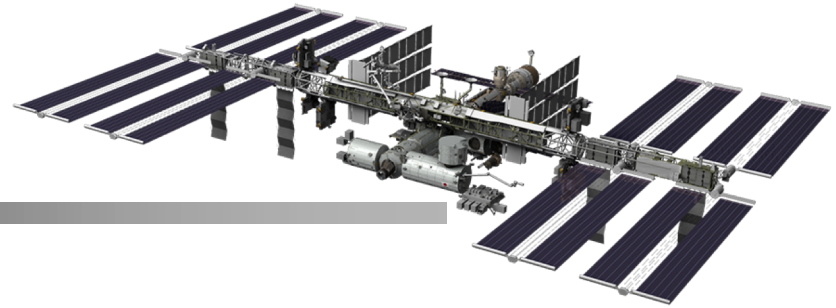


HEO NAC
International Space Station Status

Sam Scimemi- ISS Director
NASA Headquarters

August 2018

Agenda

- 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 56

- 06/03/18 – Soyuz 53S Undock/Landing (NASA/Tingle, Roscosmos/Shkaplerov, and JAXA/Kanai)
- 06/06/18 – Soyuz 55S Launch (NASA/Aunon-Chancellor, Roscosmos/Prokopev, and ESA/Gerst)
- 06/08/18 – Soyuz 55S Docking
- 06/14/18 – US EVA 51
- 06/29/18 – SpaceX CRS-15 Launch
- 07/02/18 – SpaceX CRS-15 Berthing
- 07/09/18 – Progress 70P Launch and Docking
- 07/15/18 – Northrop Grumman CRS-9 (NG-9) unberth
- 08/03/18 – SpaceX CRS-15 Release / Splashdown
- 08/15/18 – RS EVA 45
- 08/22/18 – Progress 69P Undock
- 09/10/18 – HTV-7 Launch
- 09/14/18 – HTV-7 Berth
- 10/04/18 – Soyuz 54S Undock/Landing (NASA/Feustel, NASA/Arnold, Roscosmos/Artemyev)

- 10/11/18 – Soyuz 56S Launch/Docking – Increment 57

- Two upcoming EVAs (tentatively late September)

Increment 56 Overview: Crew

54S Dock 3/23/18
54S Undock 10/4/18

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

Alexander Gerst
FE (E) – 55S
(CDR Inc 57)

55S Dock 6/8/18
55S Undock 12/13/18

Oleg Artemyev
Soyuz CDR (R) – 54S

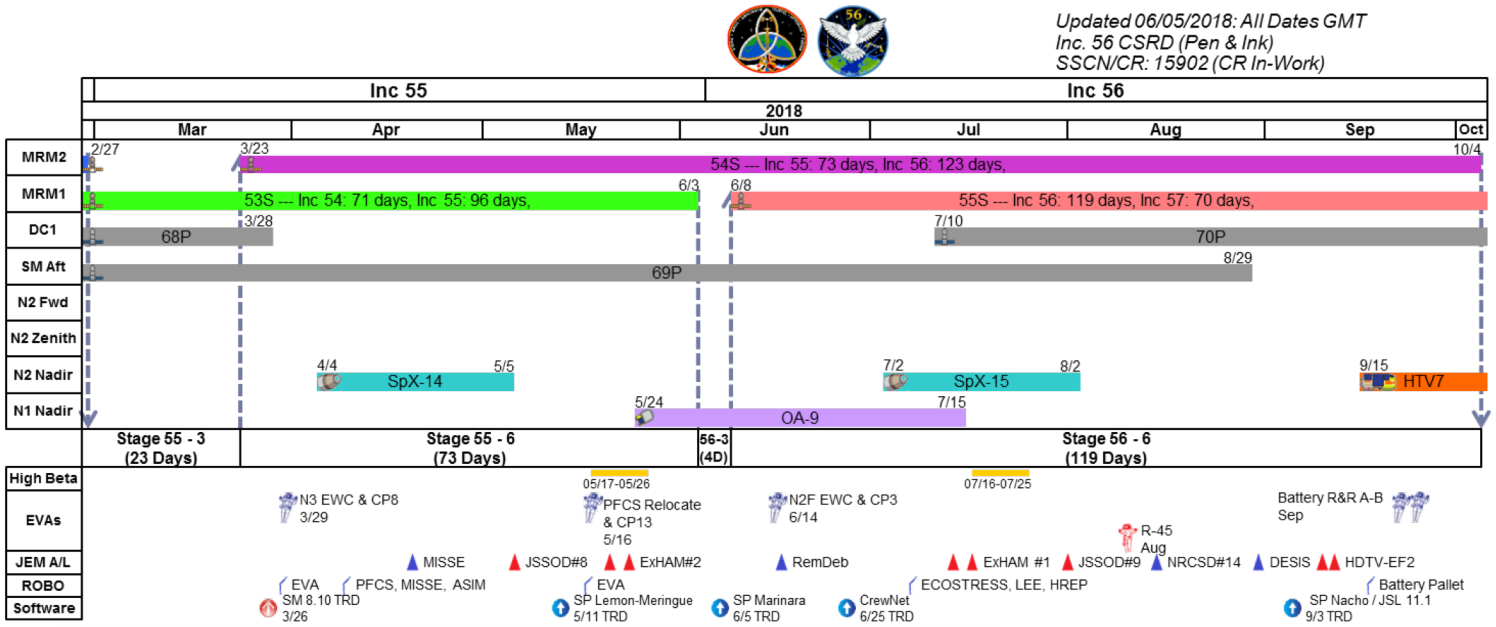
Sergey Prokopyev
Soyuz CDR (R) – 55S

Ricky Arnold
FE (US) – 54S

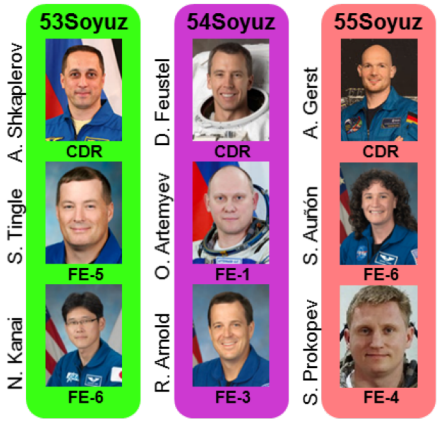
Serena Auñón-Chancellor
FE (US) – 55S

Increments 55 & 56

- Increment 56: 123 days
  - *Stage 56-3: 53S undock to 55S dock: 5 days*
  - Stage 56-6: 55S dock to 54S undock: 118 days
  - EVAs
    - *US EVA (6/14) N2 Fwd EWC, CP3 EHDC, CATS Aperture Door*
    - RS EVA (8/15) Satellite deploy, cable & antenna install
    - US EVA (9/23) P4 Battery R&R – 4A (HTV-7 EVA1)
    - US EVA (10/1) P4 Battery R&R – 2A (HTV-7 EVA2)
  - Visiting vehicles:
    - Progress 70P (Dock 7/10)
    - Progress 69P (Undock 8/29)
    - SpX-15 (Berth 7/2, Unberth 8/2)
    - OA-9 (Unberth 7/15)
    - HTV7 (Berth 9/15, Unberth 11/14)
  - Science/Utilization:
    - Augmented Utilization Hours
    - RR7
  - Maintenance/Outfitting:
    - UIA R&R (June) Upgraded Airlock Umbilical Interface Assy
    - Rack Relocations/Prep Work for HTV-7
    - LEE FSE Install/Return
  - Other:
    - Arcturus Deploy
    - EMU EVA Data Recorder Installation



	Increment 55	Increment 56
Utilization	✓ Probiotics (JAXA) ✓ SpX-14: APEX-06 ✓ SpX-14: Invitrobone (ESA) ✓ SpX-14: Mouse Stress Defense (JAXA) ✓ SpX-14: Metabolic Tracking ✓ OA-9: MSG VUE R&R	• Atomization (JAXA) • Fluid Shifts • GRIP/GRASP (ESA) • SUBSA • SpX-15: Rodent Research-7 • SpX-15: LT PCG#3 (JAXA)
	• Airway Monitoring (ESA) • ACME: E-Field Flames & CLD Flame • Marrow (CSA)	• JEM Camera Robot (JAXA) • OA-9: Barrios PCG • OA-9: Cold Atom Lab
JEM A/L Candidates	• NREP Mission 4 Transfer (TBD) • MBSU IFM	
EVA, Robotics, Systems, Software	✓ SpX-14: PFCS Xfer, ASIM Install, MISSE Install ✓ Linguini / Lemon Meringue Service Packs ✓ 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	• SpX-15: ECOSTRESS Install, LEE Xfer to ISS, HREP Dispose • Marinara Service Pack • JSL 11.1 Software Transition • HTV-7 Rack Arrival Prep • USOS EVA: N2F EWC • USOS EVA: P4 Battery R&R EVA 1 and 2 • UIA R&R **Pre-decisional, Internal Use Only**



IM - Todd Hellner (x31394), IDM - Jaime Marshik (x38796)
IE - Julie Dunning (x34360), Chris Fleming (x33019)
IPE - David Cook (x46387), CTE- Samantha Longwell (x48230)

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 for FY19:

Q1	Q2	Q3	Q4
• Thermal Amine • Spacecraft Fire Experiment (Saffire)-IV • Renal Ultrasound Autonomy • Refabricator	• Siloxane control technology • Spacesuit Evaporation Rejection Flight Experiment (SERFE) • Hybrid Electronic Radiation Assessor (HERA) • RFID Enabled Autonomous Logistics Management (REALM)-2	• Water Processor Multi-Filtration Bed Upgrade • Saffire-V • T2 Augmented Reality • Automous Mission Operations (AMO) Express 2.5 • DSG Uncrewed Operations (utilizing Astrobee)	• Mini CO2 scrubber (ISS)

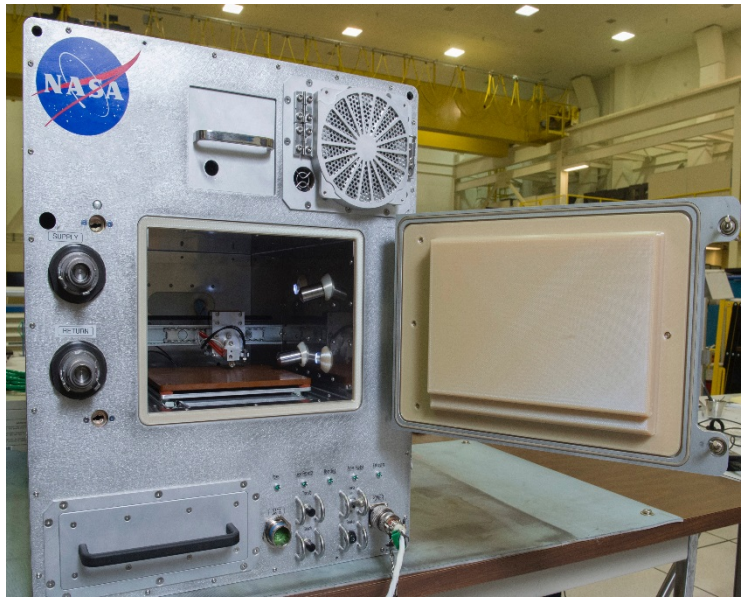
Featured Exploration Technology – Upcoming

Refabricator

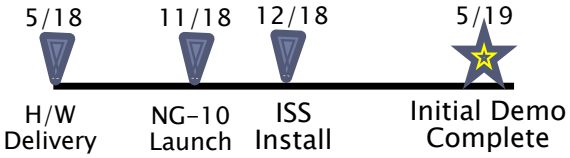
Demonstrating increased sustainability through on-demand manufacturing with an integrated , closed-Loop Recycler and 3D Printer

PM: Niki Werkheiser, NASA Marshall Space Flight Center, Huntsville, Alabama

- First integrated 3D Printer and Recycler (terrestrially or in space)
- The Refabricator will demonstrates the process of manufacturing parts, recycling them back into useable filament, and 'printing' new parts from the recycled feedstock
  - The technology demonstration includes a minimum of seven closed loop recycling/fabricating cycles with a goal of up to fourteen cycles.
  - Filament feedstock produced during each recycling process will be used to 3D print multiple tensile specimen and a plastic input block to be used in the next recycling process
  - Due to the patented extrusion process which doesn't require any grinding process like that traditionally used for recycling, little-to-no material degradation has been observed in the printed parts after multiple recycles in ground testing. The flight specimen will be returned for analyses and testing to determine what, if any, material degradation resulted from multiple recycles in microgravity.
- The payload is remotely operated from the ground with internal cameras for viewing the fabrication and recycling process real-time. The only required crew operation is for the crew to remove the parts and re-load the input block once each cycle, which can be task listed.
- Sponsored by HEOMD AES and STMD GCD
- Refabricator hardware development heavily leveraged the Small Business Innovative Research (SBIR) program via Phase I, II, II-E, and III SBIR awards to Tethers Unlimited, Inc. (TUI).
- Flight hardware has been turned with launch anticipated on NG-10 in November 2018



Refabricator Tech Demo and Ops Timeline



Note: Dates for ISS operations are estimates and may vary based on available ISS resources and priorities.

Featured Investigation Utilization – Completed

Angiex Cancer Therapy

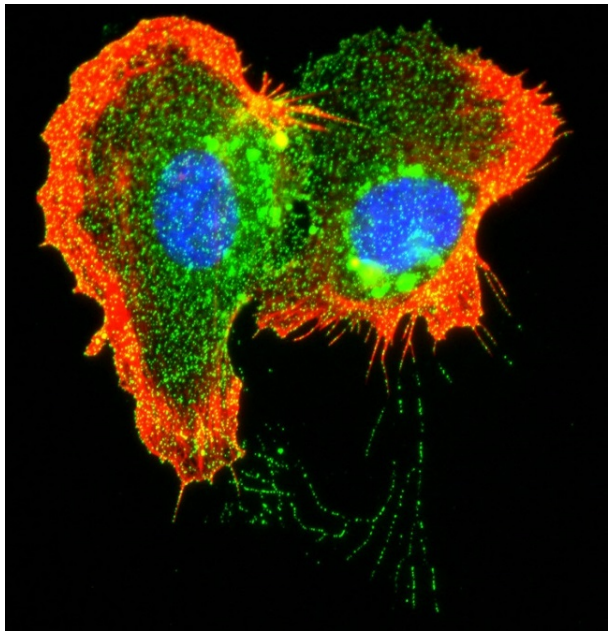
Endothelial Cells in Microgravity as a Model System for Evaluation of Cancer Therapy Toxicity

Principal Investigator: Shou-Ching Jaminet, Angiex inc

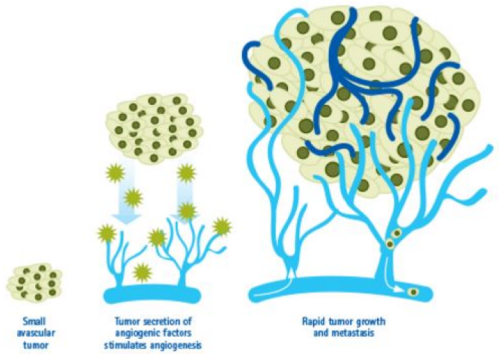
Sponsor: NASA/National Lab

Research Summary

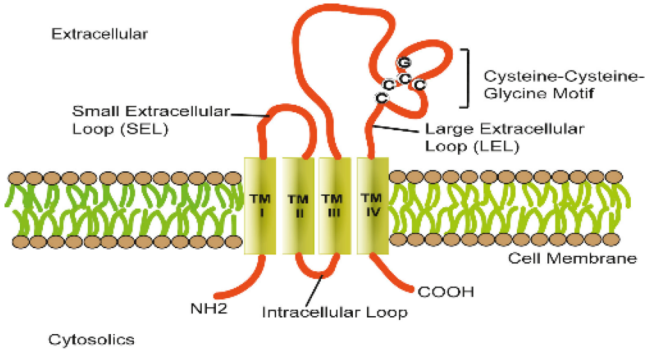
- Launched on SpX-15, this investigation examines whether endothelial cells, cultured in microgravity represent a valid *in vitro* model to test effects of vascular-targeted agents on normal blood vessels.
- Angiex has developed a treatment that targets both tumor cells and vasculature, but needs a better model on which to test it.
- The study may facilitate a cost-effective method that does not require animal testing and which may help develop safer and more effective vascular-targeted drugs.



Endothelial cells produce high levels of TM4SF1 (green) in order to engage in movement, proliferation, and intercellular interactions. [Image courtesy of Angiex]

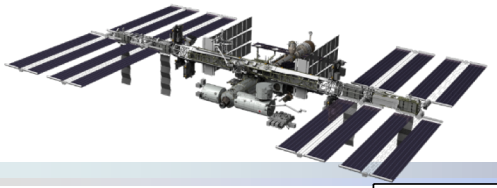


Angiogenesis in Cancer. [From Sigma-Aldrich / Millipore-Sigma, Angiogenesis Assays]



Structure of Tetraspanins. [From Yang, Y.-G. *et al.,* Experimental Hematology 2016, 44:322-328]

Angiex's anti-TM4SF1 cancer drug effectively regresses human tumors implanted into the flank of nude mice. [Image courtesy of Angiex]



HRP Path to Risk Reduction

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	SS 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 End

ISS Required
ISS Not Required
Milestone Requires ISS
Ground-based Milestone
ISS Mission Milestone
Exploration Mission Milestone
- Anticipated Milestone Shift

High LxC
Mid LxC: Requires Mitigation
Mid LxC: Accepted
Low LxC
Optimized
Insufficient Data

18 May 2018

Future ISS HRP Work

Exploration Autonomous Medical Care Capability

Extreme remoteness of Mars missions with no return/medevac and significant communication delays drives the need for almost complete autonomy in all aspects of medical care

- Smart medical image algorithms and artificial intelligence for assessment of medical conditions and decision support
- Virtual reality capability for real-time treatment training
- Ambulatory real-time monitoring system that can be worn under a spacesuit
- Advanced ultrasound technology that can both image and manipulate kidney stones

Advanced ultrasound technology to diagnose and treat kidney stones during spaceflight

Exploration Food System Capability

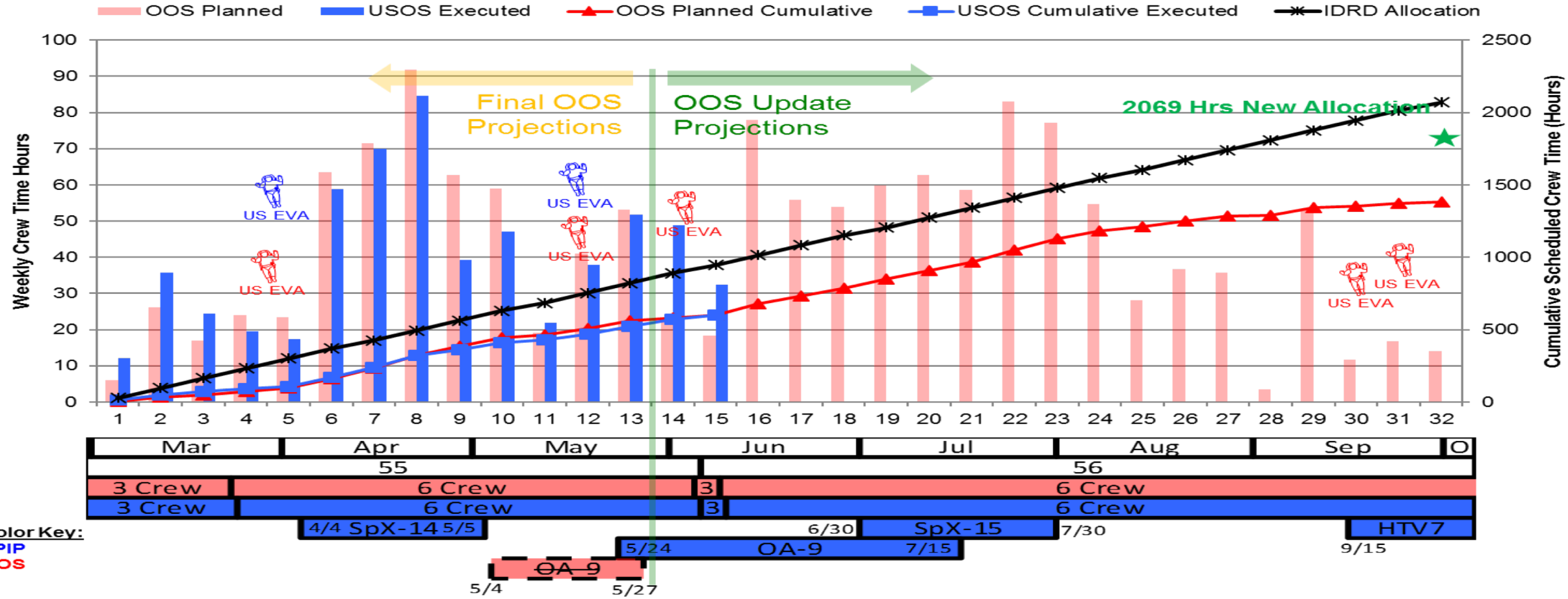
Mars Mission food system is challenging — 4 crewmembers/3 years requires approximately 23,000 lbs. of food with packaging, no resupply, limited refrigeration

- Food is critical to crew health — physiological well-being (calories, nutrition, bioactive compounds from fresh foods) and psychosocial well-being (meals)
- Optimize ISS fresh food production system (salad crops) for Mars missions
- Demonstrate 5-year shelf life packaged food with reduced mass, while maintaining safety, acceptability, and nutritional content
- Demonstrate automated food processing and printing systems — allows precision nutrient addition and personalized nutrition

Astronaut Joe Acaba harvests crops from Vegetable Production System

Utilization Summary

Inc 55/56 Utilization Crew Time



Executed through Increment Wk (WLP Week) 15 :	14.2	of 30.2 work weeks	(47.0% Complete)
USOS Actuals:	601.58	hours -> 42.37 hours/week	
USOS IDRD Allocation:	2,068.90	hours-> 68.51 hours/week	(29.1% Complete)
OOS USOS Planned Total:	1,384.00	hours (Final OOS 1203.81)	(43.5% Complete)
Voluntary Science Totals to Date:	0	hours (not included in the above totals or graph)	
RSA/NASA Joint Utilization to Date:	10.58	hours (not included in the above totals or graph)	

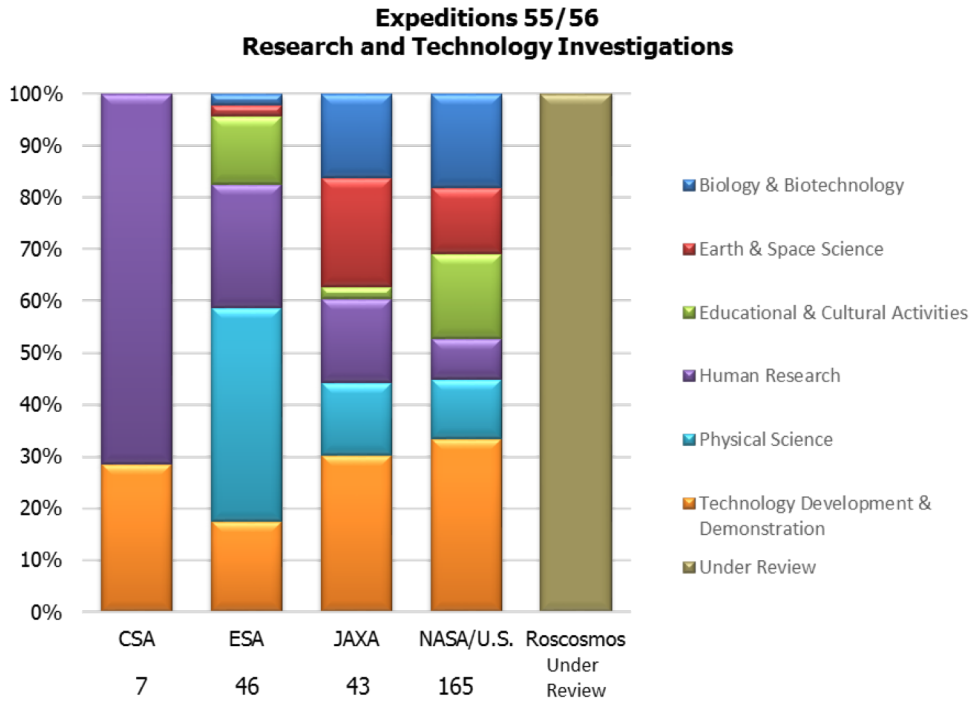
Pre-Decisional, For Internal Use Only
12-Jun-18

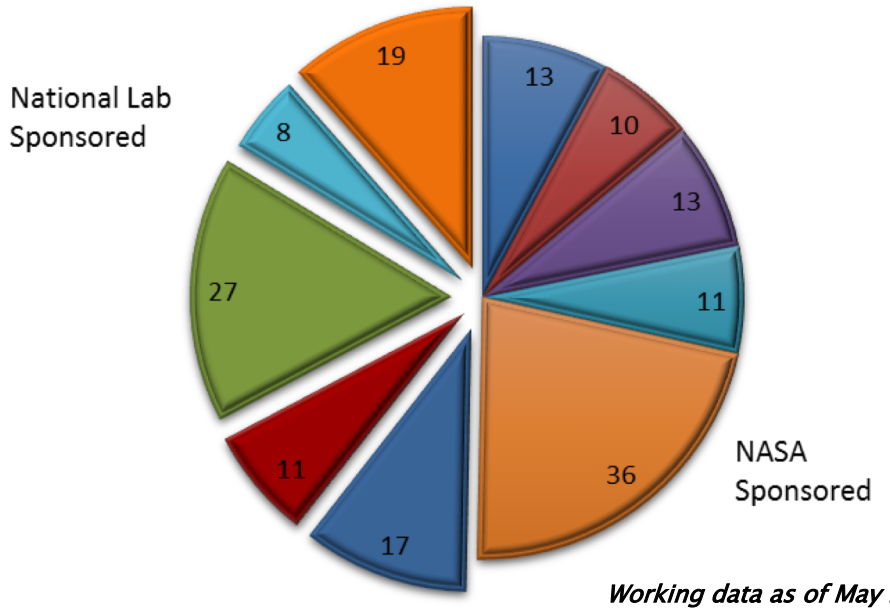
ISS Research Statistics

- **Number of Investigations for 55/56: 261**
  - 165 NASA/U.S.-led investigations
  - 96 International-led investigations
  - 105 New investigations
    - 1 CSA
    - 16 ESA
    - 7 JAXA
    - 81 NASA/U.S.

ISS Lifetime

- Estimated Number of Investigations Expedition 0-56: 2606*
- 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)

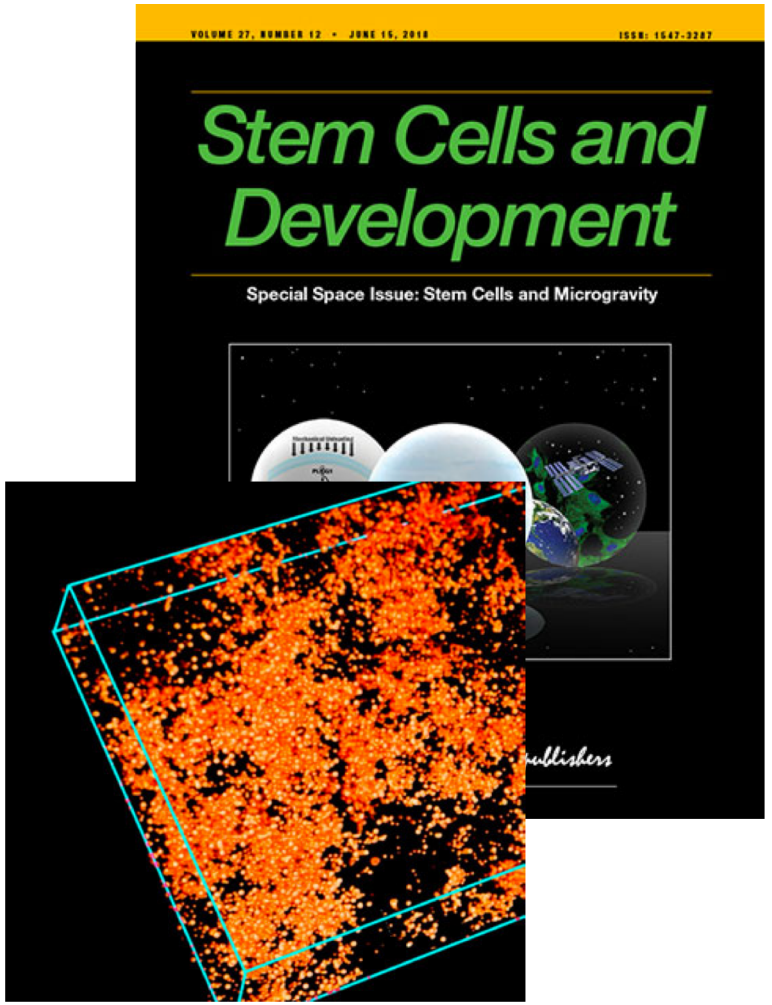




*Working data as of May 31, 2018**
Pending Post Increment Adjustments

FY18 ISS National Lab: Customer successes

- **3 patent applications** from P&G were published as a result of ISS National Lab R&D, related to product development and shelf life
- A **patent application** was published related to ZBLAN production on the ISS by Fiber Optics Manufacturing in Space
- Made in Space completed **1st demo for ZBLAN manufacturing** in space
- In June, **Apple (#4 on Fortune's 500)** previewed new aerial images of Earth, taken from the ISS (expected release Fall 2018)
- **12 new academic journal articles** from CASIS-sponsored R&D
  - Mostly cell culture & rodent research, with **one student-authored paper**
  - A **special issue of *Stem Cells and Development*** also highlighted results from ISS National Lab investigations



Increments 55 & 56 Research Plan - Investigation List

Human Research

Bone & Muscle Physiology
Brain-DTI (P),
Myotones,
TIME,
Marrow,
TBone (P),
Medical Proteomics

Cardiovascular & Respiratory Systems
Airway Monitoring,
Metabolic Space,
Vascular Echo,
Cerebral Autoregulation,
IPVI

Crew Healthcare Systems
Medical Consumables Tracking

Habitability & Human Factors
Soyuz Occupant Risk (P)

Human Behavior & Performance
Lighting Effects,
Team Task Switching,
Circadian Rhythms,
PERSPECTIVES↑,
Space Tex-2,
At Home in Space,
Cell-Free Epigenome

Immune System
Functional Immune,
Multi-Omics,
Probiotics

Integrated Physiology & Nutrition
Biochem Profile,
Food Acceptability,
Repository

Nervous & Vestibular Systems
Field Test (P),
NeuroMapping,
GRASP, GRIP,
Space Headaches
Wayfinding (P),
Labyrinth (P)

Vision
Fluid Shifts,
One-Carbon Expansion (P)

Other
Patterns↑

Prime (hrs) = 252, Reserve (hrs) = 21

Educational & Cultural Activities

Classroom Versions of ISS Experiments
NanoRacks Vuze Camera, Windows on Earth

Educational Competitions
CASIS PCG 9, NanoRacks Module-9, SPHERES-Zero-Robotics

Educational Demonstrations
ISS Ham Radio, Sally Ride EarthKAM,
Story Time From Space, AstroPI,
ESA-EPO-Flying Classroom 2,
ESA EPO Generic Videos,
ESA-EPO-GERST/Earth Guardian Seeds

Student-Developed Investigations
Genes in Space-5
NanoRacks-DreamXCG, Payload Card-6**

Other
ESA-EPO-TASK-LIST,
JAXA EPO

Prime (hrs) = 43, Reserve (hrs) = 43

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

Key New User Outreach Engagements – 3 Month View

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		
September	October	November
Silicon Valley Salon Silicon Valley, CA	**IBM IoT Keynote Presentation -** IBM Watson Research Center, Yorktown, NY	**ASGSR Customer Meetings**
IRI Fall Networks Meetings Cleveland, OH	**Geo for Good User Summit** (Google) Sunnyvale CA	**Destination Station (Pittsburgh, PA)**
NIH Tissue Chip Consortium Bethesda, MD	**Satellite Innovation 2018** Mountain View, CA	
Southern Company Birmingham, AL	**Pathways to a Space Economy**, NYC	
	Biomedical Engineering Society (BMES) Atlanta, GA	
	Harvest Summit, CA	**PANTHEON 2018 California Life Sciences Association** San Francisco, CA
	Oceans Conference Charleston, SC	

Increments 55 & 56 Research Plan - Investigation List

Technology Development and Demonstration

Air, Water, and Surface Monitoring
Aerosol Samplers*, DUST, WISENET

Avionics & Software
Spaceborne Computer, STP-H5 CSP (E), STP-H5 Space Cube-Mini (E), Telescience Resource Kit, Honeywell-Morehead-DM-7↓, SG100 Cloud Computer

Characterizing Experiment Hardware
BPC-1, MVP Fly-01, Barrios PCG, WetLab-2 Parra, NanoRacks Module-76, NanoRacks-Remove Debris, MVIS Controller-1

Commercial Demonstrations
SPHERES RINGS↓, Made in Space Fiber Optics 2, Made in Space Fiber Optics 3*, Mobile Companion (CIMON)

Communication & Navigation
Sextant Navigation, SCAN Testbed (E), MOBIPV, Vessel ID System

Food & Clothing Systems
ISSpresso↓

Life Support Systems & Habitation
MED-2, Thermal Amine System, UBNT, Nano-bubble Demo↓

Microbial Populations in Spacecraft
MATISS

Radiation Measurements & Shielding
Active Tissue Equivalent Dosimeter, FNS, Miniaturized Particle Telescope, Radiation Environment Monitor, STP-H5 RHEME (E), Radi-N2, Area PADLES-19, PS-TEPC

Repair & Fabrication Technologies
AMF-ABS Design Values, MICS

Robotics & Imaging
HDEV* (E), Moon Imagery, Robonaut↓, STP-H5 Raven (E), NanoRacks-CID↓, SUPVIS-JUSTIN, HDTV-EF2, JEM Internal Ball Camera

Small Satellites & Control Technologies
SmoothNav, NanoRacks Module-63↓, SPHERES Tether Slosh

Spacecraft & Orbital Environments
RFID Logistics Awareness, Space Debris Sensor (E)*, STP-H5 APS (E), STP-H5 GROUP-C (E) STP-H5 iMESA-R (E), STP-H5 LITES (E)

Space Structures & Spacecraft Materials
BEAM, STP-H5 ICE (E), STP-H5 SHM (E)

Thermal Management Systems
STP-H5 EHD (E), Payload Card-6**

Other
MarconISSta, Wireless Compose, Spirits Maturation

Prime (hrs) = 195, Reserve (hrs) = 93

Facilities

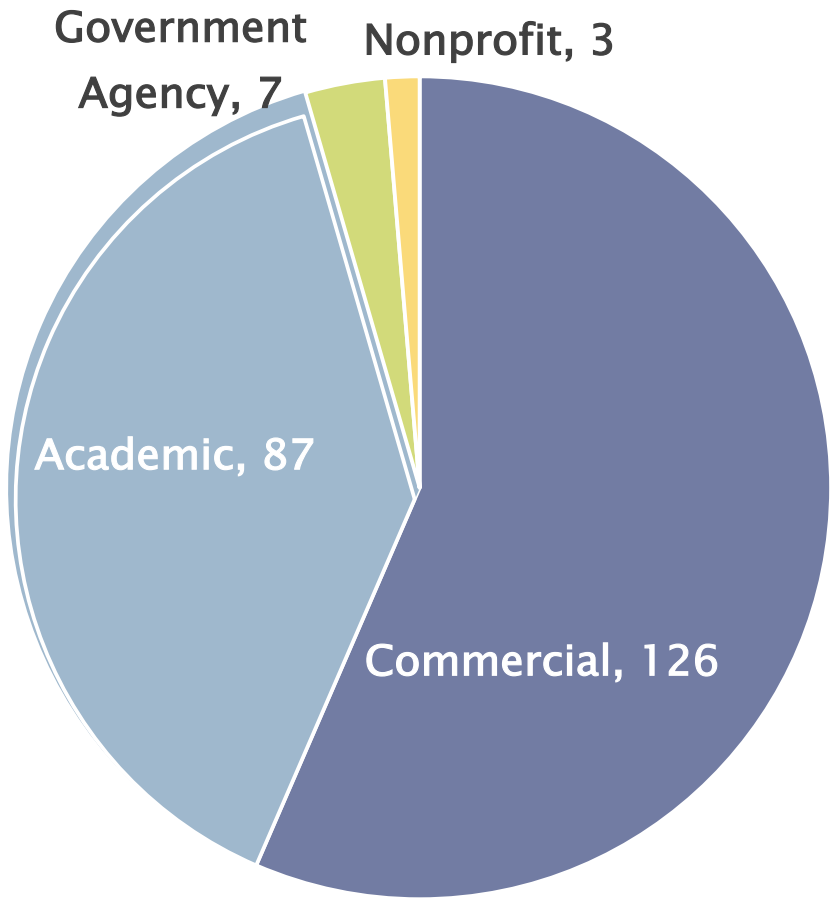
Cold Atom Lab, Mass Measurement Device, Plant Habitat, Spectrum, Manufacturing Device, MISSE-FF (E), MUSES (E), MVP, NanoRacks-extCygnus-NRCSD, NRCSD #14, NanoRacks Plate Reader, ExHAM#1-#2 (E), J-SSOD #8-#9

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

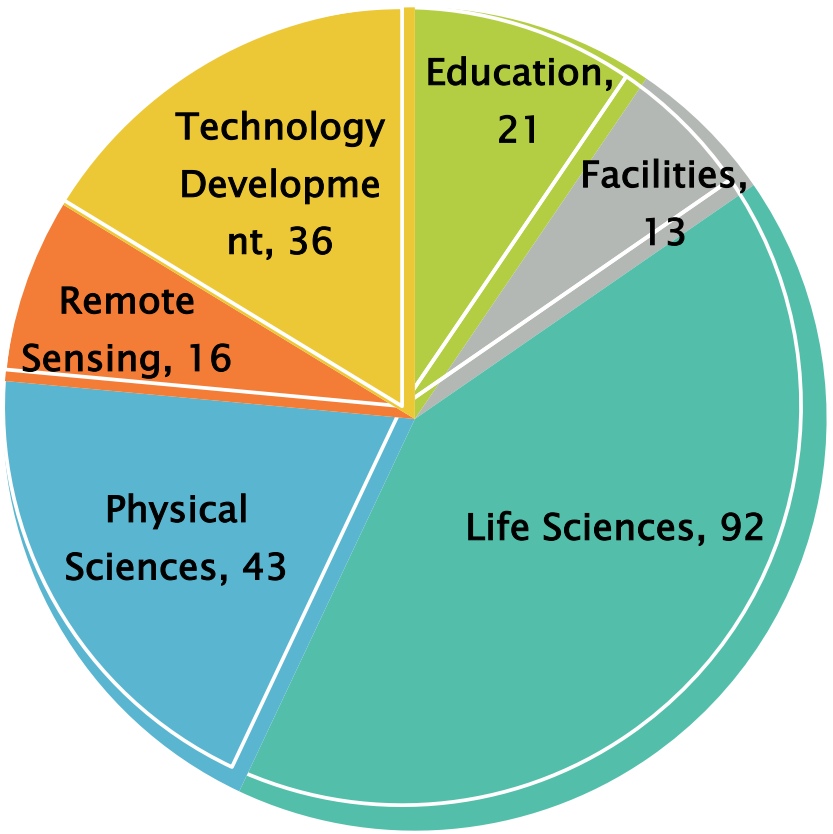
National Lab and CASIS Highlights

ISS National Lab: Portfolio to date



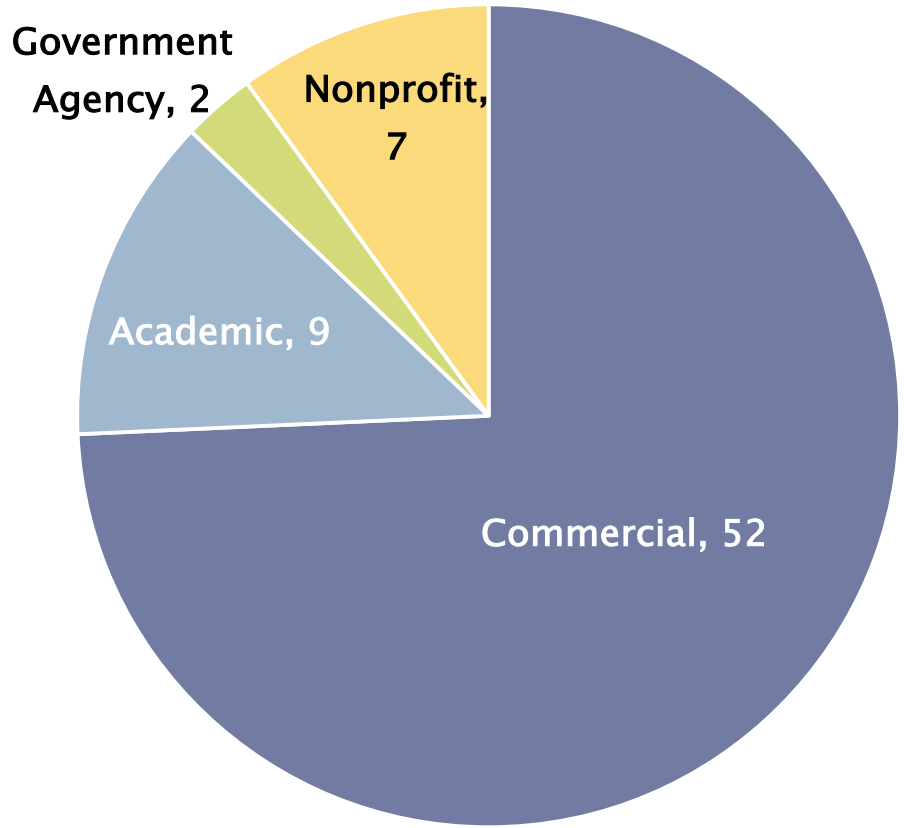
- Funding in support of this R&D:
  - **~$40M CASIS** funding (50%+ dedicated to Implementation Partners)
  - **$143M+ external** (non-CASIS, non-NASA) funding
- 40% of portfolio originated from Sponsored Programs
  - ~15% startups (via MassChallenge Accelerator Program)
- **FY18 new projects (YTD)**
  - **58% Commercial**
  - **$14.6M in external funding**

ISS National Lab: Portfolio to date (2)



- Key focus areas within the portfolio (approx. percent):
  - Sustainability (15%)
  - Tissue Engineering (15%)
  - Crystal Growth (10%)
  - Advanced Materials (5%)
  - Rodent Research (5%)

FY18 ISS National Lab: Payloads launched

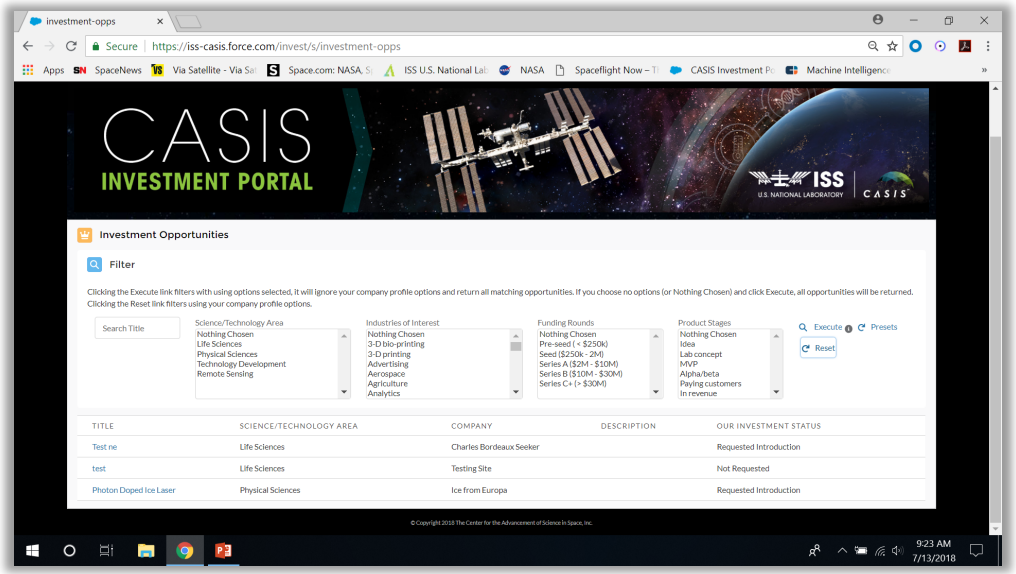


- 5 launches delivered 70 payloads (many containing multiple projects)
- Includes **two new commercially operated facilities**:
  - Multi-use Variable-gravity Platform (MVP), operated by Techshot, Inc.
  - Materials ISS Experiment Flight Facility (MISSE-FF), operated by Alpha Space Test and Research Alliance
  - *The ISS National Lab now houses 14 commercially operated facilities managed by 8 companies*

FY18 ISS National Lab: Customer/partner update

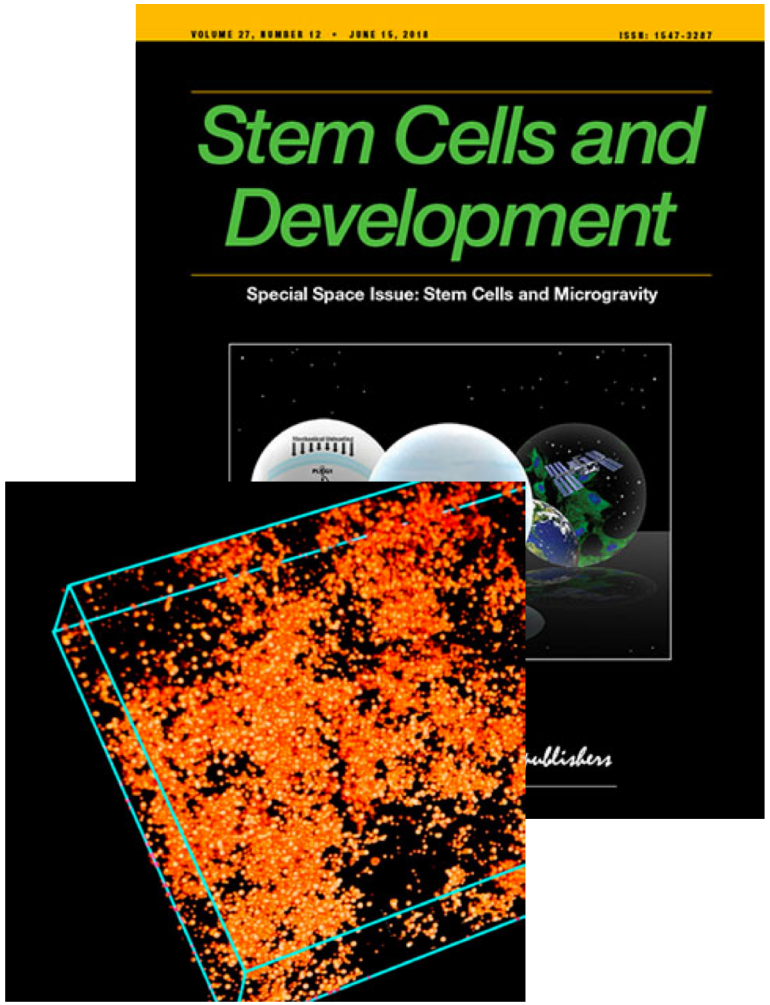
- Commercial: **IBM, Sanofi Pasteur, Lockheed Martin, Harris**
- Also National Cancer Institute, Frederick National Lab, Caltech, Stanford, Clemson
- New partnerships formalized with **Bigelow, Axiom, and Sierra Nevada**
- **Target Corp.** completed the first fully funded commercial Sponsored Program
- A CASIS-hosted Implementation Partner Portal has been operational since April and has 40+ active registered users
- A CASIS-hosted Investment Portal is also now live

ISS Cotton Sustainability Challenge



FY18 ISS National Lab: Customer successes

- **3 patent applications** from P&G were published as a result of ISS National Lab R&D, related to product development and shelf life
- A **patent application** was published related to ZBLAN production on the ISS by Fiber Optics Manufacturing in Space
- Made in Space completed **1st demo for ZBLAN manufacturing** in space
- In June, **Apple (#4 on Fortune's 500)** previewed new aerial images of Earth, taken from the ISS (expected release Fall 2018)
- **12 new academic journal articles** from CASIS-sponsored R&D
  - Mostly cell culture & rodent research, with **one student-authored paper**
  - A **special issue of *Stem Cells and Development*** also highlighted results from ISS National Lab investigations



ISS U.S. NATIONAL LABORATORY

UPCOMING EVENTS PRESENCE CALENDAR

FY2019 Q1-Q2

CASIS

OCTOBER

S	M	T	W	Th	F	Sa
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23 OCEANS	24	25	26	27
28	29	30	31			

NOVEMBER

S	M	T	W	Th	F	Sa
				1	2 ASGSR	3
4	5	6	7	8	9	10
		DS - Pittsburgh				
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	
		SpaceCom				

DECEMBER

S	M	T	W	Th	F	Sa
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	*20*	21	22
23/30	24/31	25	26	27	28	29

JANUARY

S	M	T	W	Th	F	Sa
		1	2	3	4	5
6	7	8	9	10	11	12
		CES - Vegas				
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

FEBRUARY

S	M	T	W	Th	F	Sa
					1	2
3	4	5	6	7	8	9
10	11	12 IBM Think	13	14	15 AAAS	16
17	18	19	20	21	22	23
24	25	26	27	28		

MARCH

S	M	T	W	Th	F	Sa
					1	2
3	4	5	6 DS - Dallas	7	8	9
10	11 SXSW	12	13	14	15	16
17	18	19	20	21	22	23
24/31	25	26	27	28	29	30

Key New User Outreach Engagements – 3 Month View

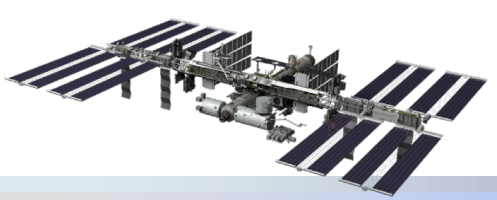
ISS U.S. NATIONAL LABORATORY

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.

CASIS

2018		
September	October	November
Silicon Valley Salon Silicon Valley, CA	**IBM IoT Keynote Presentation -** IBM Watson Research Center, Yorktown, NY	**ASGSR Customer Meetings**
IRI Fall Networks Meetings Cleveland, OH	**Geo for Good User Summit** (Google) Sunnyvale CA	**Destination Station (Pittsburgh, PA)**
NIH Tissue Chip Consortium Bethesda, MD	**Satellite Innovation 2018** Mountain View, CA	
Southern Company Birmingham, AL	**Pathways to a Space Economy**, NYC	
	Biomedical Engineering Society (BMES) Atlanta, GA	
	Harvest Summit, CA	**PANTHEON 2018 California Life Sciences Association** San Francisco, CA
	Oceans Conference Charleston, SC	

ISS Operational Status

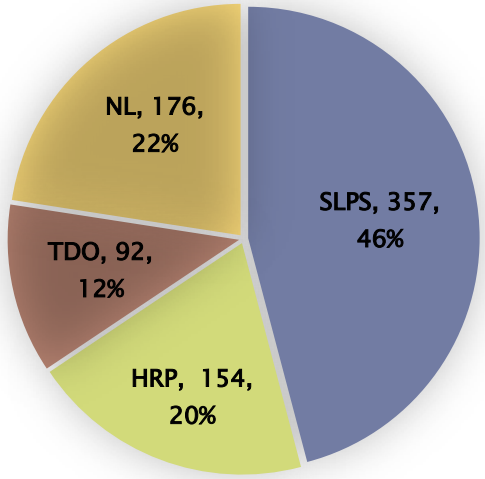


Increment 55/56 (March '18–October '18) Crew Time by Sponsor

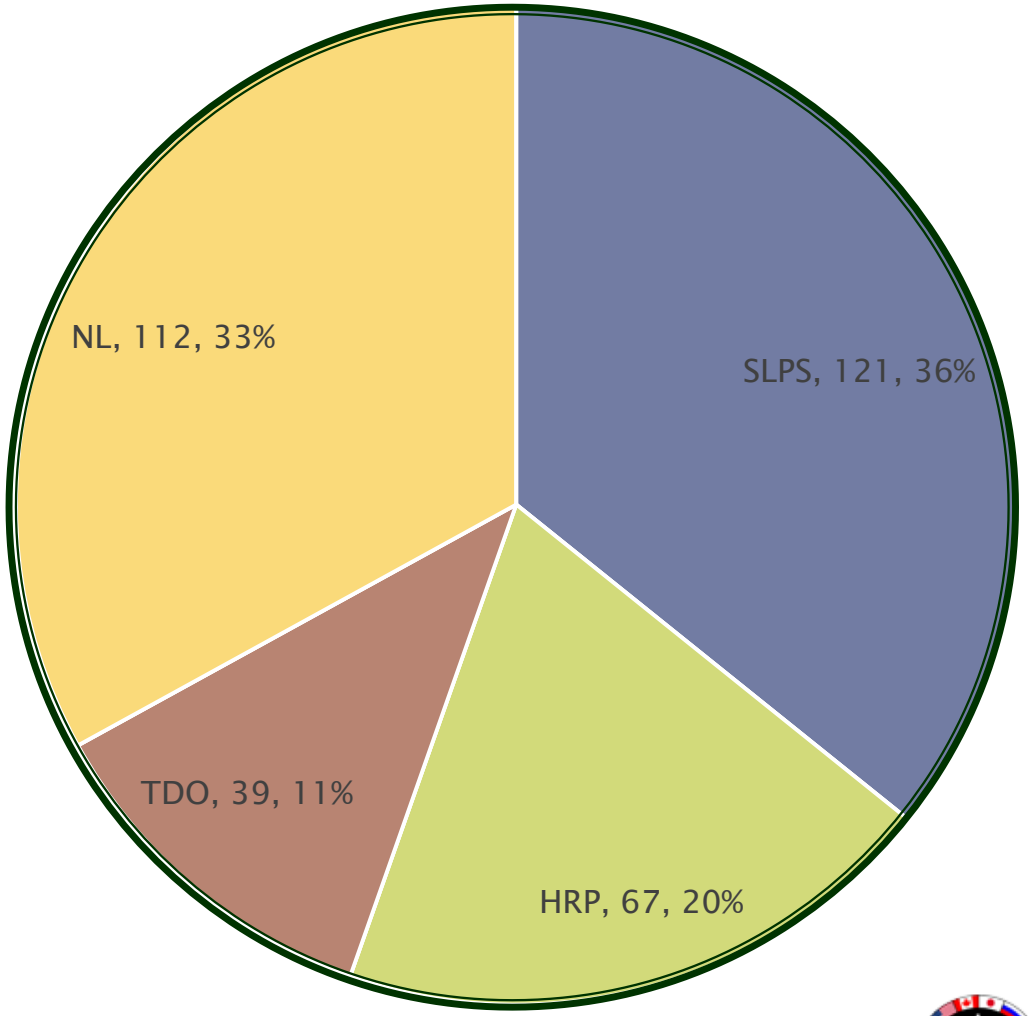
- Enablers
  - Russian Crew Time for EarthKam (NL), SPHERES Zero Robotics (NL), ACME E-Fields & CLD Flame (SLPS), EML (ESA)
  - 4th USOS Crew member
  - Increase of 112 crew days (54 Soyuz extension to Oct 4, 2018)
- Challenges
  - Lack of operationally-ready reserve complement
  - Continuous Research Planning is enabling investigations to be added later in the flow and thus reflects a lower National Lab percentage planned crew time at this time, which is anticipated to increase as National Lab investigations continue to be added to the Research Plan
  - Utilization hardware anomalies
- Delta Explanations
  - Additional 2 USOS EVAs with 54 Soyuz extension and more HTV-7 activities

March '18– October '18	Planned	Actual (6/1)
Research Hours	779	339
Total Crew Days (USOS)	454	220
Cargo Flights	SpX-14 OA-9 SpX-15	SpX-14 OA-9
# EVAs	3	3
Russian Crew hours	TBD	9.25

Planned Hours



Actual Hours as of 6/1



*Hatched wedges indicate increase from plan

Recently Completed US EVAs

US EVA 50 (05/16/2018)

- EV1/Feustel, EV2/Arnold
- **Primary Tasks included:**
  - A swap of the on-board Pump/Flow Control Subassemblies (PFCS)
  - Removal and Replacement (R&R) of Camera Port #13 on External TV Camera Group (ETVCG)
  - R&R of degraded Space to Ground Transmitter Receiver Controller (SGTRC)

US EVA 51 (06/14/2018)

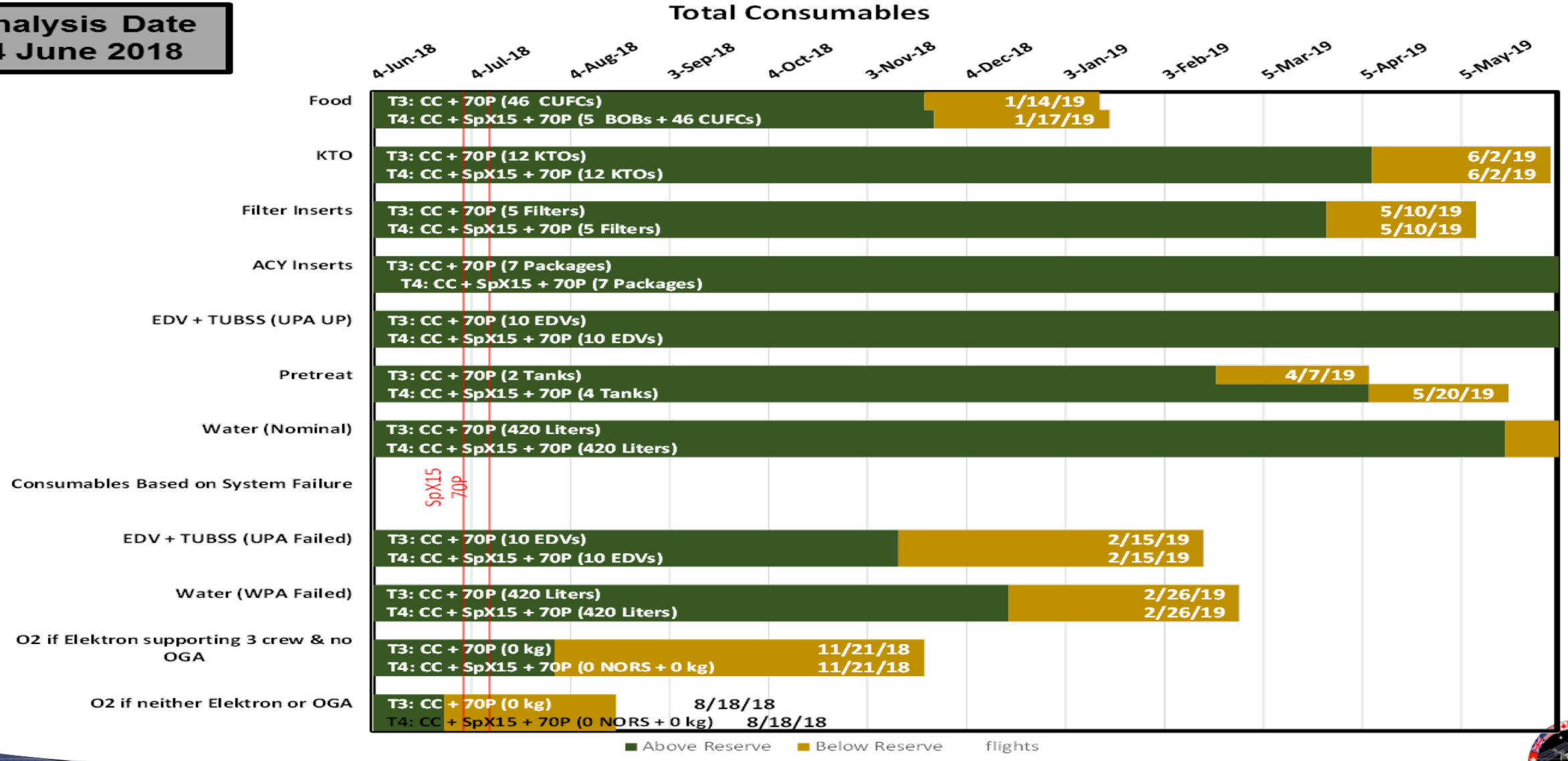
- EV1Arnold, EV2/Feustel
- **Primary Tasks included:**
  - Routing External Wireless Communications (EWC) power and Ethernet cables between Lab and Node 2
  - Installing Worksite Interface (WIF) booms and mating associated HD cameras/EWC connections.
  - Camera Port 3 External HD Camera R&R
  - Closing Cloud Aerosol Transport System (CATS) aperture door.

Upcoming US EVAs

- **US EVA 52 and US EVA 53 (tentatively September 20 and 26)**
  - 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.
  - Operations are very similar to the Increment 50 EVAs that replaced the S4 batteries with new ones that launched on HTV-6.
  - Other tasks are outboard on P6 doing some preparatory tasks for the HTV-8 mission.
    - HTV-8 scheduled to launch next year with new batteries

Total Consumables

Analysis Date
04 June 2018



OA-9 Mission Status

- Mission Planning
  - Launched 5/21; berthed 5/24
  - Unberth on 7/15
- Pressurized Cargo ~3350 kg upmass; ~3000 kg disposal
  - Ascent: 1 MERLIN, 2 Polar
- First flight of Common Communications for Visiting Vehicles (C2V2) radio and new cabin fan
- First flight of fairing frangible rail enhancement
- ISS Reboost using Cygnus engine
- Post-Departure science objectives:
  - Nanoracks CubeSat deploy
  - Flight Control Team engineering tests

OA-9 launch 5/21/18

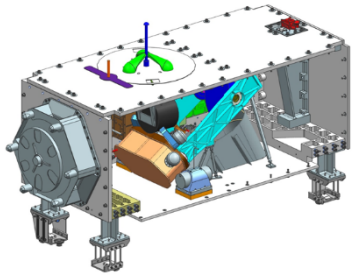
OA-9 berthing 5/24/18

SpaceX-15 Mission Status

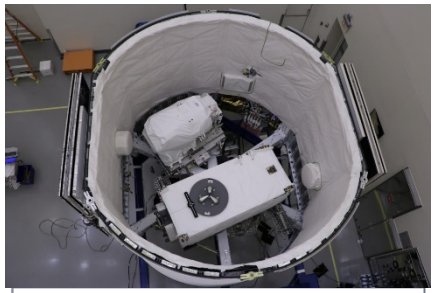
- Mission Planning
  - Launched 6/29, Berthed 7/2
  - Unberth and released on 8/3

- Over 2600kg of research, crew supplies, & hardware including…
  - ECOsystem Spacebourne Thermal Radiometer Experiment on
  - Space Station (ECOSTRESS)
  - Spare Latching End Effector (LEE)
  - Space Algae and Micro-12 investigations
  - Technology Demonstration of the Crew Interactive Mobile companion (CIMON)

- Disposal items included…
  - Hyperspectral Imager for the Coastal Ocean (HICO)/Remote Atmospheric and Ionospheric Detection System (RAIDS) Experiment Payload (HREP) and Small Adapter Plate Assembly (SAPA) with a unique LEE Flight Support Equipment (FSE)



ECOSTRESS



LEE

HII Transfer Vehicle (HTV-7) Mission Status

- Mission Planning
  - Launch tentatively planned for 9/10/18
  - Berthing tentatively planned for 9/14/18
  - Three NASA racks and one ESA rack have been installed in the Pressurized Logistics Carrier
  - Stage Operations Readiness Review (SORR) held on 8/14/18

- Pressurized Cargo – 3229 kg upmass; 1500 kg disposal planned
  - Basic Express Rack ER-9B
  - Basic Express Rack ER-10B
  - Life Sciences Glovebox (LSG)
  - Life Support Rack (LSR) from ESA

- Unpressurized Cargo – 1494 kg upmass; 1627 kg disposal
  - 6 LiON batteries up, 9 Ni-H2 batteries down
    - The Exposed Pallet (EP) with batteries attached is installed in the Unpressurized Logistics Carrier

Northrop Grumman CRS-10 (NG-10) Mission Status

- Mission Planning
  - Cargo Integration Review (CIR) completed 6/6
  - Tentative launch is November 2018

- Pressurized Cargo – 3350 kg upmass
  - Ascent: 4 Polar
    - First flight of an Enhanced Cargo Module Power Unit (eCMPU)

- Unpressurized Cargo
  - Nanoracks CubeSat deploy, operations post ISS departure

- Vehicle Status
  - Cygnus Pressurized Cargo Module (PCM) arrived at Temperanceville on 3/23
  - Cygnus Crew Equipment Interface Test (CEIT) and 1410 testing planned for 7/9
  - Antares Engine Mate completed 3/20

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
Northrop Grumman						Oct 2018	
SpaceX					Oct 2018		
Sierra Nevada				√4A: May 18 4B: Oct 18			

- ISS IR Milestone #4: Critical Design Reviews (CDR)
  - Northrop Grumman Systems delta CDR successfully completed 6/28/17
  - SpaceX CDR successfully completed 11/8/17
  - Sierra Nevada Corporation (SNC) IR #4A completed May 2018; #4B planned for Oct 2018
- ISS IR Milestone – #5 Functional Interface/Demonstration testing
  - Northrop Grumman IR#5 successfully completed 1/18/18
  - SpaceX IR #5 is planned for Oct. 2018
  - SNC IR#5A planned for Aug. 2018; #5B planned for Oct 2018
- ISS IR Milestone – #6 Systems Integration Testing
  - Northrop Grumman #6 planned for Oct 2018

ISS Transition

ISS Transition

- NASA released a NASA Research Announcement (NRA) to solicit proposals for study activities related to the development of a LEO commercial market where NASA could be one of many customers
  - Released on May 17, 2018
  - Received proposals on June 18, 2018
  - Selected companies announced on August 8, 2018 (contracts are dependent on negotiations)
  - Final study reports delivered to NASA in December 2018

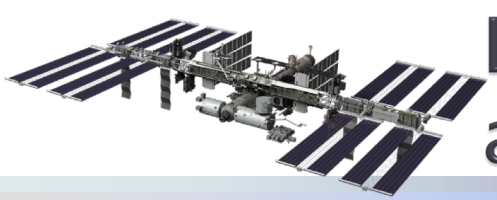
ISS Transition

- **The following study selections were announced on August 8, 2018**

  - AxiomSpace, LLC, of Houston
  - Blue Origin, LLC, of Kent, Washington
  - The Boeing Company of Houston
  - Deloitte Consulting of Manhattan Beach, California
  - KBRWyle of Houston
  - Lockheed Martin Corporation of Littleton, Colorado
  - McKinsey & Company, Inc. of Washington, D.C.
  - NanoRacks, LLC, of Webster, Texas
  - Northrop Grumman of Dulles, Virginia
  - Sierra Nevada Corp. of Louisville, Colorado
  - Space Adventures, Inc., of Vienna, Virginia
  - Space Systems/Loral, Inc. of Palo Alto, California

NASA Long Term Demand for LEO

- Working to expand on description of NASA needs in the ISS Transition Report and facilities/features required of a LEO platform to support it
  - Regular crewed operations
  - Long-term technology and system demonstrations
  - Human health performance and validation
  - Space Life and Physical Sciences Research
  - Astrophysics, Space and Earth Science



Long-term Technology/Systems Development and Demonstrations

- Exploration-enabling technology demonstrations expected to continue to require a LEO platform beyond 2024 include:
  - ECLSS – continued testing of the Exploration ECLS system on a permanently-crewed platform to validate reliability for long-duration missions and allow infusion of new technologies to be tested in u-g with the system
    - Expected to require space for ~7-8 equivalent equipment "racks"
  - Exploration Medical Devices – validation of diagnostic and treatment devices to needed for long-duration missions
- HEOMD is in the process of updating capability gaps derived to reflect current architecture needs and testing locations (ISS, Gateway, etc); additional LEO needs may be identified through this process, to be completed by end of 2018

Long term Human Health and Performance needs

- Focus on validating and integrating health and performance risk areas
  - Medical operations, isolation, countermeasures, physiological, etc.
- Potential for analog missions to understand long-duration deep space hazards to the human system, includes effects of
  - Isolation and confinement
  - Altered gravity fields, including transitions such as planetary landing
  - Distance from earth/communications delays
  - Hostile/Closed Environment
  - Potential missions of up to 30 days with up to 4 crew in a volume constrained to a Mars transit-class volume.

Long term Space Life and Physical Sciences needs

- NASA will continue to work with OGAs to ensure that research activities are complementary and not overlapping
- Life Sciences highest fundamental research priorities are plants and microbiome of the built environment.
- Physical Sciences highest fundamental research priorities are combustion and phase change-associated energy transfer.
- Research planning is based on recommendations from the National Academies of Sciences, Engineering, and Medicine's Decadal Survey and mid-term review of NASA's fundamental research (December 2017).
  - Includes "highest," "higher," and "enabled by" research critical to the expansion of human exploration into deep space.
- Most research can be supported with facilities that will already be in place on ISS in 2024.

Projected future research needs and associated ISS facilities needed:

2017 Midterm Decadal survey research priorities critical to the expansion of human exploration into deep space - "**Highest-priority recommendations**"

Priority related to Decadal Survey	Current ISS Facility or capability
AP1 Highest: Reduced-gravity multiphase flows	Flow Boiling Research-limited on ISS currently
AP6 Highest: Flammability and fire suppression in space	Combustion Integrated Rack
AP10 Highest: Development of new materials to support exploration in harsh space environment	SUBSA Translation Stage, Levitation Furnaces, High Temp Furnace, JAXA ELF, ESA EML, MSRR
CC2 Highest: Artificial gravity as a multisystem countermeasure	Centrifuge (non-human)
CC8 Highest: Space radiation risks to humans	External Payload platforms and SmallSat Launcher
P1 Highest: Microbial Observation	Multiple capabilities.
P2-Highest: Plant and Microbial responses and adaptations to spaceflight	Centrifuge (non-human)
P3 Highest: Plant and microbial systems for life support	Biofilm Facility (Generic Cell Culture)
TSES1 Highest: Active two-phase flow relevant	Two Phase Flow Separator- not currently on ISS
TSES2 Highest: Zero-boiloff propellant storage	Cryogenic Fluid Management Demo (current capability only for "model fluids")

Projected future research needs and associated ISS facilities needed:

2017 Midterm Decadal survey research priorities critical to the expansion of human exploration into deep space - "**High-priority recommendations**"

Priority related to NRC Decadal	Current ISS Facility or capability
AH3 High: Bone loss in genetically altered mice	Life Sciences Glovebox (rodent research, cell science, microbiology)
AH16 High: Transmission of structural changes over generations	Rats, multigenerational studies. Animal Enclosure Module (AEM) for mice only. Fruit Fly labs and cancer-related research using model organisms (e.g., rodents, bacteria, yeast, C. elegans, Drosophila spp., others) -(Fly Cassette System), MVP, Techshot Cell Cult adaptation for the EVOLVES experiment.

Projected future research needs and associated ISS facilities needed:

2017 Midterm Decadal survey research priorities critical to the expansion of human exploration into deep space - "**enabled-by recommendations**"

"These experiments are fully dependent on microgravity and the space environment, and can lead to game changing potential for science and as yet unappreciated future applications. Also, the 'enabled by' research has been carefully considered, as this research can become the bedrock for healthier, more efficient, and less costly exploration approaches in the future".

Priority related to NRC Decadal	Current ISS Facility or capability
AP9 Enabled By: Materials synthesis and processing (improve on existing and new materials)	SUBSA Translation Stage, Levitation Furnaces, High Temp Furnace, JAXA ELF, ESA EML, MSRR
FP1 Enabled By: Complex fluids and soft matter	OASIS Liquid Crystal Facility, Colloidal Fabrication using E-fields
FP2 Enabled By: Understanding of the fundamental forces and symmetries of nature	BECCAL Follow-on using CAL
TSES16 Enabled by: ISRU capability development and surface habitats	Ionic Liquids Facility (no current capability)

Astrophysics, Space and Earth Science

- Astrophysics, heliophysics, planetary and Earth sciences will continue to need dedicated spacecraft
- Human spacecraft scale allows for accommodation of orbit specific science objectives. Cargo supply and robotic capabilities are also critical to deploying instruments to the human spacecraft
- Recent usage history gives an indication of the types of experiments that might find a LEO platform useful. Over the past decade, ISS has hosted two Astrophysics-sponsored instruments, NICER/SEXTANT and CREAM and six Earth Science-sponsored experiments, including CATS, SAGE III, and, in the near future, OCO-3.
- SMD includes ISS (and other platforms as available) as a possible research platform in its Announcements of Opportunity