



Payload Operations Integration Working
Group (POIWG)
July, 2014

**Human Research Program
(HRP)**

Susan Torney & Marc Perry

HRP Increment 43/44 Overview

Increment Manager
Susan Torney / NASA

Increment Lead

**Peer-Reviewed NASA selected 10
PI's**

Increment 43 Operations Lead

Curtis Kershner / LM

Increment 44 Operations Lead

Kevin Rosenquist / Wyle





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**Human Research Program
(HRP)**

Susan Torney & Marc Perry

AGENDA

- **HRP Experiments**
 - One Year Mission Highlights
 - HRP Inc 43/44 Complement
 - New HRP In-flight Experiments, including
 - Twin Studies
 - Fluid Shifts
- **Other In-Flight Activities**
 - Facility Activities
 - Support to IP Activities
- **Challenges**
- **Backup Charts: Investigation Summaries**



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**Human Research Program
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HRP INC 43/44

First half of One Year Mission (1YM) and the busiest
Increment to date for HRP

- New Experiments, Hardware, and Processes
 - Multi-day sessions for Ocular Health and Fluid Shifts
 - 3 or 4 Ocular Health subjects and 2 Fluid Shifts subjects per Inc.
 - Lots of sample collection: blood, urine, saliva, etc.
 - Concurrent execution of 6-month and 1 year versions of the same experiments
- *Careful management of experiment priorities, Flight Day windows, blood volumes, and Reserve crew time*



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ONE YEAR MISSION (1YM) HIGHLIGHTS

Ongoing experiments

- 1YM compared to 6-month implementation:
 - More sessions and/or wider spacing
 - Many FD windows are widened

Several new experiments begin with 1YM

- New HRP HW and processes for Fluid Shifts and Twin Studies
- iPad for Habitability and Fine Motor Skills

Some completed studies are back for 1YM only

- Journals, Reaction Self-Test, Sleep

Twin Studies

- Crewmember's twin is participating as a ground-based control
- HRP selected 10 studies from a peer-reviewed NRA
- Features cutting-edge genetics



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ONE YEAR MISSION (1YM) HIGHLIGHTS – CONT.

Science with Russian colleagues

- Joint Studies: US and Russian PI's
 - Two complex new studies:
 - *Fluid Shifts with Ops in the USOS and Russian Segment*
 - *Field Test (Pre/Post Only)*
- Cross-participation: Both US and Russian 1YM crewmembers participate in the same studies
 - Three Russian Studies:
 - *Content, Interactions 2, Pilot-T*
 - Eight US Studies:
 - *One with Ultrasound, blood, and urine*
 - *Seven with basic in-flight ops using IPAD, PC, Joystick, and/or Actiwatch*
- Data Sharing: Each performs their own study and shares data (*e.g., Journals*)



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HRP Inc 43/44 Complement

In-Flight Experiments

- Astro Palate
- Biochemical Profile
- Bisphosphonates (Control)
- Body Measures
- Cardio Ox
- Cognition
- **Fine Motor**
- **Fluid Shifts**
- Force Shoes (if not complete)
- **Habitability**
- Journals (41S final)
- Microbiome
- NeuroMapping
- Ocular Health
- Reaction Self-Test
- Repository

Previous Increments

41/42

37/38 – 41/42

31/32 – 41/42

37/38 – 41/42

37/38 – 41/42

41/42

New

New

39/40 – 41/42

New

29/30 – 41/42; **Back for 1YM**

35/36 – 41/42

41/42

35/36 – 41/42

21/22 – 37/38; **Back for 1YM**

16 – 41/42



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HRP Inc 43/44 Complement - cont.

In-Flight Experiments

- Salivary Markers (43S final)
- Sleep
- Sprint (Active)
- Sprint (Control)
- **Telomeres**
- **Training Retention**
- **Twin Studies**

Previous Increments

37/38 – 41/42
25/26 and earlier; **Back for 1YM**
27/28 – 41/42
31/32 – 39/40
New
New
New

Pre/Post Only Experiments

- **Field Test**
- Functional Task Test (FTT)
- Hip QCT
- Intervertebral Disc Damage (IVD)
- Manual Control (41S final)

Previous Increments

New
21/22 – 37/38: **Back for 1YM**
27/28 – 37/38; **Back for 1YM**
33/34 – 41/42
33/34 – 41/42



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Participation Matrix for HRP Experiments (In-flight)

Experiment	41S US	41S ESA	42S US	42S RS	43S US	43S JAXA
Astro Palate	✓					✓
Biochemical Profile (Twin)		✓	✓		✓	✓
Bisphosphonates (Control)	✓				✓	
Body Measures	✓				✓	✓
Cardio Ox (Twin)		✓	✓		✓	
Cognition (Twin)	✓		✓	✓	✓	✓
Fine Motor Skills (New)			✓	✓		
Fluid Shifts (New) (Twin)			✓	✓		
Force Shoes (if not done in 41/42)	✓				✓	
Habitability (New)			✓	✓		
Journals (Last & back for 1YM)	✓		✓			

Note: Not all crew consent forms have been signed as of 7/15/2014



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Participation Matrix for HRP Experiments (In-flight) – cont.

Experiment	41S US	41S ESA	42S US	42S RS	43S US	43S JAXA
Microbiome		✓	✓		✓	✓
NeuroMapping	✓		✓	✓		✓
Ocular Health	✓		✓	✓	✓	✓
Reaction Self-Test (Back for IYM)			✓	✓		
Repository		✓			✓	✓
Salivary Markers		✓	✓		✓ One 43S crewmember	
Sleep (Back for 1YM)			✓	✓		
Sprint			✓ Control			✓ Active
Telomeres (New) (Twin)			✓		✓	✓
Training Retention (New)			✓	✓		
Twin Studies (New for 1YM only)			✓			



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Participation Matrix for HRP Experiments (Pre/Post Only)

Experiment	41S US	41S ESA	42S US	42S RS	43S US	43S JAXA
Field Test (new)			✓	✓		✓
Functional Task Test * Pilot Field Test only	✓*	✓*	✓			
Hip QCT			✓			
Intervertebral Disc Damage (IVD)	✓				✓	
Manual Control (final)	✓					

* Subset of FTT at landing site / airport / crew quarters called “Pilot Field Test”
or “FTT Bridge to Field Test”



HRP Inc 43/44 New In-flight Experiments

- Fine Motor Skills
- Habitability
- Sleep
(Not new; last performed in Inc 25/26)
- Telomeres
- Training Retention
- Twin Studies
- Fluid Shifts





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Fine Motor Skills (1YM; Russian)

PRINCIPAL INVESTIGATOR

- Kritina Holden, Ph.D., Lockheed Martin, Houston, TX

RESEARCH OBJECTIVES

- The Effects of Long-Duration Microgravity on Fine Motor Skills: 1-year ISS (Fine Motor Skills) Investigation measures the fine motor performance of crewmembers through a series of interactive tasks on a touch screen tablet. Fine Motor Skills is the first complete study of fine motor performance to include different phases of microgravity adaptation, long-term microgravity, and sensorimotor recovery after transition to Earth gravity. Fine motor skills are critical for interaction with touch technologies, and any measured changes could affect crew safety and efficiency in future space exploration missions.

IN-FLIGHT OPERATIONS

- Each in-flight data collection session will consist of a 15 minute test, performed on a touch screen tablet. Sessions will consist of a test battery of four tasks that examine various aspects of fine motor performance as well as a questionnaire. The tasks include a multidirectional pointing task, a dragging task, a shape tracing task, and a pinch-rotate task.
- The first in-flight session should be held soon as possible but no later than FD 2, the second at FD 5 (minimum 1 day after the first session), and then every 5 days thereafter (+/- 2 days) for the first 4 months. After 4 months (FD120), sessions should occur every 10 days (+/- 2 days). The last session should occur within 7 days of landing.



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Habitability (1YM; Russian)

PRINCIPAL INVESTIGATOR

- Sherry Thaxton, Ph.D., Johnson Space Center, Houston, TX

RESEARCH OBJECTIVES

- Habitability will assess the relationship between astronauts and their environment in order to prepare for future long-duration spaceflights to various destinations. Specific needs include the collection of observations associated with the relationship between astronauts, machines, the environment, vehicle layout, and the task to be accomplished. The ultimate goal is to understand how much habitable volume is required for vehicle internal design and layout, and if mission duration impacts the volume needed

IN-FLIGHT OPERATIONS - Subjects will use the iSHORT application on an iPad to perform:

- Observations: (every one or two weeks) Subjects will document observations from the last 1-2 weeks related to Human Factors and Habitability.
- Walk-through Videos: (monthly) Subjects will provide a guided tour of ISS locations to an audience of human factors engineers.
- Narrated Tasks: (monthly) During a task, subjects will talk to the camera about what they are thinking during the task with respect to the hardware being used and the environment in which the task is being performed.
- Questionnaires: (early/mid/late) Subjects will complete questionnaires related to behavioral health, habitability, and human factors.



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Sleep (1YM, Russian)

PRINCIPAL INVESTIGATOR

- Laura K. Barger, Ph.D., Brigham and Women's Hospital, Boston, MA
- Charles A. Czeisler, Ph.D., M.D., Harvard Medical School, Boston, MA

RESEARCH OBJECTIVES

- Sleep-Wake Actigraphy and Light Exposure on ISS12 (Sleep) examines the effects of space flight and ambient light exposure on the sleep-wake cycles of crewmembers during long duration (one-year) mission on board the International Space Station.

IN-FLIGHT OPERATIONS

- Participants will wear an Actiwatch Spectrum for the duration of the in-flight mission, donning the watch as soon as possible following arrival on station and doffing as close as possible to departure. During the first week on station and every three weeks thereafter (or during key weeks throughout the mission), participants will complete a daily sleep log within 15 minutes of awakening. Actigraphy data will be collected in one-minute epochs and sleep logs will contain subjective ratings of alertness and fatigue, subjective quantifications of sleep, and documentation of sleep disturbances and medication usage.
- Crewmembers download data from the Actiwatch Spectrum every 35 days. On the last day of the mission, crewmembers take off and stow the Actiwatch Spectrum. Another crewmember will download the data later.



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Telomeres (1YM, Twin, 6 mo.)

PRINCIPAL INVESTIGATOR

- Susan Bailey, Ph.D., Colorado State University, Fort Collins, CO

RESEARCH OBJECTIVES

- The goal of this project is to investigate the impact of space travel on telomeres, the ends of chromosomes that "cap" and protect them - much like the end of a shoelace – and telomerase, the enzyme that maintains telomere length. Telomere length and telomerase activity will be measured in blood samples from the crewmembers using standard assays. How quickly telomeres shorten can be increased by stress, the result being acceleration of aging and age-associated disease, ranging from reduced immune function to cardiovascular disease and cancer

IN-FLIGHT OPERATIONS

- Inflight collections are planned on approximately FD45 and FD233 for one-year mission and FD90 and R-1 for 6 month mission.
- Sixteen (16) mL of blood will be collected from the subject during each inflight session. It will be returned on a Soyuz vehicle at ambient temperature to the ground (JSC) for processing within 72 hours of collection. The PI will obtain information (via data share) from a Food Frequency Questionnaire completed by the crewmember in order to make correlations between astronaut health in relation to nutritional status and changes in telomere length and telomerase activity.



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Training Retention (1YM, Russian)

PRINCIPAL INVESTIGATOR

- Immanuel Barshi, Ph.D., Ames Research Center, CA

RESEARCH OBJECTIVES

- This research project studies how well astronauts remember what they learned on the ground and how well they can use that knowledge to deal with new tasks.

IN-FLIGHT OPERATIONS

- Training Retention uses experiment-unique software for inflight tasks which were previously trained on the ground (in BDC). There will be 4 in flight data collection tests (FD90, FD180, FD270 and FD330). Each will consist of a 30-40 minute test, performed on the HRF PC.
- The tasks to be trained and tested probe different cognitive processes that underlie all crew performance. Among other processes, these include perception, motoric, memory and decision making. The tests are made up of computer tasks that include the trained tasks as well as variations on these tasks. These variations probe the crew's ability to transfer the trained knowledge and skill to new situations. The tasks are designed to allow a careful examination of differences among the different cognitive processes.



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Twin Studies (1YM, Twin)

- *One-year crewmember with ground-based twin as a control subject.*
- *Peer-Reviewed NRA selected 10 PI's*
- *Cutting-edge genetics and other*

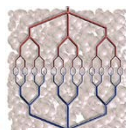
RESEARCH OBJECTIVES

- Focused on the use of integrated human -omic analyses to better understand the biomolecular responses to the physical, physiological, and environmental stressors associated with spaceflight.

Genome – Epigenome – Transcriptome – Proteome –

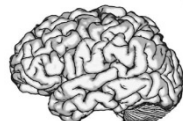
Metabolome – Microbiome – Physiology – Neurobehavioral

- The project emphasis is on the collection of biological specimens and psychological testing from one twin in orbit on the ISS and the collection of corresponding samples and data from his twin on the ground. Sample collection and data analysis will occur before, during and after the one-year mission. The integration of the investigations allows for a more complete and accurate assessment of how genes may change due to environmental factors over time during the year of space flight in a continuous effort to reduce the health impacts of human space exploration.



Vasculature

Lee



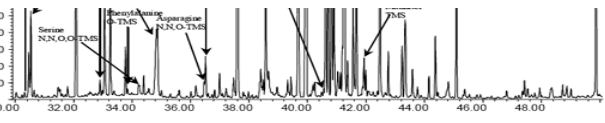
Cognition

Basner



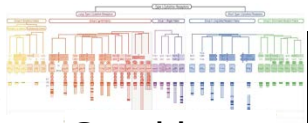
Microbiome

Turek



Metabolites and Global Metabolomics

e/Rana, Mignot/Snyder & Smith



Cytokines

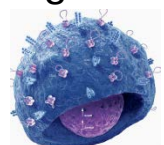
Mignot

Telomere Length

Bailey

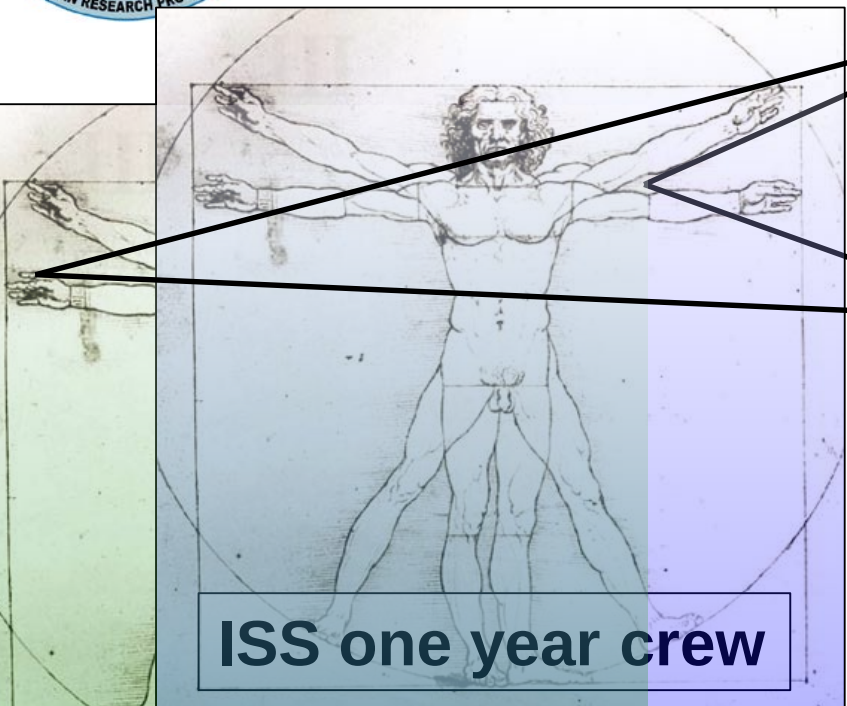
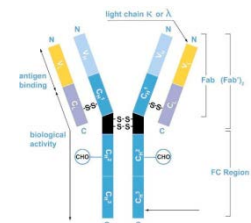
B-cells / T-cells

Mignot



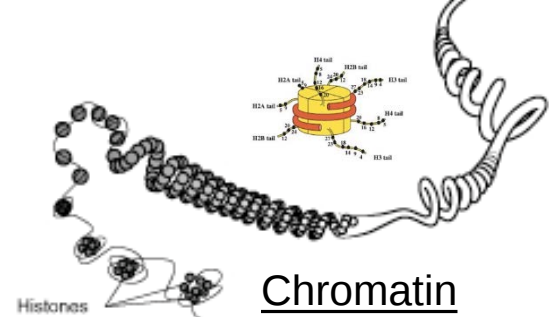
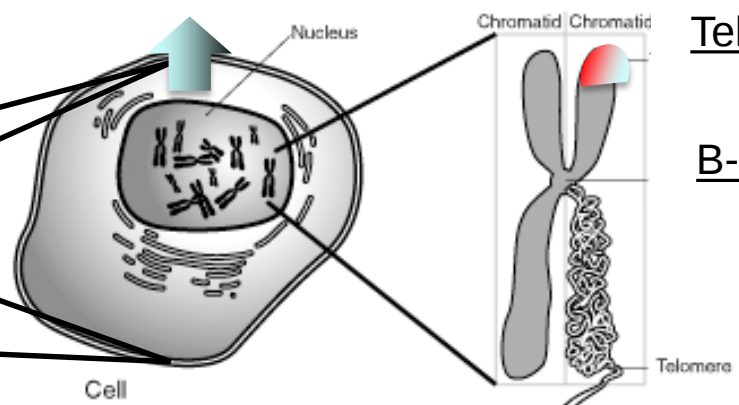
Antibodies

Mignot/Snyder



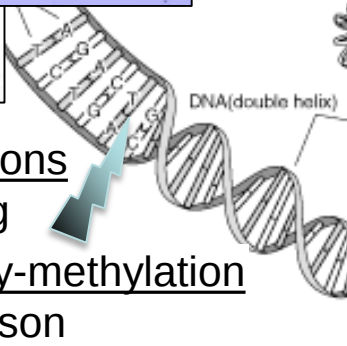
ISS one year crew

Earth control



Chromatin

Feinberg



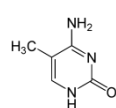
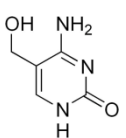
DNA(double helix)

DNA Mutations

Feinberg

DNA Hydroxy-methylation

Mason



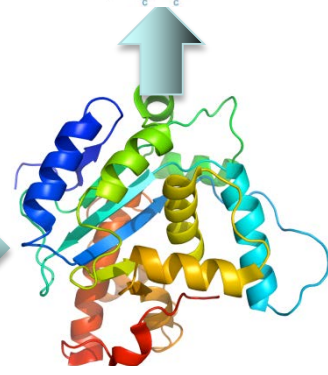
DNA Methylation

Feinberg & Mason

large/small RNA

& RNA Methylation

Mason



Proteomics

Lee/Rana



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Twin Studies – cont.

PRINCIPAL INVESTIGATORS (see Backup Charts for Research Titles by PI)

- Extend Ongoing/New Studies to Twin:
 - **Biochemical Profile:** Scott M. Smith, Ph.D., NASA/JSC
 - **Cardio Ox:** Stuart M. C. Lee, M.S., NASA/JSC (Wyle) (adds blood)
 - **Cognition:** Mathias Basner, M.D., Ph.D., University of Pennsylvania
 - **Fluid Shifts:** Brinda Rana, PhD, University of California, San Diego
 - **Telomeres:** Susan Bailey, Ph.D., Colorado State
- Additional genetic research by other PI's:
 - Andrew Feinberg, MD, MPH, Johns Hopkins University School of Medicine
 - Christopher Mason, PhD, Weill Cornell Medical College
 - Emmanuel Mignot, MD, PhD, Stanford University
 - Michael Snyder, PhD, Stanford University
 - Fred Turek, PhD, Northwestern University
- **“Twin Studies”** – Combined Protocol for sample collection and flu shot



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Twin Studies – cont.

IN-FLIGHT OPERATIONS

- Cognitive testing:
 - The 1YM USOS crew member and twin will perform the **Cognition** experiment.
- Physiological measures:
 - The 1YM USOS crew member and twin will perform
 - **Fluid Shifts tests**
 - **Cardio Ox ultrasound scans**



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Twin Studies – cont. Combined Protocol

IN-FLIGHT OPERATIONS – Typically performed with sample collection for other HRP studies

- Frozen blood
 - Blood draw on FD15, 60, 120, 180, 191, 240, 300, and R-14; Centrifuged, then stored in MELFI
 - Includes new glass tubes
- Frozen urine
 - 24 hour void-by-void collection on FD15, 60, 120 180, 240, 300, and R-14; samples stored in MELFI
- Ambient blood
 - Blood draw in association with 41S, 43S, and 44S return
 - One glass tube will be spun in centrifuge (ONLY use of centrifuge for ambient blood for ANY STUDY)
 - 72 hr return to Houston, as usual



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Twin Studies – cont. Combined Protocol – cont.

IN-FLIGHT OPERATIONS – Typically performed with sample collection for other HRP studies

- Vaccination (flu shot):
 - Flu Shot administered ASAP after the FD180 frozen blood draw
 - Vaccine requires refrigeration (2 to 8°C) during launch and while stored on-orbit prior to the vaccination
 - Frozen blood draw with glass tube 11 days (+/-3) later
- Buccal samples (cheek swab and saliva sample)
 - FD7, 90, 180, 240, and R-30/1; samples stored in MELFI
 - Uses existing Microbiome swab tubes and Saliva Session Packs
- Fecal Samples
 - FD7, 90, 180, and R-30; samples stored in MELFI
 - Note: Uses existing Microbiome fecal tubes and performed in conjunction with Microbiome sessions.



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Fluid Shifts (1YM, Russian, Twin)

PRINCIPAL INVESTIGATORS

- Michael B. Stenger, Ph.D, Wyle Science Technology and Engineering, Houston, TX
- Scott A. Dulchavsky, M.D., Ph.D., Henry Ford Hospital, Detroit, MI
- Alan R. Hargens, Ph.D., University of California San Diego, La Jolla, CA

RESEARCH OBJECTIVES

- Some astronauts experience vision changes and anatomical alterations to parts of their eyes during and after long-duration spaceflight. It is hypothesized that the headward fluid shift that occurs during space flight leads to increased pressure in the brain, which may push on the back of the eye, causing it to change shape. The Fluid Shifts Before, During and After Prolonged Space Flight and Their Association with Intracranial Pressure and Visual Impairment (Fluid Shifts) investigation measures how much fluid shifts from the lower body to the upper body, in or out of cells and blood vessels, and determines the impact these shifts have on fluid pressure in the head, changes in vision and eye structures.

IN-FLIGHT MEASUREMENTS & HARDWARE

Dilution Measures:

- Determination of fluid compartmentalization via assessment of total body water (via saliva /urine analysis) and extracellular and intracellular fluid volume (via blood/urine analysis).
- Existing sample collection HW and **Tracer kit and syringe.**



Fluid Shifts – cont.

IN-FLIGHT MEASUREMENTS & HARDWARE – Cont.

Intracranial Pressure

- **Cerebral and Cochlear Fluid Pressure (CCFP)**
- **Distortion Product Otoacoustic Emissions (DPOAE)**



Ocular Structure, Pressure, Vision

- Optical Coherence Tomography (OCT)
- Tonometry, Ultrasound, Data Sharing w/ Med Ops

Ultrasound measures of fluid shifts (**new cable** for RS)

- Arterial and venous measures of head and neck
- Cardiac, ophthalmic, and portal vein measures
- Tissue thickness of lower and upper body
- **Manometer:** Used for Mueller maneuvers with USND



Other physiological measures

- Blood Pressure / Heart Rate / Vascular Resistance (new **ESA CDL HLTA BP device**)



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Fluid Shifts – cont.

IN-FLIGHT OVERVIEW

Three sessions FD45, 150, R-45, each includes the following:

Part A: Dilution Measures (Part B within 10 days; Part C within 30)

Day 1: Setup, Data, & Stow

Part B: Imaging Measures

Day 1: Setup; Day 2: Data & Stow

Part C: LBNP Imaging Measures in Russian Segment wearing Chibis

Day 1: Move HW to RS; Day 2 & 3: Data; Day 4 Return HW to USOS

- Chibis is used to generate lower body negative pressure (LBNP). GAMMA system medical monitoring device; provides BP and ECG while in Chibis
- 2 days of Chibis Ops because Max 60 minutes Chibis use allowed per day.
- Agreements with Russians are in work.
- Will need 28VDC to 120VAC Power Inverter. **New USND cable** is in work.

IN-FLIGHT OPERATIONS – See next pages.



Fluid Shifts – cont.

Part A: Dilution Measures (spin blood; freeze all types of samples in MELFI)

- Baseline Blood, Urine, and Saliva collected after crew wake
- NaBr tracer ingested (Return empty syringe)
- Blood sample 3 hrs after tracer
- Saliva sample 3 & 5 hrs after tracer
- Urine samples void-by-void through 7 hrs after tracer
- Galley Water sample on same day



Tracer Kit



Tracer Syringe



Fluid Shifts – cont.

Part B: Imaging Measures

Day 1: Setup

Day 2: Data Collection & HW Stow

- USND: Self scan with Remote Guider & Operator (USND keyboard)
 - Locations scanned: Eye (orbit/globe), Head (forehead tissue thickness, temple, base of skull), Neck (carotid artery, vertebral, jugular, and subclavian veins), Heart, Abdomen (portal vein), Leg (shin and ankle tissue thickness)
 - Manometer used for Mueller Maneuvers (reverse valsalva)
- OCT: Operator & Remote Guider
- Tonometry: Operator & Remote Guider
- CCFP: Self scan
- DPOAE: Self scan
 - Requires use of ear muffs to attenuate ambient noise
- BP: Subject-initiated with Remote Guider coordination
 - Uses ESA CDL HLTA BP device (in USOS only)





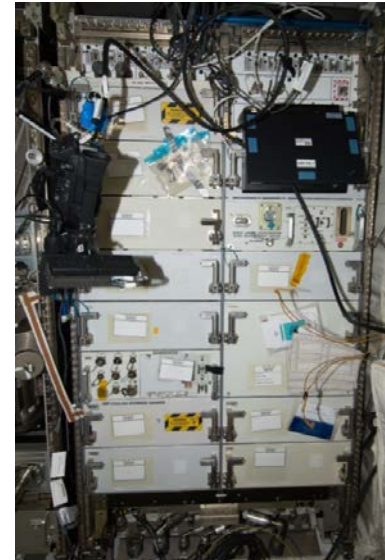


HRP Inc 43/44 Facility Activities

- HRF Supply Kit Resupply & Inventory
- Ultrasound Configuration Maintenance
- GDS/PFS Gauge Photos
- SLAMMD Control Run
- Medical Consumables Tracking

HRP Support to Med Ops

- Ultrasound for Ocular Scan





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HRP Inc 43/44 Support to IP Science

ASI

- **Bone/Muscle Check** – Uses Urine Collection Devices (UCDs), Urine Collection Bags (UCBs) and Saliva Collection Hardware.
- **Drain Brain** – Uses HRF Ultrasound2 and HRF Pulmonary Function System (PFS)

CSA

- **BP Reg** – Uses HRF PFS and CBPD

ESA

- **Airway Monitoring** – Uses HRF PuFF Calibration Syringe
- **Energy** – Uses HRF PFS

JAXA

- **Biological Rhythms 48** – Uses Actiwatch Reader & Cable



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HRP Inc 43/44 Use of IP Hardware

ESA HW

- **Sprint** – Portable Pulmonary Function System (PPFS)
- **Fluid Shifts** – CDL HLTA BP device

Russian HW

- **Fluid Shifts** – Chibis and GAMMA System (Russian medical monitoring device; provides BP and ECG while in LBNP Chibis)



HRP Strategies for Inc 43/44 Implementation

- Worked with Twin Studies PI's to develop an executable set of requirements that aligned sample collections with other studies and minimized additional crew time.
- Developed an executable blood draw plan
 - Very specific schedule; timeline changes could impact science
 - Manage “30 day rolling blood volume limits” for each crewmember
- Widened many experiment Flight Day windows to increase scheduling flexibility
- Increasing the time we can leave Ultrasound deployed to minimize crew time used for setup & stow





HRP Inc 43/44 Challenges

- Robust HRP Research Program
 - Sizeable amount of Reserve crew time
 - Many new studies
 - Two complex studies with multi-day sessions
 - Ocular Health and Fluid Shifts
- Blood Volume Limits
 - Very tight plan that will require careful management

Timeline changes affect blood volume calculations and could impact science
- Potential Visiting Vehicle Traffic Changes
 - HRP actively manages our manifests to pre-position HRP consumables and new hardware
 - Visiting Vehicle changes could affect crew time, complicate timeline management, or use HRP resources





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July, 2014

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HRP Inc 43/44 Challenges – cont.

- New Studies have new Hardware and Processes
 - Habitability and Fine Motor Skills require iPad
 - Fluid Shifts - the most complex HRP study to date
 - Agreements and implementation details for Ops in the Russian Segment are in work
 - New hardware is being developed
 - Twin Studies
 - New glass blood tubes require verification, additional containment, and larger MELFI stowage volume
 - Use of centrifuge for blood prior to packing for ambient return on Soyuz is a new process in a busy timeframe
 - Flu shot must be refrigerated for ascent and on-orbit storage prior to use





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July, 2014

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July, 2014

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Back Up Slides



Selections for Twin Studies

- Susan Bailey, Colorado State University, Differential effects on telomeres and telomerase in twin astronauts associated with spaceflight
- Andrew Feinberg, Johns Hopkins University School of Medicine, Comprehensive whole genome analysis of differential epigenetic effects of space travel on monozygotic twins
- Christopher Mason, Weill Medical College of Cornell University, The Landscape of DNA and RNA Methylation Before, During, and After Human Space Travel
- Scott Smith, NASA Johnson Space Center, Biochemical Profile: Homozygous Twin control for a 12 month Space Flight Exposure
- Emmanuel Mignot, Stanford University School of Medicine, HERO Twin Astronaut Study Consortium (TASC): Immunome Changes in Space
- Fred Turek, Northwestern University, HERO Twin Astronaut Study Consortium (TASC) Project: Metagenomic Sequencing of the Bacteriome in GI Tract of Twin Astronauts
- Stuart Lee, Wyle Laboratories, Metabolomic And Genomic Markers Of Atherosclerosis As Related To Oxidative Stress, Inflammation, And Vascular Function In Twin Astronauts
- Brinda Rana, University of California, Proteomic Assessment of Fluid Shifts and Association with Visual Impairment and Intracranial Pressure in Twin Astronauts
- Mathias Basner, University of Pennsylvania School of Medicine, HERO Twin Astronaut Study Consortium (TASC) Project: Cognition on Monozygotic Twin on Earth
- Michael Snyder, Stanford University, HERO Twin Astronaut Study Consortium (TASC) Project: Longitudinal integrated multi-omics analysis of the biomolecular effects of space travel



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July, 2014

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Pre-/Post- Investigation Summaries

Field Test (new):

NASA PI: Millard F. Reschke, Ph.D.

Brief Research Summary: The Field Test is made up of studies designed by the Neuroscience and Cardiovascular Laboratories at NASA's Johnson Space Center and the Institute of Biomedical Problems, Moscow, Russia to investigate changes in human physiology that affect returning astronauts and cosmonauts following space flight missions lasting from six months to one year. Changes in vision, balance, coordination, blood pressure and even the ability to walk have a substantial impact on the way very basic and fundamental tasks are performed. The Field Test experiment is designed to measure the complexity, magnitude, duration and recovery of these changes in order to better understand the kind of treatment that is necessary to speed-up recovery and prevent injury to our astronauts.

Data Collection:

- Three preflight sessions and one garment measuring session.
- Three landing day sessions – at approximately 2 - 5 hours, 10 hours, and 24 hours after landing.
- Five postflight sessions – 1, 4, 6, 15 and 30 days after landing.



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July, 2014

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Pre-/Post- Investigation Summaries

Functional Task Test:

Stuart M.C. Lee & Barry A. Spiering

Brief Research Summary: The primary objective of the Functional Task Test (FTT) project is to develop and evaluate an integrated set of functional and physiological tests, and then use those tests to determine how post flight changes in sensorimotor, cardiovascular, and muscle physiology impact functional performance (e.g. standing, ladder climbing, and hatch opening).

Data Collection: Pre-/Post-flight testing only; series of timed muscle performance tests



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July, 2014

**Human Research Program
(HRP)**

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Pre-/Post- Investigation Summaries

Hip QCT:

Jean Sibonga, Ph.D. & Thomas Lang, Ph.D.

Brief Research Summary: The primary objective of Hip QCT is to monitor changes in hip sub-regions in response to in-flight countermeasures (CM). This QCT study will also demonstrate how countermeasures that involve mechanical loading of the hip (e.g., exercise) could be distinguished from CMs that involve biochemical suppression of bone resorption (e.g., bisphosphonates) because these two categories of CMs affect different bone compartments of the hip (anti-resorptives on trabecular bone, exercise on cortical bone). Finally, QCT will enable hip strength estimations by Finite Element [FE] Modeling – which detects more changes in hip strength due to space than with DXA modality.

Data Collection: Pre-/Post-flight testing only; involves QCT assessment.



Payload Operations Integration Working
Group (POIWG)
July, 2014

**Human Research Program
(HRP)**

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Pre-/Post- Investigation Summaries

Intervertebral Disc Damage (IVD):

Alan Hargens, Ph.D.

Brief Research Summary: The goal of this study is to use state-of-the-art imaging technologies to comprehensively characterize and quantify space-flight induced changes in disc morphology, biochemistry, metabolism, and kinematics. Subjects will be imaged before and after prolonged spaceflight. These data will be correlated with low back pain that spontaneously arises in space so as to establish pain and disc damage mechanisms that will serve as a basis for future countermeasure development.

Data Collection: Pre-/Post-flight testing only; involves MRI testing.



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July, 2014

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(HRP)**

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Pre-/Post- Investigation Summaries

Manual Control:

Stephen Moore, Ph.D.

Brief Research Summary: Lack of gravity causes sensorimotor deficits post-landing. This experiment's comprehensive cognitive/sensorimotor test battery will determine the relative contribution of specific mechanisms (including sleepiness and fatigue) underlying decrements in post-flight operator proficiency. These results will be critical in determining whether sensorimotor countermeasures are required for piloted landings and early surface operations, and what functional areas countermeasures should target.

Data Collection: Pre-/Post-flight testing only; involves physiological and performance measures.



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July, 2014

**Human Research Program
(HRP)**

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Investigation Summaries

Astro Palate:

Zata M. Vickers, Ph.D.

Brief Research Summary: The experience of flight is inherently stressful, and individual's moods and stress levels are not just nuisance factors that affect their quality of life. Moods and stress also have a significant impact on physical health. This experiment will focus on the role of food and the eating experience as a strategy for lowering the stress or negative moods that astronauts might normally experience in flight. It will also explore ways to minimize stressful aspects of the eating situation so that individuals consume more food and are more satisfied with it.

In-Flight Data Collection: The study has three parts:

- Part A - Menu Choice: Crewmembers will choose food items from the standard on-orbit menu for lunch. Day 1 and Day 2 menu will be duplicates of each other and Day 3 and Day 4 menu will be duplicates of each other as well. The crewmember will eat lunch alone on the days of this study.
- Part B - Prepackaged Foods: Based on responses to the preflight questionnaire, six special meals will be prepared for the crewmember. The six meals are divided into two sets of three and all meals in each set are identical. For each set, one meal will be eaten alone, one with others, and one on a special day with others.
- Part C - Snack Food: This study will utilize negative moods that 'naturally' occur in space..



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July, 2014

**Human Research Program
(HRP)**

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Investigation Summaries

Biochemical Profile:

Robert Pietrzyk, M.S.

Brief Research Summary: Blood and urine are commonly used to assess an astronaut's health as well as conduct research in physiological disciplines by measuring key biomarkers found in these fluids. In support of research studies, this project will collect, process and store blood and urine samples obtained during the preflight, in-flight and postflight phases of ISS missions and maintain a database of results from the analysis of these samples. This database will offer supporting evidence to scientists by providing metabolic profiles of the effects of spaceflight on human physiology.

In-Flight Data Collection: 24-hour urine collection, blood draw and subsequent processing.



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July, 2014

**Human Research Program
(HRP)**

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Investigation Summaries

Bisphosphonates (Control): Adrian Leblanc, Ph.D. & Toshio Matsumoto, Ph.D.

Brief Research Summary: Bisphosphonates as a Countermeasure to Space Flight Induced Bone Loss. The purpose of the Bisphosphonates study is to determine whether an antiresorptive agent, in conjunction with the routine in-flight exercise program, protects International Space Station (ISS) crewmembers from the regional decreases in bone mineral density documented on previous ISS missions.

Control subjects will not ingest the bisphosphonate pill in order to provide a comparison.

In-Flight Data Collection: 24-h Urine collection, Diet/Exercise Logs



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July, 2014

**Human Research Program
(HRP)**

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Investigation Summaries

Body Measures:

Sudhakar Rajulu, Ph.D.

Brief Research Summary: Currently, NASA does not have sufficient in-flight anthropometric data (body measurements) gathered to assess the impact of physical body shape and size changes on suit sizing. This study will involve collecting anthropometric data (body measurements) using digital still and video imagery and a tape measure to measure segmental length, height, depth, and circumference data for all body segments (i.e., chest, waist, hip, arms, legs, etc.) from astronauts for pre-, post-, and in-flight conditions.

In-Flight Data Collection: Circumference measurements with a tape measure along with photographic and video imagery.



Payload Operations Integration Working
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July, 2014

**Human Research Program
(HRP)**

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Investigation Summaries

Cardio Ox:

Steven H. Platts, Ph.D.

Brief Research Summary: Future human space travel missions may increase the risk of oxidative and inflammatory damage primarily from radiation, but also from psychological stress, reduced physical activity, diminished nutritional standards and exposure to altered oxygen levels during extravehicular activity. There is evidence that higher levels of oxidative and inflammatory stress and associated damage to blood vessels contribute to cardiovascular disease. The purpose of this study is to measure levels of biomarkers in blood and urine that are affected by oxidative and inflammatory stress before, during, and after long duration spaceflight and relate them to the risk of developing atherosclerosis.

In-Flight Data Collection: Ultrasound scans (carotid/brachial) with ECG recording, blood draw and 24-h Urine collection.



Payload Operations Integration Working
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July, 2014

**Human Research Program
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Investigation Summaries

Cognition:

Mathias Basner, Ph.D., M.D., MSc

Brief Research Summary: Given the breadth of neurocognitive functions required for effective performance in space, the need to medically manage sleep and fatigue in space, the very limited neurocognitive assessment tools currently in space flight, and the often anecdotal nature of cognitive complaints from space flight, there is a critical need for rapid objective assessment of a range of neurocognitive performance functions in space flight. This project will achieve this goal by developing a much-needed practical, yet comprehensive cognitive test battery, validating its sensitivity to fatigue and fatigue countermeasures, determining astronaut norms for the test battery, and establishing space-flight feasibility of the battery.

In-Flight Data Collection: Cognition consists of 10 brief cognitive tests, each 1-3 minutes in length. The tests will be performed 11 times in-flight. Crewmembers will perform tests on the following days: 4 times early in-flight with a 1-week interval (FD 6, 13, 20, 27), 7 times later in-flight at 19-day intervals (FD 46, 65, 84, 103, 122, 141, 160).



Payload Operations Integration Working
Group (POIWG)
July, 2014

**Human Research Program
(HRP)**

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Investigation Summaries

Journals:

Jack Stuster, Ph.D.

Brief Research Summary: This study converts behavioral and human factors information contained in confidential journal entries into quantitative data concerning the importance of the various behavioral issues involved in extended-duration space exploration.

In-Flight Data Collection: Periodic journal entries



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Group (POIWG)
July, 2014

**Human Research Program
(HRP)**

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Investigation Summaries

Medical Consumables Tracking (MCT):

John Zoldak

Brief Research Summary: Medical Consumables Tracking is a hardware demonstration project that will use RFID technology to track medications and medical consumables on ISS. This will assist in determining the quantity of medicine and medical supplies needed for long duration missions. No subjects.

In-Flight Data Collection:

- Installation and activation consists of mounting the electronics box to the CHeCS Rack D2 door, installing the antennas inside the locker, and battery installation.
- Following activation, it will automatically scan the contents of the Convenience Medical Pack every 30 days and send a file wirelessly to the SSC via the JSL for downlink. Crew will change the battery periodically.



Payload Operations Integration Working
Group (POIWG)
July, 2014

**Human Research Program
(HRP)**

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Investigation Summaries

Microbiome:

Hernan Lorenzi, M.D.

Brief Research Summary: The Microbiome experiment investigates changes to astronauts' immune systems and microbiomes (the collection of microbes that live in and on the human body). These changes can be detected by taking periodic samples from different parts of the body and the surrounding International Space Station (ISS) environment. As part of this study, the likelihood and consequences of alterations in the microbiome due to extreme environments, and the related human health risk, will be assessed.

In-Flight Data Collection: Blood, Saliva, Perspiration, Potable water collections; Microbiome (body swab), ISS Surface, and optional Gastrointestinal sampling.



Payload Operations Integration Working
Group (POIWG)
July, 2014

**Human Research Program
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Investigation Summaries

NeuroMapping:

Rachael Seidler, Ph.D.

Brief Research Summary: This research is being conducted to identify if there are any changes in brain structure, function, and network integrity as well as human motor control, spatial processing and multi-task performance abilities as a function of long-duration spaceflight. It will also determine how long it would take for the human body / brain to recover from such adaptations. This research will help generate relationships between structural and functional brain changes, correlated to human performance over time.

In-Flight Data Collection: Subset of behavioral assessment tests will be performed including a mental rotation test, dual task test, and a joystick-based sensorimotor adaptation test. Three (3) in-flight sessions are required on FDs 30, 90, and 150 (flexibility +/- 10 days). Each in-flight session will require 50 minutes of crew time. In-flight sessions will utilize the existing HRF PCs and ESA's universal serial bus (USB) joystick.



Payload Operations Integration Working
Group (POIWG)
July, 2014

**Human Research Program
(HRP)**

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Investigation Summaries

Ocular Health:

Christian Otto, M.D.

Brief Research Summary: The International Space Station (ISS) Ocular Health Protocol aims to systematically gather physiological data to characterize the Risk of Microgravity-Induced Visual Impairment/Intracranial Pressure on crewmembers assigned to a 6 month ISS increment. The data collected will mirror Medical Requirements Integration Documents (MRID) requirements and testing performed during annual medical exams with an increase in the frequency of in-flight and post flight testing to more accurately assess changes that occur in the visual, vascular, and central nervous systems upon exposure to microgravity and the resulting fluid shifts. Monitoring in-flight changes, in addition to post flight recovery, is the main focus of this protocol.

In-Flight Data Collection: Fundoscopy, Tonometry, Visual Testing, Ocular Ultrasound, BP and Vascular Compliance (cardiac ultrasound, BP, EKG)



Payload Operations Integration Working
Group (POIWG)
July, 2014

**Human Research Program
(HRP)**

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Investigation Summaries

Reaction Self Test:

David F. Dinges, Ph.D.

Brief Research Summary: The Psychomotor Vigilance Self Test on the International Space Station is a portable 5-minute reaction time task that will allow the crewmembers to monitor the daily effects of fatigue on performance while on board the International Space Station.

In-Flight Data Collection: Testing using reaction feedback software, scheduled on specific days and sleep shifted schedules, and around EVAs.



Payload Operations Integration Working
Group (POIWG)
July, 2014

**Human Research Program
(HRP)**

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Investigation Summaries

Salivary Markers:

Richard J. Simpson, Ph.D.

Brief Research Summary: The Salivary Markers investigation involves the collection of blood, saliva, urine and a health assessment on six subjects pre-, in- and post-flight to determine if spaceflight induced immune system dysregulation increases infection susceptibility or poses a significant health risk to crewmembers onboard the International Space Station. The investigation utilizes a longitudinal, repeated measures design to determine the effects of long-term exposure to microgravity on a host of salivary antimicrobial proteins (AMPs), latent viral reactivation, antibacterial properties of saliva, and blood markers associated with innate host immune defense.

In-Flight Data Collection: Blood draw, Saliva sampling, 24-hour urine collection, and Health Assessment using Med Ops' Data Collection Tool (DCT). FD 90 and R-1 blood samples will return ambient on Soyuz



Payload Operations Integration Working
Group (POIWG)
July, 2014

**Human Research Program
(HRP)**

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Investigation Summaries

Sprint (Active and Control):

Lori Ploutz-Snyder, Ph.D.

Brief Research Summary: The Sprint experiment evaluates the efficacy of exercise countermeasures; this includes detailed measurements of cardiovascular and muscle function and bone health and evaluates the effectiveness of a new exercise prescription integrating both resistance and aerobic training exercise. Control subjects will not follow the Sprint exercise protocol in-flight. They will follow the standard ISS exercise protocol and share exercise data with the Principal Investigator.

Data Collection: Pre-/Post-flight testing: involves DXA, QCT, MRI, Muscle Performance and Isokinetic testing. Muscle biopsies are optional. In-flight testing for Active subject: Sprint exercise protocol. In-flight testing for Active subjects and added to Control subjects beginning Inc 39/40: VO2 Max and Ultrasound muscle volume scan.