National Aeronautics and Space Administration

Human Research Program: Human Factors and Behavioral Performance

Brian F. Gore, Ph.D.
HFBP Deputy Element Scientist
NASA Ames Research Center

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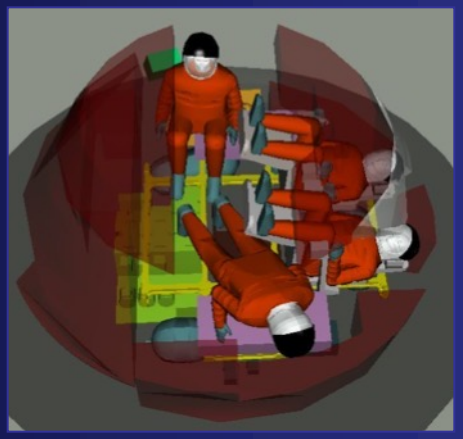
Human Research Program

- The Human Research Program (HRP) focuses on applied research
- Program goals
  - Perform research necessary to understand and reduce spaceflight human health and performance risks in support of exploration
  - Enable development of human spaceflight medical and human performance standards
  - Develop and validate technologies that serve to characterize and reduce medical risks associated with human spaceflight



An Applied Research Program

Characteristics of HRP

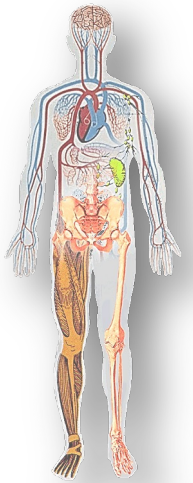
- Composed of five Elements
  - Exploration Medical Capability
    - *Medical care for deep-space missions*
  - Human Factors and Behavioral Performance
    - *Interfaces between humans, vehicles & habitats*
    - *Individual and interpersonal*
  - Human Health Countermeasures
    - *Physiology*
  - Space Radiation
    - *Biological effects of radiation exposure*
  - Research Operations and Integration
    - *Infrastructure for flight and analog experiments*

- Funds Translational Research Institute for Space Health (TRISH) through cooperative agreement to pursue disruptive, breakthrough approaches that reduce risks to human health and performance
- Collaborates with NASA Space Biology to understand causal cellular and other mechanisms that underlie adaptation to fractional gravity levels in cells, microorganisms, plants, and animals

Hazards of Spaceflight - Hazards Drive Human Spaceflight Risks

Gravity Fields - Physiological Changes

Balance Disorders
Fluid Shifts
Cardiovascular Deconditioning
Muscle Atrophy
Bone Loss



Distance from Earth

Self Sufficiency
Drives the need for additional "autonomous" capacities – e.g. cannot come home for treatment, resupply

Space Radiation

Acute In-flight effects
Long-term cancer risk
CNS-Cognitive

Hostile/ Closed Environment

Vehicle Design
Acceleration/Vibration/Noise
Environmental – CO_2 Levels, Toxic Exposures, Water, Food
Decreased Immune Function

Isolation & Confinement

Behavioral aspect of isolation – e.g. mood, morale, cogn
Sensory deprivation
Sleep disorders (circadian dysregulation) - extra 38 minutes of daylight on Mars

1. **Outliers, unexpected events**
2. **Impact is extreme**
3. **Retrospective predictability**

HRP ORGANIZATION

Human Research Program (HRP)

Director – *David K. Baumann*
Deputy Director – *Antony Jeevarajan, Ph.D.*+
Associate Director – *Charles Lloyd, Pharm. D.*
Chief Scientist – *Steven H. Platts, Ph.D.*
Deputy Chief Scientist – *Kristin Fabre, Ph.D.***
Associate Chief Scientist – *Jancy C. McPhee, Ph.D.**
Russian Science Integration Manager – *Igor Kofman**
Administrative Assistant – *Rebeca Perez**

Translational Research Institute for Space Health (TRISH)
Director – *Dorit Donoviel, Ph.D.*
Deputy Director – *James Hury*

Supporting Center Leads
ARC – *David J. Smith, Ph.D.*
GRC – *Kelly Gilkey*
JSC – *Darby Magruder*
KSC – *Ralph Fritsche*
LaRC – *Ryan Norman, Ph.D.*

Maturation and Integration Office
Manager – *Baraquiel Reyna, D. Eng.*
External Programs Lead – *Laurie Abadie*

Program Planning and Control
Manager – *Macresia Alibaruho*
Deputy Manager – *Brad Stewart*
Agreements Manager – *Lucia McCullough*
Resource Lead – *Michelle Moore*

Elements

Research Operations & Integration (ROI)
Manager
Suzanne McCollum
Scientist
Brandon Vessey, Ph.D.

FLIGHT	ANALOGS
Deputy Manager	**Deputy Manager**
Nicole Schwanbeck	*Kelle Pido*
Deputy Scientist	**Deputy Scientist**
Cherie Oubre, Ph.D.	*Sara Whiting, Ph.D.*

Space Radiation (SR)
Manager
Jason Weeks
Scientist
*Robin Elgart, Ph.D.***
Deputy Manager
Nick Meyer
Deputy Scientist
Janice Zawaski, Ph.D.

Human Health Countermeasures (HHC)
Manager
Laura Bollweg
Scientist
Michael Stenger, Ph.D.
Deputy Manager
Ryan Schulte
Deputy Scientist
Becky Brocato, Ph.D.

Exploration Medical Capability (ExMC)
Manager
Nancy Fleming
Scientist
*Kris Lehnhardt, M.D.***
Deputy Manager
Andrea Marchica
Deputy Scientist
*Ben Easter, M.D.***

Human Factors & Behavioral Performance (HFBP)
Manager
Aaron Allcorn
Scientist
Sandra Whitmire, Ph.D.
Deputy Manager
Sheikh Ahsan
Deputy Scientist
Brian Gore, Ph.D.

\+ Rotation
** IPA
* Contractor

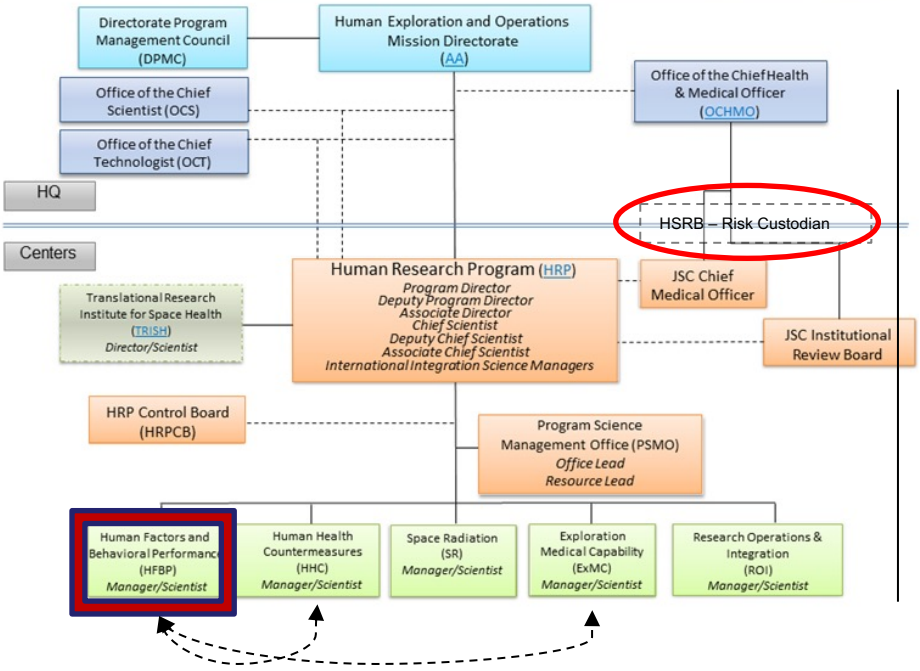
Original signed by — *4/28/2022*

David K. Baumann
Program Director

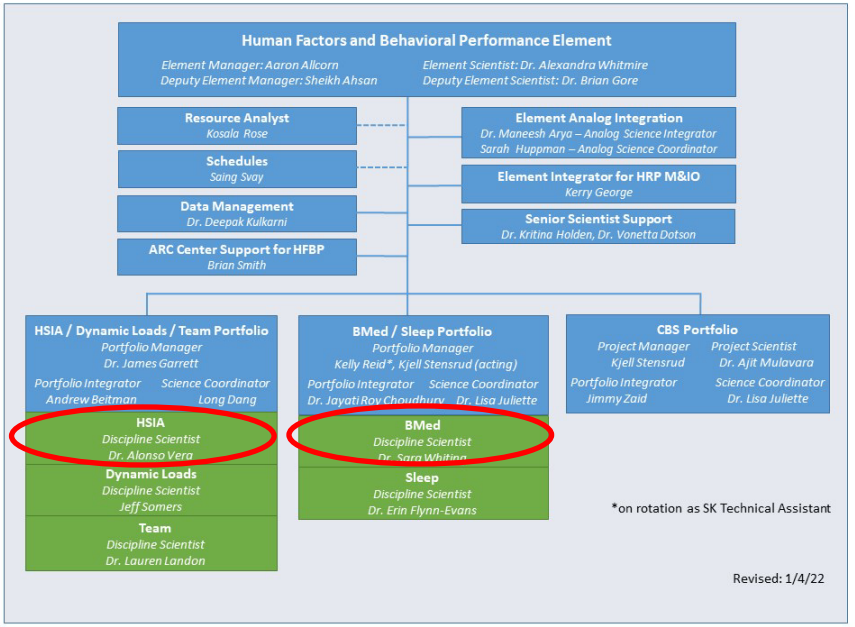
Date

Human Research Program; Human Factors and Behavioral Performance Element

Human Research Program

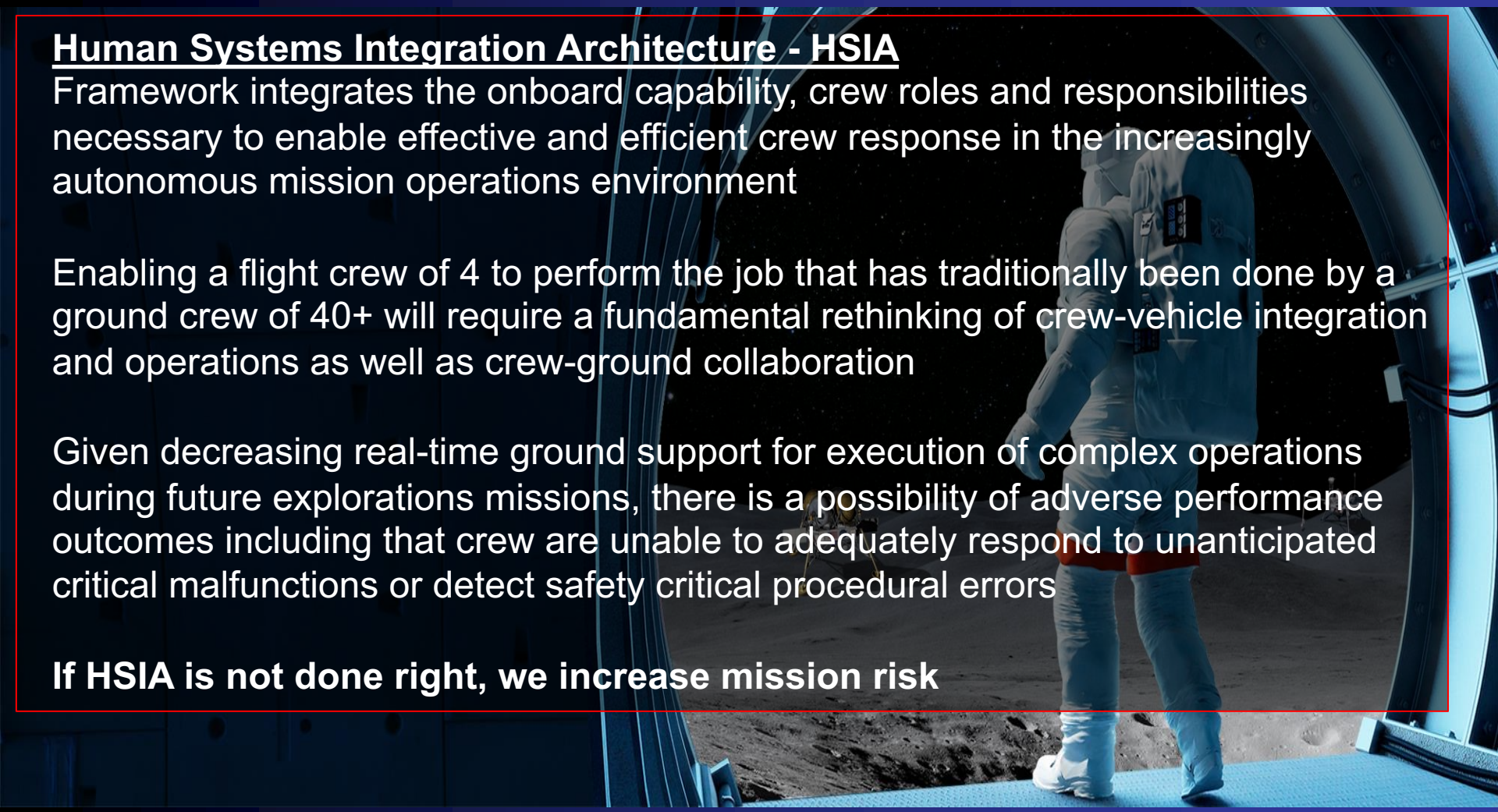


Human Factors and Behavioral Performance Element



- The Human Factors and Behavioral Performance (HFBP) Element is responsible for characterizing and mitigating human factors and behavioral performance risks associated with living and working in space, and safely returning to Earth.

HRP Human Factors Portfolio – Human Systems Integration Architecture (HSIA)



Human Systems Integration Architecture - HSIA

Framework integrates the onboard capability, crew roles and responsibilities necessary to enable effective and efficient crew response in the increasingly autonomous mission operations environment

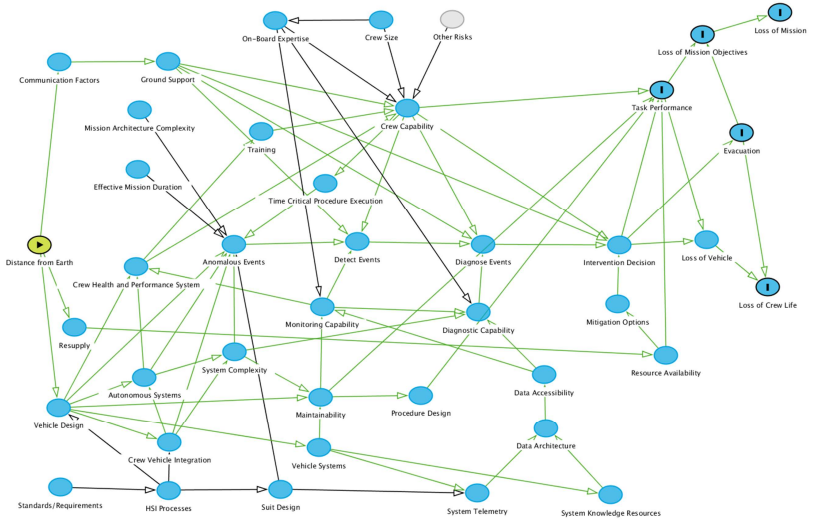
Enabling a flight crew of 4 to perform the job that has traditionally been done by a ground crew of 40+ will require a fundamental rethinking of crew-vehicle integration and operations as well as crew-ground collaboration

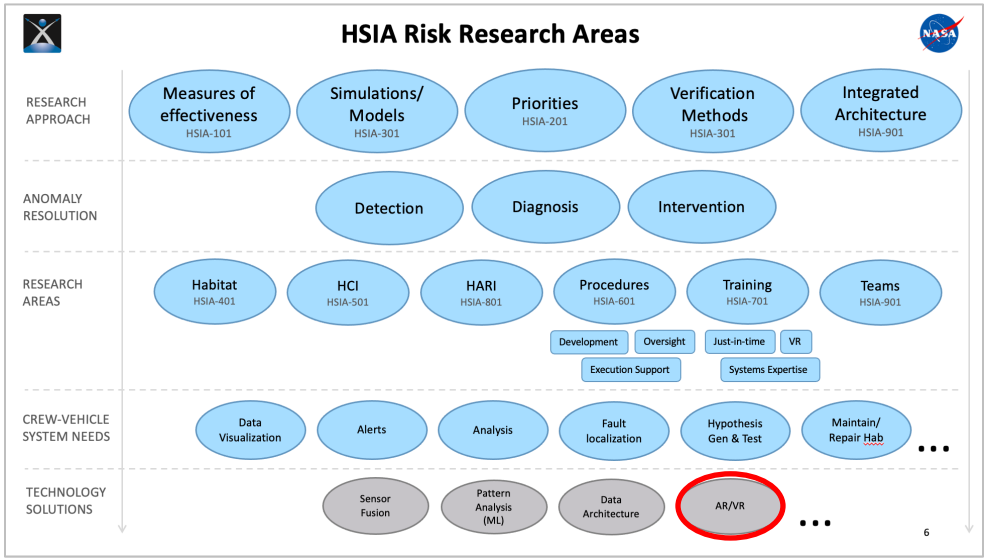
Given decreasing real-time ground support for execution of complex operations during future explorations missions, there is a possibility of adverse performance outcomes including that crew are unable to adequately respond to unanticipated critical malfunctions or detect safety critical procedural errors

If HSIA is not done right, we increase mission risk

HRP Human Factors Portfolio – Human Systems Integration Architecture (HSIA)

- Given increasing need for crew independence and greater operational complexity in future exploration missions, there is a possibility of adverse outcomes associated with deficiencies in Human Systems Integration, specifically that crew are unable to adequately respond to unanticipated critical malfunctions and/or perform safety critical procedures.

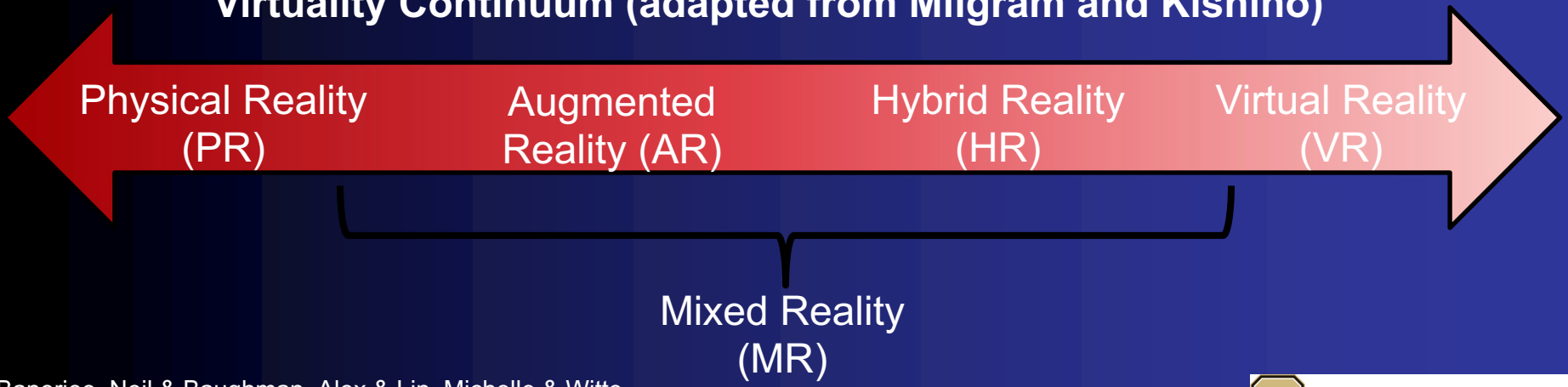




HSIA: Physical, Augmented, Hybrid, and Virtual Reality

- *Spacecraft Habitat Design Evaluation Using Alternative Reality Technologies*
  - XR may assist in spacecraft habitat design (SHD):
    - How do we define XR categories and what elements are most important for this application?
    - What advantages and disadvantages do these tools provide at different phases of the design process over current methodologies?
    - How will SHD evaluators use these tools to achieve their work?

Virtuality Continuum (adapted from Milgram and Kishino)



Banerjee, Neil & Baughman, Alex & Lin, Michelle & Witte, Zoë & Klaus, David & Anderson, Allison. (2021). Development of alternative reality environments for spacecraft habitat design evaluation. Virtual Reality. 25. 10.1007/s10055-020-00462-6.

NASA Human Research Program under NRA 80NSSC18K0198, CU Boulder DLA and SPUR undergraduate research opportunities.

Smead Aerospace
UNIVERSITY OF COLORADO BOULDER

National Aeronautics and Space Administration

Application of AR, VR, HR to HSIA

Human Research Program

Physical Reality

Augmented Reality

Hybrid Reality

Virtual Reality

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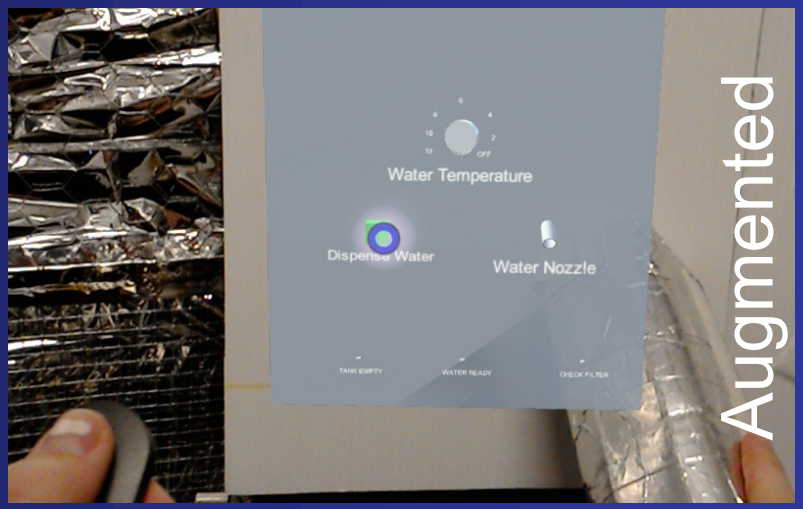
Application of AR, VR, HR to HSIA

Physical Reality



Augmented Reality

Hybrid Reality

Virtual Reality

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Additional HSIA AR, VR, HR Projects:
Human Capabilities Assessment for Autonomous Missions

- Virtual Assistant for Spacecraft Anomaly Treatment during Long Duration Exploration Missions TAMU / PI Selva
  - investigate the impact of using Virtual Assistants (VA) to support crew members in the context of anomaly treatment during long Duration Exploration Missions (LDEM), when ground support will be limited, will have the ability to take initiative in the dialog with the user (mixed-initiative mode), and the ability to provide explanations for its actions. Assessment of cognitive workload (CW), situational awareness (SA), and trust will be assessed.
- Responsive multimodal human-automation communication for augmenting human situation awareness in nominal and off nominal scenarios – MIT / PI Stirling
  - augmenting human situation awareness (SA) and task performance through multimodal displays and communication pathways based on empirical evidence. Specifically, we will evaluate the effectiveness of several multimodal virtual reality (VR) techniques in providing spatial and temporal SA to a human operator controlling multiple semi-autonomous agents
- Enabling Autonomous Crew Task Performance with Multimodal Electronic Procedure Countermeasures – UC Davis / PI Robinson
  - Emergent technologies in multimodal interaction such as augmented reality (AR) visual displays, spatial audio, and tactile feedback are likely to play a role in mitigating this need, leading to what we define as enhanced electronic procedures
- Enhancing Situation Awareness of Automated Procedures using Adaptive Multimodal Augmented Reality Displays – Traclabs / PI Shreckenghost
  - combine technology for procedure automation with technology for augmented reality multi-modal (ARMM) user interfaces using Microsoft Hololens head-mounted display to provide a virtual task assistant to assist crew in performing procedural work

Behavioral Medicine

- **Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders** (BMED)
  - Given that crews of future exploration missions will be exposed to extended durations of isolation and confinement, greater distances from Earth, as well as increased exposures to radiation and altered gravity, there is a possibility that these singular or combined hazards could lead to (a) adverse cognitive or behavioral conditions affecting crew health and performance during the mission; (b) development of psychiatric disorders if adverse behavioral health conditions are undetected or inadequately mitigated; and (c) long term health consequences, including late-emerging cognitive and behavioral changes.

Application of VR to BMED

- Quantification of Response to Virtual Reality-based Sensory Stimulation for Relaxation and Therapeutic Release in ICE
  - Project investigates the application of Virtual Reality (VR) stimulation for relaxation and therapeutic release in spaceflight-like isolated, confined, and extreme (ICE) environments.
  - Assess the impact of various core aspects of a VR-based sensory stimulation platform (e.g. program length, scene content, interactivity, haptic cues) by altering these elements and assessing (before and after VR presentation) individuals':
    - (1) psychophysiological responses (to assess relaxation) and
    - (2) performance on an operationally-relevant task (as a measure of cognitive performance and attention restoration)
  - Assessment of countermeasures to reduce boredom/stress, increase attention

Antarctica, South Pole Station

PI: Dr. A. Stankovic
NASA Human Research Program NRA 80NSSC20K1852,
Massachusetts General Hospital & Harvard Medical School, Neural Systems Group, Department of Psychiatry
https://taskbook.nasaprs.com/tbp/index.cfm?action=public_query_taskbook_content&TASKID=14074

Artificial, Virtual, and Hybrid Reality

- Projects demonstrate how AR, VR, and HR approaches can be used:
  - to develop design requirements (HAB, procedure designs) that can lead to design standards
  - formulate recommendations for updated standards and guidelines for multimodal interaction and electronic procedures
  - to recommend countermeasures to improve human behaviors during isolated/confined/extreme operations
  - to collect empirical evidence to support revisions to NASA-STD-3001 and the NASA Human Integration Design Handbook (HIDH) both of which guide human-automation and human-system designs