GSFC/WALLOPS FLIGHT FACILITY

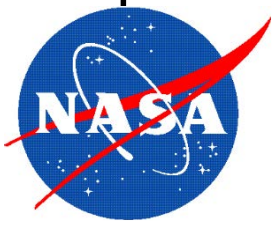
Range Safety Manual

for

Goddard Space Flight Center (GSFC)
Wallops Flight Facility (WFF)

Effective: March 15, 2013

WFF Safety Office
Suborbital and Special Orbital Projects Directorate



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FOREWORD

Safety is the responsibility of all National Aeronautic and Space Administration (NASA) personnel, NASA contractors, tenants, experimenters, and range users while conducting operations at NASA Goddard Space Flight Center's (GSFC) Wallops Flight Facility (WFF) or other off-range locations. The safe conduct of rocket, aircraft, balloon and other special range missions (including all associated activities) requires a concerted effort by all personnel to operate in a manner that mitigates and controls hazards to minimize risks and effectively manage residual risks. This document identifies the flight and ground range safety requirements established by WFF for protecting the public, workforce, and property during range operations. This document implements NASA policy defined in NPR 8715.5, Range Flight Safety Program, and sections of NPR 8715.3, NASA General Safety Program Requirements that address range safety concerns. This document also contains safety policy and requirements that are specific to GSFC/WFF and designed to address unique safety concerns associated with WFF range operations.

Safety participation early in the planning stages of a program will reduce the possibility of costly engineering changes and/or scheduling delays. Therefore, coordination with the WFF Safety Office should be established through the WFF Project Manager as early in the planning stages of a project as possible. The WFF Safety Office personnel should be notified of and be represented at technical interchange meetings, preliminary design, system design and critical design reviews, and mission and flight readiness reviews, where ground and flight safety issues are addressed.

SCOPE

This Range Safety Manual addresses operations conducted at Wallops Flight Facility or in support of NASA Programs where Wallops Flight Facility has operational responsibility.

CONFIGURATION MANAGEMENT/APPROVAL

This manual will have a complete review every five years by all identified stakeholders who shall provide comments/concurrences.

At any time administrative revisions will be accepted which will not require a full review by the stakeholders or a complete revision of this manual. An administrative revision is a correction that does not change the substance or content of the manual; it can include correction of typographical or spelling errors, corrections to organization codes or organization names, and/or corrections to identifiers or reference documents and URLS. The Change History Log shall reflect an "Administrative Change" and the description block will reflect the change(s) being made. The effective date on the Change History Log will reflect when the revision was approved the manual's revision letter will be changed. An administrative revision will not change the date of the comprehensive five year review.

If a change to this manual is required to implement/change requirements and only impacts limited, discrete portions (paragraphs) the organization requesting the change may submit only those changes for review and concurrence/approval by the Range Safety Officer or the Chief, Safety Office. This type of change will not require a full review by the stakeholders. Any changes made to the manual shall be noted on the Change History Log (the effective date will reflect when the change was approved, a description of the change will be recorded, the revision letter shall be changed and the approver shall initial in the appropriate column). The revised pages shall be incorporated into the manual. However if the changes are determined to be too extensive for a paragraph review, a review of the entire manual by all of the stakeholders shall be required.

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1.0 INTRODUCTION

Purpose

Identify WFF range requirements to implement safety policies and criteria defined in NPR 8715.5, Range Flight Safety Program and applicable sections of NPR 8715.3, NASA General Safety Program Requirements.

Define specific design requirements, restrictions, operational procedures, and support requirements.

Identify data requirements and general schedule requirements necessary for WFF to perform appropriate safety analyses and grant approval to conduct operations.

Acquaint range users with the range safety organization at WFF.

Scope/Applicability

This document applies to all programmatic operations and specific aircraft operations conducted at or managed by WFF. It applies to all NASA personnel, NASA contractors, tenants, experimenters, and range users. It is the responsibility of all personnel to acquaint themselves with the requirements set forth in this document, NPR 8715.5, NPR 8715.3 and 840-HDBK-0001, WFF Range User's Handbook.

For aircraft operations, this document contains requirements that apply to hazardous systems (e.g., payloads, instruments, and experiments) incorporated within or attached to manned aircraft platforms, operations conducted on the WFF test range, Unmanned Aircraft Systems (UAS), and any specific aspect of an aircraft operation that exposes the public, workforce, or property to risk greater than that incurred by normal piloted aircraft operations. Aircraft operational requirements for the WFF airfield are defined in 830-AOM-0001, Aircraft Operations Manual.

For WFF managed operations conducted at other ranges, the requirements established by this document apply as a minimum unless requirements of the host range are more stringent, in which case the more stringent requirements will apply.

More stringent safety requirements will be considered by WFF if requested by the range users, experimenters, or tenants.

NASA payloads involved in uninhabited orbital and uninhabited deep space missions that fly onboard Expendable Launch Vehicles (ELVs) (including aircraft assisted ELV's such as Pegasus) under the cognizance of the WFF are subject to NPR 8715.7, ELV Payload Safety Program, NASA STD 8719.24, NASA ELV Payload Safety Requirements, and the applicable requirements of this document. (See NPR 8715.7 for further details.)

2.0 RANGE SAFETY ORGANIZATION AND RESPONSIBILITIES

Center Director of Goddard Space Flight Center (GSFC) - Final authority and accountability for all aspects of safety at WFF rest with the Center Director. In order to ensure that appropriate attention is focused on WFF range safety, certain responsibilities are delegated to the Director of Wallops Flight Facility per the GPR 8710.8, GSFC Safety Program Management.

Director of Wallops Flight Facility - Also serves as the Director of Suborbital and Special Orbital Projects Directorate (SSOPD) - has established and oversees the Safety Office (Code 803), which incorporates the WFF Range Safety Program. The Director of WFF designates the WFF Range Safety Officer and makes risk management decisions for test range operations when assessed range safety risks exceed the risk criteria defined in Section 6.2 of this Manual. The Director of WFF also designates the WFF Range Safety Representative to the NASA Range Safety Program as required by NPR 8715.5.

Chief, Safety Office – The Safety Office Chief oversees the planning, development, and implementation of the WFF Range Safety Program and supervises Safety Office personnel, including the WFF Range Safety Officer.

NOTE: This Range Safety Manual summarizes the safety positions that are applicable to most programs/projects and missions. Safety office Procedural Guidelines outlines the overall Safety Office organization and provides further details on positions with functional, administrative, and supervisory responsibilities that support the range safety process.

WFF Range Safety Officer (RSO) - The WFF RSO is designated by the Director WFF and serves as an authority for range safety policy, processes, and requirements. The WFF RSO:

- Provides technical guidance and direction to the Safety Office and programs/projects.
- Is vested with the engineering authority to certify the design, test, maintenance and use of all elements of the Range Safety System.
- Approves safety team member training, certification and assignments for operations.
- Is the approval authority for Risk Analyses and Safety Plans.
- Approves the categorization of people for risk management purposes (i.e., Mission Essential Personnel, Critical Operations Personnel, or Public/Visitors) on WFF property or at locations where WFF has range safety responsibility.

NOTE: The current WFF RSO is also the delegated Range Safety Technical Authority per a letter dated February 16, 2012. Technical Authority and associated responsibilities are defined in NPR 7120.5, NASA Space Flight Program and Project Management Requirements.

Mission Range Safety Officer (MRSO) – The WFF RSO designates an MRSO for each mission. The MRSO provides operational oversight and management of the safety team during operations. The MRSO has the authority to grant operational deviations from requirements set forth in mission Ground and Flight Safety Plans as long as there are no violations of requirements from this manual. The MRSO implements the measures specified in Safety Plans during test range operations.

NOTE: Programs/projects with multiple missions or multi-day missions may interface with more than one MRSO.

Flight Safety Officer (FSO) – The WFF RSO designates an FSO for each mission that utilizes a Flight Termination Systems (FTS). The FSO is responsible for implementing flight termination according to the rules established in the mission Flight Safety Plan. The FSO also conducts pre-launch countdown FTS procedures for final certification of the FTS.

Operations Safety Supervisor (OSS) –The Safety Office designates an OSS for each ground operation classified as hazardous. Each OSS independently observes all hazardous ground operations as assigned and functions to ensure successful implementation of Ground Safety Plans and operating procedures.

All personnel designated as OSS are certified by the Safety Office through attending an OSS course, participating in on-the job training (OJT), and successfully completing OSS testing or through an equivalent process approved by the WFF RSO.

Program and Project Managers (PM) - Program and Project Manager safety responsibilities are detailed in NPD 8700.1, NASA Policy for Safety and Mission Success. The PM is also responsible for submission of variances from range safety requirements specified in this manual. Additionally, for missions that pose range safety risks above the risk criteria defined in Section 6.2 of this document, the PM is responsible for preparing and presenting an assessment of circumstances and mission benefits that warrant acceptance of the risks to the Director of WFF. See Section 9, Variance Process.

Launch Pad Manager (LPM) – When a LPM is identified for a specific mission, the LPM is responsible for oversight and coordination of all operations occurring on the Launch Pad and for maintaining the boundary of the perimeter of any hazard area created by those operations. The LPM coordinates with each assigned OSS on hazards and hazard area protection during OSS oversight of hazards operations. The LPM is responsible for communications of status to and from the Pad during all operations and for establishing, at the request of the OSS, roadblocks and for ensuring that the appropriate people and equipment are present as required at the Pad.

Campaign and Mission Managers (CM or MM) – Additional terms used to describe the PM position for missions conducted at locations other than at the WFF.

The responsibility of implementing WFF safety policy, criteria, and planning at ranges other than WFF is identified in mission specific safety plans. Delegation shall be according to the following hierarchy:

a. The WFF MRSO
b. The WFF Program or Project Manager
c. Campaign or Mission Manager

3.0 RANGE USERS PRE-ARRIVAL REQUIREMENTS

Range users shall design their systems to conform to the requirements established by this document.

Range users shall prepare and provide to WFF formal documentation pertaining to the project for safety review. This documentation shall include information describing ground and flight systems, operating procedures, and unique requirements of the project. Specific details of the data required are provided in Section 8.0, WFF Safety Data Requirements.

4.0 REFERENCES

a. 800-PG-8715.1.1, Unmanned Roadblocks for Hazardous Operations
b. 803-PG-8715.1.12, Flight Safety Process
c. 803-PG-8715.1.13, Ground Safety Process
d. 830-AOM-0001, Aircraft Operations Manual (AOM)
e. 840-HDBK-0001, Wallops Flight Facility Range User's Handbook
f. GPR 1800.6, Occupational Health, Medicine, and Employee Assistance Programs
g. GPR 1860.1, Ionizing Radiation Protection
h. GPR 1860.2, Laser Radiation Protection
i. GPR 1860.3, Radio Frequency Radiation Protection
j. GPR 8710.8, GSFC Safety Program Management
k. GPR 8719.1, Certification and Recertification of Lifting Devices and Equipment and It's Operators
l. NPD 8700.1, NASA Policy for Safety and Mission Success

m. NPD 8710.5, Policy for Pressure Vessels and Pressurized Systems
n. NPR 1800.1, NASA Occupational Health Program Procedures
o. NPR 7120.5, NASA Space Flight Program and Project Management Requirements
p. NPR 7150.2, NASA Software Engineering Requirements
q. NPR 8715.3, NASA General Safety Program Requirements
r. NPR 8715.5, Range Flight Safety Program
s. NPR 8715.7, Expendable Launch Vehicle Payload Safety Program
t NFPA 70, National Electric Code, Article 250 (Grounding and Bonding) and Article 500 (Hazardous Locations)
u. NFPA 497, Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas
v. ANSI/AIAA S-080, Space Systems - Metallic Pressure Vessels, Pressurized Structures, and Pressure Components
w. ANSI/AIAA S-081, Space Systems - Composite Overwrapped Pressure Vessels (COPVs)
x. ANSI Z136.1, Safe Use of Lasers
y. AFSPCMAN 91-710, Range Safety User Requirement Manual
z. CFR 14, Federal Aviation Administration, Part 101, Moored Balloons, Kites, Unmanned Rockets, and Unmanned Free Balloons
aa. 29 CFR 1910.134, Respiratory Protection
bb. Eastern and Western Range (EWR) 127-1, Range Safety Requirements
cc. FACSFAC VACAPES Operating Instruction, 3120.1J
dd. 803-MANL-0001, Flight Safety/Range Safety Officer Training Manual for the NASA/GSFC/Wallops Flight Facility
ee. IEEE C95.1-1991, American National Standard Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 KHz to 300 GHz
ff. NASA-STD-5005, Standard for the Design and Fabrication of Ground Support Equipment
gg. NASA STD 8719.9, Standard for Lifting Devices and Equipment
hh. NASA STD 8719.12, Safety Standard for Explosives, Propellants, and Pyrotechnics
ii. NASA STD 8719.13, NASA Software Safety Standard
jj. NASA STD 8719.17, NASA Requirements for Ground-Based Pressure Vessels and Pressurized Systems (PV/S)
kk. NASA STD 8719.24, NASA Expendable Launch Vehicle Payload Safety Requirements
ll. Range Commanders Council Standard 319 (RCC 319), Flight Termination Systems Commonality Standard
mm. Range Commanders Council Standard 321 (RCC 321), Common Risk Criteria Standards for National Test Ranges
nn. Range Commanders Council Standard 323 (RCC 323), Range Safety Criteria for Unmanned Air Vehicles
oo. The American Industrial Hygiene Association – Emergency Response Planning Guidelines

5.0 GROUND SAFETY

5.1 General

5.1.1 The ground safety goal of GSFC's WFF is to protect personnel and property involved in conducting operations for GSFC's WFF by mitigating and controlling hazards to minimize risk and effectively managing any residual risk.

5.1.2 It is a goal that all systems be designed such that it will take a minimum of two independent, unlikely failures occurring in order for personnel to be exposed to a hazard.

5.1.3 This Range Safety Manual addresses those hazards that represent heightened concern which are often not routine throughout industry but are common at a launch range. Unique hazards not addressed by this document will be addressed on a case-by-case basis and related mitigations and controls will be documented in the applicable Ground Safety Plan(s).

5.1.4 For NASA payloads involved in uninhabited orbital and uninhabited deep space missions, the WFF Safety Office shall designate a representative to the Payload Safety Working Group and conduct the WFF ground safety process in coordination with the ELV Payload Safety Review and Approval Process defined in NPR 8715.7.

5.2 Hazard Control

5.2.1 Hazard Control Methods

The methods employed by GSFC's WFF to protect personnel and property and to minimize the risk in conducting potentially hazardous operations are:

* Identify all the known hazards associated with the program
* Implement safety design criteria
* Minimize exposure of personnel to hazardous systems
* Identify and qualify residual risks
* Establish safe operating procedures
* Plan for contingencies

5.2.2 Exposure Limits

The cardinal principle to be observed in any location or operation involving explosives, severe fire hazards, high pressure systems, or other hazardous materials, shall be to limit the exposure to a minimum number of personnel, to a minimum time, and to a minimum number of potential hazards, consistent with safe and efficient operations. Operations shall be arranged such that, should an incident occur, it will cause the least possible injury to personnel and damage to facilities or surrounding property.

5.2.3 Personnel Limits

5.2.3.1 Only Mission Essential Personnel shall be permitted on launch pads, in explosives handling areas, or other hazardous areas. These areas include locations where hazardous material (hazardous chemicals, rocket motors, hazardous pressure systems, etc.) are present. These areas are identified in either mission specific Ground Safety Plans or individual hazardous procedures.

5.2.3.1.1 Hazardous Operations - For hazardous operations, the OSS shall assure that the number of personnel performing hazardous tasks is kept to a minimum (no less than 2, including the OSS).

5.2.3.1.2 Non-Hazardous Operations – For non-hazardous operations around hazardous materials, the minimum number of personnel shall be maintained by those individuals involved.

5.2.3.2 For off-range operations, WFF employees (NASA and/or NASA contractors) shall abide by the requirements of the launch range conducting the operation(s) if that range has requirements or limits more stringent than WFF.

5.2.3.3 Requirements regarding official visitors or guests, tours, etc. within established hazardous areas are as follows:

5.2.3.3.1 Early notification of an impending visit or tour to a hazardous area shall be given to the project/program and Safety Office. Potentially hazardous operations or tasks shall be brought to a safe stopping place (Category B state, Section 5.2.5.2) and all work on hazardous systems will cease while the tour is in progress.

5.2.3.3.2 If the hazardous system cannot be placed in a Category B status (e.g., pad arming has already occurred), and it has been determined by the Chief, Range and Mission Management Office (or designee) that the visit is necessary, the LPM, OSS and the MRSO shall determine the most convenient time and duration for the visit.

5.2.3.3.3 For operations at other ranges (mobile or permanent), the WFF lead manager (Campaign Manager, Project Manager, or Mission Manager), in conjunction with the local safety official(s) shall determine the necessity of the visit or tour and will determine the most convenient time, consistent with safety policies/requirements for the visit to occur.

5.2.3.3.4 Tour groups will be accompanied by a person of authority such as the OSS. If the group size is too large to be reasonably managed by the OSS, the tour group shall be split up into 2 or more groups. The person of authority shall provide a safety briefing to the tour group prior to entering the hazardous area.

5.2.3.3.5 Members of the tour group shall be kept a minimum of 3 feet from any ordnance or other hazardous hardware. No Radio Frequency (RF) emitting devices (i.e. cell phones, pagers, handheld two-way radios, etc.) shall be allowed.

5.2.3.3.6 All area-specific safety requirements shall be enforced (i.e., safety glasses, hard hats, grounding, static dissipative garments, clothing, shoes, etc.).

5.2.4 Ground Safety Documentation

Ground Safety Documentation shall be produced in accordance with the Ground Safety Process, 803-PG-8715.1.13.

5.2.5 Hazard Categories

Hazard categories are established to differentiate between hazardous and non-hazardous systems. Each system is analyzed and categorized as either Category A, Category B, or Category A/B. All hazardous systems shall be considered Category A until Category B conditions have been determined and approved.

5.2.5.1 Category A systems are those systems which meet all the following: (1) initiation of the system could lead to a chain of events which result in injury or death to personnel or damage to property; (2) sufficient potential energy exists to initiate the device; and (3) the energy output of the system is not controlled by approved mechanical restraints or other safety devices.

5.2.5.2 Category B systems are those systems which (1) are highly improbable of being initiated, or (2) shall not cause injury to personnel or damage to property by either the expenditure of their own energy or the chain of events that they initiate.

5.2.5.3 Category A/B systems are those systems which change from Category B to Category A during the various stages of processing. The change in hazard category from Category A to Category B shall

be accomplished by reducing the effects of an inadvertent actuation by containing the energetic or toxic output of the actuated system. Systems that can demonstrate that the energetic output of the system is adequately contained may use Section 5.3.4.3, Category A/B System Requirements. Otherwise, Section 5.3.4.4, Category A System Requirements shall apply, as appropriate.

5.2.5.4 The hazardous categorization of each system, the mitigating methods or devices, the danger area, restrictions, and list of responsible personnel shall be identified in the Ground Safety Plan or Ground Safety Data Package for each project.

5.2.6 Multiple Operations

Multiple unrelated operations shall not be conducted simultaneously within a single operational danger area unless the operations are reviewed and specifically approved by the Safety Office.

5.3 Specific Policies and Criteria

5.3.1 Hazard Categorization

5.3.1.1 All hazardous systems, including electrical, chemical, pressure, etc., shall be categorized into hazard categories A, B, or A/B.

5.3.1.2 Hazardous systems shall be assumed Category A until conditions have been met which shall permit a change to Category B. Category A systems can be categorized Category A/B when any of the following conditions exist:

5.3.1.2.1 Approved restraining devices are employed to reduce the effects of an inadvertent actuation to a nonhazardous condition.

5.3.1.2.2 The hazardous system is installed but not connected to its controlling electrical circuit. Hazardous ordnance systems shall also have their Electro-Explosive Devices (EED's) shorted, shielded, and grounded. See Section 5.3.4.4.3.2 for more details.

5.3.1.2.3 Ordnance systems employ an approved mechanical or electromechanical SAFE/ARM (S/A) device, which provides an out-of-line feature in the SAFE position.

5.3.1.2.4 Systems employ the man-rated circuit design requirements established in Section 5.3.4.4.5, Man-Rated Circuit Design Requirements.

5.3.1.2.5 For hazardous chemical systems, the system is closed, contains two independent verifiable safeties in the flow path, and leak integrity is verified.

5.3.1.2.6 For pressure systems, the pressure is steady-state and less than or equal to the Maximum Allowable Working Pressure (MAWP) or Maximum Expected Operating Pressure (MEOP), if available, whichever is lower.

5.3.1.3 For Category A/B systems, the change from Category B to a Category A shall be performed as late as possible in the processing sequence.

5.3.2 Danger Areas

For all hazardous systems, a danger area shall be defined which will adequately contain the hazard and protect non-participating personnel should an inadvertent actuation occur. Restrictions shall be established to prohibit access into the danger area.

5.3.2.1 Prelaunch Danger, Launch Danger, and Launch Hazard Areas and their implementation shall be defined in the Ground Safety Plan/Data Package for each mission.

5.3.2.2 Danger areas for chemical, pressure, radiation, or other hazardous subsystems shall be defined on a case-by-case basis and shall be identified in the Ground Safety Plan/Data Package for that mission.

5.3.3 Operations/Design Considerations

5.3.3.1 This document allows range users to utilize various acceptable design techniques defined in Section 5.3.4, Hazardous Circuit Design Requirements. Prelaunch operational requirements should be a factor in selecting a specific design because operations that require personnel to be located inside danger areas during power switching, power on, and RF transmissions can only be performed if:

(1) The system is in a Category B condition, or
(2) The design is man-rated as defined by Section 5.3.4.4.5, Man-Rated Circuit Design.

5.3.3.2 All Category A danger areas shall be cleared of personnel for operations that require power switching, RF transmissions or the system has been reduced to only one inhibit.

5.3.3.2.1 Personnel may be allowed in danger areas to perform work external to the vehicle when power is supplied, no power switching is occurring and two independent inhibits are verified in place. This operation shall be specifically approved by the Safety Office and can only occur after power has been cycled several (not less than 3) times and has remained ON in a steady state condition for a minimum of 5 minutes.

5.3.3.3 Prior to switching Ground Support Equipment connected to the launch vehicle, payload or other hazardous system “ON” for the first time, the applicable danger area will be cleared of all personnel regardless of the system status.

5.3.3.4 Prior to making an electrical change on a Category B system, all personnel in the vicinity shall be notified of the impending event.

5.3.4 Hazardous Circuit Design Requirements

5.3.4.1 All circuits that initiate ordnance devices or initiate other hazardous systems shall be approved by the Safety Office prior to granting approval for use on WFF projects and programs.

5.3.4.2 Category B System Requirements

Category B systems shall contain a minimum of two independent inhibits which prevent an inadvertent actuation. An inhibit is defined as an open contact between the power source and the system initiator. However two independent inhibits do NOT make a system Category B.

5.3.4.3 Category A/B system requirements

5.3.4.3.1 The electrical circuit shall contain a minimum of two independent inhibits.

5.3.4.3.2 The system shall be designed such that the conversion from Category B to Category A shall minimize personnel exposure to the hazard.

5.3.4.3.3 Mechanical restraint designs shall be approved by the Safety Office.

5.3.4.4 Category A System Requirements

5.3.4.4.1 All circuits initiating Category A devices or systems shall satisfy the circuit design criteria identified below.

5.3.4.4.1.1 All EED's shall meet a 1 amp/1 watt NO FIRE requirement and be 100% qualified with a 500 VDC megohmmeter test for 5 seconds from bridgewire to case confirming a minimum resistance of 2 MOhm.

5.3.4.4.1.2 Electrical wiring and power source shall be completely independent and isolated from all other systems; they shall not share common cables, terminals, power sources, tie points, or connectors with any other system.

5.3.4.4.1.3 All circuit wiring shall be twisted and shielded and independent of all other systems. When not physically possible to maintain the shield throughout the entire electrical circuit, as a minimum the wiring shall be twisted and shielded from the system initiator to the point of the first short circuit condition. This requirement is applicable both before and after installation of S/A type connectors. The use of single wire firing lines, with the shield as the return, is prohibited.

5.3.4.4.1.4 Shielding shall provide a minimum of 20 dB safety margin below the minimum rated function current of the system initiator (max NO-FIRE current for EED's) and provide a minimum of 85% optical coverage. (A solid shield rather than a mesh would provide 100% optical coverage.)

5.3.4.4.1.5 Shielding shall be continuous and terminated to the shell of connectors and/or components. The shield shall be electrically joined to the shell of the connector/component around the full 360 degrees of the shield. The shell of connectors/components shall provide attenuation at least equal to that of the shield.

5.3.4.4.1.6 The electrical circuit to which the system EED is connected shall be isolated from vehicle ground by no less than 10K ohms.

5.3.4.4.1.7 All circuits shall be designed with a minimum of two independent inhibits. Any time personnel are exposed to a hazardous system; a minimum of two independent inhibits are required to be in place.

5.3.4.4.1.8 The system EED shall be provided with an electrical short until its programmed actuation.

5.3.4.4.1.9 Any electrical relay or switch, which is electrically adjacent to the system initiator (either in the power or return leg of the electrical circuit), shall not have voltage applied to the switching coil (or the enable/disable circuit for solid state relays/switches) until the programmed initiation event.

5.3.4.4.2 Charged ("Hot") batteries may be installed into Category A circuits only if at least one of the following design approaches is utilized. Otherwise, the battery shall be charged at the latest feasible point in the countdown process with no personnel in the defined danger area.

5.3.4.4.2.1 The system is designed with a mechanical or electromechanical S/A device in the SAFE position, which shall adequately contain the output of the system or its initiator.

5.3.4.4.2.2 The system is designed to meet Capacitive Discharge Ignition (CDI) circuit criteria as defined in Section 5.3.4.4.4, CDI Circuit Design Requirements.

5.3.4.4.2.3 The system is designed to meet man-rated circuit requirements as defined in 5.3.4.4.5, Man-Rated Circuit Design Requirements.

5.3.4.4.2.4 The system is designed to meet Exploding Bridgewire (EBW) circuit requirements as defined in Section 5.3.4.4.6, Exploding Bridgewire Circuit Design Requirements.

5.3.4.4.3 Category A circuits shall be designed such that the following operations can be accomplished:

5.3.4.4.3.1 Mechanical installation and electrical connection of the system initiators can be performed at the latest possible time in the assembly process, consistent with other assembly operations.

5.3.4.4.3.2 Prior to connecting an EED to its electrical circuit, it shall be shielded and grounded. In addition to being shielded and grounded, the EED shall also be shorted unless all the following supplemental requirements are met:

NOTE: Grounding may be accomplished by connecting the EED to chassis ground and the chassis to a single-point earth ground.

5.3.4.4.3.2.1 The EED shall satisfy the 1 amp, 1 watt no-fire safety standard.

5.3.4.4.3.2.2 Shielding caps shall be provided and placed on each EED during shipment, storage, handling, and installation up to the point of electrical connection.

5.3.4.4.3.2.3 The shielding cap shall have an outer shell made of conductive material that provides an RF shield and makes electrical contact with the EED case.

5.3.4.4.3.2.4 There shall be no RF gaps around the full 360-degree mating surface between the shielding cap and EED case.

5.3.4.4.3.2.5 Installation of each shielding cap shall be performed by qualified personnel following written procedures approved by WFF Range Safety.

5.3.4.4.3.2.6 The written procedures shall identify any special tools, specifications (e.g., torque setting) and check points designed to ensure the shielding cap is properly installed and will serve its safety function.

5.3.4.4.3.3 Prior to connecting system initiators to their electrical circuit, voltage checks shall be made between each leg of the circuit and from each leg to ground to ensure no voltage is present.

5.3.4.4.4 <u>CDI Circuit Design Requirements</u>

5.3.4.4.4.1 The charging battery shall be current limited such that it shall not exceed 10% of the minimum rated function current of the system initiator (max NO-FIRE current for EED's).

5.3.4.4.4.2 The firing capacitor shall be provided with a low impedance path for discharge (when the circuit is in the SAFE condition) and a means of remotely monitoring capacitor voltage. Whenever personnel are exposed to the system, the firing capacitor shall be discharged through a low impedance path resistor (as a guideline, low impedance is considered less than or equal to 100 Ohms).

5.3.4.4.4.3 There shall be a minimum of two independent open switches between the power source and the system initiator.

NOTE: For CDI type systems, the power source is the CDI itself, not the battery that charges the CDI capacitor.

5.3.4.4.5 Man-Rated Circuit Design Requirements

5.3.4.4.5.1 The system initiator shall be both physically and electrically isolated from the power source by a minimum of three independent inhibits. This requirement is applicable both before and after installation of SAFE and ARM plug type connectors.

5.3.4.4.5.2 The system initiator shall be electrically isolated by switches in both the power and return legs.

5.3.4.4.5.3 The wiring shall be in a separate cable, which is twisted, shielded, double insulated, and independent of all other systems.

5.3.4.4.5.4 Protection by use of physical barriers or by physical location of components shall be employed such that short circuits to other power systems are impossible, even assuming loose or broken wires.

5.3.4.4.5.5 A Failure Mode and Effects Analysis (FMEA) or equivalent analysis shall be performed to ensure a minimum of three independent failures are required for a premature actuation to occur. The detail level of the analysis shall be established by the Safety Office and shall be based on factors such as type of system, system design, and level of hazard.

5.3.4.4.5.6 A Quality Assurance Program shall verify compliance with all requirements and certify the "as built" configuration.

5.3.4.4.6 Exploding Bridgewire (EBW) Circuit Design Requirements

5.3.4.4.6.1 A means of continuously monitoring the firing capacitor voltage shall be provided.

5.3.4.4.6.2 Two separate electrical paths to discharge the firing capacitor shall be provided. This can be provided either through the EBW circuit or through the Ground Support Equipment (GSE).

5.3.4.4.6.3 A reliable means of interrupting the capacitor charging circuit shall be provided.

5.3.4.4.6.4 A reliable means of interrupting the EBW triggering circuit shall be provided.

5.3.4.4.6.5 A time delay of several seconds between application of the arming signal and application of the trigger signal for the EBW to fire shall be provided.

5.3.5 Ground Support Equipment (GSE)

5.3.5.1 The design of GSE used to make measurements on or provide control of hazardous devices, systems, or circuits shall be approved by the Safety Office. NASA-STD-5005 or other equivalent standards shall be used as guidance to determine if adequate safeties are in place.

5.3.5.1.1 Launch vehicle firing circuits at WFF shall be capable of being interrupted from the WFF Range Control Center.

5.3.5.2 All electrical meters or test equipment used to make measurements of hazardous systems shall be current limited to the manufacturer's recommendation for that device. This value shall not exceed 50 mA**.**

5.3.5.3 All GSE used in, or to obtain measurements of, hazardous systems (electrical meters, pressure gages, slings, scales, etc.) shall be calibrated/certified and may not be used beyond the certification period. Certifications shall be performed at GSFC's WFF unless it can be shown that the range user has an equivalent certification/calibration process. To demonstrate an equivalent process the following shall be verified: 1) the laboratory performing the calibration is certified by a recognized standards organization such as ANSI or ISO; 2) the organization performing the calibration has an acceptable documented metrology and calibration program; and, 3) the specific calibration certifications/calibrations in question shall be reviewed by the GSFC/WFF Metrology and Calibration Laboratory. The equivalent process shall be reviewed and approved by the Safety Office. Any certifications/calibrations not performed by GSFC/WFF that cannot demonstrate the equivalent process shall be approved through the Range Safety Variance Process (see Section 9).

5.3.5.4 All lifting devices, fixtures, and equipment and all lifting operations shall conform to the standards and regulations of NASA STD 8719.9, Standard for Lifting Devices and Equipment and GPR 8719.1, Certification and Recertification of Lifting Devices and Equipment and It's Operators.

5.3.5.5 Electrically operated GSE (vacuum systems, heaters, pumps, etc.) used on Category A systems shall meet the following design criteria and restrictions.

5.3.5.5.1 All GSE shall be designed such that the system can be remotely switched ON/OFF.

5.3.5.5.2 GSE shall be switched OFF prior to, and remain OFF during system arming operations.

5.3.5.5.3 The design of GSE should consider the impact of the above restrictions on operations. Flyaway connectors should be used to permit system operation late in the countdown process. For vacuum systems, a remotely operated valve is recommended to maintain vacuum integrity when power is switched OFF.

5.3.5.5.4 For systems that automatically switch on and off, the system shall be turned off and remain off during arming operations.

5.3.6 Electrostatic Discharge (ESD) Hazards

5.3.6.1 Precautions shall be taken to eliminate or reduce the risk of ESD during potentially hazardous operations. The method used to eliminate or reduce static electricity is to provide an electrically continuous path to ground. All conductive objects (including personnel in contact with the hazardous system) shall be electrically connected to a common ground.

5.3.6.2 Grounding straps shall be used to bridge locations where electrical continuity may be broken by grease, paint, or rust. Equipment in contact with conductive floors or tabletops is not considered adequately grounded.

5.3.6.3 Wire used as a static ground conductor shall be large enough to withstand mechanical damage and shall not be less than American Wire Gauge (AWG) No. 8 or a braided cable of equal conductivity.

5.3.6.4 Connection of static ground conductor shall be made to certified grounding points. Grounding point certification shall be performed annually and shall be verified as having had its annual certification before the start of a hazardous procedure requiring grounding

5.3.6.5 When performing potentially hazardous operations on electrostatic sensitive systems, personnel shall comply with the following:

5.3.6.5.1 Wrist straps shall be worn and connected to a certified ground when handling EED's or when working on exposed rocket motor grain. Wrist straps shall be tested prior to use.

5.3.6.5.2 Outer garments (e.g. lab coats or overalls) that dissipate static charges shall be worn.

5.3.6.5.3 Personnel are required to touch the ground system upon entering an ordnance work area. This grounding requirement applies even when wearing protective clothing.

5.3.6.5.4 Ionization - Ionizers may be used for static neutralization in ordnance work areas, only with specific approval from the Safety Office. Use of these instruments shall be allowed only when other means of static neutralization are not effective and may never be used directly on ordnance items.

5.3.7 Electrical Storm/Lightning Criteria

5.3.7.1 Lightning Advisory - When an electrical storm is detected within 25 nautical miles of hazardous work areas and is forecast to be within 10 nautical miles of those work areas in less than 20 minutes, an advisory shall be issued to bring those operations to an appropriate stopping point.

5.3.7.2 Lightning Warning - When an electrical storm is detected within 10 nautical miles or the potential for an electrical storm is forecast within 5 nautical miles of hazardous work areas, the area shall be evacuated regardless of the status of the operations.

5.3.7.3 If a warning system is not available to determine the approach of an electrical storm; the hazardous work area shall be cleared upon hearing thunder or observing weather conditions, which have the potential of producing electrical storms.

5.3.7.4 For hazardous work areas that have an annually certified Lightning Protection System, LPS, evacuation is not required but all hazardous operations shall be brought to an appropriate stopping point. **Exception:** Evacuation is required when there is exposed solid propellant, an explosive

initiation device in a Category A state or any hazardous system susceptible to lightning as determined by the Safety Office.

5.3.8 Radiation Systems

Radiation shall be adequately controlled during all operational phases to assure the protection of personnel, facilities and equipment in compliance with applicable federal, state, and NASA regulations. Such sources may include: radio-frequency/microwave emitters, radioactive materials, X-ray devices, lasers, and optical emitters. Ionizing radiation hazards shall be coordinated with the GSFC Ionizing Radiation Safety Committee. A code 803 committee member will act as the local liaison to assist in the approval process.

5.3.8.1 Non-ionizing Radio Frequency (RF) Radiation Controls

5.3.8.1.1 The RF-radiation sources used at WFF shall be approved by the Wallops Frequency Utilization Management Working Group.

5.3.8.1.2 All operations involving the use of RF transmitters shall be coordinated through the Range Control Center and conform to the standards and regulations specified in IEEE C95.1 and GPR 1860.3, Radio Frequency Radiation Safety.

5.3.8.1.3 The use of Flight Termination System (FTS) frequencies shall be coordinated with the WFF Frequency Manager. Open air transmitting of ARM and DESTRUCT tones is prohibited unless scheduled.

5.3.8.1.4 Mission-specific descriptions of RF transmitters and restrictions shall be provided in the Ground Safety Plans/Data Packages.

5.3.8.1.5 RF radiation into areas where ordnance operations are conducted shall be controlled to assure insufficient energy exists to cause premature initiation of ordnance.

5.3.8.1.6 The RF avoidance times shall be established in operational plans.

5.3.8.1.7 Personnel and ordnance hazard distances for all transmitters shall be defined with the Ground Safety Plans/Data Packages.

5.3.8.2 Ionizing Radiation Controls

5.3.8.2.1 All operations involving the use of radioactive sources shall conform to the standards and regulations of the Nuclear Regulatory Commission, GPR 1860.1, Ionizing Radiation Protection and regulations of the host range.

5.3.8.2.2 The range user is responsible for obtaining all licenses for radioactive materials. Provide WFF and the host range with a copy of the users NRC license or state equivalent license.

5.3.8.2.3 Procedures for the use, handling, and storage of radioactive sources shall be designed to minimize the exposure of personnel. All ionizing radiation sources will be inspected and monitored upon arrival and prior to shipment to any other location.

5.3.8.2.4 Range users shall identify all radioactive sources and provide appropriate documentation for each radioactive source to be used. This includes calibration sources, x-ray producing devices as well as test sources. Identify the material or device custodian and approved users along with the training records for each.

5.3.8.2.5 Range users shall provide WFF with detailed operating procedures for use, handling, and storage of radioactive sources.

5.3.8.2.6 Ionizing radiation sources shall be removed from the range by the range user at the end of the program.

5.3.8.2.7 Radioactive materials included in a payload will need to be approved prior to launch by NASA Headquarters or receive Congressional approval depending on the quantity and activity level of the material. Range users need to allow additional time for the approval processing.

5.3.8.3 Laser Hazards Control

5.3.8.3.1 All operations involving the use of lasers shall comply with the standards and regulations of NPR 1800.1, NASA Occupational Health Program Procedures, Chapter 4, ANSI Z136.1, Safe Use of Lasers, and GPR 1860.2, Laser Radiation Protection. Lasers entering the National airspace will require the user to request a Federal Aviation Administration (FAA) letter of non-objection.

5.3.8.3.2 Access to laser illumination levels shall be controlled to insure that no personnel are present within the ocular and skin hazard areas of the laser unless suitable protection is provided.

5.3.8.3.3 Range users shall provide WFF with characteristics and detailed operating procedures for controlling and use of lasers and documentation of user laser safety training. All laser operations shall be approved by the Laser Safety Officer.

5.3.8.3.4 Lasers with potential to strike orbiting satellites will obtain a ‘site window’ from the Laser Safety Clearing House.

5.3.9 Chemical Hazards

A chemical hazard is posed by any material (solid, liquid, or gas) that presents a health risk or physical hazard to personnel, property, or the environment.

5.3.9.1 Procedures addressing use, transportation, storage, clean up, and spill response of hazardous materials shall be developed. These procedures shall be reviewed and approved by the Safety Office and WFF Environmental Office.

5.3.9.2.1 The WFF Environmental Office shall be notified of hazardous materials requiring disposal. At the completion of the user’s project, it is the responsibility of the user to properly remove hazardous materials from the facility or host site.

5.3.9.2.2 The Range user shall maintain a hazardous materials inventory and provide a copy of Safety Data Sheets (SDS, previously known as MSDS) to the Safety Office and Fire Department along with the storage location. A copy of the SDS shall be available during all operations involving hazardous materials. Hazardous material handlers, cognizant Safety Office personnel, WFF Environmental Office and Emergency Responders shall have knowledge of material

compatibilities, physical and health hazards, and first aid techniques relevant to the hazardous materials in question. The user shall maintain proper labeling on all primary and secondary containers.

5.3.9.4 The following measures shall be employed if a possibility of a hazardous chemical spill exists:

5.3.9.4.1 Spill potentials shall be evaluated by the Safety Office, and potential hazard areas shall be defined in the Ground Safety Plan.

5.3.9.4.2 A means to minimize the surface area of potential spills by diking, containment pallet, design, or other methods shall be employed.

5.3.9.5 The following measures shall be used to address potential leaks of hazardous fluids or gases:

5.3.9.5.1 All GSE electrical hardware used in areas where flammable/combustible chemicals may be present in local vapor concentrations greater than 25% of the Lower Explosive Limit (LEL) shall be rated "explosion proof" in accordance with National Fire Protection Association (NFPA), National Electric Code, Article 500 – Hazardous Locations, purged and pressurized, intrinsically safe or, if this is not possible, (1) the flammable/combustible chemical concentrations shall be continuously monitored and (2) a master switch capable of deactivating "non-explosion proof" electrical hardware shall be conveniently located in the work area. NFPA 497, Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas provides guidance on determining the proper classification of the location.

5.3.9.5.2 Areas of hazardous chemical transfer and storage shall be continuously monitored by approved equipment to detect toxic and flammable concentrations.

5.3.9.5.3 Chemical transfer operations, which are hazardous, shall not occur without prior approval of and supervision by the OSS.

5.3.10 Hazardous Chemical System Hardware

Hazardous chemical hardware shall be designed to prevent hazardous chemicals from spilling or leaking.

5.3.10.1 Hazardous chemical systems that release caustic, toxic, or reactive chemicals shall be designed such that the flow path contains two independent inhibits to prevent an inadvertent release.

5.3.10.2 Components of hazardous chemical systems shall feature redundant mechanical or welded seals at all fittings to prevent the inadvertent flow or release of caustic, toxic, and/or reactive chemicals.

5.3.10.3 Materials selected for use in hazardous chemical systems shall be compatible with the hazardous chemical used. This should include compatibility under operating pressure, shock, vibration, reactivity and temperature conditions.

5.3.10.4 Bi-propellant systems that incorporate both a fuel and an oxidizer shall be designed such that a malfunction of either the oxidizer or fuel subsystems cannot result in mixing.

5.3.10.5 Monopropellant systems that feature a fuel and a catalytic bed shall incorporate at least two independent inhibits in the flow path to prevent inadvertent fuel contact with the catalytic bed.

5.3.10.6 The need for remote status monitoring of the system and/or its components shall be evaluated by the Safety Office as well as the need for continuous monitoring of personnel who handle these systems.

5.3.10.7 GSE hardware (tanks, transfer lines, etc.) shall conform to applicable American Society of Mechanical Engineers (ASME) requirements, Department of Transportation (DoT) requirements, NASA STD 5005 /or NASA STD 8719.17. Flight hardware shall conform to AIAA S-080 or S-081 requirements.

5.3.11 Man-Rated Liquid Propulsion Systems

5.3.11.1 General Requirements

5.3.11.1.1 A man-rated propulsion system shall be employed when the following two conditions exist: (1) a leak or spill of the propellant poses a catastrophic hazard and (2) in the event of a leak, personnel will be exposed to the hazardous chemical before a spill response is possible.

5.3.11.1.2 The propulsion system's primary leak path (i.e., from the propellant tank through the thrusters) shall contain a minimum of three mechanically independent inhibits in series. If the mechanical inhibits are electrically controlled, the electrical controls shall be independent of each other. A pyrotechnically actuated isolation valve (with a "parent metal" seal and three electrical inhibits) that is located immediately downstream from the liquid propellant tank may be considered equivalent to two mechanical flow control inhibits upon Safety Office approval of the valve design and associated quality control and testing processes.

NOTE: A parent metal seal is created by machining the valve input and output orifices from a single metal block and leaving some of the "parent metal" between the input and output. The tolerances have to be tightly controlled so the seal doesn't inadvertently crack and leak yet will reliably break open when hit by the pyro-activated ram. Such pyro-valves are typically built one at a time in a process that involves significant hand work and where quality control and testing is critical to each valve's reliability and safety.

5.3.11.1.3 Secondary leak paths (i.e., through or around wetted fittings to the ambient environment) shall be a minimum of dual failure tolerant to prevent a catastrophic leak/spill past a wetted fitting. A fitting that has been sealed with certified welds shall be considered equivalent to dual failure tolerant.

5.3.11.1.3.1 Non welded connectors and fittings, such as National Pipe Thread (NPT) and flared tubing (i.e. type AN) shall not be used in hypergolic system flight hardware.

5.3.11.1.4 If a system failure may lead to a catastrophic hazard, the system shall have three independent, verifiable inhibits (dual failure tolerant). If a system failure may lead to a critical hazard, the system shall have two independent, verifiable inhibits (single failure tolerant).

5.3.11.1.5 Prior to a launch, flow control devices within the liquid propulsion system shall not be operated under condition(s) that preclude spill/leak response.

5.3.11.1.6 Launch vehicle and payload designs shall incorporate features to address contingency liquid propellant off loading operations. For example, a fairing access door, when incorporated, makes for easy access to the spacecraft propulsion system fill-and-drain valve after the integrated launch vehicle and payload have been staged on the launch pad.

5.3.11.2 Electrical Hardware

5.3.11.2.1 The electrical circuit(s) that operates the liquid propellant flow control devices shall be dual failure tolerant. See section 5.3.4.4.5, Man-rated Circuit Design Requirements for more details. At least two of the three electrical inhibits shall be remotely monitored when conditions preclude spill/leak response.

5.3.11.2.2 Electrical circuit(s) that operates components whose failure may cause the liquid propellant to catastrophically overheat (thus causing either propellant decomposition or propellant tank over pressurization) shall be dual failure tolerant.

5.3.11.3 Pressure Relief

5.3.11.3.1 The pressurant side of hazardous liquid propulsion systems shall be either electrically or mechanically single failure tolerant to exceed system Maximum Expected Operating Pressure (MEOP), or shall be equipped with a pressure relief device. The relief device shall be set and certified by tagging at 10% above system MEOP.

5.3.11.3.2 The system shall be mechanically and electrically dual failure tolerant to exceeding system burst pressure.

5.3.11.4 Seals

5.3.11.4.1 A quality control program shall verify that all system fittings and seals are properly installed and have leak integrity.

5.3.11.4.1.1 Welds shall be made only by certified welders.

5.3.11.4.1.2 Lot and batch short term compatibility testing shall be performed for elastomeric seals to assure material compatibility.

5.3.11.4.1.3 Positive means such as periodic leak checking, manufacturer's gauging techniques, and/or other measures shall assure that metal-to-metal seals do not lose leak integrity by improper installation or loosening ("backing-off") during transport or handling.

5.3.11.4.2 The optimum design for redundant mechanical seals is to seat one at the fitting face and the other radially to seal the fitting.

5.3.11.5 Monitoring

5.3.11.5.1 An instrument that continuously monitors for airborne concentrations of the toxic liquid propellant shall be used during ground operations.

5.3.11.5.2 During those operations that cannot be considered ground operations but still place personnel under the jurisdiction of WFF at risk (e.g., captive flight), and when spill/leak response is not possible, system pressure monitoring shall be required as a minimum effort.

5.3.11.5.3 All personnel who work in the proximity of the fueled liquid propulsion system shall wear passive dosimeter badges to monitor possible personnel exposures.

5.3.12 Pressure Systems

5.3.12.1 All ground support pressure systems shall meet NPD 8710.5, Policy for Pressure Vessels and Pressurized Systems and NASA STD 8719.17, NASA Requirements for Ground-Based Pressure Vessels and Pressurized Systems (PVS). Unrestricted access may be granted to ground pressure systems operating at less than 150 psi and contain non-toxic commodities.

5.3.12.2 Unrestricted access shall be granted for all airborne/flight pressure systems (gaseous and liquid) that are designed in accordance with recognized DoT and ASME standards or have stored energy levels less than 19,130 joules (14,110 ft.lbf), operating pressure less than 100 psi and contain non-toxic commodities.

5.3.12.3 If the airborne pressure system does not meet Section 5.3.12.2, then it shall be remotely pressurized or depressurized for any of the following:

5.3.12.3.1 During the initial pressurization of the system (25% of Design Burst Pressure), following system assembly or refurbishment.

5.3.12.3.2 After the pressure system has been exposed to excessive vibration or shock or it has been transported in an unknown environment.

5.3.12.3.3 During pressurization above 25% of the Design Burst Pressure.

5.3.12.4 All airborne/flight systems used on NASA orbital and NASA sub-orbital launch vehicles shall comply with the design requirements of ANSI/AIAA S-080 Space Systems - Metallic Pressure Vessels, Pressurized Structures, or Pressure Components or ANSI/AIAA S-081 Space Systems - Composite Overwrapped Pressure Vessels (COPVs).

5.3.12.5 Restricted access is permitted for airborne pressure systems designed to the requirements of ANSI/AIAA S-080 or ANSI/AIAA S-081, when the system steady state pressure is less than the MEOP.

5.3.12.6 Whenever the system pressure exceeds the MEOP, personnel shall be separated from the pressure vessel(s) by a barrier designed to protect against blast and fragmentation, or personnel shall be outside the pressure vessel danger area. This area shall be defined in the Ground Safety Plan/Data Package.

5.3.12.7 Flight pressure systems shall be re-certified by inspection, testing, or analysis prior to being reflown. The method of recertification shall be documented in a plan approved by the Safety Office for each pressure vessel.

5.3.12.8 If a pressure relief device is employed; it shall be set and certified by tagging at no greater than 10% above MEOP.

5.3.13 Personal Protective Equipment (PPE)

Safety glasses, safety shoes, hard hats, arctic clothing, shop coats, etc., are required to be used by GSFC's WFF employees, contractors, experimenters, and range users when exposed to certain hazardous conditions. Employees will be trained on the proper use and care of personal protective equipment. Appropriate physical examinations may be required in accordance with GPR 1800.6, Occupational Health, Medicine, and Employee Assistance Programs.

5.3.13.1 All personnel shall wear static-dissipating outer garment clothing in processing areas for ordnance or other hazardous systems, which are susceptible to ESD. Ordnance handlers shall not wear static producing clothing (i.e., wool, rayon, nylon, polyester, etc.) over static-dissipating clothing. Only static-dissipative gloves are permitted when handling ordnance or other hazardous systems.

5.3.13.2 During operations involving EED or exposed grain, all personnel shall wear approved, grounded wrist-straps. Approved leg-stats may be used in place of wrist-straps for specific operations approved by the Safety Office. Wrist-straps shall be tested prior to each use.

5.3.13.3 Safety glasses or face shields are required for operations where an ocular hazard may exist.

5.3.13.4 Hardhats are required for operations where personnel work on multiple levels or where overhead objects may impact the employee (i.e. crane and lifting operations). Chin straps or hard hat lanyards are required for multiple level operations over personnel or equipment.

5.3.13.5 Operations involving chemicals that pose a health risk require that personnel wear protective equipment (identified on a case-by-case basis in the specific operational procedure) that shall provide respiratory and/or full body protection during:

5.3.13.5.1 Connecting or disconnecting wet lines or contaminated (neither purged nor flushed) dry lines.

5.3.13.5.2 Sampling operations.

5.3.13.5.3 Flow/transfer operations.

5.3.13.5.4 Operations where there is only one safety device preventing a chemical spill.

5.3.13.5.5 Chemical spill cleanup.

5.3.13.6 Operations involving loading and unloading of hypergolic propellants require the use of adequate PPE such as SCAPE or Level A protection. The user shall provide information for Safety Office review and approval that demonstrates whichever PPE is selected for use shall provide appropriate skin and respiratory protection for the contaminant of concern. The user's respiratory protection program shall demonstrate that they meet OSHA requirements of 29 CFR 1910.134.

5.3.13.6.1 The following operations require maximum worker protection such as SCAPE or Level A:

Connection and disconnection of wet lines or contaminated (not purged and flushed) dry lines,

Sampling operations,

During propellant flow,

During pressurization with propellants until system integrity has been verified (no leaks),

Connections and disconnections of ground support equipment (tanker, storage container, cart, etc.) load/off load lines,

Removal and replacement of components in a liquid line,

Opening any liquid system that has not been drained, purged, and flushed with referee fluid,

Emergency clean-up of a spill,

The condition of the system is uncertain or unknown.

5.3.13.6.2 After operations are complete and system integrity has been verified the operators can request Safety Office concurrence to downgrade the full protective gear requirement.

5.3.13.7 The following non-liquid operations shall require Level B Protection as a minimum:

Removal and replacement of components on purged, isolated liquid, drained and vent lines.

Pressure leak checks

5.3.13.8 An acceptable method of communication approved by the Safety Office shall be established with personnel in Level A Protection, SCAPE or Level B Protection.

5.3.13.9 During operations involving flammable/reactive cryogen (such as liquid oxygen, liquid hydrogen, etc.) transfer, repairs, or adjustments, personnel shall wear flame-resistant treated, non-static producing coveralls. This PPE shall be constructed of liquid resistant material and should include full length sleeves and cuffs without pockets. Cryogenic service gloves, eye protection, hoods or face shields, and non-absorbent shoes are also required. The user shall provide appropriate information regarding the PPE selected for Safety Office review and concurrence.

5.3.13.10 Personnel performing operations on non-flammable cryogenic systems shall be appropriately protected from exposure. PPE shall be constructed of liquid resistant material and should include full length sleeves and cuffs without pockets. Cryogenic service gloves, eye protection, hoods or face shields, and non-absorbent shoes are also required.

5.4 Operational Security, Controls, and Procedures

All personnel at WFF shall comply with operational safety controls. These controls include:

5.4.1 Security

5.4.1.1 All personnel (NASA personnel, NASA contractors, tenants, experimenters, and range users) involved in hazardous operations shall attend hazardous operations training and maintain a Hazardous Operations badge.

5.4.1.2 Danger Area Access - The operational status of a danger area is conveyed to personnel by the

Danger Area Warning System. Admittance into an active danger area is controlled by the OSS, LPM or other range authority.

5.4.1.2.1 Danger Area Warning System - The Danger Area Warning System for each danger area involves the use of lights, signs, and/or roadblocks to alert personnel of the potential hazards present in certain areas and/or to prevent personnel from entering these areas. Under no circumstances shall personnel enter an active danger area (i.e. pass a roadblock, sign, light or other warning device that indicates an active hazardous operation) without first obtaining permission from the OSS, LPM or other range authority. For more information on unmanned roadblocks, refer to 800-PG-8715.1.1, Unmanned Roadblocks for Hazardous Operations.

5.4.1.3 Explosives Signs and/or Symbols - Based on procedures of the U. N. document "Transportation of Dangerous Goods" (documented in NASA STD-8719.12, Safety Standard for Explosives, Propellants, and Pyrotechnics); WFF utilizes four symbols to denote different classes of ordnance. These symbols are prominently displayed on International Orange signs at each magazine and refer to the most hazardous material stored within.

5.4.1.3.1 Class 1, Division 1: an octagonal-shaped sign displaying the numeral "1" in the center denotes the presence of Department of Defense (DoD) Hazard Class/Division 1.1 explosives, which present a blast and fragmentation hazard and can be expected to mass detonate when exposed to fire.

5.4.1.3.2 Class 1, Division 2: an X-shaped sign displaying the numeral "2" in the center denotes the presence of DoD Hazard Class/Division 1.2 explosives, which present a fragmentation hazard.

5.4.1.3.3 Class 1, Division 3: an inverted triangular sign displaying the numeral "3" in the center denotes the presence of DoD Hazard Class/Division 1.3 explosives, which present a mass fire hazard.

5.4.1.3.4 Class 1, Division 4: on a diamond-shaped sign displaying the numeral "4" in the center denotes the presence of DoD Hazard Class/Division 1.4 explosives, which present a moderate fire hazard.

5.4.1.4 Hazardous Operations Warning Lights – An Amber light shall be illuminated to indicate potential hazards exist within the hazardous area or building. A Red light shall be illuminated to indicate hazardous operations are taking place.

5.4.1.5 RF Radiation Controls

5.4.1.5.1 Operational Restrictions - All RF emitters used at WFF shall be periodically analyzed to determine whether or not they pose a potential hazard to personnel or ordnance. When a potential hazard exists, operational restrictions and/or controls shall be established to protect personnel and/or ordnance systems.

5.4.1.5.2 Barricades/Signs - In areas where RF hazards to personnel exist, signs and/or barricades shall be erected to prevent personnel from entering the potential hazardous area.

5.4.1.5.3 Warning Lights - On high power RF emitters such as Radar Systems, red and blue warning lights shall be utilized to warn personnel of the potential RF hazard. A red flashing light shall be illuminated whenever power is supplied to the system. A blue flashing light shall be illuminated whenever the emitter is radiating.

5.4.1.6 Safety Critical Software

5.4.1.6.1 The WFF Safety Office shall identify safety-critical software in range safety systems owned by WFF or used to support NASA missions.

5.4.1.6.2 Range safety systems that incorporate safety critical software that are owned by WFF or used to support NASA missions shall have an independent verification and validation plan in accordance with NPD 7120.4, NASA Engineering and Program/Project Management Policy.

5.4.1.6.3 NASA safety-critical software shall be developed in accordance with NPR 7150.2, NASA Software Engineering Requirements, and NASA STD 8719.13, NASA Software Safety Standard.

5.4.2 Operational Controls

For all hazardous operations at WFF, the Test Director (TD), Range Operations Assistant (ROA), MRSO, LPM and OSS exercise control over all personnel associated with the operation. For off-range operations, Section 2.0, Range Safety Organization and Responsibilities, establishes the hierarchy for operational control.

5.4.2.1 All NASA personnel, NASA contractors, experimenters, range users, and tenants are responsible for:

5.4.2.1.1 Adhering to the requirements established in this document.

5.4.2.1.2 Adhering to the directions issued by the TD, MRSO, LPM and/or OSS.

5.4.2.1.3 Reviewing vehicle and payload operations with the OSS.

5.4.2.1.4 Obtaining permission from the OSS before conducting any hazardous operation in assembly, test, or launch areas. OSS will coordinate with TD, MRSO, LPM and other range authority as appropriate.

5.4.2.1.5 Identifying active essential personnel for each operation to assure minimum number of essential personnel are present during the hazardous operation.

5.4.2.2 The use of RF sources during hazardous operations is managed by the ROA. Range users shall obtain permission through the OSS before any RF transmitters can be switched ON.

5.4.2.3 The Ground Safety Plan/Data Package defines Danger Area clearance requirements and personnel restrictions for all hazardous operations. All personnel at WFF are responsible for complying with these restrictions.

5.4.2.4 All personnel performing hazardous operations (explosives handling, chemical transfer, etc.) shall be trained and experienced. These personnel are required to be certified or directly supervised by certified personnel when performing these operations. WFF may approve certifications established by user programs. Range users shall provide documentation that supports training, experience, or certification of their personnel.

5.4.3 Operational Procedures

5.4.3.1 Range users are responsible for submitting to WFF all comprehensive handling, assembly, and/or checkout procedures for all hazardous systems for review and approval. Operations shall not be conducted until the Safety Office has approved these procedures.

5.4.3.2 Under no circumstances shall a hazardous operation begin without prior approval from the OSS.

5.4.3.3 WFF requires that no unrelated tasks be conducted simultaneously, within the danger area of a hazardous operation, on hazardous systems. It is the responsibility of all supervisory personnel to prepare work schedules to comply with this requirement.

5.4.3.4 Each meter or other instrument used to measure the resistance of EED's or other ordnance devices shall (a) have a sticker or other record of certification indicating compliance with paragraphs 5.3.5.2 and 5.3.5.3 of this RSM and (b) undergo an ammeter output check to ensure proper operation immediately prior to connecting to ordnance. Powering the meter off, any alteration to the meter (including the replacement of batteries), any change to the meter's configuration, or leaving the meter unattended shall invalidate any prior meter check and the meter's output shall be rechecked prior to connecting to ordnance.

NOTE: Numerous ordnance devices may be tested one after the other without rechecking the meter's output provided the above requirements are satisfied.

5.4.3.5 Range users shall obtain permission from the OSS prior to power switching any Ground Support Equipment, GSE, used to control any vehicle or payload hazardous system.

5.4.3.6 Emergency Procedures - Prior to conducting an operation, WFF shall establish emergency procedures and an emergency response team in the event of launch abort or recovery. Range Users shall identify personnel as required by WFF to participate on any emergency or recovery team. The termination of the emergency phase begins the mishap investigation phase. The emergency procedures will support this transition.

5.4.3.7 For off-range operations, permission to perform the above operations shall be granted by the hierarchy defined in Section 2.0, Range Safety Organization and Responsibilities.

5.4.4 Nominal Recovery or Planned Land Impacts

5.4.4.1 During recovery of any vehicle/payload (UAV, Balloon, Sounding Rocket, etc.), all possible hazards shall be eliminated or reduced to acceptable risk levels prior to personnel performing recovery operations. Risk reduction is accomplished during a mission by reducing the energy of hazardous systems to their lowest energy states and by consuming the hazardous materials. If the risk level for the hazard cannot be reduced then a waiver will need to be processed (see section 8.6). Recovery plans, procedures and hazard mitigations shall be submitted to ground safety for approval during the vehicle and/or mission design phase. It is impossible to predict every possible failure mode but mitigation of onboard hazards needs to be designed, covered and planned for when dealing with recovered vehicles, payloads and components. Status of onboard hazards shall be verified prior to allowing personnel to approach the vehicle or payload via visual, telemetry, etc.

5.4.4.1.1 Ordnance Hazards: Optimally, ordnance shall be expended prior to mission completion. Any unexpended ordnance shall be returned to a shorted state. This can be accomplished by the onboard ignition circuits which provide shorts across ordnance except during firing. If the payload

or vehicle cannot incorporate an inherent shorting device, shorts may be manually installed by a certified ordnance handler using a ground safety approved procedure during recovery or as soon as possible in terms of water recovery.

5.4.4.1.2 Pressure Hazards: Any pressure vessels/systems shall have residual pressure < 100 psi and < 14,240 ft. lbs. stored energy. Any required depressurization should be accomplished during the vehicle/payload flight. Otherwise remote depressurization shall be accomplished post flight prior to recovery.

5.4.4.1.3 Chemical Hazards: Any hazardous chemicals shall have a means of removing, containing or releasing them prior to recovery. In some situations, a wait time may be required in order to recover the payload or vehicle. A means of detecting chemical leaks using approved procedures/techniques for verification shall be required of systems where full release cannot be accomplished.

5.4.4.1.4 Cryogenic Hazards: Any hazardous cryogens shall have a means of removing, containing or releasing them prior to recovery. In some situations, a wait time may be required in order to recover the payload or vehicle.

5.4.4.1.5 Mechanical Hazards: Any mechanical hazards shall have a means of restraining all stored energy that remains on the vehicle prior to recovery. Methods of reducing this hazard include applying approved mechanical restraints while limiting access to deployment hazard areas.

5.4.4.1.6 Other Hazards: Each program/project shall develop and implement mitigations for other hazards on a case-by-case basis with approval by WFF Range Safety.

5.4.4.2 For unplanned events (vehicle or payload failures), contingency plans shall be implemented to protect recovery personnel from the potential hazards.

5.4.4.3 For missions where no recovery is planned but vehicle/payload hardware is potentially accessible to the public (such as impacts from Sounding Rockets launched at Poker Flat, Alaska), vehicle/payload designs and operational plans shall ensure public safety. Mission designs shall ensure all energy sources, hazardous chemicals/cryogens, and other hazards are expended, released, or otherwise mitigated.

6.0 FLIGHT SAFETY

6.1 Policies

6.1.1 The flight safety goal is to protect the public, the workforce (including range participants), and property during hazardous range flight operations under the control of WFF and to prevent mishaps that would result in embarrassment to NASA or the United States Government. Flight safety risks generally cannot be completely eliminated. WFF carefully plans each mission to minimize flight safety risks while enhancing the probability of attaining the mission objectives.

6.1.2 The WFF is responsible for flight safety during a mission until each flight component either reaches impact or achieves orbital insertion. The Safety Office shall implement the Flight Safety Program for all WFF launch operations and operations conducted by WFF at mobile ranges established at remote sites. For operations conducted at other established ranges, WFF is responsible for coordinating with the other range authorities to assure that NASA personnel,

NASA contractors, and NASA experimenters are provided safety protection that is equivalent to the processes, requirements, and risk criteria established by this document.

6.1.3 Flight safety is generally associated with the containment of vehicle flight within approved operational areas and impacts (spent stages, payloads, balloons, payload/parachutes, etc.) within planned impact areas. For each mission, the Safety Office shall perform and/or review and approve flight safety analysis that accounts for the entire set of mission specific variables (vehicle aerodynamic/ballistic capabilities; azimuth and elevation angles; wind effects, air and sea traffic, and proposed impact areas). Vehicle design, reliability, performance, and error predictions for each flight case shall be reviewed by Safety Office personnel to determine applicable risk mitigation measures.

6.1.4 Flight safety data shall be prepared and/or reviewed and approved by the WFF Safety Office prior to any range operations where WFF has flight safety responsibilities. Flight Safety documentation shall be prepared in accordance to the Flight Safety Process, 803-PG-8715.1.12.

6.2 Risk Criteria

All mission activities shall be planned such that the assessed risk satisfies the risk criteria listed in Section 6.2.1 and 6.2.2. In order to proceed with a mission where the risk cannot be mitigated sufficiently to satisfy the risk criteria, the project shall request and process a waiver according to Section 9.0. In all cases, the project and the Safety Office shall work to minimize the safety risk as low as reasonably practical.

When responsible for flight operations occurring at sites other than WFF, the more stringent risk criteria between the two shall apply.

Risk controls for protecting populated landmasses and property shall be implemented to satisfy the Casualty Expectation, Probability of Casualty, and property impact probability criteria defined in NPR 8715.5, Range Flight Safety Program and as stated in section 6.2 of this document. Risk controls for protecting ships and aircraft shall be implemented to satisfy the maximum hit probabilities established in section 6.2 of this document, which ensure there is no significant risk to any people on ships or aircraft.

Procedures and methodology for calculating risk values can be found in NPR 8715.5 and the Flight Safety/Range Safety Officer Training Manual (803-MANL-0001) for the NASA Goddard Space Flight Center/Wallops Flight Facility. They are consistent with those employed by other national ranges such as the Eastern and Western Ranges, and with the Range Commanders Council (RCC) Standard 321 Common Risk Criteria Standards for National Test Ranges.

Unless otherwise stated for a specific criterion, these criteria apply to the aggregate risk resulting from the combination of all hazards associated with a range operation.

6.2.1 Public Risk

6.2.1.1 Probability of casualty (P_c) for individuals shall be $<1 \times 10^{-6}$.

6.2.1.2 The casualty expectation (E_c) shall be $<100 \times 10^{-6}$.

NOTE: Three types of flight hazards shall be considered when applicable: debris (inert and explosive), distant focusing overpressure and toxic material release. For vehicles where more than one type applies, allowances for each type of hazard will be summarized. See sections 6.3.7, 6.3.8, and 6.3.9 for more details.

6.2.1.3 The probability of hitting a ship (P_i) shall be $<1 \times 10^{-5}$ for each distinct impact area.

6.2.1.4 The probability of hitting an aircraft (P_i) shall be $<1 \times 10^{-7}$ for each impact area. The minimum aircraft hazard area shall be 2 sigma for planned events.

6.2.1.5 The probability of spent stages or other vehicle debris impacting on protected property areas (P_i) shall be $<1 \times 10^{-3}$.

6.2.1.5.1 Local authorities and/or programs shall identify property that requires protection.

6.2.2 Mission Essential and Critical Operations Personnel Risk

6.2.2.1 Probability of casualty (P_c) for individuals shall be $<10 \times 10^{-6}$.

6.2.2.2 The casualty expectation (E_c) shall be $<300 \times 10^{-6}$.

6.2.2.3 The probability of hitting a ship (P_i) shall be $<10 \times 10^{-5}$ for each distinct impact area.

6.2.2.4 The probability of hitting an aircraft (P_i) shall be $<10 \times 10^{-7}$ for each impact area.

6.2.3 Risk Criteria Process

6.2.3.1 The vehicle program, the Safety Office, and the authority responsible for the range, launch site, or landing site shall coordinate to make operational decisions needed to control risk prior to initiation of flight or each phase of flight.

6.2.3.2 For an orbital Reusable Launch Vehicle (RLV) or vehicle that operates continuously for extended periods, the Safety Office may make operational decisions, including the implementation of applicable per flight risk criteria, independently for each phase of flight (e.g., launch, entry, ascent, cruise, or descent) if all three of the following are satisfied:

6.2.3.2.1 Each decision is based on a risk assessment that is conducted or validated just prior to each phase of flight.

6.2.3.2.2 The assessment or validation accounts for updated vehicle status and updated predictions of flight conditions.

6.2.3.2.3 The vehicle has sufficient controllability to allow for risk management as a prerequisite to beginning each phase of flight.

6.2.3.3 For a mission that involves the operation of more than one vehicle simultaneously, the Safety Office may make operational decisions, including the use of applicable per flight risk criteria, independently for each vehicle if each vehicle has sufficient independent controllability to allow the management of risk individually for the flight of each vehicle.

6.2.3.4 The Safety Office shall calculate Probability of Impact to identified property in the vicinity of the flight that requires protection from potential debris impact, identify the potential damage of concern if possible, and suggest mitigations to the associated risk.

NOTE: Local authorities and programs are responsible for determining what property requires protection. Local authorities may have risk management requirements that apply to certain high-value equipment, assets, or other property. There may be specific property for which the program requires risk management due to its proximity to the flight and the consequences associated with potential hazards.

6.2.3.5 The Safety Office shall quantify and document any risk through the conduct of a formal risk assessment and publish the results in a Risk Analysis Report (RAR).

6.2.3.6 The Safety Office shall ensure operational personnel are informed of the hazards and safety risk associated with the conduct of any range operation.

6.2.3.7 The Safety Office shall ensure on-site public/visitors are informed of the hazards and safety risk associated with viewing a range operation from NASA-controlled property.

6.3 Flight Safety Risk Assessment

6.3.1 A flight safety risk assessment shall be a formal documented analysis that identifies and characterizes risk for input to the risk management process. The risk assessment shall employ quantitative means unless the WFF Safety Office including the WFF Range Safety Officer agree that quantitative assessment is not necessary or not feasible; in which case the risk assessment shall employ qualitative measures.

NOTE: The flight safety risk assessment documentation can be found in a combination of the flight safety Risk Analysis Report (RAR) and Flight Safety Plan (FSP), both published by the Safety Office. A Flight Safety Data Package (FSDP) may take the place of one or more of these documents, as required by the lead flight safety organization at another range.

6.3.2 The risk assessment shall provide a best estimate of the risks and include an evaluation of uncertainty bounds or sensitivities to inputs.

6.3.3 The assessment documentation shall identify all assumptions made.

6.3.4 The risk assessment shall account for variability associated with the following:

6.3.4.1 Each source of hazard, including any associated with a payload, during flight.

6.3.4.2 Normal flight and each appropriate foreseeable failure response mode of the vehicle for each flight phase.

6.3.4.3 Each appropriate foreseeable external and internal vehicle flight environment.

6.3.4.4 Public and worker population potentially exposed to the flight.

6.3.4.5 Population growth rates in order to remain valid if a risk assessment will apply to a number of flights over a number of years.

6.3.4.6 The performance of any range safety system, control, or constraint including all associated time delays.

6.3.5 Input data used for the range safety risk assessment shall include:

6.3.5.1 Quantitative assessment of vehicle reliability unless the vehicle will operate under full containment where any associated hazard cannot reach persons and property.

6.3.5.2 Proposed trajectories (nominal, preplanned contingency, abort, and malfunction trajectories).

6.3.5.3 Description of any landing sites and/or flight paths.

6.3.5.4 Description of credible failure modes and their probability of occurrence resulting in a hazard to public safety.

6.3.5.5 Reliability of any range safety system.

6.3.5.6 All hazard controls and mitigation strategies.

6.3.5.7 Pertinent vehicle information, such as size, weight, propellant types and amounts, and any explosives, toxic materials, or radionuclides.

6.3.5.8 Other relevant data required for analysis in support of specific mission objectives, including related payload information.

6.3.6 There are typically three types of hazards considered in a range safety risk assessment. These include debris, distant focusing overpressure, and toxic material release.

6.3.6.1 A risk assessment shall account for the risk due to each hazard where applicable for each flight unless the hazard is fully contained.

6.3.6.2 Other hazards may exist based on specific mission requirements, and these hazards shall be included in the assessment on a case-by-case basis.

6.3.7 Debris Risk Assessment

6.3.7.1 A flight risk analysis shall assess any risk due to debris for input to the risk management process. For a launch, these requirements apply to any debris that does not achieve orbit. For an entry operation, these requirements apply to any debris that might be generated, intentionally or not, after the deorbit burn or sample return capsule release.

6.3.7.2 An assessment of risk to the public and workforce due to debris shall account for each of the following as a function of flight-time or loss-of-control-time:

6.3.7.2.1 All potential debris, generated intentionally or not, that could cause a casualty, including debris that could affect someone on the ground or on a waterborne vessel, or cause an aircraft accident.

6.3.7.2.2 All populated areas in the overflight area that could be impacted by the debris.

6.3.7.2.3 The probability of the debris impacting each populated area, which accounts for the probability of vehicle failure.

6.3.7.2.4 The effective casualty area of the impacting debris, which accounts for the cross-sectional area of the debris, average size of a person, and the effects of any overpressure due to any explosive debris (debris that would explode on or after impact).

6.3.7.2.5 The population density of each populated area. The assessment should consider any risk mitigation factors associated with each population, such as sheltering and time of day of the flight.

6.3.7.2.6 Debris variability, including size, shape, aerodynamic properties, weight, and potential to survive to impact.

6.3.7.2.7 The sources of debris variability, including breakup conditions.

6.3.7.2.8 The uncertainties in the state vector at the instant of jettison or destruct and any correlations used.

6.3.7.2.9 Any velocity imparted to the debris fragments during jettison, destruct, or breakup.

6.3.7.2.10 The influence of atmospheric variability, including winds.

6.3.7.3 A debris risk assessment for any protected property identified shall account for:

6.3.7.3.1 All potential debris (intentionally or unintentionally generated) that could cause property damage, which accounts for the specific nature of the property.

6.3.7.3.2 The cross-sectional area of the debris and the effects of any overpressure due to any explosive debris (debris that would explode on or after impact).

6.3.7.3.3 Debris variability, including size, shape, aerodynamic properties, weight, and potential to survive to impact.

6.3.7.3.4 The sources of debris variability, including breakup conditions.

6.3.7.3.5 The uncertainties in the state vector at the instant of jettison or destruct and any correlations used.

6.3.7.3.6 Any velocity imparted to the debris fragments during jettison, destruct, or breakup.

6.3.7.3.7 The influence of atmospheric variability, including winds.

6.3.7.3.8 The probability of the debris impacting the property, which accounts for the probability of vehicle failure and the location, size, and shape of the property.

6.3.7.4 A flight risk analysis shall establish flight commit criteria and operational constraints, such as hazard areas and impact limit lines, needed to control any risk due to debris impacts.

6.3.7.5 A flight risk analysis shall establish hazard areas needed to control risk due to debris including aircraft and ship hazard areas for notices to mariners and notices to airmen.

6.3.8 Distant Focusing Overpressure Effects Risk Assessment

6.3.8.1 A flight risk analysis shall characterize the risk to the public and the workforce due to any distant focusing overpressure from potential explosions during vehicle operations for input to the risk management process.

6.3.8.2 The analysis shall establish flight commit criteria to control risk due to potential distant focusing overpressure effects.

6.3.8.3 A distant focusing overpressure analysis shall account for:

6.3.8.3.1 The potential for distant focusing overpressure or overpressure enhancement given current meteorological conditions and terrain characteristics.

6.3.8.3.2 The potential for broken windows and related casualties.

6.3.8.3.3 Characteristics of the potentially affected windows, including their size, location, orientation, glazing material, and condition.

6.3.8.3.4 The hazard characteristics of the potential glass shards, such as falling from upper building stories or being propelled into or out of a shelter toward potentially occupied spaces.

6.3.8.3.5 The explosive capability of the vehicle at or after impact and at altitude and potential explosions resulting from debris impacts, including the potential for mixing of liquid propellants.

6.3.8.3.6 Characteristics of the vehicle flight and the surroundings that would affect the population's susceptibility to injury, for example, shelter types and time of day of the proposed activity.

6.3.9 Toxic Hazard Risk Assessment

6.3.9.1 In the case of nominal flight or a catastrophic failure of a vehicle in flight, rocket fuel and oxidizer residues (e.g., hydrazine, nitrogen tetroxide, hydrogen chloride from solid rocket motors, and their combustion products) may be present. Under certain meteorological conditions, high concentrations of these materials may drift over populated areas at levels greater than emergency health standards permit. As a result, NASA shall protect the public and workforce from toxic hazards using either hazard containment or a risk mitigation approach.

6.3.9.2 A flight risk analysis shall establish flight commit criteria to control any risk due to potential toxic material release.

6.3.9.2.1 The analysis shall assess any residual risk due to potential toxic material release not fully contained or mitigated for input to the program's risk management process.

6.3.9.2.2 The analysis shall account for:

6.3.9.2.2.1 Any foreseeable toxic material release during the proposed nominal flight or in the event of a mishap.

6.3.9.2.2.2 Any operational constraints and emergency procedures that provide protection from toxic material release.

6.3.9.2.2.3 All populations potentially exposed to any toxic material release, including all members of the public and workforce on land and on any waterborne vessels and aircraft.

6.3.9.2.2.4 Potential emissions from both nominal range operations and catastrophic events to ensure response actions are designed to prevent or mitigate possible exposures.

6.3.9.3 The American Industrial Hygiene Association – Emergency Response Planning Guidelines (ERPG) – shall be used for determining the need and requirements for emergency response action plans.

6.3.10 Containment

6.3.10.1 When controlling risk through containment, the flight risk analysis shall provide the basis for establishing the geographical areas from which people and any protected property shall be excluded during flight.

6.3.10.2 The analysis shall determine any operational controls needed to isolate each hazard and prevent/mitigate the risk due to the hazard.

6.3.10.3 The Flight Safety Group, in conjunction with the program, shall establish the containment criteria for normal and malfunctioning vehicle flight.

6.3.10.4 Any residual risk due to any hazard not fully contained shall undergo the risk management process.

6.3.11 Risk Mitigation

6.3.11.1 When controlling risk through mitigation, a flight risk analysis shall establish the operational constraints that negate the risk or reduce it to a level that is acceptable with appropriate management approval.

6.4 Range Safety Systems (RSS)

6.4.1 A RSS is required unless it is shown that the maximum range of the vehicle is less than the range to all protected areas, or a risk analysis shows that all of the mission risk criteria specified in Section 6.2, Risk Criteria, are satisfied, or the vehicle is inherently safe.

6.4.1.1 An operation is considered inherently safe if the predicted flight is based solely on launch and dispersion parameters and known system errors and if any of the following conditions are true:

6.4.1.1.1 The vehicle does not contain a guidance or control system capable of exceeding a containment area.

6.4.1.1.2 The vehicle can be accurately wind weighted to provide for an acceptable impact location.

6.4.1.1.3 The maximum energy of the vehicle can be contained such that the established risk criteria in Section 6.2 are satisfied.

6.4.2 Flight Termination System (FTS)

A FTS provides for risk mitigation during vehicle flight and may be a major component of a vehicle program's risk management approach.

6.4.2.1 Any vehicle, stage, or payload with propulsive capability that poses elevated public risk that requires mitigation as determined by the flight safety analysis, shall have a FTS.

6.4.2.2 A FTS shall satisfy the requirements of AFSPCMAN 91-710, Range Safety User Requirements Manual, RCC 319 Flight Termination Systems Commonality Standard, or a tailored set of equivalent requirements to meet specific hazard analysis requirements.

NOTE: Under the grandfathering provisions of AFSPCMAN 91-710, some existing launch vehicle programs are governed by Eastern and Western Range (EWR) 127-1, Range Safety Requirements, which is the predecessor to AFSPCMAN 91-710. NASA accepts this grandfathering where applicable.

6.4.2.3 When an FTS is used for a NASA or NASA-sponsored vehicle, the vehicle program/project coordinates with the WFF Safety Office to consider and evaluate the need for using a secure FTS.

6.4.2.4 The vehicle program/project shall implement a secure FTS unless the program/project and the WFF Safety Office document their approval of a non-secure FTS (including rationale that identifies any potential range safety risks and their mitigations).

6.4.2.5 When using a secure FTS, all command uplinks shall utilize National Security Agency-approved or endorsed techniques and products.

NOTE: In addition to flight safety considerations, each vehicle program/project should consider the mission assurance aspects of using secure FTS.

6.4.2.6 FTS command systems shall be under configuration control.

6.4.3 Autonomous Flight Safety System (AFSS)

NOTE: Autonomous in this context is defined as events or actions which occur without ground-based intervention during flight and may include flight termination for range safety purposes. NASA continues to coordinate with the Air Force and other members of the national range community to further develop and implement AFSS for space launch and other range operations, to include development of related range safety requirements.

6.4.3.1 AFSS may be used for range operations where the implementation meets vehicle and operational constraints and the system is designed and qualified to standards approved by the WFF Safety Office.

6.4.4 Recovery System or Contingency Management System (CMS)

6.4.4.1 A Recovery System or CMS may use a set of elements within the vehicle, including but not limited to, manual control or autonomous control. A Recovery System or CMS may also include elements that are independent of the vehicle.

6.4.4.2 A Recovery System or CMS may provide for deliberate termination of an errant/erratic vehicle's flight but shall not be considered a FTS unless the system meets the requirements of Section 6.4.1.

6.4.4.3 Activation of a Recovery System or CMS shall not increase the risk to people or property.

6.4.4.4 A Recovery System or CMS that does not meet FTS requirements may be considered as risk mitigation and factor into the range safety risk assessment for the range operation where applicable.

6.4.5 Requirements for Balloons

6.4.5.1 A RSS is required, unless the maximum weight and weight per surface area criteria of CFR 14, FAA, Part 101, Moored Balloons, Kites, Unmanned Rockets, and Unmanned Free Balloons are satisfied.

6.5 Operational Procedures

6.5.1 Flight Commit Criteria

6.5.1.1 The flight commit criteria for a range operation shall identify the conditions that must be met to initiate each flight or phase of flight.

6.5.1.2 The flight commit criteria shall provide for:

6.5.1.2.1 Assurance that the collision avoidance requirements of Section 6.5.2.3, Collision Avoidance are satisfied for any launch or entry.

6.5.1.2.2 Surveillance of any established hazard areas requiring surveillance.

6.5.1.2.3 Verification that all range safety systems are available and operational.

6.5.1.2.4 Verification that the meteorological conditions, such as wind, lightning, and visibility, are within the limits defined by the range safety analysis.

6.5.1.3 Implementation of the flight commit criteria shall include documenting the actual conditions at the time of flight or time of each phase of flight where applicable to verify that the flight commit criteria have been met.

6.5.2 Rocket, Missile, Drone, Unmanned Aerial Vehicle (UAV's) and Other Similar Vehicles

6.5.2.1 Hazard Areas

6.5.2.1.1 Hazard areas are developed by probabilistic calculations or by maximum range capability.

NOTE: The maximum range may be limited by the use of a RSS, taking into consideration the reliability of the RSS.

6.5.2.1.2 Aircraft hazard areas shall be developed for all operations.

6.5.2.1.3 A DoD ship hazard area shall be developed for all impacts in the Virginia Capes (VACAPES) that meets the maximum ship impact probability of 1×10^{-6}.

6.5.2.1.4 Ship impact probability calculations shall be performed for all operations where applicable.

NOTE: RCC 323, Range Safety Criteria for Unmanned Air Vehicles can be used as a guideline for analysis and operational constraints for Unmanned Aerial Vehicle flown at WFF.

6.5.2.2 Range Clearance

6.5.2.2.1 WFF shall coordinate its operations with the FAA, the U. S. Navy, the U. S. Coast Guard and other organizations, as required, to survey potential hazard areas.

6.5.2.2.2 All calculated hazard areas within the VACAPES operating areas require scheduled clearance for aircraft and ships from the Fleet Area Control and Surveillance Facility (FACSFAC) prior to launch.

6.5.2.2.2.1 Radar and/or visual assets shall be employed for surveillance.

6.5.2.2.2.2 Other surveillance strategies, such as visual flydowns, may be employed as risk mitigation efforts.

6.5.2.2.3 Clearance with the FAA is required for any aircraft hazard area that extends beyond the VACAPES operating areas.

6.5.2.2.4 Hazard Areas for NOTAMS (Notice to Airmen) and NOTMARS (Notice to Mariners) shall be submitted 10 days prior to launch to allow for the publication of those notices.

6.5.2.2.5 Public Ship Avoidance Areas shall be submitted to WFF Public Affairs Office.

6.5.2.3 Collision Avoidance (COLA)

6.5.2.3.1 NASA shall ensure that all inhabited or inhabitable spacecraft are protected from collision with sounding rocket and Expendable Launch Vehicle (ELV) motors, payloads, or other expended items that obtain a minimum apogee altitude of 150KM, with the following criteria:

6.5.2.3.1.1 Spherical volumes greater than or equal to 200 kilometers; OR

6.5.2.3.1.2 An ellipsoidal miss distance greater than or equal to 200 km in-track and 50 km cross-track or radially; OR

6.5.2.3.1.3 A probability of impact less than or equal to 1×10^{-6}.

6.5.2.3.2 All other operational satellites shall be protected with a minimum spherical volume of 5KM.

6.5.2.3.3 NASA shall notify the United States Strategic Command (USSC) of any upcoming launches or entry operations at least 15 days prior to operations, obtain a COLA analysis from USSC and inform USSC of any changes. The COLA analysis shall:

6.5.2.3.3.1 Establish each wait in a planned launch window during which the vehicle program will not initiate or commit to launch (Requirement).

6.5.2.3.3.2 Account for the vehicle, any jettisoned component, and/or payload achieving altitudes greater than 150 km (Requirement).

6.5.2.3.3.3 Account for uncertainties associated with vehicle performance and timing and ensure that any calculated launch waits incorporate all additional time periods associated with such uncertainties (Requirement).

6.5.2.3.3.4 For an orbital launch, account for ascent to orbital insertion plus a number of revolutions that: (i) accounts for each objects' orbit type, (ii) accounts for each objects altitude in relation to each other as needed to satisfy the applicable criteria, and (iii) provides sufficient time for each new orbital object to be catalogued by USSC (Requirement).

6.5.2.3.3.5 For a suborbital launch, account for the entire flight to landing or final impact (Requirement).

NOTE: The COLA analysis need not account for an inhabitable orbital object if the three-sigma maximum altitude capability of the launch vehicle, any jettisoned component, and/or payload is 50 km or more below the orbital perigee of the inhabitable object.

6.5.2.3.3.6 For an entry operation, account for the entry trajectory from the point that deorbit is committed through landing or final impact (Requirement).

6.5.2.4 Wind Weighting (Sounding Rockets)

6.5.2.4.1 All unguided Sounding Rockets shall be wind weighted, except as noted in Section 6.5.2.4.2. An unguided portion of flight for guided vehicles shall also be wind weighted.

6.5.2.4.2 Low performance Sounding Rockets may be launched without being wind weighted, provided the effective elevation is 80 degrees or less and all other safety criteria are met.

6.5.2.4.3 The operational wind weighting system shall produce solutions with errors no greater than those used to determine vehicle dispersion and potential hazard areas.

6.5.2.5 Sounding Rockets without Range Safety Systems

6.5.2.5.1 The maximum effective launcher elevation setting is 85 degrees.

6.5.2.5.2 The maximum wind corrected launcher elevation setting is 86 degrees.

6.5.2.5.3 For unproven vehicles, the maximum effective launcher elevation setting is 80 degrees. The effective azimuth shall be chosen such that the geographical advantages of the impact area are realized.

6.5.2.5.4 For unproven vehicles; the maximum wind corrected launcher elevation setting is 83 degrees.

6.5.2.5.5 Surface, ballistic, and other wind limits shall be established based on vehicle wind sensitivity.

6.5.2.5.6 Effective launch azimuth and elevation settings shall be established such that the planned impact shall occur within approved operating areas.

6.5.2.5.7 Launch limitations shall be published in the Flight Safety Plan.

6.5.2.5.8 Tracking or other data sources shall be utilized to determine impacts (either during the mission or through post mission analysis) of all vehicle components.

6.5.2.6 Vehicles with Range Safety Systems

6.5.2.6.1 Launch Limitations:

6.5.2.6.1.1 Flight limits shall be established to implement flight safety criteria. Examples include: impact limits, vehicle attitude, heading, time of flight, and position. These limits may be implemented as launch criteria and/or flight requirements.

6.5.2.6.1.2 Surface, ballistic, and other wind limits shall be established based on vehicle wind sensitivity.

6.5.2.6.1.3 Effective launch azimuth and elevation settings shall be established such that the planned impact shall occur within approved operating areas.

6.5.2.6.1.4 Launch limitations shall be published in the Flight Safety Plan.

6.5.2.6.2 Flight Termination Criteria:

6.5.2.6.2.1 Flight termination is required when valid data shows the vehicle violating a flight termination boundary.

6.5.2.6.2.2 Flight termination is required when the vehicle performance is unknown, the vehicle is capable of violating a flight termination boundary, and terminating flight would mitigate the risk.

6.5.2.6.2.3 Orbital launch vehicles must be nominally capable of achieving a minimally acceptable orbit (~70 NM perigee) prior to orbit insertion.

6.5.2.6.2.4 Flight may be terminated as a result of gross trajectory deviation or obvious erratic flight. This action may be taken if, in the judgment of the FSO, further flight is likely to increase the hazard potential.

6.5.2.6.2.5 Other flight termination criteria may be enforced due to the uniqueness of a particular mission. These criteria shall be documented in the Flight Safety Plan.

6.5.2.6.3 Prelaunch Checks:

6.5.2.6.3.1 Prelaunch checks shall be performed to operationally certify the range safety system.

6.5.2.6.3.2 Ground support components of the flight termination system shall be fully redundant and operationally certified.

6.5.2.6.4 Flight Data Requirements:

6.5.2.6.4.1 At least one tracking or other data sources shall be utilized to determine impacts (either during the mission or through post mission analysis) of all vehicle components.

6.5.2.6.4.2 For vehicles flown with a Flight Termination System (FTS):

6.5.2.6.4.2.1 At least two independent data systems (examples include: Radar, Optics, Global Positioning System (GPS), and Inertial Measurement Unit (IMU)) are required to provide real time positional/Instantaneous Impact Point (IIP) data during launch. If one of the data systems is a skin tracking radar, a ceiling limitation shall be imposed to ensure visibility until the skin tracking radar has adequate time to provide quality data. The data systems shall be designed such that no single order vehicle failure mode or ground system failure mode could cause the loss of both data systems.

6.5.2.6.4.2.2 Loss of data, such that the FSO cannot verify vehicle performance within flight safety limits, shall result in a flight termination action.

6.5.2.6.4.2.3 All data systems, which provide information used to evaluate flight safety requirements, shall be operationally certified prior to launch.

6.5.2.6.4.2.4 Telemetry (Vehicles with FTS):

6.5.2.6.4.2.5 All data systems that provide information used to evaluate range safety requirements shall undergo validation to ensure operational readiness prior to initiating any phase of flight such as launch or entry.

6.5.2.6.4.2.6 The range safety telemetry system shall provide continuous, accurate data during preflight operations and during flight.

6.5.2.6.4.2.7 The vehicle program shall coordinate with the responsible range safety organization to identify the safety data required for each flight.

6.5.2.7 Weather Constraints for Expendable Launch Vehicles (ELV's) are defined in Attachment 1.

6.5.3 Balloon Operations

6.5.3.1 All operations shall be conducted within flight limits, which satisfy the risk criteria stated in Section 6.2, Risk Criteria.

6.5.3.2 A predicted trajectory shall be calculated based on the prelaunch wind profile. The predicted trajectory and its descent vector shall be updated based on the current wind profile. The time of launch shall be coordinated with, and clearance to launch shall be obtained from the FAA or equivalent foreign agency.

6.5.3.3 A recovery point and time shall be selected that satisfies the risk criteria. The time and location of the recovery point shall be coordinated with, and clearance to terminate shall be obtained from the FAA or equivalent foreign agency.

6.5.3.4 The Safety Office shall review and approve the balloon termination/recovery system when relied upon as a range safety system used to mitigate safety risks.

6.5.3.5 A functional test of the balloon termination/recovery system shall be performed prior to launch to certify the range safety system.

6.5.4 Aircraft Operations

6.5.4.1 All aircraft operations managed by WFF or conducted on the WFF test range shall be performed within the requirements established by an approved Project Plan.

6.5.4.2 All operations that require range safety involvement shall be conducted such that the risk criteria stated in Section 6.2, Risk Criteria, are satisfied.

6.5.4.3 Aircraft shall be operated in accordance with the 830-AOM-0001, Aircraft Operations Manual and FACSFAC VACAPES Operating Instruction 31201.J or Oceanic Airspace, as applicable. Visual Meteorological Conditions (VMC) is required for all aircraft that are not Instrument Flight Rated (IFR).

6.5.4.4 For separation purposes, preassigned airspace and altitude boundaries shall be established prior to the mission for each participating aircraft. Minimum separation criteria is 1000 feet in altitude or 1 NM laterally unless formation flight is approved by the Aviation Safety Officer and a briefing with appropriate mission personnel is conducted prior to the start of the operation. Pilots shall retain the responsibility for aircraft separation; ground based coordinators shall only be used for position vectoring and advisories.

6.5.4.5 FACSFAC VACAPES shall be notified by aircraft prior to initial entry into the VACAPES area. If the aircraft is unable to notify FACSFAC, they should inform the WFF Range Control who shall notify FACSFAC.

7.0 RANGE USER AND TENANT RESPONSIBILITIES

Range users and tenants shall:

7. 1 Obtain Safety Office approval prior to conducting any hazardous operation.

7. 2 Provide data to WFF for safety analysis (see Section 8.0, GSFC WFF Safety Data Requirements).

7. 3 Identify the minimum safety requirements for test operations. If a range user or tenant determines that their safety requirements are more stringent than those imposed by the WFF, the user or tenant shall coordinate these requirements with the Safety Office.

7. 4 Participate in discussions to familiarize Safety Office personnel with all aspects of the mission.

7. 5 Participate in real time data evaluation for mission control and/or flight termination, as required by the Safety Office.

7. 6 Notify the Safety Office of all meetings pertaining to the mission that involves safety related issues, i.e., Design Reviews, Operational Planning meetings.

7. 7 Participate in failure/anomaly investigations and provide post flight data as required.

7. 8 Participate in the Range Safety Requirements Tailoring Process and satisfy the Equivalent Level of Safety and/or Waiver Processes for any requirements specified in this document that cannot be satisfied (See Section 9.0, Tailoring Equivalent Level of Safety and Waiver Processes).

8.0 WFF SAFETY DATA REQUIREMENTS

8.1 Launch Vehicle and Payload Description Data

The specifications defined in this section are intended as a synopsis of information required to perform a ground safety analysis. The actual requirements shall be mission specific. The range user is responsible for coordinating data requirements with the Safety Office.

8.1.1 Hazardous Electrical Circuits - Range users shall provide one copy of schematic and wiring diagrams of all pyrotechnic and other circuits that initiate hazardous systems. The Safety Office shall be promptly notified of any changes to hazardous electrical circuits.

8.1.2 Mechanical Systems - Range users shall provide a description, including technical details and precautions, for all hazardous mechanical systems. Approved engineering drawings shall be supplied showing the location of these and all other hazardous systems (ordnance, pressure, etc.).

8.1.3 Ordnance Devices - For each EED, data sheets shall be provided listing the minimum all fire current, maximum no-fire current, recommended firing current, normal resistance, pin-to-case resistance, and, if available, the RF sensitivity characteristics. A technical description of all SAFE/ARM type devices (out-of-line S/A, S/A connectors, mechanical restraints, etc.) employed shall be provided. For ordnance devices such as: rocket motors, shape charges, detonating cord, etc. data sheets shall be provided which identify the DoT explosive classification, normal output characteristics, composition, or any other relevant information needed to perform safety analyses.

8.1.4 Chemicals - The range user shall provide a description and approved engineering drawing of the system. All hardware "plumbing," components (tanks, fittings, valves), and system safety features shall be defined. A SDS for each chemical used on the project shall also be provided.

8.1.5 Pressure Systems - The range user shall provide a description and approved engineering drawing of all pressure systems used on the program. Technical characteristics, including design burst, proof, and MAWP pressures, internal volume, and materials of construction shall be provided.

8.1.6 Radiation Sources

8.1.6.1 Non-Ionizing (RF) Sources - The range user shall provide data on all non-ionizing emitters as outlined in GPR 1860.3 Radio Frequency Radiation Protection including frequency, type of emission, type of radiating antenna, antenna gain, radiated power (both peak and average), and verify that users are properly trained.

8.1.6.2 Ionizing Sources - The range user shall provide data on all ionizing sources and devices, as required by GPR 1860.1, Ionizing Radiation Protection, including NRC or State license, and verify that custodians and users are properly trained

8.1.6.3 Optical Sources - The range user shall provide data on all hazardous optical emitter (e.g., lasers) as outlined in GPR 1860.2 Laser Radiation Protection including wavelength, pulse width, pulse repetition frequency, beam diameter, divergence angle, average power output, laser classification, and verify that users are properly trained. Range user may need to coordinate outdoor laser operations with the FAA or the Laser Clearinghouse.

8.1.7 Ground Support Equipment (GSE) - Range users shall provide schematics, approved engineering drawings, operational description, technical details, and documentation of certification for all GSE used to support hazardous systems or operations. This includes but is not limited to pyrotechnic checkout meters, breakout boxes, calibration sources, pressure systems, chemical service modules, and lifting and handling devices. This requirement is in addition to the requirements of Section 5.3.5, Ground Support Equipment (GSE).

8.2 Operating Procedures

The specifications defined in this Section are intended as a synopsis of information required to perform a ground safety analysis. The actual requirements shall be mission specific. The range user is responsible for coordinating data requirements with the Safety Office.

8.2.1 Hazardous Systems - Detailed procedures for handling, assembly, and checkout for all hazardous systems (ordnance, mechanical, pressure, chemical, etc.) shall be provided to WFF prior to beginning operations in accordance with Attachment 2.

8.2.2 Recovery - For recovery operations, procedures shall be provided which provide a description of the items to be recovered, reasons for recovery, hazards involved, and any recovery aids and their characteristics. These procedures shall describe the methods employed to verify that all hazardous systems are in a SAFE condition during recovery operations. A list of recovery aids such as chaff (frequency, quantity), locator beacons (frequency, power output, period of operation), dye marker (color persistence, time of deployment), flashing light (color, frequency, duration, candle power, directional characteristics), smoke (color, duration, time of deployment), radar reflective parachute (when deployed, size), or any other aids used should be included. Also, provide the desired period of recovery operations and the disposition of the recovered items.

8.2.3 Contingencies - Contingency procedures shall be provided prior to beginning operations. These contingency procedures include steps to be taken in the event of launch postponement, launch cancellation (including destaging), hold or abort, booster ignition failure, unintentional land impact, emergency response, chemical spill cleanup, or any other contingency that may endanger personnel or property.

8.2.4 Approval - All procedures for handling, assembly, and checkout of hazardous systems shall be approved by the Safety Office prior to use at WFF. Approvals shall be obtained prior to performing any potentially hazardous operation.

8.3 Performance and Flight Safety Data Requirements

8.3.1 The specifications defined in this section are intended as a synopsis of information required to perform a flight safety analysis. The actual requirements shall be mission specific. The range user is responsible for coordinating data requirements with the Safety Office.

8.3.2 Rockets, Missiles, Drones, UAV's and Other Similar Vehicles

8.3.2.1 Provide a vehicle description including a scaled drawing and operating procedures. Provide a description of the mission (i.e. Test Plan). For Drones and UAV's, provide a description of Loss of Signal (LOS) contingencies.

8.3.2.2 Nominal Trajectory Inputs

8.3.2.2.1 Launch Parameters - launcher settings, launch coordinates (WGS - 84 geodetic datum), and a sequence of events (ignitions, burnouts, separations, etc.).

8.3.2.2.2 For Drones and UAV's, supply nominal flight profile, including waypoints.

8.3.2.2.3 Other information as requested.

8.3.2.3 Trajectory Outputs - Output data may be required in printed, plotted, or computer medium format for each impacting or orbital body. The output should include:

8.3.2.3.1 Time, velocity, altitude, horizontal range, weight, thrust, drag, dynamic pressure, angle of attack, velocity vector elevation and azimuth angles, body pitch, yaw and roll angles, present position and instantaneous impact prediction latitude and longitude, Earth Centered, Earth Fixed x, y, and z, slant range, azimuth, and elevation relative to the launcher. A Monte Carlo dispersion simulation must have a significant number of runs to reliably predict vehicle dispersion.

8.3.2.3.2 Maximum horizontal range, maximum velocity and turn rate analysis may be required.

8.3.2.4 Provide total dispersion data, either theoretical and/or empirical, in terms of one, two, and three sigma ellipses for all impacting bodies. A theoretical analysis may include some or all of the following effects: thrust offset, thrust misalignment, aerodynamic errors, uncompensated wind, launcher misalignments, weight and impulse errors, guidance and control system errors, ignition delay, and any other errors unique to this vehicle. Provide flight history trajectory data on previous vehicle flights.

8.3.2.5 Provide a debris analysis including technique and input parameters. The Safety Office may elect to perform a debris analysis. Therefore, chamber pressure and the number and type of debris fragments caused by vehicle breakup may be required. The data for each debris fragment shall include ballistic coefficient, weight, dimensions, drag coefficient, and the incremental velocity imparted by the vehicle breakup.

8.3.2.6 Provide Toxic hazards analysis to include types and quantities of hazardous gases and by-products of combustion of solid and liquid propellants. Provide input data for the REEDM and LATRA pre-launch analysis tools (used by the Eastern and Western Ranges).

8.3.2.7 Provide Distant Focusing Overpressure (DFO) inputs for the Blast DFO pre-launch analysis tool (used by the Eastern and Western Ranges).

8.3.2.8 Provide a wind effect analysis and the method used for calculation. Provide data consistent with currently used WFF wind compensation methods. Provide parachute data, if applicable.

8.3.2.9 A Hazard Analysis could be required on critical systems, depending on the project. Identification of each potential hazard, the preventive measures to reduce each potential hazard, and a risk assessment for those potential hazards that cannot be eliminated by preventive measures should be included in the Hazard Analysis.

8.3.3 Balloons

8.3.3.1 Identify launch site and launch window.

8.3.3.2 Provide payload and balloon characteristics.

8.3.3.2.1 Provide payload dimensions and total suspended weight.

8.3.3.2.2 Provide balloon material, volume, and weight.

8.3.3.2.3 Provide gross inflation weight.

8.3.3.2.4 Provide theoretical stress index (if applicable).

8.3.3.3 Provide payload/parachute weight, drag coefficient, and reference area.

8.3.3.4 Provide the time of day (day or night) that each of the following mission phases will be performed: launch and ascent, float, descent and impact.

8.3.3.5 Provide anticipated float direction and duration of flight.

8.3.3.5.1 Provide float altitude.

8.3.3.5.2 Provide predicted float altitude variation during day/night cycle.

8.3.3.5.3 Provide float time or distance.

8.3.3.5.4 Provide float direction and estimated wind velocity at float altitude.

8.3.3.6 Provide description of any balloon control system (such as a valving system).

8.3.3.7 Provide balloon flight history data.

8.3.3.7.1 Provide balloon system reliability data including number of flights, number and types of failures, and where the failures occurred (ascent, float, or descent).

8.3.3.7.2 Provide actual and predicted payload/parachute descent vectors. Actual balloon descent vectors if available.

8.3.3.8 Provide balloon wind limitations.

8.3.4 Aircraft

8.3.4.1 The range user shall provide flight profiles including aircraft velocities, altitudes, and separations (for multiple aircraft).

8.3.4.2 Data on platform instrumentation shall be provided if it is of a hazardous nature (i.e., pressure systems, ordnance, gases, lasers, high-voltage, etc.).

8.4 Telemetry (TM) Data Requirements for Vehicles with Flight Termination

The specifications defined in this Section are intended as a synopsis for pre-flight and real time data requirements. Actual requirements shall be mission specific and the range user is responsible for coordinating TM data requirements with the Safety Office.

8.4.1 Provide Command Receiver(s) signal strength Automatic Gain Control (AGC), check channel, arm and destruct indications.

8.4.2 Provide Inertial Navigation System (INS) Parameters

8.4.2.1 Provide Inertial position, velocity and acceleration. Inertial Earth Centered Earth Fixed coordinates are preferred. All reference systems shall be defined.

8.4.2.2 Provide INS initialization parameters.

8.4.3 Provide guidance commands including nozzle deflections in the pitch and yaw axes.

8.4.4 Provide vehicle attitude data including pitch, yaw and roll angles and rates.

8.4.5 Provide Motor Chamber Pressures.

8.4.6 Provide other FTS Parameters.

8.4.6.1 Provide Control Circuit Status.

8.4.6.2 Provide External/Internal Battery Voltage.

8.4.6.3 Provide Safe/Arm Status.

8.4.7 Provide GPS Positional and Velocity Data.

8.5 Schedules for Providing Required Data

The specifications defined in this Section are intended as a synopsis for scheduling deliverables. Actual requirements shall be mission specific and the range user is responsible for coordinating schedules with the Safety Office.

8.5.1 NASA, DoD and commercial ELV's should plan to meet the schedule defined in Attachment 2.

8.5.2 For sounding rocket vehicle or payload systems not previously launched from WFF, all final data should be supplied no later than T-90 days. Preliminary data for these systems should be submitted no later than T-120 days.

8.5.3 For sounding rocket vehicle or payload systems previously launched from WFF, final data should be submitted no later than T-60 days. Preliminary data for these systems should be submitted no later than T-90 days.

8.5.4 For balloon systems, all final data should be supplied no later than T-60 days.

8.5.5 If deadlines are not met, Safety Office personnel may not be able to prepare all necessary safety plans in time to support a proposed flight. In every case, the mission shall not be conducted until adequate safety preparations are made.

8.6 Waivers/Equivalent Level of Safety

The range user shall provide a copy of any waiver or ELS for the launch vehicle or payload granted by another range.

8.7 Reviews

8.7.1 It is highly recommended that WFF Safety Office personnel participate in Design and Readiness Reviews for each mission. The Range User should notify Safety Office personnel at least ten days prior to conducting such reviews. Safety participation in such reviews may prevent costly engineering changes and scheduling delays.

8.7.2 Should WFF not be represented at Design and Mission Readiness Reviews, a copy of the review material shall be submitted to WFF as early as possible following the review.

9.0 TAILORING, EQUIVALENT LEVEL OF SAFETY, AND WAIVER PROCESSES

9.1 Range Safety Tailoring Process

9.1.1 The overall intent of the range safety requirements tailoring process is to ensure proper interpretation and implementation of range safety requirements while providing WFF and program/vehicle managers with the authority and flexibility needed to accomplish their tasks. Tailoring is defined as the process where the range user and the WFF Safety Office reviews each requirement and jointly documents whether the requirement is applicable to the range user's operations and, if it is applicable, document whether the range user will meet the requirement as written or achieve an equivalent level of safety through an acceptable alternative.

NOTE: WFF actively participates with the national range safety community in order to effectively conduct range operations. It is necessary for the Tailoring Process to be consistent with the approach used at the national ranges. Range safety tailoring may include ELS determinations (see Section 9.2). Range safety tailoring does not include the approval of Range Safety Waivers, which is handled in a separate process (i.e., tailoring does not incorporate the acceptance of increased safety risk). See Section 9.3.

9.1.2 Each WFF range user or vehicle program shall:

9.1.2.1 Work with the WFF Safety Office to identify and assess compliance with this Range Safety Manual (RSM) and other applicable range safety requirements.

9.1.2.2 Tailor a set of program- or mission-specific range safety requirements (working directly with the WFF Range Safety Office) and compile those requirements into a program- or mission-specific document.

NOTE: Programs/Projects should not attempt to self-tailor or interpret range safety requirements without direct assistance from the WFF Safety Office. Attempting to self tailor range safety requirements may result in misinterpretation of the applicability of requirements and may lead to unnecessary schedule and cost impacts associate with late corrections.

9.1.2.3 Ensure that the document containing the tailored range safety requirements identifies any change to a requirement (including any addition or deletion) and includes sufficient rationale for the tailored change.

9.1.3 The WFF Safety Office shall coordinate as needed to allow for consistent application of range safety tailoring throughout NASA, FAA or DOD.

9.1.4 The signatories of each tailored requirements document shall include, but are not limited to the range user/vehicle program manager (or designee) and the cognizant WFF Range Safety Technical Authority after obtaining documented concurrence from the WFF Safety Office and any other authorities responsible for issues addressed by the tailoring.

NOTE: The range user/vehicle program should coordinate with the WFF Safety Office when establishing the mission timeline/schedule to ensure that it incorporates sufficient time to complete the tailoring process and to implement the tailored requirements.

9.1.5 After approval, any further proposed change to the tailored requirements document shall be documented and distributed by the vehicle program as a change page or equivalent document for coordination and approval/concurrence by the original signing authorities.

NOTE: For an ELS determination after approval of the tailored requirements document see Section 9.2.

9.1.6 If the WFF Safety Office or other range safety authority determines that proposed tailoring of a requirement (i.e., deletion of a requirement, a change to a requirement, or an approach that differs from the stated requirement) results in increased safety risk, the vehicle program shall prepare a waiver request and obtain approval per Section 9.3.

9.1.7 In the event that an authority does not concur on a tailored requirements document and the issue cannot be resolved through coordination with the WFF Range Safety Technical Authority and any other cognizant SMA Technical Authority, all interested parties shall brief their position to the next higher level SMA Technical Authority and so on until resolved.

9.2 Equivalent Level of Safety (ELS)

9.2.1 An ELS determination is a noncompliance with a range safety requirement where the WFF Safety Office approves an alternate approach that provides an approximately equal level of

safety as determined by qualitative or quantitative means. An ELS applies when there is a high degree of certainty that the alternate approach will not increase the probability that the system will fail or significantly increase the risk level to people and property (including public), considering all required design environments.

9.2.2 Each program shall ensure that ELS determinations made during the initial tailoring process are clearly identified in the tailored requirements document and that the document contains or references sufficient approval rationale for each ELS determination.

9.2.3 For any ELS requested after approval of the tailored requirements document but prior to commencement of the range operation:

9.2.3.1 The requesting program shall prepare a written ELS request that provides approval rationale.

NOTE: The WFF Safety Office maintains Range Safety ELS/Waiver request forms. Similar forms used at the various ranges are also acceptable.

9.2.3.2 The WFF Range Safety Technical Authority and the vehicle program manager (or designee) shall approve (sign) the ELS after obtaining documented concurrence from the WFF Range Safety Office and any other authorities responsible for issues addressed by the ELS.

9.2.4 If an ELS is approved in real time during a range operation, the requesting program, the WFF Range Safety Technical Authority, and the WFF Safety Office shall ensure that a record of the ELS request, rationale, and approval is generated and maintained as part of the official operation records.

NOTE: This may be accomplished in real time through the use of a recorded voice network and then documented, in writing, after the operation is complete.

9.2.5 The WFF Safety Office, WFF Range Safety Technical Authority and the NASA Range Safety Manager shall coordinate as needed to allow for consistent ELS determinations throughout the Agency.

9.3 Range Safety Waiver Process

9.3.1 The following is a specific implementation of NASA policy for processing and approving waivers as they apply to range safety requirements. A Range Safety Waiver is defined as a written authorization allowing a range operation to continue even though a specific range safety requirement is not satisfied and the range user/vehicle program is not able to demonstrate an equivalent level of safety. A Range Safety Waiver typically applies to a single mission but may have other limited applicability.

NOTE: WFF actively participates with the national range safety community in order to effectively conduct NASA range operations. It is necessary for the NASA Range Safety Waiver process to be consistent with the approach used at the national ranges. The range safety community only documents waivers in cases that involve the acceptance of increased risk (i.e., "Range Safety Waivers" always involve the acceptance of increased safety risk). The only other form of approved noncompliance with a range safety requirement is an ELS (see Section 9.2).

9.3.2 The requesting program shall coordinate each Range Safety Waiver request with the WFF Safety Office and any other cognizant range safety organization(s) to:

9.3.2.1 Ensure that the Range Safety Waiver request and accompanying data are correct and complete (including identification of appropriate risk mitigations).

9.3.2.2 Ensure that the risk is properly identified and characterized.

9.3.2.3 Assess any effects the Range Safety Waiver might have on other projects, resources, or requirements.

9.3.2.4 Ensure approval, concurrence, and risk acceptance by appropriate authorities.

9.3.3 Prior to the affected range operation, the requesting program shall draft a written Range Safety Waiver request. For real-time Range Safety Waivers, see Section 9.3.6.

9.3.4 Range Users/Vehicle Programs shall coordinate with all cognizant range safety organizations as soon as a potential noncompliance with a range safety requirement is identified.

9.3.5 The Range Safety Waiver approval process shall incorporate the following:

9.3.5.1 The WFF Safety Office shall evaluate all Range Safety Waiver requests and provide input to the SMA Technical Authority and other approval authorities.

9.3.5.2 The WFF Range Safety Technical Authority shall sign each Range Safety Waiver indicating the risk is properly characterized and recommending acceptance.

9.3.5.3 For any vehicle flown under the cognizance of WFF, whether at WFF or another location, the Director of WFF shall sign each Range Safety Waiver indicating consent to accept the associated risk to people or property (including public).

9.3.5.4 The range user/vehicle program manager (or designee) shall sign each Range Safety Waiver indicating acceptance of all safety risk associated with the waiver.

9.3.6 If a Range Safety Waiver is approved in real time during a range operation, the requesting program and WFF Safety Office shall coordinate to ensure that the requirements of Sections 9.3.4 and 9.3.5 are satisfied and that a record of the waiver request, rationale, and approval is generated and maintained as part of the official operation records.

NOTE: This may be accomplished in real time through the use of a recorded voice network and then documented, in writing, after the operation is complete.

9.3.7 The WFF Safety Office, WFF Range Safety Technical Authority, and NASA Range Safety Manager shall coordinate as needed to allow for a consistent Range Safety Waiver approach throughout the Agency.

9.3.8 In the event that a required signatory does not concur on a Range Safety Waiver and the issue cannot be resolved through coordination with the WFF Range Safety Technical Authority and the other required approval authorities, all interested parties shall brief their position to the next higher level authorities and so on until resolved.

ATTACHMENT 1: WEATHER CONSTRAINTS FOR EXPENDABLE LAUNCH VEHICLE

The RSO must have clear and convincing evidence the following constraints are not violated:

1. Do not launch if any type of lightning is detected within 10 NM of the launch site or planned flight path within 30 minutes prior to launch, unless the meteorological condition that produced the lightning has moved more than 10 NM away from the launch site or planned flight path.

2. Do not launch if the planned flight path will carry the vehicle:

   a. through cumulus clouds with tops higher than the +5 degrees Celsius level; or

   b. through or within 5 NM of cumulus clouds with tops higher than the -10 degrees Celsius level; or

   c. through or within 10 NM of cumulus clouds with tops higher than the -20 degrees Celsius level; or

   d. through or within 10 NM of the nearest edge of any cumulonimbus or thunderstorm cloud including its associated anvil.

3. Do not launch if at any time during the 15 minutes prior to launch time the one minute average of absolute electric field intensity at the ground exceeds 1 kilovolt per meter (1 kV/m) within 5 NM of the launch site unless:

   a. there are no clouds within 10 NM of the launch site; and

   b. smoke or ground fog is clearly causing abnormal readings.

4. Do not launch if the planned flight path is through a vertically continuous layer of clouds with an overall depth of 4,500 feet or greater where any part of the clouds are located between the 0 degrees Celsius and the -20 Degrees Celsius temperature levels.

5. Do not launch if the planned flight path is through any cloud types that extend to altitudes at or above the 0 degrees Celsius level and that are associated with disturbed weather within 5 NM of the flight path.

   DEFINITION: Disturbed weather is any meteorological phenomenon that is producing moderate or greater precipitation.

6. Do not launch through thunderstorm debris clouds, or within 5 NM of thunderstorm debris clouds not monitored by a field mill network or producing radar returns greater than or equal to 10DBz.

   DEFINITION: Debris Cloud is any cloud layer other than a thin fibrous layer that has become detached from the parent cumulonimbus within 3 hours before launch.

7. Do not launch if a vehicle has not been treated for surface electrification and the flight path will go through any clouds above the -10^{o}C level up to the altitude at which the vehicle's velocity exceeds 3,000ft/sec. A vehicle is considered "treated" for surface electrification if all surfaces of the vehicle susceptible to precipitation particle impact have been treated to assure;
   a) That the surface resistivity is less than 109 ohms/square; and
   b) That all conductors on surface (including dielectric surfaces that have been treated with conductive coatings) are bonded to the vehicle by a resistance that is less than 105 ohms.

   NOTE: Vehicles are exempt from this requirement if it has been shown by test or analysis that electrostatic discharges (ESDs) on the surface of the vehicle caused by triboelectrification by ice particle impact will not be hazardous to the launch vehicle or the mission.

8. Do not launch if the flight path will carry the vehicle through any cumulus cloud that has developed from a smoke plume while the cloud is attached to the smoke plume, or for the first 60 minutes after the cumulus cloud is observed to have detached from the smoke plume.

GOOD SENSE RULE: Even when constraints are not violated, if any other hazardous weather conditions exist, the RSO may hold at any time based on the instability of the weather.

ATTACHMENT 2: DATA REQUIREMENTS AND REVIEW SCHEDULE

TIME	EVENT	PURPOSE	POC	INPUT	OUTPUT
Initiation of Project	Mission Initiation Conference (MIC) or Kick-off meeting	Define Mission Objectives	WFF PM Program Manager Mission Manager Launch Vehicle Manager	(1) Description of Payload & Proposed Orbit (2) Project Team presentations	minutes and action items
Prior to Payload PDR	Safety Technical Interchange Meeting (TIM's)	Address Specific Safety Issues	WFF PM Mission Manager Launch Vehicle Manager	Formal presentation of issues by project team & WFF Range Safety	-TIM minutes -Project status memo -Action items resolution
NLT (No-Later-Than) L-18 months	Payload Preliminary Design Review (P/L PDR)	Define System Preliminary Hazard Analysis (PHA)		Project Team provides: -Preliminary Safety Analysis -Hazard Analysis -P/L Design Docs & Dwgs -Special Ops -Preliminary Trajectory	
PDR +60 days	Preliminary Safety Data Package (SDP)	User provides Preliminary Safety Document for Vehicle, P/L and Special Ops	WFF PM Mission Manager Launch Vehicle Manager	Project provides: -Preliminary Safety Data for Safety Plan Development	SDP for review
PDR + 60 days	Safety TIMS	Discuss SDP	WFF PM Mission Manager Launch Vehicle Manager	Project Team presents: -Trajectory Data -Safety Analyses -Facility Mods -Prelim Operations Plan	TIM Minutes Status Resolution Action Items

TIME	EVENT	PURPOSE	POC	INPUT	OUTPUT
NLT L-12 months	Payload Critical Design Review (P/L CDR)	Finalize Design	WFF PM Mission Manager Launch Vehicle Manager System Experts	Project Team presents Final P/L design	Preliminary Safety Approval (subsystem) Final Hazard Analysis
	Safety TIMS	Resolve Action Items and Safety Issues	WFF PM Mission Manager Launch Vehicle Manager	Project Team Identifies: - Design changes -Operational methods -Testing	TIM Minutes documenting resolution of issues
CDR +60 days	Operational Support System TIMS	Define Operational Support	WFF PM Mission Mgr. Launch Vehicle Manager Mission Ops Manager	Project Team presents Mission Operation (data) requirements WFF Safety presents: Real Time Data requirements	RF Link Analysis Mission Support Allocation
L-75 Days	Final SDP	User provides Final Safety document for Vehicle, P/L, and Operations	WFF PM Mission Manager Launch Vehicle Manager	Project provides Final Safety Data for safety plan development	Approved SDP
L-75 Days	Final Hazard Procedures Submittal	User submits to Range final procedures for all hazardous operations	WFF PM Mission Manager Launch Vehicle Manager	Project provides procedures for hazardous operations	Proposed Hazardous Operations Procedures Document
L-75 days	System Safety Action Item (A/I) Resolution Meeting	Attempt to close out safety action items	WFF PM Mission Manager Launch Vehicle Manager	Project team and WFF safety resolve all action items	Action Item close-out document

TIME	EVENT	PURPOSE	POC	INPUT	OUTPUT
NLT L-60 days	Final Trajectory Tape to WFF (including a test Telemetry Tape)	Project delivers final trajectory tape to WFF	WFF PM Mission Manager Launch Vehicle Manager	Project provides Trajectory data tape and inputs to WFF	Final Trajectory Tape (Required for Flight Plan Approval)
L-60 days	Final Flight Plan Submittal	Project delivers final Flight Plan for Aircraft Operations	WFF PM Mission Manager	Project provides Final Aircraft (A/C) Ops Plan	Final Flight Plan
L-45 days	Operational Procedures Approval	Internal WFF approval of Operation Procedures	WFF PM	WFF provides letter approving hazardous operation procedures	Formal statement from WFF identifying approved procedures
L-30 days	Mission Safety Review	Closure of all Safety Action Items Definition of Safety Status	WFF PM WFF Safety Mission Manager Launch Vehicle Manager	Final Closure of Action Items by Project Team and WFF	Memo documenting Mission Safety Readiness
L-21 days	Operation Safety Directive (OSD) or Mission Operations Directive (MOD)	Define Operational Safety Plan Flight Safety Plan Ground Safety Plan GO/NO-GO Items	WFF participating organizations	WFF provides: -Flight Safety Plan -Ground Safety Plan -GO/NO-GO Items OSD defines: -Requirements Test Directives -Air Ops Plan	OSD or MOD
L-21 days	FTS Certification	Test Plan & documentation for FTS	WFF Safety Launch Vehicle Manager	WFF defines FTS certification documents	FTS test plan and document
L-14 days	Mission/Range Readiness Review	Determine readiness of range, P/L, vehicle and supporting sites	WFF PM	Readiness Status	Readiness Status
L-5 days	Flight Readiness Review	Determine readiness of support A/C	WFF PM	Readiness Status	Readiness Status
L-2 days	Launch Readiness Review	Review all prelaunch testing and certification	WFF PM	Results of prelaunch testing and certification	Launch Readiness Certification
	LAUNCH				

ACRONYMS

A/C	Aircraft
A/I	Action Item
AFSS	Autonomous Flight Safety System
AGC	Automatic Gain Control
AIAA	American Institute of Aeronautics and Astronautics
ANSI	American National Standards Institute
AOM	Aircraft Operations Manual
ASME	American Society of Mechanical Engineers
AWG	American Wire Gauge
CDI	Capacitive Discharge Ignition
CDR	Critical Design Review
CM	Campaign Manager
CMS	Contingency Management System
COLA	Collision Avoidance
COPV	Composite Overwrapped Pressure Vessel
DFMR	Design for Minimal Risk
DFO	Distant Focusing Overpressure
DOD	Department of Defense
DoT	Department of Transportation
EBW	Exploding Bridgewire
E_c	Casualty Expectation
EED	Electro-Explosive Device
ELS	Equivalent Level of Safety
ELV	Expendable Launch Vehicle
ERPG	Emergency Response Planning Guidelines
ESD	Electrostatic Discharge
FAA	Federal Aviation Administration
FACSFAC	Flight Area Control and Surveillance Facility
FMEA	Failure Mode and Effects Analysis
FSDP	Flight Safety Data Package
FSO	Flight Safety Officer
FSP	Flight Safety Plan
FTS	Flight Termination System
GPS	Global Positioning System
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
IFR	Instrument Flight Rules
IIP	Instantaneous Impact Point
IMU	Inertial Measurement Unit
INS	Inertial Navigation System
LBB	Leak-Before-Burst
LEL	Lower Explosive Level
LOS	Loss of Signal
LPM	Launch Pad Manager
MAWP	Maximum Allowable Working Pressure

MEOP	Maximum Expected Operating Pressure
MIC	Mission Initiation Conference
MOD	Mission Operations Directive
MM	Mission Manager
MRSO	Mission Range Safety Officer
MSDS	Material Safety Data Sheet
NASA	National Aeronautics and Space Administration
NFPA	National Fire Protection Association
NLT	No-Later-Than
NOTAMS	Notice to Airmen
NOTMARS	Notice to Mariners
NPT	National Pipe Thread
OJT	On-the-Job Training
OP	Operating Pressure
OSD	Operation Safety Directive
OSS	Operations Safety Supervisor
P_C	Probability of Casualty
P_i	Probability of Impact
P/L	Payload
PDR	Preliminary Design Review
PHA	Preliminary Hazard Analysis
PM	Project Manager/Program Manager
PPE	Personal Protective Equipment
RAR	Risk Analysis Report
RF	Radio Frequency
RLV	Reusable Launch Vehicle
ROA	Range Operations Assistant
RPV	Remotely Piloted Vehicle
RSM	Range Safety Manual
RSO	Range Safety Officer
RSS	Range Safety Systems
S/A	Safe Arm
SCAPE	Self Contained Atmospheric Protective Ensemble
SDP	Safety Data Plan
SDS	Safety Data Sheet (also known as MSDS)
SMA	Safety & Mission Assurance
SSOPD	Suborbital and Special Orbital Projects Directorate
TD	Test Director
TIM	Technical Interchange Meeting
TM	Telemetry
TNT	Trinitro-toluene
UAS	Unmanned Aircraft Systems
UAV	Unmanned Aerial Vehicle
USSC	United States Strategic Command
VACAPES	Virginia Capes
VMC	Visual Meteorological Conditions
WFF	Wallops Flight Facility

DEFINITIONS

Burst Pressure -- The pressure at which pressure system components undergoing pressurize-to-burst testing rupture or exhibit an unstable fracture.

Burst Factor -- This quantity is equal to the Design Burst Pressure divided by the Maximum Allowable Working Pressure (MAWP).

Casualty Expectation -- The probabilistic number of casualties due to conduct of a mission or specific period of time or event.

Collective Risk -- The total combined risk to all individuals exposed to a particular hazard during a specified period of time or event (a specific phase of flight).

Contingency Management System -- A system designed to manage the vehicle throughout the atmospheric flight envelope that provides a controlled response under the full set of circumstances defined by the risk assessment. The system may be comprised of a set of elements within the vehicle, including but not limited to manual control, autonomous control, and recovery capability. It may be used as a risk mitigation factor in the risk assessment when applicable.

Critical Operations Personnel -- Critical Operations Personnel include persons not essential to the specific operation (launch, entry, flight) currently being conducted, but who are required to perform safety, security, or other critical tasks at the launch, landing, or flight facility. Critical Operations Personnel are notified of the hazardous operation and either trained in mitigation techniques or accompanied by a properly trained escort. Critical Operations Personnel do not include individuals in training for any job or individuals performing routine activities such as administrative, maintenance, or janitorial. Critical Operations Personnel may occupy safety clearance zones and hazardous areas and need not be evacuated with the public. Critical Operations Personnel are included in the same risk category as Mission Essential Personnel.

Danger Area -- That area defined by ground and/or flight safety analysis (including impact areas, abort areas, storage areas, or hazard areas) where normal operations or a system malfunction will create impacting objects, debris, blast, toxic release, or other hazards and where access must be restricted or otherwise controlled in order to satisfy established risk criteria.

Design Burst Pressure -- The pressure is a calculated test pressure that pressurized components shall withstand without rupture to demonstrate its design adequacy in a qualification test. It is equal to the product of the MAWP and a Burst Factor.

Electro-Explosive Device -- An electric initiator or other component in which electrical energy is used to cause initiation of explosives contained therein.

Emergency System/Component -- An emergency system component is any system/component, which prevents a hazardous event from occurring or escalating. These systems normally experience very few cycles, but their performance is extremely safety critical. Typical emergency components are relief valves and shut-off valves. Typical emergency systems are fire suppression systems and emergency purge/vent systems.

Equivalent Level of Safety (ELS) (determination) -- The approval of an alternative approach to satisfying a range safety requirement where the alternative provides an approximately equal level of safety as determined by qualitative or quantitative means

Flight Hardware -- Any hardware that is flown on or is a part of an aircraft, experimental flight vehicle, satellite, lighter than air vehicle, unmanned aerial vehicle, or space transportation system.

Flight Hazard Area -- The operational area within which the risk due to impacting object(s) may exceed the established risk criteria.

Flight Safety -- A philosophy and methodology whereby rocket, balloon, drone, Unmanned Aerial Vehicles (UAV's) and aircraft flight operations can be performed in a reasonable and prudent manner without undue risk to people or property or embarrassment to NASA or the United States Government.

Ground Safety -- Those safety considerations, procedures, and resultant restrictions associated with hazardous systems during storage, handling, prelaunch, launch, and recovery/abort operations, where by operations can be performed in a reasonable and prudent manner without undue risk to people or property or the environment.

Hangfire -- A launch attempt where current to the vehicle initiator was delivered by the firing system and the vehicle failed to ignite as planned.

Impact Area -- The operational area within which one or more objects are predicted to impact in the vicinity of each other.

Individual Risk -- The probability of an individual at a specific location suffering a casualty from exposure to a given event during a specific period. Individual risk is typically stated as a Probability of Casualty (P_c).

Inherently Safe -- The predicted trajectory of the vehicle is based solely on the launch dispersion parameters and known system errors.

Inhibit – (1) A barrier between a hazardous event and the potential energy, toxic material or hazard associated with that event (e.g., open, short, mechanical isolator, etc.). (2) An independent and verifiable mechanical and/or electrical device that prevents a hazardous event from occurring where the device has direct control and is not just a monitor.

Instantaneous Impact Point -- The point at which an object would impact if thrusting were stopped at a given time.

Launch Abort -- Premature and abrupt termination of a launch attempt because of existing or imminent degradation of mission success probability or safety requirements.

Launch Area -- The area comprising rocket launching pads, a blockhouse, and auxiliary support facilities. For airborne launches, it is the defined operational hazard area, which has been obtained from controlling authorities.

Launch Vehicle -- Any rocket, rocket system, or balloon that is used to launch a suborbital or orbital payload, probe, satellite, or other experiment.

Leak-Before-Burst (LBB) -- A fracture mechanics design concept in which it is shown that any initial flaw shall grow through the wall of the pressure vessel rather than bursting and causing catastrophic failure at the MAWP.

Maximum Allowable Working Pressure -- the maximum pressure at which a component or system can continuously operate based on allowable stress values and functional capabilities. This maximum pressure value is most often cited in requirements and standards that address ground based pressure systems, such as the ASME Boiler and Pressure Vessel Code and the NASA Standard on Ground Based Pressure Vessels.

Maximum Expected Operating Pressure -- This term is used in requirements and standards that address aerospace pressure vessels, such as AIAA/ANSI S-080, AIAA/ANSI S-081, or Mil-Std-1522. It is the highest pressure that a pressure vessel, pressurized structure, or pressure component is expected to experience during its service life and retain its functionality, in association with its applicable operating environments; synonymous with maximum operating pressure or maximum design pressure

Megger Test -- A measurement performed on Electro Explosive Devices (EED) using a megohmmeter to determine the pin-to-case insulation resistance. The test is performed at a known voltage (normally 500 volts) to verify that the insulation shall not break down and permit EED ignition in this mode.

Misfire -- A launch attempt in which current was not delivered to the vehicle initiator.

Mission Essential Personnel -- Those individuals whose activities contribute directly to the performance of a potentially hazardous operation which is actually under way, and whose presence is mandatory for completion of the operation.

Notice to Airmen (NOTAMS) -- An advisory issued to airmen listing restricted or hazardous airspace during certain times.

Notice to Mariners (NOTMARS) -- An advisory issued to mariners listing restricted or hazardous areas during certain times.

Operating Pressure (OP) -- The pressure a system shall be subjected to during static and dynamic conditions (maximum temperature, maximum relief pressures, maximum regulator pressure, and, where applicable, transient pressure excursions).

Power Switching -- Power transfers where the net energy change exceeds 1.5 volts or 10 milliamperes.

Proof Pressure -- The test pressure applied to pressure systems or individual components without failure, leakage, or permanent deformation. This pressure is obtained by multiplying MEOP or MAWP by a factor (usually 1.5, but can be as low as 1.25).

Public -- For the purposes of range safety risk management, all people who are not Mission Essential Personnel or Critical Operations Personnel. Public includes visitors and personnel inside and outside NASA-controlled property who are not Critical Operations Personnel and who may be on land, on waterborne vessels, or in aircraft.

Range Safety -- Application of safety policies, principles, and techniques to protect the public, workforce, and property from hazards associated with range operations.

Range Safety System -- A system used to mitigate risk to the public

Range Safety Waiver -- A written authorization allowing a range operation to continue even though a specific range safety requirement is not satisfied and the vehicle program is not able to demonstrate an equivalent level of safety. A Range Safety Waiver involves the formal acceptance of increased safety risk by appropriate authorities.

RF avoidance -- no radiation from any transmitters capable of producing a potential hazard to any ordnance operation within ±20 degrees (azimuth and elevation) of the ordnance site.

SCAPE -- This is a category of full body and respiratory protection suits with supplied air that is used primarily on hypergolic fuels and oxidizers, such as hydrazine and nitrogen tetroxide.

System Initiator -- Any device that initiates the action of a system. This includes but is not limited to Electro-Explosive Devices, non-explosive initiators, and exploding bridgewire initiators.

Tailoring -- The process where the authorities responsible for range safety requirements and a range user review each requirement and jointly document whether the requirement is applicable to the range user's planned operations and, if it is applicable, document whether the range user will meet the requirement as written or achieve an equivalent level of safety through an acceptable alternative. Tailoring includes ELS determinations. Tailoring does not include the approval of Range Safety Waivers, which are addressed by a separate process.

Triboelectrification -- The production of electrostatic charges by friction.

Trinitro-toluene (TNT) Equivalency -- The explosive energy per unit mass of the energetic material in question (propellants in our case) divided by the energy per unit mass of Trinitro-toluene (TNT); this number can be expressed as a percentage or a fraction.

Unmanned Aircraft Systems (UAS) -- A UAS includes an Unmanned Aerial Vehicle (UAV) or similar vehicle and all the associated support equipment, control station, data links, telemetry, communications and navigation equipment necessary to operate the vehicle.

Unmanned Aerial Vehicle (UAV) -- A vehicle that is controlled remotely or autonomously and operates at speeds ranging from subsonic to hypersonic in a manner consistent with a 'conventional' aircraft. A UAV may be launched from the ground or dropped from other aerial vehicles, subscale flight test vehicles, or lifting bodies. A UAV may also be referred to using a different name such as Unmanned Air Vehicles, Uninhabited Aerial Vehicles, Remotely Piloted Vehicles (RPVs), drones and cruise missiles. Model aircraft (normally vehicles of less than 55 lbs. gross weight flown under manual control within unaided visual contact range) are not considered.

CHANGE HISTORY LOG			
REVISION	EFFECTIVE DATE	DESCRIPTION OF CHANGES	APPROVAL
Baseline	June 28 2002	Replaces RSM-93 dated June 23, 1993	complete revision
A	November 3, 2006	-Updated GDMS document numbers (Section 4). -Updated to include NPR 8715.5 NASA Range Safety Program requirements (Section 6)	complete revision
B	July 14, 2008	-Added Range Safety Branch Head position. -Added Toxic and DFO data requirements. -Updated Reference documents. -Section 6.1.5 Changed the approval of Risk Analysis documents and Safety Plans from the RSO to the RSBH. -Section 6.2.2.4 Changed probability from 1 x 10-8 to 1 x 10-7 to align with RCC 321-07 -Section 6.4.1.2 Updated standards -Section 6.5.2.6.3.1 Updated standards	complete revision
C	March 15, 2013	- Updates to align with NPR 8715.5 - Significant changes include: Added paragraph addressing Configuration Management/Approval of Manual o 100×10^{-6} E_c for the general public versus 30×10^{-6}, also modified all criteria to be less than or equal values (6.2.1 and 6.2.2) o Section 9 added addressing Tailoring, ELS and Waivers o Tour group no longer limited to 12 (5.2.3.3.4) o Launch vehicle firing circuits at WFF shall be capable of being interrupted from the WFF Range Control Center (5.3.5.1.1) o All GSE used in, or to obtain measurements of, hazardous systems (electrical meters, pressure gages, slings, scales, etc.) shall be calibrated/certified and may not be used beyond the certification period. Certifications shall be performed at GSFC's WFF unless it can be shown that the range user has an equivalent certification/calibration process. (5.3.5.3) o The firing capacitor shall be provided with a low impedance path for discharge (when the circuit is in the SAFE condition) and a means of remotely monitoring capacitor voltage. (5.3.4.4.4.2)	complete revision

C (continued)		○ Added Triboelectrification and smoke plume lightning constraints (Attachment 1) ○ Electrical Storm Criteria (5.3.7) reworded ○ Updated References ○ Range Safety Organization and Responsibilities (2.0) reworded ○ Addition of Launch Pad Manager role ○ Additional of Hypergolic Propellant section (5.3.13.6 and 5.3.13.7) ○ Removed requirement for Enhanced Flight Termination System (6.4.2.3). Now a consideration ○ Reworded Pressure System (5.3.12) requirements ○ Center Essential Personnel now called Critical Operations Personnel to match Agency Policy ○ Range Clearance section (6.5.2.2) reworded to remove required surveillance inside VACAPES ○ Added recovery section 5.4.4	-