National Aeronautics and Space Administration

Physiological Health Protection in Space

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The Future of American Human SPACEFLIGHT

National Aeronautics and Space Administration

Exploring Further

NASA is embarking on a new era of space exploration in which humans will travel deeper into the solar system than ever before. The International Space Station is the centerpiece for space operations. Serving as a test bed for research and new technologies, the space station is a steppingstone toward future exploration destinations. The commercial industry will transport cargo and eventually crew to the space station while NASA focuses on developing the Orion Multi-Purpose Crew Vehicle, Space Launch System, and advanced exploration systems that will enable a sustainable human presence to destinations such as the moon, near-Earth asteroids and Mars.

To learn more, visit *http://www.nasa.gov/exploration*.

Following NASA's innovative partnership activities and investments in U.S. commercial launch capabilities, the agency has purchased cargo transportation services to and from the Space Station and will continue to partner in the development of crew transportation capabilities to low Earth orbit.

"This is the next chapter that we can write together here at NASA. We will partner with industry. We will invest in cutting-edge research and technology. We will set far-reaching milestones and provide the resources to reach those milestones. And step by step, we will push the boundaries not only of where we can go but what we can do...."

— President Barack Obama

The research and technology breakthroughs aboard the space station will facilitate travel to destinations beyond low Earth orbit.

NASA will use the Orion Multi-Purpose Crew Vehicle (MPCV) and Space Launch System, with additional exploration capabilities, to provide the means for crewed exploration missions beyond low Earth orbit.

Destinations

Lagrange Points

Lagrange Points are microgravity destinations beyond low Earth orbit that provide opportunities for construction, fueling and repair of complex in-space systems. These points in space can serve as a gateway to reaching multiple destinations in our solar system.

Near-Earth Asteroids

These near-Earth objects may provide answers to some of humankind's most compelling questions, such as these: How did the solar system form? Where did Earth's water and other organic materials come from?

Moon

Earth's nearest neighbor provides significant opportunities for commercial and international collaboration and has critical resources needed to sustain human explorers.

Mars

Mars provides the best opportunity to demonstrate that humans can live for extended — even permanent — stays beyond low Earth orbit. The technology and space systems required to transport and sustain explorers on Mars will expand scientific knowledge and drive technological innovation.

Commercial Spaceflight Development

NASA is investing financial and technical resources to stimulate efforts within the commercial industry to develop and demonstrate cargo and crew space transportation capabilities to and from low Earth orbit.

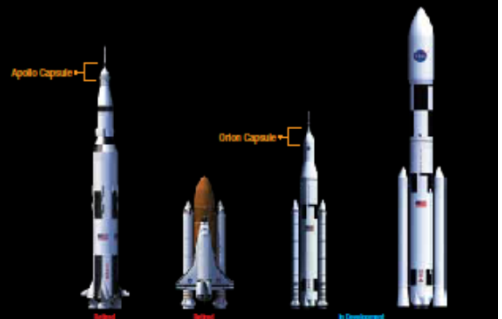
Cargo Partners	Commercial Company	Spacecraft	Launch Vehicle
	Space Exploration Technologies (SpaceX)	Dragon (Cargo)	Falcon 9
	Orbital Sciences Corporation (Orbital)	Cygnus	Antares
Funded Crew Partners			
	Blue Origin	Crew Transportation System	Initial — Atlas V Final — Own Reusable Booster System
	Sierra Nevada Corporation	Dream Chaser	Atlas V
	SpaceX	Dragon (Crew)	Falcon 9
	The Boeing Company	Crew Space Transportation (CST)-100	Initial — Atlas V

www.nasa.gov

Human Spaceflight Capabilities

NASA is developing next-generation spaceflight technology to explore multiple destinations throughout the solar system. New technology systems include the following:

Mobile Extravehicular Activity and Robotic Platform | Deep Space Habitation | Advanced Spacesuits | Advanced Space Communication | Advanced In-Space Propulsion | In Situ Resource Utilization | Human-Robotic Systems



Launch Vehicle	Saturn V	Space Shuttle	Initial Lift Capability	Evolved Lift Capability
Years	1967–1973	1981–2011	First uncrewed launch planned for 2017	To be determined
Height	111 m (363 ft)	56 m (184 ft) (Orbiter 122 ft)	97 m (318 ft) →	115 m (376 ft)
Lift Capability to Low Earth Orbit	118 metric tons	28 metric tons (to 28.5° inclination)	70 metric tons →	130 metric tons
Crew Capsule/ Capacity	Apollo Spacecraft	Orbiter	Orion MPCV	Cargo Configuration Shown

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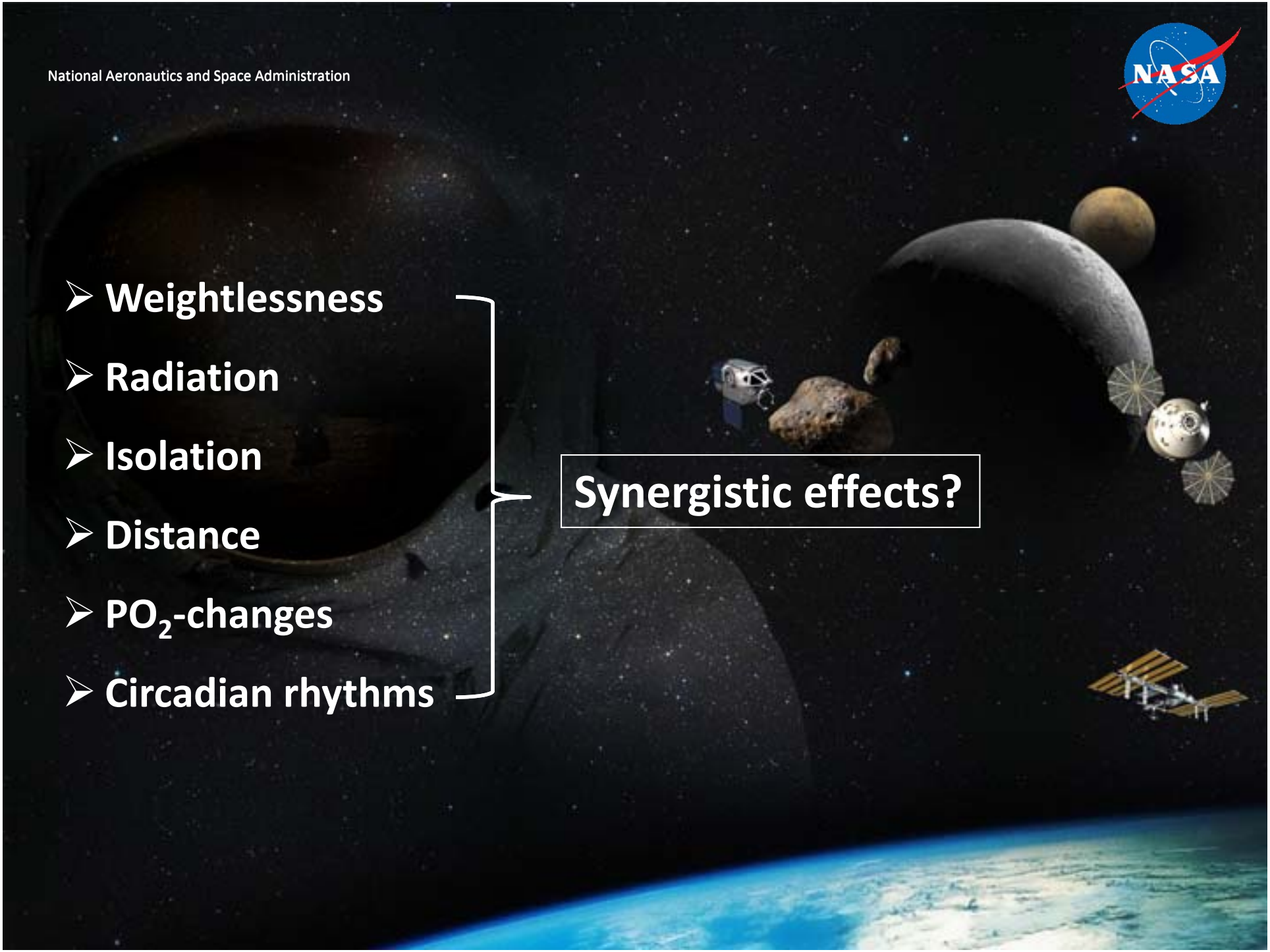
- Weightlessness
- Radiation
- Isolation
- Distance
- PO_2-changes
- Circadian rhythms


National Aeronautics and Space Administration
NASA
Weightlessness
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Isolation
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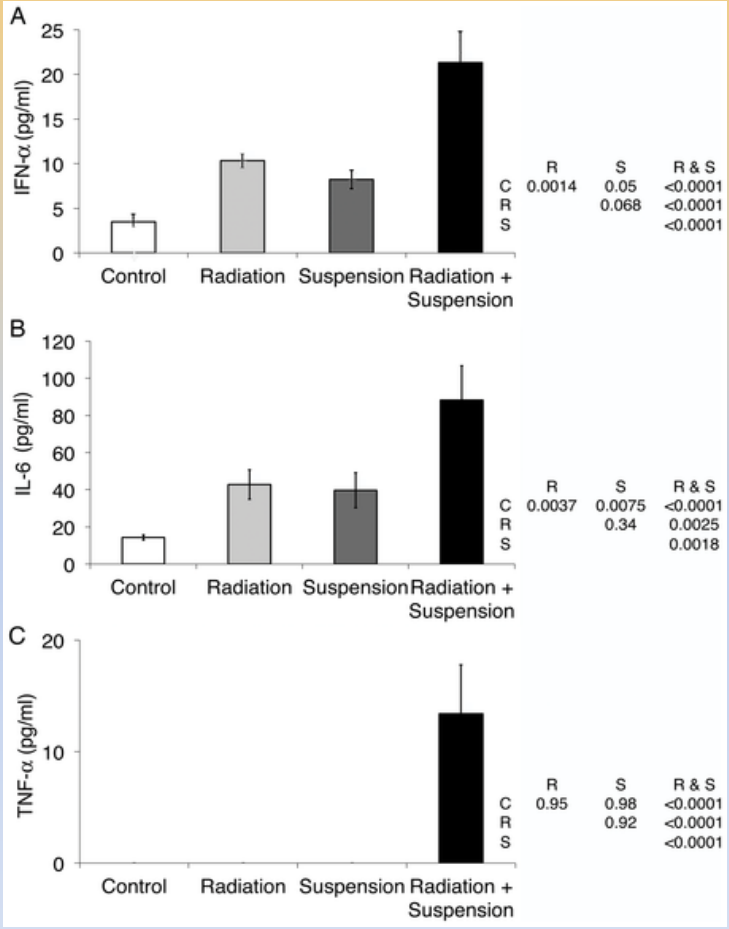
PO_2-changes
Circadian rhythms
Synergistic effects?

Example



An example of synergistic effects of 0 G-simulation and radiation (2 Gy)

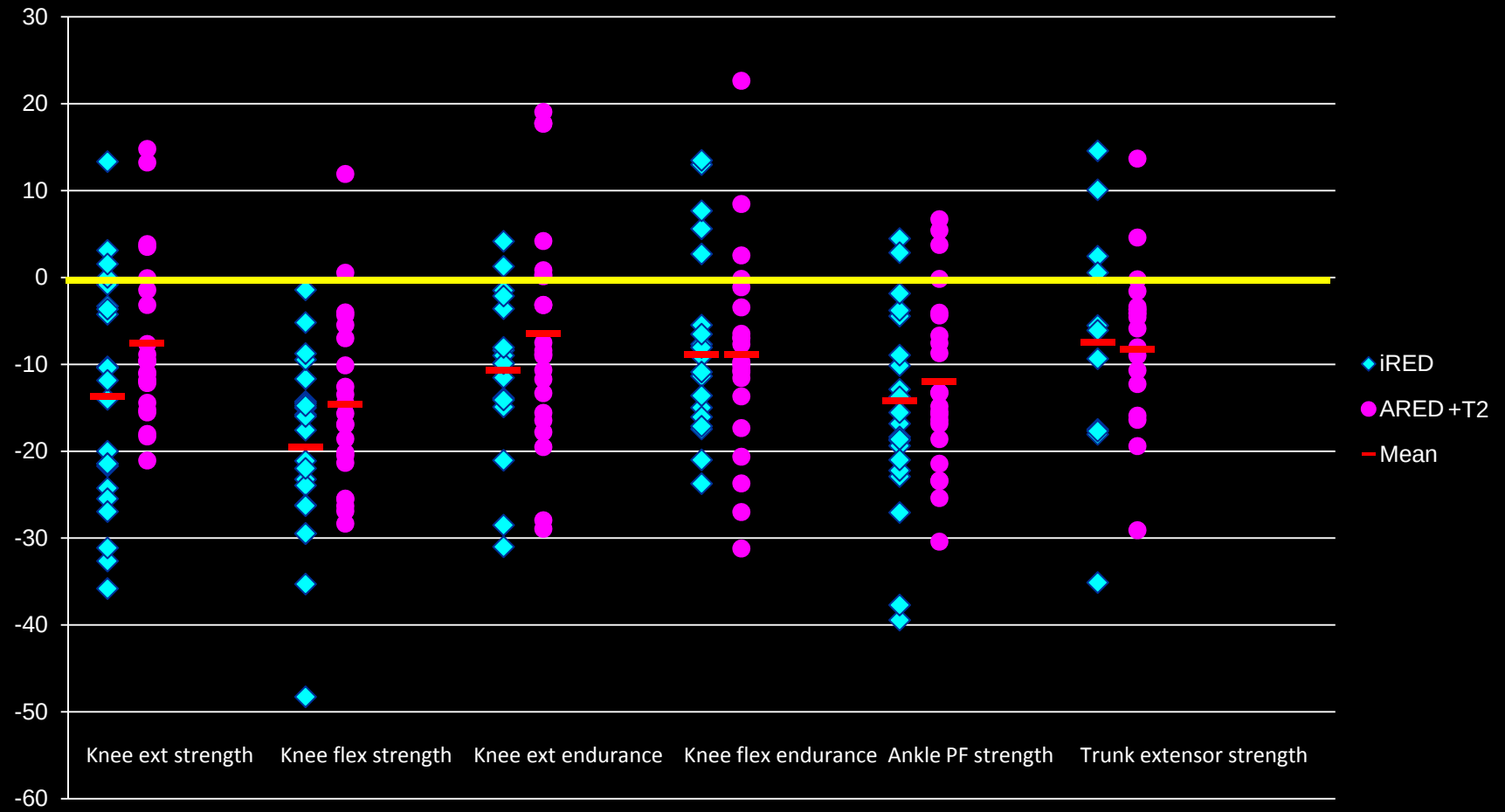
Zhou Y, Ni H, Li M, Sanzari JK, et al. (2012) PLoS ONE 7(9): e44329. doi:10.1371/journal.pone.0044329
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0044329

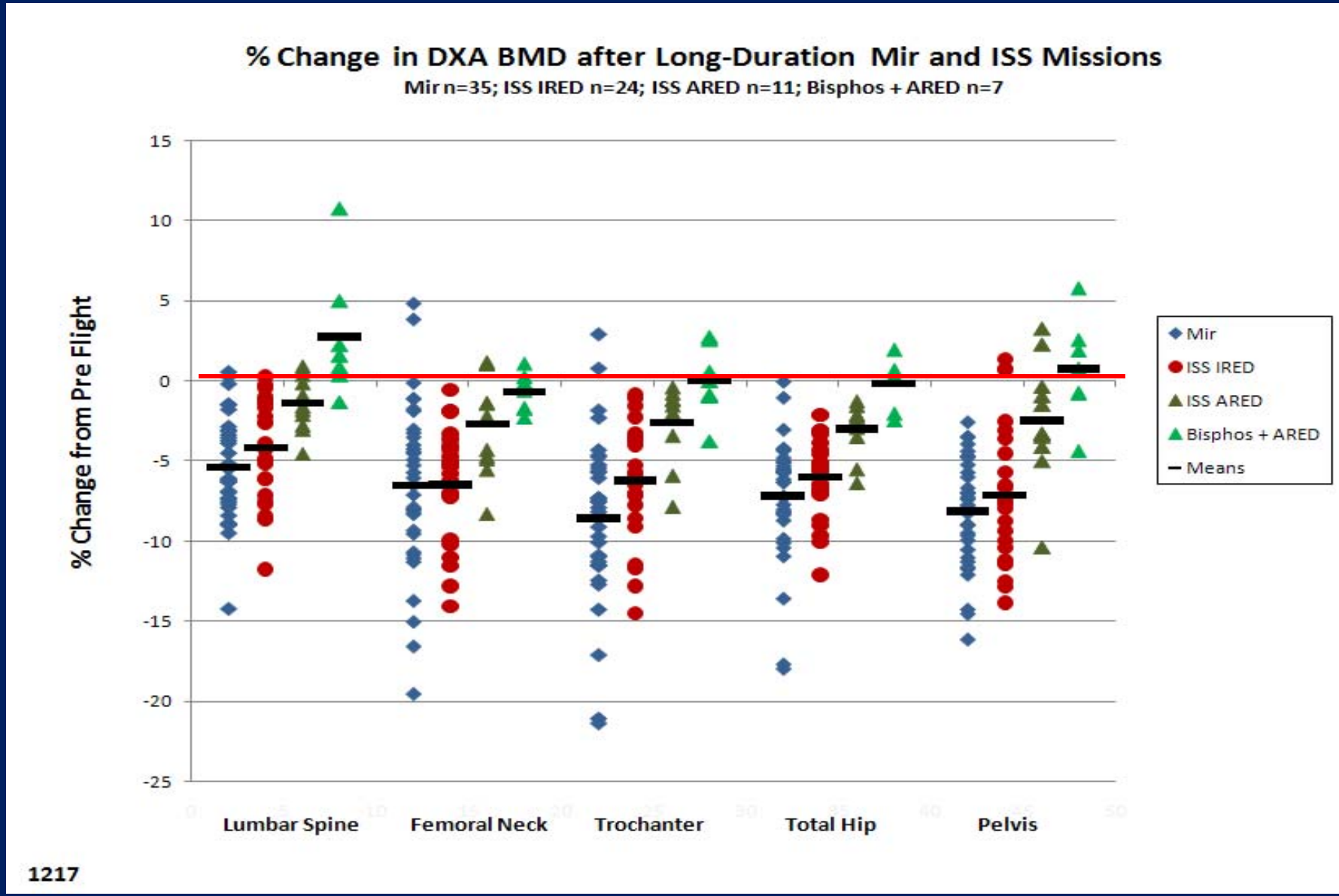
PLOS | ONE

Present platform in LEO

Muscle Function

Exp 1-32 (IRED n=22 ARED+T2 n=25)

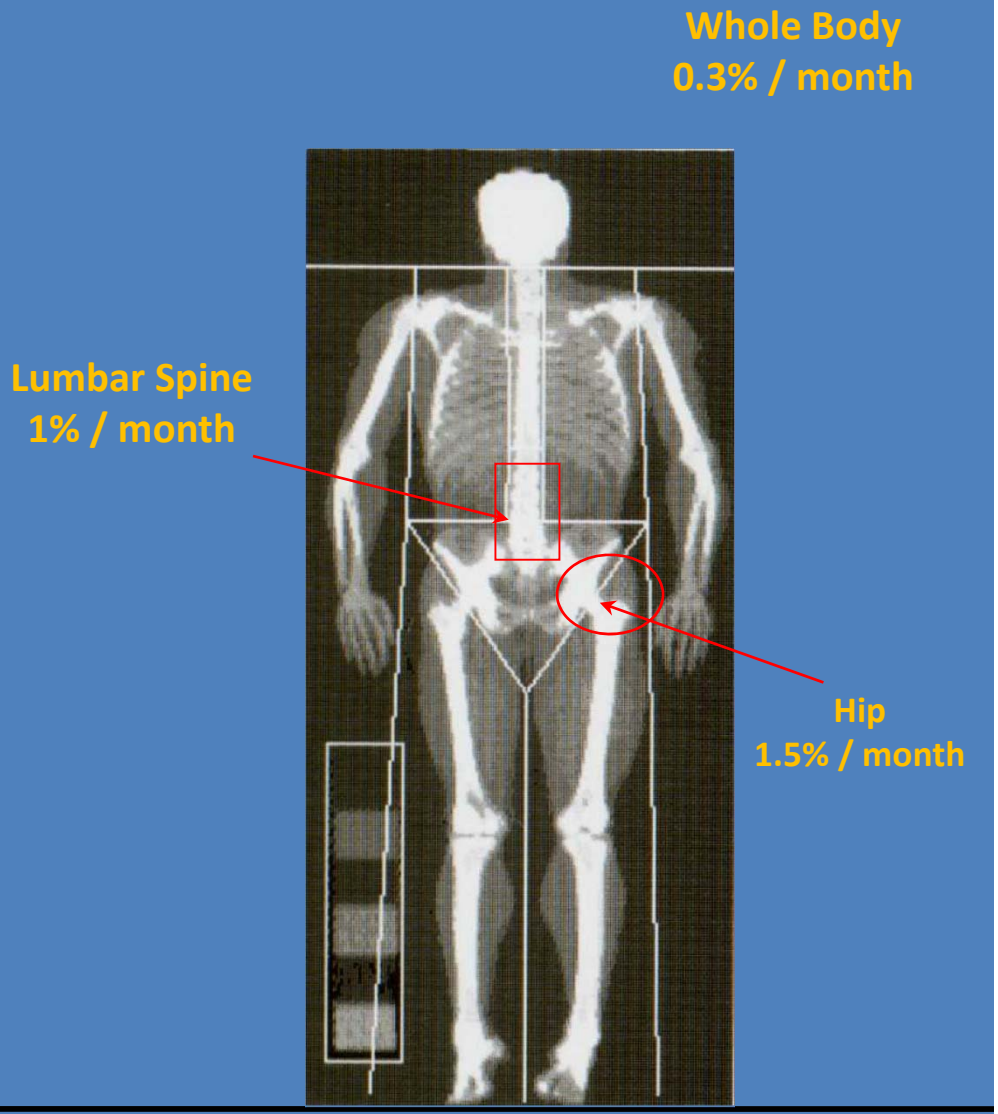




* Updated data since 2010 Bone Summit

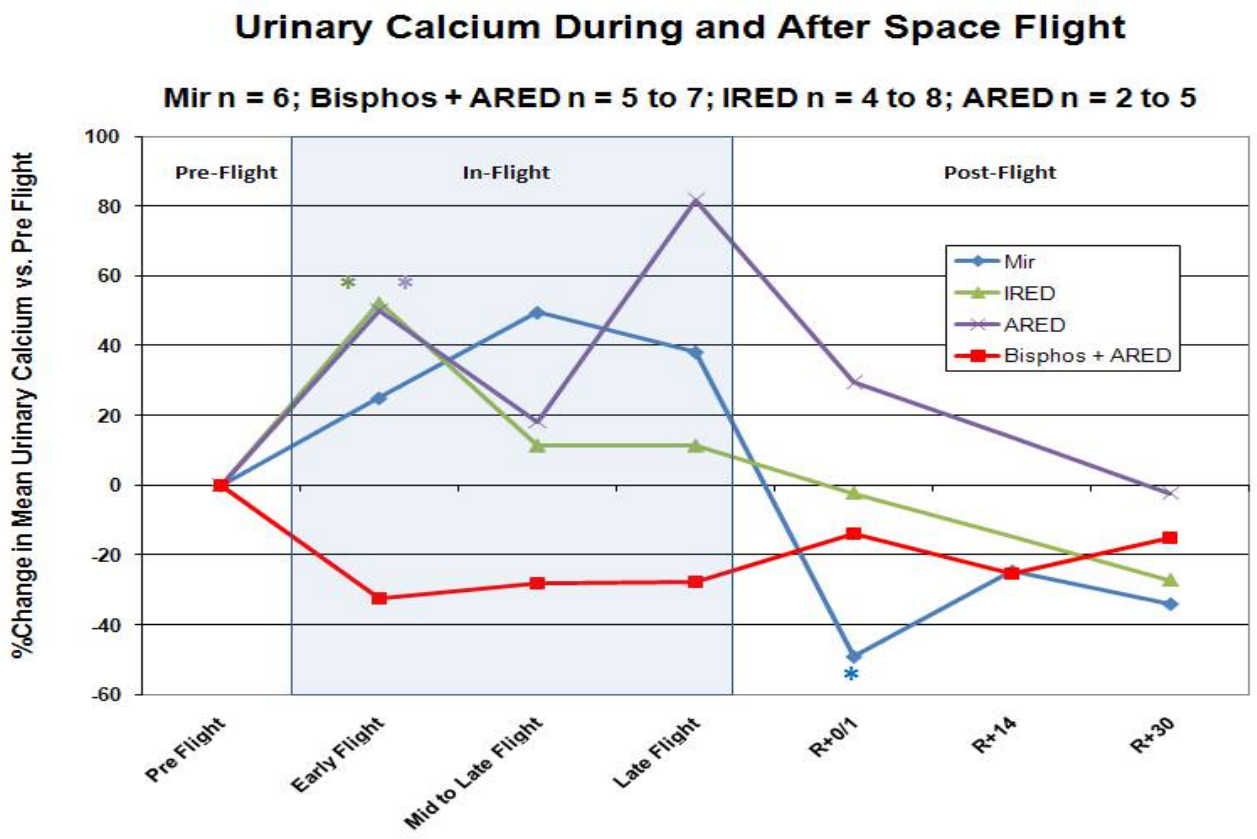
DXA: BMD losses are regional and rapid

Areal BMD g/cm2	%/Month Change ± SD
Lumbar Spine	-1.06±0.63*
Femoral Neck	-1.15±0.84*
Trochanter	-1.56±0.99*
Total Body	-0.35±0.25*
Pelvis	-1.35±0.54*
Arm	-0.04±0.88
Leg	-0.34±0.33*
*p<0.01, n=16-18	



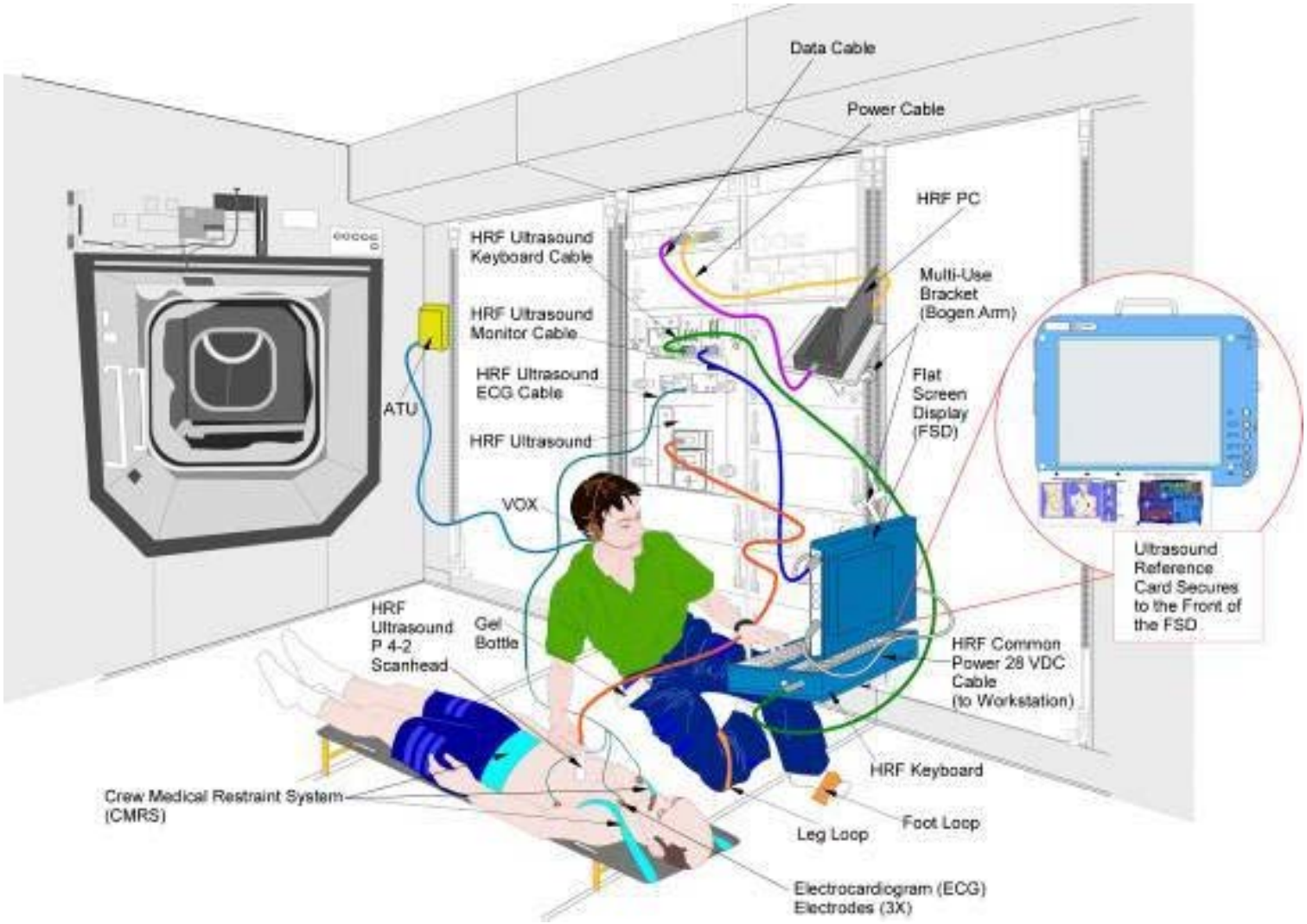
LeBlanc et al, J Musculoskeletal 2000

Bisphosphonates as a Countermeasure to Spaceflight Effects - mitigates of urinary calcium excretion

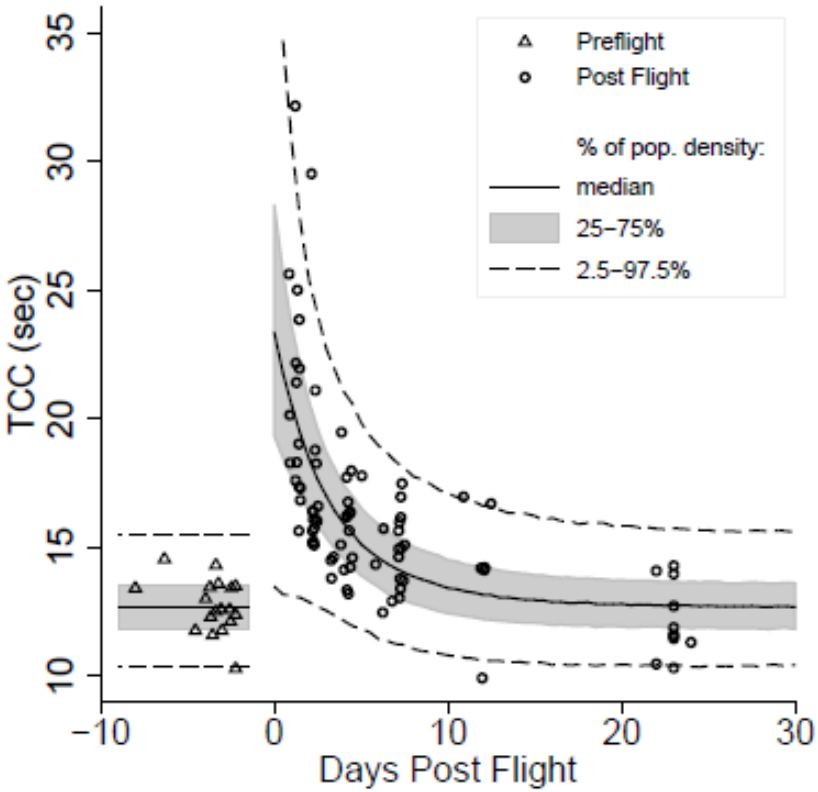


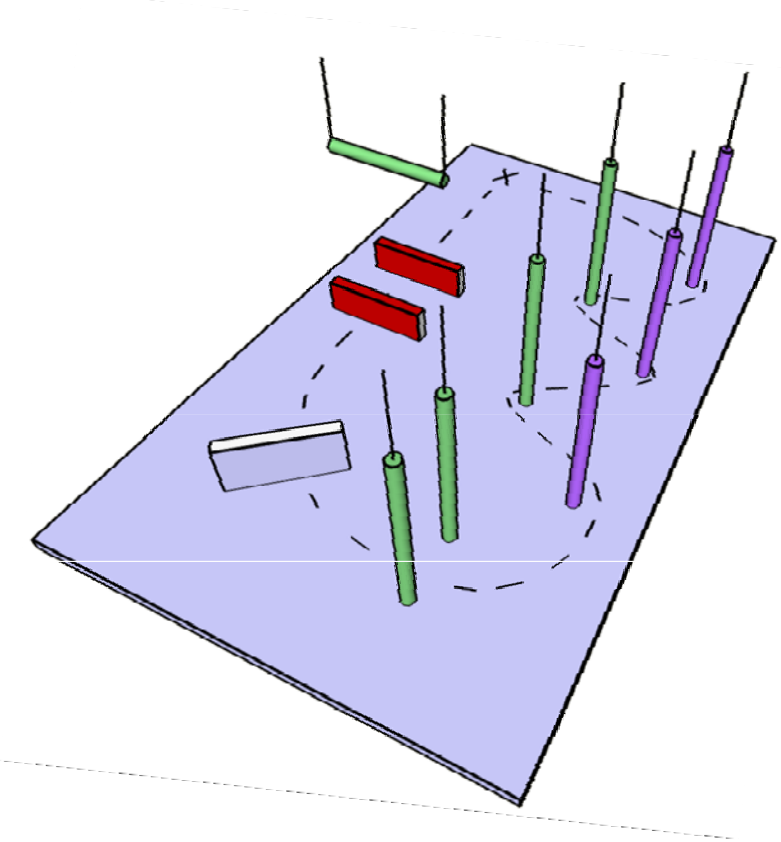
Slide courtesy of Dr. A. LeBlanc

'Integrated Cardiovascular'



Time to Complete Course



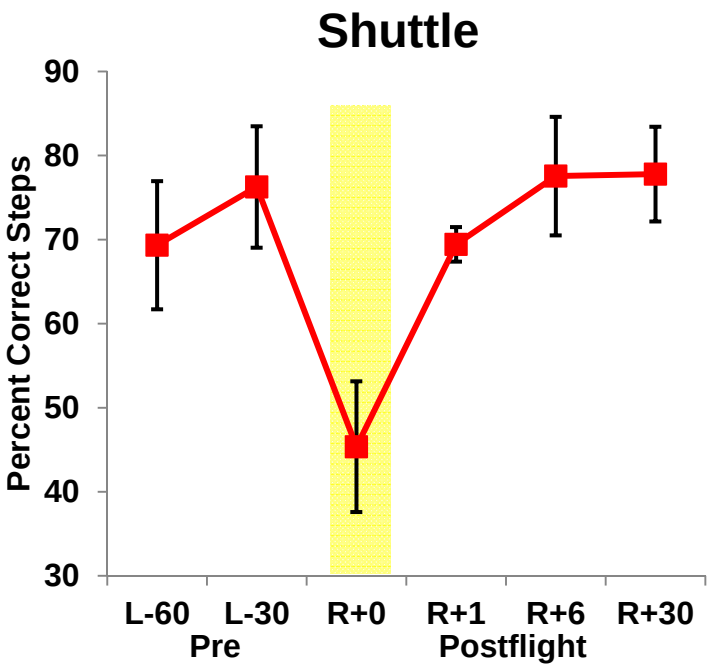


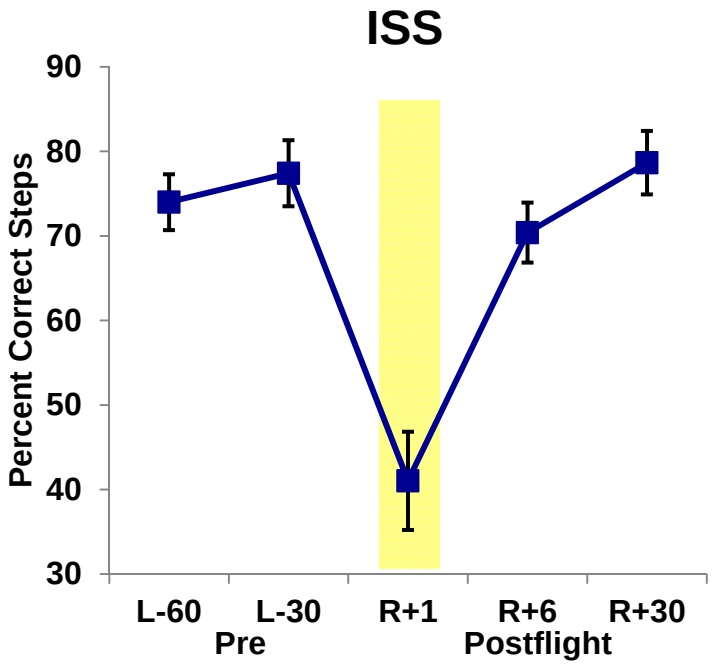
Recovery of functional mobility to 95% of preflight level took 15 days.

N = 18

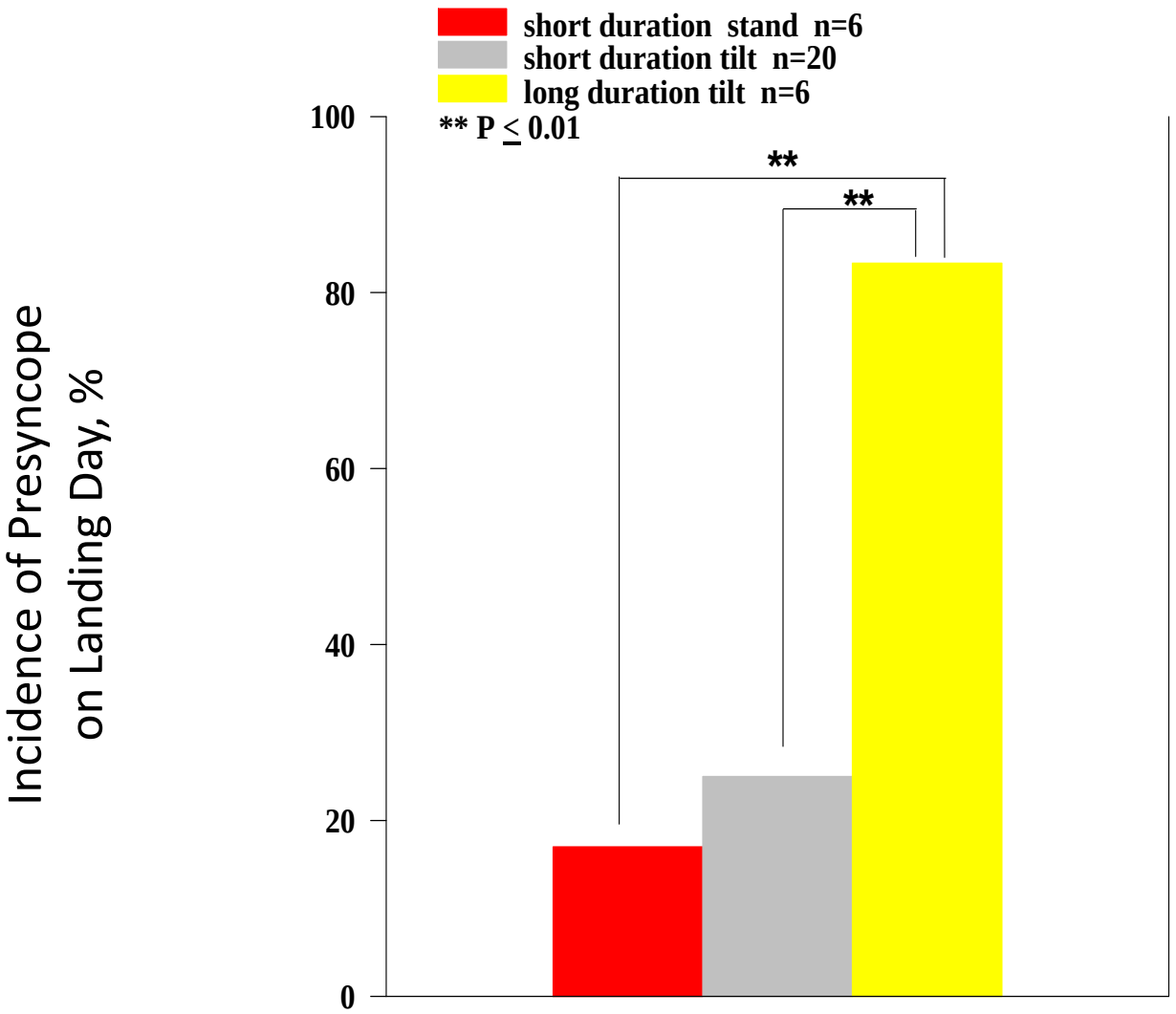
Mulavara AP, Feiveson A, Feidler J, Cohen HS, Peters BT, Miller CA, Brady R, Bloomberg JJ. Experimental Brain Research. 202(3): 649-59. 2010.

Tandem Walk Test





<u>Incorrect Steps</u>:
sidestepped, opened eyes,
or paused for more than
three seconds between steps



Meck et al., Psychosomatic Medicine, 63:865-873, 2001

Orthostatic Intolerance

- Mitigated by:
  - Oral salt and fluid loading
  - Antigravity garment
  - Additional clinical i.v fluid treatment

VIIP Syndrome

Fluid shift induced vision and intracranial pressure changes!

Example of cephalad fluid shift

Preflight press briefing

FD-2

Integrated Visual Impairment/Intracranial Pressure Project

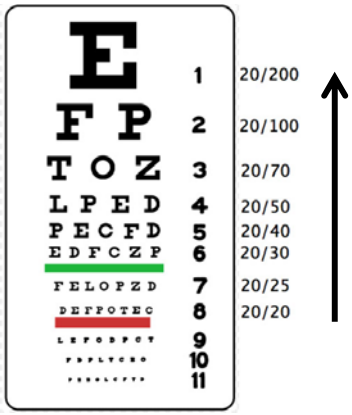
Risk Background - Symptoms

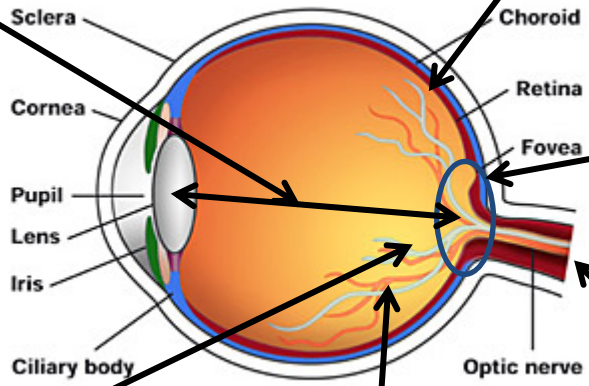
Background:

- 8 known "clinical cases" (of 34 long duration crew) members
  - Each with different degrees of symptoms
  - Elevated measures of Intracranial Pressure (ICP) post flight

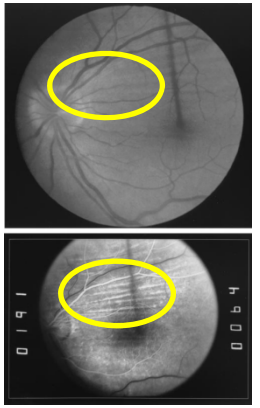
•Hyperopic Shifts

-Up to +1.75 diopters





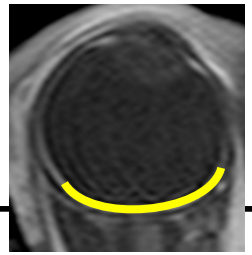
•Choroidal Folds - parallel grooves in the posterior pole



•Optic Disc Edema (swelling)

•Globe Flattening

Normal Globe



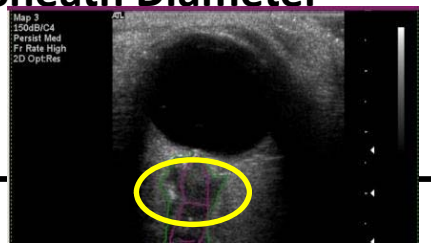
Flatten Globe

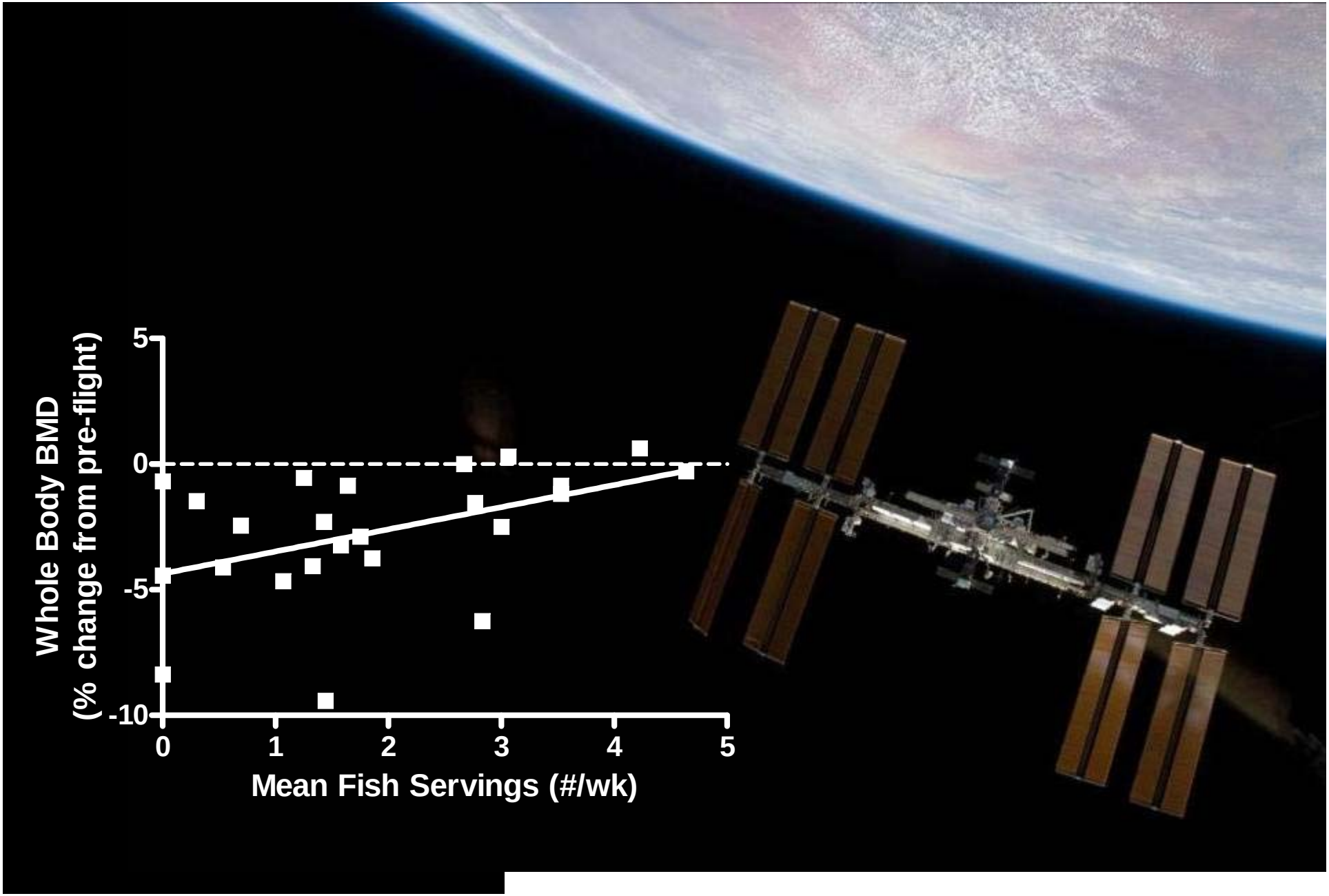
MRI Orbital Image showing globe flattening

•Altered Blood flow

•"cotton wool" spots

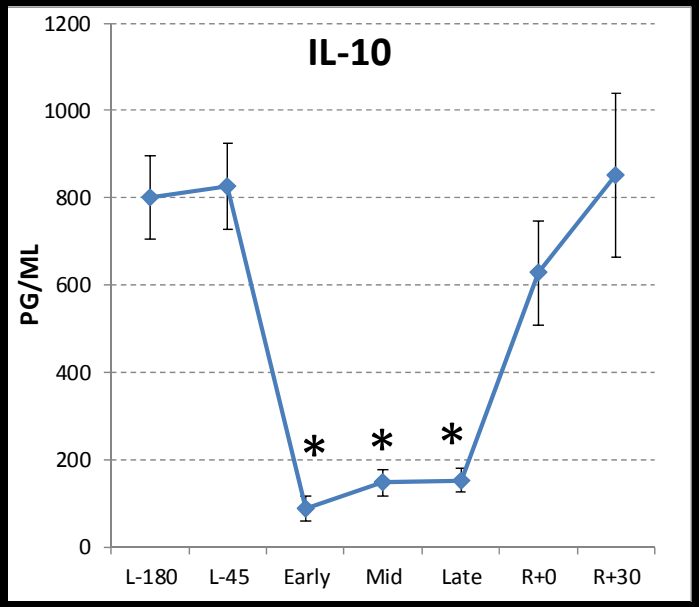
•Increased Optic Nerve Sheath Diameter



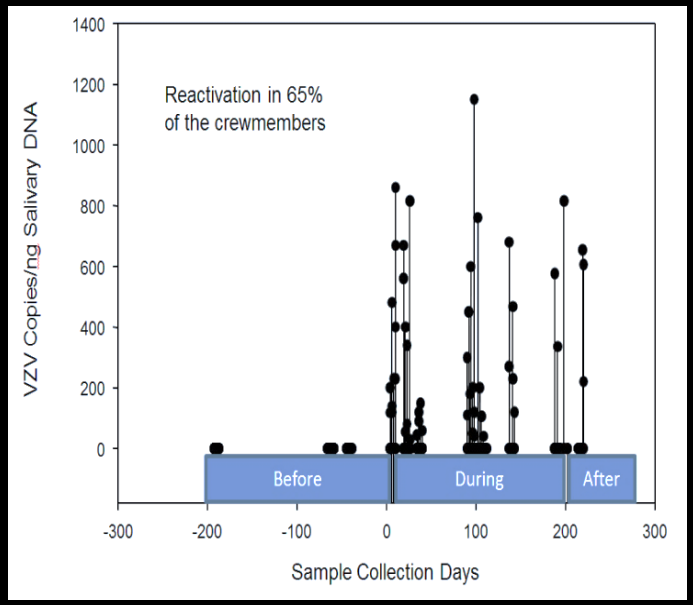

Whole Body BMD
(% change from pre-flight)
5
0
-5
-10
0
1
2
3
4
5
Mean Fish Servings (#/wk)

Immunity is Altered During Long-duration Spaceflight onboard ISS

Cytokine Production Profiles



Latent Herpesvirus Reactivation



Future approach

IPCS:

IPCS:

IPCS:

Integrated
Physiological
Countermeasure
Suite

Based on ISS Research

Integrated Physiological Countermeasure Suite

Pre-flight

- Establish healthy life style: Exercise, food intake
- Develop individualized CM-protection programs: Computer modeling, G-transition training

Integrated Physiological Countermeasure Suite

In-flight

Monitoring

- Immune/OSaD-biomarkers (Lab analysis of urine, blood, saliva)
- Cardiovascular, VIIP, muscle/bone (ultrasound, ECG, BP, OCT, CCFP/TCD, vision, cognition)

Training & Prevention

- Sensory-motor adaptation: Computer programs , vestibular (galvanic) stimulation
- Exercise prescriptions: Aerobic and resistive
- EVA pre-breathing
- Functional food items: Omega-3, anti-oxidants, low salt and iron
- Anti-osteoporotic medications: Bisphosphonates, anabolics, ACE-inhibitors

Treatment and prevention

- Anti-VIIP bracelets (+/- dynamic exercise) and/or medication
- Anti-motion sickness & anti-inflammatory medications (medication stability monitoring)
- Anti-orthostatic pre-landing fluid and salt ingestion

Integrated Physiological Countermeasure Suite

Planetary landing

- Anti-orthostatic garment and fluid/salt treatment
- G-transition medication, vestibular (galvanic) stimulation

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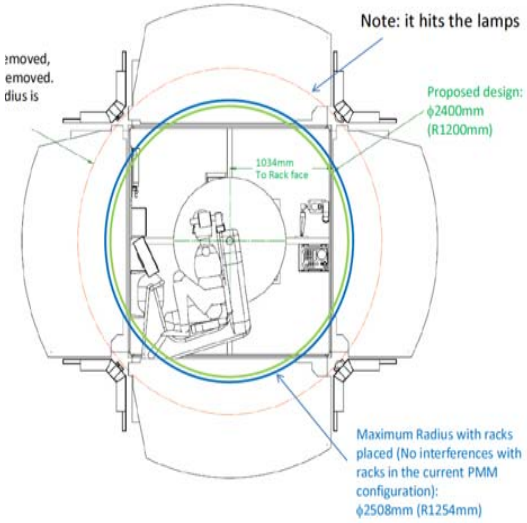
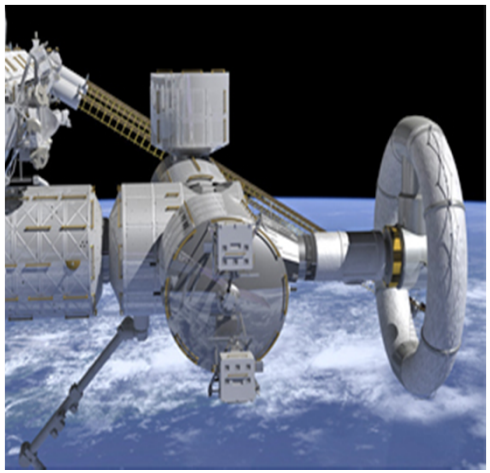
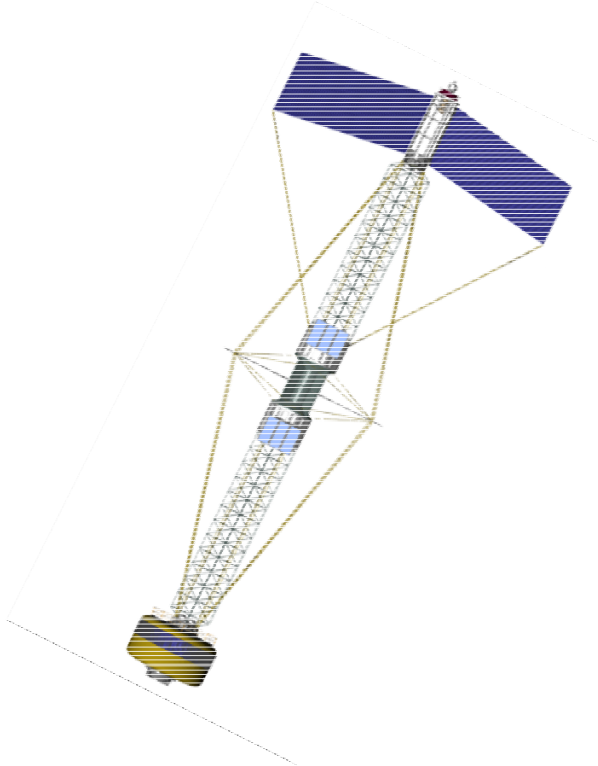
But -

But – why not bring gravity?

Artificial Gravity

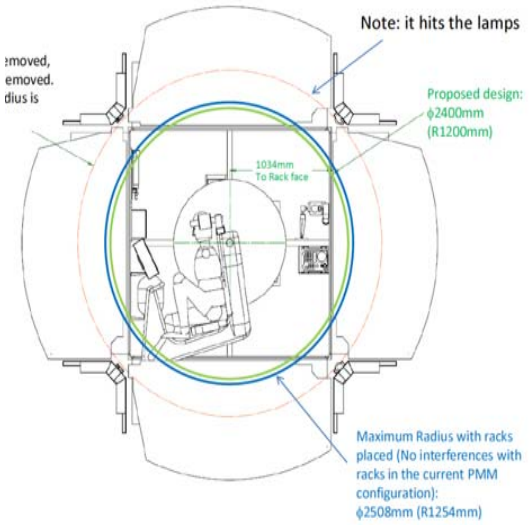


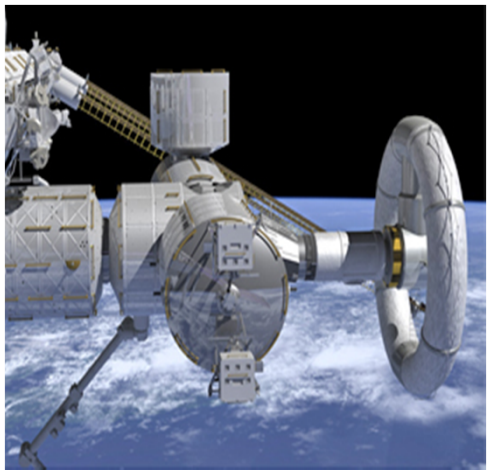


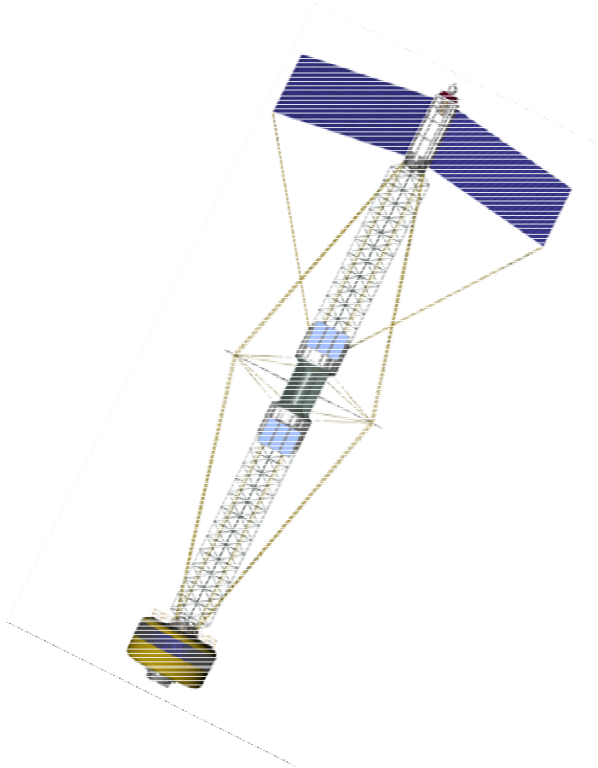


Spinning:

Artificial Gravity



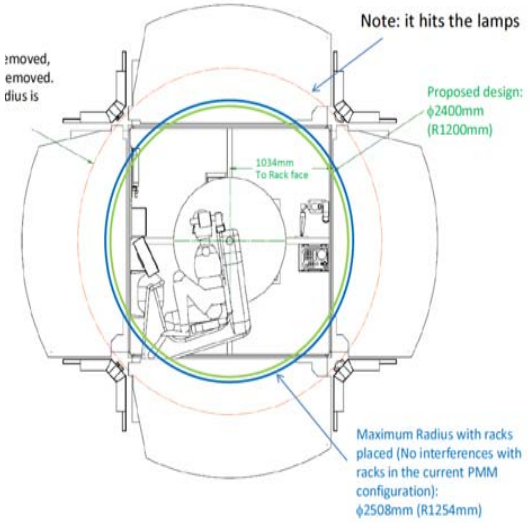




Spinning:

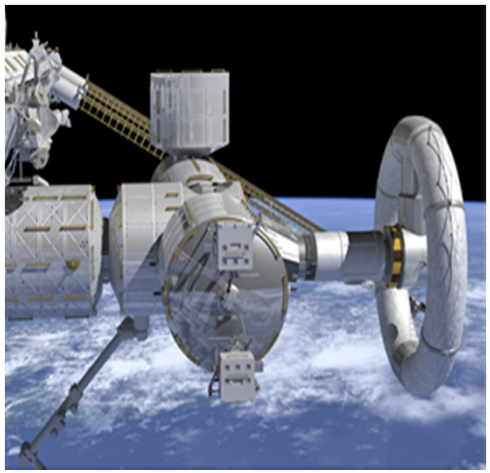
Inside

Artificial Gravity

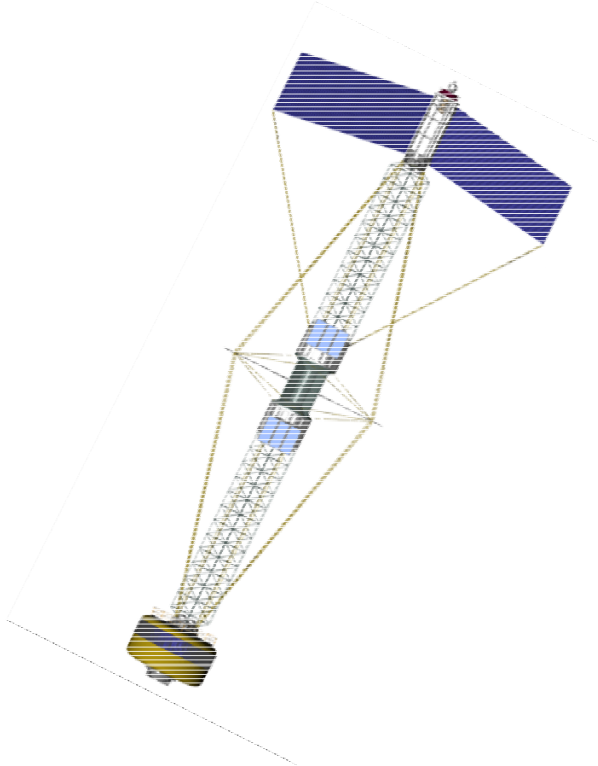


Spinning:

Inside



Part of



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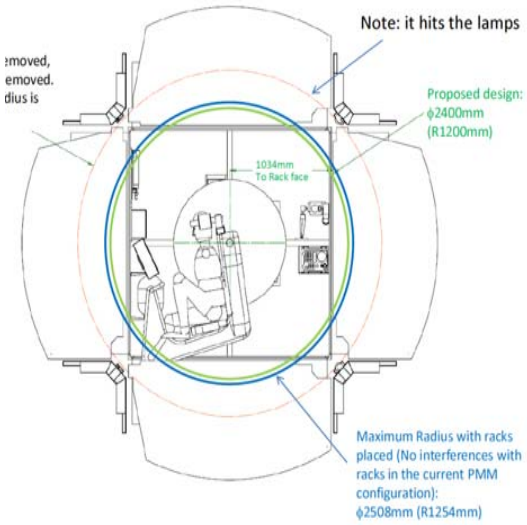

Spinning:

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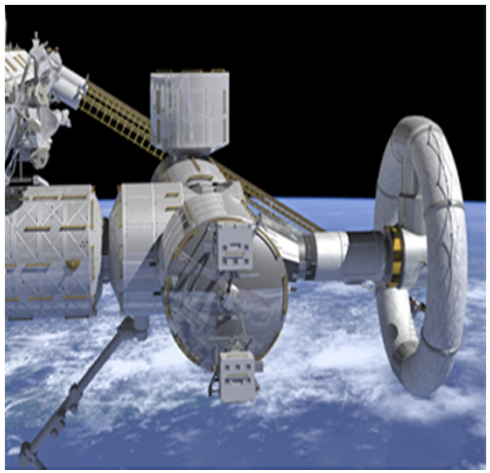

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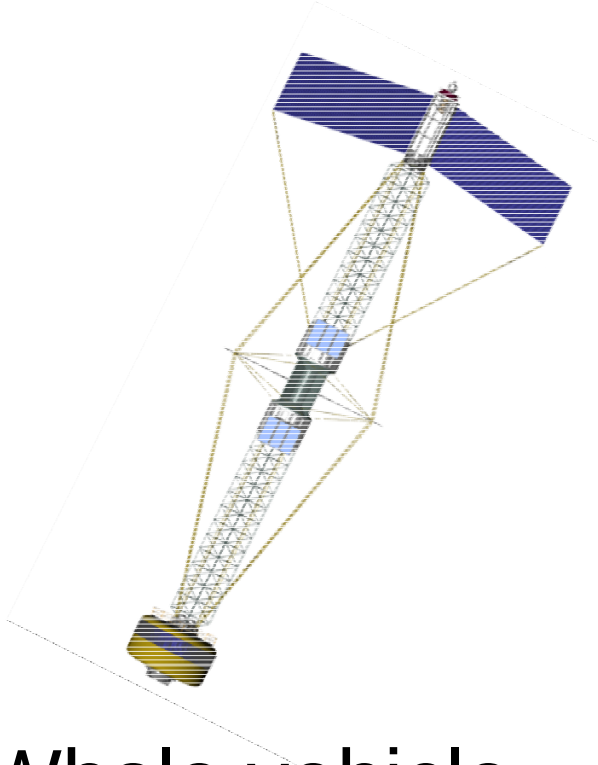
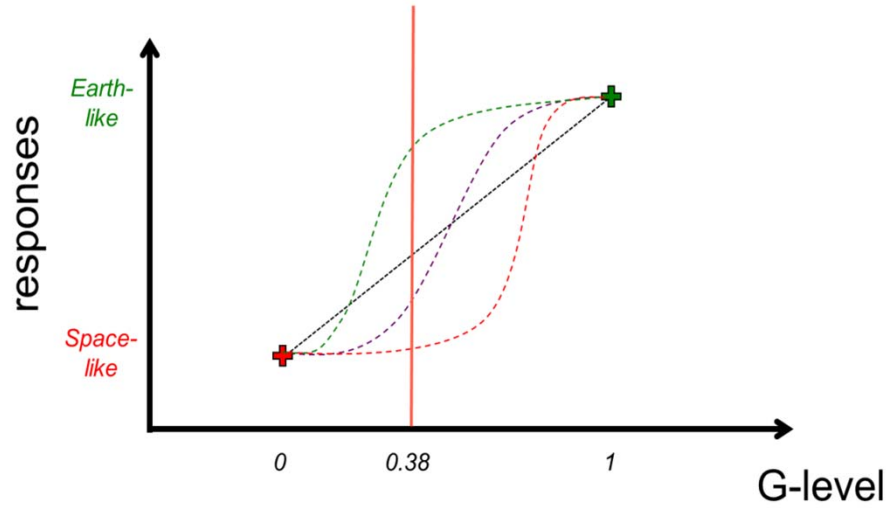


Whole vehicle

Physiological Responses to Hypogravity?



We don't know:

- The minimum artificial gravity level?
- The protection of Martian gravity?


Thank
you!