

National Aeronautics and Space Administration

Glenn Research Center Human Research Program

Overview

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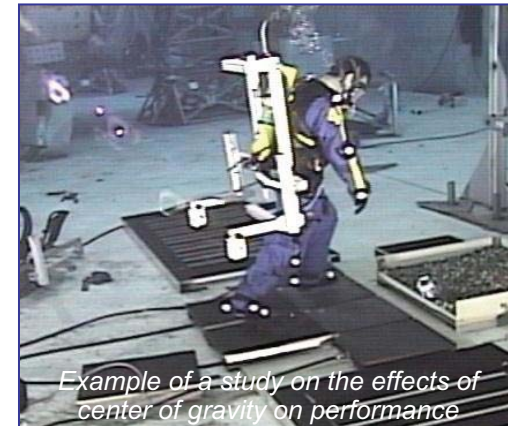
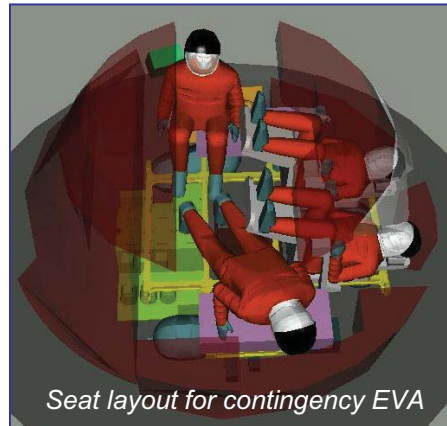




Human Research Program Goal



The goal of HRP is to provide human health and performance countermeasures, knowledge, technologies, and tools to enable safe, reliable, and productive human space exploration.



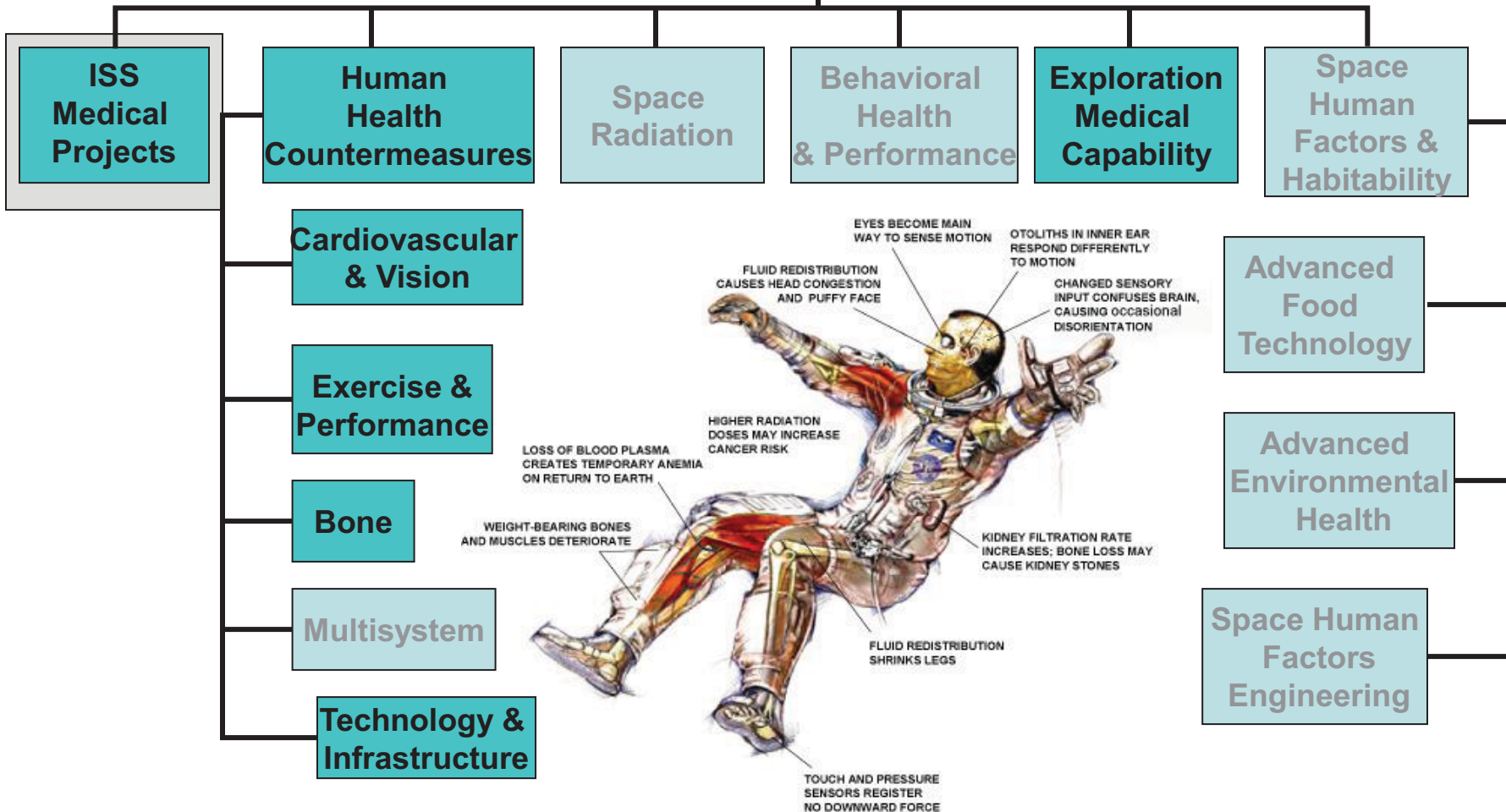


The Human Research Program



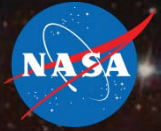
Human Research Program

NSBRI





Human Research Program Agency Participants



HRP Leverages Across the Agency



Ames

- Space Human Factors & Habitability
- Exploration Medical Capability
- Behavioral Health & Performance
- Space Radiation



Glenn

- Human Health Countermeasures
- Exploration Medical Capability

HQ

- Advocacy
- Int'l Agreements



Langley

- Space Radiation



Johnson

- ISS Medical Project
- Space Radiation
- Human Health Countermeasures
- Exploration Medical Capability
- Behavioral Health & Performance
- Space Human Factors & Habitability



Kennedy

- ISS Medical Project



GRC Unique Expertise Leveraged by HRP



- Glenn's Human Research Program is an interdisciplinary bioengineering program which applies GRC's unique expertise in the following areas to fill HRP gaps
 - Microgravity fluid physics;
 - Microgravity combustion science
 - Sensors, diagnostics, and imaging
 - Computational modeling (deterministic and probabilistic)
 - Microfluidics
 - Spaceflight experiment payload development (over 150 flown)
- HRP and GRC have worked very hard to expand and direct these skills to address HRP needs.
 - GRC has been extremely successful in adapting those skills to HRP problems
 - It is this adaptation that has made GRC doubly useful to HRP
- The GRC HRP focus is not on biology or human studies but rather on technology development and modeling
- Based on careful review of the overall Program needs, GRC HRP only advocates for content that augments, rather than duplicates, the JSC established content



GRC Unique Expertise Leveraged by HRP



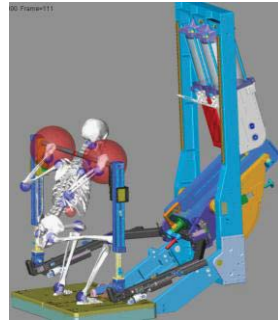
- Based on this unique expertise, Glenn has been given leadership responsibility in the following critical programmatic areas:
 - Digital Astronaut (DA) – project management for the program
 - Advanced Exercise Concepts (AEC) – project management for the program
 - In Flight Lab Analysis (IFLA) – project management for the program
 - Risk Management – manager for human health risks at the program level
 - Implementation of NASA STD 7009 for Modeling and Simulation – program level
- Glenn is also responsible for the following hardware development projects:
 - Medical Consumables Tracking (MCT) – ISS flight demo - FY15
 - In Flight Lab Analysis (IFLA) technology - ISS flight demo – FY15
 - Advanced Exercise Concept (AEC) device – ISS flight demo - FY16 (or sooner)
 - Flexible Ultrasound System (FUS) – Ground demo - FY16
 - Medical Oxygen Concentrator (OCM) – ISS flight demo - FY17
 - Medical Suction – ISS flight demo - FY19
 - Exploration Lab Analysis (ELA) technology – ISS flight demo – FY20



GRC Human Research Program



Advanced Exercise Concepts



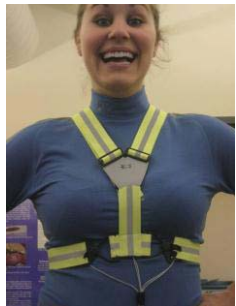
DA
Biomechanics /
Device
Integration



Glenn Flight Harness



Enhanced Zero-G Locomotion
Simulator



Lunar Health Monitor



PUMA Headgear



IVGEN in MSG



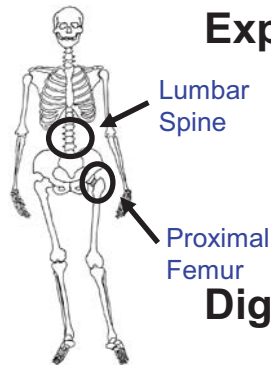
Medical
Consumables
Tracking



BioWATCH



rHEALTH
Optics Block



IMM: Fracture Risk

Exercise Countermeasures:

- Develop requirements for effective and reliable exercise hardware
- Validate candidate exercise hardware technologies

In-Flight Lab Analysis:

- Focus on near term ISS demonstration of high priority analytes

Exploration Medical Capability:

- Quantify risk of inability to adequately treat
- Develop technologies to quantify state of health
- Develop treatment technologies
- Regional technology watch for ExMC gaps

Digital Astronaut:

- Quantify space normal anatomy and physiology
- Guide research to mitigate risk



GRC Exercise Countermeasures



- Responsibility: Advanced Exercise Concepts (AEC)
 - Development of New Exercise Hardware for Exploration Missions. Address HRP Integrated Research Plan Gaps M7-M9. Severe resource constraints; Low mass, volume, power - while meeting unprecedented mission demands require significant innovation
- Capability: Ground Based Research and Simulation
 - Investigations performed on the enhanced Zero-g Locomotion Simulator (eZLS) – zero-g, lunar-g and Martian-g capable
- Proven Success: Glenn Harness – transition to ISS Operations
 - Collaboration with Cleveland Clinic - developed a more ergonomic treadmill harness for crewmembers, improving loading and comfort. Innovative sensor was developed for flight study



Advanced Exercise Concepts



Enhanced Zero-g Locomotion Simulator



Harness SDTO





AEC Portfolio of Candidates



Servomotors



Pneumatic (Low/No Power)

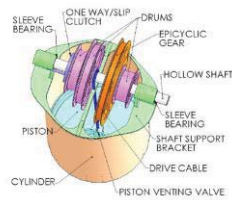


Flywheels / Energy Storage

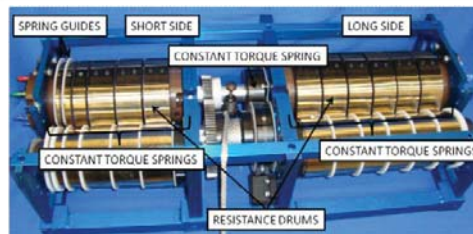


Regenerative Braking

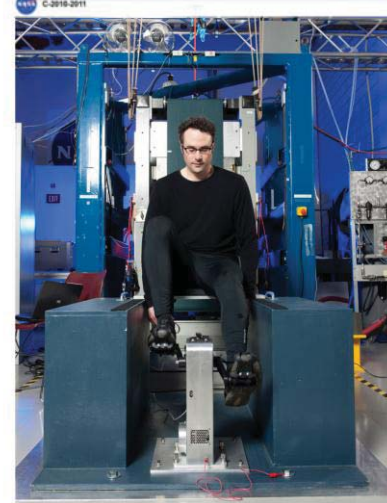
Vacuum



Torsional Springs/Elastomers



Power Generating



National Aeronautics and Space Administration
Glen Research Center at Lewis Field



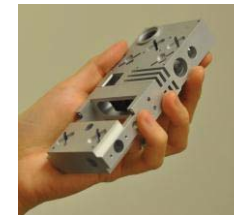
National Aeronautics and Space Administration
Glen Research Center at Lewis Field



In-Flight Laboratory Analysis



- Ensure astronaut health and safety due to injury or illness on extended (>30 days) human exploration missions.
- Address near term ‘loss of Biological Sample Return” risk carried by HRP since retirement of Shuttle by developing point-of-care biomedical analyte / lab analysis capability for technology demonstration on ISS
- Provide biomedical diagnostics capability to facilitate the recognition and treatment of several medical conditions.
- Provide analysis capability of biological fluids (i.e. blood, urine, saliva, sweat) in any habitable location



DNA Medicine Institute – Eugene Chan, M.D. (Cambridge, MA)



OPKO Health, Inc. (Claros) David Steinmiller (Woburn, MA)



Nanomix – John Burcham (Emeryville, CA)



John McDevitt Labs (Houston, TX)



GRC Exploration Medical Capability

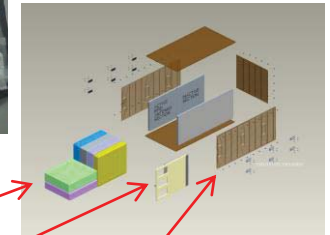


Exploration Medical Capabilities effort at GRC includes the following tasks:

- **IntraVenous fluid GENeration** for exploration (IVGEN): Generates IV fluid in situ
- **Exploration Lab Analysis:** focus on micro fluidics for reusability
- **Medical Consumables Tracking:** utilize a Radio Frequency ID (RFID) system to track medical consumables and medication usage
- **Oxygen Concentrators:** Fire risk assessment and device development
- **Flexible Ultrasound System:** a platform that provides current and future diagnostics and therapeutic capabilities integrated into a common instrument with multiple transducer interoperability



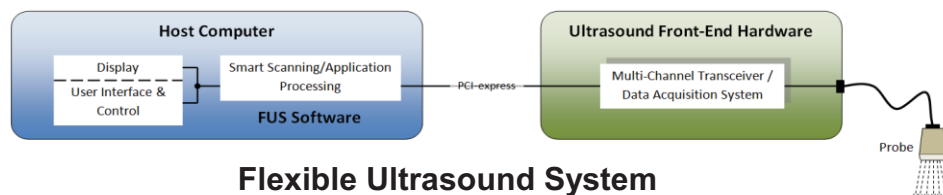
IVGEN in the MSG



Med Kits

RSR Locker door & partitions

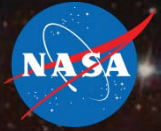
Medical Consumables Tracking



Flexible Ultrasound System



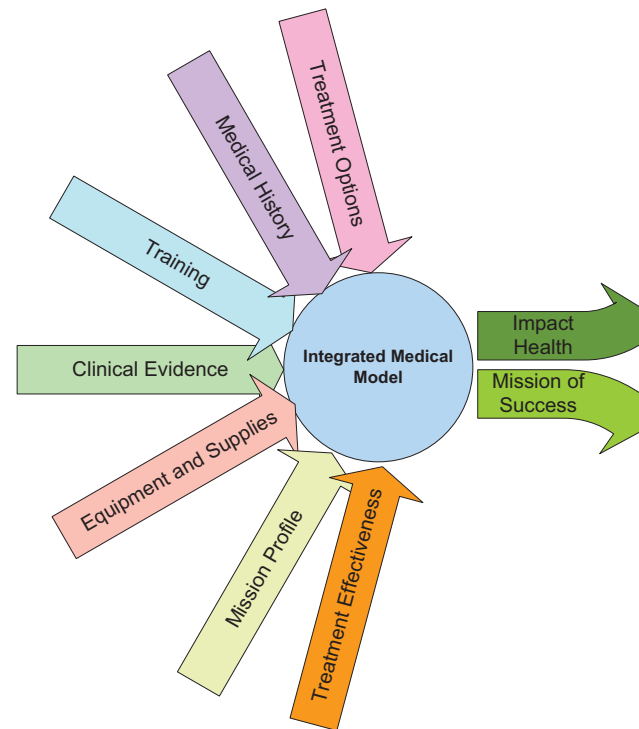
Integrated Medical Model



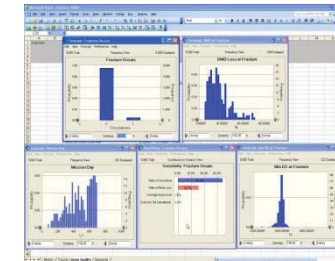
Potential Medical Condition



Evaluate
with IMM



Likelihood of occurrence,
probable severity of
occurrence, and
optimization of treatment
and resources.



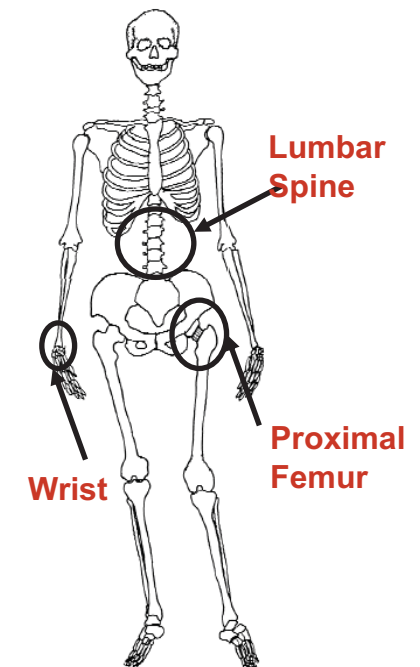
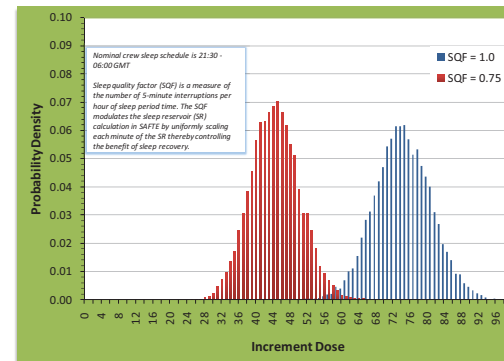
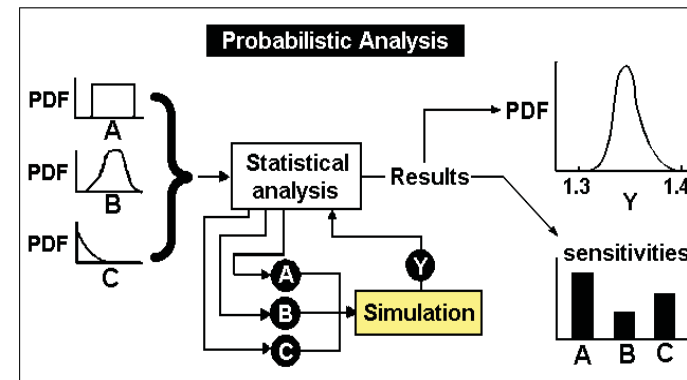
- Probability and consequences of medical risks
- Integrate best evidence in a quantifiable assessment of risk
- Identify medical resources necessary to optimize health and mission success considering 83 medical conditions



Probabilistic Modeling Of Medical Event Scenarios



- Probabilistic modeling expertise supporting risk activities
 - Integrated Medical Model (IMM)
 - Human System Risk Board (HSRB)
- Successful Modeling Efforts
 - Bone fracture at susceptible locations
 - Sleep disturbance requiring intervention
 - Renal stone frequency (top level)
 - Cervical spine injury
 - Chest, abdominal and head injury
- Other models and techniques under development
 - Renal stone formation (detailed)
 - Dynamic PRA to account for changes in risk due to changing mission events





Digital Astronaut Project



The Digital Astronaut Project (DAP) implements well-vetted computational models to predict and assess spaceflight health and performance risks, and enhance countermeasure development.

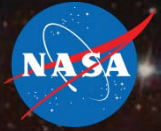
GRC Content

- Integrated biomechanical/device models to quantify exercise efficacy
- Integrated biomechanical/device models to assist in understanding advanced exercise devices
- Muscle model
- Bone turnover model
- Visual Impairment and Intracranial Pressure (VIIP)

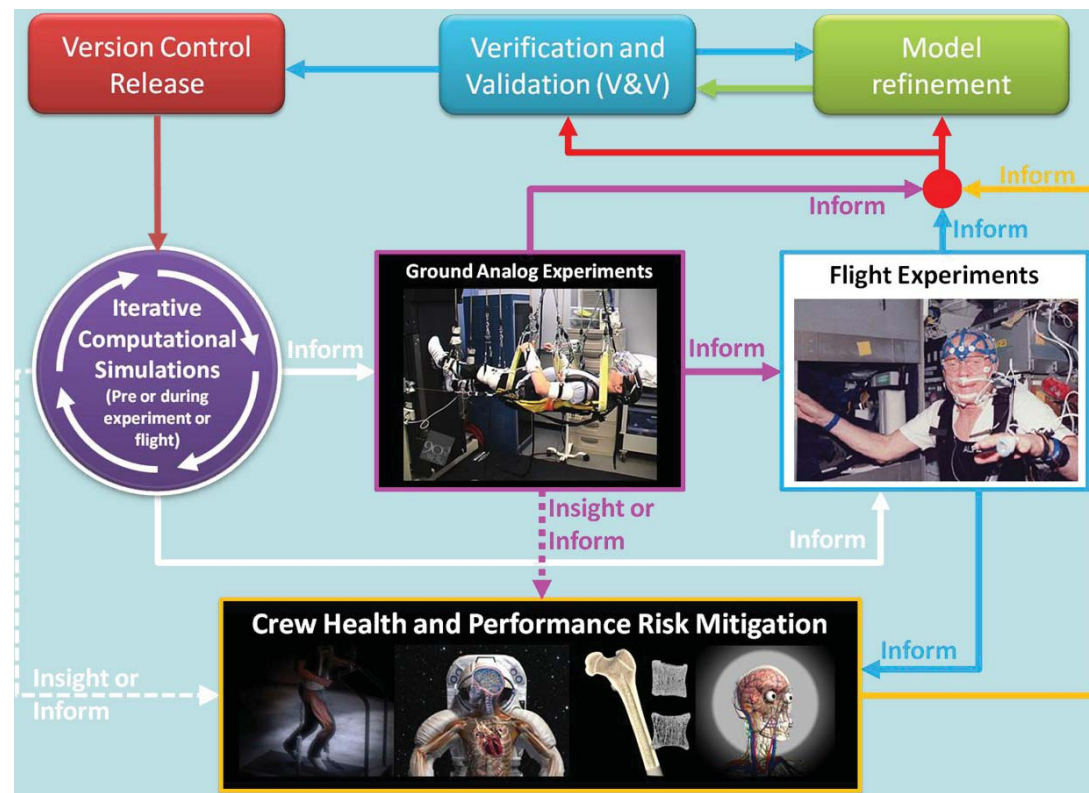




Model Credibility Assessment

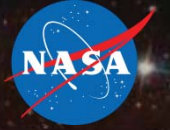


- **NEW LEADERSHIP ROLE: GRC team leads the implementation of NASA-STD-7009 to computational modeling**
 - 7009: A comprehensive set of requirements and processes for developing and applying models and simulations, while ensuring appropriate verification, validation and credibility of the M&S results





GRC Risk Management



- **Providing leadership and guidance to the existing risk management efforts for the HRP human health and performance (HHP) risks**
 - Refining existing, or defining new, processes to assist HRP team with having meaningful and timely movement of risks through the Continuous Risk Management (CRM) lifecycle
 - Strengthening HRP's working relationship with the Human System Risk Board (HSRB), soon to be called the Integrated Human Risk Control Board (IHRCB)
 - Working issues encountered with vetting risks on a timely basis (standardization of presentation content, guidance criteria for risk evaluation to risk custodians, expectations of panel/board participation and assessment)
 - Several GRC personnel are considered the “go to” authorities on quantifying the HRP risk issues and are frequently sought out to validate risk estimate activities



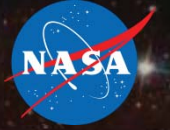
Strategic Partnerships



- **Cleveland Clinic Center for Space Medicine**
 - Promote interdisciplinary research that will exploit the unique skills, capabilities, and facilities of CCF and NASA GRC in support of long-duration spaceflight
- **National Space Biomedical Research Institute (NSBRI)**
 - Collaborative Study with University of Washington “Monitoring Bone Health Using Daily Load Stimulus During Lunar Missions”. Evaluation, guidance and Infusion of technology projects into programmatic content as appropriate.
- **Summa Health Care System**
 - Collaborate in the areas of minimally invasive surgery, specifically related minimizing the side effects and recovery period associated with prophylactic surgery , telemedicine for space applications, and development of a concept for an aerospace medicine residency for a physician crew member based on an emergency medicine residency.
- **Wright Patterson Air Force Research Laboratory - Human Effectiveness Directorate**
 - Leveraging the consolidation of all aerospace medicine and human research activities at WPAFB in response to the BRAC directive. Collaborative effort in the area of circadian rhythm upset and sleep deprivation and IV fluid generation



Strategic Partnerships



- **Case Western Reserve University/University Hospitals**
 - Leveraging expertise in the Case Biomedical Engineering Department and the University Hospitals Center for Clinical Research and Technology in the areas of physiological systems, clinical research, and patient care.
- **BioEnterprise**
 - Tech watch and collaborative efforts to further development and commercialize life-science-related technologies in Northeast Ohio.
- **NASA Human Health and Performance Center**
 - Membership in virtual forum established to connect organizations world wide interested in collaborating and advancing human health and performance innovations for spaceflight, commercial aviation and challenging environments on Earth
- **John Glenn Biomedical Engineering Consortium (Closed)**
 - Case Western Reserve University, Cleveland Clinic Foundation, University Hospitals of Cleveland, the National Center for Space Exploration Research perform interdisciplinary research leveraging GRC expertise in fluid physics and sensor technology to mitigate critical risks to crew health, safety, and performance.