to have no significant socioeconomic impacts.

3.8.2.2.3 *Spectral Decoys*

During previous hearings on changes in the use of DAF training airspace, ranchers and farmers in agricultural areas under the airspace regularly asked whether any change in use of the training airspace could affect their operations. Spectral decoys introduce a large number of light, durable iron foils (between 1,500 and 3,000 per decoy) into the environment with distributions varying with deployment altitude and wind conditions. Deployment of 3 spectral decoys at 2,000 feet AGL in a 5-mph wind is calculated to concentrate the foils in a 38-acre elliptical area. Spectral decoys deployed at 30,000 feet AGL in a 25-mph wind could disperse and drift the foils 30 to 50 miles or more downwind, depending on the decoy release altitude and winds (see Appendix A, Section 7.6.4.8). Foils from decoys deployed in a MOA over an agricultural area could settle on a variety of crops such as alfalfa, other standing crops baled or processed as livestock silage, or other crops. Alfalfa and other silage crops are harvested, dried, and baled in the field. Some harvesting equipment is fitted with magnets to intercept some metal objects before the feed enters the food chain. Alfalfa typically produces five large round bales, or comparably sized square bales, per acre. Depending on the cutting, weather, growing season, fertilization, and plant type, there could be more or fewer bales per acre. On average, each cutting produces five large round rolls per acre, and the 38 acres noted above could produce 190 rolls of hay in one cutting. The 190 rolls of hay could each have an average of approximately 32 iron foils per large round bale, unless the harvesting equipment is fitted with magnets, which would be expected to reduce the quantity. The residual foils could have a potentially adverse impact to agriculture crops and ranching operations.

Ranchers at public hearings have explained that pieces of metal, such as a part of a nail, screw, or piece of wire, cause bovine hardware disease or bovine traumatic reticuloperitonitis. The pieces of metal settle in the compartment of the cattle’s stomach called the reticulum and can irritate or penetrate the lining. It is most common in a feed lot where cattle are fed hay containing small residual iron materials, but it can also occur if grazing animals indiscriminately forage on grasses in which a metal object was enmeshed. In cases of bovine hardware disease, the metallic object can penetrate the stomach lining and have mild, severe, or even fatal consequences, although there are no known cases of livestock death due to ingestion of spectral decoy residual iron foils. The residual foils and fragmented iron particles have edges and could be another potential source of bovine hardware disease. There have been no studies comparable to the earlier studies conducted with chaff (DAF, 1997; DAF, 2011a) where calves (known to be indiscriminate eaters) were fed molasses-soaked chaff, then monitored, and finally dissected to see if the chaff impacted the digestive system or any activity or health of the calves. It is not known to what extent ingestion of residual iron foils could affect the health of cattle. Iron foils in feed could adversely impact the economics of ranching operations.

Iron foils would not be expected to impact animal products such as wool or leather. Normal processing of such products removes foreign materials such as stones or twigs and would be expected to remove particles of iron foils if, for example, they had become entrapped in sheep’s wool.

Spectral decoys could be deployed in MOAs over agricultural areas where leafy vegetable crops were being grown for human consumption. For example, lettuce is harvested by hand, a few outer leaves are removed in the field, and the heads are cleaned and boxed in the field for delivery to the market. There is no additional process for removing iron foils or particles of foils from such leafy crops. Another example is pecans or similar tree crops. Pecan trees are vibrated by a hydraulic machine to cause the pecans to fall to the ground, and then all the material under the trees is raked and collected to be taken for processing. There is no provision for removing iron foils except through increased labor to separate the pecans from the waste materials, which could include iron foils. The existence of foils on the ground under the trees could be seen by farmers as an adverse impact that increases their costs.

Testing or training use of spectral decoys over ranges that are not over or near agricultural operations could avoid foils drifting to agricultural areas. Such testing or training on ranges could result in localized effects but would not be expected to result in significant economic impacts to agricultural operations.

3.8.3 Environmental Consequences of No Action

Under the No Action Alternative, defensive countermeasure use during testing and training operations by the DAF would continue with legacy chaff and flare units included in the 1997 or 2011 Reports (DAF, 1997; DAF, 2011a), at levels identified in Table 2.3-1 through Table 2.3-4, in currently approved airspace. With continued adherence to the current management strategies for their use, there would be no significant impacts to socioeconomics, as described in Section 3.8.2.1.

3.9 SUMMARY OF ENVIRONMENTAL CONSEQUENCES

3.9.1 Use of Legacy Defensive Countermeasures

This section summarizes the results from deployment of legacy defensive countermeasures as described in Section 3.2 through Section 3.8. The environmental analysis for each environmental resource for each representative environmental setting has determined that there are no significant environmental effects from the deployment of legacy chaff and flares in DAF training airspace. The conclusion of no significant impact is based on two important factors:

1. The conclusion of no significant impact depends on the use of legacy countermeasures as specified in Table 3.1-2. For example, chaff specified for training with dipoles cut to reduce interference with FAA and weather radars would not result in a significant impact when used in DAF training airspace. Chaff with dipoles cut for combat, such as RR-170A/AL or RR-196-AL chaff, would be used for test and combat to avoid significant impacts and would have very few units deployed during special training events (see Table 2.3-1). Similarly, the MTV flares listed in Table 2.3-2 have basically the same types of residual components as the commonly used MJU-7A/B flare, and the deployment of these similar MTV flares would have no significant effects, as described for all the different environments under the DAF training airspace.

2. The finding of no significant impact for MTV flare deployment is dependent on the respective altitude restrictions and fire danger ratings for the airspaces as specified in the representative environmental documents listed in Table 1.6-1. Over non-DAF-owned or -controlled property, the minimum flare deployment altitude is 2,000 feet AGL, unless specified otherwise in governing regulations. Defensive flares are permitted to be deployed down to 500 feet AGL over DAF-owned or -controlled property if there is a fire hazard, or down to the aircraft minimum operating altitude if there is no fire hazard, unless a higher altitude is specified in range regulations (AFI 11-214). Fire risk conditions can determine whether flare use would be limited to above a specific altitude or discontinued. As examples, the Holloman AFB EIS (DAF, 2021) specifies that "during periods of 'High' fire danger, aircraft would not use flares below 18,000 feet MSL," and the PRTC EIS (DAF, 2014) explains that "altitude restrictions on flare release above 2,000 feet AGL are designed to have flares burn out at a minimum of 1,500 feet above the ground surface. Flare use would be discontinued in a MOA where an extreme fire danger existed."

The deployment of legacy chaff and flares in DAF training airspace results in the determination of no significant impact in DAF training airspace, as summarized from prior NEPA documentation.

3.9.2 Use of New Defensive Countermeasures

3.9.2.1 New Chaff

Table 3.1-3 lists the new RR-198/AL combat and RR-199/AL training chaff, which are addressed in detail in Appendix A. RR-199/AL chaff is parchment-paper-wrapped delayed deployment chaff, which is comparable to RR-196(T-1)/AL chaff. This paper wrapping material of the chaff bundles is specified as recycled paper and is biodegradable when it falls to the surface after deployment. The parchment paper is made from biodegradable cellulose fibers that are odorless and tasteless. Paper is comprised of a material which would rapidly weather and result in no expected environmental impact. RR-199/AL paper-wrapped training chaff bundles are in contrast to the combat RR-198/AL chaff, which has durable plastic Kapton wrapping materials. The Kapton plastic wrapping pieces in a marine environment could be mistaken for prey, such as jellyfish, by predatory species. The conclusion is that certain species, including marine species, could be impacted if there were an extensive use of Kapton-wrapped RR-196/AL (and by extension, RR-198/AL) chaff during training (see Appendix A, Section 4.1.3.1). Limited use of RR-198/AL chaff for testing and minimal training, as noted in Table 2.3-1, would not be expected to result in significant environmental impacts, as noted in Table 3.1-3 (see also Appendix A, Section 5.4.4). Although extensive training with the new RR-198/AL combat chaff would have the potential for environmental impacts, the proposed limited use of RR-198/AL for testing or very minimal training over land ranges, comparable to the use of RR-196/AL chaff, would not be expected to result in significant environmental impacts.

DAF training deployment of RR-199/AL chaff with parchment-paper-wrapped delayed deployment chaff bundles would not be expected to result in different environmental consequences from those already analyzed for the environments in Table 3.5-2. No significant environmental impacts would be expected from the use of RR-198/AL for testing or very limited training and for the use of RR-199/AL for training within DAF airspace.

3.9.2.2 New MTV, Standard Spectral, and Thrusted Flares

Table 2.3-2 through Table 2.3-4 list the new flares that have not been environmentally evaluated in existing environmental documents. Table 3.1-4 compares the new flares with legacy flares and describes similarities and differences.

No significant impact is anticipated from the use of new MTV and standard spectral flares without a weighted nose, which have comparable residual materials and environmental consequences to legacy countermeasures when deployed with the agreed-to management actions incorporated in the decisions from the environmental documents for the representative airspaces presented in Table 3.1-1.

3.9.2.3 New Spectral Decoys

The spectral decoys are listed and described in Table 2.3-5 and Table 3.1-4 and the potential environmental effects are presented in detail in Appendix A, Section 7.6. Spectral decoys represent a new type of defensive countermeasure and have both positive and negative aspects, when compared with legacy flares, in terms of potential for environmental effects. On the positive side, spectral decoys have fewer plastic pieces than legacy flares, and spectral decoy pyrophoric foils oxidize when exposed to air; therefore, dud spectral decoys would not be deposited on the land or water under the airspaces. The negative aspect associated with spectral decoys is the large number of oxidized thin iron foils deposited on the surface with each deployed decoy.

The potential impacts of deploying spectral decoys with resulting foils are described within each respective resource section in this PDEA and in Appendix A, Section 7.6. This section summarizes the potential environmental effects for each environmental setting under DAF training airspaces (from Table 3.1-1). For most of the resources analyzed, the potential environmental effects do not vary with the environmental setting. The primary exception would be for the ocean environment, where chaff and flare use would have no impact on safety, air quality, cultural, soils, and land use/visual resources.

3.9.2.3.1 *Woodlands*

Spectral decoy foils would be expected to disperse and not be concentrated by wind or water in any location in a woodland. During a simple 3-month weathering test, the foils were found to be as light as leaves and would be expected to become entangled in tree and undergrowth foliage just as the foils became suspended with grasses. Some of the foils could be caught in a forest canopy and would be expected to remain there until redistributed by rain or wind, at which time they would eventually drift to the ground and become covered by plant litter. Foil rusting or breakdown would occur over an estimated several months, possibly up to a year. The widely distributed iron foils would not be expected to affect the growth of vegetation or break down to such an extent that they would alter soil chemistry. During the 3-month weathering test, foils were found to not be attractive to common terrestrial bird or mammal species. Significant impacts would not be anticipated in woodlands.

3.9.2.3.2 *Desert and Arid Regions*

Oxidized foils from spectral decoys deployed in arid regions did not noticeably weather on the surface from exposure to heat in excess of 100 °F or cold below 40 °F during a simple 3-month weathering test. The foils were found to not substantially change in weight or shape and are expected to remain intact in an arid environment longer than in a moist environment. The foils in an arid environment were little changed at the conclusion of the 3-month test. Foils are light and distributed by wind currents in the air, and foils that land on barren surfaces were found to be resuspended and transported by wind, ultimately concentrating on the leeward side of barriers. Iron foils are not like aluminum and silica chaff, which break down in a matter of hours or days to particles that are effectively indistinguishable from ambient soils. The iron foils are visible and relatively long lasting on an arid surface. Repeated use of spectral decoys in an airspace could result in an accumulation of relatively long-lasting iron foils on an arid surface. There is the potential for spectral decoy iron foils to adversely affect a desert or similar arid environment due to their relative durability and potential to accumulate if large quantities are deposited in less time than it takes for them to disintegrate into iron particles. Given the potential higher visibility of oxidized decoy foils in a desert environment, and the slower rate of their breakdown into iron and iron oxide particles, there would be a higher potential for impacts to cultural and land use/visual resources than in the other environmental settings.

3.9.2.3.3 *Agricultural Areas*

Training with spectral decoys in the quantities for both historic and proposed future use listed in Table 2.3-5 releases a large number of relatively long-lasting iron foils throughout DAF training airspace in the United States that could drift 30 to 50 miles or more, depending on the decoy release altitude and winds. Spectral decoys deployed at low altitudes in MOAs over, or near, agricultural areas could result in concentrations of residual iron foils in agricultural crops, such as alfalfa or other feed crops, and could end up in the bales of feed.

With the potential that the spectral decoy iron foils could enter the cattle feed, there is the potential that the foils could be seen by feed lot managers as a new source of bovine hardware disease. Feed mills and harvesting equipment are sometimes fitted with magnets to intercept some metal objects before the feed enters the food chain to reduce the incidence of the disease. There are no known cases of livestock ingesting spectral decoy residual iron foils (See biological resources Section 3.5.2 above and Appendix A, Section 8.11, for further discussion of bovine hardware disease). Residual foils in agricultural crops could be seen by ranchers as an adverse impact on the economics of their operations.

If the spectral decoys were deployed at low altitude over (or drifted into) agricultural areas and the residual iron foils or iron particles became intermixed with a standing vegetable crop or a ground crop, harvested mechanically for human consumption (i.e., pecans or nuts) or hand harvested direct-to-market (e.g., leafy crops such as lettuce), there could also be potential impacts to the harvesting, processing, or sale of such products (see Appendix A, Section 8.11).

The deployment of spectral decoys at any altitude where the residual foils could concentrate in agricultural operations has the potential to impact ranching and agricultural economic activities, which could be seen by farmers and ranchers as an adverse impact. Spectral decoy testing and deployment over DAF ranges would be expected to result in localized impacts within the range area, and, depending on the altitude of decoy deployment and wind conditions, potential impacts to agricultural operations would be reduced.

3.9.2.3.4 *Oceans*

Residual foils on the water's surface or in the water column could result in marine species experimenting with them as possible food. Ingesting any sharp metal object would have the potential to be detrimental to the individual. If training with spectral decoys resulted in depositing large numbers of foils in warning areas, species that consume large quantities of krill-like animals could ingest the foils. Testing with spectral decoys over a marine environment would be expected to result in a determination that such limited testing "may affect, but not likely to adversely affect" sensitive marine species. Use of spectral decoys for DAF training over a marine environment, or that could drift into a marine environment, could introduce a large number of foils into the environment, which would be expected to eventually sink to the floor and rust. The 3-month test of foils in water resulted in the foils fragmenting faster and more completely than in a grassy or arid environment. Individual marine animals could be impacted by inadvertently ingesting iron foils, but the extent of any impact to ocean resources would not be expected to be significant.

3.9.2.3.5 *Wetlands*

There have been no studies for the spectral decoy foils comparable to the earlier studies conducted with chaff and flare residual materials (DAF, 1997; DAF, 2011a) that would inform assessment of potential effects of spectral decoy foils on wetlands or wetland species. As described under the ocean environment summary above, if the foils remained on the surface or, as they descend in the water column, they were seen as a potential prey item, they could detrimentally affect individual freshwater predators.

Testing of spectral decoys over wetlands would be expected to result in the iron foils being covered by natural materials in wetlands, and the oxidization process would be expected to accelerate rusting when compared with an arid environment. DAF training with spectral decoys over a wetland environment, or where numbers of foils could drift into a wetland environment, could potentially introduce larger quantities of iron foils into the wetland, which would break down and release iron and iron oxides into the wetland. It would take a very large number of iron foils from spectral decoys to be deposited in a water body to produce an impact on the water quality (see Section 3.6.2.2.3). Foils from spectral decoys would be expected to result in a “may affect, but not likely to adversely affect” determination for sensitive wetland species.

3.9.2.3.6 *Grasslands*

Spectral decoy foils deposited over a grassland introduce an iron residual material that would take an estimated several months, possibly up to a year, to break down. Limited informal 3-month tests demonstrated that the light iron foils deposited in grass would remain suspended in the vegetation, even when acted upon by rain or sprinklers. When acted upon by surface winds of 10 mph or greater, approximately 50 percent of the foils could be blown a distance of up to 5 feet before again becoming entangled and suspended in the grass. The deposit of spectral decoy foils over grasslands would be similar to that over arid areas because the foils would remain longer on or near the surface and not be covered by plant material as quickly as foils would be expected to be covered in a woodlands or wetlands environment.

Grazing animals that were indiscriminate in their consumption of grasses could ingest suspended iron foils. The potential economic and biological impacts to cattle from ingesting iron foils is described in Appendix A, Section 8.11, and under the agriculture summary above. Birds and animals were not found to use legacy chaff or flare plastic, wrapping, or chaff materials in dens or nests and would not be expected to use a foreign iron foil material in dens or nests. Foils deposited as a result of spectral decoy deployment would result in foils suspended in grasslands but would not be expected to be of sufficient quantity to affect plant growth or grazing animals’ discriminating feeding habits. Due to the drifting of residual foils after deployment (see Section 3.1.1.2.3 and Appendix A Section 7.6.4.7), repeated use of spectral decoys over the same area of grasslands could result in the accumulation of relatively durable iron foils in the environment and could affect species inhabiting the grasslands, as well as grazing animals using the grasslands.

4. CUMULATIVE IMPACTS

4.1 UPDATED CEQ REGULATIONS

In May of 2022, CEQ issued revised NEPA implementing regulations, including updated direction on the analysis of cumulative effects. The 2020 regulations repealed the 1978 regulations' definition of "cumulative impact" and stated that the analysis of effects shall be consistent with the definition of "effects"; specifically, analyses are bound by the definition of "effects" as set forth in 40 CFR 1508.1(g)(1) and (2) and should not go beyond the definition of "effects" set forth in those two paragraphs. The 2022 CEQ update restored the 1978 definition of "cumulative impacts" in its revised definitions of "effects" or "impacts" set forth in 40 CFR 1508.1(g):

"Effects or impacts means changes to the human environment from the proposed action or alternatives that are reasonably foreseeable and include the following:

1. Direct effects, which are caused by the action and occur at the same time and place.
2. Indirect effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems.
3. Cumulative effects, which are effects on the environment that result from the incremental effects of the action when added to the effects of other past, present, and reasonably foreseeable actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time.
4. Effects include ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. Effects may also include those resulting from actions which may have both beneficial and detrimental effects, even if on balance the agency believes that the effects will be beneficial."

4.2 PROGRAMMATIC CUMULATIVE IMPACTS ANALYSIS

The programmatic level of analysis in this PEA addresses the proposed continued use of legacy chaff and flares for DAF testing and training throughout military airspace in the United States and the addition of new chaff and flares for testing and training. The Proposed Action does not increase the total number of chaff and flares used in DAF testing and training (see Table 2.3-1 through Table 2.3-5). The altitude and other conditions for DAF deployment of chaff and flares would not change for any airspace over government-owned or -controlled lands or for any airspace approved for chaff and flare use over non-government lands. This means that any changes to the human environment that are reasonably foreseeable would not be different with the Proposed Action of testing and training with new chaff and most flares or with the No Action Alternative using legacy chaff and flares.

Other agencies (such as the Navy, Marines, Army, FAA, etc.) use defensive countermeasures or comparable materials and train with countermeasures to defend against threats from radar and IR-guided munitions. This PEA assumes no expected change in the quantity of defensive countermeasures deployed by other agencies during testing or training in DAF-controlled airspace. This would mean that actions of other agencies would not result in a change in effects that occur at the same time and place as the Proposed Action or No Action Alternative or that are later in time or farther removed in distance from the Proposed Action or No Action Alternative.

The qualitative analysis in this PEA for testing and training with defensive countermeasures indicates no significant impact to any resource area. The primary potential for the Proposed Action to have reasonably foreseeable cumulative effects could be from the distribution of residual foils resulting from training with spectral decoys. DAF training with spectral decoys could have a potential for ecological and economic impacts. There could be a cumulative distribution or drifting of foils from DAF training and regional expansion of agricultural or ranching operations, especially with crops for feed lots for beef or dairy operations or for grazing operations.

Should an installation request changes in training with chaff or flares, specifically changes to the airspaces and/or the agreed-to conditions of chaff and flare use in testing and training, the installation would need to conduct an additional NEPA analysis for the changed use of defensive countermeasures. The installation would need to consider those resources that have the potential to be affected by the specific changes in the training or testing use of defensive countermeasures in combination with past, present, and reasonably foreseeable future activities relative to the training airspace.

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6. LIST OF PREPARERS

The individuals who contributed to the preparation of this document are listed below.

Joseph Jimenez, Project Manager, Cultural Resources Manager, Leidos
Role in PEA: Project Management, DOPAA Development, Cultural Resources
M.A., Anthropology
B.A., Anthropology
Years of Experience: 37

David Dischner, Environmental Planner, Leidos
Role in PEA: DOPAA Development, Safety, Air Quality, Soil and Water, Land Use and Visual
B.A., Urban Affairs
Years of Experience: 30

Catherine Fitzgerald, Technical Illustrator, Leidos
Role in PEA: Illustrations
A.A., Fine Arts
Years of Experience: 40

Heather Gordon, Environmental Analyst (GIS), Leidos
Role in PEA: GIS Analysis, Illustrations
B.A., Environmental Studies and Planning
M.S., Geography
Years of Experience: 22

Robert E. Van Tassel, Program Manager, Socioeconomics, Leidos
Role in PEA: Countermeasure Report Update, Biological Resources, Socioeconomics
B.A., Economics
M.A., Economics
Years of Experience: 49

Don Wyll, Senior Project Manager, Remediation, Leidos
Role in PEA: Water Quality Evaluation
B.S., Atmospheric Sciences
Years of Experience: 30

Tara Utsey, Sr. Publications Specialist, Leidos
Role in PEA: Managing Editor, Formatting, and Document Control
B.A., Liberal Arts
Years of Experience: 26

Heather Stepp, Environmental Scientist/Editor, Leidos
Role in PEA: Managing Editor, Formatting, and Document Control
B.S., Environmental Engineering Technology
Years of Experience: 26

Jennifer Wallin, Environmental Scientist/Editor, Leidos
Role in PEA: Editing and Formatting
B.S., Biology
M.S., Environmental Toxicology
Years of Experience: 23

APPENDIX A

FINAL SUPPLEMENTAL REPORT UPDATE: ENVIRONMENTAL EFFECTS OF TRAINING WITH DEFENSIVE COUNTERMEASURES

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FINAL SUPPLEMENTAL REPORT UPDATE

ENVIRONMENTAL EFFECTS OF TRAINING WITH DEFENSIVE COUNTERMEASURES

Prepared for United States Air Force Civil Engineer Center

United States Army Corps of Engineers, Mobile District, Contract No.:
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Prepared by: Leidos

March 2023

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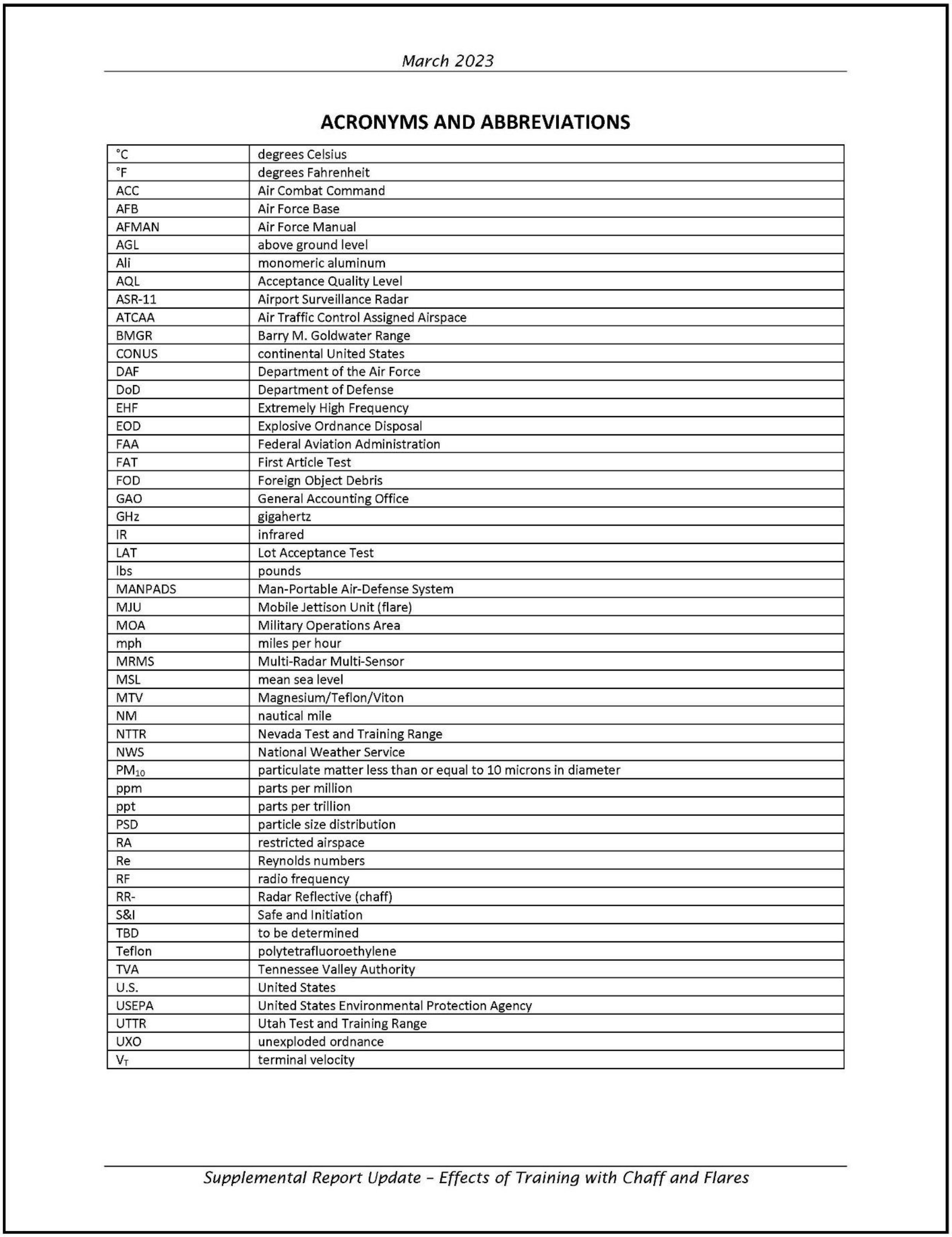
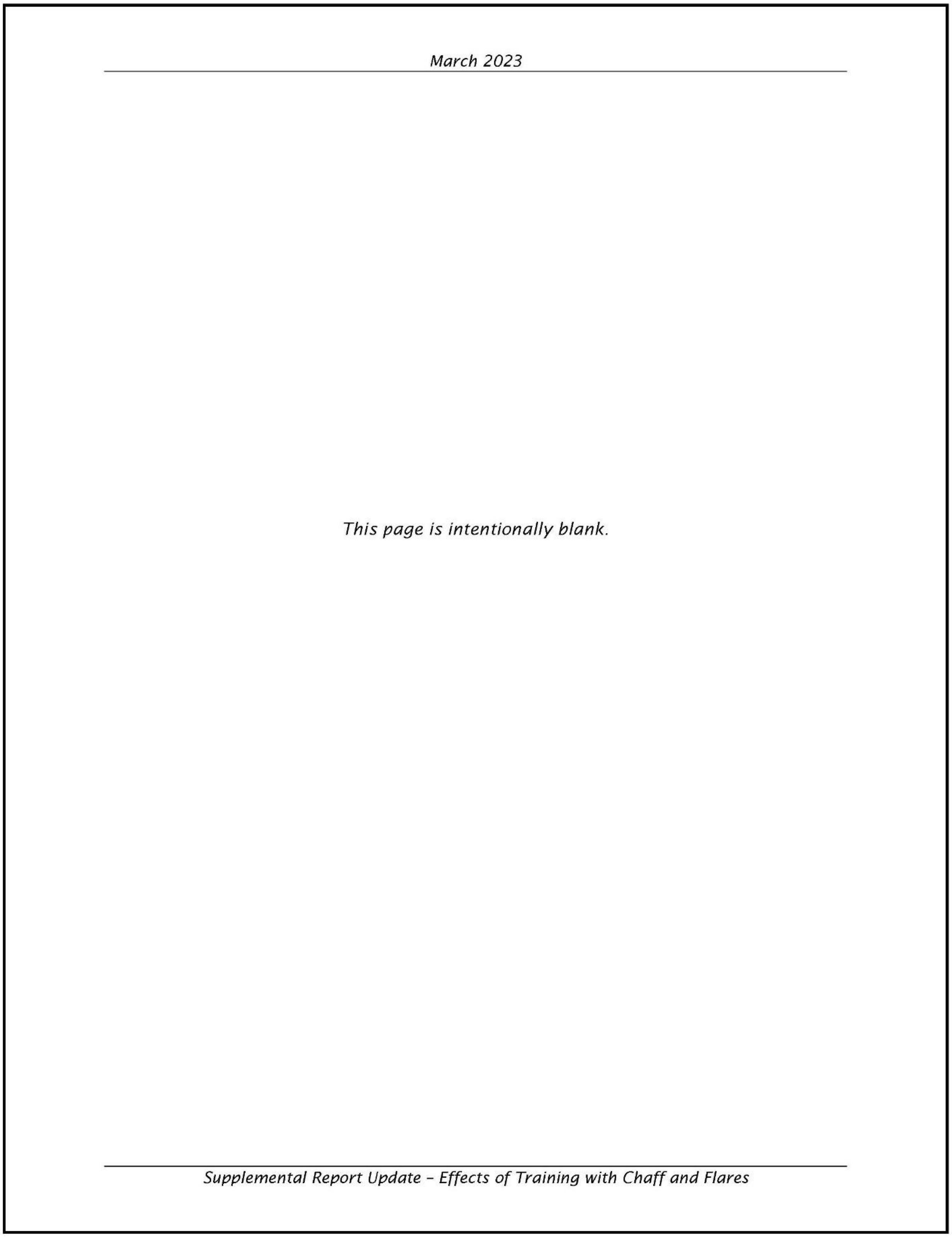


ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
°F	degrees Fahrenheit
ACC	Air Combat Command
AFB	Air Force Base
AFMAN	Air Force Manual
AGL	above ground level
Ali	monomeric aluminum
AQL	Acceptance Quality Level
ASR-11	Airport Surveillance Radar
ATCAA	Air Traffic Control Assigned Airspace
BMGR	Barry M. Goldwater Range
CONUS	continental United States
DAF	Department of the Air Force
DoD	Department of Defense
EHF	Extremely High Frequency
EOD	Explosive Ordnance Disposal
FAA	Federal Aviation Administration
FAT	First Article Test
FOD	Foreign Object Debris
GAO	General Accounting Office
GHz	gigahertz
IR	infrared
LAT	Lot Acceptance Test
lbs	pounds
MANPADS	Man-Portable Air-Defense System
MJU	Mobile Jettison Unit (flare)
MOA	Military Operations Area
mph	miles per hour
MRMS	Multi-Radar Multi-Sensor
MSL	mean sea level
MTV	Magnesium/Teflon/Viton
NM	nautical mile
NTTR	Nevada Test and Training Range
NWS	National Weather Service
PM_{10}	particulate matter less than or equal to 10 microns in diameter
ppm	parts per million
ppt	parts per trillion
PSD	particle size distribution
RA	restricted airspace
Re	Reynolds numbers
RF	radio frequency
RR-	Radar Reflective (chaff)
S&I	Safe and Initiation
TBD	to be determined
Teflon	polytetrafluoroethylene
TVA	Tennessee Valley Authority
U.S.	United States
USEPA	United States Environmental Protection Agency
UTTR	Utah Test and Training Range
UXO	unexploded ordnance
V_T	terminal velocity



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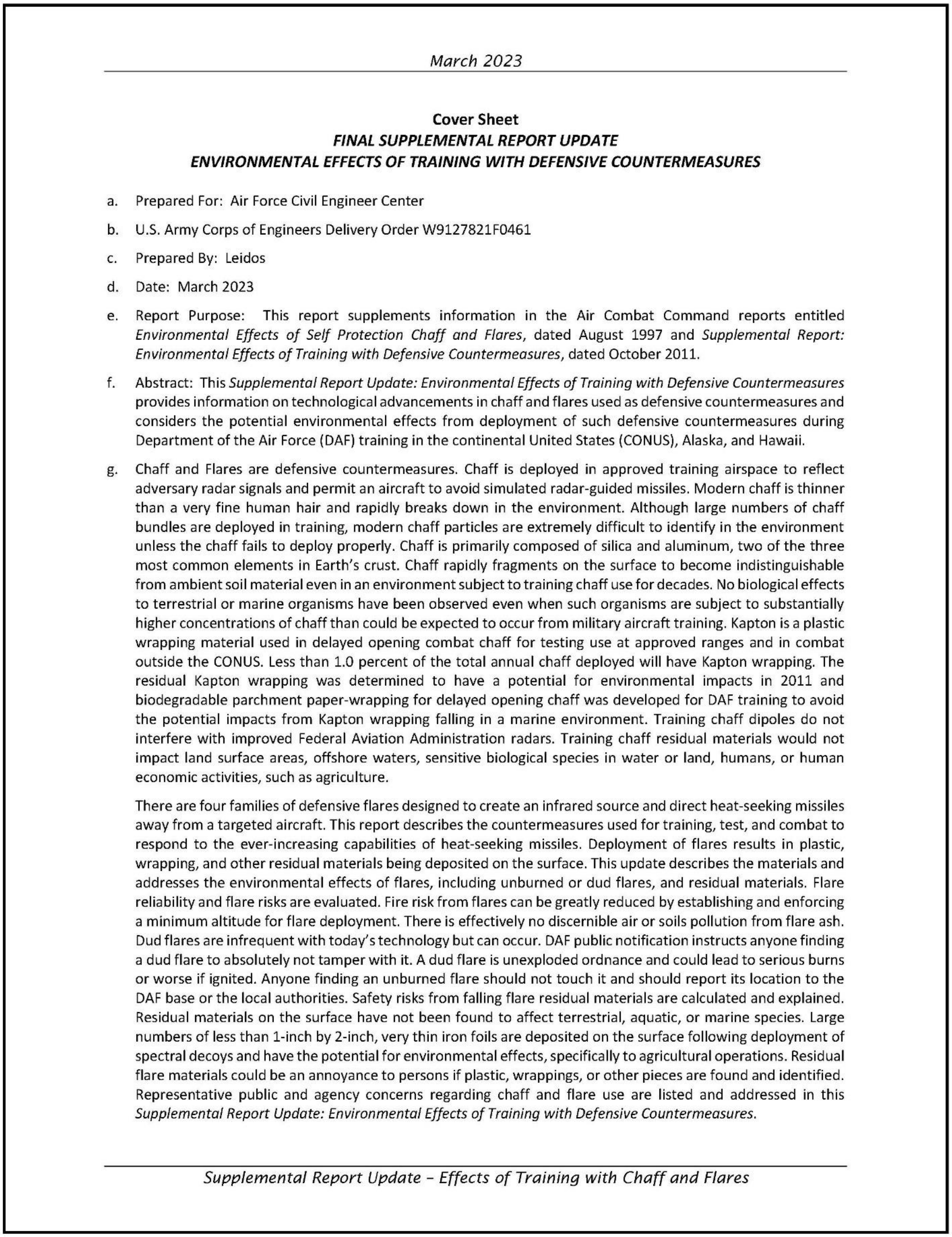


Cover Sheet
FINAL SUPPLEMENTAL REPORT UPDATE
ENVIRONMENTAL EFFECTS OF TRAINING WITH DEFENSIVE COUNTERMEASURES

a. Prepared For: Air Force Civil Engineer Center

b. U.S. Army Corps of Engineers Delivery Order W9127821F0461

c. Prepared By: Leidos

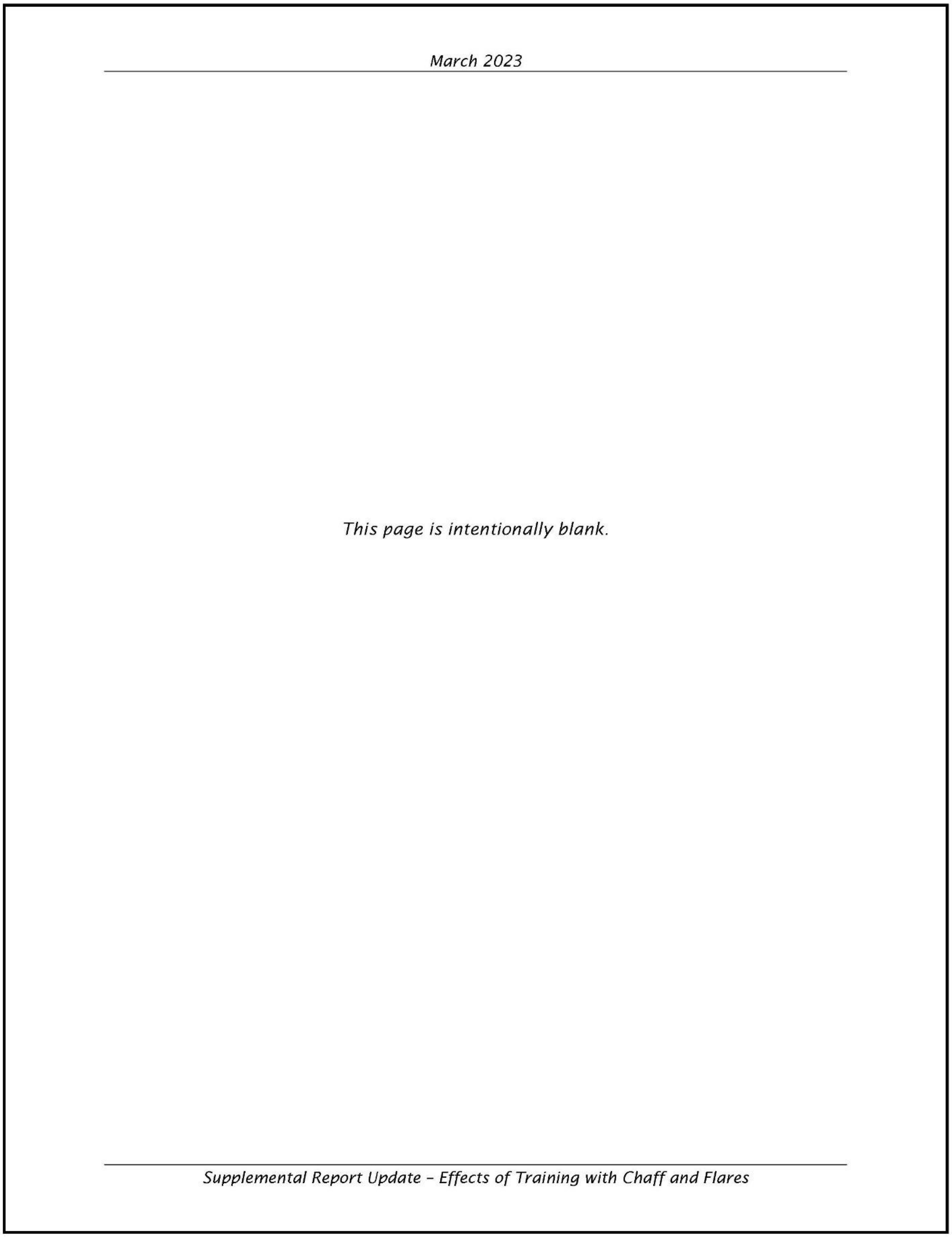
d. Date: March 2023

e. Report Purpose: This report supplements information in the Air Combat Command reports entitled *Environmental Effects of Self Protection Chaff and Flares*, dated August 1997 and *Supplemental Report: Environmental Effects of Training with Defensive Countermeasures*, dated October 2011.

f. Abstract: This *Supplemental Report Update: Environmental Effects of Training with Defensive Countermeasures* provides information on technological advancements in chaff and flares used as defensive countermeasures and considers the potential environmental effects from deployment of such defensive countermeasures during Department of the Air Force (DAF) training in the continental United States (CONUS), Alaska, and Hawaii.

g. Chaff and Flares are defensive countermeasures. Chaff is deployed in approved training airspace to reflect adversary radar signals and permit an aircraft to avoid simulated radar-guided missiles. Modern chaff is thinner than a very fine human hair and rapidly breaks down in the environment. Although large numbers of chaff bundles are deployed in training, modern chaff particles are extremely difficult to identify in the environment unless the chaff fails to deploy properly. Chaff is primarily composed of silica and aluminum, two of the three most common elements in Earth's crust. Chaff rapidly fragments on the surface to become indistinguishable from ambient soil material even in an environment subject to training chaff use for decades. No biological effects to terrestrial or marine organisms have been observed even when such organisms are subject to substantially higher concentrations of chaff than could be expected to occur from military aircraft training. Kapton is a plastic wrapping material used in delayed opening combat chaff for testing use at approved ranges and in combat outside the CONUS. Less than 1.0 percent of the total annual chaff deployed will have Kapton wrapping. The residual Kapton wrapping was determined to have a potential for environmental impacts in 2011 and biodegradable parchment paper-wrapping for delayed opening chaff was developed for DAF training to avoid the potential impacts from Kapton wrapping falling in a marine environment. Training chaff dipoles do not interfere with improved Federal Aviation Administration radars. Training chaff residual materials would not impact land surface areas, offshore waters, sensitive biological species in water or land, humans, or human economic activities, such as agriculture.

There are four families of defensive flares designed to create an infrared source and direct heat-seeking missiles away from a targeted aircraft. This report describes the countermeasures used for training, test, and combat to respond to the ever-increasing capabilities of heat-seeking missiles. Deployment of flares results in plastic, wrapping, and other residual materials being deposited on the surface. This update describes the materials and addresses the environmental effects of flares, including unburned or dud flares, and residual materials. Flare reliability and flare risks are evaluated. Fire risk from flares can be greatly reduced by establishing and enforcing a minimum altitude for flare deployment. There is effectively no discernible air or soils pollution from flare ash. Dud flares are infrequent with today's technology but can occur. DAF public notification instructs anyone finding a dud flare to absolutely not tamper with it. A dud flare is unexploded ordnance and could lead to serious burns or worse if ignited. Anyone finding an unburned flare should not touch it and should report its location to the DAF base or the local authorities. Safety risks from falling flare residual materials are calculated and explained. Residual materials on the surface have not been found to affect terrestrial, aquatic, or marine species. Large numbers of less than 1-inch by 2-inch, very thin iron foils are deposited on the surface following deployment of spectral decoys and have the potential for environmental effects, specifically to agricultural operations. Residual flare materials could be an annoyance to persons if plastic, wrappings, or other pieces are found and identified. Representative public and agency concerns regarding chaff and flare use are listed and addressed in this *Supplemental Report Update: Environmental Effects of Training with Defensive Countermeasures*.



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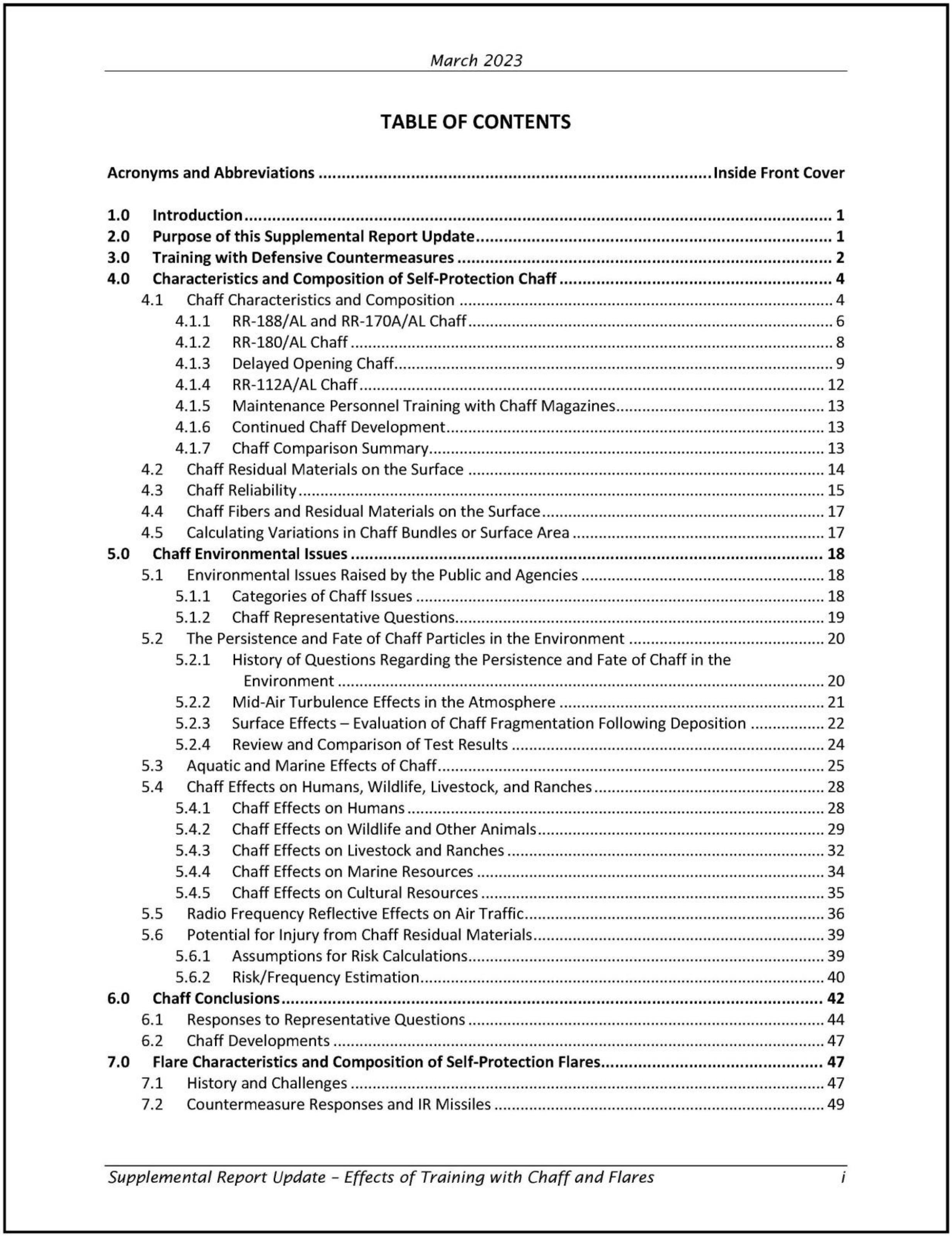
Supplemental Report Update – Effects of Training with Chaff and Flares

Final Supplemental Report Update, Environmental Effects of Training with Defensive Countermeasures



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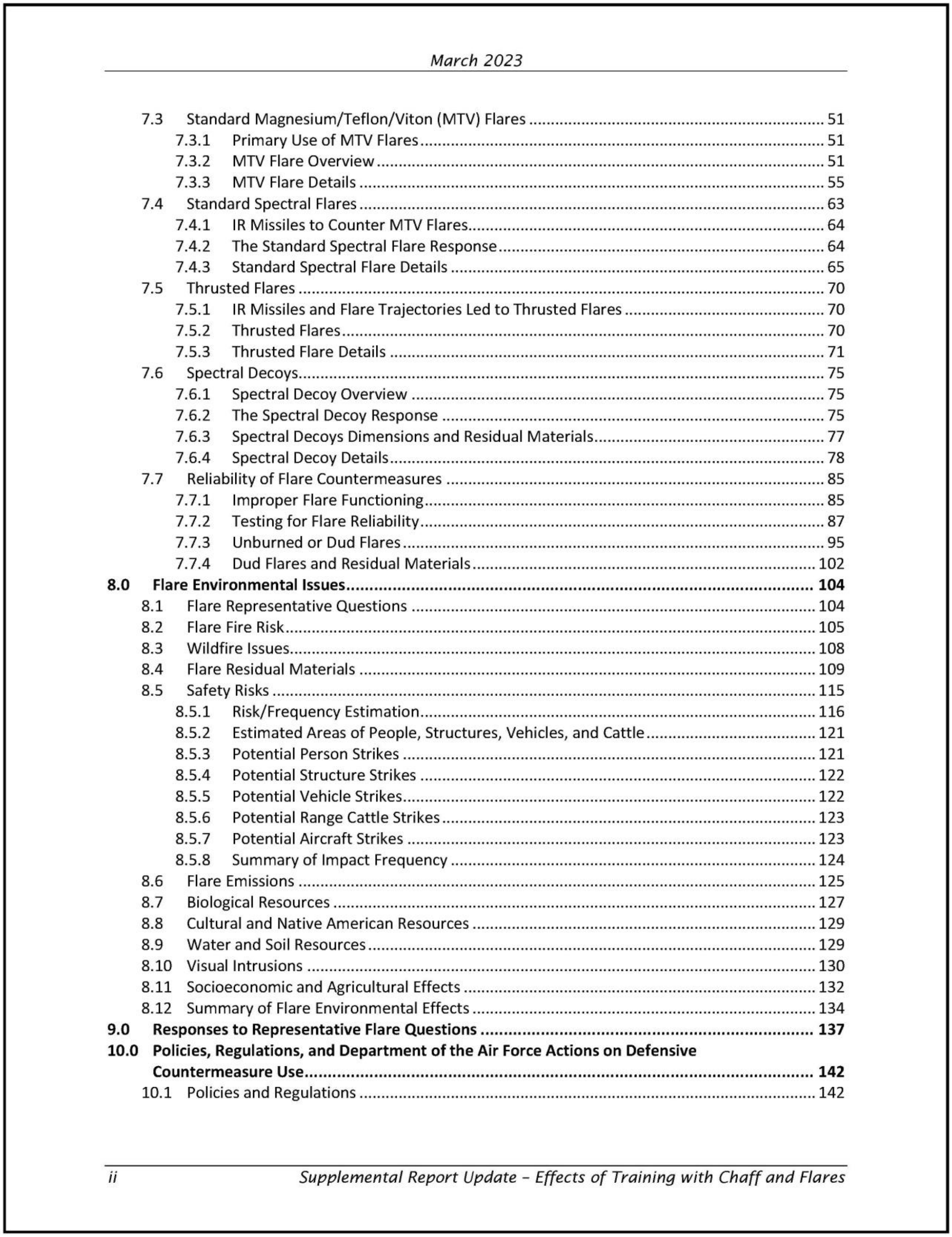

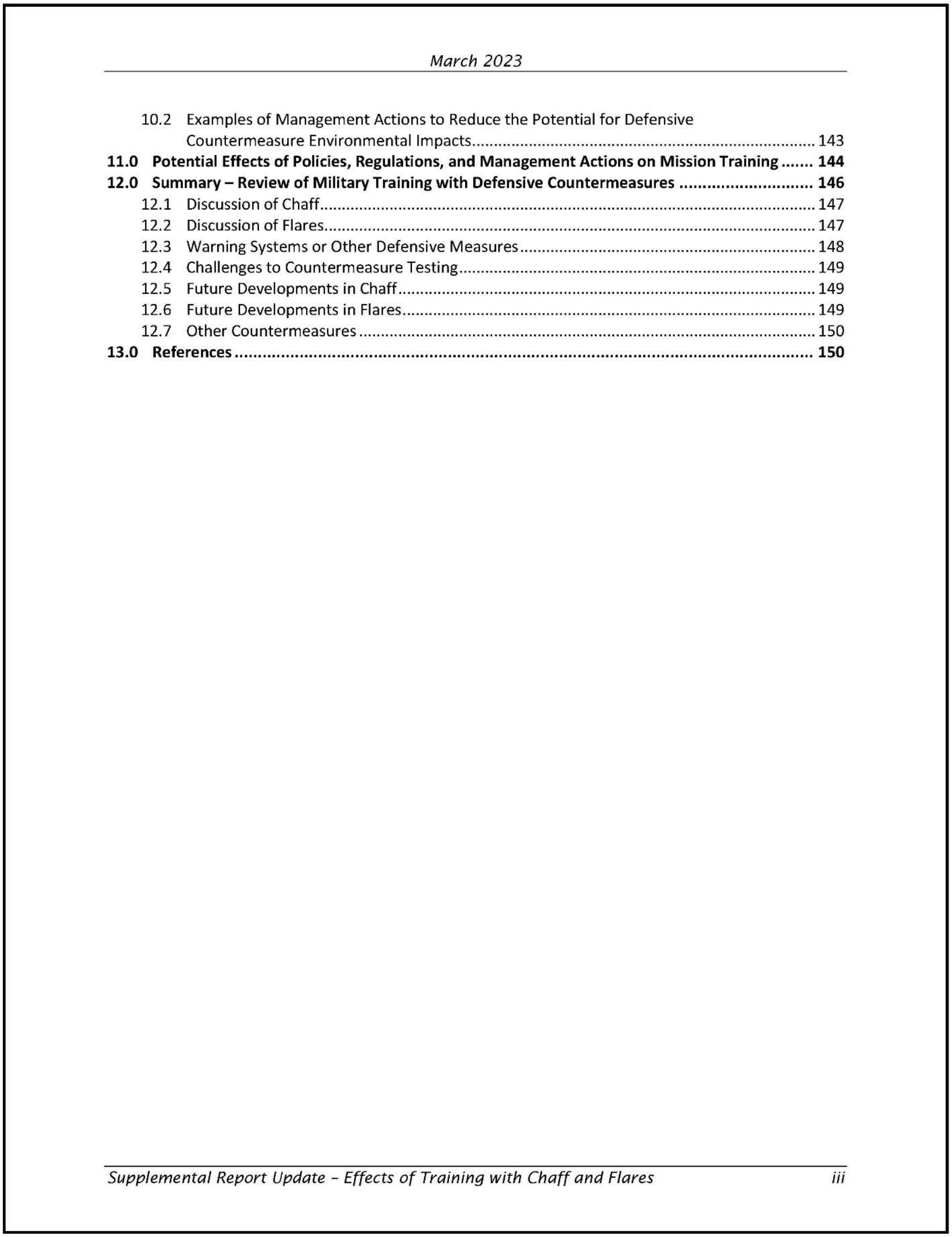

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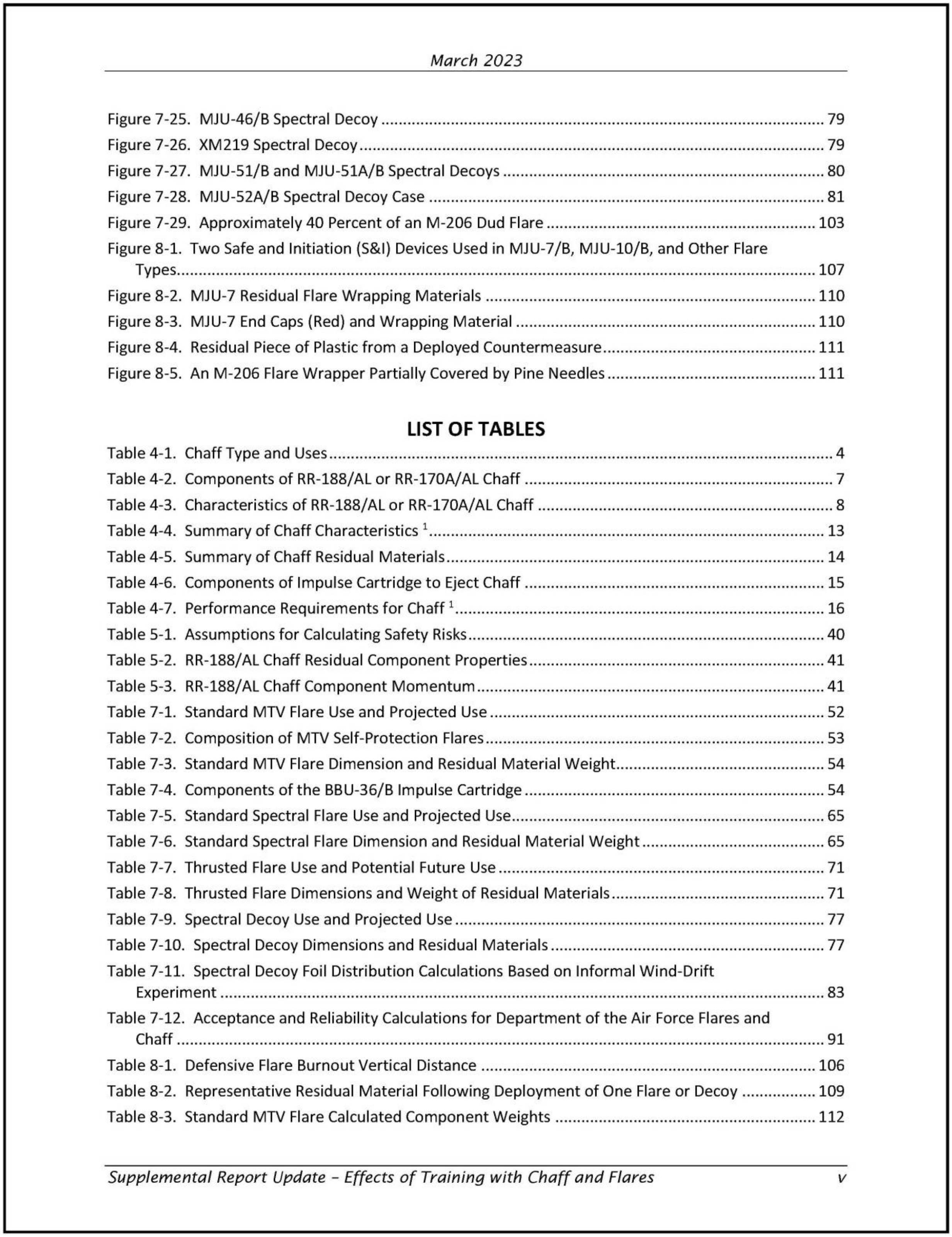

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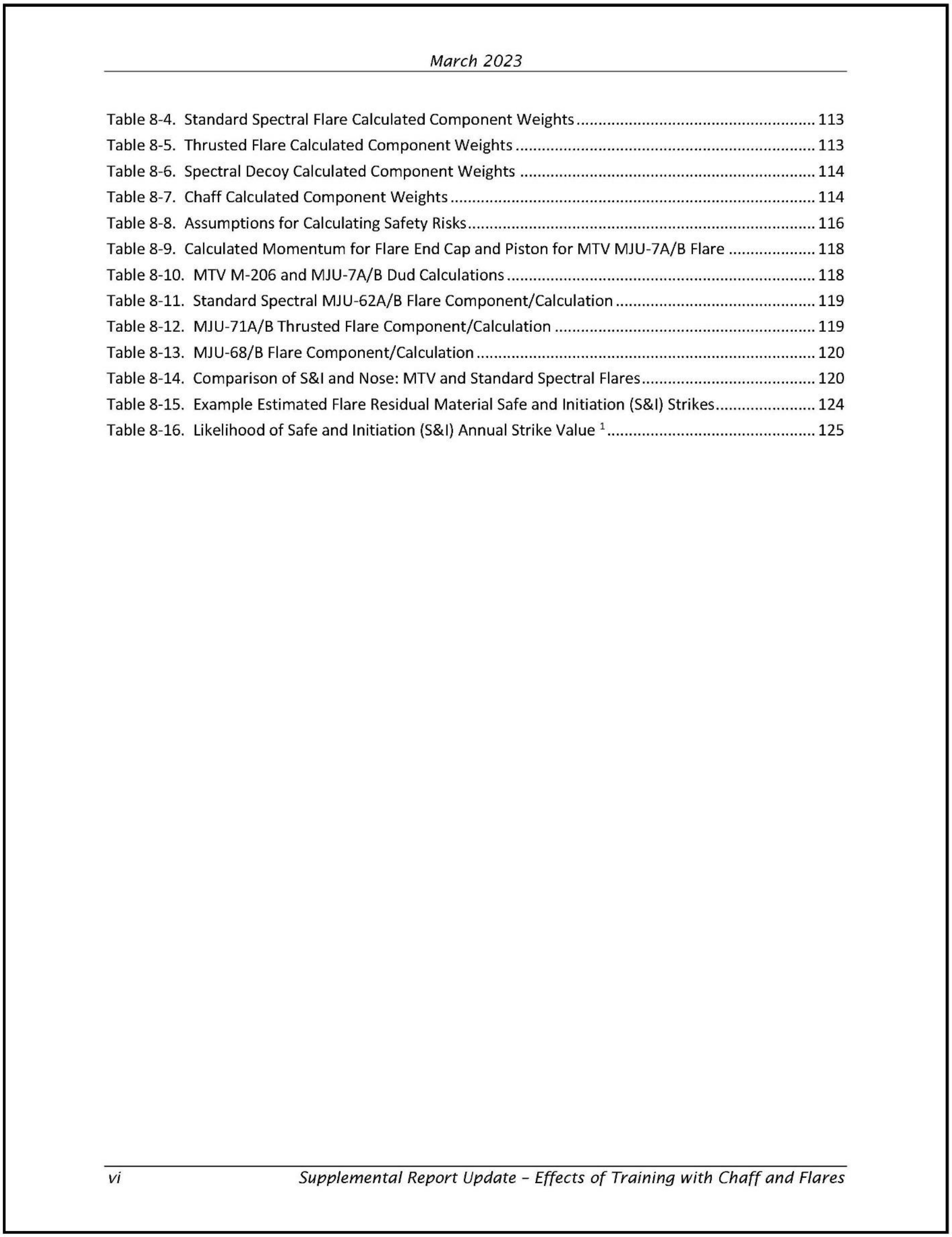
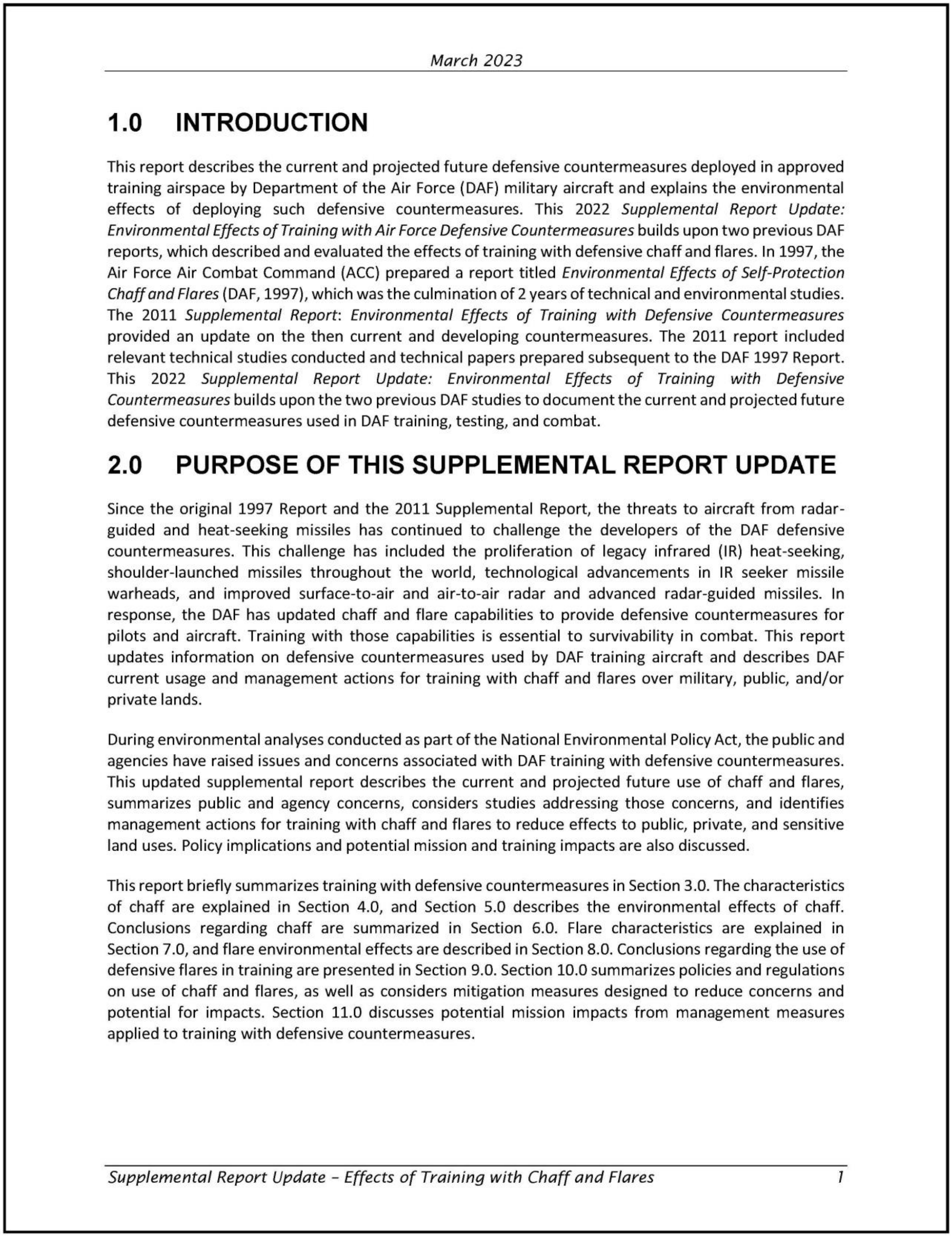




1.0 INTRODUCTION

This report describes the current and projected future defensive countermeasures deployed in approved training airspace by Department of the Air Force (DAF) military aircraft and explains the environmental effects of deploying such defensive countermeasures. This 2022 *Supplemental Report Update: Environmental Effects of Training with Air Force Defensive Countermeasures* builds upon two previous DAF reports, which described and evaluated the effects of training with defensive chaff and flares. In 1997, the Air Force Air Combat Command (ACC) prepared a report titled *Environmental Effects of Self-Protection Chaff and Flares* (DAF, 1997), which was the culmination of 2 years of technical and environmental studies. The 2011 *Supplemental Report*: *Environmental Effects of Training with Defensive Countermeasures* provided an update on the then current and developing countermeasures. The 2011 report included relevant technical studies conducted and technical papers prepared subsequent to the DAF 1997 Report. This 2022 *Supplemental Report Update: Environmental Effects of Training with Defensive Countermeasures* builds upon the two previous DAF studies to document the current and projected future defensive countermeasures used in DAF training, testing, and combat.

2.0 PURPOSE OF THIS SUPPLEMENTAL REPORT UPDATE

Since the original 1997 Report and the 2011 Supplemental Report, the threats to aircraft from radar-guided and heat-seeking missiles has continued to challenge the developers of the DAF defensive countermeasures. This challenge has included the proliferation of legacy infrared (IR) heat-seeking, shoulder-launched missiles throughout the world, technological advancements in IR seeker missile warheads, and improved surface-to-air and air-to-air radar and advanced radar-guided missiles. In response, the DAF has updated chaff and flare capabilities to provide defensive countermeasures for pilots and aircraft. Training with those capabilities is essential to survivability in combat. This report updates information on defensive countermeasures used by DAF training aircraft and describes DAF current usage and management actions for training with chaff and flares over military, public, and/or private lands.

During environmental analyses conducted as part of the National Environmental Policy Act, the public and agencies have raised issues and concerns associated with DAF training with defensive countermeasures. This updated supplemental report describes the current and projected future use of chaff and flares, summarizes public and agency concerns, considers studies addressing those concerns, and identifies management actions for training with chaff and flares to reduce effects to public, private, and sensitive land uses. Policy implications and potential mission and training impacts are also discussed.

This report briefly summarizes training with defensive countermeasures in Section 3.0. The characteristics of chaff are explained in Section 4.0, and Section 5.0 describes the environmental effects of chaff. Conclusions regarding chaff are summarized in Section 6.0. Flare characteristics are explained in Section 7.0, and flare environmental effects are described in Section 8.0. Conclusions regarding the use of defensive flares in training are presented in Section 9.0. Section 10.0 summarizes policies and regulations on use of chaff and flares, as well as considers mitigation measures designed to reduce concerns and potential for impacts. Section 11.0 discusses potential mission impacts from management measures applied to training with defensive countermeasures.

3.0 TRAINING WITH DEFENSIVE COUNTERMEASURES

Defensive countermeasures are used by military aircraft during training in response to simulated threats. The simulated threats are representative of the current and future threats from radar-guided missiles, which are defended against by chaff, and IR missiles, which are defended against by flares and decoys. Chaff consists of very fine pieces of silicon and aluminum, which are deployed by a threatened aircraft to distract and/or avoid the threat from enemy radar-directed munitions. Flares create a heat source to redirect a threat from heat-seeking munitions. The complexity and capabilities of modern heat-seeking missiles results in a need for all aircraft to train with defensive countermeasures.

Deploying defensive countermeasures in combat requires that all DAF personnel, from aircraft maintainers to pilots, "train as they will fight." The training includes maintenance personnel regularly handling and loading defensive countermeasures through to pilots who regularly train with countermeasures in approved military training airspace. All aspects, from loading through to deploying the countermeasures, must be performed in as-close-to-realistic conditions as possible to replicate combat conditions. Pilots must develop near instinctive deployment of defensive countermeasures so that they can survive in combat. Attempts to train without actually deploying defensive countermeasures have not been successful. In the 1980s, military pilots were instructed to train using their radio buttons as a proxy for a release of defensive countermeasures. For example, during training, when threatened by a simulated radar-guided or heat-seeking missile, the pilot would train by pushing the radio call button and shouting, "chaff, chaff, chaff" or "flare, flare, flare" as if he or she had actually deployed the countermeasure.

Fast forward to a combat situation in which the pilot is under extreme pressure as he or she maneuvers to strike a specific target with munitions while trying to avoid collateral damage. Real enemy radar locks onto the aircraft and/or real IR missiles are fired at the aircraft. Under the extreme combat stress of real threats, pilots reacted exactly the way they trained. Pilots instinctively pushed the radio button and shouted, "chaff, chaff, chaff." The training experience using the radio button as a proxy for deployment of defensive countermeasures did not replicate how a pilot would fight and did not instill in the pilot critical instinctive reactions needed in combination with missile warning systems for survival in combat. Pilots needed to train with real defensive countermeasures to provide realistic training that carries over to combat situations. Initially, this training occurred within restricted airspace (RA) and in offshore warning areas. In the 1990s, DAF realistic training with defensive countermeasures was expanded to include environmentally assessed Military Operations Areas (MOAs) and Air Traffic Control Assigned Airspaces (ATCAAs) over public lands (DAF, 1998). By 2001, the use of defensive countermeasures was environmentally assessed to include training in specific MOAs and ATCAAs, which could be over private lands (ACC, 2001).

Figure 3-1 is an example of a training aircraft deploying six flares during training. As the flares are deployed, the pilot maneuvers away from the flares, so that a heat-seeking missile targeting the aircraft would be directed toward the flare heat sources and away from the targeted aircraft.

Figure 3-2 depicts the life cycle of training with chaff and flare defensive countermeasures. The chaff and flares are typically inserted into magazines with a capacity of 30 to 60 units per magazine. The magazine loaded by maintenance personnel is moved from a storage structure on the base and installed in the training aircraft. During flight training, the pilot deploys chaff or flares in response to simulated threats that could include a ground-based threat or another aircraft participating in the training. During deployment, the chaff fibers are dispersed, or the magnesium flare pellet quickly burns to break the threat to the targeted aircraft. When countermeasures are deployed, residual plastic and wrapping materials fall to the surface. The characteristics and environmental effects resulting from deploying defensive countermeasures are discussed in this report, beginning with chaff.

Source: Autoevolution.

Figure 3-1. Aircraft Dispensing Flares During Training

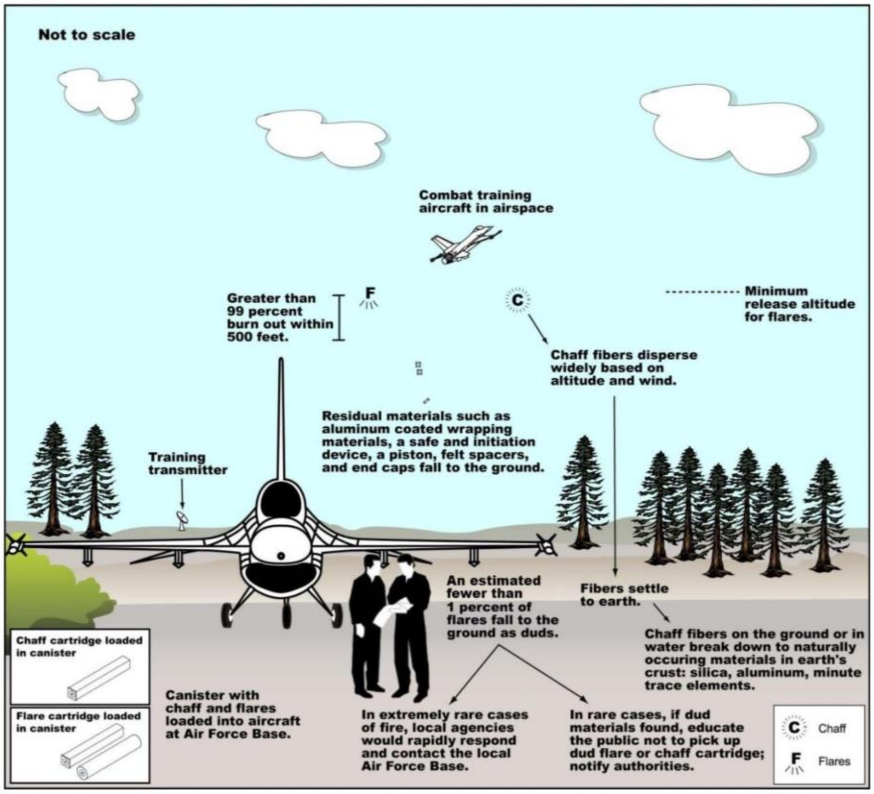
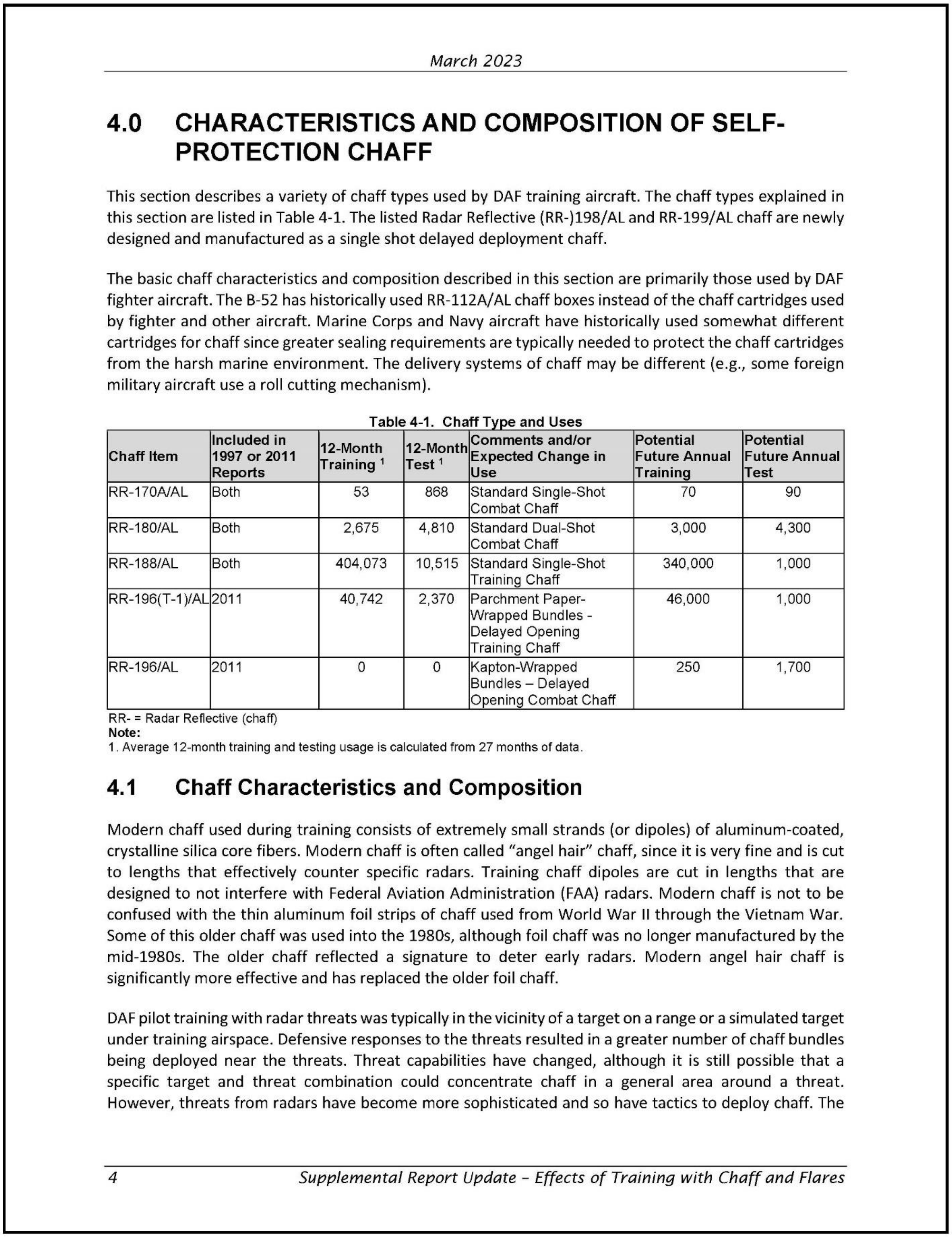


Figure 3-2. Life Cycle of Training Defensive Chaff and Standard MTV (Magnesium/Teflon/Viton) Flares



4.0 CHARACTERISTICS AND COMPOSITION OF SELF-PROTECTION CHAFF

This section describes a variety of chaff types used by DAF training aircraft. The chaff types explained in this section are listed in Table 4-1. The listed Radar Reflective (RR-)198/AL and RR-199/AL chaff are newly designed and manufactured as a single shot delayed deployment chaff.

The basic chaff characteristics and composition described in this section are primarily those used by DAF fighter aircraft. The B-52 has historically used RR-112A/AL chaff boxes instead of the chaff cartridges used by fighter and other aircraft. Marine Corps and Navy aircraft have historically used somewhat different cartridges for chaff since greater sealing requirements are typically needed to protect the chaff cartridges from the harsh marine environment. The delivery systems of chaff may be different (e.g., some foreign military aircraft use a roll cutting mechanism).

Table 4-1. Chaff Type and Uses

Chaff Item	Included in 1997 or 2011 Reports	12-Month Training [1]	12-Month Test [1]	Comments and/or Expected Change in Use	Potential Future Annual Training	Potential Future Annual Test
RR-170A/AL	Both	53	868	Standard Single-Shot Combat Chaff	70	90
RR-180/AL	Both	2,675	4,810	Standard Dual-Shot Combat Chaff	3,000	4,300
RR-188/AL	Both	404,073	10,515	Standard Single-Shot Training Chaff	340,000	1,000
RR-196(T-1)/AL	2011	40,742	2,370	Parchment Paper-Wrapped Bundles - Delayed Opening Training Chaff	46,000	1,000
RR-196/AL	2011	0	0	Kapton-Wrapped Bundles – Delayed Opening Combat Chaff	250	1,700

RR- = Radar Reflective (chaff)
Note:
1. Average 12-month training and testing usage is calculated from 27 months of data.

4.1 Chaff Characteristics and Composition

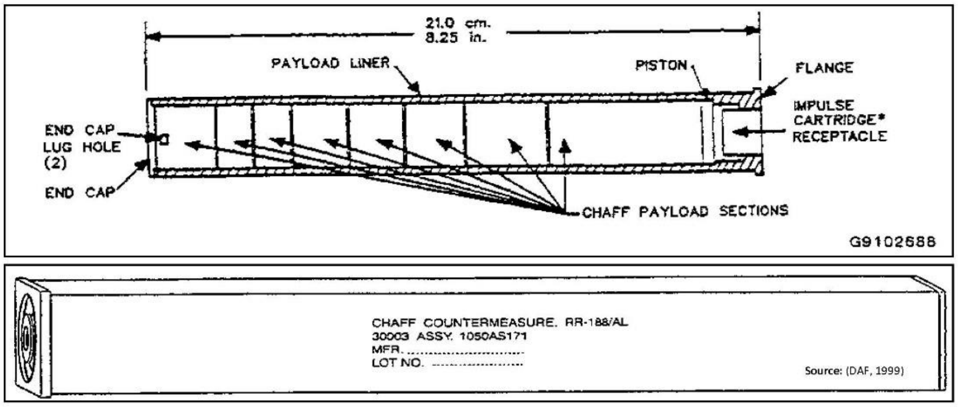
Modern chaff used during training consists of extremely small strands (or dipoles) of aluminum-coated, crystalline silica core fibers. Modern chaff is often called "angel hair" chaff, since it is very fine and is cut to lengths that effectively counter specific radars. Training chaff dipoles are cut in lengths that are designed to not interfere with Federal Aviation Administration (FAA) radars. Modern chaff is not to be confused with the thin aluminum foil strips of chaff used from World War II through the Vietnam War. Some of this older chaff was used into the 1980s, although foil chaff was no longer manufactured by the mid-1980s. The older chaff reflected a signature to deter early radars. Modern angel hair chaff is significantly more effective and has replaced the older foil chaff.

DAF pilot training with radar threats was typically in the vicinity of a target on a range or a simulated target under training airspace. Defensive responses to the threats resulted in a greater number of chaff bundles being deployed near the threats. Threat capabilities have changed, although it is still possible that a specific target and threat combination could concentrate chaff in a general area around a threat. However, threats from radars have become more sophisticated and so have tactics to deploy chaff. The improvements in radars have created threats that could occur anywhere in a training airspace. This results in chaff being deployed randomly throughout the training airspace in response to ground-based or adversary-air electronic threats. This report assumes current and future radar could threaten a training aircraft practically anywhere within the training airspace, and the use of defensive chaff could occur randomly within a training airspace.

When deployed by an aircraft, modern chaff forms a brief electronic cloud that reflects radar signals in various bands, depending on the length of the chaff fibers. Dispersed chaff forms an image of reflected signals on an enemy radar screen. The pilot maneuvers his or her aircraft, while it is momentarily obscured or masked from precise radar detection by the electronic cloud to avoid or break the radar-guided threat. Chaff is made as small and light as possible so that it will remain dispersed in the air long enough to confuse enemy radar. Individual chaff fibers are approximately one-thousandth of an inch in diameter, or one-half as thick as a very fine human hair. To put one strand of chaff in perspective, if a 1-inch-long piece, or dipole, of chaff were laid on a page of paper, most readers would not be able to see the dipole of chaff, but some readers could detect the chaff dipole by rolling a finger across the page. The act of rolling across the chaff could initiate the physical break down of the very fine chaff strand.

The chaff strands or dipoles are primarily silica and aluminum with a Neofat coating. Silica (silicon dioxide) belongs to the most common earth mineral group, silicate minerals. A chaff fiber is comprised of approximately 60 percent silica and 40 percent aluminum. Trace amounts of iron, copper, magnesium, and zinc have also been detected in the controlled combustion of chaff (DAF, 1997). Silica is inert in the environment and does not present an environmental concern with respect to soil chemistry. Aluminum is the third most abundant element in Earth's crust, forming some of the most common minerals such as feldspars, micas, and clays. According to the United States (U.S.) Environmental Protection Agency (USEPA), natural background soil concentrations of aluminum range 1 to 30 percent (USEPA, 2003). These levels vary depending on a number of environmental factors, including climate, parent rock materials from which the soils were formed, vegetation, and soil moisture alkalinity or acidity as measured by the pH factor (Lindsay, 1978). The solubility of aluminum is greater in acidic and highly alkaline soils than in neutral pH conditions. Aluminum eventually oxidizes to aluminum oxide over time, depending on its size and form and the environmental conditions. The chaff fibers' anti-clumping agent, Neofat (90 percent stearic acid and 10 percent palmitic acid), assists with rapid dispersal of the fibers during deployment (DAF, 1997). Stearic acid is a natural material that degrades when exposed to light and air.

Over 90 percent of the chaff used in a representative year (2020) to train in DAF-approved training airspace is RR-188/AL chaff (Figure 4-1). The 3.35 total ounces of chaff deployed in each bundle of RR-188/AL chaff has approximately five million chaff dipoles. The number of strands or dipoles in a chaff cartridge can range from approximately 500,000 to 5 million depending on the dipole cut and whether there are spacers or wrapping material, which take up room around the chaff. Chaff is ejected from an aircraft by a small pyrotechnic charge, and three to five chaff bundles may be deployed in rapid succession. Each chaff bundle forms an electronic cloud that can join with adjacent chaff clouds to obscure the aircraft and confuse radar-guided weapons. The light chaff fibers continue to disperse and drift with prevailing winds. A wind-borne chaff cloud disperses with distance and altitude, and the electronic radar reflection can persist over a distance of 100 miles or more, depending on the altitude of chaff release (Arfsten et al., 2002). The chaff fibers eventually settle to the surface.



Source: (DAF, 1999)

Figure 4-1. RR-188/AL or RR-170A/AL Chaff Cartridge

The length of the chaff dipoles determines the frequency range of the radio wave most effectively reflected by that particular chaff dipole. Figure 4-1, which identifies the chaff payload sections, shows how chaff fibers are cut to varying lengths to make them effective against the wide range of enemy radar systems that may be encountered. Since chaff is designed to obstruct radar, its use is coordinated with FAA. Training chaff used by DAF pilots during training in the continental United States (CONUS) has D and E band dipoles removed to reduce interference with FAA radar (DAF, 1997). Section 5.5 explains the radio frequency (RF) D and E bands and their applications. Chaff, which reflects radar energy, can result in large targets on the radar display, and improved FAA radars permit differentiation of chaff from weather events. FAA does direct air traffic controllers to issue notification of chaff areas where military electronic training activity could interfere with the operational use of radar for air traffic control. If training with chaff potentially could interfere with safe flight operations of commercial or general aviation radar, the training aircraft is requested to suspend use of chaff (FAA Order Job Order 7110.65Z).

4.1.1 RR-188/AL and RR-170A/AL Chaff

The RR-188/AL and RR-170A/AL chaff cartridges and their components are depicted in Figure 4-2. The chaff is packed inside an 8-inch by 1-inch by 1-inch rectangular tube or cartridge. The rectangular plastic tube that dispenses the chaff remains in the aircraft. Inside the plastic tube are the chaff payload, a 1-inch by 1-inch by ¼-inch-thick plastic piston, and a cushioned felt spacer the same size. A plastic end cap that is 1-inch by 1-inch by 1/8-inch-thick seals the cartridge. The piston weighs approximately 0.0043 pound (0.0688 ounce), and the end cap weighs approximately 0.0061 pound (0.0976 ounce). Chaff itself is not explosive and does not burn. A small explosive charge propels the piston to push the chaff out and pop off the end cap. The plastic end cap, plastic (or nylon) piston, and felt spacer are ejected with the chaff. The chaff fibers are fabricated to be approximately 25.4 microns (1/1,000 of an inch) in diameter and range in length from 0.3 inch to 1.0 inch. For comparison, human hair varies from 50 to 120 microns in diameter. The weight of all chaff material in an RR-188/AL cartridge is 0.2094 pounds (3.35 ounces) (DAF, 1997). Table 4-2 lists the components of the silica core and the aluminum coating. RR-188/AL chaff dipoles are cut for training to reduce the potential for interference with FAA radar. Table 4-3 presents the characteristics of RR-188/AL or RR-170A/AL chaff.

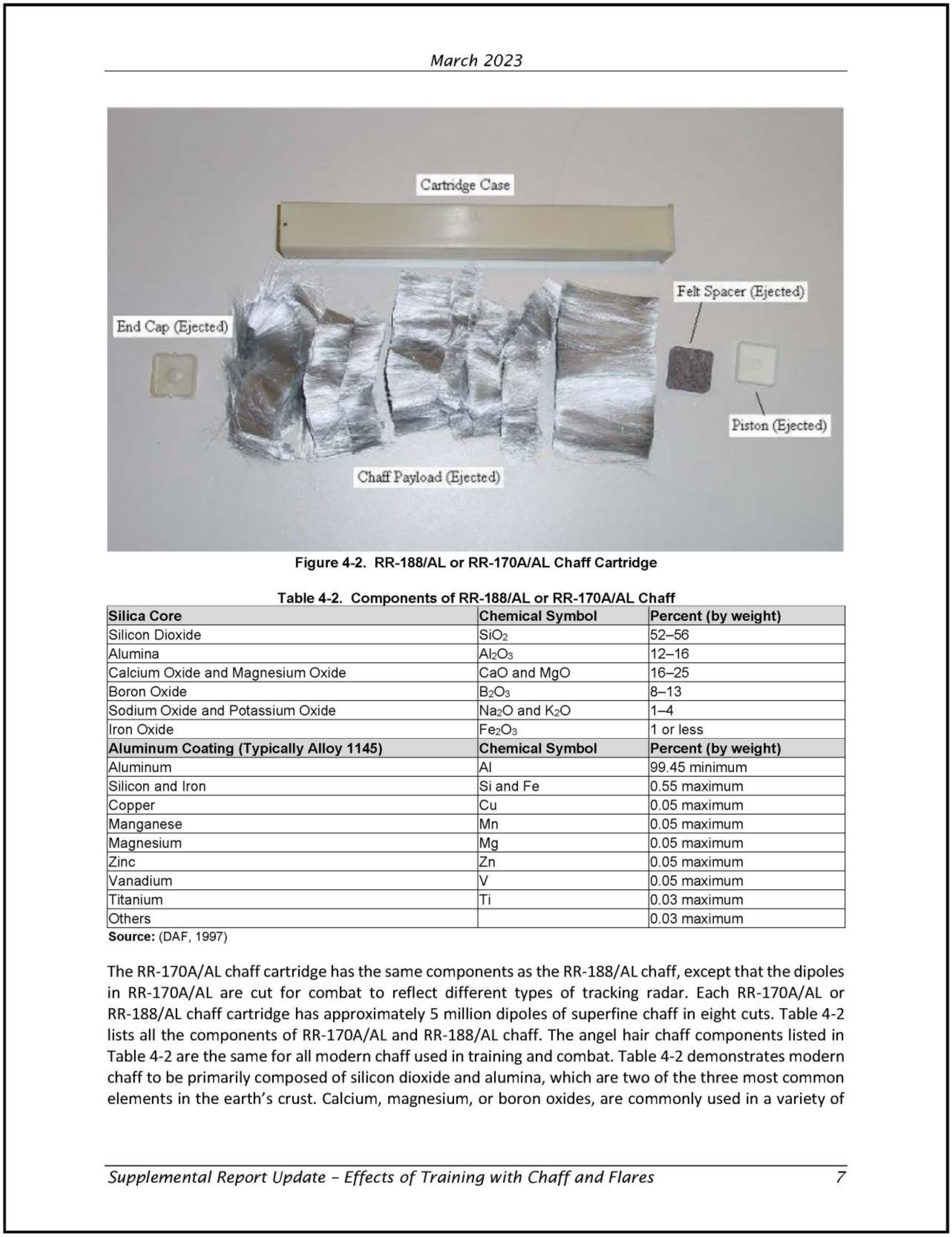


Figure 4-2. RR-188/AL or RR-170A/AL Chaff Cartridge

Table 4-2. Components of RR-188/AL or RR-170A/AL Chaff

Silica Core	**Chemical Symbol**	**Percent (by weight)**
Silicon Dioxide	SiO_2	52–56
Alumina	Al_2O_3	12–16
Calcium Oxide and Magnesium Oxide	CaO and MgO	16–25
Boron Oxide	B_2O_3	8–13
Sodium Oxide and Potassium Oxide	Na_2O and K_2O	1–4
Iron Oxide	Fe_2O_3	1 or less
Aluminum Coating (Typically Alloy 1145)	**Chemical Symbol**	**Percent (by weight)**
Aluminum	Al	99.45 minimum
Silicon and Iron	Si and Fe	0.55 maximum
Copper	Cu	0.05 maximum
Manganese	Mn	0.05 maximum
Magnesium	Mg	0.05 maximum
Zinc	Zn	0.05 maximum
Vanadium	V	0.05 maximum
Titanium	Ti	0.03 maximum
Others		0.03 maximum

Source: (DAF, 1997)

The RR-170A/AL chaff cartridge has the same components as the RR-188/AL chaff, except that the dipoles in RR-170A/AL are cut for combat to reflect different types of tracking radar. Each RR-170A/AL or RR-188/AL chaff cartridge has approximately 5 million dipoles of superfine chaff in eight cuts. Table 4-2 lists all the components of RR-170A/AL and RR-188/AL chaff. The angel hair chaff components listed in Table 4-2 are the same for all modern chaff used in training and combat. Table 4-2 demonstrates modern chaff to be primarily composed of silicon dioxide and alumina, which are two of the three most common elements in the earth's crust. Calcium, magnesium, or boron oxides, are commonly used in a variety of food products, including sugar, baking powder, food supplements, or ceramics manufacture. The small amounts of sodium, potassium, and iron oxides are materials that are used in such applications as manufacturing glass, fertilizer, soaps, and polishing compounds. Modern chaff, used in training and combat, does not have the characteristics of asbestos and does not contain hazardous materials, such as formaldehyde. The primary difference between chaff used in training and chaff used in combat is that the cut of the chaff dipoles for training reduce interference with radar, whereas the chaff used in combat specifically is cut to interfere with radar. The RR-188/AL components listed in Table 4-2 and the characteristics listed in Table 4-3 are the same for RR-170A/AL chaff as well as for the fibers in the other types of modern chaff.

Table 4-3. Characteristics of RR-188/AL or RR-170A/AL Chaff

Attribute	Description
Composition	Aluminum-coated silica
Ejection Mode	Pyrotechnic
Configuration	Rectangular tube cartridge
Size	8 x 1 x 1 inches (8 cubic inches)
Number of Dipoles	Typically 5 million or fewer (depending on the dipole cut lengths)
Dipole Size (cross-section)	1 millimeter (diameter)
Impulse Cartridge	BBU-35/B
Other Comments	Cartridge stays in aircraft; less interference with FAA radar (no D and E bands)

Source: (DAF, 1997)
FAA = Federal Aviation Administration

4.1.2 RR-180/AL Chaff

RR-180/AL combat chaff is a 1-inch by 1-inch by 8-inch dual chaff cartridge in which the two sides can be fired in sequence. The plastic I-beam separator is cut to the same lengths as the chaff and divides the two cartridges. RR-180/AL chaff has approximately 340,000 dipoles. Figure 4-3 presents the plastic cartridge, which remains in the aircraft, and one-half of the two chaff payloads in the plastic cartridge, which are ejected. Figure 4-3 also shows one of two pistons, one of two felt spacers, one of two end caps, and the seven cut I-beam pieces, which fall to the surface with each chaff bundle deployed. In the picture, one of the seven I-beam pieces is set on edge to demonstrate its thickness. The six pieces of plastic (or nylon end caps) and felt spacer are each approximately 1/8 inch by ½ inch by 1 inch, and the two end caps are each ¼ inch by ½ inch by 1 inch. In addition to the chaff, each deployed RR-180/AL chaff cartridge results in 13 pieces of plastic, felt, or rubber being deposited on the surface.

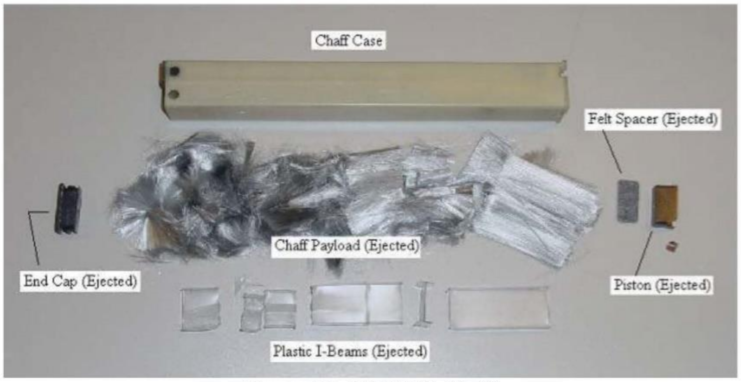


Figure 4-3. RR-180/AL Chaff

4.1.3 Delayed Opening Chaff

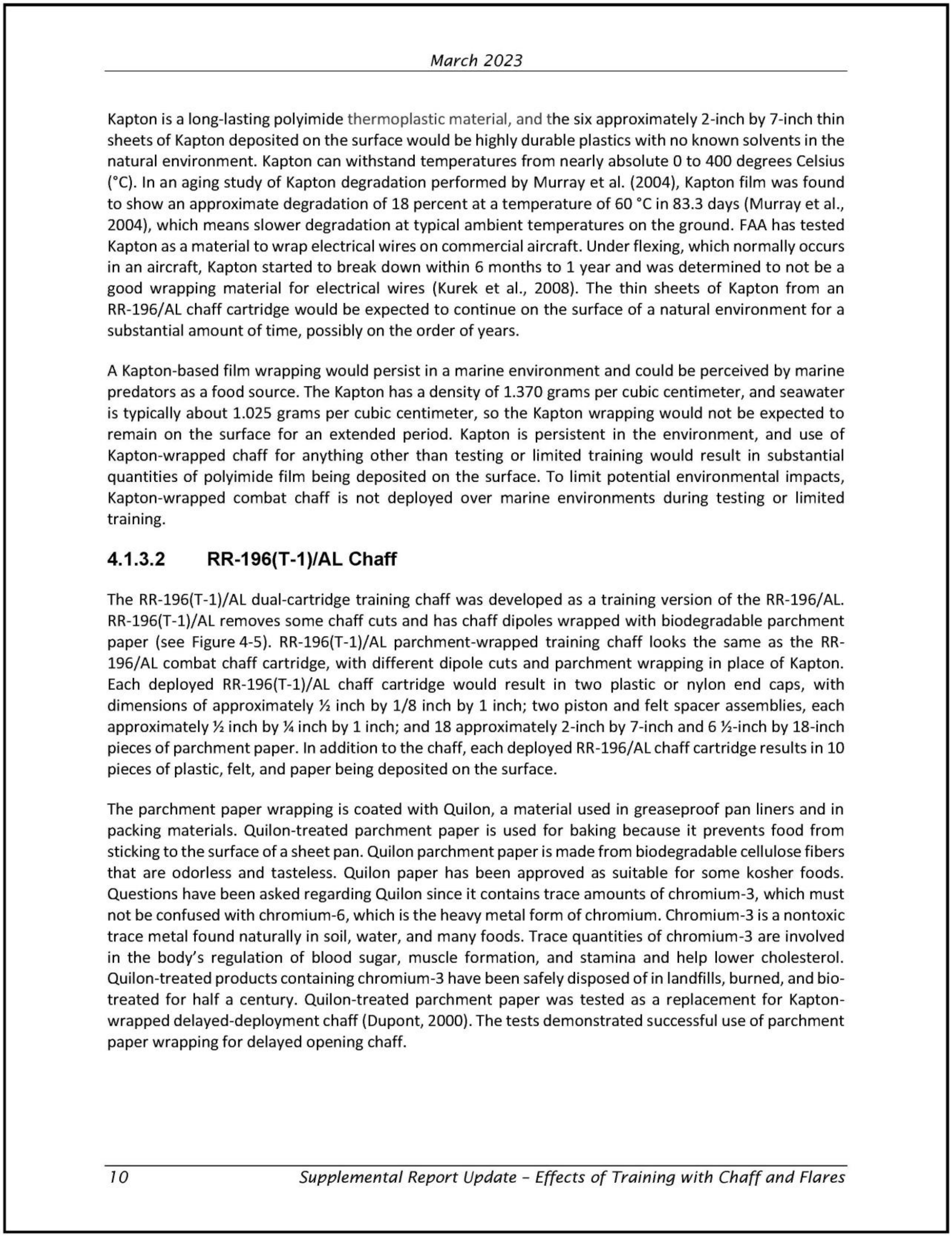
The delayed opening chaff has the chaff dipoles wrapped in different configurations or material to delay the release of the chaff dipoles for performance reasons.

4.1.3.1 RR-196/AL Chaff

Figure 4-4 presents the dual-cartridge RR-196/AL combat chaff configuration comprised of six loose chaff packs wrapped in Kapton. The rubber bands in the picture are to stabilize the chaff bundles and are not part of the deployed chaff. The piston assembly and felt spacer are glued together. During deployment, the piston assembly forces the wrapped chaff and end cap out and away from the aircraft. The piston, wrapping, and end caps fall to the surface as the delayed opening chaff is dispersed.

Figure 4-4. RR-196/AL Combat Chaff

The soft pack Kapton wrapping is comprised of multiple layers of Kapton to hold the smaller cuts together and delay release of the chaff. The Kapton wrapping made the I-beams no longer needed for this dual-chamber chaff. One deployed RR-196/AL chaff cartridge would result in two plastic or nylon end caps, two piston and felt spacer assemblies (each approximately ½ inch by ¼ inch by 1 inch), and 18 approximately 2-inch by 7-inch and 6 ½-inch by 18-inch pieces of Kapton film. In addition to the chaff, each deployment results in 10 pieces of plastic, felt, and Kapton being deposited on the surface. The Kapton-wrapped chaff is used in combat or for testing and limited training over approved land ranges.



Kapton is a long-lasting polyimide thermoplastic material, and the six approximately 2-inch by 7-inch thin sheets of Kapton deposited on the surface would be highly durable plastics with no known solvents in the natural environment. Kapton can withstand temperatures from nearly absolute 0 to 400 degrees Celsius (°C). In an aging study of Kapton degradation performed by Murray et al. (2004), Kapton film was found to show an approximate degradation of 18 percent at a temperature of 60 °C in 83.3 days (Murray et al., 2004), which means slower degradation at typical ambient temperatures on the ground. FAA has tested Kapton as a material to wrap electrical wires on commercial aircraft. Under flexing, which normally occurs in an aircraft, Kapton started to break down within 6 months to 1 year and was determined to not be a good wrapping material for electrical wires (Kurek et al., 2008). The thin sheets of Kapton from an RR-196/AL chaff cartridge would be expected to continue on the surface of a natural environment for a substantial amount of time, possibly on the order of years.

A Kapton-based film wrapping would persist in a marine environment and could be perceived by marine predators as a food source. The Kapton has a density of 1.370 grams per cubic centimeter, and seawater is typically about 1.025 grams per cubic centimeter, so the Kapton wrapping would not be expected to remain on the surface for an extended period. Kapton is persistent in the environment, and use of Kapton-wrapped chaff for anything other than testing or limited training would result in substantial quantities of polyimide film being deposited on the surface. To limit potential environmental impacts, Kapton-wrapped combat chaff is not deployed over marine environments during testing or limited training.

4.1.3.2 RR-196(T-1)/AL Chaff

The RR-196(T-1)/AL dual-cartridge training chaff was developed as a training version of the RR-196/AL. RR-196(T-1)/AL removes some chaff cuts and has chaff dipoles wrapped with biodegradable parchment paper (see Figure 4-5). RR-196(T-1)/AL parchment-wrapped training chaff looks the same as the RR-196/AL combat chaff cartridge, with different dipole cuts and parchment wrapping in place of Kapton. Each deployed RR-196(T-1)/AL chaff cartridge would result in two plastic or nylon end caps, with dimensions of approximately ½ inch by 1/8 inch by 1 inch; two piston and felt spacer assemblies, each approximately ½ inch by ¼ inch by 1 inch; and 18 approximately 2-inch by 7-inch and 6 ½-inch by 18-inch pieces of parchment paper. In addition to the chaff, each deployed RR-196/AL chaff cartridge results in 10 pieces of plastic, felt, and paper being deposited on the surface.

The parchment paper wrapping is coated with Quilon, a material used in greaseproof pan liners and in packing materials. Quilon-treated parchment paper is used for baking because it prevents food from sticking to the surface of a sheet pan. Quilon parchment paper is made from biodegradable cellulose fibers that are odorless and tasteless. Quilon paper has been approved as suitable for some kosher foods. Questions have been asked regarding Quilon since it contains trace amounts of chromium-3, which must not be confused with chromium-6, which is the heavy metal form of chromium. Chromium-3 is a nontoxic trace metal found naturally in soil, water, and many foods. Trace quantities of chromium-3 are involved in the body's regulation of blood sugar, muscle formation, and stamina and help lower cholesterol. Quilon-treated products containing chromium-3 have been safely disposed of in landfills, burned, and bio-treated for half a century. Quilon-treated parchment paper was tested as a replacement for Kapton-wrapped delayed-deployment chaff (Dupont, 2000). The tests demonstrated successful use of parchment paper wrapping for delayed opening chaff.

Figure 4-5. RR-196(T-1)/AL Training Chaff

4.1.3.3 RR-198/AL Chaff

RR-198/AL is a delayed opening with multiple layers of Kapton to hold the smaller dipole cuts together (Figure 4-6). The primary difference between the RR-196/AL and RR-198/AL combat chaff types is that the RR-196/AL is a dual-shot cartridge and the RR-198/AL is a single-shot cartridge. RR-198/AL chaff results in one plastic or nylon end cap and two felt spacers, each with a dimension of 1 inch by 1 inch by 1/8 inch; one piston approximately 1 inch by 1 inch by ¼ inch; and 18 approximately 2-inch by 7-inch and 6 ½-inch by 18-inch very thin sheets of Kapton film. In addition to the chaff, each deployed RR-198/AL chaff cartridge results in nine pieces of plastic, felt, and Kapton being deposited on the surface. The durability of the six sheets of Kapton would be as described for RR-196/AL in Section 4.1.3.1.

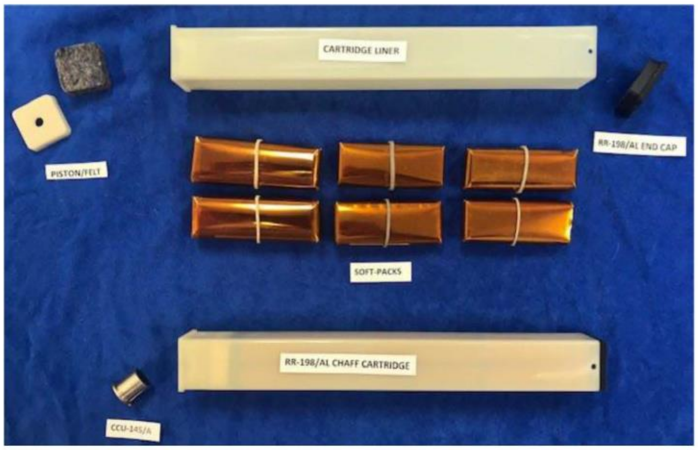


Figure 4-6. RR-198/AL Chaff

4.1.3.4 RR-199/AL Chaff

RR-199/AL chaff was developed as a training version of the RR-198/AL and has some chaff cuts removed and is wrapped in biodegradable parchment paper. The parchment paper wrapping is coated with Quilon, as described for the RR-196(T-1)/AL training chaff. The difference between RR-196(T-1) and the RR-199/AL chaff is that the RR-199/AL chaff is bundled as a single-shot chaff as compared with the dual-shot RR-196(T-1) chaff cartridge. Each deployed RR-199/AL chaff cartridge results in one plastic or nylon end cap and one felt spacer with a dimension of approximately 1 inch by 1 inch by 1/8 inch, one piston approximately 1-inch by 1-inch by ¼-inch, and 18 approximately 2-inch by 7-inch and 6 ½-inch by 18-inch thin pieces of parchment paper (Figure 4-7). In addition to the chaff, each deployed RR-199/AL chaff cartridge results in nine pieces of plastic, felt, and paper being deposited on the surface. The Quilon-treated parchment paper is as described for RR-196(T-1)/AL chaff in Section 4.1.3.2.

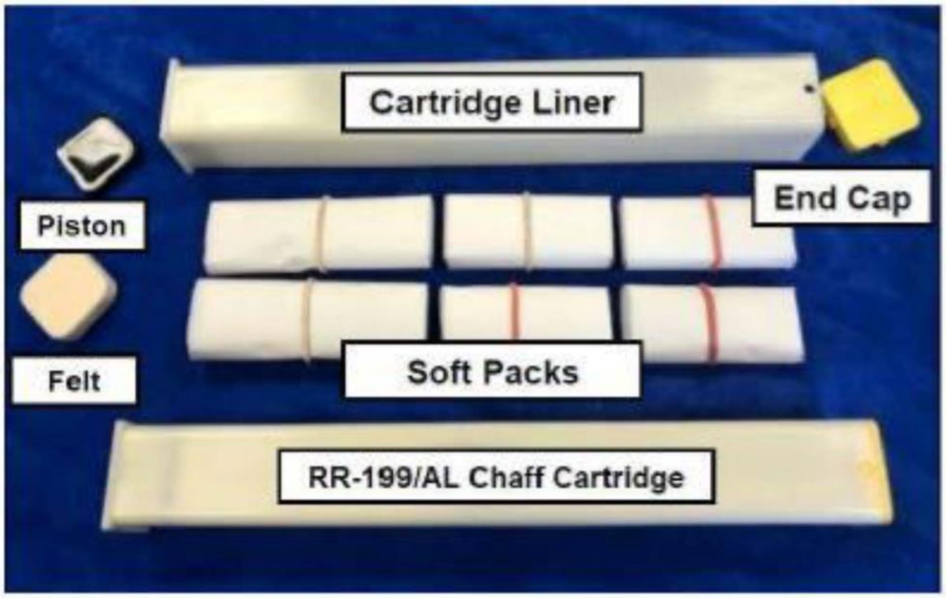
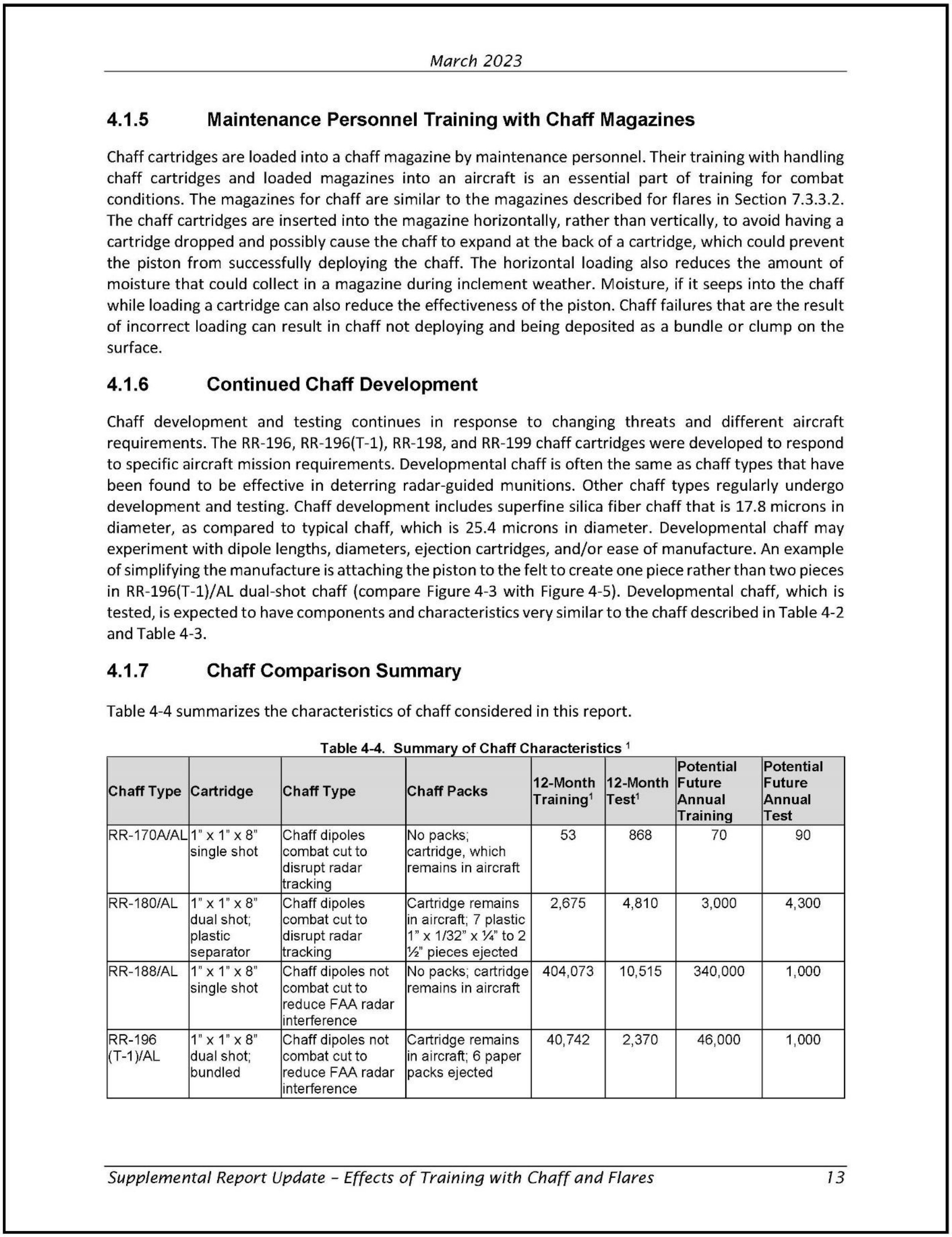


Figure 4-7. RR-199/AL Chaff

4.1.4 RR-112A/AL Chaff

The B-52H bomber uses RR-112A/AL chaff. The chaff is ejected mechanically as the 2.8-inch by 4.8-inch by 0.8-inch 7-ounce paper box (recycled paper is specified) is torn open and the chaff is ejected (Global Security, 2011). The ejected chaff dipole characteristics are the same as described for RR-188/AL (Table 4-3). The RR-112A/AL chaff residual materials consist of the empty paper box and two 2.75-inch by 4.75-inch by 0.06-inch pieces of plastic that support the box as well as the chaff fibers. B-52H aircraft also use RR-149 chaff, which has the same deployment system and different dipole cuts when compared to RR-112A/AL chaff. Pre-1980, B-52 chaff was aluminum foil-laminated chaff with traces of lead that was not manufactured after the mid-1980s. Only the silica fiber-based chaff has been acquired for B-52H use since the mid-1980s.



4.1.5 Maintenance Personnel Training with Chaff Magazines

Chaff cartridges are loaded into a chaff magazine by maintenance personnel. Their training with handling chaff cartridges and loaded magazines into an aircraft is an essential part of training for combat conditions. The magazines for chaff are similar to the magazines described for flares in Section 7.3.3.2. The chaff cartridges are inserted into the magazine horizontally, rather than vertically, to avoid having a cartridge dropped and possibly cause the chaff to expand at the back of a cartridge, which could prevent the piston from successfully deploying the chaff. The horizontal loading also reduces the amount of moisture that could collect in a magazine during inclement weather. Moisture, if it seeps into the chaff while loading a cartridge can also reduce the effectiveness of the piston. Chaff failures that are the result of incorrect loading can result in chaff not deploying and being deposited as a bundle or clump on the surface.

4.1.6 Continued Chaff Development

Chaff development and testing continues in response to changing threats and different aircraft requirements. The RR-196, RR-196(T-1), RR-198, and RR-199 chaff cartridges were developed to respond to specific aircraft mission requirements. Developmental chaff is often the same as chaff types that have been found to be effective in deterring radar-guided munitions. Other chaff types regularly undergo development and testing. Chaff development includes superfine silica fiber chaff that is 17.8 microns in diameter, as compared to typical chaff, which is 25.4 microns in diameter. Developmental chaff may experiment with dipole lengths, diameters, ejection cartridges, and/or ease of manufacture. An example of simplifying the manufacture is attaching the piston to the felt to create one piece rather than two pieces in RR-196(T-1)/AL dual-shot chaff (compare Figure 4-3 with Figure 4-5). Developmental chaff, which is tested, is expected to have components and characteristics very similar to the chaff described in Table 4-2 and Table 4-3.

4.1.7 Chaff Comparison Summary

Table 4-4 summarizes the characteristics of chaff considered in this report.

Table 4-4. Summary of Chaff Characteristics [1]

Chaff Type	Cartridge	Chaff Type	Chaff Packs	12-Month Training[1]	12-Month Test[1]	Potential Future Annual Training	Potential Future Annual Test
RR-170A/AL	1" x 1" x 8" single shot	Chaff dipoles combat cut to disrupt radar tracking	No packs; cartridge, which remains in aircraft	53	868	70	90
RR-180/AL	1" x 1" x 8" dual shot; plastic separator	Chaff dipoles combat cut to disrupt radar tracking	Cartridge remains in aircraft; 7 plastic 1" x 1/32" x ¼" to 2 ½" pieces ejected	2,675	4,810	3,000	4,300
RR-188/AL	1" x 1" x 8" single shot	Chaff dipoles not combat cut to reduce FAA radar interference	No packs; cartridge remains in aircraft	404,073	10,515	340,000	1,000
RR-196 (T-1)/AL	1" x 1" x 8" dual shot; bundled	Chaff dipoles not combat cut to reduce FAA radar interference	Cartridge remains in aircraft; 6 paper packs ejected	40,742	2,370	46,000	1,000

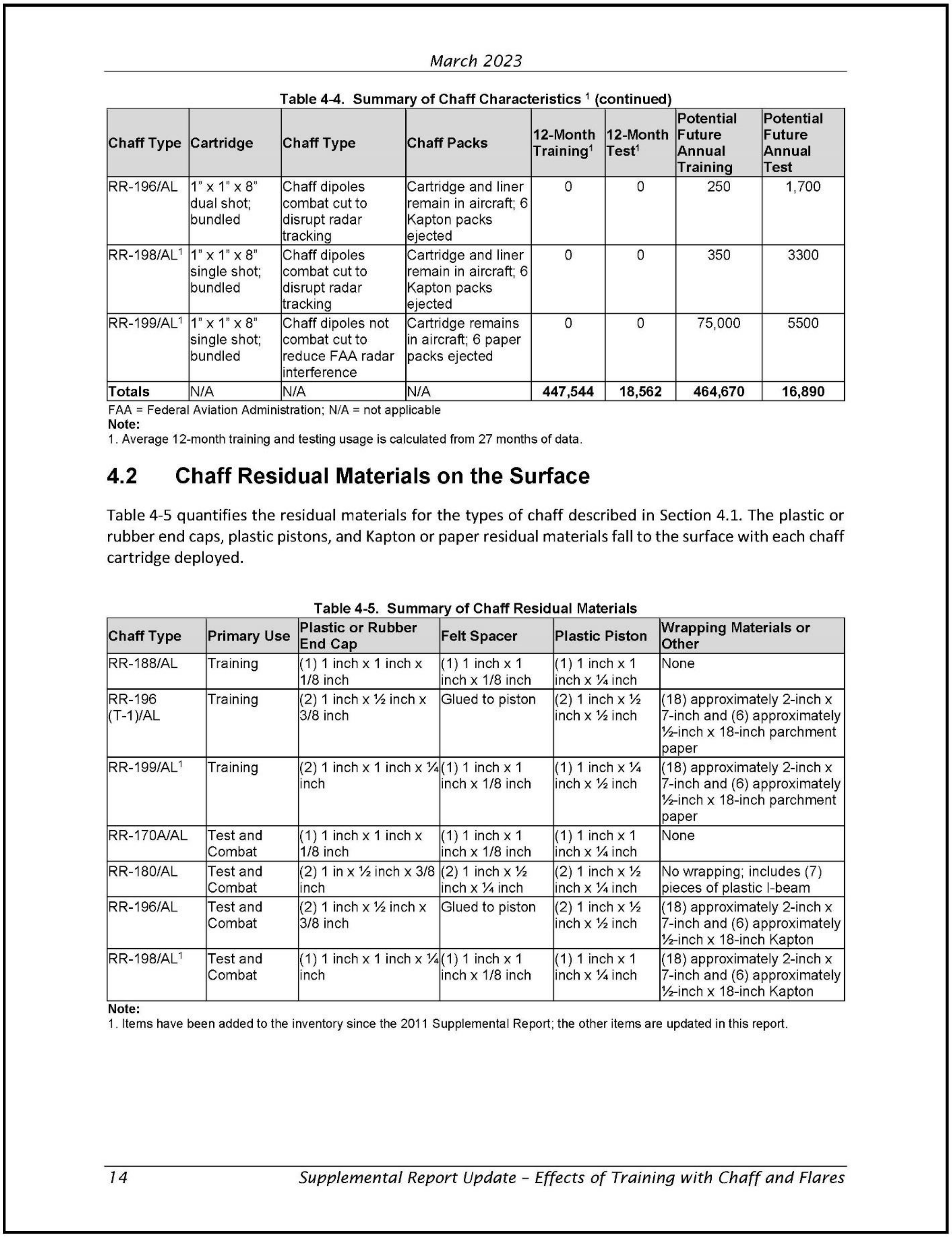


Table 4-4. Summary of Chaff Characteristics [1] (continued)

Chaff Type	Cartridge	Chaff Type	Chaff Packs	12-Month Training[1]	12-Month Test[1]	Potential Future Annual Training	Potential Future Annual Test
RR-196/AL	1" x 1" x 8" dual shot; bundled	Chaff dipoles combat cut to disrupt radar tracking	Cartridge and liner remain in aircraft; 6 Kapton packs ejected	0	0	250	1,700
RR-198/AL[1]	1" x 1" x 8" single shot; bundled	Chaff dipoles combat cut to disrupt radar tracking	Cartridge and liner remain in aircraft; 6 Kapton packs ejected	0	0	350	3300
RR-199/AL[1]	1" x 1" x 8" single shot; bundled	Chaff dipoles not combat cut to reduce FAA radar interference	Cartridge remains in aircraft; 6 paper packs ejected	0	0	75,000	5500
Totals	N/A	N/A	N/A	**447,544**	**18,562**	**464,670**	**16,890**

FAA = Federal Aviation Administration; N/A = not applicable

Note:

1. Average 12-month training and testing usage is calculated from 27 months of data.

4.2 Chaff Residual Materials on the Surface

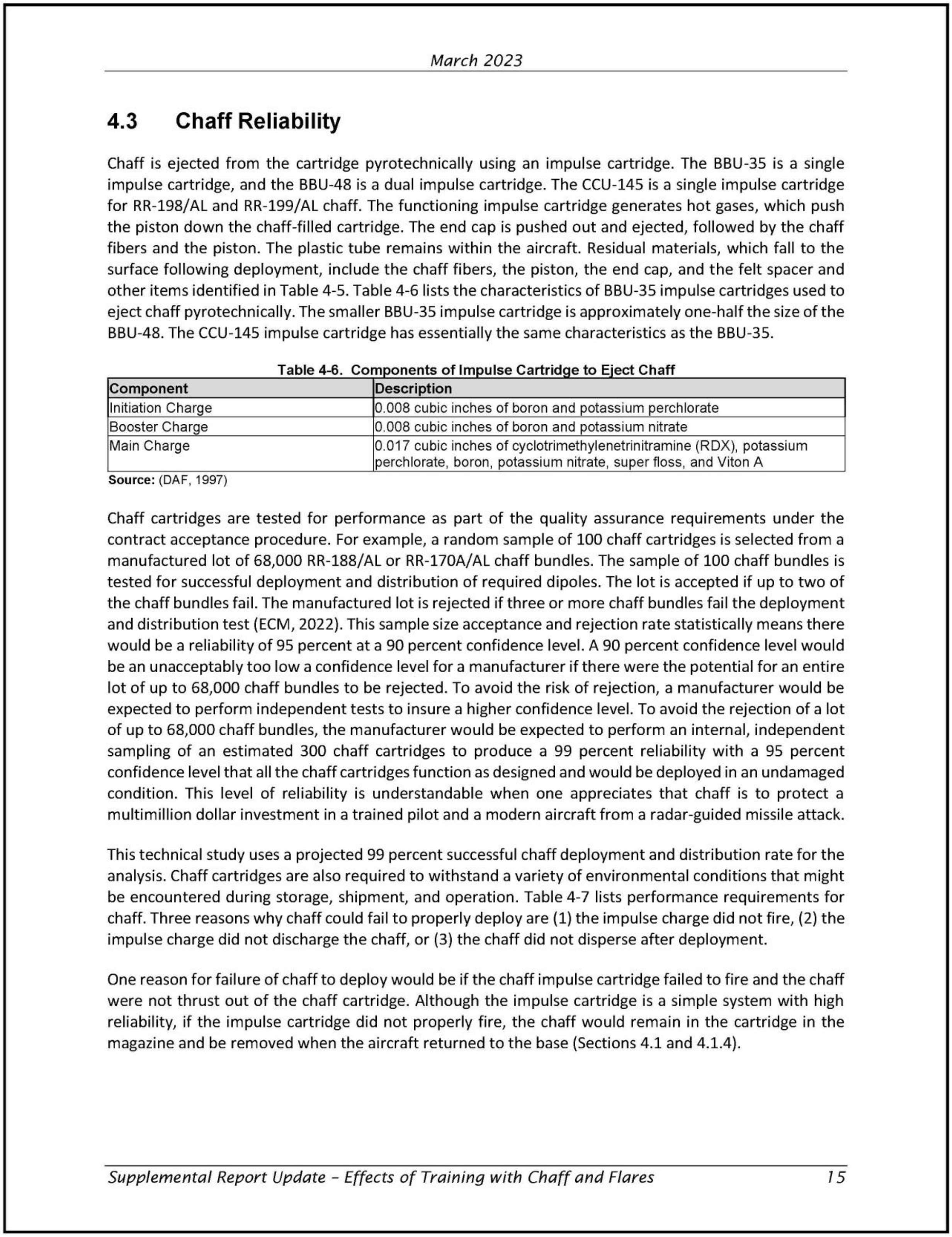
Table 4-5 quantifies the residual materials for the types of chaff described in Section 4.1. The plastic or rubber end caps, plastic pistons, and Kapton or paper residual materials fall to the surface with each chaff cartridge deployed.

Table 4-5. Summary of Chaff Residual Materials

Chaff Type	Primary Use	Plastic or Rubber End Cap	Felt Spacer	Plastic Piston	Wrapping Materials or Other
RR-188/AL	Training	(1) 1 inch x 1 inch x 1/8 inch	(1) 1 inch x 1 inch x 1/8 inch	(1) 1 inch x 1 inch x ¼ inch	None
RR-196 (T-1)/AL	Training	(2) 1 inch x ½ inch x 3/8 inch	Glued to piston	(2) 1 inch x ½ inch x ½ inch	(18) approximately 2-inch x 7-inch and (6) approximately ½-inch x 18-inch parchment paper
RR-199/AL[1]	Training	(2) 1 inch x 1 inch x ¼ inch	(1) 1 inch x 1 inch x 1/8 inch	(1) 1 inch x ¼ inch x ½ inch	(18) approximately 2-inch x 7-inch and (6) approximately ½-inch x 18-inch parchment paper
RR-170A/AL	Test and Combat	(1) 1 inch x 1 inch x 1/8 inch	(1) 1 inch x 1 inch x 1/8 inch	(1) 1 inch x 1 inch x ¼ inch	None
RR-180/AL	Test and Combat	(2) 1 in x ½ inch x 3/8 inch	(2) 1 inch x ½ inch x ¼ inch	(2) 1 inch x ½ inch x ¼ inch	No wrapping; includes (7) pieces of plastic I-beam
RR-196/AL	Test and Combat	(2) 1 inch x ½ inch x 3/8 inch	Glued to piston	(2) 1 inch x ½ inch x ½ inch	(18) approximately 2-inch x 7-inch and (6) approximately ½-inch x 18-inch Kapton
RR-198/AL[1]	Test and Combat	(1) 1 inch x 1 inch x ¼ inch	(1) 1 inch x 1 inch x 1/8 inch	(1) 1 inch x 1 inch x ¼ inch	(18) approximately 2-inch x 7-inch and (6) approximately ½-inch x 18-inch Kapton

Note:

1. Items have been added to the inventory since the 2011 Supplemental Report; the other items are updated in this report.



4.3 Chaff Reliability

Chaff is ejected from the cartridge pyrotechnically using an impulse cartridge. The BBU-35 is a single impulse cartridge, and the BBU-48 is a dual impulse cartridge. The CCU-145 is a single impulse cartridge for RR-198/AL and RR-199/AL chaff. The functioning impulse cartridge generates hot gases, which push the piston down the chaff-filled cartridge. The end cap is pushed out and ejected, followed by the chaff fibers and the piston. The plastic tube remains within the aircraft. Residual materials, which fall to the surface following deployment, include the chaff fibers, the piston, the end cap, and the felt spacer and other items identified in Table 4-5. Table 4-6 lists the characteristics of BBU-35 impulse cartridges used to eject chaff pyrotechnically. The smaller BBU-35 impulse cartridge is approximately one-half the size of the BBU-48. The CCU-145 impulse cartridge has essentially the same characteristics as the BBU-35.

Table 4-6. Components of Impulse Cartridge to Eject Chaff

Component	Description
Initiation Charge	0.008 cubic inches of boron and potassium perchlorate
Booster Charge	0.008 cubic inches of boron and potassium nitrate
Main Charge	0.017 cubic inches of cyclotrimethylenetrinitramine (RDX), potassium perchlorate, boron, potassium nitrate, super floss, and Viton A

Source: (DAF, 1997)

Chaff cartridges are tested for performance as part of the quality assurance requirements under the contract acceptance procedure. For example, a random sample of 100 chaff cartridges is selected from a manufactured lot of 68,000 RR-188/AL or RR-170A/AL chaff bundles. The sample of 100 chaff bundles is tested for successful deployment and distribution of required dipoles. The lot is accepted if up to two of the chaff bundles fail. The manufactured lot is rejected if three or more chaff bundles fail the deployment and distribution test (ECM, 2022). This sample size acceptance and rejection rate statistically means there would be a reliability of 95 percent at a 90 percent confidence level. A 90 percent confidence level would be an unacceptably too low a confidence level for a manufacturer if there were the potential for an entire lot of up to 68,000 chaff bundles to be rejected. To avoid the risk of rejection, a manufacturer would be expected to perform independent tests to insure a higher confidence level. To avoid the rejection of a lot of up to 68,000 chaff bundles, the manufacturer would be expected to perform an internal, independent sampling of an estimated 300 chaff cartridges to produce a 99 percent reliability with a 95 percent confidence level that all the chaff cartridges function as designed and would be deployed in an undamaged condition. This level of reliability is understandable when one appreciates that chaff is to protect a multimillion dollar investment in a trained pilot and a modern aircraft from a radar-guided missile attack.

This technical study uses a projected 99 percent successful chaff deployment and distribution rate for the analysis. Chaff cartridges are also required to withstand a variety of environmental conditions that might be encountered during storage, shipment, and operation. Table 4-7 lists performance requirements for chaff. Three reasons why chaff could fail to properly deploy are (1) the impulse charge did not fire, (2) the impulse charge did not discharge the chaff, or (3) the chaff did not disperse after deployment.

One reason for failure of chaff to deploy would be if the chaff impulse cartridge failed to fire and the chaff were not thrust out of the chaff cartridge. Although the impulse cartridge is a simple system with high reliability, if the impulse cartridge did not properly fire, the chaff would remain in the cartridge in the magazine and be removed when the aircraft returned to the base (Sections 4.1 and 4.1.4).

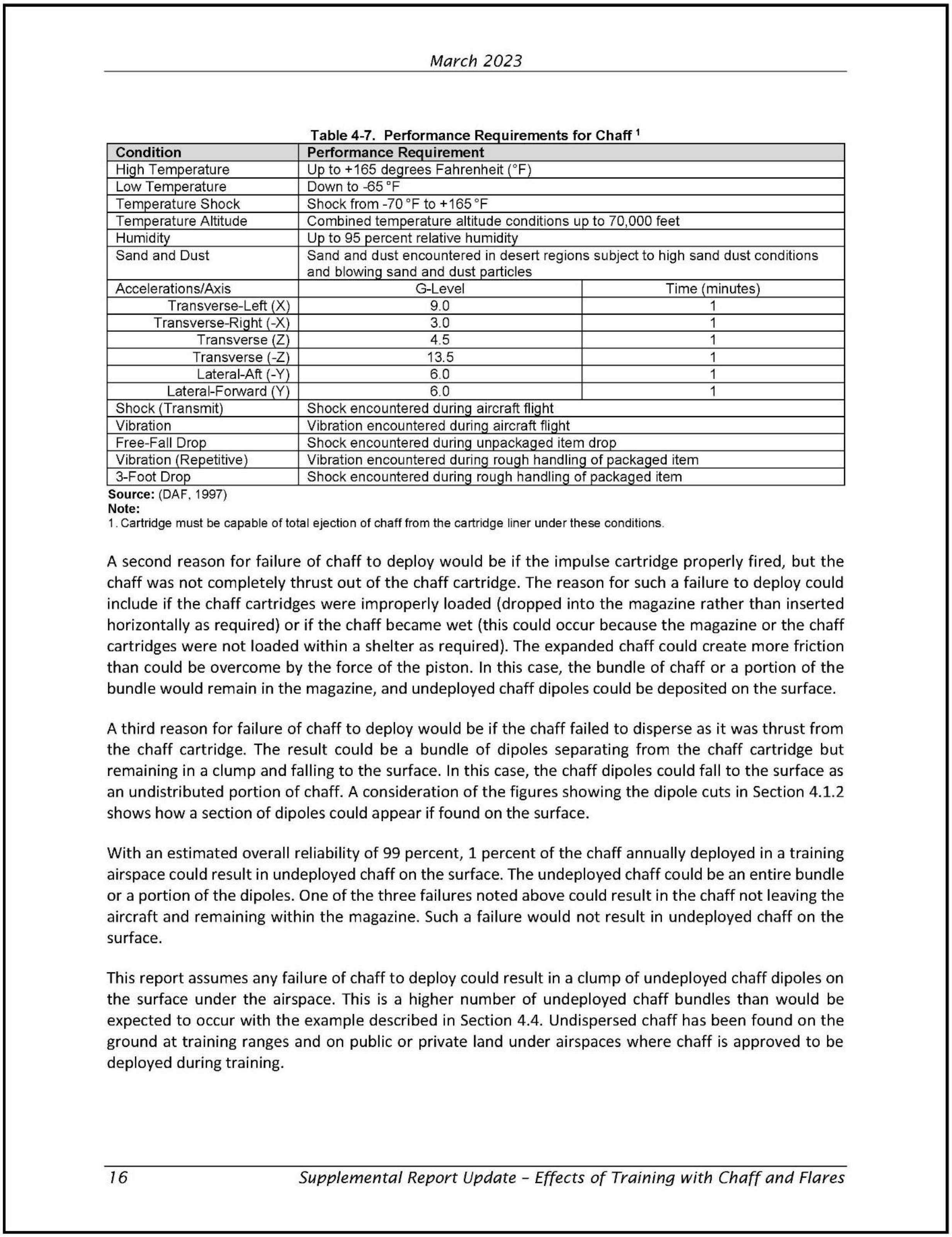


Table 4-7. Performance Requirements for Chaff [1]

Condition	Performance Requirement	
High Temperature	Up to +165 degrees Fahrenheit (°F)	
Low Temperature	Down to -65 °F	
Temperature Shock	Shock from -70 °F to +165 °F	
Temperature Altitude	Combined temperature altitude conditions up to 70,000 feet	
Humidity	Up to 95 percent relative humidity	
Sand and Dust	Sand and dust encountered in desert regions subject to high sand dust conditions and blowing sand and dust particles	
Accelerations/Axis	G-Level	Time (minutes)
Transverse-Left (X)	9.0	1
Transverse-Right (-X)	3.0	1
Transverse (Z)	4.5	1
Transverse (-Z)	13.5	1
Lateral-Aft (-Y)	6.0	1
Lateral-Forward (Y)	6.0	1
Shock (Transmit)	Shock encountered during aircraft flight	
Vibration	Vibration encountered during aircraft flight	
Free-Fall Drop	Shock encountered during unpackaged item drop	
Vibration (Repetitive)	Vibration encountered during rough handling of packaged item	
3-Foot Drop	Shock encountered during rough handling of packaged item	

Source: (DAF, 1997)
Note:
1. Cartridge must be capable of total ejection of chaff from the cartridge liner under these conditions.

A second reason for failure of chaff to deploy would be if the impulse cartridge properly fired, but the chaff was not completely thrust out of the chaff cartridge. The reason for such a failure to deploy could include if the chaff cartridges were improperly loaded (dropped into the magazine rather than inserted horizontally as required) or if the chaff became wet (this could occur because the magazine or the chaff cartridges were not loaded within a shelter as required). The expanded chaff could create more friction than could be overcome by the force of the piston. In this case, the bundle of chaff or a portion of the bundle would remain in the magazine, and undeployed chaff dipoles could be deposited on the surface.

A third reason for failure of chaff to deploy would be if the chaff failed to disperse as it was thrust from the chaff cartridge. The result could be a bundle of dipoles separating from the chaff cartridge but remaining in a clump and falling to the surface. In this case, the chaff dipoles could fall to the surface as an undistributed portion of chaff. A consideration of the figures showing the dipole cuts in Section 4.1.2 shows how a section of dipoles could appear if found on the surface.

With an estimated overall reliability of 99 percent, 1 percent of the chaff annually deployed in a training airspace could result in undeployed chaff on the surface. The undeployed chaff could be an entire bundle or a portion of the dipoles. One of the three failures noted above could result in the chaff not leaving the aircraft and remaining within the magazine. Such a failure would not result in undeployed chaff on the surface.

This report assumes any failure of chaff to deploy could result in a clump of undeployed chaff dipoles on the surface under the airspace. This is a higher number of undeployed chaff bundles than would be expected to occur with the example described in Section 4.4. Undispersed chaff has been found on the ground at training ranges and on public or private land under airspaces where chaff is approved to be deployed during training.

4.4 Chaff Fibers and Residual Materials on the Surface

The estimated number of chaff bundles that would be expected to reach the surface without dispersing can be calculated using a representative scenario with a representative quantity of chaff deployed during training, a representative area under the airspace, and a reliability rate of 99 percent. As an example, assume 20,000 chaff bundles were deployed annually in a representative training airspace overlying a 2,000-square-mile area. The chaff is assumed to be deployed randomly within the airspace and the chaff dipoles are assumed to settle to the ground within the 2,000 square miles. These assumptions result in a calculated 200 (0.01 x 20,000) bundles of undispersed chaff, each weighing up to 3.35 ounces, or an estimated annual average of one bundle of undispersed chaff fibers per 10 square miles per year. If an undispersed chaff bundle were to split into three sections, there could be three clumps of 1.1 ounces of undispersed chaff per 10 square miles annually. Undispersed chaff has been found by researchers on ranges where chaff is deployed and by ranchers on lands under training airspace evaluated for chaff use (DAF, 1997).

The weight of chaff fibers in RR-188/AL chaff is 3.35 ounces per bundle. If all the bundles deployed, the 20,000 chaff bundles over a 2,000-square-mile area would result in approximately 4,187.5 pounds of chaff distributed randomly over that area. This would be an approximate annual average of 0.052 ounces ([3.35 ounces x 20,000 bundles] / [2,000 square miles x 640 acres per square mile]) of chaff dipoles per acre per year. Training aircraft can, and do, deploy chaff as a defense anywhere throughout a training airspace, and, depending on the altitude where chaff is deployed and the atmospheric conditions, chaff may drift for an extended distance. In realistic training, a pilot deploys chaff when threatened by radar. Improvements in radar threats increase the distance from a threat where a pilot must deploy chaff, meaning that chaff could be deployed wherever there is a hostile radar threat. For the purpose of this report, random radar threats are assumed possible anywhere within the training airspace.

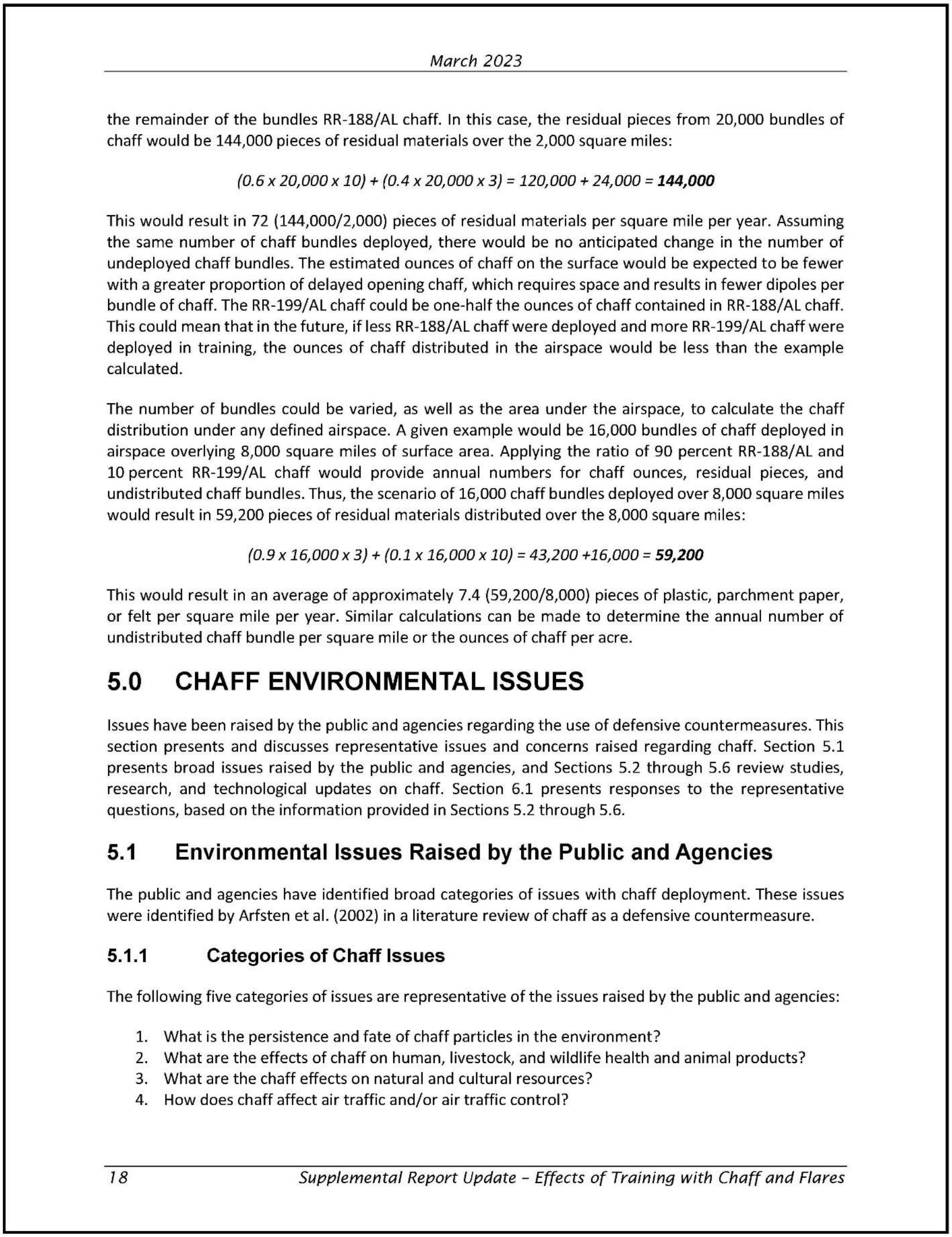
The number of plastic, felt, or paper residual pieces under the airspace can be calculated by assuming that all the chaff deployed and that all the plastic and felt materials settled to the surface under the representative 2,000-square-mile airspace. This assumption overstates the deposition of chaff dipoles under the airspace because the dipoles may drift for 100 miles or more before resting on the surface. The residual plastic, felt, and paper pieces are heavier and would descend directly to the surface under the airspace. There are three residual pieces from RR-188/AL chaff, which comprised 90 percent of the chaff used in training in the year 2020. Assuming the other 10 percent of chaff used in training would be the RR-199AL chaff, which has 10 residual pieces, the total pieces of residual materials can be calculated for this scenario. Deploying 20,000 chaff bundles over 2,000 square miles would result in the following calculation of pieces of residual materials per year:

$$(0.9 \times 20{,}000 \times 3) + (0.1 \times 10 \times 20{,}000) = 54{,}000 + 20{,}000 = \mathbf{74{,}000}$$

Over a 2,000-square-mile area, 20,000 bundles of chaff would result in an average of approximately 37 pieces of plastic, paper, or felt per square mile per year or an average of one piece per 17.3 acres per year.

4.5 Calculating Variations in Chaff Bundles or Surface Area

The calculations in Section 4.4 can be used to estimate any variation in the distribution of chaff and chaff residual pieces for any airspace under consideration. For example, training with different aircraft types could increase in a 2,000-square-mile MOA, and 60 percent of the chaff would be RR-199/AL chaff, with



the remainder of the bundles RR-188/AL chaff. In this case, the residual pieces from 20,000 bundles of chaff would be 144,000 pieces of residual materials over the 2,000 square miles:

(0.6 x 20,000 x 10) + (0.4 x 20,000 x 3) = 120,000 + 24,000 = ***144,000***

This would result in 72 (144,000/2,000) pieces of residual materials per square mile per year. Assuming the same number of chaff bundles deployed, there would be no anticipated change in the number of undeployed chaff bundles. The estimated ounces of chaff on the surface would be expected to be fewer with a greater proportion of delayed opening chaff, which requires space and results in fewer dipoles per bundle of chaff. The RR-199/AL chaff could be one-half the ounces of chaff contained in RR-188/AL chaff. This could mean that in the future, if less RR-188/AL chaff were deployed and more RR-199/AL chaff were deployed in training, the ounces of chaff distributed in the airspace would be less than the example calculated.

The number of bundles could be varied, as well as the area under the airspace, to calculate the chaff distribution under any defined airspace. A given example would be 16,000 bundles of chaff deployed in airspace overlying 8,000 square miles of surface area. Applying the ratio of 90 percent RR-188/AL and 10 percent RR-199/AL chaff would provide annual numbers for chaff ounces, residual pieces, and undistributed chaff bundles. Thus, the scenario of 16,000 chaff bundles deployed over 8,000 square miles would result in 59,200 pieces of residual materials distributed over the 8,000 square miles:

(0.9 x 16,000 x 3) + (0.1 x 16,000 x 10) = 43,200 +16,000 = ***59,200***

This would result in an average of approximately 7.4 (59,200/8,000) pieces of plastic, parchment paper, or felt per square mile per year. Similar calculations can be made to determine the annual number of undistributed chaff bundle per square mile or the ounces of chaff per acre.

5.0 CHAFF ENVIRONMENTAL ISSUES

Issues have been raised by the public and agencies regarding the use of defensive countermeasures. This section presents and discusses representative issues and concerns raised regarding chaff. Section 5.1 presents broad issues raised by the public and agencies, and Sections 5.2 through 5.6 review studies, research, and technological updates on chaff. Section 6.1 presents responses to the representative questions, based on the information provided in Sections 5.2 through 5.6.

5.1 Environmental Issues Raised by the Public and Agencies

The public and agencies have identified broad categories of issues with chaff deployment. These issues were identified by Arfsten et al. (2002) in a literature review of chaff as a defensive countermeasure.

5.1.1 Categories of Chaff Issues

The following five categories of issues are representative of the issues raised by the public and agencies:

1. What is the persistence and fate of chaff particles in the environment?
2. What are the effects of chaff on human, livestock, and wildlife health and animal products?
3. What are the chaff effects on natural and cultural resources?
4. How does chaff affect air traffic and/or air traffic control?

5. Is there a potential for injury from falling chaff residual pieces of plastic or nylon?

In 2019, the Center for Biological Diversity represented the issues identified in Arfsten et al. (2002) as:

1. The drift of chaff (which can affect radar or the distribution of chaff fragments: Arfsten et al. #1 and #4)
2. Chaff's impact on waters and species in marine or terrestrial environments (Arfsten et al. #2 and #3)
3. Potential for inhalation of chaff fibers or degraded chaff that has accumulated over time (Arfsten et al. #1 and #2) (Center for Biological Diversity, 2019)

This report considers the available studies and presents responses to each of the five concerns noted in 2002 (Arfsten et al., 2002) and repeated in 2019 (Center for Biological Diversity, 2019). Studies that have been conducted and that address chaff fragmentation and the persistence of chaff particles are presented in Section 5.2. Section 5.3 reviews the aquatic and marine effects of chaff. Section 5.4 considers studies that have addressed the effects on human, livestock, wildlife, and cultural resources. Section 5.5 reviews the effects of chaff on radar images, with an explanation of FAA radar upgrades. Section 5.6 presents the risk effects of chaff residual materials ejected whenever a bundle of chaff is deployed.

5.1.2 Chaff Representative Questions

In addition to the broad categories, the public and agencies have asked specific questions about chaff use and about chaff effects in the environment. Examples of these representative questions include those listed below: What would be the visual effects from chaff or chaff residual materials?

1. Would chaff affect water and soil where the pH is high to very high in alkaline?
2. What are the health risks from ingesting chaff residual materials?
3. What are the health risks from airborne chaff?
4. What are the frequency and amount of chaff drops over Tribal lands?
5. Could chaff use create airborne Foreign Object Debris (FOD) hazards?
6. Could chaff materials impact the economic value of wool?
7. Would chaff materials affect birthing animals?
8. What are the near-term and long-term impacts from chaff use?
9. Why is chaff use limited to 60 nautical miles (NM) from airfield radar?
10. Will chaff be distributed evenly throughout the airspace, or will it be concentrated within routine training areas?
11. Can the amount of chaff deployed be quantified?
12. How does the use of chaff affect air quality?
13. Will chaff use impact important species, such as the sage grouse or desert pronghorn?
14. Can chaff use be limited to winter months to avoid the peak fire season?
15. Will the DAF provide chaff education to fire investigators?

Each question is answered in Section 6.1, following review of the research, studies, and updated information in Section 5.2 through Section 5.6.

The General Accounting Office (GAO) reported that a variety of studies on the effects of chaff has been conducted over the past 40 years for the Army, Navy, DAF, National Guard Bureau, and Canadian Forces Headquarters (GAO, 1998). Studies addressed the effects on livestock due to ingestion of chaff (Barrett & MacKay, 1972), the effects from the deposition of chaff fibers on marine ecosystems (Wilson et al., 2002), the effects of chaff fibers on sensitive species (Marr & Velasco, 2005), and the reflective effects of chaff on FAA radars and air traffic as observed by the National Weather Service (NWS) (NWS, 2016). The extent of chaff fragmentation after deployment and the potential for chaff particle resuspension following settlement to the surface were addressed by Arnott et al. and Cook (Arnott et al., 2002; Cook, 2002). In the late 1990s, ACC prepared a research study on the environmental consequences of chaff and other defensive measures (DAF, 1997). None of the studies demonstrated significant environmental effects from the use of training chaff as a defensive countermeasure.

Prior studies addressing the environmental effects of chaff were completed, in most cases, prior to the advent of delayed opening chaff. This Report Update considers the potential environmental effects of delayed opening chaff and the residual materials associated with current projected chaff expected to be deployed during pilot training in DAF training airspace in the 50 states of the United States. The following sections address each of the five broad categories of issues and provide information on published and unpublished reports addressing the environmental issues raised by the public and agencies.

5.2 The Persistence and Fate of Chaff Particles in the Environment

The potential for effects of chaff deposition and fragmentation in the environment has been of interest to the public and land management agencies for years. In the 1980s, the concern often dealt with Vietnam-era chaff, which consisted of visible aluminum foil strips weighted with lead coating. That type of foil chaff is no longer effective and has been replaced by the very fine angel hair chaff in the photographs of chaff in Section 4.0.

5.2.1 History of Questions Regarding the Persistence and Fate of Chaff in the Environment

In response to continuing concern from private citizens regarding the military's use of defensive chaff, Senator Harry Reid (Nevada) requested that the GAO conduct an independent evaluation of chaff use. The subsequent report, *Environmental Effects of RF Chaff: A Select Panel Report to the Undersecretary of Defense for Environmental Security* (Spargo, 1999), acknowledged that citizens and various public interest groups continued to express concerns of potentially harmful or undesirable effects of chaff on the environment. The report recommended that the Secretaries of the Air Force, Army, and Navy determine the merits of open questions made in previous chaff reports to determine whether additional actions were needed to address them. Arfsten et al. (2002) noted that the first three categories of concern were especially considered in the GAO's independent Select Panel Report.

The Select Blue Ribbon Panel of independent, non-government scientists reviewed the environmental effects of RF chaff used by the U.S. military and made recommendations to decrease scientific uncertainty where significant environmental effects of chaff were possible. The report of the Blue Ribbon Panel (Spargo, 1999) identified a variety of issues of interest, presented resolutions to some issues, and included specific recommendations for the further evaluation of the environmental effects of chaff use.

One recommendation was to document the fate of chaff fibers after being deployed from the training aircraft. The Blue Ribbon Panel requested additional data on two issues (Spargo, 1999):

- **Atmospheric Effects** – What fraction of emitted chaff breaks up from mid-air turbulence into respirable particles?

- **Ground Effects** – What fraction of chaff reaching the ground is subsequently abraded, resuspended, and reduced to respirable-sized particles?

Three independent studies were conducted in response to the Blue Ribbon Panel identification of chaff fragmentation and resuspension as potential environmental issues. Arnott et al. (2002) performed fluidized bed tests for the Desert Research Institute to simulate chaff fragmentation and resuspension in the atmosphere. The study was designed to directly address the mid-air breakup and the potential for ground degradation, to determine if chaff breaks up into respirable-sized particles (Arnott et al., 2002).

Cook (2002) addressed chaff fragmentation and resuspension in atmospheric chaff fragmentation tests using a fluidized bed to simulate chaff fragmentation in the atmosphere and after surface degradation. The Cook fragmentation tests for ground chaff used a fluidized bed (wind tunnel) in a portable environmental chamber to simulate chaff fragmentation in the air and after it falls to the surface. Accelerated fragmentation on the surface was subsequently simulated using a vehicle and cattle (Cook, 2002).

Gillies and Nickling (2003) addressed chaff resuspension using series of portable wind tunnel tests to examine the propensity of chaff to become blown by wind, by defining the relationship between the threshold friction velocity of chaff and aerodynamic roughness of surfaces onto which chaff may deposit.

5.2.2 Mid-Air Turbulence Effects in the Atmosphere

Chaff in the military training environment is typically released at altitudes below 30,000 feet above ground level (AGL). Chaff has been found to be normally deposited on the ground within 10 hours of deployment (Arnott et al., 2002). Chaff clouds have been found to travel great distances, depending on atmospheric conditions. Atmospheric fragmentation, which appears to occur, takes place within the first 2 hours of release, likely immediately after release, when the density of fibers within the cloud is at its greatest. The Arnott et al. (2002) findings suggest that, in the simulated mid-air column, relatively little fragmentation occurs between 2 and 8 hours after release.

The Arnott et al. and Cook studies gathered information on the potential for chaff fragmentation between the time of its release and its deposition on the ground (Arnott et al., 2002; Cook, 2002). For both studies, a fluidized bed was used to simulate higher concentrations of chaff with higher turbulence than expected to be encountered by chaff fibers in the mid-air column following release during training missions. A quantity of chaff fibers was placed into the fluidized beds and agitated with fans from a few minutes to 24 hours. Data were collected on particle size distribution (PSD) of chaff fragments in a coarse range (greater than 2.5 millimeters) and fine range particulate matter less than or equal to 10 microns in diameter (PM_{10}) or fragments less than 10 microns.

Visual observation of the chaff fibers following treatment in the fluidized bed suggests that most fibers were unaffected or only marginally fragmented by the simulated intense mid-air treatment. Arnott et al. (2002) suggested that the chaff mass and velocity are insufficient to result in fragmentation from chaff fibers colliding in the atmosphere with other chaff particles. Though not extensive, the accelerated tests found that some atmospheric fragmentation occurred in both size ranges studied (greater than 2.5 millimeters and less than 10 microns). With regard to coarse fragments, the number of fragments in the 2.5 to 6.1 millimeter size class remained relatively constant over the first 8 hours of testing but increased substantially after 24 hours of testing. This increase coincided with a decrease in the contribution of fragments greater than 12.8 millimeters. A similar pattern was noted in the PM_{10} data. The fraction of fragments in the coarsest size class (greater than 4.5 micrograms) was relatively constant over the first 8 hours of testing but decreased substantially in the 24-hour tests. At the same time, the fraction of fibers in the finest size category (less than 1 microgram) was relatively constant over the first 8 hours of testing but increased substantially after 24 hours (Arnott et al., 2002; Cook, 2002).

5.2.3 Surface Effects – Evaluation of Chaff Fragmentation Following Deposition

The question has been raised whether chaff on the ground can be resuspended in particulate size that is respirable (GAO, 1998). Baseline sampling results from the Arnott et al. (2002) study indicated minimal chaff concentrations (1 microgram per square foot) in the soil of an area heavily utilized for military aircraft training deploying chaff. This may indicate that naturally occurring materials are the same as chaff materials, and normal wind-driven turbulence, surface fragmentation, and dispersal of any PM_{10}-size particles explain minimal chaff concentrations. In essence, chaff particles, once on the ground, appear to rapidly fragment and become indistinguishable from native soil.

Following deposition on the ground, chaff is subjected to various physical processes that may resuspend the chaff. Resuspension could break the individual chaff dipoles into fragments. Processes that may induce fragmentation include wind-driven re-suspension and deposition, wind-driven interaction with soils, wind-driven interaction with plants, disturbance by animals, and vehicular traffic. Processes that may induce fragmentation in water include both wind and wave action. Gillies and Nickling (2003) performed a field study to evaluate the relationship of wind and surface roughness to the possibility of chaff becoming resuspended following contact with the surface. Arnott et al. and Cook performed field studies to evaluate the relative importance of natural and accelerated physical processes that could result in resuspension of chaff fragments and to address different test approaches for evaluation of post-deposition fragmentation of chaff (Arnott et al., 2002; Cook, 2002).

The primary constituents of chaff are silica and aluminum, which are Two of the three most common elements in Earth's crust and soils. The component of chaff that has the potential to affect soil or water chemistry is aluminum, which tends to break down in acidic and highly alkaline environments. Aluminum is the most abundant metallic element in Earth's crust and is a common constituent of soils. Modern chaff is composed primarily of very fine silica fibers coated with aluminum to achieve its radar-reflective properties (Arfsten et al., 2002). Chaff also contains trace amounts of iron, copper, magnesium, and zinc. Chaff fibers are coated with stearic acid to prevent clumping during deployment. Stearic acid (octadecanoic acid) is a saturated fatty acid derived from animal and vegetable fats and oils (Heryanto et al., 2007). Stearic acid has been used in the development of drug delivery systems because it is considered to be inert, inexpensive, and biocompatible, as well as of a low toxicity.

Laboratory and field analyses (DAF, 1997) indicate that the pH of water in the soil or in a water body is the primary factor that determines the stability of the aluminum coating of chaff. The coating is the most soluble and is, therefore, likely to release aluminum if the soil or water pH is less than 5.0 (extremely acidic) or greater than 8.5 (strongly alkaline). In semi-arid conditions, such as those found in much of the western United States, soil pH tends to be neutral to alkaline, and there is usually insufficient water in the region's soils to react with the aluminum (DAF, 1997). Typically, 99 percent of the soils in the western United States have a pH between 5.0 and 8.5, outside the normal range for chaff coating to release aluminum into the soil. The low percentage of soils with a pH within the range to react with the chaff coating of aluminum, in combination with the low water content of soil, results in conditions that would be extremely improbable for detectable aluminum concentrations to be produced from chaff particles that weather on the ground.

Eastern U.S. areas can have localized pH levels below 4.5 and could be extremely acidic. Under such circumstances, the chaff coating of aluminum could break down. As explained in Section 5.4, studies in eastern aquatic environments were not able to detect significant differences in the aluminum concentrations between control sample areas where chaff was not used and heavy chaff use areas (Wilson et al., 2002). Analysis to detect chaff concentration in aquatic and soil environments, where chaff has been deployed for decades, was unable to detect any but a few chaff particles. This result is because chaff on the ground or in aquatic environments breaks down to silica and aluminum and essentially becomes indistinguishable from native soils (DAF, 1997; Cook, 2002).

The Gillies and Nickling (2003) study was carried out in Nevada to examine the propensity of chaff to become resuspended. They deployed a wind tunnel on different surfaces to evaluate the relationship between the threshold friction velocity of chaff and the aerodynamic roughness of surfaces upon which chaff could be deposited. Gillies and Nickling determined that chaff on different surfaces at the Nevada test location required wind speeds of 11 to 17 miles per hour (mph) to be resuspended. They concluded that the conditions for resuspension of chaff at the test sites occur infrequently.

The Arnott et al. and Cook tests (Arnott et al., 2002; Cook, 2002) were designed to determine the extent to which chaff would be fragmented following even infrequent resuspension. The tests released weighed samples of chaff into an environmental chamber and subjected the chaff to simulated high wind-driven resuspension through recirculation for different time periods. Air samples from within the chamber were collected at 30-minute intervals and analyzed for PSD. Soil samples, taken before and after each test, were also analyzed for chaff PSD.

In the natural environment, chaff fragmentation is primarily wind driven. Increasing airflow in these studies resulted in increasing fragmentation, suggesting that higher wind levels in the ambient environment would lead to increased fragmentation (Arnott et al., 2002). Other factors could produce fragmentation. Additional weathering simulation tests were conducted by Cook in which weighed chaff samples were placed on test plots and exposed to accelerated weathering through trampling by livestock for one series of tests or by vehicular traffic in another series of tests. After the accelerated weathering, the fluidized bed environmental chamber was placed over each plot, wind was created to resuspend any fragments, and samples were collected, as was done for the previous tests with the chamber (Cook, 2002).

Results of the Gillies and Nickling (2003) study indicate that, once deposited on the ground, chaff does not easily become resuspended under ambient conditions. If resuspended, Arnott et al. and Cook determined that typically between 5 and 10 percent of the chaff in these tests was reduced to particles less than 10 microns in length over a 2-hour period. In nature, assuming similar processes are at work, most chaff would be expected to be reduced to fragments of less than 10 microns within a matter of days of deposition. It would be difficult to distinguish the resulting particles from ambient silica and aluminum soil materials (Arnott et al., 2002; Cook, 2002).

Farrell and Siciliano (2004) concluded that, given the extremely low concentrations of chaff expected to be encountered in the environment, there is only a remote possibility that chaff could be ingested by humans, livestock, or wildlife. Health hazards associated with fragmented chaff following deployment were deemed to be negligible (Farrell & Siciliano, 2004). Gore (2013) reviewed the available studies and literature addressing chaff, including the Farrell and Siciliano (2004) study. Gore noted that the quantity of chaff deposited, the stability of the chaff fibers, and the surrounding water and soil could affect the environment; however, Gore's review of the studies and tests resulted in the conclusion that any impact of chaff on air or water quality would be minimal (Gore, 2013).

Following review of studies conducted on chaff fragmentation, Farrell and Siciliano (2004) determined that, even though chaff dipoles contain aluminum and other trace metals that can ultimately be leached from the chaff, the amount of chaff needed to raise concentrations of these metals above background levels far exceeds the number of chaff dipoles that can be realistically deposited in a given area of land or body of water (Farrell & Siciliano, 2004).

The overall conclusion from the tests and studies is that the atmospheric dispersion of released chaff does not result in substantial fragmentation (Arnott et al., 2002). Chaff particles fragment on the ground under natural conditions and are not easily resuspended (Gillies & Nickling, 2003). Under accelerated test conditions, the abrasion tests suggested that on the order of one part mass in 107 may be abraded to PM_{10} or smaller over a 5-hour fall period, giving an RF chaff-derived PM_{10} concentration estimate of 3 x 10-10 micrograms per cubic meters. Using fluidized beds and abrasion tests, the studies determined that, in natural conditions, virtually none of the chaff mass would be degraded to respirable size particles of PM_{10} or less.

5.2.4 Review and Comparison of Test Results

The Arnott et al. and Cook studies of chaff fragmentation used a similar fluidized bed apparatus. Fragmentation rates were estimated in both studies at about 0.0001 percent (Arnott et al., 2002; Cook, 2002). While the fluidized bed tests did not allow direct quantification of fragmentation rates, the study results were consistent. These data support the conclusion that mid-air turbulence generated in fluidized bed tests results in a minimal degree of fragmentation. To the extent that these tests reflect conditions encountered by chaff in the mid-air environment, relatively little fragmentation would be expected to occur as chaff descends to Earth. These results suggest that individual chaff fibers approximately 0.3 to 1 inch long by 1/1,000 inch in diameter remain mostly intact during their descent.

Both the Arnott et al. and the Cook studies examined chaff fragmentation over a period approximately representative of the expected maximum duration that the chaff cloud would persist in the atmosphere (i.e., roughly 10 hours) (Arnott et al., 2002; Cook, 2002). The Cook study provided fragmentation data at various time intervals (i.e., 2, 4, 8, and 24 hours). The data for the period most closely corresponding to the life expectancy of the chaff cloud (2 to 8 hours) demonstrated that fragmentation levels appeared to be more or less constant. That is, whatever fragmentation occurred, it took place prior to the initial measurement at 2 hours. It may be that fragmentation was relatively constant over this 2-hour period but had essentially ceased to occur when the 2-hour measurement was made. It is also possible that the observed fragmentation took place at test start-up and immediately dropped off after the first few seconds of testing. This would be equivalent to nearly all atmospheric fragmentation occurring during deployment or within the first few seconds after deployment from an aircraft.

Conditions within the fluidized bed chamber are quite turbulent during the first few seconds of operation, and this momentary turbulence could lead to fragmentation. After a few seconds, conditions within the chamber may stabilize, turbulence may be greatly reduced, and fragmentation could all but cease. This scenario would produce the same experimental results observed in both the Arnott et al. and Cook tests, which would be consistent with the turbulence acting on chaff in the first few seconds following deployment from an aircraft.

Assuming the fluidized bed does indeed mimic conditions within the deployed chaff cloud, the results of the Arnott et al. and Cook studies suggest that the individual chaff fibers are not expected to fragment due to air turbulence alone. Observations performed in the Arnott et al. study that tracked chaff clouds for distances of up to 200 miles suggest that the conclusions derived from the fluidized bed tests have validity. The relative stability of chaff clouds under certain meteorological conditions has been documented by the NWS (NWS, 2016).

When chaff is deposited on the ground surface, one study on surfaces in Nevada found chaff to not become resuspended until wind conditions were in the 11 to 17 mile-per-hour range (Gillies & Nickling, 2003). When chaff was dislodged from the surface and subjected to wind-driven turbulence, substantial fragmentation occurred (up to 25 percent or more over the course of a 2-hour period) (Arnott et al., 2002). The observed airspeeds leaving the environmental chamber in these tests were similar to ambient wind speeds measured by the anemometer; it would seem that turbulence, and interaction with soils and other objects inside an environmental chamber, would be similar to that which chaff fibers normally encounter once they reach ground level. Apparently, in this case, the experimental turbulence not only simulated the naturally occurring turbulence but also simulated the interaction between chaff and soil that resulted in chaff fragmentation. This is consistent with Arnott et al. (2002) and Cook (2002) findings and implies that the turbulence encountered within the mid-air conditions was likely to produce substantially less fragmentation than encountered after contact with winds on the surface.

The experimental data obtained from tests were not sufficiently robust to conclude definitively when most atmospheric chaff fragmentation occurs. Most fragmentation could occur immediately on ejection or within the first 2 hours after ejection. While chaff fragmentation in the Arnott et al. tests appeared to be minor, some fragmentation did occur, and abrasion tests suggest that approximately 1:10,000,000 particles may be abraded to PM_{10} or smaller. The data suggest that this fraction is not a significant factor in the fate of airborne training chaff. Arnott et al. (2002) concluded that virtually none of the airborne chaff was degraded to respirable-size particles of PM_{10} or less. Based on test results from these studies, the risk from airborne chaff abrading to respirable particles prior to the chaff being deposited on the surface is extremely low. In addition, there would be little, if any, risk of chaff degrading to respirable particles from resuspended chaff.

5.3 Aquatic and Marine Effects of Chaff

Potential aquatic and marine effects of chaff have been of interest to the DAF and Navy, as well as the Royal Canadian Air Force, for many years. Aquatic environments are sensitive to chemicals released from any sources. The questions asked regarding chaff in an aquatic environment deal with the dissolution of the chaff in a freshwater or marine environment; the potential for environmental effects from the wrapping for delayed opening chaff; the potential for release of chemicals from chaff, which could be mobile within the aquatic ecosystems; and the potential sensitivity of aquatic organisms to released chemicals (Farrell & Siciliano, 2004).

Confined aquatic habitats could be affected if there was a potential for significant accumulation and decomposition of chaff fibers. Since chaff was found to be broadly distributed with a low density in any one area, it is unlikely that deployed chaff would be detectable or would significantly accumulate within confined water bodies. Water bodies in the western United States are neutral-to-slightly alkaline in pH (similar to ambient soils) and are outside the pH range necessary to degrade the aluminum coating. The low pH of some eastern areas could increase the solubility of aluminum from chaff, although any increased aluminum solubility from a chaff bundle would not be adequate to be detected within the water body, as described below.

The potential toxicity from chaff was addressed in the 1997 Report (DAF, 1997). The tests of potential chaff leachates applied a series of surrogate environment treatments to samples of aluminum-coated glass-fiber chaff. Each sample was reacted with four extracting solutions designed to simulate acidic (pH 4), neutral (pH 7), alkaline (pH 10), and marine (synthetic seawater) conditions. A modified toxic characteristic leaching procedure was used for the extractions. Chaff extracts were analyzed for presence of aluminum, magnesium, copper, manganese, titanium, vanadium, zinc, boron, and silicon. Among the elements examined in chaff, only aluminum and copper have the potential for sufficiently high concentrations to be of concern in aquatic environments. The minute quantities of magnesium, boron, manganese, titanium, vanadium, and silicon possible to be derived from chaff are less than values known to cause toxicity to aquatic organisms.

Aluminum solubility and toxicity are highly pH dependent. The highest concentrations in the laboratory tests occurred at pH 4 (170 parts per million [ppm]) and the lowest at pH 7 (0.3 ppm). The freshwater acute value for aluminum is 1.496 ppm, and the chronic value is reported as 0.742 ppm for a pH range of 6.9 to 8.2. There are no data available on acute or chronic levels at the extreme pH levels of 4 and 10 used in the laboratory analysis. The extracts from the pH 7 samples, which lie within the 6.9 to 8.2 range, were approximately one-sixth the freshwater acute value for aluminum. These extracted values represent a very high chaff-to-water ratio (1:20), which could not occur in the environment beneath the airspace where chaff is deployed during training. Copper concentrations would be even less than aluminum. If two undeployed bundles of chaff were deliberately placed in a small, confined body of water, the amount of copper introduced would be approximately equivalent to the copper in one penny. It would be effectively impossible for two bundles of undeployed chaff to fall in the same body of water, and the concentration, even in that case, would be below any measure of toxicity (DAF, 1997).

Chaff particles that landed on surface water would be chemically stable and subject to mechanical fragmentation into silica and aluminum. Under normal pH, the decomposition of aluminum in chaff is extremely slow. Only under very high or low pH conditions could the aluminum in an undispersed bundle of chaff become soluble and potentially toxic (DAF, 1997), and few organisms would be present in water bodies with such extreme pH levels. Given the small amounts of aluminum, copper, or other materials in chaff, the quantity of chaff material that could potentially reach a water body, and the normal range of pH in the water bodies, chaff would not result in any discernible impact on bodies of fresh water.

Chaff deposition on marine water surfaces would be subject to physical factors and would be expected to become part of the underlying sediment. The Navy sponsored a series of studies to address the potential for chaff materials to concentrate in the sediment. A series of studies were performed in the Chesapeake Bay to address whether chaff release was contributing to aluminum levels in the Chesapeake Bay (Wilson et al., 2002). An estimated 500 tons of chaff had been deposited over the bay during Navy ship and aircraft maneuvers for both research and training purposes from the mid-1970s to 1995. As part of the Wilson et al. study, sediment sampling locations were tested at various depths to determine whether increased aluminum could be detected when compared with a control area. The control areas that had not been subject to chaff deposition were tested to establish ambient conditions.

The studies found no significant difference in mean aluminum concentrations between the sediments that were from the control site and those taken from areas where there had been decades of heavy chaff use. The results did demonstrate some variation in the types of aluminum at the test and control locations.

Inorganic monomeric aluminum (Ali) concentrations were significantly lower under the chaff use areas than in the background conditions. Mean concentrations of organic Ali were significantly higher in the sediment under the high chaff use area than in the control area. Exchangeable aluminum represents aluminum bound to the soil by an electrostatic charge. Aluminum is exchangeable at a pH less than 5.5 and is a good indicator of soil acidity and of the concentration of potential toxic aluminum present. Exchangeable aluminum concentrations under the heavy chaff use area were numerically lower but not significantly different from those of the control area (Wilson et al., 2002). Sediment sampling in the Chesapeake Bay area did not indicate that aluminum concentrations below military training areas were significantly increased due to chaff use.

Aluminum concentrations in fish, plants, or other biota were not assessed in the sediment survey. Aluminum is not known to accumulate to any great extent in most invertebrates under non-acidic conditions. Under moderately acidic conditions (pH 5.8), two species of Atlantic salmon smolts were exposed to a small $6^{\pm 2}$ micrograms per liter^{-1} (or 0.006 ppm) concentration of inorganic Ali for 3 months. A control population of smolts was not so exposed. The study in Norway determined that even very low concentrations of Ali ($6^{\pm 2}$ micrograms per liter^{-1}) can reduce seawater survival of the two strains of Atlantic salmon. Physiological responses, reduced growth, and reduced marine survival also suggest that the presmolts did not acclimate to the aluminum-acidic water conditions (Kroglund & Finstad, 2003). The aluminum concentrations used in the tests exceeded concentrations that could be expected to result from chaff.

Aluminum toxicity and mortality of caged brook trout were studied in the Adirondack Mountains in New York where acidic conditions sometimes exist during summer months. The study addressed inorganic Ali concentrations, Ali toxicity, and the role of Ali-exposure duration on mortality. Ali concentrations of 2 and 4 micromoles per liter (or 0.054 and 0.108 ppm) represent chronic- and acute-mortality thresholds for brook trout, but prolonged exposure to greater than or equal to 1 micromole per liter (or 0.027 ppm) also produced low-to-moderate mortality levels (Baldigo & George, 2020). These concentrations are greater than could be obtained from chaff in any setting other than a laboratory.

Laboratory tests were conducted to determine the potential concentration of chaff in water bodies. The highest concentrations in the laboratory tests occurred at pH 4 (170 ppm) and the lowest at pH 7 (0.3 ppm). The freshwater acute value for aluminum is 1.496 ppm, and the chronic value is reported as 0.742 ppm for a pH range of 6.9 to 8.2. There are no data available on acute or chronic levels at the extreme pH levels of 4 and 10 used in the laboratory analysis. The extracts from the pH 7 samples, which lie within the 6.9 to 8.2 range, were approximately one-sixth the freshwater acute value for aluminum (or approximately 0.25 ppm). This value represents a very high ratio of one part chaff to 20 parts water. This laboratory ratio could not occur in the environment from chaff.

An entire bundle of chaff weighs approximately 3.35 ounces. This means that if an entire bundle of undeployed chaff were to fall into a 1-acre lake (extremely unlikely) with an average depth of 2 feet, then the concentration of the chaff volume in the lake would be approximately 0.073 ppm, of which approximately 40 percent would be aluminum, and only a minute fraction of that amount would be soluble aluminum. Under extreme assumptions, which would not be anticipated in a natural environment, aluminum toxicity due to chaff would not be a concern in aquatic environments.

It is unlikely that much, if any, of the aluminum present due to chaff use would be available for uptake by aquatic plants, fish, or other biota. The conclusions suggested that deployment of chaff resulted in minimal increases that were statistically significant in nontoxic aluminum in sediment under the flight path or in ship training areas. Concentrations of aluminum of toxicological interest were significantly lower under the heavy chaff use area than in background sediment samples (Wilson et al., 2002). Chaff deployment results in residual plastic materials, which are typically inert (see Section 4.2). Inert residual materials are not expected to impact soil or water body chemistry. As explained in Section 4.1.3.2, parchment paper wrapping used in chaff for low-visibility aircraft training is natural fiber and breaks down within days. Kapton wrapping for test and combat chaff used by low-visibility aircraft would persist in the environment for an extended period, possibility a year or longer.

5.4 Chaff Effects on Humans, Wildlife, Livestock, and Ranches

Public and agency reviewers of environmental documents have questioned the effects of chaff on humans, wildlife, livestock, other agricultural operations, and economic activities. The following sections apply the chaff studies and other information to respond to the list of issues from Section 5.1. Section 6.0 provides conclusions and specific responses to the representative questions in Section 5.1.2.

5.4.1 Chaff Effects on Humans

Arfsten et al. (2002) reviewed scientific data, both published and unpublished, and concluded that there are no data indicating that inhalation or ingestion of chaff or dermal contact with chaff causes any adverse health effects in humans. This conclusion is consistent with the fragmentation and resuspension studies considered in Section 5.2.

Chaff fiber diameters were found to be too large to be inhaled into the lungs (Section 5.2). If inhaled, most chaff fibers would be deposited in the nose, mouth, or trachea and would either be swallowed or expelled. The amount of chaff silica fibers coated with aluminum that could be inhaled would be infinitesimal as compared to ambient dust conditions. Inhalation of chaff fragments would not be in any way comparable to exposure of workers at fibrous glass and mineral wool manufacturing plants. Studies at these plants did not find an association between silica or glass fiber exposure and increased incidence of death from various cancers (Enterline et al., 1983; McDonald et al., 1990). Arfsten et al. (2002) reported that deaths from nonmalignant respiratory diseases were significantly increased among workers at fibrous glass and mineral wool manufacturing plants but were not correlated with exposure to glass fibers. No evidence was found that respiratory disease rates were significantly increased among workers from seven production plants that manufactured man-made vitreous fiberglass (Arfsten et al., 2002; Hughes et al., 1993). No increased risk of mesothelioma has been demonstrated in workers exposed to glass wool, slag wool, or rock wool (De Vuyst et al., 1995). Gibbs et al. (1998) concluded that exposure to fibrous glass is not associated with increased risk of death from nonmalignant or malignant respiratory diseases. The exposure of humans to aluminum-coated chaff under any postulated conditions would be infinitesimal compared to exposure in the Hughes et al., Enterline et al., and McDonald et al. studies.

There were concerns that occupational exposure to aluminum may increase the risk of asthma (Vandenplas et al., 1998) and pulmonary fibrosis (Nemery, 2007). Arfsten et al. (2002) reviewed the literature and could not find any cases of occupationally induced asthma or pulmonary fibrosis among workers involved in the manufacture or handling of aluminum-coated chaff. Even in a manufacturing location where workers would be exposed to orders of magnitude greater quantities of chaff than could be feasible from deployed training chaff, intact chaff dipoles would not be expected to penetrate the lungs and would not be expected to increase human risk of either asthma or pulmonary fibrosis. As explained in Section 5.2, the atmospheric breakdown of chaff fibers results in a very small percentage (1/10,000,000) of respirable particles. On the ground, these particles can become resuspended and fragment, although not to discernible amounts of respirable particles (Section 5.2). Chaff particles fragment and become indistinguishable from ambient soils, which are comprised primarily of silica and aluminum (Section 5.2). Arfsten et al. (2002) could find no instances in which military or personnel exposed to deployed chaff reported adverse health effects or skin irritation associated with possible chaff exposure. Any dust particles, which could include minute amounts of chaff, could irritate the nasal and oral mucus membranes or the eyes. As with any components of soils, direct breathing of quantities of chaff fibers or finding and applying chaff fibers or chaff particles to the eyes should be avoided.

Another question public and agency reviewers of environmental documents have asked is "if chaff could be a potential source of aluminum if a piece of chaff from an open-water area was swallowed." Arfsten et al. (2002) cite several studies and notes that absorption of aluminum by the human gastrointestinal tract is minimal (1 percent), with most being passed out of the body in the feces. Absorbing aluminum from ingested chaff would be considerably less than absorbing aluminum through over-the-counter antacids. An adult would need to ingest about 3 grams of chaff, or approximately 150,000 chaff fibers, to achieve an aluminum dose level that is equivalent to one dose of antacid (Arfsten et al., 2002). Some researchers believe that aluminum may be associated with Alzheimer's and dementia diseases. In the remote chance a chaff fiber was ingested, the aluminum associated with chaff would not be absorbed but be passed out of the body.

5.4.2 Chaff Effects on Wildlife and Other Animals

Chaff and pieces of residual materials are deposited on the surface with each bundle of chaff deployed (Section 4.2). The plastic residual materials are inert and not likely to be seen by species as food. Studies were conducted at the Nevada Test and Training Range (NTTR) in 1997 to learn whether some species of birds or rodents (e.g., pack rats) select chaff residual material for their nests or burrows.

Rodent burrows and nests in areas subject to decades of chaff deployment on the military training range were dismantled. Residual materials were not found in rodent burrows, pack rat nests, or in nesting materials for bird nests (DAF, 1997). As described in Section 5.2, chaff on the surface rapidly becomes indistinguishable from ambient soils. The question has been asked whether chaff residual materials, such as a 1-inch by 1-inch plastic end cap, could be seen as prey by fish. There is no record of a fish consuming such a plastic piece. Should such a piece be approached, it is postulated that a predator fish would treat the plastic piece of an end cap or piston as a shiny pebble. Studies of wildlife nests and burrows in locations subjected to chaff deployment for decades have not found wildlife to display any behavioral responses to collect or use chaff or chaff residual materials. There is no evidence that wildlife behavior is changed by the presence of chaff or chaff residual materials.

Ground surveys were conducted at NTTR and Townsend Range to evaluate the effects of chaff release on wildlife (Arnott et al., 2002). The surveys identified visible chaff residual materials that were present, the number and species of wildlife that were present, and whether chaff materials were used by animals in burrows or birds in nests. Chaff plastic end caps and clumps of chaff that had not deployed correctly were identified during the surveys. Animal abundance and nesting activities were considered normal, and chaff was not found in the nesting material of 12 bird nests. In addition, no visible chaff or residual materials were found on the surface of a small spring at NTTR. Four sediment samples were taken from a spring at NTTR, and one sample contained recognizable chaff fibers. At Townsend Range, chaff that had not deployed correctly was identified along with two plastic end caps. No chaff materials were found in animal burrows excavated at Townsend. The NTTR and Townsend survey conclusions were consistent with the

DAF (DAF, 1997) field studies. The studies found that there was no basis to suggest that chaff would interfere with wildlife behavior or activities.

There would be no basis for suggesting that wild animals would consume chaff dipoles or a bundle of undeployed chaff. As explained in Section 5.4.3, experiments designed to determine whether domestic animals would consume chaff were unsuccessful until the chaff was soaked in molasses. The domestic species refused to eat chaff fibers. Finally, when molasses-soaked chaff was fed to calves, there was no discernible impact to the calves (Barrett & MacKay, 1972).

The question was asked whether airborne chaff could interfere with the echolocation used by bats for navigation and hunting. Chaff does affect radar as described in Section 5.5. The altitude at which bats hunt and navigate is substantially below any concentrations of deployed chaff. The 1997 Report addressed whether airborne chaff could potentially affect the process of echolocation used by bats for navigation and hunting (DAF, 1997). Arnott et al. tracked chaff plumes and determined that the chaff dispersed into small quantities over large areas before it reached ground level (Arnott et al., 2002). Although no studies have been published on the potential effects of chaff on bats, chaff rapidly disperses in the atmosphere, so the concentration of chaff near ground level (where bats hunt) is expected to be very low. Chaff fibers are so small that it is extremely unlikely that the fibers could distort sound waves or interfere with bat echolocation. Chaff is not anticipated to hinder or impede bat navigation or hunting.

Once chaff reaches the ground, the primary potential effects on wildlife include ingestion or inhalation of fibers and direct body contact. External contact with chaff is not expected to be an irritant due to the flexible nature of the chaff fibers. Studies conducted at NTTR in 1997 reported finding no difference in animal abundance and nesting activity in areas where chaff was present. Chaff was not found in rodent burrows or in nesting material of bird nests (DAF, 1997).

Inhalation of chaff fibers is not expected to have negative effects on terrestrial wildlife. Studies have demonstrated that chaff fibers are too large for inhalation and are expelled through the nose or swallowed (DAF, 1997). The probability of an individual animal (livestock or wildlife) or person encountering a single chaff fiber or bundle of fibers is extremely low. During review of environmental studies, public commenters have suggested that larger species such as bison, with their larger nostrils, could inhale greater amounts of chaff. Chaff or chaff particles on or close to the surface, where it could be encountered by mammals, would be so widely dispersed (a maximum of about 3 nanograms per cubic meter) that it could not be inhaled in any quantity by any species. In the remote chance that a chaff fiber or multiple chaff fibers were inhaled, it would be expelled through the nose or swallowed (Arnott et al., 2002).

In 2005, the federally endangered Sonoran pronghorn population was studied to determine whether the exposure of the pronghorn to training chaff was a contributing factor in the population decline on the Barry M. Goldwater Range (BMGR) in southwestern Arizona (Marr & Velasco, 2005). The study examined the oral exposure to chaff by Sonoran pronghorn on the BMGR, Cabeza Prieta National Wildlife Refuge, Organ Pipe National Monument, and Luke Air Force Range. The study sampling results indicated that exposure to aluminum or other metals in chaff would not cause adverse effects to Sonoran pronghorn. Increased chaff detection on the BMGR did not appear to influence the mean aluminum concentrations in soil or sediment. Aluminum concentrations were within Arizona background concentrations (Marr & Velasco, 2005). These findings were consistent with other studies. Chaff dipoles were not substantially differentiable from ambient conditions because chaff silicate and aluminum become indistinguishable from native soils.

The question has been posed whether chaff could affect aquatic or marine species. As explained in Section 5.4.4, a series of studies were conducted to evaluate the potential for toxicity in aquatic and marine environments. Systems Consultants performed surveys and found no evidence that chaff was acutely toxic to six species of aquatic organisms found in the Chesapeake Bay (Systems Consultants, 1977). Haley and Kurnas (1993) conducted studies to determine whether chaff concentrated in freshwater found that very little aluminum was present in water after 200 milligrams of chaff was placed in 200 milliliters of water for 21 days (Haley & Kurnas, 1993). Arfsten et al. (2002) reported on studies to determine the potential mortality of species exposed to greater quantities of chaff than could ever occur in a natural state. Mortality was not significantly increased in Mysid shrimp (*Mysidopsis bahia*) or small, planktonic crustaceans (*Daphnia magna*) placed in the 100 percent water fraction for 48 hours. Mortality was not increased in sheepshead minnows (*Cyprinodon variegates*) placed in the 100 percent water fraction for 96 hours (Arfsten et al., 2002).

The question has been posed whether chaff could affect waterfowl. If waterfowl in ponds or lakes under airspace where chaff is deployed were to ingest chaff fibers, the fibers or particles of chaff would be comparable to sand or other soil materials. Such objects are handled by the gizzard, and incidental chaff fibers would be of no consequence to the health of the bird. A bird would need to ingest a large amount of chaff before the chaff could interfere with the functioning of the gizzard. Although such an event could be postulated as theoretically feasible, the unnatural appearance and texture of undeployed chaff would not be expected to result in it being consumed by waterfowl. There is no documented case of waterfowl ingesting a clump of chaff (DAF, 1997). No data on ingestion of chaff by waterfowl are available, and no known deaths of waterfowl have occurred from ingesting chaff (DAF, 1997).

There is no evidence of increased vegetation uptake of aluminum because of chaff distribution (DAF, 2000). Aluminum is one of the most abundant materials in Earth's crust, and the extremely minute addition of aluminum from chaff would not have a discernible effect on the abundance or availability of aluminum in soils or vegetation. Dispersed chaff, described in Section 4.0, consists of very fine strands of aluminum-coated silica fibers that are thinner than human hair. In general, chaff is released at high altitudes, drifts over very large areas, and is greatly dispersed before falling to Earth's surface. The average deposition of chaff fibers, under the assumptions in Section 4.2, is estimated to average 0.052 ounces of chaff per acre per year. Chaff or chaff particles are normally widely dispersed and do not result in a measurable increase in elemental aluminum in the soils.

External contact with chaff by species is not expected to be an irritant, due to the wide distribution and flexible nature of the chaff fibers. The research studies demonstrate that it would take the ingestion of very large amounts of chaff and unique conditions for chaff to be toxic. As used in DAF training, chaff would be deposited in the environment at rates where chemicals that make up chaff would be nontoxic and rapidly become undetectable from background conditions (DAF, 1997). There was no evidence that chaff was acutely toxic to six representative species of aquatic organisms within the Chesapeake Bay. Chaff fibers are not expected to dissolve in freshwater bodies unless they fall into acidic waters, and even then, concentrations of aluminum or any other metals would not be at toxic concentrations. Since chaff is broadly distributed with low density, it is unlikely that chaff would be detectable or accumulate within any particular wetland. Given this and the mild pH (neither excessively acidic nor excessively alkaline) in most water bodies, it is not expected that the water quality or biological resources would be adversely affected by the use of defensive chaff for DAF pilot training.

Chaff or chaff residual materials from all except Kapton-wrapped chaff for low-visibility aircraft has not been found to have any effect upon soils or water bodies. Studies conducted at NTTR reported finding no difference in animal abundance and nesting activity in areas without chaff compared with areas where chaff had been deployed for decades. Chaff fragments becomes nearly indistinguishable from native soils. Chaff or chaff residual materials were not found in rodent burrows or in nesting material of bird nests. In general, for nearly all chaff components, there is no quantifiable effect of chaff on wildlife or other animals.

5.4.3 Chaff Effects on Livestock and Ranches

Concerns have been expressed by ranchers and others that chaff fibers or residual materials could harm cattle, affect sheep's wool, or otherwise be detrimental to agricultural operations. These concerns have resulted in the preparation of a series of studies and reviews to evaluate the potential effects on agricultural.

A 1972 study by the Canadian Department of Agriculture found no evidence of toxicity in calves fed chaff. The study was unsuccessful in getting calves to eat chaff until the chaff was soaked in molasses and mixed with other feed (Barrett & MacKay, 1972). Six calves were fed a molasses-soaked chaff mixture each day for 14 days. No significant differences were found in the weight gain of calves given chaff versus the weight gain of animals not given chaff. Pathological examination of brains and digestive tracts of chaff-fed animals did not find any evidence of toxicity or mechanical injury. Blood parameter measurements taken at the end of the 14-day period were not significantly different from those taken at the beginning of the test. Fragments of chaff were found in the reticulum, but no evidence was found that the particles invoked a cellular response. Similar studies were conducted in cattle and goats at the University of Wisconsin under contract to the DAF, and these studies found no evidence that chaff ingestion posed a health hazard for farm animals (DAF, 1997).

Ingestion of chaff by either ranch animals or wildlife is expected to be negligible. Studies noted above demonstrated that livestock would avoid eating chaff placed directly into their food and would only consume chaff when coated with molasses and thoroughly mixed with food. The animals that ingested molasses-soaked chaff showed no signs of health effects (Barrett & MacKay, 1972). Since deposition of chaff is expected to be minute from training operations, adverse effects from the highly unlikely ingestion by ranch animals would not be expected.

Once chaff reaches the ground, the primary potential effects on wildlife include ingestion or inhalation of fibers and direct body contact. Chaff released at altitude would drift over a very large area and widely disperse before falling to Earth's surface. Winds at the deployment altitude of chaff would affect drift and deposition. For the example presented in Section 4.4, an estimated one bundle of undispersed chaff per 10 square miles per year may fall to the surface. Such undispersed chaff has been found and identified on military and private lands (AFSOC, 2007). No instance of livestock ingesting a chaff bundle under military training airspace, where chaff has been deployed for decades, has been reported.

Public commenters raised questions about the possibility of chaff or chaff residual materials becoming trapped in sheep's wool or in some way damaging crops. As described in Section 5.2.2 chaff fibers have been found to mechanically fragment and become indistinguishable from soil materials. Sheep's wool is normally processed to remove burrs, soil, or any other foreign materials; thus, the normal process to remove impurities prior to marketing the wool would remove dust particles and any chaff particles in the unlikely event that such chaff particles had fallen on, and in some way remained on, a sheep or other farm animal. Studies performed with electron microscopes to distinguish chaff particles from representative background soils found it nearly impossible to differentiate a chaff particle from a dust particle (Cook,

2002). In the extremely unlikely event that a residual plastic piece fell on a sheep and became enmeshed in their wool, the piece would be removed as a pebble in the normal wool cleaning process.

Questions about whether chaff could harm birthing animals have also been posed. Chaff is inert and would not harm animals including birthing animals any more than existing silicate or aluminum particles in ambient soils would affect birthing animals.

Chaff particles or chaff residual materials in agricultural crops or animal feed would be comparable to naturally occurring soil particles. Any steps to clean soil from the agricultural products would remove any chaff that could be present. Should a plastic residual piece of chaff fall into an agricultural field, it would be with a force equivalent to a small hailstone and be an inert object in the field. It is not expected that the piece of plastic would be processed with food any more than a small stone would become part of the processed food. Normal steps to remove a stone or other foreign material during the processing of the agricultural products for market would remove any chaff residual piece. In the unlikely event that a piece of plastic was somehow baled with animal feed, the piece of plastic would no more be expected to be ingested any more than a stone would be.

Questions have been asked about any potential for a piece of chaff to induce bovine hardware disease. Bovine hardware disease, or traumatic reticuloperitonitis, is caused when a bovine ingests a relatively heavy and sharp object such as a nail or piece of wire. The metal object falls to the bottom of the rumen and is then pushed forward into the reticulum. The reticulum is one of the compartments in the bovine stomach, and its function is not well understood. However, the contractions of the reticulum force the sharp object into the peritoneal cavity where it initiates inflammation. This is a relatively common disease in adult cattle, and magnets are marketed for insertion into the rumen to keep the metal object from causing serious injury. Approximately 9 out of 10 affected cattle are dairy cattle older than 2 years of age. It is believed that dairy cattle are affected because they are fed hay or silage that contains the metal object (Cavedo et al., 2004).

Any residual piece of plastic from chaff is not sharp (see photographs in Section 4.0). The piece of plastic, in the unlikely event that it was consumed, would pass through the digestive tract. Range cattle, including cows and calves, have been grazing on active military ranges for over 50 years. These ranges have been under airspaces where angel hair chaff has been regularly deployed. There is no case of an animal contracting bovine hardware disease from a piece of chaff residual material. In the unlikely event that a plastic piece of chaff residual material was ingested by an animal in a feedlot, the plastic piece would not contribute to bovine hardware disease. As described in Section 5.2, chaff is inert, does not fragment to respirable dimensions in the atmosphere, and rapidly fragments on the surface to become effectively indistinguishable from naturally occurring components of soil.

Ingestion of chaff by either ranch animals or wildlife would be negligible. Studies have been conducted on cattle and goats that showed they would avoid eating chaff placed directly into their food. Calves consumed chaff only when the chaff was coated with molasses and thoroughly mixed with food. Those animals that did ingest the chaff showed no signs of health effects (Barrett & MacKay, 1972). The wide distribution of deployed chaff fibers would not be expected to result in concentrations of chaff. In addition, if chaff bundles failed to deploy, neither ranch animals nor wildlife have been found to ingest chaff, which is essentially soil. Ranch animals or wildlife have not been found to ingest chaff willingly, and no case of such ingestion has ever been documented.

5.4.4 Chaff Effects on Marine Resources

Marine resources include aquatic resources that would be exposed to chaff deposition. Studies were conducted to evaluate the potential for chaff concentrations to be harmful to aquatic organisms in the Chesapeake Bay. The study by Systems Consultants found no evidence that chaff was acutely toxic to six species of aquatic organisms (Systems Consultants, 1977). Concentration of chaff at between 10 to 100 times the exposure levels expected to be found in the Chesapeake Bay were placed in tanks containing a variety of aquatic organisms. American oysters (*Crassostrea virginica*), blue mussels (*Mytilus edulis*), blue crab (*Callinectes sapidus*), and killifish were among the species tested. There was no significance in mortality from exposure to concentrations of chaff of one to two orders of magnitude greater than expected chaff concentrations (Arfsten et al., 2002).

Chaff was not found to result in concentrations of aluminum that would produce environmental impacts in the Chesapeake Bay environment. Part of the reason for this result may be that chaff is comprised of nearly entirely aluminum and silicate, with some trace elements. Aluminum and silicate are the most common minerals in Earth's crust. Ocean waters are in constant exposure to crust materials, and there would be little reason to believe that the addition of small amounts of aluminum and silica from chaff would have any effect on either the marine environment or sediment.

Questions about whether chaff particles could have environmental consequences before becoming part of the sediment have been posed. Chaff particles in the aquatic environment are similar to natural particles produced by sponges. The most abundant ocean shallow-water sponges have siliceous spicules (small spikes) that are very similar to chaff. All freshwater sponges also contain spicules. Sponge spicules are simple, straight, needle-like silicon dioxide spikes, often with sharp pointed ends. Sponge spicules range from 1 to 30 microns in diameter and from 40 to 850 microns in length. Chaff fibers are approximately 25 microns in diameter and can break down to different lengths. Thus, naturally occurring sponge spicules are approximately the same diameter and can be the same length as chaff fibers. Both marine and freshwater sponges are abundant in the environment, and aquatic animals regularly encounter spicules. A variety of species feed on sponges, including ring-necked ducks, crayfish, sea urchins, clams, shrimp, larval king crabs, and hawks-bill turtles. These species do not purposely consume spicules, but they encounter spicules from consuming sponges. Aquatic organisms are regularly exposed to, and consume materials of, the same size and similar composition to chaff fibers (Spargo, 1999). This contact and consumption would reduce the likelihood that free-floating chaff particles would result in environmental consequences.

Delayed deployment chaff has wrappers as described in Section 4.1.3. The new RR-198/AL combat and RR-199/AL training chaff are comparable to RR-196/AL combat and RR-196(T-1)/AL training chaff. The paper wrapping material of the training chaff bundles is specified as recycled paper and is biodegradable when it falls to the surface after deployment. RR-199/AL paper-wrapped training chaff bundles are in contrast to the combat RR-198/AL chaff, which has durable plastic Kapton wrapping materials. A comparison of Quilon-coated parchment paper with Kapton wrapping shows that the parchment-based wrapping material in delayed opening chaff is cellulose-based and coated with Quilon, which contains nontoxic chromium-3. Quilon-treated parchment paper is used as liners for baking pans. The result is that training with parchment-wrapped delayed opening chaff would degrade and have a low-to-no potential for environmental consequences (Section 4.1.3.2).

Kapton, which is a polyimide film, is a durable long-lasting material that, comparable to any long-lasting plastic-like material, requires a long period of time to break down in a marine environment.

Kapton-wrapped delayed opening chaff is used for test and combat conditions (Section 4.1.3.1) and is not normally used over marine environments or public or private lands under the DAF's training airspace. Kapton 2-inch by 7-inch or larger pieces of film are long lasting in the environment and have the potential to be viewed as prey by predators, especially in a marine environment. No specific tests have been conducted to see whether sea turtles would consume Kapton sheets in a marine environment, although there is the potential for a Kapton sheet to have the appearance of a jellyfish and be ingested by a species such as a sea turtle. There are several species of sea turtles, including protected species, under DAF offshore warning areas. An incidental deployment of Kapton-wrapped chaff may not result in an environmental impact. However, there is a potential for significant biological impacts if Kapton-wrapped chaff were regularly deployed over a marine environment in testing or as part of pilot training. To avoid the potential for environmental impact, both RR-198/AL and RR-196/AL delayed opening chaff are used for testing and very limited training over land ranges and are not used for training over a marine environment. The RR-199/AL and RR-196(T-1)/AL chaff are delayed opening training chaff wrapped in biodegradable parchment paper that are used for training in approved airspace over land or marine environments.

Chaff fibers or dipoles in an aquatic environment have not been found to significantly increase the concentration of any toxic aluminum constituents in sediments under airspace that has undergone more than 25 years of military operations deploying chaff. Concentrations of chaff in test environments were not found to result in a significant change in mortality to a variety of marine organisms in the Chesapeake Bay area. No effect was seen in marine organisms exposed to concentrations of 10 times and 100 times the expected environmental exposure. Marine and freshwater sponges normally create chaff-like spicules. Foraging species are exposed to and consume these spicules on a regular basis with no detrimental effect. Chaff release in airspace above an aquatic environment is not expected to affect a freshwater environment and is likely not discernible within the environment.

5.4.5 Chaff Effects on Cultural Resources

Cultural or historic resources could be impacted if chaff or chaff residual materials or an undeployed bundle of chaff altered the visual quality or had a physical or chemical impact that would alter the aesthetic setting of cultural resources. Chaff fibers are widely dispersed and rapidly degrade and are, therefore, not expected to be visible on cultural resources. Chaff fibers are comprised of the naturally occurring aluminum and silica and would not have a chemical impact on cultural resources. Chaff residual materials fall to the ground with each deployed bundle of chaff and could land on structures or sacred sites. The wide dispersion of chaff residual materials would reduce the likelihood of a piece being located in conjunction with a sacred site. The appearance of a foreign object could be perceived as annoying to a visitor to such a site. If a residual piece of chaff or, even less likely, an undeployed chaff bundle were to be found at a site, the residual piece would not physically damage the site and would not represent a significant impact to the cultural resources. Arnott et al. concluded that chaff does not pose a visual long-lasting or permanent threat to the integrity of archaeological or architectural resources (Arnott et al., 2002). Chaff fibers or fragments would not be observable and, if undistributed chaff fibers were found, they may be mistaken for natural elements such as animal fur or plant material. If identified as a piece of man-made material, chaff fibers from an undeployed chaff bundle at a cultural site could be perceived as an unwanted intrusion onto the site. The effect would be expected to be temporary, as fibers generally dissipate within a few days due to mechanical breakdown from wind, sediment erosion, and rain or snow.

Chaff residual plastic materials are typically 1 inch x 1 inch in dimension. The residual materials from chaff fall to the ground in a dispersed fashion and would not be expected to collect in quantities great enough to adversely affect the National Register of Historic Properties status of archaeological or architectural resources. Impacts to traditional cultural resources are more difficult to assess, and no studies have been conducted on traditional cultural resources with regard to chaff residual materials. If a plastic chaff residual piece or undeployed chaff were found and identified in conjunction with a cultural resource or at a traditional resource site, the individual finding the piece may be annoyed.

5.5 Radio Frequency Reflective Effects on Air Traffic

Chaff is designed to interfere with radar so that a maneuvering aircraft can escape a radar lock from opposing systems using radar to target the aircraft. Radar systems transmit electromagnetic, or radio waves, and aircraft reflect the radio waves that can be detected by the radar system. Radar systems are often designated by the RF wavelength or frequency band in which they operate (Parker, 2017). RF is the basis for radar as well as for the communication spectrum, which includes analogue radio, aircraft navigation, marine radio, amateur radio, TV broadcasting, mobile networks, and satellite systems. The RF spectrum ranges from Very Low Frequency in the 3- to 30-kilohertz range through the Medium Frequency range of 300 kilohertz to 3 megahertz up to the Extremely High Frequency (EHF) 30- to 300-gigahertz (GHz) range. EHF bands from 110 GHz to 170 GHz are D bands used in advanced communication systems. The E bands are in the EHF range of 60 GHz to 90 GHz and have directional properties that are widely used for short range signal transmission of voice, video, and data (Baby, 2021). DAF training chaff used in U.S. airspace removes dipoles cut to interfere with the D and E bands so that the training will have little or no effect on communication systems.

Chaff does interfere with radar and radar is important to FAA air traffic controllers and NWS meteorologists in supporting both civil and military flight operations. The use of chaff for training could have RF reflective effects on air traffic as a result of creating an image on FAA, NWS, or commercial radars. Chaff interference with FAA radar was identified as the primary safety concern in the 1998 GAO report. The radars give FAA air traffic controllers and NWS meteorologists the guidance to provide radar information on weather and chaff events to pilots and others (FAA, 2020).

Chaff can interfere with radar because one chaff cartridge deployed from a training aircraft forms an electronic “cloud” approximately 30 meters in diameter in less than 1 second. Multiple cartridges deployed in close proximity by one or more training aircraft can result in the creation of a large electronic cloud. This cloud can persist and migrate depending on the meteorological conditions. Such chaff clouds are visible on FAA and weather radar displays during DAF training operations.

Chaff particles suspended in weather systems could give inaccurate information regarding precipitation or severity of weather conditions. Chaff may create electron interference with lightning strikes to the ground. In 1998, GAO reported that chaff could affect the projection of storm severity (GAO, 1998). The GAO report noted that the Department of Defense (DoD) and FAA have agreed to restrict locations, altitudes, and times at which chaff can be deployed. Those restrictions continue with some modifications to reflect improvements in radar capabilities to differentiate chaff from weather conditions. Substantial improvement in FAA radars have been made since the GAO report was prepared (FAA, 2020).

FAA had upgraded to Airport Surveillance Radar (ASR-11), which is an integrated primary and secondary radar system that has been deployed at terminal air traffic control sites. ASR-11 interfaces with both legacy and digital automation systems and provides six-level NWS calibrated weather capability that provides enhanced situational awareness for both controllers and pilots. The ASR-11 primary surveillance radar system measures the distance of the aircraft from the radar antenna and the azimuth of the aircraft in relation to the antenna. The primary radar also provides data on six levels of rainfall intensity. Trained operators are able to use the radar to distinguish chaff from weather events and provide that information to pilots. The ASR-11 secondary surveillance radar uses a second radar beacon to transmit and receive aircraft data for barometric altitude, identification code, and emergency conditions. Military, commercial, and some general aviation aircraft have transponders that automatically respond to a signal from the secondary radar by reporting an identification code and altitude (FAA, 2020).

Although the NWS has the capability to distinguish different types of radar images, private aircraft owners may not have the systems to distinguish chaff from weather. Chaff used by DAF training aircraft have dipoles cut to lengths designed to not interfere with FAA radar (See Section 4.1.1). RR-188/AL chaff reduces, but does not eliminate, chaff-caused echoes to all weather and other radars. In certain regions of the CONUS, including near DoD training areas in the west and southwest, RR-188/AL chaff was a major radar echo contaminant (Elmore et al., 2004). The chaff echo has been addressed in the first two decades of the 21st Century. FAA has substantially improved the capabilities of the national radar system in terms of distinguishing different types of radar reflective events.

The primary weather surveillance radar operated by the NWS, FAA, and the DoD had been the Next Generation Weather Radar system, which provided Doppler radar coverage. The NWS has added polarimetric capability to existing operational radars to improve the radar's ability to identify and classify hydrometeor types such as rain, hail, and ice crystals and to distinguish non-meteorological types such as chaff (Ryzhkov et al., 2003). Several radar images have distinctive properties that can be differentiated using radar classification algorithms. Ongoing improvements in radar systems permit them to detect RR-188/AL chaff.

Public commenters have asked whether chaff could be deployed at a low enough altitude and under specific meteorological conditions such that chaff particles could be predicted to stay within the surface area under the training airspace. Even if chaff could be localized, many of the areas where chaff is used are in a MOA, and private pilots can traverse an active MOA using "see and avoid" procedures. If the private pilots were using legacy radar, they would experience a radar echo from chaff within the MOA. Furthermore, chaff does not stay within a specific airspace but migrates based on meteorological conditions. By its very nature, chaff is light and designed to remain airborne to permit the evading aircraft to maneuver while the chaff's electronic cloud breaks radar contact. In most cases, both the meteorological conditions and the chaff fall rate are unpredictable. The chaff plume migrates with the prevailing wind at altitudes such that it has not been possible to determine where chaff particles would fall. In a series of case studies designed to track chaff plumes under moderate wind and stable atmospheric conditions, a chaff plume from a release at altitudes between 15,000 to 22,000 feet above mean sea level (MSL) traveled over 100 miles in 2 hours and could be expected to stay aloft for approximately another 3 hours. The total expected distance traveled by the deployed chaff prior to being deposited on the surface could be between 120 and 300 miles or more (Arnott et al., 2002).

Radar systems have continued to become more capable, and the systems now permit trained weather forecasters and air traffic controllers to differentiate chaff from weather events on the radar image. An example of improved radar capabilities is the Multi-Radar Multi-Sensor (MRMS), which was made operational in 2014 at the National Centers for Environmental Prediction (Gerard et al., 2021). The MRMS system consists of an integrated information suite of severe weather and aviation products to provide quantitative precipitation estimation. The MRMS system provides spatial resolution of approximately 1 kilometer, with 33 vertical levels, and is updated every 2 minutes over the CONUS and southern Canada. The MRMS combines data from multiple radar networks, satellites, surface observational systems, and numerical weather prediction models to produce a suite of real-time, decision-support information systems.

In addition to the capabilities to monitor weather, the MRMS system permits an air traffic controller or a weather forecaster to differentiate chaff from weather systems. The MRMS uses dual-polarization data from the radar and automatically removes chaff, which is not meteorological in origin (NWS, 2016). Weather radar transmits radio waves from a large dish antenna and then receives radio waves, which bounce back from chaff and multiple other objects. The radar reflections can include weather such as rain, hail, snow, and combinations of weather events. Other reflective images picked up by the radar include birds, swarms of insects, shifts in wind, and even the sides of mountains (NWS, 2016).

Although chaff can have a very similar radar reflection with older weather radar, it appears very different in some of the new radar products added to the dual-polarizing radar upgrades introduced in FAA radars within the past few years. The difference is most apparent because of the improved radar's ability to differentiate the shape of the reflected image. For example, falling raindrops are generally the same shape and can be differentiated from hail, which are generally irregularly shaped (NWS, 2016).

Individual pieces of chaff are irregularly shaped and tumble as they fall to the surface. The individual pieces of chaff present a variety of cross-sections to the radar. The ability to be able to differentiate chaff from weather has improved the ability to predict weather. Figure 5-1 presents two weather radar images and demonstrates the difference of chaff from weather. In the figure, the left side of the illustration depicts radar reflectivity, which includes showers in green and thundershowers in yellow. This is normally what appears on the weather forecasts that are presented during television weather forecasting programs. The illustration on the right has the same image as on the left, with the system adjustments reflecting the shapes of the different objects. The showers and thundershowers appear on the weather forecaster's radar as red and yellow. The improved radar differentiates the chaff, and it appears blue on the screen (NWS, 2016). This information permits the weather forecaster and the air traffic controller to inform pilots of weather conditions, which could affect their flight altitude or require a change in the flight plan to avoid the weather. The chaff information would permit the pilot to continue on the flight plan.

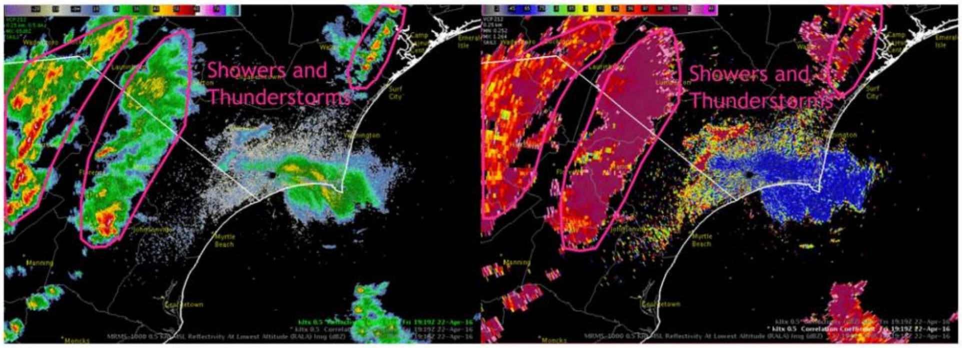


Figure 5-1. Two Reflected Images of Weather Radar, with the Left Image not Clearly Differentiating Chaff from the Rainfall Image and the Right Image Clearly Displaying the Chaff as a Distinguishable (Purple) Image on the Radar (Source: (NWS, 2016))

An anecdotal experience was related by the NWS Wilmington meteorologists on April 22, 2016. Several waves of thunderstorms were moving across North and South Carolina. Public observers of the reflected radar images on their phones (equivalent to the left image in Figure 5-1) called the NWS office to ask how much rain they should expect over the next hour. The NWS meteorologist was viewing both images in the figure and knew the reflection was from chaff, so the surprised caller was informed, "no rain at all" (NWS, 2016).

All radars are not as advanced as the Wilmington NWS office. As a result, FAA has issued directions to air traffic controllers to provide information on chaff clouds as well as severe weather (FAA, 2021). This information is to permit pilots to differentiate weather from chaff and be in a position to request adjustments in their flight plans if required by weather events.

Kurdzo et al. (2018) reviewed suspected chaff clouds from a large radar database, which included 75 cases in 2016. Their study evaluated different radar clouds at different altitudes under different levels of turbulence and with variations in chaff orientation. They determined that, although the reflected image of chaff can resemble weather returns, knowledge of chaff characteristics and different reflectivity permits trained forecasters to detect the difference between chaff and weather (Kurdzo et al., 2018).

The nature of chaff and the diversity of meteorological conditions mean that deployed chaff would continue to be a radar echo contaminant. This echo effect can be partially addressed through improvements in radar, military communication with air traffic control, and communication with NWS meteorologists to identify when and where chaff is deployed. For specific airspace proposals, the DAF has included distance setbacks from airport control radars to deploy defensive chaff. The distance of 60 NM was identified by FAA and the DAF as sufficient distance to safely separate airport radar from training aircraft deploying chaff in the Powder River Training Airspace (DAF, 2010).

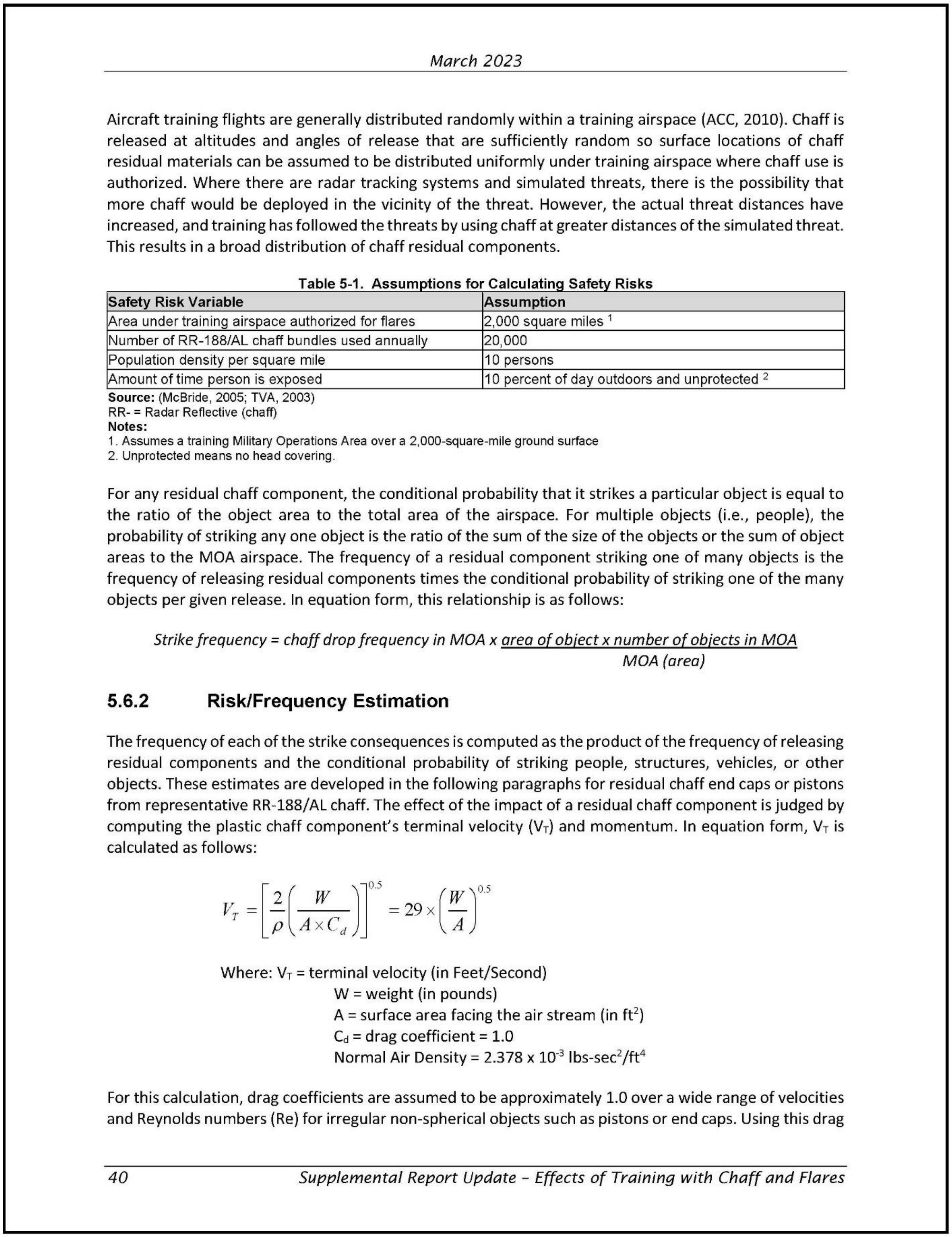
5.6 Potential for Injury from Chaff Residual Materials

Once on the ground, chaff residual plastic pieces are inert and do not have sharp edges that could cause injury. This section addresses whether a falling piece of residual chaff material could pose a safety risk from its weight and geometry.

5.6.1 Assumptions for Risk Calculations

The heaviest chaff residual materials typically consist of a 1-inch by 1-inch by ¼-inch plastic or nylon piston and a 1-inch by 1-inch by 1/8-inch plastic or nylon end cap. A similarly sized piece of felt may also be used as a cushion within the chaff cartridge (Table 4-5). Paper or Kapton wrapping materials have neither the weight nor the shape to result in personal injury from falling wrappers.

The pieces of plastic residual materials have different rates of descent and different impacts when they reach the ground. The likelihood of a strike to a person or object from a plastic piece from chaff would depend on the number of chaff bundles deployed, the area under the airspace, the population density under the airspace, and the proportion of time a person would be expected to be outdoors. This section calculates the likelihood of a piece of chaff residual plastic material striking a person, assuming a rural area with a population density of 10 persons per square mile and 20,000 bundles of chaff deployed per year over a 2,000-square-mile area. The assumptions in Table 5-1 do not reflect a specific location but are an analytical representation of a "typical" airspace training situation designed to illustrate how the risk of a strike to a person is calculated. The assumptions can be varied to reflect a greater or smaller area under the training airspace, the number or type of chaff bundles deployed, and the population density under the training airspace.



Aircraft training flights are generally distributed randomly within a training airspace (ACC, 2010). Chaff is released at altitudes and angles of release that are sufficiently random so surface locations of chaff residual materials can be assumed to be distributed uniformly under training airspace where chaff use is authorized. Where there are radar tracking systems and simulated threats, there is the possibility that more chaff would be deployed in the vicinity of the threat. However, the actual threat distances have increased, and training has followed the threats by using chaff at greater distances of the simulated threat. This results in a broad distribution of chaff residual components.

Table 5-1. Assumptions for Calculating Safety Risks

Safety Risk Variable	Assumption
Area under training airspace authorized for flares	2,000 square miles [1]
Number of RR-188/AL chaff bundles used annually	20,000
Population density per square mile	10 persons
Amount of time person is exposed	10 percent of day outdoors and unprotected [2]

Source: (McBride, 2005; TVA, 2003)
RR- = Radar Reflective (chaff)
Notes:
1. Assumes a training Military Operations Area over a 2,000-square-mile ground surface
2. Unprotected means no head covering.

For any residual chaff component, the conditional probability that it strikes a particular object is equal to the ratio of the object area to the total area of the airspace. For multiple objects (i.e., people), the probability of striking any one object is the ratio of the sum of the size of the objects or the sum of object areas to the MOA airspace. The frequency of a residual component striking one of many objects is the frequency of releasing residual components times the conditional probability of striking one of the many objects per given release. In equation form, this relationship is as follows:

$$\textit{Strike frequency} = \textit{chaff drop frequency in MOA} \times \frac{\textit{area of object} \times \textit{number of objects in MOA}}{\textit{MOA (area)}}$$

5.6.2 Risk/Frequency Estimation

The frequency of each of the strike consequences is computed as the product of the frequency of releasing residual components and the conditional probability of striking people, structures, vehicles, or other objects. These estimates are developed in the following paragraphs for residual chaff end caps or pistons from representative RR-188/AL chaff. The effect of the impact of a residual chaff component is judged by computing the plastic chaff component's terminal velocity (V_T) and momentum. In equation form, V_T is calculated as follows:

$$V_T = \left[\frac{2}{\rho}\left(\frac{W}{A \times C_d}\right)\right]^{0.5} = 29 \times \left(\frac{W}{A}\right)^{0.5}$$

Where: V_T = terminal velocity (in Feet/Second)
W = weight (in pounds)
A = surface area facing the air stream (in ft^2)
C_d = drag coefficient = 1.0
Normal Air Density = 2.378×10^{-3} $lbs\text{-}sec^2/ft^4$

For this calculation, drag coefficients are assumed to be approximately 1.0 over a wide range of velocities and Reynolds numbers (Re) for irregular non-spherical objects such as pistons or end caps. Using this drag coefficient, the computed terminal velocities produce Re values within this range (Re < 2 × 105), which justifies the use of the drag coefficient. The approximate weights and dimensions of chaff components are listed in Table 5-2. A comparison of chaff residual materials from Section 4.2 demonstrates that the dimensions and weights of residual components for RR-188/AL chaff are representative of other types of chaff.

Table 5-2. RR-188/AL Chaff Residual Component Properties

Component	Dimensions (inches)	Weight [1] (pounds)
Piston	1 × 1 × 0.250	0.0043
End Cap	1 × 1 × 0.125	0.0061

RR- = Radar Reflective (chaff)

Note:

1. Estimated weights

5.6.2.1 Terminal Velocity of Chaff Residual Materials

Terminal velocity momentums of the chaff components are computed based on maximum and minimum areas depending on the component's orientation. Actual values of momentum when striking the surface would typically be between the maximum and minimum terminal velocities in Table 5-3. The momentum values are the product of mass (in slugs) and velocity. A slug is defined as the mass that, when acted on by a 1-pound force, is given an acceleration of 1.0 foot per second squared.

Table 5-3. RR-188/AL Chaff Component Momentum

Component	Maximum Surface Area			Minimum Surface Area		
	Area (square inches)	Terminal Velocity (feet/second)	Momentum (pounds/second)	Area (square inches)	Terminal Velocity (feet/second)	Momentum (pound/second)
Piston	1.0	22.8	0.003	0.250	45.6	0.006
End Cap	1.0	27.2	0.005	0.125	76.9	0.015

RR- = Radar Reflective (chaff)

5.6.2.2 Estimated Area of a Person

It is assumed that people who are at risk of being struck by a chaff residual plastic component are outdoors under a MOA or special use airspace. People in structures or vehicles are assumed protected. The dimensions of an average person are assumed to be approximately 5 feet, 6 inches high by 2 feet wide by 1 foot deep (men – 5 feet, 10 inches; women – 5 feet, 4 inches; children – less than 5 feet, 4 inches). The residual plastic piece would be expected to strike ground objects at an angle of 80 degrees or greater to the ground, assuming 80 degrees to the ground allows for possible wind or other drift effects. With the chaff component falling at 80 degrees to the ground, a person's body (5.5 feet by 2 feet by 1 foot) projects an area of 3.9 square feet, normal to the path of the falling component. For this assessment, it is assumed that a person would be outdoors and unprotected 10 percent of the time. The 10 percent of time unprotected includes a person not wearing a hat. This assumption is based on Department of Energy and USEPA national studies (Klepeis et al., 2001; TVA, 2003).

5.6.2.3 Potential Strikes

The frequencies of strikes can be computed based on the data and assumptions discussed above. It is assumed that flight maneuvers to deploy chaff are randomly distributed throughout the training airspace. The equation for the frequency of striking a person is as follows:

$$Injury\ frequency = comp\,drop\ freq \times \frac{body\,area \times pop.density \times Fractunprot \times MOA(areainsqmi)}{MOA(areainsqft)}$$

For the assumptions in Table 5-1, the following calculates approximately 0.006 strikes per year for both plastic pieces of residual material (numbers are rounded):

$$Strike\ frequency = 20{,}000 \,/\, year \times 3.9\ ft^2 \,/\, pers \times 10\ pers \,/\, mi^2 \times 0.1 \times 3.59 \times 10^{-8}\ mi^2 \,/\, ft^2$$

This means that in a representative rural area beneath a MOA used for pilot training, the annual expected person strike frequency would be approximately six persons in every 1,000 years by a piece of 1-inch by 1-inch by ¼-inch plastic. The maximum momentum of the piece of plastic would vary between 0.003 and 0.015 pound-seconds, depending on orientation of the falling piece. In this momentum range, there would be no anticipated injuries, but a person could feel the equivalent effect of a small hailstone.

As a basis of comparison, laboratory experimentation in accident pathology indicates that there is a less than 1 percent probability of a brain concussion from an impulse of less than 0.10 pound-seconds to the head and a 90 percent probability that brain concussions would result from an impulse of 0.70 pound-seconds to the head (DAF, 1997). There is essentially no risk of injury from a falling residual piece of plastic from deployed chaff. There is a very remote possibility of an individual feeling the equivalent of a small hailstone in the unlikely event of a piece of plastic striking a person with a 0.0035 to 0.015 pound seconds of force. In one-half a century of chaff use as a countermeasure during military training, there has been no recorded case of an individual being struck by a plastic piece of residual material.

The relative force of a small Hailstone-type piece of plastic striking any object such as a structure, vehicle, domestic animal, or wildlife would not be expected to have any effect on the structure, vehicle, domestic animal, or wildlife. With an estimated average of one piece of plastic being deposited annually on an area of 30 acres, there would be little likelihood of an animal, such as sheep or range cattle, experiencing the equivalent of a strike by a small hailstone.

The probability of a bundle of chaff landing undeployed on the surface would be directly related to the use of chaff in the training airspace. At an estimated 99 percent reliability rate (Section 4.3), the example of 20,000 chaff bundles could result in 200 bundles of undeployed chaff (Section 4.4). A portion of these bundles would remain as undeployed chaff in the aircraft and would be removed at the base after landing. For the purpose of this calculation, if none of these undeployed bundles remained in the aircraft and all of the bundles or parts of all of the bundles descended to the surface, there could annually be an estimated 200 bundles of undeployed chaff on the surface. The maximum momentum of a bundle of undeployed chaff would be a fraction of the momentum for an end cap, due to the shape of the chaff bundle and aerodynamics. The probability of a person under the representative 2,000-square-mile training airspace being struck by a bundle of undeployed chaff would be an estimated 0.00003 strikes per year or approximately 3 strikes in every 100,000 years. There has never been a recorded account of any individual experiencing a strike from any chaff material.

6.0 CHAFF CONCLUSIONS

Chaff has changed from the initial aluminum strips used during World War II and through the Vietnam era to the angel hair chaff used today. As opposing electronic tracking systems improve, chaff technology has been improving. Angel hair chaff was explained in the 1997 and 2011 reports and continues to be deployed to disrupt radar-directed munitions threats. The angel hair chaff and environmental effects described in the 1997 and 2011 reports continue to be applicable to chaff improvements, such as the delayed opening chaff (RR-198/AL and RR-199/AL), described and evaluated in this 2022 report.

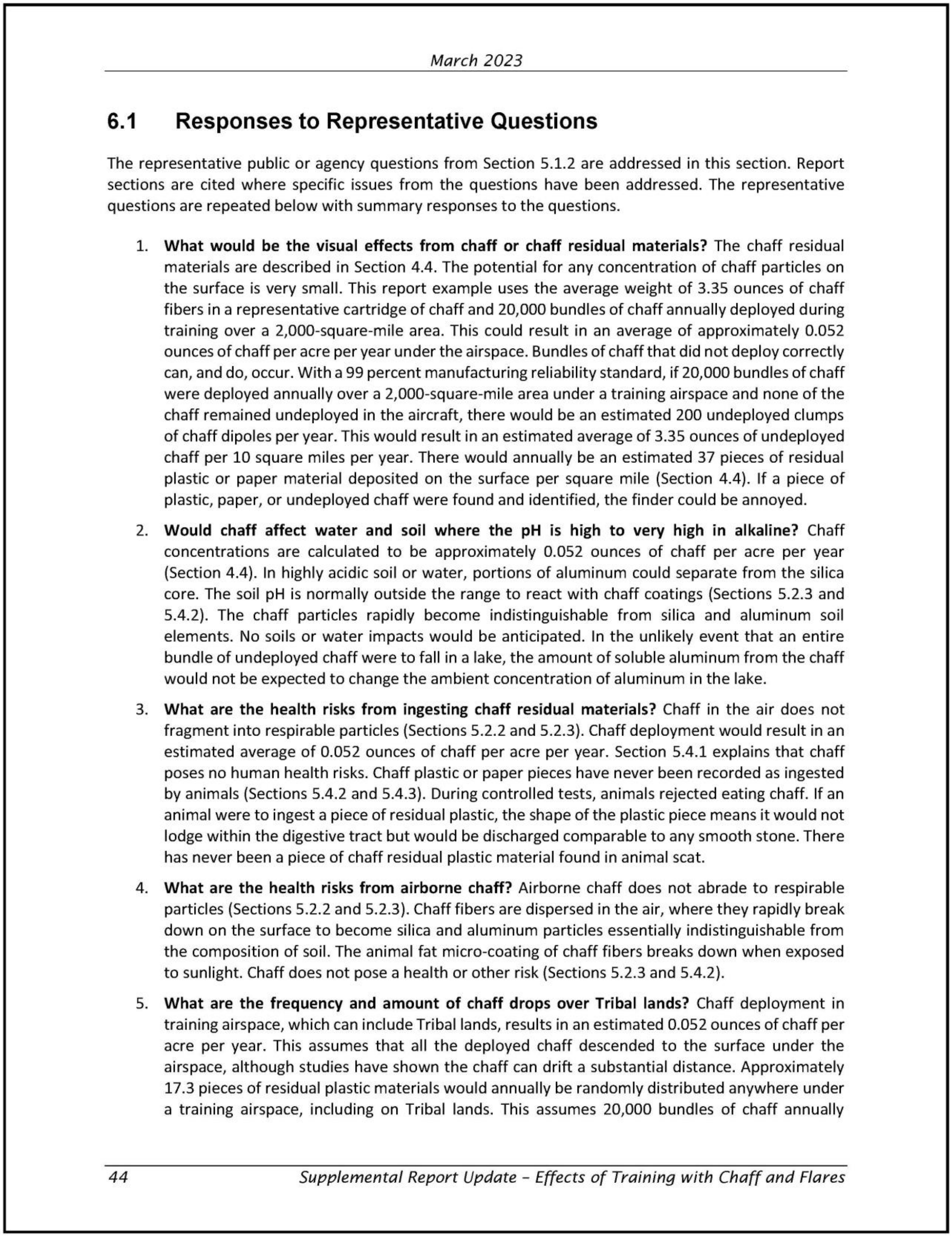
As explained in the 1997, 2011, and this 2022 report, angel hair chaff fibers are each approximately 0.3 to 1.0 inch long and 1/1,000 inch in diameter. The chaff fibers are 60 percent silica and 40 percent aluminum, with trace amounts of other chemicals. Silica and aluminum are abundant elements in Earth's crust. The chaff fibers are coated with Neofat, a natural material that degrades when exposed to light or air. Chaff residual materials are nearly undetectable chaff fibers, two small 1 inch by 1 inch pieces of plastic or felt pieces, paper, or Kapton, depending on the type of chaff in use.

Although large numbers of chaff bundles are deployed by DAF training aircraft in approved training airspace, modern chaff dipoles are very difficult to find, unless the chaff bundle fails to deploy properly and a clump of undeployed chaff is deposited on the surface. As explained in this 2022 study and in the 1997 and 2011 reports, chaff particles are extremely difficult to identify in an environment in which modern chaff has been used for decades. The reasons for the difficulty in identifying chaff particles are because chaff has been found to rapidly fragment on the surface and is composed primarily of silica and aluminum, two of the three most common elements in Earth's crust. Multiple studies to identify chaff particles or to locate elevated concentrations on the ground or in substrate have had very limited success because chaff particles become indiscernible from ambient soil particles (Cook, 2002). No biological effects to terrestrial or marine organisms have been observed even when such organisms were subject to substantially higher concentrations of chaff than could be expected to occur from DAF training. Parchment paper wrapping in delayed opening chaff used for training results in a biodegradable paper material being deposited on the surface. Kapton wrapping for dipoles used in delayed opening chaff for test or combat results in the deposition of pieces of a Kapton film. As explained in Section 4.1.3.1, Kapton is a polyimide thermoplastic material that can degrade less than 18 percent in a year. Less than 1 percent of the total annual chaff deployed will have Kapton wrapping. In 2011, the residual Kapton wrapping was seen as having a potential for environmental impacts and biodegradable parchment paper wrapped delayed opening chaff was developed for training instead of Kapton to avoid potential impacts.

The chaff projected for use by training aircraft is not expected to result in noticeable quantities of material deposited on the surface. Chaff materials are not projected to result in a discernible impact to ground surface or water areas or to sensitive biological species transiting or occupying ground surface or water areas.

Chaff radar reflectivity produces echoes on weather and air traffic radar. Chaff is designed to interfere with electronic monitoring by radar through a mechanized interference with the radar. FAA-upgraded systems and technology advances in software and hardware, as well as personnel training, have permitted trained air traffic controllers and meteorologists to be able to differentiate chaff from weather systems. The improved radar systems, combined with FAA and NWS communication with pilots and DAF agreements with FAA regarding the distances for chaff use from radars and airports, have substantially reduced chaff interference with radar echoes.

Chaff residual materials do not result in impacts on land use, economic activity, or cultural or traditional sites. An individual finding a piece of plastic or chaff that did not correctly deploy could be annoyed. There is no health or safety risk from the use of chaff.



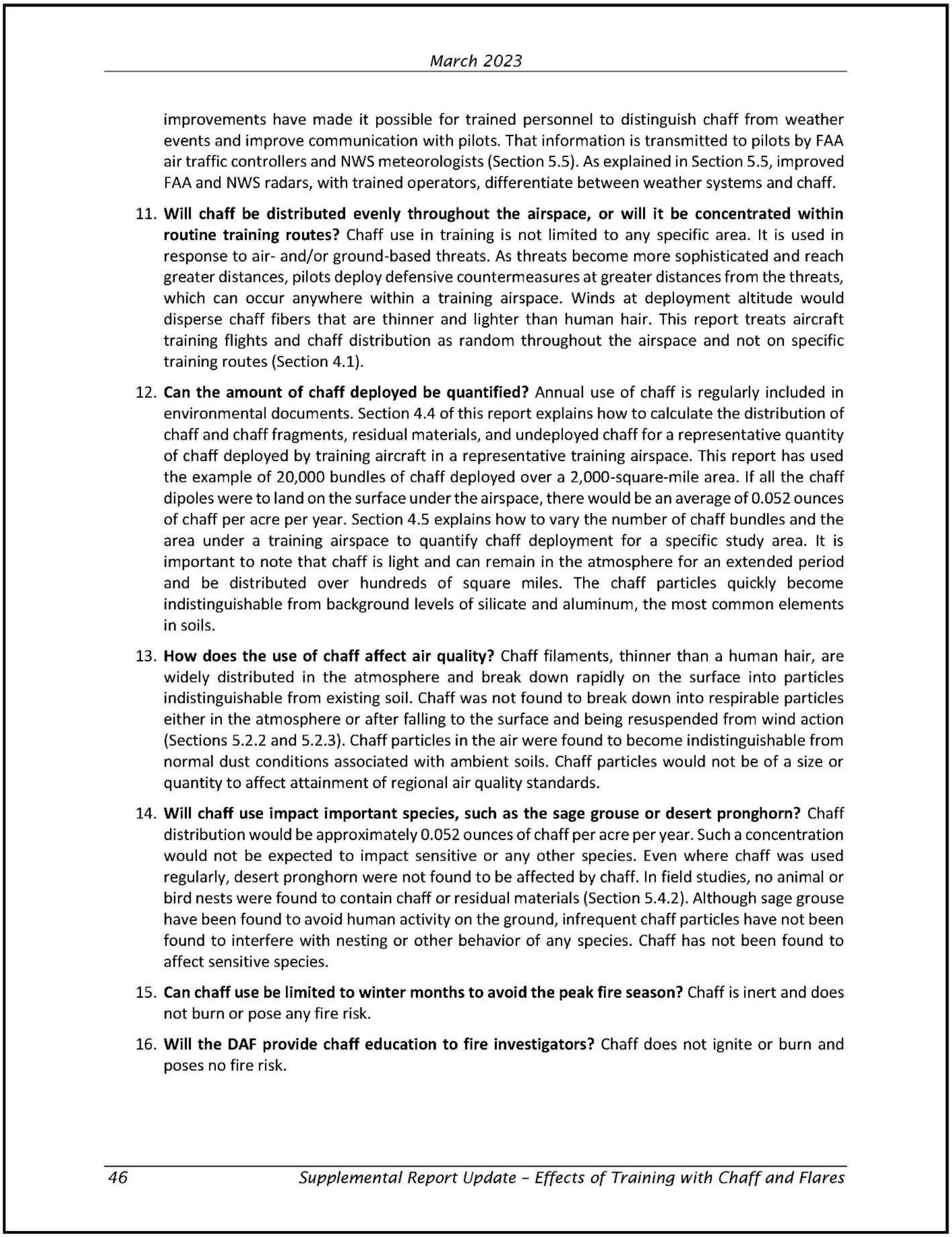
6.1 Responses to Representative Questions

The representative public or agency questions from Section 5.1.2 are addressed in this section. Report sections are cited where specific issues from the questions have been addressed. The representative questions are repeated below with summary responses to the questions.

1. **What would be the visual effects from chaff or chaff residual materials?** The chaff residual materials are described in Section 4.4. The potential for any concentration of chaff particles on the surface is very small. This report example uses the average weight of 3.35 ounces of chaff fibers in a representative cartridge of chaff and 20,000 bundles of chaff annually deployed during training over a 2,000-square-mile area. This could result in an average of approximately 0.052 ounces of chaff per acre per year under the airspace. Bundles of chaff that did not deploy correctly can, and do, occur. With a 99 percent manufacturing reliability standard, if 20,000 bundles of chaff were deployed annually over a 2,000-square-mile area under a training airspace and none of the chaff remained undeployed in the aircraft, there would be an estimated 200 undeployed clumps of chaff dipoles per year. This would result in an estimated average of 3.35 ounces of undeployed chaff per 10 square miles per year. There would annually be an estimated 37 pieces of residual plastic or paper material deposited on the surface per square mile (Section 4.4). If a piece of plastic, paper, or undeployed chaff were found and identified, the finder could be annoyed.
2. **Would chaff affect water and soil where the pH is high to very high in alkaline?** Chaff concentrations are calculated to be approximately 0.052 ounces of chaff per acre per year (Section 4.4). In highly acidic soil or water, portions of aluminum could separate from the silica core. The soil pH is normally outside the range to react with chaff coatings (Sections 5.2.3 and 5.4.2). The chaff particles rapidly become indistinguishable from silica and aluminum soil elements. No soils or water impacts would be anticipated. In the unlikely event that an entire bundle of undeployed chaff were to fall in a lake, the amount of soluble aluminum from the chaff would not be expected to change the ambient concentration of aluminum in the lake.
3. **What are the health risks from ingesting chaff residual materials?** Chaff in the air does not fragment into respirable particles (Sections 5.2.2 and 5.2.3). Chaff deployment would result in an estimated average of 0.052 ounces of chaff per acre per year. Section 5.4.1 explains that chaff poses no human health risks. Chaff plastic or paper pieces have never been recorded as ingested by animals (Sections 5.4.2 and 5.4.3). During controlled tests, animals rejected eating chaff. If an animal were to ingest a piece of residual plastic, the shape of the plastic piece means it would not lodge within the digestive tract but would be discharged comparable to any smooth stone. There has never been a piece of chaff residual plastic material found in animal scat.
4. **What are the health risks from airborne chaff?** Airborne chaff does not abrade to respirable particles (Sections 5.2.2 and 5.2.3). Chaff fibers are dispersed in the air, where they rapidly break down on the surface to become silica and aluminum particles essentially indistinguishable from the composition of soil. The animal fat micro-coating of chaff fibers breaks down when exposed to sunlight. Chaff does not pose a health or other risk (Sections 5.2.3 and 5.4.2).
5. **What are the frequency and amount of chaff drops over Tribal lands?** Chaff deployment in training airspace, which can include Tribal lands, results in an estimated 0.052 ounces of chaff per acre per year. This assumes that all the deployed chaff descended to the surface under the airspace, although studies have shown the chaff can drift a substantial distance. Approximately 17.3 pieces of residual plastic materials would annually be randomly distributed anywhere under a training airspace, including on Tribal lands. This assumes 20,000 bundles of chaff annually

deployed over a 2,000-square-mile area (Section 4.4). As noted in this report, chaff falling on the surface lands under the airspace would not impact agriculture, range animals, or native species, including those on Tribal lands. If a piece of residual plastic or paper, or a clump of undeployed chaff, were found and identified on Tribal lands, the individual finding the material could be annoyed.

6. **Could chaff use create airborne FOD hazards?** There has not been a recorded instance of chaff plastic or other residual materials striking or damaging a civil aircraft, even in extensively used training airspace such as NTTR or the Utah Test and Training Range (UTTR). There was one instance of a piece of residual plastic material from a deployed countermeasure being ingested in the engine of a military aircraft flying as a wingman to the aircraft deploying the flare. The residual flare material resulted in engine damage to the close-following aircraft. Chaff fibers, which are thinner than a human hair, disperse in the air and drift to the ground. Plastic and other residual pieces from deployment of chaff fall to the ground. The heaviest piece of chaff residual materials is a plastic piece that falls with the force of a small hailstone (Section 5.6). There has been no recorded case of such a piece striking a civil aircraft.
7. **Could chaff materials impact the economic value of wool?** Chaff fibers rapidly break down on the surface and become indiscernible from soil. Wool processing procedures include methods for cleaning the wool for soil, burrs, or other materials. In the unlikely event that a chaff particle alighted on a sheep, such a particle would be removed along with other materials in the wool cleaning process. There is no basis for believing that chaff or flare inert plastic or paper pieces could become attached to sheep or to any other animal. The normal procedures for cleaning the wool would clean out any extremely unlikely pieces of chaff residual materials (Section 5.4.3).
8. **Would chaff materials affect birthing animals?** Chaff dispersion is projected to be approximately 0.052 ounces of chaff per acre per year, assuming 20,000 bundles of chaff deployed over a 2,000-square-mile area (Section 4.4). Chaff rapidly breaks down and becomes indistinguishable from soil. Any contact with chaff or flare residual materials would be highly unlikely. Chaff plastic and other residual materials can be deposited anywhere on the ground. After several studies, neither chaff nor residual materials have been found to have any physical effect on any animals (Sections 5.4.2 and 5.4.3). Chaff does not fragment to respirable dimensions in the atmosphere and rapidly fragments to become effectively indistinguishable from naturally occurring components of soil. As described in the subsections under Section 5.2, chaff and chaff residual materials are inert and would not harm birthing or other animals.
9. **What are the near-term and long-term impacts from chaff use?** Section 5.0 describes the chaff and flare effects, including the effects of residual materials that fall to the ground. Long-term studies to identify chaff have demonstrated that chaff breaks down quickly on the surface to particles of aluminum and silica, which are the most common elements in the soil (Section 4.1). The degraded chaff particles are effectively indistinguishable from existing soil particles. Parchment paper used for wrapping training delayed opening chaff was found to be comparable to biodegradable paper and would have no long-term impact (Section 4.1.3.2). Plastic pieces including Kapton wrapping for delayed opening combat chaff would persist in the environment for an extended period of time, possibly a year or longer (Section 4.1.3.1).
10. **Why is chaff use limited to 60 NM from airfield radar?** The DAF attempts to reduce the effect of chaff on airport approach radars. Deployed chaff could give a false positive image of clouds or rain or obscure airport radar from seeing an aircraft. In the Powder River airspace, the DAF and FAA agreed that military aircraft not deploy chaff within 60 NM of airport approach radars to reduce the risk of aircraft approach radar not being able to see an aircraft. FAA and NWS radar



improvements have made it possible for trained personnel to distinguish chaff from weather events and improve communication with pilots. That information is transmitted to pilots by FAA air traffic controllers and NWS meteorologists (Section 5.5). As explained in Section 5.5, improved FAA and NWS radars, with trained operators, differentiate between weather systems and chaff.

11. **Will chaff be distributed evenly throughout the airspace, or will it be concentrated within routine training routes?** Chaff use in training is not limited to any specific area. It is used in response to air- and/or ground-based threats. As threats become more sophisticated and reach greater distances, pilots deploy defensive countermeasures at greater distances from the threats, which can occur anywhere within a training airspace. Winds at deployment altitude would disperse chaff fibers that are thinner and lighter than human hair. This report treats aircraft training flights and chaff distribution as random throughout the airspace and not on specific training routes (Section 4.1).
12. **Can the amount of chaff deployed be quantified?** Annual use of chaff is regularly included in environmental documents. Section 4.4 of this report explains how to calculate the distribution of chaff and chaff fragments, residual materials, and undeployed chaff for a representative quantity of chaff deployed by training aircraft in a representative training airspace. This report has used the example of 20,000 bundles of chaff deployed over a 2,000-square-mile area. If all the chaff dipoles were to land on the surface under the airspace, there would be an average of 0.052 ounces of chaff per acre per year. Section 4.5 explains how to vary the number of chaff bundles and the area under a training airspace to quantify chaff deployment for a specific study area. It is important to note that chaff is light and can remain in the atmosphere for an extended period and be distributed over hundreds of square miles. The chaff particles quickly become indistinguishable from background levels of silicate and aluminum, the most common elements in soils.
13. **How does the use of chaff affect air quality?** Chaff filaments, thinner than a human hair, are widely distributed in the atmosphere and break down rapidly on the surface into particles indistinguishable from existing soil. Chaff was not found to break down into respirable particles either in the atmosphere or after falling to the surface and being resuspended from wind action (Sections 5.2.2 and 5.2.3). Chaff particles in the air were found to become indistinguishable from normal dust conditions associated with ambient soils. Chaff particles would not be of a size or quantity to affect attainment of regional air quality standards.
14. **Will chaff use impact important species, such as the sage grouse or desert pronghorn?** Chaff distribution would be approximately 0.052 ounces of chaff per acre per year. Such a concentration would not be expected to impact sensitive or any other species. Even where chaff was used regularly, desert pronghorn were not found to be affected by chaff. In field studies, no animal or bird nests were found to contain chaff or residual materials (Section 5.4.2). Although sage grouse have been found to avoid human activity on the ground, infrequent chaff particles have not been found to interfere with nesting or other behavior of any species. Chaff has not been found to affect sensitive species.
15. **Can chaff use be limited to winter months to avoid the peak fire season?** Chaff is inert and does not burn or pose any fire risk.
16. **Will the DAF provide chaff education to fire investigators?** Chaff does not ignite or burn and poses no fire risk.

6.2 Chaff Developments

Chaff is a defensive countermeasure deployed to protect a pilot or aircrew and an aircraft. Chaff dipoles are continually undergoing review to determine whether there are more advanced adversary weapons systems that could counter the purpose of chaff and whether there are innovations that could, in response, counter such advanced systems. Current chaff does not address certain wave bands of 30 to 40 GHz, and current chaff material is not well suited to be cut and packaged to lengths required for countermeasures in the millimeter wave region. Millimeter chaff response levels cannot be achieved in the volume of the current chaff 47arrow47gee. Research is ongoing to determine whether higher performing chaff can be produced by applying recent advances in nanofibers, nanotubes, meta-materials, conductive polymers, graphite fibers, graphene fibers, metal nanowire technologies, and coating techniques using copper, silver, aluminum, zinc, etc. (Navy, 2015).

New technologies include consideration of different chaff delivery systems. The spectral decoy discussion in Section 7.6 includes the Mobile Jettison Unit (MJU)-52A/B decoy, which uses a plastic case to disperse the spectral pyrophoric material. The MJU-52A/B case can also be used for the deployment of chaff and could be considered for future DAF training use. New technologies will need cost-benefit studies to determine whether higher performing chaff can be produced on a large scale. If higher performing chaff were able to be produced at higher cost, the chaff would be expected to be reserved for test or combat applications. Thinner chaff cut to shorter dipoles could double, triple, or even quadruple the number of dipoles in a chaff cartridge, while not changing the weight of the deployed chaff.

Research is continuing to find dipoles and chaff material that would have high scattering in a specific frequency band and could be efficiently manufactured to meet potential future countermeasure needs (Navy, 2015). As with any study, this supplemental report addresses the available countermeasures at a point in time. Chaff countermeasures developed and deployed at some time in the future would be addressed in future documentation.

7.0 FLARE CHARACTERISTICS AND COMPOSITION OF SELF-PROTECTION FLARES

A self-protection flare is designed as a defensive countermeasure to an IR heat-seeking missile. This report describes the four groupings or "families" of defensive flares used by DAF aircraft during training, testing, or combat. The four flare families represent responses to the ever-changing threat to aircraft from developments in IR missiles.

Flares are countermeasures designed to redirect the threat from IR heat-seeking missiles away from a target aircraft. Despite the advent and advancements of flare technology, IR missiles, and especially Man-Portable Air-Defense System (MANPADS), have accounted for over 80 percent of all aircraft lost to enemy fire in the past 50 years. Over time, the seeker heads on IR missiles have become more capable, and this has required technologically more advanced countermeasures. The countermeasure goal is to redirect the missile seeker head so that the target aircraft is no longer in the field of view and the missile no longer tracks the target aircraft.

7.1 History and Challenges

Defensive flares are designed to protect an aircraft by diverting an attack from an IR missile that is guided toward the heat signature emitted by the target aircraft. The earliest heat-seeking missiles were named sidewinders after the desert rattlesnake's ability to use heat emissions to distinguish and attack its prey as well as the snake's moving side to side across the desert. The early sidewinder missiles moved side to side as they adjusted to home in on the target. The initial sidewinder heat-seeking missiles were guided by IR long wave lengths to the engine exhausts of a target aircraft. The sidewinder's combat debut in 1958 in Formosa (now Taiwan) saw Nationalist Chinese F-86 Korean War jet fighters, equipped with sidewinders, ambushing the more advanced but not as well-equipped Communist Chinese MiG-17 aircraft. One MiG-17 limped back to base with an unexploded sidewinder lodged in the fuselage. The sidewinder was reverse engineered by the Soviets and in a short time, the IR heat-seeking technology was copied by the Soviets, Chinese, and multiple other nations to become the most successful anti-aircraft system in history (White, 2012).

Within a short time, it was realized that the IR missiles also could be successfully deployed by ground forces against aircraft and helicopters. This resulted in the MANPADS, which were, in effect, a man-portable ground-based sidewinder missile. The proliferation of anti-antiaircraft IR-guided missiles throughout the world drove the development of IR countermeasures. White (2012) presents an extensive discussion on the history and development of IR missiles and countermeasures to the IR threats to aircraft.

Aircraft emit an IR signature that is highly susceptible to detection. The IR-guided missile does not use radar and has passive guidance in which the missile seeker head locks on to an aircraft's heat source. The target aircraft radiates the heat signature, and the only warning is if the IR missile has been detected. Once an IR missile is detected, the pilot has seconds to avoid the IR-guided missile by very quickly deploying heat sources, flare countermeasures, to redirect the IR missile seeker head.

Launch of an IR missile is very difficult for pilots to detect and to know when to deploy flares. IR missiles may be launched from short or long distances and the missile's tracking system is passive, so there is no detectable electronic emission to sense the incoming missile. It is difficult for a target aircraft to detect exhaust emissions from IR rocket motors because the emissions can be embedded in background radiation clutter. Systems have been developed that are able to distinguish the motion of an IR missile against a background, but by the time the motion is detected and processed, a missile impact may be seconds away.

Effectively providing pilots with an IR missile warning is essential to aircraft defensive action, but consistent warnings have been very difficult to achieve. Sensing systems have been developed that have some success in detecting the motion of the IR missile against a background or the exhaust of an IR missile. In some cases, the detection and deployment of countermeasures have been integrated into an automated system in response to a threat. This detection and integration of a reliable warning and response system continues to present technical and operational challenges. In response to undetected or detected threats, pilots are trained to continue to deploy countermeasures as they approach and depart a target area. There are continuing challenges to determine when to deploy a countermeasure because it is very difficult to achieve an acceptable compromise between a high probability of an IR missile threat detection and a low false alarm rate. These challenges are being addressed but may never be completely solved (White, 2012).

Alternatives to the use of defensive flares have not had consistent success. Efforts have been made to develop laser systems that could disable a heat-seeking warhead, but the complexity of identifying an IR missile targeting the aircraft, followed by tracking the missile and then targeting the missile tracking system with a narrow laser powerful enough to damage the seeker warhead have been extremely difficult to achieve. The weight and power demands for such a laser system, combined with an unacceptable success rate, have made continuing development of flare countermeasures crucial. Another defensive mechanism that has been employed is a decoy towed behind the target aircraft that emits a signature to attract IR missiles. The decoy is normally protected by its own countermeasures to have a degree of success against both radar- and IR-guided missiles. Despite work with additional defensive systems, the use of improving flares technology in response to IR threats is now, and is projected to continue to be, the most consistent and reliable approach to protect the targeted aircraft.

As long as there are advancements in IR seeker heads, there will very likely continue to be countermeasures similar to those shown in Figure 7-1 where a training aircraft is deploying flares and quickly maneuvering to avoid a simulated attack by a heat-seeking missile.

Figure 7-1. Aircraft Deploying Flare Countermeasures and Maneuvering to Avoid a Simulated IR Missile Threat During Training

7.2 Countermeasure Responses and IR Missiles

Deployed flares combined with an aircraft maneuver would cause the IR missile seeker head to lose the target aircraft from its field of view and no longer be a threat. Figure 7-2 depicts a training aircraft deploying flares to divert a simulated threat from a heat-seeking missile. Over the years, the capabilities of IR missile seeker heads have evolved, and the countermeasure design has evolved in response to the expanded IR missile capabilities.

The continuing sequence has been IR missiles targeting aircraft followed by flare countermeasures to protect the aircraft followed by more sophisticated IR missile counter-countermeasures to distinguish flares from the targeted aircraft. A pilot does not know whether an IR missile targeting the aircraft has a simple IR heat-seeking missile head or a more sophisticated missile head. This means an aircraft in combat must be equipped with a variety of defensive countermeasures and the pilot is required to deploy the variety of countermeasures together and in sequence to counter the wide variety of modern IR missile targeting capabilities.

Figure 7-2. Aircraft Deploying M-206 Flares During Training

The continuing challenge is to develop effective countermeasures, and, as lamented by White (2012):

- Each successful IR countermeasure advance forces development of a new countermeasure by missile designers.
- New countermeasures to IR threats are more complex and more expensive.
- Eventually, any missile can be countered.
- Eventually, any countermeasure can be defeated.

The DAF has developed four families of flares to meet the challenges of IR-guided missiles while providing efficient pilot training. This 2022 report describes the history, development, and current use of countermeasures. As countermeasures have become more complex and more costly, the DAF has continued to face the challenge of providing needed countermeasure training within budget constraints.

This report is a snapshot in time that describes the four flare families used by the DAF for training, testing, and combat. The four flare countermeasure families are:

1. standard Magnesium/Teflon/Viton (MTV) flares,
2. standard spectral flares,
3. thrusted flares, and
4. spectral decoys.

7.3 Standard Magnesium/Teflon/Viton (MTV) Flares

The standard MTV flare uses basic defensive flare technology to create a heat source that is hotter than an aircraft engine and is designed to draw an IR missile toward the flare, or series of flares. The MTV flare successfully defends an aircraft from legacy IR missiles. And since many MANPADS in different countries still use legacy technology in their missiles, the MTV flares remain a useful countermeasure against low-technology IR threats.

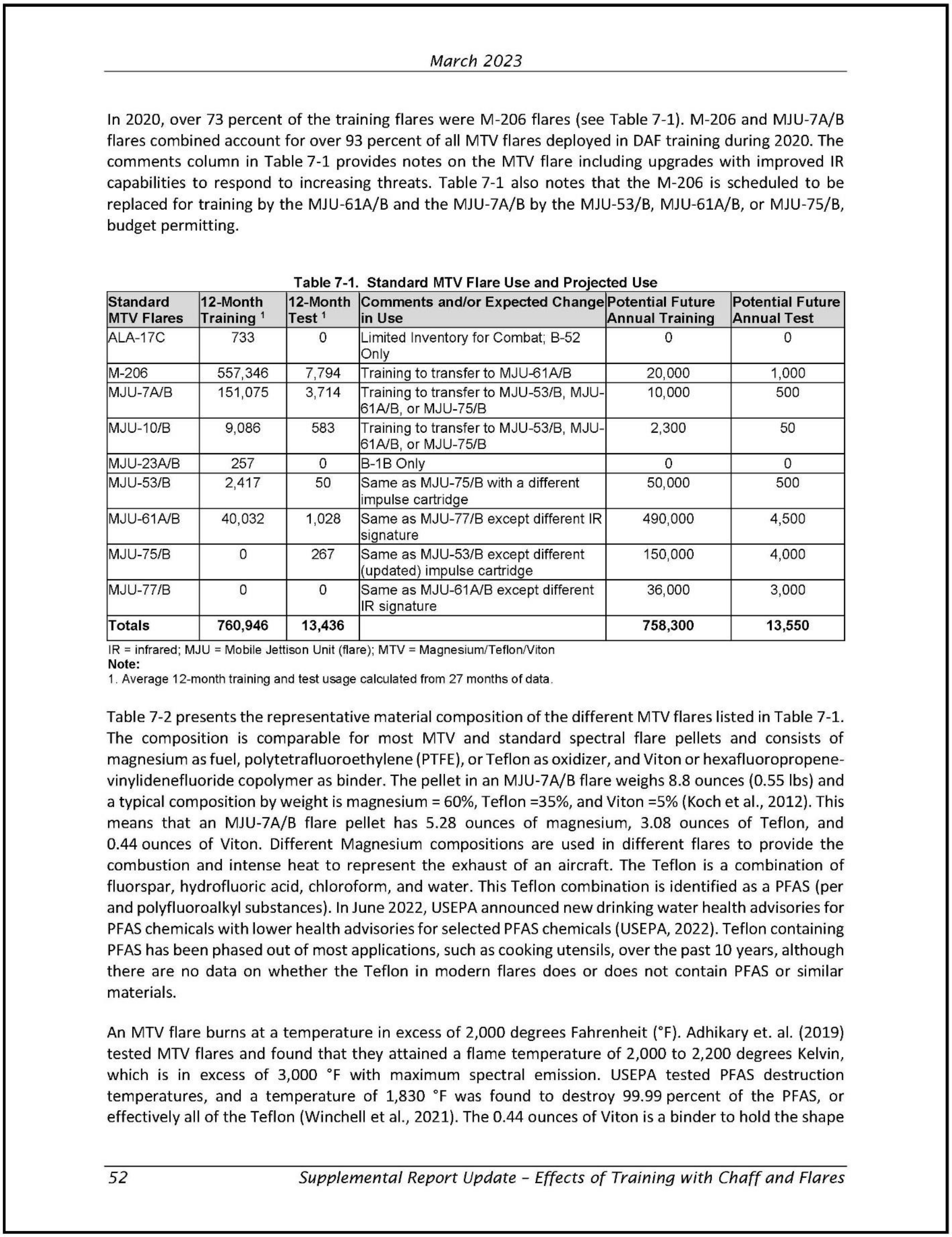
7.3.1 Primary Use of MTV Flares

MTV flares are the simplest and least costly flares available for training and combat in response to legacy IR missiles. IR radiation has wavelengths longer than those of visible light and cannot be seen by the human eye. An aircraft emits IR wavelengths day or night, so it can be successfully targeted against a cooler sky. More advanced MANPADS have the ability to detect heat from the engine exhaust as well as from the heated side of the aircraft or even from the friction heated front of an aircraft. Most MANPADS are a fire-and-forget missile system, so there is no electronic signal that the IR missile is tracking the aircraft. The pilot of the targeted aircraft needs to detect and react quickly to the IR missile threat by deploying countermeasure flares and maneuvering the aircraft. It is difficult to design an accurate alarm system to process detected information about a launched IR missile and quickly notify a pilot to deploy flares and take evasive maneuvers. The best technology has the ability to detect the relative movement of an IR missile and provide a few seconds of alarm prior to the missile striking the aircraft. As a result of the proliferation of MANPADS and the short warning time, pilots continually deploy MTV flares in a combat situation where there could be IR threats. This continual threat from IR missiles and the defensive deployment of flares in combat requires pilots to "train as they will fight," and deploy flares as they maneuver in training airspace to make an attack and depart after the attack.

MTV flares have been in production for many years and are cost efficient for training as well as useful in a low-level threat environment. As threats have become more capable, defensive countermeasures have also become more complicated and expensive. The DAF has been using lower cost MTV flares for nearly all training in DAF-managed training airspace.

7.3.2 MTV Flare Overview

This overview presents information on each of the MTV flares. Table 7-1 lists the standard MTV self-protection flares currently in use, and the extent of use during 2020, as well as potential future MTV flare distribution. The aircraft that can deploy such flares would be any DAF fighter aircraft or other aircraft such as the A-10, F-15, F-16, F-35A, F-22, C-130, and others. A few flares, including the ALA-17C, which replaced the ALA-17B and the MJU-23A/B, are aircraft specific as noted in Table 7-1.



In 2020, over 73 percent of the training flares were M-206 flares (see Table 7-1). M-206 and MJU-7A/B flares combined account for over 93 percent of all MTV flares deployed in DAF training during 2020. The comments column in Table 7-1 provides notes on the MTV flare including upgrades with improved IR capabilities to respond to increasing threats. Table 7-1 also notes that the M-206 is scheduled to be replaced for training by the MJU-61A/B and the MJU-7A/B by the MJU-53/B, MJU-61A/B, or MJU-75/B, budget permitting.

Table 7-1. Standard MTV Flare Use and Projected Use

Standard MTV Flares	12-Month Training [1]	12-Month Test [1]	Comments and/or Expected Change in Use	Potential Future Annual Training	Potential Future Annual Test
ALA-17C	733	0	Limited Inventory for Combat; B-52 Only	0	0
M-206	557,346	7,794	Training to transfer to MJU-61A/B	20,000	1,000
MJU-7A/B	151,075	3,714	Training to transfer to MJU-53/B, MJU-61A/B, or MJU-75/B	10,000	500
MJU-10/B	9,086	583	Training to transfer to MJU-53/B, MJU-61A/B, or MJU-75/B	2,300	50
MJU-23A/B	257	0	B-1B Only	0	0
MJU-53/B	2,417	50	Same as MJU-75/B with a different impulse cartridge	50,000	500
MJU-61A/B	40,032	1,028	Same as MJU-77/B except different IR signature	490,000	4,500
MJU-75/B	0	267	Same as MJU-53/B except different (updated) impulse cartridge	150,000	4,000
MJU-77/B	0	0	Same as MJU-61A/B except different IR signature	36,000	3,000
Totals	**760,946**	**13,436**		**758,300**	**13,550**

IR = infrared; MJU = Mobile Jettison Unit (flare); MTV = Magnesium/Teflon/Viton

Note:

1. Average 12-month training and test usage calculated from 27 months of data.

Table 7-2 presents the representative material composition of the different MTV flares listed in Table 7-1. The composition is comparable for most MTV and standard spectral flare pellets and consists of magnesium as fuel, polytetrafluoroethylene (PTFE), or Teflon as oxidizer, and Viton or hexafluoropropene-vinylidenefluoride copolymer as binder. The pellet in an MJU-7A/B flare weighs 8.8 ounces (0.55 lbs) and a typical composition by weight is magnesium = 60%, Teflon =35%, and Viton =5% (Koch et al., 2012). This means that an MJU-7A/B flare pellet has 5.28 ounces of magnesium, 3.08 ounces of Teflon, and 0.44 ounces of Viton. Different Magnesium compositions are used in different flares to provide the combustion and intense heat to represent the exhaust of an aircraft. The Teflon is a combination of fluorspar, hydrofluoric acid, chloroform, and water. This Teflon combination is identified as a PFAS (per and polyfluoroalkyl substances). In June 2022, USEPA announced new drinking water health advisories for PFAS chemicals with lower health advisories for selected PFAS chemicals (USEPA, 2022). Teflon containing PFAS has been phased out of most applications, such as cooking utensils, over the past 10 years, although there are no data on whether the Teflon in modern flares does or does not contain PFAS or similar materials.

An MTV flare burns at a temperature in excess of 2,000 degrees Fahrenheit (°F). Adhikary et. al. (2019) tested MTV flares and found that they attained a flame temperature of 2,000 to 2,200 degrees Kelvin, which is in excess of 3,000 °F with maximum spectral emission. USEPA tested PFAS destruction temperatures, and a temperature of 1,830 °F was found to destroy 99.99 percent of the PFAS, or effectively all of the Teflon (Winchell et al., 2021). The 0.44 ounces of Viton is a binder to hold the shape of the flare pellet until it is released and begins burning. During the burn, the magnesium, Teflon, and Viton are totally consumed.

Table 7-2. Composition of MTV Self-Protection Flares

Combustible	**Components**
Flare Pellet	Polytetrafluoroethylene (Teflon) (-[C2F4]n – n=20,000 units) Magnesium (Mg) Fluoroelastomer (Viton, Fluorel, Hytemp)
Slurry Coat (not all flares use)	Polytetrafluoroethylene (Teflon) (-[C2F4]n – n=20,000 units) Magnesium (Mg) Fluoroelastomer
Assemblage (Residual Components)	**Components**
Wrapping	Filament tape bonded to aluminum tape
End Cap	Plastic (nylon)
Felt Spacers	Felt pads (0.25 inches by cross section of flare)
Safe & Initiation (S&I) Device	Plastic (nylon) (not used in M-206)
Piston	Plastic (nylon)

Source: (DAF, 1997)
MTV = Magnesium/Teflon/Viton

Table 7-3 provides MTV flare dimensions and residual materials that fall to the surface following deployment of each flare type. Self-protection flares are primarily mixtures of magnesium and polytetrafluoroethylene (Teflon) molded into rectangular shapes (DAF, 1997). Longitudinal grooves provide space for slurry coat mixtures that aid in ignition. Typically, flares are wrapped with an aluminum-coated filament-reinforced wrap and inserted into an aluminum case (0.03 inches thick) that is closed with a felt spacer and a plastic end cap. There are two primary types of ignition mechanisms for current MTV self-protection flares used by the DAF: parasitic and non-parasitic. The M-206 is a parasitic flare that ignites inside the aluminum tube within the aircraft and is discharged already burning. As noted in Table 7-2, the M-206 parasitic flare is to be replaced by non-parasitic flares, which do not begin burning until they are expelled from the aluminum case that has a metal flange and does not leave the aircraft.

The flares listed in Table 7-3 with a Safe and Initiation (S&I) device as one of the residual materials are non-parasitic. The process of flare build up and eventual deployment consists of multiple steps. At first, an impulse cartridge is inserted into the back of the flare and then the flare is placed in the magazine. The magazine is then fastened in the aircraft that flies to the training area. During training, the impulse cartridge is activated electrically to produce hot gases that create pressure in the aluminum case and force the piston to pop off the end cap or closure from the front of the flare assembly. Flares with an S&I device have an ignition pellet (of MTV or Fluorel binder) that is ignited by impulse cartridge gases. The S&I device has a hole that is closed as long as it is in the aluminum case and the spring mechanism is depressed. The flare is "safe" because the closed S&I hole prevents the ignition pellet from igniting the magnesium flare pellet. As the piston pushes the flare pellet out of the case, the S&I device immediately follows and springs open to ignite the flare pellet through the now-open hole in the S&I device. All of this happens in less than 1 second.

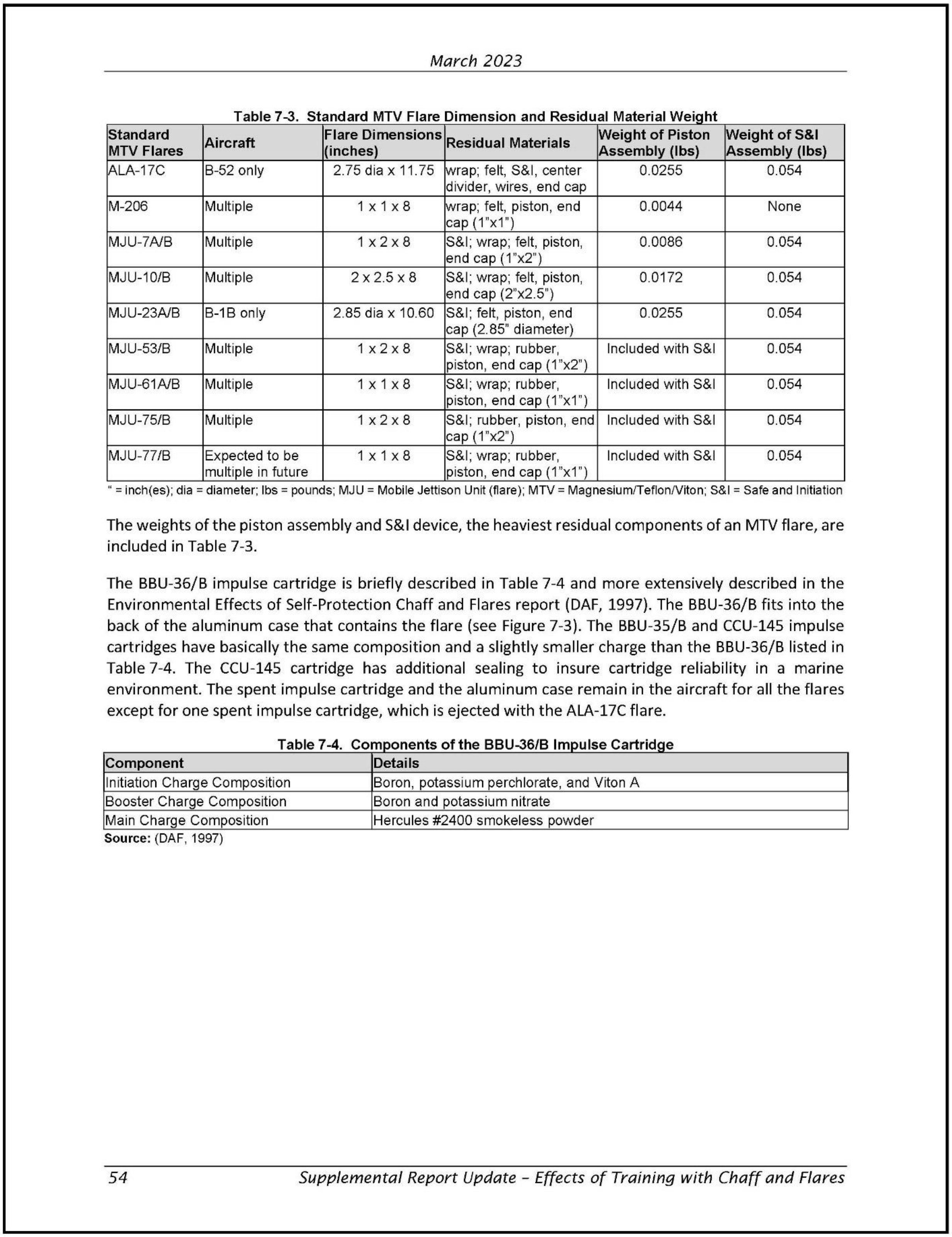


Table 7-3. Standard MTV Flare Dimension and Residual Material Weight

Standard MTV Flares	Aircraft	Flare Dimensions (inches)	Residual Materials	Weight of Piston Assembly (lbs)	Weight of S&I Assembly (lbs)
ALA-17C	B-52 only	2.75 dia x 11.75	wrap; felt, S&I, center divider, wires, end cap	0.0255	0.054
M-206	Multiple	1 x 1 x 8	wrap; felt, piston, end cap (1"x1")	0.0044	None
MJU-7A/B	Multiple	1 x 2 x 8	S&I; wrap; felt, piston, end cap (1"x2")	0.0086	0.054
MJU-10/B	Multiple	2 x 2.5 x 8	S&I; wrap; felt, piston, end cap (2"x2.5")	0.0172	0.054
MJU-23A/B	B-1B only	2.85 dia x 10.60	S&I; felt, piston, end cap (2.85" diameter)	0.0255	0.054
MJU-53/B	Multiple	1 x 2 x 8	S&I; wrap; rubber, piston, end cap (1"x2")	Included with S&I	0.054
MJU-61A/B	Multiple	1 x 1 x 8	S&I; wrap; rubber, piston, end cap (1"x1")	Included with S&I	0.054
MJU-75/B	Multiple	1 x 2 x 8	S&I; rubber, piston, end cap (1"x2")	Included with S&I	0.054
MJU-77/B	Expected to be multiple in future	1 x 1 x 8	S&I; wrap; rubber, piston, end cap (1"x1")	Included with S&I	0.054

" = inch(es); dia = diameter; lbs = pounds; MJU = Mobile Jettison Unit (flare); MTV = Magnesium/Teflon/Viton; S&I = Safe and Initiation

The weights of the piston assembly and S&I device, the heaviest residual components of an MTV flare, are included in Table 7-3.

The BBU-36/B impulse cartridge is briefly described in Table 7-4 and more extensively described in the Environmental Effects of Self-Protection Chaff and Flares report (DAF, 1997). The BBU-36/B fits into the back of the aluminum case that contains the flare (see Figure 7-3). The BBU-35/B and CCU-145 impulse cartridges have basically the same composition and a slightly smaller charge than the BBU-36/B listed in Table 7-4. The CCU-145 cartridge has additional sealing to insure cartridge reliability in a marine environment. The spent impulse cartridge and the aluminum case remain in the aircraft for all the flares except for one spent impulse cartridge, which is ejected with the ALA-17C flare.

Table 7-4. Components of the BBU-36/B Impulse Cartridge

Component	Details
Initiation Charge Composition	Boron, potassium perchlorate, and Viton A
Booster Charge Composition	Boron and potassium nitrate
Main Charge Composition	Hercules #2400 smokeless powder

Source: (DAF, 1997)

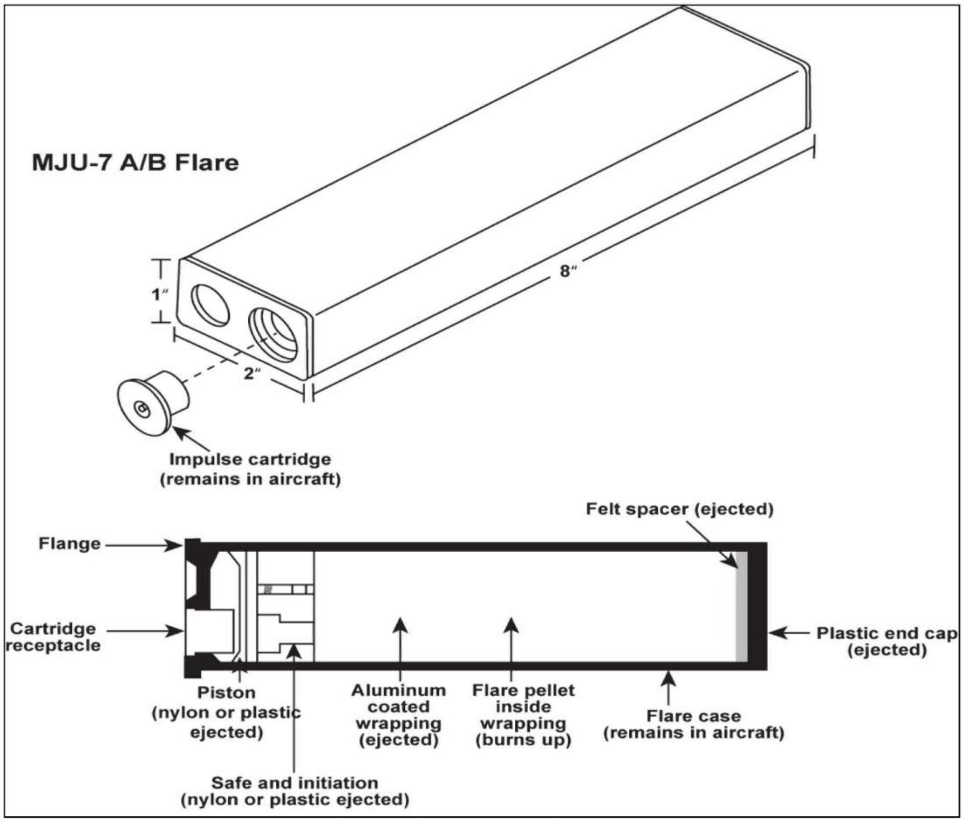


Figure 7-3. Cutaway View of MJU-7A/B Flare

7.3.3 MTV Flare Details

This section provides details, including illustrations, of the different types of MTV flares listed in Table 7-3. The MJU-7A/B flare has all the MTV flare components for a non-parasitic flare and is presented in Section 7.3.3.1. The other MTV flares are then presented in the sequence listed in Table 7-3.

7.3.3.1 MJU-7A/B MTV Flare

Figure 7-3 is a drawing of an approximately 1-inch by 2-inch by 8-inch MJU-7A/B flare, and Figure 7-4 is a photograph of the flare with the aluminum casing cut away at specific locations. The residual materials, which fall to the surface when the flare is deployed (see Table 7-3), consist of 1) the 1-inch by 2-inch by 0.25-inch plastic or nylon end cap, 2) the 1-inch by 2-inch felt or rubber cushion (that may be attached to the end cap), 3) the 1-inch by 2-inch by 0.5-inch piston that forces the magnesium flare pellet out of the aluminum case after the ignition cartridge is electrically ignited, 4) the approximately 14-inch by 6-inch aluminum foil wrapping tape that is split from the flare as the flare exits the aluminum case, and 5) the S&I device that permits ignition of the flare pellet or grain as it exits the aluminum case.

Figure 7-3 shows where the S&I device is located near the ignition cartridge. At the bottom of Figure 7-4, there is an opened S&I device that shows the hole through which the hot gases from the BBU-36/B ignition cartridge pass to ignite the magnesium flare.

The wrapping tape is split off from the burning flare as the flare exits the case. The wrapping has a large surface area and descends slowly to the surface. The spent foil wrapping tape on the surface has the appearance of stiff duct tape (see Section 8.4). The foil wrapping tape on DAF MTV flares has a printed warning in case a dud flare should fall to the surface. The warning printed on the sides of the flare wrapping reads: "**Warning – USAF IR Flare –Explosive / Highly Flammable.**" Dud flares are discussed in Section 8.0.

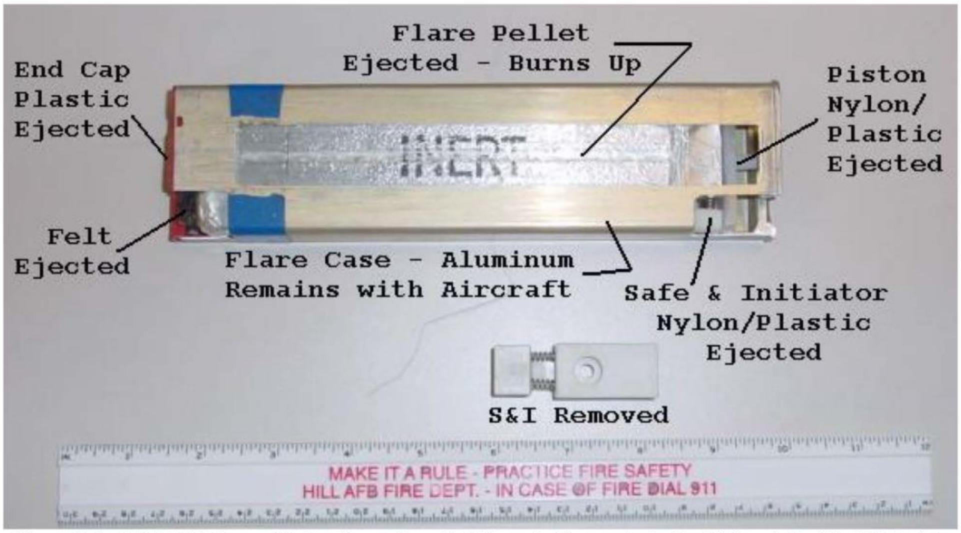


Figure 7-4. MJU-7A/B Flare with Aluminum Case Cut Away to Demonstrate the Different Residual Materials

The MJU-7A/B flare is expected to continue to be used until stores are depleted and it is replaced by the improved capabilities of the MJU-53/B and MJU-75/B flares (see Table 7-1). The components described for the MJU-7A/B flare are basically the same for other MTV flares. Where there are differences, those differences are described in the separate MTV flare discussions below.

7.3.3.2 ALA-17C MTV Flare

The B-52 specific ALA-17C flare is a round flare with a diameter of 2.75 inches and a length of 11.75 inches. Figure 7-5 is a photograph of a cut-away view of the dual shot ALA-17C flare with two separate grains of molded magnesium, which are ejected and ignited by two modified BBU-36 impulse cartridges. Residual materials that are deposited on the surface following deployment of one flare consist of one spent BBU-36 cartridge, two S&I assemblies, four felt strips, two wrappings, wires used in the deployment, an aluminum center divider, an end cap, and a piston. The flare has limited use and is scheduled to be discontinued after 2022 (Table 7-1).

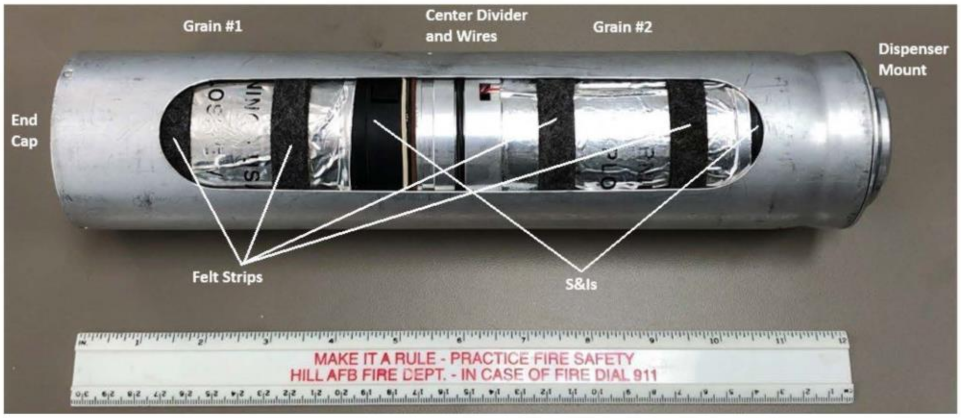
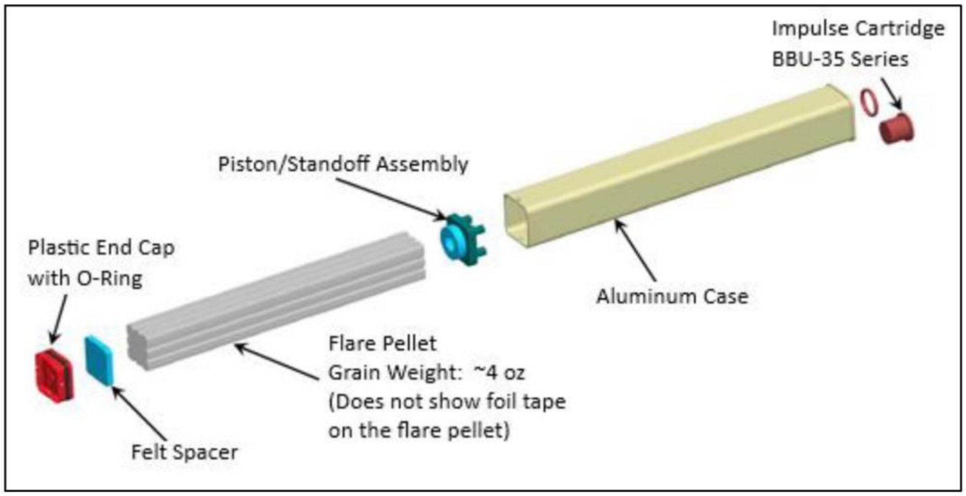


Figure 7-5. Cutaway View of an ALA-17C Flare

7.3.3.3 M-206 MTV Flare

The M-206 1-inch by 1-inch by 8-inch flare has been the primary DAF MTV training flare (see Table 7-1). The flare may also be used in combat to defend against legacy IR missiles (see Section 7.1). The M-206 is a parasitic flare in that the approximately 7-inch-long magnesium pellet is ignited by the BBU-35/B impulse cartridge before the pellet is ejected from the flare casing. Figure 7-6 presents all the components of an M-206 flare. When assembled, the piston is immediately adjacent to the impulse cartridge at the back of the flare (right side in the figure). A hole extends through the piston assembly and permits the impulse cartridge gases to contact and ignite the flare pellet. The impulse cartridge gas pressure pushes the piston and flare pellet, the plastic end cap pops off, the wrapping material splits (not pictured), and the already burning flare is deployed from the aircraft.



Note: This flare has been the primary flare used in DAF training.

Figure 7-6. M-206 Flare

The DAF uses both DAF- and Army-procured M-206 flares. As can be seen from Table 7-1, the M-206 is scheduled to be replaced by the MJU-61A/B described in Section 7.3.3.7. The M-206 is expected to be used in DAF training until production is complete and the inventory is depleted.

Figure 7-7 is a photograph of an M-206 flare being inserted into a standard 30 flare magazine for 1-inch by 1-inch by 8-inch flares. Magazines are designed to hold typically 6 to 30 countermeasures, depending on the countermeasure dimensions. The loaded magazine is then installed into the aircraft countermeasure dispenser system. The magazine limitations on the flare size and shape become more important as flare designers are required to respond to increasingly complex targeting capabilities of IR missile heads.

Note: The filled magazine is fastened into the aircraft.

Figure 7-7. A Flare Magazine that Holds Thirty 1-inch by 1-inch by 8-inch Flares

7.3.3.4 MJU-10/B MTV Flare

The MJU-10/B flare in Figure 7-8 is approximately 2 inches by 2.5 inches by 8 inches and includes all the comparable parts of the MJU-7A/B flare. The MJU-10/B flare has a 2-inch by 2.5-inch by 0.25-inch nylon or plastic piston and a 2-inch by 2.5-inch by 0.125-inch aluminum end cap. The piston and end cap are laid flat in Figure 7-8. The approximately 14-inch by 8-inch wrapping is partially cut away from the flare pellet for the picture. As with the other MTV flares, the aluminum case and BBU-36/B impulse cartridge remain in the aircraft as the S&I device, piston, end cap, and wrapping fall to the surface.

Table 7-1 notes that the MJU-10B flare is being replaced by the MJU-53/B flare and then the MJU-75/B flare, which have additional spectral capabilities against advanced IR missiles. As with the MJU-7A/B, the MJU-10/B foil wrapping tape has a warning in case a dud flare should fall to the surface (see Section 7.7.3).

Figure 7-8. MJU-10/B Flare with Aluminum Case Cut Away to Show the Different Materials

7.3.3.5 MJU-23A/B MTV Flare

The MJU-23A/B is a B-1B-specific round flare with a diameter of 2.85 inches and a length of 10.6 inches. Figure 7-9 presents all the components of the MJU-23A/B flare with the exception of the 10.6-inch by 11-inch wrapping. The BBU-46 impulse cartridge (with a greater charge than the BBU-36/B) pushes the piston, wrapped flare pellet, end cap, felt pads, plastic disc, and S&I assembly out of the aluminum cannister, and the residual pieces fall to the surface.

As noted in Table 7-1, the MJU-23A/B flare is being discontinued in the DAF inventory and has no projected use beyond the mid-2020s.

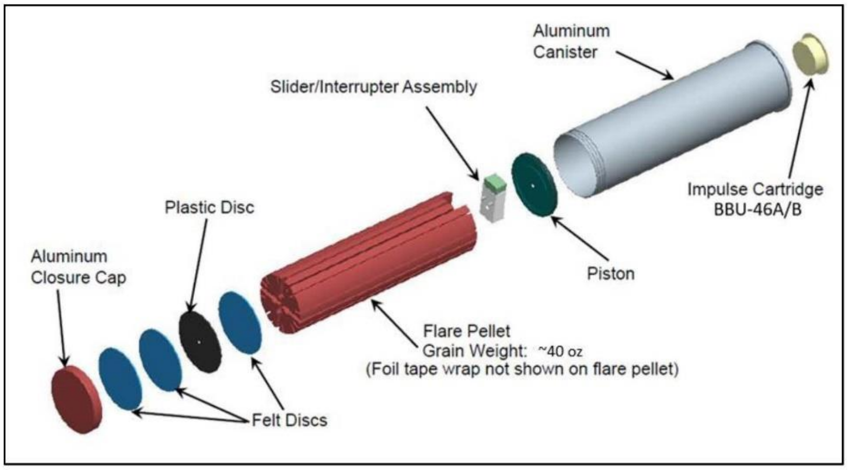


Figure 7-9. **MJU-23A/B Flare (specific to the B-1B)**

7.3.3.6 MJU-53/B MTV Flare

The MJU-53/B flare in Figure 7-10 measures approximately 1 inch by 2 inches by 8 inches. The MJU-53/B is a replacement for the MJU-7A/B by the mid-2020s.

The cutaway drawing shows the residual materials consisting of the plastic closure and end caps, the rubber spacer, the combined plastic piston screwed to the slurry holder with slider that contains the S&I assembly, and the approximately 6-inch by 14-inch aluminum coated wrapping material (not pictured). When the BBU-36 impulse cartridge deploys the flare pellet, the foil wrapping is split and separated from the burning flare. If the flare were to fall to the surface as a dud flare, the foil wrapping has printed: "**Warning – USAF IR Flare –Explosive / Highly Flammable**."

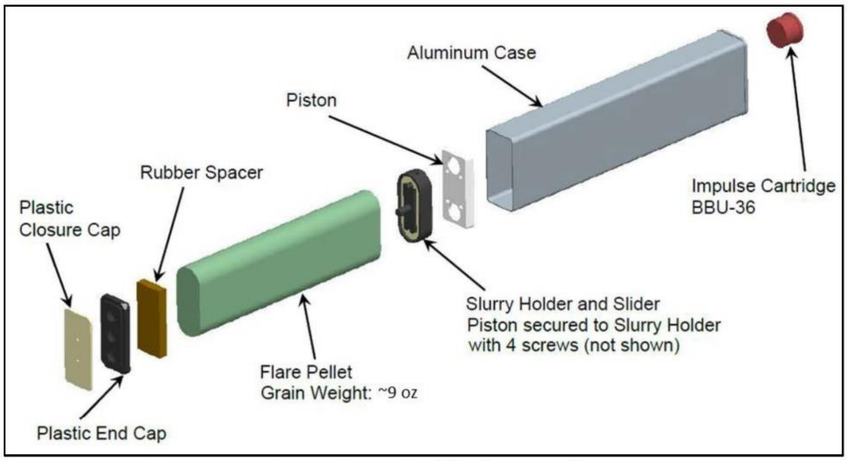
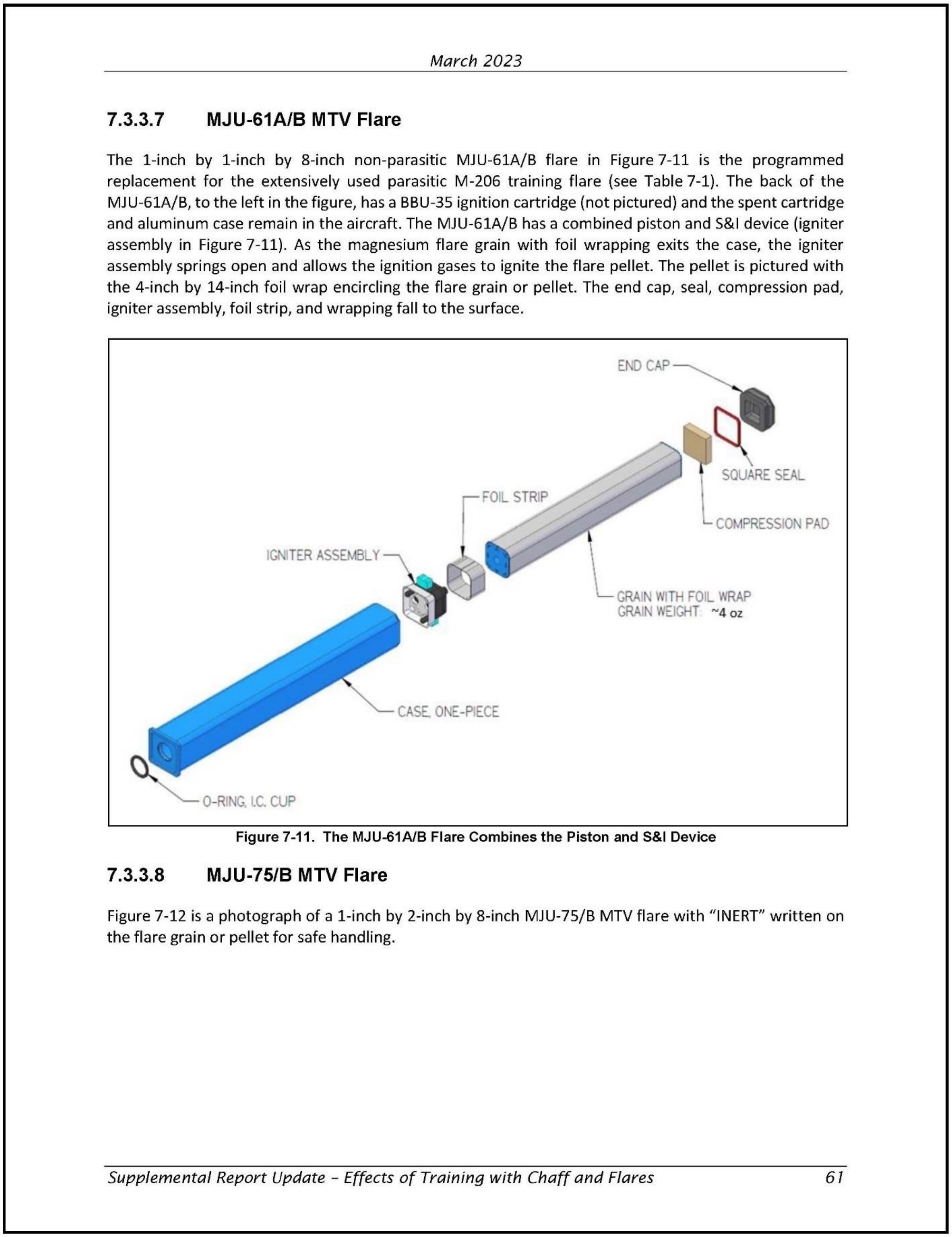


Figure 7-10. **MJU-53/B Flare Details**



7.3.3.7 MJU-61A/B MTV Flare

The 1-inch by 1-inch by 8-inch non-parasitic MJU-61A/B flare in Figure 7-11 is the programmed replacement for the extensively used parasitic M-206 training flare (see Table 7-1). The back of the MJU-61A/B, to the left in the figure, has a BBU-35 ignition cartridge (not pictured) and the spent cartridge and aluminum case remain in the aircraft. The MJU-61A/B has a combined piston and S&I device (igniter assembly in Figure 7-11). As the magnesium flare grain with foil wrapping exits the case, the igniter assembly springs open and allows the ignition gases to ignite the flare pellet. The pellet is pictured with the 4-inch by 14-inch foil wrap encircling the flare grain or pellet. The end cap, seal, compression pad, igniter assembly, foil strip, and wrapping fall to the surface.

Figure 7-11. The MJU-61A/B Flare Combines the Piston and S&I Device

7.3.3.8 MJU-75/B MTV Flare

Figure 7-12 is a photograph of a 1-inch by 2-inch by 8-inch MJU-75/B MTV flare with "INERT" written on the flare grain or pellet for safe handling.

Note: Flare has two residual pieces and does not have foil wrapping.

Figure 7-12. MJU-75/B Flare

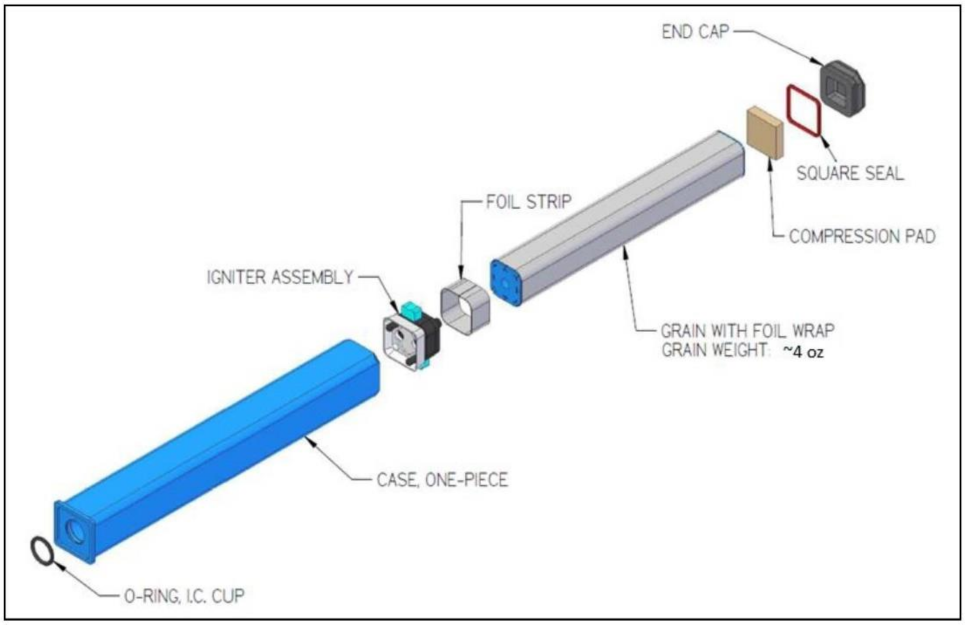
The aluminum case above the flare pellet in Figure 7-12 would include either a BBU-35 or a CCU-145 impulse cartridge. The end cap with an attached rubber pad is to the left of the flare pellet and the combined plastic S&I device and piston is to the right. When compared with other MTV flares, the MJU-75/B design results in two pieces of residual material, the end cap and the combined S&I and piston assembly. The MJU-75/B does not have a foil wrapping. The production MJU-75/B is to have the warning in Figure 7-13 printed on both sides of the flare grain.

Figure 7-13. Warning to be Printed on the MJU-75/B Flare Grain or Pellet

The MJU-75/B is projected to replace the MJU-7A/B, MJU-10/B and MJU-53/B as the inventory of those flares is depleted.

7.3.3.9 MJU-77/B MTV Flare

The 1-inch by 1-inch by 8-inch MJU-77/B flare presented in Figure 7-14 is an MJU-61A/B flare with a modified IR output for different aircraft applications. The MJU-77/B capabilities are not as comprehensive as the standard spectral flares described in Section 7.4. All the components and residual pieces that fall to the surface with the MJU-77/B are the same as those described for the MJU-61A/B flare in Section 7.3.3.7. The MJU-77/B is projected to be used as an advanced MTV flare in training, testing, and combat beyond the year 2035.



Note: The MJU-77/B flare provides improved spectral capabilities.

Figure 7-14. MJU-77/B Flare Details

7.4 Standard Spectral Flares

The MTV flares have been effective against legacy IR missiles that seek heat in a single spectral band. The burning MTV flare emits IR radiation that is essentially a spectral continuum attenuated by atmospheric absorption. The falling flare initially was successful in causing a missile seeker head, capable of detecting a narrow IR band, to lose the targeted aircraft (Global Security, 2015)

In response to MTV flares, IR missiles seeker heads were developed that could distinguish different spectral bands. Since the MTV flare emitted a higher IR signature than the aircraft, newer missile seeker heads were designed to discriminate among spectral bands and continue to track the IR bands that represented the targeted aircraft.

7.4.1 IR Missiles to Counter MTV Flares

IR missile seeker head capabilities improved to be able to distinguish the spectral signature from various heated surfaces of the targeted aircraft, including the heated exhaust from the rear, the sides of the aircraft heated by the engine, and even frontal parts of the targeted aircraft heated by friction as the aircraft flew through the atmosphere. IR missiles could now successfully track varying spectral signatures and engage a targeted aircraft from the rear, side, or front.

The high temperature MTV flares produce sufficient intensity to protect most targeted aircraft from legacy IR missiles. Unfortunately for countermeasure developers, the high temperatures of MTV flares were found to result in a very different spectral distribution than an aircraft. IR missile seeker heads were designed using different technologies to discriminate the target aircraft with more than one wavelength. One technology improved the seeker head by having different detectors that were able to discriminate among different IR bands. Another technology equipped a single detector with segments to filter for two bands (White, 2012). These improvements were able to counter most legacy MTV flares, which either did not exhibit the same IR image as the target aircraft or radiated excessively in certain bands, such as the ultraviolet band, which is detected by the improved seeker heads. The improved IR missile seeker heads were able to identify and respond to multiple radiation characteristics of the target aircraft and not follow an MTV flare that emitted a narrow IR band.

Countermeasures were needed that could successfully protect a target aircraft from the improved seeker heads on the next generation of IR missiles.

7.4.2 The Standard Spectral Flare Response

The response of countermeasure developers was to design and produce flares that provided different spectral signatures. As countermeasures and counter-countermeasures transitioned to more complex systems, the initial spectral flares were designated “Standard Spectral Flares.”

Standard spectral flares represent the second family of DAF flare countermeasures. These improved spectral flares cause the seeker head to momentarily lose a target. The pilot would typically maneuver to further distract the IR missile. Spectral flares have made it more difficult for a missile seeker head to distinguish a spectral flare with diverse IR signatures from the target aircraft also with diverse IR signatures. Because spectral flares are more expensive to produce, they are not regularly used during training but are used for testing to be sure they successfully create an image with multiple IR signatures to protect the targeted aircraft in combat. Table 7-5 presents the DAF standard spectral flares, their use in 2020, and their potential future use.

Table 7-6 presents the dimensions, residual materials, and the weights of the heavier residual materials that result from the deployment of standard spectral flares.

As noted in Table 7-6, some spectral flares have heavier brass or tungsten noses or end caps. The spectral flare weighted end cap improves the forward momentum of the spectral flare and permits the flare to divert the IR missile more effectively from the target aircraft. The weighted end cap descends with greater momentum than the S&I assembly. Section 8.5 describes the potential safety risks associated with heavy residual materials.

Table 7-5. Standard Spectral Flare Use and Projected Use

Standard Spectral Flares	12-Month Training [1]	12-Month Test [1]	Comments and/or Expected Change in Use	Potential Future Annual Training	Potential Future Annual Test
M212	0	47	Expected to be replaced as supplies of MJU-73/B become available starting in 2023.	0	0
XM216E5	0	0	Expect to be updated by MJU-78/B with improved impulse cartridge.	0	100
MJU-62/B or MJU-62A/B	1,751	79	MJU-62A/B has an updated pellet. Both versions to be used.	0	200
MJU-73/B	0	3	Updated design to replace M212 starting in 2023.	1,700	200
MJU-78/B	0	0	Updated XM216E5 with different ignition cartridge.	100	200
Totals	**1,751**	**129**		**1,800**	**700**

MJU = Mobile Jettison Unit (flare)

Note:

1. Average 12-month training and test usage calculated from 27 months of data.

Table 7-6. Standard Spectral Flare Dimension and Residual Material Weight

Standard Spectral Flares	Aircraft	Flare Dimensions (inches)	Residual Materials	Weight of End Closure (ounces)	Weight of S&I Assembly (lbs)	Weight of Nose in lbs (brass or tungsten)
M212	Multiple	1 x 1 x 8	Piston, S&I; wrapping, felt, brass nose	Included with nose	0.054	0.0822
XM216E5	The DAF expects to use MJU-78/B	1 x 1 x 8	Piston Assembly; wrapping, weighted nose, foam pad and plastic end cap	Included with nose	0.054	0.0822
MJU-62/B or MJU-62A/B	C-17, possibly others	1 x 2 x 8	Piston, S&I; wrapping, felt, plastic end cap	0.02	0.054	0.0106
MJU-73/B	Multiple	1 x 1 x 8	Piston, S&I; wrapping, felt, brass nose	Included with nose	0.054	0.0822
MJU-78/B	Expect to use as supplies become available.	1 x 1 x 8	Piston Assembly; wrapping, weighted nose, foam pad, plastic end cap	Included with nose	0.054	0.0822

DAF = Department of the Air Force; lbs = pounds; MJU = Mobile Jettison Unit (flare); S&I = Safe and Initiation

7.4.3 Standard Spectral Flare Details

Standard spectral flares provide additional capabilities to divert an IR missile seeker head as compared with the single or narrow wavelengths associated with MTV flares. Standard spectral flares are designed to be a closer match to the different wavelengths in an aircraft's IR signature. The characteristics of the DAF's standard spectral flares are presented in the following sections.

7.4.3.1 M212 Standard Spectral Flare

The M212 illustrated in Figure 7-15 is a standard spectral flare of the same size and shape as the M-206 MTV flare. The 1-inch by 1-inch by 8-inch M212 fits into the 30 flare magazine in Figure 7-7. Figure 7-15 presents an assembled flare below the aluminum case and also displays separated parts from the flare, including the combined piston and S&I assembly at the lower left, the cushion, and the brass nose or end closing at the lower right. The piston and S&I assembly are thrust out of the aluminum case by a BBU-35 impulse cartridge. The brass end cap provides momentum for the flare and falls to the ground as the burning pellet is consumed. The 4-inch by 14-inch aluminum-coated wrapping is split from the burning flare pellet and falls to the surface with the S&I assembly, spacer, and brass nose. The M212 is being replaced by the MJU-73/B beginning in 2023 (see Section 7.4.3.4). The MJU-73/B has the same dimensions as the M212 and provides improved IR performance.

7.4.3.2 XM216E5 Standard Spectral Flare

The XM216E5 is a developmental flare that has the same dimensions as the M212 and MJU-78/B flares. The XM216E5 is not expected to become part of the DAF flare inventory as is, but components of the developmental flare will be incorporated into future flares. Flare designs and capabilities are continually changing and improving, and the XM216E5 design has morphed into the MJU-78/B (see Section 7.4.3.4).

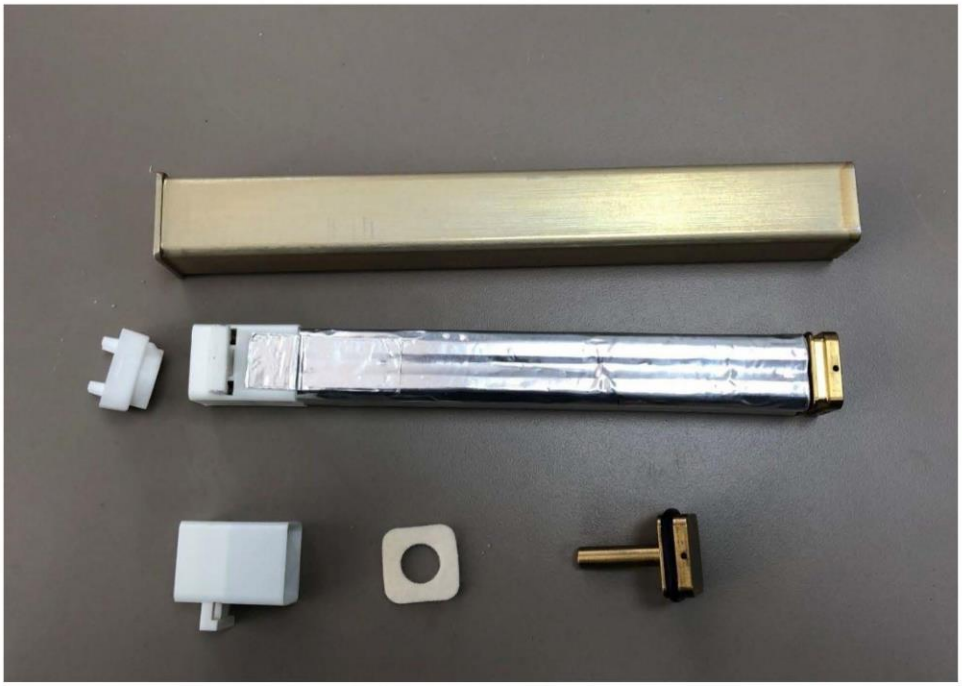


Figure 7-15. M212 Standard Spectral Flare

Figure 7-16 presents all the components of the XM216E5. The combined piston and S&I assembly is simpler and lighter than the standard S&I device. The thin slice components aid in pellet ignition. The adhesive aluminum strip is to facilitate the sliding of the S&I assembly through the aluminum case. The tungsten weight attached to the nose at the lower left of the figure falls to the surface after the flare pellet is consumed. Nearly all the components of the XM216E5 are incorporated into the MJU-78/B spectral flare (see Section 7.4.3.4).

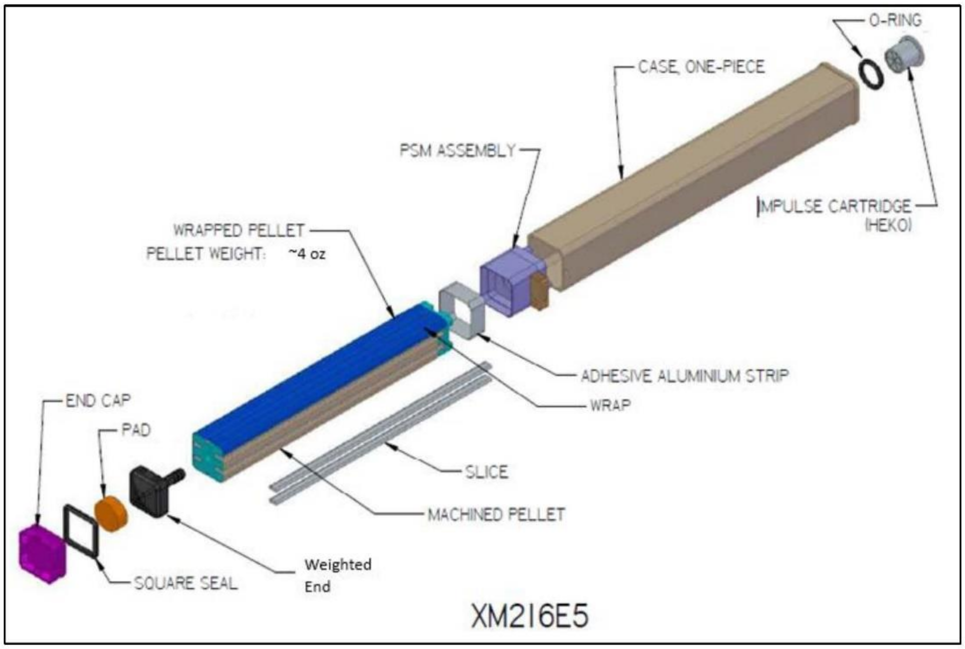


Figure 7-16. The XM216E5 Developmental Flare

7.4.3.3 MJU-62A/B and MJU-62/B Standard Spectral Flares

The MJU-62A/B and MJU-62/B standard spectral flares in Figure 7-17 are the same dimensions as the MJU-7A/B with several additional features. The 1-inch by 2-inch by 8-inch MJU-62 series simplifies the piston and S&I assembly and the end cap with an O-ring. Figure 7-17 presents two S&I devices, one attached to left side of the flare pellet and the other below the flare pellet. The pictured tapered cap on the left is for storage and the cap is removed for an impulse cartridge to be inserted into the space before the flare is loaded into the flare magazine.

The MJU-62/B will be used until supplies are exhausted. It is scheduled to be replaced by the upgraded MJU-62A/B starting in 2023. The MJU-62A/B has all the same features as the MJU-62/B and includes an improved pellet for improved spectral defense.

Note: The MJU-62A/B has the same components with an improved pellet.

Figure 7-17. MJU-62/B Flare

7.4.3.4 MJU-73/B Standard Spectral Flare

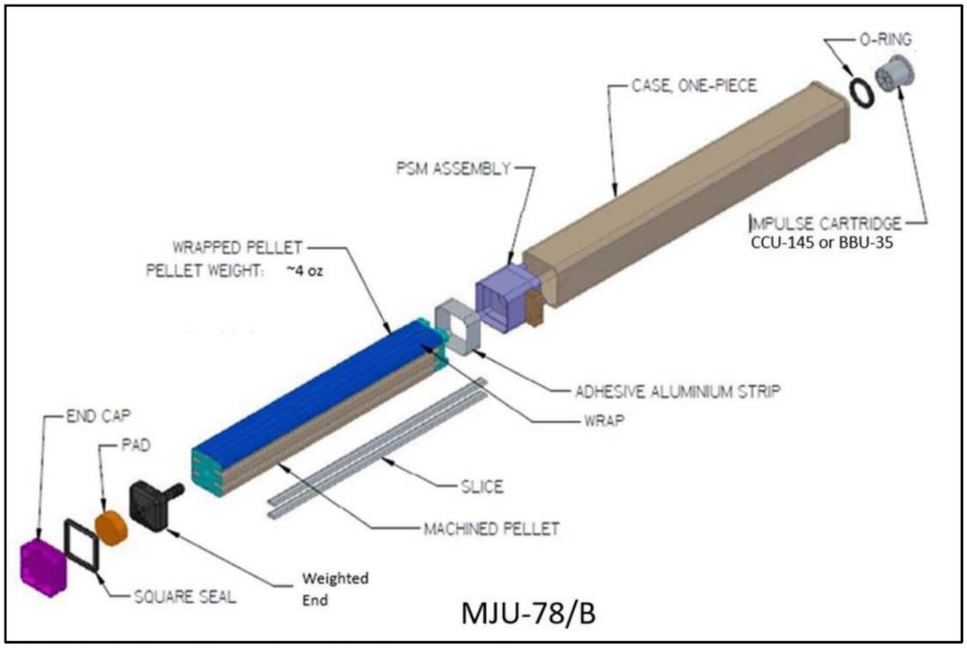
Figure 7-18 lays out all the components of the standard spectral MJU-73/B flare. At the top of the figure is the aluminum wrapping for the flare pellet and the next item from the top is the aluminum case with a fully assembled flare below the case. The bottom elements are the actual flare pellet the disassembled S&I and piston, and the brass nose with an O-ring. The approximately 4-inch by 14-inch wrapping at the top of the figure displays the warning "**Warning-USAF Flare Explosive/Highly Flammable**." After each flare is deployed, the wrapping falls to the surface and has the appearance of stiff duct tape that has been singed (see Section 8.4).

The MJU-73/B is scheduled to replace the M212 beginning in 2023 as the M212 supplies are exhausted and the MJU-73 becomes available. The BBU-35 impulse cartridge is electronically ignited as described in Section 7.3.2. The residual components that fall to the surface consist of the piston and S&I assembly, the wrapping material, and the brass head and O-ring.

Figure 7-18. **MJU-73/B with Components Spread Out**

7.4.3.5 MJU-78/B Standard Spectral Flare

The MJU-78/B is the same dimension and has effectively all the same components as the XM216E5 flare. As can be seen by comparing the expected production MJU-78/B in Figure 7-19 with the developmental XM216E5 in Figure 7-16, the flares are visually identical. The difference is that the MJU-78/B uses a standard CCU-145A/A impulse cartridge. The MJU-78/B flare is undergoing development and is expected to be in use by the DAF before the 2030s.



Note: The MJU-78/B is the follow-on to the XM216E5 experimental flare.

Figure 7-19. **MJU-78/B Flare Detail**

7.5 Thrusted Flares

The countermeasure and counter-countermeasure challenges continued even as the spectral flares are being developed. Thrusted flares do not gravitationally separate from the aircraft as quickly as the MTV flares.

7.5.1 IR Missiles and Flare Trajectories Led to Thrusted Flares

The gravitational trajectory of standard MTV flares was different from the target aircraft. This trajectory difference could be detected by advanced seeker heads on IR missiles and the flare countermeasure would not successfully divert the IR missile (Birchenall et al., 2012).

The results of this challenge are the thrusted flares presented in this section. The thrusted flare could be an MTV flare or a standard spectral flare encased in a light body and fitted with aerodynamic fins. Such thrusted flares would not quickly separate from the target aircraft and would present a viable defensive countermeasure to the advanced seeker heads on the IR missiles.

7.5.2 Thrusted Flares

Table 7-7 lists the DAF thrusted flares and the estimated use. Thrusted flares are expensive and are primarily used for testing and combat.

Table 7-7. Thrusted Flare Use and Potential Future Use

Thrusted Flares	12-Month Training [1]	12-Month Test [1]	Comments and/or Expected Change in Use	Potential Future Annual Training	Potential Future Annual Test
MJU-39A/B and MJU-40A/B	0	28	Combat flare.	0	0
MJU-68/B	0	67	Very limited training use.	25	3,000
MJU-71/B	0	997	Very limited training use.	25	100
MJU-76/B	0	0	Undergoing testing in 2022. Expected to replace MJU-71/B	25	1,000
Totals	**0**	**1,965**		**75**	**4,100**

MJU = Mobile Jettison Unit (flare)

Note:

1. Average 12-month training and test usage calculated from 27 months of data.

These flares are generally not used in training. The flare weights calculated in Table 7-8 are based on the weights of the S&I devices Table 7-3 and Table 7-6 and comparisons of the MTV and standard spectral flare figures with the thrusted flare figures. The weights for thrusted flare flight bodies and noses are based on the dimensions and materials for each thrusted flare, the weight of thin carbon fiber at 34.37 grams per square foot, and the weight of steel and aluminum with the same capabilities as carbon fiber. Steel weighs approximately five times as much as comparable carbon fiber and aluminum weighs 1.74 times as much as comparable carbon fiber. The thrusted flare tungsten nose weight is assumed to be comparable to, and scalable from, the 37.3-gram MJU-73/B brass nose weight.

Table 7-8. Thrusted Flare Dimensions and Weight of Residual Materials

Thrusted Flares	Flare Dimensions (inches) [1]	Residual Materials	Type	Calculated Weight of S&I and Piston System (lbs)	Calculated Weight of Flight Body and Nose (lbs)
MJU-39A/B and MJU-40A/B	2x2.5x10.5 (97.974 sq in)	Carbon fiber flight body and shroud, S&I, piston, aluminum end cap, tungsten nose.	Thrusted	0.068	0.311
MJU-68/B	1.5x1.5x10.5 (79.124 sq in)	Carbon fiber flight body, S&I, piston, plastic end cap, tungsten nose	Thrusted	0.068	0.236
MJU-71/B	1x1x8 (31.5 sq in)	Steel flight body w/ tungsten nose, fin base assembly, piston/S&I assembly	Thrusted	0.054	0.162
MJU-76/B	1X1X8 (33.75 sq in)	Aluminum flight body w/tungsten nose, compression pad, plastic end cap, piston/S&I assembly	Thrusted	0.054	0.162

lbs = pounds; MJU = Mobile Jettison Unit (flare); S&I = Safe and Initiation; sq in = square inches

Note:

1. Square inches includes fins.

7.5.3 Thrusted Flare Details

Thrusted flares function differently from standard MTV and standard spectral flares. A thrusted flare has the flare pellet enclosed in a flight body. The flare pellet becomes the propellant that causes thrust and makes the flare flight body to be propelled or thrusted.

7.5.3.1 MJU-39/B, MJU-39A/B, MJU-40/B, and MJU-40A/B Thrusted Flares

The MJU-39 and MJU-40 series trusted flares contain similar internal components as were described for the MTV flares, including a piston, S&I assembly, and end cap. Thrusted flares are generally not used for training but are tested to ensure their effectiveness in combat. The MJU-39 and the MJU-40 series are similar in size to the MJU-10/B (see Section 7.3.3.4) with the exception that the 2-inch by 2.5-inch by 10.5-inch MJU-39A/B and MJU-40A/B are 2.5 inches longer than the MJU-10/B MTV flare. Figure 7-20 shows the carbon fiber thrusted flare body with fins to maintain the flare's trajectory. The carbon body fits into an aluminum case (not pictured) similar to that of the MJU-10/B and has an S&I device comparable to the MJU-10/B (see Section 7.3.3.4). The BBU-36 impulse cartridge gasses push the thrusted flare body out of the aluminum case and the thrusted flare is ignited through the S&I device as described in Section 7.3.2. The ignited flare is propelled on the aircraft trajectory and stabilized by the finned carbon fiber body.

Note: These flares share the same carbon fiber flight body.

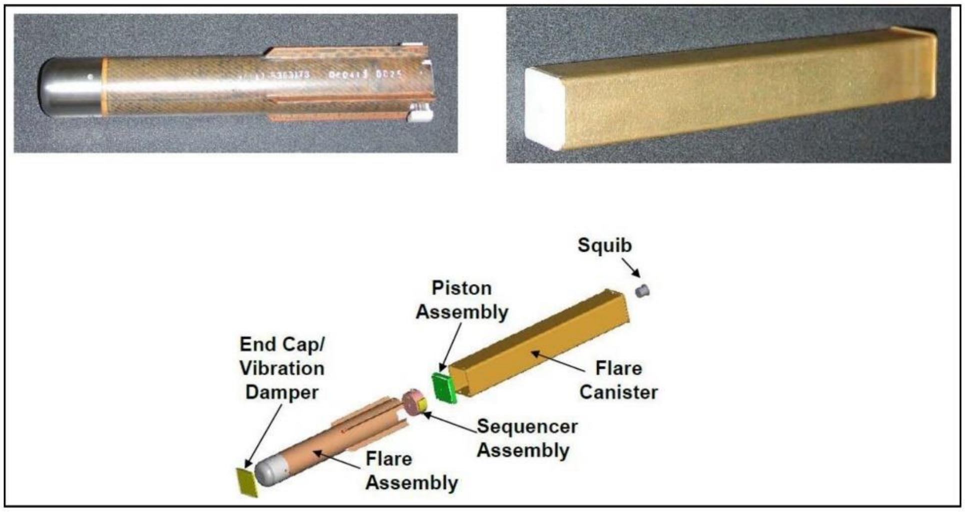
Figure 7-20. MJU-39A/B and MJU-40A/B Flares

The S&I device, aluminum end cap, plastic piston, carbon body with accompanying shroud, and the tungsten nose descend to the surface. The MJU-39 and 40 series are combat flares and are expected to be used into the 2030s in testing with very limited use in training over ranges where munitions are deployed.

7.5.3.2 MJU-68/B Thrusted Flares

The MJU-68/B is a combat flare comprised of an MTV flare in a 1.5-inch by 1.5-inch by 10.5-inch aluminum case pictured in Figure 7-21. The flare components are displayed on the bottom of the figure. The carbon fiber flight body has a nozzle to focus the flare thrust and integral fins to stabilize the flight on the aircraft's trajectory. The flare is thrust from the aluminum case by a CCU-145 impulse cartridge (squib) that ignites gases. The gases ignite the flare through the nozzle as the sequencer assembly (an S&I device) exits the case. The carbon fiber flight body continues to be propelled until the integrated magnesium compound burn is completed.

The empty carbon body, tungsten nose, sequencer assembly, end cap with vibration damper, and plastic piston become residual materials on the surface. The MJU-68/B combat flare is used in testing with very limited use in training over ranges where munitions are deployed. The MJU-68/B will be used into the 2030s and is expected to be replaced by the similar MJU-76/B.



Note: Flare and aluminum case shown assembled with parts displayed below.

Figure 7-21. MJU-68/B Flare

7.5.3.3 MJU-71/B Thrusted Flare

The MJU-71/B pictured in Figure 7-22 is a combat flare comprised of a magnesium compound encased in a standard 1-inch by 1-inch by 8-inch aluminum case. The multiple flare components are displayed in the figure. The steel and plastic flight body has a base assembly with stabilizing fins that spring out as the flare exits the aluminum case.

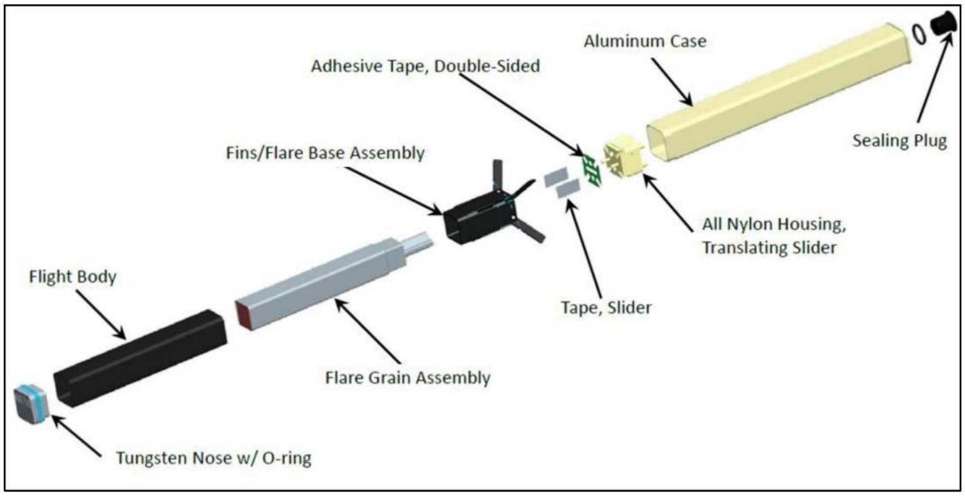


Figure 7-22. MJU-71/B Thrusted Flare Parts

The flight body, tungsten nose (which serves as the end cap), and slider with tape and translating slider (piston) sequencer assembly, become residual materials on the ground surface after deployment. The MJU-71/B is a combat flare used in testing with very limited use in training over ranges where munitions are deployed. The MJU-71/B is in production and will be used by various aircraft into the 2030s.

7.5.3.4 MJU-76/B Thrusted Flare

The MJU-76/B is a combat flare undergoing development in 2022 and planned to replace both the MJU-68/B and the MJU-71/B in the future. Figure 7-23 depicts the standard 1-inch by 1-inch by 8-inch aluminum case at lower left and the payload assembly, which contains the epoxied MTV magnesium compound on the right. The similarities with the MJU-68/B (Section 7.5.3.2) are apparent, with the integral fins in the flare body, combined piston, igniter assembly, S&I device, and tungsten weighted end cap. Figure 7-23 shows the flare nozzle at the end of the payload assembly that is ignited by the ignition pellet from the S&I assembly.

The igniter S&I assembly, empty flight body, pad and seal, and plastic end cap become residual materials on the ground surface after deployment. The MJU-76/B is a combat flare that will be used in testing with very limited use in training over ranges where munitions are deployed. The MJU-68/B is expected to start procurement in the mid-2020s and be used by multiple DAF aircraft into the late 2030s.

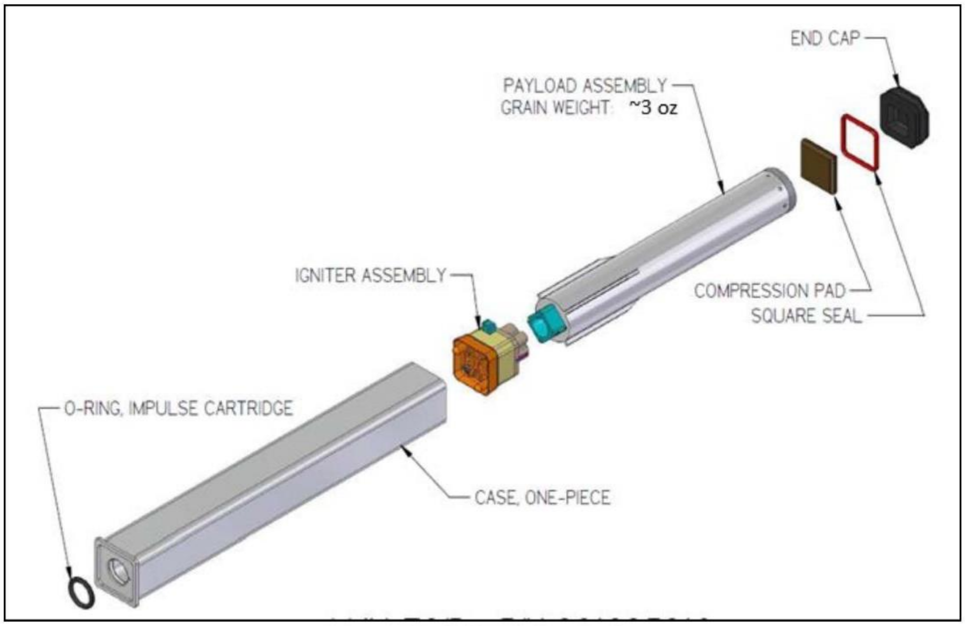


Figure 7-23. MJU-76/B Flare Parts

7.6 Spectral Decoys

Seeker heads became more capable in distinguishing between a flare and the different spectral wavelengths associated with the target aircraft features. The multiple variabilities in seeker heads required a different approach to defensive countermeasures. This continuing counter-countermeasure challenge resulted in the fourth DAF IR countermeasure family considered and evaluated in this report: spectral decoys.

7.6.1 Spectral Decoy Overview

A spectral decoy is an entirely different concept, which creates a complex display of IR signatures, images, and wavelengths to divert an incoming missile targeting different combinations of IR signatures. The target aircraft maneuvers while hidden by the complex decoy cloud of different spectral wavelengths.

7.6.2 The Spectral Decoy Response

Spectral decoys present a pyrophoric signature different from that of the pyrotechnic flares in the first three countermeasure families. The magnesium pellets in MTV, standard spectral, and thrusted flares all combust to create an IR signature that interferes with the specific IR missile's seeker head. Spectral decoys are not pyrotechnic flares, but pyrophoric decoys with payloads comprised of thin iron foils rather than a block of magnesium (see Figure 7-24). The foils in the different decoys are similar in appearance but differ in thickness, coatings, and the number of foils in the decoys. These differences affect the IR performance of each type of decoy.

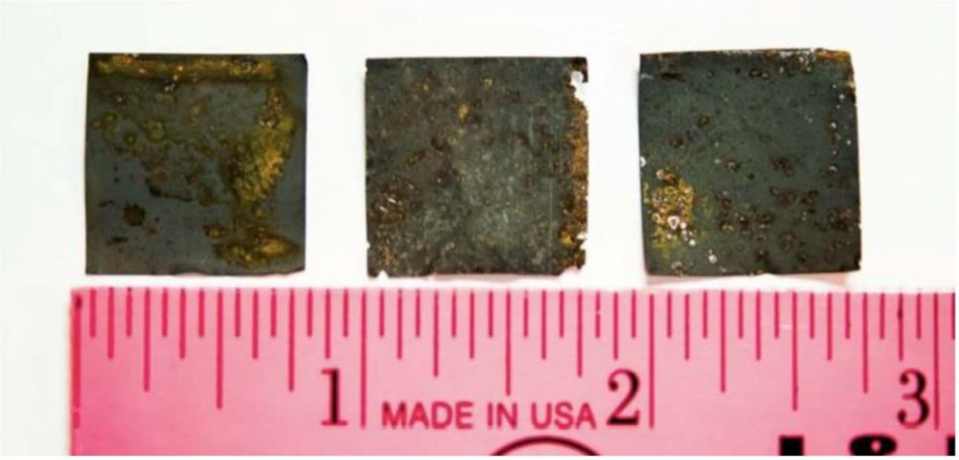
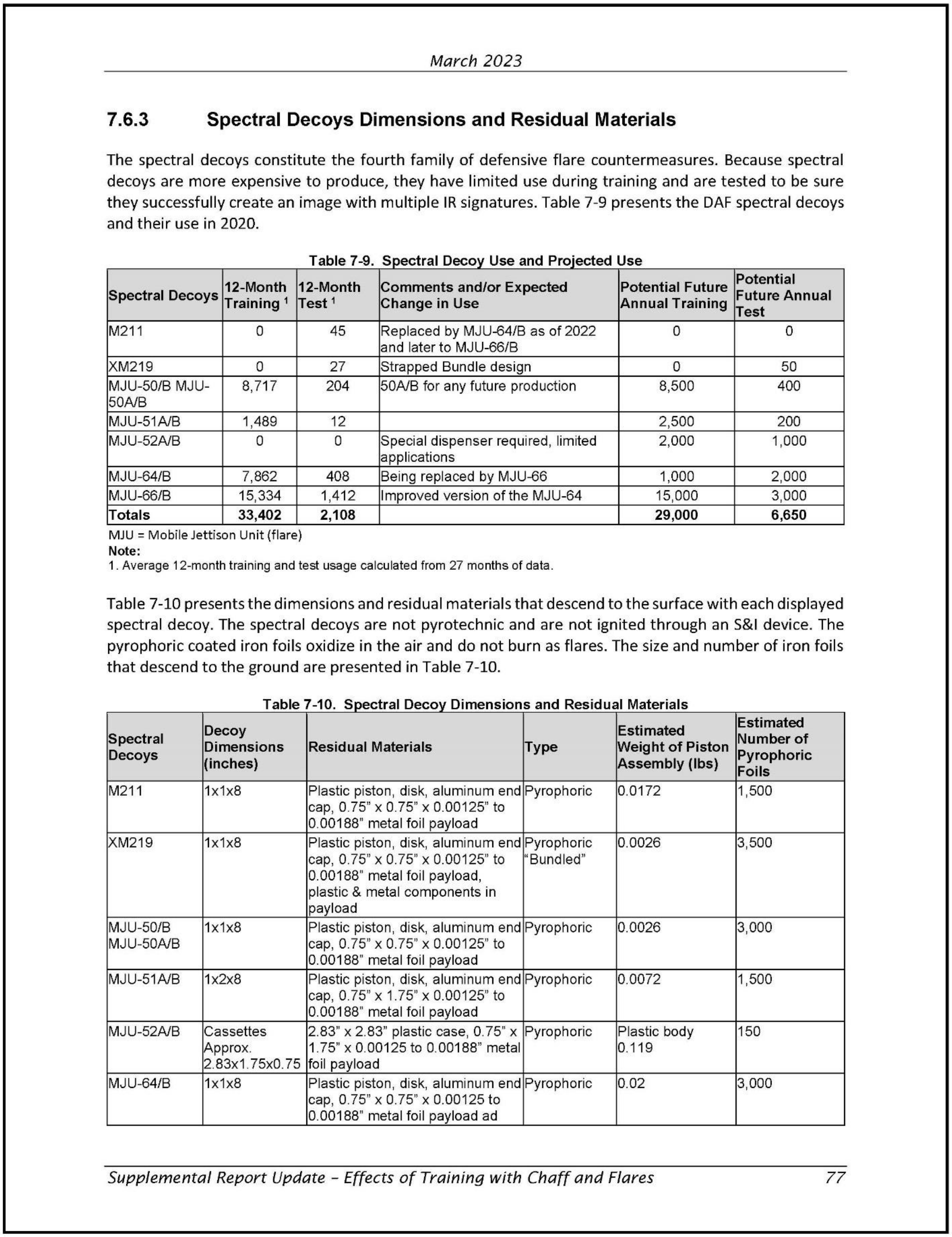


Figure 7-24. Pyrophoric Iron Foils After Spectral Decoy Deployment and Some Weathering

A spectral decoy is deployed by an electrical pulse passing through the countermeasure dispenser system to the impulse cartridge that generates gasses and pushes the piston. The sealed end cap releases and the decoy assembly is ejected from the aluminum case. When exposed to air, the differently coated and packed payload of thin foils reacts with the air to generate an IR signature. After the reaction is completed, the foils, end cap, and piston fall to the ground. The foil oxidization generates heat of approximately 700 °F to 1,500 °F for a few seconds. The iron foils reach ambient temperature before they have drifted for approximately 500 feet. The foils, which can be approximately 0.75 inch by 0.75 inch by 0.00125 inch, or thicker, can be stacked in groups and the total number of coated iron foils in a standard sized 1-inch by 1-inch by 8-inch aluminum case can be as many as 2,000 to 3,000 foils. In some respects, the spectral decoy has a similar effect to that of chaff in that the thousands of dispersed foils create many IR signatures that are able to distract the IR seeker head even though it targets different spectral wavelengths. A spectral decoy has an additional benefit for night missions because the oxidization of the thin metal foils in the IR spectral wavelengths does not produce a visible signature. This means that there is no ability to visually track the targeted aircraft.

The ability to counter diverse spectral seeker heads comes at a cost. The spectral decoy does not normally present the temperature of an MTV or later flares. This means that a spectral decoy, which can be very effective against a sophisticated IR seeker head, may not defend against a legacy exhaust heat-seeking IR missile. To disrupt the different types of potential seeker heads, the targeted aircraft needs to combine spectral decoys with other flares in what is affectionately referred to as a “cocktail” by countermeasure managers. The cocktail would include a variety of flares inserted into a flare magazine, as pictured in Figure 7-7, and deployed in accordance with the identified or anticipated threat.

It is important to note that, to date, all countermeasures have been able to be overcome by technological advances in the IR missile head tracking systems. Additionally, the IR missiles are not as constrained by weight or power source as are the defensive countermeasures. This continued high-level of threat from IR missiles is not expected to dramatically change in the future.



7.6.3 Spectral Decoys Dimensions and Residual Materials

The spectral decoys constitute the fourth family of defensive flare countermeasures. Because spectral decoys are more expensive to produce, they have limited use during training and are tested to be sure they successfully create an image with multiple IR signatures. Table 7-9 presents the DAF spectral decoys and their use in 2020.

Table 7-9. Spectral Decoy Use and Projected Use

Spectral Decoys	12-Month Training [1]	12-Month Test [1]	Comments and/or Expected Change in Use	Potential Future Annual Training	Potential Future Annual Test
M211	0	45	Replaced by MJU-64/B as of 2022 and later to MJU-66/B	0	0
XM219	0	27	Strapped Bundle design	0	50
MJU-50/B MJU-50A/B	8,717	204	50A/B for any future production	8,500	400
MJU-51A/B	1,489	12		2,500	200
MJU-52A/B	0	0	Special dispenser required, limited applications	2,000	1,000
MJU-64/B	7,862	408	Being replaced by MJU-66	1,000	2,000
MJU-66/B	15,334	1,412	Improved version of the MJU-64	15,000	3,000
Totals	**33,402**	**2,108**		**29,000**	**6,650**

MJU = Mobile Jettison Unit (flare)

Note:

1. Average 12-month training and test usage calculated from 27 months of data.

Table 7-10 presents the dimensions and residual materials that descend to the surface with each displayed spectral decoy. The spectral decoys are not pyrotechnic and are not ignited through an S&I device. The pyrophoric coated iron foils oxidize in the air and do not burn as flares. The size and number of iron foils that descend to the ground are presented in Table 7-10.

Table 7-10. Spectral Decoy Dimensions and Residual Materials

Spectral Decoys	Decoy Dimensions (inches)	Residual Materials	Type	Estimated Weight of Piston Assembly (lbs)	Estimated Number of Pyrophoric Foils
M211	1x1x8	Plastic piston, disk, aluminum end cap, 0.75" x 0.75" x 0.00125" to 0.00188" metal foil payload	Pyrophoric	0.0172	1,500
XM219	1x1x8	Plastic piston, disk, aluminum end cap, 0.75" x 0.75" x 0.00125" to 0.00188" metal foil payload, plastic & metal components in payload	Pyrophoric "Bundled"	0.0026	3,500
MJU-50/B MJU-50A/B	1x1x8	Plastic piston, disk, aluminum end cap, 0.75" x 0.75" x 0.00125" to 0.00188" metal foil payload	Pyrophoric	0.0026	3,000
MJU-51A/B	1x2x8	Plastic piston, disk, aluminum end cap, 0.75" x 1.75" x 0.00125" to 0.00188" metal foil payload	Pyrophoric	0.0072	1,500
MJU-52A/B	Cassettes Approx. 2.83x1.75x0.75	2.83" x 2.83" plastic case, 0.75" x 1.75" x 0.00125 to 0.00188" metal foil payload	Pyrophoric	Plastic body 0.119	150
MJU-64/B	1x1x8	Plastic piston, disk, aluminum end cap, 0.75" x 0.75" x 0.00125 to 0.00188" metal foil payload ad	Pyrophoric	0.02	3,000

Table 7-10. Spectral Decoy Dimensions and Residual Materials (continued)

Spectral Decoys	Decoy Dimensions (inches)	Residual Materials	Type	Estimated Weight of Piston Assembly (lbs)	Estimated Number of Pyrophoric Foils
MJU-66/B	1x1x8	Plastic piston, disk, aluminum end cap, 0.75" x 0.75" x 0.00125 to 0.00188" metal foil payload	Pyrophoric	0.02	3,000

" = inch(es); lbs = pounds; MJU = Mobile Jettison Unit (flare)

7.6.4 Spectral Decoy Details

The flares and decoys all have complex and costly components to enable them to successfully defend against ever-improving seeker heads mounted on IR missiles. The majority of the spectral decoys described in this section have been designed to fit the standard 30-flare magazine. An exception is the MJU-52A/B, which is described in Section 7.6.4.5. Most combat aircraft have the ability to accept one or more flare magazines of 30 1-inch by 1-inch by 8-inch flares (see Figure 7-7). The flare magazine can accept 1-inch by 2-inch or 2-inch by 2.5-inch flares, but the number of flares in a magazine is normally constrained by the equivalent of 30 1-inch by 1-inch dimension units.

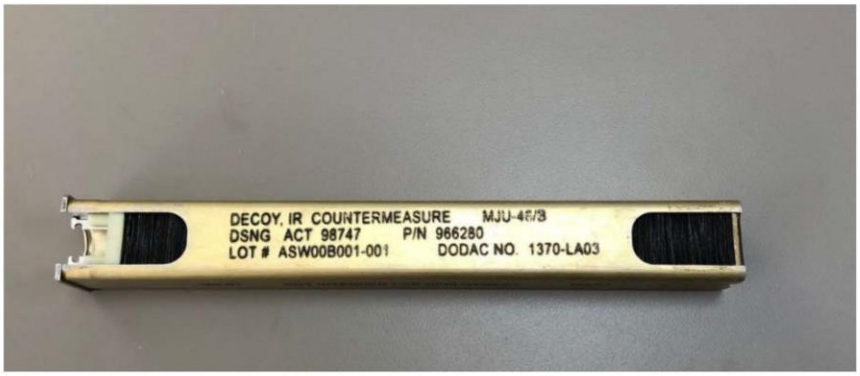
7.6.4.1 M211, MJU-50/B, MJU-50A/B, MJU-64/B, and MJU-66/B Spectral Decoys

Figure 7-25 is a picture of a cut-away view of a 1-inch by 1-inch by 8-inch MJU-46/B spectral decoy. Although the pictured MJU-46/B is no longer in DAF inventory, the M211, MJU-50/B, MJU-50A/B, MJU-64/B, and MJU-66/B are all the same size and have the same appearance and comparable pistons and end caps as the pictured MJU-46/B. The M211, MJU-50/B, MJU-50A/B, MJU-64/B, and MJU-66/B decoys contain foil payload weights ranging from approximately 8 to 11 ounces (226 to 299 grams).

The case is partially cut away in Figure 7-25 to show the sealed end cap on the right and the sealed piston on the left. The flare must be sealed because pyrophoric material reacts with air to rapidly oxidize. The BBU-35 or CCU-145 impulse cartridge (not pictured) would be inserted in the cut away area of the squib cup on the left. The impulse cartridge creates gas that pushes the piston and deploys the thin iron foils that oxidize as they are exposed to the air. The 1,500 to 3,000 0.75-inch by 0.75-inch iron foils with a thickness of approximately 0.0025 to 0.00125 inches (0.0625 to 0.03125 millimeters), plastic piston, end cap, and a 0.5-inch diameter disc used for ejection of the foils from the aircraft are residual materials that are deposited with each of the five similar spectral decoys.

The cutaway sections in Figure 7-25 show the stacked iron foils (see Figure 7-24). The difference among the spectral decoys is primarily the mix of spectral foils, which have slightly different IR reflectivity. The M211 and MJU-64/B use the same foil material, with different pistons and either a sealed aluminum end cap (M211) or a plastic sealed and crimped end cap with an O-ring (MJU-64/B). The MJU-50/B end cap is the same as the M211 and the MJU-50A/B, and the MJU-66/B uses the MJU-64/B newer plastic end cap.

The M211 inventory has been depleted and the MJU-50/B and MJU-50A/B are being used in 2022 but are to be replaced by the MJU-66/B. The MJU-64/B is expected to also be replaced by the MJU-66/B. Spectral decoys are undergoing development and modifications and are expected to change designations in the future.

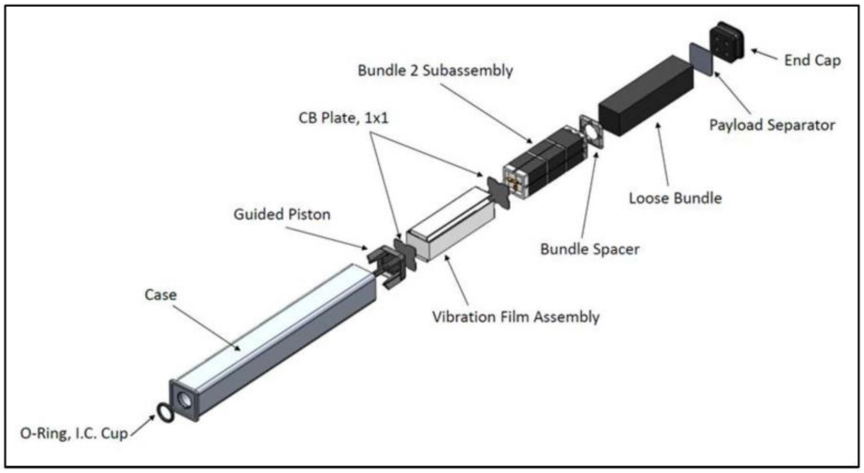


Note: The pictured MJU-46/B spectral decoy has the same dimensions and appearance as the M211, MJU-50/B, MJU-50A/B, MJU-64/B, and MJU-66/B spectral decoys.

Figure 7-25. MJU-46/B Spectral Decoy

7.6.4.2 XM219 Spectral Decoy

The XM219 spectral decoy depicted in Figure 7-26 is a strapped bundle design with delayed foil release. The XM219 has several different features from other spectral decoys. The XM219 decoy has a loose and a delayed opening second bundle of iron foils. The BBU-35 or CCU-145 impulse cartridge is inserted into the O-ring at lower left in the decoy pictured in Figure 7-26. The gases from the impulse cartridge push the payload, which pops off the end cap and spacer at upper right in the figure and ejects the loose bundle, the spacer, the second bundle, the plates, the vibration assembly, and the guided piston. The different spacers, end cap, and piston may be plastic, acrylic, or aluminum. These objects are deposited on the surface with the oxidized iron foils. There are approximately 3,500 0.75-inch by 0.75-inch by 0.00125-inch iron foils. The XM219 spectral decoy, or a derivative, is expected to be part of the DAF inventory well into the 2030s.



Note: The XM219 spectral decoy is used primarily by slower moving aircraft.

Figure 7-26. XM219 Spectral Decoy

7.6.4.3 MJU-50/B and MJU-50A/B Spectral Decoys

The description in Section 7.6.4.1 explains the 1-inch by 1-inch by 8-inch MJU-50/B and MJU-50A/B spectral decoys, which are essentially the same as the M211 except for foil payloads and the plastic or aluminum end caps. The 1,500 to 3,000 foils, end cap, plastic disk, and piston are deposited on the surface with each decoy deployed. The MJU-50/B and MJU-50A/B are scheduled to be replaced by the MJU-66/B before 2030.

7.6.4.4 MJU-51/B and MJU-51A/B Spectral Decoys

Figure 7-27 contains two spectral decoys, the MJU-51/B and MJU-51A/B, which are essentially the same except for the sealing end cap. The MJU-51A/B has a crimped plastic end cap with an O-ring for superior sealing of the pyrophoric foils. The MJU-51/B uses the aluminum end cap design. The MJU-51A/B and MJU-51/B pyrophoric decoys are each 1 inch by 2 inches by 8 inches, which are the same dimensions as the standard MJU-7A/B MTV flare (Section 7.3.3.1).

The cut away view in Figure 7-27 shows, on the left, the squib cup into which the BBU-35 or CCU-145 impulse cartridge is inserted and on the right the end cap. The pyrophoric payload in the cut away view of the MJU-51A/B consists of approximately 1,600 0.75-inch by 1.75-inch by 0.00234-inch individual coated iron foils. The foils react when exposed to air and generate heat along with the defensive IR spectral wavelengths. The foils, along with the piston, end cap, and a 0.5-inch diameter disk that facilitates deployment of the foils all descend to the surface.

Note: The inert sign on the MJU-51/B is for safe handling of the cutaway decoy.

Figure 7-27. MJU-51/B and MJU-51A/B Spectral Decoys

7.6.4.5 MJU-52A/B Spectral Decoy

The MJU-52A/B in Figure 7-28 is a different spectral decoy that has approximately 150 0.75-inch by 1.75-inch by 0.0025-inch pyrophoric iron foils sealed within a 3-inch by 2.5-inch by 0.375-inch plastic cassette frame. The cassettes are deployed by an electro-mechanical gear system. This BOL system, which can also be used for deployment of chaff, is independent from the normal flare magazine pictured in Figure 7-7.

The MJU-52A/B payload cartridge contains an integral tear strip that is attached to a mini sail. When one cassette is mechanically released into the aircraft airstream, a mini sail acts as a tiny parachute to tear open the cartridge seal and release the pyrophoric foils into the airstream. The foils are dispersed aerodynamically in the same manner as chaff. The blackened foils in Figure 7-28 are what remain after the foil is oxidized. The heat and IR signature from the oxidization are not visible to the human eye.

Residual materials that fall to the surface from the deployed MJU-52A/B consist of the 150 iron foils, the plastic cassette frame, the plastic payload tray, the sail with a soft plastic strap, and a heat seal that encases the foils. The MJU-52A/B, or a similar derivative, could continue in the DAF inventory past 2030.

Note: The MJU-52A/B spectral decoy case represents a departure from other decoys.

Figure 7-28. MJU-52A/B Spectral Decoy Case

7.6.4.6 MJU-64/B Spectral Decoy

The description in Section 7.6.4.1 explains that the MJU-64/B spectral decoy is essentially the same as the M211. The approximately 2,000 pyrophoric iron foils, end cap, plastic disk, and piston are deposited on the surface with each decoy deployed. The MJU-64/B has limited applications and is scheduled to be replaced by the MJU-66/B before 2030.

7.6.4.7 MJU-66/B Spectral Decoy

The MJU-66/B is an improved version of the MJU-64/B with spectral signatures for decoying more advanced IR missiles. The MJU-66/B is scheduled to be the replacement spectral decoy for the other pyrophoric decoys described in Section 7.6.4.1. The 1-inch by 1-inch by 8-inch MJU-66/B spectral decoy or a derivative is planned for use by multiple aircraft well into the 2030s. The approximately 2,000 0.75-inch by 0.75-inch by 0.002-inch oxidized iron foils, plastic end cap, plastic disk, and piston are deposited on the surface with each decoy deployed.

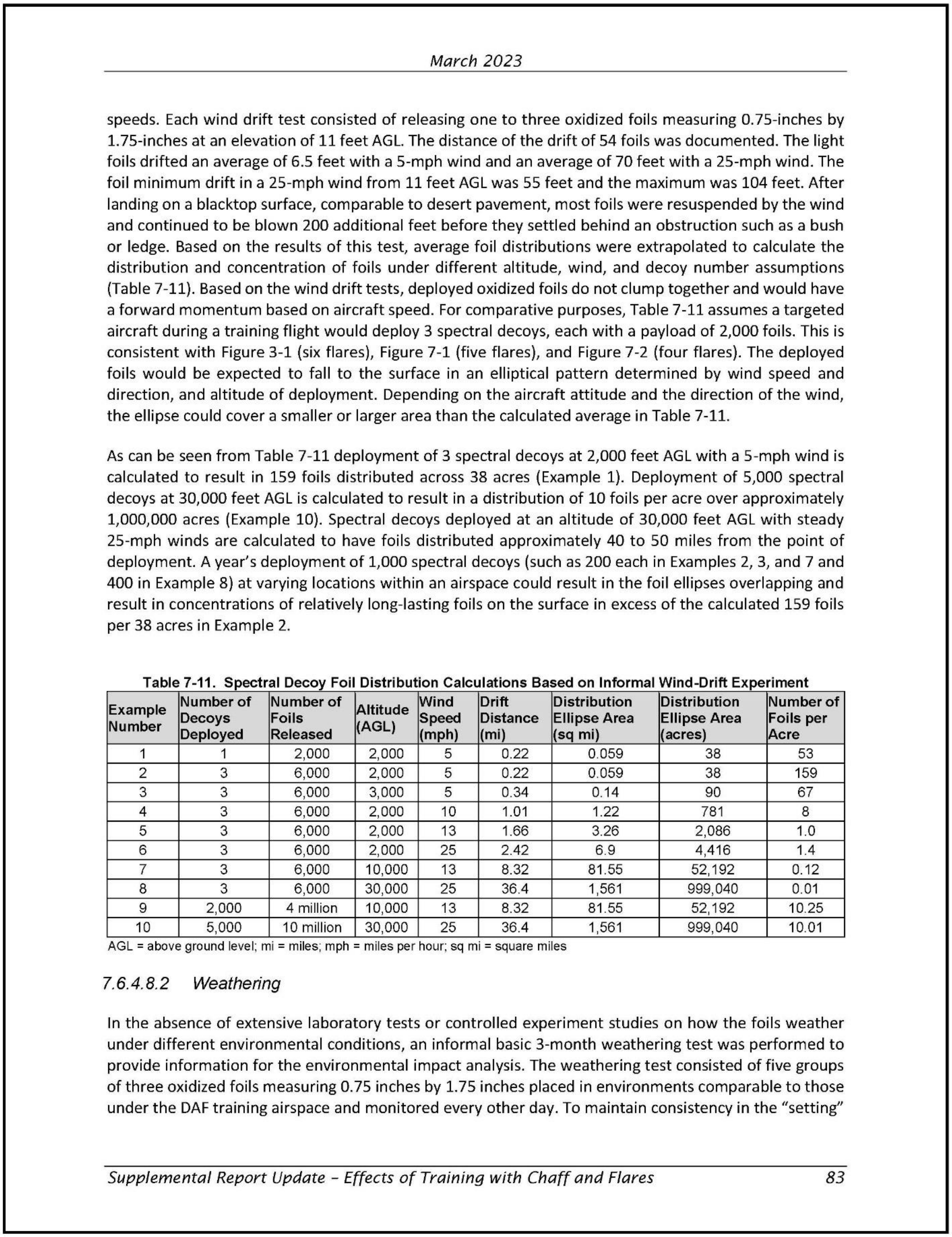
7.6.4.8 Spectral Decoy Foils

Figure 7-24 and Figure 7-28 present the two sizes of pyrophoric foils used in spectral decoys listed in Table 7-10. Spectral decoy foils are made primarily of iron (73 percent or higher) and may contain smaller amounts of other metals, such as copper, aluminum, tin, and manganese, as well as other compounds such as tantalum and boron (NAVSEA Crane, 2005). The MJU-27A/B, which is no longer in use, was composed of 73 percent iron, 7 percent copper, 12 percent aluminum, 8 percent tin, and 0.4 percent boron (NAVSEA Crane, 2005). Spectral decoys present a pyrophoric IR signature that is different from that of the magnesium pellets in MTV, standard spectral, and thrusted flares. The magnesium pellets burn to create an IR signature that interferes with the specific IR missile's seeker head. Spectral decoys do not have a pellet that burns but rather have a payload comprised of thousands of thin iron foils with chemical pyrophoric coatings that oxidize when exposed to air (see Section 7.6.4). A spectral decoy is deployed by an electrical pulse passing through the countermeasure dispenser system to the impulse cartridge, which generates gasses and pushes the piston. The sealed end cap is pushed off, and 1,500 to 3,000 foils (depending on the model) are ejected and rapidly disperse from the standard size (1-inch by 1-inch by 8-inch or 1-inch by 2-inch by 8-inch) aluminum case. The approximately 0.00125-inch thick 0.75-inch by 0.75-inch square (Figure 7-24) or 0.75-inch by 1.75-inch rectangular (Figure 7-28) foils rapidly oxidize when exposed to air and create multiple IR signatures to interfere with advanced IR missile seeker heads.

As of 2022, there had not been extensive laboratory tests or controlled experiment studies of spectral decoy iron foils comparable to those performed on chaff to ascertain how the foils behave in the air after deployment, or after landing on the surface (See DAF (2011), Appendices A, B, and C). Nor had there been any tests or studies on how the iron foils weather under different environmental conditions comparable to the tests performed for the 1997 Air Force Study (DAF, 1997). In order to have some indication of what would happen to the residual foils after spectral decoy deployment, a series of simple wind drift tests and an informal 3-month weathering test were performed to inform the environmental impact analysis.

7.6.4.8.1 Wind Drift

The light (0.0046– to 0.009-ounce or 0.13- to 0.25-gram) oxidized foils, end cap, and piston fall to the surface. Due to their lightness and surface area, the spectral decoy foils are dispersed and distributed by the wind as they fall in a manner similar to chaff. In order to understand how the foils drift and disperse in varying wind conditions, simple wind drift tests were performed at two airports with monitored wind



speeds. Each wind drift test consisted of releasing one to three oxidized foils measuring 0.75-inches by 1.75-inches at an elevation of 11 feet AGL. The distance of the drift of 54 foils was documented. The light foils drifted an average of 6.5 feet with a 5-mph wind and an average of 70 feet with a 25-mph wind. The foil minimum drift in a 25-mph wind from 11 feet AGL was 55 feet and the maximum was 104 feet. After landing on a blacktop surface, comparable to desert pavement, most foils were resuspended by the wind and continued to be blown 200 additional feet before they settled behind an obstruction such as a bush or ledge. Based on the results of this test, average foil distributions were extrapolated to calculate the distribution and concentration of foils under different altitude, wind, and decoy number assumptions (Table 7-11). Based on the wind drift tests, deployed oxidized foils do not clump together and would have a forward momentum based on aircraft speed. For comparative purposes, Table 7-11 assumes a targeted aircraft during a training flight would deploy 3 spectral decoys, each with a payload of 2,000 foils. This is consistent with Figure 3-1 (six flares), Figure 7-1 (five flares), and Figure 7-2 (four flares). The deployed foils would be expected to fall to the surface in an elliptical pattern determined by wind speed and direction, and altitude of deployment. Depending on the aircraft attitude and the direction of the wind, the ellipse could cover a smaller or larger area than the calculated average in Table 7-11.

As can be seen from Table 7-11 deployment of 3 spectral decoys at 2,000 feet AGL with a 5-mph wind is calculated to result in 159 foils distributed across 38 acres (Example 1). Deployment of 5,000 spectral decoys at 30,000 feet AGL is calculated to result in a distribution of 10 foils per acre over approximately 1,000,000 acres (Example 10). Spectral decoys deployed at an altitude of 30,000 feet AGL with steady 25-mph winds are calculated to have foils distributed approximately 40 to 50 miles from the point of deployment. A year's deployment of 1,000 spectral decoys (such as 200 each in Examples 2, 3, and 7 and 400 in Example 8) at varying locations within an airspace could result in the foil ellipses overlapping and result in concentrations of relatively long-lasting foils on the surface in excess of the calculated 159 foils per 38 acres in Example 2.

Table 7-11. Spectral Decoy Foil Distribution Calculations Based on Informal Wind-Drift Experiment

Example Number	Number of Decoys Deployed	Number of Foils Released	Altitude (AGL)	Wind Speed (mph)	Drift Distance (mi)	Distribution Ellipse Area (sq mi)	Distribution Ellipse Area (acres)	Number of Foils per Acre
1	1	2,000	2,000	5	0.22	0.059	38	53
2	3	6,000	2,000	5	0.22	0.059	38	159
3	3	6,000	3,000	5	0.34	0.14	90	67
4	3	6,000	2,000	10	1.01	1.22	781	8
5	3	6,000	2,000	13	1.66	3.26	2,086	1.0
6	3	6,000	2,000	25	2.42	6.9	4,416	1.4
7	3	6,000	10,000	13	8.32	81.55	52,192	0.12
8	3	6,000	30,000	25	36.4	1,561	999,040	0.01
9	2,000	4 million	10,000	13	8.32	81.55	52,192	10.25
10	5,000	10 million	30,000	25	36.4	1,561	999,040	10.01

AGL = above ground level; mi = miles; mph = miles per hour; sq mi = square miles

7.6.4.8.2 Weathering

In the absence of extensive laboratory tests or controlled experiment studies on how the foils weather under different environmental conditions, an informal basic 3-month weathering test was performed to provide information for the environmental impact analysis. The weathering test consisted of five groups of three oxidized foils measuring 0.75 inches by 1.75 inches placed in environments comparable to those under the DAF training airspace and monitored every other day. To maintain consistency in the "setting" of each of the five groups, a 3-inch by 4-inch by 1-inch high plastic "enclosure" was placed around them. One set of foils was on a hard, dry surface comparable to an arid environment. Three sets of foils were in vegetated environments with twice weekly watering, comparable to a grassy environment with rain showers. One set of foils was in a loose soil environment that was watered twice weekly.

Foils on the surface in an arid setting were found to be regularly windblown from the 1-inch high "enclosure" and settled on the downwind side of a 2-inch change in the surface height. In the arid environment, foils displayed minor rusting around the edges but did not lose their shape or become brittle. Foils on grass and exposed to two automatic sprinklings weekly of approximately 0.20 inches each became enmeshed in the grass and did not descend to the soil. In the grassy watered environment, foils displayed rust on the edges, became more fragile than foils in the arid environment, and, in 3 months, broke into approximately 13 pieces per foil, each ranging from as small as 0.3 inches by 0.2 inches up to 0.75 inches by 1.25 inches. Foils in the loose soil environment were periodically windblown one to two feet out of their "enclosure" and sometimes became partially covered by the loose soil before being moved back to their original location. This set of foils weathered more and demonstrated more rusting around the edges than the arid environment foils, but did not break up or become as fragile as the foils suspended in grass.

As part of the informal tests, individual foils were dropped from a height of 6 inches on a slowly moving freshwater surface subject to a 1-mph wind. Thirty-three percent of the foils landed on the water surface on edge or at an angle and immediately sank. Approximately 20 percent of the foils remained on the surface for 10 to 30 seconds before sinking. The remaining foils landed on the surface in a relatively flat trajectory and remained on the surface due to water surface tension for 10 minutes or more. Approximately 20 percent of the total number of foils dropped on the surface resisted sinking until the water was substantially agitated. Essentially the behavior of the light foils was comparable to a small leaf on a freshwater surface. No tests were conducted in a marine environment, but additional wave and wind action would be expected to counter the additional buoyancy of salt water. An additional water test consisted of submerging five oxidized foils in ¾ gallon of fresh water and agitating the water daily for 3 months. The submerged foils did not clump together. Within the three-month test window, the foil surface coating of oxidized pyrophoric material washed off, and the iron foil rusted, which turned the water a medium brown color. The submerged foils fragmented into pieces ranging from 0.01 inches square to 0.75 inches square.

There have not been extensive laboratory tests or controlled experiment studies of iron foils comparable to those performed on chaff to ascertain how long the foils take to corrode to the point they are no longer visible to the casual observer. Iron oxides form during the corrosion of iron, and the resulting oxidized surface flakes off with weathering. The 0.75-inch by 0.75-inch iron foils illustrated in Figure 7-24, which exhibit some pitting on the edges, were understood to have been deployed from a training aircraft and had drifted to an adjacent farmer's pecan orchard, where they remained on the ground for an unknown length of time before being collected from the surface and photographed. Soils samples subsequently taken within the pecan orchard did not demonstrate higher concentrations of iron than soils sampled from control areas outside the orchard.

7.6.4.9 Other and Future Flares

This 2022 report explains the flares and decoys deployed by DAF aircraft during training and testing. Several countermeasures are primarily used for testing with very little use in training except for intense training that replicates combat conditions. Defensive countermeasures are used by other DoD agencies.

For example, the Navy defensive flares may be used (where approved) for training in DAF-managed training airspace. The MJU-8A/B is one example of a Navy flare that has the appearance of a 1/2-scale MJU-23/B flare. The MJU-8A/B is 5.8 inches long and 1.42 inches in diameter and incorporates some differences when compared to DAF flares. Differences include an end cap of aluminum instead of plastic and the inside diameter of the case, which forms a positive piston stop, and the piston is not ejected as a piece of residual material. MJU-8A/B residual materials include the nearly 1 1/2-inch diameter aluminum end cap, one felt spacer of the same size, an S&I device, and an approximately 13-inch by 4.5-inch piece of aluminum-coated duct tape-type wrapping material.

There will be future flares to counter improvements in IR missile technology. Next generation heat-seeking missiles and countermeasure flare and decoy technology are continuing to advance. This report has endeavored to project the technology and the residual materials expected to be associated with developing and replacement countermeasures. For example, the MJU-66/B spectral decoy described in Section 7.6.4.7 incorporates the most recent advancements in impulse cartridges, pistons, crimped plastic end caps, and pyrophoric technology as of the year 2022. There are continuing revisions and updates to defensive countermeasures and those revisions receive different designations for system management and control. These improvements would be expected to continue for flares and decoys into the future.

It is important to note that, to date, all countermeasures have been able to be overcome by technological advances in the IR missile head tracking systems. And the IR missiles are not as constrained by weight or power source as are the defensive countermeasures. This continued high-level of threat from IR missiles is not expected to dramatically change in the future. There will be new flares and new decoys developed in the future and the residual materials and potential environmental effects of such new flares have not yet been identified.

7.7 Reliability of Flare Countermeasures

The reliability of flares begins with flare manufacture and the quality assurance and quality controls associated with testing during the manufactured product. Once delivered to a base, flares are loaded into the flare magazine and the magazine is installed in the aircraft (see Figure 7-7). When a flare is deployed, an electrical charge ignites the impulse cartridge. Hot gases from the impulse cartridge force the piston down the aluminum case, eject the end cap, eject the flare pellet, and eject the S&I device. As a flare assembly exits the case, the S&I springs open and the ejecting flare pellet ignites through the hole in the now open S&I device. The ignited flare produces the IR decoy image. All the actions from the electrical charge to the impulse cartridge to the deployed burning flare take less than one second.

Flare reliability is a function of all of these actions, from initial manufacture to storage, loading on an aircraft, and ignition and deployment of the burning flare. The flare is safe during normal handling operations at the base because flares are treated as ordnance and personnel handling ordnance are required to undergo extensive training.

7.7.1 Improper Flare Functioning

Improper flare functioning could occur with any of the actions involved in the flare manufacturing through deployment. For the purpose of this report, improper flare functioning is defined in four ways:

1. A flare was electrically triggered by the impulse cartridge but did not ignite and did not deploy from the aircraft. This could be the result of the impulse cartridge not functioning correctly or the impulse cartridge functioning but the flare not deploying from the aluminum case. The S&I device ignition pellet would not ignite the flare. Such a flare would be treated as a hung flare, which is classified as unexploded ordnance (UXO) when the aircraft returned to the base. The hung flare would be removed for disposal by Explosive Ordnance Disposal (EOD) personnel. EOD personnel also are called on to handle a flare if the end cap has separated or if a 30-flare magazine was accidentally dropped while being transported to the aircraft. EOD personnel treat any flare that has fallen or not functioned normally as UXO.
2. A flare was ignited and burned but did not release from the aircraft. Flares with S&I devices are designed to prevent this type of failure from occurring. A burning flare in the aircraft would be an extremely dangerous situation for the pilot. There is only one recorded case of this occurring. In 1980, an F-102 fighter aircraft was destroyed when a flare ignited but apparently did not deploy from the aircraft. The pilot successfully ejected. Reliability of flare ignition and deployment has been substantially improved since 1980.
3. A flare that did not burn correctly or was released at too low an altitude. If a burning flare struck the ground, it could result in a fire, with potential environmental consequences. The design, manufacturing, and testing process specifies a burn period of approximately five seconds for most countermeasure flares. Although not normal, it is possible that a flare could continue to burn for up to 10 seconds. This burn rate is typically translated into an altitude limitation for deployment of flares during training in specified airspaces. During intense realistic training under simulated combat conditions, pilots have been known to reactively deploy a flare at too low an altitude. This would not be a case of the flare improperly functioning. A still-burning defensive countermeasure flare that contacts combustible material on the surface has the potential to start a fire under the airspace.
4. An unburned or dud flare is a flare that was released from the aircraft but did not ignite or burn, either in whole or in part. It is possible to have a faulty S&I ignition pellet that either does not light or that does not ignite the flare pellet. In such a case, an unburned flare pellet would fall to the ground. If an unburned broken portion or entire flare struck the ground, it would normally not ignite although it could ignite under specific circumstances. The dud flare would not include the impulse cartridge, which would remain in the aluminum case in the aircraft. Ignition could occur if a falling dud flare were to strike a very hard surface, such as a flint rock or a concrete driveway. The strike could produce a spark and ignite the flare. Normally a flare would not ignite unless it were subjected to temperatures or friction generating a spark or heat source of 1,000 °F to 2000 °F.

The first two cases of an improperly functioning flare would be a base UXO or an aircraft safety issue. In the first case, after landing, the aircraft proceeds to a revetment and is inspected for any protruding or partially ejected flare. The second case has occurred once. The third and fourth cases of an improperly deployed or improperly functioning flare would be environmental issues, with a potential to affect the public land managing agencies or base personnel discovering a dud flare. As noted in Section 7.2, some DAF flares have a warning printed on the wrapper because there could be an unburned or dud flare that falls to the surface without burning. Spectral decoys do not have such a warning because they deploy foils in place of a burning magnesium pellet. Thrusted flares do not include such a warning because they are deployed only over test or target ranges authorized for live munitions.

7.7.2 Testing for Flare Reliability

Flares must be reliable. In practical terms, flare reliability cannot be performed by sampling flares as they are deployed from an aircraft under training conditions. Flares must be sampled and tested for component reliability. During manufacture, there are two levels of required independent testing to determine the reliability of flares. The first required test is toward the end of flare manufacture and prior to delivery of the flares. The second is when the number of manufactured flares, or lot, is delivered to the DAF but prior to DAF acceptance of the flare lot.

Reliability begins with the manufacturer and includes manufacturing processes in addition to the required tests. The required First Article Test (FAT) is performed at the manufacturer's facility to verify that the design and each manufactured feature of produced countermeasures work according to purchase order specifications. FAT is performed by the manufacturer's quality managers and independent testers at the manufacturer's facility under DAF oversight prior to delivery of the manufactured countermeasure lot. The FAT consists of randomly selecting a number of flares from the manufactured lot and testing for the reliability of ignition, flare burn rate, burn duration, and other performance criteria. Flare testing for reliability is performed in the context of the different flare components. If there was a flare component identified during FAT that could contribute to flares not being reliable, the flares in the lot may undergo reworking of the questionable component for future testing. For example, if the fire mixture that causes the flare to ignite was not accomplishing the ignition in the prescribed milliseconds, the mixture could be reworked and be retested.

The FAT for flare functioning incorporates an understanding of the flare population proportion. This means that the history of flare functioning is incorporated into the statistical sampling and becomes a factor in the confidence that the sampling of a specific manufacturing lot produces a valid conclusion that the flares are reliable within an acceptable margin of error.

As an example, the MJU-7A/B represented approximately 20 percent of DAF training flare use during 2020 (see Table 7-1). Lot acceptance testing for the MJU-7A/B examines the success of ignition and burn, pellet breakup, and indication of dispenser damage. A manufacturing lot of MJU-7A/B flares can be up to 25,000 flares. Table 7-12 assumes a lot size of 15,000 flares. The FAT sample is 120 with a 90 percent confidence that 95 percent of the flares will function as designed. The MJU-7A/B flares have been in production and successfully used for many years. This permits a population proportion which that reflects the expected success rate of the flares to be a high value, such as 95 percent. If the FAT sample of 120 randomly drawn flares from the lot, or population of 15,000 flares, passes inspection, the flares are statistically calculated to successfully function 95 percent of the time at a confidence level of 90 percent within a margin of error of +/- 1.9 percent (see Table 7-9).

The DAF performs a subsequent "Lot Acceptance Test" (LAT) on each lot of flares after successfully passing FAT. The LAT evaluates whether the manufacturer's countermeasures meet performance specifications. The LAT consists of a second random sampling of the delivered flare lot to ensure ignition and burn within certain parameters. Depending on the specifications, it may be that, if one or two flares out of the sample fails but the remaining flares in the sample perform as specified, the lot may be accepted. Flare failure could occur if the flare did not eject in the specified manner or did not burn as specified. For some flare lots, if one or more of the sampled flares fails the DAF LAT, the entire manufactured lot is rejected and returned to the manufacturer for reworking. The possibility of a lot being rejected has substantial costs to the manufacturer and requires manufacturers to establish and meet high internal quality assurance standards prior to the supervised FAT performance. The manufacturer's tests for reliability would need to produce a higher level of reliability than the DAF's LAT to avoid rejection of the lot. An example of the LAT reliability testing and results is presented for the MJU-7A/B flare below.

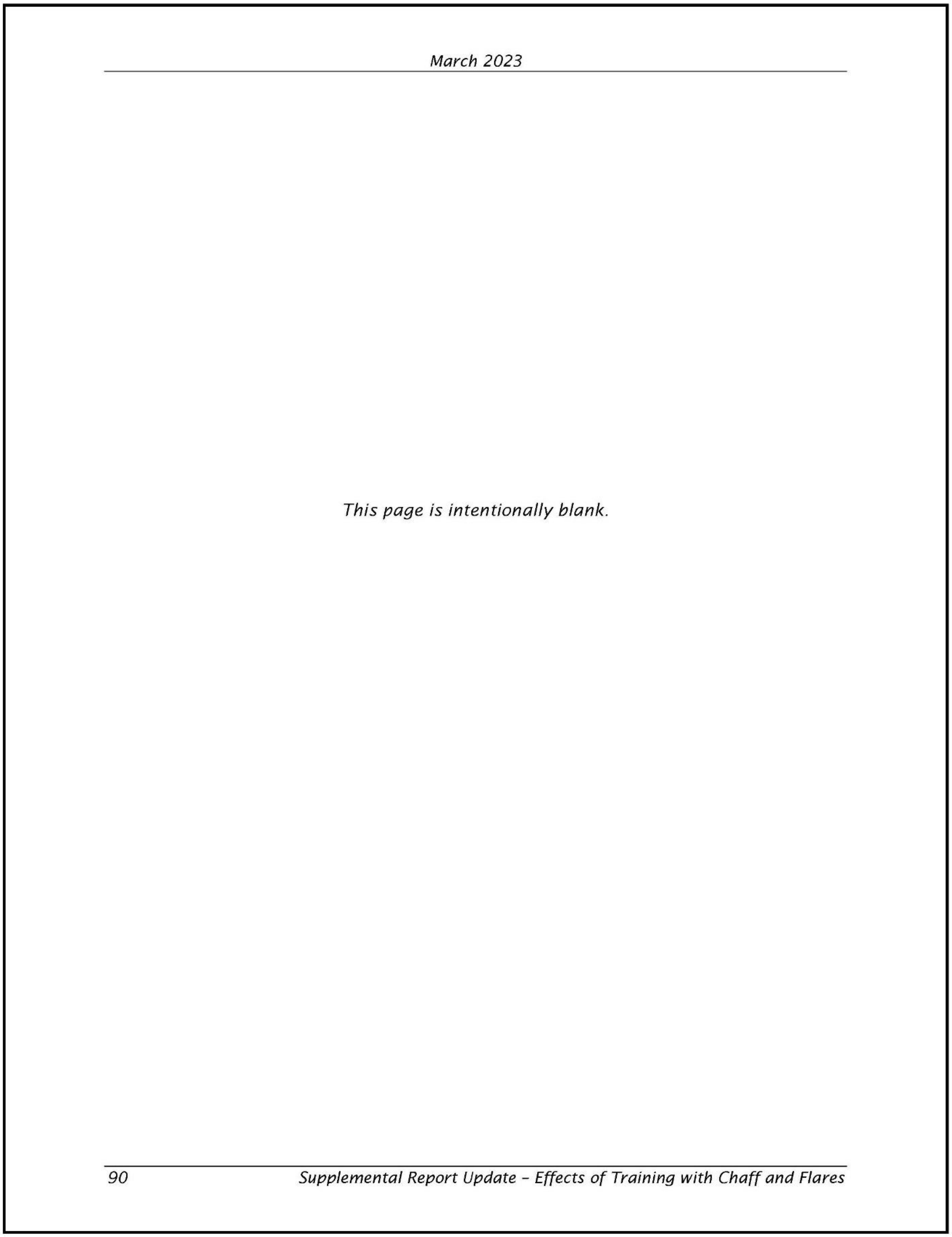
LAT for the MJU-7A/B is based on the specifications that require that a lot pass ignition, ejection, and burn tests in accordance with MIL-STD-105, Inspection Level I, Acceptance Quality Level (AQL) of 1.0. The LAT uses a minimum sample of 96 randomly selected flares from a production lot. Up to two failures, or a reliability rate of 96.25 percent, would be acceptable. However, three failures would result in the entire manufactured lot being rejected. To avoid the risk of a rejected lot, the manufacturer would perform prior tests to be sure the reliability of flares exceeded 96.25 percent and ensure that good lots were not rejected by the tests. Manufacturers would internally be expected to meet a flare reliability level of 99 percent (assuming a confidence level of 95 percent), which is consistent with an AQL of 1.0. Therefore, the reliability of the ejection, ignition, and burn duration of an MJU-7A/B flare is expected to be at least 99 percent (DAF, 1997).

Table 7-12 presents the sampling and acceptance criteria for the different types of defensive countermeasures addressed in this report. Where flare test requirements have not yet been identified, there is a "To Be Determined" (TBD) in the cell. In addition to the component testing, all personnel involved in the installation of the flares on the training aircraft are trained to ensure that the loading of the flares into the magazine and the handling of the loaded flares is in accordance with DAF safety protocols. The estimated deployment reliability in the last column of Table 7-12 represents the performance or the entire flare system based on the FAT, LAT, and management oversight of flare loading. The last column of Table 7-9 effectively states that there is at least an approximate 99 percent of flares with no flare failure. That failure could be anything from an end cap coming off during loading into the magazine to a dud flare on the surface. A failure would also occur if an unburned flare or a portion of a flare remained in the aircraft and became a hung flare that could be jolted out on the runway following landing and become a dud flare on the military base.

Once flares pass the DAF acceptance tests, they are available for use in training, test, or combat. Testing of the actual countermeasure against actual threats means an aircraft detects a threat and successfully deploys countermeasures and the countermeasures achieve the purpose of diverting a missile fired at the aircraft. It is not possible to risk a pilot or an aircraft for real-life testing. Most testing of countermeasures against an IR threat is accomplished by a systematic combination of field and flight test data that is then fed into computer models to produce realistic simulations. Actual flight tests of live IR missiles against flying unmanned targets are very costly and require extensive set up and monitoring. Live missile tests against flying targets deploying countermeasures are very infrequently performed. Such tests are so infrequent that cinematic productions regularly seek film footage of such a test and use that footage in scenes to depict destruction of an aircraft in the movie.

Countermeasure systems continue to be more complex and integrated with multiple sensors, processors, and counter-countermeasures. The complexities make the ability to quantify countermeasure effectiveness increasingly difficult, expensive, and time consuming. The greatest challenge facing the designers of countermeasures is effectiveness testing (White, 2012). The flare and decoy test numbers in Table 7-1, Table 7-5, Table 7-7, and Table 7-9 for the countermeasure families demonstrate the continuing testing of the effectiveness of the countermeasures and the aircraft deployment of the countermeasures.

This update report is focused on describing the countermeasures and assessing the consequences of deploying countermeasures on the environment. Those consequences are a combination of the residual materials that fall to the surface and the potential for an improper functioning countermeasure. Improper functioning includes the possibility of a flare coming into contact with the surface and becoming an unburned flare.



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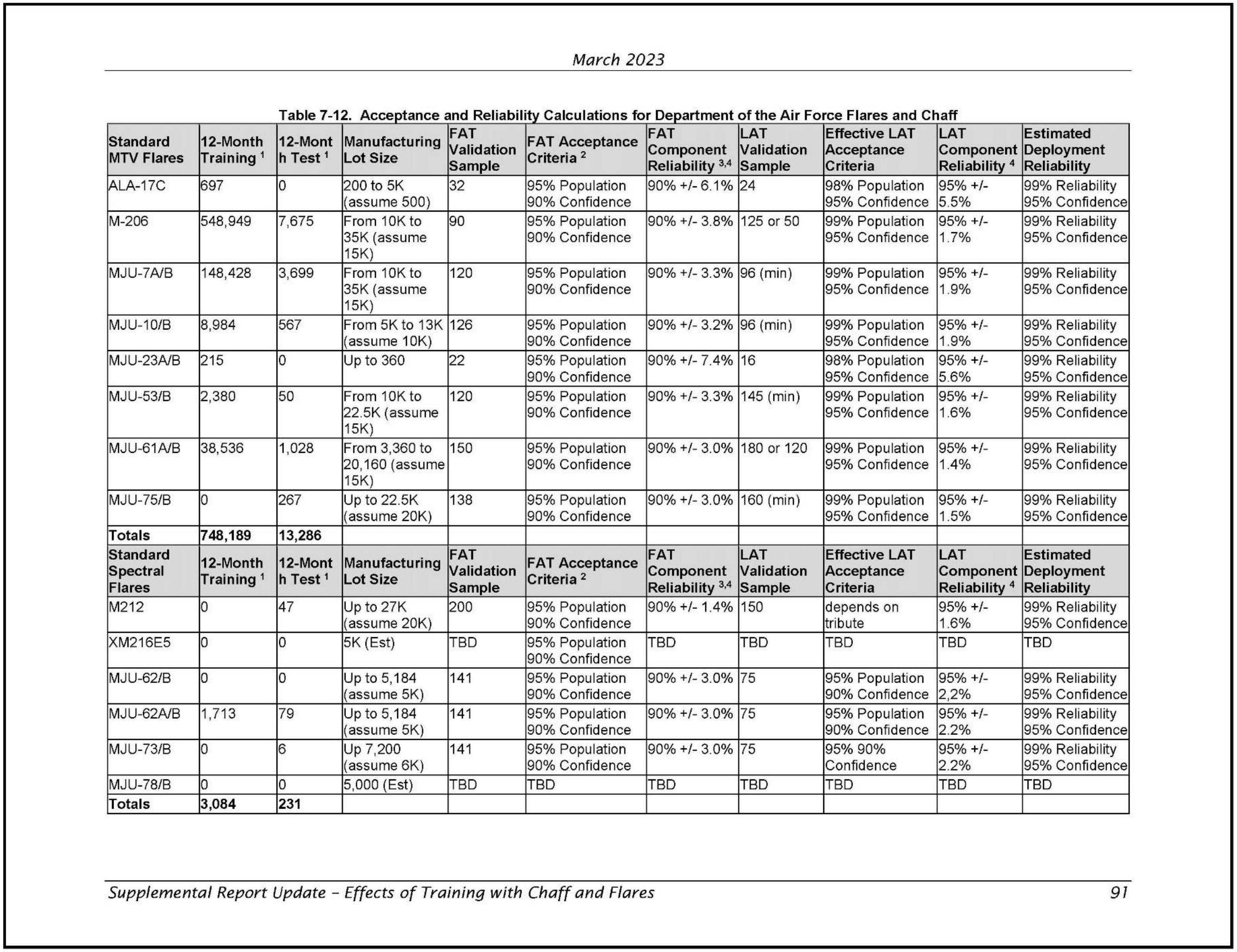


Table 7-12. Acceptance and Reliability Calculations for Department of the Air Force Flares and Chaff

Standard MTV Flares	12-Month Training [1]	12-Month Test [1]	Manufacturing Lot Size	FAT Validation Sample	FAT Acceptance Criteria [2]	FAT Component Reliability [3,4]	LAT Validation Sample	Effective LAT Acceptance Criteria	LAT Component Reliability [4]	Estimated Deployment Reliability
ALA-17C	697	0	200 to 5K (assume 500)	32	95% Population 90% Confidence	90% +/- 6.1%	24	98% Population 95% Confidence	95% +/- 5.5%	99% Reliability 95% Confidence
M-206	548,949	7,675	From 10K to 35K (assume 15K)	90	95% Population 90% Confidence	90% +/- 3.8%	125 or 50	99% Population 95% Confidence	95% +/- 1.7%	99% Reliability 95% Confidence
MJU-7A/B	148,428	3,699	From 10K to 35K (assume 15K)	120	95% Population 90% Confidence	90% +/- 3.3%	96 (min)	99% Population 95% Confidence	95% +/- 1.9%	99% Reliability 95% Confidence
MJU-10/B	8,984	567	From 5K to 13K (assume 10K)	126	95% Population 90% Confidence	90% +/- 3.2%	96 (min)	99% Population 95% Confidence	95% +/- 1.9%	99% Reliability 95% Confidence
MJU-23A/B	215	0	Up to 360	22	95% Population 90% Confidence	90% +/- 7.4%	16	98% Population 95% Confidence	95% +/- 5.6%	99% Reliability 95% Confidence
MJU-53/B	2,380	50	From 10K to 22.5K (assume 15K)	120	95% Population 90% Confidence	90% +/- 3.3%	145 (min)	99% Population 95% Confidence	95% +/- 1.6%	99% Reliability 95% Confidence
MJU-61A/B	38,536	1,028	From 3,360 to 20,160 (assume 15K)	150	95% Population 90% Confidence	90% +/- 3.0%	180 or 120	99% Population 95% Confidence	95% +/- 1.4%	99% Reliability 95% Confidence
MJU-75/B	0	267	Up to 22.5K (assume 20K)	138	95% Population 90% Confidence	90% +/- 3.0%	160 (min)	99% Population 95% Confidence	95% +/- 1.5%	99% Reliability 95% Confidence
Totals	**748,189**	**13,286**								
Standard Spectral Flares	**12-Month Training [1]**	**12-Month Test [1]**	**Manufacturing Lot Size**	**FAT Validation Sample**	**FAT Acceptance Criteria [2]**	**FAT Component Reliability [3,4]**	**LAT Validation Sample**	**Effective LAT Acceptance Criteria**	**LAT Component Reliability [4]**	**Estimated Deployment Reliability**
M212	0	47	Up to 27K (assume 20K)	200	95% Population 90% Confidence	90% +/- 1.4%	150	depends on tribute	95% +/- 1.6%	99% Reliability 95% Confidence
XM216E5	0	0	5K (Est)	TBD	95% Population 90% Confidence	TBD	TBD	TBD	TBD	TBD
MJU-62/B	0	0	Up to 5,184 (assume 5K)	141	95% Population 90% Confidence	90% +/- 3.0%	75	95% Population 90% Confidence	95% +/- 2,2%	99% Reliability 95% Confidence
MJU-62A/B	1,713	79	Up to 5,184 (assume 5K)	141	95% Population 90% Confidence	90% +/- 3.0%	75	95% Population 90% Confidence	95% +/- 2.2%	99% Reliability 95% Confidence
MJU-73/B	0	6	Up 7,200 (assume 6K)	141	95% Population 90% Confidence	90% +/- 3.0%	75	95% 90% Confidence	95% +/- 2.2%	99% Reliability 95% Confidence
MJU-78/B	0	0	5,000 (Est)	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Totals	**3,084**	**231**								

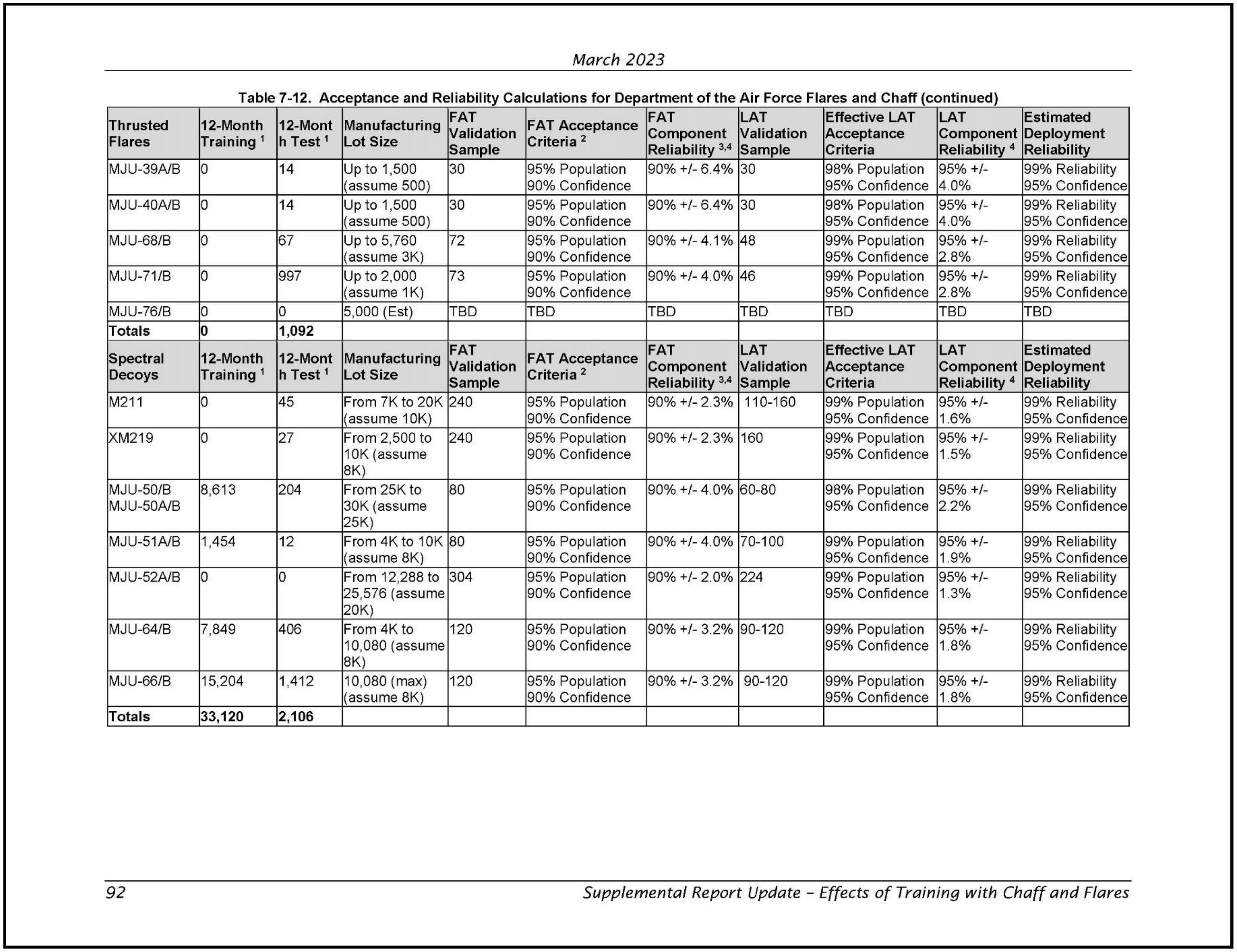


Table 7-12. Acceptance and Reliability Calculations for Department of the Air Force Flares and Chaff (continued)

Thrusted Flares	12-Month Training [1]	12-Month Test [1]	Manufacturing Lot Size	FAT Validation Sample	FAT Acceptance Criteria [2]	FAT Component Reliability [3,4]	LAT Validation Sample	Effective LAT Acceptance Criteria	LAT Component Reliability [4]	Estimated Deployment Reliability
MJU-39A/B	0	14	Up to 1,500 (assume 500)	30	95% Population 90% Confidence	90% +/- 6.4%	30	98% Population 95% Confidence	95% +/- 4.0%	99% Reliability 95% Confidence
MJU-40A/B	0	14	Up to 1,500 (assume 500)	30	95% Population 90% Confidence	90% +/- 6.4%	30	98% Population 95% Confidence	95% +/- 4.0%	99% Reliability 95% Confidence
MJU-68/B	0	67	Up to 5,760 (assume 3K)	72	95% Population 90% Confidence	90% +/- 4.1%	48	99% Population 95% Confidence	95% +/- 2.8%	99% Reliability 95% Confidence
MJU-71/B	0	997	Up to 2,000 (assume 1K)	73	95% Population 90% Confidence	90% +/- 4.0%	46	99% Population 95% Confidence	95% +/- 2.8%	99% Reliability 95% Confidence
MJU-76/B	0	0	5,000 (Est)	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Totals	**0**	**1,092**								
Spectral Decoys	**12-Month Training [1]**	**12-Month Test [1]**	**Manufacturing Lot Size**	**FAT Validation Sample**	**FAT Acceptance Criteria [2]**	**FAT Component Reliability [3,4]**	**LAT Validation Sample**	**Effective LAT Acceptance Criteria**	**LAT Component Reliability [4]**	**Estimated Deployment Reliability**
M211	0	45	From 7K to 20K (assume 10K)	240	95% Population 90% Confidence	90% +/- 2.3%	110-160	99% Population 95% Confidence	95% +/- 1.6%	99% Reliability 95% Confidence
XM219	0	27	From 2,500 to 10K (assume 8K)	240	95% Population 90% Confidence	90% +/- 2.3%	160	99% Population 95% Confidence	95% +/- 1.5%	99% Reliability 95% Confidence
MJU-50/B MJU-50A/B	8,613	204	From 25K to 30K (assume 25K)	80	95% Population 90% Confidence	90% +/- 4.0%	60-80	98% Population 95% Confidence	95% +/- 2.2%	99% Reliability 95% Confidence
MJU-51A/B	1,454	12	From 4K to 10K (assume 8K)	80	95% Population 90% Confidence	90% +/- 4.0%	70-100	99% Population 95% Confidence	95% +/- 1.9%	99% Reliability 95% Confidence
MJU-52A/B	0	0	From 12,288 to 25,576 (assume 20K)	304	95% Population 90% Confidence	90% +/- 2.0%	224	99% Population 95% Confidence	95% +/- 1.3%	99% Reliability 95% Confidence
MJU-64/B	7,849	406	From 4K to 10,080 (assume 8K)	120	95% Population 90% Confidence	90% +/- 3.2%	90-120	99% Population 95% Confidence	95% +/- 1.8%	99% Reliability 95% Confidence
MJU-66/B	15,204	1,412	10,080 (max) (assume 8K)	120	95% Population 90% Confidence	90% +/- 3.2%	90-120	99% Population 95% Confidence	95% +/- 1.8%	99% Reliability 95% Confidence
Totals	**33,120**	**2,106**								

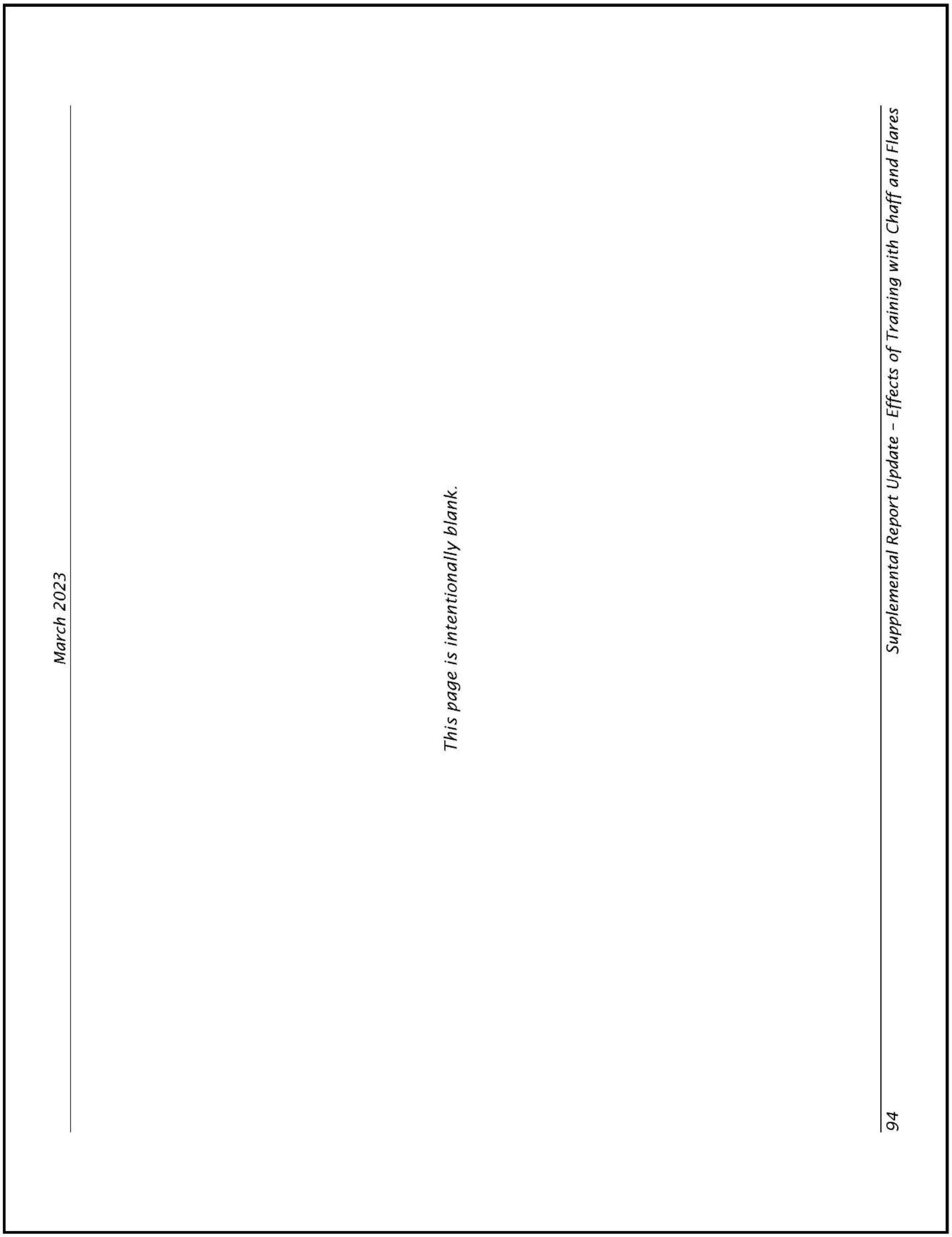
Table 7-12. Acceptance and Reliability Calculations for Department of the Air Force Flares and Chaff (continued)

Chaff	12-Month Training [1]	12-Month Test [1]	Manufacturing Lot Size	FAT Validation Sample	FAT Acceptance Criteria [2]	FAT Component Reliability [3,4]	LAT Validation Sample	Effective LAT Acceptance Criteria	LAT Component Reliability [4]	Estimated Deployment Reliability
RR-170A/AL	53	868	68,040	100	95% Population 90% Confidence	90% +/- 3.6%	100	98% Population 95% Confidence	95% +/- 2.7%	99% Reliability 95% Confidence
RR-180/AL	2,675	4,810	9,720	30	95% Population 90% Confidence	90% +/- 6.5%	30	95% Population 95% Confidence	95% +/- 4.2%	99% Reliability 95% Confidence
RR-188/AL	397,200	10,515	68,040	100	95% Population 90% Confidence	90% +/- 3.6%	100	98% Population 95% Confidence	95% +/- 2.7%	99% Reliability 95% Confidence
RR-196 (T-1)/AL	40,349	2,370	9,720	30	95% Population 90% Confidence	90% +/- 6.5%	30	95% Population 95% Confidence	95% +/- 3.5%	99% Reliability 95% Confidence
RR-196/AL	0	0	9,720	30	95% Population 90% Confidence	90% +/- 6.5%	30	95% Population 95% Confidence	95% +/- 3.5%	99% Reliability 95% Confidence
RR-198/AL	0	0	10,080	135	95% Population 90% Confidence	90% +/- 3.0%	60	99% Population 95% Confidence	95% +/- 2.5%	99% Reliability 95% Confidence
RR-199/AL	0	0	10,080	135	95% Population 90% Confidence	90% +/- 3.0%	60	98% Population 95% Confidence	95% +/- 2.5%	99% Reliability 95% Confidence
Totals	**440,277**	**18,563**								

% = percent; FAT = First Article Test; K = thousands; LAT = Lot Acceptance Test; max = maximum; min = minimum; MTV = Magnesium/Teflon/Viton; RR- = Radar Reflective (chaff); TBD = to be determined

Notes:

1. Average 12-month training and test usage calculated from 27 months of data.
2. Population proportion describes a percentage of the value of known characteristics associated with the test population.
3. If the FAT margin exceeds 5 percent, the population proportion is reduced.
4. Countermeasures acceptance percentages calculated from (https://www.calculator.net/sample-size-calculator.html



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7.7.3 Unburned or Dud Flares

There are a calculated 796,000 flares deployed during DAF annual training in the United States (from Table 7-1, Table 7-5, and Table 7-7). Approximately 32 percent of the flares are deployed over water in warning areas where a dud flare would not likely be found (DAF, 1997). The 68 percent of flares used for training over land would calculate to an annual total of 541,280 flares. A portion of these flares are estimated to not function properly and are recovered on the base. A portion of the improperly functioning flares have the potential to produce environmental consequences if they are deposited on the surface on DAF land, land managed by other agencies, or private land.

The question about how many unburned flares are annually deposited under training airspace as dud flares has continued to be asked by the public, land management agencies, and the DAF. This 2022 report attempts to address that question by drawing from source materials, including DAF records and other documentation, which were not available for the previous ACC reports entitled *Environmental Effects of Self Protection Chaff and Flares*, dated August 1997 and *Supplemental Report: Environmental Effects of Training with Defensive Countermeasures*, dated October 2011. The additional sources provide EOD records and range clearance information and are combined with a series of assumptions and calculations described in this section to produce a reasonable estimate of the percentage and number of unburned flares that annually fall to the surface under DAF training airspace.

The conclusion, derived from the sections below, is that 99.6 percent of training flares deploy, ignite, and burn correctly. The estimated percentage of unburned or dud flares, which annually fall to the surface under DAF training airspace nationwide, is calculated to be 0.4 percent or four flares for every 1,000 flares deployed during DAF training. Of these, EOD records, discussed in the following sections, indicate that an estimated one out of the four dud flares are recovered by the DAF EOD personnel, and the other three out of four are not recovered and presumed to still be on the ground surface of DAF access-controlled land, public land, private land, or Tribal land under DAF training airspace where flares are approved for use in training.

7.7.3.1 Estimating the Percentage of Unburned Flares

The estimated percentage of successfully deployed flares and the percentage of unburned flares, which annually fall to the surface during DAF training in airspace approved for use of flare countermeasures, takes into consideration several factors:

1. Flare Testing for Reliability During Manufacture and Prior to Acceptance by the DAF (see Section 7.7.2)
2. Documented 14 years of EOD UXO responses that Included Unburned or Dud Flares (see Section 7.7.3.1.1)
3. Documented 10 Years of EOD Range Clearance at Avon Park and UTTR Ranges (see Section 7.7.3.1.2)
4. Description of DAF Operational Aircraft Training Missions that Include Target Ranges (see Section 7.7.3.1.3)
5. Estimated Number of Flares Annually Deployed in UTTR Training Airspace (see Section 7.7.3.1.4)
6. Estimated Number of Flares Annually Deployed over UTTR Ranges Cleared by EOD Personnel (see Section 7.7.3.1.5)
7. Additional Range Clearance Observations (see Section 7.7.3.1.6)

8. Applying the UTTR Estimates of Annual Unburned Flares to UTTR and to the Representative Airspace (see Section 7.7.3.1.7)
9. Applying UTTR Results to Estimate Annual Unburned Flares Under DAF Training Airspace Nationwide (see Section 7.7.3.1.8)
10. Discussion of Assumptions and Calculations (see Section 7.7.3.1.9)
11. Conclusions Regarding Unburned Flares (see Section 7.7.3.2)

The first factor listed above, testing for reliability before acceptance, is explained in Section 7.7.2 and results in a flare reliability rate of at least 99.0 percent based on acceptance parameters and acceptance testing. A 1 percent failure rate would include the four different types of flare failures (see Section 7.7.1). The first type of flare failure, hung flares that could drop, and the fourth type of flare failure, a flare or part of flare that is deployed but does not ignite, could result in an unburned or dud flare on the surface.

Factors 2 through 10 listed above are expanded below to refine the flare reliability percentage and estimate the annual number of unburned or dud flares on the surface under DAF training airspace where flares are approved for use.

7.7.3.1.1 Documented 14 years of EOD UXO Responses that Included Unburned or Dud Flares

DAF EOD personnel perform UXO clearance incident responses on military ranges where munitions are deployed to identify and render safe any located UXO, which includes unburned flares. EOD provided records from March 2008 through March 2022 (14 years) that specifically involved flare incidents. The EOD records reviewed for this 2022 report documented 758 UXO incidents that involved flares. The incidents included non-CONUS incidents, aircraft accidents, dropped flares, dropped 30-flare magazines, flares accidently soaked in water or other liquids, and other training activities that did not represent a flare malfunction or failure.

EOD records documented 414 on-base incidents, which in many cases included multiple flares. These included flare failures from hung flares that did not deploy; lost end caps, which rendered the flares as UXO; and unburned flares located on runways, taxiways, or on the base, which are typically hung flares bumped out during landing. An annual average of 36 unburned flares were located on base property. In addition, EOD handled 91 unburned flares identified on public, Tribal, or private land under the airspace during the period, for an average of 6.5 (rounded to 7) flares annually located by the public. In most instances, the EOD 14-year records documented the nearby community when a dud flare was recovered. Individuals on Tohono O'odham Tribal land located approximately 19 of the total 91 unburned flares. EOD personnel also located and rendered safe unburned flares found during range clearance. UXO clearance reports did not always specify dud flares separately from other UXO. The estimated number of unburned flares recovered is 418 flares based on the information in Section 7.7.3.1.8, below.

7.7.3.1.2 Documented 10 Years of EOD Clearance at Avon Park and UTTR Ranges

EOD personnel provided 10-years of range clearance information for Avon Park Range in central Florida (2012-2021) and 10 years of range clean-up data (May, 2012 through May, 2022) for the UTTR in Utah. The EOD cleanup was on the active target ranges subject to bombing with practice bombs and aerial gunnery targets. At the Avon Park and UTTR ranges, defensive countermeasures are authorized for use.

The 10 years of reports for the Avon Park 106,000-acre range documented the acreage surveyed by EOD personnel and cleared for UXO as 16,000 acres of the south range and the 22,000 acres of the north range. This means that approximately 60 square miles of the range were surveyed multiple times over the

10-year period. The EOD cleanup documented the recovery of training ordnance and other munitions. There were no unburned countermeasure flares recorded. The only unburned flares recorded were six target illumination flares used in night operations to light up a ground target for aerial gunnery, such as for a C-130 gunship. The range clearance was not a comprehensive survey of the entire range and did not extend to acreage outside the north and south bombing ranges. There was no corresponding record of the number of flares deployed annually over the range. Nevertheless, the nearly 10 years of documented UXO clearance at Avon Park Range did not report locating any dud flares.

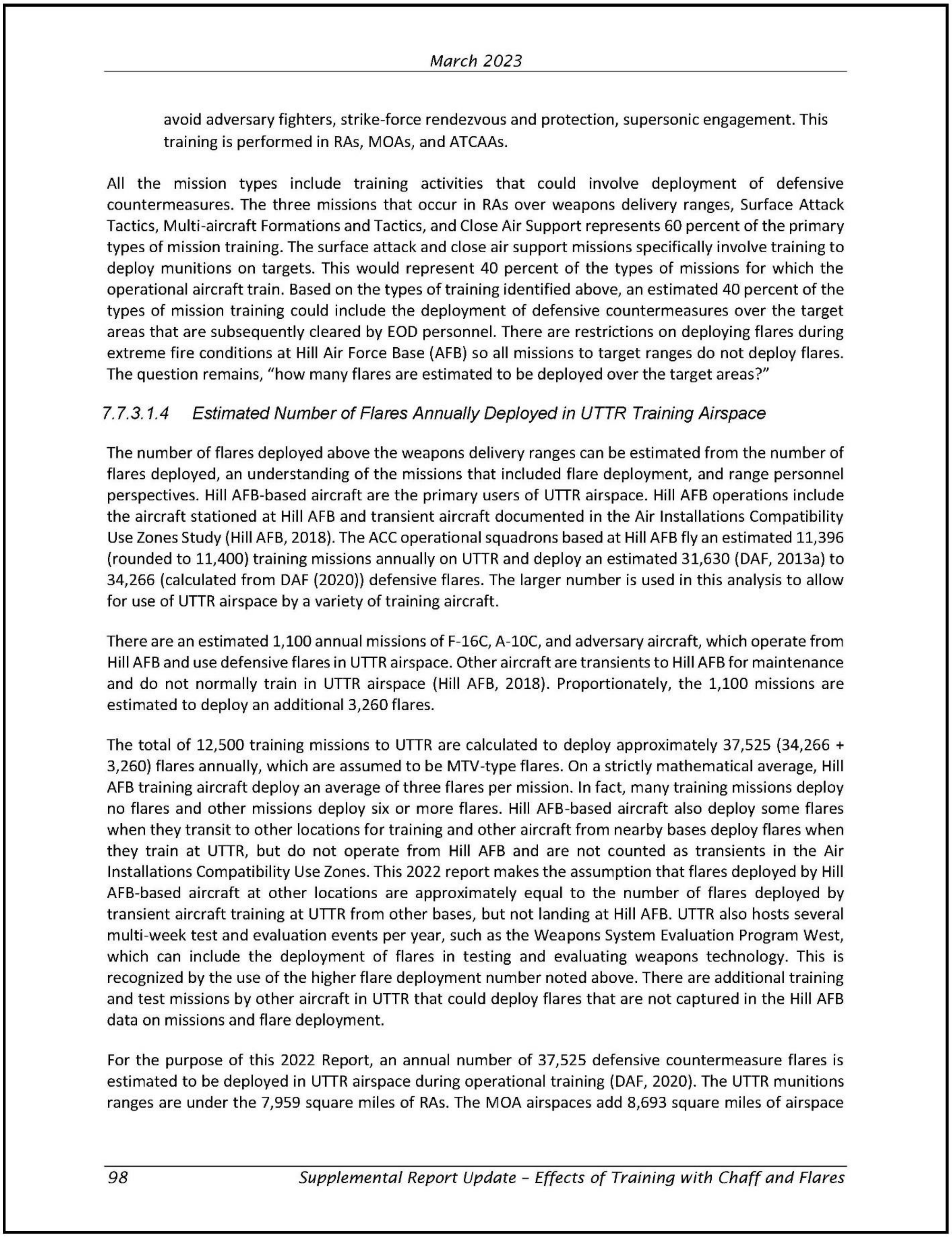
The 10 years of UTTR range clearance data separately recorded and documented 289 recovered unburned flares for an average of 29 unburned flares per year. The total area of all the UTTR ranges where UXO was cleared was approximately 46,000 acres (rounded to 72 square miles). The data from UTTR represents a comprehensive record of unburned flares collected on the surface within a defined area. Other EOD clearance of UXO did not necessarily differentiate unburned flares from other UXO. The comprehensive UTTR record of an annual average of 29 unburned flares per year located on 72 square miles of targets under DAF training airspace provides a basis to estimate flare reliability and the rate and number of unburned flares based on the number of flares deployed.

The key component to calculating flare reliability is the quantification of flares deployed during training over the 72 square miles of targets subject to EOD clearance. Because pilots are training to address targets and avoid threats, the flares are deployed either manually or automatically in response to a sensed threat. During combat training, pilots do not specifically track when or where flares are deployed relative to the target. Therefore, understanding more about the training missions that are flown over the targets contributes to estimating the number of flares deployed there.

7.7.3.1.3 Description of DAF Operational Aircraft Training Missions that Include Target Ranges

Flares are deployed during combat training missions. Operational fighter aircraft use different airspace units to train to primarily accomplish the following missions (DAF, 2020):

- Basic Fighter Maneuvers: Train for G-force awareness, maneuverability, break turns, high angle of attack maneuvering, acceleration maneuvering, gun tracking, offensive and defensive positioning, air refueling, stall recovery. This training is performed in RA, MOAs, and ATCAA.
- Surface Attack Tactics: Train for single to multiple aircraft attacking a wide range of ground targets using different ingress and egress methods, delivery tactics, ordnance types, angles of attack, and combat scenarios. This training is performed in RAs, specifically over weapons delivery ranges, and MOAs.
- Multi-aircraft Formations and Tactics: Train for systems check, G-force awareness, two-versus-four and four-versus-six aircraft intercepts, combat air patrol, defense of airspace sector from composite force attack, intercept and destroy bomber aircraft, avoid adversary fighters, supersonic engagement. This training is performed in RAs, specifically over weapons delivery ranges, MOAs, and ATCAAs
- Close Air Support: Train for air support of ground-based offensive and defensive operations, work with Joint Terminal Attack Controllers, use Surface Attack Tactics and Basic Surface Attack components. This training is performed in RAs, specifically over weapons delivery ranges, and MOAs.
- Multi-aircraft and multi-adversary defense and combat air patrol: Train for defense of airspace sectors from composite force attack, intercept and simulate destruction of bomber aircraft,



avoid adversary fighters, strike-force rendezvous and protection, supersonic engagement. This training is performed in RAs, MOAs, and ATCAAs.

All the mission types include training activities that could involve deployment of defensive countermeasures. The three missions that occur in RAs over weapons delivery ranges, Surface Attack Tactics, Multi-aircraft Formations and Tactics, and Close Air Support represents 60 percent of the primary types of mission training. The surface attack and close air support missions specifically involve training to deploy munitions on targets. This would represent 40 percent of the types of missions for which the operational aircraft train. Based on the types of training identified above, an estimated 40 percent of the types of mission training could include the deployment of defensive countermeasures over the target areas that are subsequently cleared by EOD personnel. There are restrictions on deploying flares during extreme fire conditions at Hill Air Force Base (AFB) so all missions to target ranges do not deploy flares. The question remains, "how many flares are estimated to be deployed over the target areas?"

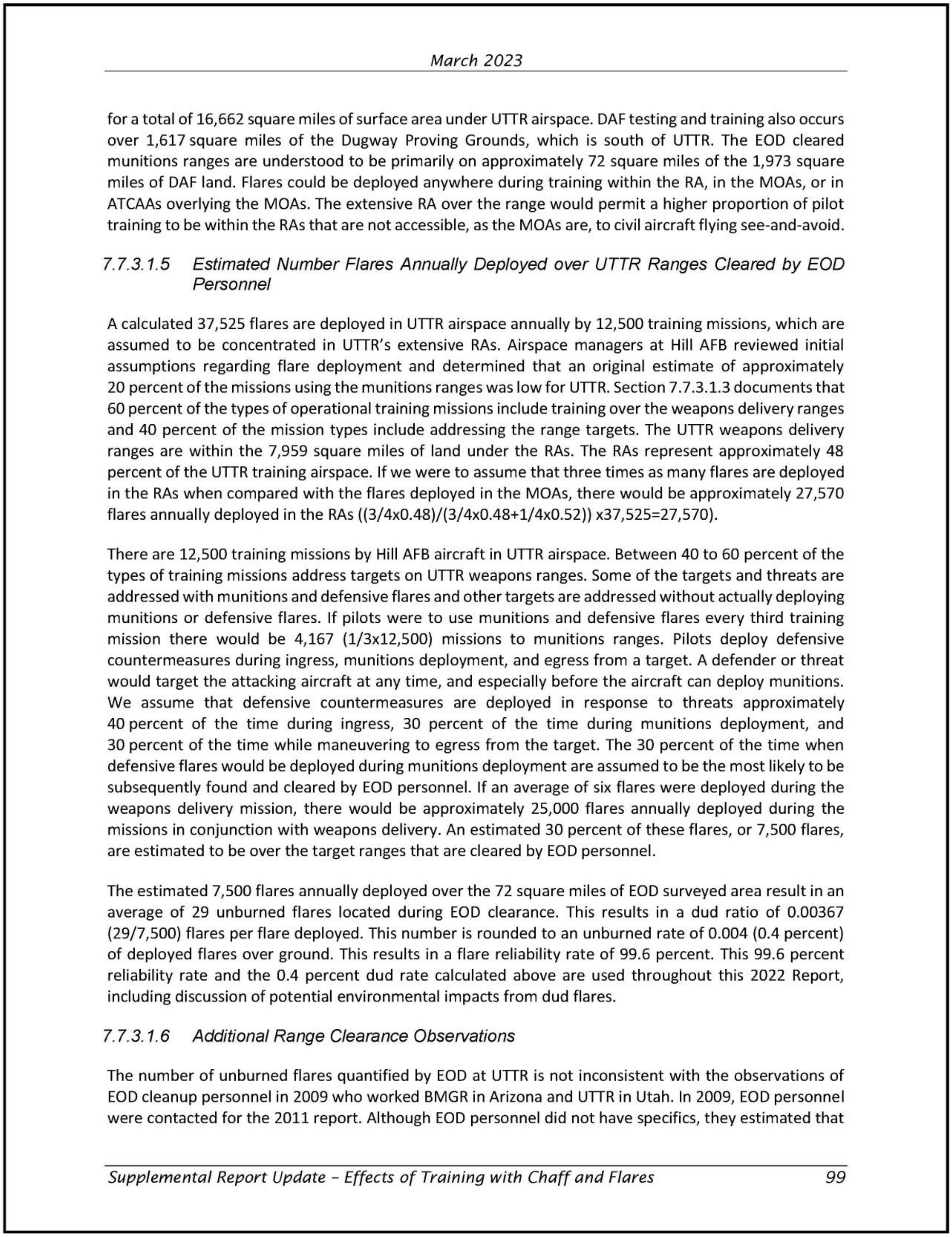
7.7.3.1.4 Estimated Number of Flares Annually Deployed in UTTR Training Airspace

The number of flares deployed above the weapons delivery ranges can be estimated from the number of flares deployed, an understanding of the missions that included flare deployment, and range personnel perspectives. Hill AFB-based aircraft are the primary users of UTTR airspace. Hill AFB operations include the aircraft stationed at Hill AFB and transient aircraft documented in the Air Installations Compatibility Use Zones Study (Hill AFB, 2018). The ACC operational squadrons based at Hill AFB fly an estimated 11,396 (rounded to 11,400) training missions annually on UTTR and deploy an estimated 31,630 (DAF, 2013a) to 34,266 (calculated from DAF (2020)) defensive flares. The larger number is used in this analysis to allow for use of UTTR airspace by a variety of training aircraft.

There are an estimated 1,100 annual missions of F-16C, A-10C, and adversary aircraft, which operate from Hill AFB and use defensive flares in UTTR airspace. Other aircraft are transients to Hill AFB for maintenance and do not normally train in UTTR airspace (Hill AFB, 2018). Proportionately, the 1,100 missions are estimated to deploy an additional 3,260 flares.

The total of 12,500 training missions to UTTR are calculated to deploy approximately 37,525 (34,266 + 3,260) flares annually, which are assumed to be MTV-type flares. On a strictly mathematical average, Hill AFB training aircraft deploy an average of three flares per mission. In fact, many training missions deploy no flares and other missions deploy six or more flares. Hill AFB-based aircraft also deploy some flares when they transit to other locations for training and other aircraft from nearby bases deploy flares when they train at UTTR, but do not operate from Hill AFB and are not counted as transients in the Air Installations Compatibility Use Zones. This 2022 report makes the assumption that flares deployed by Hill AFB-based aircraft at other locations are approximately equal to the number of flares deployed by transient aircraft training at UTTR from other bases, but not landing at Hill AFB. UTTR also hosts several multi-week test and evaluation events per year, such as the Weapons System Evaluation Program West, which can include the deployment of flares in testing and evaluating weapons technology. This is recognized by the use of the higher flare deployment number noted above. There are additional training and test missions by other aircraft in UTTR that could deploy flares that are not captured in the Hill AFB data on missions and flare deployment.

For the purpose of this 2022 Report, an annual number of 37,525 defensive countermeasure flares is estimated to be deployed in UTTR airspace during operational training (DAF, 2020). The UTTR munitions ranges are under the 7,959 square miles of RAs. The MOA airspaces add 8,693 square miles of airspace



for a total of 16,662 square miles of surface area under UTTR airspace. DAF testing and training also occurs over 1,617 square miles of the Dugway Proving Grounds, which is south of UTTR. The EOD cleared munitions ranges are understood to be primarily on approximately 72 square miles of the 1,973 square miles of DAF land. Flares could be deployed anywhere during training within the RA, in the MOAs, or in ATCAAs overlying the MOAs. The extensive RA over the range would permit a higher proportion of pilot training to be within the RAs that are not accessible, as the MOAs are, to civil aircraft flying see-and-avoid.

7.7.3.1.5 Estimated Number Flares Annually Deployed over UTTR Ranges Cleared by EOD Personnel

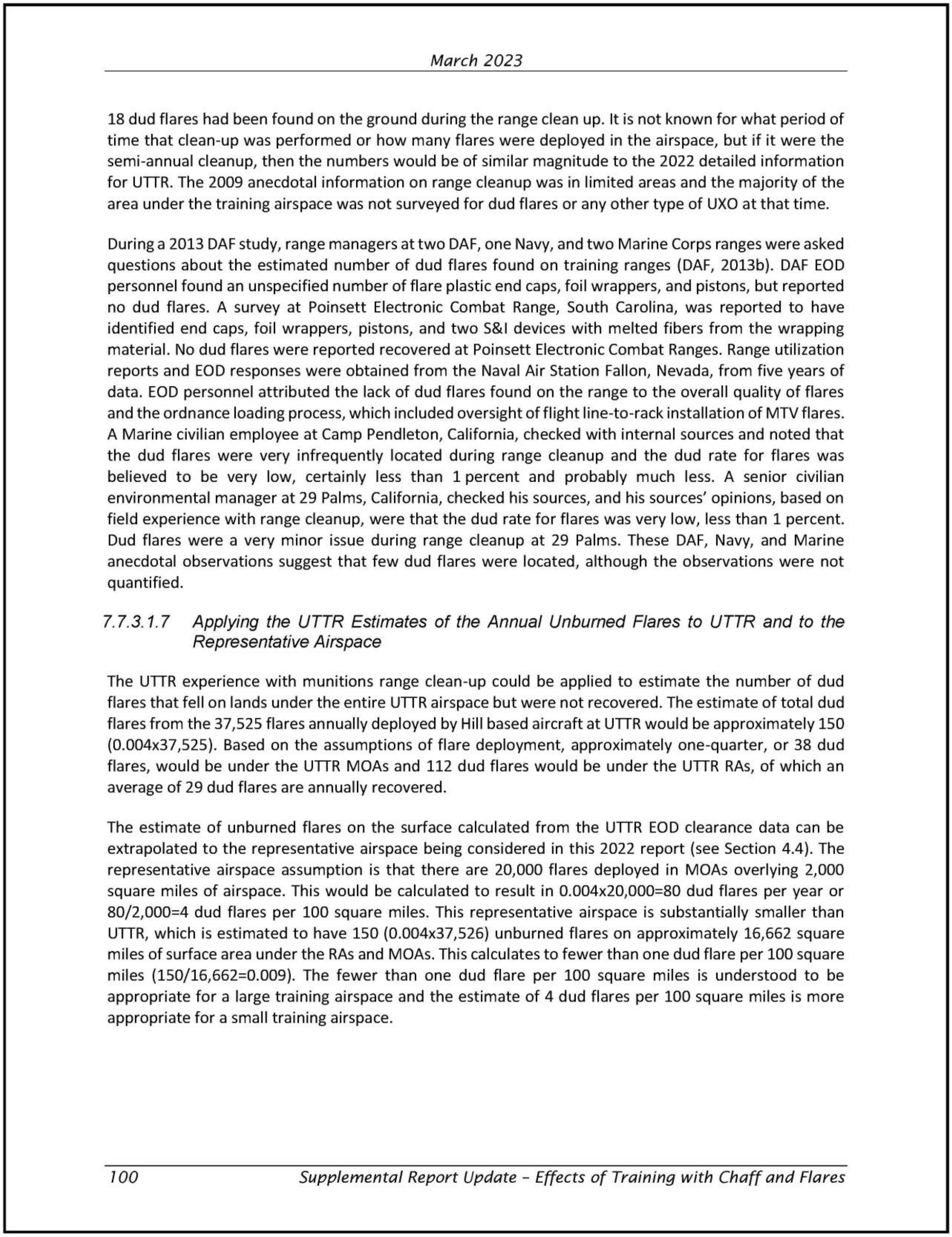
A calculated 37,525 flares are deployed in UTTR airspace annually by 12,500 training missions, which are assumed to be concentrated in UTTR's extensive RAs. Airspace managers at Hill AFB reviewed initial assumptions regarding flare deployment and determined that an original estimate of approximately 20 percent of the missions using the munitions ranges was low for UTTR. Section 7.7.3.1.3 documents that 60 percent of the types of operational training missions include training over the weapons delivery ranges and 40 percent of the mission types include addressing the range targets. The UTTR weapons delivery ranges are within the 7,959 square miles of land under the RAs. The RAs represent approximately 48 percent of the UTTR training airspace. If we were to assume that three times as many flares are deployed in the RAs when compared with the flares deployed in the MOAs, there would be approximately 27,570 flares annually deployed in the RAs ((3/4x0.48)/(3/4x0.48+1/4x0.52)) x37,525=27,570).

There are 12,500 training missions by Hill AFB aircraft in UTTR airspace. Between 40 to 60 percent of the types of training missions address targets on UTTR weapons ranges. Some of the targets and threats are addressed with munitions and defensive flares and other targets are addressed without actually deploying munitions or defensive flares. If pilots were to use munitions and defensive flares every third training mission there would be 4,167 (1/3x12,500) missions to munitions ranges. Pilots deploy defensive countermeasures during ingress, munitions deployment, and egress from a target. A defender or threat would target the attacking aircraft at any time, and especially before the aircraft can deploy munitions. We assume that defensive countermeasures are deployed in response to threats approximately 40 percent of the time during ingress, 30 percent of the time during munitions deployment, and 30 percent of the time while maneuvering to egress from the target. The 30 percent of the time when defensive flares would be deployed during munitions deployment are assumed to be the most likely to be subsequently found and cleared by EOD personnel. If an average of six flares were deployed during the weapons delivery mission, there would be approximately 25,000 flares annually deployed during the missions in conjunction with weapons delivery. An estimated 30 percent of these flares, or 7,500 flares, are estimated to be over the target ranges that are cleared by EOD personnel.

The estimated 7,500 flares annually deployed over the 72 square miles of EOD surveyed area result in an average of 29 unburned flares located during EOD clearance. This results in a dud ratio of 0.00367 (29/7,500) flares per flare deployed. This number is rounded to an unburned rate of 0.004 (0.4 percent) of deployed flares over ground. This results in a flare reliability rate of 99.6 percent. This 99.6 percent reliability rate and the 0.4 percent dud rate calculated above are used throughout this 2022 Report, including discussion of potential environmental impacts from dud flares.

7.7.3.1.6 Additional Range Clearance Observations

The number of unburned flares quantified by EOD at UTTR is not inconsistent with the observations of EOD cleanup personnel in 2009 who worked BMGR in Arizona and UTTR in Utah. In 2009, EOD personnel were contacted for the 2011 report. Although EOD personnel did not have specifics, they estimated that



18 dud flares had been found on the ground during the range clean up. It is not known for what period of time that clean-up was performed or how many flares were deployed in the airspace, but if it were the semi-annual cleanup, then the numbers would be of similar magnitude to the 2022 detailed information for UTTR. The 2009 anecdotal information on range cleanup was in limited areas and the majority of the area under the training airspace was not surveyed for dud flares or any other type of UXO at that time.

During a 2013 DAF study, range managers at two DAF, one Navy, and two Marine Corps ranges were asked questions about the estimated number of dud flares found on training ranges (DAF, 2013b). DAF EOD personnel found an unspecified number of flare plastic end caps, foil wrappers, and pistons, but reported no dud flares. A survey at Poinsett Electronic Combat Range, South Carolina, was reported to have identified end caps, foil wrappers, pistons, and two S&I devices with melted fibers from the wrapping material. No dud flares were reported recovered at Poinsett Electronic Combat Ranges. Range utilization reports and EOD responses were obtained from the Naval Air Station Fallon, Nevada, from five years of data. EOD personnel attributed the lack of dud flares found on the range to the overall quality of flares and the ordnance loading process, which included oversight of flight line-to-rack installation of MTV flares. A Marine civilian employee at Camp Pendleton, California, checked with internal sources and noted that the dud flares were very infrequently located during range cleanup and the dud rate for flares was believed to be very low, certainly less than 1 percent and probably much less. A senior civilian environmental manager at 29 Palms, California, checked his sources, and his sources' opinions, based on field experience with range cleanup, were that the dud rate for flares was very low, less than 1 percent. Dud flares were a very minor issue during range cleanup at 29 Palms. These DAF, Navy, and Marine anecdotal observations suggest that few dud flares were located, although the observations were not quantified.

7.7.3.1.7 Applying the UTTR Estimates of the Annual Unburned Flares to UTTR and to the Representative Airspace

The UTTR experience with munitions range clean-up could be applied to estimate the number of dud flares that fell on lands under the entire UTTR airspace but were not recovered. The estimate of total dud flares from the 37,525 flares annually deployed by Hill based aircraft at UTTR would be approximately 150 (0.004x37,525). Based on the assumptions of flare deployment, approximately one-quarter, or 38 dud flares, would be under the UTTR MOAs and 112 dud flares would be under the UTTR RAs, of which an average of 29 dud flares are annually recovered.

The estimate of unburned flares on the surface calculated from the UTTR EOD clearance data can be extrapolated to the representative airspace being considered in this 2022 report (see Section 4.4). The representative airspace assumption is that there are 20,000 flares deployed in MOAs overlying 2,000 square miles of airspace. This would be calculated to result in 0.004x20,000=80 dud flares per year or 80/2,000=4 dud flares per 100 square miles. This representative airspace is substantially smaller than UTTR, which is estimated to have 150 (0.004x37,526) unburned flares on approximately 16,662 square miles of surface area under the RAs and MOAs. This calculates to fewer than one dud flare per 100 square miles (150/16,662=0.009). The fewer than one dud flare per 100 square miles is understood to be appropriate for a large training airspace and the estimate of 4 dud flares per 100 square miles is more appropriate for a small training airspace.

7.7.3.1.8 Applying UTTR Results to Estimate Annual Unburned Flares Under DAF Training Airspace Nationwide.

The 99.6 percent reliability rate can be applied to estimate the number of annual unburned flares on the surface that are not recovered by EOD personnel. Extrapolating the UTTR calculations and assumptions to the DAF training airspace where flares are approved for training results in an estimated 2,165 unburned flares on the ground surface per year. This is calculated by multiplying the dud rate (.004) times the calculated number of flares deployed over land (541,280; see Section 7.7.3). Of these, EOD records document an annual average of approximately 36 dud flares or hung flares found on DAF bases. EOD clearance of range targets include all UXO, and dud flares are included with other UXO. The proportion of dud flares located during EOD clean-up of UTTR ranges can be extrapolated to estimate that EOD locates 418 dud flares per year during UXO range clean-up. At UTTR, 29 unburned flares were located where 37,526 flares were estimated to have been deployed. This would calculate to 418 unburned flares located during target range UXO clearance of all ranges (29/37,526x541,280=418). Another seven dud flares are annually identified for EOD handling by individuals on public, private, or Tribal lands. This produces an annual estimate of 1,704 unburned flares (2,165-36-418-7=1,704). Between three out of four to four out of five dud flares are not recovered and presumed to still be on the ground under DAF airspace where flares are approved for training. These unburned flares are on DAF access-controlled land, public land managed by government agencies (such as the Bureau of Land Management), Tribal land, or private land under DAF training airspace.

7.7.3.1.9 Summary of Assumptions and Calculations

This discussion describes a set of assumptions applied to estimate the flare reliability of 99.6 percent. The assumptions are based primarily on the data provided by EOD regarding 14 years of incidents with flares and 10 years of UXO clearance of UTTR targets. Assumptions include that Hill AFB based aircraft are the primary users of UTTR munitions ranges and that approximately 75 percent of the deployed flares would be in the large UTTR RAs and 25 percent in the MOAs. These assumptions are reasonable given the extent of UTTR's RAs and the fact that pilots training in the RAs do not have to contend with the presence of non-participating aircraft.

Based on the type of missions conducted by operational squadrons, the assumption is made that every third mission would include addressing a target where munitions could be deployed. The assumption is that during the one-third of the missions, the aircraft would deploy an average of six flares and approximately 30 percent of those flares would be deployed over target areas where EOD clearance subsequently occurred. This flare deployment number may appear low, except that the total number of flares calculated to be deployed in the RAs in conjunction with range targets would be 25,002 (4,167 missions x 6 flares = 25,002). This number of flares deployed in conjunction with target ranges would represent 67 percent (25,002/37,526) of all flares estimated to be deployed in all UTTR airspace. Given the extent of the airspace and the diversity of training missions, the average number of flares deployed over the targets is a reasonable estimation.

The estimate of the total number of flares deployed by operational aircraft based at Hill AFB is high to allow for the use of an undefined number of flares in the multi-week test and evaluation programs, due to the lack of detail on those programs. The additional number of flares attributed to Hill-based aircraft and the unknown number of flares deployed during the test and evaluation programs are assumed to balance out. Flares deployed by transients, which visit to train on UTTR, and flares deployed by Hill-based aircraft, which visit other ranges for training, are also assumed to balance out.

UTTR data are used as a primary source due to its degree of completeness. The scarcity of unburned flares reported during EOD clearance of Avon Park Range and the Poinsette Electronic Combat Range is assumed to be the result of non-specific information or the grouping of any unburned flares with other UXO for disposal.

Assumptions could be varied. As an example, fewer missions could train with munitions on targets but deploy more flares when they do train. Identical flare reliability results would be obtained if pilots trained with munitions on every 6th training mission and deployed 12 flares when addressing the targets. Or a greater or lesser proportion of flares could be deployed in the MOAs than assumed in this Report. In most cases, varying the assumptions could result in potentially greater or fewer numbers of flares deployed over the EOD surveyed target areas with differences in the estimated rate of unburned flares and subsequent differences in flare reliability. If additional information resulted in a greater number of flares deployed over the EOD survey area, the resulting flare reliability percentage could increase. The reasoning behind the assumptions is clearly presented and based upon cited and referenced sources. If additional information should become available, that information could refine the flare reliability rate.

7.7.3.2 Conclusions Regarding Unburned Flares

Unburned flares do fall to the surface under DAF training airspace where defensive countermeasure flares are approved for training. Unburned flares are recovered during EOD clearance of munitions targets, located on bases, and found under training airspace. A falling unburned flare can ignite if it strikes a rock or flint-like surface and there are accounts of dud flares being mishandled and causing serious injury if they are ignited. Accounts of dud flares igniting under such unusual circumstances are extremely rare.

The reason such incidents are extremely rare is because defensive countermeasure flares are 99.6 per cent reliable and correctly ignite and burn when deployed during DAF training. The estimated percentage of unburned flares, which annually fall to the surface under DAF training airspace nationwide, is calculated to be 0.4 percent or 4 flares for every 1,000 flares deployed during DAF training. The 99.6 percent reliability rate calculates to 2,165 unburned flares on the ground surface per year. Of these, EOD records document an annual average of approximately 36 dud flares or hung flares found on-base. The proportion of dud flares located during EOD cleanup of UTTR ranges can be extrapolated to estimate that EOD locates 418 dud flares per year during UXO range clean-up. Another seven dud flares are annually identified for EOD handling by individuals on public, private, or Tribal lands. This produces an annual estimate of 1,704 (2,165-36-418-7) dud flares from DAF training nationwide, which are calculated to fall to the surface on DAF access-controlled land, public land, private land, or Tribal land under DAF training airspace. Dud flares are rarely found because, on average, fewer than one to four unburned flares annually fall within 100 square miles of area under DAF training airspace.

7.7.4 Dud Flares and Residual Materials

This set of assumptions and calculations results in an estimated 1,704 flares or parts of flares annually being deposited as dud flares under training airspace but not recovered. This would calculate to an estimated 40 unburned flares on the surface under training airspace for every 10,000 flares deployed during DAF pilot training. For the representative airspace over 2,000 square miles where 20,000 flares were deployed in training, there would be an estimated 80 dud flares deposited annually on the ground under the training airspace. The annual estimate of 1,704 dud flares on the ground under training airspace is primarily based upon acceptance testing and hard data from EOD and other cleanup activities.

Unburned or dud flares are extremely rare, but a small number of deployed flares fall to the surface as dud flares. And individuals have found dud flares under training airspaces. The EOD 14-year records document 91 incidents where non-military individuals found unburned flares and responsibly notified the base of the dud flare. The dud flare can be a whole or a part of a flare. Figure 7-29 shows approximately 40 percent of an M-206 flare and wrapping. Apparently, the flare broke in two parts as it was ejected from the case but before the magnesium within the pictured half of the flare was ignited. The unburned portion of the flare was discovered on the ground at a military training range where it had been deployed.

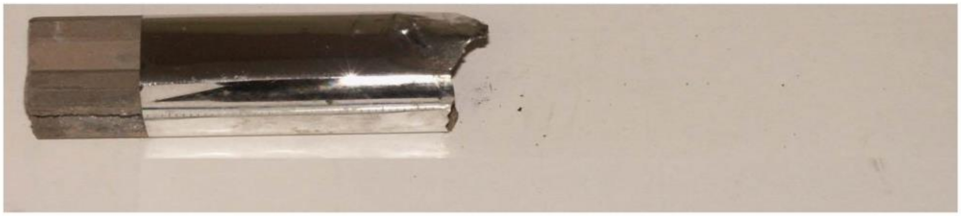
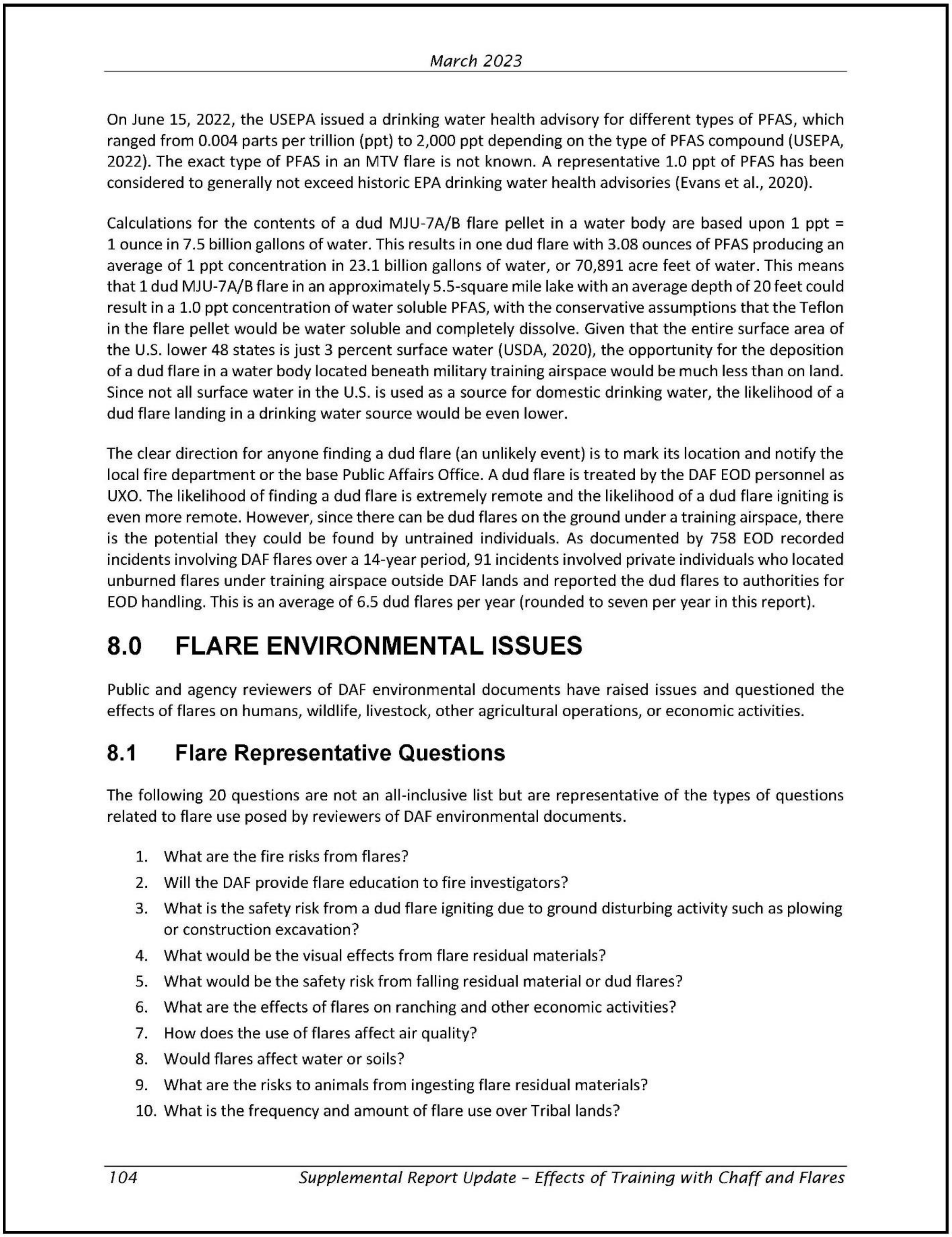


Figure 7-29. Approximately 40 Percent of an M-206 Dud Flare

Any located dud flare should be treated as UXO. A dud flare or a portion of a dud flare is not likely to ignite spontaneously; however, flares are impact, friction, spark, and flame sensitive. For this reason, the DAF makes it clear to the public that a dud flare, if located, can be ignited, should not be moved, and the flare's location should be reported to the DAF base or local authorities. The squib or ignition cartridge remains in the aircraft with the aluminum case and could not produce the hot gases needed to ignite a flare. If a dud flare were shot with a bullet or cut with a power saw, the friction could reach an instantaneous flash point and cause the flare to ignite. One anecdotal report describes an individual who found a dud flare beneath training airspace, took it to his shop, and attempted to cut the magnesium flare with a power saw. The flare ignited and burned at over 2,000 °F, causing severe injury. If a dud flare were struck by an ax, it is unlikely, but possible, that a spark would cause it to ignite. There is one anecdotal report of static electricity igniting a dud flare that a person brought home, placed on a table, and walked across a carpet before touching the dud flare. The spark created by static electricity can be from 1,800 to 3,000 °F, which is consistent with the ignition temperature of a flare. The individual was severely burned. In addition, there were two separate reported cases of dud flares igniting when they fell and struck volcanic rock or a rock-type driveway surface. Apparently, such a strike can cause a spark similar to the spark from static electricity, which could begin the ignition of the magnesium. Should a dud flare be ignited, it would burn at a temperature in excess of 2,000 °F and could result in severe injury or death.

There is no instance of a falling dud flare or any flare residual materials striking an individual. As explained in Section 8.4, the probability that a dud flare could strike a person on the ground is extremely low. Section 8.5.1 includes calculations showing that a dud M-206, the most commonly used flare, would be an approximately 1/3-pound piece of material falling at a speed of between 62 and 169 mph, depending on the falling flare's orientation. It is extremely unlikely that an individual could be struck by such a falling object, but if someone were to be struck with that much force, it could cause severe injury or death.

A rare intact dud MJU-7A/B flare pellet would have 5.28 ounces of magnesium, 3.08 ounces of Teflon, and 0.44 ounces of Viton. An M-206 flare pellet would have one-half the weight of the different components of an MJU-7A/B pellet. As explained at the beginning of this section, an estimated 1,704 flares or parts of flares annually are deposited as dud flares under training airspace but not on military land. Under the representative assumption used in this report of 20,000 flares deployed over a 2,000-square mile range, the incidence of dud flares results in an estimated 1 dud flare on 25 square miles of surface area per year.



On June 15, 2022, the USEPA issued a drinking water health advisory for different types of PFAS, which ranged from 0.004 parts per trillion (ppt) to 2,000 ppt depending on the type of PFAS compound (USEPA, 2022). The exact type of PFAS in an MTV flare is not known. A representative 1.0 ppt of PFAS has been considered to generally not exceed historic EPA drinking water health advisories (Evans et al., 2020).

Calculations for the contents of a dud MJU-7A/B flare pellet in a water body are based upon 1 ppt = 1 ounce in 7.5 billion gallons of water. This results in one dud flare with 3.08 ounces of PFAS producing an average of 1 ppt concentration in 23.1 billion gallons of water, or 70,891 acre feet of water. This means that 1 dud MJU-7A/B flare in an approximately 5.5-square mile lake with an average depth of 20 feet could result in a 1.0 ppt concentration of water soluble PFAS, with the conservative assumptions that the Teflon in the flare pellet would be water soluble and completely dissolve. Given that the entire surface area of the U.S. lower 48 states is just 3 percent surface water (USDA, 2020), the opportunity for the deposition of a dud flare in a water body located beneath military training airspace would be much less than on land. Since not all surface water in the U.S. is used as a source for domestic drinking water, the likelihood of a dud flare landing in a drinking water source would be even lower.

The clear direction for anyone finding a dud flare (an unlikely event) is to mark its location and notify the local fire department or the base Public Affairs Office. A dud flare is treated by the DAF EOD personnel as UXO. The likelihood of finding a dud flare is extremely remote and the likelihood of a dud flare igniting is even more remote. However, since there can be dud flares on the ground under a training airspace, there is the potential they could be found by untrained individuals. As documented by 758 EOD recorded incidents involving DAF flares over a 14-year period, 91 incidents involved private individuals who located unburned flares under training airspace outside DAF lands and reported the dud flares to authorities for EOD handling. This is an average of 6.5 dud flares per year (rounded to seven per year in this report).

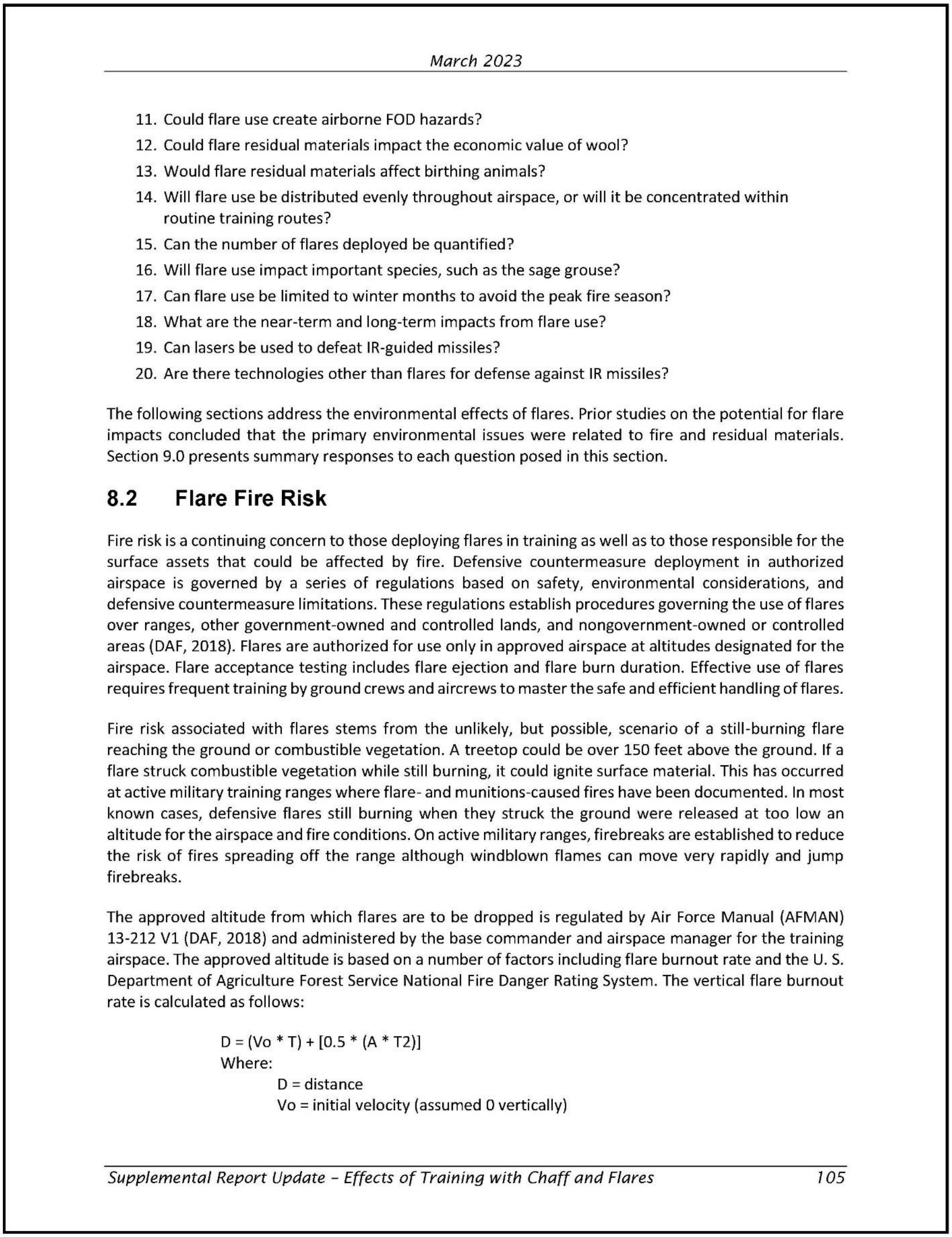
8.0 FLARE ENVIRONMENTAL ISSUES

Public and agency reviewers of DAF environmental documents have raised issues and questioned the effects of flares on humans, wildlife, livestock, other agricultural operations, or economic activities.

8.1 Flare Representative Questions

The following 20 questions are not an all-inclusive list but are representative of the types of questions related to flare use posed by reviewers of DAF environmental documents.

1. What are the fire risks from flares?
2. Will the DAF provide flare education to fire investigators?
3. What is the safety risk from a dud flare igniting due to ground disturbing activity such as plowing or construction excavation?
4. What would be the visual effects from flare residual materials?
5. What would be the safety risk from falling residual material or dud flares?
6. What are the effects of flares on ranching and other economic activities?
7. How does the use of flares affect air quality?
8. Would flares affect water or soils?
9. What are the risks to animals from ingesting flare residual materials?
10. What is the frequency and amount of flare use over Tribal lands?



11. Could flare use create airborne FOD hazards?
12. Could flare residual materials impact the economic value of wool?
13. Would flare residual materials affect birthing animals?
14. Will flare use be distributed evenly throughout airspace, or will it be concentrated within routine training routes?
15. Can the number of flares deployed be quantified?
16. Will flare use impact important species, such as the sage grouse?
17. Can flare use be limited to winter months to avoid the peak fire season?
18. What are the near-term and long-term impacts from flare use?
19. Can lasers be used to defeat IR-guided missiles?
20. Are there technologies other than flares for defense against IR missiles?

The following sections address the environmental effects of flares. Prior studies on the potential for flare impacts concluded that the primary environmental issues were related to fire and residual materials. Section 9.0 presents summary responses to each question posed in this section.

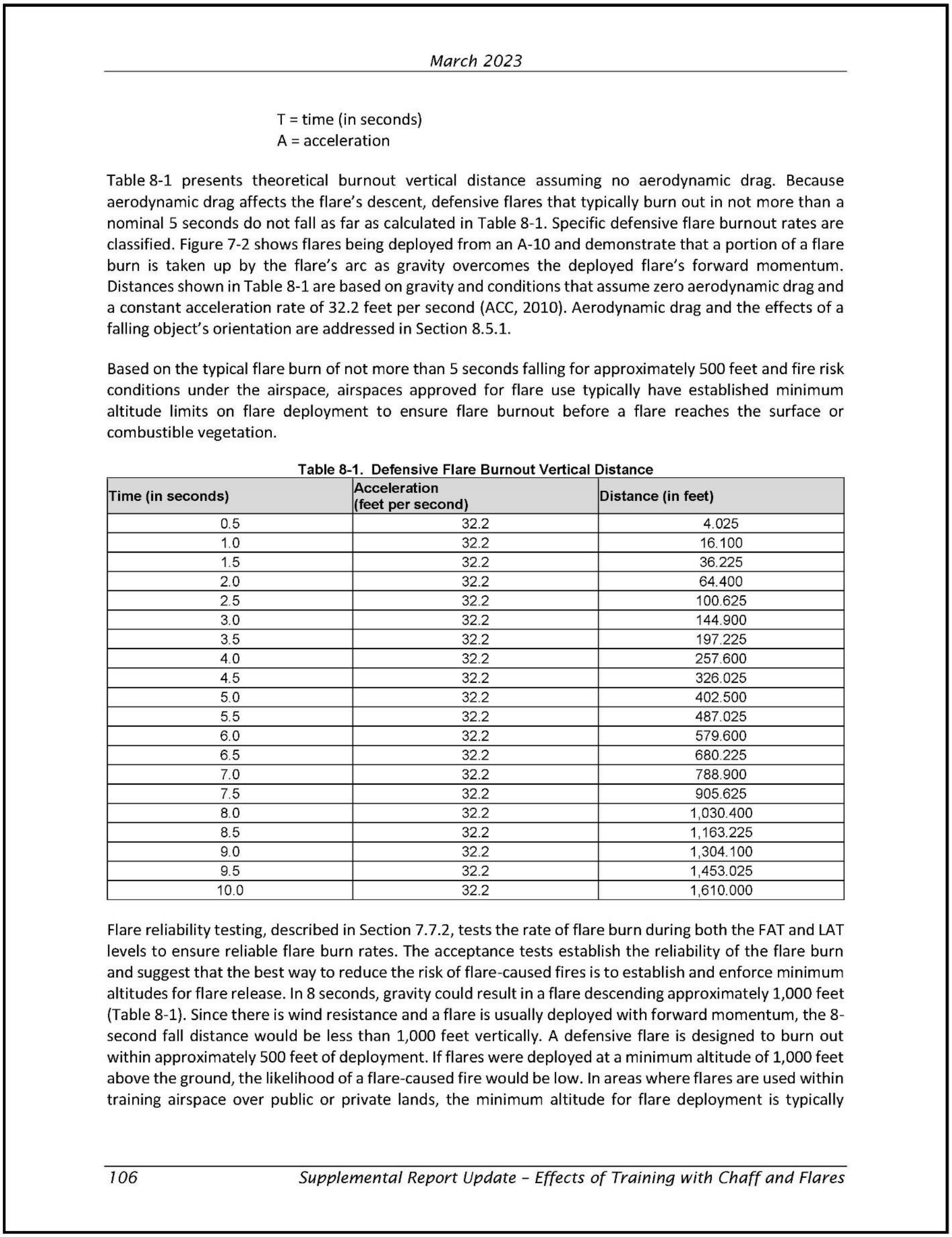
8.2 Flare Fire Risk

Fire risk is a continuing concern to those deploying flares in training as well as to those responsible for the surface assets that could be affected by fire. Defensive countermeasure deployment in authorized airspace is governed by a series of regulations based on safety, environmental considerations, and defensive countermeasure limitations. These regulations establish procedures governing the use of flares over ranges, other government-owned and controlled lands, and nongovernment-owned or controlled areas (DAF, 2018). Flares are authorized for use only in approved airspace at altitudes designated for the airspace. Flare acceptance testing includes flare ejection and flare burn duration. Effective use of flares requires frequent training by ground crews and aircrews to master the safe and efficient handling of flares.

Fire risk associated with flares stems from the unlikely, but possible, scenario of a still-burning flare reaching the ground or combustible vegetation. A treetop could be over 150 feet above the ground. If a flare struck combustible vegetation while still burning, it could ignite surface material. This has occurred at active military training ranges where flare- and munitions-caused fires have been documented. In most known cases, defensive flares still burning when they struck the ground were released at too low an altitude for the airspace and fire conditions. On active military ranges, firebreaks are established to reduce the risk of fires spreading off the range although windblown flames can move very rapidly and jump firebreaks.

The approved altitude from which flares are to be dropped is regulated by Air Force Manual (AFMAN) 13-212 V1 (DAF, 2018) and administered by the base commander and airspace manager for the training airspace. The approved altitude is based on a number of factors including flare burnout rate and the U. S. Department of Agriculture Forest Service National Fire Danger Rating System. The vertical flare burnout rate is calculated as follows:

$D = (Vo * T) + [0.5 * (A * T2)]$
Where:
D = distance
Vo = initial velocity (assumed 0 vertically)



T = time (in seconds)
A = acceleration

Table 8-1 presents theoretical burnout vertical distance assuming no aerodynamic drag. Because aerodynamic drag affects the flare's descent, defensive flares that typically burn out in not more than a nominal 5 seconds do not fall as far as calculated in Table 8-1. Specific defensive flare burnout rates are classified. Figure 7-2 shows flares being deployed from an A-10 and demonstrate that a portion of a flare burn is taken up by the flare's arc as gravity overcomes the deployed flare's forward momentum. Distances shown in Table 8-1 are based on gravity and conditions that assume zero aerodynamic drag and a constant acceleration rate of 32.2 feet per second (ACC, 2010). Aerodynamic drag and the effects of a falling object's orientation are addressed in Section 8.5.1.

Based on the typical flare burn of not more than 5 seconds falling for approximately 500 feet and fire risk conditions under the airspace, airspaces approved for flare use typically have established minimum altitude limits on flare deployment to ensure flare burnout before a flare reaches the surface or combustible vegetation.

Table 8-1. Defensive Flare Burnout Vertical Distance

Time (in seconds)	Acceleration (feet per second)	Distance (in feet)
0.5	32.2	4.025
1.0	32.2	16.100
1.5	32.2	36.225
2.0	32.2	64.400
2.5	32.2	100.625
3.0	32.2	144.900
3.5	32.2	197.225
4.0	32.2	257.600
4.5	32.2	326.025
5.0	32.2	402.500
5.5	32.2	487.025
6.0	32.2	579.600
6.5	32.2	680.225
7.0	32.2	788.900
7.5	32.2	905.625
8.0	32.2	1,030.400
8.5	32.2	1,163.225
9.0	32.2	1,304.100
9.5	32.2	1,453.025
10.0	32.2	1,610.000

Flare reliability testing, described in Section 7.7.2, tests the rate of flare burn during both the FAT and LAT levels to ensure reliable flare burn rates. The acceptance tests establish the reliability of the flare burn and suggest that the best way to reduce the risk of flare-caused fires is to establish and enforce minimum altitudes for flare release. In 8 seconds, gravity could result in a flare descending approximately 1,000 feet (Table 8-1). Since there is wind resistance and a flare is usually deployed with forward momentum, the 8-second fall distance would be less than 1,000 feet vertically. A defensive flare is designed to burn out within approximately 500 feet of deployment. If flares were deployed at a minimum altitude of 1,000 feet above the ground, the likelihood of a flare-caused fire would be low. In areas where flares are used within training airspace over public or private lands, the minimum altitude for flare deployment is typically designated as 2,000 feet AGL or above. Additional restrictions on flare use based on fire conditions may be established by Major Command policy or be based on specific airspace conditions. Establishment and strict adherence to deployment altitude restrictions would result in very few, if any, countermeasure flares reaching the surface while still burning.

The 2,000-feet AGL deployment altitude restriction over public or private land would normally be adequate to prevent any burning or hot materials from a deployed flare from reaching the surface. There would not be any part of the flare that would be still burning or hot after being deployed at or above 2,000 feet AGL. The flare pellet is completely consumed in the burning process and would be consumed within 500 feet from the aircraft. The S&I device can be heated and singed by the burning flare (see Figure 8-1); however, the plastic S&I device would not retain enough heat to cause vegetation to combust. If the aircraft were in a steep dive when flares were released and the aircraft was at 2,000 feet, the flare could have additional momentum and still be burning for approximately 1,000 feet from the release point. However, it is extremely unlikely that a pilot would put an aircraft in a steep dive only 2,000 feet above the surface.

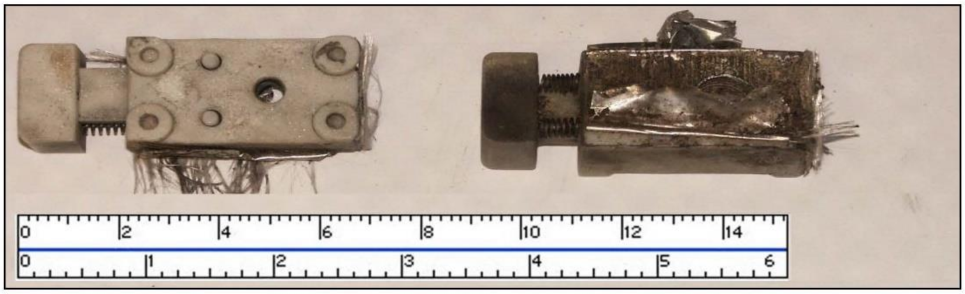


Figure 8-1. Two Safe and Initiation (S&I) Devices Used in MJU-7/B, MJU-10/B, and Other Flare Types

The difficulty would continue to be strictly adhering to not deploying flares below 2,000 feet AGL over public or private lands. Under intense combat-like conditions, rapid changes to aircraft altitude can occur that could result in flares inadvertently being deployed below the prescribed altitude. This could be the case particularly if there were rapidly changing topography under the training airspace. The aircraft could be closer to the surface for a few seconds as it flew over higher topography, and, if defensive flares were released at exactly the time the aircraft was closer to the surface, there could be flare deployment below 2,000 feet AGL. If the training airspace were overlying terrain changes of, for example, 1,000 feet or more, an MSL altitude for flare release could be applied to specific conditions, such as very high or extreme fire conditions. In such cases, the MSL altitude at, for example, 2,000 feet above the nearest topographic feature, could serve as an additional insurance that a pilot would not deploy flares below the AGL altitude. Such an MSL restriction would not be required to reduce fire risk for most conceivable cases. Strict adherence to the deployment of defensive flares above 2,000 feet AGL should adequately avoid fire risk on public or private lands under the airspace.

8.3 Wildfire Issues

Any fires of a natural or non-natural source may adversely affect vegetation, injure wildlife or livestock, and destroy property such as fences or buildings. A wildland fire may result in direct effects on wildlife and livestock including displacement from important habitat or range. The degree of effect varies by the severity of the fire, the season of the fire, and the type of habitat that was burned. Fires temporarily decrease available cover and foraging habitat and fires started during breeding season could adversely affect ground-nesting birds and interrupt breeding rituals for resident species.

Ranching operations and public land managers have expressed concern over any risk of a flare-caused fire. Flare-caused fires could damage crops, rangelands, timber, and/or ranch infrastructure, national grasslands, forests, and agricultural areas under the airspace. Defensive countermeasure flares have a potential to start fires that can spread, adversely and indirectly affecting many resources. Flare-induced fires depend on the probabilities of flare materials reaching the ground, igniting vegetation, and causing significant damage if fire spreads (DAF, 1997).

Whenever a burning object such as a flare is deployed over ground with combustible materials, there is potential for fire. The primary way to prevent a wildfire is to take steps or establish and enforce procedures that avoid any burning object from coming in contact with combustible materials.

Flares are tested for burn duration, and a manufacturing lot can be rejected if the flare burns beyond the specified number of seconds, which is nominally 5 seconds. Flares are also tested for deployment from the cartridge case and successful separation. As described in Section 8.2, there is a risk of a dud flare landing on the surface. In an unusual case, if a dud flare were to fall at a specific angle and strike a hard rock surface and cause a spark, the flare could ignite. There is one known and one suspected instance of a dud flare falling, striking a hard rock surface, and starting a fire. However, the potential for a dud flare landing on the surface is very small and the potential for a dud flare striking a hard surface at a specific angle and igniting is much smaller. The primary way to ensure that flares do not reach combustible materials on the surface is to establish and enforce altitude restrictions consistent with DAF policy and flare manufactured specifications. Altitude restrictions on flare release are designed to ensure flares burn out well above the ground surface (AFRC, 2000; DAF, 2006; DAF, 2018). In defined airspaces, flare use could be discontinued in specified fire danger conditions.

The possibility of a flare-caused fire is remote although there have been instances of where flares were deployed at too low an altitude during intense combat-like conditions and rapid changes to aircraft altitude. Use of flares in the MOAs would have altitude release restrictions to reduce the risk of wildland fires as a result of flare use (DAF, 2019). Depending on the airspace conditions, the following Best Management Practices have been implemented as appropriate to the specific fire conditions:

- Comply with DAF and local procedures
- Establish a capability to analyze fire risks on a site-specific basis
- Work with other agencies to adjust training with defensive countermeasures in accordance with local conditions

Any potential loss of forage, livestock, or infrastructure due to fire could result in economic impacts to affected landowners. The DAF follows established procedures for claims in the unlikely event that a DAF-caused fire should occur and subsequently damage livestock or infrastructure.

8.4 Flare Residual Materials

Questions have been raised regarding flare materials that are not consumed during the flare burn and are deposited on the surface following flare deployment. Unlike dud flares, which are projected to be approximately 40 flares per 10,000 flares deployed (see Section 7.7.3), residual flare materials are deposited on the surface after each flare deployment.

Table 8-2 is derived from Table 7-3, Table 7-6, Table 7-8, and Table 7-10 to present the residual materials from representative flares. Flare residual materials include plastic end caps and foil wrappers; plastic parts and iron foils have been located on military ranges and/or public or private property beneath training airspace.

Table 8-2. Representative Residual Material Following Deployment of One Flare or Decoy

Material/Geometry	Flare Type				
	M-206 [1]	MJU-7A/B [1]	62A/B [2]	MJU-68/B [3]	MJU-51A/B [4]
End Cap/ Rectangular Plate	One 1”x1”x1/4” plastic or nylon	One 2”x1”x1/4” plastic or nylon	One 1”x2”x1/4” plastic or nylon	One 1.5”x1.5”x1/4” thick plastic end cap	One 2”x1”x1/4” inch plastic or nylon
Piston/ Rectangular Open	One 1”x1”x1/4” plastic or nylon	One 2”x1”x1/4” plastic or nylon	One 1”x2”x1/4” plastic	One 1.5”x1.5”x1/4” plastic	One 2”x1”x1/4” plastic or nylon
Spacer/ Rectangular Piece	One or two 1”x1” felt	One or two 2”x1” felt	One or two 1”x2” felt	N/A	One 0.5” diameter plastic disc
Wrapping/ Rectangular Open	One up to 3”x17” piece of aluminum-coated stiff duct-tape type material	One up to 4”x17” piece of aluminum-coated stiff duct-tape type material	One up to 4”x17” piece of aluminum-coated stiff duct-tape type material	One 1.5” diameter x 10” long carbon fiber body with weighted nose	N/A
S&I Device/ Rectangular Solid	N/A	One 2”x1”x.5” nylon and plastic spring device	One 2”x1”x.5” nylon and plastic spring device	One 1.5” diameter x 0.5” plastic sequencer assembly	N/A
Pyrophoric Foils	N/A	N/A	N/A	N/A	1,600 0.75”x1.75”x 0.002” pyrophoric foils

" = inch/inches; MJU = Mobile Jettison Unit (flare); N/A = not applicable; S&I = Safe and Initiation

Notes:

1. MTV Flare
2. Standard Spectral Flare
3. Thrusted Flare
4. Spectral Decoy

Figure 8-2 is a photograph of two MJU-7A/B rectangular wrappings recovered from rangeland by a New Mexico rancher. The 5-inch long pen is included for scale.

Figure 8-2. MJU-7 Residual Flare Wrapping Materials

Figure 8-3 includes wrapping material with burned wrapping fiber and four end caps from MJU-7A/B flares recovered from private ranch property.

Figure 8-3. MJU-7 End Caps (Red) and Wrapping Material

Figure 8-4 is a residual piece of plastic from a deployed countermeasure located on a DAF range.

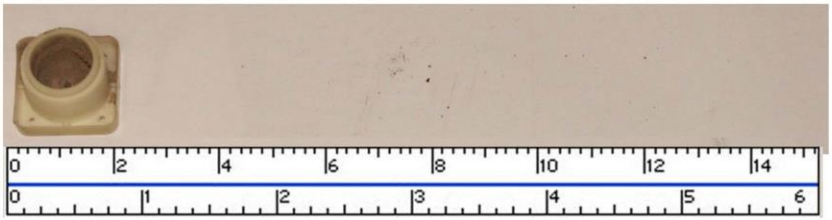


Figure 8-4. Residual Piece of Plastic from a Deployed Countermeasure

Figure 8-5 is an M-206 flare wrapping on a training range in an eastern piney woodland. Pine needles have begun to cover the wrapper, and the wrapper itself has similar features to the adjacent stick. Such a wrapping would not result in an environmental impact but could be annoying to a person who recognized the flare wrapping.

Figure 8-1 is a photograph of two 2.25-inch long extended S&I devices with melted fibers from the wrapping material attached. The used S&I devices can be compared with the unused S&I device, which has not been deployed, in Figure 7-4.

Table 8-3 through Table 8-6 present the sizes, shapes, and weights of residual flare materials. The estimated weight of flare pellets is included in the tables. Chaff residual materials are included in Table 8-7 for comparison to flare residual materials.

Figure 8-5. An M-206 Flare Wrapper Partially Covered by Pine Needles

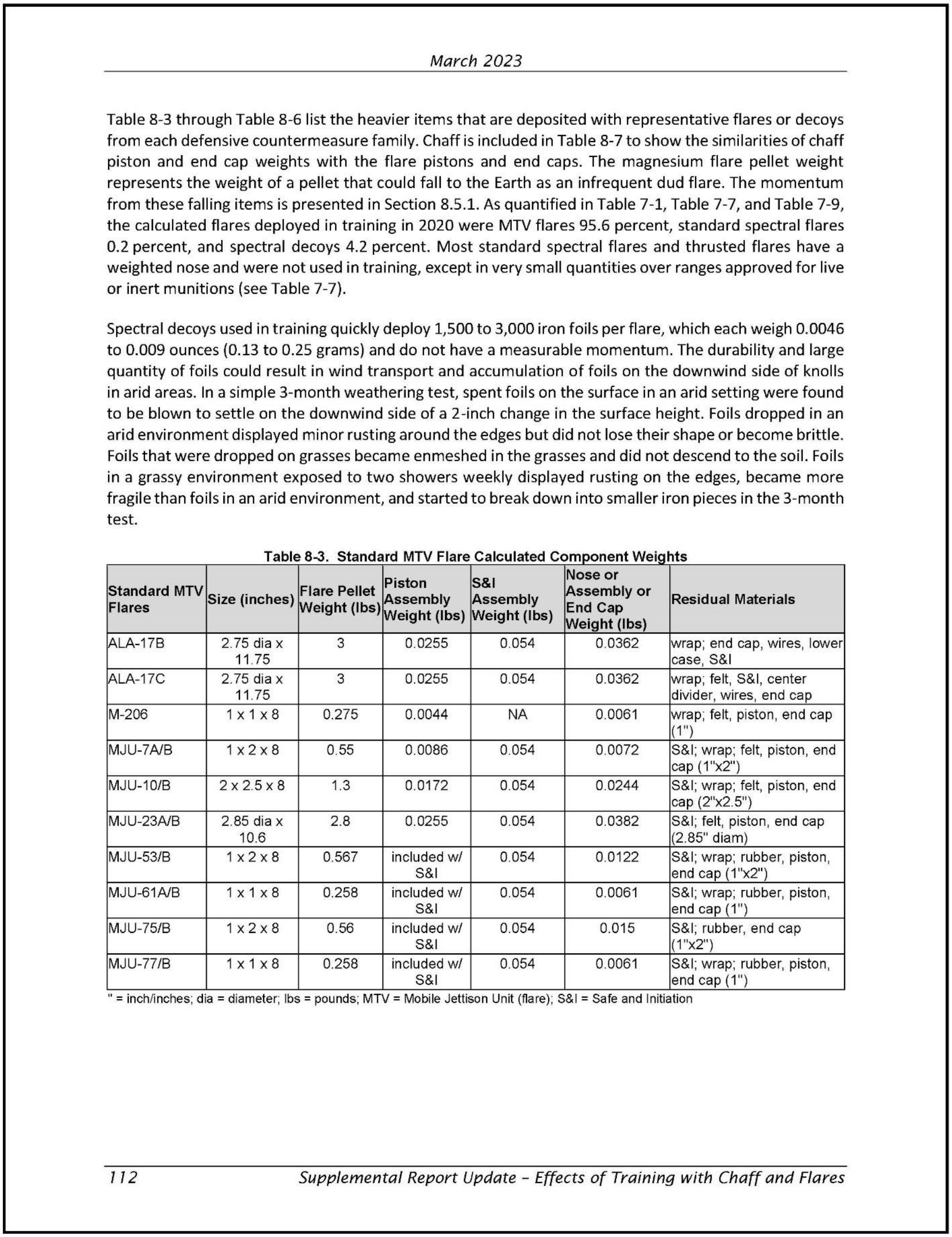


Table 8-3 through Table 8-6 list the heavier items that are deposited with representative flares or decoys from each defensive countermeasure family. Chaff is included in Table 8-7 to show the similarities of chaff piston and end cap weights with the flare pistons and end caps. The magnesium flare pellet weight represents the weight of a pellet that could fall to the Earth as an infrequent dud flare. The momentum from these falling items is presented in Section 8.5.1. As quantified in Table 7-1, Table 7-7, and Table 7-9, the calculated flares deployed in training in 2020 were MTV flares 95.6 percent, standard spectral flares 0.2 percent, and spectral decoys 4.2 percent. Most standard spectral flares and thrusted flares have a weighted nose and were not used in training, except in very small quantities over ranges approved for live or inert munitions (see Table 7-7).

Spectral decoys used in training quickly deploy 1,500 to 3,000 iron foils per flare, which each weigh 0.0046 to 0.009 ounces (0.13 to 0.25 grams) and do not have a measurable momentum. The durability and large quantity of foils could result in wind transport and accumulation of foils on the downwind side of knolls in arid areas. In a simple 3-month weathering test, spent foils on the surface in an arid setting were found to be blown to settle on the downwind side of a 2-inch change in the surface height. Foils dropped in an arid environment displayed minor rusting around the edges but did not lose their shape or become brittle. Foils that were dropped on grasses became enmeshed in the grasses and did not descend to the soil. Foils in a grassy environment exposed to two showers weekly displayed rusting on the edges, became more fragile than foils in an arid environment, and started to break down into smaller iron pieces in the 3-month test.

Table 8-3. Standard MTV Flare Calculated Component Weights

Standard MTV Flares	Size (inches)	Flare Pellet Weight (lbs)	Piston Assembly Weight (lbs)	S&I Assembly Weight (lbs)	Nose or Assembly or End Cap Weight (lbs)	Residual Materials
ALA-17B	2.75 dia x 11.75	3	0.0255	0.054	0.0362	wrap; end cap, wires, lower case, S&I
ALA-17C	2.75 dia x 11.75	3	0.0255	0.054	0.0362	wrap; felt, S&I, center divider, wires, end cap
M-206	1 x 1 x 8	0.275	0.0044	NA	0.0061	wrap; felt, piston, end cap (1")
MJU-7A/B	1 x 2 x 8	0.55	0.0086	0.054	0.0072	S&I; wrap; felt, piston, end cap (1"x2")
MJU-10/B	2 x 2.5 x 8	1.3	0.0172	0.054	0.0244	S&I; wrap; felt, piston, end cap (2"x2.5")
MJU-23A/B	2.85 dia x 10.6	2.8	0.0255	0.054	0.0382	S&I; felt, piston, end cap (2.85" diam)
MJU-53/B	1 x 2 x 8	0.567	included w/ S&I	0.054	0.0122	S&I; wrap; rubber, piston, end cap (1"x2")
MJU-61A/B	1 x 1 x 8	0.258	included w/ S&I	0.054	0.0061	S&I; wrap; rubber, piston, end cap (1")
MJU-75/B	1 x 2 x 8	0.56	included w/ S&I	0.054	0.015	S&I; rubber, end cap (1"x2")
MJU-77/B	1 x 1 x 8	0.258	included w/ S&I	0.054	0.0061	S&I; wrap; rubber, piston, end cap (1")

" = inch/inches; dia = diameter; lbs = pounds; MTV = Mobile Jettison Unit (flare); S&I = Safe and Initiation

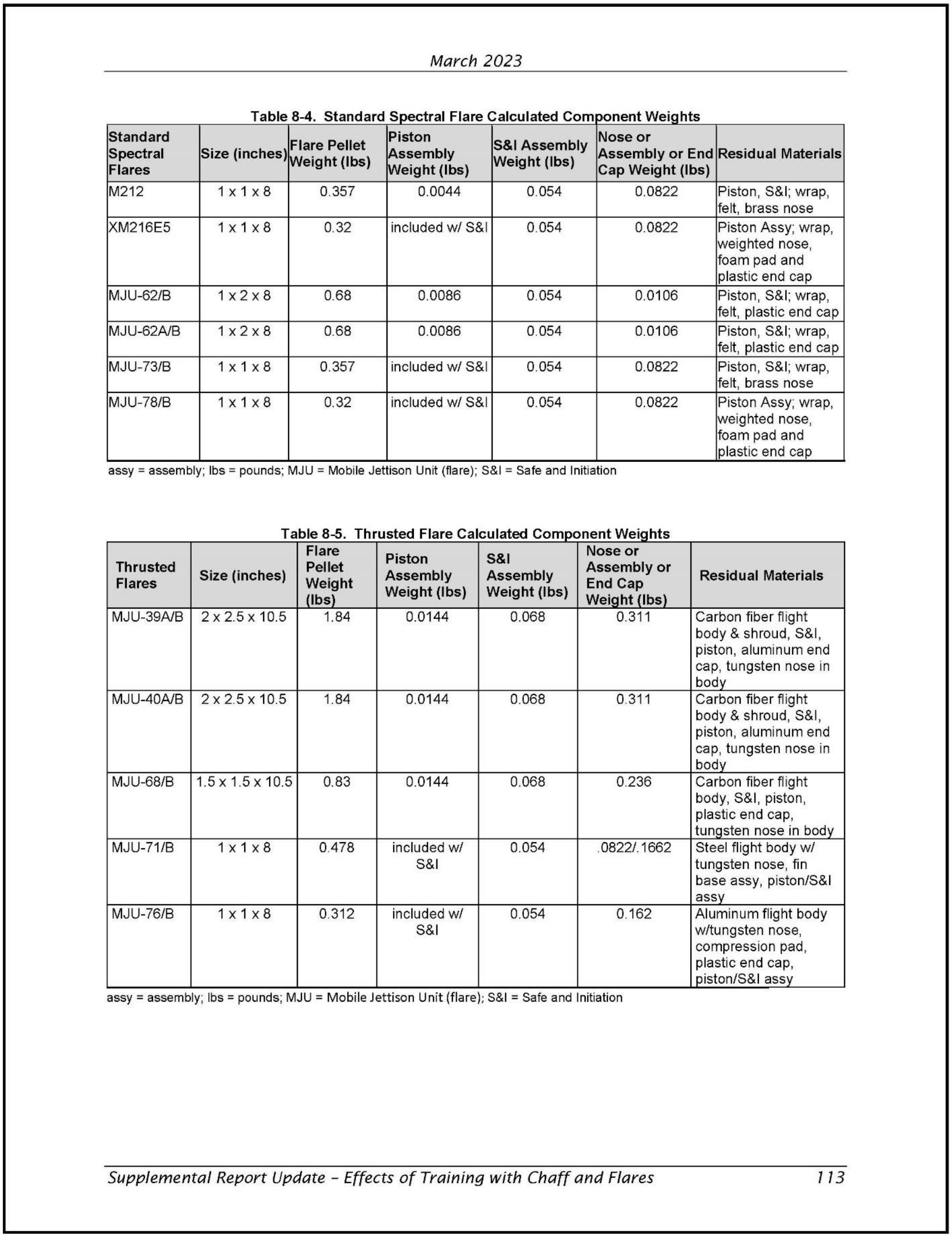


Table 8-4. Standard Spectral Flare Calculated Component Weights

Standard Spectral Flares	Size (inches)	Flare Pellet Weight (lbs)	Piston Assembly Weight (lbs)	S&I Assembly Weight (lbs)	Nose or Assembly or End Cap Weight (lbs)	Residual Materials
M212	1 x 1 x 8	0.357	0.0044	0.054	0.0822	Piston, S&I; wrap, felt, brass nose
XM216E5	1 x 1 x 8	0.32	included w/ S&I	0.054	0.0822	Piston Assy; wrap, weighted nose, foam pad and plastic end cap
MJU-62/B	1 x 2 x 8	0.68	0.0086	0.054	0.0106	Piston, S&I; wrap, felt, plastic end cap
MJU-62A/B	1 x 2 x 8	0.68	0.0086	0.054	0.0106	Piston, S&I; wrap, felt, plastic end cap
MJU-73/B	1 x 1 x 8	0.357	included w/ S&I	0.054	0.0822	Piston, S&I; wrap, felt, brass nose
MJU-78/B	1 x 1 x 8	0.32	included w/ S&I	0.054	0.0822	Piston Assy; wrap, weighted nose, foam pad and plastic end cap

assy = assembly; lbs = pounds; MJU = Mobile Jettison Unit (flare); S&I = Safe and Initiation

Table 8-5. Thrusted Flare Calculated Component Weights

Thrusted Flares	Size (inches)	Flare Pellet Weight (lbs)	Piston Assembly Weight (lbs)	S&I Assembly Weight (lbs)	Nose or Assembly or End Cap Weight (lbs)	Residual Materials
MJU-39A/B	2 x 2.5 x 10.5	1.84	0.0144	0.068	0.311	Carbon fiber flight body & shroud, S&I, piston, aluminum end cap, tungsten nose in body
MJU-40A/B	2 x 2.5 x 10.5	1.84	0.0144	0.068	0.311	Carbon fiber flight body & shroud, S&I, piston, aluminum end cap, tungsten nose in body
MJU-68/B	1.5 x 1.5 x 10.5	0.83	0.0144	0.068	0.236	Carbon fiber flight body, S&I, piston, plastic end cap, tungsten nose in body
MJU-71/B	1 x 1 x 8	0.478	included w/ S&I	0.054	.0822/.1662	Steel flight body w/ tungsten nose, fin base assy, piston/S&I assy
MJU-76/B	1 x 1 x 8	0.312	included w/ S&I	0.054	0.162	Aluminum flight body w/tungsten nose, compression pad, plastic end cap, piston/S&I assy

assy = assembly; lbs = pounds; MJU = Mobile Jettison Unit (flare); S&I = Safe and Initiation

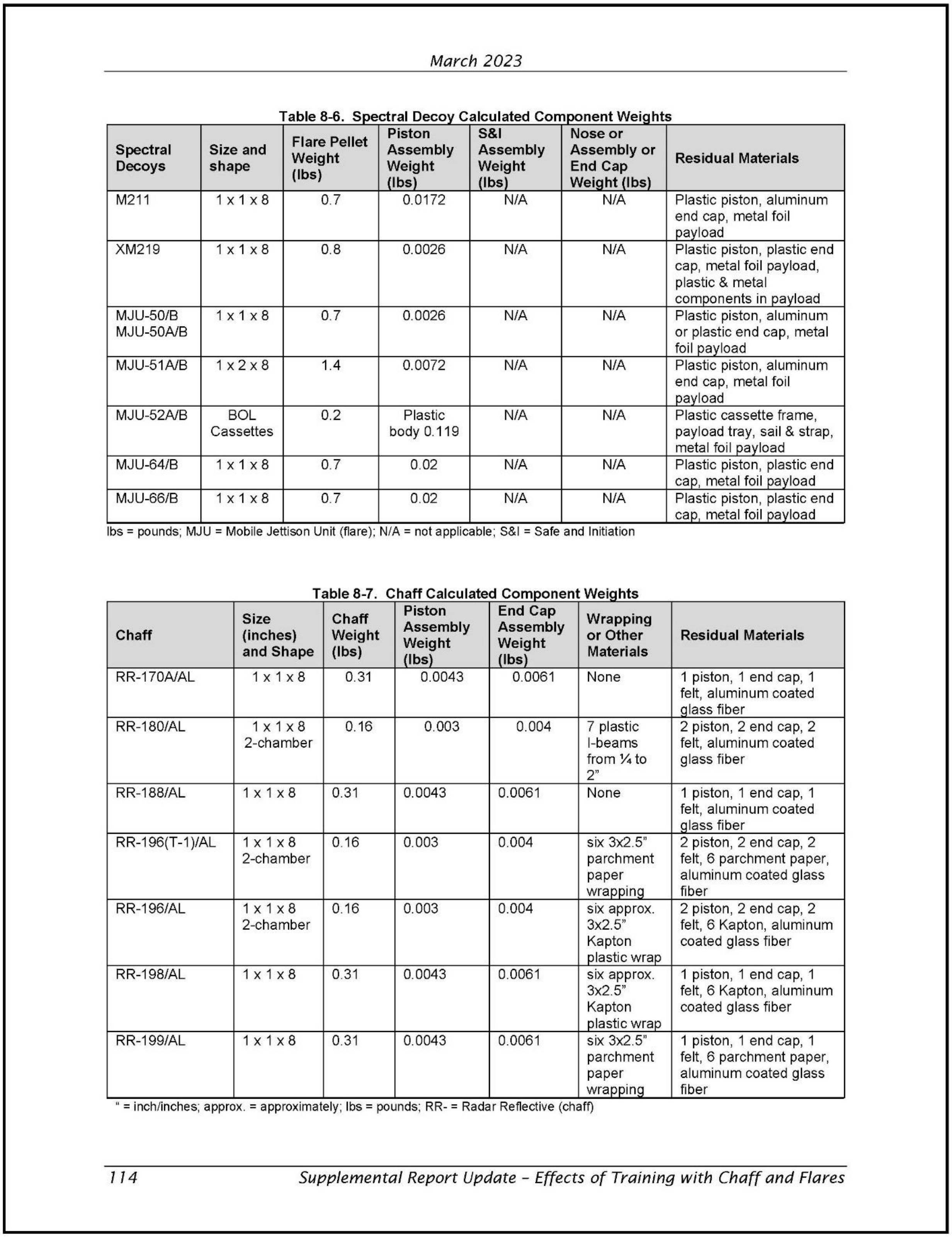


Table 8-6. Spectral Decoy Calculated Component Weights

Spectral Decoys	Size and shape	Flare Pellet Weight (lbs)	Piston Assembly Weight (lbs)	S&I Assembly Weight (lbs)	Nose or Assembly or End Cap Weight (lbs)	Residual Materials
M211	1 x 1 x 8	0.7	0.0172	N/A	N/A	Plastic piston, aluminum end cap, metal foil payload
XM219	1 x 1 x 8	0.8	0.0026	N/A	N/A	Plastic piston, plastic end cap, metal foil payload, plastic & metal components in payload
MJU-50/B MJU-50A/B	1 x 1 x 8	0.7	0.0026	N/A	N/A	Plastic piston, aluminum or plastic end cap, metal foil payload
MJU-51A/B	1 x 2 x 8	1.4	0.0072	N/A	N/A	Plastic piston, aluminum end cap, metal foil payload
MJU-52A/B	BOL Cassettes	0.2	Plastic body 0.119	N/A	N/A	Plastic cassette frame, payload tray, sail & strap, metal foil payload
MJU-64/B	1 x 1 x 8	0.7	0.02	N/A	N/A	Plastic piston, plastic end cap, metal foil payload
MJU-66/B	1 x 1 x 8	0.7	0.02	N/A	N/A	Plastic piston, plastic end cap, metal foil payload

lbs = pounds; MJU = Mobile Jettison Unit (flare); N/A = not applicable; S&I = Safe and Initiation

Table 8-7. Chaff Calculated Component Weights

Chaff	Size (inches) and Shape	Chaff Weight (lbs)	Piston Assembly Weight (lbs)	End Cap Assembly Weight (lbs)	Wrapping or Other Materials	Residual Materials
RR-170A/AL	1 x 1 x 8	0.31	0.0043	0.0061	None	1 piston, 1 end cap, 1 felt, aluminum coated glass fiber
RR-180/AL	1 x 1 x 8 2-chamber	0.16	0.003	0.004	7 plastic I-beams from ¼ to 2”	2 piston, 2 end cap, 2 felt, aluminum coated glass fiber
RR-188/AL	1 x 1 x 8	0.31	0.0043	0.0061	None	1 piston, 1 end cap, 1 felt, aluminum coated glass fiber
RR-196(T-1)/AL	1 x 1 x 8 2-chamber	0.16	0.003	0.004	six 3x2.5” parchment paper wrapping	2 piston, 2 end cap, 2 felt, 6 parchment paper, aluminum coated glass fiber
RR-196/AL	1 x 1 x 8 2-chamber	0.16	0.003	0.004	six approx. 3x2.5” Kapton plastic wrap	2 piston, 2 end cap, 2 felt, 6 Kapton, aluminum coated glass fiber
RR-198/AL	1 x 1 x 8	0.31	0.0043	0.0061	six approx. 3x2.5” Kapton plastic wrap	1 piston, 1 end cap, 1 felt, 6 Kapton, aluminum coated glass fiber
RR-199/AL	1 x 1 x 8	0.31	0.0043	0.0061	six 3x2.5” parchment paper wrapping	1 piston, 1 end cap, 1 felt, 6 parchment paper, aluminum coated glass fiber

” = inch/inches; approx. = approximately; lbs = pounds; RR- = Radar Reflective (chaff)

The residual materials from MTV or most standard spectral flares are unlikely to pose a risk of injury or environmental damage. The effects of the residual pieces on ranch or agricultural operations would be as described in Section 8.11. The residual flare wrapper would be expected to be seen as an undesirable object in the environment. The effects of the residual pieces on cultural or Native American resources would be a described in Section 8.8. No significant impacts would be anticipated, although individuals finding and identifying these pieces could express annoyance with the residual flare materials. The plastic pistons, end caps, and S&I devices are inert and do not decompose. They would not be expected to impact soil resources, but the visual effect of such manmade objects could affect recreational areas or waters. The felt spacers would decompose over time. The aluminum coated wrapping materials would decompose over a much longer period. Flare residual materials would not be expected to measurably affect water or soil resources (see Section 8.9).

Spectral decoys represent a different type of residual material from the other three flare families. The residual materials of spectral decoys, including the oxidized pyrophoric foils, are described in Section 7.6.4.8.

8.5 Safety Risks

When an object separates from an aircraft in flight, numerous physical factors act on the object and influence the force with which the object strikes the ground. These factors include the size, shape, and weight of the object, as well as aerodynamic forces that act on the object as it falls.

When an object is dropped, it is subjected to the force of gravity where it enters free-fall toward the ground, which creates an acceleration of approximately 32.2 feet per second squared (see Table 8-1). The object's shape influences the effect of aerodynamic drag forces exerted on it, which reduces the rate of acceleration to varying degrees such that after a period, the object is no longer accelerating and has reached a state referred to as terminal velocity. When terminal velocity is reached, the object would continue to fall at that velocity indefinitely. Once terminal velocity is known, the momentum (in pound-seconds) can be calculated. Momentum is the metric used to quantify the relative hazard associated with a falling object striking a person, animal, or property on the ground. The likelihood of a strike to a person or object from a piece of flare residual material would depend on the number of flares deployed, the area under the airspace, the population density under the airspace, and the proportion of time a person would be expected to be outside.

This section calculates the likelihoods of a piece of flare residual material striking a person, a private structure, a vehicle, or range cattle under the set of assumptions in Table 8-8. The assumptions in Table 8-8 do not reflect a specific location. They were designed to reflect a representative training airspace, numbers of flares, and underlying population characteristics. The assumptions can be scaled to apply to a specific airspace as desired.

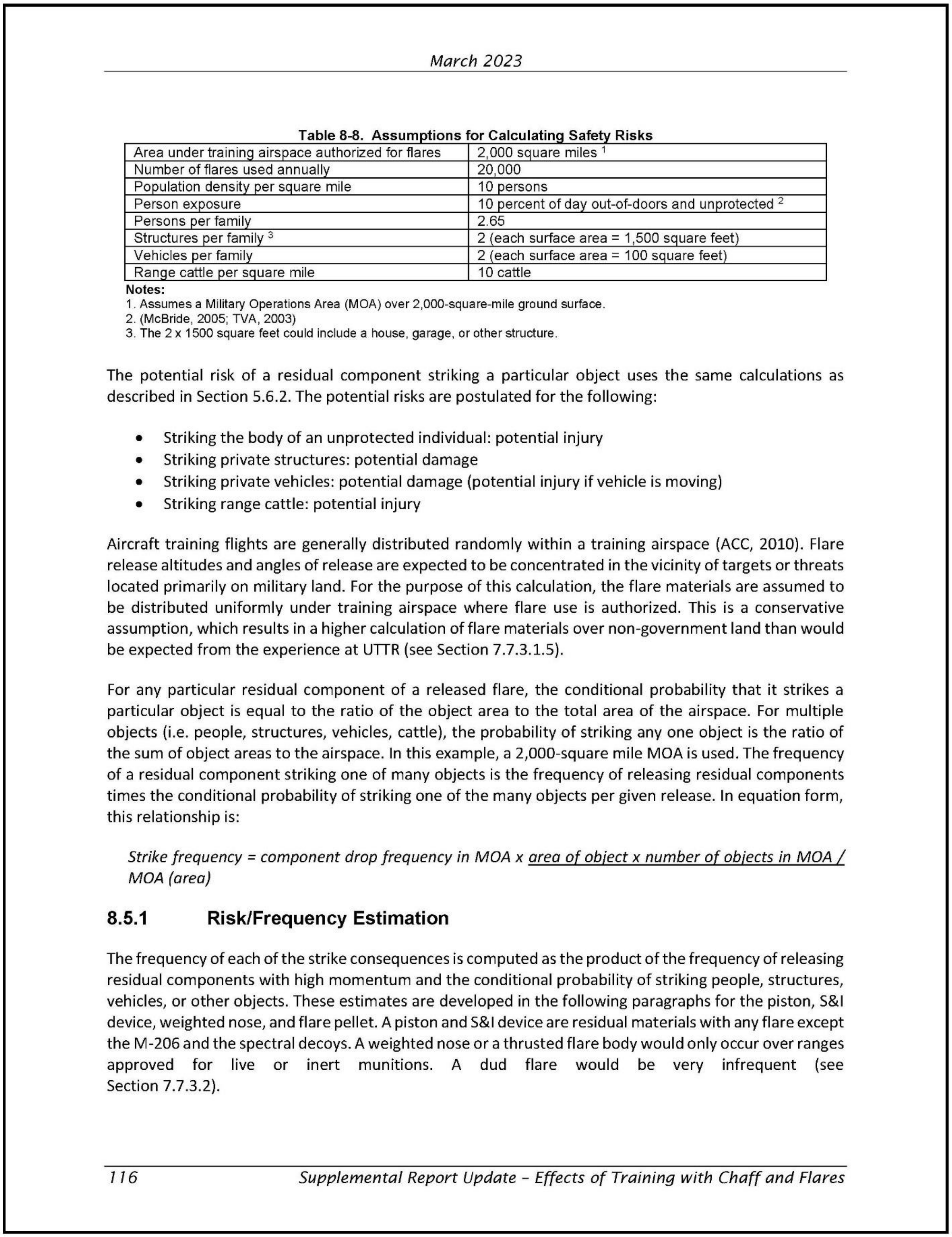


Table 8-8. Assumptions for Calculating Safety Risks

Area under training airspace authorized for flares	2,000 square miles [1]
Number of flares used annually	20,000
Population density per square mile	10 persons
Person exposure	10 percent of day out-of-doors and unprotected [2]
Persons per family	2.65
Structures per family [3]	2 (each surface area = 1,500 square feet)
Vehicles per family	2 (each surface area = 100 square feet)
Range cattle per square mile	10 cattle

Notes:
1. Assumes a Military Operations Area (MOA) over 2,000-square-mile ground surface.
2. (McBride, 2005; TVA, 2003)
3. The 2 x 1500 square feet could include a house, garage, or other structure.

The potential risk of a residual component striking a particular object uses the same calculations as described in Section 5.6.2. The potential risks are postulated for the following:

- Striking the body of an unprotected individual: potential injury
- Striking private structures: potential damage
- Striking private vehicles: potential damage (potential injury if vehicle is moving)
- Striking range cattle: potential injury

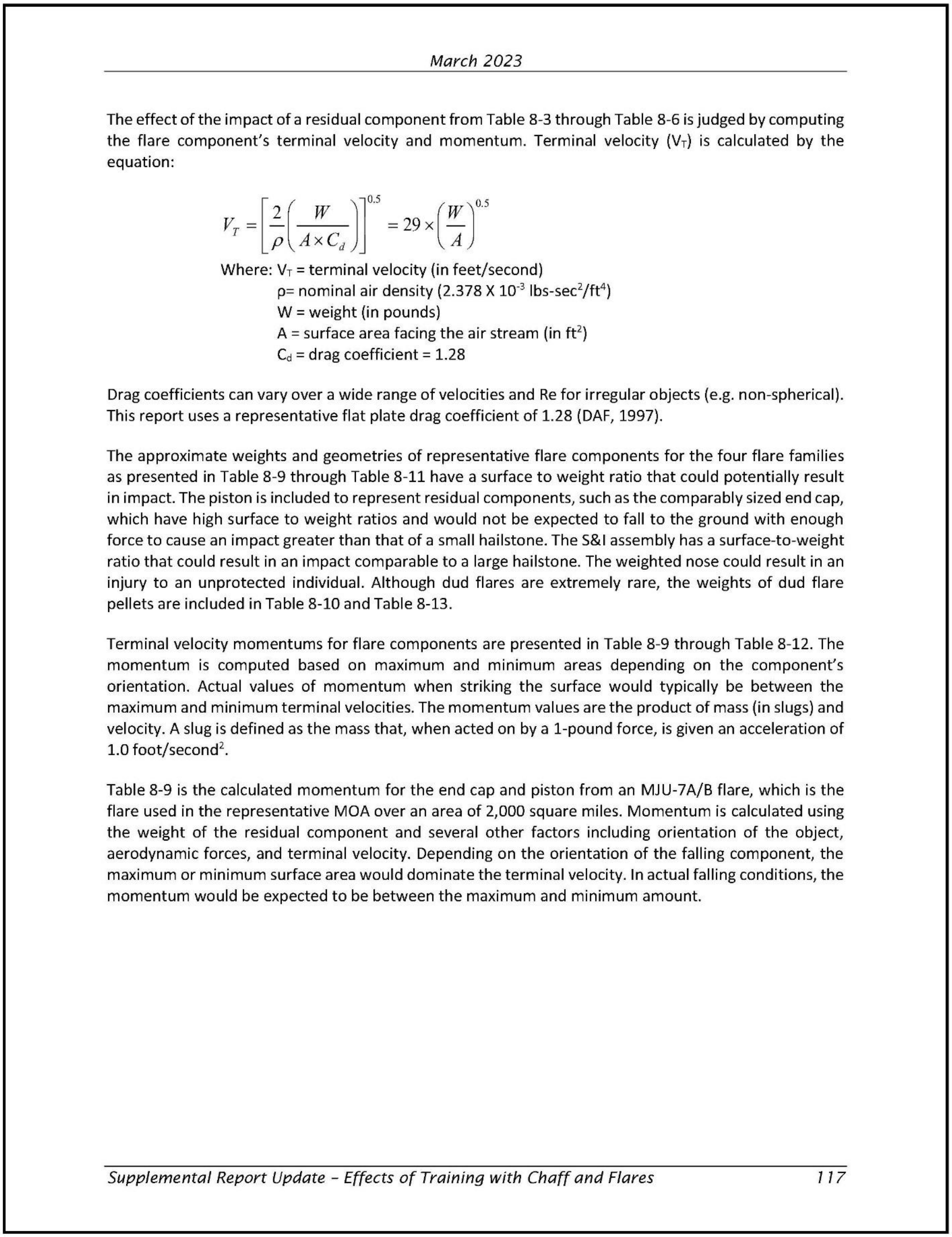
Aircraft training flights are generally distributed randomly within a training airspace (ACC, 2010). Flare release altitudes and angles of release are expected to be concentrated in the vicinity of targets or threats located primarily on military land. For the purpose of this calculation, the flare materials are assumed to be distributed uniformly under training airspace where flare use is authorized. This is a conservative assumption, which results in a higher calculation of flare materials over non-government land than would be expected from the experience at UTTR (see Section 7.7.3.1.5).

For any particular residual component of a released flare, the conditional probability that it strikes a particular object is equal to the ratio of the object area to the total area of the airspace. For multiple objects (i.e. people, structures, vehicles, cattle), the probability of striking any one object is the ratio of the sum of object areas to the airspace. In this example, a 2,000-square mile MOA is used. The frequency of a residual component striking one of many objects is the frequency of releasing residual components times the conditional probability of striking one of the many objects per given release. In equation form, this relationship is:

> *Strike frequency = component drop frequency in MOA x <u>area of object x number of objects in MOA /</u> MOA (area)*

8.5.1 Risk/Frequency Estimation

The frequency of each of the strike consequences is computed as the product of the frequency of releasing residual components with high momentum and the conditional probability of striking people, structures, vehicles, or other objects. These estimates are developed in the following paragraphs for the piston, S&I device, weighted nose, and flare pellet. A piston and S&I device are residual materials with any flare except the M-206 and the spectral decoys. A weighted nose or a thrusted flare body would only occur over ranges approved for live or inert munitions. A dud flare would be very infrequent (see Section 7.7.3.2).



The effect of the impact of a residual component from Table 8-3 through Table 8-6 is judged by computing the flare component's terminal velocity and momentum. Terminal velocity (V_T) is calculated by the equation:

$$V_T = \left[\frac{2}{\rho}\left(\frac{W}{A \times C_d}\right)\right]^{0.5} = 29 \times \left(\frac{W}{A}\right)^{0.5}$$

Where: V_T = terminal velocity (in feet/second)
ρ= nominal air density ($2.378 \text{ X } 10^{-3}$ lbs-sec^2/ft^4)
W = weight (in pounds)
A = surface area facing the air stream (in ft^2)
C_d = drag coefficient = 1.28

Drag coefficients can vary over a wide range of velocities and Re for irregular objects (e.g. non-spherical). This report uses a representative flat plate drag coefficient of 1.28 (DAF, 1997).

The approximate weights and geometries of representative flare components for the four flare families as presented in Table 8-9 through Table 8-11 have a surface to weight ratio that could potentially result in impact. The piston is included to represent residual components, such as the comparably sized end cap, which have high surface to weight ratios and would not be expected to fall to the ground with enough force to cause an impact greater than that of a small hailstone. The S&I assembly has a surface-to-weight ratio that could result in an impact comparable to a large hailstone. The weighted nose could result in an injury to an unprotected individual. Although dud flares are extremely rare, the weights of dud flare pellets are included in Table 8-10 and Table 8-13.

Terminal velocity momentums for flare components are presented in Table 8-9 through Table 8-12. The momentum is computed based on maximum and minimum areas depending on the component's orientation. Actual values of momentum when striking the surface would typically be between the maximum and minimum terminal velocities. The momentum values are the product of mass (in slugs) and velocity. A slug is defined as the mass that, when acted on by a 1-pound force, is given an acceleration of 1.0 foot/second^2.

Table 8-9 is the calculated momentum for the end cap and piston from an MJU-7A/B flare, which is the flare used in the representative MOA over an area of 2,000 square miles. Momentum is calculated using the weight of the residual component and several other factors including orientation of the object, aerodynamic forces, and terminal velocity. Depending on the orientation of the falling component, the maximum or minimum surface area would dominate the terminal velocity. In actual falling conditions, the momentum would be expected to be between the maximum and minimum amount.

Table 8-9. Calculated Momentum for Flare End Cap and Piston for MTV MJU-7A/B Flare

Calculation/Measures	MJU-7A/B End Cap		MJU-7A/B Piston	
	Max Surface Area	**Min Surface Area**	**Max Surface Area**	**Min Surface Area**
Dimension in inches	1x2	1x.25	1x2	1x.5
A=surface area in in^2	2	0.25	2	0.5
A=surface area in ft^2	0.01389	0.00174	0.01389	0.00347
Cd=drag coefficient (1997)	1.28	1.28	1.28	1.28
Weight (lbs)	0.0072	0.0072	0.0086	0.0086
r=air density in lb/sec^2/ft^2	0.002378	0.002378	0.002378	0.002378
2/r	841.0429	841.0429	841.0429	841.0429
W/(A*Cd) in lb/ft^2	0.4050	3.2400	0.4838	1.9350
(2/r*W/(A*Cd))	340.6224	2724.9790	406.8545	1627.4180
Terminal Velocity (ft/sec)	18.4560	52.2013	20.1706	40.3413
[V_T=(2/r*W/(A*Cd)) sqrt in ft/sec]				
Momentum = mass*V_T lbf-s	0.004	0.012	0.005	0.011

ft = feet; ft^2 = square feet; in^2 =square inches; lbs = pounds; lbf-s = pound force-second; max = maximum; min = minimum; MJU = Mobile Jettison Unit (flare); MTV = Magnesium/Teflon/Viton; sec = second; sec^2 = square seconds; sqrt = square root; V_T = terminal velocity; W = weight

Table 8-10 demonstrates the weight of falling unburned flare pellets from an M-206 and an MJU-7A/B flare. The weight, even from an M-206 flare, would result in a momentum that could result in serious injury or worse. The likelihood of an individual being struck by a dud flare in the representative airspace used in this report is calculated to be fewer than 1 person in 100,000 years.

Table 8-10. MTV M-206 and MJU-7A/B Dud Calculations

Calculation/Measures	M-206 Dud		MJU-7A/B Dud	
	Max Surface Area	**Min Surface Area**	**Max Surface Area**	**Min Surface Area**
Dimension in inches	1x1x7.5	1x1	1x2x7.5	1x2
A=surface area in in^2	7.5	1	15	2
A=surface area in ft^2	0.05208	0.00694	0.10417	0.01389
Cd=drag coefficient (1997)	1.28	1.28	1.28	1.28
Weight (lbs)	0.275	0.275	0.55	0.55
r=air density in lb/sec^2/ft^2	0.002378	0.002378	0.002378	0.002378
2/r	841.0429	841.0429	841.0429	841.0429
W/(A*Cd) in lb/ft^2	4.1250	30.9375	4.1250	30.9375
(2/r*W/(A*Cd))	3469.3019	26019.7645	3469.3019	26019.7645
Terminal Velocity (ft/sec)	58.9008	161.3064	58.9008	161.3064
[V_T=(2/r*W/(A*C)) sqrt in ft/sec]				
Momentum = mass*V_T lbf-s	0.503	1.379	1.563	2.758

ft = feet; ft2 = square feet; in2 = square inches; lbs = pounds; lbf-s = pound force-second; max = maximum; min = minimum; MJU = Mobile Jettison Unit (flare); MTV = Magnesium/Teflon/Viton; sec = second; sec2 = square seconds; sqrt = square root; V_T = terminal velocity; W = weight

Table 8-11 is a calculation of momentum for residual materials from a representative standard spectral flare. The values are comparable to the MTV flare in Table 8-9.

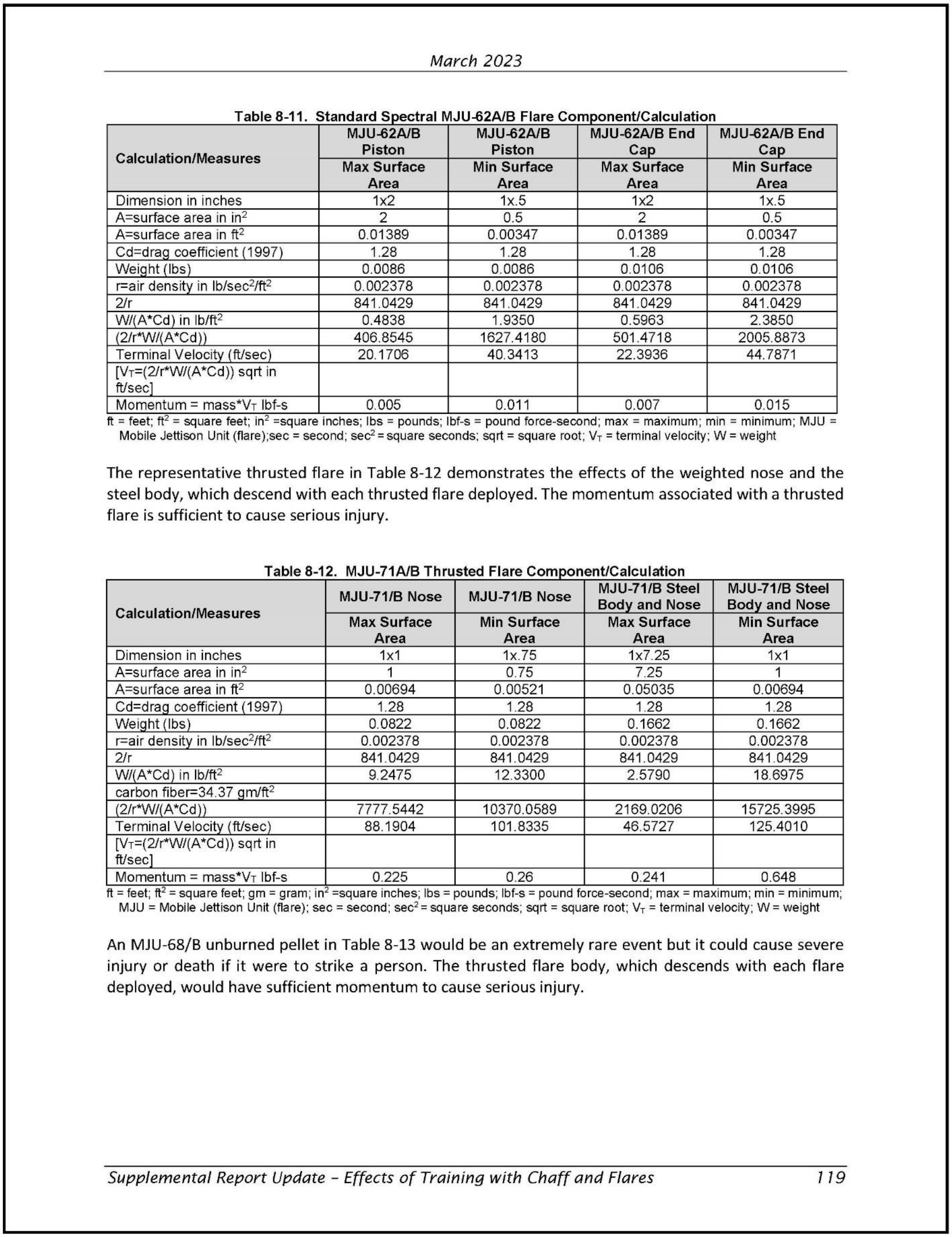


Table 8-11. Standard Spectral MJU-62A/B Flare Component/Calculation

Calculation/Measures	MJU-62A/B Piston	MJU-62A/B Piston	MJU-62A/B End Cap	MJU-62A/B End Cap
	Max Surface Area	Min Surface Area	Max Surface Area	Min Surface Area
Dimension in inches	1x2	1x.5	1x2	1x.5
A=surface area in in^2	2	0.5	2	0.5
A=surface area in ft^2	0.01389	0.00347	0.01389	0.00347
Cd=drag coefficient (1997)	1.28	1.28	1.28	1.28
Weight (lbs)	0.0086	0.0086	0.0106	0.0106
r=air density in lb/sec^2/ft^2	0.002378	0.002378	0.002378	0.002378
2/r	841.0429	841.0429	841.0429	841.0429
W/(A*Cd) in lb/ft^2	0.4838	1.9350	0.5963	2.3850
(2/r*W/(A*Cd))	406.8545	1627.4180	501.4718	2005.8873
Terminal Velocity (ft/sec)	20.1706	40.3413	22.3936	44.7871
[V_T=(2/r*W/(A*Cd)) sqrt in ft/sec]				
Momentum = mass*V_T lbf-s	0.005	0.011	0.007	0.015

ft = feet; ft^2 = square feet; in^2 =square inches; lbs = pounds; lbf-s = pound force-second; max = maximum; min = minimum; MJU = Mobile Jettison Unit (flare);sec = second; sec^2 = square seconds; sqrt = square root; V_T = terminal velocity; W = weight

The representative thrusted flare in Table 8-12 demonstrates the effects of the weighted nose and the steel body, which descend with each thrusted flare deployed. The momentum associated with a thrusted flare is sufficient to cause serious injury.

Table 8-12. MJU-71A/B Thrusted Flare Component/Calculation

Calculation/Measures	MJU-71/B Nose	MJU-71/B Nose	MJU-71/B Steel Body and Nose	MJU-71/B Steel Body and Nose
	Max Surface Area	Min Surface Area	Max Surface Area	Min Surface Area
Dimension in inches	1x1	1x.75	1x7.25	1x1
A=surface area in in^2	1	0.75	7.25	1
A=surface area in ft^2	0.00694	0.00521	0.05035	0.00694
Cd=drag coefficient (1997)	1.28	1.28	1.28	1.28
Weight (lbs)	0.0822	0.0822	0.1662	0.1662
r=air density in lb/sec^2/ft^2	0.002378	0.002378	0.002378	0.002378
2/r	841.0429	841.0429	841.0429	841.0429
W/(A*Cd) in lb/ft^2	9.2475	12.3300	2.5790	18.6975
carbon fiber=34.37 gm/ft^2				
(2/r*W/(A*Cd))	7777.5442	10370.0589	2169.0206	15725.3995
Terminal Velocity (ft/sec)	88.1904	101.8335	46.5727	125.4010
[V_T=(2/r*W/(A*Cd)) sqrt in ft/sec]				
Momentum = mass*V_T lbf-s	0.225	0.26	0.241	0.648

ft = feet; ft^2 = square feet; gm = gram; in^2 =square inches; lbs = pounds; lbf-s = pound force-second; max = maximum; min = minimum; MJU = Mobile Jettison Unit (flare); sec = second; sec^2 = square seconds; sqrt = square root; V_T = terminal velocity; W = weight

An MJU-68/B unburned pellet in Table 8-13 would be an extremely rare event but it could cause severe injury or death if it were to strike a person. The thrusted flare body, which descends with each flare deployed, would have sufficient momentum to cause serious injury.

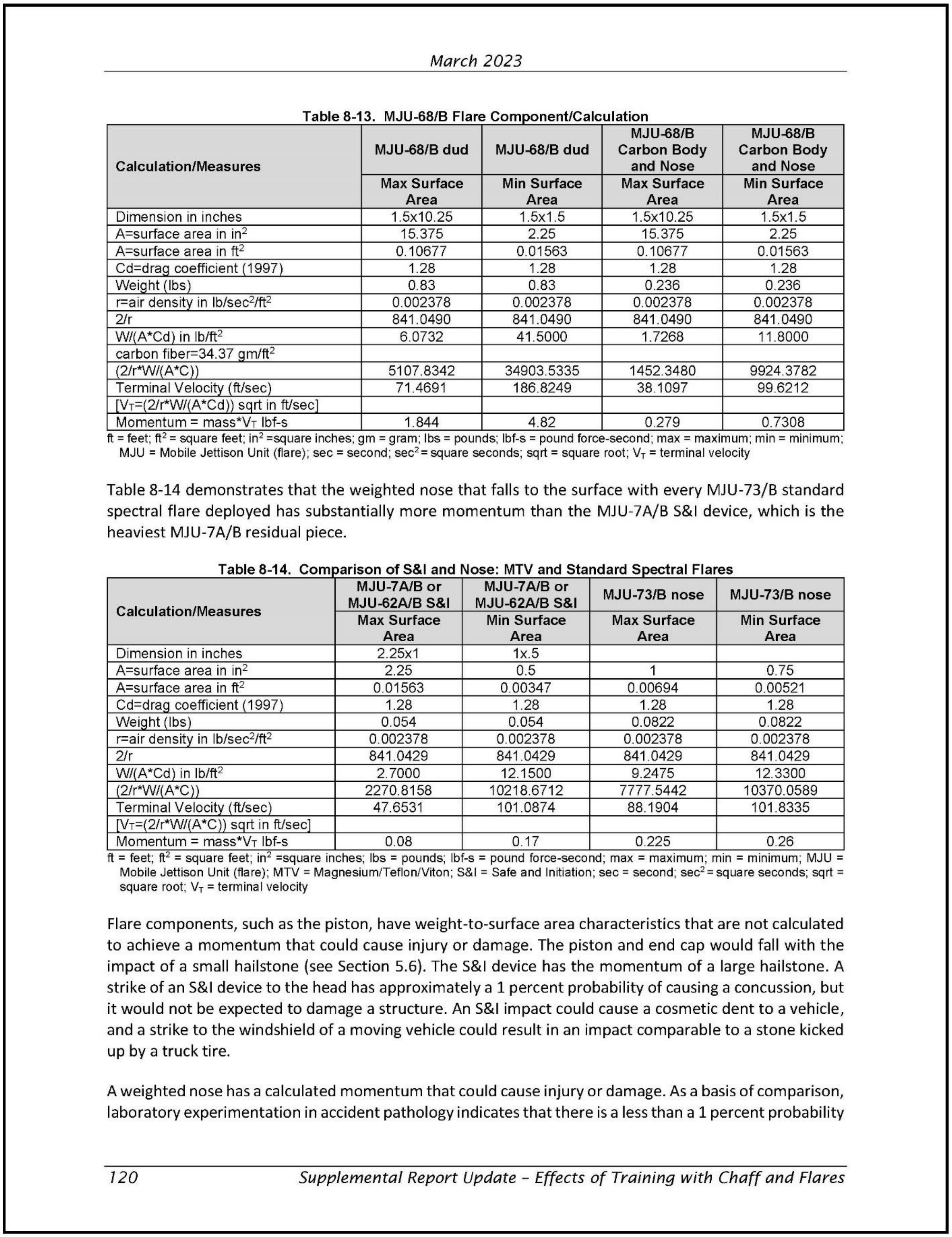


Table 8-13. MJU-68/B Flare Component/Calculation

Calculation/Measures	MJU-68/B dud	MJU-68/B dud	MJU-68/B Carbon Body and Nose	MJU-68/B Carbon Body and Nose
	Max Surface Area	Min Surface Area	Max Surface Area	Min Surface Area
Dimension in inches	1.5x10.25	1.5x1.5	1.5x10.25	1.5x1.5
A=surface area in in^2	15.375	2.25	15.375	2.25
A=surface area in ft^2	0.10677	0.01563	0.10677	0.01563
Cd=drag coefficient (1997)	1.28	1.28	1.28	1.28
Weight (lbs)	0.83	0.83	0.236	0.236
r=air density in lb/sec^2/ft^2	0.002378	0.002378	0.002378	0.002378
2/r	841.0490	841.0490	841.0490	841.0490
W/(A*Cd) in lb/ft^2	6.0732	41.5000	1.7268	11.8000
carbon fiber=34.37 gm/ft^2				
(2/r*W/(A*C))	5107.8342	34903.5335	1452.3480	9924.3782
Terminal Velocity (ft/sec)	71.4691	186.8249	38.1097	99.6212
[V_T=(2/r*W/(A*Cd)) sqrt in ft/sec]				
Momentum = mass*V_T lbf-s	1.844	4.82	0.279	0.7308

ft = feet; ft^2 = square feet; in^2 =square inches; gm = gram; lbs = pounds; lbf-s = pound force-second; max = maximum; min = minimum; MJU = Mobile Jettison Unit (flare); sec = second; sec^2 = square seconds; sqrt = square root; V_T = terminal velocity

Table 8-14 demonstrates that the weighted nose that falls to the surface with every MJU-73/B standard spectral flare deployed has substantially more momentum than the MJU-7A/B S&I device, which is the heaviest MJU-7A/B residual piece.

Table 8-14. Comparison of S&I and Nose: MTV and Standard Spectral Flares

Calculation/Measures	MJU-7A/B or MJU-62A/B S&I	MJU-7A/B or MJU-62A/B S&I	MJU-73/B nose	MJU-73/B nose
	Max Surface Area	Min Surface Area	Max Surface Area	Min Surface Area
Dimension in inches	2.25x1	1x.5		
A=surface area in in^2	2.25	0.5	1	0.75
A=surface area in ft^2	0.01563	0.00347	0.00694	0.00521
Cd=drag coefficient (1997)	1.28	1.28	1.28	1.28
Weight (lbs)	0.054	0.054	0.0822	0.0822
r=air density in lb/sec^2/ft^2	0.002378	0.002378	0.002378	0.002378
2/r	841.0429	841.0429	841.0429	841.0429
W/(A*Cd) in lb/ft^2	2.7000	12.1500	9.2475	12.3300
(2/r*W/(A*C))	2270.8158	10218.6712	7777.5442	10370.0589
Terminal Velocity (ft/sec)	47.6531	101.0874	88.1904	101.8335
[V_T=(2/r*W/(A*C)) sqrt in ft/sec]				
Momentum = mass*V_T lbf-s	0.08	0.17	0.225	0.26

ft = feet; ft^2 = square feet; in^2 =square inches; lbs = pounds; lbf-s = pound force-second; max = maximum; min = minimum; MJU = Mobile Jettison Unit (flare); MTV = Magnesium/Teflon/Viton; S&I = Safe and Initiation; sec = second; sec^2 = square seconds; sqrt = square root; V_T = terminal velocity

Flare components, such as the piston, have weight-to-surface area characteristics that are not calculated to achieve a momentum that could cause injury or damage. The piston and end cap would fall with the impact of a small hailstone (see Section 5.6). The S&I device has the momentum of a large hailstone. A strike of an S&I device to the head has approximately a 1 percent probability of causing a concussion, but it would not be expected to damage a structure. An S&I impact could cause a cosmetic dent to a vehicle, and a strike to the windshield of a moving vehicle could result in an impact comparable to a stone kicked up by a truck tire.

A weighted nose has a calculated momentum that could cause injury or damage. As a basis of comparison, laboratory experimentation in accident pathology indicates that there is a less than a 1 percent probability of a brain concussion from an impulse of less than 0.10 pound-seconds to the head. There is a 90 percent probability that brain concussions would result from an impulse of 0.70 pound-seconds to the head (DAF, 1997). A strike from a weighted nose from an MJU-71B or an MJU-73B would have an approximately 40 to 60 percent probability of causing a concussion. Thrusted flares are not used for training and are tested over ranges approved for deploying munitions.

8.5.2 Estimated Areas of People, Structures, Vehicles, and Cattle

People who are at risk of being struck by a flare residual piece would be outdoors under a MOA (people in structures or vehicles are assumed protected). The dimensions of an average person are assumed to be approximately 5 feet 6 inches high by 2 feet wide by 1 foot deep (men, 5 feet 10 inches; women, 5 feet 4 inches; children, less than 5 feet 4 inches). The residual flare device would be expected to strike ground objects at an angle of 80 degrees or greater to the ground, assuming 80 degrees to the ground allows for possible wind or other drift effects. With the flare component falling at 80 degrees to the ground, a person's body (5.5 feet by 2 feet by 1 foot) projects an area of 3.9 square feet normal to the path of the falling component. For this assessment, it is assumed that a person would be outdoors and unprotected 10 percent of the time. This assumption is based on Department of Energy and USEPA national studies (Klepeis et al., 2001; TVA, 2003).

Structure and vehicle densities are estimated from the 2020 Census Bureau data. DAF training airspace is often over low density rural western areas or higher density eastern areas. This study uses a representative average family size of 2.60 persons (Census, 2022). The assumed 10 persons per square mile equates to approximately 3.8 families per square mile. It is assumed that each family would have, or otherwise use, the equivalent of two structures associated with their property and own two vehicles, which would be outside the structures. Thus, it was assumed that there would be the equivalent of eight structures and eight vehicles per square mile under the training airspace.

It is assumed that range cattle density is 10 cattle per square mile. In the arid west, the annual carrying capacity is more typically four to five range cattle per square mile. A cow-calf combination of range cattle is projected to have a surface area of 3 feet by 6 feet (18 square feet) and be unprotected 100 percent of the time (Bullock, 2007).

8.5.3 Potential Person Strikes

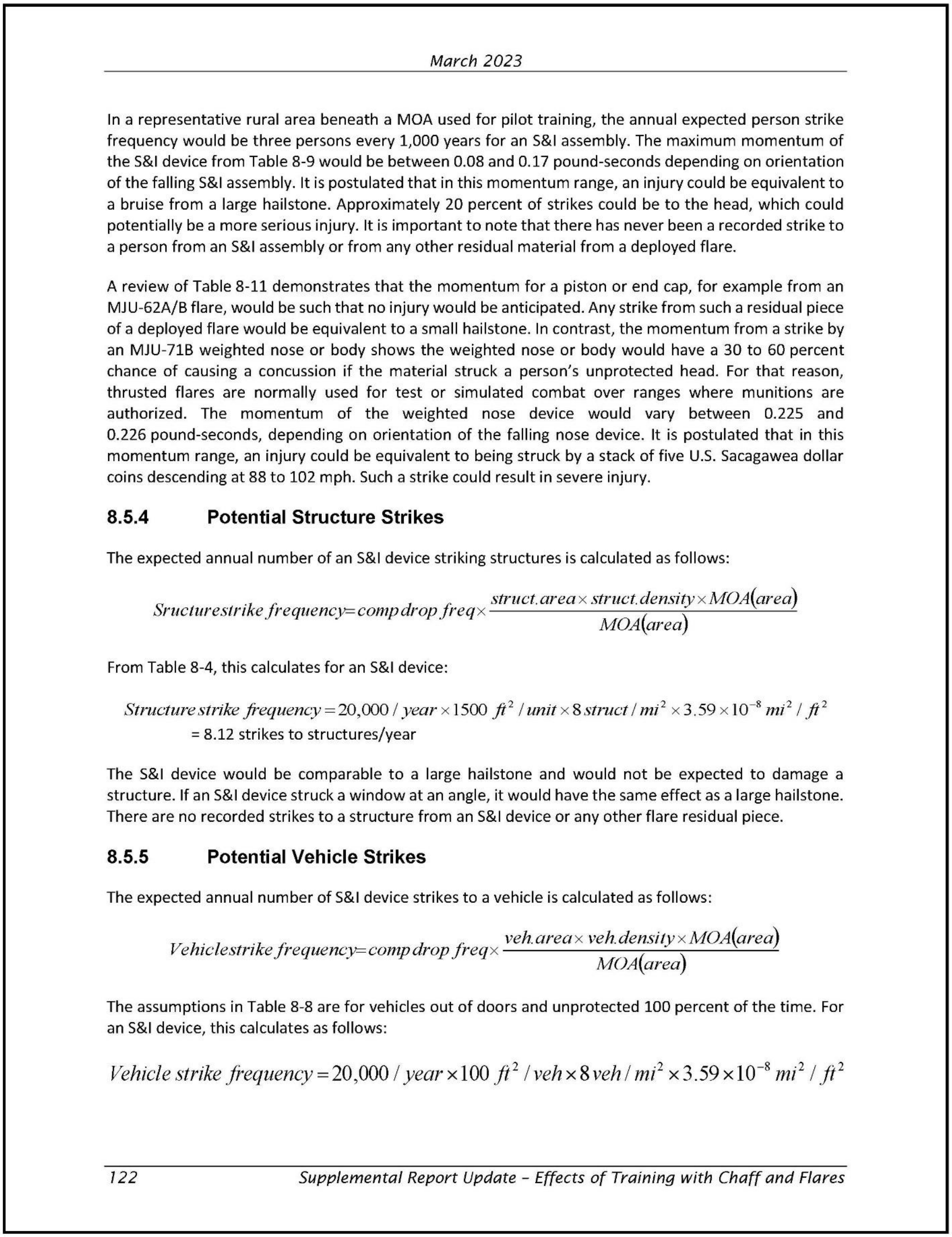
The frequencies of strikes can be computed based on the data and assumptions explained above. It is assumed that flight maneuvers to deploy flares are randomly distributed throughout the training airspace. Minor injury to a person could occur if an S&I assembly struck an unprotected person. The frequency of striking a person is:

$$Injury\ frequency = comp\,drop\ freq \times \frac{body\,area \times pop.density \times Fract\,unprot \times MOA(area\,in\,sq\,mi)}{MOA(area\,in\,sq\,ft)}$$

For the assumptions in Table 8-9, this calculates for an S&I assembly as:

$$Strike\ frequency = 20{,}000 / year \times 3.9\ ft^2 / pers \times 10\ pers / mi^2 \times 0.1 \times 3.59 \times 10^{-8}\ mi^2 / ft^2$$

= 0.003 strikes/year for an S&I (numbers are rounded).



In a representative rural area beneath a MOA used for pilot training, the annual expected person strike frequency would be three persons every 1,000 years for an S&I assembly. The maximum momentum of the S&I device from Table 8-9 would be between 0.08 and 0.17 pound-seconds depending on orientation of the falling S&I assembly. It is postulated that in this momentum range, an injury could be equivalent to a bruise from a large hailstone. Approximately 20 percent of strikes could be to the head, which could potentially be a more serious injury. It is important to note that there has never been a recorded strike to a person from an S&I assembly or from any other residual material from a deployed flare.

A review of Table 8-11 demonstrates that the momentum for a piston or end cap, for example from an MJU-62A/B flare, would be such that no injury would be anticipated. Any strike from such a residual piece of a deployed flare would be equivalent to a small hailstone. In contrast, the momentum from a strike by an MJU-71B weighted nose or body shows the weighted nose or body would have a 30 to 60 percent chance of causing a concussion if the material struck a person's unprotected head. For that reason, thrusted flares are normally used for test or simulated combat over ranges where munitions are authorized. The momentum of the weighted nose device would vary between 0.225 and 0.226 pound-seconds, depending on orientation of the falling nose device. It is postulated that in this momentum range, an injury could be equivalent to being struck by a stack of five U.S. Sacagawea dollar coins descending at 88 to 102 mph. Such a strike could result in severe injury.

8.5.4 Potential Structure Strikes

The expected annual number of an S&I device striking structures is calculated as follows:

$$Sructurestrike\ frequency = comp\,drop\ freq \times \frac{struct.area \times struct.density \times MOA(area)}{MOA(area)}$$

From Table 8-4, this calculates for an S&I device:

$$Structure\ strike\ frequency = 20{,}000 / year \times 1500\ ft^2 / unit \times 8\, struct / mi^2 \times 3.59 \times 10^{-8}\ mi^2 / ft^2$$

= 8.12 strikes to structures/year

The S&I device would be comparable to a large hailstone and would not be expected to damage a structure. If an S&I device struck a window at an angle, it would have the same effect as a large hailstone. There are no recorded strikes to a structure from an S&I device or any other flare residual piece.

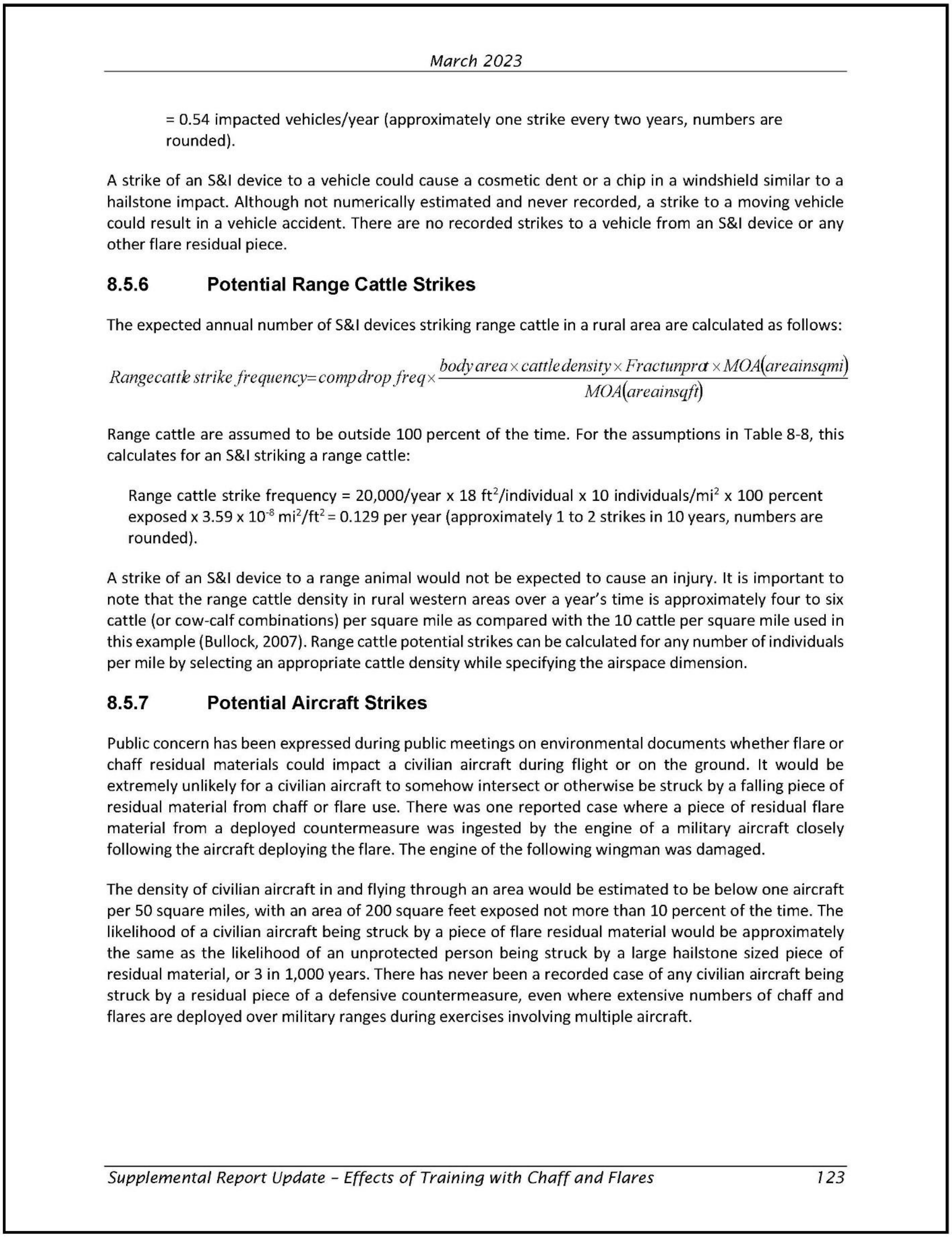
8.5.5 Potential Vehicle Strikes

The expected annual number of S&I device strikes to a vehicle is calculated as follows:

$$Vehiclestrike\ frequency = comp\,drop\ freq \times \frac{veh.area \times veh.density \times MOA(area)}{MOA(area)}$$

The assumptions in Table 8-8 are for vehicles out of doors and unprotected 100 percent of the time. For an S&I device, this calculates as follows:

$$Vehicle\ strike\ frequency = 20{,}000 / year \times 100\ ft^2 / veh \times 8\, veh / mi^2 \times 3.59 \times 10^{-8}\ mi^2 / ft^2$$



= 0.54 impacted vehicles/year (approximately one strike every two years, numbers are rounded).

A strike of an S&I device to a vehicle could cause a cosmetic dent or a chip in a windshield similar to a hailstone impact. Although not numerically estimated and never recorded, a strike to a moving vehicle could result in a vehicle accident. There are no recorded strikes to a vehicle from an S&I device or any other flare residual piece.

8.5.6 Potential Range Cattle Strikes

The expected annual number of S&I devices striking range cattle in a rural area are calculated as follows:

$$Rangecattle\ strike\ frequency = compdrop\ freq \times \frac{body\ area \times cattle\ density \times Fractunprot \times MOA(areainsqmi)}{MOA(areainsqft)}$$

Range cattle are assumed to be outside 100 percent of the time. For the assumptions in Table 8-8, this calculates for an S&I striking a range cattle:

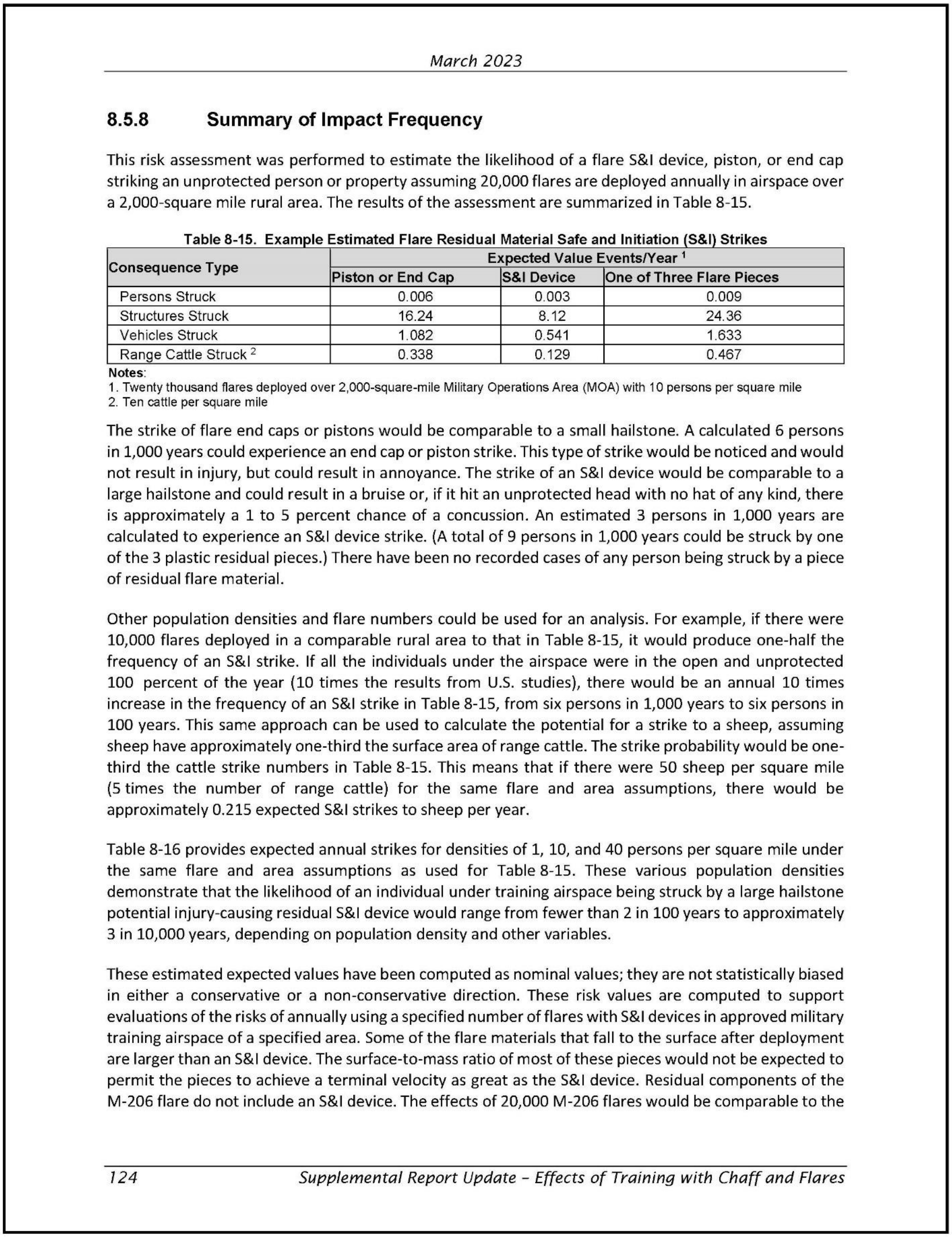
> Range cattle strike frequency = 20,000/year x 18 ft^2/individual x 10 individuals/mi^2 x 100 percent exposed x 3.59 x 10^{-8} mi^2/ft^2 = 0.129 per year (approximately 1 to 2 strikes in 10 years, numbers are rounded).

A strike of an S&I device to a range animal would not be expected to cause an injury. It is important to note that the range cattle density in rural western areas over a year's time is approximately four to six cattle (or cow-calf combinations) per square mile as compared with the 10 cattle per square mile used in this example (Bullock, 2007). Range cattle potential strikes can be calculated for any number of individuals per mile by selecting an appropriate cattle density while specifying the airspace dimension.

8.5.7 Potential Aircraft Strikes

Public concern has been expressed during public meetings on environmental documents whether flare or chaff residual materials could impact a civilian aircraft during flight or on the ground. It would be extremely unlikely for a civilian aircraft to somehow intersect or otherwise be struck by a falling piece of residual material from chaff or flare use. There was one reported case where a piece of residual flare material from a deployed countermeasure was ingested by the engine of a military aircraft closely following the aircraft deploying the flare. The engine of the following wingman was damaged.

The density of civilian aircraft in and flying through an area would be estimated to be below one aircraft per 50 square miles, with an area of 200 square feet exposed not more than 10 percent of the time. The likelihood of a civilian aircraft being struck by a piece of flare residual material would be approximately the same as the likelihood of an unprotected person being struck by a large hailstone sized piece of residual material, or 3 in 1,000 years. There has never been a recorded case of any civilian aircraft being struck by a residual piece of a defensive countermeasure, even where extensive numbers of chaff and flares are deployed over military ranges during exercises involving multiple aircraft.



8.5.8 Summary of Impact Frequency

This risk assessment was performed to estimate the likelihood of a flare S&I device, piston, or end cap striking an unprotected person or property assuming 20,000 flares are deployed annually in airspace over a 2,000-square mile rural area. The results of the assessment are summarized in Table 8-15.

Table 8-15. Example Estimated Flare Residual Material Safe and Initiation (S&I) Strikes

Consequence Type	Expected Value Events/Year [1]		
	Piston or End Cap	S&I Device	One of Three Flare Pieces
Persons Struck	0.006	0.003	0.009
Structures Struck	16.24	8.12	24.36
Vehicles Struck	1.082	0.541	1.633
Range Cattle Struck [2]	0.338	0.129	0.467

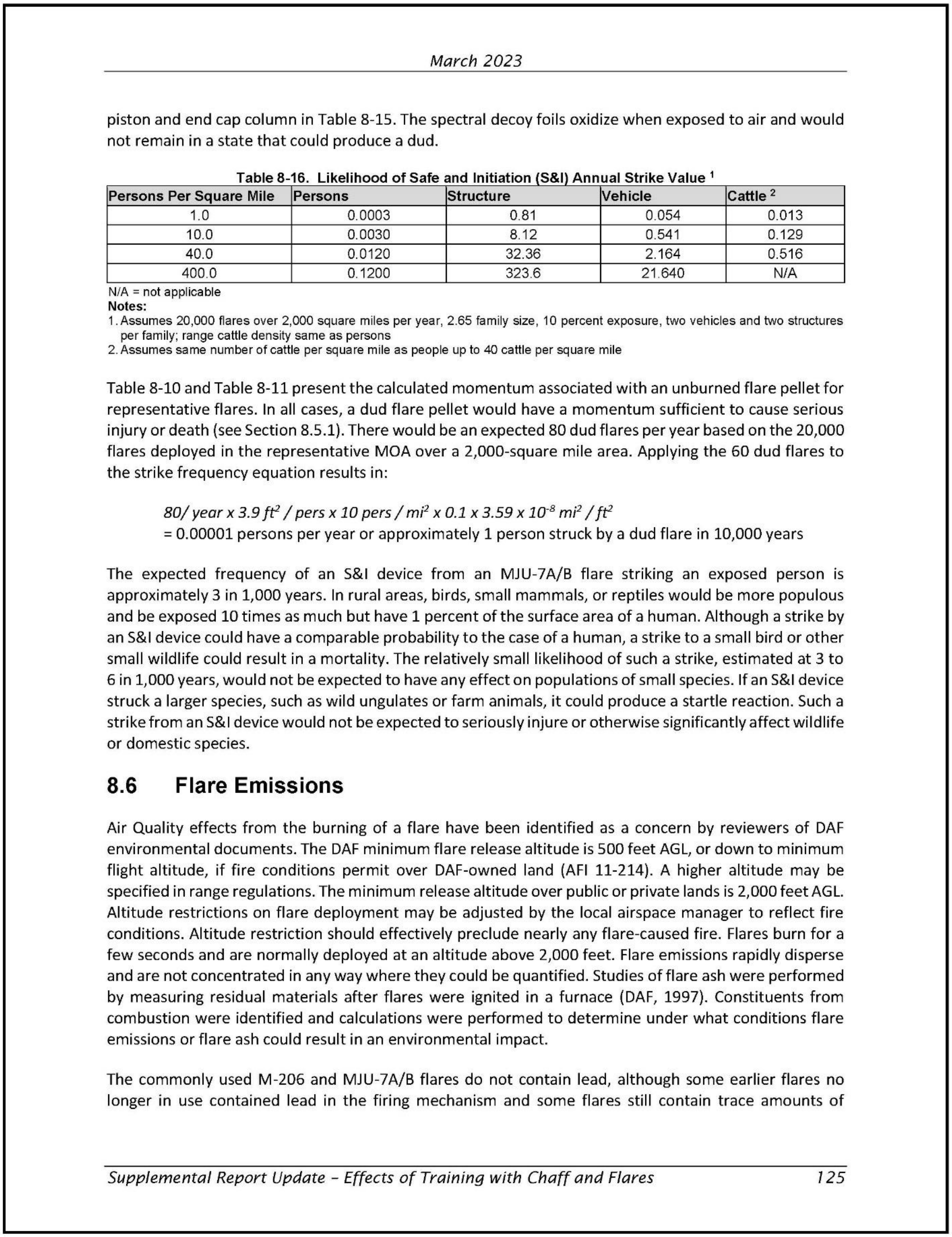
Notes:
1. Twenty thousand flares deployed over 2,000-square-mile Military Operations Area (MOA) with 10 persons per square mile
2. Ten cattle per square mile

The strike of flare end caps or pistons would be comparable to a small hailstone. A calculated 6 persons in 1,000 years could experience an end cap or piston strike. This type of strike would be noticed and would not result in injury, but could result in annoyance. The strike of an S&I device would be comparable to a large hailstone and could result in a bruise or, if it hit an unprotected head with no hat of any kind, there is approximately a 1 to 5 percent chance of a concussion. An estimated 3 persons in 1,000 years are calculated to experience an S&I device strike. (A total of 9 persons in 1,000 years could be struck by one of the 3 plastic residual pieces.) There have been no recorded cases of any person being struck by a piece of residual flare material.

Other population densities and flare numbers could be used for an analysis. For example, if there were 10,000 flares deployed in a comparable rural area to that in Table 8-15, it would produce one-half the frequency of an S&I strike. If all the individuals under the airspace were in the open and unprotected 100 percent of the year (10 times the results from U.S. studies), there would be an annual 10 times increase in the frequency of an S&I strike in Table 8-15, from six persons in 1,000 years to six persons in 100 years. This same approach can be used to calculate the potential for a strike to a sheep, assuming sheep have approximately one-third the surface area of range cattle. The strike probability would be one-third the cattle strike numbers in Table 8-15. This means that if there were 50 sheep per square mile (5 times the number of range cattle) for the same flare and area assumptions, there would be approximately 0.215 expected S&I strikes to sheep per year.

Table 8-16 provides expected annual strikes for densities of 1, 10, and 40 persons per square mile under the same flare and area assumptions as used for Table 8-15. These various population densities demonstrate that the likelihood of an individual under training airspace being struck by a large hailstone potential injury-causing residual S&I device would range from fewer than 2 in 100 years to approximately 3 in 10,000 years, depending on population density and other variables.

These estimated expected values have been computed as nominal values; they are not statistically biased in either a conservative or a non-conservative direction. These risk values are computed to support evaluations of the risks of annually using a specified number of flares with S&I devices in approved military training airspace of a specified area. Some of the flare materials that fall to the surface after deployment are larger than an S&I device. The surface-to-mass ratio of most of these pieces would not be expected to permit the pieces to achieve a terminal velocity as great as the S&I device. Residual components of the M-206 flare do not include an S&I device. The effects of 20,000 M-206 flares would be comparable to the



piston and end cap column in Table 8-15. The spectral decoy foils oxidize when exposed to air and would not remain in a state that could produce a dud.

Table 8-16. Likelihood of Safe and Initiation (S&I) Annual Strike Value [1]

Persons Per Square Mile	Persons	Structure	Vehicle	Cattle [2]
1.0	0.0003	0.81	0.054	0.013
10.0	0.0030	8.12	0.541	0.129
40.0	0.0120	32.36	2.164	0.516
400.0	0.1200	323.6	21.640	N/A

N/A = not applicable

Notes:

1. Assumes 20,000 flares over 2,000 square miles per year, 2.65 family size, 10 percent exposure, two vehicles and two structures per family; range cattle density same as persons
2. Assumes same number of cattle per square mile as people up to 40 cattle per square mile

Table 8-10 and Table 8-11 present the calculated momentum associated with an unburned flare pellet for representative flares. In all cases, a dud flare pellet would have a momentum sufficient to cause serious injury or death (see Section 8.5.1). There would be an expected 80 dud flares per year based on the 20,000 flares deployed in the representative MOA over a 2,000-square mile area. Applying the 60 dud flares to the strike frequency equation results in:

$$80/\ year \times 3.9\ ft^2 / pers \times 10\ pers / mi^2 \times 0.1 \times 3.59 \times 10^{-8}\ mi^2 / ft^2$$

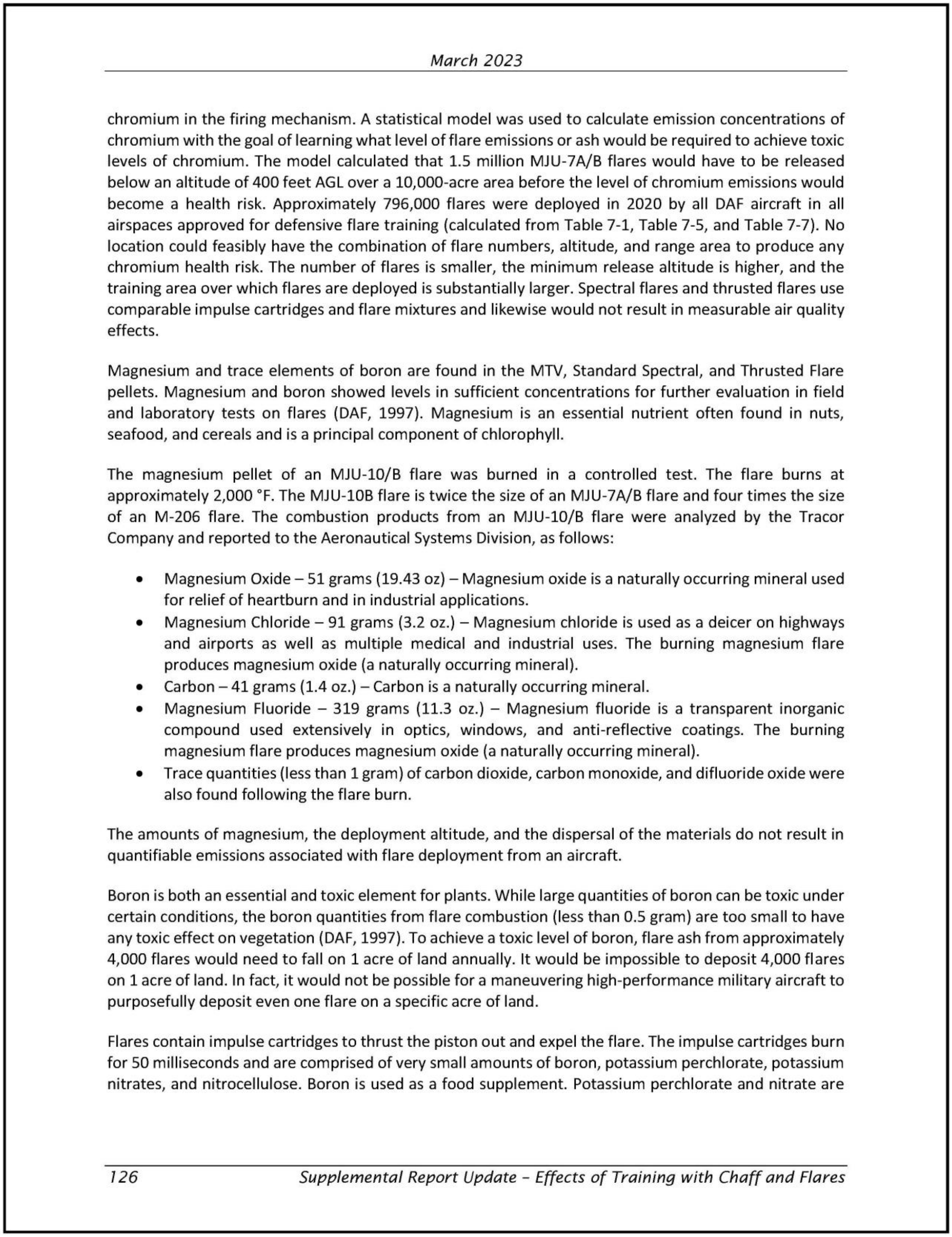
= 0.00001 persons per year or approximately 1 person struck by a dud flare in 10,000 years

The expected frequency of an S&I device from an MJU-7A/B flare striking an exposed person is approximately 3 in 1,000 years. In rural areas, birds, small mammals, or reptiles would be more populous and be exposed 10 times as much but have 1 percent of the surface area of a human. Although a strike by an S&I device could have a comparable probability to the case of a human, a strike to a small bird or other small wildlife could result in a mortality. The relatively small likelihood of such a strike, estimated at 3 to 6 in 1,000 years, would not be expected to have any effect on populations of small species. If an S&I device struck a larger species, such as wild ungulates or farm animals, it could produce a startle reaction. Such a strike from an S&I device would not be expected to seriously injure or otherwise significantly affect wildlife or domestic species.

8.6 Flare Emissions

Air Quality effects from the burning of a flare have been identified as a concern by reviewers of DAF environmental documents. The DAF minimum flare release altitude is 500 feet AGL, or down to minimum flight altitude, if fire conditions permit over DAF-owned land (AFI 11-214). A higher altitude may be specified in range regulations. The minimum release altitude over public or private lands is 2,000 feet AGL. Altitude restrictions on flare deployment may be adjusted by the local airspace manager to reflect fire conditions. Altitude restriction should effectively preclude nearly any flare-caused fire. Flares burn for a few seconds and are normally deployed at an altitude above 2,000 feet. Flare emissions rapidly disperse and are not concentrated in any way where they could be quantified. Studies of flare ash were performed by measuring residual materials after flares were ignited in a furnace (DAF, 1997). Constituents from combustion were identified and calculations were performed to determine under what conditions flare emissions or flare ash could result in an environmental impact.

The commonly used M-206 and MJU-7A/B flares do not contain lead, although some earlier flares no longer in use contained lead in the firing mechanism and some flares still contain trace amounts of



chromium in the firing mechanism. A statistical model was used to calculate emission concentrations of chromium with the goal of learning what level of flare emissions or ash would be required to achieve toxic levels of chromium. The model calculated that 1.5 million MJU-7A/B flares would have to be released below an altitude of 400 feet AGL over a 10,000-acre area before the level of chromium emissions would become a health risk. Approximately 796,000 flares were deployed in 2020 by all DAF aircraft in all airspaces approved for defensive flare training (calculated from Table 7-1, Table 7-5, and Table 7-7). No location could feasibly have the combination of flare numbers, altitude, and range area to produce any chromium health risk. The number of flares is smaller, the minimum release altitude is higher, and the training area over which flares are deployed is substantially larger. Spectral flares and thrusted flares use comparable impulse cartridges and flare mixtures and likewise would not result in measurable air quality effects.

Magnesium and trace elements of boron are found in the MTV, Standard Spectral, and Thrusted Flare pellets. Magnesium and boron showed levels in sufficient concentrations for further evaluation in field and laboratory tests on flares (DAF, 1997). Magnesium is an essential nutrient often found in nuts, seafood, and cereals and is a principal component of chlorophyll.

The magnesium pellet of an MJU-10/B flare was burned in a controlled test. The flare burns at approximately 2,000 °F. The MJU-10B flare is twice the size of an MJU-7A/B flare and four times the size of an M-206 flare. The combustion products from an MJU-10/B flare were analyzed by the Tracor Company and reported to the Aeronautical Systems Division, as follows:

- Magnesium Oxide – 51 grams (19.43 oz) – Magnesium oxide is a naturally occurring mineral used for relief of heartburn and in industrial applications.
- Magnesium Chloride – 91 grams (3.2 oz.) – Magnesium chloride is used as a deicer on highways and airports as well as multiple medical and industrial uses. The burning magnesium flare produces magnesium oxide (a naturally occurring mineral).
- Carbon – 41 grams (1.4 oz.) – Carbon is a naturally occurring mineral.
- Magnesium Fluoride – 319 grams (11.3 oz.) – Magnesium fluoride is a transparent inorganic compound used extensively in optics, windows, and anti-reflective coatings. The burning magnesium flare produces magnesium oxide (a naturally occurring mineral).
- Trace quantities (less than 1 gram) of carbon dioxide, carbon monoxide, and difluoride oxide were also found following the flare burn.

The amounts of magnesium, the deployment altitude, and the dispersal of the materials do not result in quantifiable emissions associated with flare deployment from an aircraft.

Boron is both an essential and toxic element for plants. While large quantities of boron can be toxic under certain conditions, the boron quantities from flare combustion (less than 0.5 gram) are too small to have any toxic effect on vegetation (DAF, 1997). To achieve a toxic level of boron, flare ash from approximately 4,000 flares would need to fall on 1 acre of land annually. It would be impossible to deposit 4,000 flares on 1 acre of land. In fact, it would not be possible for a maneuvering high-performance military aircraft to purposefully deposit even one flare on a specific acre of land.

Flares contain impulse cartridges to thrust the piston out and expel the flare. The impulse cartridges burn for 50 milliseconds and are comprised of very small amounts of boron, potassium perchlorate, potassium nitrates, and nitrocellulose. Boron is used as a food supplement. Potassium perchlorate and nitrate are inorganic salts, and nitrocellulose is an ingredient in modern gunpowder. The impulse cartridges would not produce measurable amounts of air pollutants (DAF, 2019).

The pyrophoric foils from spectral decoys oxidize or combust upon contact with air. There are small quantities of chemical byproducts as a result of the emission, which would be released at an altitude that would permit dissipation prior to reaching the surface. The wide distribution of the foils and the very slight emissions with each foil would not be expected to result in any measurable emissions form the foils within a few feet of the deployment point.

In summary, most flare ignition pellets are comprised of magnesium, Teflon resin (similar to that used in cooking pans), and Viton (a synthetic rubber used as a seal in scuba tanks). The burning magnesium flare produces MgO (a naturally occurring mineral). The burning flare components do not emit measurable toxic constituents. No surface concentration of flare ash would be detectable on the ground under areas where flares were deployed. Flare emissions are not now, nor is it feasible that they could become, a health hazard (DAF, 1997). Flare ash and flare emissions are not of sufficient quality or concentration to result in measurable air quality or physical effects to the environment.

8.7 Biological Resources

The public and agencies regularly express the concern that a wildfire associated with a still-burning flare striking combustible vegetation could have substantial biological effects. A wildland fire would result in a loss of canopy and/or understory vegetation, depending on the severity of the fire, land condition at the time, and if and how soon fire control can respond. Recovery of the vegetation would depend on the plant species burned, season, and severity. Vegetation types such as grasslands naturally have a frequent fire regime, and therefore are composed of species that can recover quickly from fires. Woodlands and shrubland communities recover over longer periods depending on severity of the fire and climatic conditions (especially precipitation and temperature regimes) available following a fire. Fires also create a loss of plant cover and could increase erosion and sedimentation downslope in some areas. Bare ground resulting from fires can allow the spread of invasive non-native plant species such as annual grasses (e.g., cheatgrass) depending on the nature of the vegetation burned and the presence of invasive species in surrounding areas. Post-fire conditions of erosion, sedimentation, or invasion of non-native species are generally unfavorable for wildlife and reduce productively of habitats to support species.

Surveys conducted as part of the 1997 DAF countermeasures study found no residual chaff or flare pieces that had been collected or used by birds or animals (DAF, 1997). There is no case recorded where a domestic or wild duck or other bird or animal consumed a residual plastic piece from a deployed flare. There is no reason to believe that a duck or other bird or animal would consume a plastic piece from a deployed flare or be impacted by such a piece of inert plastic material. The plastic piece would be treated as a relatively large stone and, effectively, ignored.

Toxicological studies on flare residual materials indicate that no chemical effects to biological resources would be expected. The amount of magnesium dispersed from flares (as the combustion product magnesium oxide) is too small to result in levels that would be associated with acute exposure to any species (DAF, 1997). The concentration of flare ash residue at any location would be undetectable under normal circumstances due to dispersal of the minimal amount of residue produced by a burning flare deployed in the airspace. Due to the low concentrations of flare residual materials and the extremely low probability of such materials coming in contact with wildlife, MTV, spectral, and thrusted flare releases are expected to have minimal and less than significant effects on wildlife.

At night, a flare would create a brief (nominally 5-second) bright light in the air at deployment altitudes above 2,000 feet AGL over public and private lands. This light would not be expected to interfere with nocturnal species. It would not be bright enough, nor last long enough, to light a portion of the ground. Depending on the flare altitude and duration, the light could result in a momentary freezing behavior on the part of an individual, which would not be expected to occur frequently nor have any long-term effects on either an individual or a population.

Pyrophoric iron foils are inert iron that, in a simple 3-month test, retained their shape in an arid environment. The small change in the foils during the 3 months suggests they would persist in an arid environment a year or longer. A potential exists for accumulation of iron foils on the surface by wind, which could affect surface water flow in an arid environment. Any effect would be expected to be minor and be comparable to the concentration of surface water flow adjacent to any impermeable surface.

Iron foils deployed over a grassland, or that were transported by wind into a grassland, introduced an iron residual material that, during a 3-month test, continued to be enmeshed in the grassland vegetation. In a grass environment subject to watering twice weekly, the foils did not descend to the ground surface. When acted upon by surface winds of 10 mph or greater, approximately 50 percent of the foils in the grassland could be blown a distance of up to 5 feet before again becoming enmeshed with grasses. At the conclusion of the 3-month test, the grassland foils were found to become more fragile and rusted around the edges, with some foils breaking down into smaller iron pieces. The grassland foils would be expected to break into iron particles within a year. The oxidization process of foils would be accelerated in grassy watered climates and slowed in arid climates.

It is not known how the metal foils or smaller foil fragments would be viewed by terrestrial or aquatic species. Most terrestrial species would be expected to ignore the full-sized foils because they would not have use as nesting materials or food. Iron particles that result from foil breakdown could be perceived differently from full-sized foils. During the 3-month weathering test, foils in grasses or on the surface, even when they began to fragment, were ignored by common birds such as crows, magpies, towhees, doves, sparrows, or woodpeckers. There was no interest displayed by skunks, ground squirrels, or possums to the foils. A racoon chewed one foil and spat out the foil particles. Iron foils or particles suspended in grasses could be consumed by indiscriminate grazing animals. Any ingestion of metal pieces would not be beneficial to the individual.

Weathering tests included dropping foils on the surface of fresh water from a height of 6 inches. The water was subject to minor wind (1 mph) and water movement. Foils that entered the water on edge immediately descended below the surface and slowly sank. Foils that landed on the water in a flatter trajectory either remained on the surface for 10 to 30 seconds or remained on the surface for a period of 10 minutes or until they were acted upon by agitation of the water surface. In this simple experiment, a calculated 33 percent of the foils sank immediately, 20 percent sank in a period of 10 to 30 seconds, 27 percent remained on the surface until the water was agitated, and 20 percent remained on the surface until the water was substantially agitated. Comparable tests were not performed in a brackish or a marine environment.

Aquatic species could initially experiment with foils as a possible food source, and indiscriminate ingesting of any metal object would be expected to be detrimental to the individual. Species that consume large quantities of krill-like animals could ingest foils deployed in warning areas as part of their consumption pattern. Although the foils would be distributed widely, ingesting metal objects would not be expected to benefit any species consuming them.

Foils deposited as a result of intermittent spectral decoy testing could be performed during weather conditions or at altitudes that reduce the potential for foils to blow into and be suspended in grasslands. A limited number of decoys used in testing would not be expected to be of sufficient quantity to significantly affect biological resources, including grazing animals. Extensive training with spectral decoys over grasslands, or where the foils could drift into grasslands, would result in the deposition of durable iron foils in the environment, which could affect species inhabiting the grasslands as well as grazing animals using the grasslands.

8.8 Cultural and Native American Resources

Flare residual materials can fall on any lands or objects under training airspace approved for flare use in pilot training. The EOD records document 19 incidents during 14 years of records where EOD personnel were notified of unburned flares on Tribal lands under DAF training airspace. Residual materials, such as end caps, pistons, or wrapping, on Tribal lands would not have been seen as a danger and EOD did not receive requests to handle them. For the representative airspace considered in this report, there would be an estimated average of one residual flare piece per 16 acres per year. As noted in Section 8.10, someone staring into the night sky, such as a Tribal member participating in a vision quest, a camper in an isolated location, or a rural resident, could observe what appeared to be blinking lights when flares are deployed during a training mission after dark.

Cultural resources on the surface would not be damaged by plastic pieces falling with the force of a small or large hailstone. The existence of such plastic or nylon pieces of residual materials could be seen as an unnatural element at a cultural or historic site. The distribution of cultural sites and the wide distribution of residual materials would suggest that the likelihood of a residual piece of a flare would not be a common occurrence at a cultural site. If spectral decoys were deployed in airspace overlying cultural sites or Tribal lands, or drifted into these sites or lands, they could have a noticeable presence if a quantity sufficient to be noticed fell on the site and were observed before the relatively durable iron foils disintegrated or were obscured by natural processes. See Section 7.6.4.8 for the potential per acre concentration of foils. The foils would be an annoyance but would not be expected to affect the quality of the resource.

8.9 Water and Soil Resources

Effects of residual plastic or nylon flare materials would be comparable to the effects described in Sections 5.4.2, 5.4.3, and 5.4.4 for chaff residual materials. If a dud flare or materials from an unburned flare reach the ground, the components that have any potential to affect soil and water chemistry are minute quantities of chromium, magnesium, aluminum, boron, and barium. The number of dud flares on the ground is few and if a dud flare fell in a water body, it would deteriorate over time.

An estimated 4 in 1,000 deployed flares would be expected to fall to the surface. This number would be the same for any deployed flares over land or water surfaces. A total of 7 percent of the United States is surface water. A substantial portion of DAF training airspace is over the more arid areas of the country. If a flare were to fall in a surface water body, there would be minimal to no measurable effect of the metallic magnesium from the flare on water quality. Magnesium is already a significant natural component of earth and the amount from a flare would be comparably insignificant (DAF, 1997).

The chemicals released during deterioration of a dud flare would not be expected to be of sufficient quantity to cause a noticeable reduction in the water quality or impact marine resources (DAF, 1997).

Only in extremely large quantities can magnesium affect water properties. Given the number, dispersal, and reliability of flares, accumulations of multiple unburned flares in an enclosed water body is effectively not possible. Magnesium leachate from a dud flare would not be sufficient to affect water quality. The environmental effects of residual materials are further explained in Section 8.4.

Water and soil resources include wetlands and marine environments. Spectral decoy foils would generally be expected to be covered by debris in a freshwater or marine environment and disintegrate into rust particles. If a large number of foils is deployed over a given area, it could result in foils or foil particles aggregating in a wetland or soils, due to the relative durability of the iron foils. Section 7.6.4.8 presents the calculations of potential concentration and distribution of deployed foils. Foil rusting or breakdown would occur over an estimated number of months, possibly up to a year. In a simple informal experiment, foils in a freshwater container were found to rust, break down to particles smaller than one-half of a foil, and turn the water brown in a 3-month period. It is calculated that it would take four completely dissolved 0.25-gram foils per cubic meter of water to reach USEPA's National Recommended Water Quality Criteria – Aquatic Life Criteria water quality cleanup standard of 1,000 micrograms per liter. Foils exposed to two showers weekly in a grass environment displayed rust coloring on the surface in 3 months of exposure and began to become more fragile and break apart into smaller pieces. Foils in a dry environment displayed less rusting on the surface and no change in durability after 3 months of exposure.

8.10 Visual Intrusions

The release of flares could have a visual effect from residual materials, which remain on the ground or land on structures or at sacred sites, or from the burning flare at night. Flare residual materials do not pose a significant threat to the visual integrity of archaeological and architectural resources. MTV or standard spectral flare residual plastic end caps or pistons are typically 1 inch by 1 inch or 1 inch by 2 inches and are usually red or blue (see Section 8.4). The flare residual materials fall to the ground in a dispersed fashion and do not collect in quantities great enough to affect the National Register of Historic Places status of archaeological or architectural resources adversely. Impacts to traditional cultural resources are more difficult to assess and no studies have been conducted on them with regard to flare residual materials. EOD recorded an annual average of two dud flares on Tribal lands and documented the flare recovery.

Flare residual materials have been identified by ranchers and brought to DAF public hearings considering environmental documents. When a plastic flare component or a wrapper is found and identified on private property, in an unexpected public location, or in conjunction with a cultural resource, the individual finding the piece may be annoyed. This has been the case at public hearings on training airspace modifications in the southwest. The flare residual materials did not result in an impact to any environmental resource, but they did result in annoyance.

One or more deployed flares produce a brief visual effect as a light that lasts for a few seconds. If a pilot repeatedly releases several flares in succession, the flares may appear as blinking lights in the sky when one set burns out and other flares are deployed. Although this would not be noticed by most individuals, someone staring into the night sky, such as a Tribal member participating in a vision quest, a camper in an isolated location, or a rural resident, could observe what appeared to be blinking lights. At a public hearing in Roswell, New Mexico, an older couple attended a hearing on an environmental document. They were convinced that the blinking lights they observed were Unidentified Flying Objects (UFOs) and possibly aliens. The countermeasure flares that are deployed miles away could be seen for a few seconds in the clear night sky. Observers may or may not perceive the few second flare burn as deployed flares from a training aircraft.

The majority of flare components and residual materials have been reviewed for environmental effects for over 25 years. In general, residual materials from flares do not have chemical or biological effects, but they can be a visual intrusion. These studies and reports do not find any significant environmental effects to natural resources or species nor to natural areas such as Wilderness Areas, Wild and Scenic Rivers, wildlife and habitat project areas, and areas designated to have outstanding visual quality. The studies do note that residual materials, if found where no sign of human presence was expected, could result in annoyance from the visual intrusion (DAF, 2011).

A visual intrusion could be an inducement for someone to remove the flare residual material or to remove an unburned flare pellet. There would be no danger in picking up a residual plastic piece or wrapping, but there would be a very real danger from the very remote possibility of a person locating and mishandling an unburned or dud flare. The infrequency of dud flares and the continued warning to treat dud flares as UXO was recorded in 14 years of EOD actions. During that time, 91 persons located a dud flare under DAF training airspace on public, Tribal, or private land and contacted the base regarding the flare to have an EOD response team render the dud flare safe.

There are two flare issues that could result in environmental impact. The first issue is fire, which is separately addressed in Section 8.2. A flare is a burning object and, if deployed where fire could reach combustible material, a flare could start a wildland fire. That combustible item could be a tree standing 150 feet above the ground surface. A burned area could have multiple environmental impacts. As explained in Section 8.3 and Section 8.4, establishing and thoroughly enforcing altitudes for deployment of flares would nearly completely remove the risk of flare-caused fires.

The second potential residual materials flare issue deals with the foils deployed by spectral decoys. Most of the spectral decoys release from 1,500 to 3,000 foils for each decoy deployed. The 0.75-inch by 0.75-inch by 0.00125-inch, or somewhat longer or thicker, iron foils oxidize with the air and reach ambient temperature within a few seconds. Unless a spectral decoy were deployed at near treetop level, there would effectively be no fire risk.

Section 7.6.4.8 describes the potential concentration of foils under representative wind and deployment altitudes. Three spectral decoys deployed at 2,000 feet AGL in a 5-mph wind would result in an estimated 159 foils per acre across approximately 38 acres. Based on the 3-month tests, the oxidized foils would be projected to remain in approximately the same shape and weight for a year or longer in an arid environment and for somewhat less time in a vegetated and watered environment. Durable foils in an arid environment with little vegetation could be seen as a visual intrusion by visitors or residents under the airspace where there was a concentration of foils. Durable foils blown by surface winds could be especially noticed if they aggregated on the backside of a mound or ledge out of the wind.

There have not been extensive laboratory tests or controlled experiment studies of iron foils comparable to the tests performed on chaff to ascertain how long foils take to corrode to the point they are no longer visible to the casual observer. Iron oxides form during the corrosion of iron, and the resulting surface flakes off easily. The iron foils in Figure 7-24, which exhibit some pitting on the edges, were understood to have been deployed from a training aircraft and to have drifted to an adjacent farmer's pecan orchard, remained on the ground for an unknown length of time before they were picked up from the surface and photographed. In an informal 3-month test, iron foils on an arid surface remained unchanged except for minor weathering around the edges. In a grassy watered environment, some foils started to break down to smaller fragments in 3 months. Based on these tests, durable iron foils would slowly oxidize and be expected to rust to a reddish-brown iron oxide in a year or longer before becoming iron particles in the soil.

The potential environmental and visual effects of the foils would be the result of a potentially relatively high quantity deposited in any given location and the potential to accumulate due to their relative durability. As an example, in a two-ship versus two-ship mock combat training mission, where each aircraft used spectral decoys, each aircraft could deploy part of a magazine of 30 flares. Such a training engagement with spectral decoys could result in 20 or so decoys with an average of 2,000 foils each being released per aircraft. Accordingly, one engagement of four aircraft could result in 40,000 0.75-inch by 0.75-inch by 0.00125-inch foils being deposited on the surface. If the training missions were on DAF ranges that are off-limits to the general populace and where munitions are approved, there would not be an expectation of a visual effect. If the same missions were conducted in MOAs overflying off-range land occupied or used regularly by the populace, the residual iron foils could have a noticeable visual effect, especially in an arid environment, if a large number of spectral decoy foils is deployed over a given area and observed on the ground before they disintegrated or were obscured by natural processes.

8.11 Socioeconomic and Agricultural Effects

As explained in Section 8.3, any wildland fire could impact ranching or agricultural operations. Those impacts include infrastructure, animals, crops, and subsequent invasive vegetation as explained in Section 8.7. Unburned flares are impact, friction, heat, spark, and flame sensitive. Friction from a power saw could ignite a flare, and a bullet could have a similar effect. If a dud flare were on the ground and a grass fire swept over the flare, the temperature could be sufficient to ignite the flare. There is no reported case of agricultural equipment striking a dud flare on the ground and creating the required level of friction to ignite an unburned flare. Flare grains on the surface would become less sensitive with time after exposure to moisture, but flares in any condition should be treated as UXO and reported to authorities. The likelihood of a dud flare being located on the ground is extremely remote. An estimated 15 dud flares per year over a 2,000 square mile area would be expected using the assumptions in Section 8.4. A dud flare should not be handled, and safety personnel should be notified in the extremely unlikely event that a dud flare were found. In locations where flares are deployed over non-DoD lands, a public information program can educate the public about the hazards of dud flares and proper procedures to follow if a dud flare is found (DAF, 2019).

Residual pieces of plastic or wrapping material have not been found to affect ranching or agricultural operations. Pieces of flare wrapping, pistons, and end caps have been picked up on ranching property under DAF training airspace and brought to public hearings on Draft Environmental Impact Statements. Section 8.5.2 quantifies the potential for a residual piece from a deployed flare striking a range animal. The effect would be comparable to a hailstone and would not be expected to be much different from a biting fly. There is no known case of a ranch animal ingesting a plastic piece of residual material. Some standard spectral flares and thrusted flares have greater momentum when they descend and could cause injury to grazing animals. The weighted flares have restrictions to be used for test or training only over ranges approved for munitions.

Spectral decoys introduce a different type of flare residual material. During hearings on changes in the use of training airspace, ranchers and farmers in agricultural areas under the airspace regularly ask whether any change in use of the training airspace could affect their operations. In most cases, the

response is that animals and crops would not be affected by an aircraft overflight or from chaff or MTV flare residual materials; that is not necessarily the case with residual pyrophoric foils from spectral decoys. The iron foils could affect the quality of crops such as hay or alfalfa. Unlike chaff, which essentially becomes indistinguishable from ambient soils, iron foils scattered through a large-scale agricultural operation would be expected to become enmeshed in grasses or similar crops and last from months to a year or longer. Iron foils randomly intermixed with feed could result in the feed being of lower quality or unsalable.

Section 7.6.4.8 presents the calculated distribution of residual iron foils based on wind and altitude of deployment. One aircraft deploying 3 spectral decoys at an altitude of 2,000 feet AGL is calculated to result in 159 foils per acre across 38 acres. Acreage under a MOA with agriculture crops could have the foils become enmeshed with the plants, depending on the type of crop plants and the density of the foliage. The typical alfalfa crop produces approximately five large rolls or five comparable very large bales of hay per acre. The number of cuttings and the number of rolls can vary as a result of climate, growing season, fertilizer, and other factors. If there were 5 rolls per acre from 38 acres, the field could produce 190 rolls of hay each cutting, and each roll could contain up to approximately 32 iron foils. A farmer marketing hay could see such a number of foils in so many rolls of hay as a significant impact.

A specific issue to ranchers regarding iron objects is bovine hardware disease. Bovine hardware disease, or bovine traumatic reticuloperitonitis, is usually caused by the ingestion of a sharp metallic object such as a nail, screw, or wire. These pieces of metal settle in the compartment of the cattle's stomach called the reticulum and can irritate or penetrate the lining. It is most common in dairy cattle but is occasionally seen in beef cattle. The metallic object can penetrate the stomach lining and have mild, severe, or even fatal consequences (Johnson, 2022). The disease usually comes from contaminated cattle feed containing pieces of iron. Feed mills and harvesting equipment are sometimes fitted with magnets to intercept some metal objects before the feed enters the food chain to reduce the incidence of the disease. Ranchers could question the distribution of pyrophoric iron foils as increasing the risk for a condition that could affect their operations.

Other crops can be impacted by iron foils from deployed spectral decoys. In a pecan nursery in Georgia, a farmer found iron foils distributed on the ground in his nursery and was able to trace the source of the foils to the DAF. The foils were seen by the farmer as interfering with his harvest operation, which is performed by hydraulic arm shakers that dislodge the pecans from the trees. The pecans and all other materials under the trees are then swept up and processed for packaging the pecans. Introducing iron foils under the tree adds materials and costs to cleaning and preparing the pecans for market. The farmer and the DAF saw the foils in the orchard as an impact, and the DAF conducted soil sample analysis that demonstrated that samples from within the pecan orchard did not have higher concentrations of iron than soil samples from control areas outside the orchard. Many other nuts are gathered and processed in the same way and could be similarly impacted by residual iron foils from spectral decoys.

There could also be an impact to other crops such as leafy vegetables that are for human consumption. Lettuce is harvested by hand with a few outer layers removed in the field before the heads are placed in cartons for delivery to the market. Other leafy vegetables are similarly harvested and boxed directly during harvesting, including multiple types of lettuce, spinach, kale, arugula, and others. As a result of the harvesting process, if any iron foils are on these crops, it is anticipated they would be removed during harvesting. Any foils that are not removed during harvesting could end up in a market where additional cleaning would be required, or in a very unlikely event, with a consumer. A farmer, supplier, or seller of such products could see the existence of iron foils or iron particles in their crop as an adverse impact.

Public and agency comments on environmental documents have identified concerns about metallic chaff from World War II and Vietnam eras falling on power poles and cutting off electricity. There have been historic cases of the no longer used foil chaff causing power outages. The response in DAF environmental documents has been that the metal foil chaff from World War II and Vietnam eras has been replaced by angel hair chaff, which results in no risk for power outages. There is no metallic chaff currently used that could short out electricity. The residual iron foils from spectral decoys are not of the size or shape to be able to create an electrical short or disrupt electrical transmission systems and would not impact any ground utilities or structures.

As of 2022, there have not been extensive laboratory tests or controlled experiment studies of spectral decoy iron foils comparable to those performed on chaff to ascertain how long the foils take to corrode to the point they are no longer visible to the casual observer. In previous studies, chaff was soaked in molasses and fed to calves; chaff was evaluated for durability, break up, and particulate resuspension; flare residual materials were reviewed; and surveys were performed to ascertain if animals were consuming defensive countermeasure residual materials (DAF, 1997; DAF, 2011). No comparable studies have been performed on iron foils from spectral decoys.

8.12 Summary of Flare Environmental Effects

Flares have developed and changed since they were first introduced to counter IR missiles. This 2022 report expands upon the information from the 1997 and 2011 reports, which included the then available information on flares and flare environmental effects. The initial evaluation in the 1997 and 2011 reports and the research performed for those reports are applicable to flares that continue to be deployed for training. This 2022 report explains the groupings of flares as the "families of flares" described in Section 7.0. This 2022 report goes beyond the 1997 and 2011 reports and updates information on the environmental effects of MTV flares, spectral flares, and thrusted flares. This report also includes new information on, and environmental effects of, spectral decoys, which were not available for the 2011 report.

Refinements for, and additions to, the flare discussion from the 1997 and 2011 reports include:

1. **Expanded information to determine flare reliability to be 99.6 percent.** This rate can be applied to any DAF training airspace to estimate the annual number of unburned flares from the number of flares deployed in the airspace and the area of the surface under the airspace. This 2022 report performed simple calculations for two locations to estimate the number of unburned flares on the surface annually under the DAF training airspace approved for flare use to be in the approximate range of fewer than one to four unburned flares per 100 square miles.
2. **An additional understanding of the shape and functioning of thrusted flares.** The shape and weight of residual materials that fall to the surface after deployment mean the thrusted flares would normally be used for testing over munitions ranges or in combat. The flares would not normally be used within DAF training airspace outside live or inert munitions ranges.
3. **Addition of spectral decoys to the report, including Information about the contents of the decoys.** Thousands of very light iron foils deployed by spectral decoys could be concentrated in a 38-acre area or drift up to 30 to 50 miles and disperse into an approximately 999,000-acre area, depending on the altitude and wind conditions from where they are deployed. Depending on the environment under the training airspace, the iron foils can maintain their shape for months, possibly up to a year, or longer after being deployed and before they degrade to small iron

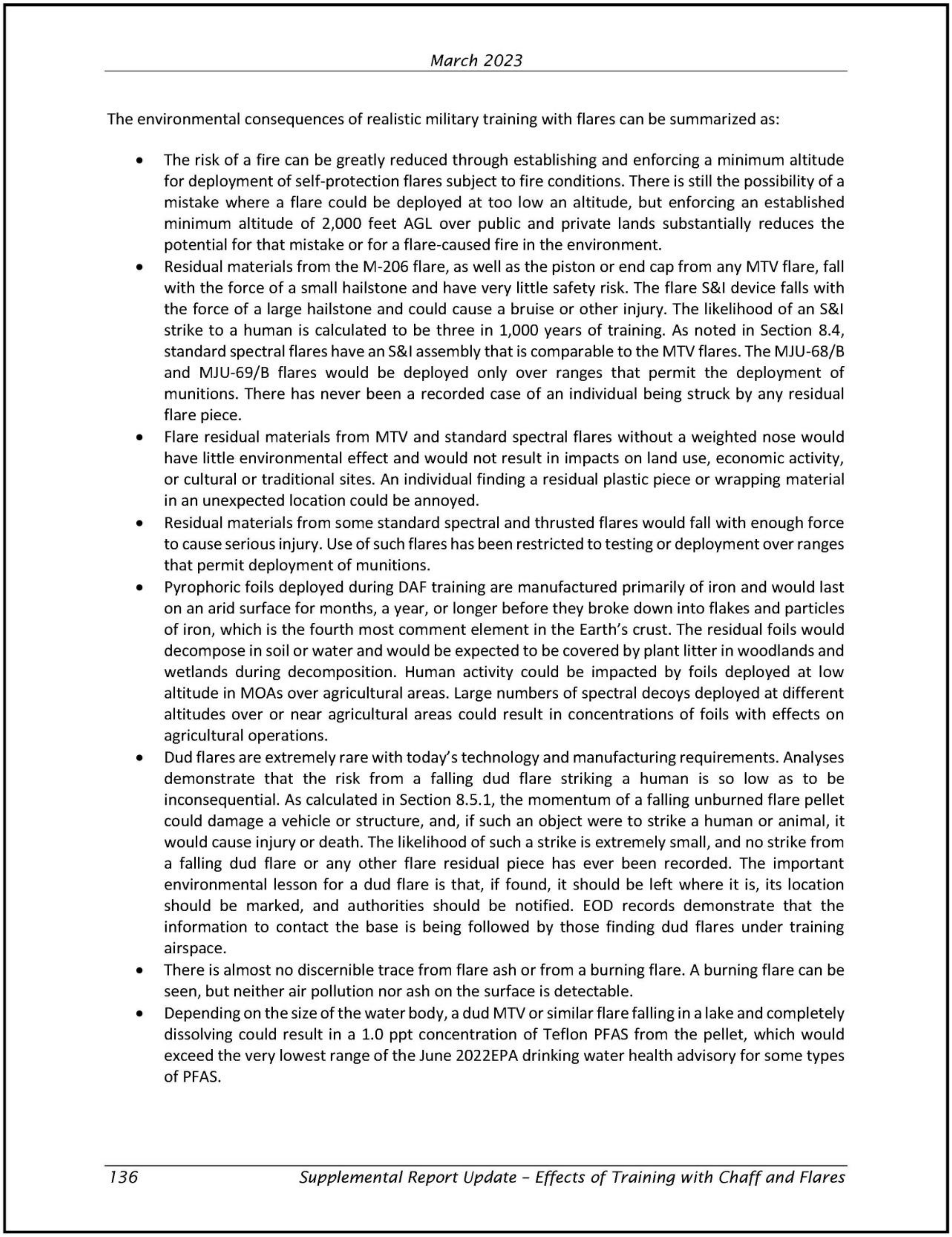
particles. Foils have the potential for environmental effects to the natural and human environments.

4. **Information from EOD clearance records regarding flare use and target areas.** EOD clearance of targets suggests that a greater portion of flares are likely to be deployed near threats or targets where the training aircraft is threatened by radar-guided or heat-seeking munitions. Prior to this information, flares were assumed to be deployed randomly within a training airspace.

Most flare environmental effects have been described in previous reports and are primarily those associated with safety, including falling residual materials, unburned flares on the surface, and the potential for flare caused fires. Different flares have different residual materials with different rates of descent and different impacts when they reach the ground. Most MTV residual flare materials that fall have surface area to weight ratios that would not produce any substantial impact when the residual flare material struck the ground. The largest MTV flare item is the approximately 2-inch by 1-inch by 0.5-inch plastic and spring S&I device with a weight of approximately 0.864 ounces. The S&I device could strike the ground with a maximum momentum of a calculated 0.17 pounds per second or approximately the same force as a large hailstone. If an S&I device were to strike an unprotected individual, it could cause a bruise or more serious injury. The likelihood of a strike would depend on the number of flares deployed, the area under the airspace, the population density under the airspace, and the proportion of time a person would be expected to be outside. Assuming a rural area with a population density of 10 persons per square mile and 20,000 flares with S&I devices annually deployed in a MOA overlying a 2,000 square mile area, the potential person strike from a large hailstone sized S&I residual piece has been calculated as 0.003 strikes per year, or approximately 3 strikes in 1,000 years of training. Training flare residual pieces of plastic or wrappers fall with a force that would not be expected to result in a serious injury even if a person were struck. There has never been a case of a person being struck by an S&I device or by any other piece of flare residual material. If a nylon/plastic or other piece of flare residual material were found on the ground and identified, the finding individual could be annoyed.

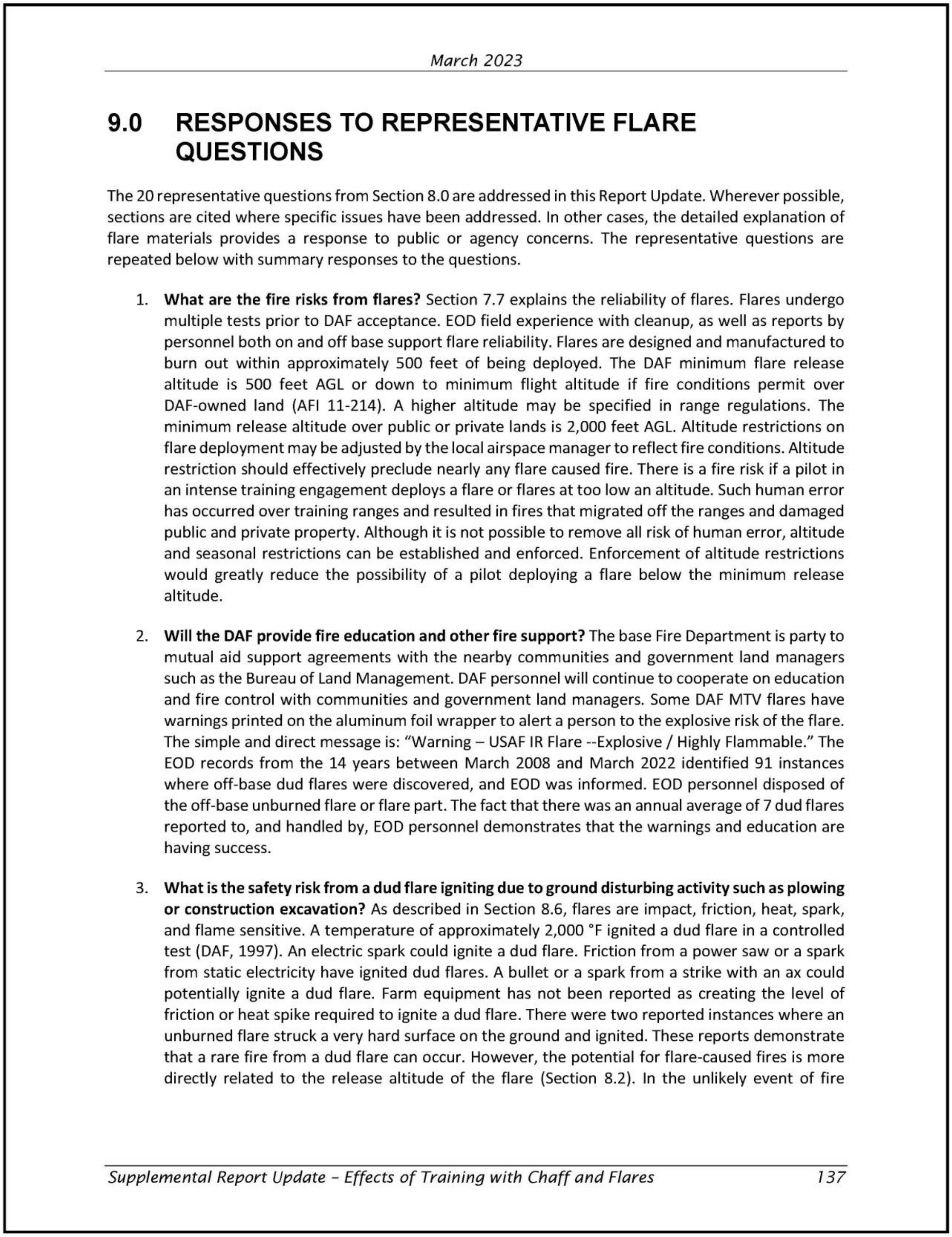
Flare manufacturing reliability, DAF acceptance standards, and EOD range cleanup experience were incorporated in this report to result in an estimated 99.6 percent flare reliability rate. The estimated annual total number of failed flares from a calculated 541,280 (796,000 times 0.68) flares deployed over land during DAF training is 2,165, of which an estimated 1,704 dud flares are deposited, but not recovered, on DAF access-controlled land, public land, Tribal reservations, or private land under training airspace. For the representative airspace used in this report, there would be approximately 80 dud flares annually deposited over 2,000 square miles per 20,000 flares deployed, or four flares per 100 square miles. An unburned flare on the surface is a dud flare and is treated by the EOD as UXO. If a dud flare is found, it should not be moved, the location should be identified, and the local fire department or base Public Affairs Office should be contacted and provided with the location of the dud flare. Fourteen years of EOD records document a total of 91 incidents where dud flares or parts of dud flares were recovered on public, Tribal, or private land under training airspace, for an average of 7 dud flares per year recovered by the public.

Fire from a flare is a continuing concern of individuals living or working under airspace authorized for training with flares. Fires can result from a flare deployed at too low an altitude, a flare that burns longer than proscribed, or an unburned flare striking or being struck by an object that causes enough of a spark to ignite the flare. Maintaining quality production of reliable flares and trained maintenance personnel who handle and load the flares reduces the potential for flare failures that could result in fires. Establishing and enforcing altitude restrictions for flare deployment and ensuring that pilots training in the airspace fully appreciate the fire risks from flares are continuing practices of the DAF to reduce the risk of a fire resulting from deployment of a defensive countermeasure flare.



The environmental consequences of realistic military training with flares can be summarized as:

- The risk of a fire can be greatly reduced through establishing and enforcing a minimum altitude for deployment of self-protection flares subject to fire conditions. There is still the possibility of a mistake where a flare could be deployed at too low an altitude, but enforcing an established minimum altitude of 2,000 feet AGL over public and private lands substantially reduces the potential for that mistake or for a flare-caused fire in the environment.
- Residual materials from the M-206 flare, as well as the piston or end cap from any MTV flare, fall with the force of a small hailstone and have very little safety risk. The flare S&I device falls with the force of a large hailstone and could cause a bruise or other injury. The likelihood of an S&I strike to a human is calculated to be three in 1,000 years of training. As noted in Section 8.4, standard spectral flares have an S&I assembly that is comparable to the MTV flares. The MJU-68/B and MJU-69/B flares would be deployed only over ranges that permit the deployment of munitions. There has never been a recorded case of an individual being struck by any residual flare piece.
- Flare residual materials from MTV and standard spectral flares without a weighted nose would have little environmental effect and would not result in impacts on land use, economic activity, or cultural or traditional sites. An individual finding a residual plastic piece or wrapping material in an unexpected location could be annoyed.
- Residual materials from some standard spectral and thrusted flares would fall with enough force to cause serious injury. Use of such flares has been restricted to testing or deployment over ranges that permit deployment of munitions.
- Pyrophoric foils deployed during DAF training are manufactured primarily of iron and would last on an arid surface for months, a year, or longer before they broke down into flakes and particles of iron, which is the fourth most comment element in the Earth's crust. The residual foils would decompose in soil or water and would be expected to be covered by plant litter in woodlands and wetlands during decomposition. Human activity could be impacted by foils deployed at low altitude in MOAs over agricultural areas. Large numbers of spectral decoys deployed at different altitudes over or near agricultural areas could result in concentrations of foils with effects on agricultural operations.
- Dud flares are extremely rare with today's technology and manufacturing requirements. Analyses demonstrate that the risk from a falling dud flare striking a human is so low as to be inconsequential. As calculated in Section 8.5.1, the momentum of a falling unburned flare pellet could damage a vehicle or structure, and, if such an object were to strike a human or animal, it would cause injury or death. The likelihood of such a strike is extremely small, and no strike from a falling dud flare or any other flare residual piece has ever been recorded. The important environmental lesson for a dud flare is that, if found, it should be left where it is, its location should be marked, and authorities should be notified. EOD records demonstrate that the information to contact the base is being followed by those finding dud flares under training airspace.
- There is almost no discernible trace from flare ash or from a burning flare. A burning flare can be seen, but neither air pollution nor ash on the surface is detectable.
- Depending on the size of the water body, a dud MTV or similar flare falling in a lake and completely dissolving could result in a 1.0 ppt concentration of Teflon PFAS from the pellet, which would exceed the very lowest range of the June 2022EPA drinking water health advisory for some types of PFAS.



9.0 RESPONSES TO REPRESENTATIVE FLARE QUESTIONS

The 20 representative questions from Section 8.0 are addressed in this Report Update. Wherever possible, sections are cited where specific issues have been addressed. In other cases, the detailed explanation of flare materials provides a response to public or agency concerns. The representative questions are repeated below with summary responses to the questions.

1. **What are the fire risks from flares?** Section 7.7 explains the reliability of flares. Flares undergo multiple tests prior to DAF acceptance. EOD field experience with cleanup, as well as reports by personnel both on and off base support flare reliability. Flares are designed and manufactured to burn out within approximately 500 feet of being deployed. The DAF minimum flare release altitude is 500 feet AGL or down to minimum flight altitude if fire conditions permit over DAF-owned land (AFI 11-214). A higher altitude may be specified in range regulations. The minimum release altitude over public or private lands is 2,000 feet AGL. Altitude restrictions on flare deployment may be adjusted by the local airspace manager to reflect fire conditions. Altitude restriction should effectively preclude nearly any flare caused fire. There is a fire risk if a pilot in an intense training engagement deploys a flare or flares at too low an altitude. Such human error has occurred over training ranges and resulted in fires that migrated off the ranges and damaged public and private property. Although it is not possible to remove all risk of human error, altitude and seasonal restrictions can be established and enforced. Enforcement of altitude restrictions would greatly reduce the possibility of a pilot deploying a flare below the minimum release altitude.

2. **Will the DAF provide fire education and other fire support?** The base Fire Department is party to mutual aid support agreements with the nearby communities and government land managers such as the Bureau of Land Management. DAF personnel will continue to cooperate on education and fire control with communities and government land managers. Some DAF MTV flares have warnings printed on the aluminum foil wrapper to alert a person to the explosive risk of the flare. The simple and direct message is: "Warning – USAF IR Flare --Explosive / Highly Flammable." The EOD records from the 14 years between March 2008 and March 2022 identified 91 instances where off-base dud flares were discovered, and EOD was informed. EOD personnel disposed of the off-base unburned flare or flare part. The fact that there was an annual average of 7 dud flares reported to, and handled by, EOD personnel demonstrates that the warnings and education are having success.

3. **What is the safety risk from a dud flare igniting due to ground disturbing activity such as plowing or construction excavation?** As described in Section 8.6, flares are impact, friction, heat, spark, and flame sensitive. A temperature of approximately 2,000 °F ignited a dud flare in a controlled test (DAF, 1997). An electric spark could ignite a dud flare. Friction from a power saw or a spark from static electricity have ignited dud flares. A bullet or a spark from a strike with an ax could potentially ignite a dud flare. Farm equipment has not been reported as creating the level of friction or heat spike required to ignite a dud flare. There were two reported instances where an unburned flare struck a very hard surface on the ground and ignited. These reports demonstrate that a rare fire from a dud flare can occur. However, the potential for flare-caused fires is more directly related to the release altitude of the flare (Section 8.2). In the unlikely event of fire

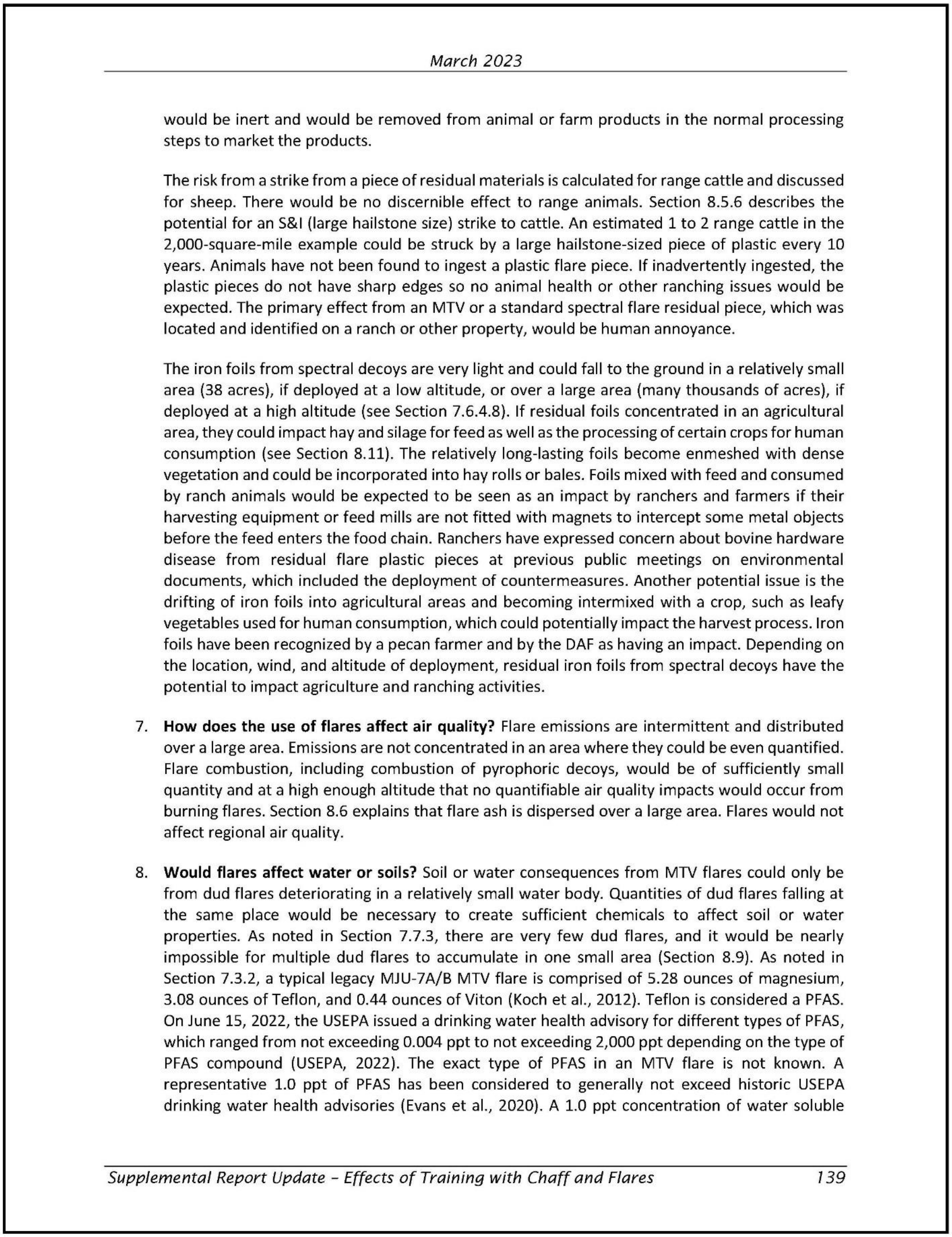
damage from a dud flare, the base Public Affairs Office should be contacted to determine how to file a damage claim.

4. **What would be the visual effects from flare residual materials?** The flare residual materials are described in Section 8.4. Figure 8-1 through Figure 8-5 represent residual materials that result from flare use. If a piece of plastic or wrapping material from an MTV flare were found and identified, such material could be an annoyance. For the representative MOA used in this study, an estimated 20,000 MTV or standard spectral flares would result in a calculated 80,000 residual plastic felt or wrapper pieces under the 2,000 square mile MOA or an annual average of 1 flare residual piece per 16 acres. Most spectral decoys result in 1,500 to 3,000 thin iron foils, which would be seen as a visual intrusion.

5. **What would be the safety risk from falling residual material or dud flares?** Sections 7.3 through 7.6 describe the number and type of residual materials from deploying different types of flares. An MJU-7A/B MTV flare results in 3 pieces of plastic residual materials weighing from 0.009 to 0.054 pounds. The piston and end cap would fall with the force of a small hailstone, and the S&I assembly would fall with the force of a large hailstone. Standard spectral flares generally have the same piston, end cap, and S&I assembly as the MTV flares with the same effects. In some cases, the standard spectral flares have a weighted nose that could fall with enough force to cause an injury or a concussion if the residual piece were to strike an unprotected head. Thrusted flares, after burnout, would fall to Earth as a carbon fiber or steel case with a weighted nose. The thrusted flare residual casing would fall with enough momentum to cause serious injury. The thrusted flares and standard spectral flares with weighted nose are for use in tests over DAF ranges that permit deployment of munitions. Spectral decoys would have an end cap and piston similar to MTV flares. The 2,000-square-mile MOA example with a projected 10 persons per square mile would result in a calculated risk of persons in 1,000 years that could be struck by an S&I plastic piece of residual material with the force of a large hailstone. In addition to residual plastic pieces, each spectral decoy results in 1,500 to 3,000 0.75-inch by 0.75-inch by 0.00125-inch or thicker oxidized iron foils. The foils would not descend with sufficient momentum to cause an injury.

   There would be a calculated 80 unburned flares annually deposited on the surface of the representative 2,000 square mile MOA where 20,000 flares had been deployed. The probability that an individual under the training airspace in this representative MOA could be struck by a falling unburned flare pellet would be approximately 0.000006, or 6 persons in 1,000,000 years. The momentum of a falling flare pellet from Table 8-9 would be of a magnitude that it could result in severe injury or death. The probability of such an event is very low, and no one has ever been struck by a falling flare. Neither has there ever been a recorded instance of a person being struck by any flare (or chaff) residual piece.

6. **What are the effects of flares on ranching and other economic activities?** Section 8.0 describes the effects of flares, including fire and residual materials effects. Fire can result in loss of animals and infrastructure. The potential for a flare-caused fire is discussed in Section 8.2. With the reliability of flares, the primary reason for a flare-caused fire would be deployment too close to combustible material on the ground, and that risk is typically avoided through altitude restrictions on flare use. Infrequent dud flares would be unlikely to have any effect on agricultural activities. The flare residual plastics pieces or wrapper would result in approximately 1 piece per 16 acres per year given the representative airspace assumptions in Table 8-8. The plastic or nylon pieces



would be inert and would be removed from animal or farm products in the normal processing steps to market the products.

The risk from a strike from a piece of residual materials is calculated for range cattle and discussed for sheep. There would be no discernible effect to range animals. Section 8.5.6 describes the potential for an S&I (large hailstone size) strike to cattle. An estimated 1 to 2 range cattle in the 2,000-square-mile example could be struck by a large hailstone-sized piece of plastic every 10 years. Animals have not been found to ingest a plastic flare piece. If inadvertently ingested, the plastic pieces do not have sharp edges so no animal health or other ranching issues would be expected. The primary effect from an MTV or a standard spectral flare residual piece, which was located and identified on a ranch or other property, would be human annoyance.

The iron foils from spectral decoys are very light and could fall to the ground in a relatively small area (38 acres), if deployed at a low altitude, or over a large area (many thousands of acres), if deployed at a high altitude (see Section 7.6.4.8). If residual foils concentrated in an agricultural area, they could impact hay and silage for feed as well as the processing of certain crops for human consumption (see Section 8.11). The relatively long-lasting foils become enmeshed with dense vegetation and could be incorporated into hay rolls or bales. Foils mixed with feed and consumed by ranch animals would be expected to be seen as an impact by ranchers and farmers if their harvesting equipment or feed mills are not fitted with magnets to intercept some metal objects before the feed enters the food chain. Ranchers have expressed concern about bovine hardware disease from residual flare plastic pieces at previous public meetings on environmental documents, which included the deployment of countermeasures. Another potential issue is the drifting of iron foils into agricultural areas and becoming intermixed with a crop, such as leafy vegetables used for human consumption, which could potentially impact the harvest process. Iron foils have been recognized by a pecan farmer and by the DAF as having an impact. Depending on the location, wind, and altitude of deployment, residual iron foils from spectral decoys have the potential to impact agriculture and ranching activities.

7. **How does the use of flares affect air quality?** Flare emissions are intermittent and distributed over a large area. Emissions are not concentrated in an area where they could be even quantified. Flare combustion, including combustion of pyrophoric decoys, would be of sufficiently small quantity and at a high enough altitude that no quantifiable air quality impacts would occur from burning flares. Section 8.6 explains that flare ash is dispersed over a large area. Flares would not affect regional air quality.

8. **Would flares affect water or soils?** Soil or water consequences from MTV flares could only be from dud flares deteriorating in a relatively small water body. Quantities of dud flares falling at the same place would be necessary to create sufficient chemicals to affect soil or water properties. As noted in Section 7.7.3, there are very few dud flares, and it would be nearly impossible for multiple dud flares to accumulate in one small area (Section 8.9). As noted in Section 7.3.2, a typical legacy MJU-7A/B MTV flare is comprised of 5.28 ounces of magnesium, 3.08 ounces of Teflon, and 0.44 ounces of Viton (Koch et al., 2012). Teflon is considered a PFAS. On June 15, 2022, the USEPA issued a drinking water health advisory for different types of PFAS, which ranged from not exceeding 0.004 ppt to not exceeding 2,000 ppt depending on the type of PFAS compound (USEPA, 2022). The exact type of PFAS in an MTV flare is not known. A representative 1.0 ppt of PFAS has been considered to generally not exceed historic USEPA drinking water health advisories (Evans et al., 2020). A 1.0 ppt concentration of water soluble

PFAS could result from one dud MJU-7A/B flare with 3.08 ounces of Teflon falling in a 5.5-square mile or smaller lake with an average depth of 20 feet, with the conservative assumptions that the Teflon in the flare pellet would be water soluble and completely dissolve. Flare ash would not be expected to affect water or soils, and dud flares would not be expected to affect soils. Regular training with spectral decoys could result in large quantities of foils being deposited on soils or water resources. The manufactured foils could persist in the environment, and wind transport could result in aggregating iron filings in the soils or water areas where foils settled.

9. **What are the risks to animals from ingesting flare residual materials?** Livestock have grazed for decades on military ranges where flares are deployed. Flare plastic or wrapping pieces, have never been recorded as ingested by animals. If a plastic piece were inadvertently consumed by an animal, it would pass through the digestive tract as with any inert material. Iron foils from spectral flares, if they were ingested as a result of cattle indiscriminately grazing or eating feed, such as in a feed lot, could result in increased risk of bovine hardware disease or otherwise impact agriculture or ranching.

10. **What is the frequency and amount of flare use over Tribal lands?** Defensive flare deployment would be random over lands underlying the airspace. Flare and chaff residual materials in the representative MOA included in this study could have approximately one piece of flare residual materials per 16 acres per year. This amount of residual pieces could be randomly distributed anywhere under a training airspace, including on Tribal lands. Tribal members have located dud flares on their land and informed EOD personnel for EOD clean-up. Tribal members found fewer than 2 dud flares per year on Tribal lands in 14 years of EOD records. Environmental documents that address the impacts from training airspace operation include the estimated number of flares deployed within the airspace.

11. **Could flare use create airborne FOD hazards?** There has never been a recorded instance of a flare plastic piece or wrapper striking or damaging a non-involved aircraft. There was one instance of a piece of residual plastic material from a deployed countermeasure being ingested in the engine of a military aircraft flying as a wingman to the aircraft deploying the flare. The piece of residual flare material resulted in engine damage to the closely following aircraft. Plastic and paper residual pieces from flare deployment fall to the ground. The heaviest piece of flare residual materials, outside a test range, is a plastic S&I assembly, which falls with the force of a large hailstone (see Section 8.4). There has never been a recorded case of such a piece striking an aircraft on the ground.

12. **Could flare residual materials impact the economic value of wool?** The plastic or nylon residual materials from flare deployment are listed in Sections 7.3 through 7.6 and pictured in Figure 7-24 and Figure 8-1 through Figure 8-5. If the smallest 1-inch by 1-inch end cap or piston were to fall on a sheep and somehow remain in the wool, it would be removed as if it were a burr from vegetation during processing of the wool. Flare residual materials would be removed and not have any effect on the economic value of the wool. There are no recorded instances where a residual piece of plastic from a flare was found during processing of sheep wool. Iron foils from spectral decoys are small and light enough to become entangled in wool. Normal cleaning for processing wool would be expected to remove any foreign materials.

13. **Would flare residual materials affect birthing animals?** Any contact with flare residual materials would be highly unlikely. Flare plastic and wrapper residual materials are inert. In the extremely

improbable case where a birthing animal were to be struck by a hailstone-sized piece of residual plastic material, it would likely be no more noticed than a biting fly. The residual plastic materials associated with an MTV flare or most standard spectral flares would have no more physical effect on an animal than a piece of gravel. Most standard spectral flares and thrusted flares would not be used over agricultural operations. The potential agricultural effects from spectral decoy iron foils are discussed in Section 8.11. There would not be any anticipated effect on birthing animals.

14. **Will flare use be distributed evenly throughout airspace, or will it be concentrated within routine training routes?** Flares are deployed in response to air- and/or ground-based threats, which can occur anywhere within a training airspace. Ground-based threats from IR missiles are more likely to occur where surface targets are being defended. Although current threats can exist miles from a target, there would be a higher percentage of flares deployed near a target. The remaining deployment of defensive flares is expected to be distributed randomly throughout the training airspace.

15. **Can the number of flares deployed be quantified?** Flare use can be quantified for specific training aircraft in specific training airspace. Environmental documents provided for public review quantify the estimated annual number flares countermeasures use in training airspace. This Report Update has used the example of 20,000 flares deployed in a MOA over a 2,000-square mile area for representative analysis (see Table 8-8).

16. **Will flare use impact important species, such as the sage grouse?** Flare residual pieces would not be expected to impact species such as the greater sage grouse. Even where flares are used regularly, no animal or bird nests were found to contain residual materials, such as end caps or pistons, from any defensive countermeasure (DAF, 1997) (see also Section 5.4.2). No effects to sensitive species would be expected from MTV or standard spectral flares. Spectral flare iron foils introduce a large amount of manufactured material into the environment. In an informal 3-month foil weathering test, common bird species ignored foils. The effect on marine or aquatic species is not known.

17. **Can flare use be limited to winter months to avoid the peak fire season?** As explained in Section 8.2, seasonal and altitude restrictions for flare use are determined by DAF policy and then by the Base Commander in consultation with the base Airspace Manager and local agencies. Regional land use managers determine fire danger levels and communicate the fire conditions to the local DAF airspace manager. Altitude restrictions for flare use are then communicated to pilots training in the airspace, which occurs at any time of the year.

18. **What are the near-term and long-term impacts from flare use?** Section 8.0 describes the flare effects including the effects of residual materials that fall to the ground. MTV and spectral flare residual materials are inert and would be expected to remain on the ground unless disturbed. Figure 8-5 demonstrates that natural occurrences such as falling pine needles can, over time, reduce the visual effects of residual materials. Plastic flare residual materials would remain on the surface or be covered by wind or other natural action over a period of months. The plastic pieces would be expected to persist in the environment for a year or years. Most spectral decoys deposit 1,500 to 3,000 iron foils on the ground per flare. Spectral decoys are being used in training, and regular use could result in a build-up of iron foils that could last a year or years on the surface.

19. **Can lasers be used to defeat IR-guided missiles?** Laser jamming of missiles has been evaluated. Existing lasers, as of 2022, require substantial power to be effective. Capabilities of lasers will continue to be tested; however, expendable countermeasures are expected to be part of any military aircraft defensive systems beyond the 2030 timeframe.

20. **Are there technologies other than flares for defense against IR missiles?** Other technologies are being evaluated for aircraft self-protection. However, there are technological challenges and power demands to field a reliable alternative to flare countermeasures. The technologies being evaluated have demonstrated that flares will continue to be the only reliable defense to IR missiles for the foreseeable future.

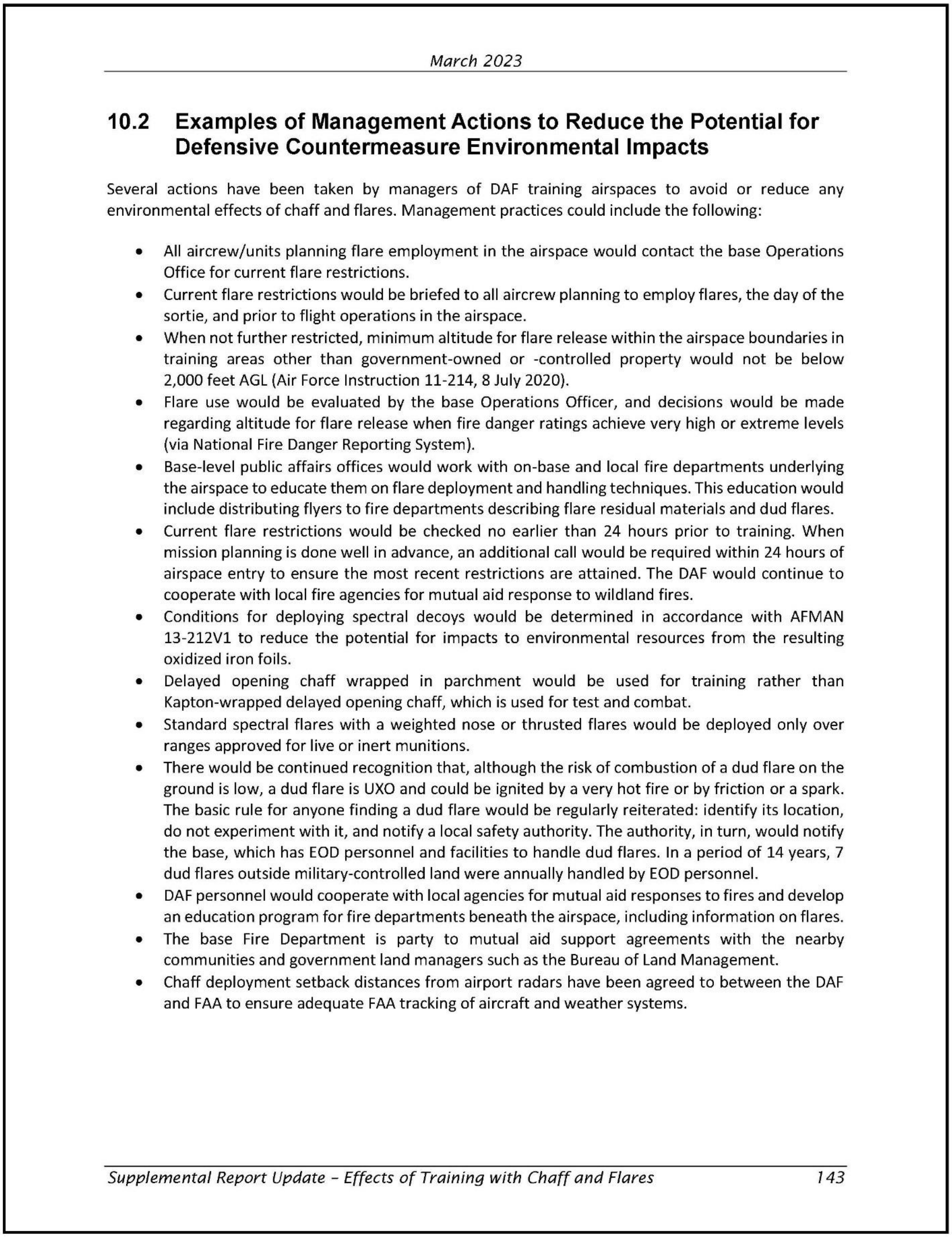
10.0 POLICIES, REGULATIONS, AND DEPARTMENT OF THE AIR FORCE ACTIONS ON DEFENSIVE COUNTERMEASURE USE

This section identifies policies and regulations on flare use and discusses potential management actions to reduce possible impacts from training with defensive flares.

10.1 Policies and Regulations

Effective use of countermeasures in combat requires frequent training by aircrews to master the timing of deployment and the capabilities of the defensive countermeasure as well as by ground crews to ensure safe and efficient handling of the flares. Defensive countermeasures deployment in authorized airspace is governed by a series of policies and regulations based on safety, environmental considerations, and defensive countermeasures limitations. These policies, regulations, and guidance are included in this section. Procedures govern the use of flares over ranges, other government-owned and controlled lands, and nongovernment-owned or controlled areas. The following regulations are applicable.

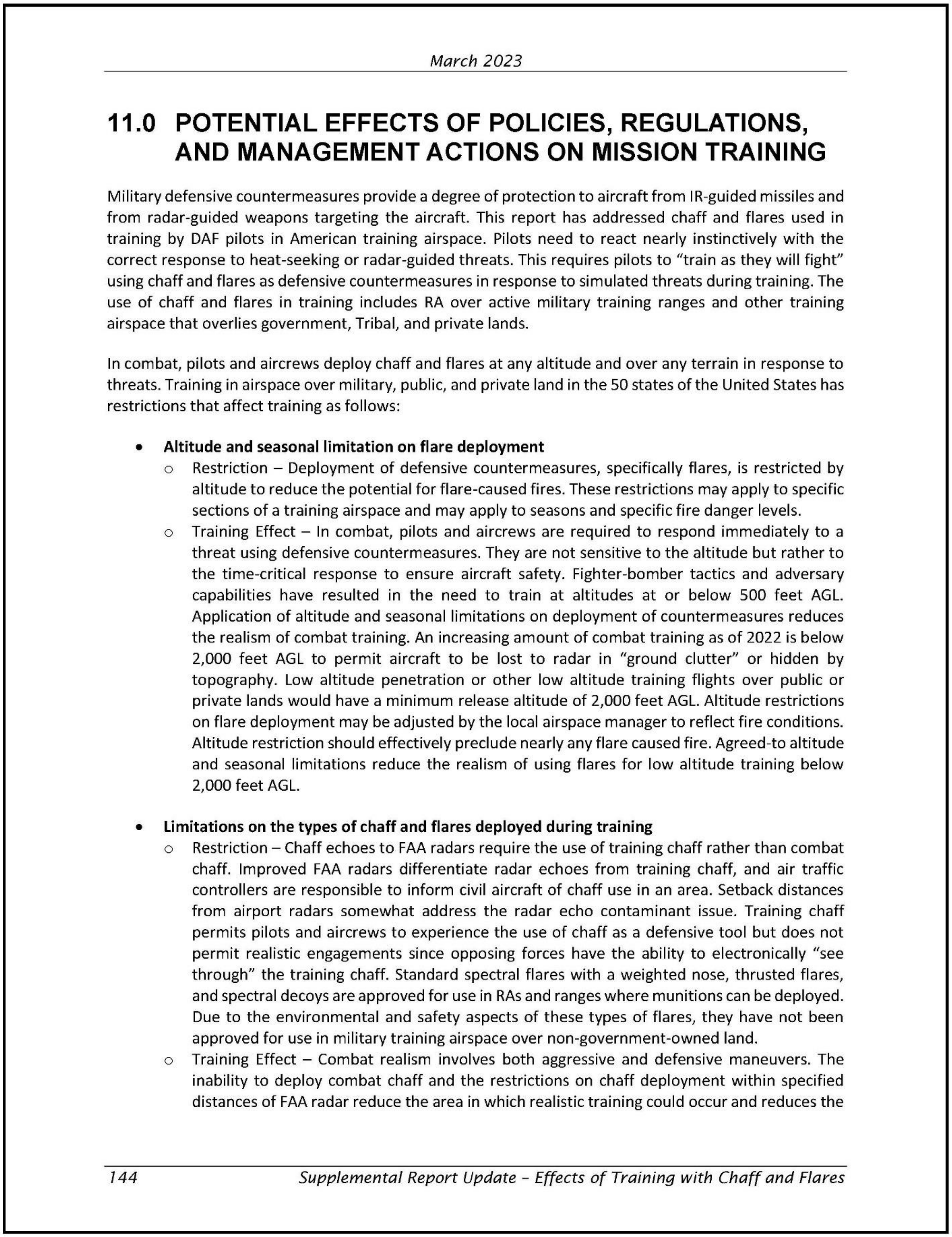
- **AFMAN 13-212 VI, Section 4.14, 22 June 2018**. This manual established practices for chaff and flare employment and specifies that proposals for defensive chaff and flare use have an adequate environmental analysis. The use of spectral decoys with pyrophoric foils is restricted to authorized test and evaluation activities subject to Major Command authorization.
- **AFI 11-214 – Air Operations Rules and Procedures, July 2020**. This instruction delineates procedures for chaff and flare use. It prohibits use unless in an approved area. Fire hazard conditions governing flare use are specified. The DAF minimum flare release altitude is 500 feet AGL, or down to minimum flight altitude if fire conditions permit, over DAF-owned land (AFI 11-214). A higher altitude may be specified in range regulations. The minimum release altitude over public or private lands is 2,000 feet AGL. Altitude restrictions on flare deployment may be adjusted by the local airspace manager to reflect fire conditions. Altitude restriction on flare deployment over public or private land should effectively preclude nearly any flare caused fire on these lands.
- **40 CFR**. Classifies flares as munitions under the military munitions rule.
- **FAA Job Order 7110.65Z, Chg 1, Section 2.6-4, December 2, 2021**. Section 2.6-4 requires air traffic controllers to issue information on chaff use areas to potentially affected aircraft, including the radar band affected and, when feasible, the expected duration of the chaff suspension.



10.2 Examples of Management Actions to Reduce the Potential for Defensive Countermeasure Environmental Impacts

Several actions have been taken by managers of DAF training airspaces to avoid or reduce any environmental effects of chaff and flares. Management practices could include the following:

- All aircrew/units planning flare employment in the airspace would contact the base Operations Office for current flare restrictions.
- Current flare restrictions would be briefed to all aircrew planning to employ flares, the day of the sortie, and prior to flight operations in the airspace.
- When not further restricted, minimum altitude for flare release within the airspace boundaries in training areas other than government-owned or -controlled property would not be below 2,000 feet AGL (Air Force Instruction 11-214, 8 July 2020).
- Flare use would be evaluated by the base Operations Officer, and decisions would be made regarding altitude for flare release when fire danger ratings achieve very high or extreme levels (via National Fire Danger Reporting System).
- Base-level public affairs offices would work with on-base and local fire departments underlying the airspace to educate them on flare deployment and handling techniques. This education would include distributing flyers to fire departments describing flare residual materials and dud flares.
- Current flare restrictions would be checked no earlier than 24 hours prior to training. When mission planning is done well in advance, an additional call would be required within 24 hours of airspace entry to ensure the most recent restrictions are attained. The DAF would continue to cooperate with local fire agencies for mutual aid response to wildland fires.
- Conditions for deploying spectral decoys would be determined in accordance with AFMAN 13-212V1 to reduce the potential for impacts to environmental resources from the resulting oxidized iron foils.
- Delayed opening chaff wrapped in parchment would be used for training rather than Kapton-wrapped delayed opening chaff, which is used for test and combat.
- Standard spectral flares with a weighted nose or thrusted flares would be deployed only over ranges approved for live or inert munitions.
- There would be continued recognition that, although the risk of combustion of a dud flare on the ground is low, a dud flare is UXO and could be ignited by a very hot fire or by friction or a spark. The basic rule for anyone finding a dud flare would be regularly reiterated: identify its location, do not experiment with it, and notify a local safety authority. The authority, in turn, would notify the base, which has EOD personnel and facilities to handle dud flares. In a period of 14 years, 7 dud flares outside military-controlled land were annually handled by EOD personnel.
- DAF personnel would cooperate with local agencies for mutual aid responses to fires and develop an education program for fire departments beneath the airspace, including information on flares.
- The base Fire Department is party to mutual aid support agreements with the nearby communities and government land managers such as the Bureau of Land Management.
- Chaff deployment setback distances from airport radars have been agreed to between the DAF and FAA to ensure adequate FAA tracking of aircraft and weather systems.



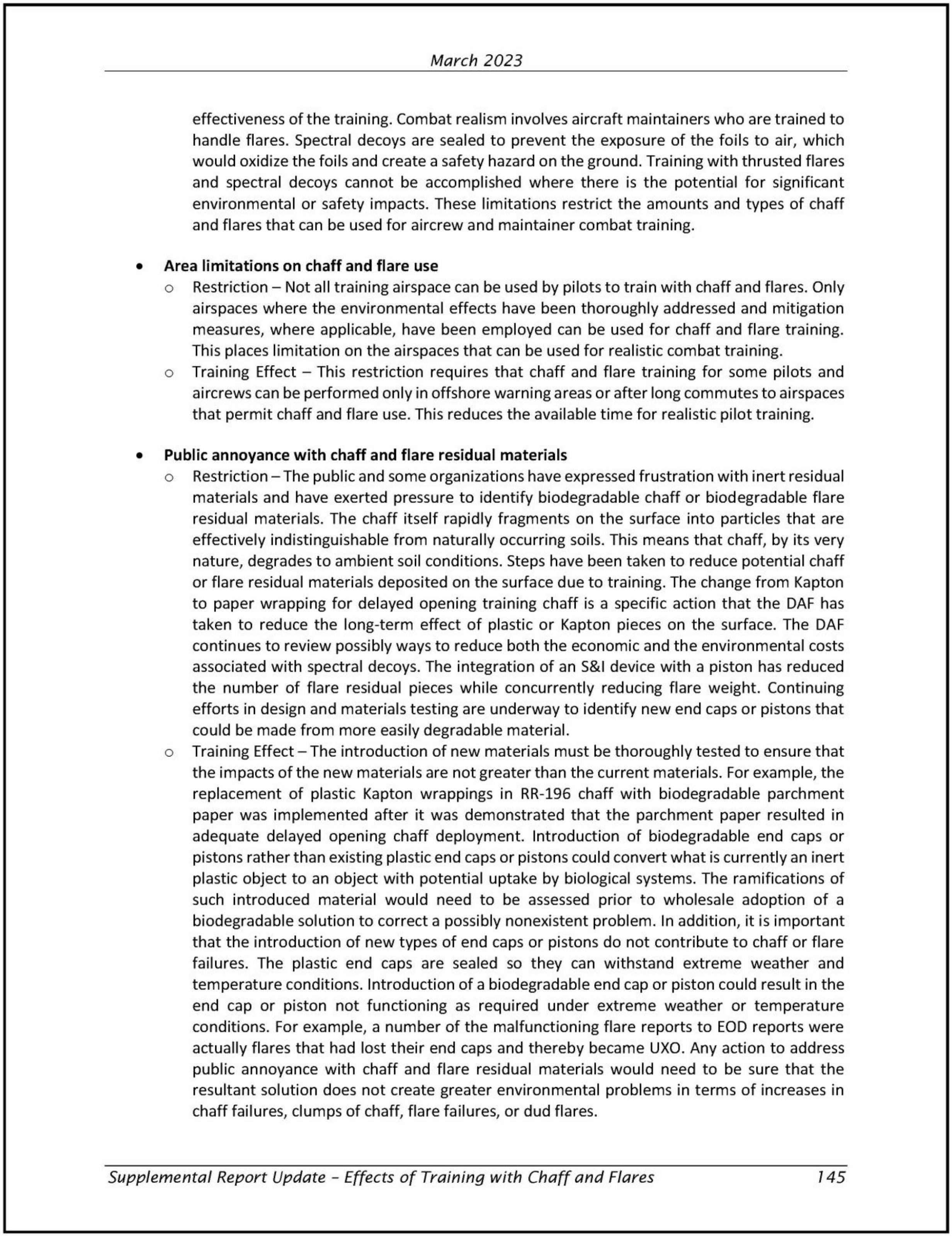
11.0 POTENTIAL EFFECTS OF POLICIES, REGULATIONS, AND MANAGEMENT ACTIONS ON MISSION TRAINING

Military defensive countermeasures provide a degree of protection to aircraft from IR-guided missiles and from radar-guided weapons targeting the aircraft. This report has addressed chaff and flares used in training by DAF pilots in American training airspace. Pilots need to react nearly instinctively with the correct response to heat-seeking or radar-guided threats. This requires pilots to "train as they will fight" using chaff and flares as defensive countermeasures in response to simulated threats during training. The use of chaff and flares in training includes RA over active military training ranges and other training airspace that overlies government, Tribal, and private lands.

In combat, pilots and aircrews deploy chaff and flares at any altitude and over any terrain in response to threats. Training in airspace over military, public, and private land in the 50 states of the United States has restrictions that affect training as follows:

- **Altitude and seasonal limitation on flare deployment**
  - Restriction – Deployment of defensive countermeasures, specifically flares, is restricted by altitude to reduce the potential for flare-caused fires. These restrictions may apply to specific sections of a training airspace and may apply to seasons and specific fire danger levels.
  - Training Effect – In combat, pilots and aircrews are required to respond immediately to a threat using defensive countermeasures. They are not sensitive to the altitude but rather to the time-critical response to ensure aircraft safety. Fighter-bomber tactics and adversary capabilities have resulted in the need to train at altitudes at or below 500 feet AGL. Application of altitude and seasonal limitations on deployment of countermeasures reduces the realism of combat training. An increasing amount of combat training as of 2022 is below 2,000 feet AGL to permit aircraft to be lost to radar in "ground clutter" or hidden by topography. Low altitude penetration or other low altitude training flights over public or private lands would have a minimum release altitude of 2,000 feet AGL. Altitude restrictions on flare deployment may be adjusted by the local airspace manager to reflect fire conditions. Altitude restriction should effectively preclude nearly any flare caused fire. Agreed-to altitude and seasonal limitations reduce the realism of using flares for low altitude training below 2,000 feet AGL.

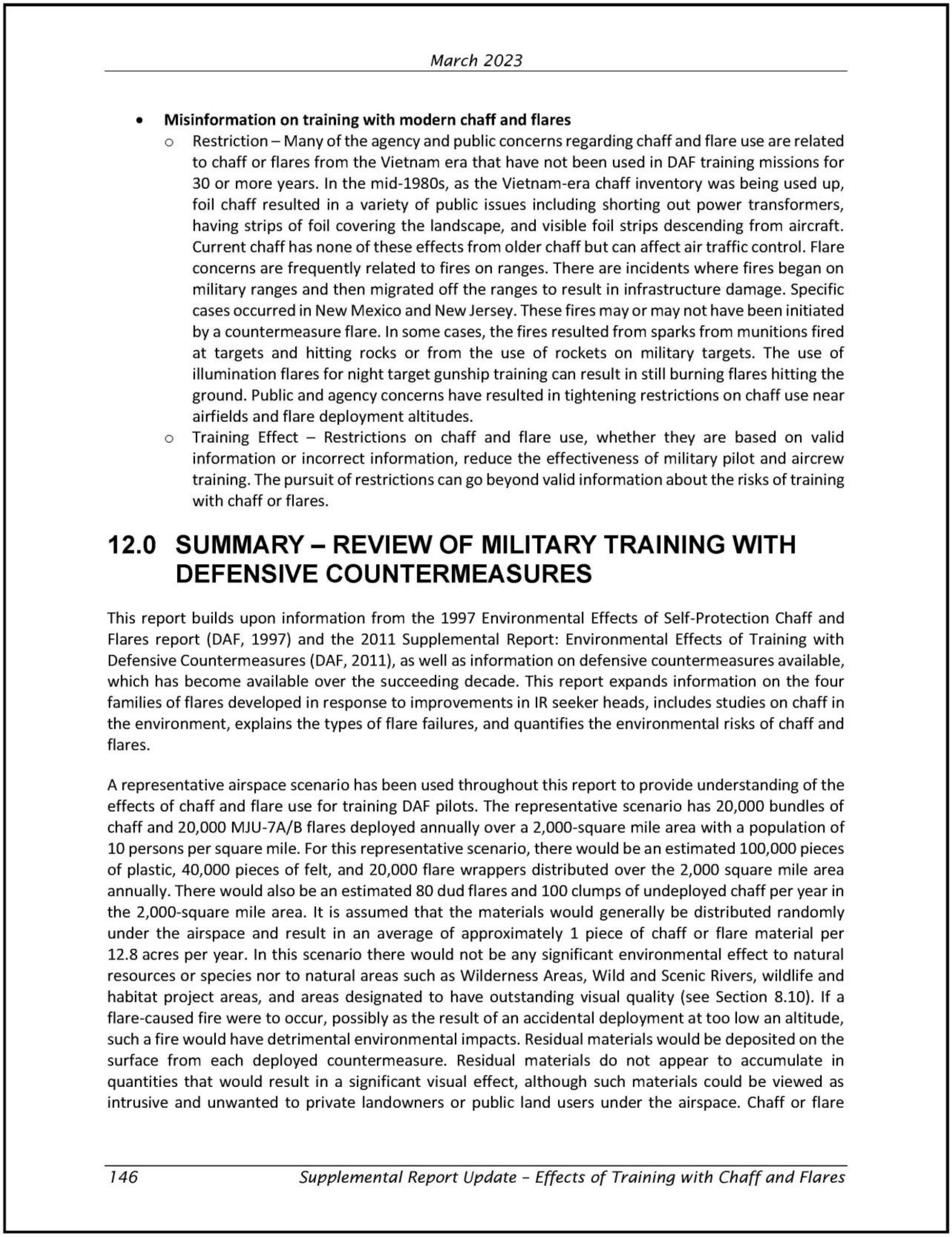
- **Limitations on the types of chaff and flares deployed during training**
  - Restriction – Chaff echoes to FAA radars require the use of training chaff rather than combat chaff. Improved FAA radars differentiate radar echoes from training chaff, and air traffic controllers are responsible to inform civil aircraft of chaff use in an area. Setback distances from airport radars somewhat address the radar echo contaminant issue. Training chaff permits pilots and aircrews to experience the use of chaff as a defensive tool but does not permit realistic engagements since opposing forces have the ability to electronically "see through" the training chaff. Standard spectral flares with a weighted nose, thrusted flares, and spectral decoys are approved for use in RAs and ranges where munitions can be deployed. Due to the environmental and safety aspects of these types of flares, they have not been approved for use in military training airspace over non-government-owned land.
  - Training Effect – Combat realism involves both aggressive and defensive maneuvers. The inability to deploy combat chaff and the restrictions on chaff deployment within specified distances of FAA radar reduce the area in which realistic training could occur and reduces the



effectiveness of the training. Combat realism involves aircraft maintainers who are trained to handle flares. Spectral decoys are sealed to prevent the exposure of the foils to air, which would oxidize the foils and create a safety hazard on the ground. Training with thrusted flares and spectral decoys cannot be accomplished where there is the potential for significant environmental or safety impacts. These limitations restrict the amounts and types of chaff and flares that can be used for aircrew and maintainer combat training.

- **Area limitations on chaff and flare use**
  - Restriction – Not all training airspace can be used by pilots to train with chaff and flares. Only airspaces where the environmental effects have been thoroughly addressed and mitigation measures, where applicable, have been employed can be used for chaff and flare training. This places limitation on the airspaces that can be used for realistic combat training.
  - Training Effect – This restriction requires that chaff and flare training for some pilots and aircrews can be performed only in offshore warning areas or after long commutes to airspaces that permit chaff and flare use. This reduces the available time for realistic pilot training.

- **Public annoyance with chaff and flare residual materials**
  - Restriction – The public and some organizations have expressed frustration with inert residual materials and have exerted pressure to identify biodegradable chaff or biodegradable flare residual materials. The chaff itself rapidly fragments on the surface into particles that are effectively indistinguishable from naturally occurring soils. This means that chaff, by its very nature, degrades to ambient soil conditions. Steps have been taken to reduce potential chaff or flare residual materials deposited on the surface due to training. The change from Kapton to paper wrapping for delayed opening training chaff is a specific action that the DAF has taken to reduce the long-term effect of plastic or Kapton pieces on the surface. The DAF continues to review possibly ways to reduce both the economic and the environmental costs associated with spectral decoys. The integration of an S&I device with a piston has reduced the number of flare residual pieces while concurrently reducing flare weight. Continuing efforts in design and materials testing are underway to identify new end caps or pistons that could be made from more easily degradable material.
  - Training Effect – The introduction of new materials must be thoroughly tested to ensure that the impacts of the new materials are not greater than the current materials. For example, the replacement of plastic Kapton wrappings in RR-196 chaff with biodegradable parchment paper was implemented after it was demonstrated that the parchment paper resulted in adequate delayed opening chaff deployment. Introduction of biodegradable end caps or pistons rather than existing plastic end caps or pistons could convert what is currently an inert plastic object to an object with potential uptake by biological systems. The ramifications of such introduced material would need to be assessed prior to wholesale adoption of a biodegradable solution to correct a possibly nonexistent problem. In addition, it is important that the introduction of new types of end caps or pistons do not contribute to chaff or flare failures. The plastic end caps are sealed so they can withstand extreme weather and temperature conditions. Introduction of a biodegradable end cap or piston could result in the end cap or piston not functioning as required under extreme weather or temperature conditions. For example, a number of the malfunctioning flare reports to EOD reports were actually flares that had lost their end caps and thereby became UXO. Any action to address public annoyance with chaff and flare residual materials would need to be sure that the resultant solution does not create greater environmental problems in terms of increases in chaff failures, clumps of chaff, flare failures, or dud flares.



- **Misinformation on training with modern chaff and flares**
    - Restriction – Many of the agency and public concerns regarding chaff and flare use are related to chaff or flares from the Vietnam era that have not been used in DAF training missions for 30 or more years. In the mid-1980s, as the Vietnam-era chaff inventory was being used up, foil chaff resulted in a variety of public issues including shorting out power transformers, having strips of foil covering the landscape, and visible foil strips descending from aircraft. Current chaff has none of these effects from older chaff but can affect air traffic control. Flare concerns are frequently related to fires on ranges. There are incidents where fires began on military ranges and then migrated off the ranges to result in infrastructure damage. Specific cases occurred in New Mexico and New Jersey. These fires may or may not have been initiated by a countermeasure flare. In some cases, the fires resulted from sparks from munitions fired at targets and hitting rocks or from the use of rockets on military targets. The use of illumination flares for night target gunship training can result in still burning flares hitting the ground. Public and agency concerns have resulted in tightening restrictions on chaff use near airfields and flare deployment altitudes.
    - Training Effect – Restrictions on chaff and flare use, whether they are based on valid information or incorrect information, reduce the effectiveness of military pilot and aircrew training. The pursuit of restrictions can go beyond valid information about the risks of training with chaff or flares.

12.0 SUMMARY – REVIEW OF MILITARY TRAINING WITH DEFENSIVE COUNTERMEASURES

This report builds upon information from the 1997 Environmental Effects of Self-Protection Chaff and Flares report (DAF, 1997) and the 2011 Supplemental Report: Environmental Effects of Training with Defensive Countermeasures (DAF, 2011), as well as information on defensive countermeasures available, which has become available over the succeeding decade. This report expands information on the four families of flares developed in response to improvements in IR seeker heads, includes studies on chaff in the environment, explains the types of flare failures, and quantifies the environmental risks of chaff and flares.

A representative airspace scenario has been used throughout this report to provide understanding of the effects of chaff and flare use for training DAF pilots. The representative scenario has 20,000 bundles of chaff and 20,000 MJU-7A/B flares deployed annually over a 2,000-square mile area with a population of 10 persons per square mile. For this representative scenario, there would be an estimated 100,000 pieces of plastic, 40,000 pieces of felt, and 20,000 flare wrappers distributed over the 2,000 square mile area annually. There would also be an estimated 80 dud flares and 100 clumps of undeployed chaff per year in the 2,000-square mile area. It is assumed that the materials would generally be distributed randomly under the airspace and result in an average of approximately 1 piece of chaff or flare material per 12.8 acres per year. In this scenario there would not be any significant environmental effect to natural resources or species nor to natural areas such as Wilderness Areas, Wild and Scenic Rivers, wildlife and habitat project areas, and areas designated to have outstanding visual quality (see Section 8.10). If a flare-caused fire were to occur, possibly as the result of an accidental deployment at too low an altitude, such a fire would have detrimental environmental impacts. Residual materials would be deposited on the surface from each deployed countermeasure. Residual materials do not appear to accumulate in quantities that would result in a significant visual effect, although such materials could be viewed as intrusive and unwanted to private landowners or public land users under the airspace. Chaff or flare residual materials could be undesirable in areas specifically protected to preserve naturalness and pristine qualities. In such locations, any human-made object would be incongruous and unexpected, and people walking, camping, or hiking could be annoyed if they saw residual plastic or wrapper materials on the ground. The number and durability of residual iron foils from the use of spectral decoys during DAF training in airspace outside DAF ranges could impact human and human-used natural environments.

12.1 Discussion of Chaff

Chaff is a defensive countermeasure that disrupts radar-guided weapons targeting an aircraft. Although large numbers of chaff bundles are deployed in training, modern chaff is typically not easy to identify in the environment unless the chaff bundle fails to deploy properly, and a clump of chaff is deposited on the ground. The reasons for the difficulty in identifying chaff or chaff particles is because chaff rapidly fragments on the surface and is nearly entirely composed of silica and aluminum, two of the most abundant elements in soils. Studies to identify chaff particles and the chaff fragments on the ground have had limited success, primarily because chaff rapidly fragments in the environment and becomes indiscernible from ambient soil particles (Marr & Velasco, 2005).

The fluidized bed tests described in Appendices A and B of the 2011 report (DAF, 2011) resulted in fragmentation rates that are believed to occur as chaff descends to the ground. The majority of chaff fibers would reach the surface largely intact, with minimal formation of PM_{10} or smaller particles. Winds could result in the extensive dispersion and rapid break down of chaff fibers, which could be deposited relatively distant from the release point. Both the Arnott et al. and Cook studies demonstrated that once the chaff fibers reach ground level, considerable fragmentation occurs (Arnott et al., 2002; Cook, 2002). Given the rapid fragmentation suggested by these studies, it is likely that chaff fiber fragmentation becomes relatively complete within days of deposition. A clump of undeployed chaff undergoes the same fragmentation over a longer period. Animals have not been shown to willingly ingest or otherwise use chaff or chaff materials. No chemical risk to water or soil could occur from the amount of chaff deposited in any specific location.

12.2 Discussion of Flares

Flares must perform in a combat situation where a pilot's life and an aircraft depend on the successful deployment of the flares. Flares used for DAF pilot training are manufactured to achieve a high level of reliability. Potential flare failures are identified in this report for four cases. One failure would be the result of a flare failing to ignite and remain in the aircraft (treated at the base after the aircraft's return as UXO). A second failure would be if the flare ignited but did not deploy from the aircraft. One case of this occurring was documented in 1980 and resulted in the loss of the aircraft. A third type of failure is if the flare were deployed but burned longer than designed and reached the surface still burning. Release of a flare at too low an altitude would have the same effect but not constitute a flare failure. A fourth failure would occur if a flare were deployed by the aircraft but failed to ignite, which would result in a whole or part of a dud flare on the surface. This could occur on government land or on public or private land under training airspace authorized for flare training.

Flares undergo a series of rigorous testing processes prior to DAF acceptance of a manufactured lot. Flare testing, EOD records, and other input are the basis for this report estimating a 99.6 percent rate for flare reliability of ejection and burn. A calculated annual average of seven off-base dud flare reports were responded to by UXO personnel over a period of 14 years. Combining the approximately 541,280 flares deployed annually over lands under training airspace and a reliability rate of 99.6 percent calculates an estimated 1,704 annual flare failures that result in dud flares deposited on land under training airspace but not recovered. For the purpose of this report, a flare failure off base is assumed to be a dud flare on the surface. In the example used in this report of 20,000 flares deployed in a MOA over 2,000-square miles of land, there would be an estimated 80 dud flares deposited on the ground annually. Although dud flares are very infrequent with today's technology, unburned flares do occur on the ground under training airspace. The important environmental message for someone finding a dud flares is to leave it alone, document where it is located, and notify safety authorities. This message has been successful, with public, Tribal, and land use management representatives notifying the base so that EOD personnel can be dispatched to recover a dud flare and record the recovery.

Methods that could be used to reduce flare risks to the environment include reducing or avoiding the risk of fire. Fire risks can be greatly reduced through strict adherence to established minimum altitudes for deployment of self-protection flares. The intensity of realistic training for combat can contribute to human error where a flare could be deployed at too low an altitude and still be burning when it reached combustible material on the ground. Adherence to minimum altitudes for flare deployment based on ground and fire risk conditions substantially reduces the potential for that error or for a flare-caused fire in the environment. There is almost no discernible trace of flare ash from burning flares. A burning flare can be seen, but there is almost no detectable air or soil pollution from the number of flares potentially deployed within a training airspace.

Flare residual materials are explained in this report. Most residual materials from flares used in training fall with the force of a small hailstone (end cap or piston) or large hailstone (S&I device). Such inert flare residual materials have little environmental effect except that a piece of plastic or wrapper could be viewed as an annoyance if found on the ground. Carbon fiber of steel bodies from thrusted flares and some standard spectral flares with a weighted nose represent a potential for serious injury or death if a person were to be struck by such a residual piece from countermeasure deployment. The momentum of such objects for representative countermeasures is included in Section 8.5.1. Countermeasures, with the momentum to cause serious injury, have been restricted to testing or other deployment over ranges authorized for munitions.

Spectral decoy iron foils are light, relatively durable, and have the potential to fall to the surface within 0.25 mile of deployment at 2,000 feet AGL in a 5-mph wind to 30 to 50 or more miles from deployment at 30,000 feet AGL in a sustained 25-mph wind. When the foils settle to the surface, they could take months, possibly up to a year, or longer to break down into metal particles. Iron foils have not been studied, as has chaff, to determine how and over what duration foils remain in the environment. The thin iron foils have the potential to impact agricultural operations. The effect of foils in the marine environment is not well understood at this time; but, if the foils were seen as potential prey, they could detrimentally affect marine predators. An estimated 52 million 0.75-inch by 0.75-inch by 0.0125-inch foils were deployed during training in 2020. It is not known if these foils were distributed the average of 32 percent in warning areas over marine resources and 68 percent in training airspace over land. Iron foils deployed extensively for training throughout training airspace have the potential for diverse environmental impacts.

12.3 Warning Systems or Other Defensive Measures

Substantial power is required for warning systems and other defensive measures. Warning systems or warning receivers are designed with the ability to detect a radar or IR threat. IR missiles have a relatively short range with a distinctive motor burn, and warning receivers have been developed that permit a brief warning prior to the missile striking the aircraft. This ability to detect and track a burning rocket motor may provide seconds to react by deploying countermeasures and maneuvering to avoid the threat. IR missiles continue to account for the largest majority of aircraft lost in combat.

There are even greater complexities to achieve accurate and timely recognition of threats from air-to-air missiles. Air-to-air missiles have a much longer range than surface-to-air missiles, and the rocket motor may burn out miles from the targeted aircraft. A warning system needs to recognize and successfully track a missile body rather than an engine or exhaust signature. The targeted aircraft is required to deploy chaff to create an electronic cloud to escape the threat from radar-guided munitions.

Effective missile warning systems and power demands for alternative defensive systems will continue to be researched and may be developed for the future, but as of 2022, such alternative capabilities for aircraft defense are not technologically available. This means that chaff and flare defensive countermeasures, as described and considered in this report, will continue to be the primary defensive system for the future.

12.4 Challenges to Countermeasure Testing

Advanced warning receiver systems that need to be integrated into deployment of countermeasures present substantial challenges. As described in Section 7.7.2, there is limited ability to test a countermeasure system against real-life threats. The need to test systems places greater reliance on simulations. Simulations require valid input, which requires rigorous and costly tests to validate the countermeasures. The testing of systems will continue, as will continuing improvements in IR-seeker heads and air-to-air missiles. In response, defensive countermeasures will need to be further developed to meet the ever-changing threats. Countermeasure testing challenges include reliable input, realistic simulations, and continual evaluation to determine what constitutes an adequate testing of countermeasures.

12.5 Future Developments in Chaff

Angel hair chaff has demonstrated success against radar threats in combat. The need to continue to have viable defensive chaff has resulted in changes in chaff dipole cuts, dual chamber chaff, and chaff wrappings. This report has addressed a variety of training and combat chaff used in training airspace. The chaff used in training has some limitations on deployment to avoid interference with modern FAA or NWS radars. Potential interference with tracking and weather radars has led to chaff release setbacks from airport radars and improved communications to reduce effects from radar contaminants. Technological advances in radar targeting systems continually change the requirements for combat chaff. These changes in chaff dimensions and dispersion are expected to continue to be coordinated for training within FAA-controlled airspace.

12.6 Future Developments in Flares

The four flare families described in this report have been developed in direct response to IR-seeker head improvements. This report has focused on flares used regularly during training with DAF aircraft. The different flares considered in this report include defensive countermeasures used by aircraft, including fighters, cargo aircraft, and helicopters. Aircraft from other services generally have flare types that are comparable to the flares addressed in this report. Flares are required to be highly reliable because survival of the pilot and the aircraft depends on reliable flares that are successfully deployed.

As targeting systems continue to technologically advance, defensive countermeasures will continue to advance to provide pilots and aircraft protection in combat conditions. Flare technology considered in this Report Update are the MTV flares, standard spectral flares, thrusted flares, and spectral decoys. Each provides different defense capabilities for aircraft against technologically advancing threat systems. Residual materials and potential environmental effects of these flares are expected to be similar for future flare defensive countermeasures.

12.7 Other Countermeasures

Chaff and flares are defensive countermeasures designed to defeat radar and IR targeting systems. As explained in this report, IR seeker head capabilities and radar-guided threats are in constant conflict with enhanced countermeasures and this conflict is expected to continue into the indefinite future. Other types of defensive countermeasures including jammers, lasers, and directed energy pulses to defeat the electronics of radio transmitters or IR trackers have not yet met the technological or power demands to be used in current fighter aircraft.

Conventional radar-guided and heat-seeking missiles will continue to threaten aircraft for the foreseeable future. There will continue to be advancements in missiles and technological developments to counter such missiles. The requirement for training to near instantly deploy chaff and flare countermeasures to defeat IR and radar-guided weapons will continue to be a part of DAF pilot training well into the future.

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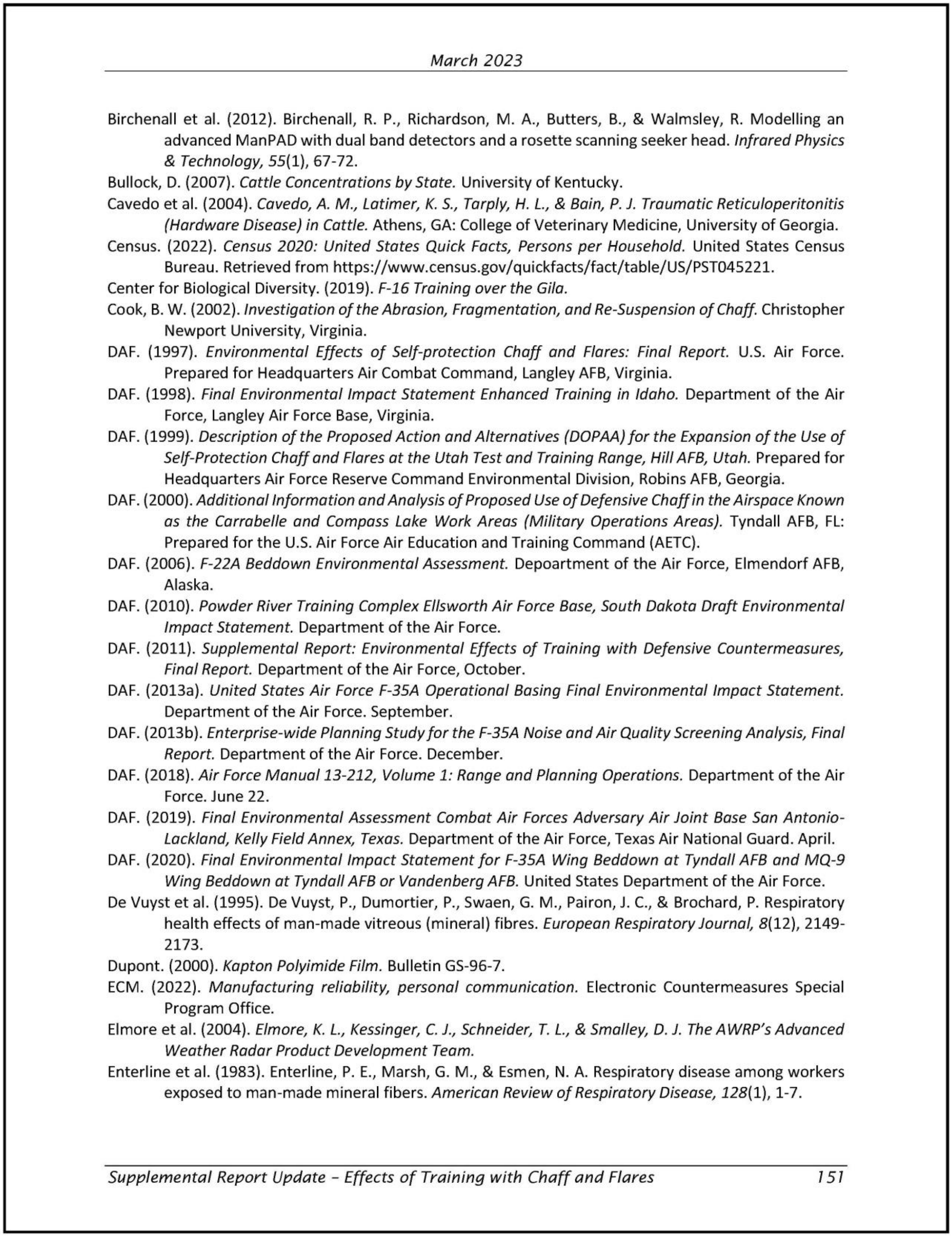

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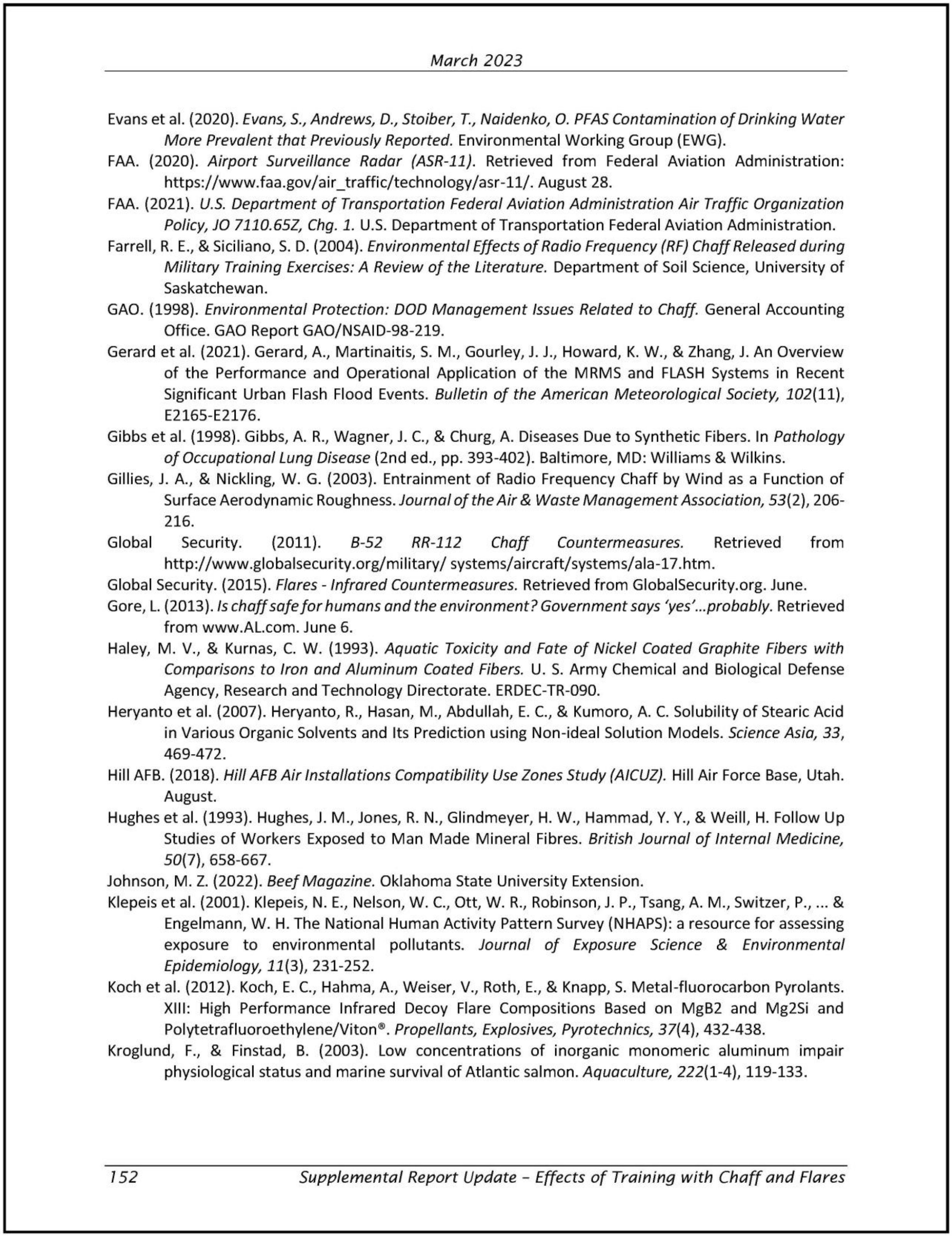

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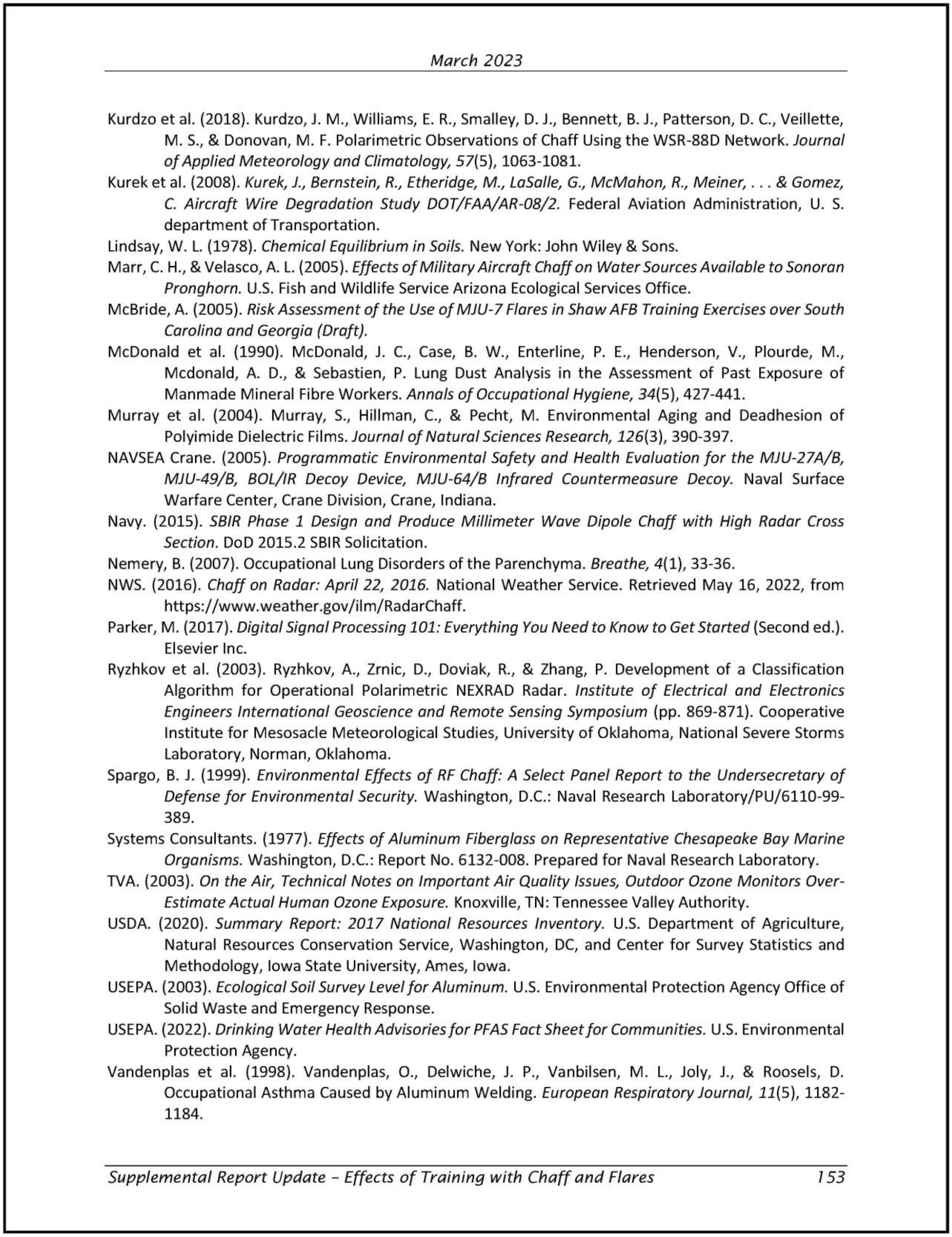

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APPENDIX B
INTERAGENCY CORRESPONDENCE AND PUBLIC INVOLVEMENT

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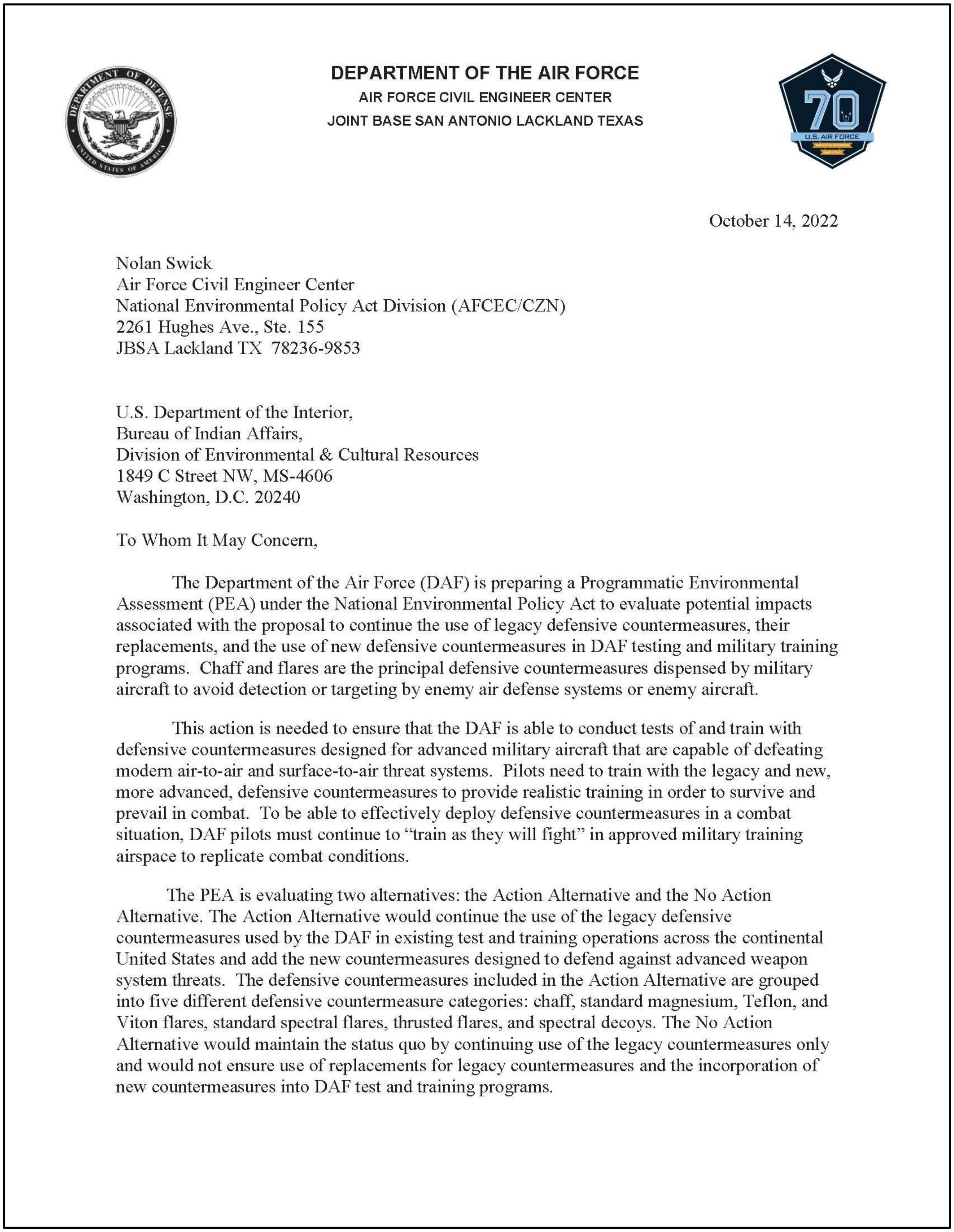
B.1 SCOPING LETTER EXAMPLE



DEPARTMENT OF THE AIR FORCE
AIR FORCE CIVIL ENGINEER CENTER
JOINT BASE SAN ANTONIO LACKLAND TEXAS

October 14, 2022

Nolan Swick
Air Force Civil Engineer Center
National Environmental Policy Act Division (AFCEC/CZN)
2261 Hughes Ave., Ste. 155
JBSA Lackland TX 78236-9853

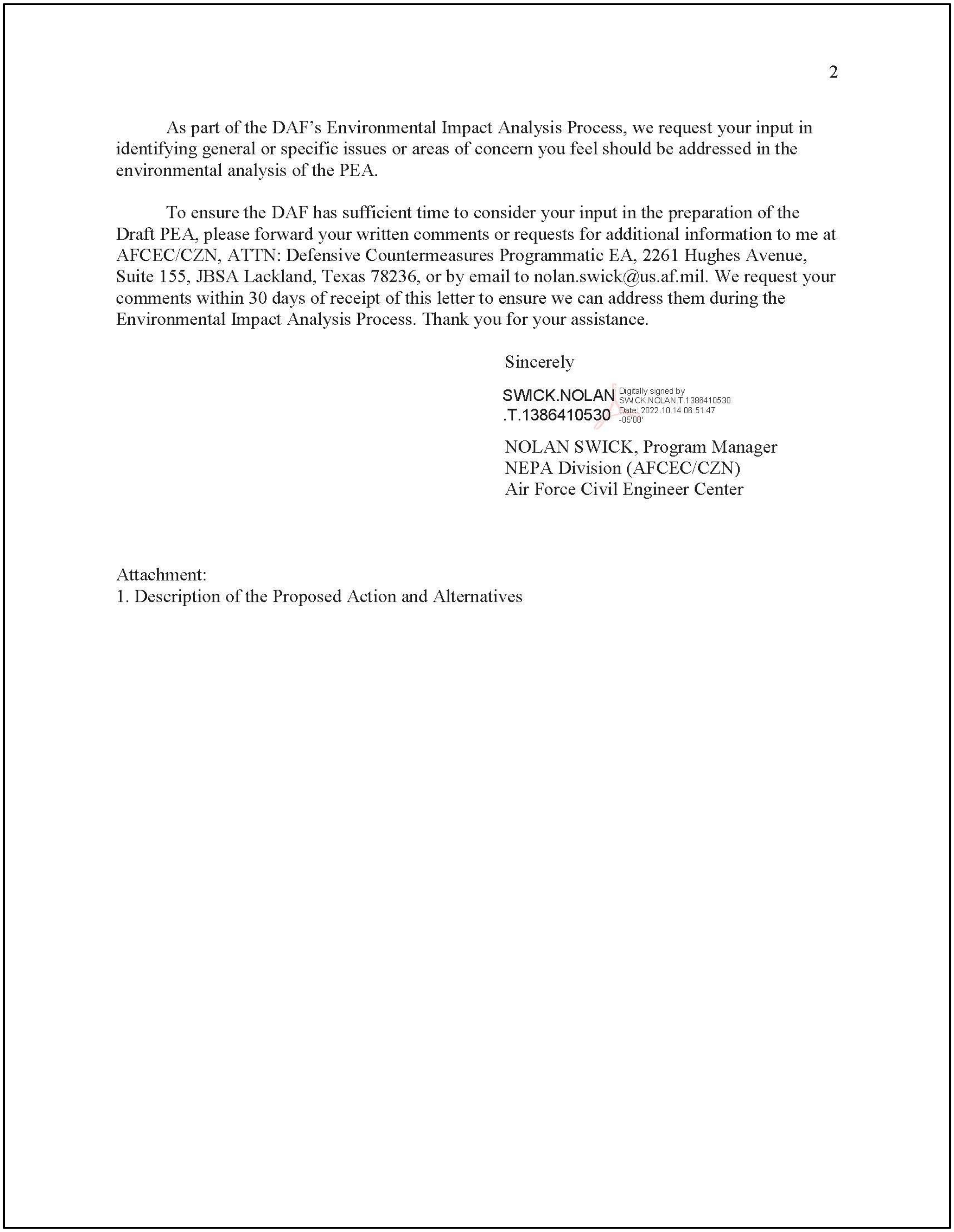
U.S. Department of the Interior,
Bureau of Indian Affairs,
Division of Environmental & Cultural Resources
1849 C Street NW, MS-4606
Washington, D.C. 20240

To Whom It May Concern,

The Department of the Air Force (DAF) is preparing a Programmatic Environmental Assessment (PEA) under the National Environmental Policy Act to evaluate potential impacts associated with the proposal to continue the use of legacy defensive countermeasures, their replacements, and the use of new defensive countermeasures in DAF testing and military training programs. Chaff and flares are the principal defensive countermeasures dispensed by military aircraft to avoid detection or targeting by enemy air defense systems or enemy aircraft.

This action is needed to ensure that the DAF is able to conduct tests of and train with defensive countermeasures designed for advanced military aircraft that are capable of defeating modern air-to-air and surface-to-air threat systems. Pilots need to train with the legacy and new, more advanced, defensive countermeasures to provide realistic training in order to survive and prevail in combat. To be able to effectively deploy defensive countermeasures in a combat situation, DAF pilots must continue to "train as they will fight" in approved military training airspace to replicate combat conditions.

The PEA is evaluating two alternatives: the Action Alternative and the No Action Alternative. The Action Alternative would continue the use of the legacy defensive countermeasures used by the DAF in existing test and training operations across the continental United States and add the new countermeasures designed to defend against advanced weapon system threats. The defensive countermeasures included in the Action Alternative are grouped into five different defensive countermeasure categories: chaff, standard magnesium, Teflon, and Viton flares, standard spectral flares, thrusted flares, and spectral decoys. The No Action Alternative would maintain the status quo by continuing use of the legacy countermeasures only and would not ensure use of replacements for legacy countermeasures and the incorporation of new countermeasures into DAF test and training programs.



As part of the DAF's Environmental Impact Analysis Process, we request your input in identifying general or specific issues or areas of concern you feel should be addressed in the environmental analysis of the PEA.

To ensure the DAF has sufficient time to consider your input in the preparation of the Draft PEA, please forward your written comments or requests for additional information to me at AFCEC/CZN, ATTN: Defensive Countermeasures Programmatic EA, 2261 Hughes Avenue, Suite 155, JBSA Lackland, Texas 78236, or by email to nolan.swick@us.af.mil. We request your comments within 30 days of receipt of this letter to ensure we can address them during the Environmental Impact Analysis Process. Thank you for your assistance.

Sincerely

SWICK.NOLAN.T.1386410530 Digitally signed by SWICK.NOLAN.T.1386410530 Date: 2022.10.14 06:51:47 -05'00'

NOLAN SWICK, Program Manager
NEPA Division (AFCEC/CZN)
Air Force Civil Engineer Center

Attachment:
1. Description of the Proposed Action and Alternatives

B.2 SCOPING LETTER NOTIFICATION LIST

NATIONAL FEDERAL AGENCY OFFICES

U.S. Department of Transportation, Federal Aviation Administration
Michael Lamprecht
Environmental Protection Specialist
800 Independence Avenue, SW
Washington, DC 20591

U.S. Department of Commerce, National Ocean and Atmospheric Administration, NOAA
Fisheries Directorate
Brianne Szczepanek
Chief of Staff
1315 East-West Highway, 14th Floor
Silver Spring, MD 20910

U.S. Environmental Protection Agency
Alison Cassady
Deputy Chief of Staff for Policy
1200 Pennsylvania Avenue, NW
Washington, DC 20460

U.S. Department of the Interior, Fish and Wildlife Service
Gary Frazer
Assistant Director, Ecological Services
1849 C Street, NW
Washington, DC 20240

U.S. Department of the Interior, Bureau of Land Management National Office
David Jenkins
Resources and Planning
1849 C Street, NW, Rm 5665
Washington, DC 20240

U.S. Department of the Interior, Bureau of Indian Affairs, Division of Environmental & Cultural Resources
1849 C Street NW, MS-4606
Washington, DC 20240

U.S. Department of Agriculture, United States Forest Service National Office
Jim Smalls
Assistant Director, Ecosystem Management Coordination (NEPA, Administrative Review, Litigation)
1400 Independence Ave., SW, Mailstop Code 1104
Washington, DC 20250-1104

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APPENDIX C
RESOURCE DEFINITIONS AND METHODOLOGY FOR ANALYSIS

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APPENDIX C RESOURCE DEFINITIONS AND METHODOLOGY FOR ANALYSIS

C.1 SAFETY

C.1.1 Resource Definition

The analysis of safety evaluates whether a Proposed Action would have the potential to affect the safety or well-being of members of the public. A safe environment is one in which there is no, or optimally reduced, potential for death, serious bodily injury or illness, or property damage. The primary goal is to identify and prevent potential accidents or impacts to the general public. The affected environment for safety encompasses the airspace associated with the Proposed Action and alternatives and the land area beneath that airspace.

This analysis evaluates flight safety impacts from operations within existing training airspaces. Proposed activities include the use of legacy defensive countermeasures, their replacements, and new defensive countermeasure items. The primary flight safety issues related to chaff deployment are the potential to interfere with Air Traffic Control RADAR and the risk of residual materials striking property or the public.

Countermeasure flares are pyrotechnic devices used to defend against heat-seeking missiles, where the missile seeks out the heat signature from the flare rather than the aircraft’s engines. The primary impacts associated with flare use are the remote potential for wildland fires to occur as a result of burning flares reaching the ground and the potential for residual materials to strike persons or property.

Ground safety assesses safety issues related to day-to-day handling operations of defensive countermeasures, which evaluates whether procedures to minimize hazards to workers and are completed in accordance with required safety standards.

C.1.2 Regulatory Setting

Flight safety is based on the physical risks associated with aircraft flight. A variety of Department of the Air Force (DAF) regulations govern the various aspects of safety. In addition, military aircraft fly in accordance with Federal Aviation Administration (FAA) regulations at 14 Code of Federal Regulations (CFR) Part 91 (General Operating and Flight Rules), which govern such things as operating near other aircraft, right-of-way rules, aircraft speed, and minimum safe altitudes. These rules include the use of testing and training flight areas, arrival and departure routes, and airspace restrictions as appropriate to help control air operations. A variety of federal and DAF regulations address and govern day-to-day ground safety at military installations and are summarized below:

- The Occupational Safety and Health Act is the primary federal law that governs occupational health and safety in the private sector and federal government in the United States. Its main goal is to ensure that employers provide employees with an environment free from recognized hazards, such as exposure to toxic chemicals, excessive noise levels, mechanical dangers, heat or cold stress, or unsanitary conditions. (Note: Under Title 29

CFR 1960 series, Occupational Safety and Health Administration [OSHA] standards do not apply to military-unique workplaces, operations, equipment, and systems. However, according to Department of Defense [DoD] Instruction [DoDI], they will be followed insofar as is possible, practicable, and consistent with military requirements.)

- DoDI 6055.1, *DoD Safety and Occupational Health Program*, dated October 2014, establishes occupational safety and health guidance for managing and controlling health and safety risks for DoD personnel and operations worldwide during peacetime and military deployments. It specifically addresses risk management, aviation safety, ground safety, radiation safety, traffic safety, occupational safety, and occupational health.
- Air Force Manual (AFMAN) 91-203, *Air Force Occupational Safety, Fire and Health Standards*, updated September 2019, implements applicable OSHA requirements related to occupational safety, fire prevention, and health regulations governing DAF activities and procedures associated with safety in the workplace.

C.1.3 Methodology

C.1.3.1 Flight Safety

Flight safety is based on the physical risks associated with aircraft flight. In addition to the regulatory drivers presented above, military aircraft fly in accordance with FAA Regulations Part 91, *General Operating and Flight Rules*, which govern such things as operating near other aircraft, right-of-way rules, aircraft speed, and minimum safe altitudes. These rules include the use of testing and training flight areas, and airspace restrictions as appropriate, to help control air operations.

There is no generally recognized threshold of flight safety that defines acceptable or unacceptable conditions. Instead, the focus of airspace managers is to reduce risks through numerous measures. These include, but are not limited to, providing and disseminating information to airspace users, setting appropriate standards for equipment performance and maintenance, defining rules governing the use of airspace, and assigning appropriate and well-defined responsibilities to the users and managers of the airspace.

The DAF values safety and professionalism and has adopted many measures to promote aviation safety. All personnel are provided continuous safety training throughout their career with the DAF. Specifically, all DAF pilots use state-of-the-art simulators for training purposes that include all facets of flight operations and comprehensive emergency (such as mechanical failure or bird strike) response procedures that minimize the mishap risks associated with pilot error.

C.1.3.2 Ground Safety

The DAF implements OSHA standards through DoDI 6055.1 and AFI 91-203. In addition, the Air Force Safety Center has developed the Air Force Occupational and Environmental Safety, Fire Protection, and Health (AFOSH) standards to supplement OSHA standards to ensure worker safety. The goal is to ensure that all guidance complies with OSHA and other federal standards and incorporates “lessons learned” and appropriate parts of consensus standards to provide the supervisor and worker with the tools to prevent mishaps.

Day-to-day operations at the installation are conducted in accordance with applicable DAF safety regulations, published DAF Technical Orders, and standards prescribed by AFOSH requirements. Maintenance crews are also highly trained to perform preventative maintenance actions, maintenance repairs, diagnostic testing of the repair, and inspections on each component of the countermeasures systems in accordance with DAF regulations.

C.2 AIR QUALITY

C.2.1 Resource Definition

Air quality relates to the presence of pollutants in the air. The United States Environmental Protection Agency (USEPA) has determined that certain pollutants raise a concern for the health and welfare of the public. The major pollutants of concern, called “criteria pollutants,” are carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone, particulate matter with a diameter less than or equal to 10 microns, and particulate matter with a diameter less than or equal to 2.5 microns, and lead. USEPA has established National Ambient Air Quality Standards (NAAQS) for these pollutants (USEPA, 2020).

Ambient air quality refers to how much a pollutant is concentrated in the air at a particular geographic location. Ambient air quality concentrations are generally reported as an amount of pollutant per unit of air (such as micrograms per cubic meter of air) or as a volume fraction of the air (e.g., parts per million). The ambient air quality concentrations at a particular location are determined by the interactions of air emissions, weather, and chemistry. Emission considerations include the types, amounts, and locations of pollutants emitted into the atmosphere. Meteorological (weather) considerations include wind and precipitation patterns affecting the distribution, dilution, and removal of pollutant emissions. Chemical reactions can transform pollutant emissions into other chemical substances.

The potential effects of greenhouse gas emissions from the Proposed Action are by nature global. Given the global nature of climate change and the current state of the science, it is not useful at this time to attempt to link the emissions quantified for local actions to any specific climatological change or resulting environmental impact. Nonetheless, the greenhouse gas emissions from the Proposed Action and alternatives have been quantified to the extent feasible in this Programmatic Environmental Assessment (PEA) for information and comparison purposes, including possible reasoned choices among alternatives.

C.2.2 Regulatory Framework

The DAF must comply with all applicable requirements under the Clean Air Act.

C.2.2.1 Hazardous Air Pollutants

In addition to the NAAQS for criteria pollutants, national standards exist for hazardous air pollutants. These are regulated under Section 112(b) of the 1990 Clean Air Act Amendments.

Aircraft gas turbine engines burn fuel more efficiently than most mobile sources. Because most fuel is consumed at higher power settings and most operational time is spent at cruising speed, greater than 99 percent of fuel undergoes complete combustion and is efficiently converted to carbon dioxide and water. Hazardous air pollutant emissions are greatest under idle conditions when the engines are operating in a less efficient cycle (USEPA and FAA, 2009). Idle conditions would not occur within the airspace associated with the Proposed Action. Therefore, hazardous air pollutants are not addressed further in this PEA.

C.2.2.2 General Conformity Rule

USEPA designates an area as in attainment when it complies with the NAAQS. Areas that violate these ambient air quality standards are designated as nonattainment areas. Areas that have improved air quality from nonattainment to attainment are designated as attainment and/or maintenance areas. Areas that lack monitoring data to demonstrate attainment or nonattainment status are designated as unclassified and are treated as attainment areas for regulatory purposes. When an area is designated in nonattainment and/or in maintenance, Clean Air Act Section 176(c), the General Conformity Rule, is applied. The intent of this rule is to ensure that federal actions do not adversely affect the timely attainment of air quality standards in areas of nonattainment or maintenance.

C.2.3 Analysis Methodology

The first step in the analysis of potential impacts to air quality for this PEA was to document the affected air environments and environmental consequences of testing and training use of legacy chaff and flares as evaluated in the prior National Environmental Policy Act (NEPA) documents for the representative environments under the airspaces authorized for their use. The representative documents relied upon emission factors from the Air Emissions Guide for Air Force Stationary Sources (June 2020) for Munitions Open Burn/Open Detonation of Aircraft Countermeasures Flare (M206) and guidance provided by Air Force Civil Engineering Center, Environmental Quality Technical Support Branch. The previous analyses incorporated by reference clearly show all emissions from hazardous air pollutant and toxic chemical emissions associated with flares are too insignificant to include in any air quality impact assessment because they would not register in an impact assessment (i.e., value will show up as 0.0 ton/year) (Solutio Environmental, Inc., 2022).

Also based on the previous studies (DAF, 1997; DAF, 2011; Appendix A), it can be concluded that there is little to no risk of chaff breaking apart in the air to the size of inhalable particles before being deposited on the ground. Furthermore, chaff is rapidly fragmented after it settles to the ground and becomes indiscernible from ambient soil materials.

Potential impacts to air quality are evaluated with respect to the extent, context, and intensity of the impact in relation to relevant regulations, guidelines, and scientific documentation. Council on Environmental Quality (CEQ) regulations require that the significance of an action be analyzed with respect to the setting of the action and be based relative to the severity of the impact. Impact analysis for use of new chaff and flares was next conducted by comparing the legacy countermeasure items with the new chaff and flare items and identifying where the new flare effects were essentially the same as the legacy effects analyzed in the prior representative NEPA and technical documents incorporated by reference. Those flare items that are substantially different from the flares previously evaluated, specifically the spectral decoys and the oxidization of their foils, are evaluated in the context of qualitative effects of those foils on air quality, based on prior quantitative analysis of legacy flares demonstrating that flares cannot be used in sufficient quantities for their emissions to affect air quality.

C.3 SOILS AND WATER RESOURCES

C.3.1 Resource Definition

Soil refers to unconsolidated earthen materials overlying bedrock or other parent material. Soil structure, elasticity, strength, shrink-swell potential, and erodibility determine the ability for the ground to support structures and facilities. Soils are typically described in terms of their type, slope, physical characteristics, and relative compatibility or limitations with regard to particular construction activities and types of land use.

Water resources include surface water, groundwater, and floodplains. Surface water resources include lakes, rivers, and streams, and are important for a variety of reasons, including economic, ecological, recreational, and human health factors. Groundwater includes the subsurface hydrologic resources of the physical environment; its properties are often described in terms of depth to aquifer or water table, water quality, and surrounding geologic composition. Floodplains are lowland areas adjacent to surface waterbodies where flooding events periodically cover areas with water. Wetlands are commonly included in analysis of water resources; however, in this document, wetlands are addressed in biological resources analysis (PEA Section 3.5).

For the purposes of this analysis of soil and water resources, the region of influence (ROI) for the Proposed Action and the No Action Alternative, includes the areas beneath test and training airspaces where DAF aircraft operate, including any overwater Warning Areas or Test and Training Ranges (e.g., Eglin Gulf Test Range in the Gulf of Mexico).

C.3.2 Regulatory Setting

The Clean Water Act (CWA) of 1972 (33 United States Code [U.S.C.] 1251 et seq.) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. Pollutants regulated under the CWA include “priority” pollutants, which include various toxic chemicals, and other pollutants such as nutrients, total suspended solids, fecal coliform, oil and grease, and pH (a measure of the acidity or basicity of water). The National Pollutant Discharge Elimination System permit program, created in 1972 by the CWA, helps address water pollution by regulating point sources that discharge pollutants to waters of the United States. The permit provides two levels of control: technology-based limits and water quality-based limits (if technology-based limits are not sufficient to provide protection of the waterbody).

Section 303(d) of the CWA requires states to identify waters where current pollution control technologies alone cannot meet the water quality standards set for that waterbody. Every two years, states are required to submit a list of impaired waters plus any that may soon become impaired to USEPA for approval. The impaired waters are prioritized based on the severity of the pollution and the designated use of the waterbody (e.g., fish propagation or human recreation). States must establish the total maximum daily load(s) of the pollutant(s) in the waterbody for impaired waters on their list.

C.3.3 Methodology

Criteria for evaluating impacts related to soil resources associated with the continued use of legacy defensive countermeasures and the use of replacements, and of new countermeasures items identified in Appendix A, are impacts to unique soil resources, and contamination of soils with residual materials from the deployment of chaff and flares.

Criteria for evaluating impacts related to water resources associated with the continued use of legacy defensive countermeasures and the use of replacements, and of new countermeasures items identified in Appendix A, are water availability, water quality, and adherence to applicable regulations. Impacts are measured by the potential to endanger public health or safety by creating or worsening health hazards or safety conditions, or violate laws or regulations adopted to protect or manage water resources.

Groundwater impacts are evaluated by determining if groundwater resources beneath the training airspace would be potentially affected.

C.4 BIOLOGICAL RESOURCES

C.4.1 Resource Definition

Biological resources include the native and introduced terrestrial and aquatic plants and animals found under, or that migrate through, the airspaces approved for DAF training with chaff and flares. Biological resources for a programmatic NEPA analysis are considered in the context of representative species and specific species, including sensitive species, which are identified and evaluated in the different NEPA documents that are the basis for the affected environment and environmental consequences in this PEA. The referenced NEPA documents explain the habitat types based on floral, faunal, and geophysical characteristics under training airspace.

NEPA review typically concerns environmental effects over a large geographic and/or time horizon; therefore, the depth and detail in programmatic analyses reflects the major broad and general impacts that might result from making broad programmatic decisions. The explained biological resources and potential environmental effect to those resources can be used for broad, high-level, or sequenced decisions which allow the DAF to subsequently tier in order to analyze biological effects for narrower, site-, or proposal-specific issues. Identifying potential impacts early for the representative training airspace biological resources permits NEPA reviews the opportunity to modify program components in order to avoid or mitigate adverse impacts when developing subsequent proposals for deployment of legacy and new chaff and flare countermeasures.

C.4.2 Regulatory Setting

The separate NEPA documents used for the representative analysis in this PEA consider sensitive species which are subject to regulations under the authority of federal (United States Fish and

Wildlife Service [USFWS] and National Marine Fisheries Service) and state agencies. Sensitive species include species designated as threatened, endangered, or candidate species by state or federal agencies. Under the Endangered Species Act (ESA) (16 U.S.C. 1536), an endangered species is defined as any species in danger of extinction throughout all or a significant portion of its range. A threatened species is defined as any species likely to become an endangered species in the foreseeable future. Candidate species are those species for which the USFWS has sufficient information on their biological status and threats to propose them as endangered or threatened under the ESA, but for which development of a proposed listing regulation is precluded by other higher-priority listing activities. Although candidate species receive no statutory protection under the ESA, the USFWS believes it is important to advise government agencies, industry, and the public that these species are at risk and could warrant protection under the ESA.

The NEPA documents incorporated an analysis based on the Migratory Bird Treaty Act of 1918 (16 U.S.C. 703-712), which is the domestic law that affirms, or implements, the United States' commitment to four international conventions (with Canada, Japan, Mexico, and Russia) for the protection of a shared migratory bird resource. Each of the conventions protect selected species of birds that are common to both countries (i.e., species occur in both countries at some point during their annual life cycle). The act protects all migratory birds and their parts (including eggs, nests, and feathers).

The NEPA representative documentation incorporated an analysis of the Bald and Golden Eagle Protection Act (BGEPA) (16 U.S.C. 668-668d), which is legislation in the United States that protects two species of eagles. The BGEPA prohibits anyone without a permit issued by the Secretary of the Interior from "taking" bald eagles. Taking involves molesting or disturbing birds, their parts, nests, or eggs. The BGEPA prescribes criminal penalties for persons who "take, possess, sell, purchase, barter, offer to sell, purchase or barter, transport, export or import, at any time or any manner, any bald or golden eagles... [or any golden eagle], alive or dead, or any part, nest, or egg thereof."

The NEPA documentation addressed species covered under the Marine Mammal Protection Act (MMPA) which is a statute enacted in 1972 by the United States to protect marine mammals and their habitat. The MMPA prohibits the "taking" of marine mammals, and enacts a moratorium on the import, export, and sale of any marine mammal, along with any marine mammal part or product within the United States. The Act defines "take" as "the act of hunting, killing, capture, and/or harassment of any marine mammal; or the attempt at such." The MMPA defines harassment as "any act of pursuit, torment or annoyance which has the potential to either: a) injures a marine mammal in the wild, or b) disturbs a marine mammal by causing disruption of behavioral patterns, which includes, but is not limited to, migration, breathing, nursing, breeding, feeding, or sheltering."

The NEPA analysis used in this PEA incorporates an analysis based on Executive Order (EO) 11990, *Protection of Wetlands*, which requires federal agencies, including the DAF, to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands. EO 11990 requires federal agencies to avoid, to the extent possible, the long- and short-term, adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative; if construction in wetlands cannot be avoided, the DAF would issue a Finding of No Practicable Alternative.

C.4.3 Methodology

The first step in the analysis of potential impacts to biological resources for this PEA was to document the affected biological environments and environmental consequences of testing and training use of legacy chaff and flares as evaluated in the prior NEPA documents for the representative environments under the airspaces authorized for their use. The representative documents identified sensitive habitats and species associated with each airspace. As explained in Appendix A, scientific literature was reviewed for studies that examined similar types of chaff or flare effects to biological resources. Where available, information was also gathered relative to ongoing management actions which affect the potential for impacts to biological resources. Impact analysis was next conducted by comparing the legacy countermeasure items with the new chaff and flare items and identifying where the new flare effects were essentially the same as the legacy effects analyzed in the prior representative NEPA and technical documents incorporated by reference. The new chaff and flares would be subject to the same management actions to avoid and/or reduce adverse impacts to biological resources which resulted in biological “no effect” or “may affect, but not likely to adversely affect” determinations for species under the airspaces.

Those flare items that are substantially different from the flares previously evaluated, specifically the spectral decoys and their residual oxidized foils, are evaluated in the context of qualitative effects of those foils on biological resources in woodlands, desert and arid regions, agricultural areas, oceans, wetlands, and grasslands.

C.5 CULTURAL RESOURCES

C.5.1 Resource Definition

Cultural resources are any prehistoric or historic district, site, building, structure, or object considered important to a culture, subculture, or community for scientific, traditional, religious, or other purposes. They include archaeological resources, historic architectural resources, and traditional cultural resources. Archaeological resources are locations where prehistoric or historic activity measurably altered the earth or produced deposits of physical remains (e.g., arrowheads, bottles). Historic architectural resources include standing buildings and other structures of historic or aesthetic significance. Architectural resources generally must be more than 50 years old to be considered for inclusion in the National Register of Historic Places; however, more recent structures, such as Cold War–era resources, may warrant protection if they have the potential to gain significance in the future and are considered extraordinary in nature. Traditional cultural properties are associated with cultural practices and beliefs of a living community that are rooted in its history and are important in maintaining the continuing cultural identity of the community. Historic properties (as defined in 36 CFR 60.4 and 36 CFR 800.15(l)(1)) are significant archaeological, architectural, or traditional resources that are defined as eligible for listing in the National Register of Historic Places.

C.5.2 Regulatory Setting

As a federal agency, the DAF is required to consider the effects their actions may have on historic properties. These requirements are considered under AFMAN 32-7003 and the National Historic Preservation Act (NHPA) of 1966, as amended. The NHPA of 1966 sets federal policy for managing historic properties. Federal agencies must identify historic properties and consult with the Advisory Council on Historic Preservation and State Historic Preservation Officer as necessary (AFMAN 32-7003). Section 106 of the NHPA specifically requires that federal agencies analyze the impacts of federal activities on historic properties. NHPA obligations for a federal agency are independent from NEPA and must be complied with even when an environmental document is not required.

The DoD published the *American Indian and Alaska Native Policy* in 1999, and DoDI 4710.02 in 2006. Both of these emphasize the importance of respecting and consulting with tribal governments on a government-to-government basis. The policy requires that before decisions are made, an assessment should be conducted through consultation of proposed DoD actions that may have the potential to affect protected tribal resources, tribal rights, and Indian lands significantly. The DAF implements DoDI 4710.02 through Air Force Instruction 90-2002, *Interactions with Federally Recognized Tribes*.

C.5.3 Methodology

Analysis of potential impacts to cultural resources considers both direct and indirect impacts. Direct impacts may be the result of physically altering, damaging, or destroying all or part of a cultural resource. Indirect impacts may be the result of altering characteristics of the surrounding environment that contribute to the importance of the resource, introducing visual, atmospheric, or audible elements that are out of character for the period the resource represents (thereby altering the setting), or neglecting the resource to the extent that it deteriorates or is destroyed.

For the purposes of cultural resources analysis, the ROI for cultural resources is considered equivalent to the Area of Potential Effects (APE), as defined by 36 CFR 800.16(d). The APE for cultural resources is based on the type of potential impacts that might occur within the area. The APE for direct impacts is the area directly affected by deployment of defensive chaff and flares that could physically alter or damage all or part of a cultural resource; in this case, it includes the area underlying all the DAF training airspace in the United States where defensive countermeasure use is approved (Figure 1.2-3).

C.6 LAND USE AND VISUAL RESOURCES

C.6.1 Resource Definition

Land use describes the way the natural landscape has been modified or managed to provide for human needs. Land management plans, comprehensive plans, and zoning regulations determine the type and extent of land use in specific areas to limit conflicting uses and protect certain designated or environmentally sensitive areas. The attributes of land use addressed in this analysis include the land use regulatory setting, general land-use patterns, specific uses, and attributes in the area of interest, and Special Use Land Management Areas (SULMAs). SULMA is a term used to categorize types of land uses for analysis purposes and is not an official term used by federal or state agencies. SULMAs generally include designated parks, monuments and recreation areas, conservation and wildlife refuges, and other natural areas underlying the airspace owned by state and federal agencies, in this case, the military airspace used for proposed operations. SULMAs also include Native American Reservation lands. Issues related to Native American lands are addressed in the Cultural Resources section in this PEA (see Appendix C, Section C.5).

The visual resources of an area are composed of the scenery, vegetation, surface rocks, and soil of the foreground, experienced when a person passes through an area. Visual resources are defined by what an observer sees in a landscape (e.g., land, water, vegetation, animals, structures, and other features) that all together form the overall impressions of an area or its landscape character. The type, arrangement, and contrast between all the elements of the visual landscape, both distant and close, create a visual impression. This impression reflects the viewer’s values, associations, and experiences. The landscape includes both the ground and the sky, which is an important element in terms of composition, scale, color and contrast, and magnitude.

For the purposes of this analysis of land use and visual resources, the ROI for the Proposed Action and the No Action Alternative, includes the areas beneath test and training airspaces where DAF aircraft operate, including any over-water Military Operations Areas and Special Use Airspaces (e.g., Eglin Gulf Test Range in the Gulf of Mexico).

C.6.2 Regulatory Setting

The regulatory framework for land use includes the key federal, state, and local statutes, regulations, plans, policies, and programs applicable to land use under the airspace used for training. The following are the primary regulations and guidance documents applicable to land use in relation to the actions evaluated in this PEA.

The Federal Land Policy and Management Act of 1976, as amended, establishes Bureau of Land Management’s (BLM’s) mandate to serve and conserve public lands for present and future generations. The Federal Land Policy and Management Act directs BLM to manage the public lands in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water, and archaeological resources. BLM manages public rangeland for various uses and values, including livestock grazing, recreational opportunities, healthy watersheds, and wildlife habitat.

The National Forest Management Act of 1976 governs the management responsibilities of the United States Forest Service in regard to renewable resources on 193 million acres of national forest lands. The National Forest Management Act requires the Secretary of Agriculture to assess forestlands; develop a management program based on multiple-use, sustained-yield principles; and implement a Resource Management Plan for each unit of the National Forest System. These plans must balance economic and environmental factors.

The Wilderness Act of 1964 established the National Wilderness Preservation System, composed of federally owned areas that are identified and potentially designated by Congress as wilderness. The Wilderness Act defines five qualities of wilderness character: (1) untrammeled, (2) natural, (3) undeveloped, (4) solitude or primitive and unconfined recreation, and (5) other features of value.

Federal agencies are required by various mandates to manage public land with a responsibility to manage and conserve important resources for the benefit of the public at large. One of those resources is visual quality, a resource that contributes to people’s appreciation and enjoyment of the outdoors and contributes to the selective management of some exceptional areas, such as National Parks, Wilderness Areas, and Wild and Scenic Rivers. The Federal Land Policy and Management Act, National Forest Management Act, and agency-prepared management plans provide for the careful management and sustainment of visual resources according to their quality. This is particularly important in the area of interest where much of the land has high scenic value based on remoteness, naturalness, and interesting landforms, such as found in Wilderness Areas and Wild and Scenic Rivers.

C.6.3 Methodology

The assessment of impacts to land use resources evaluates if proposed use of defensive countermeasures would (1) conflict with applicable land use management plans and policies, (2) prevent or displace continued use or occupation of an area, (3) diminish the attributes of an area for ongoing or intended uses, or (4) cause unsafe or unhealthy conditions to the extent that public health or safety is at risk.

The visual impact analysis considers the following factors in assessing the degree of impact to visual resources:

- The relative value of the affected landscape, as determined by managing agencies or the public
- The noticeability or contrast of any physical changes to the visual environment
- The duration, frequency, or proximity of the visual change either in the landscape or for the viewer

The Proposed Action would not result in any physical changes to the visual setting of underlying areas nor add a new light source. Therefore, the proposal has no potential to change the scenic quality of any landscape. Consequently, this analysis did not undertake an analysis of any change to the physical terrestrial environment or new light sources.

C.7 SOCIOECONOMICS

C.7.1 Resource Definition

Socioeconomics for a programmatic NEPA analyses provides the basis for broad, high-level, or sequenced decisions and allows the DAF to subsequently tier in order to analyze narrower, site- or proposal-specific issues. Socioeconomics refers to features or characteristics of the social and economic environment under the DAF training airspaces where chaff and flares are authorized for use.

NEPA review typically concerns environmental effects over a large geographic and/or time horizon; therefore, the depth and detail in programmatic analyses reflects the major broad and general impacts that might result from making broad programmatic decisions. Identifying potential impacts early for the representative training airspace environmental resources provides NEPA reviews the opportunity to modify program components in order to avoid or mitigate adverse impacts when developing subsequent proposals for deployment of legacy and new chaff and flare countermeasures.

C.7.2 Regulatory Setting

The CEQ regulations implementing NEPA state that when economic or social effects and natural or physical environmental effects are interrelated, these effects on the human environment should be discussed (40 CFR 1508.14). The regulations also state that the human environment shall be interpreted comprehensively to include the natural and physical environment and the relationship of people with that environment. In addition, 40 CFR 1508.8 states that agencies need to assess not only direct effects but also aesthetic, historic, cultural, economic, social, or health effects. Accordingly, the socioeconomic analysis evaluates how economic elements of the human environment could be affected.

C.7.3 Methodology

The socioeconomic analysis evaluates the potential impacts to economic activities in response to previous public and agency inputs and comments on proposed chaff and flare use in the different environments considered. Representative concerns expressed by the public have included primarily socioeconomic impacts to agriculture and ranching. The socioeconomics section in this PEA documents the affected environment and the potential environmental consequences examined in multiple environmental documents. These NEPA documents address the environmental effects of chaff and flare use in representative environments which occur under DAF training airspace approved for chaff and flare use. The new chaff and flare countermeasures explained in Chapter 2 and Appendix A are then compared with the existing chaff and flare effects previously evaluated to relate the past analysis with the potential for environmental effects of the Proposed Action new chaff and flares. The social and economic resources are defined in terms of types of economic activity which occur under the airspace. The analysis considers whether an action would result in (1) consequences to ranching and cattle operations, (2) consequences to agriculture for crops used in feed lots, and (3) consequences to row crops and the economic values of such crops. The programmatic nature of this EA identifies qualitative social and economic effects and does not provide a quantitative calculation of potential economic effects from deployment of new chaff and flare countermeasures.

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