

**MEASUREMENT SYSTEM
IDENTIFICATION**



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National Aeronautics and Space Administration

NASA-STD-8719.25

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Baseline

Range Flight Safety Requirements

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FOREWORD

This NASA Technical Standard is published by the National Aeronautics and Space Administration (NASA) to provide uniform engineering and technical requirements for processes, procedures, practices, and methods that have been endorsed as standard for NASA facilities, programs, and projects, including requirements for selection, application, and design criteria of an item.

This standard is approved for use by NASA Headquarters and NASA Centers, including Component Facilities, and is intended to be applied on NASA contracts. It may also apply to the Jet Propulsion Laboratory and other contractors only to the extent specified or referenced in applicable contracts.

NASA operates and uses ranges for the purpose of launching, flying, landing, and testing space and aeronautical vehicles and associated technologies. This standard establishes range flight safety requirements for protecting the public, the NASA workforce, and property during these flight activities. This standard serves as a companion to NPR 8715.5 and provides each NASA program, project, and Range with specific technical requirements and assessment methods to assure compliance.

This standard was developed by NASA Headquarters Office of Safety and Mission Assurance (OSMA). Requests for information, corrections, or additions to this standard should be submitted to the NASA, OSMA, by email to Agency-SMA-Policy-Feedback@mail.nasa.gov or via the "Email Feedback" link at <https://standards.nasa.gov>.



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NASA Chief, Safety and Mission Assurance

2/5/2018

Approval Date

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NASA RANGE FLIGHT SAFETY REQUIREMENTS

1. SCOPE

1.1 Purpose

The purpose of this NASA Technical Standard is to provide the technical requirements for the NPR 8715.5, Range Flight Safety Program, in regards to protection of the public, the NASA workforce, and property as it pertains to risk analysis, Flight Safety Systems (FSS), and range flight operations.

1.2 Applicability

1.2.1 This standard is approved for use by NASA Headquarters and NASA Centers, including Component Facilities and Technical and Service Support Centers, and may be cited in contract, program, and other Agency documents as a technical requirement. This standard may also apply to the Jet Propulsion Laboratory or to other contractors, grant recipients, or parties to agreements to the extent specified or referenced in their contracts, grants, or agreements, when these organizations conduct or participate in missions that involve range flight operations as defined by NPR 8715.5.

1.2.2 In this standard, all mandatory actions (i.e., requirements) are denoted by statements containing the term “shall.”

1.3 Tailoring

Tailoring of this standard for application to a specific program or project shall be formally documented as part of program or project requirements and approved by the responsible Technical Authorities, Institutional Safety Authorities, and Range Flight Safety Program Manager in accordance with NPR 8715.1, NASA Safety and Health Programs.

2. APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable Documents

The documents listed in this section contain provisions that constitute requirements of this standard as cited in the text. Use of more recent issues of cited documents may be authorized by the responsible Institutional Safety Authority.

| | |
|-----------------|---|
| 14 CFR Part 101 | Moored Balloons, Kites, Amateur Rockets, Unmanned Free Balloons, and Certain Model Aircraft |
| 14 CFR Part 107 | Operation and Certification of Small Unmanned Aircraft Systems |
| 14 CFR Part 417 | Launch Safety |

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| NPR 1800.1 | NASA Occupational Health Program Procedure |
| NPR 7150.2 | NASA Software Engineering Requirements |
| NPR 7900.3 | Aircraft Operations Management |
| NPR 8705.2 | Human-Rating Requirements for Space Systems |
| NPR 8715.1 | NASA Safety and Health Programs |
| NPR 8715.3 | NASA General Safety Program Requirements |
| NPR 8715.5 | Range Flight Safety Program |
| NPR 8715.6 | NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments |
| NASA-STD-8719.14 | Process for Limiting Orbital Debris |
| NASA-STD-8739.8 | Software Assurance and Software Safety Standard |
| AFSPCMAN 91-710 | Air Force Space Command Range Safety User Requirements Manual |
| RCC 319 | Range Commanders Council Flight Termination Systems Commonality Standard |
| RCC 321 | Range Commanders Council Common Risk Criteria for National Test Ranges |

2.2 Reference Documents

The reference documents listed in this section are not incorporated by reference within this standard, but may provide further clarification and guidance.

| | |
|------------|--|
| NPR 7120.5 | NASA Space Flight Program and Project Management Requirements |
| NPR 7120.8 | NASA Research and Technology Program and Project Management Requirements |
| NPR 8000.4 | Agency Risk Management Procedural Requirements |
| NPR 8621.1 | NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping |
| EWR 127-1 | Range Safety Requirements |

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|---|---|
| FDSS-21-0182 | Launch COLA Operations: An Examination of Data Products, Procedures, and Thresholds |
| RCC 323 | Range Commanders Council Range Safety Criteria for Unmanned Air Vehicles |
| RCC 555 | User Guide for Unmanned Aerial System (UAS) Operations on the National Ranges |
| American Conference of Government and Industrial Hygienists - Threshold Limit Value (TLV) | |
| American Industrial Hygiene Association - Emergency Response Planning Guidelines (ERPG) | |
| Environmental Protection Agency - Acute Emergency Guidance Level (AEGL) | |
| Occupational Safety and Health Administration - Permissible Exposure Limit (PEL) | |

2.3 Order of Precedence

2.3.1 The requirements and practices established in this standard do not supersede or waive existing requirements and standard practices found in other Agency documentation.

2.3.2 Conflicts between this standard and other requirements documents shall be resolved by OSMA.

3. ACRONYMS AND DEFINITIONS

3.1 Acronyms and Abbreviations

| | |
|----------------|--|
| AFSPCMAN | Air Force Space Command Manual |
| AFSS | Autonomous Flight Safety System |
| CMS | Contingency Management System |
| COLA | Collision Avoidance |
| CRFSL | Center Range Flight Safety Lead |
| DFO | Distant Focusing Overpressure |
| E _c | Expectation of Casualty |
| ELV | Expendable Launch Vehicle |
| ERPG | Emergency Response Planning Guidelines |

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| FSO | Flight Safety Officer |
| FSS | Flight Safety System(s) |
| FTS | Flight Termination System |
| JSpOC | Joint Space Operations Center |
| MFCO | Mission Flight Control Officer |
| NOTAM | Notice to Airmen |
| NOTMAR | Notice to Mariners |
| P_c | Probability of Casualty |
| P_i | Probability of Impact |
| RLV | Reusable Launch Vehicle |
| RSO | Range Safety Officer |
| SR | Sounding Rocket |
| UAS | Unmanned Aircraft System |
| UAV | Unmanned Aerial Vehicle |

3.2 Definitions

Autonomous Flight Safety System (AFSS). An onboard system that includes all hardware and software needed to make a flight termination decision (or other safety decision) and initiate actions that end vehicle flight (or otherwise restrict vehicle flight) without ground-based intervention. An Autonomous Flight Termination System (AFTS) is a type of AFSS.

Casualty. An injury requiring overnight hospitalization or worse, including death. For the purpose of casualty modeling, any injury that, due to its severity, qualifies as a Level-3, 4, 5, or 6 injury per the Abbreviated Injury Scale (AIS), Association for the Advancement of Automotive Medicine, would be counted as a casualty.

Certificate of Authorization or Waiver. A Certificate of Authorization or Waiver is a document issued by the FAA's Air Traffic Organization to a public operator (e.g. Government organizations, public universities and law enforcement entities) for a specific unmanned aircraft activity for a specified period of time (i.e. temporary). The Certificate of Authorization or Waiver will specify the operations that are permitted, define the area where the operations may be conducted, and specify altitudes at which they may be conducted.

Collective Risk. The total combined risk to all individuals exposed to one or more particular hazards during a specific period of time or event (a specific phase of flight). Unless otherwise noted, collective risk for a range flight operation is the mean number of casualties expected (E_c) during an established period or event (e.g., a launch) due to the combination of all hazards associated with the operation.

Collision Avoidance. A process designed to prevent collisions between on-orbit tracked objects and launched or re-entering vehicles (including spent stages)/payloads by determining and implementing courses of action through careful analysis of validated conjunction assessments and satellite health and mission requirements. The process includes establishing wait periods in either the launch/entry window or spacecraft maneuvering based on validated conjunction assessments and accounts for uncertainties in spatial dispersions, arrival time of orbiting objects or the launch vehicle/payload, and modeling accuracy.

Commercial Launch Service. A service supplied by the private sector that provides the capability of placing a vehicle and any payload into a suborbital trajectory, Earth orbit, or into outer space.

Containment. A range safety technique that precludes hazards from reaching the public, the workforce, or property that requires protection during normal and malfunctioning vehicle flight.

Contingency Management System (CMS). A system designed to manage the vehicle that provides a controlled response under the full set of circumstances defined by the mission's 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.

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.

Distant Focusing Overpressure (DFO). An atmospheric phenomenon that can produce greatly enhanced overpressure due to sonic velocity gradients with respect to altitude. These enhanced overpressures can break windows in distant communities, which may result in personal injury. Distant focusing overpressure, sometimes referred to as far field blast overpressure, is of concern in the event of a large explosion on or around the launch pad and occurs only under certain meteorological conditions.

Emergency Response Planning Guidelines - Level 2. The Emergency Response Planning Guidelines - Level 2 is the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.

Entry Operation. The sequence of controlled thrust maneuvers or other events that brings a space vehicle or spacecraft from Earth orbit or outer space to Earth. Entry operations do not include suborbital flights.

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.

Expectation of Casualty (E_c). The average number of casualties expected per an event, such as vehicle flight, if a large number of events could be carried out under identical circumstances.

Expendable Launch Vehicle. A vehicle that, once launched, is not reused and typically is not retrieved.

Explosive Debris. Solid propellant fragments or other pieces of a launch or entry vehicle or payload that result from breakup of the vehicle during flight and could explode upon impact with the Earth's surface or on their own.

Flight. Launch or entry of an orbital or suborbital space vehicle/spacecraft or operation of an aeronautical vehicle (to include aircraft, UAS, and balloons). For the purposes of this standard, "flight" does not include on-orbit operations.

Flight Safety Analyst. A person responsible for identifying and analyzing all hazards to people and property associated with flight operations, e.g. debris, toxics, DFO, and COLA, through qualitative and quantitative methods. A flight safety analyst performs risk assessments on the flight operation design to determine risk levels and support risk management efforts to ensure criteria are met by establishing any design or operational constraints needed to control hazards and risks to people and property.

Flight Safety Officer (FSO). A person responsible for real-time safety during a range flight operation. An FSO has the authority to hold or abort the operation, or take a risk mitigation action, which includes terminating the flight. FSO is synonymous with the term MFCO used at some DoD ranges.

Flight Safety System(s) (FSS). A system (including any subsystem) whose performance is factored into the Range Safety Analysis and relied upon during flight to mitigate hazards. These systems include range safety displays, range clearance capability, radar, optic tracking systems, telemetry, tracking display systems (including instantaneous impact predictors), contingency management systems, flight termination systems, and command and control capability for flight termination systems.

Flight Safety System Engineer. A person responsible for ensuring that the flight safety system (which includes the Flight Termination System (FTS) or Contingency Management System (CMS), and associated tracking and telemetry systems) is designed, qualified, and operated in accordance with applicable requirements or standards.

Flight Termination System (FTS). A type of Range Safety System designed, tested, and incorporated into vehicles that provides for the independent and deliberate termination of an errant/erratic vehicle's flight.

FTS Command System. All components needed to send a flight termination command signal to an onboard vehicle flight termination system. An FTS command system starts with flight termination activation controls and ends at each command-transmitting antenna. It includes all intermediate equipment linkages, software, and auxiliary transmitters that ensure a command signal will reach the onboard vehicle flight termination system during flight.

Hazard. A state or condition that could potentially lead to an undesirable consequence (i.e., casualty or property damage).

Hazard Area. A defined region of land, water, or airspace within which hazards exist or have the potential to exist during a range flight operation such that the risks associated with the hazards may be mitigated by controlling access to the defined region.

Individual Risk. The probability of an individual from a certain group (or subgroup) at a specific location suffering a casualty from exposure to hazards from a given event during an established period (e.g., a launch). Individual risk is stated as a Probability of Casualty (P_c).

Landing Site. The location on which a vehicle impacts, lands, or is recovered.

Launch. To place a vehicle and any payload from Earth in an altitude (balloons or UAVs), in a suborbital trajectory, in Earth orbit, or in outer space. For an orbital mission, launch begins with lift-off and ends with orbital insertion. For a suborbital mission, launch begins with lift-off and ends with landing/final impact of all vehicle components.

Launch Site. The location from which a launch takes place. This includes land, air, or a sea-based position.

Mishap. Any unplanned event or series of events that results in death, injury, occupational illness, or damage to or loss of property.

Mission Essential Personnel. Government or contractor personnel who are directly involved in ensuring the safety and success of a mission. For the purposes of range safety, mission essential personnel do not include any personnel on board the vehicle.

NASA Controlled Range Flight Operations. These are operations: 1) from a NASA range, or an offsite range where NASA is the range authority for the operation (e.g. KSC, WFF, or Kodiak, AK); 2) by a NASA operated or controlled vehicle; or 3) involving a NASA crew or payload which are not FAA licensed.

NASA Workforce. Government and contractor personnel who are directly involved in a range flight operation or who work at a range, launch site, or landing site where a NASA range flight operation takes place. For the purposes of this standard, “workforce” does not include any crew on board a vehicle during flight.

National Airspace System (NAS). The common network of U.S. airspace controlled by the FAA including air navigation facilities, equipment and services, airports or landing areas, aeronautical charts, information and services, rules, regulations, and procedures, technical information, and manpower and material. Also included are system components shared jointly with the military.

Orbital Insertion. With regard to the application of requirements and criteria in this standard to a space launch, orbital insertion occurs when the vehicle or component achieves a minimum 70 nm perigee based on a computation that accounts for drag.

Payload. The object(s) carried or delivered by a vehicle to a desired location or orbit.

Probability of Casualty (P_c). A measure of individual risk. P_c is the probability that an individual at a specific location would be a casualty per an event, such as vehicle flight, if a large number of events could be carried out under identical circumstances. For example, if an individual would be a casualty once per one million identical launches, the P_c for such a launch would be 1×10^{-6} .

Probability of Impact (P_i). The probability that one or more pieces of debris from a vehicle will impact a given location or object (e.g., aircraft, ships).

Property. In the context of this standard, the term property is intended in the broadest sense. Property includes, but is not limited to public or privately owned land/real estate, homes, factories, livestock, natural resources, facilities, equipment, and other assets (including those on or off a range or launch or landing site). Local authorities and Programs are responsible for identifying property that requires protection per NPR 8715.5. In general, the range safety function to protect property does not include protection of the vehicle or payload being flown in a range flight operation.

Public. For the purposes of range safety risk management, public refers to visitors and personnel (excluding NASA workforce) inside and outside NASA-controlled locations who may be on land, on waterborne vessels, or in aircraft.

Range. A permanent or temporary area or volume of land, sea, or airspace within or over which orbital, suborbital, or atmospheric vehicles are tested or flown. This includes the operation of launch vehicles from a launch site to orbital insertion or final landing or impact of suborbital vehicle components. This also includes the entry of space vehicles from the point where the vehicle falls below 100 km to the point of

intact vehicle impact or landing or the impact of all associated debris. This includes range flight operations with aeronautical vehicles from takeoff to landing.

Range Flight Operation. The flight of a launch or entry vehicle or experimental aeronautical vehicle including any payload, at, to, or from a range, launch site, or landing site. Range flight operations utilize specific infrastructure as well as trained and certified human interfaces to monitor, command, and control the range safety elements associated with Programs. Range flight operations do not include the flight of conventional piloted aircraft unless specific aspects of the operation require range safety involvement to protect the public, workforce, or property. Range flight operations do not include on orbit operations of vehicles after orbital insertion or prior to initiation of entry.

Range Flight Safety Program. A Program implemented to ensure that the risk to the public, workforce, and property during range flight operations is effectively managed.

Range Operator. A range operator is either a NASA, DoD, commercial, or foreign entity responsible for providing the ground, sea, air, or space-based assets required to support range flight operations.

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

Range Safety Officer (RSO). A person responsible for real-time safety during a range flight operation. An RSO has the authority to hold or abort the operation, or take a risk mitigation action, which includes terminating the flight. RSO is synonymous with the term MFCO used at some DoD ranges.

Range Safety Organization. An organization that reports to the safety authority for range flight operations, oversees the implementation of range safety requirements, and may provide range safety-related services and operational support to Programs.

Range Safety Waiver. A written authorization allowing a range flight operation to continue even though a specific range safety requirement is not satisfied and the 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.

Range User. A range user is considered a flight test or launch or entry vehicle Program that conducts range flight operations on a range.

Recovery System. A system that is installed on a flight test, launch, or entry vehicle that may be activated as planned (e.g. to preserve hardware for possible reuse) or when the vehicle has malfunctioned and cannot be recovered under its own capacity. Recovery systems are intended to preserve the vehicle and do not necessarily address range safety concerns.

Reusable Launch Vehicle. Experimental or operational space launch vehicle that is intended to be reused (at least in part).

Risk. A measure that takes into account both the probability of occurrence and the consequence of a hazard or combination of hazards to a population or installation. Unless otherwise noted, risk to people is measured in casualties and expressed as individual risk or collective risk.

Secure Flight Termination System. National Security Agency approved cryptography incorporated into the operations center and vehicle that provides a capability for the secure or authenticated transmissions of a flight termination command or the activation of the FTS.

Special Use Airspace. Airspace wherein activities must be confined because of their nature, or wherein limitations are imposed on aircraft operations that are not a part of those activities, or both. Warning areas, military operations areas, alert areas, and controlled firing areas are nonregulatory special use airspace. (Special Use Airspace is designated by the FAA.)

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 Equivalent Level of Safety determinations. Tailoring does not include the approval of Range Safety Waivers, which are addressed by a separate process.

Unmanned Aerial Vehicle (UAV). A vehicle that is controlled remotely or that is autonomous 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 Uninhabited Air Vehicle, Unmanned Aircraft, Drone, Remotely Piloted Aircraft, Remotely Operated Aircraft, or Remotely Piloted Vehicle.

Unmanned Aircraft System (UAS). A UAS includes a UAV or similar vehicle and all the associated support equipment, control station, data links, telemetry, communications and navigation equipment necessary to operate the vehicle. A UAS can be operated via a remotely located, manually operated flight control system or ground control system.

4. RANGE SAFETY ANALYSIS

4.1 General

The following sections define the processes, criteria, assessments, and risk management procedures that make up the range safety risk analysis as required by NPR 8715.5.

4.2 Range Safety Risk Management Process

Note: The Range Safety Risk Management Process is a specific implementation of the general risk management approach defined in NPR 8000.4, Agency Risk Management Procedural Requirements.

4.2.1 A Center's or Program's Range Safety Risk Management Process shall include assessment of the risk to the public, workforce, and property in accordance with this standard.

4.2.2 A Program's Range Safety Risk Management Process incorporates the applicable requirements of any range, launch site, or landing site that supports the Program's range flight operations.

4.2.3 The Range Safety Risk Management Process shall:

- a. Eliminate or mitigate risk to members of the public and workforce.
- b. Identify any property in the vicinity of the flight that requires protection from potential debris impact or other hazards, identify the potential damage of concern, and mitigate 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 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.

- c. Include the risk assessment performed in accordance with paragraph 4.4 of this standard.
- d. Make risk acceptance or disposition decisions that integrate concerns for public risk, workforce risk, risk to any property identified under paragraph 4.2.3.b, mission risk, including the risk to the safety of any flight crew, and mission constraints.

Note: Risk to flight crew and risk acceptability for aircraft activities will be determined by the cognizant Center. Risk to crew for spaceflight missions will be determined per NPR 8705.2, Human-Rating Requirements for Space Systems.

- e. Make operational decisions needed to control risk prior to initiation of flight or each phase of flight (e.g. launch, take-off, ascent, cruise, descent, entry, or landing).

(1) For an orbital Reusable Launch Vehicle or vehicle that operates continuously for extended periods, the responsible organization(s) 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:

- (a) Each decision is based on a risk assessment that is conducted or revalidated just prior to each phase of flight.

- (b) The assessment or revalidation accounts for updated vehicle status and updated predictions of flight conditions.
- (c) The vehicle has sufficient controllability to allow for risk management as a prerequisite to beginning each phase of flight.
- (2) For a mission that involves the operation of more than one vehicle simultaneously, the responsible organization(s) 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.
- f. Document decisions concerning approval of operations, acceptance/disposition of safety risk including justification, and the application of any additional safety controls or constraints based on safety evaluations.
- g. Ensure all employees and visitors on NASA-controlled property are informed of potential hazards associated with range flight operations and the actions to take in the event of an emergency.
- h. Manage any risk associated with planned and unplanned debris or potentially hazardous material that may remain after impact (e.g., potential hazards to navigation due to floating debris, potential public exposure to explosive debris or toxic material, etc.).

4.3 Risk Criteria

The following risk criteria define a level of assessed risk to the public, workforce, and property that the Agency accepts for all range flight operations without higher management review. If a range flight operation is to exceed any of these criteria, the Range Safety Waiver Process and associated requirements outlined in NPR 8715.5 apply. The following risk criteria apply per flight. They may be applied per phase of flight in accordance with paragraph 4.2.3.e of this standard. The exceptions are with respect to UAS and balloons which may be defined per flight hour.

Note 1: The risk criteria within paragraph 4.3 of this standard are consistent with RCC 321, Range Commanders Council Common Risk Criteria for National Test Ranges, and RCC 323, Range Commanders Council Range Safety Criteria for Unmanned Air Vehicles. RCC 321 and 323 and their respective Supplements contain background and justification for the risk criteria. For FAA licensed commercial launches, FAA interpretation and implementation of the public risk criteria applies.

Note 2: Unless otherwise stated for a specific criteria, these criteria apply to the aggregate risk resulting from the combination of all hazards associated with a range flight operation. For purposes of consistency with DoD and FAA range safety policy, the specific hazards considered in a range safety risk assessment are identified in paragraph 4.4.8 of this standard.

4.3.1 Property Risk

The Probability of Impact (P_i) for any property and damage of concern identified under paragraph 4.2.3.b shall be less than or equal to $(\leq) 1 \times 10^{-3}$, applied for each flight.

4.3.2 Individual Risk

4.3.2.1 The Probability of Casualty (P_c) for Mission Essential or Critical Operations Personnel shall be less than or equal to $(\leq) 10 \times 10^{-6}$.

4.3.2.2 The P_c for people who are not Mission Essential or Critical Operations Personnel shall be less than or equal to $(\leq) 1 \times 10^{-6}$.

4.3.3 Collective Risk

4.3.3.1 The Expectation of Casualty (E_c) for the combination of Mission Essential Personnel and Critical Operations Personnel shall be less than or equal to $(\leq) 300 \times 10^{-6}$.

4.3.3.2 The E_c for the Public shall be less than or equal to $(\leq) 100 \times 10^{-6}$.

Note 1: Public refers to visitors and personnel (excluding NASA workforce) inside and outside NASA-controlled locations who may be on land, on waterborne vessels, or in aircraft. Range safety implementation of the E_c criteria often includes the use of probability of impact for any people on waterborne vessels or in aircraft to ensure that their risk does not contribute significantly to the overall public collective risk. For FAA licensed commercial launches, FAA interpretation and implementation of the public collective risk criteria applies.

Note 2: For small UAS operations, in most cases, the methodology found in RCC 323, Rationale and Methodology Supplement, Appendix D can be used to calculate E_c . When insufficient empirical data exists, this criteria can be met if the route is confined to sparsely populated areas and qualitative methods indicate casualty expectation is negligible.

4.4 Range Safety Risk Assessment

4.4.1 A range safety risk assessment shall be a formal documented analysis that identifies and characterizes risk for input to the Range Safety Risk Management Process.

4.4.2 The risk assessment shall employ quantitative means unless all cognizant Range Safety Organizations and other authorities agree that quantitative assessment is not necessary or not feasible; in which case the risk assessment shall employ qualitative measures.

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

4.4.4 The risk assessment documentation shall include a description of the methodology used and shall identify all assumptions made.

4.4.5 For UAS operations, the risk assessment documentation shall identify if the operation is contained, any additional mitigations or controls that are required, and if a RSO/FSO is required for the operation.

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

- a. Each source of hazard, including any associated with a payload, during flight.
- b. Normal flight and each appropriate foreseeable failure response mode of the vehicle for each flight phase.
- c. Each appropriate foreseeable external and internal vehicle flight environment.
- d. Public and worker population potentially exposed to the flight.
- e. Population growth rates in order to remain valid if a risk assessment will apply to a number of flights over a number of years.
- f. The performance of any FSS, control, or constraint including all associated time delays.

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

- a. Vehicle reliability unless the vehicle will operate under full containment according to this standard.
- b. Proposed trajectories (nominal, preplanned contingency, abort, and malfunction trajectories).
- c. Description of any landing sites or flight paths.
- d. Description of credible failure modes and their probability of occurrence resulting in a hazard to public safety.
- e. Reliability of any FSS.
- f. All hazard controls and mitigation strategies.
- g. Pertinent vehicle information, such as size, weight, propellant types and amounts, and any explosives, pressurized vessels potential for high energy release, toxic materials, or radionuclides.
- h. Other relevant data required for analysis in support of specific mission objectives, including related payload information and data from pertinent lessons-learned reports.

4.4.8 There are typically three types of hazards considered in a range safety risk assessment. These include debris, Distant Focusing Overpressure (DFO), and toxic material release.

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

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

4.4.9 A range safety analysis shall establish launch/flight commit criteria and operational constraints, such as hazard areas and impact limit lines, needed to control risks due to the hazards identified.

4.5 Debris Risk Assessment

4.5.1 A Range Safety Analysis shall assess any risk due to debris for input to the risk management process.

Note: For a launch, these requirements apply to any debris that does not achieve orbital insertion. For an entry operation, these requirements apply to any debris that might be generated, intentionally or not, after the deorbit or equivalent initial burn targeting for an earth entry. Any orbital debris is subject to the requirements of NPR 8715.6, NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments, and NASA-STD-8719.14, Process for Limiting Orbital Debris.

4.5.2 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:

- a. 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 mishap.

Note: Casualty models used in range safety risk assessments typically evaluate certain impact parameters, such as kinetic energy, and incorporate thresholds on those parameters that define when a debris impact has the potential to cause a casualty or down an aircraft. These thresholds may change as our knowledge of human vulnerability/aircraft vulnerability evolves. Sources of the latest casualty and aircraft impact thresholds developed for use by the range safety community include RCC 321, and Air Force Space Command Manual (AFSPCMAN) 91-710, Air Force Space Command Range Safety User Requirements Manual.

- b. All populated areas in the overflight area that could be impacted by the debris.
- c. The probability of the debris impacting each populated area, which takes into account the probability of vehicle failure.
- d. 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 explosive debris.
- e. The population density of each populated area.

Note: The assessment should consider any risk mitigation factors associated with each population, such as sheltering and time of day of the flight.

- f. Debris variability, including size, shape, aerodynamic properties, weight, and potential to survive to impact.
- g. The sources of debris variability, including breakup conditions.
- h. The uncertainties in the state vector at the instant of jettison or destruct and any correlations used.
- i. Any velocity imparted to the debris fragments during jettison, destruct, or breakup.
- j. The influence of atmospheric variability, including winds.

4.5.3 A debris risk assessment for any property identified under paragraph 4.2.3.b shall account for:

- a. All potential debris (intentionally or unintentionally generated) that could cause property damage, which accounts for the specific nature of the property.
- b. The cross-sectional area of the debris and the potential for damage due to any explosive debris.
- c. Debris variability, including size, shape, aerodynamic properties, weight, and potential to survive to impact.
- d. The sources of debris variability, including breakup conditions.
- e. The uncertainties in the state vector at the instant of jettison or destruct and any correlations used.
- f. Any velocity imparted to the debris fragments during jettison, destruct, or breakup.
- g. The influence of atmospheric variability, e.g. winds.
- h. 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.

4.5.4 A range safety analysis shall establish hazard areas needed to control risk due to debris including aircraft and ship hazard areas which would necessitate issuing Notices to Airmen (NOTAM) or Mariners (NOTMAR).

4.6 Distant Focusing Overpressure (DFO) Effect Risk Assessment

4.6.1 A range safety analysis shall characterize the risk to the public and the workforce due to any DFO from potential explosions during vehicle operations for input to the risk management process.

4.6.2 A DFO analysis shall account for:

- a. The potential for DFO or overpressure enhancement given current meteorological conditions and terrain characteristics.
- b. The potential for broken windows and related casualties.
- c. Characteristics of the potentially affected windows, including their size, location, orientation, glazing material, and condition.
- d. 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.
- e. 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 and ignition of liquid propellants, ignition of flammable propellants, and other propellant hazards, pyrotechnic and other explosive devices, and pressurized vessels with the potential for high energy release.
- f. 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.

4.7 Toxic Hazard Risk Assessment

4.7.1 In the case of a catastrophic failure of a vehicle in flight, the fire, explosion, reactivity, and safety hazards of propulsion and power fluids (e.g., hydrazines, nitrogen tetroxide, solid rocket motors fuels, and their combustion or decomposition products) may be released. 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, the public and workforce shall be protected from toxic hazards using either hazard containment or a risk mitigation approach.

4.7.2 The range safety analysis shall assess any residual risk due to potential toxic material release not fully contained or mitigated for input to the Program Range Safety Risk Management Process.

4.7.3 The range safety analysis shall account for:

- a. Any foreseeable toxic material release during the proposed flight or in the event of a mishap.
- b. Any operational constraints and emergency procedures that provide protection from toxic material release.
- c. 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.
- d. Potential emissions from both nominal range flight operations and catastrophic events to ensure response actions are designed to prevent or mitigate possible exposures.

4.7.4 When an airborne toxic material released in a nominal or aborted launch/flight may produce concentrations above applicable Federal and local response guidelines identified or established by the cognizant CRFSL, Centers and Programs shall take appropriate actions to protect people.

Note: Sources of toxic material release response guidelines include: American Industrial Hygiene Association - Emergency Response Planning Guidelines (ERPG), Occupational Safety and Health Administration - Permissible Exposure Limit (PEL), American Conference of Government and Industrial Hygienists - Threshold Limit Value (TLV), and Environmental Protection Agency - Acute Emergency Guidance Level (AEGL).

4.8 Containment

4.8.1 When controlling risk through containment, the range safety analysis shall provide the basis for establishing the geographical areas from which people and any property identified under paragraph 4.2.3.b are to be excluded during flight.

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

4.8.3 Containment criteria for normal and malfunctioning vehicle flight shall be established.

4.8.4 Any residual risk due to any hazard not fully contained shall undergo the Range Safety Risk Management Process.

4.9 Risk Mitigation

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

4.9.2 Any residual risk not fully mitigated shall undergo the Range Safety Risk Management Process.

5. FLIGHT SAFETY SYSTEMS

5.1 Flight Termination System

5.1.1 As defined in NPR 8715.5, each NASA Program Manager obtains a determination from the CRFSL as to whether a FTS is required for the operation.

5.1.2 If an FTS is required, the NASA Program Manager shall implement an FTS that is fully compliant with the requirements of this standard unless the flight risks are controlled through other means of containment or risk mitigation per the policy of NPR 8715.5 and the requirements of paragraphs 4.8, and 4.9 of this standard that are approved by the cognizant CRFSL.

Note: NPR 8705.2 contains requirements that apply when a Range Safety Destruct System (i.e., a form of FTS) is used on any component of an inhabited vehicle. When designing future inhabited aerospace vehicles, the Program should consider vehicle designs, operational characteristics, procedures, and controls that negate the need for an FTS; e.g., controllability and high reliability, fuels, materials, pressurized or explosive components, and trajectories for launch and entry that limit exposure of populations to hazards. Based on a case-by-case assessment, an inhabited vehicle might incorporate an FTS only on certain components and not on the inhabited portion of the vehicle. Programs should evaluate the need for an FTS to provide the ability to terminate thrust without destroying (i.e., exploding) the vehicle as a distinct action. This ability may be critical to support crew survivability and may allow for the establishment of termination criteria/rules that provide significant reductions in risk to people or property on the ground.

5.1.3 An FTS shall satisfy the requirements of AFSPCMAN 91-710 or RCC 319, Range Commanders Council Flight Termination Systems Commonality Standard.

Note: Under the grandfathering provisions of AFSPCMAN 91-710, some existing vehicle Programs are governed by EWR 127-1, Range Safety Requirements, which is the predecessor to AFSPCMAN 91-710. NASA accepts this grandfathering where applicable.

5.1.4 The need for using a secure FTS shall be evaluated to mitigate risk as part of the Range Safety Risk Management Process requirements of this standard.

5.1.4.1 The decision to use a secure or non-secure FTS (including rationale that identifies any potential range safety risks and their mitigations) shall be documented and included as part of the Range Safety Risk Management Process documentation (as required in NPR 8715.5).

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

Note: In addition to range safety considerations of using secure FTS (e.g., ensuring robust ability to terminate the mission), each Program should consider the mission assurance aspects of using secure FTS (i.e., ensuring robust ability to prevent unintended termination. For example, any human-rated vehicle program would require a secure FTS.)

5.1.5 Authorization criteria for the use of the FTS for uninhabited vehicles shall include conditions for when:

- a. Valid data shows the vehicle violating a flight termination boundary, unless other documented mitigations are in effect.
- b. Vehicle performance or location is unknown, the vehicle is capable of violating a flight termination boundary, and terminating flight would mitigate the risk.

c. There is a gross trajectory deviation or obvious erratic flight rendering the vehicle uncontrollable.

d. Other mission-specific conditions present rationale for additional criteria.

5.1.6 When an inhabited vehicle or its launch systems require an FTS, flight termination activation criteria shall be established and incorporate the requirements of NPR 8705.2.

5.2 Autonomous Flight Safety System

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.

5.2.1 An Autonomous Flight Safety System (AFSS) may be used for NASA range flight operations where the implementation meets vehicle and operational constraints and the system is designed and qualified to standards (i.e. AFSPCMAN 91-710 or RCC 319) approved by the cognizant the responsible Technical Authorities, Institutional Safety Authorities, and Range Flight Safety Program Manager.

5.2.2 For human spaceflight, the primary purpose and operational concept for any FSS, including AFSS, is to protect the public while maximizing the likelihood of crew survival. To assure crew safety, any AFSS concept employed shall provide failure tolerance to catastrophic events per NPR 8705.2.

Note: The design and implementation of a human-rated AFSS may be highly specific to the human spaceflight vehicle and may incorporate, or work in conjunction with, unique aspects of the vehicle systems as appropriate.

5.3 Recovery Systems and Contingency Management Systems (CMS)

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

5.3.2 Recovery Systems and CMS may provide for deliberate termination of an errant/erratic vehicle's flight but shall not be considered an FTS unless the system meets the requirements of paragraph 5.1 of this standard and the related tracking, telemetry, and command requirements of this standard.

5.3.3 Recovery Systems and CMS that do not meet FTS requirements may be considered as risk mitigation and factor into the range safety risk assessment for the range flight operation where applicable.

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

5.3.5 If a Recovery System or a CMS is to be used for risk mitigation, verification of system functions shall be demonstrated prior to flight.

5.4 Vehicle Tracking

Note: Most ranges that support NASA missions have local vehicle tracking requirements that apply (e.g., Air Force range safety vehicle tracking requirements are outlined in AFSPCMAN 91-710).

5.4.1 For a vehicle that is flown with an FTS, the FSS used to support a flight termination decision shall include a minimum of two sources of vehicle tracking data, where the two sources are independent of each other and at least one of the sources is independent of any vehicle guidance system.

5.4.2 For a vehicle that is flown with an FTS, the tracking data from each source shall be of sufficient quality to determine the vehicle's real-time position and instantaneous impact point throughout the period of time that the data is needed to support a flight termination decision.

Note: For orbital vehicles, this tracking time period includes launch through the time that tracking and command capability is needed to protect the public from hazards of vehicle flight. This tracking time period is throughout the mission for suborbital or aeronautical vehicles and upon entry through landing for entry vehicles. The tracking time period may consider operational constraints. For example, for a launch, the tracking may not be needed immediately after liftoff as long as it will be available prior to the earliest time that the vehicle could endanger people or property.

5.4.3 For the flight of an uninhabited vehicle that is flown with an AFSS or without an FTS, the FSS shall include tracking or other data sources sufficient to determine the impact footprint of all vehicle components.

5.5 Telemetry

Note: Most ranges that support NASA missions have local telemetry requirements that apply (e.g., Air Force range safety telemetry requirements are outlined in AFSPCMAN 91-710).

5.5.1 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.

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

5.5.3 The safety data required for each flight shall be identified in coordination with the CRFSL.

5.5.4 For a vehicle that uses an FTS, the telemetry data shall include parameters that describe the health and status of the FTS and the vehicle needed to support a flight termination decision. These parameters may include, but are not limited to:

- a. FTS:
 - (1) Receiver signal strength, command, and pilot tone or check channel status.
 - (2) Safe/arm status.
 - (3) Battery voltage.
 - (4) Battery temperature.
- b. Navigation system parameters such as position, velocity, and acceleration.
- c. Guidance commands to flight control effectors (e.g. nozzle deflections in the pitch and yaw axes or aerodynamic surface deflections).
- d. Flight control effector position feedback.
- e. Vehicle attitude data including pitch, yaw, and roll angles and rates.
- f. Engine chamber pressures.
- g. Indicators of separation or jettison events.
- h. Global Positioning System positional and velocity data, when used for range safety purposes.

5.6 Flight Termination System Command System

5.6.1 An FTS command system used to support missions that require an FTS shall incorporate fully redundant and independent command paths.

5.6.2 An FTS command system shall undergo validation to ensure operational readiness prior to every mission.

5.6.3 FTS command systems shall be under configuration control.

5.6.4 An FTS command system used to support missions that require an FTS shall have a reliability of 0.999 at the 95% confidence level.

Note: The exception to this would be long duration UAS missions as defined by the CRFSL.

Note: For FAA licensed launches, the FTS command system must meet the requirements in 14 CFR Part 417, Launch Safety, Section 417.303 for Command control system requirements.

5.7 Safety-Critical Software

Safety-critical software in FSS owned by NASA or used to support NASA missions shall be identified and satisfy NPR 7150.2, NASA Software Engineering Requirements, and NASA-STD-8739.8, Software Assurance and Software Safety Standard, or other software engineering and software safety standards as accepted by the CRFSL.

6. OPERATIONAL REQUIREMENTS

6.1 Launch/Flight Commit Criteria

6.1.1 The launch/flight commit criteria for a range flight operation shall include identification of the conditions required to safely initiate each flight or phase of flight.

6.1.2 The launch/flight commit criteria shall provide for:

- a. Assurance that the collision avoidance requirements of paragraph 6.3 are satisfied for any launch or entry.
- b. Surveillance of established hazard areas as required to meet the risk criteria in this standard.
- c. Verification that all FSS are available and operational.
- d. Verification that the meteorological conditions, such as wind and visibility, are within the limits defined by the range safety analysis.
- e. Verification that natural and triggered lightning constraints are within limits.
- f. Verification that the range safety risk criteria are satisfied including any specific range safety risk constraints.

6.1.3 Implementation of the launch/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 launch/flight commit criteria have been met.

6.2 Entry Operations

6.2.1 An entry operation that is primarily for mission purposes other than disposal begins with the final commitment to entry and landing (e.g., the final command that initiates or enables the entry and landing sequence or the final decision point to allow the entry to proceed) and ends when all vehicle components associated with the entry come to rest on the Earth, are burned up in the atmosphere, or are accounted for and assessed to not be capable of causing injury or damage (including any jettisoned components).

Note: NPR 8715.6 and NASA-STD-8719.14 contain requirements for limiting orbital debris generation, including requirements that apply to entry for the primary purpose

of disposal, such as controlled or uncontrolled entry of spent launch vehicle upper stages after orbital insertion or orbital spacecraft that have completed their mission.

6.2.2 Entry-and-landing shall not be committed until the Program confirms that all conditions critical to safety are met.

6.2.3 The entry phase of a Program's Range Safety Risk Management Process, including the vehicle's reliability to achieve controlled entry to the targeted landing site or debris footprint, shall be approved by the cognizant Center Range Flight Safety Lead prior to entry operations.

Note: The intent is to provide assurance that the vehicle will deorbit in a predictable manner that allows for appropriate risk management for the entry operation in accordance with this standard.

6.3 Collision Avoidance

6.3.1 Prior to launch and entry operations, the vehicle, including any jettisoned component, or payload shall meet one of the following criteria with regard to all orbital inhabited or inhabitable spacecraft:

- a. A P_i less than or equal to (\leq) 1×10^{-6} ; or
- b. An ellipsoidal miss distance greater than or equal to (\geq) 200 km in-track and 50 km cross-track or radially; or
- c. A spherical miss distance greater than or equal to (\geq) 200 kilometers.

Note: These options are listed in the order of preference. Option a. has been shown to be the best estimate of risk and directly incorporates the trajectory covariance estimates and options b. and c. have been shown not to correlate directly to risk.

6.3.2 Prior to entry operations, an analysis shall be performed which indicates that the vehicle, including any jettisoned component, or payload would have a P_i less than or equal to (\leq) 1×10^{-4} with respect to all uninhabited space objects.

Note: For launch operations, FDSS-21-0182 "Launch COLA Operations: an Examination of Data Products, Procedures, and Thresholds" Revision A demonstrates that this threshold is currently satisfied without operational launch collision avoidance screening due to the large uncertainties inherent in launch vehicle flight. Therefore, active launch collision avoidance screening against the uninhabited on-orbit object population presently adds no risk management value, and is not required for NASA-managed launches. This position will be periodically evaluated based on the evolution of launch vehicle guidance, navigation, and control systems as well as growth in the on-orbit population.

6.3.3 The Joint Space Operations Center (JSpOC) shall be informed of an upcoming launch or entry operation at least 15 days before the operation.

6.3.4 The JSpOC shall be notified immediately of any change in the planned launch or entry operations that occurs after the initial notification.

6.3.5 A Collision Avoidance (COLA) analysis shall be obtained from the JSpOC or an equivalent analysis shall be performed that satisfies the criteria of this standard.

6.3.6 The COLA analysis shall:

- a. Establish each wait in a planned launch/entry window during which the Program will not initiate or commit to launch/entry in order to satisfy the criteria of this standard and any Program or range specific criteria.
- b. Account for the vehicle, any jettisoned component, or payload achieving altitudes greater than 150 km.
- c. Account for uncertainties associated with vehicle performance and timing and ensure that any calculated launch/entry waits incorporate all additional time periods associated with such uncertainties.
- d. For an orbital launch, account for the period starting from ascent through at least 3 hours after liftoff. This time period should:
 - (1) Account for each objects' orbit type,
 - (2) Account for each objects altitude in relation to each other as needed to satisfy the applicable criteria, and
 - (3) Provide sufficient time for each new orbital object to be catalogued by JSpOC.
- e. For a suborbital launch, account for the entire flight to landing or final impact.

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, or payload is 50 km or more below the orbital perigee of the inhabitable object.

- f. For an entry operation, account for the entry trajectory from the point that deorbit is committed through landing or final impact.

6.3.7 Launch/entry waits and any other constraints needed to satisfy the COLA requirements of this standard shall be implemented as launch/flight commit criteria per this standard.

6.4 Unmanned Aircraft System (UAS) Operations

6.4.1 In addition to the range safety requirements and methodologies found in this standard, NASA UAS operations are subject to the requirements of NPR 7900.3, Aircraft Operations Management.

Note: RCC 323 and RCC 555, User Guide for Unmanned Aerial System (UAS) Operations on the National Ranges, provide additional guidance for UAS operations.

6.4.2 UAS operations conducted within special use airspace shall be coordinated with and approved by the using agency for that airspace.

6.4.3 In the event that a UAS project intends to utilize software safeguards as part of their flight control process or hazard mitigation, verifications of software functions shall be demonstrated prior to the first operational flight of the UAS and each 'first flight' following any change to the relevant software. Prior to any operational flight, the Pilot In Command shall verify that the software safeguards are in place and properly configured as required for the particular flight. In addition, a software hazard analysis may be performed and provided to support hazard controls evaluation as part of the flight approval process.

Note: Example software safeguards may include "lost link" or "emergency mission" routines.

6.4.4 The UAS risk assessment shall identify if an RSO/FSO is required for the operation.

6.4.5 An RSO/FSO is required for operations that exceed risk criteria or that implement mitigations to eliminate the possibility of exceeding risk criteria.

6.5 Aerostat/Balloon Systems Operations

6.5.1 Aerostat and balloon operations are subject to 14 CFR Part 101, Moored Balloons, Kites, Amateur Rockets, Unmanned Free Balloons, and Certain Model Aircraft.

6.5.2 For free balloons, the blunt force trauma requirements for debris in RCC 321 shall apply.

Note: Guidance for operating an aerostat or balloon in special use airspace can be found in AFSPCMAN 91-710.

6.6 Amateur Rockets

A NASA Program involved in operating or launching an amateur rocket are be subject to 14 CFR Part 101 - Subpart C, and the applicable range safety requirements and methodologies of this standard.

6.7 Radiation Systems

NASA Centers and Programs with range flight operations that use radiation sources (e.g., radio-frequency/microwave emitters, radioactive materials, X-ray devices, lasers, and optical emitters) are subject to the requirements of NPR 1800.1, NASA Occupational Health Program Procedure, and local range requirements. NPR 8715.3, NASA General Safety Program Requirements, contains requirements and guidance applicable to space launch of radioactive materials.

6.8 Laser Hazard Controls

NASA range flight operations involving the use of lasers are subject to the requirements of NPR 1800.1, and local range requirements.

7. PERSONNEL TRAINING, QUALIFICATIONS, AND CERTIFICATIONS

7.1 Training

Minimum training requirements are found in Appendix A for personnel performing range flight safety related functions during NASA range flight operations. The training program for range flight safety personnel who support NASA range flight operations shall:

- a. Provide qualified personnel to support nominal and contingency range flight operations.
- b. Include a recurring training process to ensure personnel retain their qualifications.
- c. Include a requalification process for personnel who lose qualification status, such as someone who exhibits substandard performance or has health problems.

Note: It is expected that Centers will develop unique individual training plans which utilize a number of different training sources to include those found within and outside NASA in support of their unique flight activities. In cases where such training is unavailable internal to a Center they should seek training at another Center who has the requisite expertise.

7.2 Qualification and Certification

Qualifications for personnel who perform a range flight safety function for a NASA range flight operation (including RSOs, FSOs, and personnel responsible for FSS and range safety analysis) shall include:

- a. Successful completion of knowledge-based training (self-study or classroom) applicable to the range safety function.
- b. Successful completion of instructor-led, hands-on training on how to perform the range safety function followed by satisfactory on-the-job performance as a trainee, as applicable.
- c. Proficiency demonstrated to a qualified range flight safety professional during simulation scenarios that exercise hands-on operations of FSS and use of safety decision-making tools or processes, as applicable.
- d. Proficiency demonstrated to a qualified range flight safety professional during exercises of nominal and contingency actions, as applicable.

7.3 Documentation

A documentation process shall be established for training and qualification that captures the initial training, qualification, recurring training, requalification, and certification status of all range flight safety personnel.

7.4 Range Safety Officer/Flight Safety Officer Qualification and Certification Requirements

7.4.1 RSOs/FSOs with real-time decision making responsibilities shall perform these responsibilities during operations at a minimum of once per year per vehicle type (e.g. SR, ELV, UAV, balloon).

7.4.2 RSOs/FSOs with real-time safety decision-making responsibilities shall meet the Certification Examination requirements for Ordnance Handlers in NPR 1800.1 (Appendix C, A3.L) in addition to the requirements of this standard.

APPENDIX A. MINIMUM TRAINING REQUIREMENTS FOR RANGE FLIGHT SAFETY PERSONNEL

A.1 Purpose

The purpose of this appendix is to provide the minimum training requirements for personnel performing range flight safety related functions during NASA range flight operations.

Table A-1. Minimum Training Requirements for Flight Safety Analysts

| Plan of Instruction | Flight Safety Analyst | | | |
|---|-----------------------|-----|-----|----------|
| | SR | UAV | ELV | Balloons |
| Review NASA Agency Documentation | | | | |
| NPR 8715.5, Range Flight Safety Program | X | X | X | X |
| NPD 8700.1, Policy for Safety and Mission Success | X | X | X | X |
| NPD 8715.3, General Safety Program | X | X | X | X |
| NPR 7900.3, Aircraft Operations Management | | X | | |
| NPR 8705.6, Safety and Mission assurance Audits, Reviews, and Assessments | | | | |
| Review National Range Safety Standards | | | | |
| RCC 319 Flight Termination Systems Commonality Standard | | | | |
| RCC 321 Common Risk Criteria Standards for National Test Ranges | X | X | X | X |
| RCC 323 Range Safety Criteria for Unmanned Air Vehicles | | X | | |
| RCC 324 Global Positioning and Inertial Measurements Range Safety Tracking Systems Commonality Standard | | | | |
| RCC 555 User Guide For Unmanned Aerial Systems (UAS) Operations on the National Ranges | | X | | |
| Review FAA Regulations | | | | |
| 14 CFR Part 101 (Moored Balloons, Kites, Amateur Rockets, Unmanned Free Balloons, and Certain Model Aircraft) | X | | | X |
| 14 CFR Part 417 (Launch Safety) | X | | X | |
| 14 CFR Part 107 (Operation and Certification of Small Unmanned Aircraft Systems) | | X | | |
| Safety Training (On-Line SATERN & Instructor Led) | | | | |
| Range Safety Orientation (SMA-AS-WBT-410) | X | X | X | X |
| Flight Safety System (FSS) (SMA-AS-WBT-335) | | | | |
| Flight Safety Analysis (SMA-AS-WBT-435) | X | X | X | X |
| Range Safety Operations (Instructor Led) (SMA-SAFE-NSTC-0097) | | | | |
| Overview of Mishap Investigations (SMA-002-07) | | | | |
| Risk Management Overview (SMA-OV-WBT-111) | X | X | X | X |
| System Engineering Overview (SMA-OV-WBT-113) | X | X | X | X |
| Basics of Aviation Safety (SMA-AS-WBT-100) | | X | | X |
| Basics of Reliability and Maintainability (SMA-RM-WBT-100) | X | X | X | X |
| Basics of System Safety (SMA-SS-WBT-100) | X | X | X | X |
| Decision Analysis Overview (SMA-OV-WBT-112) | | | | |
| Probability Risk Assessment Methods (PRAM) for Practitioners and Managers (SMA-SS-WBT-0001) | X | X | X | |
| Probability & Statistics I (SMA-SS-WBT-0005) | X | X | X | X |
| Unmanned Aircraft System (UAS) Range Flight Safety (SMA-AS-WBT-300) | | X | | |
| *NASA Center Specific Training | | | | |
| Understand Center Range Safety Process | X | X | X | X |
| Understand Vehicle Systems | X | X | X | X |
| Understand Flight Safety Systems (FSS) | X | X | X | X |
| Understand Range (Infrastructure) Assets | | | | |
| Understand Mission Rules | X | X | X | X |
| Understand Range Flight Safety Risk Analysis | X | X | X | X |
| Understand Area Surveillance Control Operations | X | X | X | X |
| Understand Mission Weather Constraints | X | X | X | X |
| Understand Range Instrumentation Launch Commit Criteria | X | X | X | X |
| Use Operational Mission Console | | | | |

*These knowledge skills are recommended training topics that could be applicable for a particular NASA Center. If your Center does not have the level of expertise or the training resources, other NASA centers may offer potential unique training opportunities.

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Table A-2. Minimum Training Requirements for Flight Safety System Engineers

| Plan of Instruction | Flight Safety System Engineer | | | |
|---|-------------------------------|-----|-----|----------|
| | SR | UAV | ELV | Balloons |
| Review NASA Agency Documentation | | | | |
| NPR 8715.5, Range Flight Safety Program | X | X | X | X |
| NPD 8700.1, Policy for Safety and Mission Success | X | X | X | X |
| NPD 8715.3, General Safety Program | X | X | X | X |
| NPR 7900.3, Aircraft Operations Management | | X | | |
| NPR 8705.6, Safety and Mission assurance Audits, Reviews, and Assessments | | | | |
| | | | | |
| Review National Range Safety Standards | | | | |
| RCC 319 Flight Termination Systems Commonality Standard | X | X | X | X |
| RCC 321 Common Risk Criteria Standards for National Test Ranges | | | | |
| RCC 323 Range Safety Criteria for Unmanned Air Vehicles | | X | | |
| RCC 324 Global Positioning and Inertial Measurements Range Safety Tracking Systems Commonality Standard | X | | X | |
| RCC 555 User Guide For Unmanned Aerial Systems (UAS) Operations on the National Ranges | | X | | |
| | | | | |
| Review FAA Regulations | | | | |
| 14 CFR Part 101 (Moored Balloons, Kites, Amateur Rockets, Unmanned Free Balloons, and Certain Model Aircraft) | X | | | X |
| 14 CFR Part 417 (Launch Safety) | X | | X | |
| 14 CFR Part 107 (Operation and Certification of Small Unmanned Aircraft Systems) | | X | | |
| | | | | |
| Safety Training (On-Line SATERN & Instructor Led) | | | | |
| Range Safety Orientation (SMA-AS-WBT-410) | X | X | X | X |
| Flight Safety System (FSS) (SMA-AS-WBT-335) | X | X | X | X |
| Flight Safety Analysis (SMA-AS-WBT-435) | | | | |
| Range Safety Operations (Instructor Led) (SMA-SAFE-NSTC-0097) | | | | |
| Overview of Mishap Investigations (SMA-002-07) | | | | |
| Risk Management Overview (SMA-OV-WBT-111) | | | | |
| System Engineering Overview (SMA-OV-WBT-113) | X | X | X | X |
| Basics of Aviation Safety (SMA-AS-WBT-100) | | X | | X |
| Basics of Reliability and Maintainability (SMA-RM-WBT-100) | X | X | X | X |
| Basics of System Safety (SMA-SS-WBT-100) | X | X | X | X |
| Decision Analysis Overview (SMA-OV-WBT-112) | | | | |
| Probability Risk Assessment Methods (PRAM) for Practitioners and Managers (SMA-SS-WBT-0001) | | | | |
| Probability & Statistics I (SMA-SS-WBT-0005) | | | | |
| Unmanned Aircraft System (UAS) Range Flight Safety (SMA-AS-WBT-300) | | X | | |
| | | | | |
| *NASA Center Specific Training | | | | |
| Understand Center Range Safety Process | X | X | X | X |
| Understand Vehicle Systems | X | X | X | X |
| Understand Flight Safety Systems (FSS) | X | X | X | X |
| Understand Range (Infrastructure) Assets | X | X | X | X |
| Understand Mission Rules | X | X | X | X |
| Understand Range Flight Safety Risk Analysis | | | | |
| Understand Area Surveillance Control Operations | | | | |
| Understand Mission Weather Constraints | | | | |
| Understand Range Instrumentation Launch Commit Criteria | X | X | X | X |
| Use Operational Mission Console | | | | |

*These knowledge skills are recommended training topics that could be applicable for a particular NASA Center. If your Center does not have the level of expertise or the training resources, other NASA centers may offer potential unique training opportunities.

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Table A-3. Minimum Training Requirements for RSOs/FSOs

| Plan of Instruction | RSOs/FSOs | | | |
|---|-----------|-----|-----|----------|
| | SR | UAV | ELV | Balloons |
| Review NASA Agency Documentation | | | | |
| NPR 8715.5, Range Flight Safety Program | X | X | X | X |
| NPD 8700.1, Policy for Safety and Mission Success | X | X | X | X |
| NPD 8715.3, General Safety Program | X | X | X | X |
| NPR 7900.3, Aircraft Operations Management | | X | | |
| NPR 8705.6, Safety and Mission assurance Audits, Reviews, and Assessments | | | | |
| Review National Range Safety Standards | | | | |
| RCC 319 Flight Termination Systems Commonality Standard | X | X | X | X |
| RCC 321 Common Risk Criteria Standards for National Test Ranges | X | X | X | X |
| RCC 323 Range Safety Criteria for Unmanned Air Vehicles | | X | | |
| RCC 324 Global Positioning and Inertial Measurements Range Safety Tracking Systems Commonality Standard | X | | X | |
| RCC 555 User Guide For Unmanned Aerial Systems (UAS) Operations on the National Ranges | | X | | |
| Review FAA Regulations | | | | |
| 14 CFR Part 101 (Moored Balloons, Kites, Amateur Rockets, Unmanned Free Balloons, and Certain Model Aircraft) | X | | | X |
| 14 CFR Part 417 (Launch Safety) | X | | X | |
| 14 CFR Part 107 (Operation and Certification of Small Unmanned Aircraft Systems) | | X | | |
| Safety Training (On-Line SATERN & Instructor Led) | | | | |
| Range Safety Orientation (SMA-AS-WBT-410) | X | X | X | X |
| Flight Safety System (FSS) (SMA-AS-WBT-335) | X | X | X | |
| Flight Safety Analysis (SMA-AS-WBT-435) | | | X | |
| **Range Safety Operations (Instructor Led) (SMA-SAFE-NSTC-0097) | X | X | X | |
| Overview of Mishap Investigations (SMA-002-07) | | | | |
| Risk Management Overview (SMA-OV-WBT-111) | X | X | X | X |
| System Engineering Overview (SMA-OV-WBT-113) | | | | |
| Basics of Aviation Safety (SMA-AS-WBT-100) | | X | | X |
| Basics of Reliability and Maintainability (SMA-RM-WBT-100) | | | | |
| Basics of System Safety (SMA-SS-WBT-100) | | | | |
| Decision Analysis Overview (SMA-OV-WBT-112) | | | | |
| Probability Risk Assessment Methods (PRAM) for Practitioners and Managers (SMA-SS-WBT-0001) | | | | |
| Probability & Statistics I (SMA-SS-WBT-0005) | | | | |
| Unmanned Aircraft System (UAS) Range Flight Safety (SMA-AS-WBT-300) | | X | | |
| *NASA Center Specific Training | | | | |
| Understand Center Range Safety Process | X | X | X | X |
| Understand Vehicle Systems | X | X | X | X |
| Understand Flight Safety Systems (FSS) | X | X | X | X |
| Understand Range (Infrastructure) Assets | X | | X | |
| Understand Mission Rules | X | X | X | X |
| Understand Range Flight Safety Risk Analysis | X | X | X | X |
| Understand Area Surveillance Control Operations | X | X | X | X |
| Understand Mission Weather Constraints | X | X | X | X |
| Understand Range Instrumentation Launch Commit Criteria | X | X | X | X |
| Use Operational Mission Console | X | X | X | |

*These knowledge skills are recommended training topics that could be applicable for a particular NASA Center. If your Center does not have the level of expertise or the training resources, other NASA centers may offer potential unique training opportunities.

**This course is required and will be scheduled based on instructor and resource availability.

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Table A-4. Minimum Training Requirements for Center Range Flight Safety Leads

| Plan of Instruction | CRFSL | | | |
|---|-------|-----|-----|----------|
| | SR | UAV | ELV | Balloons |
| Review NASA Agency Documentation | | | | |
| NPR 8715.5, Range Flight Safety Program | X | X | X | X |
| NPD 8700.1, Policy for Safety and Mission Success | X | X | X | X |
| NPD 8715.3, General Safety Program | X | X | X | X |
| NPR 7900.3, Aircraft Operations Management | | X | | |
| NPR 8705.6, Safety and Mission assurance Audits, Reviews, and Assessments | X | X | X | X |
| | | | | |
| Review National Range Safety Standards | | | | |
| RCC 319 Flight Termination Systems Commonality Standard | X | X | X | X |
| RCC 321 Common Risk Criteria Standards for National Test Ranges | X | X | X | X |
| RCC 323 Range Safety Criteria for Unmanned Air Vehicles | | X | | |
| RCC 324 Global Positioning and Inertial Measurements Range Safety Tracking Systems Commonality Standard | X | | X | |
| RCC 555 User Guide For Unmanned Aerial Systems (UAS) Operations on the National Ranges | | X | | |
| | | | | |
| Review FAA Regulations | | | | |
| 14 CFR Part 101 (Moored Balloons, Kites, Amateur Rockets, Unmanned Free Balloons, and Certain Model Aircraft) | X | | | X |
| 14 CFR Part 417 (Launch Safety) | X | | X | |
| 14 CFR Part 107 (Operation and Certification of Small Unmanned Aircraft Systems) | | X | | |
| | | | | |
| Safety Training (On-Line SATERN & Instructor Led) | | | | |
| Range Safety Orientation (SMA-AS-WBT-410) | X | X | X | X |
| Flight Safety System (FSS) (SMA-AS-WBT-335) | X | X | X | X |
| Flight Safety Analysis (SMA-AS-WBT-435) | X | X | X | X |
| Range Safety Operations (Instructor Led) (SMA-SAFE-NSTC-0097) | | | | |
| Overview of Mishap Investigations (SMA-002-07) | X | X | X | X |
| Risk Management Overview (SMA-OV-WBT-111) | X | X | X | X |
| System Engineering Overview (SMA-OV-WBT-113) | X | X | X | X |
| Basics of Aviation Safety (SMA-AS-WBT-100) | | X | | X |
| Basics of Reliability and Maintainability (SMA-RM-WBT-100) | X | X | X | X |
| Basics of System Safety (SMA-SS-WBT-100) | X | X | X | X |
| Decision Analysis Overview (SMA-OV-WBT-112) | X | X | X | X |
| Probability Risk Assessment Methods (PRAM) for Practitioners and Managers (SMA-SS-WBT-0001) | | | | |
| Probability & Statistics I (SMA-SS-WBT-0005) | | | | |
| Unmanned Aircraft System (UAS) Range Flight Safety (SMA-AS-WBT-300) | | X | | |
| | | | | |
| *NASA Center Specific Training | | | | |
| Understand Center Range Safety Process | X | X | X | X |
| Understand Vehicle Systems | X | X | X | X |
| Understand Flight Safety Systems (FSS) | X | X | X | X |
| Understand Range (Infrastructure) Assets | X | X | X | X |
| Understand Mission Rules | X | X | X | X |
| Understand Range Flight Safety Risk Analysis | X | X | X | X |
| Understand Area Surveillance Control Operations | X | X | X | X |
| Understand Mission Weather Constraints | X | X | X | X |
| Understand Range Instrumentation Launch Commit Criteria | X | X | X | X |
| Use Operational Mission Console | X | X | X | X |

*These knowledge skills are recommended training topics that could be applicable for a particular NASA Center. If your Center does not have the level of expertise or the training resources, other NASA centers may offer potential unique training opportunities.