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Standard Guide for Training and Qualification of Safety-Critical Space Operations Personnel¹

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1. Scope

1.1 This guide covers training and qualification of space operations personnel with safety-critical responsibilities during launch and reentry phases of flight.

1.2 This guide will assist in identifying safety-critical positions, determining level of training required, and developing a system for qualifying personnel to perform safety-critical operations duties.

1.3 In this guide, a wide range of operational positions will be addressed, including test, launch, and flight controllers; mission decision authorities; personnel handling safety-critical flight hardware; aerospace ground systems; facilities; and crew onboard human spaceflight missions.

1.4 Though not specifically addressed within this scope, many of these practices may be useful in informing training and qualification of on-orbit operations personnel, as well as operators performing functions critical to mission success.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 OSHA Standard:²

OSHA 2254 Training Requirements in OSHA Standards

¹ This guide is under the jurisdiction of ASTM Committee F47 on Commercial Spaceflight and is the direct responsibility of Subcommittee F47.03 on Unoccupied Launch and Reentry Vehicles.

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² Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, <https://www.osha.gov/sites/default/files/publications/osha2254.pdf>.

3. Terminology

3.1 Definition:

3.1.1 *safety-critical personnel, n*—people who direct or perform actions, or monitor systems, that are safety-critical.

3.1.1.1 *Discussion*—This may include people directly interfacing with or controlling safety-critical systems or hazardous materials, remotely controlling safety-critical systems, or making safety-critical decisions.

4. Significance and Use

4.1 In this guide, a process to develop and execute a training program to qualify operators for safety-critical launch and reentry operations is defined. This process provides a means of compliance for training and qualification requirements under Federal Aviation Administration (FAA) commercial spaceflight licensing regulations.

5. Positional Training Needs Assessment

5.1 Identify safety-critical operations tasks using any or all of the following methods:

5.1.1 Reference applicable safety standards (for example, OSHA 2254, National Fire Protection Association (NFPA), and AFSPCMAN 91-710³).

5.1.2 Identify operations that involve hazards from facility, ground, or flight systems. This assessment should address all applicable mission phases: prelaunch, launch, ascent, reentry, and post-landing.

5.1.3 Reference formal hazard analyses for operational controls used to mitigate the hazard.

5.1.4 Review lessons learned from mishap reports and investigations.

5.1.5 Identify safety-critical operations positions.

5.1.6 Assessment should consider positions in which an operator could create, control, or respond to a hazard. The operator could accomplish this through direct handling of safety-critical hardware or hazardous materials or configuration of safety-critical systems before or during hazardous

³ *Range Safety User Requirements Manual Volume 1, Air Force Space Command Range Safety Policies and Procedures*, <https://static.e-publishing.af.mil/production/1/spoc/publication/afspcman91-710v1/afspcman91-710v1.pdf>.

operations. Additionally, positions that exercise go/no-go authority during hazardous operations shall understand the hazards and mitigations that may result from their decisions. Determine necessary knowledge and skill levels for each safety-critical position to perform tasks at the required level of competency. Note that this should consider both nominal and off-nominal operations.

5.1.7 Identify the required knowledge and skills to enter training for each safety-critical position based on expected education or prior experience, or both. If a prospective operator does not meet the minimum, supplemental training may be used as a prerequisite for positional training.

5.1.8 Identify the required level(s) of competency for each task. This may vary between different safety-critical positions based on how directly they impact safety, for example, troubleshooting requires a higher level of performance than executing planned actions. *Bloom's Taxonomy for Teaching, Learning, and Assessment*⁴ can be useful for identifying competency levels. Following are standard levels of learning and performance used in training development listed from lowest to highest:

5.1.8.1 *Remember*—Recognize and recall.

5.1.8.2 *Understand*—Interpret, exemplify, classify, summarize, infer, compare, and explain.

5.1.8.3 *Apply*—Execute and implement.

5.1.8.4 *Analyze*—Differentiate, organize, and attribute.

5.1.8.5 *Evaluate*—Check and critique.

5.1.8.6 *Create*—Generate, plan, and produce.

5.2 Determine the appropriate type of positional training for each knowledge and skill.

5.2.1 *Knowledge Training*—Includes reading assignments, classroom training, and computer-based training.

5.2.2 *Demonstration Training*—Watching a qualified individual perform the task, whether in person or on video.

5.2.3 *Performance Training*—Accomplishing the task, either through simulation (for example, task trainers, table-top simulations, and rehearsals), by executing test procedures or performing the operational task. A qualified operator or subject matter expert should observe the performance for evaluation purposes.

6. Team Training Needs Assessment

6.1 Identify team composition. This could be specified by positions for a functional team or individuals for a fixed team.

6.2 Determine the appropriate team training for group tasks to ensure operator communications, dependencies, and interactions are trained consistent with the level of complexity and criticality.

6.2.1 *Demonstration Training*—Observing a qualified operator during group training or performance of the operational integrated task.

6.2.2 *Performance Training*—Participating in a group simulation or performing the operational integrated task.

⁴ Armstrong, P., *Bloom's Taxonomy*, Vanderbilt University Center for Teaching, 2010, retrieved 7/14/2021 from <https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/>.

6.2.3 Use of operational systems or data simulations, or both, when practical, in performance training is beneficial for high fidelity individual and group training.

7. Initial Training and Qualification Requirements

7.1 For each operations position, develop a list of training topics, tasks, methods of training, and number of performance events for individual qualification.

7.2 Create a list of team training topics and tasks along with types and number of performance training events required for team qualification.

7.3 In addition to satisfying training requirements, qualification may involve other prerequisites, such as meeting physical, psychological, or medical requirements.

8. Recurring Training and Qualification Requirements

8.1 For individual positions and teams, determine recurring training and qualification requirements. Qualification frequency may be time- or milestone-based depending on the frequency of operations. Requirements should consider:

8.1.1 Task complexity;

8.1.2 Extent of automation involved;

8.1.3 Safety risk of tasks not properly executed;

8.1.4 Frequency of operations or training delivery, or both, accounting for knowledge or skill degradation, or both, over time;

8.1.5 Method of training (see 5.2);

8.1.6 Number and significance of changes to tasks or procedures (supplemental training); and

8.1.7 Deficiencies in task performance (corrective training).

9. Positional Training and Qualification Plan

9.1 For each position, develop a training and qualification plan that documents individual training requirements, applicable team training requirements, and other requirements necessary to qualify and maintain currency for that position. Reference **Appendix X1** for general categories of training applicable to various types of operations positions.

10. Training Administration

10.1 Conduct individual and team training as determined by positional training and qualification plan requirements and mission needs.

10.1.1 Personnel conducting safety-critical training should have significant experience or education, or both, in the subject matter and be competent to address all relevant training objectives.

10.1.2 Individuals should accomplish knowledge training before proceeding into task training.

10.1.3 Individuals should be proficient in positional tasks that support integrated team procedures before participating in team training.

10.1.4 Training should incorporate mission systems and data simulations when practical to enable high-fidelity simulation.

10.1.5 Training should exercise nominal, off-nominal/contingency, and emergency procedures.