FAA | AST Commercial Space Transportation

FAA's Recommended Practices for Human Space Flight Occupant Safety

Jennifer Bailey
Manager, Horizontal Operations Branch
Safety Authorization Division

Rachita Puri
Aerospace Engineer, Enterprise Operations Branch
Safety Authorization Division

April 18, 2024

Federal Aviation Administration

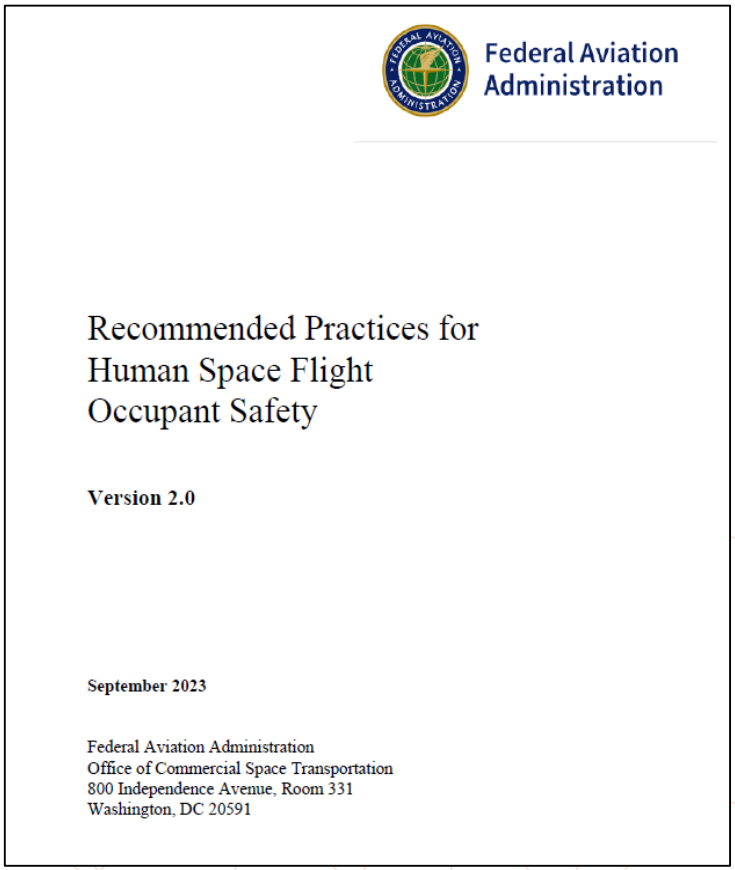
Federal Aviation Administration

Agenda

- Introduction
- Purpose & Scope
- Development Process
- Levels of Protection
- Performance and Process Based Practices
- Structure
- Major Additions & Changes
- Recommended Practices

Introduction

- On August 27, 2014, FAA released “Recommended Practices for Human Space Flight Occupant Safety”
- On September 29, 2023, FAA released “Recommended Practices for Human Space Flight Occupant Safety Version 2.0”


Federal Aviation Administration

Recommended Practices for Human Space Flight Occupant Safety

Version 2.0

September 2023

Federal Aviation Administration
Office of Commercial Space Transportation
800 Independence Avenue, Room 331
Washington, DC 20591

Purpose

- To create a dialogue among government, industry, and academia on practices that will support the continuous improvement of the safety of launch and reentry vehicles designed to carry humans.
- Can also be used to help identify subject areas that could benefit from industry consensus standards.

Scope

- Suborbital and orbital launch and reentry vehicles.
- Extravehicular activity was added from Version 1.
- Covers the safety of occupants only.
- Assumes no other regulations act to protect occupants from harm, including AST's existing regulations in 14 CFR Chapter III.
- Does not cover long duration missions, rendezvous and docking, or any flights beyond Earth orbit.

Development Process

- Reviewed existing government and private sector requirements and standards.
- Primarily used NASA's requirements and guidance for its Commercial Crew Program* as our guide.
  - Purpose was not to copy NASA's requirements, but to use them as a means to capture relevant safety concepts.
- Consulted with -
  - NASA
  - FAA's Civil Aerospace Medical Institute
  - Center of Excellence for Commercial Space Transportation
  - Commercial Space Transportation Advisory Committee (COMSTAC)

* CCT-PLN-1120, CCT-REQ-1130, CCT-STD-1150

Levels of Protection

- Three **levels of protection** are articulated in the document:

  1. Occupants: should not experience an environment during flight that would cause death or serious injury (this is a low bar).

  2. Flight Crew: level of protection increased to the level necessary to perform those operations.

  3. Emergency: the same level of care is not expected to be maintained - only a reasonable chance of survival.

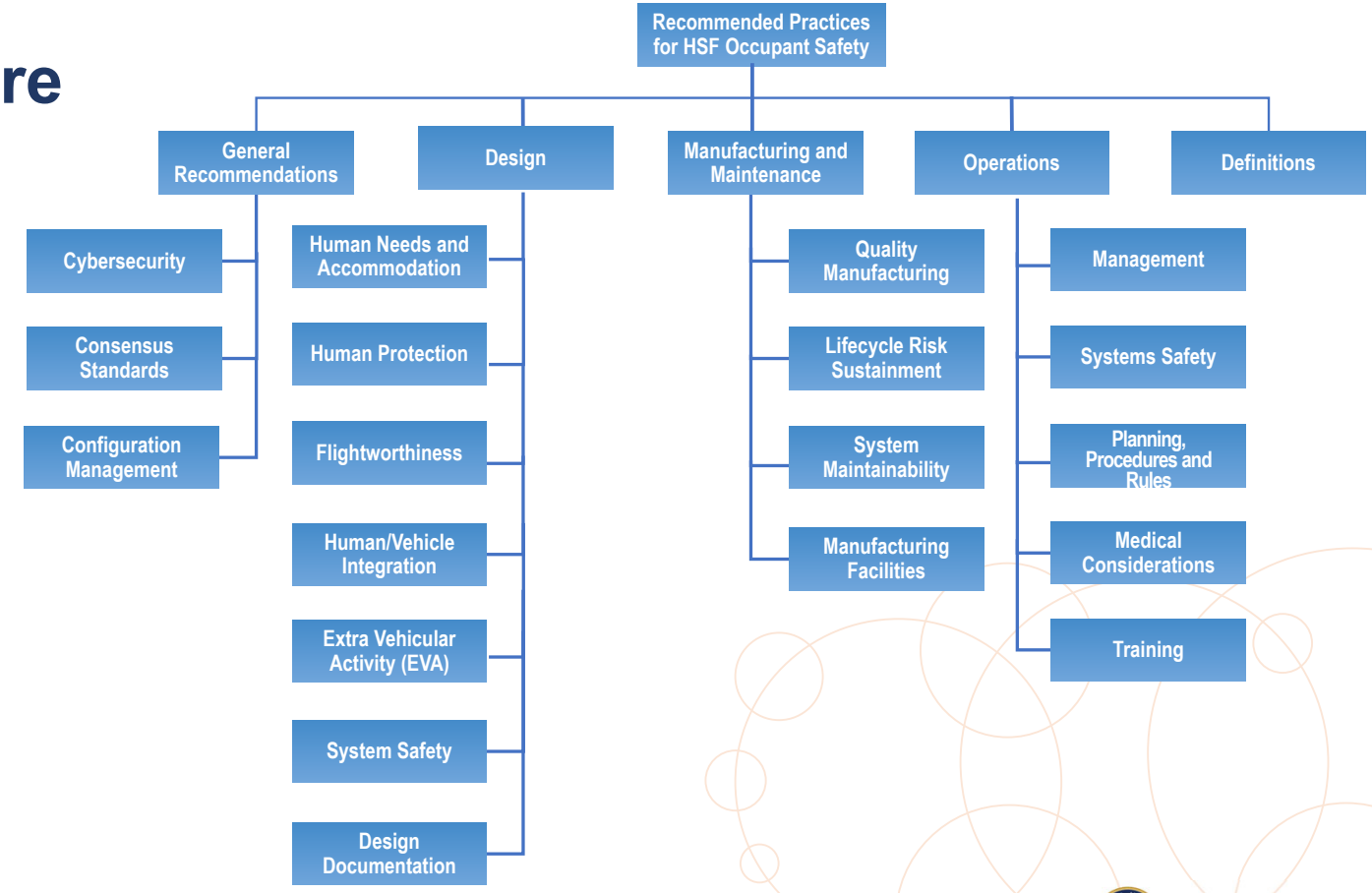
- Version 1 called this “level of care.”

Performance and Process Based Practices

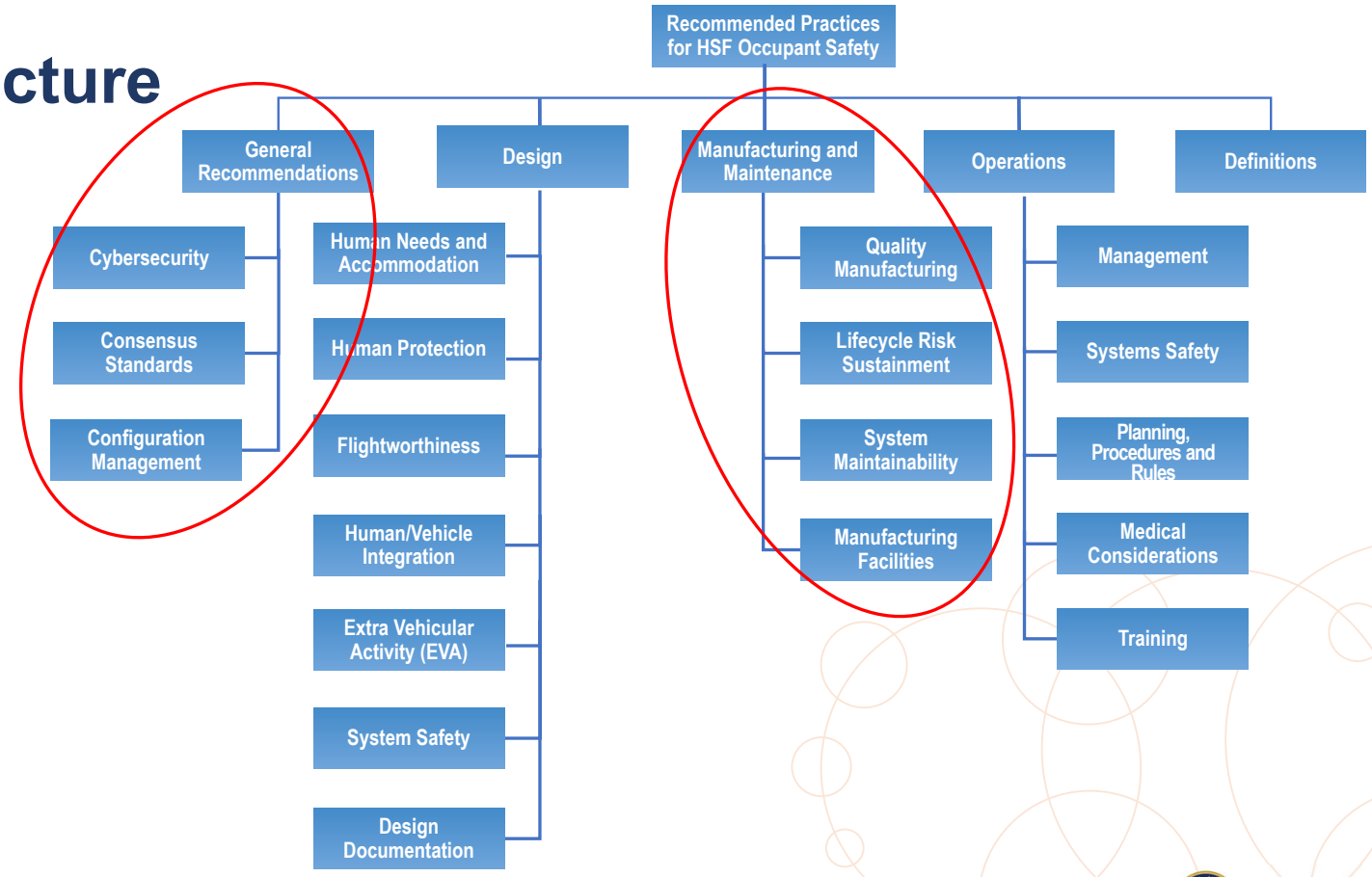
- The recommended practices are primarily performance-based:
  - States a safety objective to be achieved and leaves the design or operational solution up to the designer or operator.
  - Address hazards that are present regardless of system design and operation.

- Some are process-based:
  - System safety, software safety, and payload safety.
    - To systematically address design and operations-unique hazards.
  - Survivability analysis.
    - To determine if there are design changes that may increase the chances of crew survival in an emergency situation.

Structure


Recommended Practices for HSF Occupant Safety
General Recommendations
Design
Manufacturing and Maintenance
Operations
Definitions
Cybersecurity
Consensus Standards
Configuration Management
Human Needs and Accommodation
Human Protection
Flightworthiness
Human/Vehicle Integration
Extra Vehicular Activity (EVA)
System Safety
Design Documentation
Quality Manufacturing
Lifecycle Risk Sustainment
System Maintainability
Manufacturing Facilities
Management
Systems Safety
Planning, Procedures and Rules
Medical Considerations
Training

Structure


Recommended Practices for HSF Occupant Safety
General Recommendations
Design
Manufacturing and Maintenance
Operations
Definitions
Cybersecurity
Consensus Standards
Configuration Management
Human Needs and Accommodation
Human Protection
Flightworthiness
Human/Vehicle Integration
Extra Vehicular Activity (EVA)
System Safety
Design Documentation
Quality Manufacturing
Lifecycle Risk Sustainment
System Maintainability
Manufacturing Facilities
Management
Systems Safety
Planning, Procedures and Rules
Medical Considerations
Training

Major Additions

- "General Recommendations" section
  - Integration of Cybersecurity Best-Practices in Design, Manufacturing, and Operations
  - Development and Use of Consensus Standards for Occupant Safety
- Additional practices under "Manufacturing and Maintenance"-
  - Lifecycle Risk Sustainment
  - System Maintainability
  - Manufacturing Facilities
- Extra Vehicular Activity -
  - Extra Vehicular Activity System Suit Protection Considerations
  - Extra Vehicular Activity System Environment Protection
  - Extra Vehicular Activity System Capabilities
- Verification statements
- References

Separation of Redundant Systems

The design of the vehicle should separate or protect redundant safety-critical systems and subsystems such that an unexpected event that damages one system does not inhibit the other systems' function.

Verification Statement:

The separation of redundant safety-critical systems should be verified by analysis or simulation. The verification should be considered successful when analysis or simulation show that probable failure modes will not cause redundant systems to fail with the related primary system.

Other Additions in Operations

Management
- Post Flight Data Review

Planning, Procedures, and Rules
- Selection of Safe Flight Profile
- EVA

Medical
- Flight Crew Medical Assessment After Flight

Training
- Psychological Training
- Communications Training

Changes

- Many changes made throughout to individual practices.
- Notable changes in System Safety:
  - Version 1:
    - Safety Management
    - System Safety Engineering
    - Software Safety Engineering
  - Version 2:
    - System Safety Program Organization
    - System Safety Program Hazard Management
    - Management of Lifecycle Risks
    - System Safety Analysis
    - Software Safety

Recommended Practices: Design

Human Needs and Accommodations

- Includes the steps necessary to accommodate specific human needs, such as consumables, human waste disposal, etc., that have no relation to specific mission tasks or physical stress, unless not met.
  - Atmospheric Conditions
  - Food and Water
  - Flight Crew Rest
  - Body Waste and Vomitus Management
  - Biological Waste and Wet Trash Management
  - Emergency Survival Equipment and Supplies

Recommended Practices (continued): Design

Human Protection

- Includes the steps necessary to keep an occupant's physical or psychological stress at levels that can be considered safe for space flight participants, and sufficient for flight crew to execute the flight.
  - Acceleration Protection
  - Vibration Protection
  - Radiation Protection
  - Noise Exposure Protection
  - Mechanical Hazards Protection
  - Orthostatic Protection
  - Medical Equipment and Supplies
  - Fire Event Detection and Fire Suppression
  - Emergency Response to Contaminated Atmosphere
  - Emergency Response to Loss of Cabin Pressure Integrity
  - Emergency Response – Abort and Escape

Recommended Practices (continued): Design

Flightworthiness

- Identifies the minimum system capabilities necessary to maintain occupant safety.

  - Failure Tolerance to Catastrophic Events
  - Limitations on Failure Tolerance
  - Separation of Redundant Systems
  - Isolate and Recover from Faults
  - Structural Design
  - Electrical Systems
  - Vehicle Stability
  - Materials and Processes
  - Natural and Induced Environments
  - Probability of No Penetration by Micrometeoroids or Orbital Debris
  - Qualification Testing
  - Flight Demonstration
  - Emergency Occupant Location Post-Landing
  - Emergency Communication with Rescue Personnel

Recommended Practices (continued): Design

Human/Vehicle Integration

- Includes operational and design constraints necessary to integrate humans with a human space flight system.
  - Physical Considerations
  - System Health, Status, and Data
  - Manual Override of Automatic Functions
  - Detection and Annunciation of Faults
  - Voice Communication with the Vehicle
  - Occupant Communication
  - Views for Flight Crew Operations
  - Inadvertent Actions
  - Flight Crew Loads
  - Instrumentation Displays
  - Control of Glare and Reflection
  - Handling Qualities
  - Workload
  - Emergency Control Markings
  - Emergency Equipment Access
  - Emergency Lighting
  - Emergency Vehicle Egress

Recommended Practices (continued): Design

System Safety

- Includes engineering and management principles, criteria, and techniques to achieve acceptable risk, within the constraints of operational effectiveness and suitability, time, and cost, throughout all phases of the system life cycle.
  - Safety Management
  - System Safety Engineering
  - Software Safety Engineering
  - Occupant Survivability Analysis

Recommended Practices (continued): Design

Design Documentation

- Includes documentation related to the design of the human space flight system necessary to operate the system safely.
  - Operational Documentation
  - Configuration Management

Recommended Practices (continued): Manufacturing

(No Subcategories)

- Quality Assurance
- Acceptance of Flight Hardware
- Configuration Management

Recommended Practices (continued): Operations

Management

- Includes program controls necessary to ensure proper implementation of safety requirements.
  - Flight Operations Authority
  - Flight Crew Decision Authority
  - Configuration Management
  - Quality Assurance
  - Flight Readiness
  - Anomaly Investigation, Tracking, and Resolution
  - Accident and Incident Investigation

Recommended Practices (continued): Operations

System Safety

- Includes system safety management and engineering principles, criteria, and techniques applicable during the operational phase of a system's life cycle.
  - Safety Management
  - System Safety Engineering
  - Payload Safety

Recommended Practices (continued): Operations

Planning, Procedures, and Rules

- Includes plans and procedures necessary to safety operate a human space flight system.
  - Operating Within Constraints
  - Operations Products
  - Procedures
  - Integrated Operations Coordination
  - Fatigue Management
  - Maintenance and Preventative Maintenance
  - Cabin Hygiene
  - Launch Commit Criteria and Flight Rules
  - Communications Protocol
  - Consumables
  - Landing Sites
  - Collision Avoidance
  - Early End of Flight
  - Atmospheric Conditions
  - Food and Water
  - Body Waste and Vomitus Management
  - Biological Waste and Wet Trash Management
  - Probability of No Penetration by Micrometeoroids or Orbital Debris
  - Control of Glare and Reflection
  - Emergency Operations Management

Recommended Practices (continued): Operations

Medical Considerations

- Includes medical needs and constraints for flight crew and space flight participants.
  - Flight Crew Medical Fitness for Flight
  - Space Flight Participant Medical Consultation
  - Health Stabilization and Medical Planning

Recommended Practices (continued): Operations

Training

- Includes training needs of flight crew, space flight participants, ground controllers, and safety-critical ground operations personnel.
  - Safety-Critical Training Requirements and Standards
  - Safety-Critical Training
  - Instructor Qualification
  - Crew Resource Management and Communication
  - Aerospace Physiology Training
  - Medical Training
  - Space Flight Participant Training
  - Emergency Survival Equipment Training


Questions?
FAA | AST Commercial Space Transportation
Federal Aviation Administration