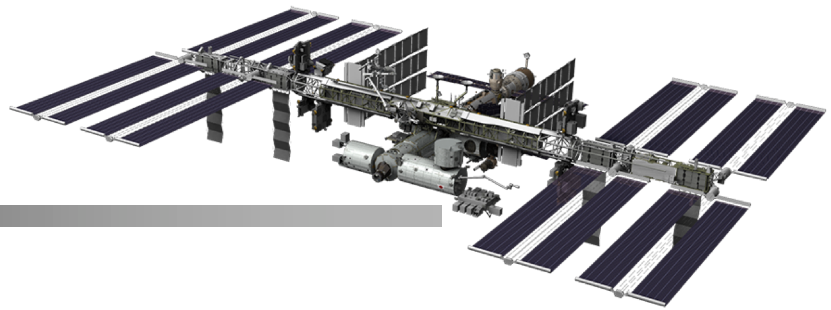
INTERNATIONAL SPACE STATION PROGRAM



HEO NAC
International Space Station Status

Robyn Gatens– ISS Deputy Director

March 2018

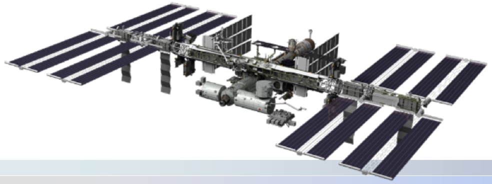
A New Format

- ISS increment overview
- Exploration research and technology highlights (including HRP)
- Utilization summary
- National Lab and CASIS highlights
- ISS operational status
- ISS transition

Flight Plan – Increment 55/56

- 03/21/18 – Soyuz 54S Launch (NASA/Feustel, NASA/Arnold, and Roscosmos/Artemyev)
- 03/23/18 – Soyuz 54S Docking
- 03/26/18 – Progress 68P Undock
- 04/02/18 – SpaceX CRS-14 Launch
- 04/04/18 – SpaceX CRS-14 Berthing
- May 2018 – Orbital ATK CRS-9 Launch and Berthing
- 05/02/18 – SpaceX CRS-14 Release / Splashdown
- 06/03/18 – Soyuz 53S Undock/Landing (NASA/Tingle, Roscosmos/Shkaplerov, and JAXA/Kanai)
- June 2018 – SpaceX CRS-15 Launch and Berthing
- 06/06/18 – Soyuz 55S Launch (NASA/Aunon-Chancellor, Roscosmos/Prokopev, and ESA/Gerst)
- 06/08/18 – Soyuz 55S Docking
- July 2018 – Progress 70P Launch / Docking
- July 2018 – SpaceX CRS-15 Release / Splashdown
- July 2018 – Orbital ATK CRS-9 Release

- Three upcoming EVAs (one in March and two in May).



Increment 55 Overview: Crew

53S Dock 12/19/17
53S Undock 06/3/18

Scott Tingle
FE (US) – 53S

Anton Shkaplerov
Soyuz CDR (R) – 53S
(CDR Inc 55)

Norishige Kanai
FE (J) – 53S

Drew Feustel
FE (US) – 54S
(CDR Inc 56)

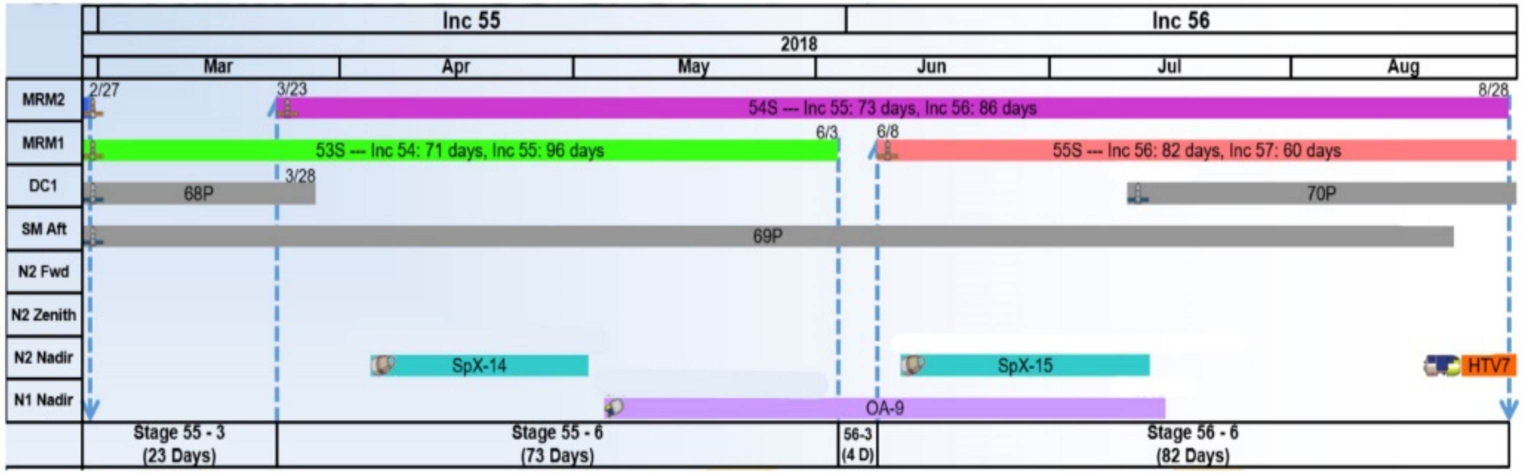
Oleg Artimyev
Soyuz CDR (R) – 54S

54S Dock 3/23/18
54S Undock 8/28/18

Ricky Arnold
FE (US) – 54S

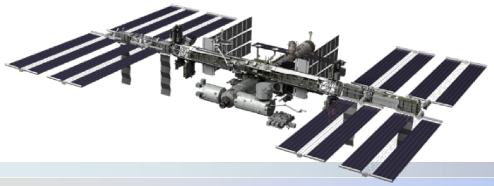
Increment 55 & 56

- Increment 55: 96 days
  - Stage 55-3: 52S undock to 54S dock: 23 days
  - Stage 55-6: 54S dock to 53S undock: 73 days
  - US EVAs (*March and May*)
    - N3 External Wireless Comm (EWC) & Camera Port 8 (CP8)
    - N2F EWC
    - PFCS Relocate & CP13
  - Cargo vehicles:
    - SpaceX-14
    - Progress 68P Undock
    - Orbital ATK-9
  - Science/Utilization:
    - Human Research Facility (HRF) Centrifuge
    - Veggie Ponds
    - Plant Habitat 01
    - Divert Unwanted Space Trash (DUST)
    - NanoRacks RemoveDebris (NR RemDeb)
    - Robonaut (return SpX-14)
  - Maintenance/Outfitting:
    - RPCM R&Rs
    - Umbilical Interface Assembly (UIA) R&R
    - PMA3 Inter-Module Ventilation (IMV) Duct Install
    - Bigelow Expandable Activity Module (BEAM) Stowage



	Increment 55	Increment 56
Utilization	• Airway Monitoring – Lab Session (ESA) • ACME E-Field Flames • Marrow (CSA) • Probiotics (JAXA) • SpX-14: APEX-06 • SpX-14: Invitrobone (ESA) • SpX-14: Mouse Stress Defense (JAXA) • SpX-14: Metabolic Tracking	• Airway Monitoring – Lab Session (ESA) • Fluid Shifts • GRIP/GRASP (ESA) • SpX-15: Cell Science-02 • SpX-15: Rodent Research-7
JEM A/L Candidates	• NREP Mission 4 Transfer (TBD) • NRCSD #15 Deploy (OA-9) • MBSU IFM	
EVA, Robotics, Systems, Software	• SpX-14: PFCS Xfer, ASIM Install, MISSE Install • Linguini Service Pack • JSL 11.0 Software / Firewall Hardware Install • ESA MPCC 2.1 Software Transition • New USOS Printer Install / Checkout • USOS EVA: N3 EWC & CP8 R&R • USOS EVA: PFCS Relocate & CP13 R&R • USOS EVA: N2F EWC	• SpX-15: ECOSTRESS Install, LEE Xfer to ISS, HREP Dispose • Marinara Service Pack • JSL 11.1 Software Transition • USOS ITCS Gas Trap Plug Installation

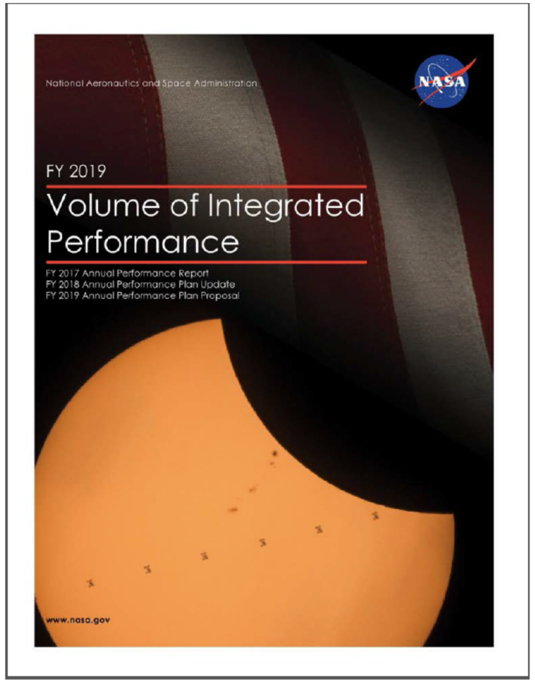
Exploration Research and Technology Highlights



FY18-19 Agency Priority Goal

Use the International Space Station (ISS) as a testbed to demonstrate the critical systems necessary for long-duration missions. Between October 1, 2017, and September 30, 2019, NASA will initiate at least eight in-space demonstrations of technology critical to enable human exploration in deep space.

- New Agency Priority Goal released with FY19 Budget and Volume of Integrated Performance
- Goal focuses on Exploration-enabling demonstrations to be conducted on ISS
- Includes demonstrations funded by ISS, AES, HRP, and Orion
- Demonstrations currently planned for FY18/19
  - Thermal Amine for CO2 removal (FY18)
  - In-space manufacturing Refabricator (FY18)
  - Spacesuit Evaporation Rejection Flight Experiment (SERFE) (FY18)
  - Acoustic Monitor (FY18 – on ISS)
  - Brine Processing Assembly (BPA) (FY19)
  - Spacecraft Atmosphere Monitor (SAM) (FY19)
  - Universal Waste Management System (UWMS) (FY19)
  - Siloxane control technology (FY19)
  - Water Processor Multi-Filtration Bed Upgrade (FY19)
  - Long Duration In-Suit Waste Management (FY19 – late)
  - Anomaly Gas Analyzer (AGA) on SAFFIRE (FY19)



https://www.nasa.gov/sites/default/files/atoms/files/nasa_2019_volume_of_integrated_performance.pdf

ISS Exploration Technology Demonstration Fly-Off Plan

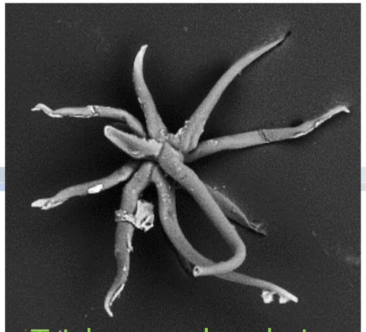
Capability Gap	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28
Environmental Control and Life Support															
Reliable CO2 Removal + ppCO2<2 mmHg	CDRA-5		LDST						Expl system						
Trace contaminant sorbents/siloxane control						siloxane contr			Expl system						
Regen particulate filtration/surface dust pre-															
Smaller, simpler O2 Gen						OGA Upgrades									
High pressure O2 (3000 psi) for EVA & medical use								HP OGA or concentrator							
Reliable urine processing =85% recovery			alt pt		DA mods										
Reliable H2O processing w/ reduced expendables				MF life ext				CR mod							
Compact waste & trash mngmt, stable, 90% water					UWMS				HMC						
Additional O2 recovery from CO2 >75%								PPA			alt tech				
>90% recovery of water from urine brine						BPA									
Condensing HX robust, inert, anti-microbial								flt demo							
Environmental Monitoring, Safety and Emergency Response															
Trace Gas (on orbit, no grab sample return)	AQM					SAM									
Targeted Gases (fire products, NH3, hydrazine)		MGM				AGA on saffire									
Water (individual compounds)			suite early demo				final flt suite								
Microbial (ID & qty species)			Razor demo				Expl PCR								
Major Constitutents (small, no maintenance)						SAM/MPAM									
Particulates				aerosol sampler				flight monitor							
Acoustic (automated, alerting, no crew time)						Combination acoustic monitor									
Emergency Mask (single cartridge)	dual							single; sorbent demo on Saffire IV-VI							
Contingency Air Monitor (overlap with targeted gas)								Demo in Saffire IV-VI							
Smoke Eater								Demo in Saffire IV-VI							
Water Mist PFE			ISS size					Expl. Size, lightwt tank for Orion							
Large fire behavior in ug				Saffire-I-III				Saffire-IV-VI							

Capability Gap	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28
Extravehicular Activity															
Exploration Extravehicular Mobility Unit (xEMU)													ISS demo		
Long Duration In-Suit Waste Management															
Active Thermal Management for xEMU						SERFE									
Human Health & Performance															
Exercise Equipment				MED-2				ATLAS							
Medical Equipment					*(ground testing only - no flight tests currently planned)*										
Food System									Adv food system						
Radiation															
Radiation Monitoring					FNS										
Communications, Navigation, and Networking															
High speed comm/internetworking	DTN & OPALS, SCAN TB							ILLUMA-T		TDRS Ka-band upgrades					
Position, navigation, and timing					NICER/SEXTANT										
Materials, Manufacturing, Sustainability, and Supportability															
10:1 volume reduction logistical & clothing		adv clothing			REAL 3				simple laundr						
ISM Recycling & Fabrication				Refab Demo		ERASMUS (Medical, Food Grade Recyling)									
ISM FabLab Demo (Metals, Electronics, etc.)									Flight Demo						
Avionics, Software and Autonomy															
Augmented Reality					T2 AR										
Automated Mission Operations					AMO Express 2.5										
Other Phase 0 demonstrations															
Zero Boil Off Cryo				ZBOT Ph I											
Solar arrays				ROSA (USAF)											
Structures & Health Monitoring				BEAM											

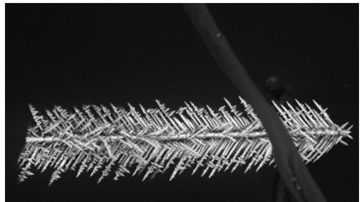
As of 1/25/18 - reflects PPBE19 submit

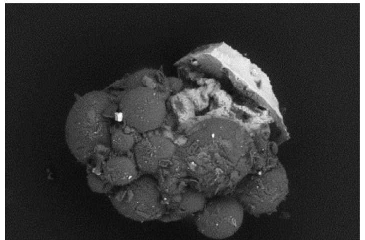
ISS demo - flying
ISS demo - in development
Proposed ISS demo

Featured Exploration Technology – Completed


Trichome, plant hairs

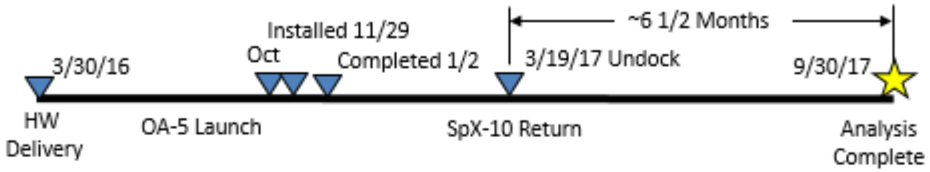
Aerosol Sampling Experiment
Collecting Particles on ISS for Indoor Air Quality Data
PI: Dr. Marit Meyer, NASA Glenn Research Center, Cleveland, Ohio


Silver dendrite with sulfur

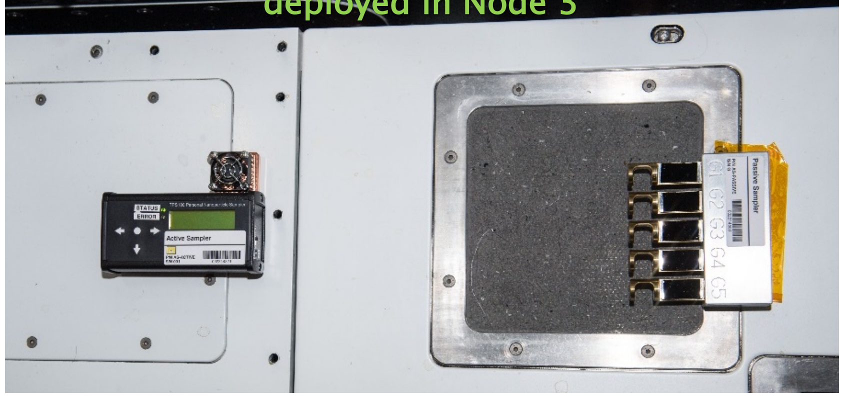

C, Si agglomerate with NaCl

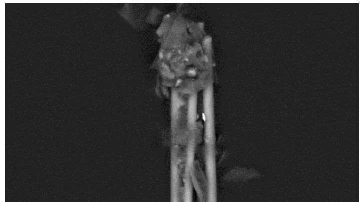
- Two types of samplers collected particles in seven ISS locations in December 2016
- Samples returned to Earth for analysis
  - Computer-controlled & manual microscopy, EDS, Raman
  - 27 metals identified, ubiquitous fibers
- Particles range from ~80 nm to >400 μm
- Currently identifying particle sources for future mitigation
- Low cost, low risk experiment, short timeline
- Data informs design of future particulate monitor for long-duration missions
- Re-fly samplers 2018 (SpX-15), planned Instrument Tech Demo 2019

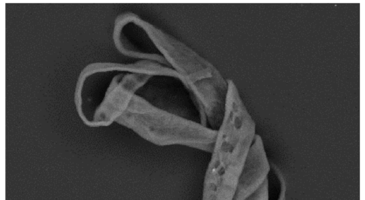
Aerosol Samplers payload and ops timeline

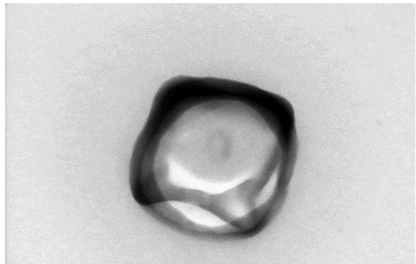


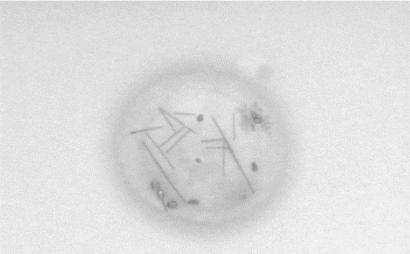
Active Sampler (left) and Passive Sampler (right) deployed in Node 3

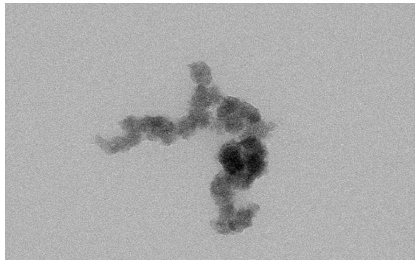


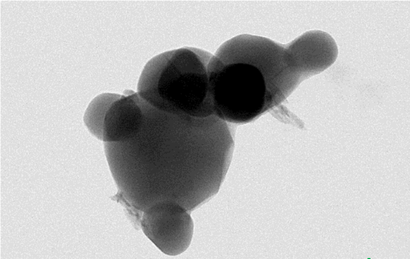

Fiberglass bundle

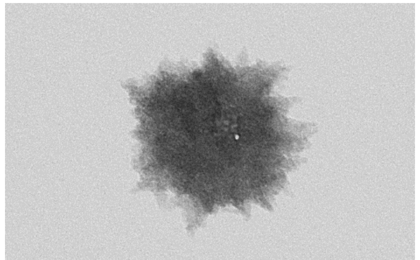

Possible plant fiber

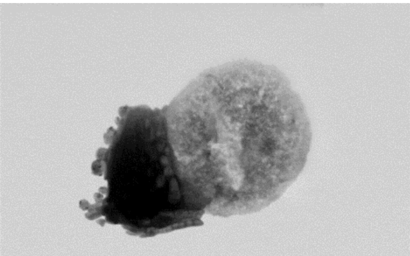

Crystalline Carbon and Silicon


Carbon rich particle with Si, S, Ca


Soot particle


TiO_2 particle


Fe/Cr fume particle


Particle with C, Si, S, Na, Ca

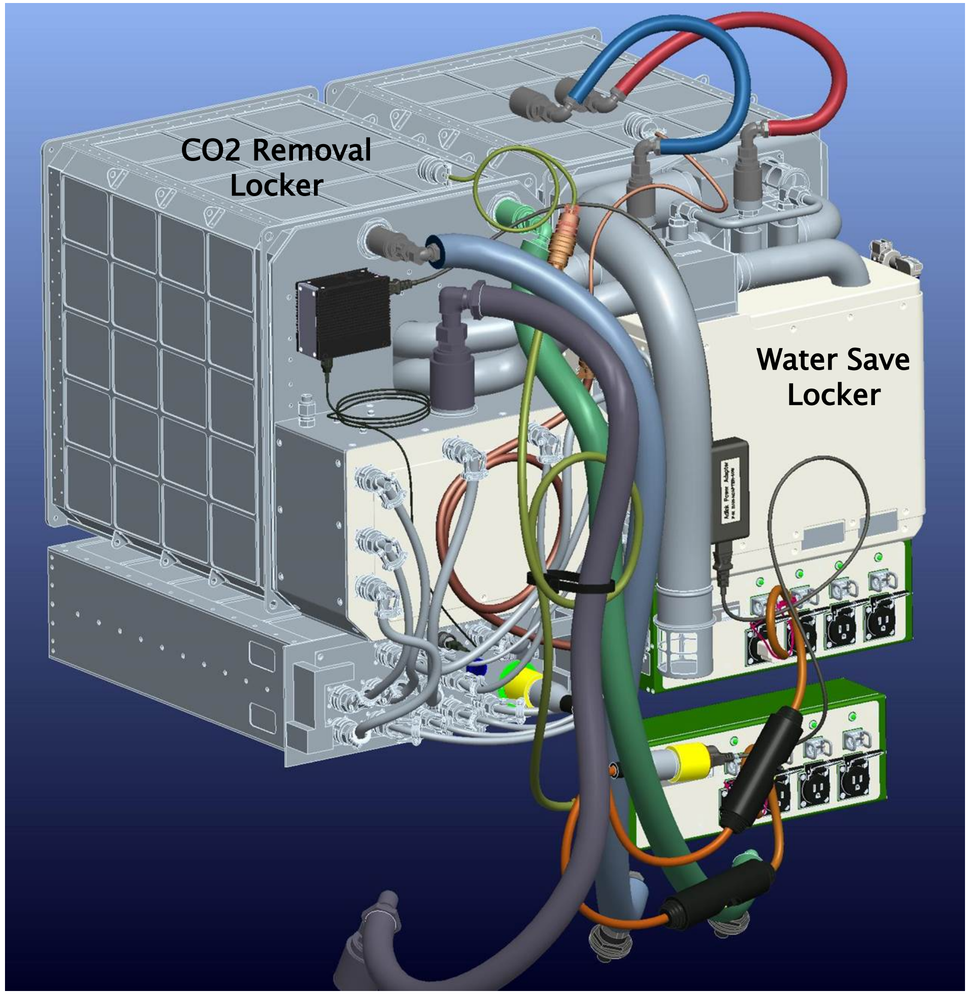
[Images of particles sampled on ISS, Microscopy by RJ Lee Group]

Thermal Amine Scrubber

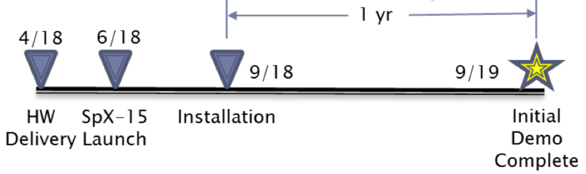
Demonstrating Carbon Dioxide Removal for Exploration Missions

PI: John Garr, MS, NASA Johnson Space Center, Houston, Texas

- Tests carbon dioxide (CO_2) removal technology which uses alternating actively heated and cooled solid amine fixed beds
- Removes 4 crew CO_2 load at 2 mmHg cabin air concentration
  - Lower cabin CO_2 may reduce crew symptoms compared to ~3 mmHg cabin air concentration using existing ISS CO_2 removal technology
- First of three CO_2 removal technology demonstrations planned
  - Performance and reliability data gathered over at least one year on each technology will inform downselect of technology that will undergo 3 year closed loop, integrated demonstration on ISS from 2021 to 2024
- Demonstrates more efficient air and water saving technologies compared to Orion and previous ISS amine scrubbers
- Expect improved reliability as compared to existing ISS system
- First tech demo to utilize new Ku-Band command/telemetry system for MCC-H control of exploration demonstrations
- Projected to launch on SpX-15 in June 2018



Thermal Amine tech demo and ops timeline



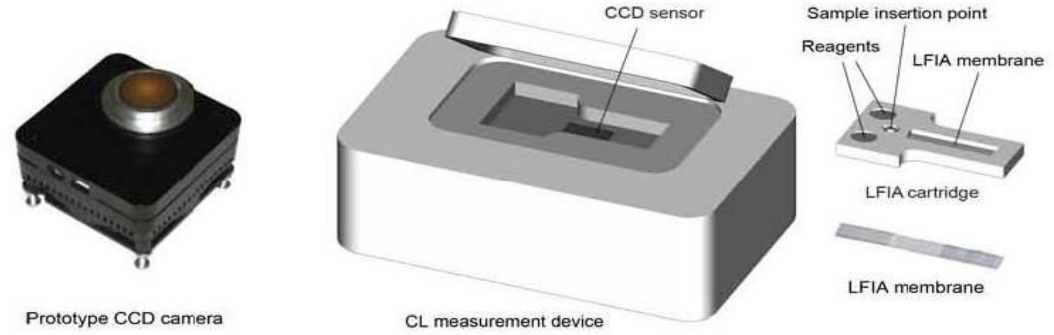
In Situ Bioanalyzer

The Non-Invasive Sample Investigation and results Transmission to Ground with the Utmost Easiness (IN SITU)

PI: Professor Aldo Roda, D.Sc., Ph.D., Department of Chemistry "Giacomo Ciamician", University of Bologna, Bologna, Italy
Sponsoring Space Agency: NASA

Research Overview

- Performs diagnostic tests and biomedical research involving the analysis of biosamples directly within the ISS rather than collecting and storing samples for analysis upon return to Earth
- Each session one crew member collects a saliva sample, analyzes it, and discards the cartridge, and sends data to ground
- Saliva analysis is used to monitor stress levels and appetites among crew members
- A miniature analytical device that can detect certain biomarkers using non-invasively collected samples would benefit health care workers on Earth, from emergency medical technicians on call, to small rural clinics in developing countries



Measurement Device (Center) and the disposable analytical cartridge (right)

Astronaut Paulo Nespoli collects and processes a saliva sample in the bioanalyzer

The Detrimental Effects of Long Duration Spaceflight on Human Wayfinding
The Behavioural and Neural Mechanisms

Principal Investigator: Giuseppe Iaria, University of Calgary, Calgary, Alberta, Canada
Sponsoring Space Agency: CSA

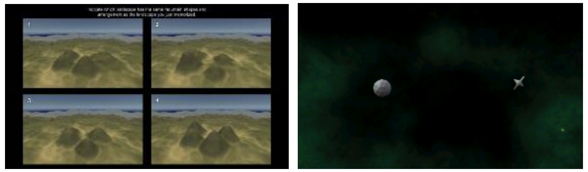
Image: http://en.wikipedia.org/wiki/Vancouver

Image: http://amyhooton.deviantart.com/art/A-Maze-Zing-Brain-174370203

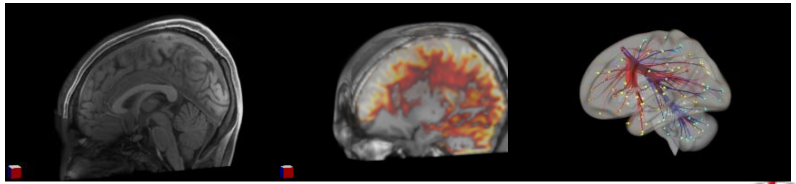
Research Overview

- The microgravity environment in space does not allow astronauts to process vestibular cues as provided by Earth's gravity, and this may affect their wayfinding skills and their ability to perform complex spatial tasks (i.e., robotics) during stays on the ISS
- Wayfinding investigates the impact of long-duration exposure to microgravity on the behavioural and neurological mechanisms of wayfinding in astronauts
- The study also explores how long the astronauts' cognitive and neurological changes persist following their return on Earth.

Computerized battery of neuropsychological tests

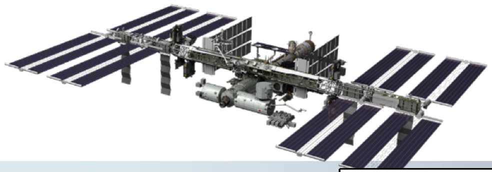


Behavioural Assessment



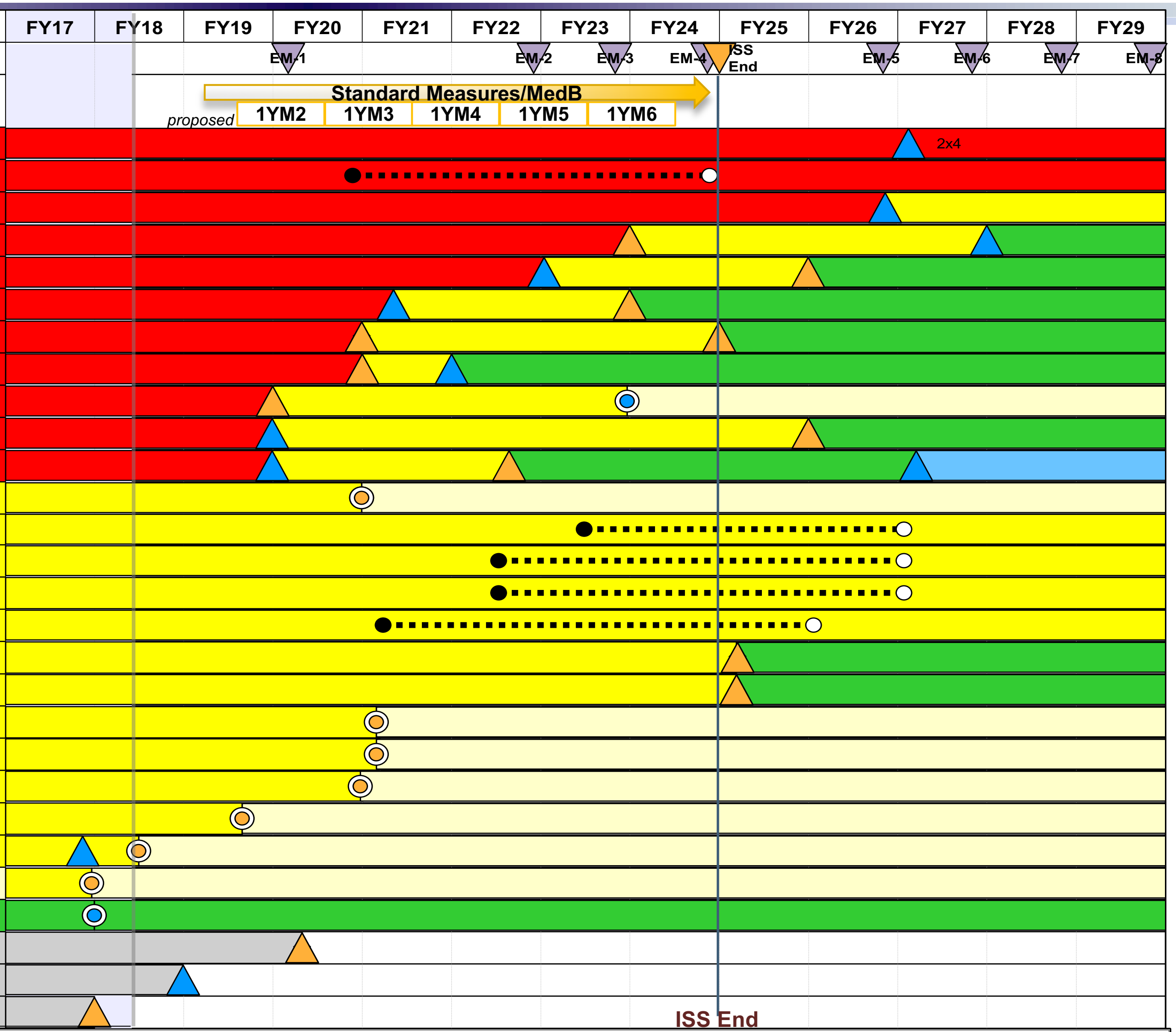
Neuroimaging Assessment

[Images from A.C. Matin et al., *Life Sciences in Space Research* 15 (2017) 1-10]



HRP Path to Risk Reduction

Mars Flyby Risks	LxC
Space Radiation Exposure (Cancer Biological CMs) *	3x4
Space Radiation Exposure (Cancer LTH) *	3x4
Space Radiation Exposure (Degen/CVD/Late CNS) *⋀	3x4
Cognitive or Behavioral Conditions (BMed) *⋀	3x4
Inadequate Food and Nutrition (Food) *⋀	3x4
Team Performance Decrements (Team) *	3x4
Spaceflight Associated Neuro-Ocular Syndrome (SANS/VIIP) *⋀	3x4
Renal Stone Formation (Renal) *	3x4
Human-System Interaction Design (HSID) *	3x4
Medications Long Term Storage (Stability)	2x4
Inflight Medical Conditions (Medical) *	3x4
Injury from Dynamic Loads (OP)	3x3
Sensorimotor Alterations (SM) *⋀	3x3
Injury Due to EVA Operations (EVA)	3x3
Hypobaric Hypoxia (ExAtm)	3x3
Decompression Sickness (DCS) *	3x2
Altered Immune Response (Immune) *⋀	3x3
Host-Microorganism Interactions (Microhost) *	3x3
Reduced Muscle Mass, Strength (Muscle) *⋀	3x3
Reduced Aerobic Capacity (Aerobic) *⋀	3x3
Sleep Loss and Circadian Misalignment (Sleep) *⋀	3x3
Orthostatic Intolerance (OI) ⋀	3x2
Bone Fracture (Fracture) *⋀	1x4
Cardiac Rhythm Problems (Arrhythmia) *	3x2
Space Radiation Exposure (Acute Radiation SPE)	2x2
Concern of Intervertebral Disc Damage (IVD) *	TBD
Celestial Dust Exposure (Dust)	TBD
Celestial Dust Exposure (Dust)	TBD



ISS Required
ISS Not Required
Milestone Requires ISS
Ground-based Milestone
ISS Mission Milestone
Exploration Mission Milestone
Delayed for Planetary ops
* Standard Measures/MedB
⋀1YM# - proposed 1-year missions (ISS)
- Standard Measures/MedB schedule
Risk accepted by HMTA (with countermeasures)
High LxC
Mid LxC: Requires Mitigation
Mid LxC: Accepted
Low LxC
Optimized
Insufficient Data

HRPCB-approved PPBE19 Baseline 28 Feb 2018

Featured Investigation for Human Research

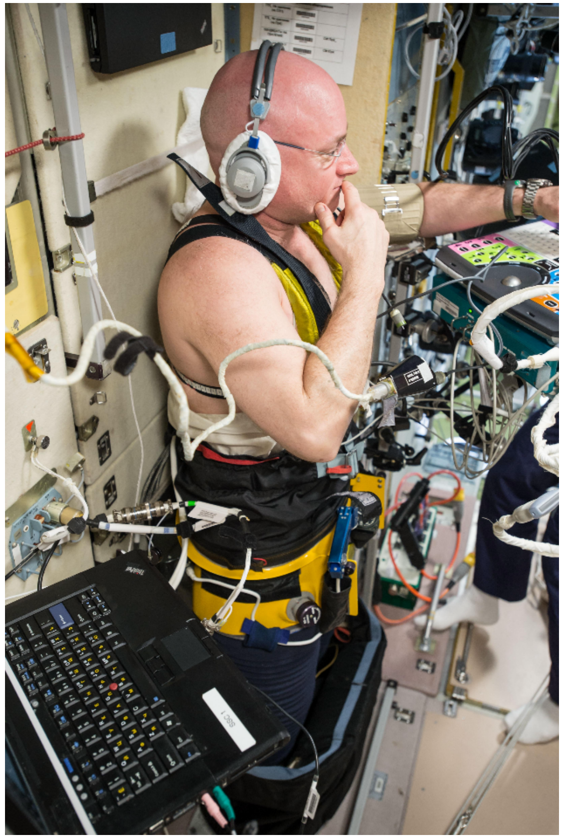
Fluid Shifts

Fluid Shifts Before, During and After Prolonged Space Flight and Their Association with Intracranial Pressure and Visual Impairment

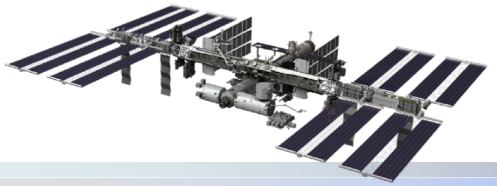
Principal Investigator: Michale B. Stenger, PhD, KBRwyle; Scott A. Dulchavsky, MD, PhD, Henry Ford Hospital; Alan R. Haragnes, PhD, University of California San Diego
Sponsoring Space Agency: NASA

Research Overview

- More than half of American astronauts experience vision changes after long duration space flights. Findings have also included structural changes of the eye, as well as signs of elevated intracranial pressure. This is thought to be the result of prolonged exposure to space flight-induced headword fluid shifts and elevated intracranial pressure
- The purpose of this investigation is to characterize the space flight-induced fluid shifts using noninvasive techniques.
- Lower body negative pressure is being investigated for its ability to mitigate some of the effects of the space flight-induced fluid shift.
- Results from this investigation are expected to help define the causes of the ocular structure and vision changes associated with long duration space flight, and assist in the development of countermeasures
- Results from the investigation are expected to improve scientists' understanding of how blood pressure in the brain affects eye shape and vision, which could also benefit people confined to long-term bed rest, or suffering from disease states that increase swelling and pressure in the brain

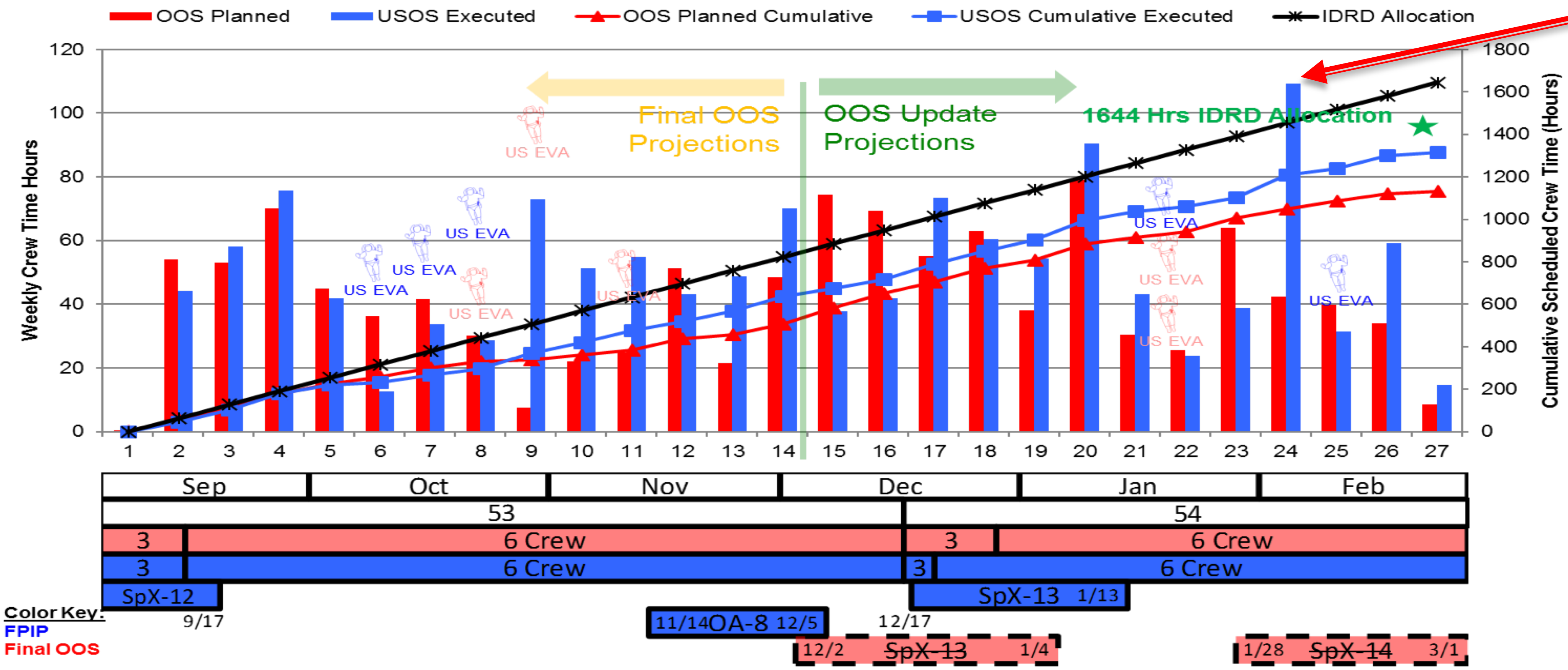


Utilization Summary

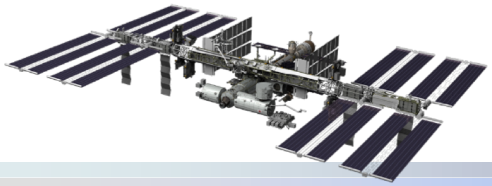


Inc 53-54 Utilization Crew Time

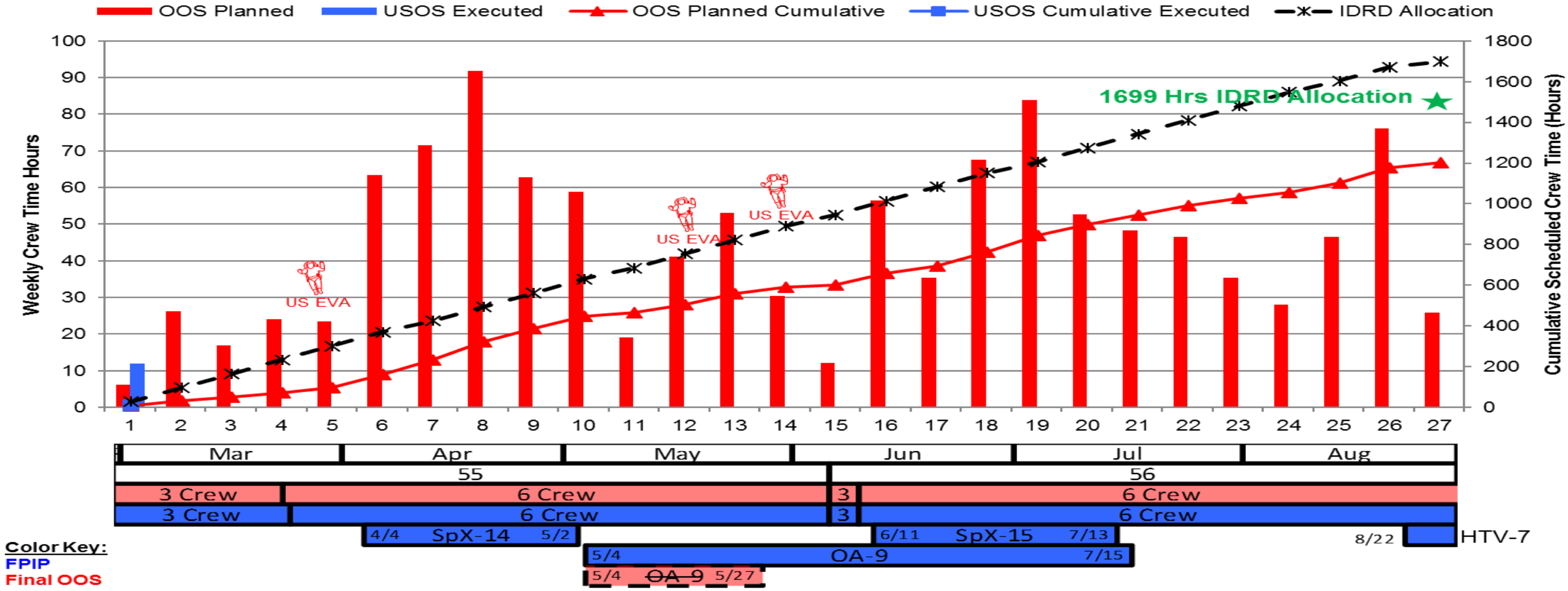
New ISS Record of 109 hours



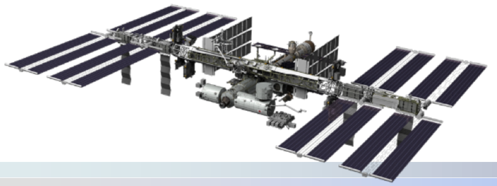
Executed through Increment Wk (WLP Week) 27 :	24.2	of 24 work weeks	(100.8% Complete)
USOS Actuals:	1,314.07	hours -> 54.30 hours/week	
USOS IDRD Allocation:	1,644.00	hours-> 68.50 hours/week	(79.9% Complete)
OOS USOS Planned Total:	1,129.85	hours (Final OOS 1164.94)	(116.3% Complete)
Voluntary Science Totals to Date:	0	hours (not included in the above totals or graph)	
RSA/NASA Joint Utilization to Date:	75.17	hours (not included in the above totals or graph)	



Inc 55/56 Utilization Crew Time



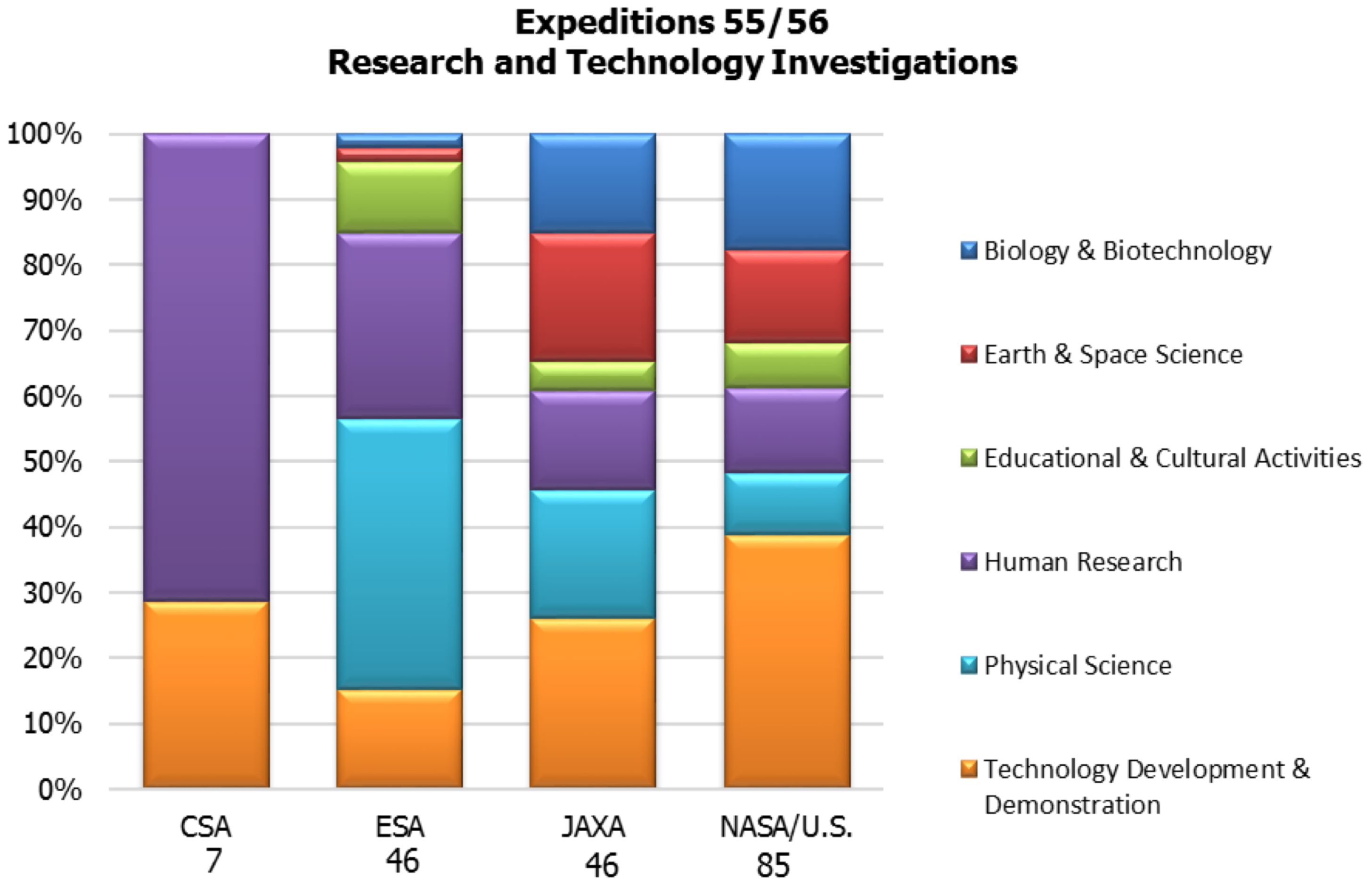
Executed through Increment Wk (WLP Week) 1 :	0.4 of 24.8 work weeks	(1.6% Complete)
USOS Actuals:	12 hours -> 30.00 hours/week	
USOS IDRD Allocation:	1,698.80 hours-> 68.50 hours/week	(0.7% Complete)
OOS USOS Planned Total:	1,203.81 hours	(1.0% Complete)
Voluntary Science Totals to Date:	0 hours (not included in the above totals or graph)	
RSA/NASA Joint Utilization to Date:	0 hours (not included in the above totals or graph)	



ISS Research Statistics

Number of Investigations for 55/56: 184

- 85 NASA/U.S.-led investigations
- 99 International-led investigations
- 47 New investigations
  - 1 CSA
  - 13 ESA
  - 7 JAXA
  - 26 NASA/U.S.



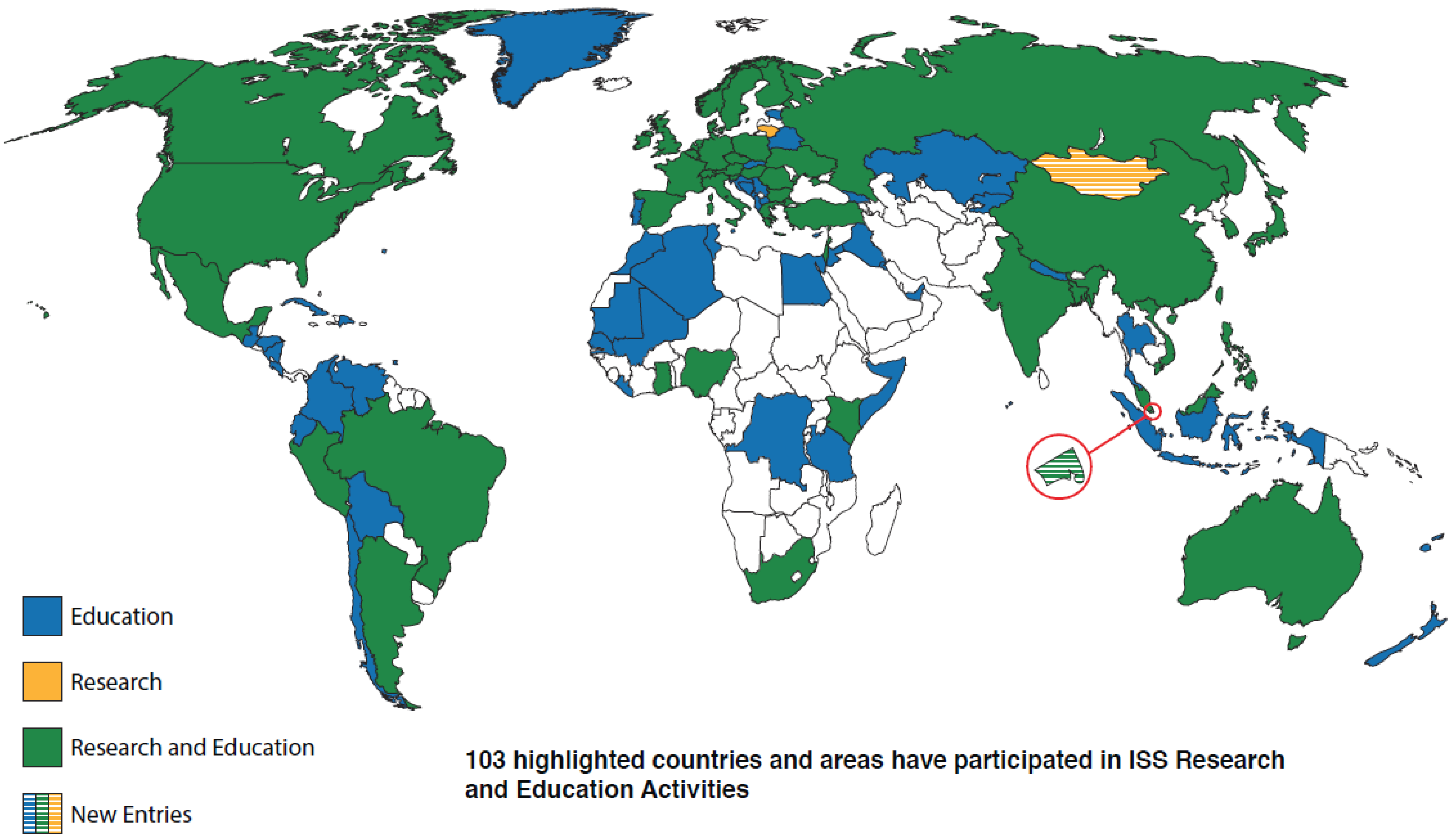
<u>ISS Lifetime</u>

- Estimated Number of Investigations Expedition 0-56: 2566*
- Over 3000 Investigators represented (Exp 0 – present)
- Over 1400 scientific results publications (Exp 0 – present)

Working data as of 1an 31, 2018
*Pending Post Increment Adjustments

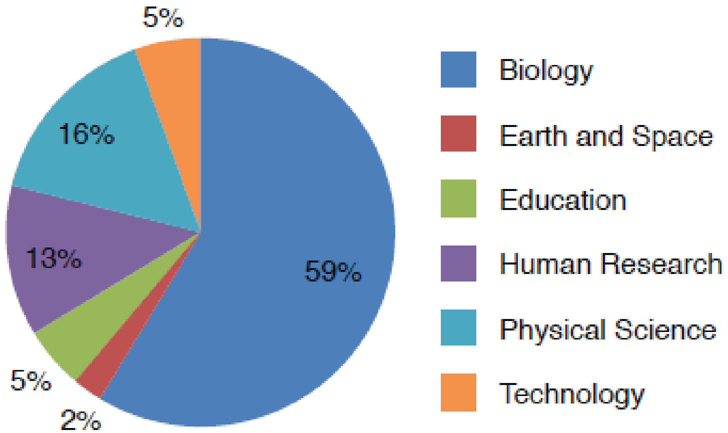
Global Involvement in Utilization

Expeditions 1-52



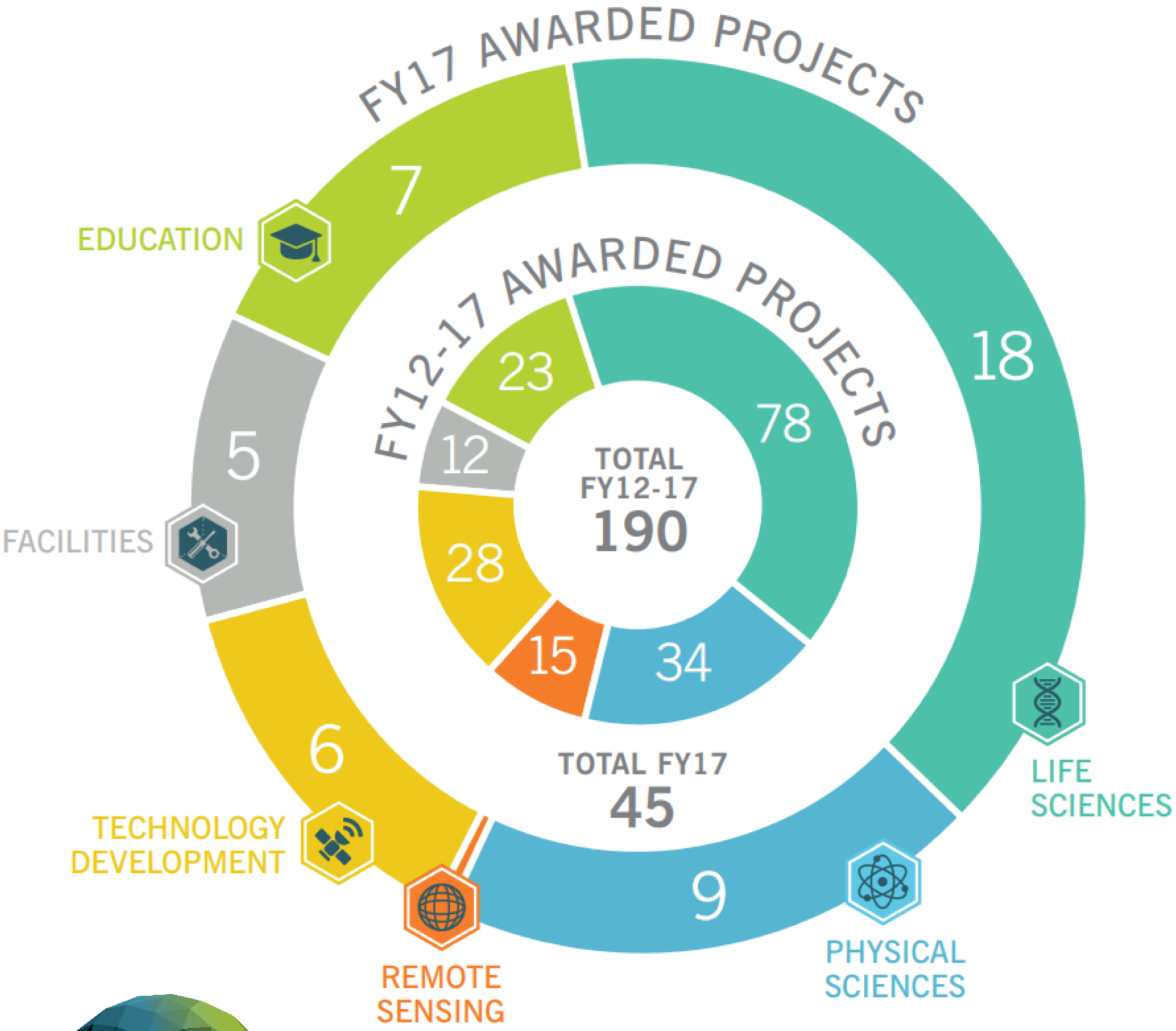
103 highlighted countries and areas have participated in ISS Research and Education Activities

Newly added countries: Mongolia *(Research)* and Singapore *(Research & Education)*



National Lab and CASIS Highlights

CASIS FY17 Annual Report



NEW PROJECTS **FY17** FAST FACTS about the FY17-selected projects:

50%+ life sciences projects co-sponsored by the National Institutes of Health or another third party

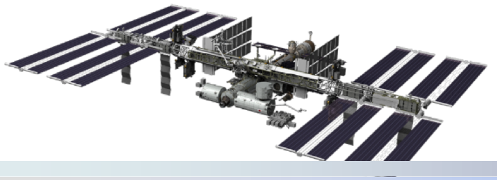
55%+ physical sciences projects co-sponsored by the National Science Foundation or another third party

75%+ education projects involving commercial sponsorship

70%+ projects from new-to-space customers

$6M+ awarded by CASIS in FY17 to support these projects and related programs

CASIS™



Implementation Partners with CASIS

AIRBUS DS SPACE SYSTEMS, INC. Houston, Texas

Alpha Space Test & Research Alliance

ASTROTECH SPACE OPERATIONS A Lockheed Martin Company

bionetics VISION • VALUE • INTEGRITY

BIOSERVE SPACE TECHNOLOGIES

BOEING

CSS-Dynamac Scientific Minds. Common Sense Solutions.

Emerald City Initiatives, Inc. Connect • Collaborate • Contribute

FedEx fedex.com/spacesolutions

HNU-PHOTONICS LIGHT SOLUTIONS

IRON RING TECHNOLOGIES

JACOBS

KBRwyle

M & B ENGINEERING

leidos

MDA

MEI TECHNOLOGIES Merging Excellence and Innovation

μ

NANORACKS

OCEANEERING

ORBITEC

PARAGON SPACE DEVELOPMENT CORPORATION

RAVEN AEROSPACE TECHNOLOGY INC.

Space Tango

SPACE TECHNOLOGY AND ADVANCED RESEARCH SYSTEMS INC. STAARS

SPACEPHARMA simply microgravity

TMI Tec-Masters, Inc. Where Technology Meets Imagination What a Concept!

techshot

TELEDYNE BROWN ENGINEERING Everywhereyoulook

ThalesAlenia Space A Thales / Finmeccanica Company

AEROSPACE

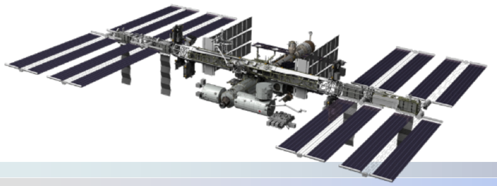
THINKSPACE

UAB SCHOOL OF ENGINEERING

UTC Aerospace Systems

VENCORE

ZIN TECHNOLOGIES



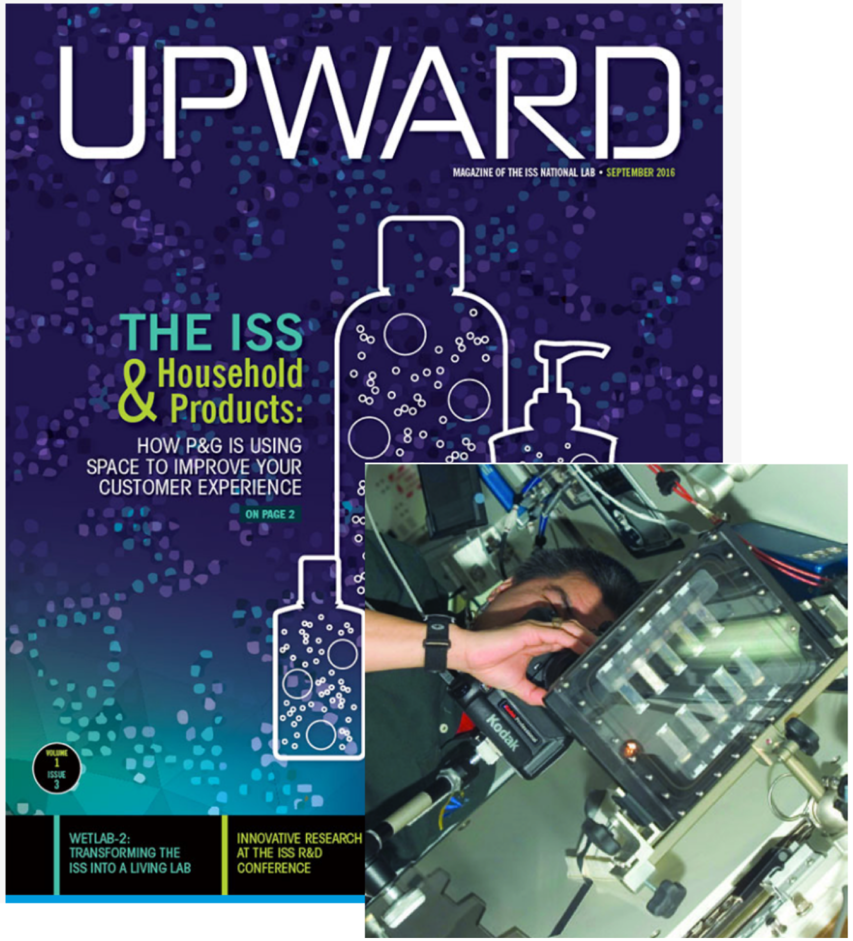
FY17 ISS National Lab: New Customers

- The Michael J. Fox Foundation: Disease research
- Budweiser: Crop science
- Massachusetts Institute of Technology: Musculoskeletal disease
- Time Inc.: Educational outreach
- Hewlett Packard Enterprise: Tech validation
- Sanofi Pasteur: Immune response and aging

- The Boeing MassChallenge Technology in Space awardees (start-up companies):
  - Angiex, Inc.: Cancer drug testing
  - Dover Lifesciences: Drug discovery
  - LambdaVision, Inc.: Retinal

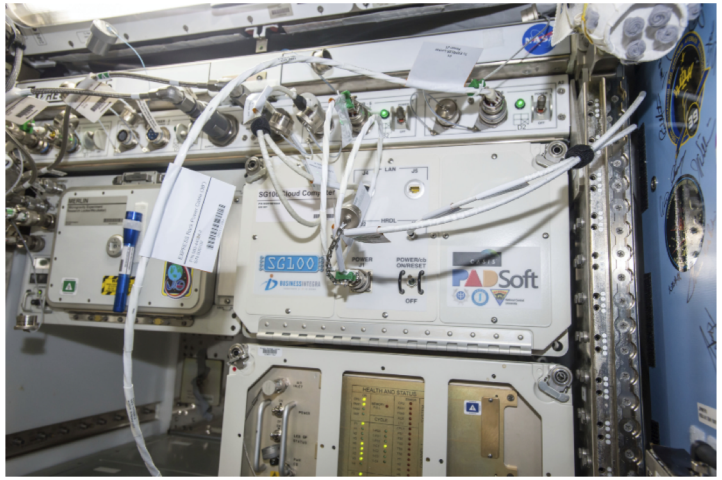
National Lab Results: Procter & Gamble

- A P&G experiment has correlated the microscopic behavior of complex fluids with the macroscopic properties of commercial products—over length-scales relevant to improving product shelf life.
- 4 patents inspired by work; Anticipated product launch next year
- Almost 5 billion people use P&G products every day



National Lab Results: SG100 Cloud Computer

- Business Integra Technology Solutions achieved the maximum technology readiness level (TRL9) for their new single-board computer (SG100)
- Enabled company to begin actively marketing this new product, which has 12 times the processing capability of common low Earth orbit processors at 40% of the cost.

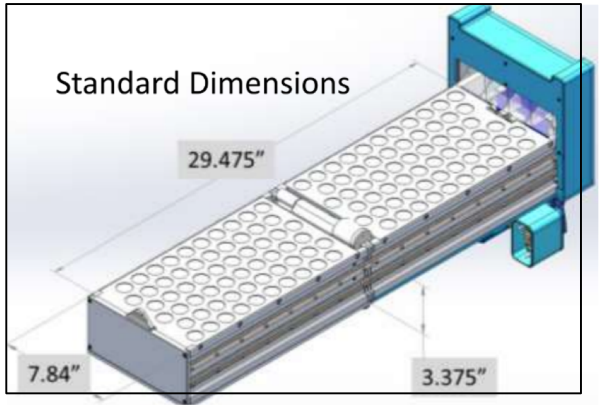


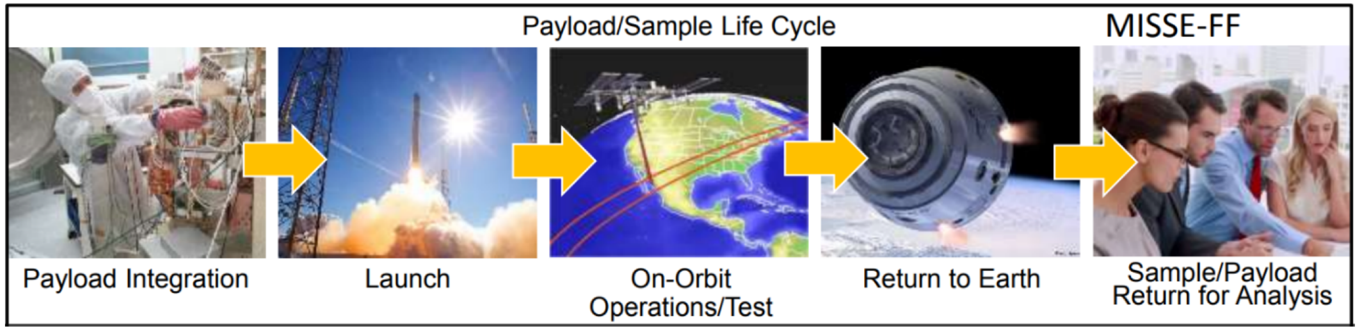
"I'm not sure we ever could have sold the product without completing the CASIS project." (BI Tech)

Upcoming Commercial Facilities on ISS

Material International Space Station Flight Facility (MISSE-FF) by Alpha Space

- Platform that provides the ability to test materials, coatings, and components or other larger experiments in the harsh environment of space
- Remotely controllable MISSE Sample Carriers (MSCs) provide sample protection and on-demand picture data
- On-orbit durations can be from six months to one year, with the possibility of longer durations if requested
- Available to the private sector and government agencies
- Launching on SpX-14





CASIS™

Alpha Space
Test & Research Alliance

ISS Operational Status

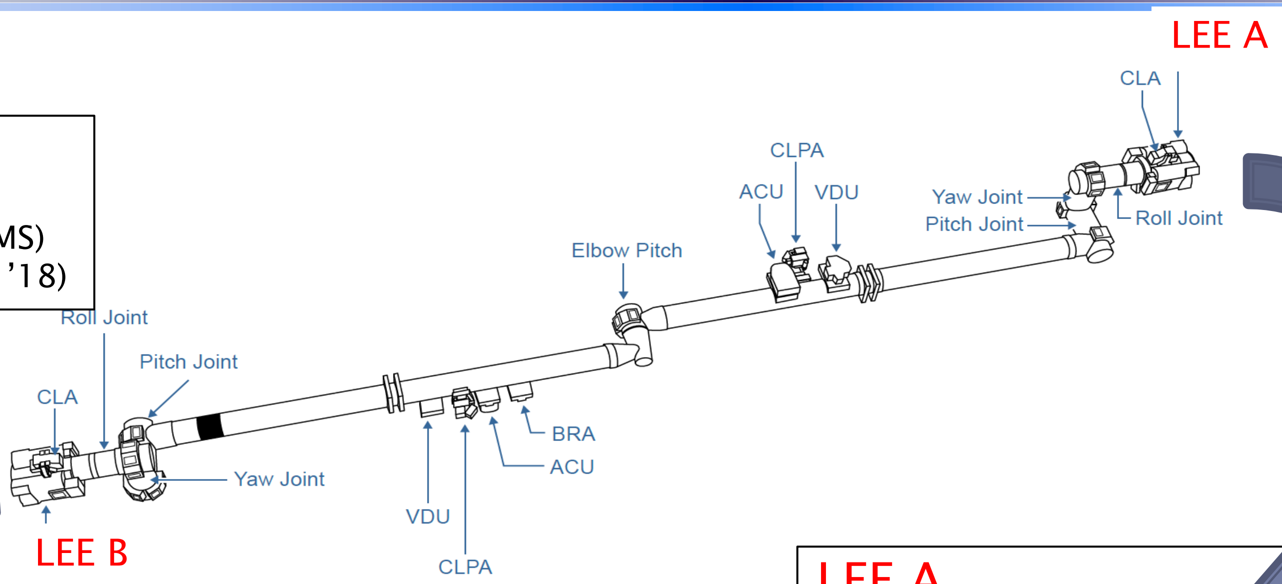
Operations Status

Robotics Maintenance – Several robotics maintenance issues were resolved over the past three spacewalks including replacing both Latching End Effectors (LEE), installing new LEE on Payload ORU Attachment (POA) mechanism, and lubricating the new LEEs. Functional and redundant LEEs are critical for future robotic operations, including visiting vehicle berthings. More details on upcoming slides.

Year of Education on Station – NASA Astronaut Joe Acaba participated in 16 of the 24 downlinks, bringing outer space to students and doing “STEMonstrations”—science, technology, engineering and math (STEM) concepts such as Newton’s Laws of Motion, surface tension and advances in technology. These demos are then filmed and sent down to Earth for teachers to use in their own classrooms. Additionally, 30 years after the Challenger accident, in which teacher Christa McAuliffe perished, Acaba and Exp55 NASA Astronaut, Ricky Arnold, would film the educational videos that originally planned to bring to children worldwide.

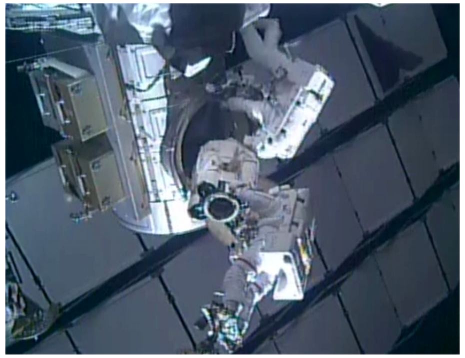
Problem Resolution – The crew successfully R&R’d a circuit breaker using a Hot Mate/Demate technique to minimize cycling of downstream loads. This was the second Hot Mate/Demate replacement performed on-orbit, made possible by the updated firmware load. Following the crew activity, ground teams recovered power to the External Stowage Platform -1 (ESP-1) Primary Heaters, previously lost due to a trip in October 2017.

Latching End Effector (LEE) R&R Summary



LEE B

- Original On-orbit spare
- No Force/Moment Sensors (FMS)
- Lubricated on US EVA 48 (Feb '18)

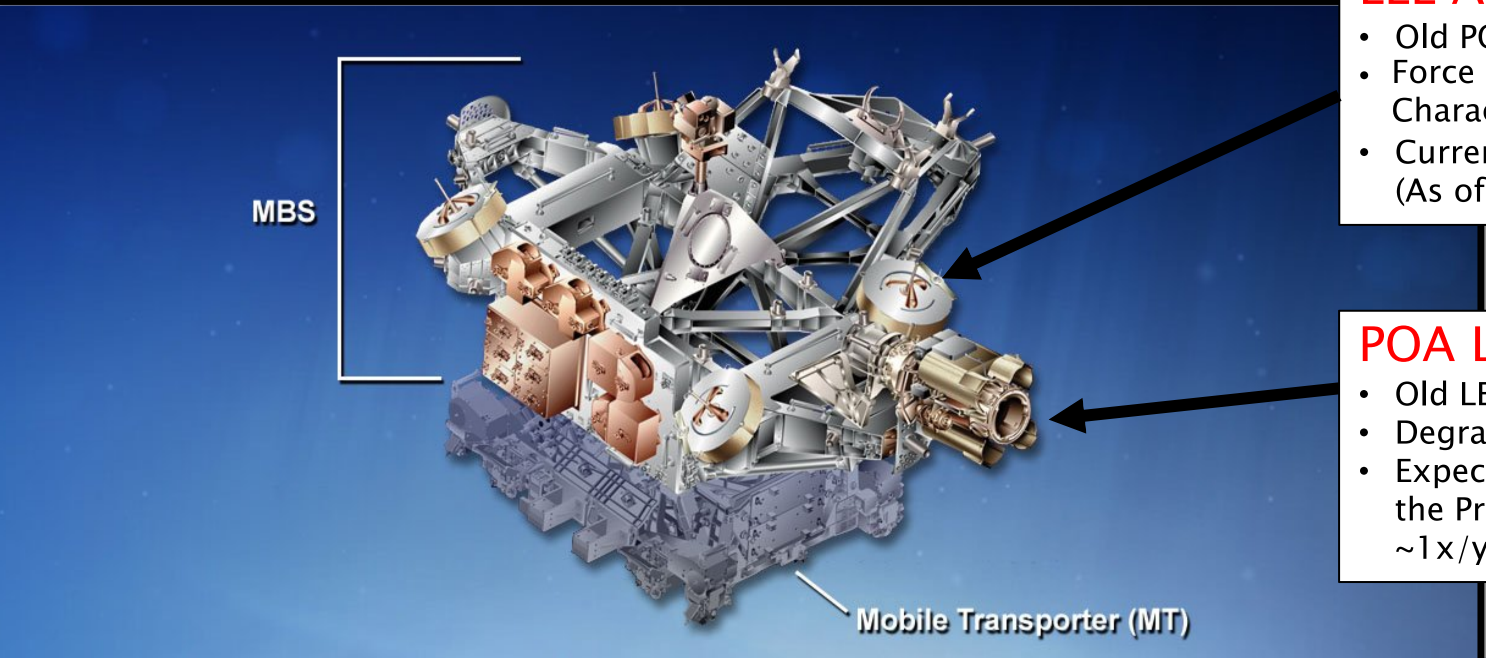


Internal LEE

- Old LEE A
- Degraded Snare Cables
- Failed Latches
- Suspect Space Station Buffer Amplifiers (SSBAs)
- Returning on SpX-15

LON LEE

- Will launch on SpX-15 Trunk
- To be stowed outside.



LEE A

- Old POA LEE
- Force Moment Sensor (FMS) Characterization In-work
- Currently based on MBS PDGF 3 (As of 3/1/18)

POA LEE

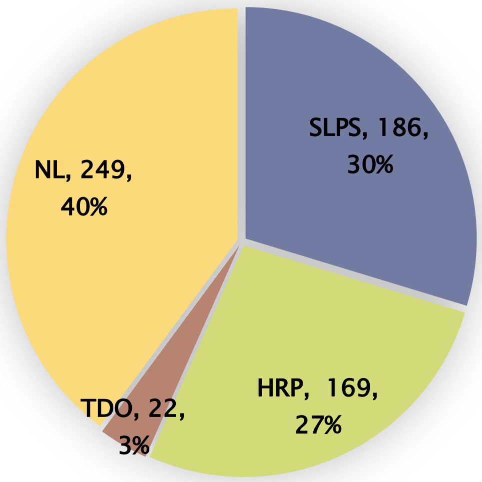
- Old LEE B
- Degraded Snare Cables
- Expected to last the rest of the Program (avg duty cycle ~1x/year)

Increment 53/54 (Sept ’17– Feb ‘18) Crew Time by Sponsor

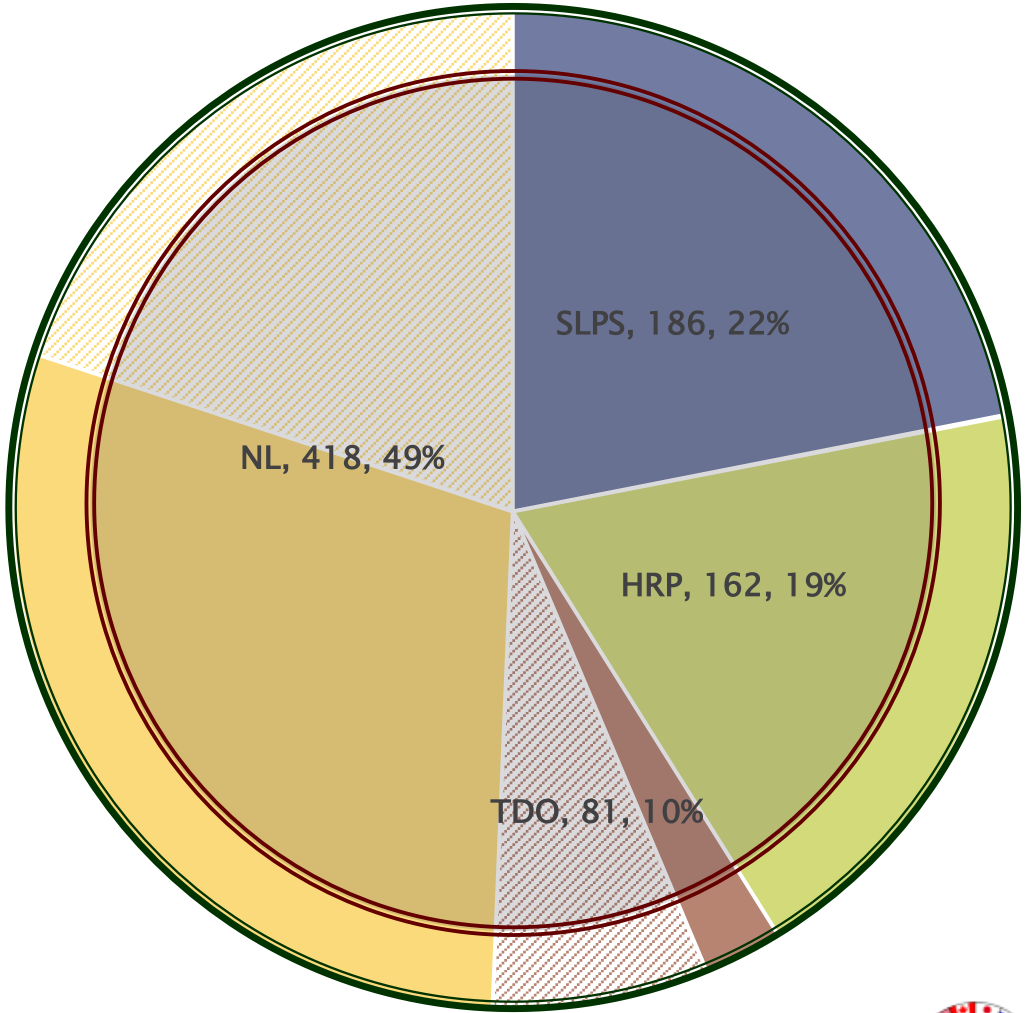
- Enablers
  - Operationally-ready reserve complement
  - Russian Crew Time for EarthKAM (NL), MARES Sarcolab-3 (ESA), EML (ESA)
- Challenges
  - Utilization hardware anomalies (e.g., CIR/ACME, FIR/LMM, Robonaut, DECLIC)
  - Loss of research requirements due to slip of HTV7 and part of SpX-14 flights from Increment Pair
- Delta Explanations
  - Implemented the majority of the available science, including reserve science, for all sponsors as permitted by constraints, including facility throughput

Sept ’17 – Feb ‘18	Planned	Actual
Research Hours	625	847
Total Crew Days (USOS)	456	466
Cargo Flights	OA-8 SpX-13 SpX-14	OA-8 SpX-13
# EVAs	4	5
Russian Crew hours	0	TBD

Planned Hours



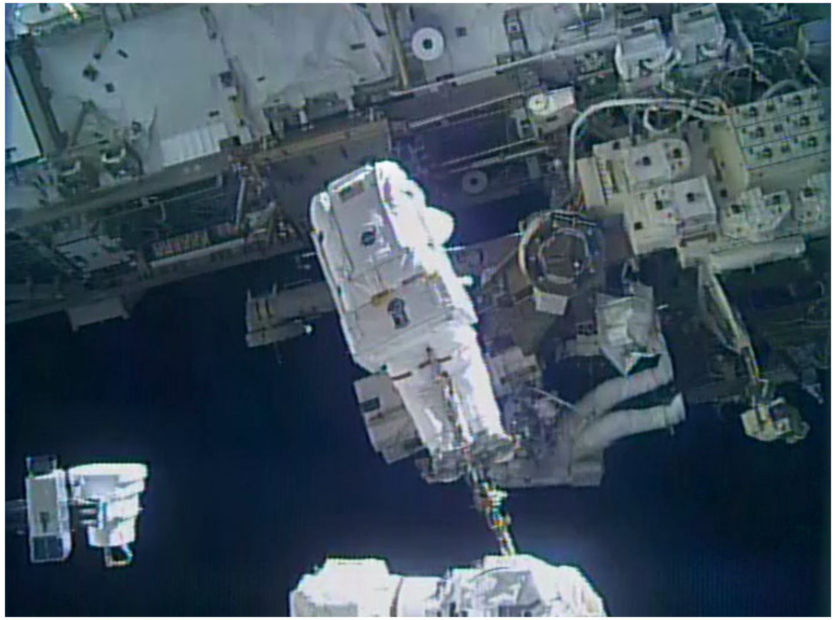
Actual Hours



Recently Completed US EVAs

US EVA 47 (January 23, 2018)

- Crew: Mark Vande Hei
  Scott Tingle
- EVA Time – 7:24
- Planned tasks completed:
  - Swapped degraded Latching End Effector (LEE) B with spare LEE from the External Stowage Platform (ESP).
  - Removed the Camera & Lighting Assembly from the degraded LEE and installed on spare LEE.
  - Removed Worksite Interface adapter from degraded LEE and installed on spare LEE.



US EVA 48 (February 16, 2018)

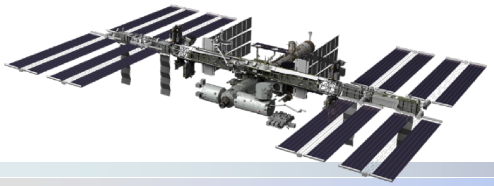
- Crew: Mark Vande Hei
  Norishige Kanai
- EVA Time – 5:57
- Planned tasks completed:
  - Removed Payload ORU Accomodation (POA) LEE and brought inside.
  - Removed LEE from ESP and installed on the POA.
  - CLA removed from the LEE previously on the POA.
  - Get-Aheads completed:
    - Force Moment Sensor Grounding Strap Install
    - RMCT Deploy
    - LEE B Lubing
    - FHRC Strut Correction at ESP-2

Upcoming US EVAs

- **US EVA 49 (tentatively March 29, 2018)**
  - Installation of External Wireless Communications (EWC) Antennas on Node 3. Extending EWC coverage is important for the external HD camera (EHDC) assemblies that have begun deployment to the exterior of the ISS. Other tasks include Camera Port 8 External TV Camera Group R&R and P1 Radiator Beam Valve Module (RBVM) flex hose retrieval.

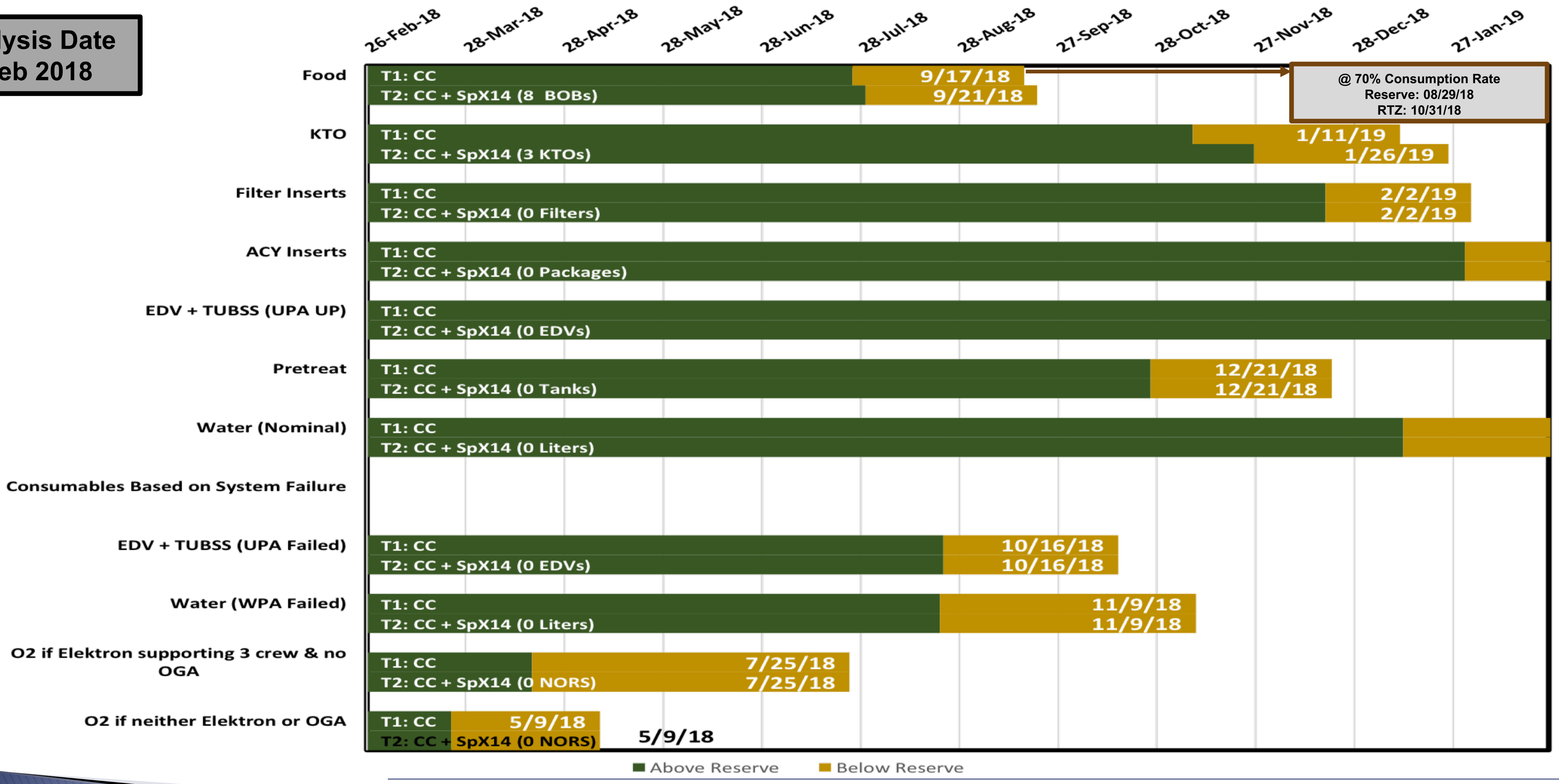
- **US EVA 50 (tentatively planned for May 2018)**
  - Relocation of a pair of Pump Flow Control Subassemblies (PFCS) between external stowage platforms for inspection/data retrieval. The PFCS is the mechanism which circulates ammonia throughout the external coolant loops.

- **US EVA 51 (tentatively planned for May 2018)**
  - Installation of a pair of EHDCs, which will provide HD video of future visiting vehicle dockings at the Node 2 Forward and Zenith ports.



Total Consumables

Analysis Date
26 Feb 2018



OA-8 Mission Success!

- Launch 11/12/17; berthed 11/14/17
- Unberth 12/5/17; release 12/6/17; re-entry 12/18/17
- Pressurized Cargo – 3338 kg upmass; 2912 kg disposal
- First use of “Extend the Lab”; TangoLab Operations conducted inside Cygnus
- Post-departure science objectives
  - Cubesats were deployed above ISS on 12/6/2017
  - Three DTOs were completed successfully:
    - GPS DTO data collection
    - Cygnus burn observations
    - Cabin Depress Assembly DTO

Launch on 11/12

Hatch opening 11/14, closure 12/5

Unberth 12/5, release 12/6

SpaceX-13 Mission Success!

- Launch occurred 12/15/17; berthed 12/17/17
  - First use of re-flown stage 1 booster for a NASA mission
  - First launch from refurbished SLC-40
- Unberth 1/12/18; release and splashdown successful on 1/13/18
- Pressurized Cargo – 1635 kg upmass; 1860 kg return
  - Launch: 2 AEM-T, 1 Cell Science Validation
  - Return: 1 AEM-T, 1 Cell Science Validation, 3 Polars
  - Flew 1st RISE pressurized cargo – Bioculture
- Unpressurized Cargo – 648 kg upmass; 548 kg disposal
  - Space Debris Sensor (SDS) and Total and Spectral Solar Irradiance Sensor (TSIS)
  - RapidScat disposal in the trunk

SpX-13 launch on 12/15/17

SpX-13 berthed on 12/17/17

SpaceX-14 Mission Status

- Mission Planning
  - Stage Operations Readiness Review held on 3/7/2018
- Pressurized Cargo - 1776kg upmass; 1750 kg return estimated
  - Launch: 1 Polar, 1 JAXA Rodent Module, 2 InVitroBone
  - Return: 3 Polars, 1 JAXA Rodent Module, 2 InVitroBone
- Unpressurized Cargo – 855 kg upmass; 106 kg disposal
  1. Replacement Pump/Flow Control Subassembly (PFCS)
  2. Materials International Space Station Experiment-Flight Facility (MISSE-F
  3. Atmosphere Space Interaction Monitor (ASIM)
- Dragon Status
  - Dragon capsule reuse (flew on SpX-8)
- Falcon 9 Status
  - 1st Stage re-flown booster (flew on SpX-12)
  - 2nd Stage shipped to the Cape on 3/1/18

OA-9 Mission Status

- Mission Planning
  - SRP Phase 3 held on 3/8/18
  - Flight Readiness and Certification Review (FRCR) planned for 4/10/18
  - Stage Operations Readiness Review is planned for 4/11/18
- Pressurized Cargo – 3350 kg upmass
  - Ascent: Three Powered MDL capability for science research, 1 MERLIN, 2 Polar
- Unpressurized Cargo
  - Nanoracks CubeSat deploy, operations post ISS departure
- Cygnus Status
  - Final Integrated Systems Test (FIST) successfully completed 12/3/17
  - Service Module (SM-9) completed 1/10/18
  - First flight of Common Communications for Visiting Vehicles (C2V2) radios and new cabin fan
  - DTO planning for an ISS Reboost using Cygnus is in work
- Antares Status
  - 1st flight of fairing frangible rail enhancement

Commercial Resupply Services CRS-2 Status

- CRS-2 missions are planned for launch beginning in 2019
- ISS Integration Review (IR) Milestones – 7 in total
  - 3 fully complete for all providers
    - IR #1: Kickoff
    - IR #2: System Requirements Review
    - IR #3: Preliminary Design Review (PDR)

	Integration Review Milestones						
Provider	1	2	3	4	5	6	7
Orbital-ATK							
SpaceX							
Sierra Nevada				May 2018			

- ISS IR Milestone #4: Critical Design Reviews (CDR)
  - Orbital-ATK Systems delta CDR successfully completed 6/28/17
  - SpaceX CDR successfully completed 11/8/17
  - Sierra Nevada Corporation (SNC) CDR planned for 3/12-23/18; IR#4 in May
- ISS IR Milestone – #5 Functional Interface/Demonstration testing
  - Orbital-ATK IR#5 successfully completed 1/18/18
  - SNC IR#5 planned for Aug. 2018
  - SpaceX IR #5 is planned for Oct. 2018

ISS Transition

ISS Transition Principles

- The NASA Transition Authorization Act of 2017 directed NASA to develop a plan to transition ISS from the current regime that relies heavily on NASA sponsorship to a regime where NASA could be one of many customers of a LEO non-governmental human space flight enterprise.

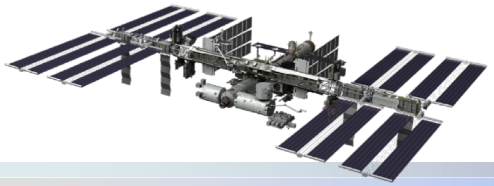
- There are key principles for a strategy for the future of ISS and LEO:

  - Continuity among NASA's LEO, deep space exploration, and development and research activities and missions toward expanding human presence into the solar system
  - Expanding U.S. human spaceflight leadership in LEO and deep space exploration, including continuity of the relationship with our current ISS international partners
  - Increase platform options in LEO to enable more ISS transition pathways, security through redundant capabilities, and industrial capability that can support NASA's deep-space exploration needs
  - Spur vibrant commercial activity in LEO
  - Maintaining critical human spaceflight knowledge and expertise within the Government in areas such as astronaut health and performance, life support, safety, and critical operational ground and crew experience
  - Continuing to return benefits to humanity through Government-sponsored basic and applied on-orbit research
  - Continuing Government-sponsored access to LEO research facilities that enable other Government agencies, academia, and private industry to increase U.S. industrial competitiveness and provide goods and services to U.S. citizens
  - Continuing to reduce the Government's long-term costs through private industry partnerships and competitive acquisition strategies

ISS Transition Strategy

- Begin a step-wise transition of ISS operations from a government-directed activity to a model where private industry is responsible for planning how to meet and executing NASA's requirements. NASA maintains leadership and governing responsibilities as outlined in the Partnership agreements, and continues to maintain the essential elements of human spaceflight such as astronaut safety and the high-risk exploration systems.
  - In order to effect a smooth transition, NASA is proposing that this transition of ISS execution responsibility to private industry is essentially complete by 2025.

- Solicit information from industry on the development and operations of private on-orbit modules and/or platforms and other capabilities that NASA could utilize to meet its long-term LEO requirements that are consistent with the *ISS Transition Principles*. The scope of the solicitation may include risk reduction development activities or modules or elements that could either be attached to the ISS or be free-flying.



NASA's Expected Future Needs in LEO

- Maintaining the Partnership with our current ISS international partners and possibly adding new international and domestic participants
- Regular LEO crewed operations, including short and long durations:
  - Enables operational space proficiency
  - Shift from human health and performance countermeasures development (the ISS portion of which is expected to be complete by 2024) to validations of integrated long-duration system, habitation, operations, and crew isolation
- Long-term technology/systems development and demonstrations (e.g. life support)
- Space life and physical sciences basic and applied research at current level and capabilities
- National Laboratory-based research and technology development
- Opportunities for astrophysics, space, and Earth science research

Could be met with various types of modules or platforms that do not necessitate a vehicle (or vehicles) as complex as the ISS

ISS Transition Near Term Planning

- Solicit inputs from industry on what LEO capabilities it wants to provide, and resources required that could meet NASA's needs as one of many customers
  - Monetary
  - Physical (e.g. ISS port)
  - Expertise
- Develop ISS commercial use policy to allow private industry to use spare ISS resources for commercial for-profit activities