1. Purpose

This guide discusses the Space Launch 30 implementation of AFSPCMAN 91-710, Range Safety User Requirements Manual. In particular, this guide focuses on the system safety requirements, list of deliverables, timelines, and path to Missile System Ground Safety Approval (MSGSA). It also provides comparison to the Federal Aviation Administration (FAA) ground system safety requirements, identifying similarity and commonality. The following guide is presented for the benefit of Range Users to facilitate understanding of AFSPCMAN 91-710 and to foster a close working relationship with the Space Launch Delta 30 Safety office.

The guide is structured as follows:

1. Purpose
2. Philosophy of Requirements
3. AFSPCMAN 91-710 Range User Safety Requirements
    3.1. 91-710 Document Layout
    3.2. Tailoring of Requirements
    3.3. Equivalent Level of Safety and Waivers
4. Correlation of AFSPCMAN 91-710 and FAA Requirements
5. System Safety Process
    5.1. Commonality to FAA Title 14 Part 417 Subpart E and Part 450 Subpart C Ground Safety Requirements.
    5.2. Requirements Data Products Matrix
6. System Safety Approach in Context
    6.1. Range Safety Determination of Acceptable Level of Risk
    6.2. Iterative Development Program Approach to 91-710 Compliance
    6.3. Fully Developed Program Approach to 91-710 Compliance
    6.4. Safety Analysis Process
    6.5 Deliverables Need and Purpose
7. Systems Safety SLD 30/SEAL

Appendix A: Requirements Data Products Matrix

2. Requirements Philosophy

Space Systems are typically unique and are produced in very limited quantities. By nature, they are highly complex, interconnected systems, encompassing multiple hazards, and are subject to deliberate process of development and deployment.[1] Therefore, a rigorous system safety program is inherently required during concept, design, development, test, validation, processing and launch.

As quoted in the Columbia Accident Investigation Board report[2],

> *Building and launching rockets is still a very dangerous business, and will continue to be so for the foreseeable future while we gain experience at it. It is unlikely that launching a space vehicle will ever be as routine an undertaking as commercial air travel - certainly not in the lifetime of anybody who reads this. The scientists and engineers continually work on better ways, but if we want to continue going into outer space, we must continue to accept the risks.*

As designated representatives of the Eastern and Western Range Space Launch Delta Commander, the Safety Offices assure that the public, launch site personnel, and public resources are protected from the inherent hazards of space launch vehicles, payloads, and their associated supporting systems and facilities. These hazards exist during the course of normal operations, and may result in accidents and anomalies. The Safety Offices endeavor to assure that safe operations on the Ranges are achieved from the beginning of a program until the last mission is accomplished. In this role of assessing and minimizing the danger posed by launch and pre-launch operations, the Safety Offices at the Deltas are known as Range Safety.[1]

Range Safety works closely with the Range Users from the time a program is first introduced. Range Safety strives to maintain the maximum flexibility in the methods used to achieve the ultimate safety objectives, while not imposing undue or overly restrictive requirements on the Range User. All Range User proposals for meeting the safety objectives receive careful consideration. Early and continuous coordination between Range Users and Range Safety is a key success factor in this partnership.[1]

1. Range User Handbook, EWR 127-1. 21 August, 1995.
2. Report of Columbia Accident Investigation Board, Volume I, Chapter 1. Aug. 26, 2003.

3. AFSPCMAN 91-710 Range User Safety Requirements[3]

To protect the public, the launch site, and government resources, the US Space Force has developed AFSPCMAN 91-710 (commonly referred to as 91-710), which was developed from a series of earlier range safety manuals, and primarily, its predecessor EWR 127-1, Eastern Western Range Safety Requirements. 91-710 represents a compilation of design methods and solutions derived from lessons learned over decades of space launch missions. It also consolidates other military, government and consensus standards, sometimes paraphrased, in order to minimize cross-referencing standards.

91-710 codifies the Space Force's launch risk criteria. It defines acceptable risk in order to best manage how the design, manufacture, test and operations are conducted at the Ranges, ensuring a high level of safety is achieved and maintained at all times. The set of requirements specified in the 91-710 permit the Range User to benefit from lessons learned and distilled requirements sources, so as not to have to develop their own set of compliance requirements.

3.1. 91-710 Document Layout

The following section provides brief descriptions of 91-710 Volumes 1 through 7. Note that the system safety process is described in Volumes 1, 3, 5 and 6.

AFSPCMAN 91-710 VOLUME 1, Air Force Space Command Range Safety Policies and Procedures

Volume 1 describes the Range Safety Program and defines authorities and responsibilities. This Volume presents policies, and discusses the approval processes including appropriate approval levels for all activities from, or on the Eastern and Western Ranges. Also covered are discussions of mishap investigation and reporting practices.

3. Description of the Air Force requirements is based on independent assessment consensus study report performed by the National Research Council: Streamlining Space Launch Range Safety. 2000

Attachments to Volume 1 address the following topics:

- Tailoring AFSPCMAN 91-710
- System Safety Program Requirements
- Submitting Noncompliance Requests
- Acceptable Risk Criteria
- Making Changes to AFSPCMAN 91-710
- Generic Payload Policy and Approval Requirements
- Launch complex Safety Training and Certification
- Range Safety Concept-to-Launch Process

Of primary importance to the System Safety aspect of launch processing of Volume 1 are:

- System Safety Program Requirements
- System Safety Program Plan
- The 91-710 Tailoring Process
- Identification of Non-Compliances

Volume 1 outlines specific requirements for the system safety program (aligned with MIL-STD-882, System Safety), the requirement of a system safety program plan, design review requirements, and safety analysis development. It also defines the requirements for Waivers and Equivalent Levels of Safety (ELS) should the Range User program need to deviate from the prescribed 91-710 requirements, and explains the process for submitting these non-compliances for approval.

Note: the identification of ELS or Waivers can only be addressed during, or after the requirements tailoring process has been completed (see 3.3, below). At this point the user compares requirements to design and processing, reviews safety analysis, identifies incongruities and informs the Range Safety office.

AFSPCMAN 91-710 VOLUME 2, Flight Safety Requirements

Volume 2 establishes the requirements for assuring the public's safety during the portion of an operation involving transition through the airspace above the Range, downrange, and overflight of any public land through orbit insertion. This volume lists data necessary for the Safety Office to review and approve flight plans. In addition to space launch vehicles and ballistic missiles, the volume also

addresses reusable vehicles, cruise missiles, unmanned aerial vehicles (UAVs), small unguided rockets and probes, air-dropped bodies, and aerostats and balloons.

Additionally, this volume covers aircraft and ship intended support plans, directed energy plans (e.g., laser operations), and procedures for approving launch of nuclear sources.

The attachments to Volume 2 address:

- Trajectory Data
- Malfunction Turn Data
- Fragment Data
- Jettisoned Body Data
- Flight Trajectory Data Preparation, Submittal and Processing
- Super Combo/Caliper Input File Formats
- RRAT Covariance Input File Formats

AFSPCMAN 91-710 VOLUME 3, Launch Vehicles, Payloads, and Ground Support Systems Requirements

Volume 3 presents design, inspection, and testing requirements for flight hardware and ground systems. This volume also details documentation and data products, and safety program requirements. This volume has been organized by hazard types that are frequently encountered with launch vehicle design and processing.

The systems, equipment and material addressed in this volume include:

- Documentation Requirements
- The Pad Safety Console
  - used to monitor health and status of vehicle destruct system during prelaunch checkout and launch
- Material Handling Equipment
  - cranes and other lifting devices
- Equipment presenting acoustic hazards
  - high decibel or vibration inducing
- Non-Ionizing Radiation Sources

- lasers and radiofrequency (RF) emitters
- Ionizing Radiation Sources
  - X-Ray, N-Ray, Nuclear Power Systems
- Hazardous Materials
  - toxic, corrosive, flammable, explosive
- Flight and Ground Support Pressure Systems
  - tank safety margins, high pressures, relief valves
- Ordnance and explosives
  - detonators, initiators, fuses, propellants, volatiles
- Electrical equipment and hazardous atmospheres
  - shock, electromagnetic fields, stray voltage, toxic or non-oxygen environments
- Motor Vehicles
  - spark arrestors, use in explosive environment
- Computer Systems and software
  - safety critical software requirements
- Seismic Hazards (Western Range only)
  - survivability, retest requirements
- Solid Rocket Motors
  - propellant class, explosive and thermal characteristics,

Attachments to Volume 3 include:

- Missile System Prelaunch Safety Package (MSPSP) requirements

AFSPCMAN 91-710 VOLUME 4, Airborne Flight Safety System Design, Test, and Documentation Requirements

Volume 4 focuses on the Flight Safety Systems, including Flight Termination Systems (FTS), Range Tracking Systems (RTS) and Telemetry Data Tracking Systems (TDTS). The volume heavily relies on referencing requirements from the Range Commander's Council RCC-319, Flight Termination Systems Commonality Standard, and RCC-324, Global Positioning and Inertial Measurements Range Safety Tracking Systems Commonality Standard. Both these latter documents, in addition to design and test, also address required documentation and data products. An area of particular interest is batteries essential to power the flight components of these systems.

AFSPCMAN 91-710 VOLUME 5, Facilities and Structures

Volume 5 addresses unique facilities' requirements pertaining to processing and launch vehicles, and the inherent hazards that can affect facility design, construction, test, and inspection requirements. This volume also contains documentation and data requirements.

Volume 5 is not intended to replace any construction or building statutes and codes, and in fact, relies on many such standards as a baseline. The Ranges do not regulate construction, and set requirements only to the extent needed to protect the public and personnel from the unique hazards presented by processing and launching rockets and operating their associated equipment.

The attachment to Volume 5 describes the required content of the Facility Safety Data Package.

AFSPCMAN 91-710 VOLUME 6, Ground and Launch Personnel, Equipment, Systems, and Material Operations Safety Requirements

Volume 6 addresses safe processing and operations on the Ranges. This volume is organized in a very similar fashion to Chapter 3 (organized by types of hazards encountered), which contains design and test requirements.

Attachments to Volume 6 include:

- Content requirements for the Ground Operations Plan
- Content requirements for Hazardous and Safety Critical Procedures
- Indices of Safety Plans
- Range Safety Launch Commit Criteria.

AFSPCMAN 91-710 VOLUME 7, Glossary of References, Abbreviations and Acronyms, and Terms

Volume 7 includes a comprehensive list of references used in the development of the safety requirements. It also includes all abbreviations, acronyms, and definitions of terms used in other volumes of 91-710.

3.2. Tailoring of Requirements

Due to the unique and varied nature of Space Systems, and the fact that they often encompass evolving technologies, a rigid and uncompromising safety standard may not be appropriate. While the safety objectives must be accomplished, it is not the intent of the Safety Office to impede emerging technological advances, nor to place an unreasonable burden upon the Range User. The resolution to this dilemma is tailoring of the safety requirements, which provides Range Users with added flexibility.

Tailoring is performed by representatives from the Range User, the Safety Office(s), and the FAA/AST, if appropriate. This team is referred to as the High Performance Work Team (HPWT). Tailoring is typically accomplished using a three-column matrix format (Original Requirement/ New Text/ Rationale).

Tailoring may encompass all of the following:

- Deletion of requirements which are not applicable
- Modification of requirements to accommodate the unique nature of the specific program, so long as an EQUIVALENT LEVEL OF SAFETY (ELS) is achieved
- Addition of information addressing safety issues not covered in the original requirement
- Use of text from Range User controlled command media that addresses/controls how Range User meets the requirement

Rationale for each tailored item is an integral part of the process.

Tailoring of the Safety requirements is strongly encouraged as mutually beneficial to both the user and Range Safety. It also provides a means of assessing Range User program requirements against historical lessons learned.

Tailoring is conducted under the guidance found in Volume 1 of AFSPCMAN 91-710, paragraph 1.2.2., paragraph 4.4, and Attachment 2. Specific details are included in Attachment 2 of Volume 1.

3.3. Equivalent Level of Safety and Waivers

During the tailoring process the ELS determinations for the tailoring may be provided and approved through the tailoring change process. This is usually accomplished through evaluation of safety analysis, or technical rationale determining that the intent of the requirement is met, within the general design inhibit requirements set forth by 91-710. The final approved tailored edition shall be placed on the Range User's contract or applied through a Commercial Space Operations Support Agreement. Depending on the relationship to Public safety, the approval is granted by either the SW/CC, the Chief of Safety, or the Safety section chief.

The HPWT cannot provide or approve waivers.

Definition: equivalent level of safety—an approximately equal level of safety; may involve a change to the level of expected risk that is not statistically or mathematically significant as determined by qualitative or quantitative risk analysis; equivalent level of safety replaces the former "meets intent" certification process.

After the tailoring process is complete. Any changes, deletions or non-compliances are handled on an individual basis through a formal documentation, review, and approval process.

4. Correlation of AFSPCMAN 91-710 and FAA Requirements

The Federal Aviation Administration (FAA) in support of commercial programs, implements similar ground system safety requirements as the AFSPC. The current relevant FAA regulations are 14 CFR part 417 Launch Safety and 14 CFR part 431 Launch and Reentry of a Reusable Launch Vehicle. These will be replaced with 14 CFR 450 Launch and Reentry License Requirements, five years and 90 days after March 2021. Programs licensed under either 417 or 431 will require to show compliance with 450 by this date.

There are three licensing components to 14 CFR part 417 which pertain to Ground Systems Safety (Subpart E, 417.402)[4]:

1. Ground safety analysis conducted at the Federal launch range, where the FAA accepts the safety process conducted from a Federal launch range without the need for further demonstration of compliance; if (a) the launch operator has contracted with the Federal launch range for the provisions of the ground safety process, and (b) the FAA has assessed the Federal launch range.
2. Demonstration of compliance, whereby the launch operator demonstrates compliance with the Part 417 – Launch Safety FAA requirements of Subpart A and E, and appendices I and J.
3. Alternate methods, which is an alternate hazard control method that provides an equivalent level of safety to either item 1 or 2 above.

Item 1 above describes the commonality between the FAA processes and the Federal Ranges, which is discussed in the FAA Streamlining of Commercial Space Launch Activities report[5]. Therefore, contracting with the Federal Ranges (i.e. Western Range (WR), or Eastern Range (ER)) and implementing the requirements of the AFSPCMAN 91-710 will meet the intent of the requirements for ground safety processes.

For the 14 CFR part 431, the requirements are less well defined[6] and only list that,

1. There must be demonstrated "*compliance with acceptable risk criteria*" and "*shall employ a system safety process to identify the hazards and assess the risks to public health and safety and the safety of property associated with the mission*." (431.35(c)).

2. The user must enter into an agreement with the Federal Range for services (431.75(a)).

Under the second requirement above, the user then must adhere by agreement with 91-710 requirements. Therefore, for WR and ER licensed launches, the user must comply with 91-710.

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4. Also required by Subpart E, 417.402 is the development of a toxic release hazard analysis conducted for the launch processing at a Federal launch range. This is not included in the list above due to the focus of this paper being ground processing systems safety requirements.

5. FAA Report on Streamlining of Commercial Space Launch Activities. August 2017

6. Note: because the lack of guidance on requirements under FAA part 431, described as too open and lacking sufficient regulatory clarity, the FAA is moving to publish a new rule part 450 that will cover re-entry of expendable, reusable and suborbital vehicles to make use of "Acceptable Means of Compliance".

For FAA 450, the Ground Safety requirements allow for the following (450.179(b)):

> An operator is not required to comply with §§ 450.181 through 450.189 of this part if:
>
> (1)The launch or reentry is being conducted from a Federal launch or reentry site;
>
> (2)The operator has a written agreement with the Federal launch or reentry site for the provision of ground safety services and oversight; and
>
> (3)The Administrator has determined that the Federal launch or reentry site's ground safety processes, requirements, and oversight are not inconsistent with the Secretary's statutory authority over commercial space activities

Under the 450, the Ground Safety requirements are delegated to the Federal Range requirements.

5. System Safety Process

The Space Force Launch Safety requirements and lessons learned are captured in Volumes 1, 3, 5, and 6 of 91-710. These requirements are detailed and prescriptive, providing specific details on required data, methods, number of inhibits, factors of safety, testing frequency, data product deliverables (including schedules), data product content format, and include line item references to regulations from industry and consensus standards. The large amount of requirements appears daunting, but the format provides the Range User with a one-stop-source of requirements that ensures the consistency and technical level of rigor in the application of safety standards. This latter point is the value added from these requirements.

Figure 1 shows the flow chart of ground safety requirements from Program Introduction (PI) at the Federal Range to Missile System Ground Safety Approval (MSGSA). Of note is the number of deliverable data products (rose colored boxes) required for final system safety approval.

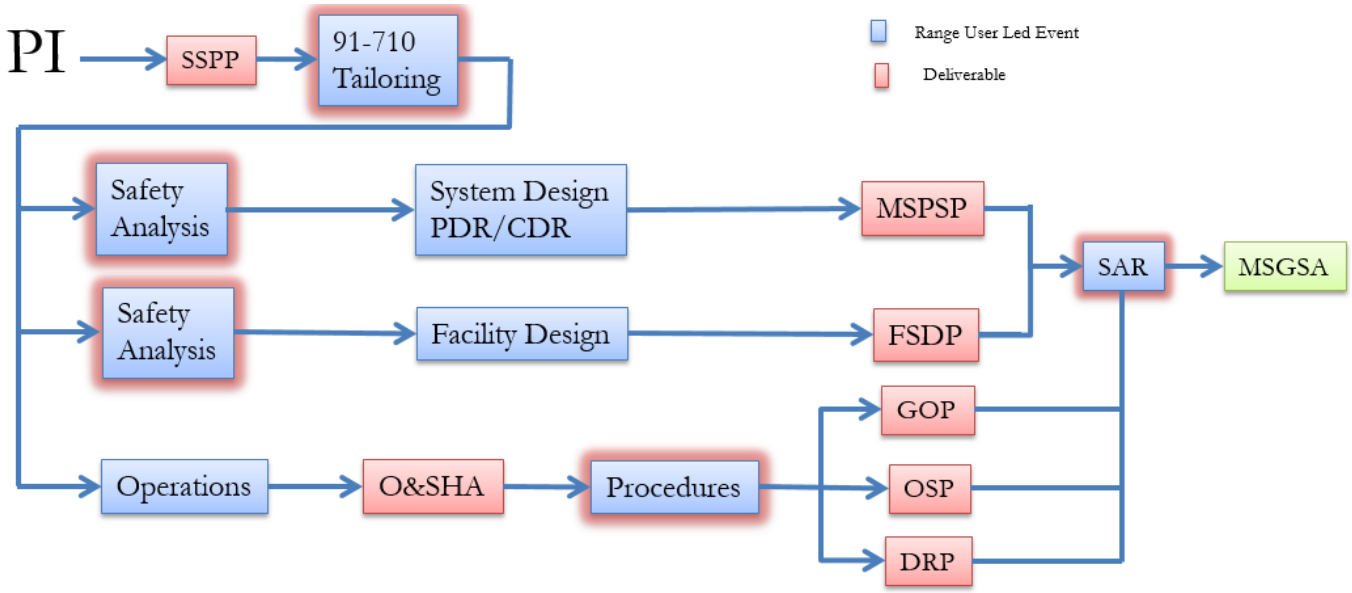

Figure 1: AFSPCMAN Ground Systems Safety Process

Notes: MSPSP – Missile System Pre-launch Safety Package,
FSDP – Facility Safety Data Package,
GOP – Ground Operations Plan,
OSP – Operations Safety Plan,
DRP – Debris Recovery Plan,
O&SHA – Operations and Support Hazards Analysis,
SSPP – Systems Safety Program Plan.
SAR – Safety Assessment Report

The specific purpose of the documentation requirements is to allow Range Safety the ability for due diligence as a third party oversight function to determine that the acceptable level of risk is being implemented, maintained and managed.

5.1. Commonality to FAA Title 14 Part 417 Subpart E and Part 450 Subpart C Ground Safety Requirements.

The following section is included to provide the Range User a reference of commonality of system safety[7] requirements between the FAA and AFSPC and to highlight the similarity in processes, and how FAA documentation (for previously FAA licensed systems) can be arranged to meet 91-710 requirements without duplication.

7. What the AFSPCMAN 91-710 refers to as “System Safety” the 14 CFR FAA requirements refer to as “Ground Safety”.

The FAA ground safety requirements are primarily captured in 14 CFR Part 417, Subpart E, but are also interlaced within other sections of Part 417 and 415. Figure 2 below shows a flow chart of the ground safety requirements from application of license to approval of license. Deliverables shown are a condensed list of Part 415, Appendix B, Safety Review Documents, which are associated with the ground safety process. The licensing safety review documents need not be individual submittals.

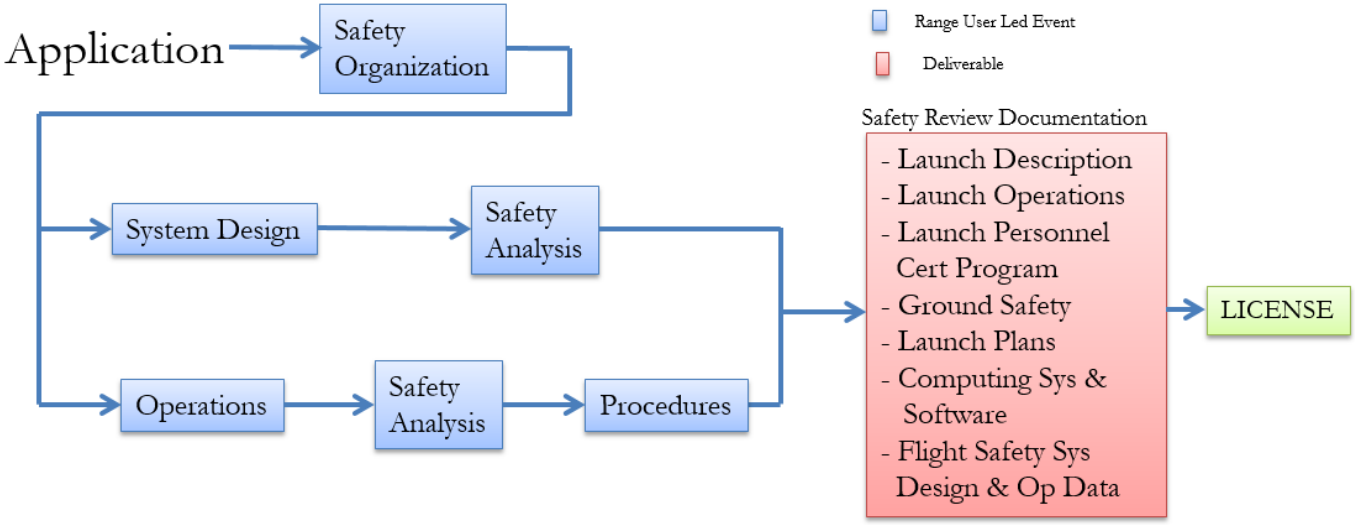

Figure 2: FAA Title 14 Part 417 Subpart E Ground Systems Safety Process

Notes: 1. FAA flow chart is deliberately arranged to show apparent commonality with 91-710 requirements.

2. Formal design reviews are not explicitly identified in 417, but rather are encompassed by the review of safety documentation.
3. The Safety Organization is the launch providers Safety Organization.

Expanded details on safety review documentation required in Part 415, Appendix B, included in Figure 2 that are associated with Ground Systems Safety are as follows (App B contains 12 total sections):

1.0 Launch Description (§415.109)
- 1.1 Launch Site Description
- 1.2 Launch Vehicle Description
- 1.3 Payload Description

2.0 Launch Operator Organization (§415.111)
- 2.1 Launch Operator Organization (§415.111 and §417.103 of this chapter)
  - 2.1.1 Organization Summary
  - 2.1.3 Organization Charts
  - 2.1.4 Office Descriptions and Safety Functions

3.0 Launch Personnel Certification Program (§415.113 and §417.105 of this chapter)

- 3.1 Program Summary
- 3.2 Program Implementation Document(s)
- 3.3 Table of Safety Critical Tasks Performed by Certified Personnel

5.0 Ground Safety (§415.117)
- 5.1 Ground Safety Analysis Report
- 5.2 Ground Safety Plan

6.0 Launch Plans (§415.119 and §417.111 of this chapter)
- 6.1 Launch Support Equipment and Instrumentation Plan
- 6.2 Configuration Management and Control Plan
- 6.5 Accident Investigation Plan
- 6.7 Hazard Area Surveillance and Clearance Plan

8.0 Computing Systems and Software (§415.123)
- 8.1 Hardware and Software Descriptions
- 8.2 Flow Charts and Diagrams
- 8.3 Logic Diagrams and Software Design Descriptions
- 8.4 Operator User Manuals and Documentation
- 8.5 Software Hazard Analyses
- 8.6 Software Test Plans, Test Procedures, and Test Results
- 8.7 Software Development Plan

10.0 Flight Safety System Design and Operation Data (§415.127)
- 10.1 Flight Safety System Description
- 10.2 Flight Safety System Diagram
- 10.3 Flight Safety System Subsystem Design Information
- 10.4 Flight Safety System Analyses
- 10.7 Flight Termination System Installation Procedures

The FAA ground safety requirements for 14 CFR Part 450 Subpart C can also be similarly represented, as shown in Figure 3, below. Deliverables shown are a condensed list of Part 450 Safety Review Documents associated with the ground safety process.

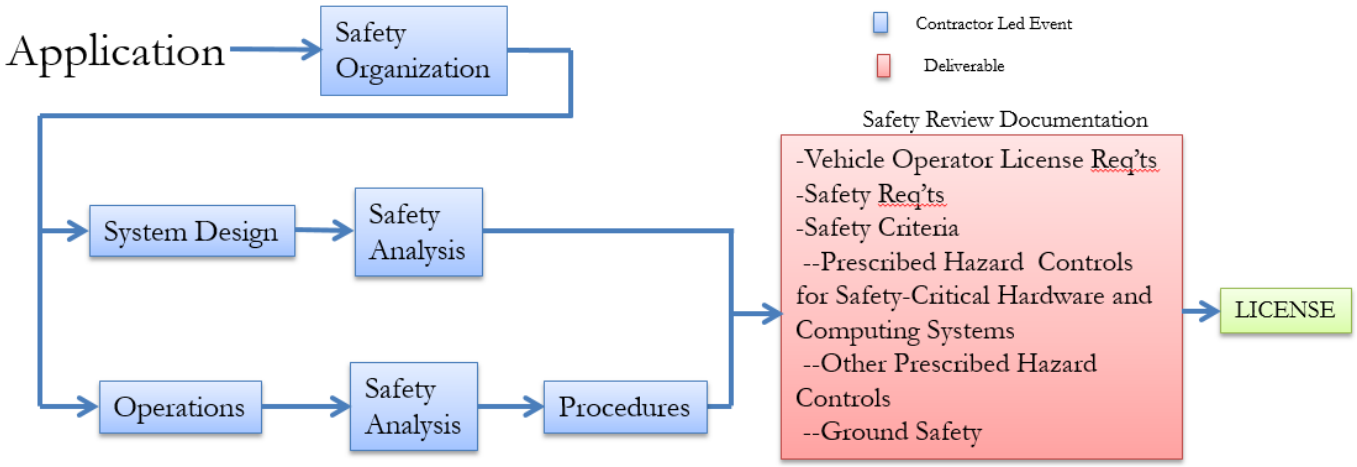

Figure 3: FAA Title 14 Part 450 Subpart C Ground Systems Safety Process

Notes: 1. FAA flow chart is deliberately arranged to show apparent commonality with 91-710 requirements.

2. Formal design reviews are not explicitly identified in 450, but rather are encompassed by the review of safety documentation.
3. The Safety Organization is the launch providers Safety Organization.

Expanded details on safety review documentation required in Part 450, included in Figure 3 that are associated with Ground Systems Safety are as follows (App B contains 12 total sections):

Vehicle Operator License Requirements (§450.37, 43, 45)

Safety Requirements

Safety Criteria (§450.103)

Prescribed Hazard Controls for Safety-Critical Hardware and Computing Systems (§450.141, 143)

Other Prescribed Hazard Controls (§450.149, 151, 159)

Ground Safety (§450.179 – 189)

Individual deliverables, or final deliverables, required by either approach are on the same order and include the same content. Table 1 on the next page shows a cross-reference of requirements from both the 91-710 and FAA that are shown in Figures 1, 2 and 3. This table should not be considered as all inclusive, but is provided as a means of a visual cross reference of ground system safety requirements.

Table 1. AFSPCMAN 91-710 and FAA Ground System Safety Requirements Cross-Reference

Data Product	91-710 Requirement	417 FAA Requirement	450 FAA Requirement
SSPP	Vol 1 Attch 3, A3.2.2	415.33, 415.111, 417.103, 417.105, 417.111(c) & (e), 417.405(b)&(c)	450.103(a),(b),(c),(e)(1), 450.149, 450.151, 450.189
91-710 Tailoring	Vol 1 Attch 2, A2.2.2.1.1	No equivalent	450.37
Sys Design PDR/CDR	DoD Acquistion System, Vol 3	417.117	450.43
Facility Design	DoD Acquistion System	417.117	450.45(e)(2), 450.183
Operations	Vol 1 Attch 3, Vol 6	415.35	450.159, 450.183
Safety Analysis	Vol 1 Attch 3, Vol 3 4.1, Vol 6 Attch 1	414.19, 417.405, 417.407, 417.409, 417.411, 407.413, 407.415, 407.417	450.103(b), 450.141, 450.185, 450.187, 450.189
O&SHA	Vol 6 Attch 1	417.405, 417.407, 417.409, 417.411, 407.413, 407.415, 407.417	450.185, 450.187, 450.189
Procedures	Vol 6 Attch 2	417.113(b), 417.407(c), 417.407(e)	450.159, 450.179, 450.183, 450.189
MSPSP	Vol 3 Attch 1	415.33, 417.17(c)(7), 417.111(c), 417.115, 417.407(d), 417 App J	450.41(e)(1)&(2), 450.43(c)&(i)(1)&(i)(2), 450.45(e)(3)&(6), 450.143
FSDP	Vol 5 Attch 1	417.111(c), 417.407(d), 417 App J	450.45(e)(2), 450.159, 450.185, 450.187, 450.189
GOP	Vol 6 Attch 1, Para 4.1.3 & 4	415.33, 417.111(c) & (d), 417.407(d), 417 App J	450.45(e)(2), 450.185, 450.187, 450.183, 450.189
OSP	Vol 6 Para. 4.3.1	417.111(c), 417 App J	No equivalent
DRP	30SWI 91-101	415.41, 417.111(h), 417.415(c)	420.59, 450.173
SAR	Vol 1 Attch 3, Task 5	417 App J	450.185
MSGSA	SEA Approval	Ground Safety Licensing Equivalent	Ground Safety Licensing Equivalent

Note: FAA Title 14 Part 450 Subpart C, § 450.181, Coordination with a site operator is not included in the above table for 450, because the AFSPCMAN 91-710 requirements incorporate coordination with the site operator, the USSF.

The take away is that there is commonality in the set of requirements and deliverable reporting between the various FAA licensing approaches and those of 91-710. Understanding this similarity and the need for documentation can assist the Range User in the importance for demonstrating compliance.

5.2. Requirements Data Products Matrix

The requirements data products matrix included in Attachment A is a specific SLD 30/SEAL tool that captures all the ground system safety data product deliverables in one place with cross-references to 91-710 sections, schedules, and design reviews (anchor points). It can be used by Range Users for planning, status, and scheduling throughout the program.

6. System Safety Approach in Context

The conventional approach to a launch campaign has traditionally followed the standard Defense Acquisition System and the Milestone Decision Authority process. This approach begins at the Federal Range with tailoring meetings, soon after the Program Introduction, and after submittal of DRAFT Systems Safety Program Plan (SSPP). This is then followed by the SRR/PDR/CDR (system requirements review/preliminary design review/critical design review) and the validation and verification (V&V) process (identified in the SSPP). This approach has been historically anchored, for Government aerospace contractors, in the technology maturation and risk reduction phase prior to Milestone B (Figure 3). The System Safety Program Tasks as identified in 91-710 Volume 1, Attachment 3 revolve around this process and set of milestones.

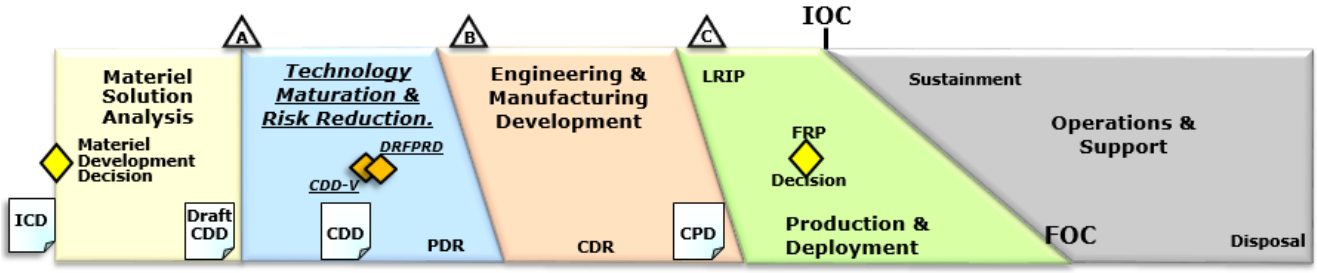

Figure 3. Defense Acquisition Life Cycle Milestone Phases

Source: www.dau.mil, Space Acquisition Rapid Deployment

What should be gleaned from Figure 3 is that Government aerospace contractors familiar with the Defense Acquisition process are already positioned to begin tailoring program requirements, well before coming to the Federal Range, at the Material Solution Analysis phase.

New commercial entrants may not be familiar with, nor do they follow the standard Defense Acquisition approach. The Range User may be seeking access to the Federal Range at what could be considered the equivalent of the material solution analysis phase (prior to milestone A) with only target guidance from FAA requirements (with respect to the ground systems safety). If the Range User, on the other hand, is coming to the Federal Range with a fully developed program, then their ground system safety program may only be geared to FAA (or an Alternate Method) requirements.

Taking these two possible approaches, the rest of this document provides the background to assimilate either level of program development to allow for an efficient transition to 91-710 compliance.

6.1. Range Safety Determination of Acceptable Level of Risk

91-710 documentation requirements allow Range Safety the ability for due diligence to determine the acceptable level of risk that is being implemented, maintained and managed. In this function Range Safety performs a third party oversight. This allows for "*protecting the uninvolved public from damage and providing for well-informed consent of participants and other involved parties*."[8] As noted previously, Range Safety personnel act as designated representatives of the Federal Range Space Launch Delta Commander.

Specific areas of review that are important to ground system safety that ensure "*well-informed consent*", as shown in Figure 1 are,

- A developed safety management program
- System Safety Program Plan (SSPP)
- Documented requirements
- Safety analyses
- Design specifics: FS, inhibit strategy, materials, procedural processes
- Identification of formal design reviews
- Integration of verification and validation process.
- Developed operational plans and procedures

8. GAO-07-16. COMMERCIAL SPACE LAUNCHES: FAA Needs Continued Planning and Monitoring to Oversee the Safety of the Emerging Space Tourism Industry. United States Government Accountability Office. October 2006.

In the traditional acquisition model the "Verification and Validation Triangle" (V&V Triangle) is commonly used to show the process evolution from requirements development to final system validation. (See Figure 4.) The data products required by 91-710 (Fig. 1) capture the results of this process from beginning to end.

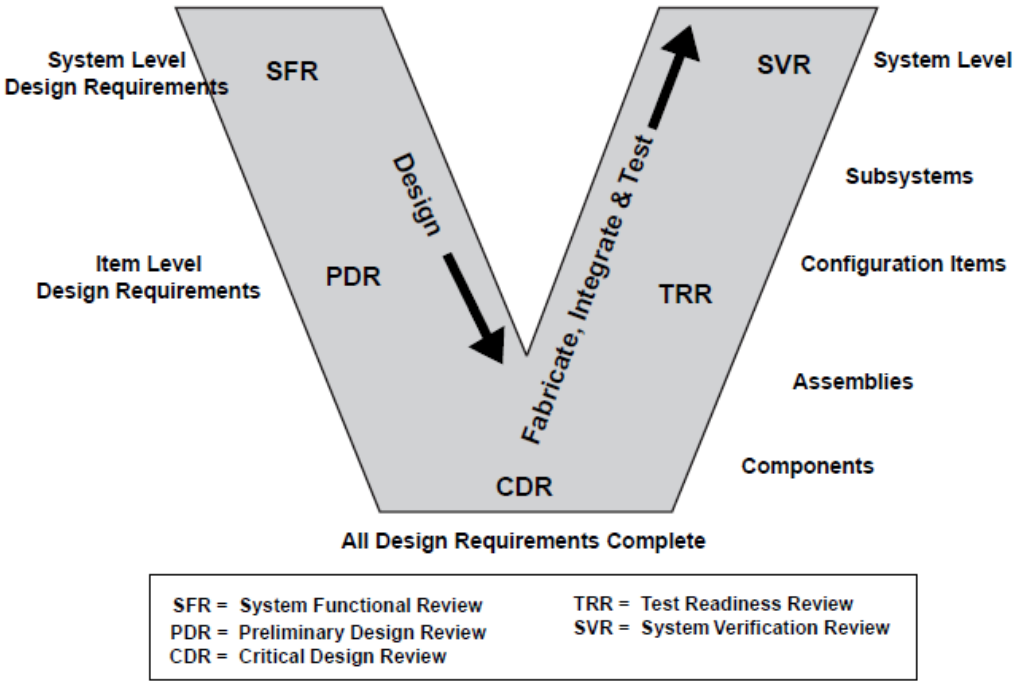

Figure 4. Verification and Validation Triangle
Source: DAU – Systems Safety Fundamentals Manual

6.2. Iterative Development Program Approach to 91-710 Compliance

For commercial programs that do not follow the standard Defense Acquisition process, the complexity may lie with the iterative development process that may be present, or where in the program development stage the Range User requires access to the Federal Range. A scenario of iterative development attempts to minimize the system development curve by testing early and often, on partial design concepts: design, test, learn, re-design, and analyze approach. An example of this process is shown in Figure 5 on the next page. In this example, there is less linear process flow; therefore it is beneficial that prospective commercial Range Users have an understanding of the Federal Range's requirements ahead of time (purpose of this document), to simplify the incorporation of 91-710 compliance into the process flow.

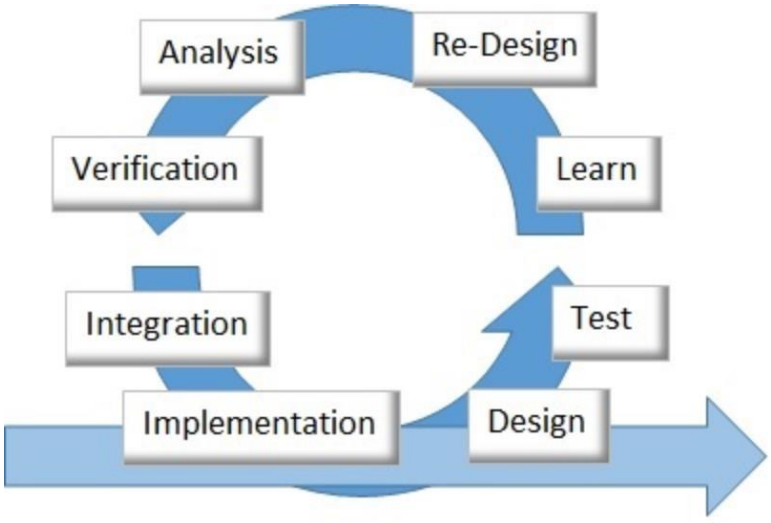

Figure 5. Iterative Design, Test, Learn, Re-Design, and Analyze Process

Prospective Range Users need to identify their individual program requirements and compare/contrast against 91-710 range requirements via the safety analysis process. This is what is captured as part of 91-710 tailoring process. This systems safety engineering function can identify certain 91-710 requirements as being non-applicable, or determine that the program maintains an ELS. More importantly, the safety analysis review can identify areas where new requirements are essential and must be accounted for. Figure 6 shows the safety analysis process flow and its association to the requirements process.

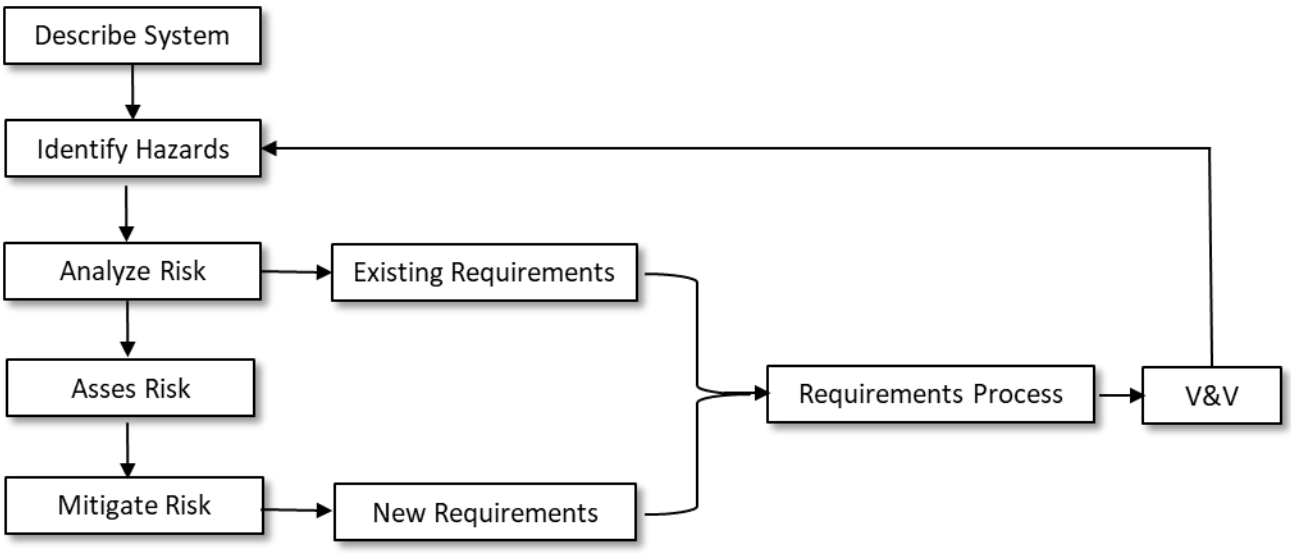

Figure 6. Safety Analysis Process

Source - FAA - NextGen, Modernization of U.S. Airspace

Once the requirements have been defined, the next step to a successful 91-710 compliance outcome must address specific verifiable steps that are captured in the V&V Triangle. Figure 7 shows the V&V approach as it may be applied to an iterative development program. This process is documented by data products listed in Figure 1.

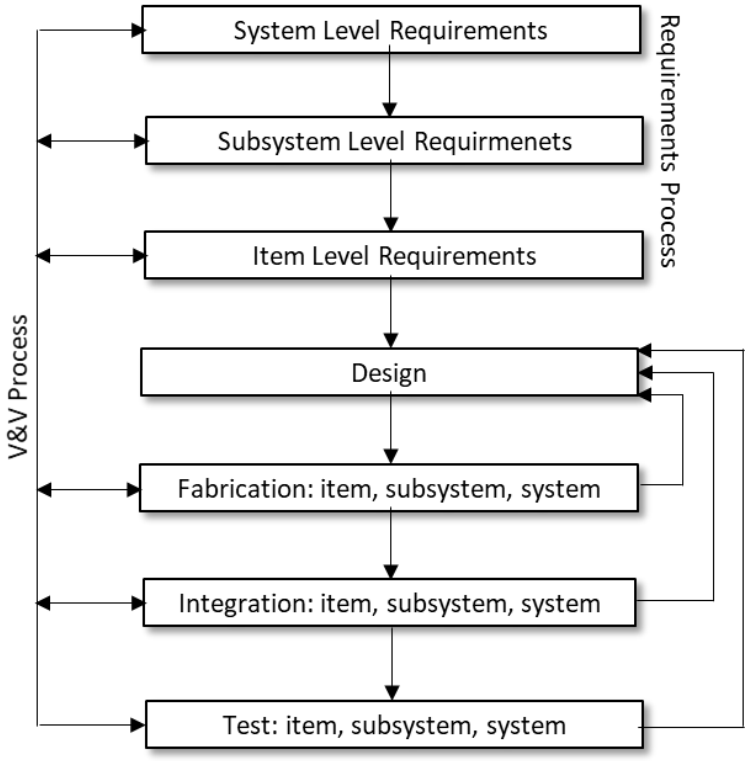

Figure 7. Iterative Verification and Validation Process

6.3. Fully Developed Program Approach to 91-710 Compliance

For fully developed programs[9] seeking access to the Federal Range, compliance can be streamlined through the similarity of requirements and data product submittals that are required from FAA and 91-710 (see Table 2). A review of the safety analysis process should be conducted to address program requirements, evaluate gaps in requirements, and identify any additional requirements[10] not captured in 91-710. Existing FAA documentation should be reviewed and evaluated similar to the requirements review, and submitted using guidance from Table 2. Specific data product requirements details are captured in 91-710.

9. Fully developed programs refers to programs that may already have been commissioned or tested elsewhere and are now requesting access to the Federal Range.

10. An example of additional requirements are the use of composite or adaptive manufacturing airframes, which are not currently captured in 91-710.

6.4. Safety Analysis Process

Inherent to the design process and procedure development for aerospace applications is the safety analysis, commonly referred to as the hazard analysis. A complex system cannot be developed without it. The importance of detailed safety analyses become apparent when other launch related factors may be introduced that lead to unintended consequences, such as socio-technical[11] influences, human factors, or varying levels of consistency and rigor. Identification of hazards early on in the program life cycle is paramount, because of the high costs of retrofitting mature systems.[12]

Safety analysis is at the core of 91-710 compliance. Safety is not assured by the reliance on design standards alone. As noted in 91-710, Volume 1, with respect to the preliminary hazards analysis (PHA), "The results of the PHA shall be used as a guide for tailoring AFSPCMAN 91-710 for the program." Additionally, Volume 1 notes that the safety studies (analysis) identify provisions and alternatives needed to eliminate hazards or reduce associated risk to a level acceptable to the Space Launch Delta/Federal Range. In the absence of any 91-710 safety requirements, the Range User would be required to provide a detailed safety analysis (item, subsystem, system, operations, etc.) to derive their own set of requirements for development. Hence, the safety analysis is the most pertinent part of systems engineering and the 91-710 compliance process.

6.5. Deliverables Need and Purpose

As shown in Figure 1 above, there are various 91-710 data product deliverables that are required to achieve MSGSA. The deliverables represent structured information specifically for Range Safety review that become a set of configuration control documents. These reference documents for the launch program form a specific overall system configuration that is associated with a specific launch mission or missions and captures all aspects of the launch program.

11. Leveson, Nancy, *Engineering a Safer World*: *Systems Thinking Applied to Safety.* MIT Press. 2011, pg 14. Leveson delves into the non-linearity of mishap events, especially in light of what she refers to sociotechnical influences, or the human factor. "*Bottom-up decentralized decision making can lead-and has led-to major accidents in complex sociotechnical systems. Each local decision may be "correct" in the limited context in which it was made but lead to an accident when the independent decisions and organizational behaviors interact in dysfunctional ways*."

12. Bahr, N.J. System Safety Engineering and Risk Assessment: A practical approach. Taylor & Francis. 1997.

For Range Users not familiar with the AFSPC requirements and processes, the deliverables are sometimes viewed as burdensome bureaucratic requirements, or another layer of '*paper work*'. What is not readily evident to new Range Users is that the set of deliverables provide the basis of "well-informed consent" (see 6.1). They serve as the single source of information to educate multiple-stakeholders (having a need-to-know[13]) about the launch program at any one time. This need-to-know may take various forms (whole program, subsystems, CONOPS, environmental, COPVs, etc.) and these deliverables will be the first set of documentation that is reviewed during an incident/accident investigation.

Another aspect that is usually overlooked is that the set of deliverables also serve an educational/training purpose, for both the AFSPC and stakeholders, as well as the Range User.

Figure 8, below is included as a visual aid reflecting the associated level of effort required in the development of MSGSA deliverables based on program experience (no scale, for visual comparison only).

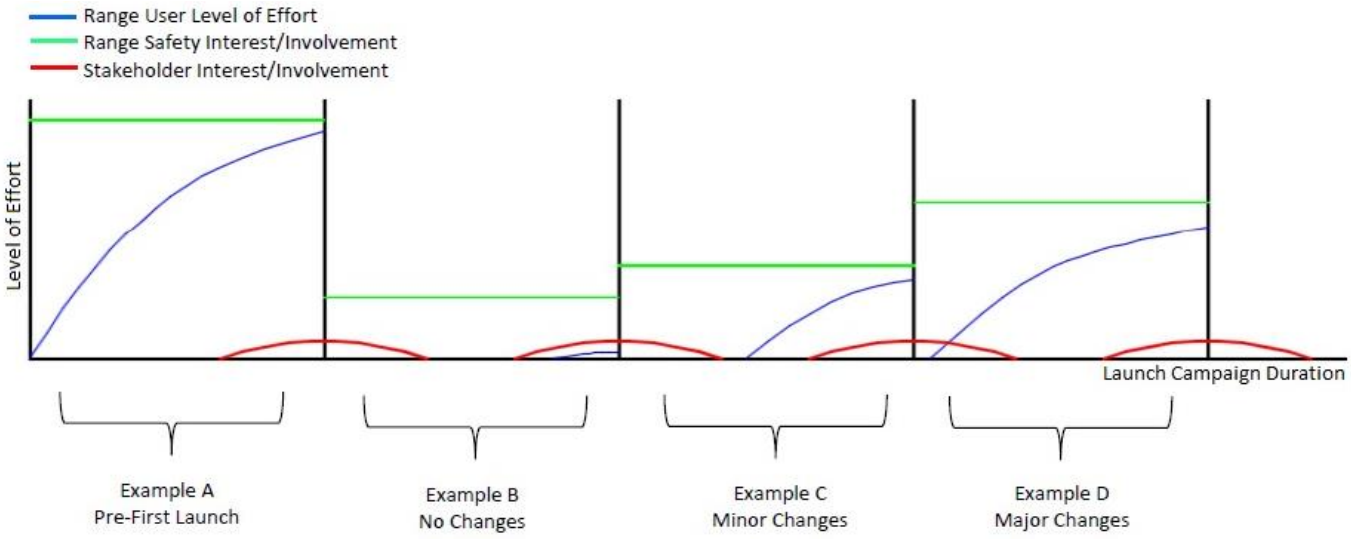

Figure 8. Relative Range User Level of Effort in Support of Deliverables Requirements

13. It should be noted that the Range User maintains primary control of document distribution. Range Safety by agreement as a Range User partner is given full access to required documentation. Any stakeholder having need-to-know is required to interface with a Range User identified point of contact that determines if they meet need-to-know and grants access to information.

Focus should be placed on the first pre-launch level of effort, which is the highest and represents the learning curve for document development and review/comment interaction with Range Safety (Example A). Three other representative examples are provided: no change (Example B), minor design change (Example C), and major redesign. The associated changes can be to the vehicle, operations, facilities and ground handling equipment, or the whole program in the case of a major redesign. Range Safety involvement will always be coincident with the level of Range User effort. The stake holder involvement will be similar from launch to launch.

7. Launch Assessment, Safety Engineering, SLD 30/SEAL

The ground systems safety function at Vandenberg SFB is performed by the Space Launch Delta, Launch Assessment Safety Engineering office (SLD30/SEAL). Specific questions (formal or informal) about the AFSPCMAN 91-710 Range Safety Requirements, or this document can be addressed to this office. Please contact your XP point of contact and they will provide further contact information for SLD 30/SEAL.

AFSPCMAN 91-710 Range Safety Requirements, Volumes 1 through 7 can be accessed at:

https://www.e-publishing.af.mil/ >> Publications + Forms >> Publications United States Space Force >> Space Operations Command >> 91 Safety

Status of Range User Supplied Documents Required for Missile System Ground System Safety Approval as of: (date)

(Program Name)

Launch Date: (date)

Item	AFSPCMAN 91-710 Requirement	Date Required	Status
System Safety Program Plan (SSPP)	Vol 1, Attachment 3 Paragraph A3.2.2, Task 2		
• Draft		PI+45 days	
• Final		SRR-45 days	
91-710 Tailoring (Vol 1, 3, 5 and 6)	Vol 1, Attachment 2		
• Volume 1 (Draft / Final)		PDR-30 days / CDR+30 days	
• Volume 3 (Draft / Final)		PDR-30 days / CDR+30 days	
• Volume 5 (Draft / Final)		PDR-30 days / CDR+30 days	
• Volume 6 (Draft / Final)		PDR-30 days / CDR+30 days	
System Safety Reviews	Vol 1, Attachment 3, Paragraph A3.2.2.2.4		Combined with or independent of specific program review milestones
• Program Introduction (PI)		PI	
• System Requirements Review (SRR)		SRR	
• Preliminary Design Review (PDR)		PDR	
• Critical Design Review (CDR)		CDR	
• Pre-Ship Review (PSR)		PSR	
Hazard Analyses (HA)			
• Preliminary HA (PHA) **Note:** PHA is used to provide guidance for Tailoring	Vol 1, Attachment 3 Vol 3, Chapter 4	SRR-45 days	
• Subsystem HA (SSHA) [Preliminary]	Vol 1, Attachment 3 Vol 3, Chapter 4	At PDR	
• Subsystem HA (SSHA) [Draft]	Vol 1, Attachment 3, Vol 3, Chapter 4	CDR-45 days	

Status of Range User Supplied Documents Required for Missile System Ground System Safety Approval as of: (date)

(Program Name)

Launch Date: (date)

Item	AFSPCMAN 91-710 Requirement	Date Required	Status
• Subsystem HA (SSHA) [Final] **Note:** Final SSHA is submitted with final MSPSP.	Vol 1, Attachment 3 Vol 3, Chapter 4	Hardware Shipment to Range – 45 days	
• System HA (SHA) [Plan]	Vol 1, Attachment 3	At PDR	
• System HA (SHA) [Draft]	Vol 1, Attachment 3	CDR – 45 days	
• System HA (SHA) [Final] **Note:** Final SHA is submitted with final MSPSP.	Vol 1, Attachment 3	Hardware Shipment to Range – 45 days	
• Facility Safety HA (FSHA) [Preliminary]	Vol 1, Attachment 3 Vol 5, Attachment 1	30 days prior to PDR	
• Facility Safety HA (FSHA) [Draft]	Vol 1, Attachment 3 Vol 5, Attachment 1	30 days prior to CDR	
• Facility Safety HA (FSHA) [Final] **Note:** Summary of each HA performed is summarized in FSDP	Vol 1, Attachment 3 Vol 5, Attachment 1	30 days prior to facility activation	
• Operating and Support HA (O&SHA) [Plan]	Vol 1, Attachment 3	At PDR	
• Operating and Support HA (O&SHA) [Draft]	Vol 1, Attachment 3 Vol 6, Attachment 1	CDR - 45 days	
• Operating and Support HA (O&SHA) [Final] **Note:** O&SHA performed for each procedure and summarized in GOP	Vol 1, Attachment 3 Vol 6, Attachment 1	45 days prior to hardware delivery to the range	
Missile System Pre-Launch Safety Package (MSPSP)	Vol 3, Attachment 1		
• Draft (SRR)		SRR-45 days	
• Draft (PDR)		PDR-45 days	
• Draft (CDR)		CDR-45 days	

Status of Range User Supplied Documents Required for Missile System Ground System Safety Approval as of: (date)

(Program Name)

Launch Date: (date)

Item	AFSPCMAN 91-710 Requirement	Date Required	Status
• Final		Hardware Shipment to Range - 45 days	
Facility Safety Data Package (FSDP)	Vol 5, Attachment 1		Includes Facility Safety Hazard Analyses
• Draft (SRR)		SRR-30 days	
• Draft (PDR)		PDR-30 days	
• Draft (CDR)		CDR-30 days	
• Final		30 days prior to facility activation	
Ground Operations Plan (GOP)	Vol 6, Attachment 2		Includes submission of following: ▪ Range User Training Plan (Volume 6, Paragraph 4.5) ▪ Accident Notification Plan (Volume 6, Paragraph 4.6.2.)
• Draft (SRR)		SRR-45 days	
• Draft (PDR)		PDR-45 days	
• Draft (CDR)		CDR-45 days	
• Final		45 days prior to hardware delivery to the range	
Operations Safety Plan (OSP) / Complex Safety Plan	Vol 6, Para. 4.3.1		Can also be referred to as Complex Safety Plan
• Draft		CDR-30 days	
• Final		45 days prior to start of any hazardous operation	

Status of Range User Supplied Documents Required for Missile System Ground System Safety Approval as of: (date)

(Program Name)

Launch Date: (date)

Item	AFSPCMAN 91-710 Requirement	Date Required	Status
Facility Emergency Operating Plans (FEOPs)	Vol 6, Paragraph 4.3.2		Can be combined with Operations (OSP)
• Final		45 days prior to launch	
Emergency Evacuation Plans (EEPs)			
	Volume 6, Paragraph 4.3.3.	Prior to First Use of Facility	
Procedures	Volume 6, Paragraph 4.4. Volume 6, Attachment 3		Includes ALL procedures and operating instructions. Volume 6, Attachment 3 address specific requirements for Hazardous and Safety Critical procedures.
• Draft		At least 52 days prior to procedure need date	
• Final		At least 7 days prior to procedure need date	
Hazard Log	Vol 1, Attachment 3, Paragraph A3.2.1.8		Also referred to as a Hazard Tracking Summary (HTS)
• Draft (SRR)		SRR-45 days	
• Draft (PDR)		PDR-45 days	
• Draft (CDR)		CDR-45 days	
• Final Note: Dates listed to show progress prior to start of operations.		30 days prior to start of operations	
Compliance Checklist			

Status of Range User Supplied Documents Required for Missile System Ground System Safety Approval as of: (date)

(Program Name)

Launch Date: (date)

Item	AFSPCMAN 91-710 Requirement	Date Required	Status
	Vol 3, Attachment 2, Para A2.3 Vol 6, Attachment 1, Para A1.2.2.8	Hardware Shipment to Range – 30 days	Due in conjunction with MSPSP and O&SHA products
Noncompliance Request			
	Vol 1, Attachment 3	As Required	As early as they are known to be necessary
Safety Assessment Report	Vol 1, Attachment 3, Task 5		
• Plan		At PDR	Range User presents SAR development plan
• Draft		CDR-30 days	Pre-approval version of SAR
• Final		Pre-ship review (PSR)	Approval version of SAR
Range User Training Plan			
	Volume 6, Paragraph 4.5.	See GOP entries	
Mishap Reporting			
	Volume 6, Paragraph 4.6.	Range User	Post-Mishap
Debris Recovery Plan			
	Volume 6, Paragraph 4.7.	60 days prior to launch	Must be submitted prior to initiating operations.

NOTES

1. Effective with the transition to the Space Force, the command designation for 91-710 will change. Whatever the designation (e.g., AFSPCMAN, SPFCMAN, USSFMAN, et al.), the most current version of 91-710 will apply to the Range User.

2. In the event of conflict between this table and AFSPCMAN 91-710, the requirements of AFSPCMAN 91-710 shall supersede this table. The Range User is responsible for complying with the tailored version of AFSPCMAN 91-710 for all requirements; use of this table does not relieve the Range User from those obligations.

Status of Range User Supplied Documents Required for Missile System Ground System Safety Approval as of: (date)

(Program Name)

Launch Date: (date)

3. The program milestones (i.e., SRR, PDR, CDR, hardware delivery, etc.) identified in this table are for a standard acquisition program using a DoD standard methodology as defined in DoDI 5000.01, "The Defense Acquisition System" and associated sub-tier and/or descriptive documents. If this DoD process is NOT followed, the Range User must summarize their system development process in the SSPP. The intent is to ensure the Range User and Delta Safety have a mutual understanding of the specific process the Range User employs. It is NOT the intent to require the use of a specific process. It is the responsibility of the Range User to discuss their development process and convey anchor point milestones to use in this status table. The resulting development process and associated program anchor point milestones will be discussed in detail by the Range User in the specific System Safety Program Plan.