



HUMAN FACTORS STANDARDS FOR US GOVERNMENT AGENCIES

CONSISTENCY ACROSS STANDARDS OR STANDARDS IN A NEW BUSINESS MODEL



Human Factor and Ergonomics Society
54th Annual Meeting
San Francisco, CA
September 27-30, 2010

Standards in a Changing Business Model

- The business model for human spaceflight is rapidly changing. A question for today's discussion is:
 - *Does the changing business model call for a change with regard to standards?*
 - *What is the appropriate role for standards in the new model?*
 - *How can standards facilitate success in the new model?*
 - *What will be characteristics of success-oriented standards?*

The New National Space Policy is Driving Change

- One goal of our new national space policy is to:
 - Energize competitive domestic industries to participate in global markets and advance the development of: satellite manufacturing; satellite-based services; space launch; terrestrial applications; and increased entrepreneurship.
- From the policy comes specific charge to NASA to:
 - *"Contract with industry, to provide ISS transport to and from the ISS for NASA astronauts as soon as possible to reduce the risk of dependence on foreign transport."*



A New Paradigm for Human Spaceflight

- In previous human spaceflight programs NASA:
 - Had total oversight responsibility
 - Made all major decisions
 - Closely oversaw all details of design, development, testing, production, and launch preparation
 - Civil Servants maintained ultimate decision authority in all matters

A New Paradigm (continued)

- In the new model, NASA:
 - Assumes an insight / oversight partnership with its industry providers
 - Closely follows the design, development, integration, and testing of the vehicle
 - Observes production practices of the provider
 - Civil Servants become trusted key members of the overall commercial crew provider team
 - Gains significant insight into issues or concerns that impact vehicle
 - Final decisions on high-expense or contentious recommendations made by NASA *and* the partner.



Consistency Across Standards

What is the appropriate role for standards in the new model?

The Purpose of Standards

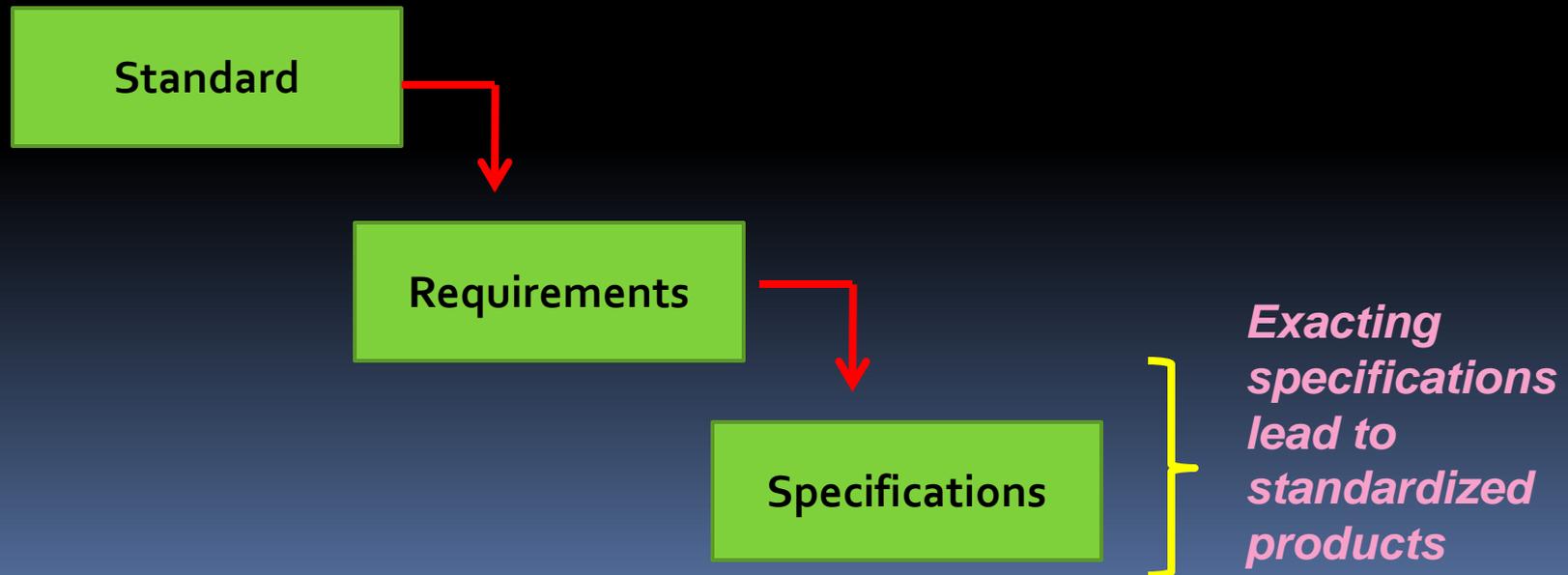
Use #1: Ensure attributes of end product

- *The primary role of standards is to standardize the process, material, application, and testing of an "acquisition product" to ensure that the end product achieves minimum attributes deemed essential to its service.*
 - **Standardization Journal; July, 2005**

The Purpose of Standards

Use #1 (continued)

- Standards lead to standardized processes and materials through end product requirements and specifications.



The Purpose of Standards

- NASA examples:

NASA-STD-3001, Vol 2



Commercial Human System Integration Requirements (CHSIR)

| | | | |
|-------------------------|--|--|---|
| Rate of Pressure Change | [6007] The rate of change of total internal vehicle pressure shall be limited to between -206842 Pa/min (-30 psi/min) (-1552 mmHg/min) and 93079 Pa/min (+13.5 psi/min) (698 mmHg/min) | | [CH6002] The system shall limit exposure of the crew to the rate of change of total internal pressure to between -207 kPa (-30.0 psi) (-1,550 mmHg)/min and +93.1 kPa (+13.5 psi) (+698 mmHg)/min during nominal operations. |
| Temperature Range | [6013] The system shall maintain the atmospheric temperature within the range of 18 °C (64.4 °F) to 27 °C (80.6 °F) during all nominal operations, excluding suited operations, ascent, entry, landing, and post-landing. | | [CH6005] The system shall maintain the atmospheric temperature within the range of 18 °C (64.4 °F) to 27 °C (80.6 °F) during all nominal flight operations, excluding suited operations, ascent, entry, landing, and post-landing. |
| Atmospheric Control | [6017] The system shall allow the crew to control atmospheric pressure, humidity, temperature, and ppO2. | | [CH6009] The system shall provide the capability for crew control of atmospheric parameters and set-points for atmospheric pressure, ppO2, temperature, humidity, and ventilation. |
| Combustion Monitoring | [6024] The system shall continuously monitor toxic atmospheric components that would result from pre-combustion and combustion events before, during, and after the event and alert the crew in sufficient time for them to take appropriate action. | | [CH6029] The system shall provide a real time capability for the measurement and display to the crew of the atmospheric concentrations of toxic combustion products in the following ranges: carbon monoxide (CO) from 5 to 500 ppm, hydrogen cyanide (HCN) from 1 to 50 ppm, and hydrogen chloride (HCl) from 1 to 50 ppm. |

The Purpose of Standards

Use #2: Ensure Confidence in Design

- Over 49 years, that experience is based on only a few hundred launches of just a handful of designs.
- Use of fully-vetted standards to derive design requirements leads to confidence in (and insight into) design
- *The breadth and depth of the flight test program will depend on a number of factors including system maturity and depth of insight into design and verification. (from the NASA Commercial Human-Rating Plan CCT-1001, May 21, 2010)*

The Purpose of Standards

Use #3: Document Lessons Learned

- *It is imperative that new engineers have access to the wisdom behind the specifications, so explanations like "that's the way it's always been done" are replaced by "that specific requirement is in there because...." A standardized process for capturing lessons learned from specifications is needed. July 2005 Standardization Journal*

The Purpose of Standards

Use #4: Human Rating of Spacecraft

- Standards are an important part of the process for human rating of a spacecraft
 - Human spaceflight is an important aspect of our overall space program, and human rating is an incredibly important part of making that successful, safe.
 - *"Because it's illogical to rely on commercial providers to provide their own requirements for contractual services on human spaceflight, the Aerospace Advisory Panel strongly believes that specific criteria should be developed to establish how safe is safe enough..."* **Robert Dickman, Executive Director AIAA**



Consistency Across Standards

How can standards facilitate success in the new model?



Consistency Across Standards

- All COTS and Commercial Resupply Service programs set up to supply the ISS launches will be FAA-licensed.
- **We need consistent, consensus standards to facilitate the licensing process.**

- *"I'd really like to see a dialogue within the aerospace community, with the goal of coming up with what are really industry consensus standards, even if the first draft is provided by NASA through an RFI, that would lay out some top-level principles and practices we can all agree on that would provide a basic safety foundation."*
 - George C. Nield, Associate Administrator for Commercial Space Transportation, FAA

Danger of Over-Prescriptive Standards

- *"The danger if we're too prescriptive on the requirements, we may inadvertently prevent the innovation and creativity needed for safer, more cost effective systems."*
 - George C. Nield, Associate Administrator for Commercial Space Transportation, FAA

A Balance Is Needed



Consistency Across Standards

- *"We worked very hard with the Air Force on the Eastern Range to develop common safety standards, so that even if it wasn't word for word, the intent of every requirement for launching off the Range is equivalent, so there wouldn't be conflicting standards whether it was a launch for the Air Force or a commercial vehicle."*
 - George C. Nield, Associate Administrator for Commercial Space Transportation, FAA

Enabling vs Inhibiting

- *"It's important that we build **standards** that will enable companies to build alternatives to Soyuz and not set up roadblocks that guarantee that we'll be flying on Soyuz forever."*
 - **Ken Bowersox**, vice president of astronaut safety and mission assurance development, Space Exploration Technologies



Consistency Across Standards

What will be characteristics of success-oriented standards?



Characteristics of Success-Oriented Standards

- The FAA will soon be licensing commercial providers to carry astronauts into space and to ISS.
 - To facilitate certification and licensing, we can identify some characteristics of success-oriented standards.
- 

Success-Oriented Standards

Standards should:

1. **Be evidence-based**

- Clear linkage to references (peer-reviewed literature)

2. **Include a rationale**

- Explains basis of the standard and captures lessons learned
- For example, is the air quality standard based upon concerns about crew health or the health of the air revitalization system?

Success-Oriented Standards

Standards should: (continued)

3. Enable progress

- No single model or approach is mandated.
- Encourages contribution and provides the taxonomy and formalism for making contributions
- Robust in scope and format to support and encourage evolutionary progress
- Performance-based and process-based standards typically enable progress

Success-Oriented Standards

Standards should:

3. Enable progress (continued)

- Example of a process-based standard: ISO 21348:2007(E) Space environment (natural and artificial) — Process for determining solar irradiances
- **4.3 Process-based standard:** *This International Standard does not specify one measurement set, one reference spectrum, one solar model or one solar irradiance proxy/index as a single standard. In order to encourage continual improvements in solar irradiance products, this International Standard is a process-based standard for determining solar irradiances. A solar irradiance product, after its development, may follow the process described in Clause 7 to certify compliance with this International Standard.*

Conclusions

- Standards serve many the same functions in the new human spaceflight business model:
 - Standardize key aspects of end products
 - Drive requirements and specifications
 - Lead to confidence in design
 - Document Lessons Learned
 - Human Rating of Spacecraft
- Consistency across standards can help assure success in the new model
 - In the writing of a standard, a proper balance must be struck between prescriptive specificity and enabling generality



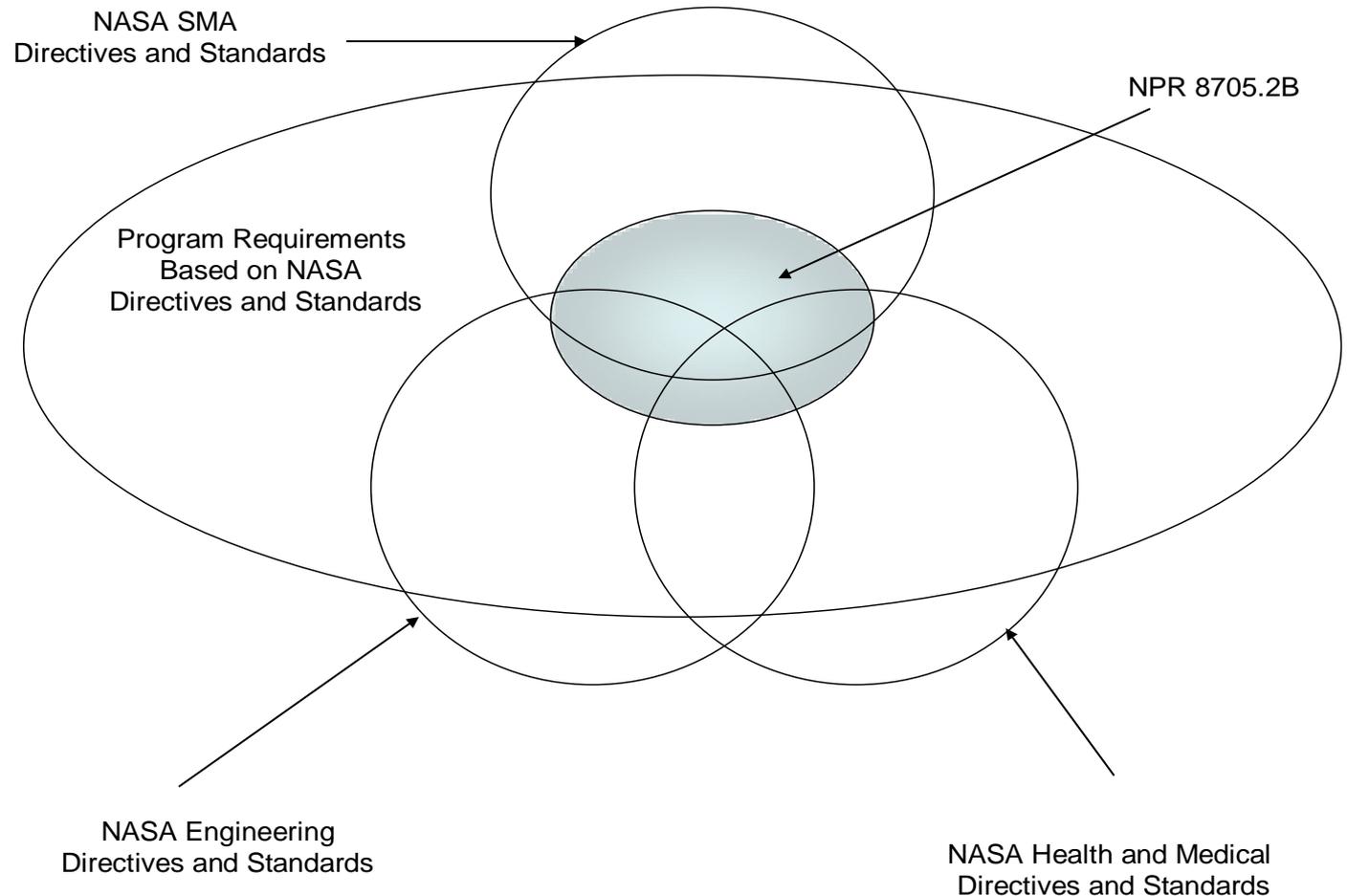
Conclusions

- To facilitate success, future standards should:
 - Be evidence based
 - Include rationale
 - Enable progress



Backup Information

NASA Procedural Requirements 8705.2B Identifies Human Rating Standards & Requirements



Draft Health & Medical Standards for Human Rating

Mandatory Standards for Health and Medical

NASA-Standard-3001 Volumes 1 and 2

FAA Human Factors Design Standard
(applicable for ground processing)

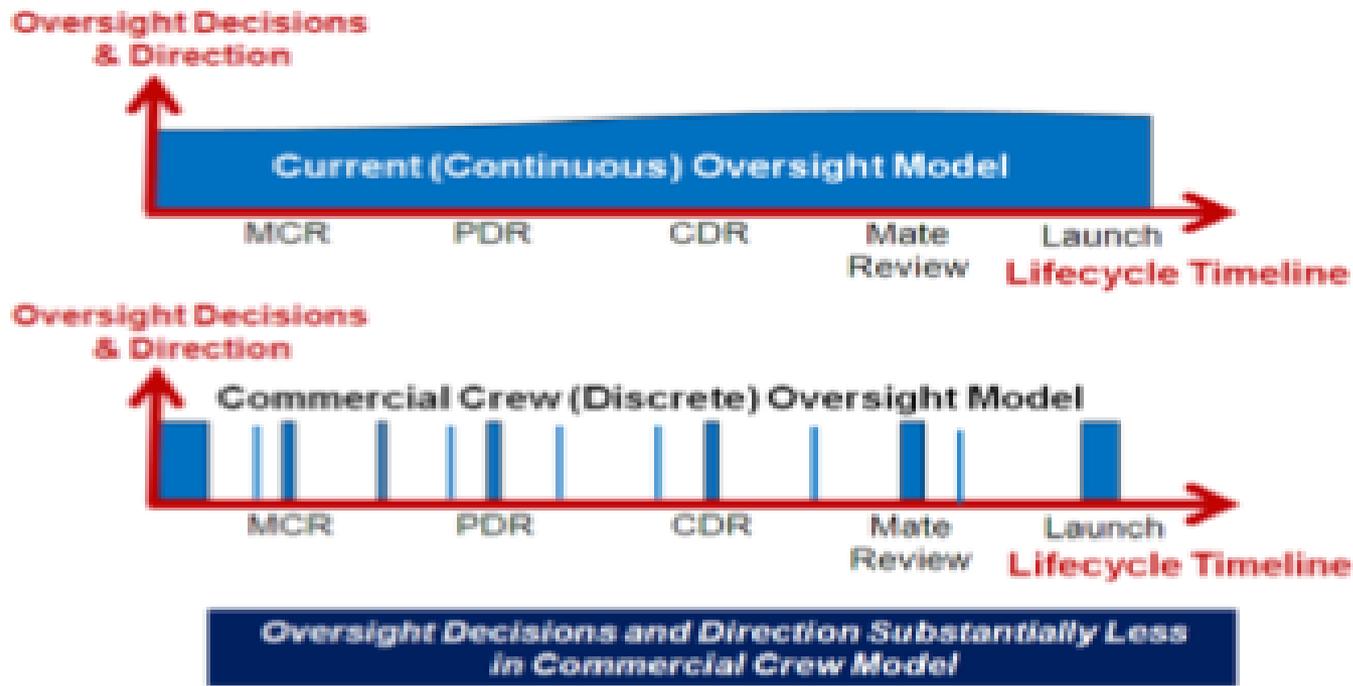
MIL-STD-1472 Human Engineering,
Design Criteria for Military Systems,
Equipment, and Facilities (applicable for
ground processing)

NASA-STD-3000 Volumes I-II, Man
Systems Integration Standard

What's Been Done

- In May, 2010, NASA sent out Commercial Crew Transportation (CCT) Request For Information (RFI) (NNH10ZTT005L)
- The RFI lists mandatory requirements for human rating and requests industry input.
 - Discuss any aspects of the NASA documents contained in this RFI that result in significant cost, schedule, or technical impacts to your company's CCT system.
 - What clarifications or suggestions do you propose to minimize impacts or improve design flexibility, safety, or reliability?
 - Provide rationale for any alternative suggestions that may meet or exceed the intent of these requirements and standards

Government Oversight Models



Government Oversight Models

Examples of Consistency: Anthropometry

1st and 99th Percentiles

| Measure (in) | HFES | HDIH | Max Delta |
|----------------------|-----------|-----------|-----------|
| Stature | 58.4/75.2 | 58.5/76.6 | 1.4 (2%) |
| Sitting Height | 30.5/39.0 | 30.6/39.9 | 0.9 (2%) |
| Eye Height, sitting | 26.1/34.2 | 26.2/35.0 | 0.8 (2%) |
| Knee Height, sitting | 17.9/24.5 | 17.9/25.0 | 0.5 (2%) |

5th and 95th Percentiles

| Measure (in) | HFES | Mil Std 1472 | Max Delta |
|----------------------|-----------|-----------------|-----------|
| Stature | 60.2/73.5 | 60.0/73.1 | 0.4 (1%) |
| Sitting Height | 31.3/38.3 | 31.0/38.1 | 0.3 (1%) |
| Eye Height, sitting | 27.0/33.4 | 26.7/33.3 | 0.3 (1%) |
| Knee Height, sitting | 18.7/23.9 | 18.5/23.7 | 0.2 (1%) |

Example of Inconsistency: Air Quality

| Compound | GOST *(ppm) | NRC** (ppm) |
|----------|----------------|--------------------------|
| Ethanol | 10 (360 days) | 1000 (180 and 1000 days) |
| Benzene | 0.2 (180 days) | 0.07 (180 days) |
| Butanol | 0.8 (360 days) | 12 (180 and 1000 days) |
| Toluene | 8.0 (360 days) | 4.0 (180 and 1000 days) |

* STATE STANDARD OF THE RUSSIAN FEDERATION - COSMONAUT'S HABITABLE ENVIRONMENTS ON BOARD OF MANNED SPACECRAFT, GOST 50804

** National Research Council, Spacecraft Maximum Allowable Concentrations (multiple volumes)



Appendix A

List of Government Human Factors Standards

- NASA-STD-3001, NASA SPACE FLIGHT HUMAN-SYSTEM STANDARD VOL 2: HUMAN FACTORS, HABITABILITY, AND ENVIRONMENTAL HEALTH; 2009
- CxP 70024, CONSTELLATION PROGRAM HUMAN-SYSTEMS INTEGRATION REQUIREMENTS, Rev D; 2009
- MIL-STD-1472D, HUMAN ENGINEERING DESIGN CRITERIA FOR SYSTEMS, EQUIPMENT AND FACILITIES; 1989
- DOT/FAA/CT-03/05, HF-STD-001, HUMAN FACTORS DESIGN STANDARD (HFDS) For Acquisition of Commercial Off-The-Shelf Subsystems, Non-Developmental Items, and Developmental Systems; 2003
- NASA/SP-2010-3407, HUMAN INTEGRATION DESIGN HANDBOOK (HIDH), 2010



Appendix B

Non-Goovernmental Human Factors Standards

- **IEEE Std 1023-1988, Guide for the Application of Human Factors Engineering to Systems, Equipment and Facilities of Nuclear Power Generating Stations**