

Standard

Commercial Launch Safety

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American National Standard

Commercial Launch Safety

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Abstract

This AIAA Standard establishes criteria for the establishment of the safety roles and responsibilities and relationships between the various operators who may conduct simultaneous aerospace vehicle operations at a launch or landing site. Risk management processes for ensuring the safety of the public, its property and the safety of the personnel involved in the preparatory and launch operations are addressed. The training and qualifications of the personnel involved in operations at the launch and landing sites are addressed. The appendices to this standard provide guidelines for the design, testing and safe operation of aerospace vehicles and their support equipment.

January 1999

American National Standard

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Foreword

This American National Standard for Commercial Launch Safety is sponsored by the American Institute of Aeronautics and Astronautics (AIAA) as part of its Standards Program.

The idea for an AIAA standard addressing the minimum requirements for safe operation of commercial launch activities was conceived by the Space Launch Systems Committee on Standards in January 1992 under the leadership of Todd J. Mosher. The Standards Technical Council approved the project in April 1992. The leading goal of the project was that the document would be an evolving source of consensus information for the commercial launch industry and its customers. In particular, it was intended that advantage would be taken of the many other non-government standards.

The momentum initiated by the "Perry memo" directed the Department of Defense to cease support of military standards except for militarily critical procurement and to use non-government standards in all possible situations. The ongoing thrust of OMB Circular A-119 had earlier directed other Federal agencies to participate in and use non-government standards in their procurement and regulatory activities. The Office of Commercial Space Transportation in the Department of Transportation sought to follow this pattern and advised AIAA that it would recommend applicants for launch licenses to use suitable non-government standards, if they became available.

The first draft of this document was prepared by a team of retired US Air Force officers with launch command experience. In June 1995, an AIAA public forum was held to introduce the document. Approximately sixty industry and government representatives attended this meeting and contributed comments on it and the overall project. An editing committee was formed, and a second draft was released in September 1995. A third draft was released in January 1996 followed by a fourth draft in September 1996. Based on the comments received from both government and industry a different approach is presented in this fifth draft. This draft begins to define the relationship between the various operators who may conduct simultaneous operations on a launch or landing site. Roles and responsibilities related to the

safety of ground operations and flight operations are established. The training and qualifications of personnel involved in the preparatory and launch and re-entry activities are defined. The concept presented in this draft parallels that contained in the ISO DIS 14620, "Space Systems - Launch Site Operations- Safety Requirements" Draft currently being circulated for international voting. The requirements that have been presented in previous drafts of the AIAA standard are now presented in annexes as guidelines for the design, testing and safe operation of aerospace vehicles and their support equipment. None of this material is intended to be mandatory, and the annexes are marked as "Informative." A great deal of credit for the concepts in this document is owed to Bobby R. Quisenberry.

One of the key elements in the document now is the principal of bridging between launch activities planned for either Federal government launch sites and those owned by other organizations. Currently all commercial launches are conducted from Air Force, Army, or NASA facilities. There is a significant experience with the evolved requirements for launch activities from these locations. However, this standard begins to recognize the need for the development of commercial, industry-based criteria to be implemented for new and evolving aerospace vehicles and their support systems. Considerations are given to the development of commercial launch sites that are not within the confines of federal launch sites; operations of US and foreign launch vehicles from non-standard launch platforms (e.g., Sea Launch); reusable launch vehicles planned to conduct airline type operations, etc. The standard presents a sound basis for planning and implementing a safety program that will facilitate safe aerospace vehicle operations, and speed evaluation of a launch license. This standard does not presume to preempt continued adherence to DoD and NASA requirements for operations at their launch sites. (e.g. EWR 127-1 & NASA 1740)

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At the time of completion, the AIAA Space Launch Systems Committee on Standards consisted of the following individuals:

Leo Aragon	Air Force 30 th Space Wing
Herbert Bachner	Federal Aviation Administration
Daniel Cassidy	Sedgwick Space Services
Tom Daniels	Pacific Missile Range
Dave Donahe	White Sands Missile Range
Joe Fury	Air Force Space Command
Lou Gomez	New Mexico Office of Space Commercialization
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Harold Reck	ACTA, Inc.
Harold Rhodes	Air Force 45 th Space Wing
Richard Scredon	Allied Signal
Alvin Sheffler	Motorola Satellite Communications
Wayne Woodhams	Virginia Commercial Space Flight Authority

1.0 Safety Policies and Processes

1.1 Introduction

This standard has been developed by the American Institute of Aeronautics and Astronautics (AIAA) with the cooperation of the commercial space industry as a basic approach for ensuring the safety of operations from commercial launch sites. The standard has been reviewed and input obtained from the commercial space launch industry, government launch agencies, and state spaceports.

The U. S. commercial space industry includes several launch vehicle operators, payload operators, and launch site operators with many different existing and emerging launch and aerospace vehicle configurations, as well as existing and new spaceport launch sites/locations and modes (i.e., land, sea, and airplane). This standard includes provisions to accommodate these various options.

The majority of the current commercial launch vehicle operators are primarily companies that have served as contractors for government launch operations. Their vehicles and procedures have been designed to comply with existing DoD and NASA launch range safety requirements. These existing safety requirements are envisioned to remain in place for launch operations conducted at the DoD and NASA facilities. This standard provides for the beginning of a transition to commercially developed and operated aerospace vehicles as well as commercial launch and re-entry operations at various locations by identifying the roles and responsibilities of the various operators involved.

The U. S. Commercial Space Launch Act (CSLA) of 1984, as codified at 49 USC Subtitle IX, Commercial Space Launch Activities, 49 USC §§ 70101-70119 (1994), assigns the responsibility to the Secretary of Transportation for ensuring public health and safety during the conduct of commercial space launch operations. Pursuant to this responsibility, the CSLA establishes the authority of the Department of Transportation (DOT) to license the launch of launch vehicles and operation of a launch site. This standard is envisioned to support the development of the documentation necessary to secure the licensing

for commercial space launch operations from any regulatory agency.

Individual state statutes define the authorities and operational structure of the state sponsored / operated spaceports.

International treaties and conventions have established the legal framework for space launch activities and the liabilities associated with space launch activities. The Outer Space Treaty of 1967 and the Liability Convention of 1972 are key references in understanding these obligations by launching countries. Complete reference citations are:

- a. Treaty on principles governing the activities of States in exploration and use of outer space, including the Moon and other celestial bodies, 27 January 1967 (the Outer Space Treaty).
- b. Agreement on the rescue or astronauts, the return of astronauts and the return of objects launched into outer space, 22 April 1958 (the Rescue Agreement).
- c. Convention on international liability for damage caused by space objects, 29 March 1972 (the Liability Convention).
- d. Convention on registration of objects launched into outer space, 14 January 1975 (the Registration Convention).
- e. Agreement governing the activities of States on the Moon or other celestial bodies, 18 December 1979 (the Moon Agreement).

The International Organization for Standardization (ISO) Standard 14620-2, "Space Systems - Safety Requirements - Launch Site Operations" should be consulted for international guidance regarding launch site safety at sites not under US. control.

1.2 Scope

Space launch ground and flight activities by their nature create safety risks to personnel, public and private property and the environment. This standard identifies the safety roles and responsibilities for the conduct of aerospace vehicle ground and flight activities and provides a framework for the allocation of these

responsibilities between the launch vehicle operator, the operator of the launch site, payload provider and other operators who may be conducting operations simultaneously on the same launch site.

This standard defines a process for conducting the safety risk management analyses necessary to define the requirements and procedures for the protection of personnel involved in launch activities, the public, and property on and off the launch site. This standard also addresses the processing of aerospace vehicles on the launch site and during the flight phase. It provides basic principles to enable the operators to implement their own safety methods, tools, and procedures, to ensure the safety of people, public and private property, and the environment, in a consistent and homogeneous manner.

1.3 Purpose

The purpose of this standard is to establish a commercial approach to the safety process necessary to achieve acceptable levels of safety risk associated with commercial aerospace vehicle operations.

1.4 Safety Policies and Objectives

This standard addresses the allocation of safety roles and responsibilities; its appendices define a minimum set of safety guidelines for the protection of the launch site personnel, launch site equipment and facilities and the public, public and private property and facilities external to the launch or landing complex.

The principal objective of this standard is to achieve safety performance for commercial aerospace vehicle operations comparable to that of other hazardous industrial operations for activities at the launch site. Risks during the pre-launch and flight phase of commercial launch operations should be no greater than those posed by the hazards from other hazardous operations (e.g., general aviation over flight). The criteria for commercial aerospace vehicle operations should be no more restrictive than that applied to US. government launch vehicle activities at U. S. Launch Sites

The allocation of safety responsibilities between the launch vehicle operator, other operators, and

the launch site operator shall be determined by the relevant parties and documented formally via "use agreements", contracts, etc.

1.5 Application of Standard

It is intended that the provisions of this standard could be adopted by all operators of aerospace vehicles, launch vehicles, space vehicles, payloads, and launch sites. It is envisioned that the commercial space industry will use it as a uniform, accepted set of guidelines which, if implemented by contract, will meet industry and statutory requirements for health and safety. Additionally, the goal of this standard is that operators of launch sites shall find these requirements adequate to ensure public safety .

1.6 Safety Documentation

The safety documentation of a launch site should be structured into several levels as follows:

a. Safety Regulations: Safety regulations reflect the regulatory agencies' safety policy and should be based on state, federal, and international laws. Safety regulations should establish the safety liabilities, roles and responsibilities of the operators performing activities on the launch site, identify all safety requirements, and describe the general method for ensuring the requirements are followed.

b. Application Documents: Application documents translate the safety rules stipulated for an operator into procedures, safety instructions, operation plans, and emergency plans, and should make it possible for the safety organization to guarantee that the safety requirements are followed and applied. These documents should complete and set out in detail the safety requirements associated with hazardous operations for ensuring the latter are carried out safely.

1.7 Compliance and Approvals

This standard addresses minimum requirements for ensuring the safety of launch operations. The operators of the launch site, ground support equipment, launch vehicles, payloads, and, if required, flight safety systems shall meet the requirements of this standard, if the standard is mutually accepted by all parties as stating the minimum requirements for launch operations.

This standard recognizes that local, state and federal regulations are applicable to the conduct of launch operations and the operation of a launch and/or landing site.

The launch operator shall provide analysis and test data to demonstrate compliance with the requirements of this standard. Industry accepted specifications and standards should be used, but this standard does not dictate how these requirements will be met. Analyses performed in accordance with other federal or state regulatory requirements may be used when they meet the intent of this standard, e.g., CFR 29, OSHA Standard 1910.119, Process Safety Management for Highly Hazardous Chemicals. In the absence of accepted commercial or industry developed standards and specifications, government military standards and military specifications may be used on an interim basis. Appendix F provides a list of general references including applicable government standards and specifications.

Approval to conduct launch site operations shall be granted only after the cognizant launch site safety operators have reviewed and approved the planned launch site operational planning and procedures. It is understood that FAA/AST will issue licenses for either launch or launch site operations only after the requirements of 14 CFR Chapter III- Office of Commercial Space Transportation, Department of Transportation, Parts 400 through 499 are met.

2.0 Vocabulary and References

2.1 Definitions

Accident: An unplanned event occurring during commercial space launch activities resulting in:

- (1) Known impact of a commercial launch vehicle, its payload or any component thereof outside the impact limit lines designated by the launch range facility; or
- (2) A fatality or serious injury (as defined in 49 CFR 830.2) to any person who is not associated with commercial space launch activities and who is not located on the launch range facility; or
- (3) Any damage estimated to exceed \$25,000 to property that is not associated with commercial space launch activities and that is

not located on the launch facility.

Aerospace Vehicle: An object intended for launch or returned from outer space, one that is launched, assembled in or returned from outer space, including systems and components of an aerospace transportation system, together with related equipment, devices, components and parts.

Casualty: Serious injury or death

Collective Risk: The total risk to an exposed population; the expected total number of individuals who will be fatalities. Defined as Expected Fatalities. Collective risk is specified as either a per mission or per year value.

Critical Items: Items that involve a significant hazard such as: ordnance items, propellant items, or items such as missile components, spacecraft or other high value items, and items that are irreplaceable or could cause serious mission processing delays.

Damage: Loss of human life or personal injury or other health impairments, or occupational illness or loss of public or private property.

Deviation: A designation used when a design noncompliance known to exist prior to hardware production or an operational noncompliance known to exist prior to beginning operations at the launch or landing/reentry site.

Errant launch vehicle: A launch vehicle that, during flight, violates established flight safety criteria and/or operates erratically in a manner inconsistent with its intended flight performance.

Expected Fatalities (EF): The expected number of individuals who will be fatalities. Used to define Collective Risk.

Fail Safe: The ability to sustain a failure without posing a hazard to the launch site personnel, facilities, equipment or public safety.

Failure: The termination of the ability of an item to perform a required function.

Fail-Operational: The ability to sustain a failure and retain full operational capability for

safe mission continuation.

Fatal Injury: As defined in 49 CFR sec. 830.2, a fatal injury means “an injury that results in death within 30 days of the accident.”

Flight Plan: Official submittal of data defining vehicle and payload configuration and pertinent mission analysis, data such as mission flight profile and performance, flight dispersions, impact areas for jettisoned components, schedule of events (timeline), probability study of exposed or potentially exposed areas (over flight or near flight conditions) .

Flight Safety: All processes intended to control safety risks from launch through the flight of an aerospace vehicle, and to protect people, public and private property, and the environment, against any damage that may be caused by inflight maneuvers of the aerospace vehicle

Flight Safety System: The combination of equipment, facilities, procedures, and people required to monitor and, if necessary, control the flight of launch systems for the purpose of maintaining public safety. May include both on-board (airborne) and off-board (external) elements necessary to monitor and control the flight of launch systems. An airborne flight safety system typically consists of a flight termination system, range tracking system, and a telemetry data transmitting system.

Ground Safety: All processes intended to control safety risks identified in ground activities contributing to the flight of a manned or unmanned aerospace or launch vehicle, and which include or are in addition to the governmental occupational safety and health regulations.

Hazard: Equipment, systems, events, or situations with an existing or potential condition that may result in a mishap. Definition also applies to “hazardous”.

Hazard Analysis: The analysis of systems, subsystems, components or operations to determine potential hazards and recommended actions to eliminate or control the hazards.

Hazardous Materials: Liquids, gases, or solids that may be toxic, reactive, or flammable

or that may cause oxygen deficiency either by themselves or in combination with other materials. They include but are not limited to commodities specified in laws, statutes and regulations such as the OSHA Stds stated in 29 CFR1910.

Hazardous Operation: Activities, processes, and procedures that, because of the nature of the equipment, facilities, personnel or environment involved or function being performed, may result in damage. Specifically operations on systems that contain or involve the use of high energy potentials or toxic substances.

Hazardous Systems: Systems that incorporate hazardous commodities, to include but not be limited to liquid propellants, solid propellants, high pressures, ordnance, lasers, high power RF emitters.

Incident: An unplanned event occurring during commercial space launch activities, other than an accident, involving a malfunction of the flight safety system or failure of the licensee safety operations plan which affects or could affect public safety. A failure of the safety operations plan could include actions taken or not taken by the commercial operator or range operator.

Individual Risk: The risk that an individual at a given location becomes a casualty from a defined event.

Inhibit: An independent and verifiable mechanical and/or electrical device that prevents a hazardous event from occurring; device has direct control and is not the monitor of such a device.

Landing Site: A facility designed and prepared for use by reusable launch vehicles after a mission. Such a facility may be part of a launch-complex, but may be dedicated to one phase of the RLV operations. The landing site is the place where the re-entry phase of the mission ends.

Launch Complex: The site assigned to or owned by a launch vehicle operator to operate a launch vehicle, including a contingent carrier aircraft or ocean-based platform.

Launch Phase: Begins when the aerospace or launch vehicle is no longer in physical contact

with the launch complex that made its preparation and ignition possible (therefore, when the launch vehicle is dropped from the carrier aircraft, if any). The phase continues to the end of the mission assigned to the launch vehicle when the latter has reached a terrestrial orbit non-secant with Earth (i.e., has reached orbital velocity) or an interplanetary trajectory or, conversely until it is in physical contact with the ground again. Definition also applies to "Flight Phase".

Launch Range: A geographical area and infrastructure necessary to conduct launch operations. Typically the launch range includes the launch site, flight corridor, and the facilities, instrumentation, communications, and people required during the flight of the launch vehicle.

Launch Site: Physical infrastructure necessary for pre-launch and launch operations. For a land-based launch system, it includes the necessary land, facilities, roads and utilities.

Launch Site Operator: Organization authorized to operate a launch / landing site. Typically, a launch site operator provides the facilities and services required by a launch vehicle operator for pre-launch and launch operations. The launch site operator may also provide range services during launch operations.

Launch System: A system made up of an aerospace or launch vehicle, the associated launch complex, the launch site, payload(s), ground support equipment, control systems, navigational system, trajectories, procedures, necessary personnel and other associated items.

Launch Vehicle Operator: Organization authorized to conduct operations of aerospace or launch vehicles.

Mishap: An unplanned event or series of events resulting in death, injury, occupational illness, or damage to or loss of equipment or property, or damage to the environment, an accident.

Mishap Probability: The aggregate probability of occurrence of the individual event that might be created by a specific hazard.

Mishap Risk Index: A risk code representation of potential mishap severity, and probability,

assigned for the purpose of ranking relative risk between hazards.

Mishap Severity: An assessment of the consequences of the worst-case credible mishap that could be caused by a specific hazard.

Mission Essential: Those personnel, aircraft, and ships whose activities are directly relevant to the mission, or are declared essential by the safety decision making authority.

Ordinary Operations: Those which have mishap potential, but normal industrial safety practices are sufficient to prevent mishaps.

Other Occurrence: Includes any unplanned events occurring during commercial space launch activities, other than an accident or incident, which result in any of the following:

- (1) Property Damage: Greater than \$25,000 damage to a commercial payload, a launch vehicle, a support facility, or government property
- (2) Personnel Injury: A fatal or serious injury, as defined herein, of a civilian or a launch team member occurring in a launch related area or facility.
- (3) Mission Failure: A failure to complete the mission as planned.

Payload: A space vehicle that a person undertakes to place in outer space by means of an aerospace or launch vehicle, including sub components of the aerospace or launch vehicle specifically designed or adapted for it.

Probability of Fatality (PF): The likelihood that a person or persons will die from a hazardous event.

Public Safety: For the purposes of this standard, public safety deals with the safety involving risks to the general public of the US or foreign countries and/or their property.

Range Operator: A government entity (e.g. the Eastern Space and Missile Center, the Western Space and Missile Center, White Sands Missile Range, Wallops Flight Facility), or a commercial entity providing one or more range functions (e.g. manpower, facilities, tracking instrumentation, data collection, safety)

Range Safety Officer: The individual trained and certified to monitor the performance of launch vehicles in flight and initiates flight termination actions when required.

Regulatory Agency: The organization having jurisdiction over launch site operator and/or launch vehicle operator's pre-launch and launch operations.

Residual risk: Risk remaining in a system after completion of the hazard reduction and control process.

Reusable Launch Vehicle: An aerospace vehicle capable of multiple launches on successive missions.

Risk: An expression of the possibility / consequence of a mishap in terms of potential mishap severity and probability.

Risk Assessment: The process by which the results of risk analysis are used to make decisions

Risk Mitigation: Action taken to alleviate or control risk.

Safety: Freedom from those conditions that can cause death, injury, occupational illness, or damage to or loss of equipment or property, or damage to the environment.

Safety Clearance Zone: Safety Clearance Zones are restricted areas designated for pre launch and launch operations to protect the public, launch area and launch complex personnel on land, on the sea, and in the air.

Safety Critical: A term that describes any condition, event, operation, process or item of whose proper recognition, control, performance or tolerance is essential to safe system operation or use; e.g., safety critical function, safety critical path, safety critical component, etc.

Safety Objective: The overall safety objective is to eliminate or minimize and control hazards.

Safety Risk: A measure of the potential consequences of a hazard (e.g., expected number of fatalities) considering the probability of

the associated event and the severity for people, public and private property, and environment (to be differentiated from political, financial, technical, industrial, project, etc., risks)

Serious Injury: As defined in 49 CFR sec. 830.2, a serious injury "means any injury which: (1) Requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns, or any burns affecting more than 5 percent of the body surface."

Site: Land, infrastructure, ground facilities, equipment, and utilities assigned to or owned by an operator of a launch site.

Space Vehicle: Any vehicle constructed or assembled for the purpose of maneuvering, moving, operating or being placed in outer space.

Subsystem: An element of a system that, in itself may constitute a system.

System: A composite, at any level of complexity, of personnel, procedures, materials, tools, equipment, facilities, and software. The elements of this composite entity are used together in the intended operational or support environment to perform a given task or achieve a specific purpose, support or mission requirement.

System Safety: The application of engineering and management principles, criteria, and techniques to achieve acceptable risk, within the constraints of operational effectiveness, schedule, and cost throughout all phases of the system life cycle.

Toxic Hazard Corridor: A safety clearance zone in which the hazard is characterized by toxicity levels potentially exceeding the personnel hazard limit as defined by Occupational Safety and Health Administration (OSHA), National Institute of Occupational Safety and Health (NIOSH), or National Academy of Science (NAS) standards.

Waiver: A designation used when a design noncompliance is discovered after hardware

production or an operational noncompliance is discovered after operations have begun at the launch or landing/reentry site.

2.2 Principal References

Refer to Annex F for military, other government, international, and industry standards and documents that can be used as guidelines for design, analysis, and test.

Designator	Title	Source
CSLA	Commercial Space Launch Act of 1984, as amended	FAA / AST
NEPA	National Environmental Protection Act	EPA
PL 81 - 60	Guided Missiles - Joint Long Range Proving Ground Act	DoD
10 CFR	Energy	DoE
14 CFR Parts 400 - 499	Commercial Space Transportation Licensing Regulations, 14 CFR, Chapter III	FAA / AST
18 USC 40	Federal Explosives Law	DoT
27 CFR 55	Commerce in Explosives	DoT
29 CFR Parts 1910 and 1926	Occupational Safety and Health Administration Regulations	OSHA
40 CFR	Environmental Protection Agency Regulations	EPA
49 CFR Subchapter C	Hazardous Materials Regulations	DOT
ISO 14300-1 (DIS)	Space Systems - Program Management	AIAA
ISO 14620-2 (DIS)	Space Systems - Safety Requirements -Launch Site Operations	AIAA
IEC 56/555/NP (Draft)	Risk Management Standard	ANSI

OCST-RD-RES01-88	Hazard Analysis of Commercial Space Transportation	FAA AST
Un-numbered	Accident Response and Investigation Plan, Revision A, November 1995	FAA / AST
Mil-Std-882D	Standard Practice for System Safety Requirements	DoD
EWR 127-1	Range Safety Requirements	45 SW
RSM 93	Range Safety Manual for GSFC/WFF	NASA
Un-numbered	WSMR Range Customers Handbook	WSMR
RCC Standard 319-92	Flight Termination Systems Commonality Standard	RCC

2.3 Abbreviations and Acronyms

AIA	Aerospace Industries Association
AIAA	American Institute of Aeronautics and Astronautics
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
API	American Petroleum Institute
ARIA	Advanced Range Instrumentation Aircraft
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
AWS	American Welding Society
CCAS	Cape Canaveral Air Station
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CMAA	Crane Manufacturers Association America
CPIA	Chemical Propulsion Information Agency
CRD	Command Receiver Decoder
CSLA	Commercial Space Launch Act
DoT	Department of Transportation

DoD	Department of Defense	RCC	Range Commanders Council
EBW	Exploding Bridgewire	RLV	Reusable Launch Vehicle
EED	Electro Explosive Device	RSO	Range Safety Officer
EEE	Electrical, Electronic, and Electro-mechanical	RSS	Range Safety System
EMC	Electromagnetic Compatibility	RTLS	Return To Launch Site
EMI	Electromagnetic Interference	RTS	Range Tracking System
EPA	Environmental Protection Agency	S&A	Safe and Arm
ETS	Explosive Transfer System	TDTS	Telemetry Data Transmitting System
EWR	Eastern Western Range	THC	Toxic Hazard Corridor
FAA /	Office of the Associate	UHF	Ultra High Frequency
AST	Administrator for Commercial Space Transportation	UN	United Nations
FEMA	Federal Emergency Management Agency	VAFB	Vandenberg Air Force Base
FOCA	Fiber Optic Cable Assembly	VSWR	Voltage Standing Wave Ratio
FTS	Flight Termination System	WFF	Wallops Flight Facility
FS	Fail Safe	WSMR	White Sands Missile Range
FU	Firing Units	WSMRR	White Sands Missile Range Regulation
GPS	Global Positioning System		
GSE	Ground Support Equipment		
GSFC	Goddard Space Flight Center		
IEC	International Electrotechnical Commission		
IRIG	Inter Range Instrumentation Group		
ISO	International Organization for Standardization		
LFU	Laser Firing Unit		
LID	Laser Initiated Device		
MPE	Maximum Expected Environment		
NAS	National Aerospace Standard		
NAS	National Academy of Science		
NASA	National Aeronautics and Space Administration		
NIST	National Institute of Standards and Technology		
NEC	National Electric Code		
NEPA	National Environmental Protection Act		
NFPA	National Fire Protection Association		
NIOSH	National Institute of Occupational Safety and Health		
NTIA	National Telecommunications and Information Administration		
OSHA	Occupational Safety and Health Administration		
OSTP	Office of Science and Technology Policy		

3.0 Operators Safety Responsibilities

3.1 Relationship of Launch Vehicle / Aerospace Vehicle Operators and Launch Site Operators

The division of roles and responsibilities for the overall safety of commercial space launch operations may vary from situation to situation. In some cases, commercial space launch operations will occur from state or federal government installations and must meet the requirements established by use agreements between the operators and the government. This standard is intended to permit commercial operators flexibility, in assigning these roles and responsibilities, where applicable. For example:

In some cases the operator of the flight vehicle may own and operate its own launch site; in these cases, the launch vehicle operator or aerospace vehicle operator and launch site operator are, in effect, the same party, and there is no division of responsibilities.

In other cases, a commercial launch site operator may offer minimal facilities. In these cases, it would be necessary for the launch vehicle operator/aerospace vehicle operator to provide many of the support systems related to safety.

In yet other cases, a commercial launch site

operator may offer substantial safety-related support systems (e.g., tracking). In these cases, the launch vehicle/aerospace vehicle and launch site operators divide the responsibilities for ensuring that overall requirements for safety are met. It is also possible that some safety-related support systems could be provided by a third party.

Several operators, e.g., launch site operator, site operator(s), launch vehicle operator(s), aerospace vehicle operator(s), payload operator(s), etc. can operate simultaneously on the same launch site. They can be concerned either with the same launch system or with different ones.

Safety requirements governing these operations must be documented in a set of safety manuals and the process by which each operator plans to use to demonstrate compliance must be documented in a safety program plan. The safety requirements are most logically developed by the launch site operator. The safety program plans should be reviewed and approved by both the operator and the designated approving authority.

Irrespective of the operators organizational structure, safety personnel shall have the right of access to all data relevant to safety. The operator shall not permit any report which addresses matters related to safety to be issued without the signed approval by the responsible safety authority. No hazardous operation shall be permitted to proceed without prior safety review and written approval of the responsible safety authority.

3.2 Occupational Safety and Health

All operators carrying out operations on a launch site shall comply with the applicable federal and/or state occupational safety and health and environmental regulations.

3.3 Ground Safety

The allocation of the ground safety roles, responsibilities and requirements among various operators may vary from situation to situation. This standard prescribes the minimum ground safety responsibilities.

The following five criteria shall be considered:

- a. Can multiple hazardous operations be performed simultaneously?
- b. Which hazardous operations will involve multiple operators?
- c. Which hazardous operations carried out by one operator could adversely effect personnel or property of one or more other operators?
- d. Which hazardous operations could cause damage to people, public or private property external to the launch site facilities, or the environment?
- e. Are hazardous operations emergency response plans in effect for all credible accidents/incidents?

3.3.1 Ground Safety Operator.

A "ground safety operator" shall be responsible for ensuring the following criteria are met. For purposes of this standard, the "launch site operator" is designated as the "ground safety operator". However, contractual agreements may designate another operator (e.g., launch vehicle operator) as the responsible agent.

The ground safety operator shall be responsible for:

- a. Supervising and coordinating the allocation of ground safety roles, responsibilities and requirements among the operators with specific attention to fire prevention and siting of explosive materials.
- b. Identifying and communicating, to all operators, the ground safety rules to be applied when operations are planned that meet one or more of the above criteria
- c. Verifying the compliance to the identified rules
- d. Approving the schedule of operations meeting one or more of the five criteria in 3.3
- e. Reviewing and approving the procedures of operations meeting one or more of the above criteria in 3.3
- f. Supervising and/or coordinating operations

meeting one or more of the previous criteria

g. Verifying the emergency plans of the operators meeting one or more of the previous criteria are consistent

h. Verifying and ensuring that the safety training of each operator is consistent and homogeneous with all others

i. Defining and providing general safety training (Annex C Para 3.0)

j. Verifying that each participant possesses a current safety certification (Annex C Para 3.3) before beginning hazardous operations

k. Setting up a ground safety organization and providing the staffing capable of performing these responsibilities

3.3.2 Individual Operator Ground Safety Responsibilities

The individual operators on a launch site are responsible for safety of their operations. These responsibilities include:

a. Protecting personnel, public and private property, and environment, against any damage caused by its own hazardous items or operations

b. Implementing the ground safety rules established by the "ground safety operator"

c. Developing, implementing and maintaining safety rules for its operations consistent with the rules established in paragraph b above and with applicable local, state and federal safety and environmental regulations

d. Identifying, eliminating or controlling ground safety risks to an acceptable level

e. Subjecting its space vehicle, ground support equipment, facilities and operations to hazard analysis in order to identify and assess associated ground safety risks

f. Managing the residual ground safety risks inherent in its space vehicles, ground support equipment, facilities, and operations (including personnel and procedures), to achieve safe operations

g. Developing, implementing and maintaining an emergency plan for mishaps which can occur during its own hazardous operations

h. Defining and providing the specific safety training related to its operations

i. Setting up a ground safety organization and providing qualified staffing capable of assuming these responsibilities

j. Providing the "Ground Safety Operator" with all necessary information for coordination with and disclosure to interested local governments.

Where there is conflict between individual operator safety rules and requirements, coordination between operators and the ground safety operator to resolve the conflict shall be accomplished

3.4 Flight Safety

The allocation of the flight safety roles, responsibilities and requirements among various operators may vary from situation to situation. This standard prescribes minimum flight safety responsibilities. This standard allows for determination of responsibilities of each operator involved in flight safety to be made by contractual arrangements between the various parties so long as the overall public safety objectives are met. However, these agreements must be in compliance with applicable licenses possessed by the operators.

3.4.1 Flight Safety Operations

The flight safety roles, responsibilities and requirements should only be allocated between a specific operator, who is responsible for performing in-flight safety operations during the launch phase of a launch vehicle and the launch vehicle operator conducting preparation and launch operations on the launch site. For flights originating from government range facilities, the government range operator normally will assume these responsibilities. At commercial launch sites, the launch site operator may provide this function or it may be provided by another operator. Contractual and use agreements between involved parties (commercial and government) will designate the flight safety operator

Flight safety operations shall be responsible for:

- a. Protecting people, public and private property, and environment from safety risks that may arise from the maneuvers of a space vehicle (whether manned or unmanned) during its launch and recovery/landing phases
- b. Controlling the flight safety risks during the launch and recovery/landing phase(s) of a space vehicle
- c. Developing, implementing and maintaining the flight safety rules to be applied to the launch and/or recovery/landing phase(s), as applicable, consistent with the laws and regulations of the local, state and federal governments. Coordination and notification of local government entities as appropriate.
- d. Identifying and communicating to the affected operators, the flight safety roles, responsibilities and requirements
- e. Defining and implementing the associated flight safety requirements, facilities and equipment that make it possible to ensure the flight safety risks are compatible with the stated safety objectives and are safely controlled
- f. Ensuring hazard analyses are performed on the flight vehicle, support equipment, facilities, and equipment, and the intended operations to identify and assess the flight safety risks
- g. Ensuring that identified hazards are mitigated to an acceptable level or are identified as residual risks
- h. Managing residual flight safety risks inherent during the launch and/or recovery/landing phase(s)
- i. Verifying and ensuring the space vehicle operators apply the specified flight safety rules
- j. Approving on board equipment specified by the space vehicle operators for allowing Flight Safety Operations to control the flight safety risks
- k. Approving the flight plan of a launch vehicle, including preliminary, nominal and dispersed trajectories

l. Coordinating and approving the operations of a reusable launch vehicle

m. Setting up a flight safety organization with qualified staffing capable of assuming these responsibilities.

3.4.2 Aerospace Vehicle Operator Responsibilities

For the launch, reentry, recovery and/or landing phase, each aerospace vehicle operator (launch vehicle operator and payload operators) shall be responsible for:

- a. Defining and implementing the associated flight safety rules and onboard equipment, if required, that make it possible to ensure the flight safety risks are compatible with the stated safety objectives, and that allow the flight safety operator to ensure the flight safety risks will be safely controlled
- b. Submitting the design, analysis and test data of flight safety equipment to the flight safety operator for its review and assessment
- c. Submitting the flight plan of a launch vehicle, including preliminary, nominal, and dispersed trajectories, to the flight safety operator for its approval
- d. Applying the flight safety rules specified by the flight safety operator
- e. Subjecting its space vehicle and intended operations to hazard analysis in order to identify and assess the associated flight safety risks
- f. Verifying and ensuring payloads will not cause damage to the launch vehicle that could result in failure of the flight vehicle during the launch and flight phases

4.0 Safety Requirements

General safety requirements are both qualitative and quantitative expressions of safety risk that can occur during the pre launch processing and launch operations of a space vehicle. These requirements are based on the assessed risk, but include practices, methods, and standards to

eliminate or minimize hazards and keep risk to the lowest practicable levels.

4.1 Risk Assessment

Decisions regarding resolution of identified hazards shall be based on the assessment of the risk involved. The risk assessment process must consider both the severity of the hazard if propagated to a mishap and its probability of occurrence. Early in the design phase of systems it is much easier to eliminate hazards by designing them out. However, for space programs there are inherent hazards and risks that cannot be eliminated in the design process. Thus, a program of risk assessment is necessary to evaluate the residual risk associated with the preparation and flight of space vehicles. This analysis should include:

- Description of the consequences of a mishap (hazard severity)
- Probability of a mishap occurring, regarded as being the maximum acceptable value (risk probability)
- Qualitative rules that make it possible to prevent occurrence of, or the possibility of occurrence to an acceptable level of risk

4.2 Severity Classes

Hazard severity categories are defined to provide a qualitative measure of the worst credible mishap resulting from personnel error; environmental conditions; design inadequacies; procedural deficiencies; or system, subsystem, or component failure or malfunction. These severity categories are shown in Table 1.

Table 1. Hazard Severity Categories

Category	Definition
CATASTROPHIC	Death or system loss.
CRITICAL	Severe injury, severe occupational illness, or major system damage

MARGINAL	Minor injury, occupational illness, or system damage.
NEGLIGIBLE	Less than minor injury, occupational illness or minor system damage.

Note: The operators at a launch site should define what constitutes system damage. System damage and occupational illness assessments are applicable during preparatory activities prior to flight. Death and injury are applicable during all phases of activity.

4.3 Mishap Probability

The probability that a hazard will propagate into a mishap can be described as the potential occurrences per unit of time, events, population, or activity. Assigning a quantitative or qualitative probability of occurrence may be derived from analysis, test, or research and evaluation of historical safety data from similar systems. An example of qualitative mishap probability levels is shown in Annex B.

4.4 Mishap Risk Assessment

The overall safety objective is to eliminate or control hazards, thus preventing mishaps. Since all hazards in space flight operations cannot be eliminated, there should be a prioritization of the hazards to be eliminated. A categorization of hazards using the criteria from the Hazard Severity Categories (Table 1) and the Mishap Probability Levels (Annex B), can be accomplished according to risk level. Categorization may be based on severity since not all hazards are of equal magnitude or criticality to public and personnel safety. In some cases, the anticipated consequences of hazardous events may be minimal, while in others catastrophic.

4.5 Quantitative Safety Objectives

The quantitative safety objectives, i.e., the maximum acceptable value of the safety risk probability, shall be established for hazardous systems with catastrophic or critical consequences of safety risk. The objectives should be compliant with government regulations. On the launch site, the safety objectives for the ground hazardous