DEVELOPMENT OF A HUMAN SYSTEMS INTEGRATION PLAN

Jackelynne Silva-Martinez and Sherry Thaxton

NASA Johnson Space Center

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Lab Window
Vacuum Line
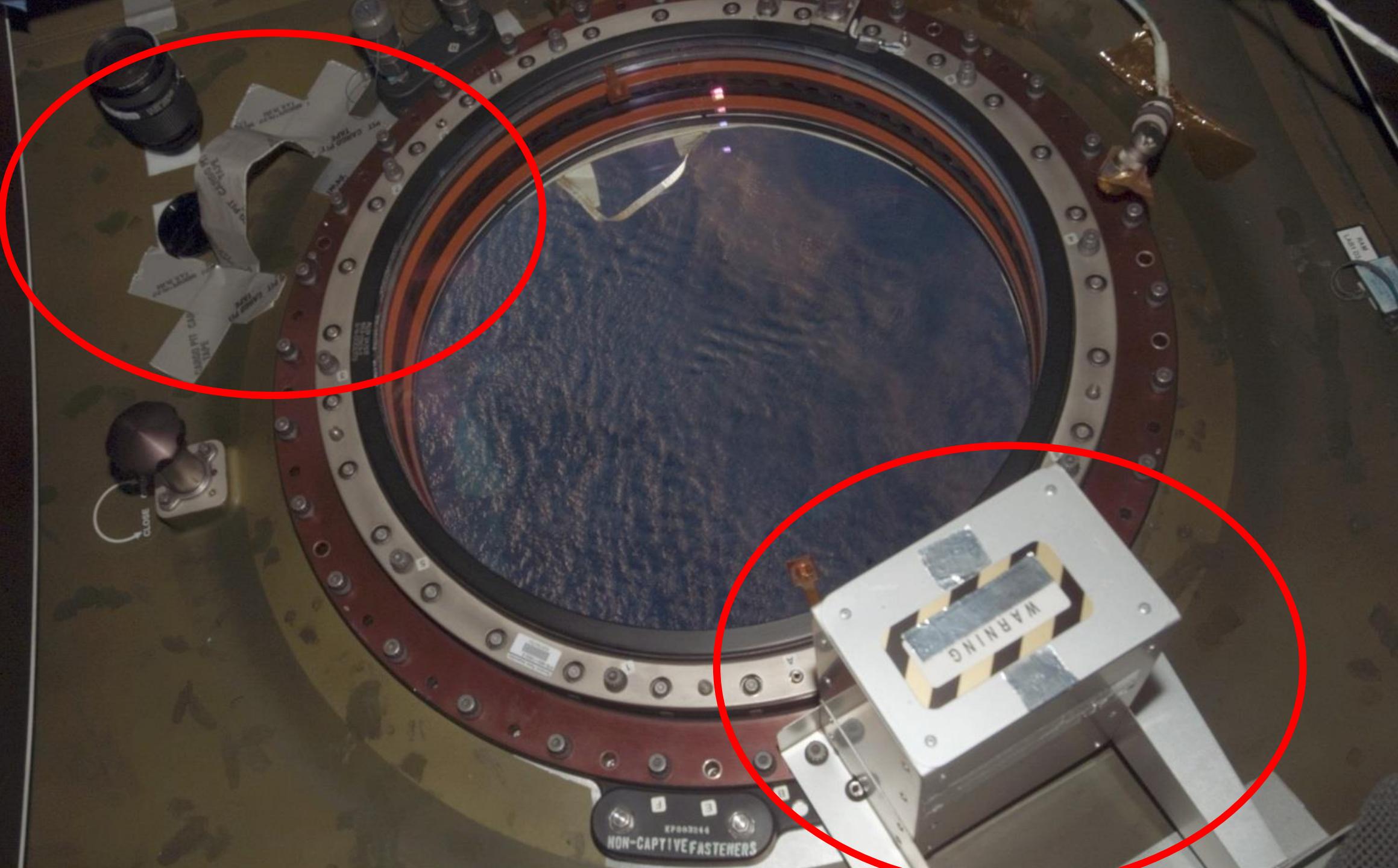
Carbon Dioxide Removal Assembly

Robonaut on ISS
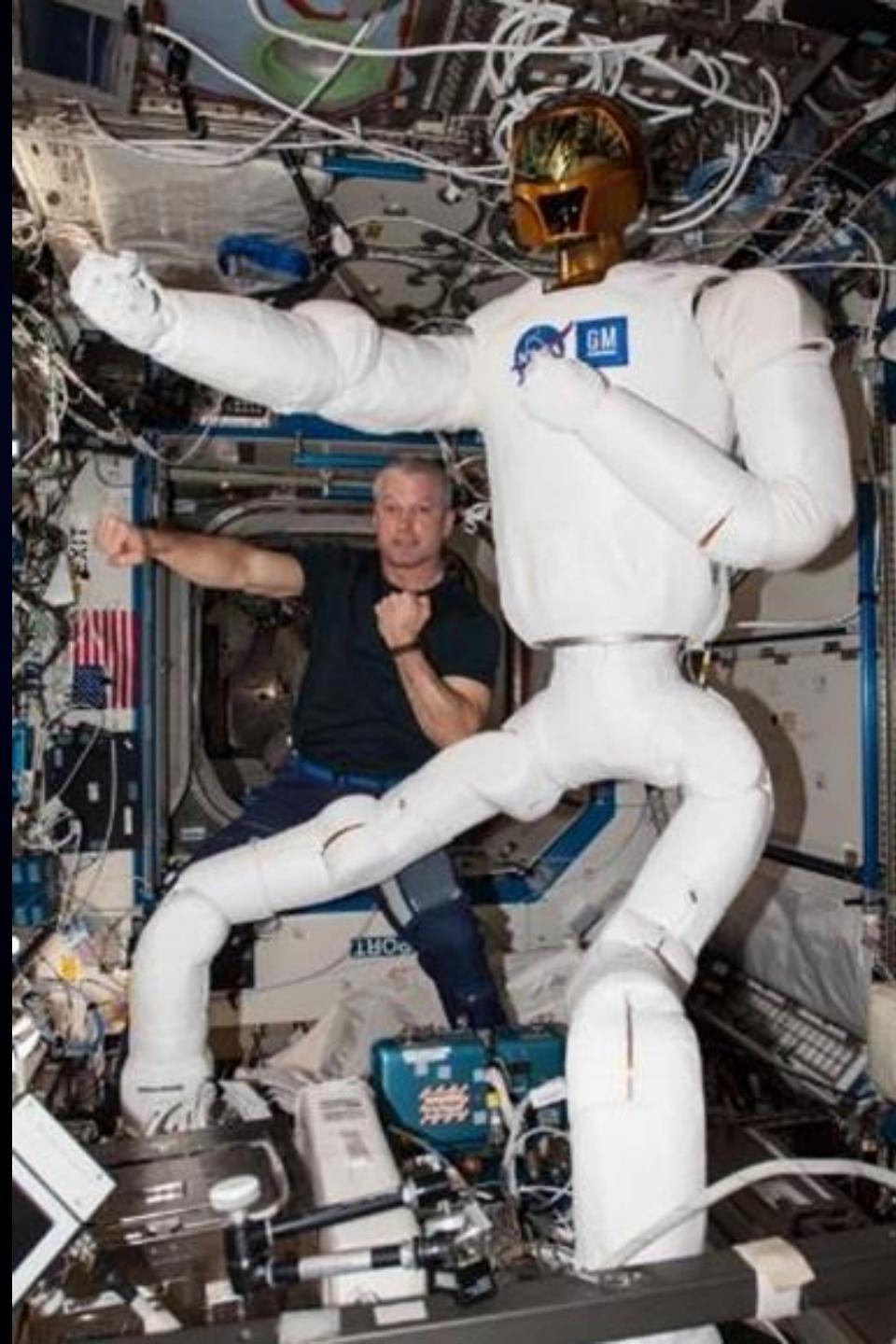
HSI Overview

HSI Definition per NPR 7123.1C NASA Systems Engineering Processes and Requirements

An interdisciplinary and comprehensive management and technical process that focuses on the integration of human considerations into the system acquisition and development processes to enhance human system design, reduce lifecycle ownership cost, and optimize total system performance. Human system domain design activities associated with operations, training, human factors engineering, safety, quality, maintainability and supportability, habitability, and survivability are considered concurrently and integrated with all other systems engineering design activities.
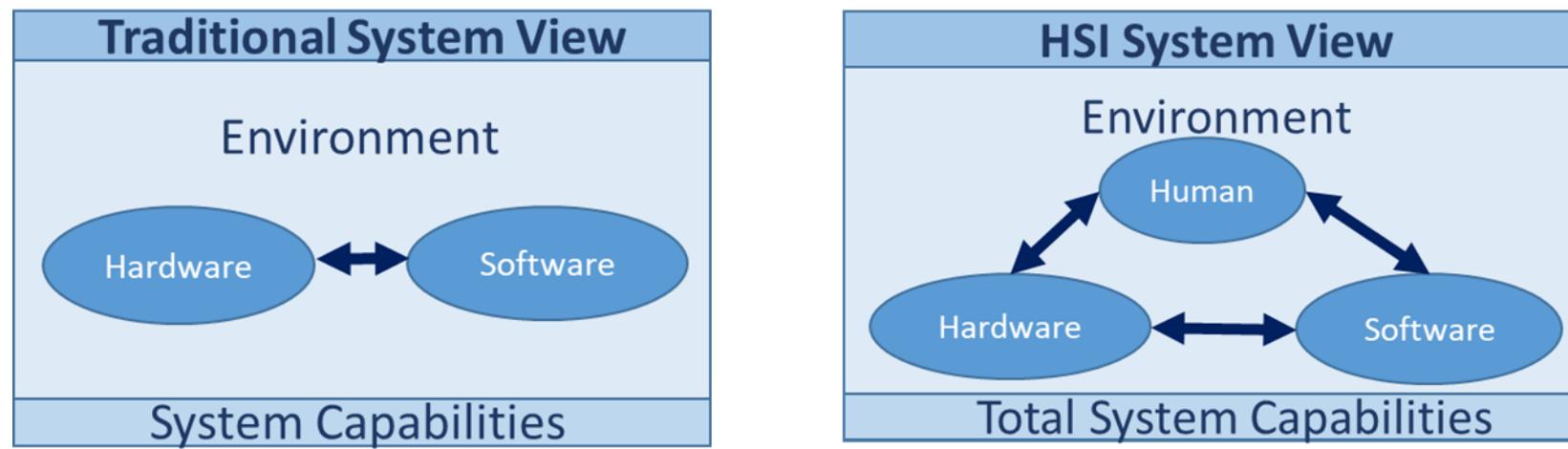
HSI enables better error management

HSI within Systems Engineering

System

System Or System of Systems

Software

Hardware

Paradigm Shift

Capability

Humans
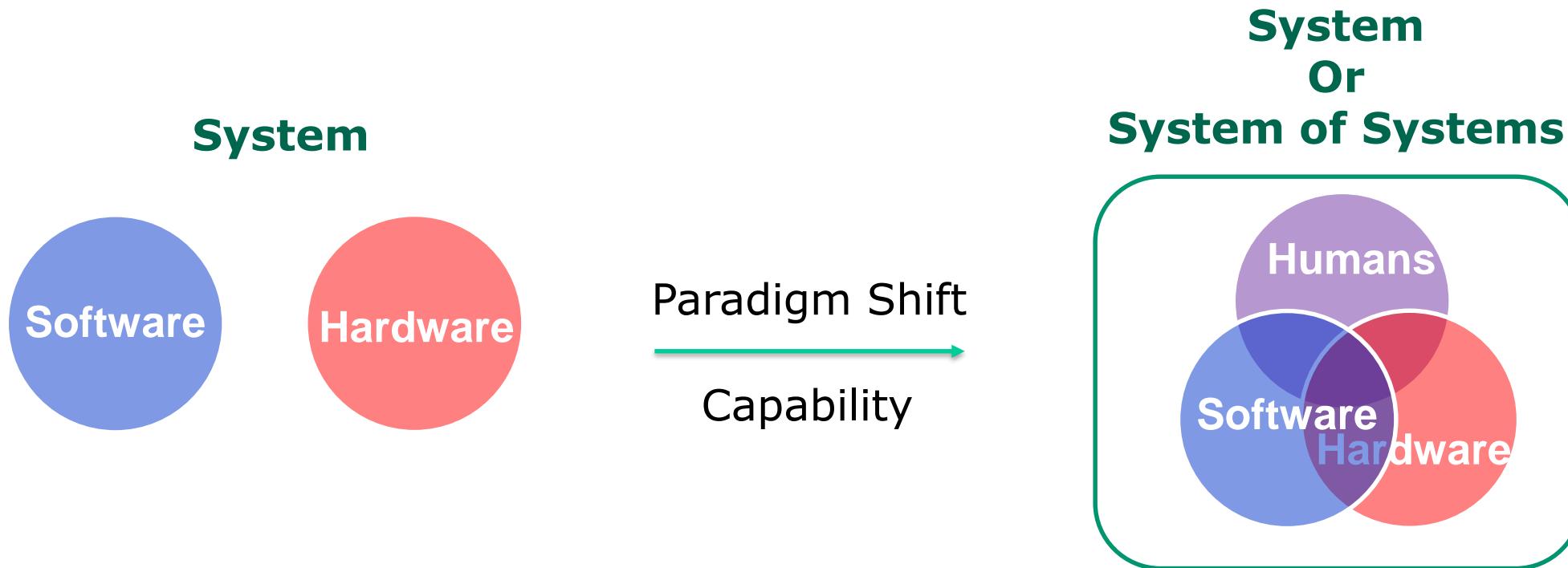
Software

Hardware

$$Total\ System = SoS = Mission = Human + Hardware + Software$$

Human in HSI refers to all personnel involved in a given system

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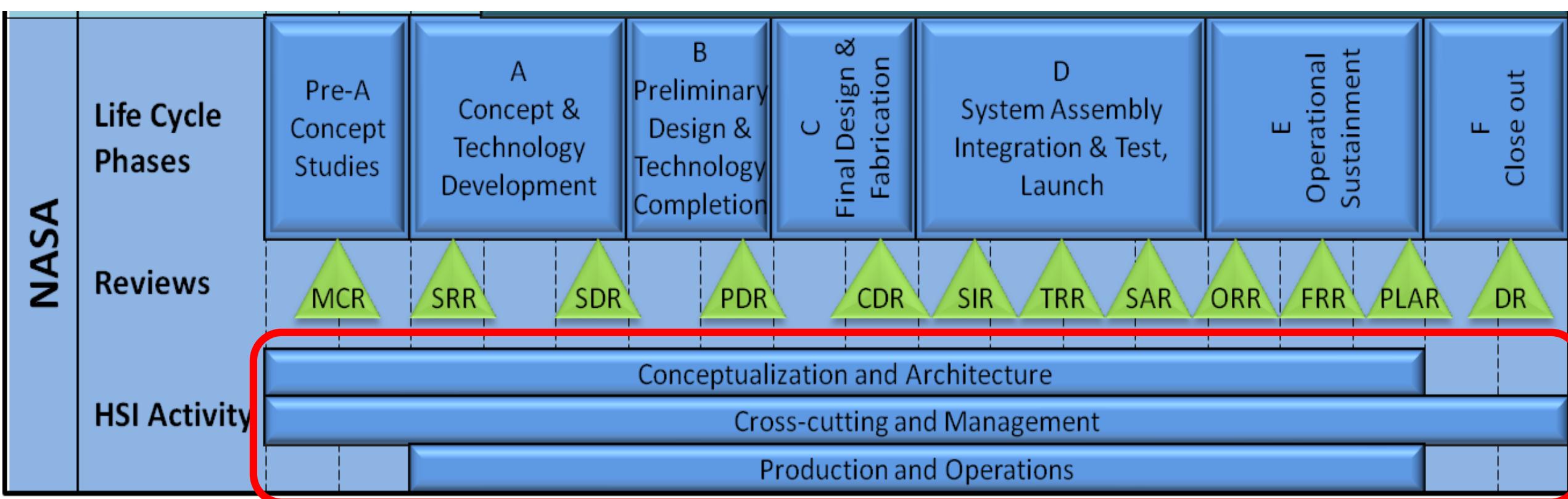
- **Conceptualization and Architecture:** ConOps, HSI requirements, human prototypes, human assessments and inputs to technology maturation

- **Cross-cutting and Management:** program or product's HSI plan, trade study reports, MOE, MOP, HSI domain risks, lessons learned, TPMs

- **Production and Operations:** Operations concept, human in the loop testing, operations/logistics/handling documents review, and monitoring of human performance

HSI Plan

- *NPR 7123.1C NASA Systems Engineering Processes and Requirements*, and *NPR 8705.2C Human-Rating Requirements for Space Systems* require the use of an HSI Plan and the formation of an HSI Team

- HSI Plan content is guided by the NASA/SP-2015-3709 Human Systems Integration Practitioner's Guide
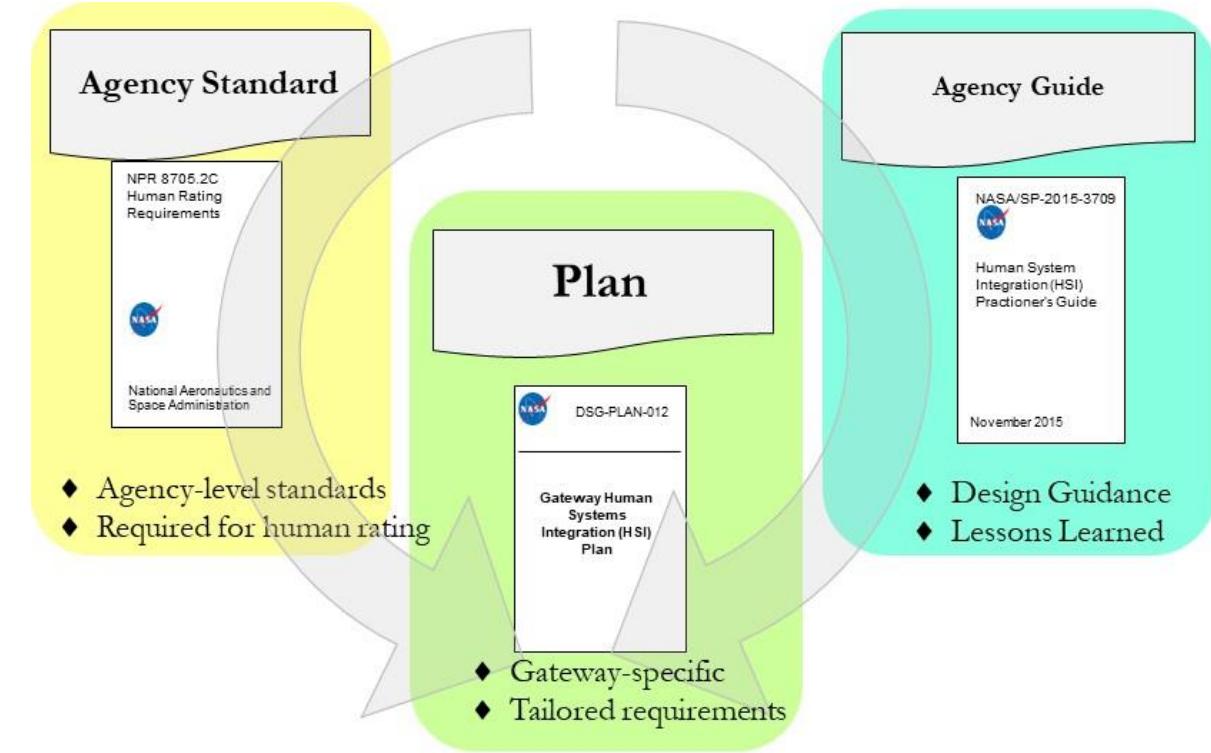
Contents of HSI Plan

A Human Systems Integration Plan:
- Describes planned HSI methods, tools, requirements, activities, processes, and standards for conducting HSI
- Addresses strategies to identify HSI issues and concerns, and explains how they will be tracked and resolved
- Defines the coordination of HSI analysis, evaluations, cross-team collaboration and communication
- Explains contributions to lessons learned and how are they are being implemented into current design
- Describes HSI organizational roles and responsibilities across HSI domains
- Defines HSI goals and deliverables for each phase of the lifecycle
- Defines entry and exit criteria with defined metrics for each phase, review, and milestone
- Explains alignment strategy with Systems Engineering Management Plan

Example of HSI Plan Contents

1.0 Introduction (Purpose, Scope, Definitions)
2.0 Documents (Applicable, Reference)
3.0 HSI Objectives
    3.1 System Description
    3.2 HSI Relevance
4.0 HSI Strategy
    4.1 HSI Strategy Summary
    4.2 HSI Domains
5.0 Requirements, Organization, and Risk Management
    5.1 HSI Requirements
    5.2 HSI Organization, Roles, and Responsibilities
    5.3 HSI Issues and Risks Processing
6.0 HSI Implementation
    6.1 HSI Implementation Summary
    6.2 HSI Products
    6.3 HSI Plan Update
Appendices

NASA HSI Domains Overview

Design for human-system interactions given human limitations and capabilities

Human Factors Engineering

The HSI Plan defines and emphasizes the HSI approach in each of the HSI Domains

Efficient and effective training systems and training design

Training

Operations Resources

Design for flight and ground crew objectives and constraints including autonomy and automation

HSI

Maintainability and Supportability

Safety

Minimize risks to personnel and design for mission success

Design to simplify and optimize human resources for M&S with given mission constraints

Habitability and Environment

Ensure design supports crew human health and performance for all living and working conditions

Roles & Responsibilities

HSI Domains Representatives • Human Factors Engineering • Training • Safety • Maintainability and Supportability • Operations Resources • Habitability and Environment	**Systems Engineering Leads** • System leads • Subsystem leads
Directorate/Department Representatives • Operations • Engineering • Safety and Mission Assurance	Program/Project Leads
Provider Representatives	International Partners
Cross-Program Representatives	Ad-hoc Members

Human Health & Performance
- Human-Centered Standards
- Human Factors
- Environmental Factors
- Habitability
- Training
- Occupational Health & Flight Medicine

Flight Operations
- Operations Experience
- Maintenance & Logistics
- Training
- Personnel & Manpower

Budgeting
- Full-cost Accounting
- Life Cycle Cost Estimates

Astronaut Office
- Astronaut Support
- Flight Crews Summaries
- Anecdotal Evidence

Legal & Contracts
- Acquisition Strategy

Engineering
- Design
- Systems Engineering
- Program Management
- Training

Safety & Mission Assurance
- Safety
- Human-Rating
- Human Reliability
- Survival Analyses
- Maintainability
- Supportability
- Probabilistic Risk Assessment

Ground Operations
- Logistics
- Personnel & Manpower

HSI

HSI Activities, Products, Risk Mitigation by Lifecycle Phase

Life Cycle Phase	Phase Description	Activity, Product, or Risk Mitigation
Pre-Phase A	Concept Studies	• ConOps (Preliminary—to include training, maintenance, logistics, etc.)
Phase A	Concept & Technology Development	• HSI Plan (Baseline) • ConOps (Initial) • HSI responsible party(ies) and/or Team identified before SRR • Develop mockup(s) for HSI evaluations • Crew Workload Evaluation Plan • Function allocation, crew task lists • Validation of ConOps (planning)
Phase B	Preliminary Design & Technology Completion	• HSI Plan (update) • ConOps (Baseline) • Develop engineering-level mockup(s) for HSI evaluations • Define crew environmental and crew health support needs (e.g., aircraft flight decks, human space flight missions) • Assess operator interfaces through task analyses (for, e.g., aircraft cockpit operations, air traffic management, spacecraft environments, mission control for human space flight missions) • HITL usability plan • Human-Rating report for PDR
Phase C	Final Design & Fabrication	• HSI Plan (update) • First Article HSI Tests • Human-Rating report for CDR
Phase D	System Assembly, Integ. & Test, Launch & Checkout	• Human-Rating report for ORR • Validation of human-centered design activities • Validation of ConOps
Phase E	Operations & Sustainment	• Monitoring of human-centered design performance
Phase F	Closeout	• Lessons Learned report

HSI Plan Development and Refinement

Life Cycle Phase	Guidelines for Development and Refinement of the HSI Plan
Pre-Phase A Phase A	Develop the HSI Plan based on the results of functional analyses and derived human-centered requirements.
Phase B	Revise HSI Plan to reflect results of human, hardware, and software task allocation determination, system specifications, and source selection strategies and results.
Phase C	Identify potential human-related shortfalls and failures in human-system integration. Develop and execute mitigation strategies. Update HSI Plan to include latest system specifications, integration strategy, analyses of training and support requirements.
Phase D	Update HSI Plan to address issues related to system integration with training and support strategies. After evaluation, incorporate results of evaluations regarding usability, operability, and supportability of the system. Ensure testing is accomplished by operational users in operating conditions. Identify human-related shortfalls and failures in human-machine integration. After the Plan is updated, document lessons learned to prepare for the next iteration of design.
Phase E Phase F	These phases realize the execution of plans derived during the development and acquisition of the system (e.g., training plan, disposal plan, operational resources, survivability, etc.). This is another opportunity to collect data (e.g., habitability, usability, training, environment, safety, occupational health issues, etc.) and document lessons learned.

Conclusions

- HSI is a process by which human capabilities and limitations are effectively and affordably integrated with system design and development

- HSI Plan is developed to ensure the human elements of the total system are effectively integrated with hardware and software elements, to ensure all human capital required to develop and operate the system is accounted for in life cycle costing, and to ensure that the system is built to accommodate the characteristics of the user population that will operate, maintain, and support the system

- HSI enables the integration of human considerations throughout the lifecycle of our missions
  - Applies across all systems (system of systems)
  - Reduces total system life-cycle costs

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