



SLPSRA

Status Overview to the Committee on Biological and Physical Sciences in Space

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Human Exploration & Operations Mission Directorate

March 29, 2016

Human Research Program: FY 2016 – FY 2017 Plans



- HRP will experience impacts to FY 2016 activities due to lower-than-planned appropriation
 - Delay or cancel collaborative research projects with Germany on astronaut visual impairment research and Russia on behavioral health/space human factors research
 - Delay transitioning new biomedical monitoring tools and countermeasures to operational use aboard ISS and/or Orion
 - Reduce research selections in critical areas such as space radiation and behavioral health
- Conclude joint One Year U.S./Russian and Twins Studies
 - Obtain unprecedented long-duration data on ocular health, immune and cardiovascular systems, cognitive performance testing, and countermeasure effectiveness against bone and muscle loss
 - Advance understanding of impacts on human body via identical twin study; may provide new “omics” data to understand effects of spaceflight on genetic makeup, and leverage this with non-human models via GeneLab project



American Astronaut Scott Kelly and Russian Cosmonaut Mikhail Kornienko; identical twin astronauts Scott and Mark Kelly



Studying blood and urine samples from crew members to learn how exposure to microgravity impacts the body

Human Research Program

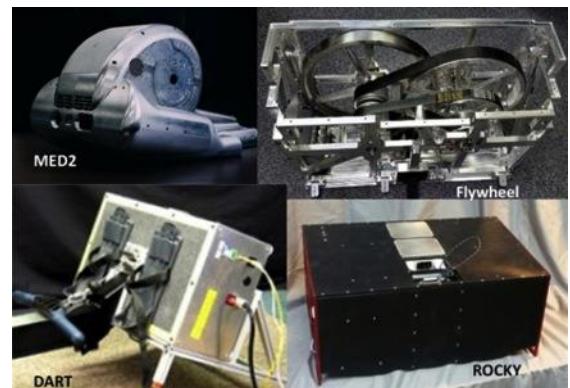
FY 2016 – FY 2017 Plans (continued)



- Collaborate with Crew Health and Safety on studies related to visual impairment, CO₂, exercise systems, cognitive function measures, and astronaut occupational surveillance
- Implement integrated ISS research and analog studies with international partners including hardware, data, and subject sharing to maximize research throughput
- Conduct required assessments with Orion, including E-Procedure Validation (electronic communication to be tested on EM-2), food mass reduction, exercise hardware and human testing using Orion seat and suit prototypes
- Initiate joint HRP/National Science Foundation Antarctic analog studies to support Behavioral Health and Performance
- Commence Human Translational Research Institute co-operative agreement to translate cutting edge emerging terrestrial biomedical research and technology development into applied space flight human risk mitigation strategies for exploration missions

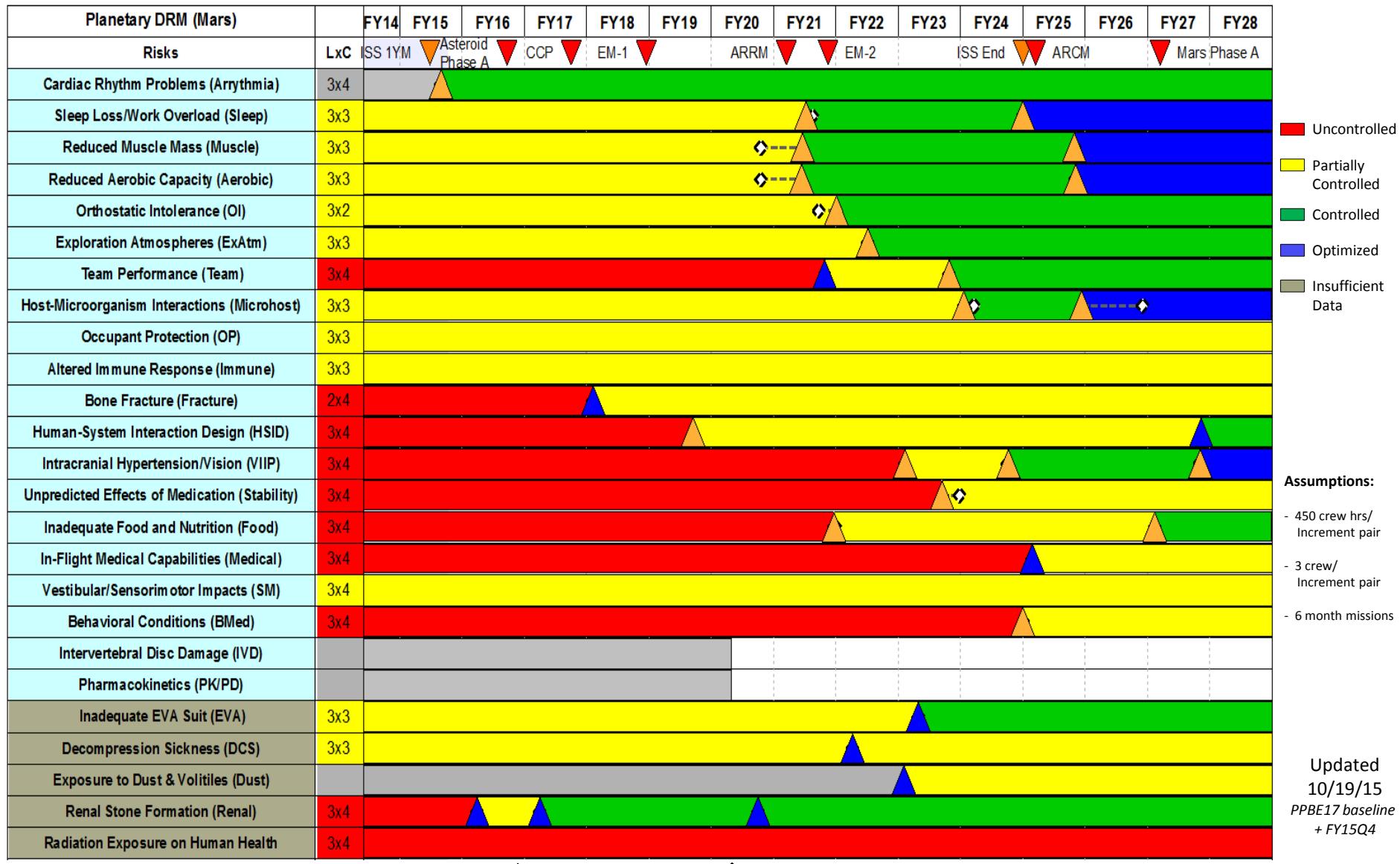


Cosmonaut Gennady Padalka images the interior surface of his eye, with assistance from astronaut Terry Virts



HRP is evaluating four exercise device concepts for EM-2

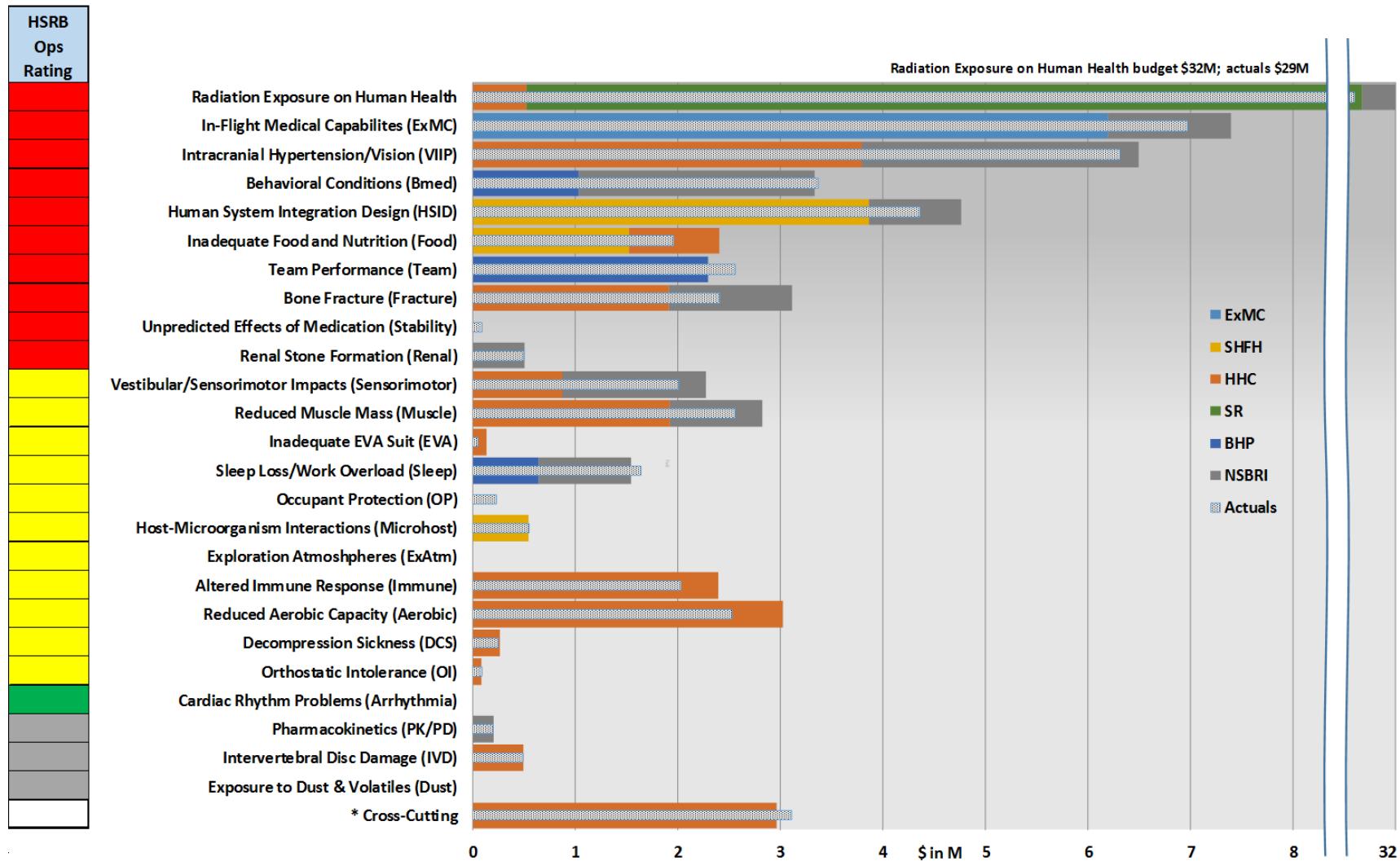
Integrated Path to Risk Reduction (Rev C, 2015)



Cost of Countermeasure Development



Re- assessment of R&D Investment by risk: FY15 Planned vs Actual Investment



One-Year Mission & Twins Updates



Multilateral biomedical investigations on US and Russian crewmembers

FY 2012

- Agency-level bilateral agreement. Candidate investigations exchanged.

FY 2013

- Developed milestones, overarching principles for hardware & data sharing, cross-participation
- Field Test experiment (joint, pre/post flight) initiated, transitioned to operations
- Fluid Shifts experiment (joint, in-flight) initiated; implementation issues identified, resolved
- Identified complementary ESA, JAXA, CSA investigations (thus “multilateral”)
- NRA issued for Twins Study

FY 2014

- Completed informed consent for US investigations for both crewmembers
- Data Sharing Principles signed by SSCB
- Ten investigators selected to form Twins Study
- JSC Interim Directive policy developed to protect flight subjects participating in genetic research
- Two Twins Study Investigator Workshops held
- First baseline sample and data collection for Twins Study



FY 2015

- Completed informed consent for Russian investigations, BDC, crew training
- Finalized documentation for joint investigations implementation under guidance of KNTS (Soloviev)
- Twins Study pre-flight sample and data collection complete
- Expedition launched



Q4 One Year Mission

- Completed Multilateral Data Sharing Agreements for 8 investigations
- Substantial public attention to 1YM, Twins, relationship to Mars mission and “The Martian”
- First two (of three) in-flight sessions successfully completed for complex joint investigation (Fluid Shifts)
- Conducted first full up Field Test data collection on 42S crew landing.
- Roscosmos management changes have delayed future one-year mission discussions



Q4 Twins Study

- Genetic information now being obtained (not yet being shared with the participants)
- One additional data collection session on ground-subject accomplished, one more in discussion

Completed: Pilot Field Test (PFT)



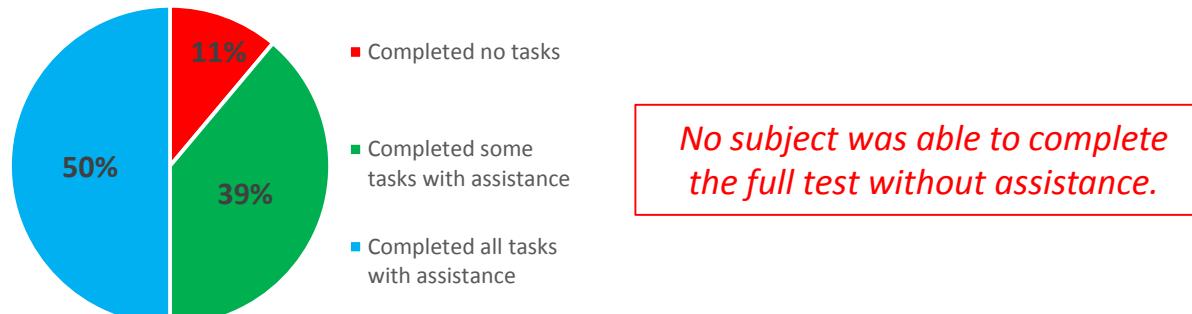
Goals:

- Understand autonomous crew capabilities after landing at exploration destinations
- Exercise renewed joint US (Reschke)/Russian (Kozlovskaya) research collaborations.
- Demonstrate capability to collect HRP research data within 5 hrs of Soyuz landing
 - o Prerequisite for implementing full Field Test experiment.
 - o Implemented a subset (three tasks) of the Full Field Test experiment:



Results:

- Performed successfully on all scheduled Expeditions (34S – 41S; n=18 crewmembers).



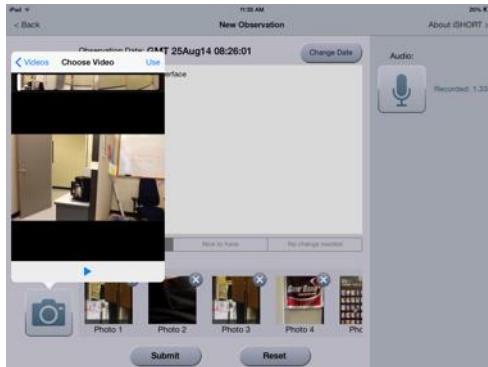
- Demonstrated feasibility of collecting data at the landing site (and other remote locations).
- Authorized implementation of full Field Test: 1st [Russian] subject completed on 42S.

ISS Flight Observations Tool: iSHORT



Space Habitability Observation Reporting Tool (iSHORT)

- iPad app developed by Space Human Factors Investigator
- Deployed aboard ISS in March 2015
- Used by crewmembers to collect science data for the ISS Habitability study:
 - captures photographic, video, and text observations about the living and working environment
 - part of an effort to define/characterize habitability and human factors needs for future long-duration vehicles and habitats.
- iSHORT provides a quick, easy way for the crew to capture and submit observations
- Other groups have expressed interest in using iSHORT to capture real-time information:
 - **Astronaut Office:** to capture operational notes similar to “Crew Notes” currently collected via text in scheduling software
 - **ISS Operations:** to capture on-orbit crew debriefs
 - **Space Medicine:** to capture private communications with crewmembers
 - **Other science payloads:** to capture journal entries, survey data, audio recordings of environmental noise, photos, etc.



Analog Facility Acquisition/Access Status



Analog	Status	Risks/ Threats	Expected Completion	Comments
IMBP/NEK Chamber	Green	NEK delivery	12/31/15	<ul style="list-style-type: none"> Contract in place for IMBP to provide feasibility and management plan. Contract requires document by 3/31/2016. IMBP NEK indicates draft to be provided prior to 12/31/2015.
Isolated, Confined, Controlled Analog(s)	Green	May not be able to effect a procurement in time to meet initial need in FY17.	2/29/2016	<ul style="list-style-type: none"> RFI closed on 8/31/2015. Total of 9 responses indicating potential for domestic ICC analog exists Developing detailed requirements for potential procurement, target RFP release Feb 2016. Determine best overall analog strategy, including feasibility to use NEK and/or domestic analogs.
DLR/:envihab	Yellow	Appropriate agreement mechanism acceptable to NASA and DLR	1/30/2016	<ul style="list-style-type: none"> Renegotiated schedule with procurement to have contract in place by 12/10/2015 to implement 30-day bedrest study in Fall 2016. DLR unable to accept terms of proposed contract. Working with HQ and procurement to determine most appropriate agreement mechanism to enable use of :envihab by NASA
NSF/Antarctic Stations	Yellow	HQ-led MOU	TBD/2016	<ul style="list-style-type: none"> HQ/OCS leading effort to develop MOU with NSF, including Polar Program Office Have provided study protocols and support materials to HQ and NSF PPO requesting access to Antarctica for FY17. NSF PPO provided response to protocols, expressed interest in 1 of 3 studies; had significant questions on other studies. NSF PPO invited to observe during peer reviews; invited to attend IWS in Feb. 2016 Investigating options to use International Antarctic stations for FY17 if NSF PPO not able to accommodate studies

Translational Research Institute (TRI) Planning

NSBRI & USRA Cooperative Agreements Re-compete



Mission of the TRI: The mission of the TRI is to lead a National effort in translating cutting edge emerging terrestrial biomedical research and technology development into applied space flight human risk mitigation strategies for exploration missions.

Approach: Single Cooperative Agreement covering current NSBRI & USRA Cooperative Agreement Content

- Open competition and any qualified entity is eligible to compete.
- Competitively select by July 2016 with a start date of October 1, 2016
- 6-year base period with one 6-year option – ending September 30, 2028
- Total Value estimated at ~\$246M (includes both base & one 6-year option funding)
- The technical approaches of all proposals will go through Peer Review coordinated by NRESS
- SEB takes input from peer review and evaluates additional factors (management, cost, previous experience, and key personnel)
- Recommendation presented to HEOMD SSA (Summer of 2016)

Current Status:

- Draft Cooperative Agreement Notice (CAN) released on 8/24/2015
- Pre-proposal conference completed on 10/8/2015
- 27 entities identified on the Interested Parties List
- NASA-wide Blackout Notice Issued 10/14/2015
- Final Cooperative Agreement Notice (CAN) released on 10/30/2015.
- Four Rounds of Questions and Answers Posted to procurement website
- Notice of Intent Letters received 11/13/2015

Upcoming Key Dates:

- Proposals due on 1/8/2016
- Contract Award 07/06/2016
- Contract Phase-in 9/1/2016
- Contract Start 10/1/2016

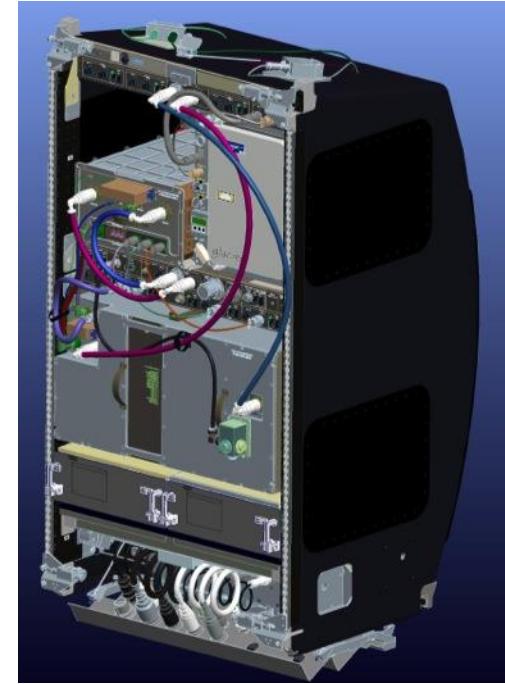
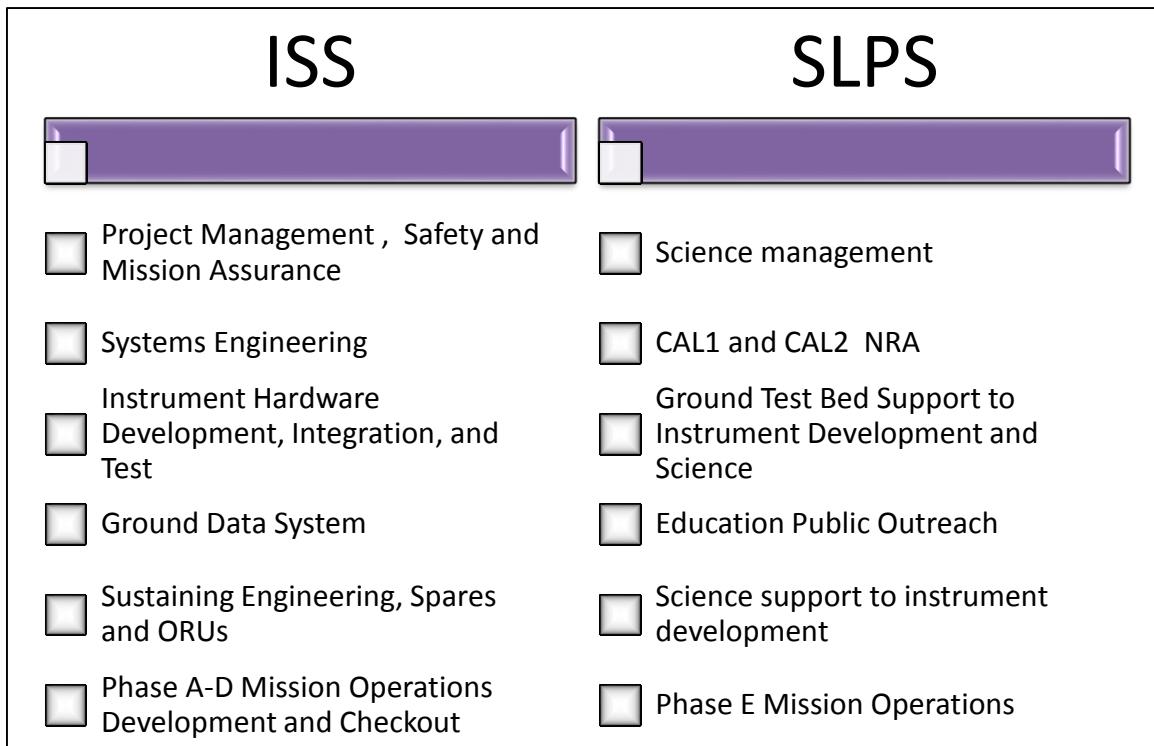


Physical Science Highlights



Cold Atom Laboratory (CAL) Re-Baseline

- **Re-baseline CAL for Phase C/D Implementation with new FHA and a cost cap**
- **Refine Joint management approach between SLPS, ISS and JPL**
- **Define Mission Cost Cap and UFE release process**
- **Successful review with HEOMD & OCS February 10**



CAL in Express Rack

CAL Mission Overview



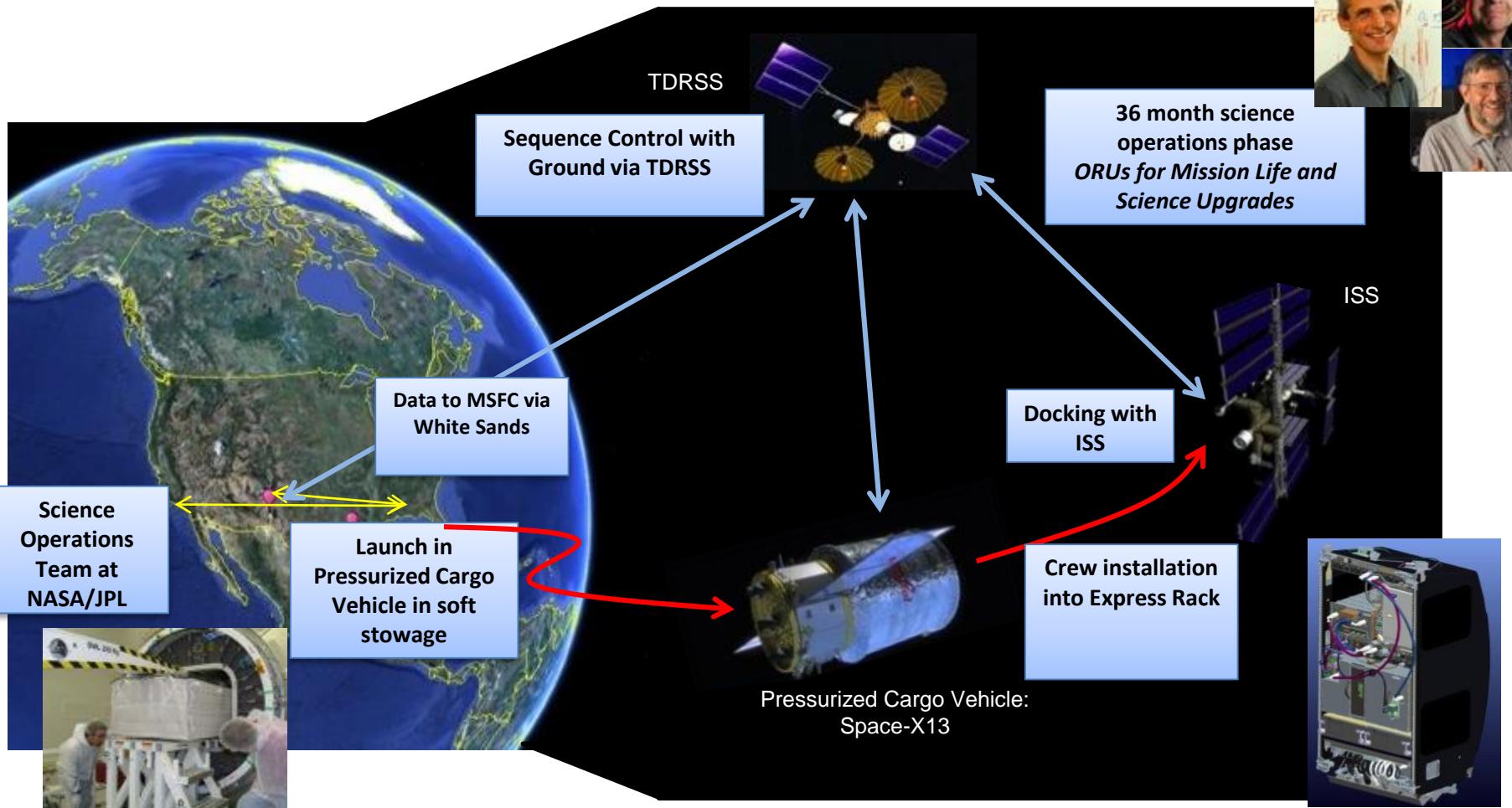
Science
Definition
Sept 2012

Development
2012-2017

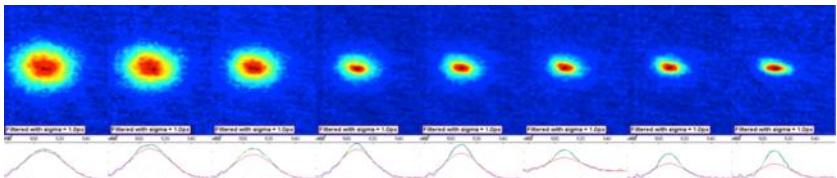
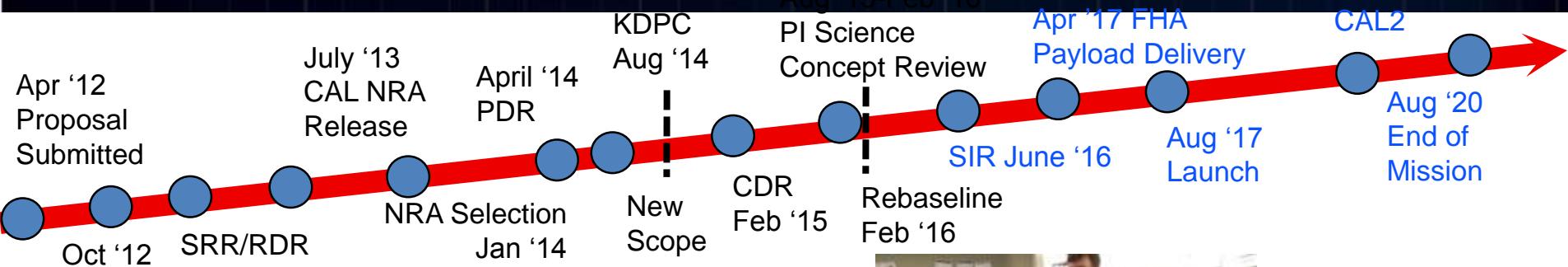
Delivery
Apr 2017

Target
Launch
Aug 2017

Mission
Operations
Aug 2017-2020



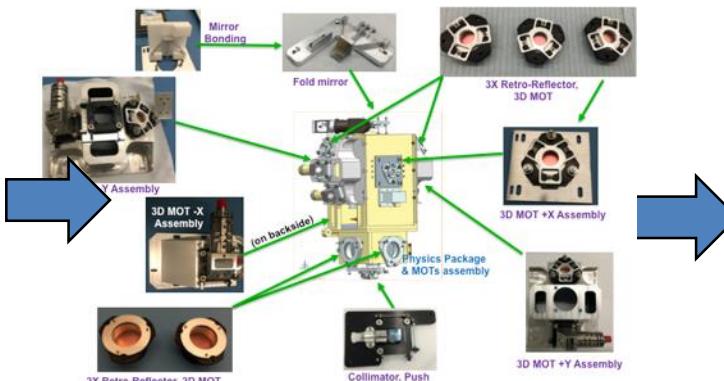
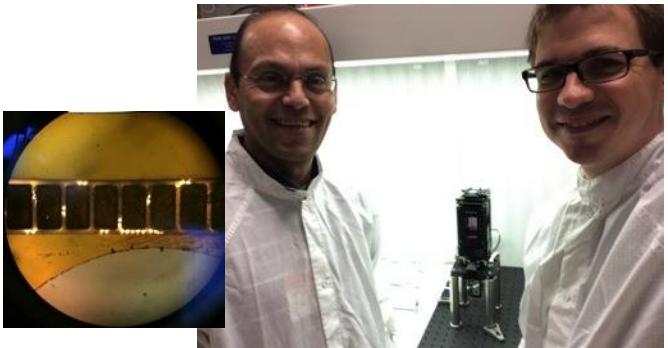
CAL Mission Major Milestones and Phase C Highlights



Sept 2014 - Jan 2015 – BEC with EM HW in GTB
Validating CAL Engineering Approach



Nov - Feb 2014 –
PSR3, Human
Factors, Crew
Operations, and
Critical Design
Complete



Sept 2015 - Root Cause Determination
for loss of vacuum, and receipt of
Flight Unit Physics Package

Oct 2015 - Optical Bench
Fabrication Complete

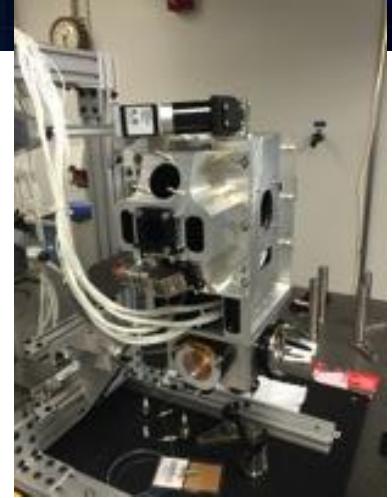


Nov 2015- Flight Physics
Package Installation into
Optical Bench

CAL Instrument Progress to Date



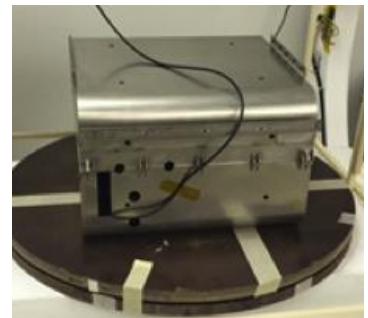
Subsystem	Design	Fab	Planned Completion
Physics Package (1a)	100%	100%	9/18/15
AI Physics Package (1b)	100%	10%	5/20/16
Laser Optics	100%	100%	3/1/16
Electronics	70%	54%	6/10/16
Software	60%		6/10/16
Heat Exchangers	66%	63%	3/31/16
Structure	100%	80%	3/31/16
Cabling	100%	33%	3/31/16



Flight Physics Package and Science Module



Flight Electronics and Laser Subsystem



All Flight Hardware in Build and Assembly

Flight Structure and Magnetic Shield

JPL Recommendations to HEOMD



- Fully fund the completion of the rebaselined cost capped CAL through FY17 Initial Operational Capability (IOC)
- Implement full science and mission duration capability with Delivery to Launch Vehicle Provider on April 25th 2017
- CAL project holds 60 days funded schedule reserve to enable cost efficient management
- ISS Program holds at least \$6.8M UFE to cover Phase C/D development risk to go for 70% Confidence Level
- ISS/SLPS follows joint process to release reserves in a timely fashion to JPL

Elements of Cost	Sunk Cost FY13-FY15 (\$M)	Cost to IOC (\$M)
ISS	23.4	15.2
SLPS	8.8	9.4*
Program held UFE to Go		6.8
Estimate to Complete (\$M)	32.2	31.4

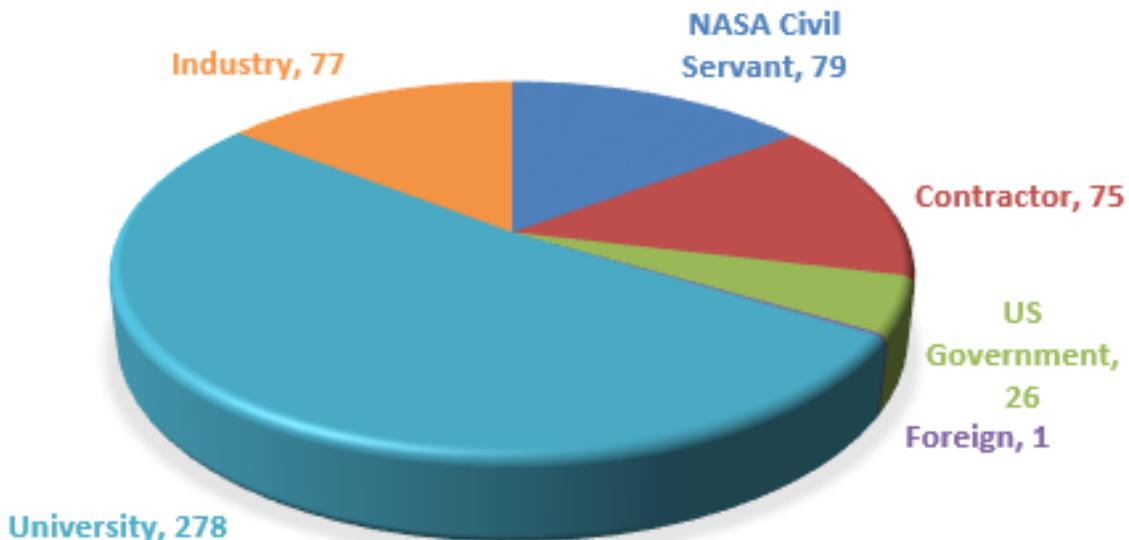
*SLPS Cost Includes NRA funding of \$4.2M in FY13/14/15 and \$5.7M in FY16/FY17

Physical Science Informatics (PSI) Systems Status



- The PSI team completed the processing and loading of ACE-M1 raw and analyzed data.
- The PSI team completed processing and loading , BASS raw image and video data.
- The PSI team completed the re-organization of the MABE raw and analyzed data to enhance data navigation and usability.
- Letter to Space Consortium Directors was sent on January 11th and followed up with phone calls
- NRA Appendix B was released on January 19th.
- The PSI team conducted a virtual Proposers' Conference on January 26, 2016 to support the release of the NRA Appendix B.--57 people participated
- Appendix B Notices of Intent were due on February 9th.
- Two Appendix A NRA selections were announced on January 22nd
- Appendix B proposals are due on March 17th.
- The PSI team hosted a booth at the 145th Annual Meeting of the TMS (The Minerals, Metals and Materials Society) on Feb 15-17 in Nashville, TN.

PSI User Demographics



Current total = 536
(as of Feb 12th)

Flight Experiment Data Progress

Data Sets Complete or Eligible for NRA proposals

Acronym	Title	Research Area	Completion Status	NRA Eligibility
ACE-M1	Advanced Colloids Experiment-Microscopy-1	Combustion Science	Complete	Yes
BCAT-3	Binary Colloidal Alloy Test - 3	Complex Fluids	Complete	Yes
BCAT-4	Binary Colloidal Alloy Test - 4	Complex Fluids	Complete	Yes
BCAT-5	Binary Colloidal Alloy Test - 5	Complex Fluids	Complete	Yes
BCAT-6	Binary Colloidal Alloy Test - 6	Complex Fluids	Complete	Yes
CCF	Capillary Channel Flow	Fluid Physics	Complete	Yes
CFE	Capillary Flow Experiment	Fluid Physics	Complete	Yes
CSLM	Coarsening in Solid-Liquid Mixtures	Materials Science	Complete	Yes
CSLM-2	Coarsening in Solid-Liquid Mixtures-2	Materials Science	Complete	Yes
CSLM-2R	Coarsening in Solid-Liquid Mixtures-2 Reflight	Materials Science	Complete	Yes
CSLM-3	Coarsening in Solid Liquid Mixtures-3	Materials Science	Complete	Yes
CVB	Constrained Vapor Bubble	Fluid Physics	Complete	Yes
DAFT	Dust and Aerosol Measurement Feasibility Test	Combustion Science	Complete	Yes
DAFT-2	Dust and Aerosol Measurement Feasibility Test-2	Combustion Science	Complete	Yes
FLEX-1	Flame Extinguishment Experiment	Combustion Science	Complete	Yes
GRADFLEX	Gradient Driven Fluctuation Experiment	Fundamental Physics	Complete	Yes
InSPACE-3	Investigating the Structure of Paramagnetic Aggregates from Colloidal Ellipsoids-3	Complex Fluids	Complete	Yes
InSPACE-3+	Investigating the Structure of Paramagnetic Aggregates from Colloidal Ellipsoids-3+	Complex Fluids	Complete	Yes
ISSI	In-Space Soldering Investigation	Materials Science	Complete	Yes
MABE	Microheater Array Heater Boiling Experiment	Fluid Physics	Completed 2016	Yes
NPBX	Nucleate Pool Boiling Experiment	Fluid Physics	Complete	Yes
PFMI	Pore Formation and Mobility Investigation	Fluid Physics	Complete	Yes
PHaSE	Physics of Hard Spheres Experiment	Materials Science	Complete	Yes
SAME	Smoke Aerosol Measurement Experiment	Complex Fluids	Complete	Yes
SAME-R	Smoke Aerosol Measurement Experiment Reflight	Combustion Science	Complete	Yes
SHERE	Shear History Extensional Rheology Experiment	Combustion Science	Complete	Yes
SHERE II	Shear History Extensional Rheology Experiment II	Complex Fluids	Complete	Yes
SHERE-R	Shear History Extensional Rheology Experiment Reflight	Complex Fluids	Complete	Yes
SPICE	Smoke Point in Coflow Experiment	Complex Fluids	Complete	Yes

Representative of the 45 completed and current investigations identified in initial scope.
 The 63 awarded investigations are not represented in these listings.

Investigation Loading Progress



Data Sets Remaining

Acronym	Title	Research Area	Completion Status	NRA Eligibility
BASS	Burning and Suppression of Solids	Combustion Science	Completed 2016	No
CFE-2	Capillary Flow Experiment-2	Fluid Physics	Completed 2016	No
CVB-2	Constrained Vapor Bubble-2	Fluid Physics	Completed 2016	No
DECLIC-ALI*	DEvice for the study of Critical Liquids and Crystallization - Alice Like Insert	Fundamental Physics	Completed 2016	No
DSI-DSIP	DEvice for the study of Critical Liquids and Crystallization - Directional Solidification Insert	Materials Science	Completed 2016	No
DSI-R/SPADES	DEvice for the study of Critical Liquids and Crystallization - Directional Solidification Insert-Reflight	Materials Science	Completed 2016	No
FLEX-2	Flame Extinguishment Experiment-2	Combustion Science	Completed 2016	No
HT1-R/SCWM*	DEvice for the study of Critical Liquids and Crystallization - High Temperature Insert-Reflight	Fluid Physics	Completed 2016	No
InSPACE	Investigating the Structures of Paramagnetic Aggregates from Colloidal Emulsions	Complex Fluids	Completed 2016	No
InSPACE-2	Investigating the Structures of Paramagnetic Aggregates from Colloidal Emulsions-2	Complex Fluids	Completed 2016	No
MICAST/CSS B1	Comparison of Structure and Segregation in Alloys Directionally Solidified in Terrestrial and Microgravity Environments	Materials Science	Completed 2016	No
MICAST/CSS B2A	Comparison of Structure and Segregation in Alloys Directionally Solidified in Terrestrial and Microgravity Environments	Materials Science	Completed 2016	No
PCS	Physics of Colloids in Space	Complex Fluids	Completed 2016	No
PK-3*	Dusty Plasma	Fundamental Physics	Completed 2016	No
PK-3+*	Dusty Plasma	Fundamental Physics	Completed 2016	No
SLICE	Structure and Liftoff in Combustion Experiment	Combustion Science	Completed 2016	No
SUBSA	Solidification Using a Baffle in Sealed Ampoules	Materials Science	Completed 2016	No

*Identified as International flight experiments.

- DECLIC-ALI and HT1-R/SCWM were French CNES experiments and the data will have to be provided from those project teams.
- PK-3 and PK-3+ were Russian experiments and the data will have to be provided from those project teams.

Representative of the 45 completed and current investigations identified in initial scope.
The 63 awarded investigations are not represented in these listings.



Space Biology Highlights



Next Up: Space Biology on SpaceX-8



- **Wetlab-2 Validation Flight:** 1st flight of NASA's on-orbit PCR system will demonstrate Quantitative Real-time Polymerase Chain Reaction (qRT-PCR) onboard ISS as an important bio-research tool.
- **Microbial Tracking-1c:** (PI: Kasthuri Venkateswaran) third of three sampling sessions on ISS to study microbes on surfaces and in the air over a 1-year period to characterize microbial populations over time.
- **Micro-9:** (PI: Timothy Hammond) study of cellular and genetic differentiation of giant yeast colonies in space to uncover unique physiological conditions for drug and novel pathway discovery.
- **Micro-10:** (PI: Clay Wang) Influence of microgravity on the production of secondary metabolites in fungus—a novel drug discovery approach with potential benefits to astronaut health.
- **Veg-03R:** 12 Pillows with Tokyo Bekana Cabbage & 6 pillows with Red Romaine Lettuce.



Wetlab2 Smart Cycler



Surface Sampling Kit for Microbial Tracking



Tokyo Bekana Cabbage



Red Romaine Lettuce



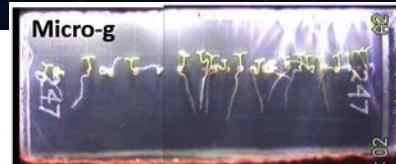
Micro-9 and Micro-10 PHab from Bioserve

Space Biology: More ISS Utilization in FY16

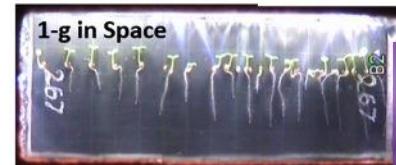


- **SpaceX-9 (March 2016)**

EMCS-1: Plant RNA Regulation (PI: Perera) PI/GeneLab collaborative experiment with *Arabidopsis* will study molecular networks to understand how to design plants which can withstand space flight, microgravity, and adverse environmental conditions

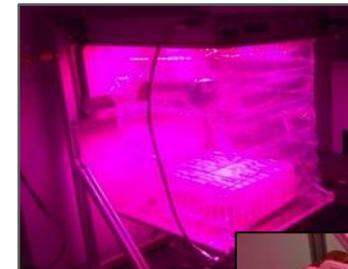


6-day old
Arabidopsis
seedlings in the
EMCS seed
Cassette



- **SpaceX-10 (June 2016)**

APEX-04 (PI: Paul) PI/GeneLab collaborative experiment with *Arabidopsis* will be the first spaceflight experiment to directly investigate how the plant methylome contributes to space adaptation.



APEX *Arabidopsis*
plates in Veggie
(bellows up).



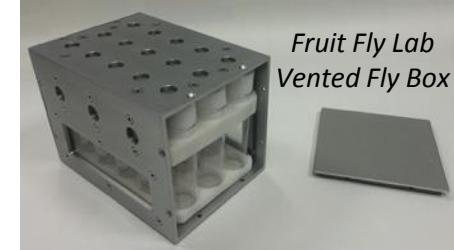
Arabidopsis
after 12 days
growth.

- **SpaceX-11 (August 2016)**

Fruit Fly Lab-2 (PI: Bodmer) PI/translational GeneLab collaborative study of cardiac genes in the fruit fly that relate to human heart health and arrhythmia



COTS *Arabidopsis*
plate holder for
APEX



Seedling Growth-3 (PIs: Kiss & Medina) an ESA-led experiment with NASA and ESA PIs using the EMCS to study gravity and light sensing and control in *Arabidopsis*



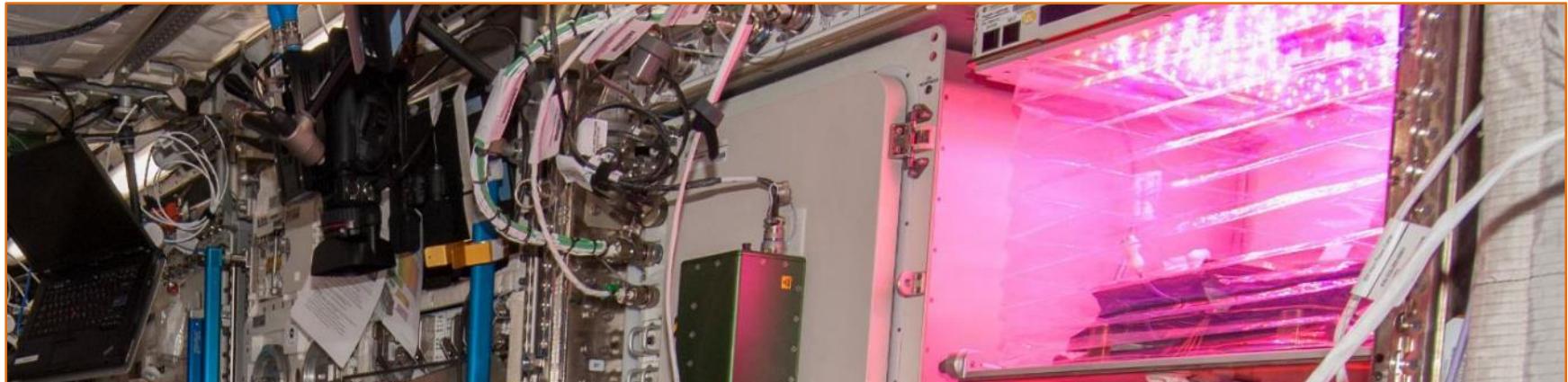
Fruit Fly Lab
Vented Fly Box

Veg-01C: First Flowering Plants Grown in Veggie

- Zinnias were placed in Veggie and growth was initiated November 16th
- Planned 60 day grow-out with return on SpX-9
- EMCS anomaly on 11/19 caused brief power loss, but no loss of science
- Science and Technology Demonstration for ISS
 - Zinnia is being used to test a longer duration flowering crop in Veggie
 - Test of ISS environment for plant reproductive development which is critical for other longer duration vegetable crops such as peppers and tomatoes
 - Microbial populations associated with flowering plants will be assessed
 - Other important science questions to answer include: is pollen developed normally? Is flower formation normal? How do watering requirements change over the growth cycle?



*Zinnia Flowers,
Several Colors
Sent to ISS.*



GeneLab: Recent Highlights



- **Data System:** Current version (1.0.7) has 44 data sets (November 22, 2015) GeneLab has a continuing effort to identify existing data for inclusion and work with investigators to submit their new data
- **GeneLab Workshop at ASGSR:** a great success
 - Rooms Full to capacity in main session and breakouts
 - PI community must post data to publish and want to use GeneLab
 - Many offers of flight sample data for incorporation into GeneLab
 - Questions about RFI and new NRA were addressed
- **New Data Released for ASGSR:** new novel data is being released from recent collaborative spaceflight experiments
 - **BRIC19:** Simon Gilroy (UW-M): GeneLab augmented the number of *Arabidopsis* ecotypes (ASGSR Session 6 – R. Barker, Thurs Nov 12)
 - **BRIC20:** Sarah Wyatt (U. Ohio): GeneLab enabled augmented proteomic analysis (ASGSR Session 23: Sat Nov 14)
 - **RR1:** GeneLab performed transcriptomic, proteomic and epigenomic analysis of mouse liver to be released December 15th.

GeneLab: RFI and Innovation NRA

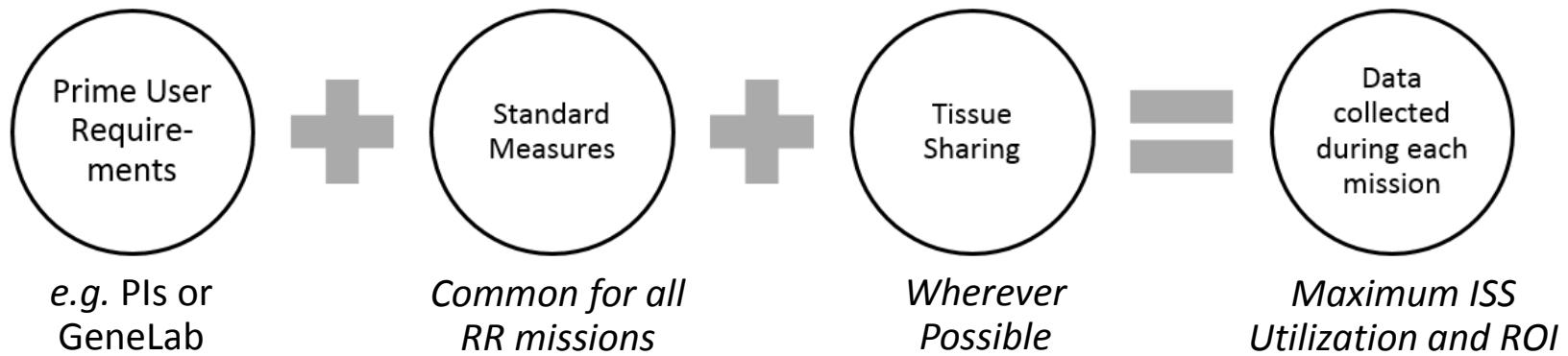


- **RFI:** on Developing a “NASA Space Life and Physical Sciences (SLPS) GeneLab ISS Reference Mission” that will be used to Collect, Manage, and Distribute “Omics-type” Data Collected in the Course of Space Biology Research
 - NASA Workshops will be held on topics from the RFI
 - NASA and Community will develop reference missions together
- **NRA:** GeneLab Innovation Awards for Translational Systems Biology and Informatics Research Using the GeneLab Data System (planned for release)
 - **Systems Biology Informatics Research:** aimed at developing new tools, algorithms and techniques to perform novel informatics research and produce new informatics products that *enhance the usability and value of GeneLab*
 - **Systems Biology Experimental Research:** ground based hypothesis-driven research from GeneLab which *translates spaceflight derived data into new knowledge*

SLPS/CASIS Rodent Research Collaborations



- MOU Appendix A signed in October, for “ISS National Laboratory/Space Life and Physical Sciences Joint Strategic Direction on ISS Rodent Research”
- Guide NASA SLPSRA and CASIS in the development and implementation of collaborative scientific studies utilizing rodents on ISS.
- Key implementation principles established for improving efficiency and scientific value returned from each rodent research mission



- Near-term series of Prime Users on Rodent Research missions established

