National Aeronautics and
Space Administration

HEO NAC October 2019

International Space Station Status

Sam Scimemi

Director, International Space Station

Agenda

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

Flight Plan – Increment 61

- 09/25/19 – Soyuz 61S Launch & Dock (NASA/Morgan, NASA/Meir, Roscosmos/Skripochka)
- 10/03/19 – Soyuz 58S Undocking (NASA/Hague, Roscosmos/Ovchinin, UAE/Almansoori)
- 10/06/19 – US EVA #56 (P6 Battery R&R)
- 10/11/19 – US EVA #57 (P6 Battery R&R)
- 10/18/19 – US EVA #58 (BCDU R&R)
- 11/01/19 – HTV-8 Release
- 11/02/19 – Northrop Grumman CRS-12 Launch (Capture/Berth on 11/04/19)
- Nov. '19 – AMS Repair Spacewalks (series of 4-5 EVAs)
- Dec. '19 – SpaceX CRS-19 Launch, Capture and Berth
- 12/17/19 – Boe-OFT Launch (Docking on 12/18/19)
- 12/20/19 – Progress 74P Launch (Docking on 12/22/19)
- Dec. '19 – SpaceX-Demo2 Launch and Docking
- Jan. '20 – SpaceX CRS-19 Release
- Jan. '20 – SpaceX-Demo2 Undock
- 02/06/19 – Soyuz 59S Undock (NASA/Koch, ESA/Parmitano, Roscosmos/Skvortsov)

Increment 61 Overview: Crew

Increment 61 began upon Soyuz 58S undock on 10/03/19

Andrew Morgan
FE (NASA)

Oleg Skripochka
(Roscosmos)

Luca Parmitano
(ESA)
ISS CDR Exp 61

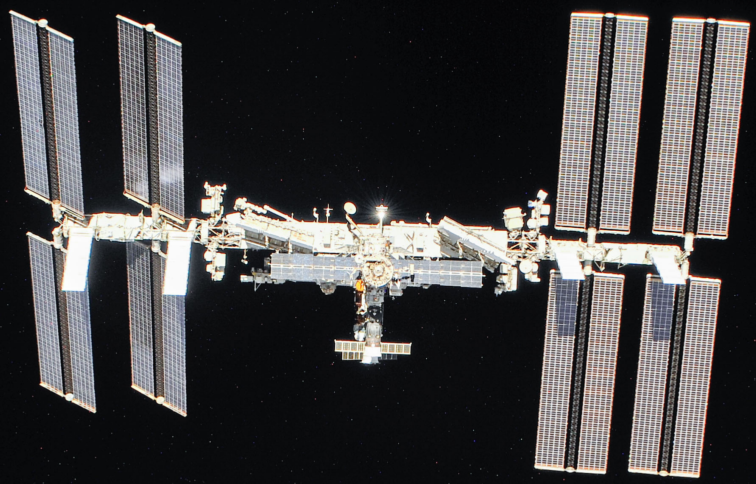
Increment 61 concludes upon Soyuz 59S Undock on 2/6/20

Alexander Skvortsov
(Roscosmos)

Jessica Meir
(NASA)

Christina Koch
(NASA)

National Aeronautics and
Space Administration



Exploration Research and Technology Highlights

Capability Gap Closure Pathways

Development Gap Examples

- Adaptive space network

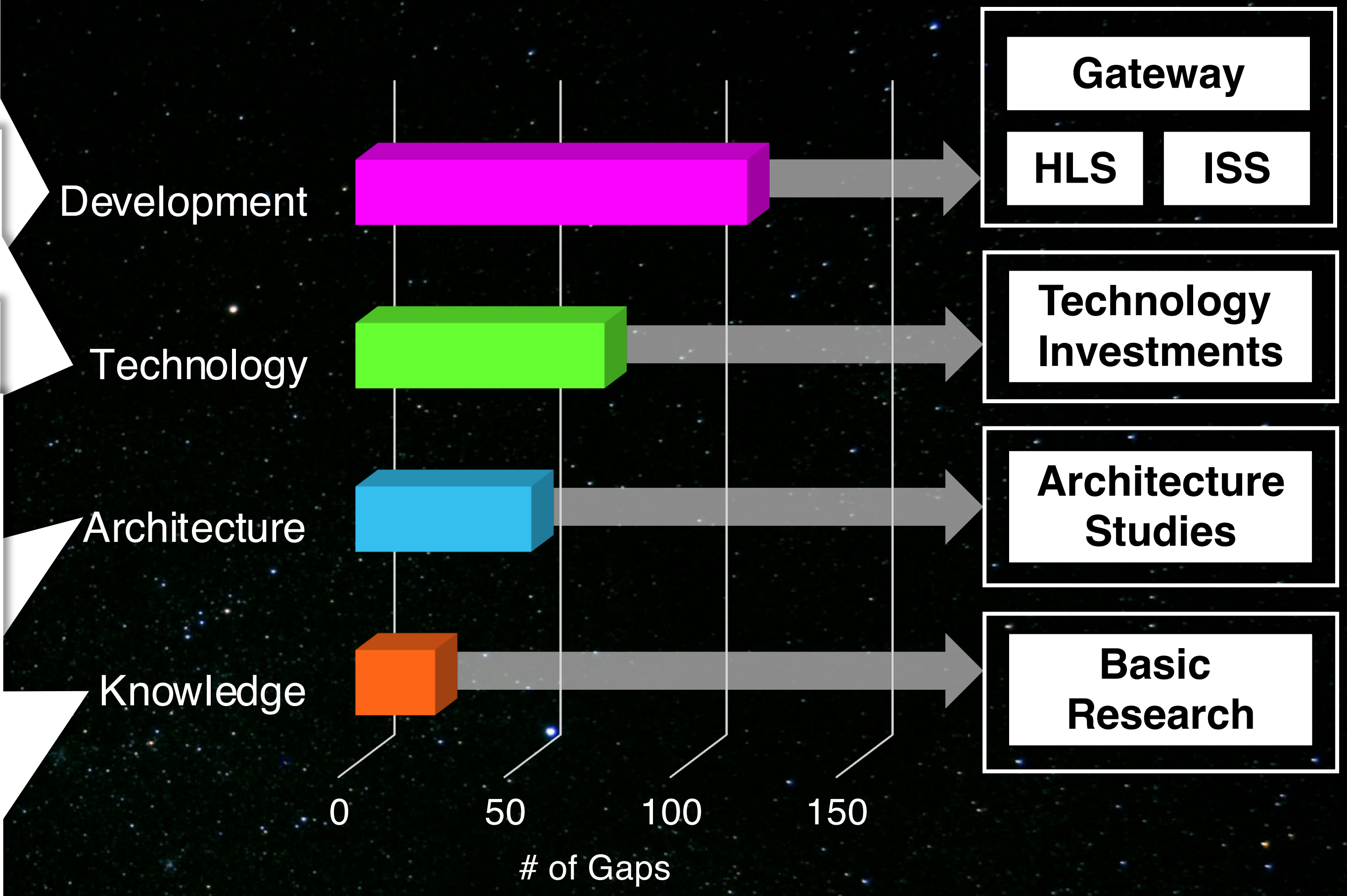
Technology Gap Examples

- Cryogenic propellant in-space transport and

Architecture Gap Examples

Knowledge Gap Examples

- Degradation of landed materials in lunar & Martian environments
- Impact of altered gravity fields on human health & performance
- Low and partial gravity material flammability



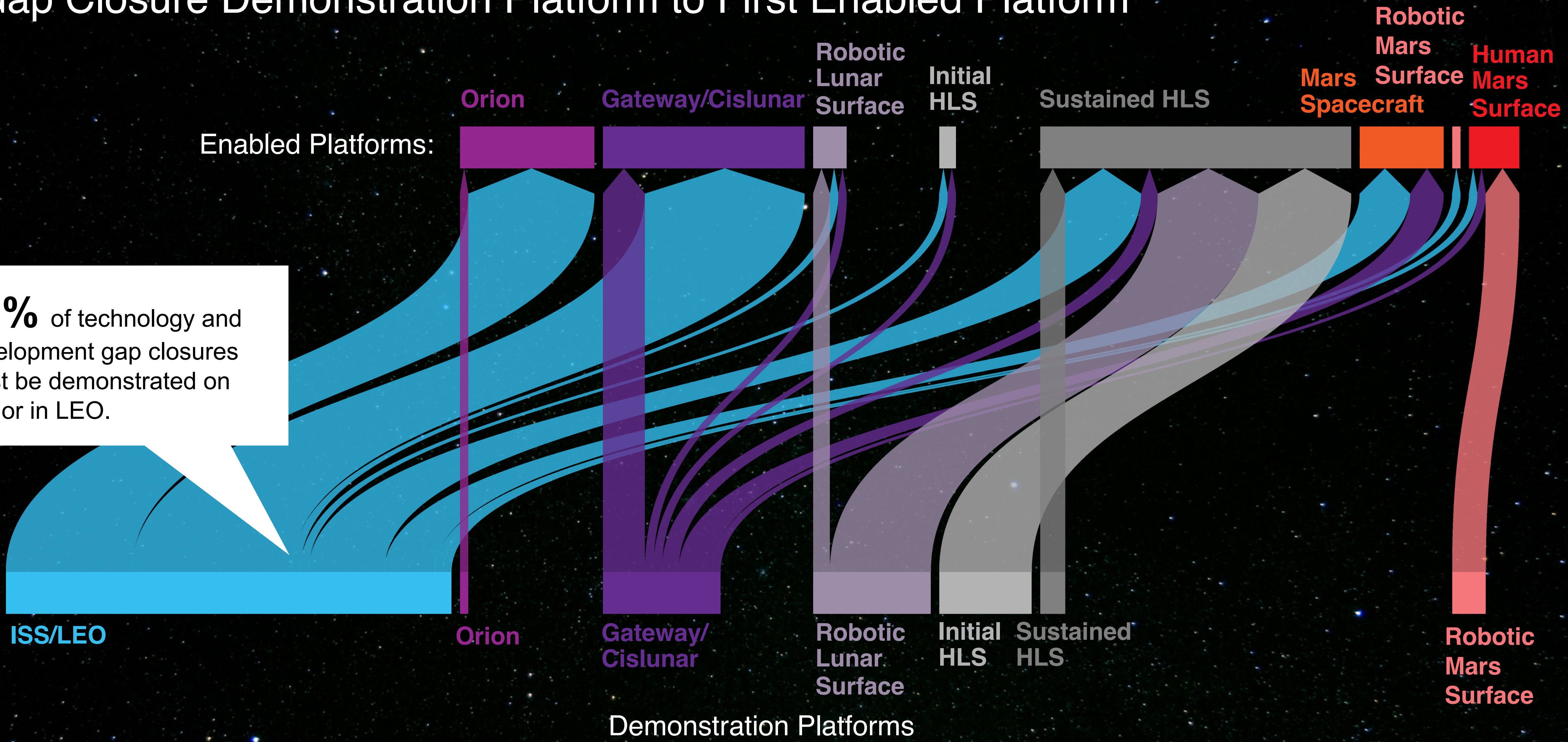
Multiple possible architectures considered

Approximately **270** proposed gaps when all architecture options included

HLS = Human Landing Systems
ISS = International Space Station

Technology and Development Capability Gaps

Gap Closure Demonstration Platform to First Enabled Platform



30% of technology and development gap closures must be demonstrated on ISS or in LEO.

Data as of September 27, 2019

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**

FY18	FY19
1. Aerosol Sampler 2. Combination Acoustic Monitor	3. Refabricator 4. Hybrid Electronic Radiation Assessor (HERA) 5. Siloxane control technology (CHIPS filters) 6. Thermal Amine 7. Astrobee 8. RFID Enabled Autonomous Logistics Management (REALM)-2 9. SAM Major Constituents Analyzer

Featured Exploration Technology – Cabin Air Analysis

Spacecraft Atmosphere Monitor

Miniaturized mass spectrometer based instrument for measuring the constituents of astronaut cabin air

PM: Murray Darrach, Caltech/NASA Jet Propulsion Laboratory, Pasadena California

- characterization of the spacecraft cabin atmosphere for trace ISS on SpaceX-21 in August 2020. chemicals and the major constituents is vitally import to safeguard astronaut health.
- when terrestrial atmospheric analyses are performed, it typically requires the use of gas chromatograph mass spectrometers (GCMS).
- S.A.M. is 9.3kg and consumes 44W, making it the smallest (mass, power) autonomous GCMS every built.
- S.A.M. has an expected lifetime of at least one year on-orbit operations.
- The first demonstration unit (TDU1), for major constituents monitoring, flew to the International Space Station on SpaceX-19 (07/25/19) and started operations 08/8/19.
- TDU1 is operating very successfully, reporting the concentration major constituents (N_2, O_2, CO_2, CH_4, and H_2O), every 2 seconds.
- The second unit, TDU2, will have both trace gas and major constituent capabilities. TDU2 is manifested for launch to ISS on SpaceX 21 in August 2020

22 x 22 x 24 cm
9.3 kg
44 Watts

S.A.M. TDU1 Installed and operating in ISS Express Rack August 8, 2019

Featured Exploration Technology – Upcoming (SERFE)

Spacesuit Evaporation Rejection Flight Experiment

Next Generation Space Suit Active Thermal Control Loop Demonstration

PM: Ben Greene, Johnson Space Center, Houston, TX

Exploration Extravehicular Mobility Unit (xEMU) Thermal Loop

- Contains all elements of the Exploration Portable Life Support System (xPLSS) Thermal Loop in a compact unit called the Mini-PLSS
- Utilizes Spacesuit Water Membrane Evaporator (SWME) flight design
- Includes two alternative technology Water Pump designs, Thermal Control Valve, and new titanium baseplate with imbedded water channels

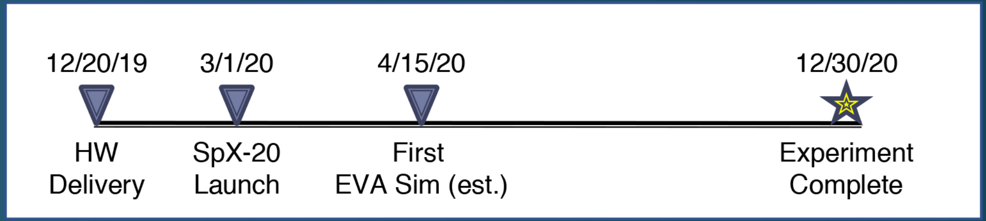
Simulates on-orbit environment and expected cycle life of an xEMU

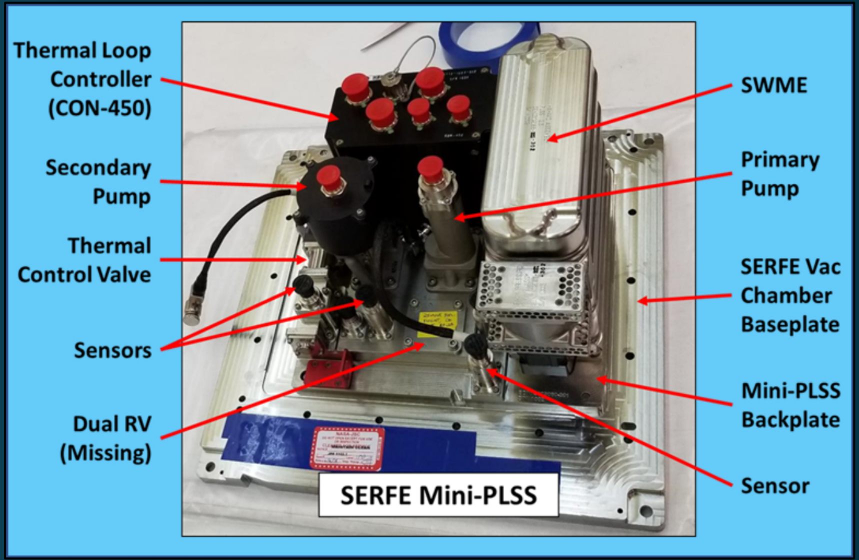
- Will perform 25 simulated 8 hour Extravehicular Activities (EVAs)
- Self contained sensor package will evaluate all elements of the water system performance, including water conductivity and video monitoring of vacuum chamber
- A second ground unit will perform identical experiments for data comparison
- Periodic water Mini-PLSS samples will be taken for on-orbit and ground evaluation of thermal loop water quality
- SERFE flight unit will be returned to the ground for full component analysis

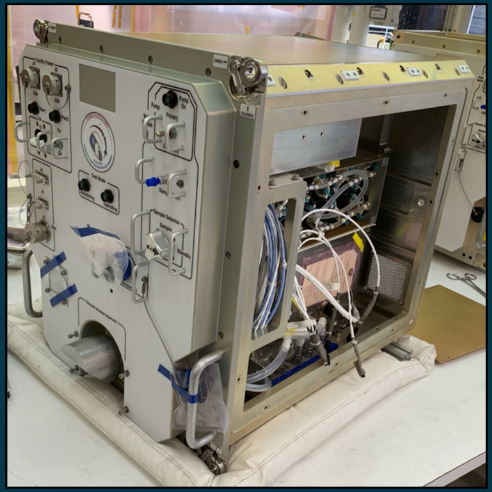
Technology development for Gateway and HLS

- SERFE technology is the basis for the xEMU Active Thermal Control Loop (ATCL)
- Data from SERFE hardware development had significant impact on xEMU PDR
- Data from the flight experiment will heavily influence xEMU CDR design in 2021

Scheduled for launch on SpX-20 in March 2020





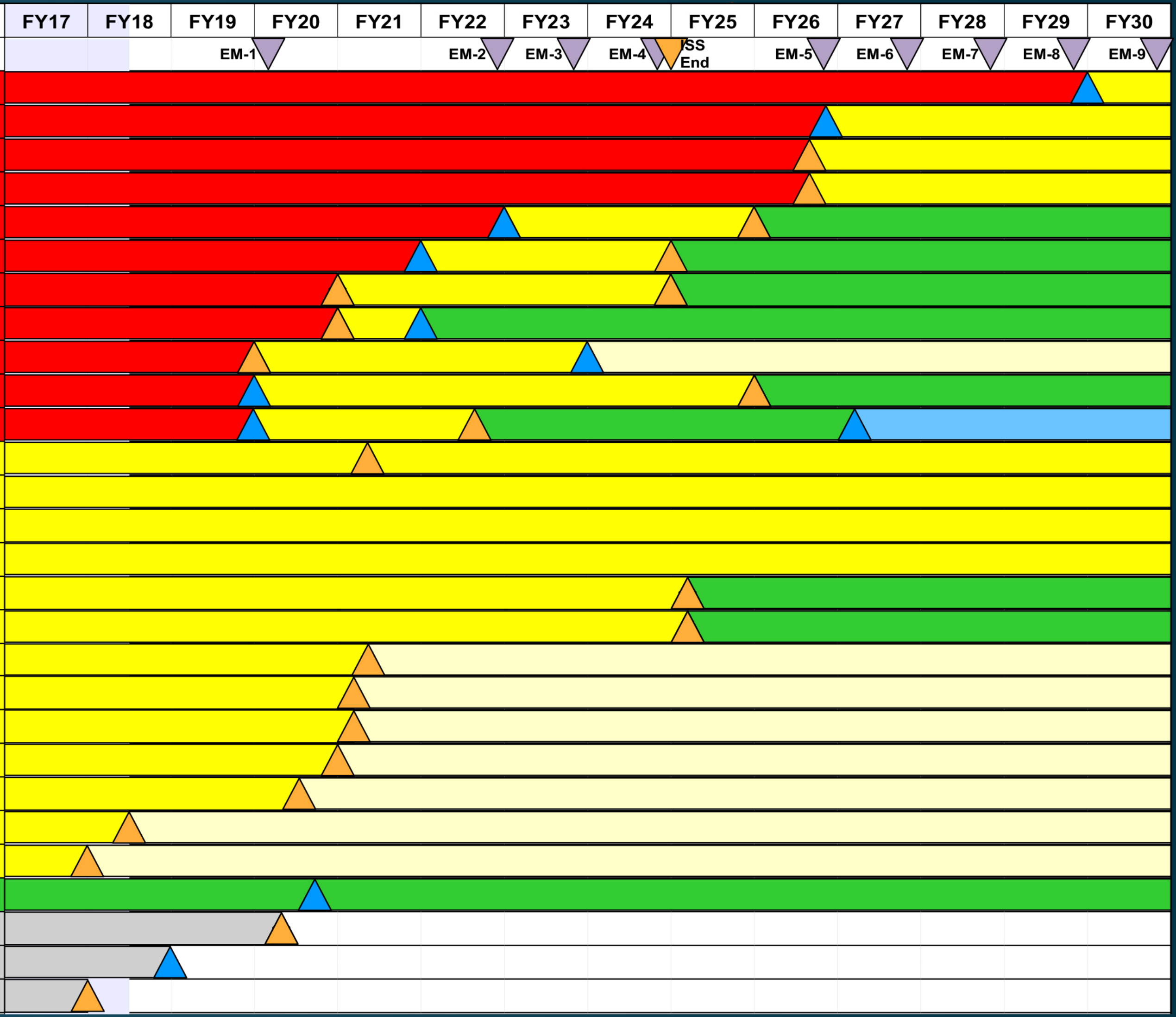


SERFE Flight Unit 9/2019

HRP Path to Risk Reduction

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

Mars Flyby	
Risks	LxC
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

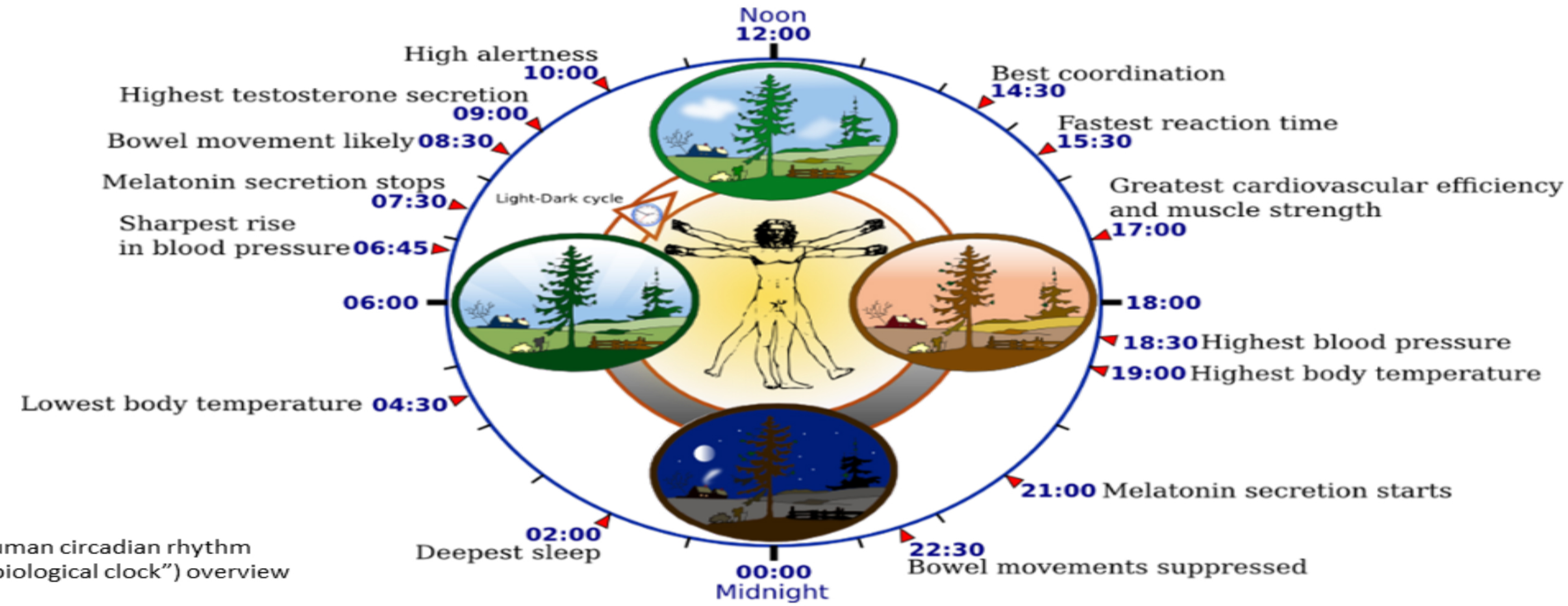


Rodent Research-14 (RR-14)

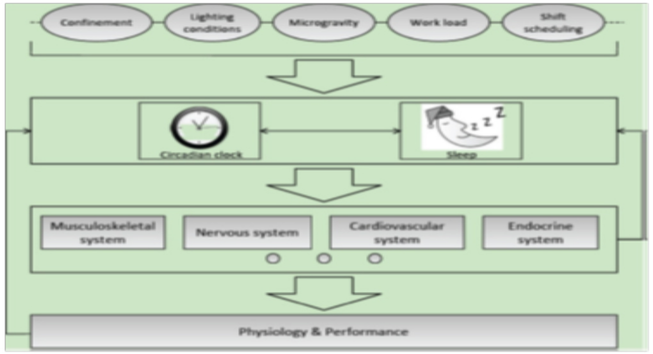
Microgravity as a Disruptor of the 12-hour Circatidal Clock

PI: Brian York, Baylor College of Medicine
Sponsoring Space Agency: NASA

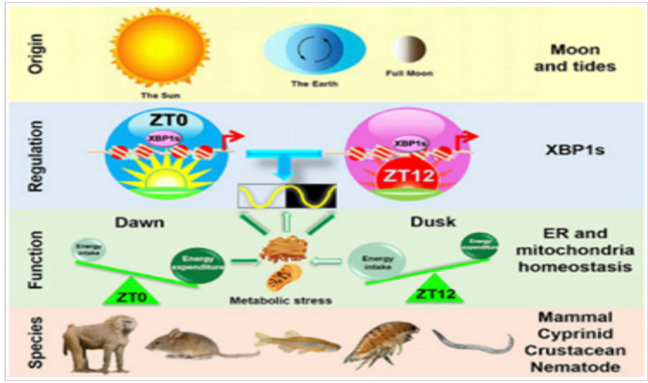
- This investigation tests whether disruptions to the 12-hour circatidal clock in microgravity affect the body on a cellular and organ level.
- Previous research established the role of the 12-hour daily clock in maintenance of stress responsive pathways.
- By exposing cellular systems in mice to the stress of microgravity, this investigation allows examination of cellular adaptation to changes in the daily clock and the effects on behavior.
- Understanding how the unique stressor microgravity impacts the 12-hr circatidal clock of metabolism may lead to insights and therapeutic targets to address human diseases on Earth like diabetes, liver disease, and other metabolic disorders.



Human circadian rhythm
("biological clock") overview



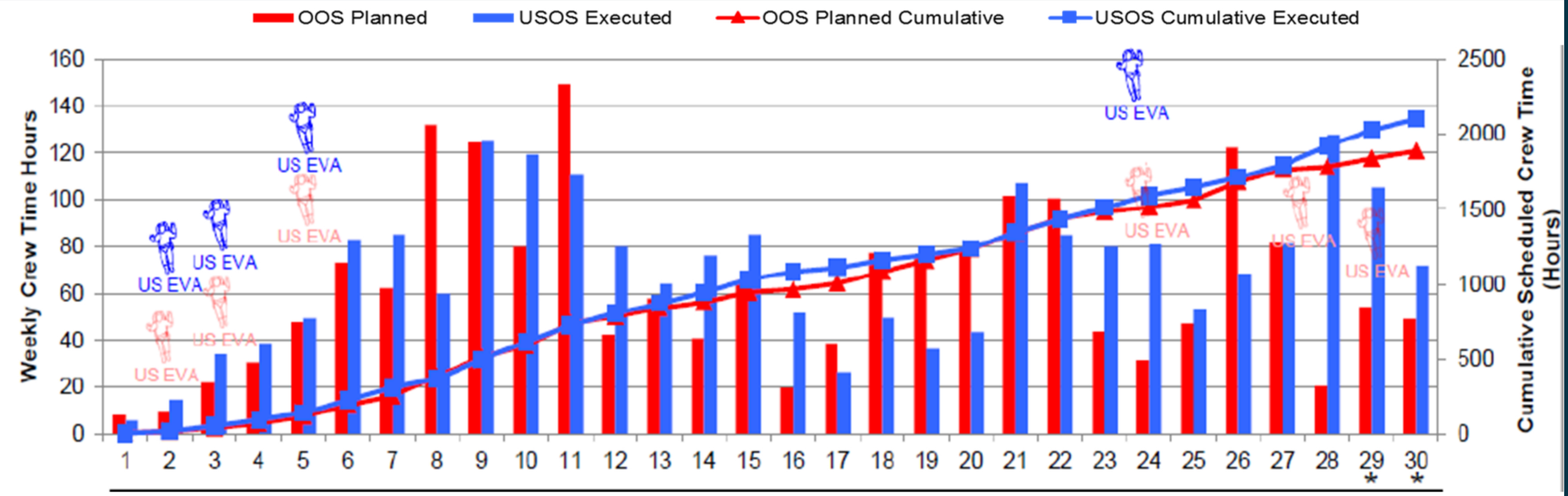
Circadian clock, sleep, physiology, and behavior in space (MMR, 2014)



12-hour clock origin, regulation, function, and species conservation (JES, 2018)

Utilization Summary

Increments 59 & 60 Utilization Crew Time

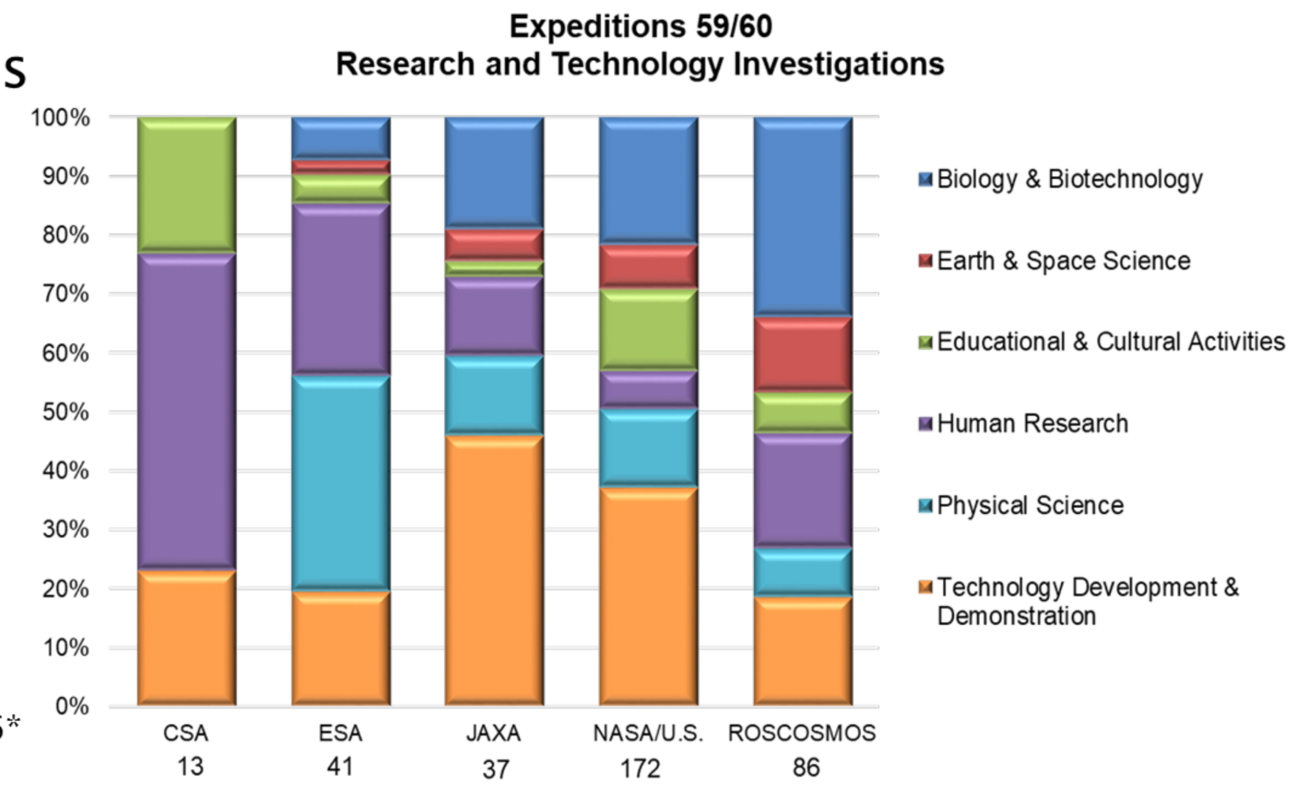


Executed through Increment Wk (WLP Week) 30 :	28 of 28	work weeks	(100.0% Complete)
USOS Actuals:	2,099.20	hours -> 74.97 hours/week	
USOS IDRD Allocation:	1,918.00	hours-> 68.50 hours/week	(109.4% Complete)
OOS USOS Planned Total:	1,887.93	hours	(111.2% Complete)
Voluntary Science Totals to Date:	0	hours (not included in the above totals or graph)	
RSA/NASA Joint Utilization to Date:	16.42	hours (not included in the above totals or graph)	

*ESA Utilization reconciliation in work

Research Statistics

- **Number of Investigations for 59/60: 349**
  - 172 NASA/U.S.-led investigations
  - 177 International-led investigations
  - 101 New investigations
    - 3 CSA
    - 4 ESA
    - 11 JAXA
    - 76 NASA/U.S.
    - 7 Roscosmos

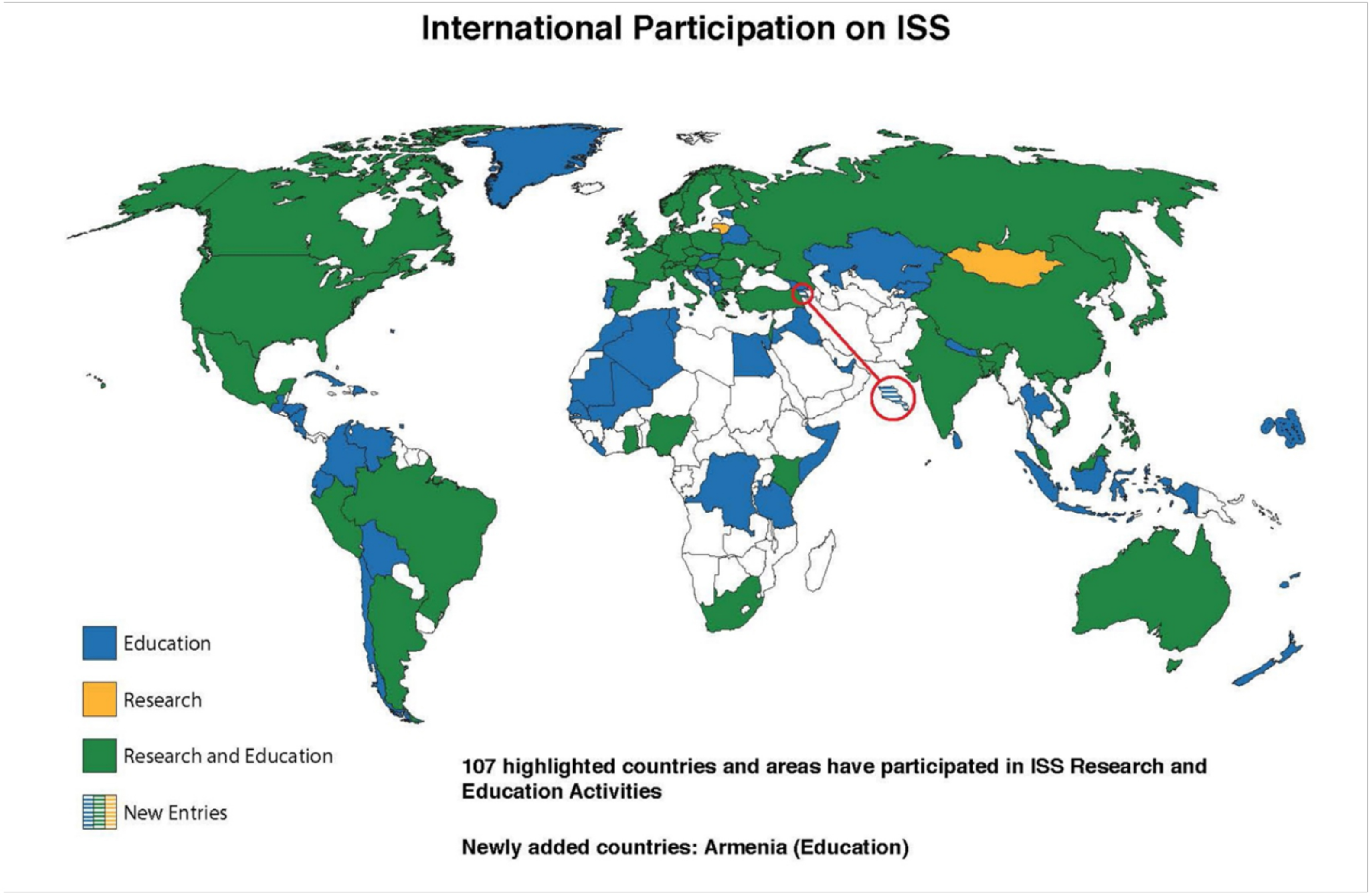


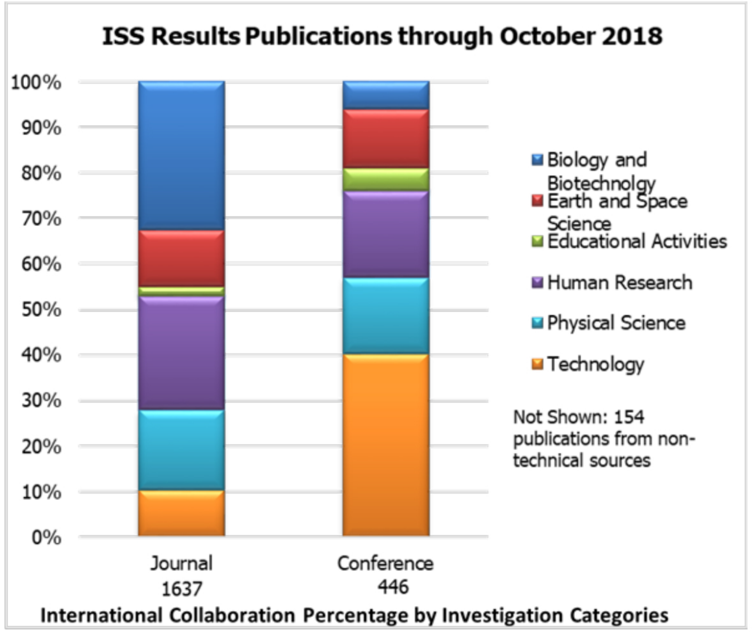
<u>ISS Lifetime</u>

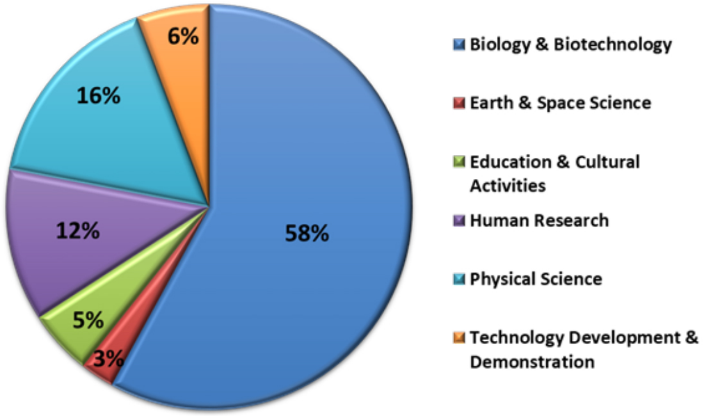
- Estimated Number of Investigations Expedition 0-60: 2876*
- Over 3908 Investigators represented (Exp 0 – present)
- Over 1768 scientific results publications (Exp 0 – present)
- 107 Countries/Areas with ISS Research and Educational Investigations (Exp 0 – present)

*Working data as of June 30, 2019**
Pending Post Increment Adjustments

Global Involvement in Utilization







Increments 61 & 62 Research Plan - Investigation List

Human Research

Bone & Muscle Physiology
Vertebral Strength (P)
EDOS-2
Myotones

Cardiovascular & Respiratory Systems
Vascular Aging
Vascular Echo
Cerebral Autoregulation

Crew Health Care Systems
Acoustic Diagnostics

Habitability and Human Factors
Soyuz Occupant Risk (P)
AstroRad Vest

Human Behavior & Performance
Time Perception in Micro-g

Immune System
Functional Immune
Probiotics

Cross-Disciplinary/Other
Standard Measures

Integrated Physiology & Nutrition
Food Acceptability
Food Physiology
Repository
NutrISS

Nervous & Vestibular Systems
VECTION
Wayfinding (P)
GRASP
GRIP
Labyrinth (P)

Vision
Fluid Shifts

Facilities

ActiveWatch Spectrum↓
Astrobee
Confined Combustion↑
Cold Atom Lab
Coldbag
Cryo Chiller
EXPRESS ↑
Fluids and Combustion Facility (FCF) ↑
GLACIER
Glovebox Freezer
Hermes
HRF-1
HRF-2
Ice Bricks ↑
Iceberg
Life Support Glovebox (LSG) ↑*
MELFI
MERLIN
Mini Coldbags ↑/↓
MSG ↑
Plant Habitat
Polar
SAMS-II
Spectrum
Ultrasound 2
ADSEP
BioFabrication (BFF)
Bone Densitometer
Faraday
Manufacturing Device
Mobile SpaceLab
MUSES (E)
MVP
Nanorack External Cygnus NRCSD (E)
NanoRacks-GoPro Fusion
NanoRacks Plate Rdr
NanoRacks Platforms
Slingshot (E)
TangoLab-1↑
Bartolomeo (E)
EDR
EML
FSL
LSR (ACLS)
MSL
PPFS ↑/↓
Solar (E)
CBEF-L
EFU Adapter (E)
ExHAM (E)
J-SSOD #12 (E)
J-SSOD #13 (E) ↑
Saibo

Key: NASA/ASI (blue) · National Lab (purple) · CSA (green) · ESA (red) · JAXA (gray) · (P) Pre/Post Only · (E) External Payload · *CEF approval pending · ↑/↓ Launch Return Only, **Category for child investigation

Increments 61 & 62 Research Plan - Investigation List

Biology & Biotechnology

Animal Biology – Invertebrates
- Micro-16
- Rotifer-B1*

Animal Biology – Vertebrates
- Rodent Research-12 ↓
- Rodent Research-14
- Rodent Research-17 ↓
- Rodent Research-19
- JAXA Mouse Mission (MHU5)

Cellular Biology
- Rad-Dorm
- Kidney Cell ↓
- MVP Cell-03
- TangoLab-14**
- Ribosome Profiling
- Sperm Stem Cells

Macromolecular Crystal Growth
- Perfect Crystals
- CASIS PCG 10
- CASIS PCG 15 ↓
- CASIS PCG 19 ↓
- JAXA Low Temp PCG #6
- JAXA Mod Temp PCG #4
- JAXA PCG #17

Microbiology/Macrobiology
- BEST ↓
- BioNutrients
- MVP Cell-02 ↓
- Veggie Monitoring
- TangoLab-14**
- Rotifer-B2* ↑/↓

Plant Biology
- BRIC-Light Emitting Diode (LED)
- Plant Habitat-01 ↓*
- Veg-03 JKL ↑ *
- Veg-04B ↓
- TangoLab-14**
- Space Moss

Other
- Hourglass

Physical Science

Combustion Science
- S-Flame
- Confined Combustion*

Complex Fluids
- ACE T-2 ↑
- ACE T-4
- ACE T-5
- ACE T-9 ↑
- ACE-T-11
- CommuBioS
- NanoRacks Module-73
- PK-4

Fluid Physics
- Fluid Boiling Condensation (FBCE)↑
- PBRE-2
- PBRE-WR
- Capillary Driven Microfluidics
- Drop Vibration
- Droplet Formation Study
- Electrolysis Measurement
- Inertial Spreading
- NanoRacks-Emulsion Tube↓
- FLUIDICS

Fundamental Physics
- adidas OS SPIN ↓
- DOSIS-3D
- JAXA Colloidal Clusters

Materials Science
- Space Biofilms
- SUBSA↑*
- NanoRacks Module-79
- NREP Inserts (E)**
- Polymer Convection
- EML Batch 2
- MSL SCA Batch 2b
- Transparent Alloys
- Advanced Nano Step
- ELF Investigations**

Earth & Space Science

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

Earth Remote Sensing
- Crew Earth Obs (CEO)
- ECOSTRESS (E)
- OCO-3 (E)
- SAGE III-ISS (E)
- TSIS (E)
- NREP Inserts (E)
- ASIM (E)
- HISUI (E)
- iSIM (E)

Other
- GEDI (E)

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

Increments 61 & 62 Research Plan - Investigation List

Technology Development & Demonstration

Air, Water and Surface Monitoring
Spacecraft Atmosphere Monitor

Avionics & Software
AMO-EXPRESS 2.5
Telescience Resource Kit
Faraday * **
NanoRacks Module-83

Characterizing Experiment Hardware
STPSat-4 (E)
Mochii
SoundSee Mission

Characterizing Software Technology
ECHO

Commercial Demonstrations
Made In Space Fiber Optics*
Mobile Companion (Cimon)
SOLISS (E)

Communication & Navigation
Vessel ID (E)

EVA Systems
SERFE

Fire Suppression and Detection
Saffire-IV

Food and Clothing Systems
Zero-G Oven*

Imaging Technology
HDEV (E)
HDTV-EF2 (E)
JEM Internal Ball Camera 2

Life Support Systems & Habitation
Thermal Amine Scrubber
Universal Waste Management System (UWMS)
Water Capture Device ↑
Photobioreactor
JEM Water Recovery System

Microbial Populations in Spacecraft
MATISS

Radiation Measurements & Shielding
FNS
ISS HERA
LIDAL
Radi-N2
Fiber Dosimeter

Repair and Fabrication Technologies
3D Printing In Zero-G ↓*
Refabricator

ExHAM WHISKER(E)

Robotics
Gecko-Inspired Adhesive Grasping
Robonaut
RRM3 (E)
Analog-1

Small Satellites and Control Tech
RED-EYE #2 (E)
RED-EYE #3 (E)↑
NRCSD #17 (E)

Spacecraft Materials
MISSE-12 (E)
NREP Inserts (E)**

Space Structure
ExHAM-Long Term Composite Reliability (E)

Spacecraft & Orbital Environments
RFID Logistics Awareness
RFID Recon
Space Debris Sensor
STP-H5 (E)
STP-H6 (E)
Teldasat ↑ *

Educational & Cultural Activities

Commercial Demonstrations
The ISS Experience*
ExHAM-Space Travel* ↑

Educational Competitions/Student Investigations
NanoRacks Module-9 ↓
ICE Cubes
Robo-Pro Challenge

Educational Demonstrations
XENOGRISS
NanoRacks Module-82 ↓
NanoRacks Module-86 ↓
ISS Ham Radio (ARISS)
Sally Ride EarthKam
AstroPi
ESA EPO
JAXA EPO

Student-Developed Investigations
HUNCH-Ball Clamp Monopod
HUNCH-Tape Dispenser
Faraday * **
Genes in Space-6

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

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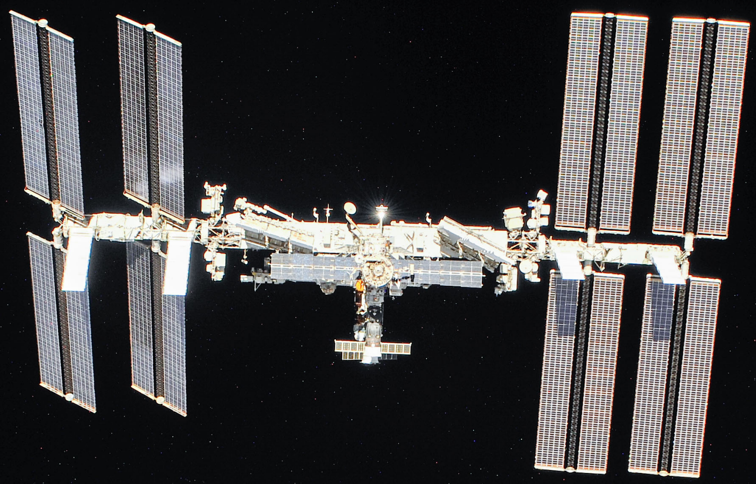
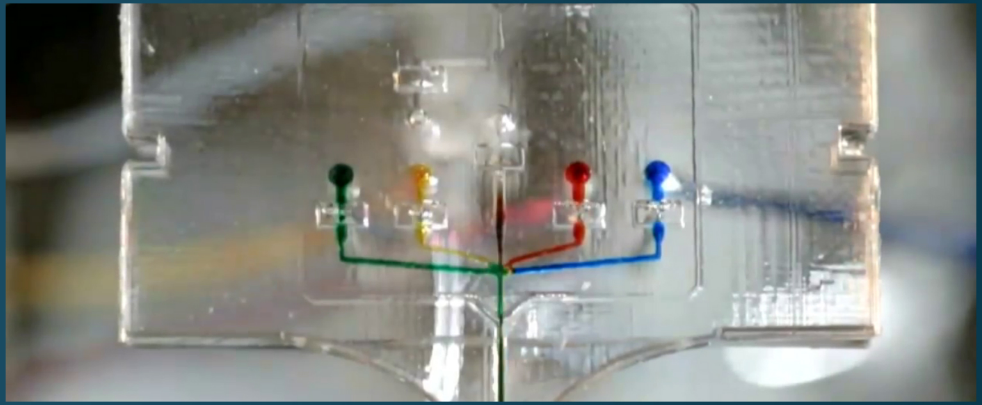


ISS National Lab Highlights

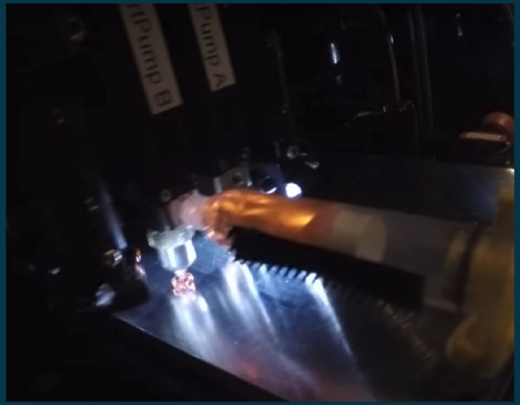
Featured Facility: Biofabrication Facility (BFF) by Techshot

- Imagine a 3D printer that deposits living cells rather than molten plastic.
- The cells need:
  - a fluid bath, provided by capillaries and internal passageways, to nourish them
  - a support scaffolding to hold the cells apart and give them surfaces to adhere to while growing
- BioPrinting of living cells into therapeutic tissues and possible replacement organs is a huge attraction for startups and venture capitalists
- Recent advances in learning how to stimulate and direct stem cell differentiation, mostly with timelined recipes of gene transcription factors, has made bioprinting possible with limited ground success.
- Gravity and the weight of the hydrogel passageways and bioink cells causes the passageways and cells to collapse.
- Experimentation in weightlessness with hydrogels that do not have to support weight should overcomes the collapsing problem and allow researchers to find the next hurdles in a progression towards successful BioPrinting.

TechShot Flight Hardware



Credit: Aspect Biosystems, LTD
https://www.youtube.com/watch?v=nbtz8fhhMhE&t=628s



TechShot 0-g test flight
https://www.youtube.com/watch?v=tAzcB_3dVzE

Featured Investigation: Pushing the Limits of Silica Fillers for Tire Applications by GoodYear Tire

- Tires are comprised of up to 60 different components, ranging from chemicals and fillers to multiple types of rubber and reinforcing cords.
- Silica is an additive (filler) that makes the tire more durable and wear resistant
- The Pushing the Limits of Silica Fillers for Tire Applications (Goodyear Tire) investigation evaluates creation of novel silica forms and structures, or morphologies, using traditional techniques to form silica fillers in microgravity.
- The space environment may yield results not possible in ground-based environments.
- Better understanding of silica morphology and the relationship between silica structure and properties may improve the silica design process as well as silica rubber formulation and tire manufacturing and performance on the ground.

Preflight image of silicas, a common element used in tires to help enhance performance in areas such as fuel efficiency and wet traction.

Independent Review Team (IRT) Status

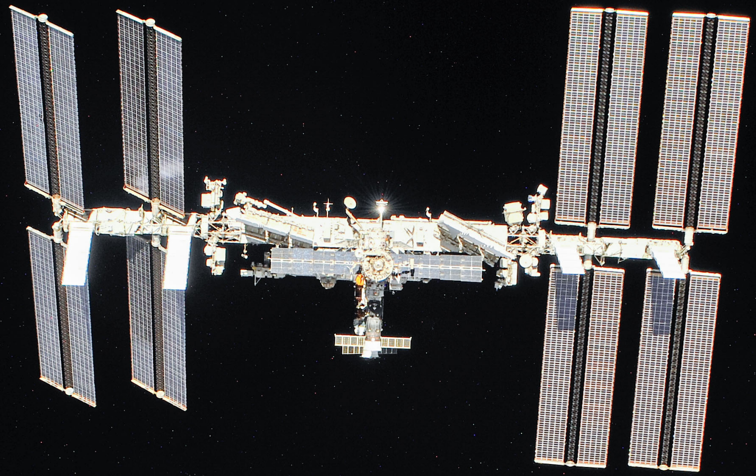
- The IRT met on October 7th at NASA Headquarters to interview representatives from OIG, SLSPRA, HEO, ISS Program, congressional staffers, OCT, ASGSR, NSpC and OMB
- Final report on findings is expected late December/early January

Membership:

- Chair: Elizabeth (Betsy) Cantwell – Chair; Senior Vice President, Research and Innovation at University of Arizona
- James Pawelczyk; Associate Professor of Physiology and Kinesiology at Pennsylvania State University
- Dr. George Poste; Chief Scientist, Complex Adaptive Systems; Regents' Professor and Del E. Webb Chair in Health Innovation at Arizona State University
- Tommy Sanford; Executive Director at Commercial Spaceflight Federation
- Christian Zur; Executive Director, Procurement and Space Industry Council, US Chamber of Commerce
- Peter Banks
- Al Sacco; Dean, Edward E. Whitacre Jr. College of Engineering, Texas Tech University

NASA Points of Contact

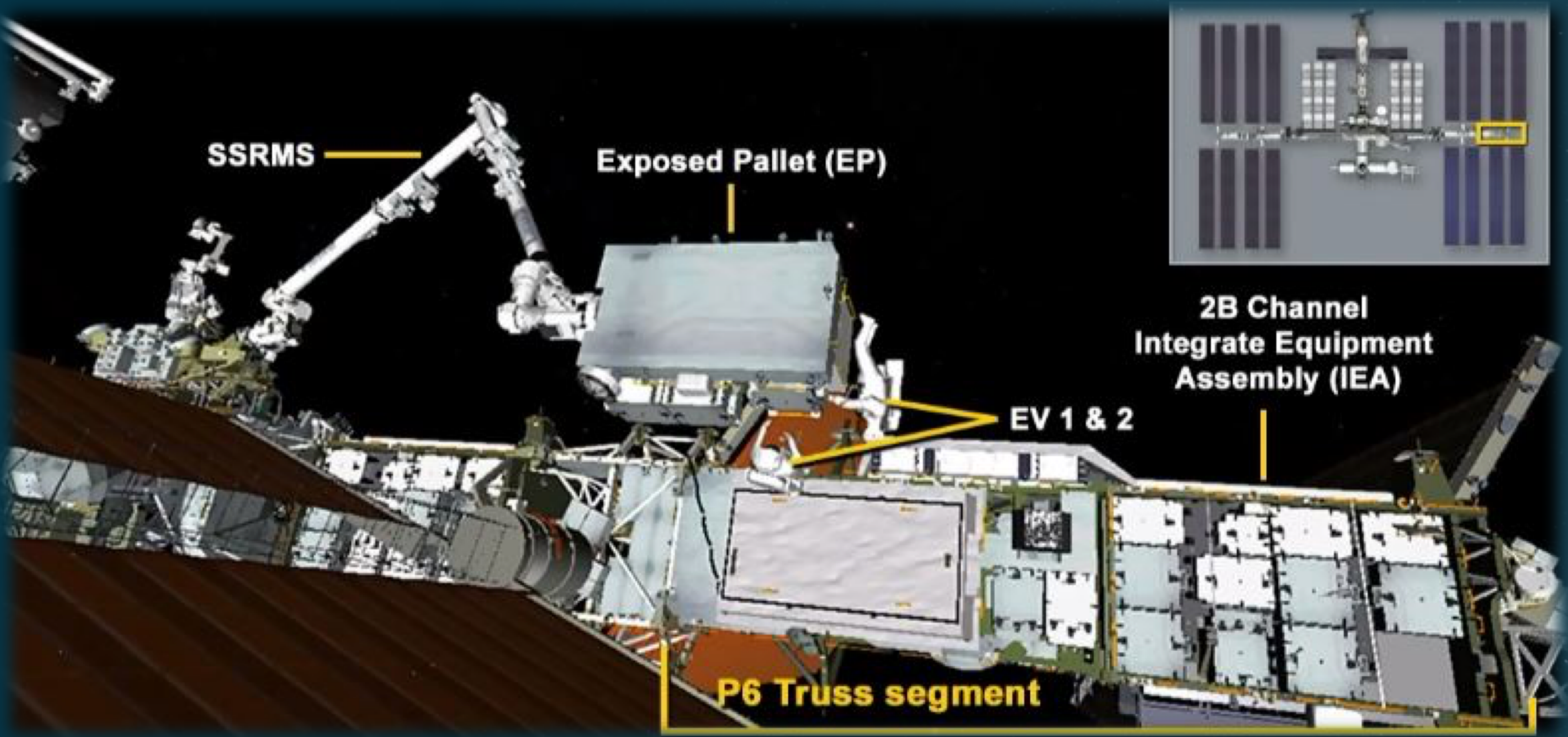
- Doug Comstock, Human Exploration and Mission Directorate, NASA Headquarters
- Ellen Gertsen - Executive Secretary/Task Manager; Executive Officer, NASA Science Mission Directorate
- Melissa (Missy) Gard, Contracting Officer Technical Representative for ISS National Laboratory, ISS Program, NASA JSC
- Grey Hautaluoma, Senior Public Affairs Officer, NASA Headquarters



ISS Operational Status

EVA Summary – P6 Battery Upgrade / BCDU R&R

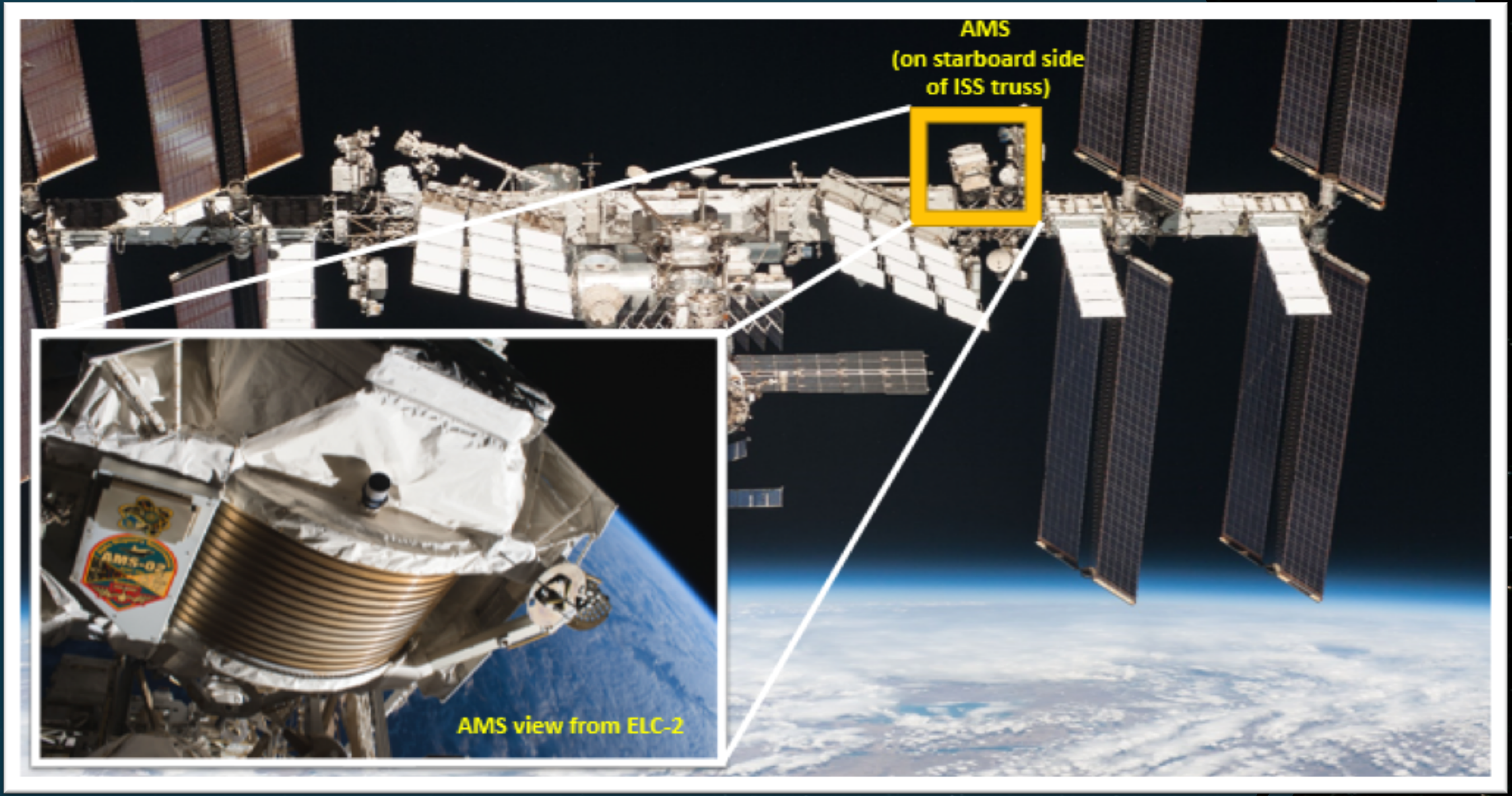
A series of five spacewalks was planned to replace 12 nickel-hydrogen (NiH2) batteries on power channels 2B and 4B of the P6 truss segment with six lithium-ion (Li-Ion) batteries and six battery adapter plates. The existing batteries will be upgraded with newer, more powerful batteries recently transported to the station and part of the overall upgrade of the station's power system that began with similar battery replacement during spacewalks in January 2017. The first two of these spacewalks was successfully completed in early October. However, the remaining three spacewalks are being rescheduled in order to first replace a Battery Charge / Discharge Unit (BCDU) that failed to activate following successful installation of the first set of Li-Ion batteries.



The new BCDU, hardware that regulates the amount of charge put into the batteries, was successfully replaced on October 18. This spacewalk also made history as the first all-woman spacewalk and was performed by NASA astronauts Christina Koch and Jessica Meir.

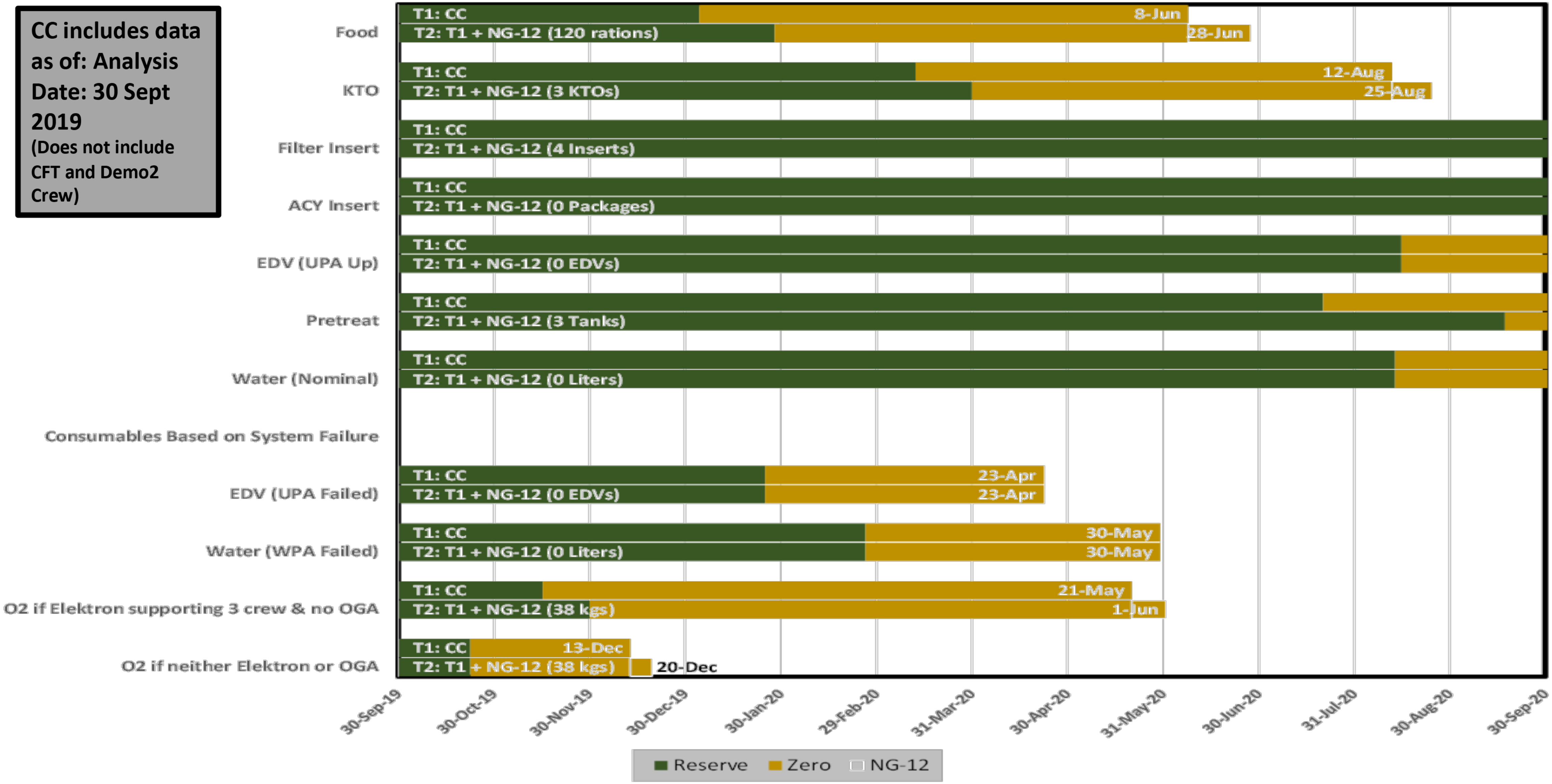
Upcoming EVA Overview – AMS Repair

This set of spacewalks will focus on repairs to the space station’s Alpha Magnetic Spectrometer (AMS), a renowned scientific instrument that explores the fundamental nature of the universe. The AMS Tracker Thermal Control System (TTCS) will be repaired due to degraded pumps and coolant leak. The pumps will be replaced with an external pump system (the Upgraded TTCS, or UTTCS) on the starboard side of the AMS. This complex and challenging set of tasks is expected to take five spacewalks, likely beginning in early November and continuing into early December.



Total Consumables

CC includes data as of: Analysis Date: 30 Sept 2019
(Does not include CFT and Demo2 Crew)



SpaceX CRS-17 Mission Success!

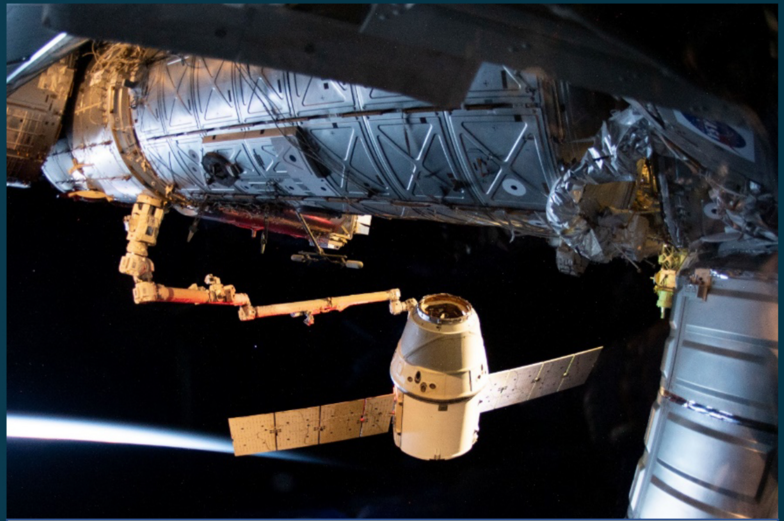
- Mission Planning
  - Launch 5/4/19 with berthing on 5/6
  - Unberth/Splashdown occurred 6/3/19

- Upmass – 2,815 kg manifested; Return/disposal – 2,747 kg

- Pressurized Cargo
  - Ascent: 1 Polar, 1 MERLIN, 1 JAXA MHU, 1 Kidney Cells, 1 PAUL
  - Return: 5 Polar, 1 JAXA MHU

- Unpressurized Cargo – all transfers completed by 5/13
  - Orbiting Carbon Observatory-3 (OCO-3)
  - Space Test Program-Houston6 (STP-H6)
  - Disposal: Cloud-Aerosol Transport System (CATS) & Space Communications and Navigation (SCaN)

SpaceX-17 Capture with Canadarm2 by astronaut David Saint-Jacques.
(image credit: NASA)



SpaceX-17 Release with Canadarm2 by astronaut David Saint-Jacques.
(image credit: NASA)

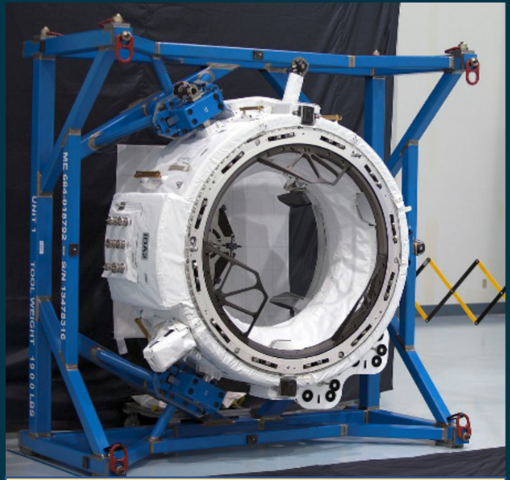
SpaceX CRS-18 Mission Success!

- Mission Planning
  - Launched 7/25/19 with capture on 7/27 and berthing 7/28
  - Unberth/splashdown occurred 8/27/19

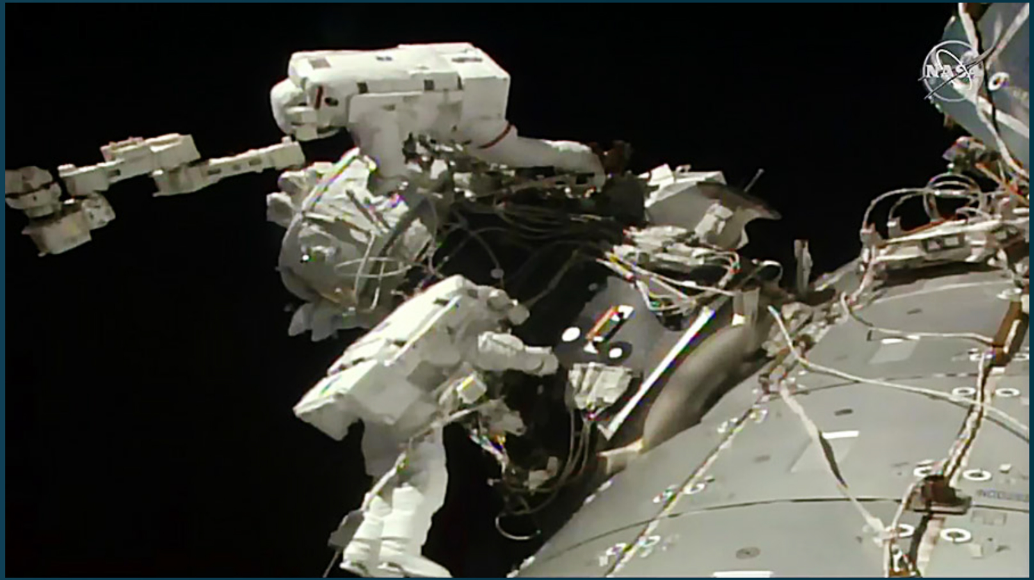
- Upmass – 2,196 kg estimated; Return/disposal – 2,500 kg estimated

- Pressurized Cargo
  - Ascent: 2 Polar, 2 AEM-T, Bioculture
  - Return: 4 Polar, 1 AEM-T, 1 MERLIN

- Unpressurized Cargo
  - International Docking Adaptor (IDA)-3
    - Installed via EVA on 8/21. Provides visiting vehicle docking capability for N2Z



IDA-3 upright



Spacewalkers complete installation of IDA-3 in August 2019.

Northrop Grumman CRS-11 Mission On-Orbit

- Mission Planning
  - Launched 4/17/19 with capture and berthing on 4/19/19
  - Unberth occurred 8/6/19
  - Following release from the ISS, the Cygnus spacecraft will remain in orbit until mid-December and will coincide with a second Cygnus spacecraft scheduled for launch in November. This feature is an example of how a commercially developed free flyer would facilitate research, experiments and other activities in Earth orbit.

- Upmass – 3,426 kg manifested; Disposal – 2,443 kg

- Pressurized Cargo
  - Ascent: 2 AEM-T units, 1 AEM-E unit, and 1 POLAR
  - First flight items: rodent capability, L-24 hour final cargo load, and scrub turnaround capability (48 hours)

- Unpressurized Cargo
  - Operations post ISS departure: Nanoracks External CubeSat Deployer, Seeker Payload (mass part of Nanoracks), CMG Experiment, Slingshot External Cubesat deploy

NG-11 Launch on 4/17/19

NG Antares Team Demonstrates New Capability to Load Cargo Just Before Launch

HTV-8 Mission On-Orbit

- Mission Planning
  - Launched 9/24/19 with capture and berthing on 9/28
  - The launch was originally scheduled for 9/10/19, but was postponed because of a fire at the mobile launch pad exit hole during the countdown operation.
  - Unberth planned for 11/1/19

- Upmass – 3793 kg manifested; Disposal - 2600 kg estimated

- Pressurized Cargo
  - Loaded two NORS tanks, one with Oxygen, one with Nitrogen and
  - 8 Water Storage System (WSS) tanks

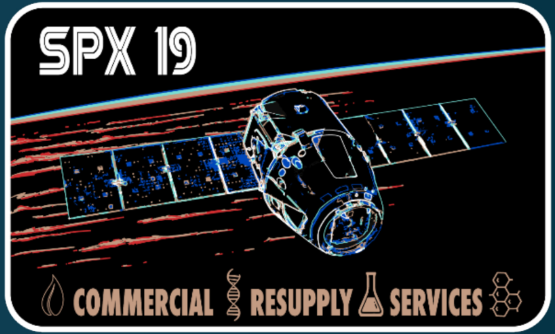
- Unpressurized Cargo
  - Launch: 6 Lithium-Ion batteries
    - All 6 Lithium-Ion batteries are installed on Exposed Pallet and fully charged
  - Disposal: 9 Ni-H2 Batteries

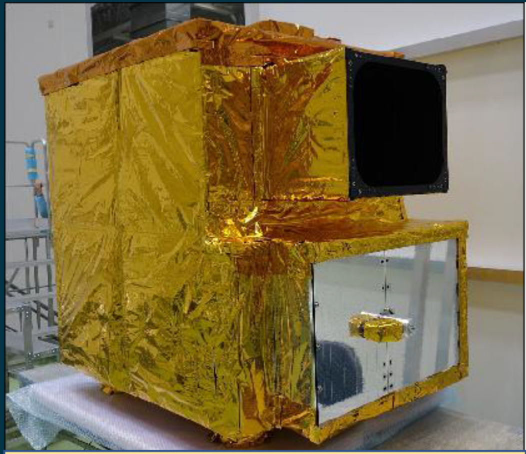
Exp 61 spacewalk to perform P6 Battery Upgrade


HTV-8 capture by Space Station Remote Manipulator System (SSRMS)

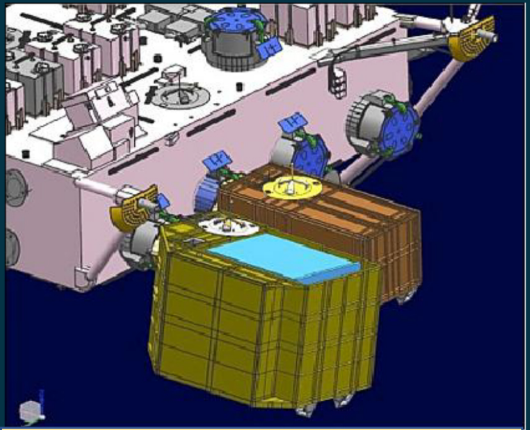
SpaceX-19 Mission Status

- Mission Planning
  - Launch, capture and berth planned for December 2019
  - Unberth/splashdown planned for January 2020
- Upmass – ~3310 kg planned; Return - 2500 kg estimated
- Pressurized Cargo
  - Ascent: 1 PAUL, 2 AEM-T, 3 Polar
  - Return: 1 Merlin, 2 AEM-T, 3 Polar
- Unpressurized Cargo
  - Ascent: Hyperspectral Imager Suite (HISUI) and 1 Lithium-Ion Battery
  - Disposal: BCDU FSE (Battery Charge/Discharge Unit Flight Support Equipment) plus ascent restraint for HISUI and Li-Ion Battery




HISUI Flight Model (image credit: HISUI Team)


Li-Ion Battery (image credit: NASA)


HISUI Exposed Payload System attached to ISS/JEM/EF (image credit: HISUI Team)

Northrop Grumman CRS-12 Status
1st CRS-2 Flight

- Mission Planning
  - Launch planned for 11/2/19 with capture and berthing on 11/4/19
  - Unberth planned for 1/13/20

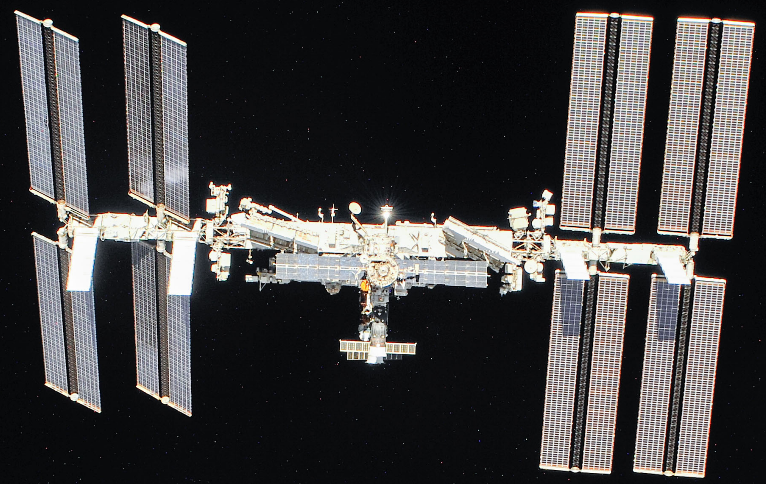
- Upmass – 3,726 kg manifested; Disposal – 3,700 kg estimated

- Pressurized Cargo
  - Ascent: 2 AEM-T units, 1 AEM-E unit, 2 POLARs, and 1 MERLIN
  - Final set of hardware to ISS in support of the EVAs to repair AMS
  - First flight items: Advanced Thermal Control Assembly (ATCA), Unpressurized Disposal, Additional MDL (Mid-deck Locker) capability, MDL Command & Telemetry, Scrub turnaround with 24-hr refresh capability

- Unpressurized Cargo
  - Operations post ISS departure: Nanoracks External CubeSat Deployer (NRCSD-E), SlingShot CubeSat Deployer (launched on SpX-19)

NG-12 Preparations
Sept 2019
(image credit: Northrop Grumman)

National Aeronautics and
Space Administration



ISS Transition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