Office of the Chief Health and Medical Officer
OCHMO
Human Spaceflight Standards
Health and Medical Technical Authority (HMTA)

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OCHMO
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https://www.nasa.gov/offices/ochmo/human_spaceflight/index.html

NASA Standards for Spaceflight

Knowledge Capture, Sets Agency Risk Posture, Generation of Program Requirements

Selection, Certification and Crew Health Standards

OCHMO-STD-100.1A
NASA Crewmembers Medical Standards
- Selection and Periodic Certification

NASA Space Flight Human-System Standard
NASA-STD-3001, VOLUME 1, Crew Health -
Rev. B Pending

Detailed Guidance

NASA Handbook
NASA/SP-2010-3407, Human Integration Design Handbook, June 2014 - Update in Progress

Technical Briefs

Engineering Application Notes
https://www.nasa.gov/offices/ochmo/human_spaceflight/index.htm

Vehicle Design for Humans

NASA Space Flight Human-System Standard
NASA-STD-3001, VOLUME 2, HUMAN FACTORS…
Rev. C - Pending

Spacecraft Water Exposure Guidelines for Selected Waterborne Contaminants JSC 63414

Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants JSC 20584

Guidelines for Assessing the Toxic Hazard of Spacecraft Chemicals and Test Materials JSC 26895

NASA Office of the Chief Health & Medical Officer

Human Spaceflight Standards NASA-STD-3001

Protecting Health Outcomes
- Cardiovascular Deconditioning
- Muscular Atrophy
- Bone Loss
- Radiation Exposure
- Renal Stones
- Behavioral Support
- Sleep
- Nutrition – food system
- Microbiome

Performance Bands
- Aerobic
- Muscular
- Orthostatic
- Sensorimotor
- Cognitive

} Mission Tasks

Spacecraft System Design
- Dynamic Loads, Vibration
- Landing Control – Sensorimotor
- Net Habitable Volume/Layout
- Automation
- Usability, Error Analysis, cognitive workload
- Displays and Controls, Lighting
- Acoustics
- Shielding

Environmental Levels
- Air – CO_2
- Water Quality and Quantity
- Maximum Allowable Concentrations of Compounds Celestial Dust
- Microbial

LEA/EVA Suit Design
- Performance
- Biometric Data
- Decompression Protocol
- Suit Pressure

Medical Care
- Determination of Medical Conditions
- In-mission Treatment
- Medical Equipment
- Supplies
- Protocols
- Clinical Practice Guidelines

Medical Operations
- Roles and Responsibilities
- Flight and Ground Care
- Console Operations

Mission Operations
- Autonomy, Task Evaluations
- Training

Ground Processing
- Ground Crew Human – H/W Interfaces
- Maintenance Requirements

ISS
Gateway
Dragon
Starliner
Orion
Soyuz

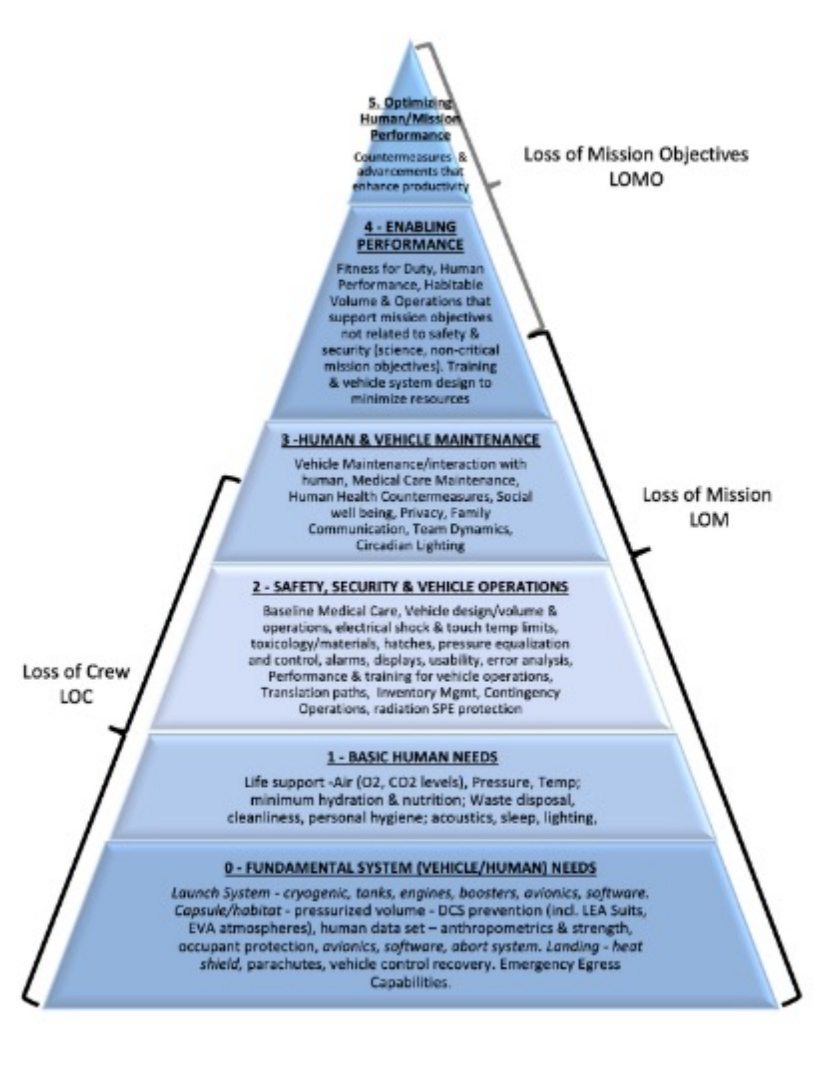
Human Spaceflight Standards Hierarchy Pyramid

- “Standards pyramid of hierarchy” was developed to aid in the determination of individual standard's impact on missions.

- The purpose of this tool is to help look “across” all of the standards and assess their impact on a mission’s success related to loss of crew (LOC), loss of mission (LOM), and loss of individual mission objectives (LOMO).

- Categorizes standards that increase the probability of achieving mission objectives.

- Standards are in a CRADLE database that can be searched with keywords, sorted, exported and linked to program requirements



Goal is to maintain proper risk posture while determining the minimum applicability of standards for programs during the formulation stage of development

https://www.nasa.gov/offices/ochmo/human_spaceflight/index.html

OCHMO Human Spaceflight Standards - 3001

Educate vendors on Human Spaceflight Requirements and Implementation

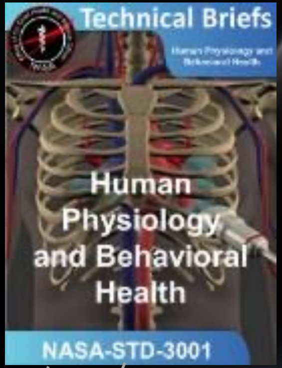
Technical Briefs (4-12 pages)

Educate vendors on Human Spaceflight

Integration of Requirements, Evidence/reference Data, Design and Application notes

Over 200 standards summarized and Integrated in Tech Briefs below:

- Acceleration
- Acoustics
- Apollo Lunar Lander
- Cabin Architecture
- Cognitive Workload
- Electrical Shock
- Lighting Design
- Hatch Design
- Radiation Protection
- Usability, Workload, Error
- Toxicology



- Behavioral Health
- Bone Loss
- DCS Technical Brief
- Carbon Dioxide (CO_2)
- Food and Nutrition
- Lunar Dust
- Orthostatic Intolerance
- Waste Management
- Water Consumption

- Health Stabilization Program
- Longitudinal Health Surveillance
- Medical Care
- Pharmaceuticals

- Behavioral Health
- Decompression
- Entry Landing
- EVA Mishaps

Vehicle Design Notes on how to design hatches, implement acoustics, electrical shock, radiation protection

Waste Mgmt System Considerations, food, water

Decompression Sickness Application Notes – Resources vs. DCS Risk

Provides information to develop end to end medical care, Selection, Health Stabilization, In flight Medical, Pharmaceutical list, and Post flight care

https://www.nasa.gov/offices/ochmo/human_spaceflight/index.htm
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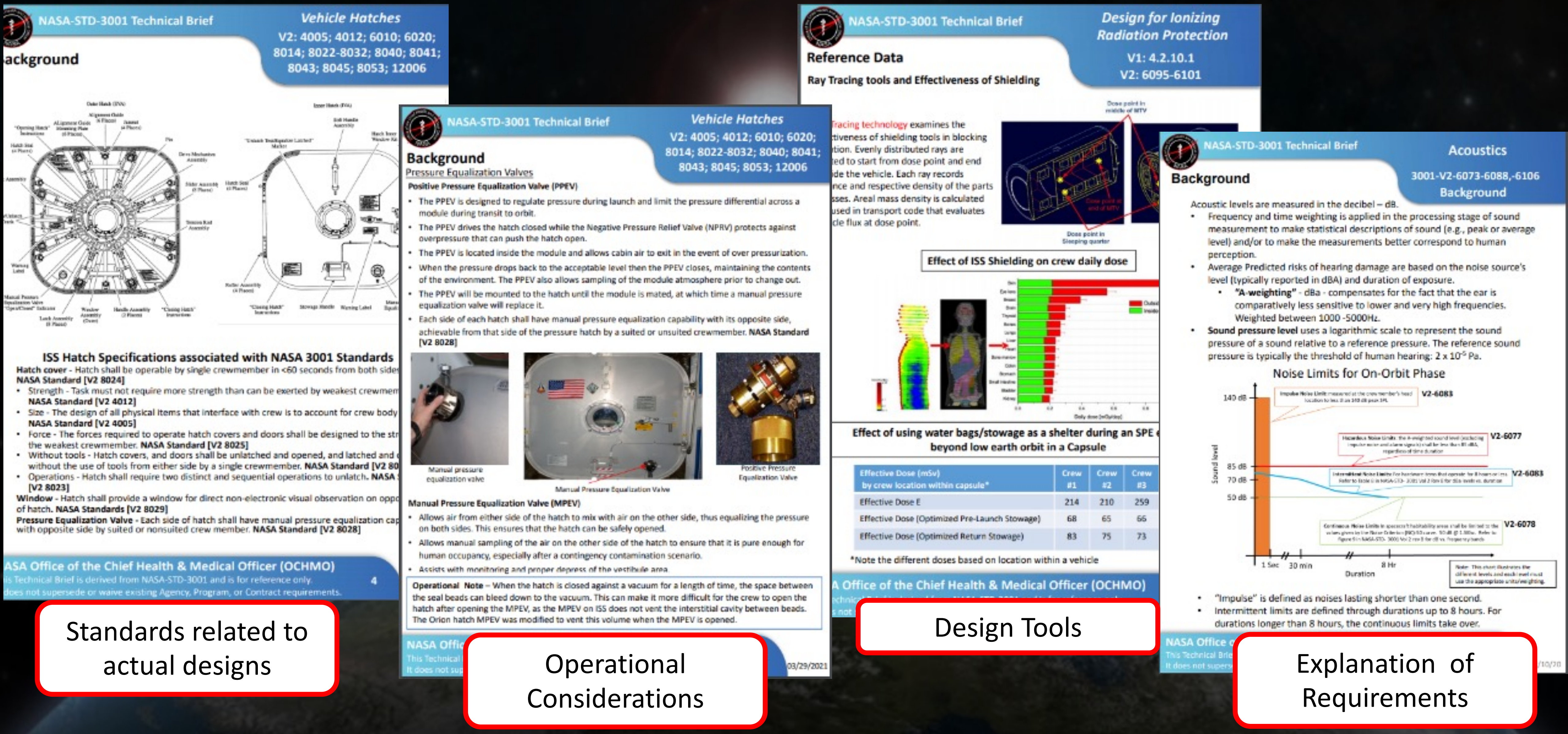
Technical Briefs - Examples



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OCHMO Radiation Standards

Astronaut's total career effective radiation dose (In 3001, Vol 1 Rev B) **600 mSv**

Universal for all ages and sexes, 3% mean risk of cancer mortality, effective dose calculated using 35-year-old female

An individual astronaut's total career effective radiation dose due to space flight radiation exposure shall be less than **600 mSv.**

Galactic Cosmic Radiation (GCR) (under consideration) - achievable with ~10g/cm^2 Al

For missions beyond low Earth orbit, vehicles and habitat systems shall provide sufficient protection to reduce exposure from galactic cosmic radiation (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.

250 mSv

20 mSv

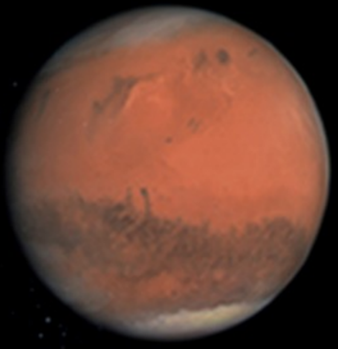
Nuclear Technologies (In 3001, Vol 1 Rev B)

Radiological exposure from nuclear technologies emitting ionizing radiation (e.g., radioisotope power systems, fission reactors, etc.) to crew members shall be less than an effective dose of **20 mSv** per mission year (prorated/extrapolated to mission durations).

Solar Particle Event (SPE) (In 3001, Vol 1 Rev B)

The program shall protect crewmembers from exposure to the Design Reference Solar Particle Event (SPE) Environment Proton Energy Spectrum (sum of the October 1989 events) to less than an effective dose of **250 mSv**).

Space Flight Human System Standards – NASA-STD-3001, Vol 1
Crew Career Permissible Exposure Limit for Space Flight Radiation

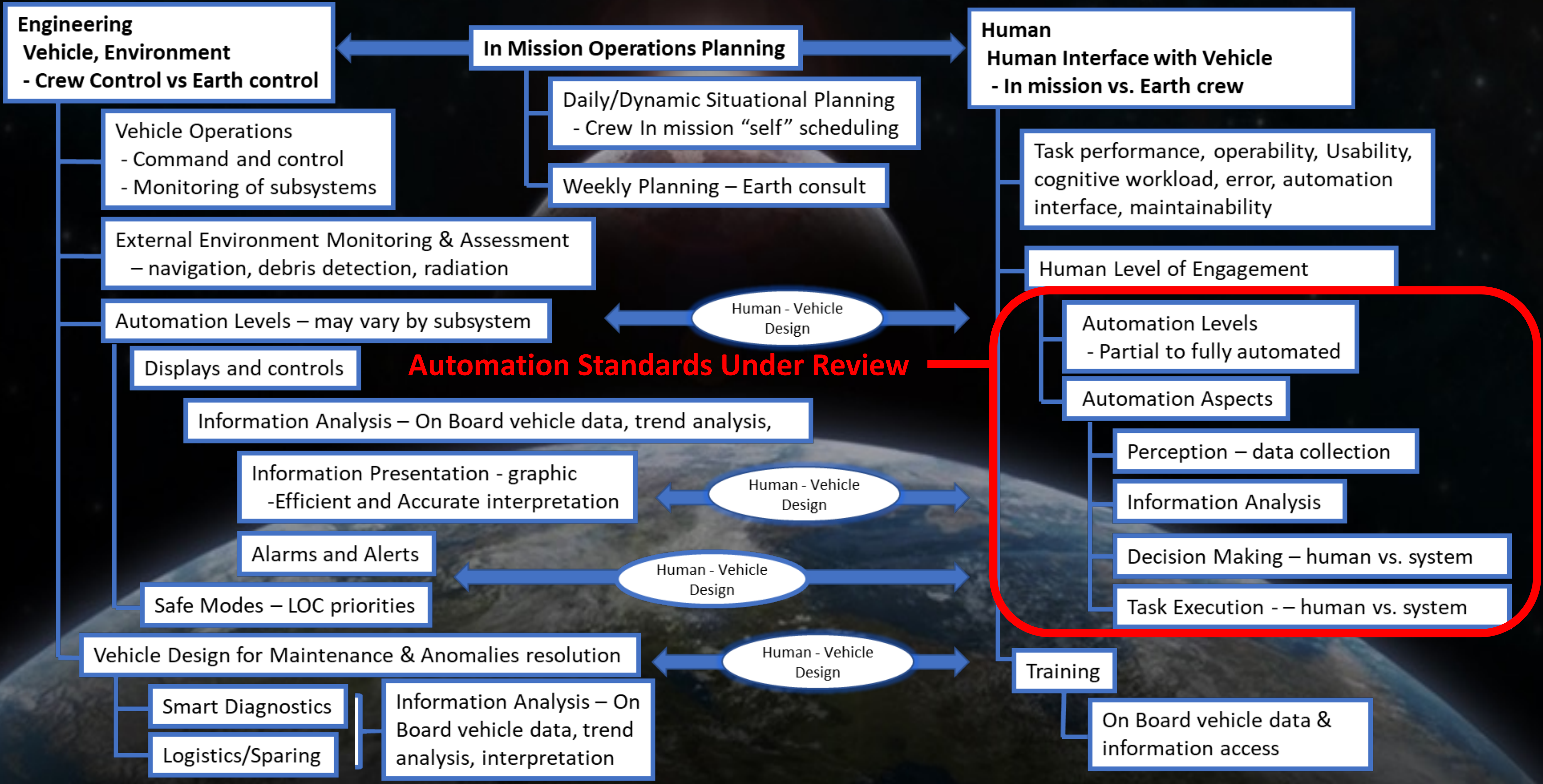


Sample Calculation – Male & Female Crew Members - 3 Missions						
Age	**Location**	**Duration Days**	**Solar Cycle**	**Universal Effective Dose mSv**	**Female Mean REID %**	**Male Mean REID %**
38	ISS	180	Min	86	0.37	0.27
44	ISS	180	Max	77	0.31	0.23
50	Lunar Surface	180	Min	222	0.82	0.61
50	Fission Power Source on Lunar Surface (Standard is < 20 mSv/year)	180	N/A	10	0.04	0.03
50	SPE Event in Orion Shielded (low probability occurrence)		N/A	125	0.50	0.37
	Totals	**540 Days**		**520 mSv**	**2 %**	**1.5 %**

520 mSv of 600 mSv Career Dose Limit

Effective dose equivalent is based on known variations in human organ susceptibility to radiation (weighting factors) to radiation of the various organs of the body and is sex dependent. To determine career dose, female weighting factors (most conservative) are utilized for both male and female crew calculations.

Earth Independent Operations
Less Reliance on Ground Support
Hardware and Software Design to enable Automation



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Summary

There are many opportunities for collaboration to reduce the human risks of exploration!

https://www.nasa.gov/offices/ochmo/human_spaceflight/index.html

OCHMO Human Spaceflight Standards Backup

4.8.2 Career Space Permissible Exposure Limit for Space Flight Radiation

[V1 4030] An individual astronaut's total career effective radiation dose due to space flight radiation exposure shall be less than 600 mSv.

[Rationale: This limit is universal for all ages and sexes. The total career dose limit is based on ensuring all astronauts (inclusive of all ages and sexes) remain below 3% mean risk of cancer mortality (risk of exposure-induced death [REID]) above the non-exposed baseline mean. Individual astronaut career dose includes all past space flight radiation exposures, NASA biomedical research exposures, plus the projected exposure for an upcoming mission. The effective dose is calculated using the NASA Q (based on the NASA cancer model of 2012) 35-year-old female model parameters (weighting factors, quality factors, etc.) for both males and females. This standard protects the career limits for all organs in Table 3, Dose Limits for Short-Term or Career Non-Cancer Effects (in mGy-Eq or mGy) (see [V1 4032]). Due to variability and subjectivity of the selection of model parameters, the model should not be updated unless a 25-30% change is seen in the effective dose associated with the 3% mean REID calculation.]

https://www.nasa.gov/offices/ochmo/human_spaceflight/index.html

OCHMO Human Spaceflight Standards Team Backup

4.8.3 Short-Term Radiation Limits – Solar Particle Events

[V1 4031] The program shall protect crewmembers from exposure to the Design Reference Solar Particle Event (SPE) Environment Proton Energy Spectrum (sum of the October 1989 events) to less than an effective dose of 250 mSv).

[Rationale: The 250 mSv effective dose threshold was chosen to minimize acute effects and protects for the short-term limits for all organs listed in Table 3. See Table 3 for short-term dose limits. In the design process, ALARA ensures optimization of the design to afford the most protection possible within other constraints of the vehicle systems. The additional protection significantly contributes to the mitigation of long-term health effects such as cancer (refer to crew career radiation dose standard [V1 4031]).

The Design Reference SPE Environment Proton Energy Spectrum is referenced in Table 4, Design Reference SPE Environment Proton Energy Spectrum.

https://www.nasa.gov/offices/ochmo/human_spaceflight/index.html

OCHMO Human Spaceflight Standards

4.8.4 Crew Radiation Limits for Nuclear technologies

[V1 4032] Radiological exposure from nuclear technologies emitting ionizing radiation (e.g., radioisotope power systems, fission reactors, etc.) to crew members shall be less than an effective dose of 20 mSv per mission year (prorated/extrapolated to mission durations) and ALARA.

[Rationale: This limit is based on not adding more than 10% radiation exposure beyond the space environment radiation of the mission. Based on an analysis for a surface-based mission (see Figure 2, Effective Dose (mSv per Mission Day) Variation with Solar Cycle), the radiation environment exposure is approximately 0.5 mSv per day; and 10% of this value sets the standard to 0.05 mSv per day and ~20 mSv/mission year. This standard is applied to both surface and free-space missions.

For a typical surface power application, the allowable astronaut dose can be converted to an effective reactor dose for shield sizing. The effective reactor dose would be calculated by estimating the time an astronaut spends in a shielded habitat versus the time spent during unshielded EVAs over a typical mission timeline. Exact mission assumptions should be considered when performing the calculation; parameters should include estimates of time in a habitat, habitat shielding, and EVA frequency. Example parameters to be considered: time fraction (67%) in the habitat, habitat shielding (20 g/cm2), terrain shielding, distance from source, line of sight to source, and time fraction (33%) of performing EVAs.

Space radiation and radioactive source tradeoff for a waiver of standard consideration: For missions that are leveraging nuclear sources for a propulsion system, the tradeoff of reduced mission duration due to faster transit which reduces the crew exposure to space flight radiation exposure should be considered compared to the increased exposure due to the nuclear source. For example, if the nuclear propulsion system saved 90 days of exposure during the transit to Mars which equates to 1.5 mSv/day × 90 days = 135 mSv "saved" space flight radiation exposure and the source generates 150 mSv, then the net exposure is +15 mSv. Other considerations for reduced mission time on engineering risks (systems reliability, logistics, etc.) and other human risks such as bone loss, renal stone development, and medical care should also be considered in the waiver process.]