National Aeronautics and Space Administration

Commercial Crew Program
John F. Kennedy Space Center

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Crew Transportation Operations Standards

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DRAFT 3.0	Release for formal CCP review and baseline.	4/6/2011
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DRAFT 1.5	First formal draft release.	1/7/2011
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1.0 Introduction

This document works in conjunction with the processes defined in *Crew Transportation Plan* (CCT-PLN-1100), *Crew Transportation Technical Management Processes* (CCT-PLN-1120), *ISS Crew Transportation and Services Requirements Document* (CCT-REQ-1130), *International Space Station (ISS) to Commercial Orbital Transportation Services Interface Requirements Document* (SSP 50808), and *Crew Transportation Technical Standards and Evaluation Criteria* (CCT-STD-1140) to convey the design and technical standards for the development of Crew Transportation Systems (CTS). In addition to meeting the design requirements and standards, achieving NASA certification for crew transportation is also dependent on establishing rigorous operations processes that preserve the integrity of the design and manage operational risks. This document conveys the expected characteristics of the operations architecture and processes. These standards are designed to assure the safety of the flight crew and the public by ensuring that mission planning and procedure development, personnel training, and operation of the CTS are consistent with the end-to-end system design capabilities and limits on which the certification is based.

Management processes for review, verification, and validation of operations practices and products will adhere to the same principles of informed risk management used in the design and production of flight vehicles and systems.

Every mission exposes the flight crew to risk, and the execution of the mission must balance those risks with the consequences of loss of the mission objectives (such as the incremental risk of repeating the mission or impacts to ISS operations). Effective real-time launch countdown and flight operations must inherently address the ability to make timely and informed decisions to continue or terminate a mission based on the full understanding of the immediate and future risks.

1.1 Purpose

The standards included in this document are intended to establish the minimum criteria and practices for human space flight operations. They are applicable to all missions carrying NASA crews in any capacity. These standards are not intended to prescribe detailed implementation of specific operations architectures, processes, or team structures, but are instead intended to identify standards for the Commercial Partner's operations approach. The operations architecture, team structure, and execution processes will be designed to meet the needs of the individual flight system, while conforming to these minimum standards.

1.2 Scope

These standards address the operation of the CTS for all missions that include NASA flight crew. CTS operations are broadly defined to encompass the production, assembly/integration/test, launch preparation, and launch countdown of the flight system (i.e., procedurally controlled tasks); preflight planning, training, and product development; mission execution activities encompassing ground and onboard operations with provisions for mission risk management; and post-flight operations activities, such as vehicle and flight crew recovery, incorporation of lessons learned, and knowledge capture for the purpose of informing the next mission(s).

The operations concept for the CTS will influence the design of flight hardware and ground architecture, therefore, these standards should be acknowledged as an influence in the design phase of human space flight transportation systems.

1.3 Verb Application

Throughout this document set: "will" is used in a statement of fact, declaration of purpose, or expected occurrence; "shall" is used for binding requirements that must be verified and have an accompanying method of verification; and "should" denotes a statement of best practice.

1.4 Precedence

In the event of a conflict between the text of this document and references cited herein (listed in Section 2.0), the text of this document takes precedence. The exception to this statement is for SSP 50808, which takes precedence during the arrival, docked, and departure operations. Nothing in this document supersedes applicable laws and regulations, unless a specific exemption has been obtained.

1.5 Delegation of Authority

This document was prepared by NASA's Commercial Crew Program (CCP), and will be maintained in accordance with standards for CCP documentation. The responsibility for assuring the definition, control, implementation, and verification of the requirements identified in this document is vested with the NASA CCP.

2.0 Reference Documents

This section provides a list of documents with technical and manufacturing standards that can be used as a reference during the launch vehicle, spacecraft, and ground system design activities. These documents represent "best practices" for human space flight operations, and the Commercial Partner is expected to meet the intent of standards contained therein. Additional reference documents for a variety of technical disciplines can be found in CCT-STD-1140.

Document Number (link)	***Title***
CFR Title 14: Aeronautics and Space, Part 460	*Human Space Flight Requirements, FAA Draft Requirements, Part 460, § 460.5 Crew qualifications and training*
DA-WI-16 Rev. E	*Mission Operations Directorate Space Flight Personnel Certification Plan*
ISS Internal File	*ISS MCOP: Principles Regarding Processes and Criteria for Selection, Assignment, Training and Certification of ISS (Expedition and Visiting) Crewmembers, Rev. D*
NASA-STD-3001	*NASA Space Flight Human System Standard - Volume 1: Crew Health, Volume 2: Human Factors, Habitability and Environmental Health*
NASA/SP-2008-56	*Columbia Crew Survival Investigation Report*
NASA/SP-2010-3407	*Human Integration Design Handbook*
NPR 8621.1B	*NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping*
NPR 8705.2B	*Human-Rating Requirements for Space Systems (w/change 1 dated 12/7/2009)*
NPR 8900.1	*Health and Medical Requirements for Human Space Exploration*
NSTS 8080-1	*Manned Spacecraft Criteria and Standards*
NSTS 08117	*Space Shuttle Requirements and Procedures for Certification of Flight Readiness*
NSTS 12820	*Space Shuttle Operational Flight Rules, Volume A, All Flights*
NSTS 16007	*Shuttle Launch Commit Criteria and Background*
JSC 07268A	*Human Space Systems Operational Design Criteria Manual*
JSC-29229 (ISS) JSC-26843 (STS)	*Flight Control Operations Handbooks*
JSC-65994	*Commercial Medical Operations Requirements Document (CMORD)*
NASA-STD-3001, Vol. 1	*NASA Space Flight Human System Standard - Volume 1: Crew Health*
NASA-HDBK-8739.18	*Procedural Handbook for NASA Program and Project Management of Problems, Nonconformances, and Anomalies*
NASA/SP-2010-576	*NASA Risk-Informed Decision Making Handbook*

3.0 Personnel Training and Certification Process

All personnel with safety critical or mission critical roles will be adequately trained and fully capable of performing their duties in a competent manner. The Personnel Training and Certification Process will:

a. Establish and document appropriate qualification criteria for personnel performing or training safety and mission success critical tasks and functions.
b. Establish and maintain documented training requirements and certification standards for all critical CTS positions.
    1) Formal training records and evidence of satisfactory completion will be documented, maintained, and readily accessible to ensure that necessary qualifications, licensing, or currency requirements are met prior to performance of safety and mission critical tasks.
    2) Ensure appropriate, verifiable certifications apply to safety and mission critical operations. Industry standards or specialized unique certification may be utilized where applicable.
c. Ensure that the certification for joint operations (involving cooperative operations with another vehicle, program, or external organization) includes joint integrated training.
d. Ensure that at least one training environment includes high-fidelity hardware or software representations of actual CTS systems.
e. Ensure that the training will be delivered by qualified training personnel.
f. Identify or establish medical certification standards for safety critical positions. Medical standards will be consistent with comparable aviation or other applicable occupational standards or certifications appropriate for the criticality of the function, and will be approved by qualified medical personnel. Medical certifications will be renewed on a periodic basis, the frequency of which is appropriate to a task or as otherwise recommended/required by standards established by the responsible medical authority.

3.1 General Training Standards

The training processes for flight crew and operations personnel will:

a. Provide training that is tailored according to function or position.
b. Ensure that the training programs represent actual operations to the greatest extent practical.
c. Ensure that any training provides an adequate fidelity simulation of the CTS system(s) or operation represented, and informs the trainee of any differences between the training environment and the actual CTS. This may include hardware or software configuration, behavior or response, procedures and processes, and mission function.
d. Ensure that training programs are updated to incorporate lessons learned from training, actual operations, and changes in hardware/software design with a process for tracking these updates.
e. Document method(s) employed to determine satisfaction of performance criteria, and maintain documentation of completed training for each individual.
f. Document method(s) and frequency with which training requirements and/or certification standards are satisfied to maintain currency.
g. Ensure completion of all training activities prior to certification.

At a minimum, the baseline training lessons that will be provided to all flight crew and operations personnel will include:

a. Vehicle hardware and software hazards and safety procedures.
b. Knowledge of vehicle systems operations (hardware and software, as well as operations products) at a level commensurate with CTS roles and responsibilities.
c. Thorough knowledge of tools (hardware and/or software) and methods that will be applicable to each task.
d. Development and demonstration of hands-on skills necessary for the production, assembly/integration/test, and operation of flight hardware, if applicable.
e. Development of communication skills and crew resource management techniques.
f. Simulations, as appropriate, to address nominal and off-nominal (stressing) operations scenarios, including joint simulations.
g. Situational awareness and recognition of medical and environmental contingencies (such as hypoxia, hypercapnia, and decompression sickness) related to mission preparation and execution.

3.2 Flight Crew Training Standards

Training for all members of the flight crew will include:

a. Spacecraft systems knowledge.
b. Spacecraft habitability.
c. Launch vehicle knowledge.
d. Ground operations (vehicle and personnel interactions during the pre-launch timeframe).
e. Flight operations (vehicle and personnel interactions during the in-flight timeframe).
f. Flight crew (or cockpit) resource management (CRM).
g. Procedures for all critical functions that flight crew personnel may be expected to perform.
h. Simulation training to practice nominal, off-nominal, and emergency mission activities, including joint operations.
i. Generic survival training (i.e., wilderness, exposure, and crash), including use of crew survival equipment and emergency hardware.
j. Familiarization with physiological issues associated with space flight.
k. Familiarization with medical and environmental contingencies associated with space flight.
l. Use of medical kits and procedures.
m. Any on-orbit training provided during the course of a mission, as required.

3.2.1 Pilot

The Pilot role is defined as persons authorized to operate and control the flight-critical functions of the spacecraft during flight. If there are two or more pilots aboard, one will be designated the Pilot-in-Command (PIC) or Commander. The Pilot or PIC will:

a. Be responsible at all times for safe operation of the CTS spacecraft and conduct of the crew and mission.
b. Be responsible for the safety of the occupants of the spacecraft.
c. Be the final authority to initiate action deemed necessary for flight crew safety.
d. Ensure that flight crew readiness to execute the mission plan, safety procedures, and emergency responses.

3.2.1.1 Pilot Training

The Pilot training program will include:

a. Operational knowledge of the integrated vehicle design, dependencies, interfaces, capabilities, and limitations.
b. Nominal and off-nominal systems and trajectory performance, which may require manual intervention or abort action, especially during powered flight or re-entry.
c. Autonomous operation of the vehicle with an awareness of resultant effects to minimize the risk to the public, ground facilities, or on-orbit assets.
d. Operation of vehicle subsystems in normal and degraded modes.
e. Vehicle fault recovery.
f. Integrated training with operations personnel for mission cognizance, team building, and establishment of communication discipline.
g. All modes of control or propulsion, including any transition between modes and degraded modes, and the resultant changes to vehicle trajectory.
h. Emergency procedures exercises for ensuring crew survival in the event of a mishap during any phase of the mission.
i. Aircraft, simulator, or program training designed to simulate nominal and off-nominal vehicle flight paths for any flight phase where manual piloting can affect safety of flight.

3.2.2 Specialist Training

Specialists are flight crew personnel that will be trained to assist the Pilot(s) with operating the vehicle, managing vehicle systems as appropriate, or improving the crew resource management environment within the vehicle. Specialists will receive training commensurate with their mission role, which will include:

a. Mission and task-specific training pertinent to all phases of flight as it relates to assisting the Pilot(s) with successful completion of the nominal mission.
b. Assisting the Pilot(s) with vehicle systems management and fault recovery.
c. Assisting the Pilot(s) with contingency operations of the spacecraft.
d. Mission-specific tasks, as appropriate, involving vehicle and systems management, payload-specific operations, or running experiments.

3.2.3 Space Flight Participant Training

Space Flight Participants are flight crew personnel that serve no operational role or critical function in managing the vehicle or any vehicle subsystems. There are no additional qualifications to be a Space Flight Participant beyond those listed in Section 3.2, Flight Crew Training Standards. Space Flight Participants will be adequately trained in space flight physiological issues, spacecraft emergencies, egress, and habitability so as to not pose a safety risk to other members of the flight crew. Space Flight Participants are not authorized to operate and control the vehicle or to configure any vehicle subsystems unless adequately trained.

3.3 Operations Personnel Training Standards

These standards apply to personnel who have been assigned roles and responsibilities that ensure the safety and integrity of flight hardware and software, flight crew, and the general public. Assignments

include, but are not limited to, production, processing, assembly/integration/test, launch preparation, launch countdown, preflight planning and product development, training of flight crews and operations personnel, vehicle and subsystem performance analysis, mission execution and operations support, and recovery support. Training for operations personnel will include, at a minimum:

a. Instruction on and execution of all nominal and off-nominal operations, joint operations, and emergency procedures relevant to their roles and responsibilities.
b. In-depth knowledge of all applicable flight and ground systems, data monitoring and analysis tools, and procedures that are primary to their assigned roles, responsibilities, and tasks.
c. General knowledge of additional flight systems, procedures, processes, and tools that are not directly covered by, but may influence or affect, their assigned roles, responsibilities, and tasks.
d. General knowledge of additional non-flight systems, procedures, processes and tools utilized in production, assembly/integration/test, and launch operations that are not directly covered by, but may influence or affect their assigned roles, responsibilities, and tasks (e.g., Integrated Work Control Systems, Configuration Management Systems, Integrated Logistics Systems, etc.).
e. Failure recognition and response.
f. General knowledge of standard operations common to all missions (including vehicle(s), facility(s), and personnel interactions).
g. Communication skills and protocol with other operations personnel, flight crew, and external organizations, if applicable.
h. Simulation or on-the-job training of critical procedures and events, if applicable.

4.0 Operations Products

Operations products consist of plans, analyses, procedures, process schedules, and supporting information developed prior to the execution of operations. The purpose of these products is to ensure that:

a. Preparation and execution of all mission operations are conducted safely.
b. Complex, integrated, or safety critical activities are adequately planned and integrated.
c. Vehicles and facilities are operated within design limits.
d. Responses to contingencies and off-nominal situations are given adequate consideration and executed in a safe and controlled manner.

The standards outlined in each category below apply to all operations products which could affect the flight qualification or integrity of flight systems or the safe execution of flight operations.

4.1 Standards for Operations Products

a. Operations products will be validated prior to use in operations. Validation of procedures may include human-in-the-loop testing, real or simulated flight hardware, operational or programmatic simulations, etc. Validation of procedures involving software will utilize real flight (or ground) software to the greatest extent practical.
b. Operations products will address nominal operations as well as off-nominal and emergency scenarios which have been identified by test, analysis, or system experience, or which are determined to be safety critical based on likelihood or resulting consequence.
c. Plans and procedures for integrated operations will be coordinated among all affected elements of the CTS and, where appropriate, external interfaces.
d. Operations products will be made readily available to operations personnel and flight crew.
e. Operations products will be configuration managed. After validation, operations products will be controlled through the approved configuration management, to ensure the accuracy and currency of the products for mission use. Production or design changes to the flight vehicle or other elements of the CTS, or accumulated training and flight experience, may require changes to previously validated operations products. These changes may be flight-specific configuration changes or incremental, permanent changes.

4.2 Operational Plans

Operational plans will be developed for implementing the entire operations sequence. This sequence includes production, processing, scheduling, assembly/integration/test, launch preparation, launch countdown and ascent, on-orbit mission execution, and reentry and recovery. The plans will encompass all hardware, software, facilities, and personnel that support a mission. Operational plans will dictate what plans and products are required from all CTS elements to prepare or certify readiness for the mission. Operational plans will include personnel training plans, personnel workload plans, a ground processing plan for launch preparation, a flight plan for launch countdown and mission execution, and abort plans for all mission phases. Separate plans for different mission phases or for different CTS elements will contain clear guidance for coordinated transition between mission phases or CTS elements.

4.2.1 Ground Processing Plans

Ground processing plans provide a framework for coordinating and managing the nominal flow of activities among all CTS elements while on the ground, including production activities, mission design activities, launch vehicle and spacecraft hardware integration, cargo activities, launch site and ground support equipment operations, flight crew activities, recovery operations, and post-flight operations. An effective ground processing plan addresses CTS element inter-dependencies to enable schedule efficiency while ensuring that vehicle integrity is maintained within the CTS certification. The ground processing plan will include, to the extent practical, methods to maximize the efficiency of the production, processing, assembly/integration/test, and launch preparation of the vehicle(s) for a mission. Ground processing plans address:

a. Production processing and scheduling.
b. Assembly/integration/test processing.
c. Launch countdown planning and execution.
d. Pre-flight crew interface tests with flight hardware.
e. All flight crew activities at the launch site and recovery site(s), including post-flight plans for recovery and transportation of flight crew and support personnel to an appropriate post-flight facility.
f. Pre-flight environmental sampling such as air, water, surfaces, and acoustics.
g. Pre- and post-flight processing of cargo (including flight crew equipment and time-critical cargo).
h. Post-flight plans for CTS elements, including any recovery and refurbishment.
i. Coordination/schedule management/resource loading of vehicle, flight crew, operations personnel, facilities, ground support equipment, and launch site activities for production, assembly/integration/test, launch countdown, recycle, scrub, and recovery.

4.2.2 Flight Plans

Flight plans provide a framework of the nominal mission, including scheduled operation of flight hardware and software, mission objectives and events, attitude timeline, and flight crew activities. The plans will encompass the entire mission from launch countdown through ascent, orbit, docking and undocking (if required), re-entry and landing. Generic and mission-specific Planning Ground Rules and Constraints will be developed to provide the flight crew and operations personnel activity guidelines for generation of the mission timeline, including ground commanding. Effective flight plans will:

a. Integrate mission objectives, flight crew task assignments, vehicle requirements, trajectory, consumables, and resource usage into an efficient and cohesive plan.
b. Integrate operations timelines among all CTS elements.
c. Provide a timeline of nominally scheduled mission events, spacecraft maneuvers and attitude hold periods, including estimated durations for each, to be utilized for mission execution, as well as power and consumables analyses.
d. Provide a list of flight crew activities and corresponding information, which may include but is not limited to:
    1) Procedure references/callouts used to perform nominally scheduled tasks.
    2) Time constraints with context for overall schedule.
e. Identify the availability of communication coverage with flight operations personnel.
f. Designate flight crew and/or operations personnel responsible for each mission event, task, and command execution, if appropriate.

g. Contain all planned commanding data.
h. All times or clocks utilized, referenced, or provided when interfacing with NASA or other external programs will be formatted in Coordinated Universal Time (UTC). This ensures that the timing of major events is coordinated to a standard reference time across all systems.
i. Be created in a format which allows for revisions/replanning to occur in a timely manner.
j. Include contingency steps for managing off-nominal mission events for which time-critical responses are necessary by flight crew or flight operations personnel, including:
    1) Backout/breakout plans.
    2) Emergency deorbit plans.
    3) Consumables (propulsive and non-propulsive) and resources required to execute contingency plans.
k. Utilize a scheduling constraints plan for managing the flight crew timeline (e.g., awake times, sleep cycles, pre- and post-sleep activities, meals, off-duty time, launch day, docking, entry day, etc.).
l. Coordinate a joint flight plan for those missions that dock with a vehicle belonging to an external program.

4.2.3 Operational Communication Plans

Effective operational communication processes are critical for ensuring proper flow of information to all CTS elements and maintaining situational awareness onboard the vehicle, among operations personnel, and at dependent external partners. Communication plans and protocols must encompass the entire life-cycle of the CTS mission, and will address:

a. Internal communication. Establish a communication hierarchy and protocol internal to the CTS. The hierarchy will define communication among CTS elements for managing pre-flight planning and among flight crew and operations personnel for mission execution. The protocol will define methods and oral standards by which the communication among CTS elements will occur.
b. External communication. Establish a plan for communicating with external entities such as NASA program management, Governmental insight/oversight, external customers, Search and Rescue (SAR), and others as appropriate.
c. Joint operations. If planning to engage in joint operations with cooperative vehicles or ground stations, the Commercial Partner will develop a plan for coordinating or participating in communications among all participants. Some cooperative vehicles (such as ISS) or ground stations [such as Mission Control Center - Houston (MCC-H)] already utilize well-established communication protocols. If required, the Commercial Partner will adhere to established protocols and must be able to perform joint operations in a coherent, integrated, and effective manner.
d. A secure, private communication mechanism for private flight crew medical conferences, medical data, family discussions, etc.

4.2.4 Aborts Plan

Aborts are highly integrated events that may involve the launch vehicle, spacecraft, flight crew, operations personnel, ground facilities, and external entities. Aborts are a response to credible, life-threatening hazards which occur or could occur despite design mitigations and preventative measures and preclude continuance of the current mission plan. The aborts plan will:

a. Account for abort execution in all mission phases.
b. Address roles and responsibilities of the flight crew and operations personnel.
c. Provide for coordination of rescue and recovery assets, including joint development of contingency plans and operations protocols with external entities (e.g., FAA, State Department, DOD, etc.).
d. Clearly identify any manual or automatic aborts and abort thresholds or limits that can be changed, initiated, or inhibited manually by the flight crew or remotely by operations personnel.

4.2.5 Contingency Action Plan

A Contingency Action Plan contains provisions for immediate protection/recovery of flight crew and operations personnel in the event of a mishap, emergency, natural disaster, or act of terrorism. The plan will provide notifications and coordinated interactions with other NASA or external Agency/Center Mishap Preparedness and Contingency Plans, as appropriate (for example, in the case of a launch using KSC facilities).

At a minimum, the Contingency Action Plan will:

a. Document response plans and procedures for catastrophic events, ascent abort, emergency deorbit, or other scenarios beyond the scope of normal ground and mission operations plans to maximize the chances of flight crew survival.
b. Include provisions for the immediate embargo of operations personnel, data, telemetry, and recovered hardware to ensure integrity of mishap information for coordinating an immediate mishap response.
c. Identify the responsibilities of internal parties, the external organizations that must be notified, and any existing agreements with external entities for mishap response (such as SAR, State Department, Department of Defense, Intergovernmental Agreements, etc.).
d. Address medical care of the flight crew and operations personnel for contingency operations emergencies, launch aborts, on-orbit events, or reentry and landings, including what major facilities are nearby pre-planned or designated contingency landing zones.
e. Identify the requirements for vessels supporting as first responders, and perform minimal pre-coordination with facilities at the nearby ports. For example, this may include aircraft in flight-ready status that can be called up to get any key/critical personnel or equipment (including medical) to a contingency or emergency site.
f. Be maintained throughout the mission and current enough to be executable in the time available. This includes backout/breakout plans, emergency deorbit plans, consumables (i.e., prop and non-prop) required to execute the plans, center of gravity management, and ground support at a suitably ready state (i.e., on alert, on call). Time constraints may drive some details to be pre-computed, but allow others to be computed after a failure is recognized.

4.3 Procedures

Procedures formalize the steps to execute nominal operational plans and respond to off-nominal situations, enabling operations personnel and flight crew to ensure successful preparation and operation of the CTS through mission completion. Procedures will ensure operations within the limits of CTS

certification and vehicle performance, as well as consistency with the Launch Commit Criteria and Flight Rules. Procedures will:

a. Be consistent between flight crew and operations personnel. This standard will:
    1) Ensure that the procedures used to train flight crew and operations personnel are the same procedures used during the mission.
    2) Ensure that the procedures implemented by operations personnel are consistent with the flight hardware or ground facilities that are being operated on.
    3) Provide onboard contingency procedures for the flight crew that match the response that will be expected/initiated by operations personnel on the ground.
b. Maintain or enforce security protocols and standards for personnel, facilities, hardware, software, and data.
c. Provide placards, cautions, warnings, etc., when a hazardous operation or procedure affects or could affect a safety-critical system or the safety of personnel.
d. Explicitly state when Personal Protective Equipment (PPE) is needed to perform an operation, task, or procedure.
e. Explicitly state operations and procedures which cannot be performed concurrently.
f. Be written in a standard format, consistent among the CTS elements to facilitate ease of use by operations personnel and flight crew, and adhere to standard nomenclature or shorthand when referring to vehicle actions, commands, and naming conventions.
g. Clearly designate who is to perform which actions, especially between flight crew and operations personnel, as required. Identify if the action must be performed at a specific time, or if the action is time-critical.
h. Provide logical sequences of action and evaluation steps (onboard and/or ground) with which nominal mission events and tasks are accomplished.
i. Provide logical sequences of action and evaluation steps (onboard and/or ground) with which anomalies are correctly diagnosed and responded to such that flight crew and vehicle safety are maintained.
j. Maintain a work schedule aligned with procedural events.
k. Consider the criticality of the operation, access availability, and operational timeline.
l. Highlight any flight-specific hardware or configuration differences (parameter values, etc.).
m. Contain rules governing handoff of authority or control from one CTS element to another.
n. Include a list of tools or special equipment required to execute the procedure.

4.3.1 Ground Operations

Ground operations procedures are designed to protect personnel, flight hardware, and facilities during the production, processing, assembly/integration/test, launch preparation, launch countdown, post-launch, and post-landing phases of a mission. Ground operations procedures will:

a. Ensure successful launch countdown by including the following:
    1) Guidance for preparing and safely operating the launch site prior to and after a launch.
    2) Servicing of the launch vehicle and spacecraft.
    3) Conducting launch countdown, scrub, and recycle.
    4) Flight crew preparation (e.g., launch day preflight briefings, ingress, etc.).
b. Ensure successful flight crew recovery and vehicle recovery (if applicable) by including the following:

1) Nominal post-landing spacecraft safing (splashdown/touchdown) events.
2) Ascent aborts, including search and recovery of the flight crew.
3) Flight crew egress and post-egress flight crew assessments.
4) Post-landing science and medical operations with flight crew.
5) Flight crew equipment and cargo installation and removal.

c. Clearly identify needs of critical skills at the step/task level (e.g., use of tooling, safety wiring, torquing, etc.).
d. Verify readiness of all ground support equipment, tooling, special test equipment, and facilities to support the operation.
e. Verify hardware is within the life-cycle and/or shelf-life limits and will remain so throughout the mission (e.g., ordnance, batteries, paints, soft goods, sealants, desiccants, etc.).
f. Include provisions to ensure flight crew and system safety by accounting for operations personnel activities which could affect flight systems certification.
g. Maintain/verify the integrity of the flight hardware, preserved within CTS certification throughout handling/transportation operations.
h. Include instructions for the inspection of the flight hardware prior to, and after, any handover transaction between CTS elements occurs.
i. Include instructions for the reconfiguration of flight hardware (e.g., rotating orientation).
j. Include instructions for installation and removal of non-flight hardware on or into the launch vehicle or spacecraft (e.g., platforms, protective covers, remove before flight tagged items, etc.).
k. Include instructions for any hazardous or non-hazardous assembly, installation, removal, and repair of flight hardware.
l. Include instructions for test, checkout, power on/off, and monitoring.
m. Include instructions for handling, storing, and servicing of commodities (e.g., fuel, oxidizer, helium, nitrogen, etc.).
n. Include instructions for conducting emergency power-down procedures.
o. Include emergency launch vehicle and spacecraft safing procedures for any hazardous operation.
p. Contain rules governing handoff of authority or control from one CTS element to another that:
    1) Clearly identify roles and responsibilities of each party involved in the hand off.
    2) For the receiving party, clearly define and document any incomplete work at the time of the transaction.
    3) For the receiving party, clearly define and document any unplanned work content at the time of the transaction.

4.3.2 Flight Operations

Flight operations procedures will encompass all aspects of final launch preparations, vehicle operations, and mission-specific tasks/payloads/experiments to safely and successfully execute missions from launch through post-landing safing and recovery. Flight operations procedures will include:

a. Instructions to the flight crew for performing all onboard tasks, inclusive of nominal and contingency operations.
b. Instructions to flight operations personnel for:
    1) Assigned roles and responsibilities.
    2) Management of vehicle resources, consumables, and systems.
    3) Fault detection and response.
    4) End-to-end verification of all communication and command interfaces.

5) Operation of monitoring and analysis tools.
6) Remote commanding of the vehicle (crewed or uncrewed).
7) Telemetry processing and management.
8) Tracking the vehicle trajectory.
9) Natural environments analyses (including launch/landing weather).
10) Establishing and maintaining communications with the flight crew, spacecraft, operations personnel, and external stakeholders.

c. Provisions such that the flight crew can perform essential mission tasks if communication with operations personnel is lost.
d. Provisions to ensure that a flight crew can safely execute emergency operations (e.g., loss of cabin pressure, fire, contingency deorbit, etc.) without communication from flight operations personnel.
e. All emergency procedures onboard in a readily available and highly reliable form, independent of the nominal display method, control systems, and power system.
f. Joint operations procedures developed for all operations with two or more actively controlled spacecraft (crewed or uncrewed). At a minimum, joint operations procedures will include:
    1) Coordination with and validation by parties from all vehicles involved to ensure concurrent operations do not conflict.
    2) Joint responses to off-nominal or emergency situations, including priorities for safing multiple vehicles (concurrently, if necessary).
    3) Rules for abandoning one vehicle to seek safe haven in another, if appropriate.

4.3.3 Facility Operations

Procedures for operations facilities will ensure the readiness of that facility to support flight hardware or training operations, including mission-specific tasks. The procedures for an operations facility will include:

a. Associated limits, controls, and requirements that will be incorporated as necessary to assure that hazards are controlled.
b. Functional verification of the hardware, software, and command interfaces from the operations facilities to other CTS elements.
c. Protection of the integrity of flight hardware consistent with operational requirements and design assumptions of the CTS certification.
d. Maintenance of the integrity of the facility and connections to external elements for a critical safety function during processing or flight operations.

4.4 Management of Operational Risks

Mission execution plans and products will employ structured and documented processes for ensuring safety, monitoring mission progress, making informed mission decisions, and addressing situations outside of nominal planned events. These processes will include sufficient technical rationale based upon the best available analysis and understanding of CTS capabilities and the risks of operating in the relevant condition.

4.4.1 Launch Commit Criteria and Flight Rules

Launch Commit Criteria (LCC) and Flight Rules will be developed to provide direction and guidance for mission safety decisions and management of operational risks during mission execution. These criteria

and rules will establish predetermined and approved actions to be taken in response to planned or contingency events. LCC will manage operational risks in the pre-launch and launch countdown phases of the mission, and Flight Rules will manage operational risks from launch initiation through post-landing and recovery. LCC and Flight Rules will:

a. Protect the health and safety of the flight crew and operations personnel above mission objectives.
b. Protect public safety.
c. Assure that nominal launch and flight operations are performed within the limits to which the CTS systems and configuration were designed, tested, and certified.
d. Identify nominal mission decision points or events and the necessary criteria for continuing (such as the minimum system functionality to initiate the next mission phase or major event).
e. Address system or component failure conditions, immediate responses to safe the system, resultant mission constraints and impacts to system operations, mission events, and duration.
f. Provide specific, documented methods for accepting a violation or deviation, if applicable.
g. Rank planned objectives and tasks by mission priority to facilitate real-time decision making.
h. Be approved by a technical review process that includes relevant system experts for concurrence.

4.4.2 Operational Hazard Analysis and Procedural Mitigation

The approved hazard analysis process will identify operationally induced risks, or the mitigation of identified risks through operational controls. A closed-loop process will be incorporated to verify that all hazards accepted on the basis of an operational control (e.g., flight rule, limit, or procedural control) are accurately reflected in the mission products.

The Operational Hazard Analysis and implementation of resultant Procedural Mitigations will:

a. Identify and document operational hazards and operational controls for hazards.
b. Identify accepted hazards that have no operational controls and document strategies to mitigate those hazards and maximize survival probability.
c. Identify hazards for which an abort action is appropriate, through systematic processes such as fault tree analysis and Failure Modes and Effects Analysis (FMEA).
d. Ensure that any hazards associated with or controlled by an operation are clearly identified (e.g., through physical placards, or warning notes in a procedure).
e. Establish a verification process to ensure that all hazards accepted as operationally controlled have procedures in place to accomplish that control.
f. Ensure that personnel who may be exposed to hazards or hazardous operations are appropriately trained and informed.
g. Address perceived hazards brought forth by stakeholders or external partners.

4.5 Integrated Analyses

Mission analyses will be performed to ensure that all planned operations are within the CTS design and resource limits and no contingency operations are expected to be required. These analyses will address mission-specific configurations that may have capabilities that are not enveloped by the original CTS certification. Mission analyses will be approved by certified analysts using validated methods or tools. Analysts will be certified according to the standards of Section 3.0. Quality Assurance will be performed

commensurate with the criticality of the data. Mission analyses will be integrated across all CTS elements and mission phases.

4.5.1 Mission Trajectory Analyses and Verification Process

Pre-mission, trajectory analysis, and verification will be performed to ensure safety and mission requirements can be successfully met. These requirements include but are not limited to performance, constraint, and dispersion characteristics that influence or limit trajectory design and CTS certification requirements. This process will include:

a. Design, analysis, and verification of the nominal and off-nominal trajectories flown by the integrated vehicle, vehicle elements, and jettisoned or expended components during the ascent, orbit, rendezvous, and re-entry phases of flight under nominal, dispersed, and pre-determined failure conditions.
b. Launch clearance and orbital collision avoidance.
c. Satisfaction of mission, hardware, and software constraints.
d. Provisions for incorporating changes to mission requirements into revised analyses and verification of the results, as appropriate.

4.5.2 Mission Design Analyses

To ensure a mission is operated safely, mission design analyses will:

a. Assess separation events to satisfy recontact requirements.
b. Determine the minimum required on-orbit propellant, plus reserves, required to support all orbital maneuvering, rendezvous and proximity operations (if required), deorbit burn, and controlled reentry.
c. Assess all operations within proximity of another spacecraft to ensure safety of relative motion, including contingencies, breakouts, etc.
d. Ensure that trajectory plans provide sufficient pre- and post-translational maneuver tracking arcs or other determination methods to assure that a sufficiently accurate state vector is available for targeting and execution of subsequent maneuvers.
e. Assess nominal and contingency deorbit and landing opportunities.
f. Analyze the communication coverage and availability of ground and orbital assets.
g. Predict splashdown point or landing site, assess probable climatological conditions at the site, and determine the ability to dispatch rescue forces.
h. Determine public safety risks for launch, ascent, aborts, and re-entry, including disposal of non-recoverable elements.
i. Ensure the design provides continuous abort coverage during ascent.
j. Be performed with math models that include sufficient dispersions to assure that trajectory-driven mission objectives and safety constraints (e.g., rendezvous, re-entry, etc.) are not compromised.

4.5.3 Consumables and Resources Analyses and Verification Process

Analyses will be generated and verified for propulsive and non-propulsive consumables and onboard resources used by the vehicle and flight crew. The intent of these analyses is to:

a. Determine and verify consumables and resources loading profiles that support the planned mission, as well as dispersions and contingencies deemed highly probable and/or critical to flight crew and vehicle safety or high-priority mission objectives.
b. Provide consumables loading profile and vehicle mass properties data to ensure the vehicle is operated within capability/certification limits for the duration of the mission.
c. Assess and manage propulsive consumables profile and vehicle mass properties with respect to nominal mission plan and launch abort execution.
d. Assess and manage on-orbit power generation and demand based on mission profile, as required.
e. For joint operations, track and update analyses based upon consumables and resources that are transferred to/from another docked vehicle, if applicable.

4.5.4 Real-Time Analyses

Analyses will be performed during mission execution to evaluate actual on-orbit spacecraft performance against pre-flight analysis products (trajectory, mission design, consumables, and resources utilization predictions). This will enable:

a. Situational awareness of current and future vehicle performance.
b. Independent verification of major onboard trajectory calculations.
c. Verification of mission continuation or termination criteria (e.g., consumables limits, etc.).
d. Reallocating consumables margin to extend a mission if desired or required.

5.0 Operations Execution

CTS risks will be mitigated through disciplined execution of operations. Execution of operations includes the processing of flight hardware, major facility or hardware tests, and the flight phases of a mission. The operations processes will employ a clear definition of authority, roles and responsibilities, and communication protocols that allow for informed decision-making and risk management. The process for execution of operations must remain flexible so that with sufficient evaluation and approval, the process can accommodate changes to the vehicle processing flow or flight plan, unplanned events, or vehicle anomalies. The Commercial Partner will establish and coordinate a plan and daily schedule for managing operations personnel workday/sleep constraints during the execution of operations.

5.1 Operations Authority

The chain of command and the authority granted to each person involved in space flight operations will be clearly delineated and documented. Definition of operations authority will identify:

a. Specific personnel authorized to make safety critical mission decisions.
b. Personnel responsible for authorizing and conducting critical mission events or delivering mission products.
c. Stakeholders, owners, or other external parties that must be coordinated with for each operation, decision, and product.
d. Time effectivity and scope of authority of each entity in the operations process.

Personnel will possess an understanding of the Commercial Partner's standards for real-time team interactions and roles and responsibilities. Certified flight crew and operations personnel are authorized to operate the vehicle within hardware and software certification limits, within the rules and procedures approved for flight or operation, and only to the extent that is covered by their roles and responsibilities.

5.2 Operations Management

An operations management structure will be developed for the CTS that will:

a. Assume responsibility for all significant management decisions involving the CTS operations, including proceeding with a major test, or granting authority to proceed to the next mission phase (e.g., Go/No-go for launch, docking, etc.).
b. Manage and coordinate the response to an anomaly, contingency event, or emergency.
c. Manage the process for making an informed decision on acceptance of increased risk when departing from previously agreed-to operational plans or vehicle limits.

5.3 Anomaly Tracking and Resolution

An anomaly tracking and resolution process will be developed for flight operations that identifies and resolves any hardware or software performance characteristic that is or may be inconsistent with operational or design expectations. These anomalies can include, but are not limited to, facility or vehicle problems, operations issues, nonconformances, deficiencies, integrated anomalies with cooperative vehicle(s), and 'process escapes.'

The anomaly tracking and resolution process will identify how anomalies are reported, tracked, investigated, and resolved. This process will address the following:

a. Immediate Response – Through established LCC, Flight Rules, training, or other plan(s), the process will provide documented guidance for an immediate response required from flight crew, operations personnel, or automated software to maintain the vehicle in a safe state, if possible. This response will account for:
    1) Short-term impacts to CTS systems, hardware, software, flight crew, and operations personnel.
    2) Short-term corrective actions to resolve and/or mitigate the impacts associated with the anomaly.
    3) Measures for preventing or minimizing recurrence of the anomaly.
    4) Any other actions or controls required for safety or mission assurance.
b. Long-Term Recovery Actions Required – The process will provide guidance to determine and document whether any actions, beyond those already taken by the flight crew, operations personnel, or automated software, are required to reduce the risk to CTS or to restore systems to nominal or degraded functionality.
c. Safety Hazards and Risks – The process will document the current and potential safety hazards and risks associated with the anomaly, and any recovery actions already taken or being considered.
d. Impacts to Mission Operations and Operational Constraints – Any impacts to on-going or upcoming operations, including constraints that have been or need to be established to protect the flight crew or vehicle systems, hardware, or software, as a result of the anomaly will be documented. The establishment of temporary placards or constraints will be documented.

6.0 Data Availability and Integrity

The CTS will establish a plan for maintaining data availability and integrity. This plan will address the following areas of concern:

a. Provide operations personnel with near-real-time access to stored engineering data and telemetered/stored flight data for the launch vehicle and spacecraft. This data will be available to assess the health of the vehicle for the ongoing flight, and to support troubleshooting during a mission or major test, to provide flight crew with additional vehicle insight, and to inform future flights.
b. Provide flight crew, operations personnel, and cooperative vehicle(s) with real-time data required for safe and successful proximity operations for missions involving cooperative vehicle(s).
c. At a minimum, ensure that other engineering and operations data (not accessible in near-real-time) is available to operations personnel in a timely fashion in response to mission events, if required.
d. Ensure that data availability and integrity is maintained for operations personnel continuously and redundantly during a mission to protect for ground systems failure(s).
e. Develop a plan that implements an integrated system architecture to capture, confiscate, and embargo all data for use in reconstruction of an accident or mishap. Coordinate this plan with the Contingency Action Plan.

7.0 Operations Facilities

Operations Facilities will ensure that mission critical infrastructure is protected, maintained, and kept in a state of readiness, flight hardware that interfaces with a facility or ground system is operated within design constraints, and the safety of flight crew and operations personnel is maintained. Redundancy, availability, hardware and software configuration integrity, and data and command latency will be consistent with end-to-end CTS design requirements and assumptions. These standards will be observed for any facility or the applicable portion of a facility, that:

a. Is critical to ensuring safety of the overall mission.
b. Is critical to the execution of the mission.
c. Manufactures hardware or software for a CTS vehicle.
d. Houses high fidelity training equipment.
e. Conducts or participates in activities that are potentially hazardous to operations personnel, flight crew, ground hardware, and flight hardware.

Each Operations Facility will document, where applicable:

a. Standards for facility operations that are consistent with CTS vehicle operational requirements, design assumptions, and CTS certification.
b. Standards for verification of critical infrastructure and processes.
c. Procedures that describe how to operate the facility while maintaining the safety of the general public, flight crew, operations personnel, and flight hardware.
d. All integrated, end-to-end testing that will be conducted between the facility, the vehicle(s), and other CTS elements.
e. Basic policies addressing personnel training and certification requirements.
f. Maintenance and calibration requirements, including schedule, for all hardware and equipment (manufacturers' procedures and industry standards will be used to fulfill these requirements when available).
g. Security (access control) protocols and standards for personnel, facilities, hardware, software, and data.
h. Associated limits, controls, and requirements utilized to assure that hazards are mitigated and operating constraints are maintained.
i. A configuration management plan for tracking and verifying changes to facility documentation, systems, hardware, software, equipment, protocols, and data. Flight-critical ground systems will be configuration-controlled commensurate with flight systems.
j. Flight-specific configuration changes and verification.
k. Facility software validation.
l. Organization interface agreements that define the responsibilities of external organizations that use or operate this facility and how those organizations work together.
m. Data management requirements that define how to handle, distribute, control, and store data from tests or operations of the facility.
n. Unique safety requirements and related procedures that may include:
    1) Operations involving human subjects that may not be covered by OSHA standards.
    2) Operations in vacuum, oxygen-depleted, or oxygen-enriched environments.
    3) Operations with hazardous or energetic materials.

o. Contingency plans for all credible loss of functionality from safety critical operations facilities to ensure the safety of flight crew and operations personnel and, when possible, mission completion.

8.0 Post-Flight Activities

Post-flight activities capture potential process improvements, lessons learned, and mission data to improve and inform future missions, operations, and CTS designs. The Commercial Partner will support the post-flight activities outlined in the sections below.

8.1 Flight Crew and Operations Personnel Debrief

A process will be established for debriefing the flight crew and the operations personnel after a mission. This debrief will provide the flight crew and operations personnel with a forum (parts of which may be confidential) for discussing activities and issues that occurred during a mission flow (encompassing pre-launch through post-landing), with appropriate program management, additional operations personnel, and medical participants in attendance. The flight crew debrief will address:

a. Mission summary (e.g., adherence to plans, objectives met, hardware/software performance, contingencies, etc.).
b. Habitability (e.g., facility and vehicle environments, human factors, etc.).
c. Lessons learned from training.
d. Effectiveness of operations and mission execution when conducted:
    1) Autonomously by the onboard flight crew.
    2) Cooperatively while interacting with operations personnel on the ground.
e. Utility of mission products.
f. Scheduling/workload.
g. Anomaly review.
h. Medical operations and personal hygiene.
i. Forward actions.
j. Other recommendations.

The operations personnel debrief will address:

a. Lessons learned from training and execution of operations.
b. Effectiveness of operations and communication.
c. Utility of mission products.
d. Anomaly review.
e. Forward actions.
f. Other recommendations.

8.2 Lessons Learned

A lessons learned database and capture process will be developed to identify operational issues, deficiencies, and 'process escapes,' and incorporates them as corrective actions into future engineering and operational processes prior to the next mission or event. Sources of information for these lessons learned include the personnel training process, the development of mission products, the conduct of mission execution, the flight crew and operations personnel debriefs, and the anomaly tracking and resolution process. The mission products are expected to reflect these lessons learned, and changes will be highlighted at the next flight readiness review. Lessons learned will be documented and incorporated into dependant elements of the CTS, such as the flight crew training processes, as soon as practical (even

during a mission). Lessons learned from previous spaceflight programs, if available, will be collected and made available to the Commercial Partner as a resource.

Appendix A: Acronyms

Acronyms	Phrase
CCP	Commercial Crew Program
CoFR	Certificate of Flight Readiness
CP	Commercial Provider
CRM	Crew Resource Management
CTS	Crew Transportation System
CVCC	Commercial Vehicle Control Center
DAM	Debris Avoidance Maneuver
DOD	Department of Defense
FAA	Flight Aviation Administration
FMEA	Failure Modes and Effects Analysis
GIDEP	Government Industry Data Exchange Program
ISS	International Space Station
JSC	Johnson Space Center
KSC	Kennedy Space Center
LCC	Launch Commit Criteria
LOC/LOM	Loss of Crew/Loss of Mission
MCC-H	Mission Control Center – Houston
MER	Mission Evaluation Room
MMT	Mission Management Team
NASA	National Aeronautics and Space Administration
ODF	Operations Data File
PIC	Pilot-in-Command
PPE	Personal Protective Equipment
PSA	Probabilistic Safety Analysis
V&V	Verification and Validation

Appendix B: Definitions

Term	Definition
Abort	Early termination of the mission or mission phase prior to reaching the mission destination or objective, due to a failure or other condition that does or could endanger the flight crew or the spacecraft.
Analysis	A verification method utilizing techniques and tools such as math models, prior test data, simulations, analytical assessments, etc. Analysis may be used in lieu of, or in addition to, other methods to ensure compliance to specification requirements. The selected techniques may include, but not be limited to, engineering analysis, statistics and qualitative analysis, computer and hardware simulations, and analog modeling. Analysis may be used when it can be determined that rigorous and accurate analysis is possible, testing is not cost effective, and verification by inspection is not adequate.
Ascent	The period of time from initial motion away from the launch pad until physical separation from the launch vehicle during nominal flight or during an abort.
Ascent Abort	An abort initiated during the ascent phase. Depending on the scenario and spacecraft/launch vehicle architecture, some ascent aborts may require insertion to a lower-than-planned orbit, and provide some orbital stay time; these are still considered ascent aborts if the initiating action is taken during the ascent phase.
Automated	Automatic (as opposed to human) control of a system or operation.
Autonomous	Ability of a space system to perform operations independent from any ground-based systems. This includes no communication with, or real-time support from, mission control or other ground systems.
Backout	During mission execution, the coordinated cessation of a current activity or procedure and careful return to a known, safe state.
Breakout	Any action that interrupts the nominally planned free flight operations that are intended to place the spacecraft outside of a threatening location to the cooperative vehicle. This may be an automated or manually executed action. For the ISS, the area within which a vehicle poses a threat to ISS is called the Approach Ellipse (AE).
Catastrophic Event	An event resulting in the death or permanent disability of any flight crew personnel or an event resulting in the unplanned loss/destruction of a major element of the CTS.
Catastrophic Hazard	A condition that could result in the death or permanent disability any flight crew personnel or in the unplanned loss/destruction of a major element of the CTS.
Certification	For Operations Personnel: Meeting specified requirements or standards through successful completion of predefined criteria (for example, completion of a training program for certification of operations personnel). For Hardware or Software: Testing, verification, and formal signoff that

	hardware or software meets prescribed requirements, is performing or will perform as designed, and has been configuration controlled to ensure it is maintained or operated within certification.
Command	Directive to a processor or system to perform a particular action or function.
Commercial Partner (CP)	Refers to the entity providing any assets and services required to meet the requirements in this document for safe and successful Human Space flight missions including pre-flight planning, trajectory and abort analysis, ground processing and manufacturing, ground and flight operations, training, post-landing recovery operations, safety and mission assurance, and all other functions as required.
Consumable	Resource that is consumed in the course of conducting a given mission. Examples include propellant, power, habitability items (e.g., gaseous oxygen), and crew supplies.
Contingency	Provisioning for an uncertified event or circumstance that is possible but cannot be predicted with certainty.
Crew Resource Management	Training provided to the flight crew and operations personnel to develop and improve the following skills: leadership, situational awareness, interpersonal communication, workload management, task delegation, decision making, procedure usage, coordination of available resources (including other flight crew personnel), and the process of building and maintaining an effective team relationship on the spacecraft and on the ground.
Crew Transportation System (CTS)	The collection of all space-based and ground-based systems (encompassing hardware and software) used to conduct space missions or support activity in space, including, but not limited to, the integrated space vehicle, space-based communication and navigation systems, launch systems, and mission/launch control. This definition is the same as the definition of Space System found in NPR 8705.2B.
Critical Function	Mission capabilities or system functions that, if lost, would result in a catastrophic event or an abort. Source: NPR 8705.2B - Human Rating Standards.
Critical (Sub)System	A (sub) system is assessed as critical if loss of overall (sub)system function, or improper performance of a (sub)system function, could result in a catastrophic event or abort.
Demonstration	A method of verification that consists of a qualitative determination of the properties of a test article. This qualitative determination is made through observation, with or without special test equipment or instrumentation, which verifies characteristics such as human engineering features, services, access features, and transportability. Demonstration requirements are normally implemented within a test plan, operations plan, or test procedure.
Element	Physical entities within a Program that have functional capabilities allocated to them necessary to satisfy system-level mission objectives. Elements can perform all allocated functions within a mission phase, or

	through docked operations with other Program elements or systems (e.g., Crew Module, Core Stage, etc).
Emergency	A sudden, generally unexpected occurrence, situation, or event that if unabated may cause injury, loss of life, or damage to flight hardware and that demands an immediate response.
Failure	Inability of a system, subsystem, component, or part to perform its required function within specified limits. Source: NPR 8715.3.
Fault	An undesired system state and/or the immediate cause of failure (e.g., maladjustment, misalignment, defect, or other). The definition of the term "fault" envelopes the word "failure," since faults include other undesired events such as software anomalies and operational anomalies. Source: MIL-STD-721C. Faults at a lower level could lead to failures at the higher subsystem or system level.
Flight Crew	Any human onboard the space system during the mission that has been trained to inhabit, monitor, operate, or control the space system (synonymous with the term "crew").
Flight Operations	All operations of the flight vehicle, the flight crew, and ground teams supporting the flight vehicle from liftoff through splashdown/landing and recovery.
Flight Operations Personnel	Persons developing detailed pre-mission flight plans (analysts and designers), persons managing the mission during flight (flight controllers), persons training the flight crew and flight controllers to perform that mission (spacecraft instructors), and personnel supporting the operations facilities.
Flight Phase	A particular segment or timeframe during a mission. Typical flight phases include pre-launch, ascent, abort, orbit (also referred to as on-orbit, which includes sub-phases of free-flight and docked operations), deorbit/entry, landing, and post-landing.
Flight System	Any equipment, system, subsystem or component that is part of the integrated space system.
Flight Hardware	All components and systems that comprise the internal and external portions of the spacecraft, launch vehicle, launch abort system, and flight crew worn equipment.
Ground Hardware	All components and systems that reside on the ground in support of the mission including the control center(s), launch pad, ground support equipment, recovery equipment, facilities, communications, network, and tracking equipment.
Ground Operations Personnel	Persons involved with, or performing, the actual hands-on production and preparation of the launch vehicle and spacecraft, including supporting or managing the launch countdown and post-flight recovery. This includes but is not limited to production; assembly/integration/test; launch preparation; launch countdown; maintenance of flight hardware, launch site facilities, and ground support equipment (GSE); managing the launch countdown, Search and Rescue, and recovery operations.
Ground Processing	The work required to prepare the launch vehicle and spacecraft for their

	mission from post-landing through launch. This work includes launch vehicle*/spacecraft*/flight crew recovery, spacecraft return to the processing facility*, spacecraft preparation at the processing facility, transport to the launch site, support during final assembly/integration/test with the launch vehicle, and launch countdown activities. [*Applies only to reusable spacecraft.]
Habitable	A description of the environment that is necessary to sustain the life of the flight crew and to allow the flight crew to perform their functions in an efficient manner. These environments are described in NASA-STD-3001, Volume 2.
Hazard	A state or a set of conditions, internal or external to a system, that has the potential to cause harm (Source - NPR 8715.3).
Hazard Analysis	The process of identifying hazards and their potential causal factors.
Health & Status Data	Data, including Emergency, Caution and Warning data, that can be analyzed or monitored describing the ability of the system or system components to meet their performance requirements.
Human-Rated Space System	A human-rated system accommodates human needs, effectively utilizes human capabilities, controls hazards with sufficient certainty to be considered safe for human operations, and provides the capability to safely recover from emergency situations. The concept of human-rating a space system entails three fundamental tenets: 1. Human-rating is the process of evaluating and assuring that the total system can safely conduct the required human missions. 2. Human-rating includes the incorporation of design features and capabilities that accommodate human interaction with the system to enhance overall safety and mission success. 3. Human-rating includes the incorporation of design features and capabilities to enable safe recovery of the flight crew from hazardous situations. Human-rating is an integral part of all program activities throughout the life-cycle of the system, including design and development, test and verification, program management and control, flight readiness certification, mission operations, sustaining engineering, maintenance/upgrades, readiness certification, sustaining engineering, maintenance/upgrades, and disposal.
Integrated Medical Group (IMG)	NASA's team of personnel responsible for health and safety of the NASA Crew. Members of the IMG include NASA and International Partner Flight Surgeons; the NASA Radiation Health Officer; the Space Radiation Analysis Group; the Behavioral Health and Performance team; the Environmental Health Discipline Experts; the Astronaut Strength, Conditioning, and Rehabilitation Specialist; and Biomedical Engineers. This group supports the NASA Crew pre-flight, in-flight, and post-flight.
Integrated (Space) Vehicle	The integrated (space) vehicle consists of all the system elements that are occupied by the flight crew during the space mission and provide life support functions for the flight crew (i.e., the inhabited elements). The

	integrated vehicle also includes all elements physically attached to the inhabited element during the mission. The integrated vehicle is part of the larger space system used to conduct the mission. This definition is the same as the definition for crewed space system found in NPR 8705.2B. The following examples are provided for clarification: Example 1: A launch vehicle for a crewed spacecraft is part of the integrated vehicle for ascent. Example 2: When the flight crew ingresses a vehicle for launch, the vehicle is physically connected to the launch pad. The specific launch pad systems that interface with the launch vehicle and spacecraft are considered part of the integrated vehicle but the entire launch pad is not part of the integrated vehicle.
Integrated Work Control System (IWCS)	A tool that may be utilized in a production, assembly/integration/test, launch preparation, and launch countdown environment that integrates and shares data from independent systems (e.g., Schedule Management tools, Configuration Management tools, Work Execution tools, Constraints Management tools, Supply Chain Management tools, etc.) to execute operations.
Landing	The final phase or region of flight consisting of transition from descent, to an approach, splashdown/touchdown, and coming to rest.
Launch Vehicle	The vehicle that contains the propulsion system necessary to deliver the energy required to insert the spacecraft into orbit or provide the propulsion capability necessary to execute an ascent abort.
MCC-H	The NASA Mission Control Center in Houston, Texas.
MCOP	The Multilateral Crew Operations Panel (MCOP) is the primary forum for the coordination and resolution of top-level International Space Station (ISS) flight crew matters which affect all partners including establishing: (1) the processes, standards, and criteria for selection, certification, assignment, and evaluation, and (2) the policies and processes for training, operations, and post-flight activities, of ISS flight crew, including ISS visiting flight crew, as appropriate.
Mission	This term is used in this document to encompass the entire process of planning for and executing an orbital space flight. This includes pre-flight vehicle processing, hardware and software tests, facility preparations, flight operations, and post-flight activities.
Mission Critical	Item or function that must retain its operational capability to assure no mission failure (i.e., for mission success).
NASA Crew	The NASA flight crew or the NASA-sponsored crewmembers being transferred to and from the ISS. These include international partner crewmembers.
Operations Personnel	All persons supporting ground operations or flight operations functions of the CTS. Examples of these personnel are listed below: Persons responsible for the production, assembly/integration/test, validation, and maintenance of flight hardware, production facilities, launch site facilities, operations facilities, or ground support equipment

	(GSE). Persons involved with supporting or managing the launch countdown, flight crew training, or mission during flight. Persons involved in post-flight recovery.
Operator	Any human interacting with the integrated space vehicle during the mission.
Override	To take precedence over system control functions.
Passenger	Any human onboard the space system while in flight that has no responsibility to perform any mission task for that system. Often referred to as "Space Flight Participant."
Pilot	A person certified and assigned to operate and control the vehicle during one or more phases of flight.
Production	All phases in which hardware is being manufactured, assembled, or produced from approved raw materials, piece parts, or components.
Qualification	Satisfaction of entrance criteria to begin a training program.
Reliability	The probability that a system of hardware, software, and human elements will function as intended over a specified period of time under specified environmental conditions.
Rendezvous	The process of executing a sequence of on-orbit maneuvers starting with orbit insertion and ending with the approach initiation maneuver.
Rescue	The process of locating the flight crew, proceeding to their position, providing assistance, and transporting them to a location free from danger.
Risk	The combination of (1) the probability (qualitative or quantitative) including associated uncertainty that the space system will experience an undesired event (or sequences of events) such as internal system or component failure or an external event and (2) the magnitude of the consequences (personnel, public, and mission impacts) and associated uncertainties given that the undesired event(s) occur(s).
Risk Assessment	An evaluation of a risk item that determines (1) what can go wrong, (2) how likely is it to occur, and (3) what the consequences are.
Safety	The absence from those conditions that can cause death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment.
Safety Critical	A procedure, operation, limit, event, personnel role, hardware, or software which has the potential to constitute a significant risk to human life, ground facilities, flight hardware, or mission success. Often, items that are safety critical are subject to highly time-sensitive events, where prior rehearsal is necessary for success.
Search And Rescue (SAR)	The Search And Rescue (SAR) team is assigned to locate the flight crew and spacecraft (if the spacecraft is recoverable), proceed to their position, provide assistance, and transport them to a location free of danger. This team is expected to support nominal ascent aborts, nominal post-landing (splashdown/touchdown), and contingency re-entry and landing.
Software	Computer instructions or data, stored electronically. Systems software

	includes the operating system and all the utilities that enable the computer to function. Applications software includes programs that do real work for users, such as word processors, spreadsheets, data management systems, and analysis tools. Software can be Commercial Off-The-Shelf (COTS), Contractor developed, Government Furnished, or combinations thereof.
Spacecraft	All system elements that are occupied by the flight crew during the space mission and provide life support functions for the flight crew. The crewed element includes all the subsystems that provide life support functions for the flight crew/passengers. Defined as "crewed space element" in NPR 8705.2B.
Space Flight Participant	A passenger onboard the flight vehicle that serves no operational role or critical function in managing the vehicle or any vehicle subsystems.
Space System	The collection of all space-based and ground-based systems (encompassing hardware and software) used to conduct space missions or support activity in space, including, but not limited to, the integrated space vehicle, space-based communication and navigation systems, launch systems, and mission/launch control.
Specialist	Persons onboard the spacecraft that are certified to assist in its operation during any phase of flight, and/or certified to perform particular tasks during the mission (such as a robotic operation or an extravehicular activity).
Subsystem	A secondary or subordinate system within a system (such as the spacecraft) that performs a specific function or functions. Examples include electrical power, guidance and navigation, attitude control, telemetry, thermal control, propulsion, and structures subsystems. A subsystem may consist of several components (hardware and software) and may include interconnection items such as cables or tubing and along with the support structure to which they are mounted.
System	The aggregate of the ground segment, flight segment, and workforce required for flight crew rescue and transport.
Validation	A process using objective evidence to confirm that the requirements which define an intended use or application have been met. Whenever all requirements have been met, a validated status is achieved. The process of validation can be carried out under realistic use conditions or within a simulated use environment. Design and development validations use objective evidence to confirm that products meet the requirements which define their intended use or application. Operations validations use objective evidence to confirm that operations processes are capable of producing planned results.
Verification	Proof of compliance with a requirement or specifications based on a combination of test, analysis, demonstration, and inspection.
Verification Plan	A formal document listing the specific technical process to be used to show compliance with each requirement.