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# **Risk Interfaces to Support Integrated Systems Analysis and Development**

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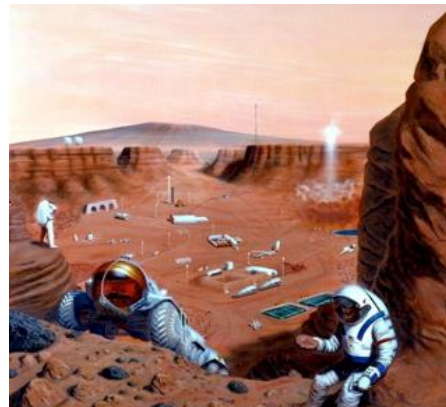
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# Objectives for Systems Analysis Capability

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- Develop integrated understanding of how complex human physiological-socio-technical mission system behaves in spaceflight
- Why?
  - ✓ Support development of **integrated solutions** that prevent unwanted outcomes
    - Implementable approaches to minimize mission resources (mass, power, crew time, etc.)
  - ✓ Support development of tools for autonomy (need for exploration)
    - Assess and maintain resilience – individuals, teams, **integrated system**

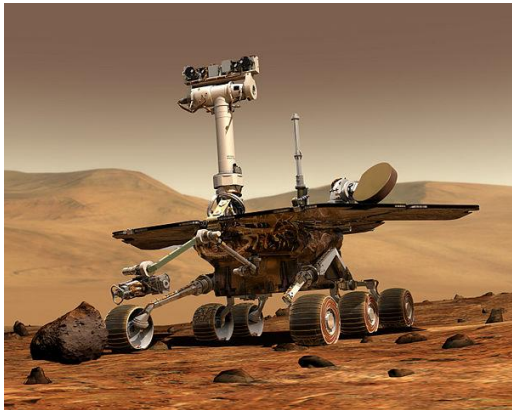
*Thrive, not just survive,  
during long-duration  
missions*



# Purpose of this Limited-Scope Exercise

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- Demonstrate techniques to systematically identify, organize, and manage interfaces among Risks
- Why?
  - Interfaces are where many challenges appear
  - We do not currently have a systematic way to manage interfaces and ensure that appropriate work is addressed



- In spacecraft engineering, subsystem scopes (e.g., structures, avionics, power, propulsion) are well-defined in a common conceptual model
- This enables management of interfaces to build an effective system
- Our Risk scope and interfaces would benefit from similar approach

# Output of this Exercise

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- Output of this exercise:
  - Representation of interfaces based on Human System Risk Board (HSRB) Risk Summary information and simple status based on Human Research Roadmap
  - Consolidated HSRB information applied to support communication
  - Point-of-Departure for HRP Element planning
  - Ability to track and communicate status of collaborations

# Approach

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- 1) Normalized HSRB Risk Summary content using an existing framework
  - Created combined data set
  
- 2) Identified Risk interfaces
  - Defined types of interfaces
  - Applied HSRB data to identify related Risks
  
- 3) Performed first pass comparison to plans
  - Determined if related Risks share Tasks in Human Research Roadmap
  
- 4) Visualized options for collaborations and their status

# Methods – Normalize Content

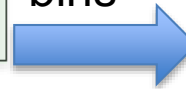


## Risk One-Pager Information\*

<b>Risk Title:</b> Risk of Renal Stone Formation		RMAT -
<b>Risk Statement:</b> Given changes in urinary biochemistry during space flight, there is a possibility that symptomatic renal stones may form, resulting in urinary calculi or <u>urolithiasis</u> , renal colic (pain), nausea, vomiting, hematuria, infection, <u>hydronephrosis</u> .		
<b>Primary Hazard:</b> Micro-gravity (excess calcium excretion, low urine volume, urinary supersaturation)	<b>Secondary Hazard:</b> Closed Environment - (limited H <sub>2</sub> O resource), Distance from Earth (in some DRMs, inability of immediate return for treatment)	<b>Countermeasures:</b> <u>Preventative</u> Screening, Crew Education, Diet (includes H <sub>2</sub> O), K-Cit/ bisphosphonates <u>Treatment</u> - Return to Earth
<b>Contributing Factors:</b> Increased Urinary Calcium Excretion (bone loss/calcium excretion), Decreased Urine Volume, Increased Urinary Supersaturation, Dietary Factors (↓ fluid intake, ↑Na+ Intake, etc. reference MLD), Mission Duration - Mission Resources, Hypercapnia.		

Metric: Renal stone incidence

Translate to framework bins



- Hazards and Contributing Factors
  - Acceleration or Gravity
  - Distance From Earth
  - Food System
  - Genitourinary Function
  - Mission Duration
  - CO<sub>2</sub>
- Countermeasures
  - Ground Medical Care
  - Crew Selection
  - Food System
  - In-Flight Medications
  - Mission Scenarios
- Metrics
  - Genitourinary (Systemic Clinical Outcome)

# Methods: Identify Risk Interfaces

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- 6 types of interfaces defined for this exercise
  - 1) Risks whose scope of work addresses contributing factors of other Risks
  - 2) Risks whose scope of work addresses mitigations of other Risks
  - 3) Risks whose scope of work addresses metrics of other Risks
    - Example “scope of work” assumed for Renal Risk:*
      - *Physiological adaptations of the genitourinary system*
      - *Clinical outcomes such as renal stones*
  - 4) Risks that share common contributing factors
  - 5) Risks that share common mitigation factors
  - 6) Risks that share common metrics

# Interface Visualization

- Nodes are HSRB Risks
- Line is drawn (interface is indicated) based on information in HSRB Risk Summaries
- Color is given based on HRR information

Line Color	Do Risks Share Tasks in HRR?
Red	No
Green	Yes
Blue	N/A (not HRP Risks)

## Types of interfaces:

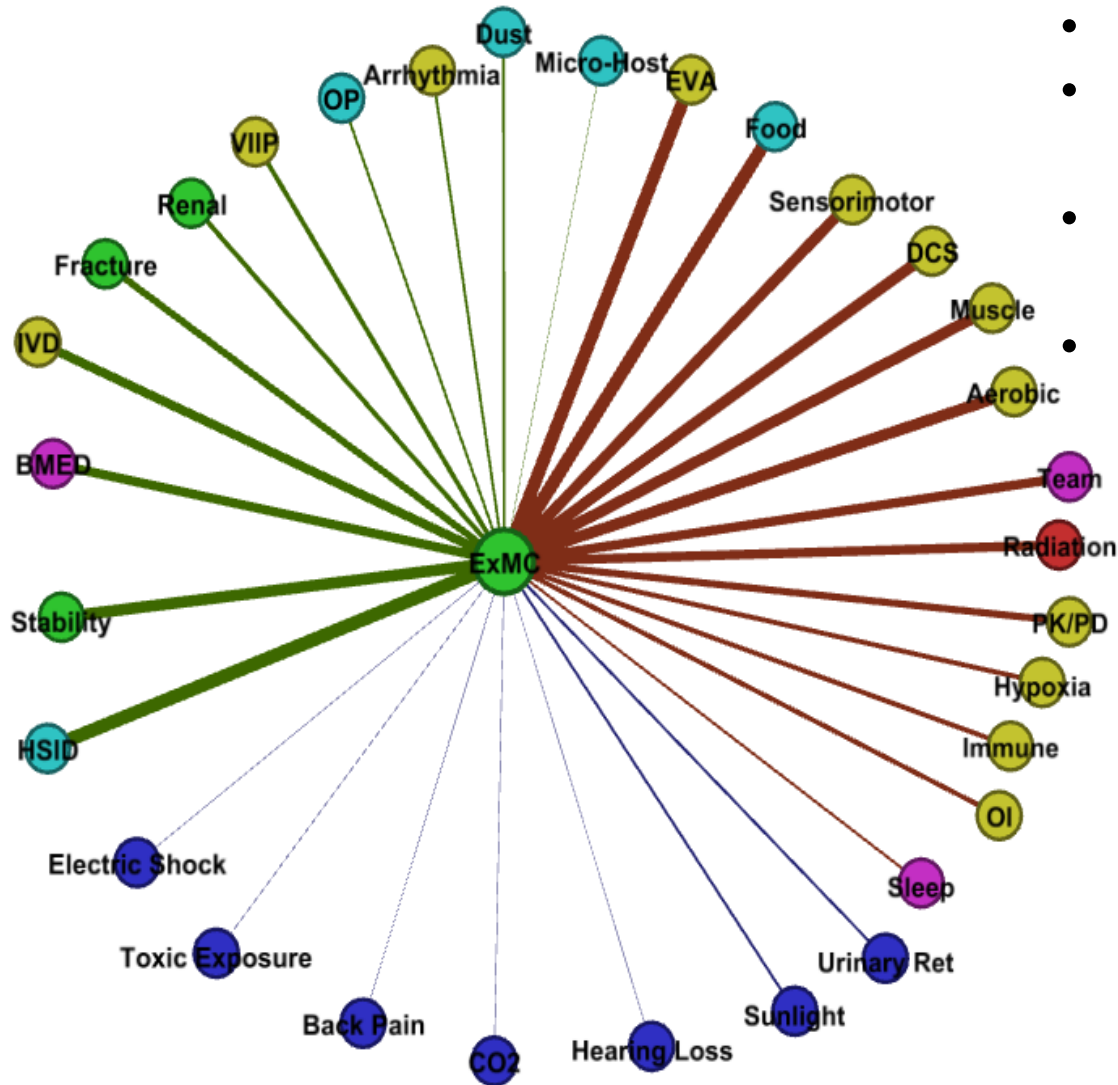
- 1 = Risk at arrow head has contributing factor(s) in scope of Risk at arrow start
- 2 = Risk at arrow head has mitigation(s) in scope of Risk at arrow start
- 3 = Risk at arrow head has metric(s) in scope of Risk at arrow start

*Work taking place in a Risk at an arrow start influences the state of a Risk at the arrow head.*



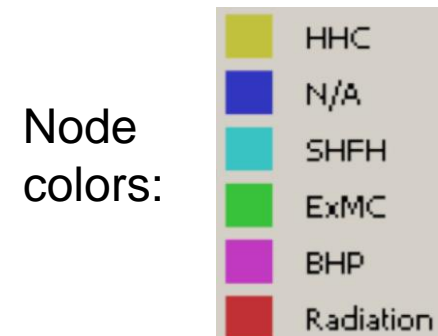


# ExMC Risk Interfaces Based on Common Contributing Factors (Interface Type 4)



- Nodes are HSRB Risks
- Line is drawn based on info in HSRB Risk Summaries
- Line thickness indicates # of shared contributing factors
- Line color indicates if Risks share Tasks in HRR

Line Color	Do Risks Share Tasks in HRR?	% in Category
Red	No	42%
Green	Yes	35%
Blue	N/A (not HRP Risks)	23%



# Insights on Interfaces

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- Red lines are example candidates for cross-Element work
  - Green lines can also be candidates, depending on details of existing work

No new action	New action
Shared Tasks in place, and adequate integration is in place	Shared Tasks in place, but additional integration is needed
Shared Tasks not in place, but adequate integration is in place	Shared Tasks not in place, and additional integration is needed

- ExMC examples for candidates with other Elements:
  - Many considerations with HHC: Immune, EVA, DCS, Exploration Atmosphere, OI, Arrhythmia, Sensorimotor, VIIP, PK/PD (details in backup)
  - SHFH: Microhost, Dust (details in backup)
  - SR: Radiation (details in backup)

# Forward Work

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- Solicitation planning using Human Research Roadmap content
- Element interface identification, planning, management
  - Reduce assumptions
  - Evaluate link status
  - Define additional types of interfaces if necessary (e.g., flow of information, consulting, deliverables)

# Summary

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- Demonstrated techniques to systematically identify, organize, and manage interfaces among Risks
- Output of this exercise:
  - Representation of interfaces based on HSRB Risk Summary information and simple status based on Human Research Roadmap
  - Consolidated HSRB information applied to support communication
  - Point-of-Departure for Element planning
  - Ability to track and communicate status of collaborations



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# Backup

# ExMC Type 1,2,3 Interfaces

ExMC Risk of Interest	Related Risk	Contributing Factors of Related Risk in ExMC Risk's Scope	Mitigations of Related Risk in ExMC Risk's Scope	Metrics of Related Risk in ExMC Risk's Scope	Shared task in HRR?
ExMC	Fracture	N/A	In-flight Medical System	N/A	Yes
ExMC	Arrhythmia	N/A	In-flight Medical System	Circulatory	Yes
ExMC	Hearing Loss	N/A	In-flight Medical System	N/A	No
ExMC	EVA	N/A	In-flight Medical System	Shoulder, Arm, Elbow	No
ExMC	Sunlight	N/A	In-flight Medical System	Head, Mouth, Dental, Eye, Ear; Skin and Subcutaneous Tissue	N/A
ExMC	Hypoxia	Altitude or Decompression Sickness	In-flight Medical System	N/A	No
ExMC	DCS	In-flight Medical System	N/A	Altitude or Decompression Sickness	No
ExMC	Stability	In-flight Medical System	N/A	N/A	Yes
ExMC	HSID	In-flight Medical System	N/A	N/A	Yes
ExMC	OP	N/A	N/A	Head, Mouth, Dental, Eye, Ear; Neck, Airway; Chest, Upper Back; Abdomen, Lower Back; Shoulder, Arm, Elbow; Wrist, Hand, Finger; Hip, Leg, Knee; Ankle, Foot, Toes	Yes
ExMC	SABP	N/A	N/A	Chest, Upper Back; Abdomen, Lower Back	N/A
ExMC	Microhost	N/A	N/A	Head, Mouth, Dental, Eye, Ear; Blood, Blood-Forming Organs, Immune; Digestive	Yes
ExMC	Immune	N/A	N/A	Blood, Blood-Forming Organs, Immune; Digestive; Skin and Subcutaneous Tissue	No
ExMC	CO2	N/A	N/A	Head, Mouth, Dental, Eye, Ear	No
ExMC	Radiation	N/A	N/A	Circulatory; Malignancy, Tumor	No
ExMC	Renal	N/A	N/A	Genitourinary	Yes
ExMC	OI	N/A	N/A	Circulatory	No
ExMC	UrinaryRet	Blood, Blood-Forming Organs, Immune; Space Motion Sickness	In-flight Medical System	Genitourinary	N/A
ExMC	VIIP	N/A	In-flight Medical System	Head, Mouth, Dental, Eye, Ear	Yes
ExMC	ElecShock	N/A	In-flight Medical System	N/A	N/A

# ExMC Type 1,2,3 Interfaces Cont.

ExMC Risk of Interest	Related Risk	Contributing Factors of Related Risk in ExMC Risk's Scope	Mitigations of Related Risk in ExMC Risk's Scope	Metrics of Related Risk in ExMC Risk's Scope	Shared task in HRR?
Stability	Renal	N/A	In-Flight Medications	N/A	Yes
Stability	ExMC	N/A	In-Flight Medications	N/A	Yes
Stability	BMed	N/A	In-Flight Medications	N/A	Yes
Stability	Fracture	N/A	In-Flight Medications	N/A	Yes
Stability	Arrhythmia	N/A	In-Flight Medications	N/A	No
Stability	Sensorimotor	N/A	In-Flight Medications	N/A	No
Stability	Sleep	N/A	In-Flight Medications	N/A	Yes
Stability	Immune	N/A	In-Flight Medications	N/A	No
Stability	Microhost	N/A	In-Flight Medications	N/A	No
Stability	DCS	In-Flight Medications	In-Flight Medications	N/A	No
Stability	Hypoxia	N/A	In-Flight Medications	N/A	No
Stability	SABP	N/A	In-Flight Medications	N/A	No
Stability	Sunlight	In-Flight Medications	In-Flight Medications	N/A	No
Stability	Dust	N/A	In-Flight Medications	N/A	No
Stability	OI	In-Flight Medications	N/A	N/A	No
Stability	Hearing Loss	In-Flight Medications	N/A	N/A	N/A
Stability	VIIP	In-Flight Medications	N/A	N/A	No
Stability	UrinaryRet	In-Flight Medications	In-Flight Medications	N/A	N/A



# ExMC Type 1,2,3 Interfaces Cont.

ExMC Risk of Interest	Related Risk	Contributing Factors of Related Risk in ExMC Risk's Scope	Mitigations of Related Risk in ExMC Risk's Scope	Metrics of Related Risk in ExMC Risk's Scope	Shared task in HRR?
Fracture	PK/PD	Bone Strength	N/A	N/A	No
Fracture	EVA	Bone Strength	N/A	Shoulder, Arm, Elbow	No
Fracture	OP	Bone Strength	N/A	Head, Mouth, Dental, Eye, Ear; Neck, Airway; Chest, Upper Back; Abdomen, Lower Back; Shoulder, Arm, Elbow; Wrist, Hand, Finger; Hip, Leg, Knee; Ankle, Foot, Toes	Yes
Fracture	Arrhythmia	Physical Work Load	N/A	N/A	No
Fracture	DCS	Physical Work Load	N/A	N/A	No
Fracture	Sensorimotor	Physical Work Load	N/A	N/A	No
Fracture	Muscle	Physical Work Load	N/A	N/A	Yes
Fracture	Aerobic	Physical Work Load	N/A	N/A	Yes
Fracture	SABP	N/A	N/A	Chest, Upper Back; Abdomen, Lower Back	N/A
Renal	PK/PD	Genitourinary Function	N/A	N/A	No
Renal	UrinaryRet	N/A	N/A	Genitourinary	N/A

Left off relationships between Fracture and CO2, Microhost, Sunlight, VIIP that would appear due to those 4 having metrics within Head, etc. injury.

# ExMC Risk Scope Assumptions

RISK	FACTOR
ExMC	Head, Mouth, Dental, Eye, Ear
	Neck, Airway
	Chest, Upper Back
	Abdomen, Lower Back
	Shoulder, Arm, Elbow
	Wrist, Hand, Finger
	Hip, Leg, Knee
	Ankle, Foot, Toes
	Blood, Blood-Forming Organs, Immune
	Endocrine, Nutritional, Metabolic
	Nervous
	Circulatory
	Respiratory
	Digestive
	Genitourinary
	Skin and Subcutaneous Tissue
	Musculoskeletal and Connective Tissue
	Altitude or Decompression Sickness
	Space Motion Sickness
	Acute Radiation Syndrome
	Burns, Corrosion
	Poison, Toxin
	Malignancy, Tumor
	Complications of Medical or Surgical Care
	In-flight Medical System

RISK	FACTOR
Stability	In-flight Medications
Fracture	Bone Strength
	Head, Mouth, Dental, Eye, Ear
	Neck, Airway
	Chest, Upper Back
	Abdomen, Lower Back
	Shoulder, Arm, Elbow
	Wrist, Hand, Finger
	Hip, Leg, Knee
	Ankle, Foot, Toes
	Physical Work Load
Renal	Genitourinary function
	Genitourinary

# SHFE Type 1,2,3 Interfaces

SHFE Risk	Non-SHFE Risk	Contributing Factors of Non-SHFE in SHFE's Scope (Type 1)	Mitigations of Non-SHFE in SHFE's Scope (Type 2)	Metrics of Non-SHFE in SHFE's Scope (Type 3)	Shared task in HRR?
HARI	Team	Coordination; Cooperation; Communication within the Team; Team Psychosocial Adaptation	N/A	Coordination; Cooperation; Communication within the Team	No
HARI	BMed	Coordination; Cooperation; Communication within the Team; Team Psychosocial Adaptation	N/A	Cooperation	No
HARI	Fracture	Task Allocation; Human & Vehicle Automation Integration; Human & Robotics Integration	N/A	N/A	No
HARI	Sensorimotor	Task Allocation; Human & Vehicle Automation Integration; Caution & Warning Functionality	N/A	N/A	Yes
HARI	EVA	Task Allocation; Coordination; Cooperation; Communication within the Team; Team Psychosocial Adaptation; Human & Vehicle Automation Integration; Human & Robotics Integration; Caution & Warning Functionality	Task Allocation	N/A	No
HARI	UrinaryRet	Team Psychosocial Adaptation	N/A	N/A	N/A
HCI	Sensorimotor	Attention or Alertness; Memory or Knowledge; Situational Awareness; Information Displays or Decision Aids; Control Panels or Input Devices; Software Ease of Use; Information Management Support	Information Displays or Decision Aids; Control Panels or Input Devices	N/A	Yes
HCI	EVA	Attention or Alertness; Memory or Knowledge; Situational Awareness; Information Displays or Decision Aids; Control Panels or Input Devices; Software Ease of Use; Information Management Support	N/A	N/A	No
HCI	Bmed	N/A	N/A	Attention or Alertness; Memory or Knowledge; Situational Awareness	Yes
TASK	Sleep	Sleep Shifting; Cognitive Work Load	Consecutive Days On & Off; Work Shifts & Breaks; Sleep Shifting	Consecutive Days On & Off; Work Shifts & Breaks; Sleep Shifting	Yes
TASK	Team	Task Timeline; Level of Crew Autonomy	N/A	Task Timeline	Yes
TASK	BMed	Cognitive Work Load	N/A	N/A	No
TASK	Arrhythmia	Cognitive Work Load	N/A	N/A	No
TASK	Fracture	Task Definition; Task Allocation; Task Design; Task Timeline; Novelty of Task; Context or Setting as Expected	Task Design	N/A	No
TASK	Sensorimotor	Task Definition; Task Allocation; Task Design; Task Timeline; Novelty of Task; Context or Setting as Expected; Work Load	N/A	Observation; Interpretation; Planning; Execution	No
TASK	EVA	Feelings of Accomplishment or Frustration; Task Definition; Task Allocation; Task Design; Task Timeline; Availability of Procedures; Familiarity of Reponse Patterns & Standardization; Organization of Procedural Inputs & Info Availability; Clarity, Ease of Use, Comprehensibility of Procedures	Task Definition; Task Allocation; Task Design; Task Timeline	N/A	No
TASK	ExMC	Level of Crew Autonomy	Level of Crew Autonomy	N/A	Yes
TASK	Food	Execution	N/A	N/A	No

# SHFE Type 1,2,3 Interfaces Cont.

SHFE Risk	Non-SHFE Risk	Contributing Factors of Non-SHFE in SHFE's Scope (Type 1)	Mitigations of Non-SHFE in SHFE's Scope (Type 2)	Metrics of Non-SHFE in SHFE's Scope (Type 3)	Shared task in HRR?
TRAIN	Sleep	N/A	Applicability of Training	N/A	No
TRAIN	Team	Feelings of Accomplishment or Frustration; Applicability of Training; Crewmembers Training Together; Language or Cultural Barriers to Training	Applicability of Training	N/A	Yes
TRAIN	Muscle	N/A	Level of Training	N/A	No
TRAIN	Aerobic	N/A	Level of Training	N/A	No
TRAIN	DCS	N/A	Applicability of Training	N/A	No
TRAIN	Hearing Loss	N/A	Applicability of Training	N/A	N/A
TRAIN	Sunlight Exposure	N/A	Applicability of Training	N/A	N/A
TRAIN	Hypobaric Hypoxia	N/A	Applicability of Training	N/A	No
TRAIN	Sensorimotor	Applicable Operational Experience	N/A	N/A	No
TRAIN	EVA	Applicability of Training; Recency of Training; Level of Training; Applicable Operational Experience; Crewmembers Training Together	N/A	N/A	No
TRAIN	ExMC	N/A	Applicability of Training; Recency of Training; Level of Training; Applicable Operational Experience	N/A	Yes
TRAIN	UrinaryRet	N/A	Applicability of Training	N/A	N/A
TRAIN	ToxExpos	N/A	Applicability of Training; Recency of Training; Level of Training; Applicable Operational Experience	N/A	N/A
TRAIN	ElecShock	N/A	Applicability of Training; Recency of Training; Level of Training; Applicable Operational Experience	N/A	N/A

# SHFE Type 1,2,3 Interfaces Cont.

SHFE Risk	Non-SHFE Risk	Contributing Factors of Non-SHFE in SHFE's Scope (Type 1)	Mitigations of Non-SHFE in SHFE's Scope (Type 2)	Metrics of Non-SHFE in SHFE's Scope (Type 3)	Shared task in HRR?
HAB	CO2	Air Flow	N/A	N/A	N/A
HAB	Dust	Air Flow; Isolation & Confinement	Air Flow; Safety Accommodations	N/A	No
HAB	Microhost	Air Flow; Isolation & Confinement; Hygiene Support	Hygiene Support	N/A	No
HAB	OP	Anthropometric Accommodations; Mobility Aids & Restraints Availability & Design; Body Surface Area, Volume, & Mass Props Accommodations	N/A	N/A	Yes
HAB	Sleep	Noise; Ambient Lighting; Temperature; Habitable Volume; Isolation & Confinement	Ambient Lighting	N/A	Yes
HAB	Team	Isolation & Confinement	Habitable Volume	N/A	Yes
HAB	BMed	Window Availability & Design; Isolation & Confinement	Window Availability & Design; Habitable Volume	N/A	Yes
HAB	Muscle	Habitable Volume; Isolation & Confinement	N/A	N/A	Yes
HAB	Aerobic	Habitable Volume; Isolation & Confinement	N/A	N/A	No
HAB	Fracture	Arrangement of Functional Areas; Anthropometric Accommodations; Access to Work Items; Translation Paths, Location Aids; Safety Accommodations; Range of Motion Accommodations; Body Surface Area, Volume, & Mass Props Accommodations; Hardware Tool Availability & Design; Hardware Ease of Use; Reach Envelope Accommodations; Strength Accommodations	N/A	N/A	No
HAB	Hearing Loss	Noise; Isolation & Confinement	Noise, Safety Accommodations	N/A	N/A
HAB	Sunlight Exposure	Window Availability & Design	Window Availability & Design; Safety Accommodations	N/A	N/A
HAB	SABP	Habitable Volume	Habitable Volume	N/A	N/A
HAB	IVD	Habitable Volume	N/A	N/A	No
HAB	Immune	Air Flow; Isolation & Confinement	N/A	N/A	No
HAB	Hypobaric Hypoxia	Isolation & Confinement	N/A	N/A	No
HAB	Sensorimotor	Arrangement of Functional Areas; Window Availability & Design; Hatch Availability & Design; Anthropometric Accommodations; Access to Work Items; Translation Paths, Location Aids; Safety Accommodations; Mobility Aids & Restraints Availability & Design; Situation-Specific Lighting; Range of Motion Accommodations; Body Surface Area, Volume, & Mass Props Accommodations; Identifiability; Standardization; Hardware Tool Availability & Design; Hardware Ease of Use; Orientation of User Interfaces; Reach Envelope Accommodations; Strength Accommodations	N/A	N/A	No
HAB	EVA	Humidity; Temperature; Window Availability & Design; Hatch Availability & Design; Anthropometric Accommodations; Translation Paths, Location Aids; Safety Accommodations; Hygiene Support; Mobility Aids & Restraints Availability & Design; Situation-Specific Lighting; Range of Motion Accommodations; Body Surface Area, Volume, & Mass Props Accommodations; Identifiability; Standardization; Hardware Tool Availability & Design; Hardware Ease of Use; Reach Envelope Accommodations; Strength Accommodations	Anthropometric Accommodations; Range of Motion Accommodations; Body Surface Area, Volume, & Mass Props Accommodations; Hardware Tool Availability & Design; Hardware Ease of Use; Reach Envelope Accommodations; Strength Accommodations	N/A	No
HAB	ExMC	Isolation & Confinement	N/A	N/A	No
HAB	Arrhythmia	Isolation & Confinement	N/A	N/A	No
HAB	Stability	Vibration; Humidity; Ambient Lighting; Temperature; Air Flow; Hygiene Support	N/A	N/A	No
HAB	Food	Isolation & Confinement; Hygiene Support	N/A	N/A	No
HAB	UrinaryRet	Isolation & Confinement	N/A	N/A	N/A
HAB	ElecShock	Safety Accommodations	Safety Accommodations	N/A	N/A
HAB	ToxExpos	N/A	Hatch Availability & Design; Safety Accommodations	N/A	N/A

# SHFE Risk Scope Assumptions

RISK	FACTOR
TRAIN	Applicability of Training
	Recency of Training
	Level of Training
	Applicable Operational Experience
	Crewmembers Training Together
	Language or Cultural Barriers to Training
HCI	Attention or Alertness
	Memory or Knowledge
	Situational Awareness
	Information Displays or Decision Aids
	Control Panels or Input Devices
	Software Ease of Use
	Information Management Support
HARI	Task Allocation
	Coordination
	Cooperation
	Communication within the Team
	Team Psychosocial Adaptation
	Human & Vehicle Automation Integration
	Human & Robotics Integration
	Caution & Warning Functionality

RISK	FACTOR
MPTASK	Feelings of Accomplishment or Frustration
	Task Definition
	Task Allocation
	Task Design
	Task Timeline
	Consecutive Days On & Off
	Work Shifts & Breaks
	Sleep Shifting
	Level of Crew Autonomy
	Available Time
	Beginning, Middle or End of Shift
	Novelty of Task
	Context or Setting as Expected
	Cognitive Work Load
	Availability of Procedures
	Familiarity of Reponse Patterns & Standardization
	Organization of Procedural Inputs & Info Availability
	Clarity, Ease of Use, Comprehensibility of Procedures
	Observation
	Interpretation
	Planning
	Execution

RISK	FACTOR
HAB	Noise
	Vibration
	Humidity
	Ambient Lighting
	Temperature
	Air Flow
	Odor
	Arrangement of Functional Areas
	Window Availability & Design
	Hatch Availability & Design
	Anthropometric Accommodations
	Access to Work Items
	Translation Paths, Location Aids
	Safety Accommodations
	Habitable Volume
	Isolation & Confinement
	Hygiene Support
	Mobility Aids & Restraints Availability & Design
	Situation-Specific Lighting
	Range of Motion Accommodations
	Body Surface Area, Volume, & Mass
	Props Accommodations
	Identifiability
	Standardization
	Hardware Tool Availability & Design
	Hardware Ease of Use
	Orientation of User Interfaces
	Reach Envelope Accommodations
	Strength Accommodations

# System Risk-Reduction Questions (1/2)

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- 1) What aspects of the integrated system influence the state of other aspects (i.e., what **relationships** exist)?
- 2) What are the **strengths** of those influences?
- 3) What are the **integrated constraints** on controlling aspects of the system (e.g., resources such as mass, power, volume, crew time)?
- 4) What are the most influential aspects we can **control** (in sets or individually) over appropriate time scales? *This will lead to integrated countermeasures and identification of new countermeasure options. It will inform what **countermeasures to pursue**.*
- 5) How does the state of the **integrated system change** during and after a mission? *This addresses adaptation processes and emergent behavior. This supports **identification of risks**.*

## System Risk-Reduction Questions (2/2)

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- 6) How can we gain insight into **trends** to prevent undesired outcomes (e.g., for medical or psychological health)?
- 7) How can we identify and describe **preferential states** (e.g., states such as “healthy” or “space-normal” for an individual)?  
*This identifies **acceptable levels of risk**.*
- 8) How can we **direct** the trajectory of the system state toward preferential states while **minimizing resource use**? *This addresses identifying **effective and efficient countermeasures**. This leads to increasing the likelihood of health and performance success.*
- 9) How can we enhance the system’s **resilience** in the presence of perturbations (e.g., triggers to the individual such as increased CO<sub>2</sub>, mold, or stress; or to the team such as operational stressors)? *This leads to increasing the likelihood of **health and performance success**.*

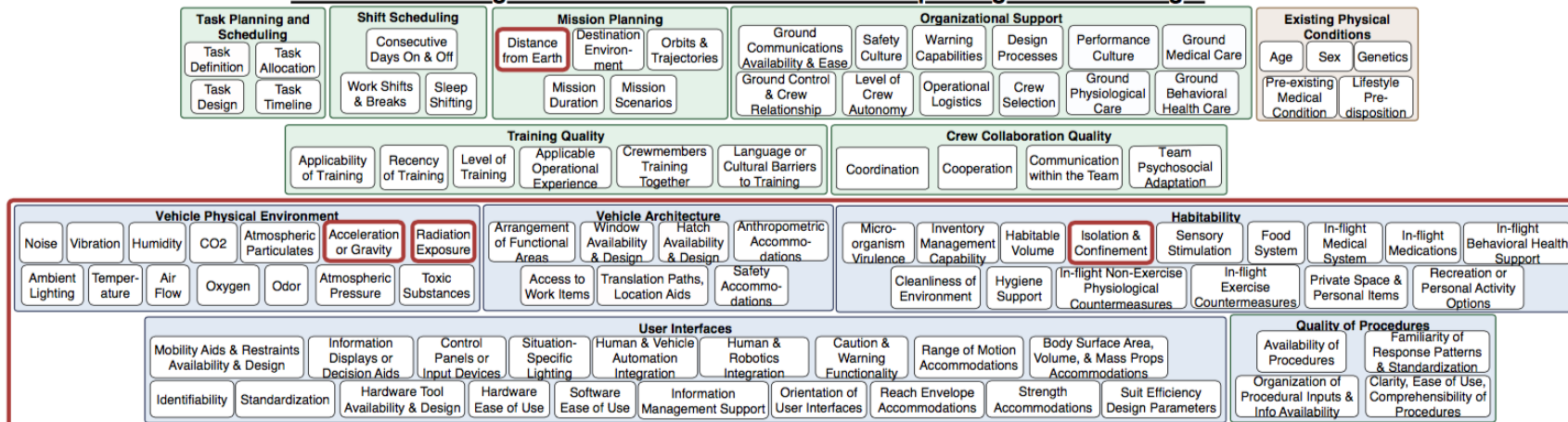


# Contributing Factor Map

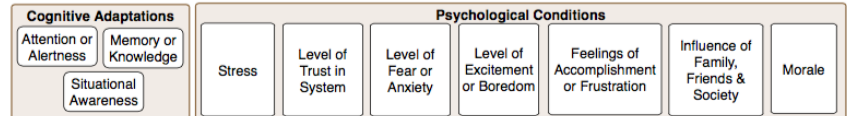
## Factors Influencing Human Health and Performance in Spaceflight and Post-Flight

- Factor Domain  
Color Key:
- Operations
  - Vehicle Design
  - Human

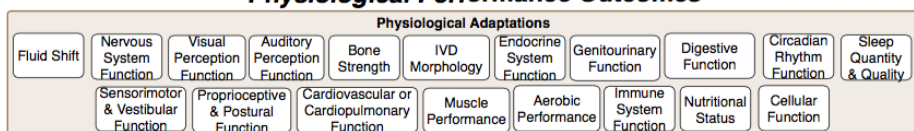
HSRB Hazard:



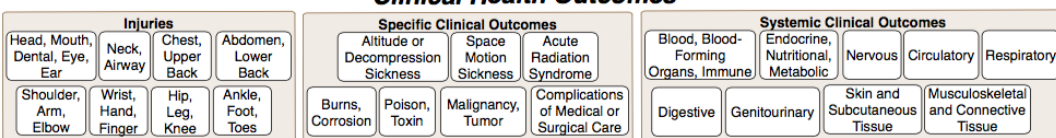
### Behavioral Health Outcomes



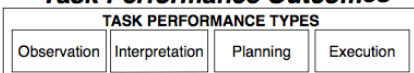
### Physiological Performance Outcomes



### Clinical Health Outcomes



### Task Performance Outcomes



Above factors and outcomes for each individual can influence overall mission outcomes

### Mission Outcomes



Adapted from Mindock, J. and Klaus, D. "Contributing Factor Map: A Taxonomy of Influences on Human Performance and Health in Space." IEEE Transactions on Human-Machine Systems, Vol. 44, No. 5, October 2014.