International Space Station Status

Sam Scimemi
Director, ISS

HEO NAC
January 2015

Agenda

- ISS Goals
  - Highlight Exploration and Commercial Market Development
- ISS Overview Status
- Visiting Vehicle Status
- Utilization Highlights

NASA's and America's goals onboard the Station

Advance benefits to humanity through research

Enable long duration human spaceflight beyond LEO

Enable the commercial market in LEO

Basis for international HSF leadership & partnerships

ISS and Exploration

ISS is essential to developing and demonstrating the capabilities needed beyond LEO

- Major differences between ISS and Mars missions
  - Large multipurpose research platform vs. purpose built spacecraft
  - Near real time communications vs. ~42 min delay round trip
  - Regular resupply vs. no resupply
  - < 1 day transportation vs. months and years
  - 6 month crew duration vs. 2-3 years
- ISS is critical to closing the gap between LEO and long-duration spaceflight
  - Reliable/low maintenance life support and monitoring systems
  - Crew health research and countermeasures
  - Crew performance systems development
  - EVA systems
  - Rendezvous and docking system
  - Human robotic operations and capabilities
  - Mars mission-based simulations

Closing the gap in Human Health and Performance

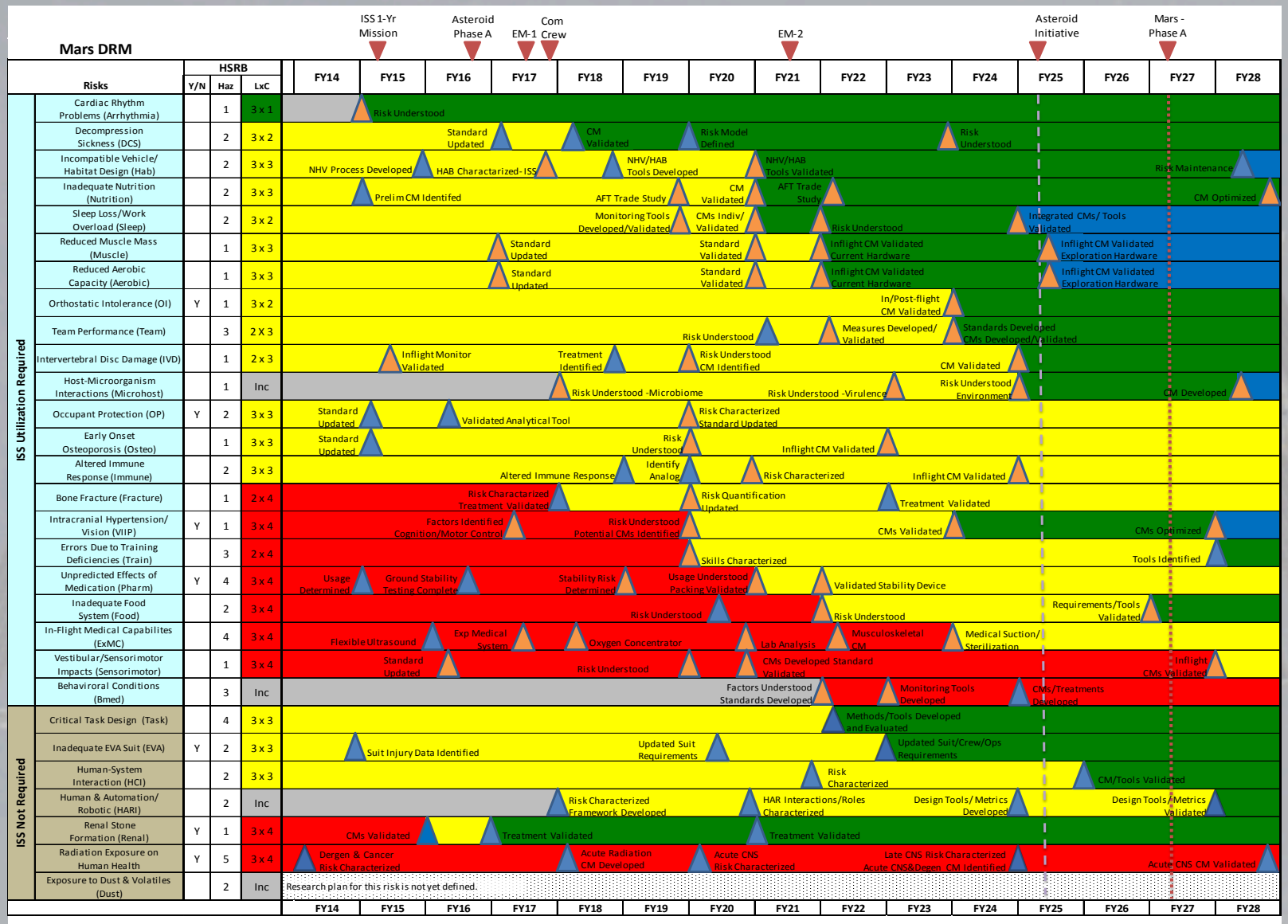
The ISS is necessary to mitigate 21 of the 32 human health risks anticipated on exploration missions

Some of the primary drivers for the length of research onboard ISS are:

- Number of subjects
- Pharmacology
- Visual Impairment and Intracranial Pressure
- Muscle
- Exploration Medical Capability
- Arrhythmia

Given the current number of subjects expected, HRP research and mitigations for long duration deep space missions should be mature enough by the mid-2020's

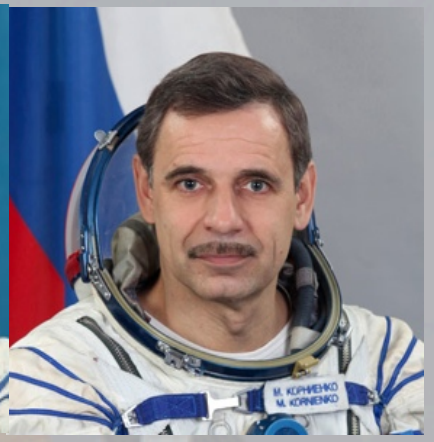
Integrated HRP Path to Risk Reduction



ISS One-Year Mission

- 2015 marks the launch of astronaut Scott Kelly and cosmonaut Mikhail Kornienko to the ISS for 12 months – the longest mission ever assigned to a US astronaut
  - Joint US/Russian ISS research includes studies on: ocular health, immune and cardiovascular systems, cognitive performance testing, and effectiveness of countermeasure against bone and muscle loss

Scott Kelly
STS-103, STS-118, ISS 25/26



Mikhail Kornienko ISS 23/24

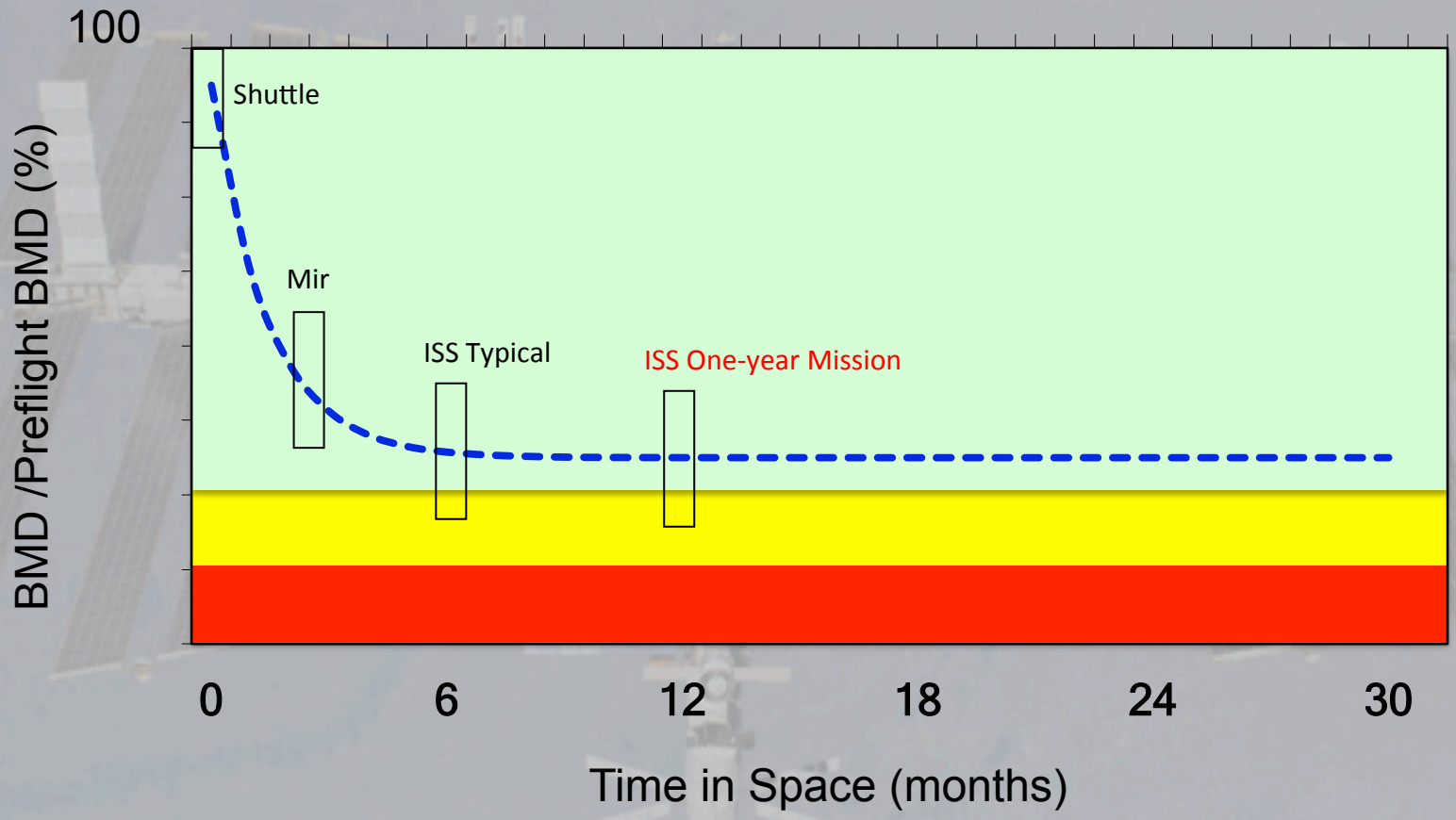
- HRP study of identical twins astronaut Scott Kelly, and retired astronaut, Mark Kelly
  - Provides unprecedented opportunity to research effects of spaceflight on twin genetic makeup, and better understand the impacts of spaceflight on the human body

http://www.nasa.gov/exploration/humanresearch/index.html

Retired astronaut Mark Kelly (left) and his twin brother, astronaut Scott Kelly, who will spend a year on ISS

ISS One-Year Mission: Primary Question

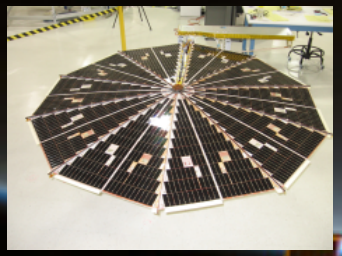
How confidently can we extrapolate our current experience to 30-month deep space missions?



One Year Crew Expedition Objectives

- Validation of physical countermeasures
  - Bone density and strength, muscle mass and strength, aerobic capacity, postural tolerance – ability of current countermeasures to maintain bone, muscle, fitness for one year
- Assess temporal threshold effects in health and performance metrics beyond 6 months
  - Serial assessments of vision/intracranial pressure (VIIP) and other microgravity effects
  - Establish trend of progression vs. plateau of changes in human physiology
- Understanding behavioral health & performance trends and effectiveness of countermeasures: sleep/wake cycles, cognitive performance, brain structure, and team dynamics
- Testing of exploration mission biomedical monitoring and hardware
- How best to leverage existing and future 6-month mission database?
- Pilot studies for future one-year flights
- Inform ongoing exploration planning activity

Exploration Systems Flight Testing on ISS



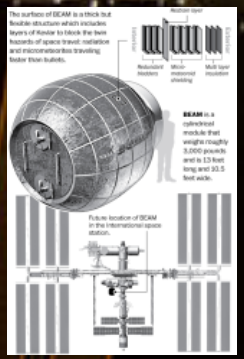
Solar arrays

Life Support Systems

Crew Support Systems

NASA Docking System

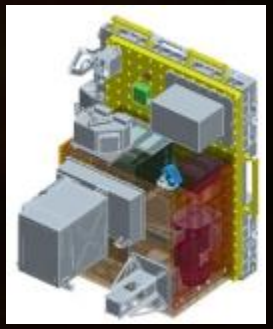
Refueling



Habitation Structures

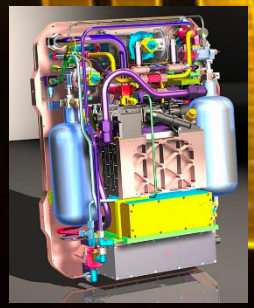
Crew Medical Systems

Trash compactor



Rendezvous sensors

Leak detection



EVA Systems

ISS and the development of the Commercial Market

Enabling the Commercial Market

Transportation

- Vehicle launches to the ISS account for ~15% of the global launch market (for 2013-14, 25 out of ~168 launches)
- Development and operations of the domestic ISS commercial cargo providers SpaceX and Orbital have stimulated the global competition in launch services

Micro-gravity Utilization and Application

- Private companies are now utilizing the ISS to stimulate broader commercial use of the LEO environment (e.g. NanoRacks, UrthCast)
- CASIS has significantly expanded the commercial use of ISS through private partnership
- NASA is exploring further demand development thru LEO Commercialization Workshops

In-space capabilities

- Commercial service, capability or commodity provider
  - Bigelow/BEAM demonstration, Sabatier
- NASA is exploring additional supply areas thru LEO Commercialization Workshops

Extension to at least 2024 enables maturation of the commercial market in LEO

CASIS Commercial Utilization

Also in proposal development with Cargill, John Deere, ADM, Dow, and J&J

LEO Commercialization Workshop

- Workshop held on Dec 10-11 in Washington DC
  - Purpose was to gather first hand input from industry on their perspectives on enabling the commercial supply and demand of LEO through the use and operation of the ISS
  - Over 100 participants from large and small private companies, FAA, CASIS, and stakeholders
  - Organized by NASA and CASIS
- Some summary finding highlights
  - Need for routine and regular access to ISS
  - More clarification on insurance, intellectual property rights, cross-waivers, and government and non-government use of materials developed on ISS
  - Potential government incentives could include free trade/tax free zones
  - Recommendation for NASA to include commercialization in a strategic plan
  - NASA should not be in competition with industry
- Workshop material are available at: http://www.nasa.gov/directorates/heo/LEO_commercialization
- Findings will be availabe at the same website later in January

ISS Status Overview

For current baseline refer to SSP 54100 Multi-Increment Planning Document (MIPD)

ISS Flight Plan

Flight Planning Integration Panel (FPIP)

(Pre-decisional, For Internal Use, For Reference Only)

NASA: OC4/John Coggeshall
MAPI: OP/Randy Morgan

Chart Updated: Dec 08th, 2014
SSCN/CR: 14211,14299,14322A & 14348(In-Work)

2014 | 2015 | 2016

Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug

Inc 41 | Inc 42 | Inc 43 | Inc 44 | Inc 45 | Inc 46 | Inc 47 | Inc 48

Crew Rotation

(38S) N B. Wilmore (CDR-42) 168 days (40S)
(38S) R Y. Serova 168 days (40S)
(38S) R A. Samokutyaev 168 days (40S)
N S. Kelly (CDR-45/46) (1 Yr Crew) 342 days (44S)
R M. Kornienko (1 Yr Crew) 342 days (44S)
R G. Padalka (CDR-44) 168 days (42S) R S. Volkov 184 days (44S)
N J. Williams (CDR-48) 170 days (46S)
R A. Ovchinin 170 days (46S)
R O. Skripochka 170 days (46S)
R M. Suraev (CDR) (39S) N T. Virts (CDR-43) 169 days (41S) N K. Lindgren 163 days (43S) N T. Kopra (CDR-47) 174 days (45S) R A. Ivanishin(C-49) (47S)
N R. Wiseman (39S) E S. Cristoforetti 169 days (41S) J K. Yui 163 days (43S) E T. Peake 174 days (45S) J T. Onishi 170 days (47S)
E A. Gerst 166 days (39S) R A. Shkaplerov 169 days (41S) R O. Kononenko 163 days (43S) R Y. Malenchenko 174 days (45S) N K. Rubins170 days (47S)
R S. Volkov (44S)↑ (42S)↓
(SFP) S. Brightman (44S)↑ (42S)↓
E A. Mogensen (44S)↑ (42S)↓
10 day direct handover

Soyuz Lit Landing
9/14 10/21 11/11 12/22 01/08 02/17 03/14 04/15 05/20 06/11
09/18 11/5 01/12 03/18 05/24

Stage S/W
SM 8.08 8/17
X2 R14 9/14
X2 EXT_R9(EPIC) NET

Stage EVAs
(PM) 10/7 (SSU) 10/15 R-40 10/22
(IDA Prep) 2/2 (C2V2) 2/6
(IDA Prep) 1/28
(IDA Install) R-41
(PMA3) A-B
(IDA Install)

Port Utilization

MRM2 / SM Zenith
9/10 9/26 (early GMT) 3/12 3/28 (early GMT) 8/28 9/1 3/3 4/1
168 / 168 168 / 168 184 / 184 170 / 168
38S 40S 42S 44S 46S

MRM1 / FGB Nadir
11/10 11/24 (early GMT) 5/11 5/27 (early GMT) 11/5 11/20 5/12 6/1
166 / 166 169 / 169 163 / 163 174 / 174 170 / 168
39S 41S 43S 45S 47S

DC1 / MLM / RS Node
10/27 10/29 4/26 4/28 8/4 8/7 (early GMT) 2/10 2/12 7/28 7/31
96 / 96 179 / 179 98 / 98 188 / 188 167 / 167 179 / 179
56P 57P 59P 60P 62P 64P

SM Aft
2/10 2/17 8/26 9/11 10/22 4/27 4/30
196 / 182 190 / 190 188 / 188 166 / 166
ATV5 58P 61P 63P

N2 Fwd / PMA2 (Dock)
Under Review
♦ IDA #1 installed on PMA2

N2 Zenith
4/4 5/4 30 Days Orb-4
♦ PMA3 moved from N3P to N2Z (Robotics)
♦ IDA #2 installed on PMA3

N2 Nadir (Berth)
9/23 10/21 28 Days SpX-4
12/18 1/19 32 Days SpX-5
4/10 5/14 34 Days SpX-6
6/15 7/15 30 Days SpX-7
9/4 10/4 30 Days SpX-8
12/7 1/6 30 Days SpX-9
2/11 3/12 30 Days SpX-10
4/4 5/4 30 Days Orb-6
6/8 7/8 30 Days Orb-7
7/15 8/14 30 Days SpX-11
8/22 Orb-8

N1 Nadir (Berth)
PMM relocation from N1N to N3F (Robotics) ♦
N1 berthing kit installed ♦
8/23 10/7 45 Days HTV5
10/15 11/25 41 Days Orb-5

Solar Beta >60
10/31 -11/07 | 12/28 -01/07 | 05/28 -06/07 | 07/27 -08/04 | 10/28 -11/03 | 12/24 -01/03 | 02/26 -02/27 | 05/23 -06/02 | 07/22 -07/31

External Cargo
SpX-4: RapidScat | SpX-5: CATS RS Adapter Bracket | SpX-6: CREAM, IDA#1 or Empty | SpX-7: IDA #1 or CREAM | SpX-8: BEAM HTV5: CALET, MUSES | SpX-9: IDA #2 | SpX-10: STP-H5, SAGE IP, SAGE NVP | SpX-11: ACES, ASIM, ROSA

Launch Schedule
SpX-4 9/21 | Orb-3 Launch Loss | EFT-1 12/5 (Test Flight) | SpX-5 12/16 | Orb-4 4/1 | SpX-6 4/8 | SpX-7 6/13 | HTV5 8/17 | SpX-8 9/2 | Orb-5 10/12 | SpX-9 12/5 | SpX-10 2/9 | Orb-6 4/1 | Orb-7 6/5 | SpX-11 7/13 | Orb-8 8/19

N°714 TMA-14M | N°24 M-25M | N°715 TMA-15M | N°425 M-26M | N°716 TMA-16M | N°426 M-27M | N°717 TMA-17M | N°428 M-28M | N°718 TMA-18M | N°431 MS-01 | N°719 TMA-19M | N°432 MS-02 | N°720 TMA-20M | N°429 M-29M | N°721 TMA-21M | N°433 MS-03

40S 9/25 | 57P 10/29 | 41S 11/23 | 58P 2/17 | 42S 3/27 | 59P 4/28 | 43S 5/26 | 60P 8/6 | 44S 9/1 | 61P 10/22 | 45S 11/20 | 62P 2/12 | 46S 3/30 | 63P 4/30 | 47S 5/30 | 64P 7/31

41 Soyuz Launch/Increment 42
November 2014 – May 2015

Vehicle: 41 Soyuz

Launch: November 23, 2014 (with 4 orbit rendezvous)

Docking: November 24, 2014

Undock/Landing: May 11, 2015

40 Soyuz Crew

Aleksandr Samokutyayev, Soyuz Commander
Barry Wilmore, Increment 42 Commander
Yelena Serova, Flight Engineer

41 Soyuz crew

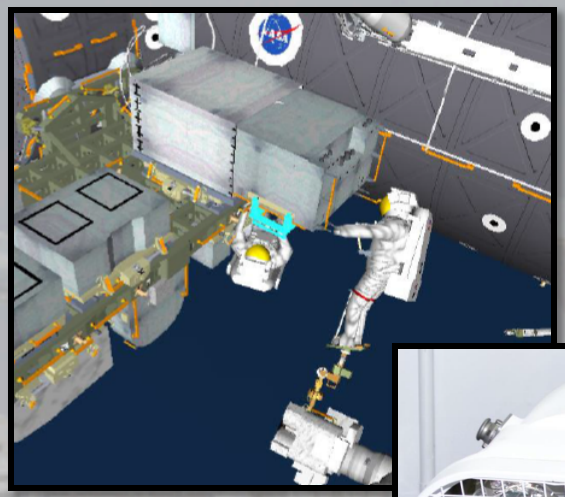
Anton Shkaplerov, Soyuz Commander
Terry Virts, Increment 43 Commander
Samantha Cristoforetti, (ESA) Flight Engineer

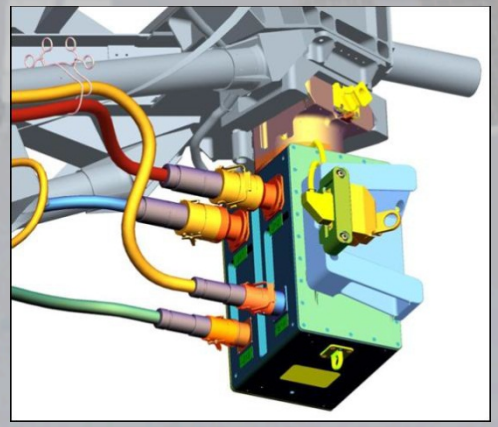
Increment 42 Highlights

- IMAX
- Nitrogen Oxygen Recharge System (NORS) Airlock Installation Kit
- Cloud Aerosol Transport System (CATS) External Payload (SpX-5)
- Deployment of SpinSat, Special Purpose Inexpensive Satellite
- EVA – International Docking Adapter (IDA1) Prep
  - Pressurized Mating Adapter (PMA2) Umbilical Stow
  - IDA1 Cable Routing
- EVA – IDA1/Latching End Effector (LEE) Lube
  - PMA2 Cover Removal
  - IDA1 Cable Routing
  - SSRMS LEE A Lubrication
- EVA 42-3 Planned Tasks:
  - Complete Common Communication for Visiting Vehicle (C2V2) Route
  - Starboard C2V2 Antenna Install
  - Port C2V2 Antenna Install
- Begin ISS Reconfiguration Modifications
- Rodent Research 2 (SpX-6)
- ATV-5 Reentry Observation

Increment 41
USOS EVA Conducted

- USOS EVA 27
  - Date: October 7, 2014
  - Crew:
    - EV1 – R. Wiseman
    - EV2 – A. Gerst
    - Suit IV/EVR – B. Wilmore
  - Tasks:
    - Pump Module (PM) Stow on ESP-2
      - WIF Adapter install
      - AGB Removal/Stow
      - Handrail clamp install on ESP-2
    - Mobile Transporter Relay Assembly (MTRA) Install
    - CP13 Light R&R





Increment 41
USOS EVA Conducted

- USOS 28
  - Date: October 15
  - Crew:
    - EV1 – R. Wiseman
    - EV2 – B. Wilmore
    - Suit IV – A. Gerst
  - Tasks:
    - SSU 3A R&R
    - Wireless Video System External Transceiver Assembly (WETA) Relocate – CP8 to CP11
    - CP7 External Television Camera Group (ETVCG) retrieval (brought inside)
    - CP7 Video Stanchion Support Assembly (VSSA) relocate to CP11
    - CP8 ETVCG install
    - Articulating Portable Foot Restraint (APFR) Relocate

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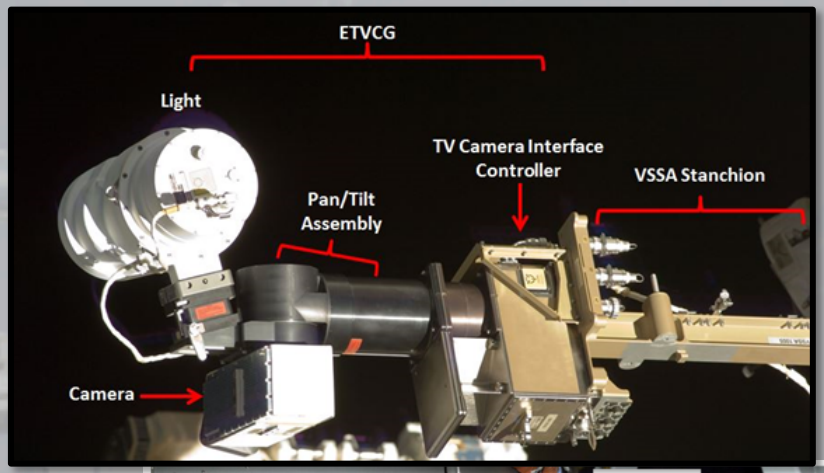
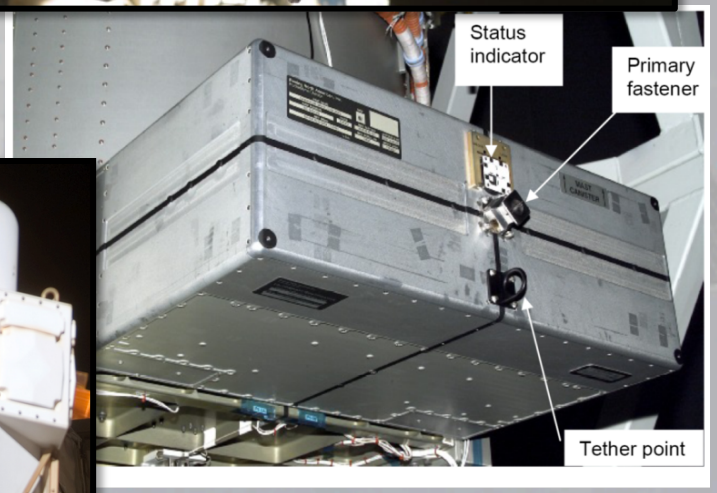




Total ISS Consumables Status

	T1: Current Capability (w/o Orb-3)		T2: Current Capability + Spx-5 (w/o Orb-3)	
Consumable – based on current, ISS system status	**Date to Reserve Level**	**Date to zero supplies**	**Date to Reserve Level**	**Date to zero supplies**
Food – 100%	March 26, 2015	May 16, 2015	April 25, 2015	June 18, 2015
KTO	March 03, 2015	April 25, 2015	April 10, 2015	June 02, 2015
Filter Inserts	November 14, 2015	January 01, 2016	November 14, 2015	January 01, 2016
Toilet (ACY) Inserts	November 02, 2015	December 25, 2015	November 02, 2015	December 25, 2015
EDV + TUBSS (UPA Operable)	October 23, 2015	March 15, 2016	October 23, 2015	March 15, 2016
Pre-Treat Tank	August 17, 2015	September 26, 2015	August 17, 2015	September 26, 2015
Water (Nominal Usage)	June 01, 2015	September 04, 2015	June 01, 2015	September 04, 2015
Consumable - based on system failure				
EDV + TUBSS (UPA Failed)	June 26, 2015	August 27, 2015	June 26, 2015	August 27, 2015
Water, if no WPA (Ag & Iodinated)	March 13, 2015	May 31, 2015	March 13, 2015	May 31, 2015
O_2 if Elektron supporting 3 crew & no OGA	December 16, 2014	April 26, 2015	December 16, 2014	April 26, 2015
O_2 if neither Elektron or OGA	November 22, 2014	January 19, 2015	November 22, 2014	January 19, 2015
LiOH (CDRAs and Vozdukh off)	~0 Days	~14 Days	~0 Days	~14 Days

USOS Consumables Status

	U1: Current Capability (w/o Orb-3)		U2: Current Capability + SpX-5 (w/o Orb-3)	
Consumable – based on current, ISS system status	**Date to Reserve Level**	**Date to zero supplies**	**Date to Reserve Level**	**Date to zero supplies**
Food – 100%	May 30, 2015	July 14, 2015	July 24, 2015	September 05, 2015
KTO	December 24, 2014	February 07, 2015	April 28, 2015	June 23, 2015
Filter Inserts	August 29, 2015	October 06, 2015	August 29, 2015	October 06, 2015
Toilet (ACY) Inserts	June 17, 2016	August 01, 2016	June 17, 2016	August 01, 2016
EDV + TUBSS (UPA Operable)	July 06, 2015	June 15, 2016	July 06, 2015	June 15, 2016
Pre-Treat Tanks	August 09, 2015	September 16, 2015	August 09, 2015	September 16, 2015
Water (Nominal Usage)	March 11, 2015	September 02, 2015	March 11, 2015	September 02, 2015
Utilization		> May 2015		> May 2015
Consumable - based on system failure				
EDV + TUBSS (UPA Failed)	January 31, 2015	May 04, 2015	January 31, 2015	May 04, 2015
Water, if no WPA (Ag & Iodinated)	November 24, 2014	January 18, 2015	November 24, 2014	January 18, 2015
O_2 if neither Elektron or OGA	December 12, 2014	February 20, 2015	December 12, 2014	February 20, 2015
LiOH (CDRAs and Vozdukh off)	~0 Days	~13.3 Days	~0 Days	~13.3 Days

Pertinent ISS Vehicle Issues (cont.)

Issue	Impact to Stage Ops	Rationale
SSRMS LEE Latching Anomaly	Yes	Degradation has been seen on both LEEs, and 3 instances of aborted latching have been seen on LEE A • Trending shows that LEE lubing and/or replacement will be necessary in the future • A number of planned robotics ops have been deferred to preserve LEE latching cycles • LEE A lubrication activity targeted for US EVA 42-2
Black Flakes in WHC Flush Water	Yes	On-orbit photos of WHC Pressure Relief EDV (aka “burp bag”) show presence of ~1-2mm black flakes • Flakes also found in Flush Tank (Inspected on 10/10) • Presence of flakes poses risk to downstream dose pump • Samples upstream of WHC, at ACTEX filter and UMS port, were clean • An activity to flush of the Water Valve Block and replace the Flush Tank EDV is planned for 10/24. • Plans are in work to return a sample of the flakes on 39S

Visiting Vehicles Status

SpaceX-4 Mission - Completed

- **Mission Planning**
  - Manifest assessment 1557 kg pressurized cargo upmass; 1597 kg pressurized cargo returned
    SpaceX Launch Readiness Review conducted on 9/17/14
  - Successful Launch occurred on 9/21/14
  - Berthing to the ISS on 9/23/14
  - Post Flight pressurized cargo review was conducted on 11/17/14

- **Pressurized Cargo**
  - Launch: GLACIER, Commercial Generic Bioprocessing Apparatus (CGBA), Rodent Transporter and Habitat, SpinSat, Cyclops, Bone Densitometer, MSG Video Upgrade, and 6 Cold Bags
  - Return: GLACIER, CGBA, 2 MERLINs, Rodent Transporter, Microgravity Science Lab (MSL), and 7 Cold Bags
- **External Cargo**
  - ISS RapidScat (RapidScat Nadir Adapter and RapidScat Instrument) was extracted from trunk on 9/29/14 and installed on Columbus Starboard Deck-X (SDX)
  - Materials on ISS Experiment (MISSE) Flight Support Equipment (FSE) was disposed
- **Dragon/F9 Status**
  - Unberth and splashdown was successful on 10/25/14
  - Completed cargo unloading activities at McGregor on 10/31/14

SpaceX-5 Mission Status

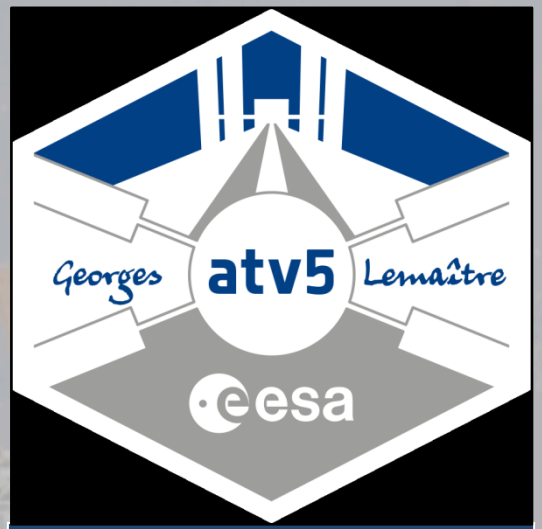
- **Mission Planning**
  - Manifest assessment 2073 kg upmass; 1580 kg return cargo
  - Cargo Integration Review (CIR) was conducted on 9/9/14
  - Post Qualification Review (PQR) was conducted on 11/13/14
  - Stage Operations Readiness Review (SORR) conducted on 11/18/14
  - SpaceX Launch Readiness Review (LRR) conducted on 1/4/15
- **Pressurized Cargo**
  - Launch: GLACIER, Commercial Generic Bioprocessing Apparatus (CGBA), Polar, Bioculture System, and 5 Cold Bags
  - Return: GLACIER, CGBA, Polar, Bioculture System, and 6 Cold Bags

- **External Cargo**
  - Cloud Aerosol Transport System (CATS); CATS transfering to ISS post berthing
- **Dragon/F9 Status**
  - Dragon mate to F9 was completed on 12/15/14
  - Static fire was completed on 12/17/14
  - Cargo late load was performed on 1/5/15; late load rescheduled to 1/9/15 based on 1/10/15 launch date

ATV5 Mission Status

ATV5: *Georges Lemaitre*

- **Mission Planning**
  - Manifest assessment > 6000 kg upmass/disposal
  - Launched successfully on 7/29/14
  - Docked successfully on 8/12/14
  - Undocking Stage Operations Readiness Review (SORR) is planned for 1/22/15
  - Undocking/disposal is schedule for 2/14/15
- **Cargo**
  - Cargo on-orbit removal began on 8/14/14
- **On-orbit Status**
  - Performed an ISS fly-by a few days before docking to allow experimental rendezvous sensors to collect data
  - Systems are nominal
  - The IMMT approved ATV5 PDE1 Flight Application Software (FAS) patch load on 8/16/14 (Chit 12660). First use of the patch will occur during use of ATV propulsive support for CMG desaturations as required during the RS EVA 39
  - Concern of buckles flacking has been resolved and work around for airflow was performed. Also, the hatch closed 8/17/14 to support the RS EVA



Georges Lemaitre (ATV5)

ATV5 cargo rack loaded

Photo Credits: ESA

Orbital-2 Mission- Complete

- Mission Status
  - Launched successfully on 7/13/14
  - Berthed to ISS on 7/16/14
  - As-flown Manifest: 1664 kg upmass; 1616 kg disposal
    - Delivered pressurized cargo complement, including four passive lockers and two double cold bags
    - Vehicle fully loaded with trash for departure, including endcone and standoff volume
  - Unberthed successfully on 8/15/14
    - Successful DTOs performed post-unberth
  - Re-entry occurred on 8/17/14
  - Post Flight Review completed on 8/26/14

Vehicle filled with ISS trash ready for unberth on 8/15/14

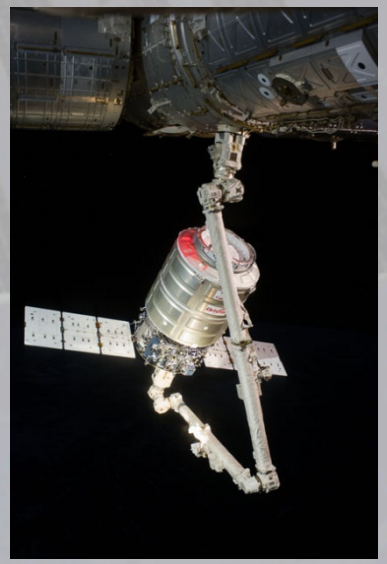


Photo Credit: NASA

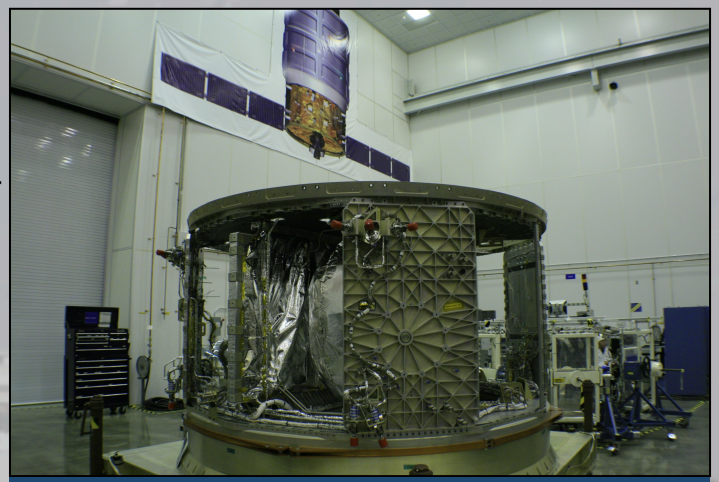
Orbital-3 Mission

- Mission Status
  - Mission launch attempted on 10/28/14
  - Mission failure just after liftoff
  - Investigation is currently underway and being led by Orbital with NASA and FAA participation

- Return to Flight
  - Orbital has proposed a recovery plan to deliver the remaining cargo on the CRS contract
    - Next Cygnus flight (Orb-4) expected to be flown on Atlas V in 4th quarter 2015
    - Orb-5 in 2016 – option for 2nd Atlas V; possible transition to updated Antares launch vehicle

Orbital-4 Mission Status

- **Mission Planning**
  - Pending outcome of Orb-3 investigation – upcoming milestones listed below are subject to change or re-evaluation upon investigation analysis
  - Program reviewing Return to Flight (RTF) plan
  - Cargo Integration Review (CIR) date will be set after RTF plan is approved and new launch schedule is set
- **Pressurized Cargo complement**
  - Final ISS cargo manifest will be due at Launch minus 3 (L-3) months to new launch schedule
- **Cygnus Status**
  - First enhanced Cygnus with a longer Pressurized Cargo Module (PCM) is planned
  - Thermal Vacuum (TVac) testing was completed in Oct 2014
  - Completed Electromagnetic Interference (EMI) testing in Nov 2014
  - Final Integrated Systems Test (FIST) began in Dec 2014
  - All testing will be reviewed to determine delta testing for different launch vehicle
- **Launch vehicle under review in RTF plan**

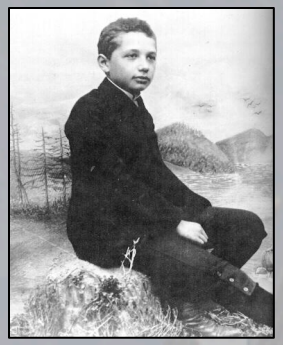


Orb-4 Service Module (SM)

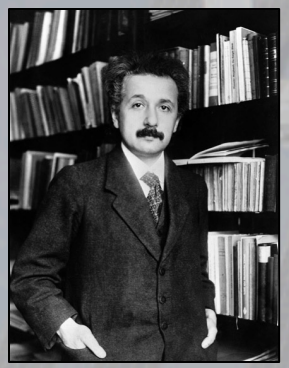
Photo Credit: Orbital

Utilization Update

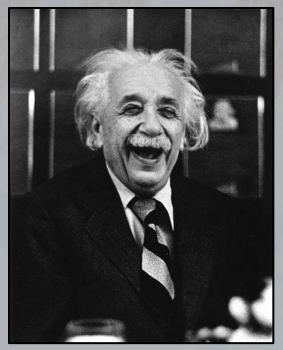
“Time works so hard for us, if only we can let it.”
Tana French



Time to complete a study in orbit
- 2 weeks to 5+ years



Time from completion of study in orbit to first publication
- 1 to 3 years for majority of investigations



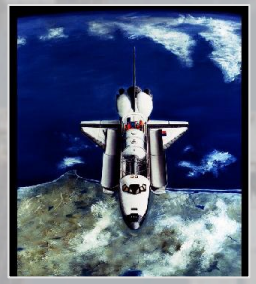
Time from publication/patent to product being in the marketplace
- 3 to 20 years (shorter for technologies, longer for drug development)

Historical Micro-G Research Perspective

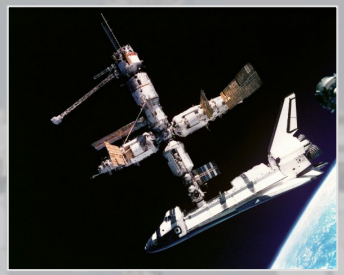
Exploratory | Survey | Application

1973-1979

1981-2011



1994-1998



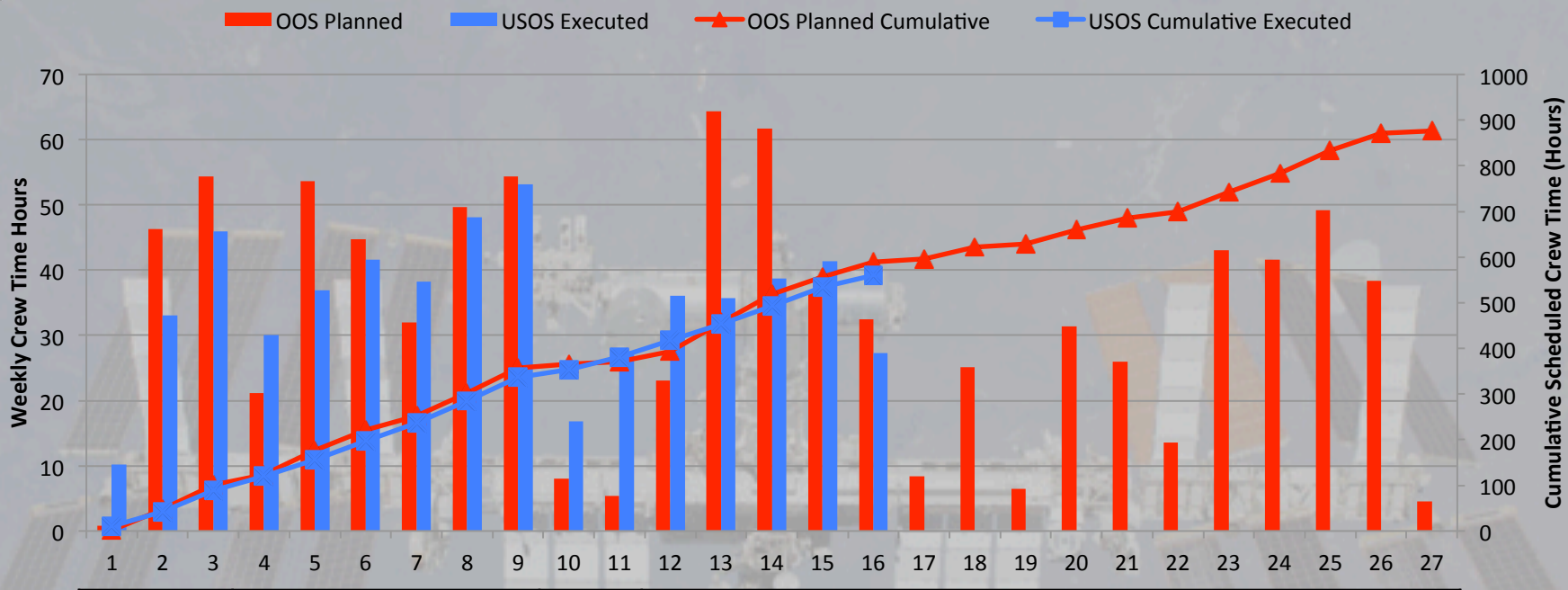
1998

2011
Assembly Complete

~1.5 years of productive on-orbit micro-g research

M. Uhran, Positioning the ISS for the Utilization Era

Inc 41 - 42 Utilization Crew Time



3-Crew	6-Crew	3-Crew	6-Crew
Increment 41		Increment 42	
Sep	Oct / Nov	Dec	Jan / Feb / Mar

Color Key:
Completed
Final OOS
FPIP Plan

SpX-4
Berth 09/23/14
Berth 09/14/2014
Unberth 10/21/14
Unberth 10/25/14

US EVA 27 *

US EVA 28 *

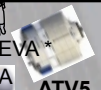
Orb-3
Berth N/A
Berth 10/24/14
Unberth N/A

SpX-5
Berth 1/8/14
Berth 12/11/14
Unberth 2/7/15

US EVA

US EVA

US EVA *



ATV5

SpX-6
Berth 02/6/15
Unberth 03/09/15

Undock 02/14/15
Undock 01/25/15

OP/OZ reconciliation is complete through Week 15

US EVA 27, 28 & the third EVA in Inc 42 were added real-time and not planned in the Final OOS

Pre-Decisional, For Internal Use Only

		of 25.0 work weeks (58.40 % through the
Executed through Increment Wk (WLP Week) 16 =	14.6	Increment)
USOS IDRD Allocation:	875.0	hours (35 hrs/week)
OOS USOS Planned Total:	876.25	hours
USOS Actuals:	560.83	hours
	64.10%	through IDRD Allocation
	64.00%	through OOS Planned Total
Total USOS Average Per Work Week:	38.41	hours/work week
Voluntary Science Totals to Date:	0	hours (Not included in the above totals or graph)

ISS Research Statistics

Working data as of September 30, 2014

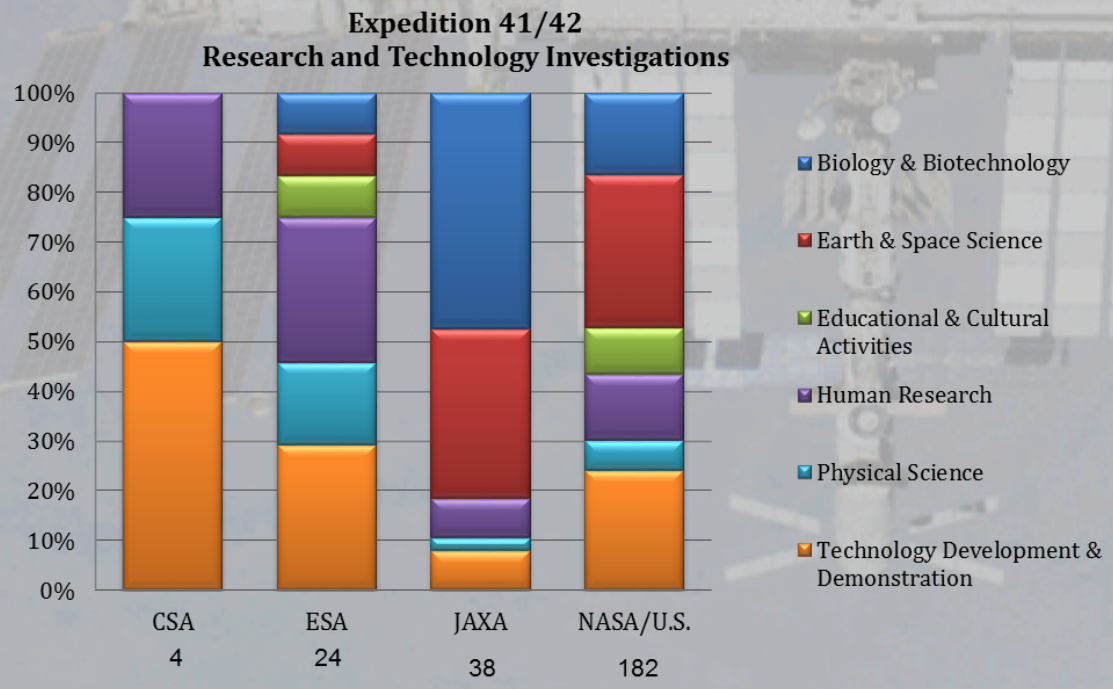
Number of Investigations for 41/42 : 248

- 182 NASA/U.S.-led investigations
- 66 International-led investigations
- 101 new investigations
  - 0 CSA
  - 6 ESA
  - 18 JAXA
  - 77 NASA/U.S
  - Roscosmos data in work

Statistics Exp 0-38

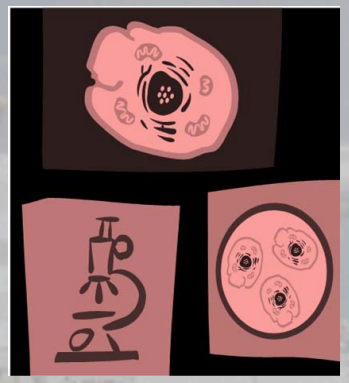
- Approx. 400 investigators
- Over 1000 scientific results published
- 1661 individual investigations

**Expeditions 0-38 statistics have been approved by the PSF & SSCB; currently pending approval by the MCB.*

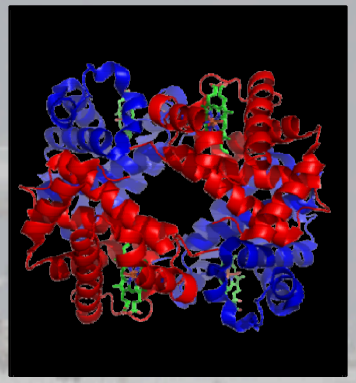


High Demand/High Impact Research

Medicine



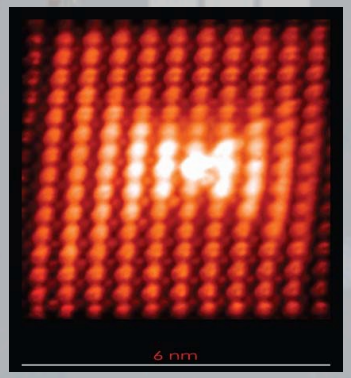
Cell Biology



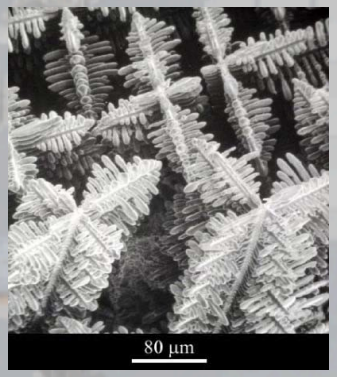
Protein Crystals

Disasters

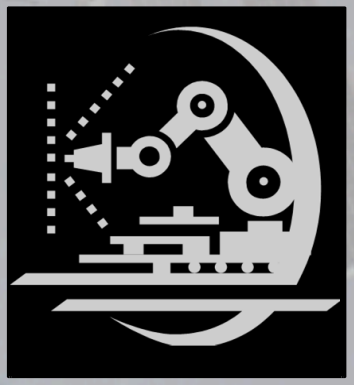
Combustion



Nanomaterials



Alloys



Robotics

Increment 41 & 42
Research Complement Snapshot

Human Research

Bone & Muscle Physiology
Bisphosphonates (Control), Force Shoes, Intervertebral Disc Damage (P), NATO* (CEF 5938), Sprint

Immune System
Salivary Markers

Vision
Fluid Shifts ↑, Ocular Health

Cardiovascular & Respiratory Systems
Airway Monitoring, BP Reg, Cardio Ox, Drain Brain, Orthostatic Tolerance, Wearable Monitoring

Habitability & Human Factors
Astro Palate, Body Measures, Fine Motor Skills↑

Human Behavior & Performance
Cognition, Comm Delay Assessment (P), Journals, Synergy (P)

Crew Healthcare Systems
Bone/Muscle Check, Cartilage (P), Skin-B

Nervous & Vestibular Systems
Blind and Imagined, Grip, Manual Control (P), NeuroMapping, Space Headaches, V-C Reflex (P)

Integrated Physiology & Nutrition
Biochemical Profile, Biological Rhythms 48hrs, Circadian Rhythms, ENERGY, Pro K, Repository, Twin Studies ↑

Human Microbiome
Microbiome

Biology and Biotechnology

Animal Biology
Embryo Rad, Epigenetics, Flatworm Regeneration, Fruit Fly Lab 01, Nematode Muscles, Rodent Research-1, -2, Space Aging, Space Pup, Zebrafish Muscle

Plant Biology
Aniso Tubule, APEX-03, BRIC-19, -20, -21, Plant Gravity Sensing-2 , Plant Rotation, Seedling Growth-2, Veg-01* (CEF 5744)

Macromolecular Crystal Growth
CASIS PCG-3, JAXA PCG, Nanoracks PCG-1, -2

Vaccine Development
Drug Metabolism

Microbiology / Cellular
AES-1, Bioculture System, Bone Densitometer Validation, ~~CASIS Dev-3, CASIS RFP 2013-01~~ (CEF 5591), CYTOSPACE* (CEF 5938), Cell Mechanosensing-2, ~~Exomed~~-2 (CEF 5591), Micro 5, -8, -9, Microbe-IV, Microbial Observatory-1 (CEF 5157), NanoRacks Modules-28, -30, -31, NanoRacks-CellBox-PRIME, ~~NIH Osteo~~ (CEF 5591), Osteo-4, RJR Microbial Sampling (CEF 5329), Stem Cells, T-Cell Act in Aging, Triplelux-A, -B, Viable

Physical Sciences

Combustion Science
FLEX-2, Group Combustion

Fluid Physics
BCAT-KP, CFE-2, DECLIC DSI-R, -HTI-R, Dynamic Surf -3, Fluids Education, SODI-CA#4

Complex Fluids
ACE-H1, ACE-H2, ACE-M3, BCAT-C1,

Materials Science
Alloy Semiconductor, CSLM-4, EML, NanoRacks Module 50, Soret-Facet, Superconductor Sample Bag↓

Fundamental Physics
Plasma Kristall-4

Earth & Space Science

Astrobiology/Astrophysics/ Heliophysics
AMS-02 (E), CALET (E), CREAM (E), MAXI (E), MCE (E), Meteor, Solar-SOLACES/SOLSPEC (E)

Earth Remote Sensing
~~CASIS RFP 2013-02*~~ (CEF 5591), CATS, CEO, HICO-RAIDS (HREP) (E), IMAX, ISERV, MUSES, RapidScat (E), Windows on Earth

Near-Earth Space Environment
SEDA-AP (E)

Technology Development and Demonstration

Small Satellites & Control Technologies
~~NODeS-1, -2~~ (CEF 6046), J-SSOD Cubesats, RACE, SPHERES-Slosh

Radiation Measurements & Shielding
Area PADLES, DOSIS-3D, Free Space PADLES* (CEF 5933), Radiation Environment Monitor (REM), Radi-N2

Food & Clothing Systems
IVA Clothing Study, Space Tex

Communications & Navigation
LIRIS Demonstrator (E), LoneStar, OPALS (E), SCAN Testbed (E), Vessel ID

Characterizing Experiment Hardware
Cyclops Demo, Centennial-1, GOSTE-1, HATHOR, LIRIS ↓, NanoRacks Module 29, METERON OpsCom-2, MVIS Controller-1, SHARC , SpinSat, SporeSat-2, TEPCE-1, Universal Battery Charger

Spacecraft & Orbital Environment
STP-H4 (E), ALL

Life Support Systems & Habitation
AMO-TOCA, UBNT

Spacecraft Materials
ExHAM#1 (CFRP Mirror, SolarSail, Array Mark, MDM2, PEEK), MISSE-8 FSE, REBR-W

Robotics & Imaging
3DA1 Camcorder, HDEV (E), Robonaut, RRM-Phase 2 (E), Haptics-1

Repair & Fabrication Technologies
3D Printing in Zero G

Air, Water, Surface Monitoring
Amine Swingbed, Multi-Gas Monitor, WISENET

Avionics & Software
SNFM

Educational Activities

Education Competitions
Zero Robotics

Educational Demos
EPO Cristoforetti, EPO Demos, EPO Gerst, Flying Classroom, ISS Ham Radio, Sally Ride EarthKAM, Story Time from Space ~~2~~* (CEF 5826), -3

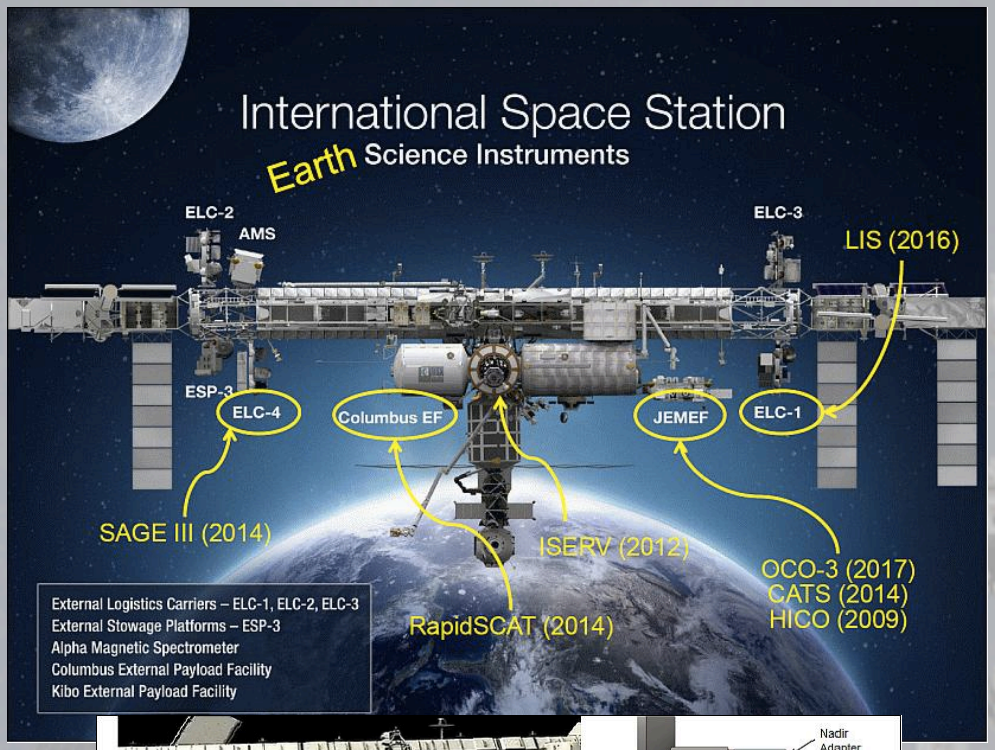
Student-Developed Investigations
NanoRacks Modules 9 (S/N 1012, 1013, 1015, 1016), 16-22 ↓, 24, 32, 41 – 47; STMSat-1

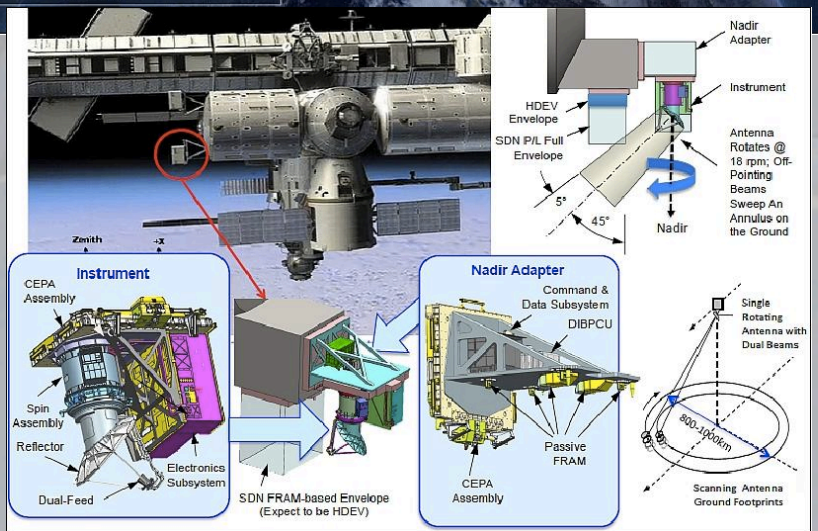
Cultural Activities
NanoRacks Module 48

Key: NASA, CSA, ESA, JAXA, NASA – Commercially Funded

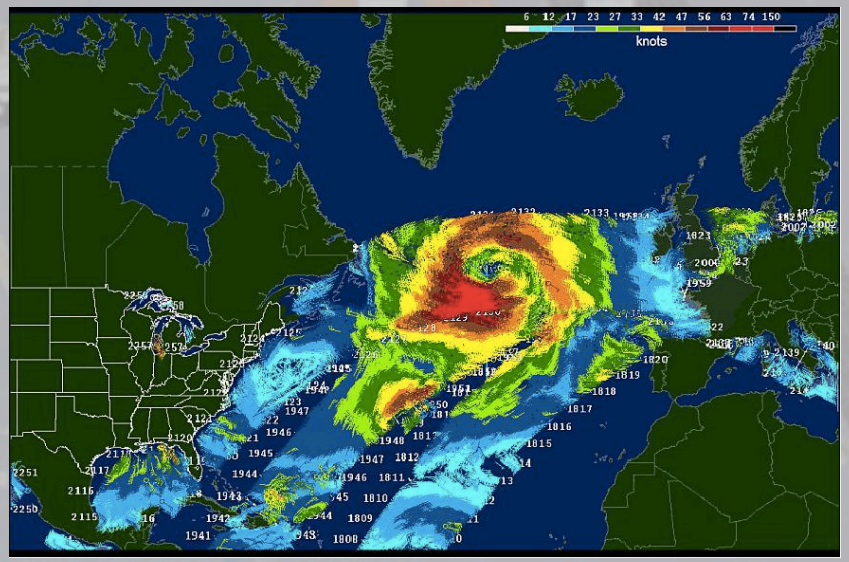
(P) Pre/Post BDC only, no In-flight ops
(↑ ↓) Launch or Return only
(E) External Payload
* CEF approval pending

Example of an immediate benefit – RapidScat

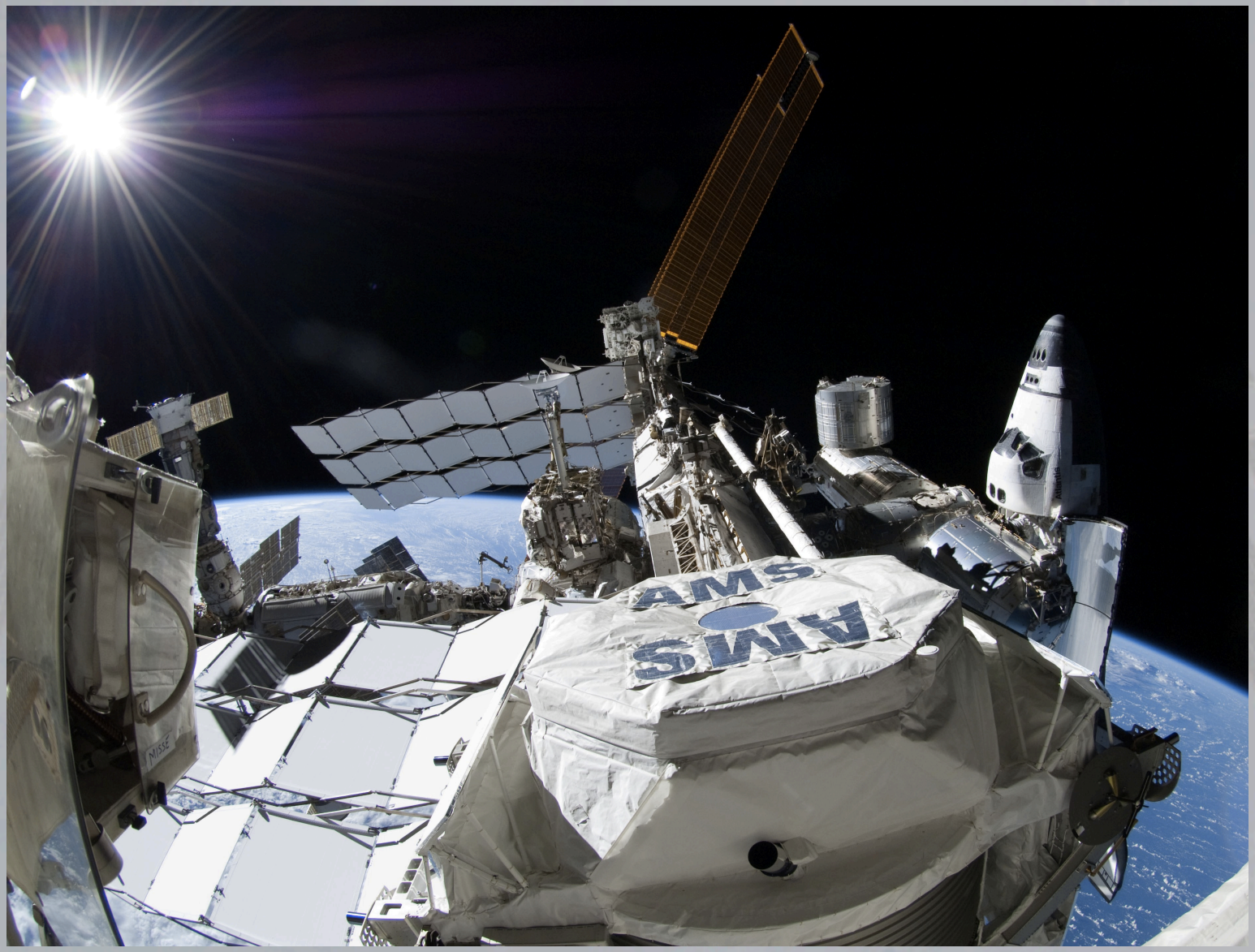




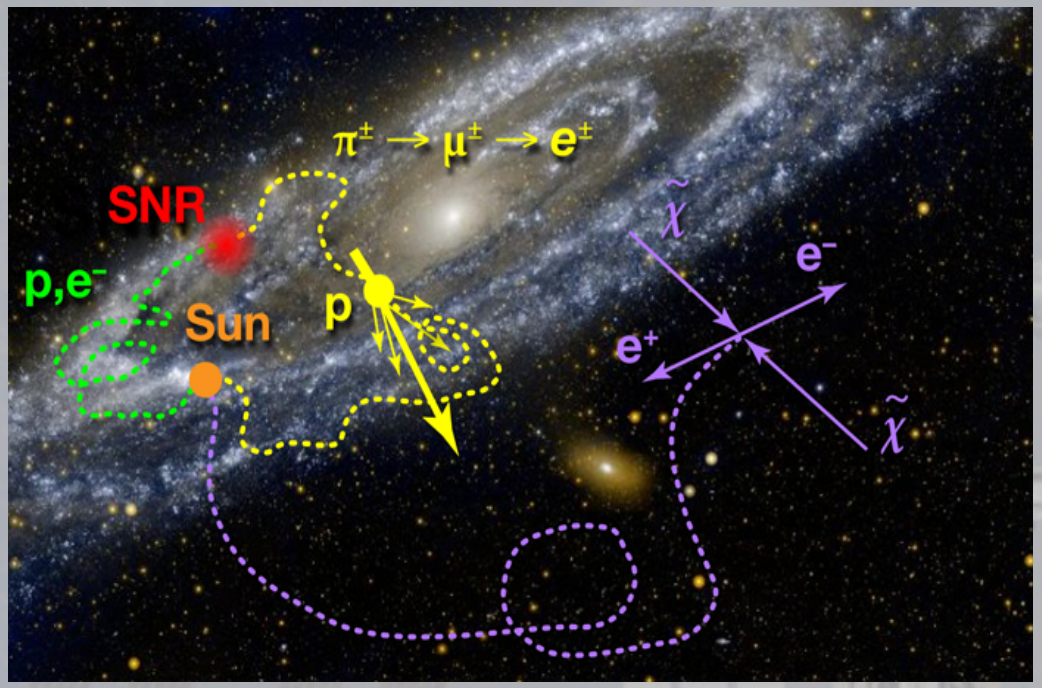
RapidScat launched on SpaceX-4 is already producing operational data products on sea surface winds to weather forecasting worldwide



Example of long term research - Alpha Magnetic Spectrometer

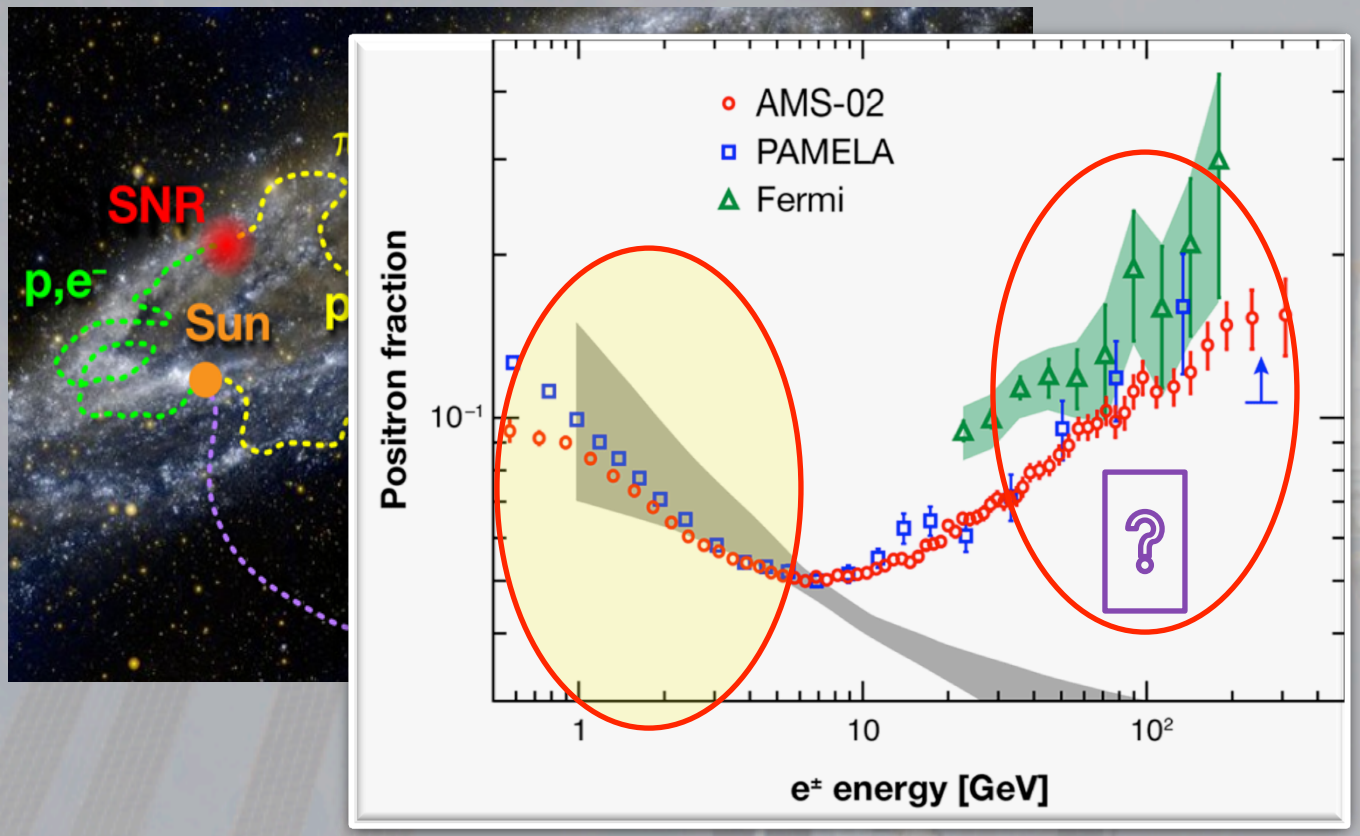


Latest Results from the Alpha Magnetic Spectrometer on ISS



Stars, planets and the molecules that make them are only about five percent of the total mass in the universe — the rest is either dark matter or dark energy, but no one has ever seen this material or been able to study it. What's more, the Big Bang theory holds that the universe should be made of equal parts matter and antimatter, but scientists have never detected naturally occurring antimatter. The Alpha Magnetic Spectrometer looks for evidence of these mysterious substances, along with very high-energy radiation coming from distant stars.

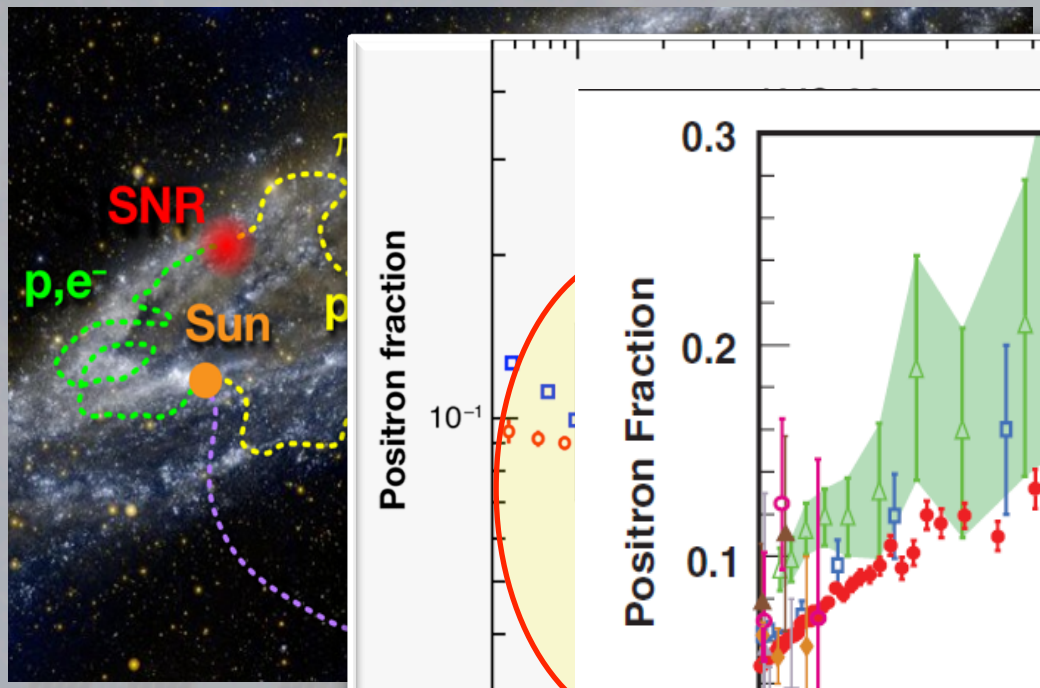
Latest Results from the Alpha Magnetic Spectrometer on ISS



0.5-350 GeV. Measurements Physical Review Letters. April 2013

"These observations show the existence of new phenomena, whether from a particle physics or an astrophysical origin"*

Latest Results from the Alpha Magnetic Spectrometer on ISS



0.5-350
2013

***0.5-500 GeV. Measurements. Physical Review Letters. Sep 2014*

"This measurement extends the energy range of our previous observation and increases its precision. The results show, for the first time, that above ~200GeV the positron fraction no longer exhibits an increase in energy**"