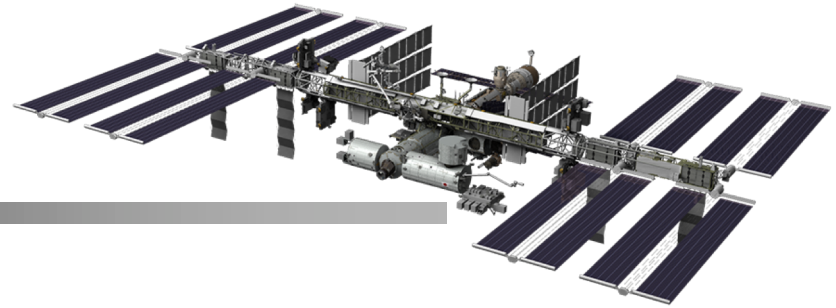



# HEO NAC
# International Space Station Status


Sam Scimemi- ISS Director

December 2018

# Agenda

- ISS Increment Overview
- Exploration Research and Technology Highlights (including HRP)
- Utilization Summary
- National Lab Highlights
- ISS Operational Status
- ISS Transition
- ISS EVA Investments and EVA for Exploration

# Flight Plan – Increment 57

- 10/04/18 – Soyuz 54S Undock/Landing (NASA/Feustel, NASA/Arnold, Roscosmos/Artemyev)
- 10/11/18 – Soyuz 56S Launch Abort (NASA/Hague, Roscosmos/Ovchinin)
- 11/07/18 – H-II Transfer Vehicle 7 (HTV-7) Unberth and Release
- 11/17/18 – Northrop Grumman CRS-10 (NG-10) Launch
- 11/16/18 – Progress 71P Launch
- 11/18/18 – Progress 71P Docking
- 11/19/18 – NG-10 Capture/Berth
- 12/03/18 – Soyuz 57S Launch/Docking (NASA/McClain, CSA/Saint-Jacques, Roscosmos/Kononenko)
- 12/04/18 – SpaceX CRS-16 (SpX-16) Launch
- 12/06/18 – SpX-16 Capture/Berth
- 12/11/18 – RS EVA #45A (Soyuz 55S Hole Inspection)
- 12/20/18 – Soyuz 55S Undock (NASA/Aunon-Chancellor, Roscosmos/Prokopev, and ESA/Gerst)

- Two upcoming US EVAs (P4 Battery R&R) – dates under evaluation.

# Increment 57/58 Overview: Crew


**NASA/S.Aunon-Chancellor - Roscosmos/S. Prokopyev – ESA.A. Gerst**

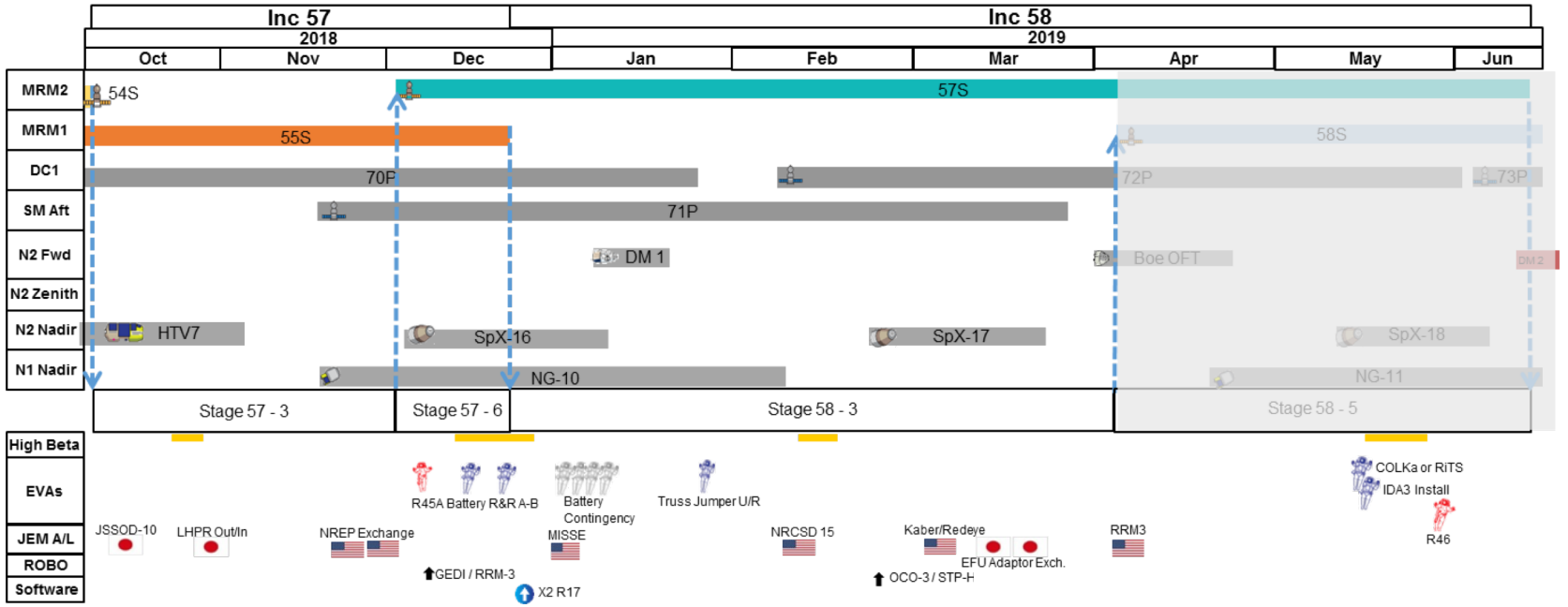
55S Dock 6/8/18
55S Undock 12/20/18


**NASA/Anne McClain - Roscosmos/Oleg Kononenko - CSA/David Saint-Jacques**

57S Dock 12/03/18
57S Undock 06/17/19

# Increments 57 & 58

- Increment 57: 77days
  - Stage 57-3: 53S undock to 55S dock: 60 days
  - Stage 56-6: 55S dock to 54S undock: 17 days
  - EVAs
    - RS EVA (12/11) Soyuz Inspection
    - US EVA (TBD) P4 Battery R&R – 4A
    - US EVA (TBD) P4 Battery R&R – 2A
  - Visiting vehicles:
    - HTV7 (Unberth 11/7)
    - Progress 71P (Launch 11/16, Dock 11/18)
    - NG-10 (Launch 11/17, Berth 11/19)
    - SpX-16 (Launch NET 12/4, Berth12/6)
  - Science/Utilization:
    - Augmented Utilization Hours
    - RR11
  - Maintenance/Outfitting:
    - LSG Installation
    - EXPRESS Rack 108 and 98 Installation
    - X2R17 Software Update
    - Wate Storage System (WSS) Installation
  - Other:
    - GEDI and RRM3 Installation




| | Increment 57 | Increment 58 |
|---|---|---|
| Utilization | ✓ GRIP/GRASP<br>• Microbial Tracking-2<br>• SODI DCMIX4<br>✓ HTV Small Re-entry Capsule (HSRC)<br>• Loop Heat Pipe Radiator (LHPR) | • Rodent Research 11<br>• JAXA Mouse Mission<br>• Fluid Shifts<br>• At Home in Space<br>• Behavioral Core Measures<br>• Airway Monitoring<br>• Veg-04<br>• Standard Measures<br>• Vection<br>• Marrow |
| | ✓ Life Support Rack (LSR)<br>• Life Science Glovebox (LSG)<br>• Rodent Research 8<br>• Joint ESA/RSA Plasma Kristall-4 (PK-4)<br>✓ J-SSOD 10<br>• Probiotics<br>• Lighting Effects<br>• Vascular Echo<br>• Repository<br>• GEDI<br>• RRM-3<br>• OCO-3<br>• STP-H6 | |
| EVA, Robotics, Systems, Software | • USOS EVA Tasks<br>o HTV7 Battery R&R EVA 1 and 2<br>• Rack Outfitting (HTV7)<br>o Life Science Glovebox in JPM1F5<br>✓ EXPRESS Rack 10B in JPM1A5<br>✓ EXPRESS Rack 9B in COL1F2<br>✓ Life Support Rack (LSR) in LAB1P1<br>✓ Disposals (HTV7)<br>✓ Resupply Stowage Racks PMM104, PMM102, and PMM1D4<br>• iPEHG Install into ER-1 and HRF-1 | • X2R17 Software Update<br>• Water Storage System (WSS) Rack Install<br>• Gas Trap Plug Install into LABP6, LABS6, NOD2D1, NOD2O1, NOD3D1, NOD3O1<br>• 16 Port Network Switch install in Node 3<br>• USOS EVA Tasks<br>o Truss Jumper Routing<br>o Ethernet Cable Routing<br>o CP8 EHDC Upgrade for EWC<br>o COLKa or RiTS<br>o IDA3 Install on PMA3<br>• RS EVA #46 (MLM) |

# 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.

- Goal focuses on Exploration-enabling demonstrations to be conducted on ISS
- Includes demonstrations funded by ISS, AES, HRP, Orion, and STMD
- Demonstrations completed in FY18
  - Aerosol sampler
  - Combination Acoustic Monitor
- Demonstrations currently planned in FY19:

| Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|
| • Refabricator<br>• Hybrid Electronic Radiation Assessor (HERA) | • Spacecraft Fire Experiment (Saffire)-IV<br>• Thermal Amine<br>• Siloxane control technology (CHARPA) | • Water Processor Multi-Filtration Bed Upgrade<br>• Spacesuit Evaporation Rejection Flight Experiment (SERFE)<br>• T2 Augmented Reality<br>• Autonomous Mission Operations (AMO) Express 2.5<br>• Astrobee<br>• RFID Enabled Autonomous Logistics Management (REALM)-2 | • Saffire-V<br>• Renal Ultrasound Autonomy<br>• Mini $CO_2$ scrubber (ISS) |

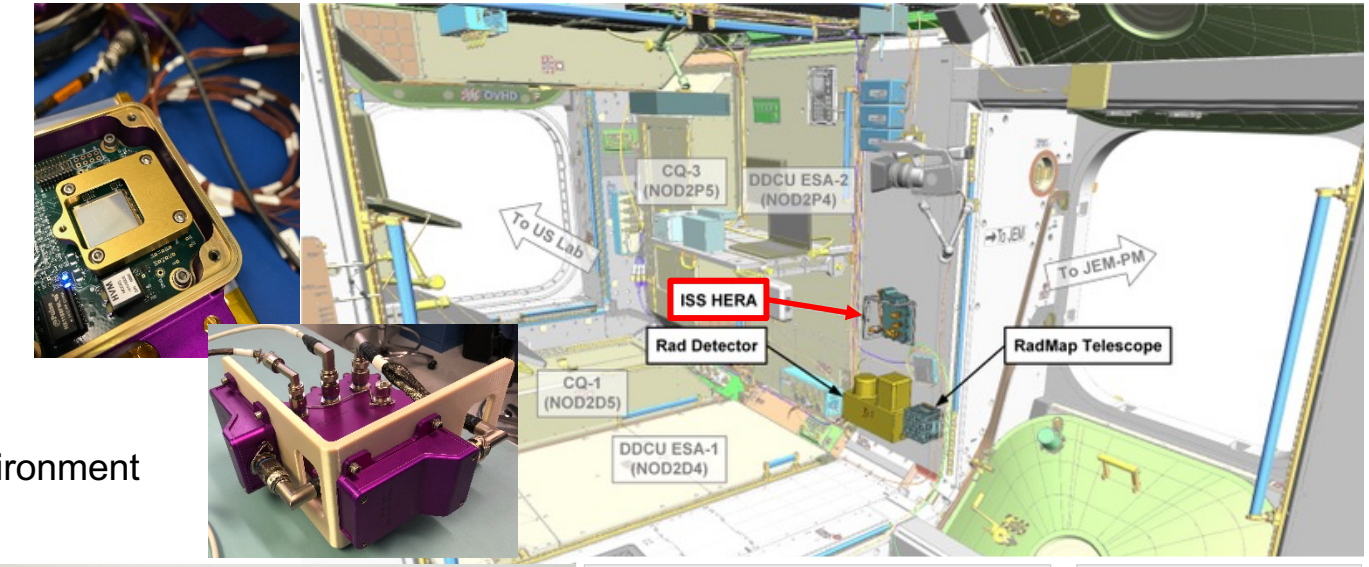
# Featured Exploration Technology – Upcoming

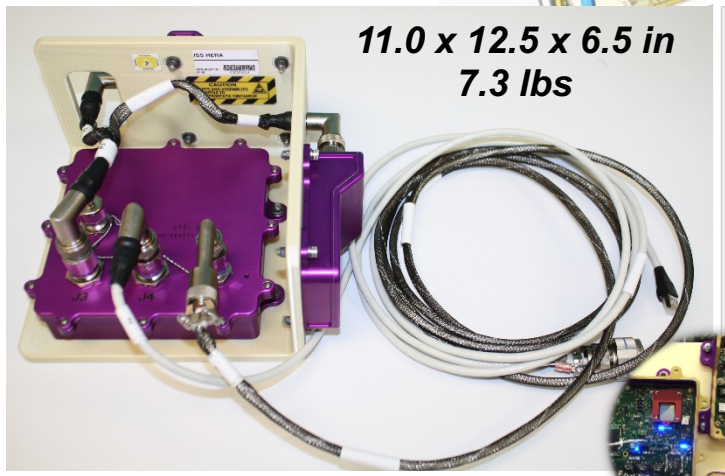
## ISS HERA

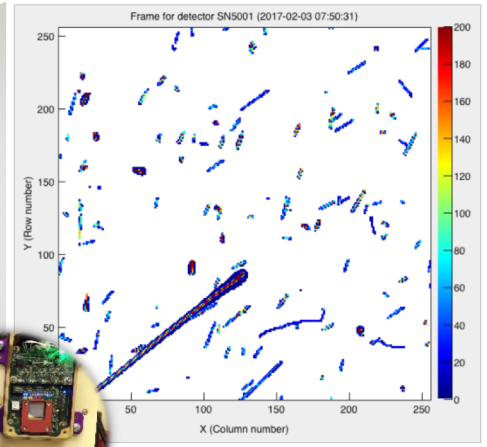
### ISS Hybrid Electronic Radiation Assessor

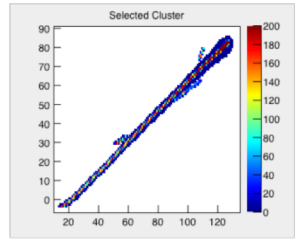
*PM: Michael Ecord, NASA Johnson Space Center, Houston, Texas*

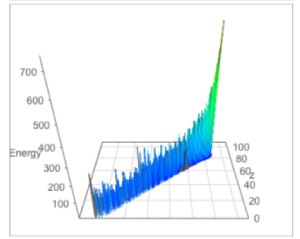
- Orion EM-1 radiation detection system modified for ISS operation
  - 2 sensing units and 1 processing unit (3 detectors total)
  - 120V power and data downlink via Station Support Computer
  - 3D printed mounting bracket for ISS deploy
  - Autonomous operation with SSC application to retrieve data for downlink
- Opportunity to exercise an Orion system in the space radiation environment
  - Verify operational parameters and configuration settings prior to EM-1
  - Raw data and stored telemetry downlinked weekly
- Testbed for exploration and gateway radiation analysis
  - Flight-like telemetry download provides realistic operational data
  - Informs operational tool development and evaluation (ARRT)
  - Provide HERA radiation data to aid analysis enhancements
- Manifested for launch on SpX-16 in Dec 2018




| Oct 2017 | July 2018 | Sept 2018 | Oct 2018 | Dec 2018 | Jan 2019 |
|---|---|---|---|---|---|
| Project start | SSC Flight Application Delivered | Mounting Bracket and Cables complete | Hardware Delivered for Flight | SpX-16 Launch | On-orbit Deploy |

# HRP Path to Risk Reduction

5/18/18

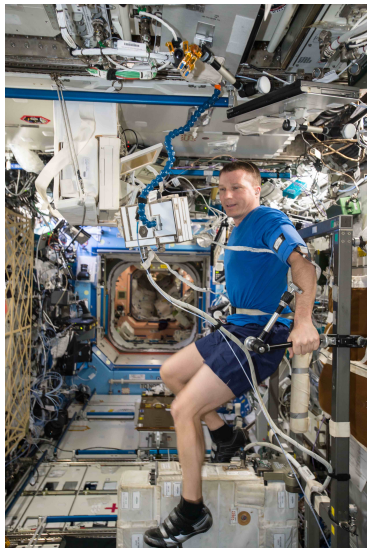
| Mars Flyby | | FY17 | FY18 | FY19 | FY20 | FY21 | FY22 | FY23 | FY24 | FY25 | FY26 | FY27 | FY28 | FY29 | FY30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Risks | LxC | | | EM-1 | | | EM-2 | EM-3 | EM-4 | ISS End | EM-5 | EM-6 | EM-7 | EM-8 | EM-9 |
| Space Radiation Exposure - Cancer | 3x4 | | | | | | | | | | | | | | |
| Space Radiation Exposure - Degen | 3x4 | | | | | | | | | | | | | | |
| Space Radiation Exposure - Integrated 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 | | | | | | | | | | | | | | |
| 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 | | | | | | | | | | | | | | |
| Sensorimotor Alterations (SM) | 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 | | | | | | | | | | | | | | |
| Concern of Effects of Medication (PK/PD) | TBD | | | | | | | | | | | | | | |

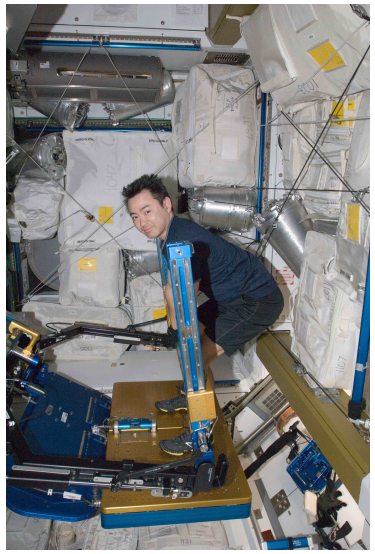
ISS Required
ISS Not Required
Milestone Requires ISS
Ground-based Milestone
ISS Mission Milestone
Exploration Mission Milestone
High LxC
Mid LxC: Requires Mitigation
Mid LxC: Accepted
Low LxC
Optimized
Insufficient Data

8 Aug 2018

# New Exercise Device in Development

**CEVIS + COLBERT + ARED = Advanced Exploration Exercise System — ATLAS**





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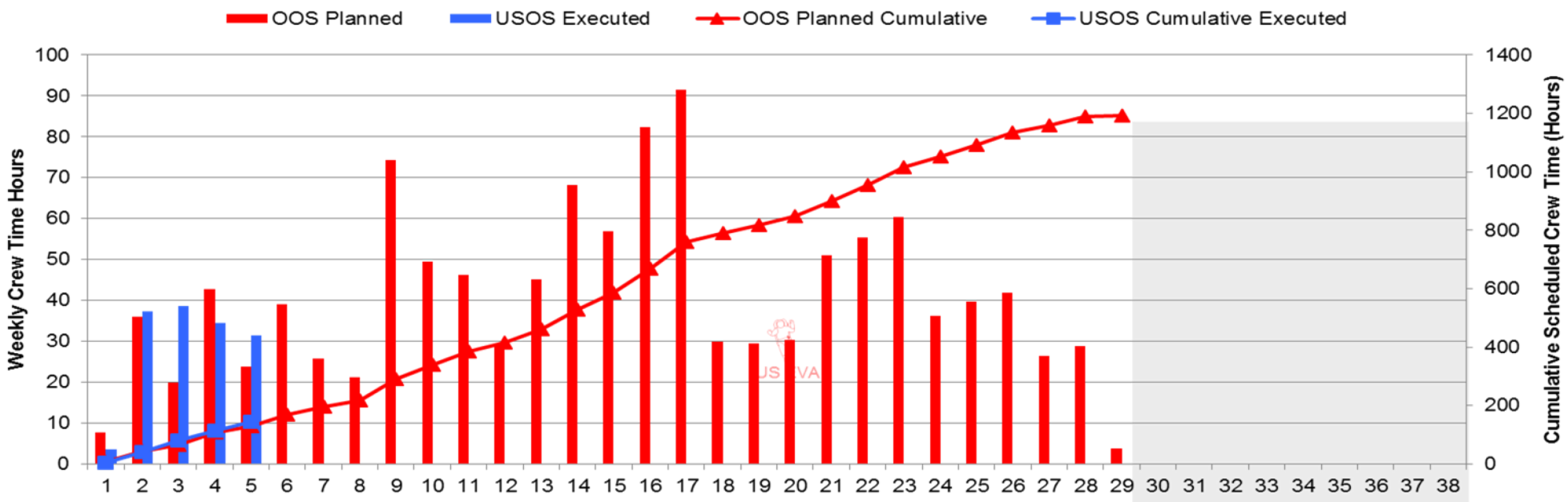
Aerobic and Resistance Exercise in a small and light package

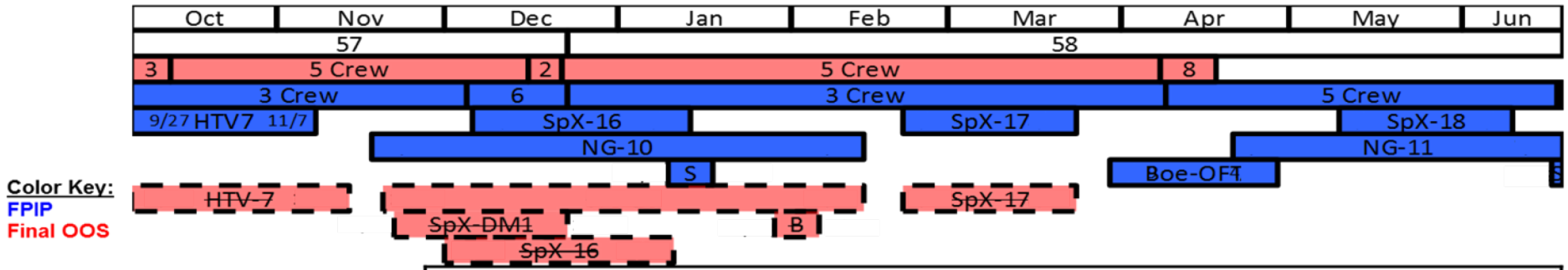
ISS testing in 2020

1
0

# Utilization Summary

# Inc 57 Utilization Crew Time

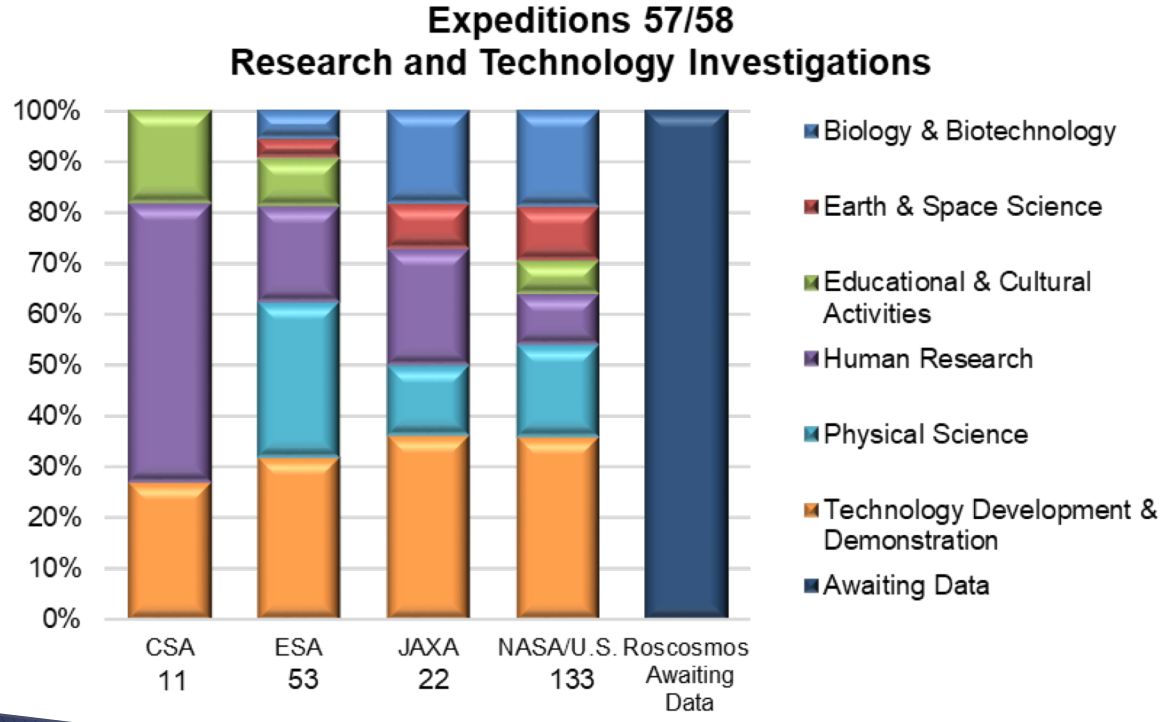



| | | |
|---|---|---|
| Executed through Increment Wk (WLP Week) 5 : | 4.2 of 35.4 work weeks | (11.9% Complete) |
| USOS Actuals: | 145.25 hours -> 34.58 hours/week | |
| USOS IDRD Allocation: | 1,131.00 hours-> 42.20 hours/week | (12.8% Complete) |
| OOS USOS Planned Total: | 1,191.83 hours -> 44.47 hours/week | (12.2% Complete) |
| Voluntary Science Totals to Date: | 0 hours (not included in the above totals or graph) | |
| RSA/NASA Joint Utilization to Date: | 15.17 hours (not included in the above totals or graph) | |

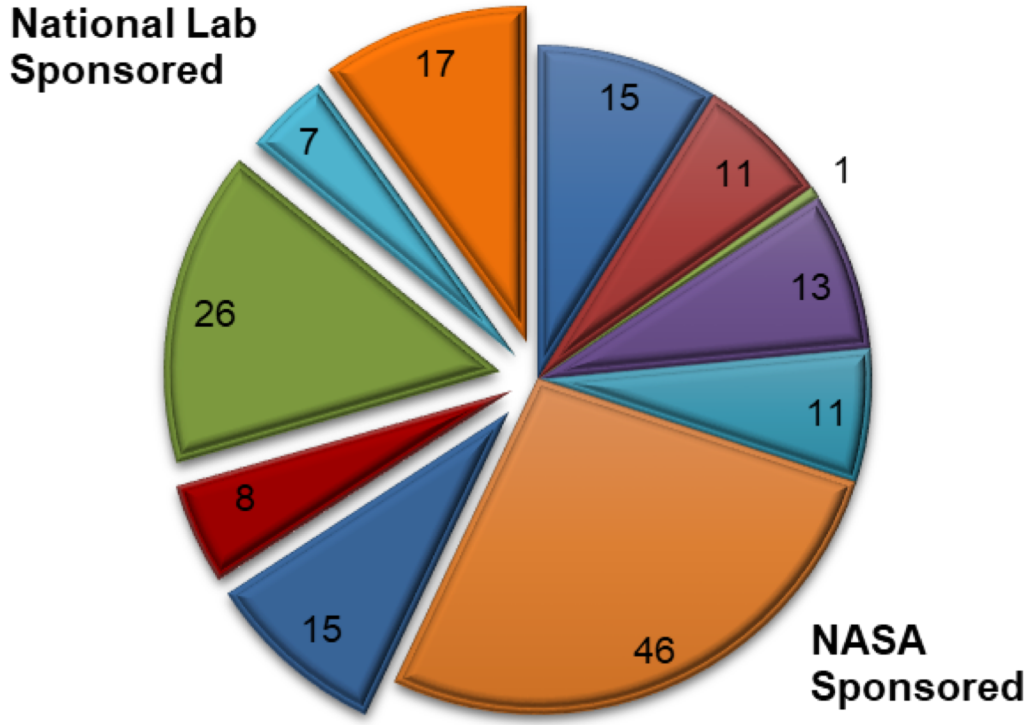
# ISS Research Statistics

- **Number of Investigations for 57/58: 219**
- 133 NASA/U.S.-led investigations
- 86 International-led investigations
- 75 New investigations
  - 4 CSA
  - 3 ESA
  - 5 JAXA
  - 63 NASA/U.S.
  - † Roscosmos – Awaiting Data



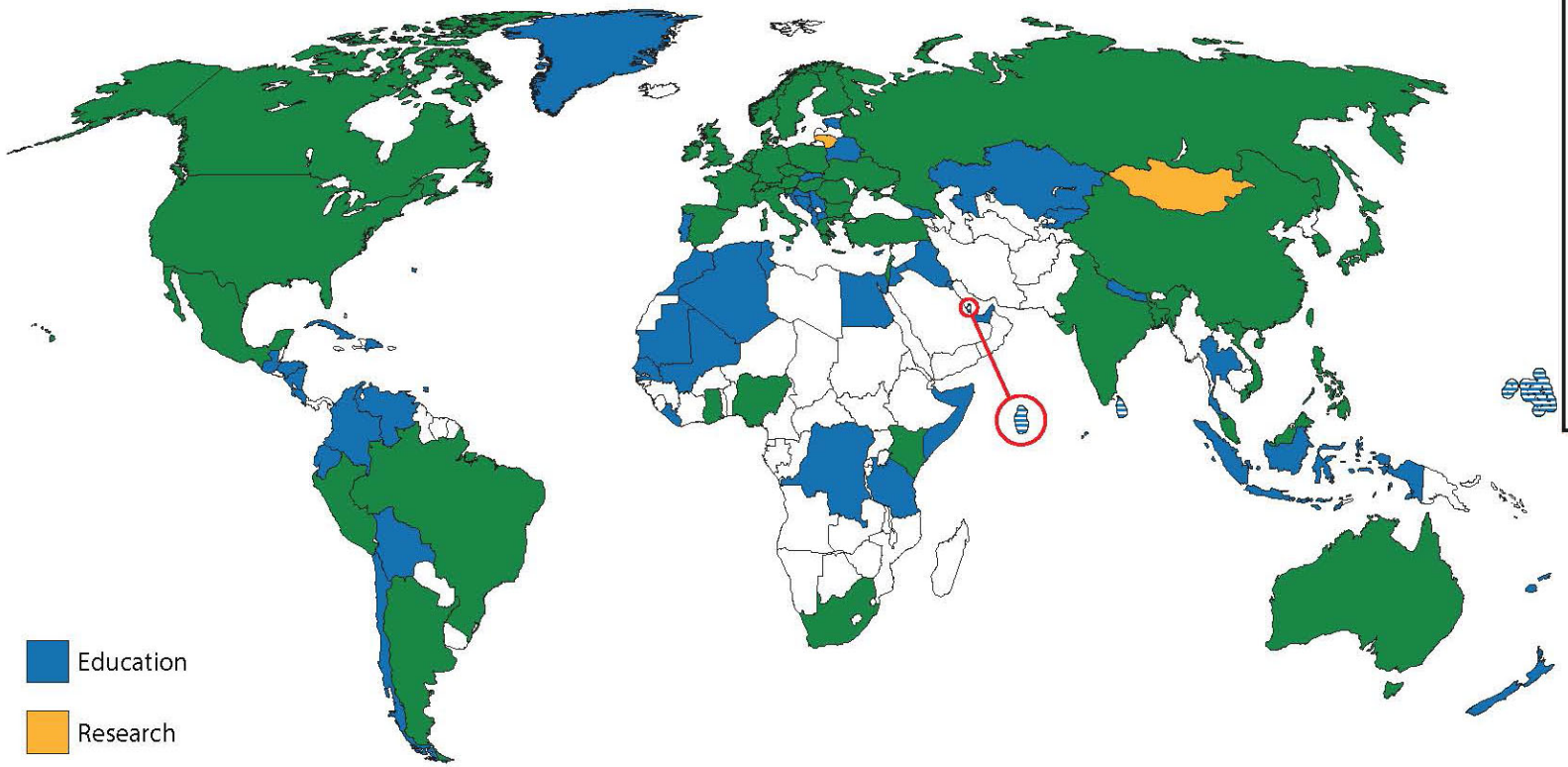

## ISS Lifetime

- Over 3000 Investigators represented (Exp 0 – present)
- Over 1500 scientific results publications (Exp 0 – present)
- 103 Countries/Areas with ISS Research and Educational Investigations (Exp 0 – present)



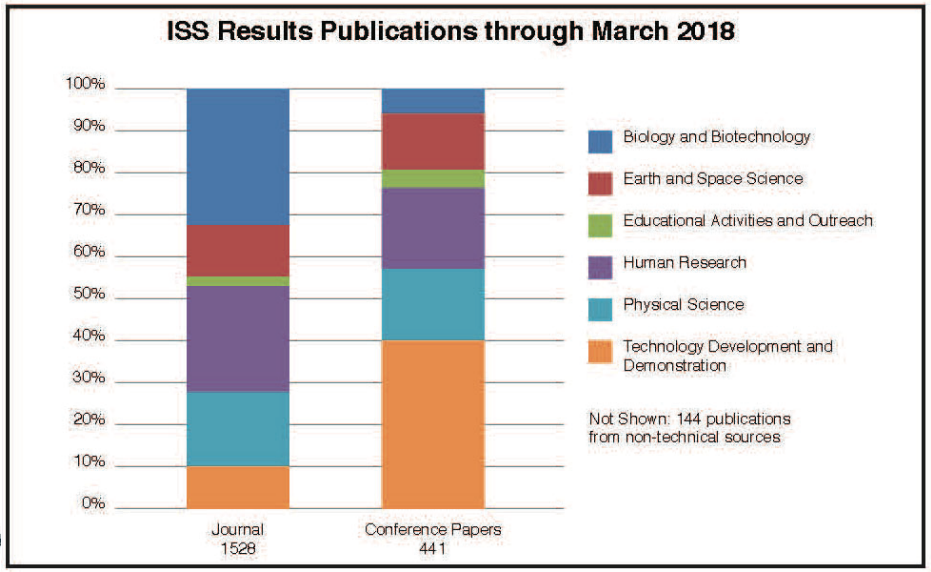
# Global Involvement in Utilization (Inc 1-54)

## International Participation on ISS

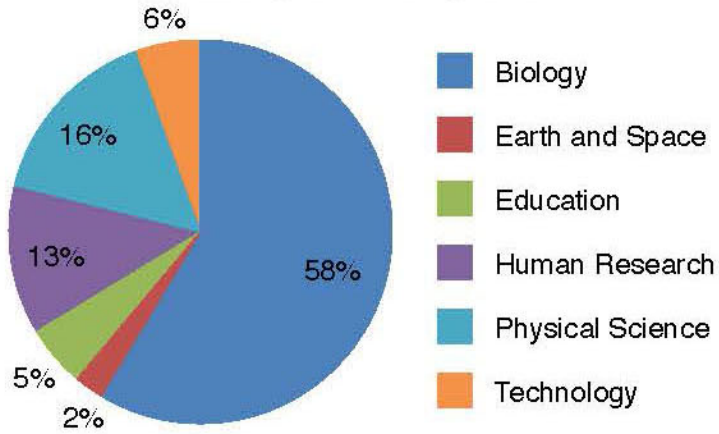



**106 highlighted countries and areas have participated in ISS Research and Education Activities**

**Newly added countries: The Marshall Islands (Education), Qatar (Education) and Sri Lanka (Education)**




## International Collaboration Percentage by Investigation Categories



# Increments 57 & 58 Investigation List

## Human Research

**Bone & Muscle Physiology**
Vertebral Strength (P)
Marrow
Tbone (P)
EDOS-2
Muscle Biopsy (P)
Myotones
Medical Proteomics

**Cardiovascular & Respiratory Systems**
Vascular Echo
Airway Monitoring
Cerebral Autoregulation

**Crew Healthcare Systems**
Medical Consumables Tracking ↓

**Habitability & Human Factors**
Soyuz Occupant Risk (P)

**Human Behavior & Performance**
Behavioral Core Measures
Lighting Effects
Team Task Switching
At Home in Space
Circadian Rhythms
SpaceTex-2 ↓
Time Perception in Microgravity
Cell-Free Epigenome

**Immune System**
Functional Immune
Probiotics

**Integrated Physiology & Nutrition**
Biochem Profile
Food Acceptability
Repository

**Nervous & Vestibular Systems**
NeuroMapping
VECTION
Wayfinding (P)
GRASP
GRIP
Straight Ahead in Microgravity (P)
Labyrinth (P)

**Vision**
Fluid Shifts
One-Carbon Expansion (P)

**Cross-Disciplinary/Other**
Standard Measures

## Facilities

Astrobee
Cold Atom Lab
DECLIC
EXPRESS Support Equipment ↓
Glovebox Freezer
Hermes
HRF
HRF-1
HRF-2
Life Science Glovebox
MSG ↑
PFS ↓
SAMS-II ↑
Spectrum*
SPHERES ↓
Ultrasound 2
Veggie ↑
ADSEP*
Bone Densitometer*
Carbon Dioxide Meter (E) ↑
Manufacturing Device
MISSE-FF (E)
MUSES (E)
NanoRacks-GoPro
Fusion
NanoRacks Plate Reader
NanoRacks Platforms
NREP* (E)
SABL* ↑ ↓
Wet Lab Kit* ↑
Bio-Analyzer
Bio-Monitor
Bartolomeo (parts) (E)
EDR
EMCS ↓
FSL
Kubik
Life Support Rack
MSL
CBEF-L ↑
EFU Adapter (E)
ExHAM #2 (E)
JAXA Laptop L&M
J-SSOD
Kobairo Rack
MSPR
Ryutai
Saibo

Key: NASA/ASI | National Lab | CSA | ESA | JAXA | (P) Pre/Post Only | (E) External Payload | *CEF approval pending | ↑/↓ Launch Return Only

# Increments 57 & 58 Investigation List

## Biology & Biotechnology

**Animal Biology – Invertebrates**
Molecular Muscle

**Animal Biology – Vertebrates**
Rodent Research-7 ↓
Rodent Research-11
Rodent Research-8
JAXA Mouse Mission
Space Pup

**Celullar Biology**
Rad-Dorm ↑
Kidney Cells
Nanoparticle Formulation
STaARS BioScience-3
STaARS BioScience-7
Nano Antioxidants

**Macromolecular Crystal Growth**
LMM Biophysics 4* ↓
LMM Biophysics 6
CASIS PCG 10
CASIS PCG 11
CASIS PCG 13 ↑ ↓
CASIS PCG 16
JAXA Low Temp PCG
JAXA PCG

**Microbiology**
BEST ↑ ↓
BioNutrients
Microbial Tracking-2
Nalco Biofilms

**Plant Biology**
APEX-05
BRIC-LED*
Microalgae
Plant Habitat-01 ↓
Veg-03-G
Veg-04-A
Veggie PONDS Validation
NanoRacks Module-78
TangoLab Mission-9
TangoLab Mission-10

**Other**
Micro-14

## Physical Science

**Biophysics**
NanoRacks Module-74

**Combustion Science**
BRE*
Flame Design*
S-Flame

**Complex Fluids**
ACE-T-4 ↑
ACE-T-10 ↑
ACE-T-12 ↑
NanoRacks Module-73
ACE-T-6 ↓
NanoRacks Module-76 ↓
PK-4

**Fluid Physics**
BCAT-CS ↓
Capillary Driven Microfluidics
Droplet Formation Study
FLUIDICS
Foam Coarsening
SODI-DCMIX
Marangoni-UVP

**Fundamental Physics**
LMM Biophysics 2
LMM Biophysics 5
DOSIS-3D

**Materials Science**
Chemical Gardens ↓
DECLIC-DSI-R
Hermes Cassette-1
MVP Cell-05
SUBSA ↑
Cemsica
NanoRacks Module-75 ↓
NanoRacks Module-77
Space Fibers*
EML Batch 1
EML Batch 2
MSL SCA-Batch 2b-ESA
ELF2
Interfacial Energy

## Earth & Space Science

**Astrobiology**
Meteor

**Astrophysics**
ISS-CREAM (E)
NICER (E)
AMS-02 (E)
CALET (E)
MAXI (E)

**Earth Remote Sensing**
CATS (E) ↓
ECOSTRESS* (E)
GEDI (E)
OCO-3 (E)
SAGE III-ISS (E)
TSIS* (E)
ASIM (E)

**Near-Earth Space Environment**
SEDA-AP* (E)

**Key:** NASA/ASI | National Lab | CSA | ESA | JAXA | (P) Pre/Post Only | (E) External Payload | *CEF approval | pending | ↑/↓ Launch Return Only

# Increments 57 & 58 Investigation List

## *Technology Development & Demonstration*

**Air, Water and Surface Monitoring**
Aerosol Samplers
DUST ↓
Formaldehyde Gas Monitor

**Avionics & Software**
Spaceborne Computer
Telescience Resource Kit

**Characterizing Experiment Hardware**
T2 Augmented Reality
Zero-g Battery Testing ↓
Furphy
MVIS Controller-1
ECHO

**Commercial Demonstrations**
Made in Space Fiber Optics 4
Cimon
ICE Cubes
SOLISS (E)

**Communication & Navigation**
DOD SPHERES-RINGS ↓
SCAN Testbed (E)
NanoRacks-SpaceAI (E)
MarconISSta
MOBIPV
Vessel ID System (E)
Wireless Compose

**EVA Systems**
SERFE

**Imaging Technology**
HDEV (E)
Moon Imagery
HDTV-EF2 (E) ↓

**Life Support Systems & Habitation**
Thermal Amine System
UWMS
Photobioreactor
Nano-bubble Demo*

**Microbial Populations in Spacecraft**
MATISS

**Radiation Measurements & Shielding**
HELIOS* ↑
ISS HERA
Miniaturized Particle Telescope
REM*
Radi-N2
Fiber Dosimeter
PS-TEPC ↓

**Repair & Fabrication Technologies**
MICS ↓
Refabricator
ORFOM-II

**Robotics**
RRM3 (E)

**Small Satellite and Control Technologies**
RED-EYE (E)
NRCSD #14* (E) ↓
NRCSD #15 (E)

**Spacecraft & Orbital Environments**
Space Debris Sensor (E)
STP-H5 (E)
STP-H6 (E)
HTV Small Reentry Capsule

**Spacecraft Materials**
MISSE-10* (E)
NanoRacks-Craig-X FTP (E)

**Thermal Management Systems**
Loop Heat Pipe Demo (E)

**Other**
ExHAM #1 (E)

## *Educational & Cultural Activities*

**Cultural Activities**
NanoRacks Module-48
The ISS Experience

**Educational Competitions**
NanoRacks Module-9
SPHERES-Zero-Robotics

**Educational Demonstrations**
In-flight Education Downlinks
ISS Ham Radio (ARISS)
Sally Ride EarthKAM
Story Time from Space ↓
Tomatosphere 6
AstroPi
ESA-EPO-Flying Classroom 2
ESA EPO Generic Videos
ESA-EPO-TASK-LIST

**Student-Developed Investigations**
Genes in Space ↓
NanoRacks Module-80
Earth Guardian Seeds

**Other**
Communications and Outreach-C3-CSA

**Key:** NASA/ASI | National Lab | CSA | ESA | JAXA | (P) Pre/Post Only | (E) External Payload | *CEF approval pending | ↑/↓ Launch Return Only

# Global Ecosystem Dynamics Investigation (GEDI)

- Overview
  - First high-resolution observations of forest vertical structure at a global scale
  - Goal is to advance the ability to characterize the effects of changing climate and land use on ecosystem structure and dynamics
  - Science from GEDI/ECOSTRESS/OCO are complementary

- Ops Concept
  - Installed on Japanese Experiment Module's Exposed Facility (JEM-EF)
  - Uses a light detection and ranging (lidar) system to collect canopy profile measurements over a two-year mission
  - Data will provide the ability to map the world's forests in 3-D
  - Inhibits will be in place during VV/EVR/EVA operations (similar to CATS)

# Earth Observation Instruments Synergy

## ECOSTRESS

- Launched July 2018
- Multispectral thermal infrared sensor to measure the brightness temperature of plants, and use that information to better understand how much water plants need and how they respond to stress

## OCO-3

- Launching in Feb 2019
- Will collect measurements needed to improve the understanding of surface carbon dioxide sources and the processes controlling their variability over the seasonal cycle

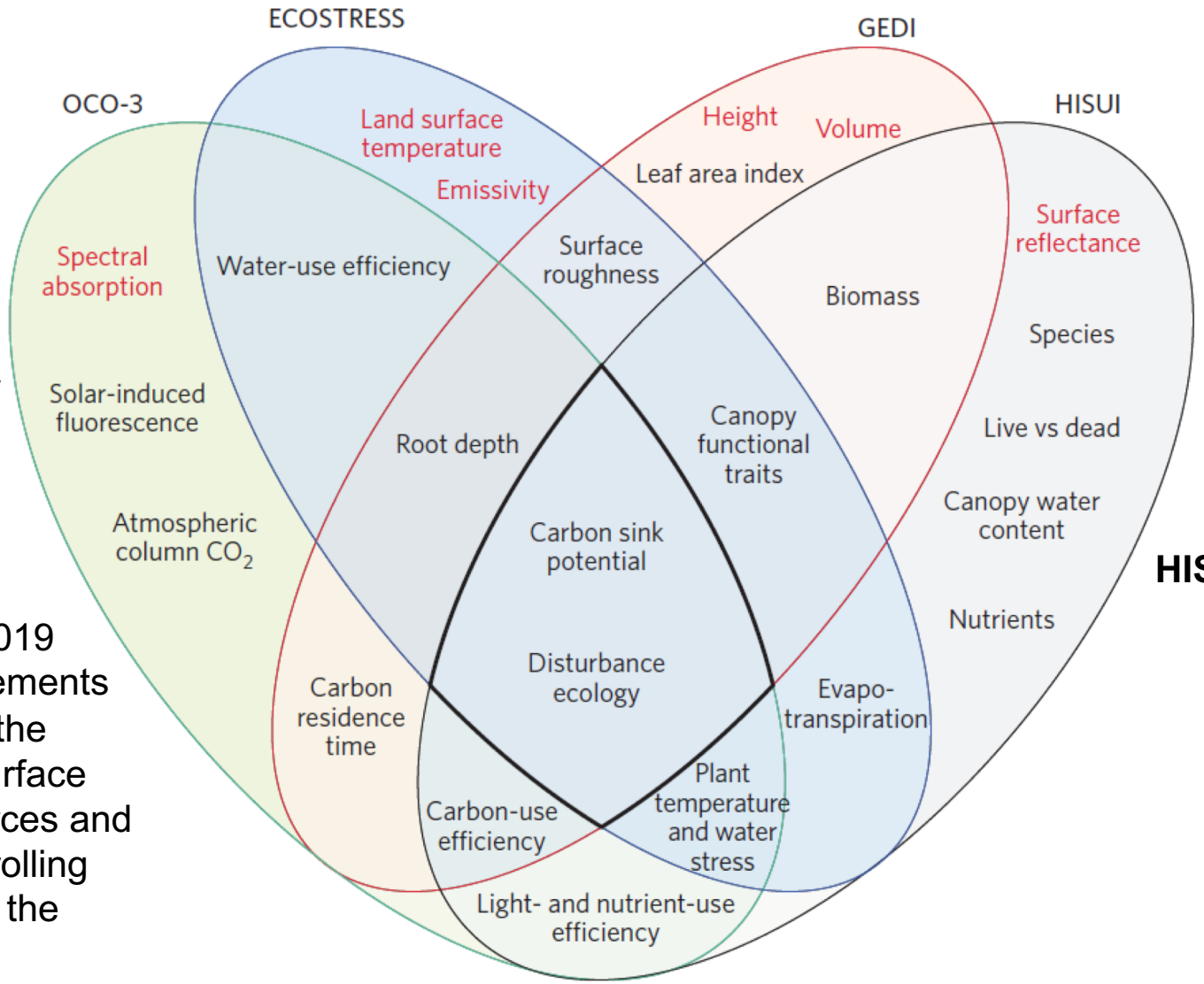



Photo Credit: ISS observations offer insights into plant function PUBLISHED: 22 JUNE 2017 | VOLUME: 1 | ARTICLE NUMBER: 0194 NATURE ECOLOGY & EVOLUTION 1, 0194 (2017)

## GEDI

- Launching in Dec 2018
- Active sensor system to characterize the effects of changing climate and land use on ecosystem structure and dynamics to enable improved quantification and understanding of the Earth's carbon cycle and biodiversity.

## HISUI

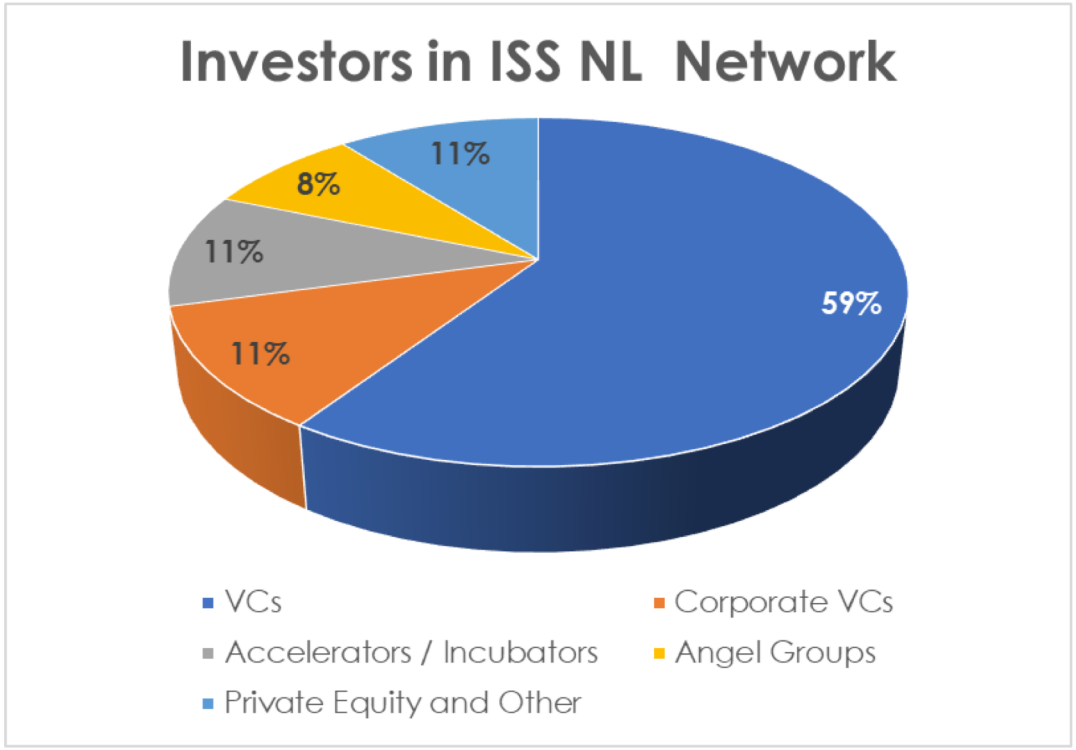
Launching Jan 2020
Will obtain calibration and data to start a full-scale practical application development for hyperspectral remote sensing through the manufacturing and in-flight performance verification

# National Lab Highlights

# National Lab Investor Network

- **Funding Access:** increased ability for matchmaking for companies/projects
- **Feeder for BD**: intros to portfolio companies and/or new ventures
- **Thought Leadership**: we are an unbiased source of education on LEO
- **Network Building:** increased flow of introductions to investors, stakeholders, and entrepreneurs
- **Market Intelligence**: valuable source of information to direct our resources

120+ members and growing



# National Lab Investor Portal

**New tool for our investor network**: funding opportunities and intros, targeted content, complements ISS R&D pitch events


**Space Investment 2018: Connecting Start-Ups and Investors in San Francisco**

**Investment Perspectives: Opportunity and Economics of ISS National Lab Research**

**Boeing and the ISS National Lab Award $500,000 Through MassChallenge**

**Investment Perspectives: Conferring on On-Orbit Satellite Servicing**

NOVEMBER 15, 2018 · BY SVEN EENMAA, ISS U.S. NATIONAL LABORATORY SENIOR INVESTMENT AND ECONOMIC ANALYST

CONFERS (the Consortium for Execution of Rendezvous and Servicing Operations) hosted its 2018 Global Satellite Servicing Forum in Washington, D.C. last week. Below are some quick takeaways from the event that shed light on a subset of emerging commercial opportunities in the space industry.

The sold-out event brought together industry participants across global satellite network operators and satellite services and technology companies, as well as government agencies and regulatory bodies,

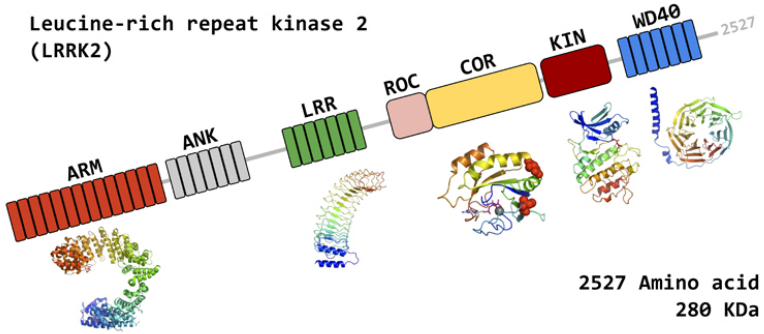
## CASIS Protein Crystal Growth (PCG) 16: Crystallization of LRRK2 Under Microgravity Conditions -2

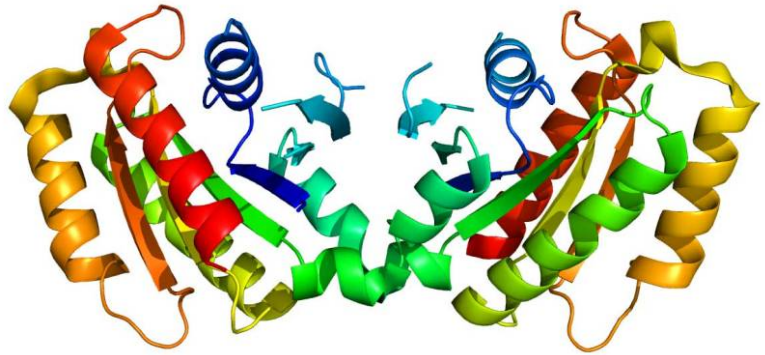
**Continuing pursuit of the atomic structure of the leading Parkinson's Disease protein**

*Principal Investigator: Michael J Fox Foundation, Goethe University Frankfurt, University of California – San Diego*

Sponsor: ISS National Lab

- Determining the structure of the Leucine Rich Repeat Kinase 2 (LRRK-2) protein is the leading approach for developing drugs that would mitigate Parkinson's Disease
  - If the structure is known, a drug can be developed to attach to the protein to render it un-functional
- Many attempts to grow the LRRK-2 protein on Earth have not been successful due to sedimentation and convection, making the crystal too small to study
- Microgravity environment allows crystal to grow larger in structure to make it easier to see and evaluate
- Second attempt to grow crystal on ISS, (first was unsuccessful) but is utilizing the CASIS PCG-13 experiment by Eli Lilly to increase chances of success
  - Experiment assists the astronauts in observing imperfections while growing crystals in microgravity and training them to make real time adjustments



# Key New User Outreach

U.S. NATIONAL LABORATORY

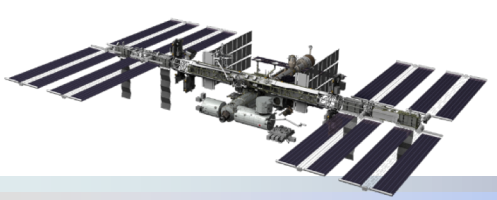
## Demand Creation

Targeted conferences, speaking opportunities and new user engagements where the ISS National Laboratory is reaching out to new users and promoting the International Space Station.

| | 2018 | | |
|---|---|---|---|
| | December | January | February |
| 1 | | | |
| | | CES 2019<br>Las Vegas | ISS National Laboratory Public Board Meeting<br>Washington, DC |
| 5 | State-of-the-Science Meeting: 3D Tissues and Microphysiological Systems<br>Washington, DC | ISS Coffee and Donuts in the Senate<br>Washington, DC | FAA Commercial Space Transportation Conference<br>Washington, DC |
| 10 | | World Stem Cell Summit<br>Miami, FL | |
| | ISS National Laboratory Microgravity Day at Corning Headquarters<br>New York | National Academies of Science GUIRR<br>Webinar | New Organ Alliance Road-Mapping Workshop<br>Washington, DC |
| 15 | | | |
| 20 | Catalyst Space Accelerator Demo Day<br>Colorado Springs, CO | | |
| 25 | | | |



# ISS Operational Status

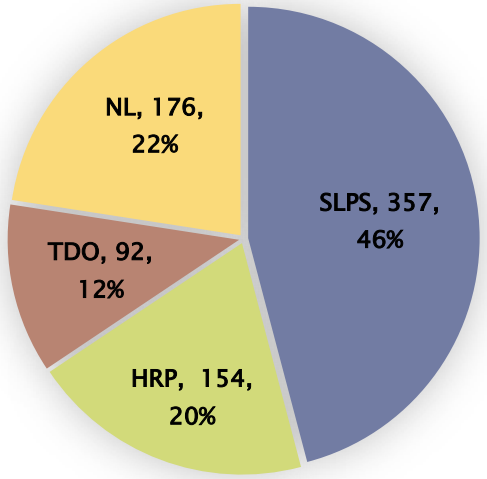


# Increment 55/56 (March '18–October '18) Crew Time by Sponsor

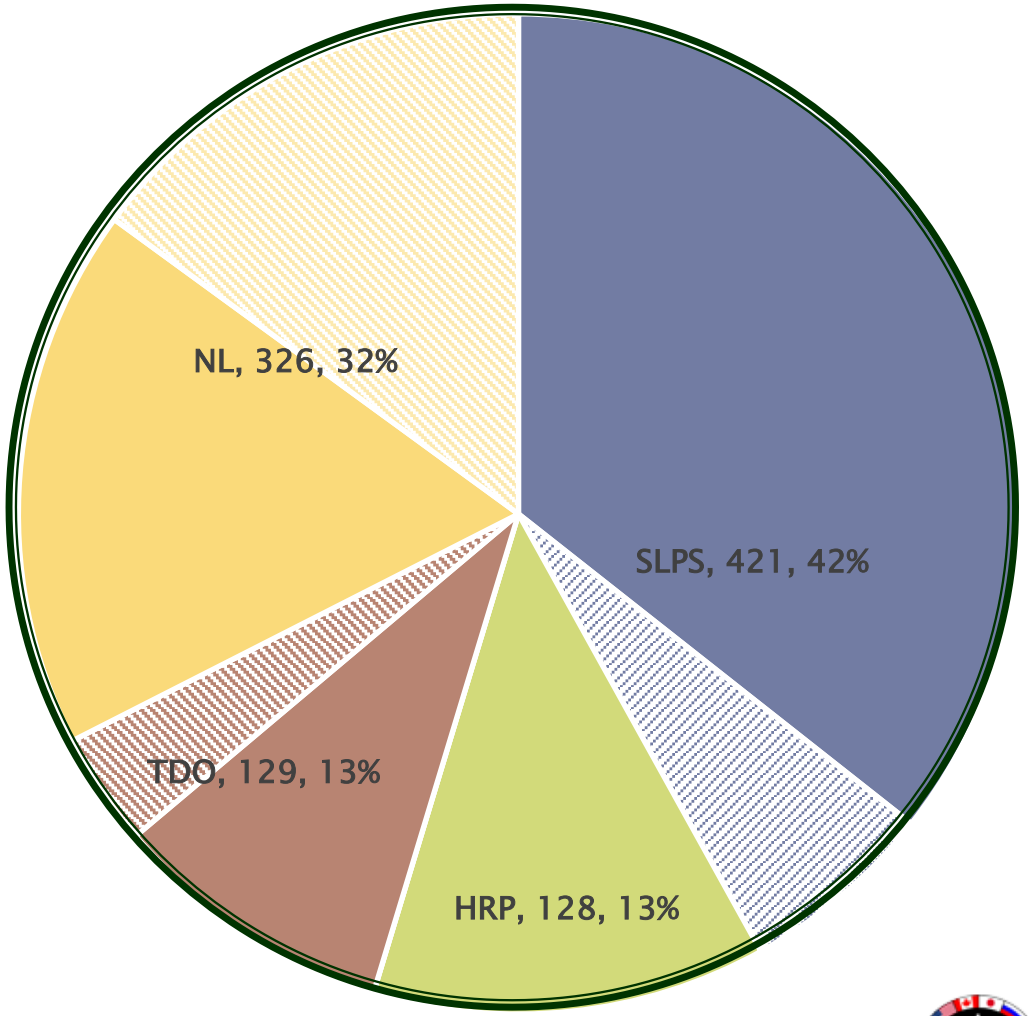
- Enablers
  - Russian Crew Time for EarthKam (NL), SPHERES Zero Robotics (NL), ACME E-Fields & CLD Flame (SLPS), EML (ESA)
  - 4th USOS Crew member
  - Increase of 112 crew days (54 Soyuz extension to Oct 4, 2018)
  - Continuous Research Planning enabled investigations to be added later in the flow
- Challenges
  - Lack of operationally-ready reserve complement
  - Continuous Research Planning enabled investigations to be added later in the flow, which contributed to lack of operationally-ready complement
  - Utilization hardware anomalies (eg: CIR, FIR, EMCS, MSRR, CAL, Manufacturing Device, Veggie PONDS, HRF-RC, ER5 leak, etc…)
- Delta Explanations
  - Additional 2 USOS EVAs with 54 Soyuz extension and more HTV-7 activities

| March '18- October '18 | Planned | Actual (9/17) |
|---|---|---|
| Research Hours | 779 | 1003 |
| Total Crew Days (USOS) | 454 | 220 |
| Cargo Flights | SpX-14<br>OA-9<br>SpX-15 | SpX-14<br>OA-9<br>SpX-15 |
| # EVAs | 3 | 3 |
| Russian Crew hours | TBD | 17.4 |

Planned Hours




Actual Hours as of 9/17

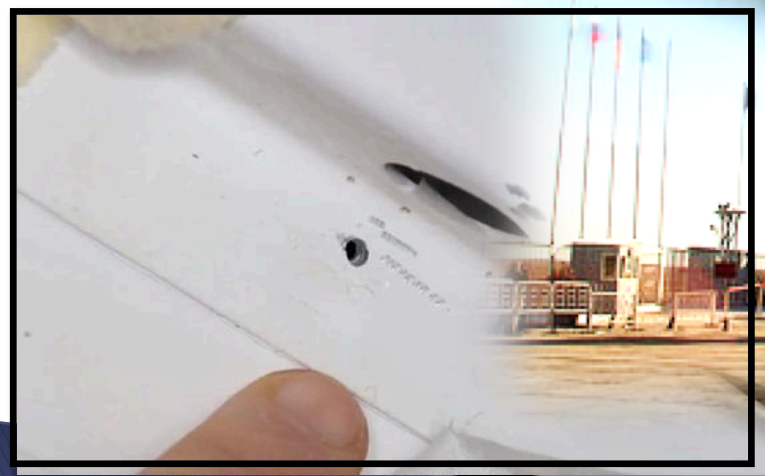



*Hatched wedges indicate increase from plan

# Soyuz Anomalies

## Soyuz 55S Hole (Aug 29/30, 2018)

- Flight Control Team in MCC-H noticed drop in cabin air pressure. Crew isolated the leak to a ~2mm hole in the orbital module of Soyuz 55S.
- After discussion with ground, crew repaired the hole using an onboard patch kit. Following re-pressurization, onboard pressure has been stable since completion of the repair.
- Roscosmos commission established to investigate the cause of the hole. Spacewalk planned in December to gather more data.



## Soyuz 56S Launch Abort (Oct. 11, 2018)

- Shortly after launch, an anomaly with a first-stage booster triggered events which initiated a launch abort resulting in a ballistic landing of the spacecraft.
- Launch Abort System worked as designed, crew (NASA/Hague, Roscosmos/Ovchinin) returned safely.
- Roscosmos commission performed thorough investigation and determined cause to be deformation of contact sensor.
- Flight Readiness Review on 11/15 to evaluate next crewed Soyuz launch planned for 12/3.

# Recently Completed US EVAs

## US EVA 51 (06/14/2018)

- EV1 Arnold, EV2/Feustel

- **Primary Tasks:**
  - Installed new HD cameras to provide enhanced views during the final phase of approach and docking of upcoming Commercial Crew spacecraft.
  - Swapped a camera assembly on the starboard truss.
  - Closed Cloud Aerosol Transport System (CATS) aperture door.
  - Relocated grapple bar to aid future spacewalkers
  - Secured hardware associated with spare cooling unit on truss.
  - 211th spacewalk in support of ISS assembly and maintenance.

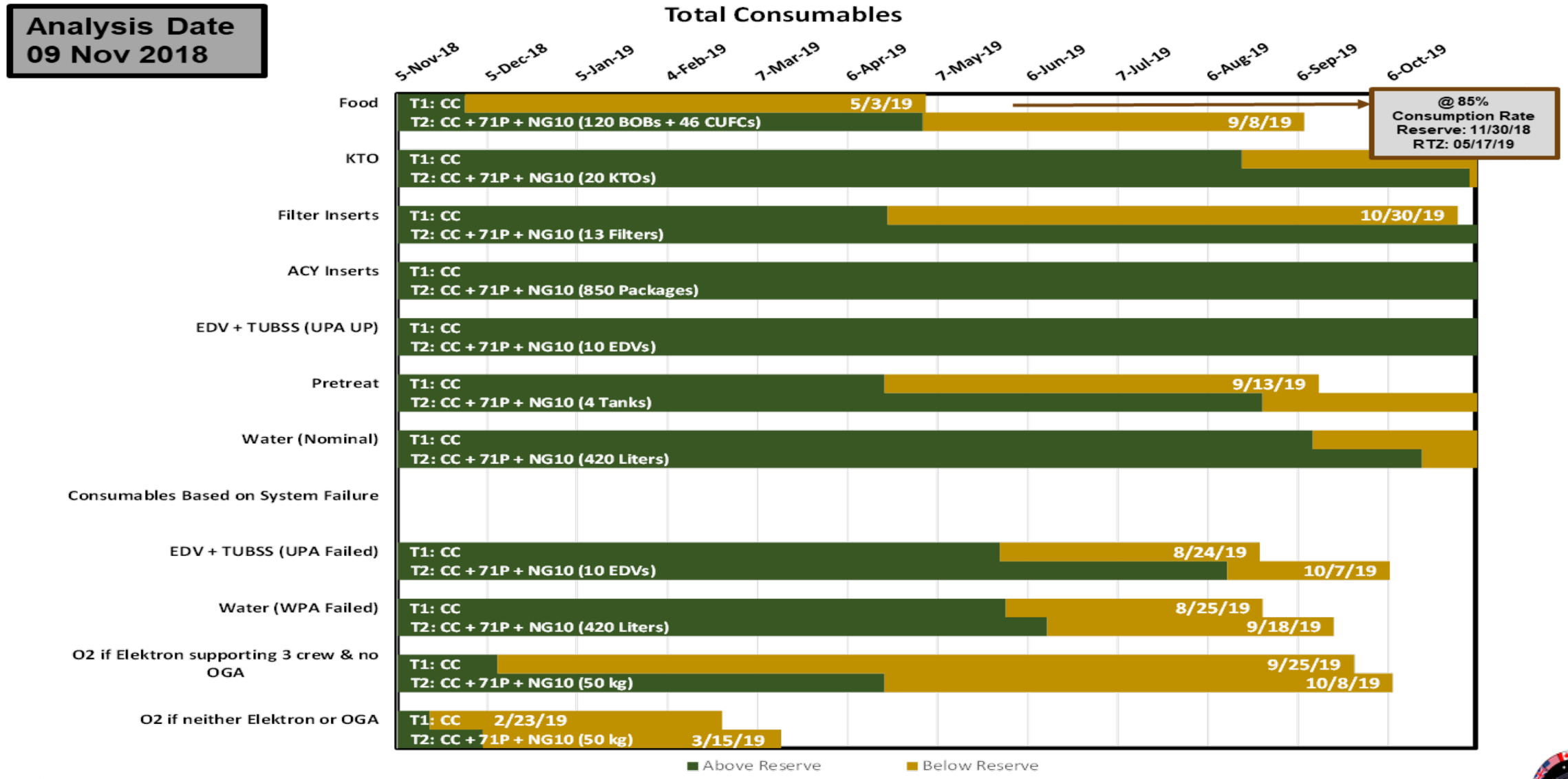
# Upcoming US EVAs

## US EVA 52 and US EVA 53
**(execution date under evaluation pending upcoming mission status)**

- P4 Battery Removal & Replacement – Over the course of two planned EVAs and multiple days or robotic activities, the primary task will be to replace 12 NiH2 batteries on the P4 Integrated Equipment Assembly (IEA) with 6 Li-Ion Batteries and 6 Adapter Plates. These operations are very similar to the Increment 50 EVAs that replaced the S4 batteries with new ones that launched on HTV-6. The remainder of the EVA time is spent outboard on P6 doing some preparatory tasks for the HTV-8 mission and associated EVAs. That flight is scheduled to launch next year with new batteries for the P6 IEA that EVA will R&R.
- These spacewalks were originally planned in the October timeframe. However, due to the Soyuz 56S launch abort (and associated reduction in USOS crew), many Increment 57 tasks were re-evaluated based on onboard resources.

# Total Consumables

**Analysis Date**
**09 Nov 2018**



# HII Transfer Vehicle (HTV7) Mission Success!

- Launch occurred 9/22/18; berthing occurred 9/27/18
- Release occurred 11/7/18, re-entry occurred 11/10/18
- Pressurized Cargo – 3412 kg upmass, ~1850 kg disposal
- Delivered 3 racks: Life Science Glovebox (LSG) from ESA,and two EXpedite the PRocessing of Experiments for Space Station (EXPRESS) racks
- 6 LiON batteries to replace 9 Ni-H2 batteries, EVA dates under evaluation
- First successful test of the HTV Small Re-entry Vehicle (HSRV) to test payload return technology

HTV-7 ready to launch
*Photo Credit: JAXA*

HTV7 Captured on ISS
*Photo Credit: JAXA*

HSRV returned to Earth sucessfully
*Photo Credit: JAXA*

# Northrup Grumman (NG-10) Mission Status

- Launch occurred 11/17/18; berthing occurred 11/19/18
- Release planned for 2/12/19
- Pressurized Cargo – 3185 kg; 3000 kg disposal estimated
  - Ascent:  2 Polar and 1 MERLIN
  - First flight of an Enhanced Cargo Module Power Unit (eCMPU)
- Unpressurized Cargo
  - Nanoracks External CubeSat Deployer, operations post ISS departure
  - SlingShot External CubeSat deploy post ISS departure (up on SpX-16)

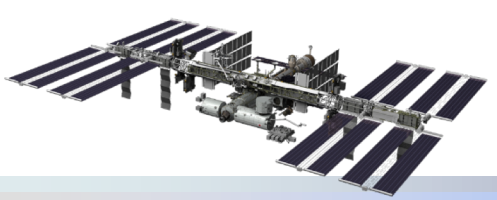
NG-10 launch seen from Washington DC
*Photo Credit: NASA*

NG-10 Captured on ISS
*Photo Credit: NASA*


Cygnus during prelaunch, named for Astronaut John Young
*Photo Credit:* Ken Kremer/kenkremer.com/SpaceUpClose.com

# SpaceX-16 Mission Status

- Mission Planning
  - Launch planned for 12/4/18, berthing planned for 12/6/18
  - Unberth and re-entry planned for 1/13/19
- Pressurized Cargo – 1890 kg planned; 1750 kg return estimated
  - Launch: 2 Polar, 2 AEM-T, 1 Powered Ascent Utility Locker (PAUL)
  - Return:  5 Polar, 1 AEM-T
- Unpressurized Cargo – 975 kg upmass; no disposal payloads
  1. Global Ecosystem Dynamics Investigation (GEDI)
  2. Robotics Refueling Mission-3 (RRM-3)



GEDI

RRM-3

Need to update if launch successful

# ISS Transition

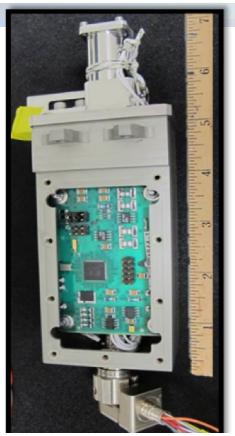
# ISS EVA Investments and EVA for Exploration

# Overview

- Summary of ISS investments in current and future EVA flight systems
  - Current EVA Flight System Investments
    - Upgrades to EVA flight systems to improve reliability and operations
      - Inclusive of development of components that could “drop-in” to advanced EVA suits or new vehicle support hardware
    - Supplier Supportability and Material Obsolescence
      - By necessity ISS is helping to maintain supplier base and material upgrade availability
  - ISS as a Platform for Advanced EVA capability demonstration
    - Using ISS Lab capabilities to assess advanced EVA capabilities
    - Using ISS Joint Airlock to demonstrate advanced Suit systems and vehicle support
      - Development of Exploration EMU (xEMU) demonstration flight unit

# Current Flight System Upgrades

- EMU Suit Component Upgrades
  - CO2 Sensor: Replace current suit sensor with new design using infrared source and detector (same technology as current EMU sensor) with upgraded electronics
    - New sensor will be certified for EMU and xEMU
  - EMU Data Recorder (EDaR): Enable high-speed recording of all critical sensor data. Enable transmission of data real-time when WIFI available.
    - Will be directly incorporated into xEMU Demo
  - Long Life Battery (LLB-2): EVA Battery upgraded to Li-Ion cell chemistry and incorporate the latest safety features for mitigating thermal runaway.



CO2 Sensor

Li-Ion Batts

- EVA Tools
  - High-definition EVA Camera Assembly (HECA): Real-time transmission and on-board data storage/forward capability
    - Upgrade for EMU and the baseline camera set for the xEMU.
  - All batteries used during EVA are being upgraded to Li-Ion technology with thermal runaway propagation mitigations incorporated
  - Life extension certifications for long duration tethers materials and numerous other tools continues for use with both ISS assets and future needs

HECA



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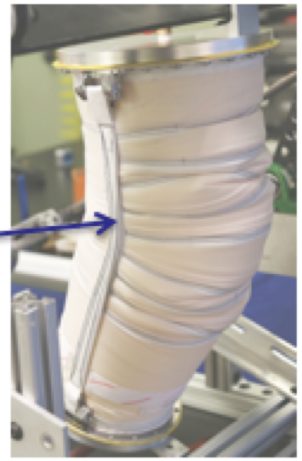
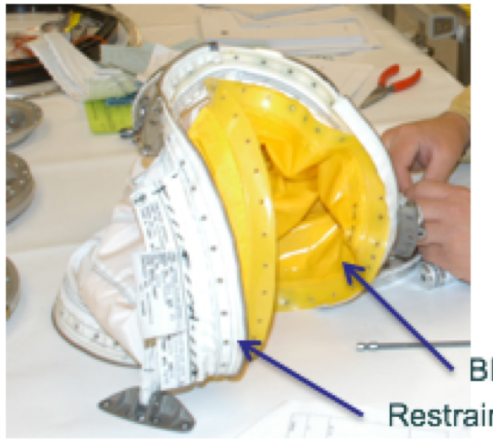
# EVA Supplier Supportability & Material Obsolescence

- EVA Material Replacement for EMU and xEMU
  - Helmet bubble

  - Pressure garment bladder and Restraint




*Restraint layer (white) takes pressure loads off of bladder layer (yellow) by providing attachment for axial load restraint lines and carrying circumferential loads*





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# ISS Ground and Flight Infrastructure Investments

- Ground Testing & Validation (ISS Facilities)
  - In FY17, 18 NBL runs were conducted to assess mobility and compatibility with ISS operations for the advanced pressure garment “Z2”
  - In early FY19 several NBL runs will be conducted to assess improvements made to upper torso design (Z2.5) based on lesson learned during FY17

- ISS Joint Airlock Infrastructure Upgrades: Suit servicing equipment replacements to address expiring hardware certifications and to support advanced EVA demonstrations
  - Cooling Loop Scrubbing – ALCLR redesign launched in late FY17
  - UIA Panel: Scarred to support higher pressure oxygen (up ~3k psi O2 needed to recharge advanced suit oxygen system)
    - Installed in June 2018
  - Point-of-use Filtering (Feedwater loop) – launch in late FY18
  - Fluid Pumping Unit (FPU)
  - Battery Charging: EBOT capability to support Lithium Ion charging




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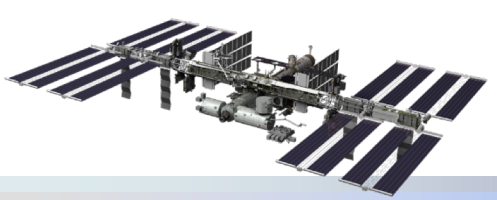
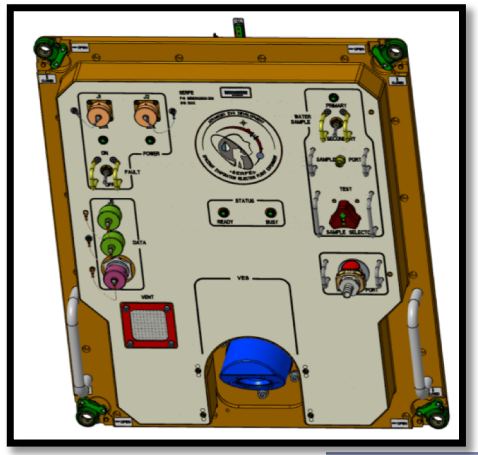
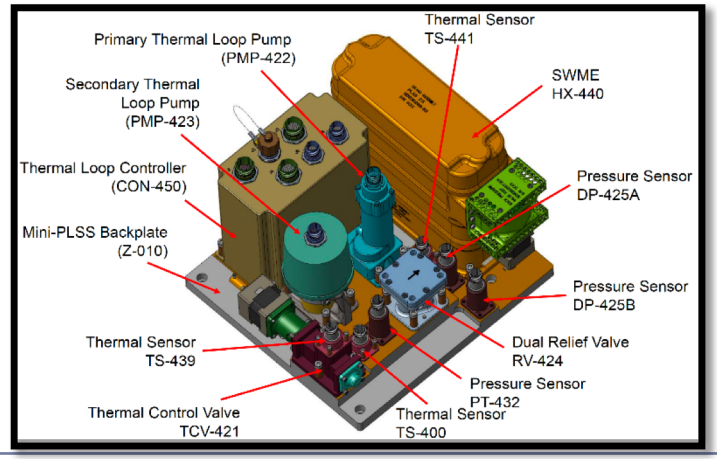


# ISS as a Platform for Advanced EVA Subsystem Demonstration: SERFE

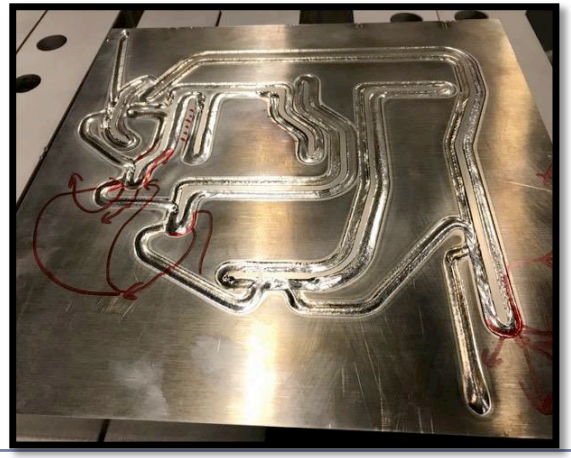
- An ISS Payload is being developed and flown in order to reduce risk for both the xEMU PLSS development and ISS vehicle thermal systems
- This pathfinder, called “SERFE” (Suit Evaporation Rejection Flight Experiment) is a high-fidelity prototype of the Exploration PLSS thermal loop mounted in an EXPRESS Rack
- Objective is to validate evaporative cooling from Suit Water Membrane Evaporator (SWME, replaces Sublimator) in a microgravity environment
  - This also provides an opportunity to explore candidate pumps, thermal control valve, and thermal loop controller under consideration for the xEMU
  - Additional benefits include process development and validation of the welded titanium Backplate w/integral cooling lines, further reducing risk for xEMU
- SERFE flight unit assembly will be complete and tested and flown in 2019



SERFE Front Panel




SERFE Mini-xPLSS mounted on welded Backplate



SERFE Back-Plate: Weld Process Precursor for xEMU



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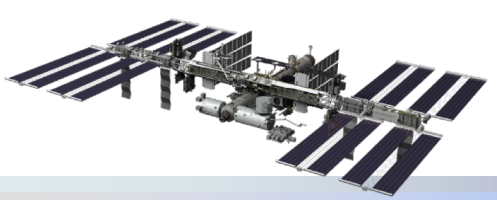

# ISS as a Platform for Demonstration of Advanced Suit Systems

- The objective of this flight project is to develop a exploration-class EVA suit and perform EVA demonstrations on ISS
  - Will perform demonstration with 1 xEMU and 1 current EMU per EVA sortie
- The xEMU designed and built is being lead using the NASA team that has been performing EVA technology development for 10+ years
  - NASA will be procuring components and will perform the role of system integrator
  - 1 Qual Unit and 1 Flight Unit will be assembled
- Major milestones are shown in the table below working towards a flight demonstration at the ISS in 2023
- xEMU demo will form the basis for the system that will be used at the Gateway and the lunar surface

xEMU Demo

<table>
<tr><th>FY18</th><th>FY19</th><th>FY20</th><th>FY21</th><th>FY22</th><th>FY23</th></tr>
<tr><td>SRR (Jan)</td><td>PDR</td><td></td><td>CDR</td><td></td><td>SAR & Delivery</td></tr>
<tr><td colspan="2" rowspan="2">DVT Build/Assy</td><td rowspan="2">DVT Testing</td><td colspan="2">Qual & Flight HW Build</td><td rowspan="2">Acceptance Testing</td></tr>
<tr><td></td><td>Qual Testing</td></tr>
<tr><td colspan="6">Terms and Definitions: SRR – System Requirements Review, PDR – Preliminary Design Review, CDR – Critical Design Review, DVT – Design Verification Testing, SAR–Systems Acceptance Review</td></tr>
</table>



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# xEMU Demo (Heritage vs. New Hardware)

- Current EMU components used on xEMU (white items)
  - Lower Arms & Gloves
  - Lower Torso Assembly
  - Legs & Boots
- Other shared items
  - Lights & Hi-def cameras
  - Tools
  - SAFER
  - Material certs, ex. Polycarbonate for helmet bubbles, TMG, etc

- New XEMU Demo components
  - Portable Life Support System (PLSS)
  - Hemi-ellipsoid Helmet & Visors
  - Rolling convolute shoulders
  - Hard Upper Torso (rear entry) with new control module
  - Liquid Cooling & Ventilation Garment
  - In-suit comm system

Use of heritage components allows NASA to focus on development of critical Space Suit elements (and diminish ISS logistics / operations integration)


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