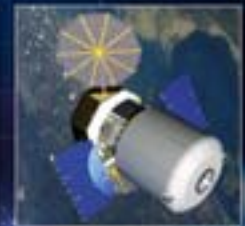




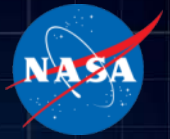
Long Duration Space Missions: Human Subsystem Risks and Requirements

**Target NEO:
Providing a Resilient NEO Accessibility Program
for Human Exploration Beyond LEO**

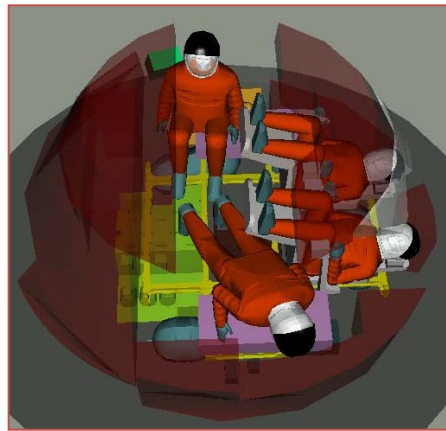
**Craig E. Kundrot, PhD
February 22, 2011**



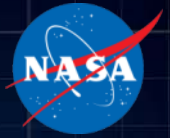
Human Research Program



- The Human Research Program (HRP) in the Exploration Systems Mission Directorate was created in October 2005
- 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



Human Subsystem Risks




- The Office of the Chief Health and Medical Officer tracks about 60 risks for human space flight
- The Human Research Program has been working on 28 risks for missions to the Moon and Mars

humanresearchroadmap.nasa.gov

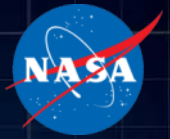
- These 28 risks provided the basis for input to the Human Exploration Framework Team (HEFT)




Human Exploration Framework Team (HEFT) Charter 




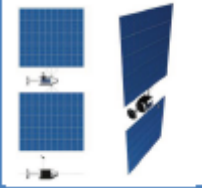


- **Mission:** The HEFT team is responsible for creating an evolvable decision framework for our Human Space Exploration Enterprise that drives out the knowledge, capabilities and infrastructure NASA needs to send people to explore multiple destinations in the Solar System in an efficient, sustainable way.
- **Objectives**
 - The initial HEFT activity will focus on standing up the organizational structure, getting it functioning, and conducting a first full iteration of the process
 - Near-term outcome of the process will be a suite of investment strategies and recommendations for human spaceflight capabilities and missions for 5, 10, and 15 year horizons, keeping Mars as the ultimate destination in mind
 - Impact the FY2012 Budget planning and budgeting process
 - Proposal must (and will) fit within NASA's space flight budget profile
 - Potential to influence the FY2011 budget priorities

HEFT Architecture Elements




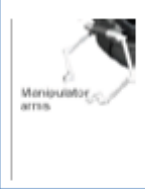




Notional Architecture Elements



					
Space Launch System (SLS)-HLLV	Multi-purpose Crew Vehicle (MPCV)	Cryogenic Propulsion Stage (CPS)	Solar Electric Propulsion (SEP)	Lander	Mars Elements

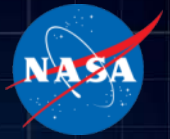
Graphics are Notional Only – Design and Analysis On-going

					
EVA Suit	Multi-Mission Space Exploration Vehicle (MMSEV)	Deep Space Habitat (DSH)	Robotics & EVA Module (REM)	Kick Stage	NEA Science Package

For Public Release

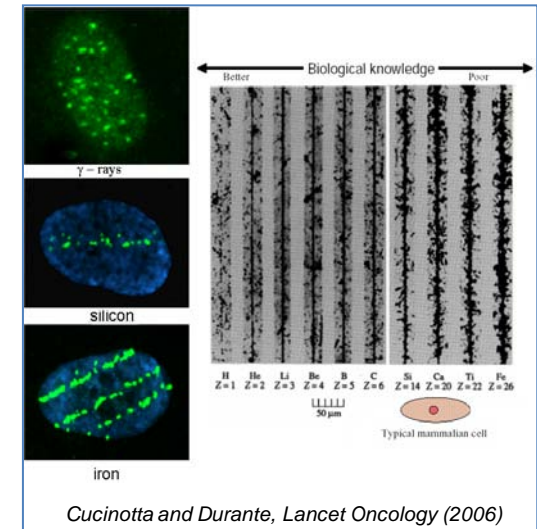
24

Potentially Unacceptable Risks - 1

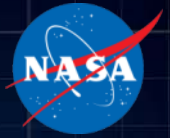


1. Risk of radiation carcinogenesis

- NASA's radiation exposure standards permit a 3% risk of radiation exposure induced death (REID)
- Cancer is the primary driver of REID
- The REID standard limits mission durations in deep space to approximately
 - solar minimum
 - 5 months for males
 - 3 months for females
 - solar maximum
 - 7 months for males
 - 6 months for females
- These mission durations could increase by two months for individuals who have never smoked



Potentially Unacceptable Risks - 2



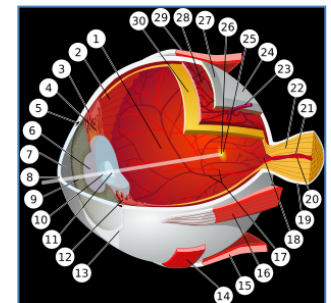
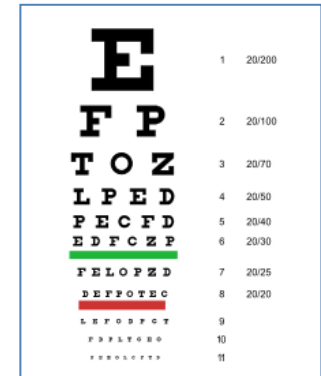
2. Risk of Visual Impairment/ Increased Intracranial Pressure

➤ Observations

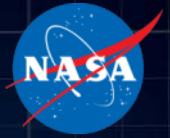
- seven long duration astronauts
- in- and post-flight changes in vision and eye anatomy
 - degraded distant vision
 - swelling of the back of the eye
 - changes in the shape of the eye
- Some individuals return to the pre-flight levels of visual function
- Some individuals have changes that persist post-flight
- Increased Intracranial Pressure also persists post-flight

➤ Underlying cause(s) are unknown

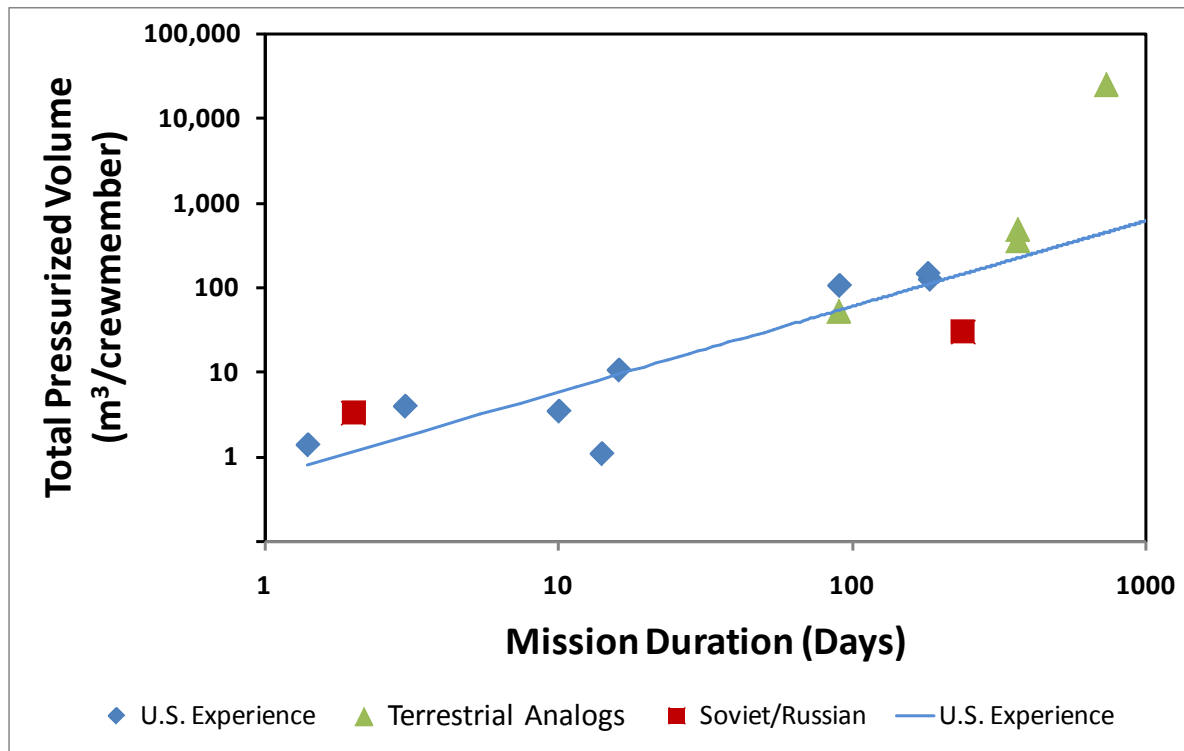
- One candidate cause
 - the shift of blood toward the head and resulting changes in physiology that accompany it, such as increased intracranial pressure



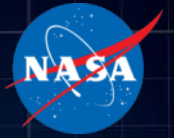
Major Mission Drivers of Risk



1. Habitable volume \Rightarrow Behavioral health issues



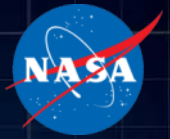
Major Mission Drivers of Risk



2. Exercise equipment \Rightarrow Muscle atrophy, cardiovascular atrophy, bone loss



Major Mission Drivers of Risk



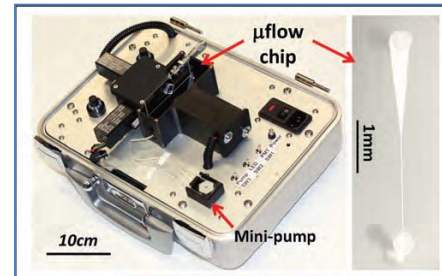
3. Food storage & trash handling \Rightarrow
Inadequate nutrition



4. EVA suitport or airlock \Rightarrow
Exposure to dust and volatiles



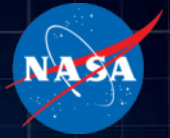
5. Abort options \Rightarrow
Lack of treatment for ill or injured
crewmember



6. EVA glove or end effector \Rightarrow
Decompression sickness



Conclusion



- HRP is concerned with human health and performance risks for exploration missions beyond LEO
- Potentially Unacceptable Risks
 1. Radiation Exposure
 2. Visual Impairment
- Major Mission Drivers
 1. Habitable Volume
 2. Exercise Equipment
 3. Food Storage
 4. EVA Suitport
 5. Abort Options
 6. EVA End Effector

