Office of the Chief Health and Medical Officer (OCHMO)
Human Spaceflight Standards Newsletter
February 2022

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What is NASA-STD-3001?

NASA-STD-3001, NASA Spaceflight Human-System Standard Volumes 1 and 2, establishes Agency standards that enable human spaceflight missions by minimizing health risks, providing vehicle design parameters, and enabling the performance of flight and ground crew. Applicability and tailoring of standards are determined based on each program's mission profile and procurement strategy.

NASA-STD-3001 Volume 1 covers the standards needed to support astronaut health and Volume 2 covers system design that will maintain astronaut safety and promote performance.

Visit the OCHMO Standards

NASA-STD-3001 Volume 1, Rev B and Volume 2, Rev C

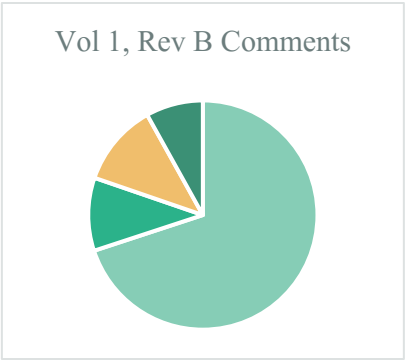
NASA Space Flight Human-System Standard: Volume 1 – Crew Health (Revision B)

Link to approved Volume 1 Rev B

NASA Standard 3001 Volume 1 Revision B has received agencywide approval and is now available for public viewing on the OCHMO standards website!

NASA-STD-3001 Volume 1, Crew Health, sets standards for fitness for duty, space permissible radiation exposure limits and permissible outcome limits, health and medical care, medical diagnosis, intervention, treatment and care, and countermeasures.

The revision of Volume 1 consisted of the following:
223 total comments dispositioned
- 156 comments accepted
- 23 comments accepted with modifications
- 26 comments not accepted
- 18 comments deferred



Major changes to NASA-STD-3001 Vol 1, Rev B included:

Levels of Care transition to Health and Medical Care Standards

- Volume 1 Revision A contained descriptive information (not requirements) regarding levels describing the amount and type of care rendered based on perceived need and ability of the provider. The levels ranged from Level of Care Zero, where no perceived threat to health or life existed, through Level of Care Five, where a high level of potential risk exists that personnel may experience medical problems during a mission.
- Volume 1 Revision B contains 18 requirements that detail information needed to provide astronaut health care starting at selection, throughout training, space flight missions, post-mission reconditioning, and past retirement from the astronaut core. Revision B also provide an appendix to detail the use of probability risk assessment to inform clinical decision makers in developing an inflight medical system.

Radiation Standards

- The Radiation Astronaut career exposure radiation limits were updated based on input from the National Academies of Science, Engineering and Medicine. The new standard is exposure based (600 mSv) based on a 3% mean Risk of Exposure-Induced Death (REID) for cancer mortality. The exposure limit is universal for males and females.
- Additionally, two new requirements were added:
  - Short-Term Radiation Limits – Solar Particle Events
  - Crew Radiation Limits for Nuclear Technologies

Bone Standards

- The Bone section was updated to requirements that reflect current acceptable pre-mission and post-mission bone mineral density guidelines.
- Bone countermeasures were updated to requirements that quantify maintaining bone mass of hip and spine at or about 95% of pre-mission values and at or above 90% for femoral neck.

Muscle Standards

- The Muscle section was updated, and a table (Table 2) was added with specific Pre-Mission Muscle Strength Requirements for mission situations including EVAs and Unaided Egress.

What is a Standard?

The majority of NASA-STD-3001 Vols. 1 & 2 are performance standards, meaning they state standards in terms of desired results without stating a method for achieving it. All standards contain a "shall" statement and can be followed by a short, italicized rationale statement. Rationales are intended to provide additional information for the implementation of the standards.

3001 Standards are overarching and apply to all of NASA's Spaceflight Programs. These standards are essential pieces used to create program requirements that lead to successful designs and implementations.

Through partnerships with the programs (e.g., xEMU, Gateway, HLS, etc.), the Human Research Program, and SMEs (internal and external to NASA), the standards are constantly evolving and being reworked to minimize human health and performance risks. The Standards Team works with all NASA Spaceflight Programs to help tailor the standards for their specific missions.

Links

The NASA-STD-3001 SharePoint (including where to submit recommendations for changes to standards, suggestions for new tech briefs, links to standards documents, and SME lists) can be found at the following link: https://sashare.sp.jsc.nasa.gov/Teams/NASA-STD-3001/SitePages/Home.aspx

NASA-STD-3001 Vols. 1 & 2 can be found at the following link: https://www.nasa.gov/offices/ochmo/human_spaceflight/index.html

Visit the OCHMO Standards

Major changes to NASA-STD-3001 Vol 1, Rev B (continued)

Aerobic Capacity for Surface EVAs

- The Aerobic Capacity section was changed to include the following:
  - Pre-flight and in-flight aerobic capacity section was replaced with microgravity EVA Aerobic Capacity and Celestial Surface EVA Aerobic Capacity.
  - In-flight aerobic capacity section was updated to in-mission aerobic capacity requirement and the maintenance requirement changed from at or above 75% to at or above 80% of pre-mission capacity, determined by direct or indirect measures.

Deceased Crew Capability

- A new standard was added to Volume 1 that provides guidance for the requirement of programs to have the capability to handle deceased crewmembers, including considerations for facilities and plans that are socially, biologically, and physically acceptable while minimizing risk to surviving crewmembers, potential forensics collection, biohazard containment, and legal jurisdiction.

NASA Space Flight Human-System Standard: Volume 2 – Human Factors, Habitability, and Environmental Health (Revision C)

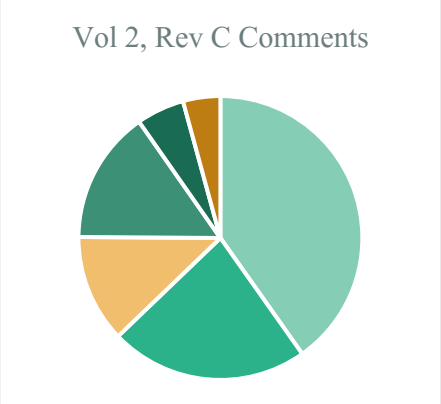
Link to Pre-Publication Copy of Volume 2 Rev C

NASA Standard 3001 Volume 2 Revision C has been approved by the Chief Health and Medical Officer and the pre-publication copy is available on the OCHMO standards website! The final version will be uploaded in the near future.

NASA-STD-3001 Volume 2, Human Factors, Habitability, and Environmental Health, sets standards for the design, selection, and application of hardware, software, processes, procedures, practices, and methods for human-rated systems. It focuses on human-system integration and how the crew interacts with designed systems and the environment to maintain health, safety, and overall mission performance.

The revision of Volume 2 consisted of the following:
659 total comments dispositioned

- 265 comments accepted
- 149 comments accepted with modifications
- 81 comments not accepted
- 100 comments deferred
- 36 comments editorial
- 28 comments withdrawn



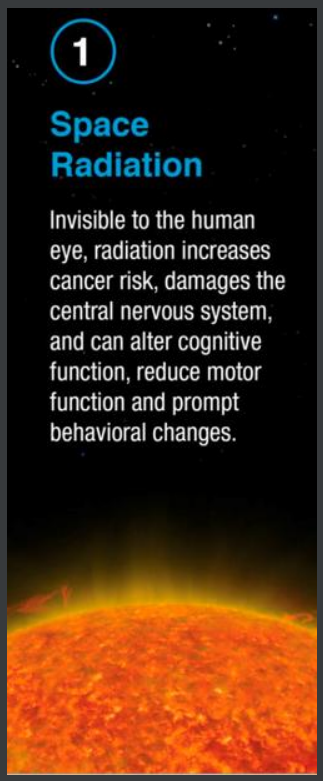
Major changes to NASA-STD-3001 Vol 2, Rev C included:

Physical Data Sets/Anthropometrics

- To improve understanding of numerous physical data set standards that must be considered together when designing a vehicle, Section 4.1 Physical Data Sets was consolidated into one revised standard requiring programs to use datasets provided by NASA. This minimizes the number of verifications while still providing the required information.
- Appendix F: Physical Characteristics and Capabilities Data Sets was added as a reference to Section 4. The datasets provided include characteristics and capabilities for anthropometric dimensions, range of motion, strength, mass, volume, and surface area.

Hazards of Spaceflight

There are many hazards associated with spaceflight, and the 3001 Standards Team seeks to address as many risks associated with these hazards as possible to protect crewmember health. The following are 5 largely contributing hazards of human spaceflight.



Major changes to NASA-STD-3001 Vol 2, Rev C included:

Lunar Dust

- During a recent review of the Risk of Adverse Health and Performance Effects of Dust Exposure (approved 12/2021), it was identified that a new standard was needed for future programs where celestial dust is a known hazard to have the capability for monitoring and alerting. As stated by the risk custodian team, "the capability of dust monitoring that enables crews to detect atmospheric dust levels must be included in the ECLS System in order to determine the appropriate contamination levels that should prompt dust removal (filtration) and cleaning of surfaces." The new standard, [V2 6153] Celestial Dust Monitoring and Alerting, is one of many that will aid in the mitigation of known risks ensure the health of crew and performance of ECLSS designs.

Water Quantities and Temperatures

- To streamline the information indicating water needs for crew, 14 standards associated with required quantities and temperatures of water were consolidated into two ([V2 6109] Water Quantity and [V2 6110] Water Temperature), which are now easily referenced within Table 4 – Water Quantities and Temperatures.

Body Waste Quantities

- In addition to the recognized need for a table to easily determine body waste quantities (mass, volume, etc.), the values were updated and added to help facilitate the calculations needed for future programs and missions. Seven standards associated with crew body waste quantities were consolidated into one ([V2 7102] Body Waste Quantities), which is now easily referenced within Table 16 – Body Waste Quantities.

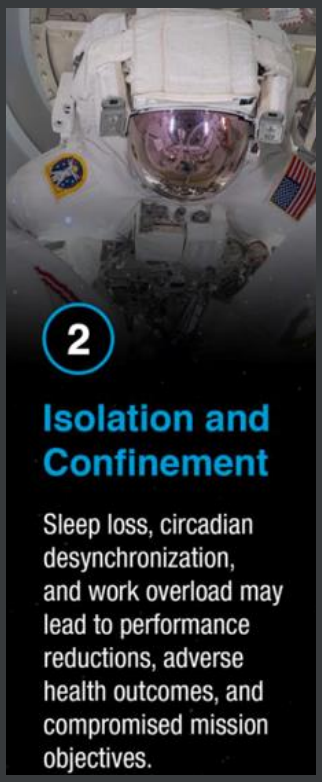
Touch Temperature Limitations

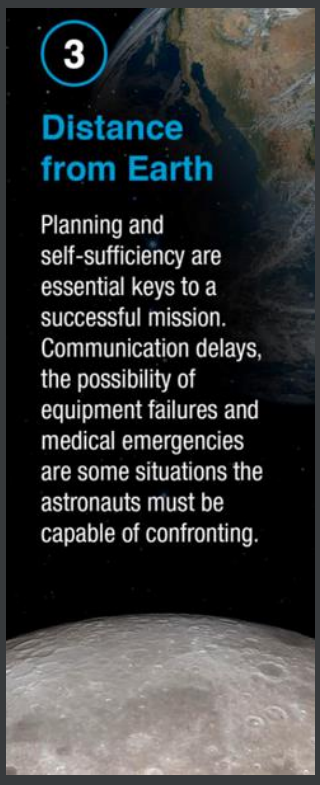
- Recent guidance received in section 9.3.2 Temperature Exposures were added to NASA-STD-3001 to provide details on touch temperatures limits. These values better clarify low and high limits to help prevent pain and tissue damage to crewmembers when skin is exposed to equipment. New figures, tables and calculations have been added to provide the additional guidance needed.

NASA-STD-3001 Forward Work - Overview

The following topics are currently being assessed within the NASA-STD-3001 documents and will soon undergo significant revisions or additions. The Standards Team will work collaboratively with SMEs, program integrators, and other various stakeholders to update existing standards and content to be aligned with current guidelines and best practices.

- **Suits** – During the disposition of comments received for NASA-STD-3001 Volume 2 Revision C, approximately 23 comments received were deferred that were associated with the needs of the suit. As a result, future efforts are planned to review all standards that impact suit design and the crewmember when worn. Additionally, information available from the team working on Incapacitated Crew Rescue will be assessed for additional updates to the NASA-STD-3001.
- **Section 10: Human Performance and Crew Interfaces** – The 3001 Standards Team is currently conducting a comprehensive review of Volume 2 Section 10 to identify gaps, update existing standards, and streamline existing standard to facilitate improved understanding and implementation. These updates will be a part of a separate Agency Change Request (CR).
- **Galactic Cosmic Radiation (GCR) Shielding –** Based on a recommendation from subject matter experts from the joint OCHMO and NESC Workshop on Beyond Low Earth Exploration, the standards team will be proposing a standard to reduce exposure from GCR by 15% compared with free space such that the effective dose from GCR remains below 1.3 mSv/day for systems in free space and below 0.8 mSv/day for systems on planetary surfaces.

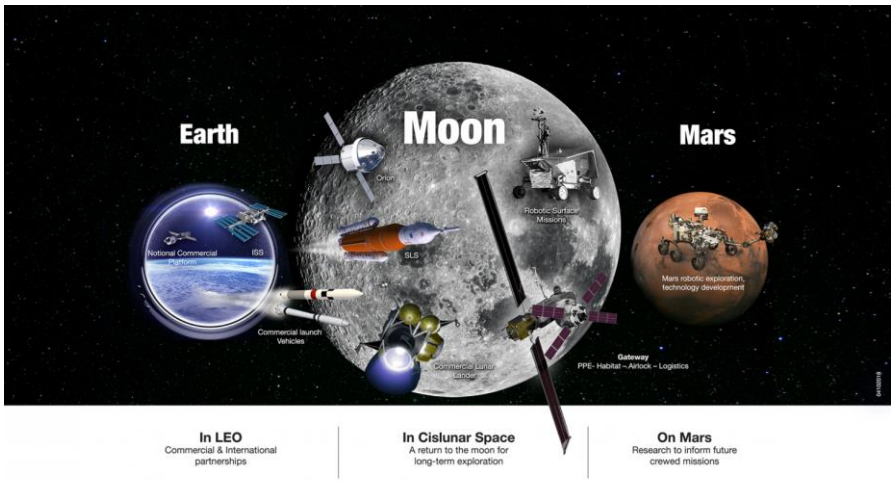




NASA-STD-3001 Forward Work (continued):

- **Sleep** – SMEs and various program integrators have found current standards related to crew sleep to be insufficient. In addition, new evidence from the Human Research Program (HRP) has been released and is ready to be integrated into the 3001 documents. We will work to update the sleep standards to build a stronger foundation to ensure program requirements adequately address crewmember sleep.
- **Surface Vehicles** – We are working closely with the Lunar Terrain Vehicle (LTV) team to identify gaps between the LTV requirements and the latest revision of NASA-STD-3001 Volume 2. Eventually, we will adapt LTV requirements into new standards, which will have their own "Surface Vehicles" section in 3001.
- **External lighting capabilities** – Our work on updating 3001 Volume 2 revealed a gap in our lighting section. Current efforts include the development of a new technical brief, Artemis Lighting Considerations Overview, which provides guidance on development of an integrated lighting architecture plan that accommodates human and machine vision related EVA tasks. Future work will involve consulting with lighting SMEs to develop new standards to address the unique challenges of exterior/planetary surface lighting.

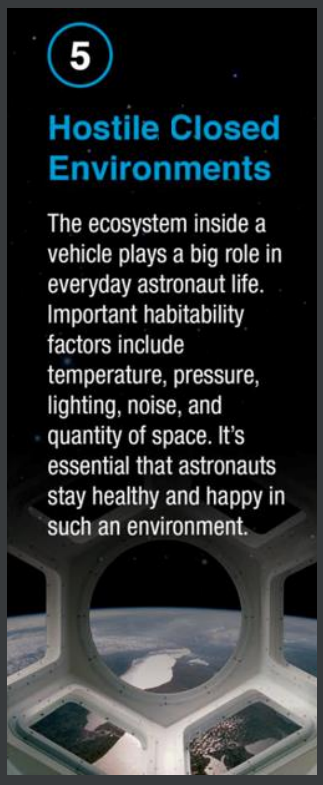
Commercial Destination Free Flyer Program (CDFF)



The purpose of the Commercial Lower Earth Orbit (LEO) Destinations project is to stimulate U.S. private industry development of free flyer orbital destinations and capabilities, and to create a market environment in which commercial LEO destination services are available to government and private sector customers. As part of current CDFF program activities, NASA is in the process of developing requirements for Phase 2. This will include potential competitive procurement by NASA of services in LEO, which would include certification of transportation and accommodations of NASA crew and payloads on CDFF by NASA. The 3001 Standards Team is supporting this process to help ensure there are no identified gaps within the drafted requirements, as well as within the NASA-STD-3001 as we move further towards Commercial Space.

Human System Risk Board (HSRB)

The NASA HSRB has the overall responsibility of managing and tracking the top ~30 human system risks of human spaceflight that are identified by the Health and Medical Technical Authority. As part of this process, the Board is charged with maintaining a consistent, integrated process to identify and assess the risks and identify possible mitigations by developing evidence-based risk posture recommendations. Recently, all HSRB risks incorporated a Directed Acyclic Graphs (DAGs) as a communication tool for describing how astronaut exposure to spaceflight hazards leads to meaningful mission-level health and performance outcomes, and is the basis for understanding intermediate causal relationships between risk contributing factors and countermeasures that link hazards to outcomes. The 3001 Standards Team has been supporting this project, along with the associated human system risks, to help identify any updates or gaps to the NASA-STD-3001 documents. The continued communication with the Board and OCHMO Team has established new working relationships to facilitate knowledge sharing throughout the agency.

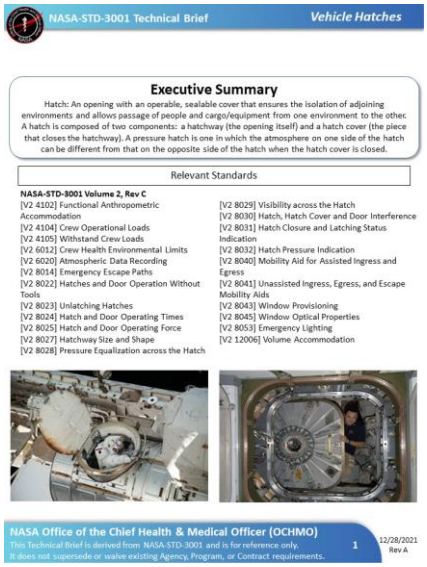


Standards Technical Briefs

Technical Briefs have been developed for certain topics to offer technical data, background, and application notes to aid with the development of hardware, systems, and vehicles, as well as human needs/limitations. These tech briefs integrate content from multiple Standards and provide a quick, informative resource to reference when working with NASA-STD-3001.

The Standards Team is currently updating all versions of the existing technical briefs to be consistent with the new NASA-STD-3001 Volume 1 Rev B and Volume 2 Rev C documents. In addition, since the last Newsletter release there have been 4 technical briefs added to the website:

- Carbon Dioxide (CO_2)
- Vehicle Hatches
- Health Stabilization Program (HSP)
- Artemis Lighting Considerations Overview
  (see page 4 for additional information)


NASA-STD-3001 Technical Brief — Vehicle Hatches

Executive Summary

Hatch: An opening with an operable, sealable cover that ensures the isolation of adjoining environments and allows passage of people and cargo/equipment from one environment to the other. A hatch is composed of two components: a hatchway (the opening itself) and a hatch cover (the piece that closes the hatchway). A pressure hatch is one in which the atmosphere on one side of the hatch can be different from that on the opposite side of the hatch when the hatch cover is closed.

Relevant Standards

NASA-STD-3001 Volume 2, Rev C
[V2 4102] Functional Anthropometric Accommodation
[V2 4104] Crew Operational Loads
[V2 4105] Withstand Crew Loads
[V2 6012] Crew Health Environmental Limits
[V2 6020] Atmospheric Data Recording
[V2 8014] Emergency Escape Paths
[V2 8022] Hatches and Door Operation Without Tools
[V2 8023] Unlatching Hatches
[V2 8024] Hatch and Door Operating Times
[V2 8025] Hatch and Door Operating Force
[V2 8027] Hatchway Size and Shape
[V2 8028] Pressure Equalization across the Hatch
[V2 8029] Visibility across the Hatch
[V2 8030] Hatch, Hatch Cover and Door Interference
[V2 8031] Hatch Closure and Latching Status Indication
[V2 8032] Hatch Pressure Indication
[V2 8040] Mobility Aid for Assisted Ingress and Egress
[V2 8041] Unassisted Ingress, Egress, and Escape Mobility Aids
[V2 8043] Window Provisioning
[V2 8045] Window Optical Properties
[V2 8053] Emergency Lighting
[V2 12006] Volume Accommodation

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This Technical Brief is derived from NASA-STD-3001 and is for reference only. It does not supersede or waive existing Agency, Program, or Contract requirements.

There are also several technical briefs in progress:

- Human-in-the-Loop (HITL)
- Mars Exploration
- Microbial Considerations in Spaceflight
- Environmental Control and Life Support System (ECLSS)

Human Integration Design Handbook (HIDH) Update

The HIDH is a companion document to NASA-STD-3001 Volume 2. It is a compendium of human space flight history, lessons learned, and design information for a wide variety of disciplines and provides background information on the rationale for human-system design Standards. The original HIDH was published in January 2010 with a Revision released in June 2014.

We are in the early stages of pre-revision, and the HIDH will be updated in its entirety. Due to the large size of this document (currently 1,100+ pages), we will be revising each section individually to better address all the content and topics with precision.

The current chapters of the HIDH include:

1. Scope
2. Applicable Documents
3. General
4. Anthropometry, Biomechanics and Strength
5. Human Performance Capabilities
6. Natural and Induced Environments
7. Habitability Functions
8. Architecture
9. Hardware and Equipment
10. Crew Interfaces
11. Extravehicular Activity (EVA)
12. Operations
13. Ground Maintenance and Assembly

If you have a question about the forthcoming HIDH update, please contact Kristin Coffey (kristin.m.coffey@nasa.gov) or Sarah Childress (sarah.d.childress@nasa.gov). If you have a suggestion for changes to be included in the revised HIDH, you can submit them using the NASA 3001 Document Standard Changes form in SharePoint, and selecting HIDH as the Document.

Thank You!

The OCHMO Human Spaceflight Standards Team is honored to have been recently recognized for their work by NASA with the Group Achievement Award and by the Human Health and Performance Contract (HHPC) with the HHPC Team Bravo Award!! We greatly appreciate the recognition, and we wish to acknowledge all the SMEs who help ensure the appropriate and correct information is captured in all NASA-STD-3001 standards.

Contact Us

The OCHMO Standards Team, led by NASA Technical Standards Manager Dave Francisco, has experience working with the NASA-STD-3001 documents as well as the program requirements that flow from them. They are willing to meet for consultations to clear any confusion regarding technical standards, provide clarification for the intent of specific standards, or further describe the formation of standards from risks.

They can be contacted via e-mail:

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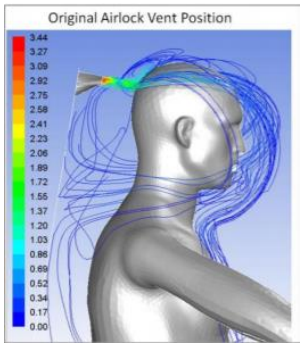
Collaborative HRP Research Studies to Inform Standards

CO_2 Washout

CO_2 washout studies are ongoing, and the National Engineering and Safety Center (NESC) will provide additional insight to the new data collected and human risks associated with inspired CO_2 during suited operations. This data will be used to update relevant existing standards and create new standards as needed.



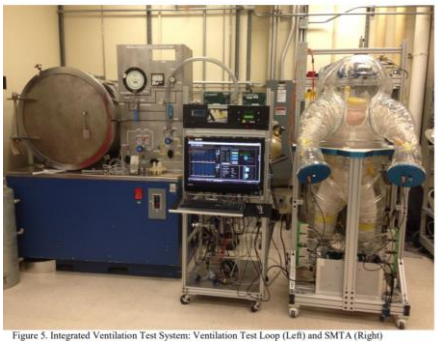


Figure 5. Integrated Ventilation Test System: Ventilation Test Loop (Left) and SMTA (Right)

Acceleration & Vibration Guidelines for Lunar Terrain Vehicles (LTV)

The HRP generated a proposed list of new acceleration and vibration standards specific to LTVs and the Standards team generated a set of standards and program requirements for the LTV program. In addition, the Standards Team is in the process of building a new section to add to NASA-STD-3001 Volume 2 dedicated to Surface Vehicles, which will include the new LTV standards.

Automation/Autonomy Guidelines and Standards for Space Vehicles

The HRP reviewed over 100 documents, captured relevant standards, and quantified the co-occurrence of those standards across the most relevant documents. This analysis was corroborated with interviews conducted with subject matter experts in the Department of Defense (DoD), the Federal Aviation Administration (FAA), the nuclear industry, Apple, and Google. The Automation/Autonomy team generated a final report for OCHMO-Human Factors and Behavioral Performance (HFBP) that is being reviewed by the Standards Team. The report yielded guidance for new automation standards organized into topic areas such as human-automation itneraction, transparency, development processes, and crew preparation. The Standards Team is currently drafting new standards based on the guidance received.