International Space Station
National Research Council

April 2013

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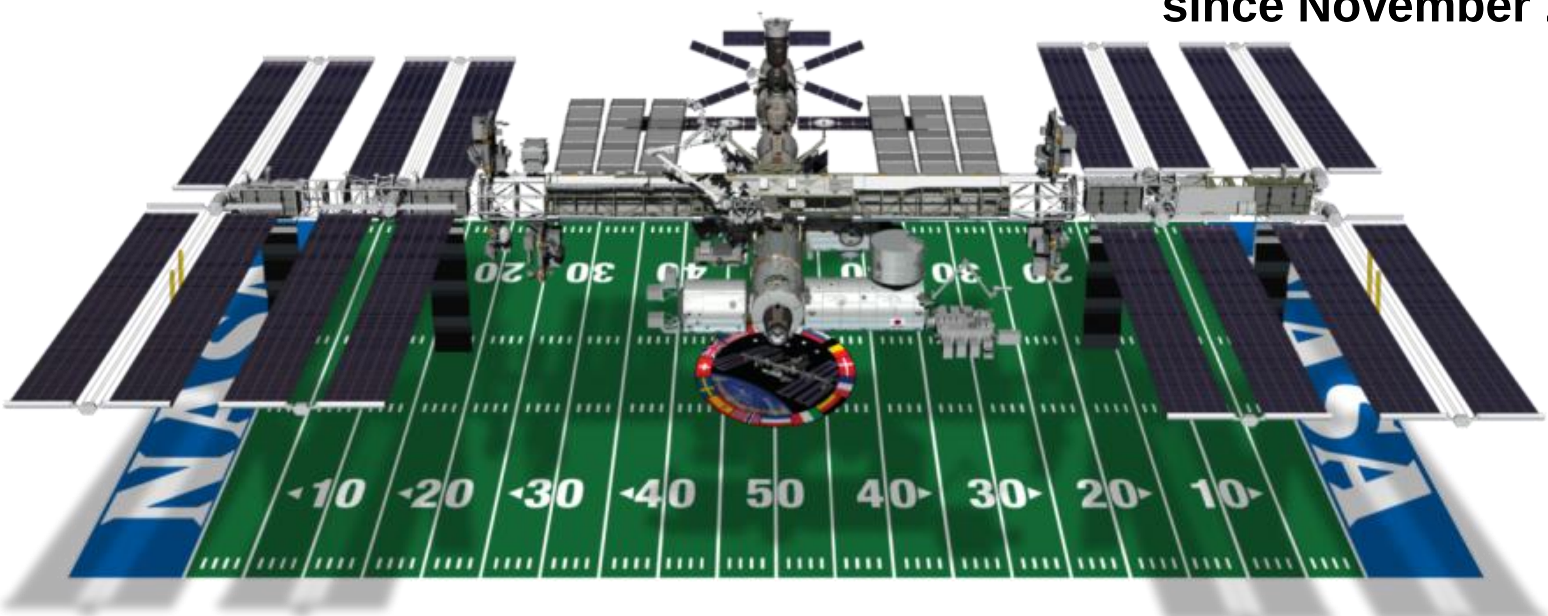
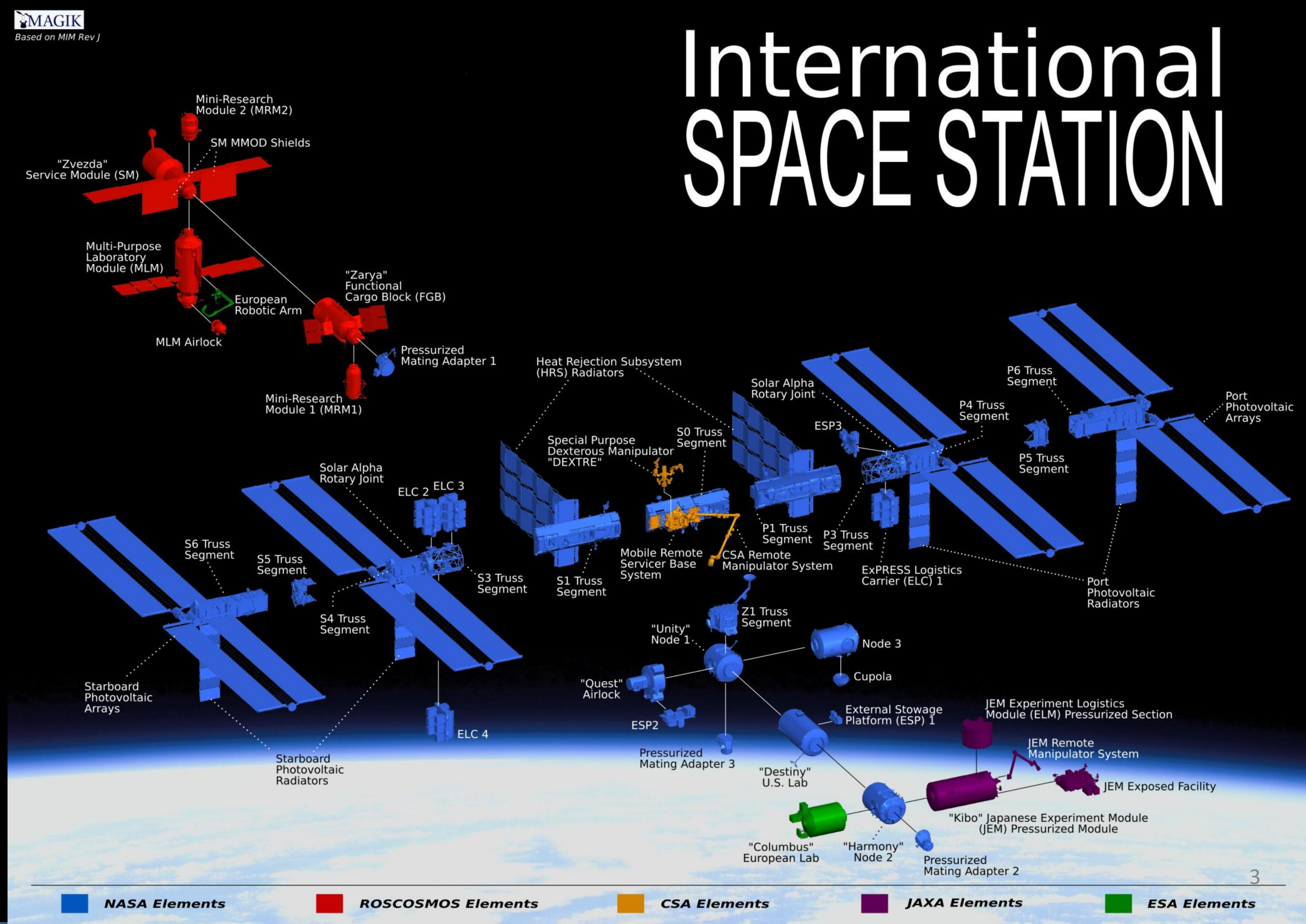
ISS Facts and Figures

- Mass = 902,000 lbs
- Truss Length = 358 ft
- Altitude = 224 nautical miles
- Living space = 32,333 ft3
- Velocity = 17,500 mph
- Solar array surface area = 38,400 ft2 (0.88 acre) generating 84 kW
- Assembly flights = 41
- Spacewalks = 161 (1015 hours)
- Crew members = 205 different people from 15 countries

Continuous human presence since November 2000



ISS Configuration



ISS Transportation Systems

ROSCOSMOS

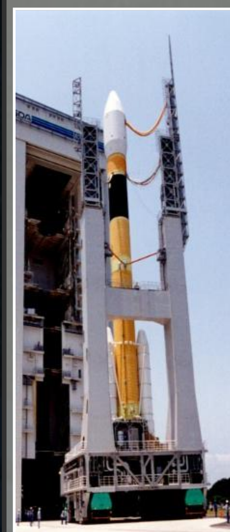
Proton

Soyuz / Progress

esa

Ariane/ ATV

JAXA



H-IIB/ HTV

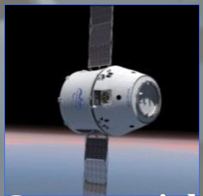
Falcon 9/ Dragon

Antares/ Cygnus

BOEING

SNC SIERRA NEVADA CORPORATION

SPACEX

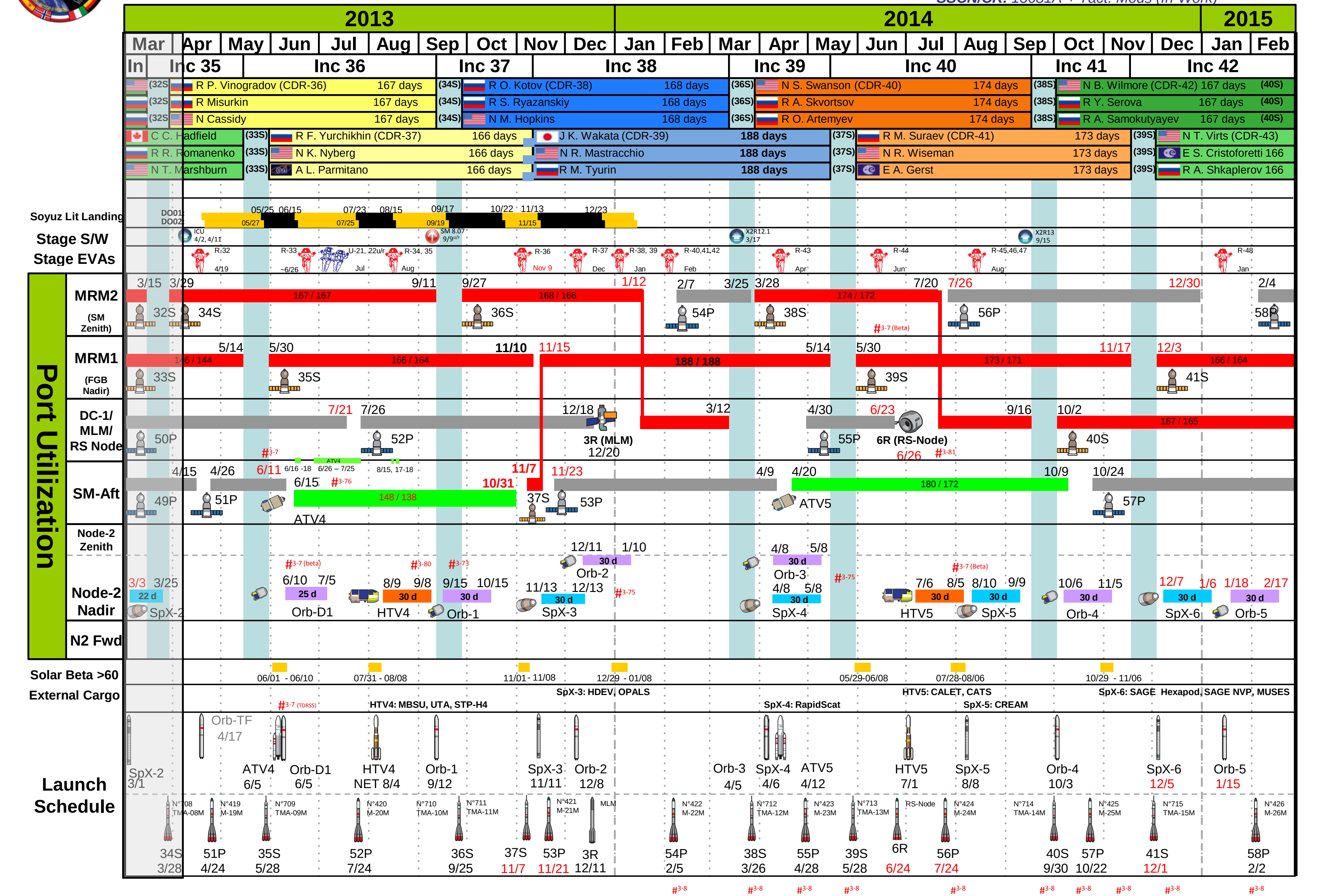


Commercial Crew
Potential Candidates

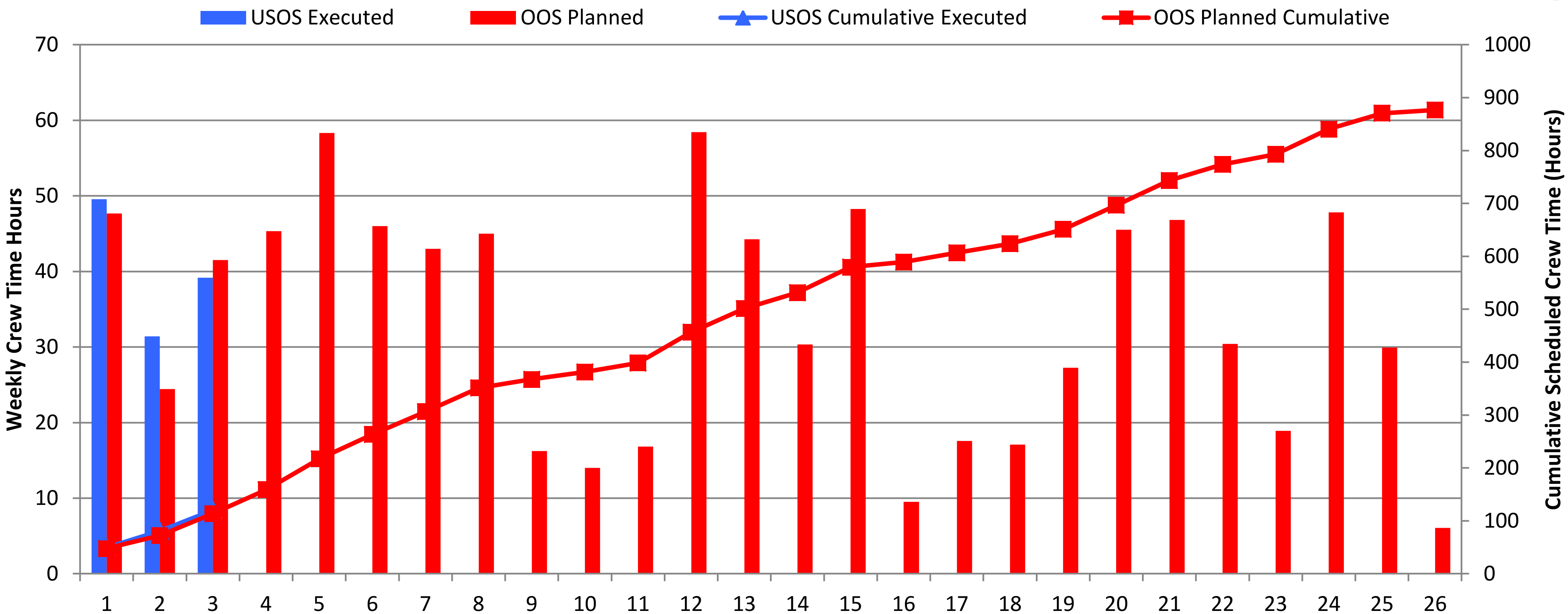
For current baseline refer to SSP 54100 Multi-Increment Planning Document (MIPD)

ISS Flight Plan
Flight Planning Integration Panel (FPIP)

NASA: OC4/John Coggeshall
MAPI: OP/Scott Paul
Chart Updated: April 3rd, 2013
SSCN/CR: 13681A + Tact. Mods (In-Work)



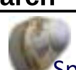
Inc 35 - 36 Utilization Crew Time



3-Crew | 6- Crew | 3-Crew | 6-Crew

Increment 35 | Increment 36

March | April | May | June | July | August | Sept



(Unberth on 3/24/13)

(Unberth on 3/26/13)

(Dock on 5/1/13) → (Dock on 6/15/13)

(Berth on 5/8/13) Below the line → (Berth on 6/10/13)

(7/20/13 – 8/19/13) → (8/9/13 – 9/8/13)

Date Color Key:

Completed

35-36 Final OOS

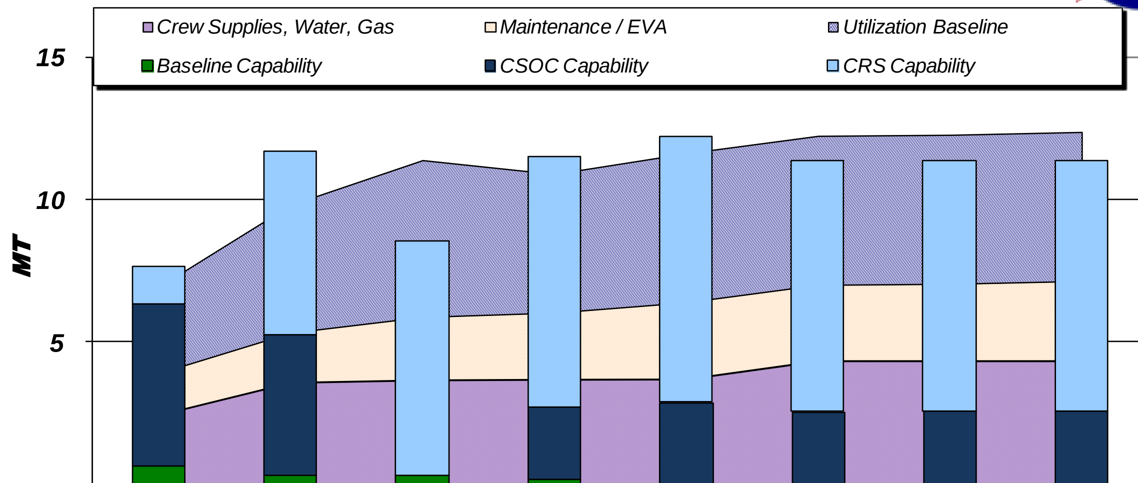
FPIP Plan

WLP 2 contains 35 minutes of ESA Utilization that has not been agreed upon.

OC/OZ reconciliation completed as of Week 3.

Executed through Increment Wk (WLP Week) 3 =	3	of 24.4 work weeks (12.30% through Increment)
USOS IDRD Allocation:	875	hours
OOS USOS Planned Total:	876.5	hours
USOS Actuals:	120.17	hours
	13.73%	through IDRD Allocation
	13.71%	through OOS Planned Total
Total USOS Average Per Work Week:	40.06	hours/work week
Voluntary Science Totals to Date	0	hours (Not included in the above totals or graph)

PPBE-15: Capability vs. Demand and Flight Rate – Pressurized



(FY)		2013	2014	2015	2016	2017	2018	2019	2020
Baseline	US Crew Vehicle						2	2	2
	USOS Progress	0.7 MT	0.3 MT	0.3 MT	0.3 MT	0.3MT	0.3* MT	0.3* MT	
	USOS Soyuz	2	2	2	2	2	2*	2*	
	RS Progress	4	4	4	4	4	4	4	4
	RS Soyuz	2	2	2	2	2	2	2	2
CSOC	ATV	1	1						
	HTV	1	1		1	1	1**	1**	1**
CRS	[redacted]								
Margin (Shortfall)		676	1,840	(2,849)	599	573	(892)	(916)	(1,017)
Internal Upmass Capability (FY)		7.6 Mt	11.7 Mt	8.5 Mt	11.5 Mt	12.2 Mt	11.4 Mt	11.4 Mt	11.4 Mt
Baseline Capability		[redacted]							
CSOC Capability		[redacted]							
CRS Capability		[redacted]							
Internal Upmass Demand (FY)		6.9 Mt	9.8 Mt	11.4 Mt	10.9 Mt	11.6 Mt	12.2 Mt	12.3 Mt	12.4 Mt
Crew Supplies, Water, Gas		[redacted]							
Maintenance / EVA Demand		[redacted]							
Utilization Baseline		[redacted]							
Contingency Maintenance		[redacted]							

*Overguide request – will submit 2 year Soyuz overlap

Notes:

-Demo flights are not included in the flight rate table.

- Flight rate supports 4th crewmember beginning in Nov. 17

USOS System Enhancements

- **Carbon Dioxide Removal Assembly (CDRA) "-4" Desiccant/Adsorbent Beds- Monitoring**
  - Two new CDRA beds will be launched on SpX-2
  - New features include a redesigned heater core with significantly thicker Kapton insulation to reduce risk of short, and completely re-engineered attachment points to the wiring harness to reduce strain at the wiring interface
  - New beds have been manufactured under clean-room conditions to reduce chance for built-in FOD
  - Sheets for the heater core have been re-engineered to reduce sharp edges and weld points which were potential FOD sources from welding slag
  - Beds incorporate new temperature sensors which have been changed from a thin-film sandwich type to a completely new helical wire-wound construction, significantly improving sensor survivability under repeated thermal cycles (similar to commercial applications in aircraft brakes)
  - Shape of the desiccant and absorbent materials were changed to allow for more efficient packing on the ground and to potentially reduce dusting due to material abrasion when exposed to long term thermal/vacuum cycles on-orbit
  - Housing of the bed was updated to accommodate the addition of captive fasteners and other features to allow the crew to partially disassemble the adsorbent bed on-orbit to remove the dust that accumulates from operation of the CDRA without having to return the beds to the ground for refurbishment

USOS System Enhancements

- **Continue replacement of legacy ISS avionics with Obsolescence Driven Avionics Replacement (ODAR) components**
  - Integrated Communications Unit (ICU) has been installed and activiated - doubling the downlink data rate (300 Mbps) and an eight-fold increase in the uplink data rate (25 Mbps)
  - Increases crew communication loops with ground from 2 to 4.
  - Automatic switching between redundant Ku-band systems
  - 6 channels of video down (was 4)
  - improved Payload Ethernet Hub Gateway (iPEHG) ready for activation in late May – tenfold increase in medium rate onboard data communications (100 Mbps)
  - 2 flight ICUs and 4 iPEHGs are on-orbit; 3rd flight ICU planned for launch on ATV4

USOS System Enhancements

- **The ELC Wireless system provides a COTS solution for external high data rate 802.11n wireless capability to payloads on the Express Logistic Carrier (ELC)**
- **The system consists of two separate segments**
  - US Lab
    - COTS Wireless Access Points (WAP) placed inside the lab with external antennas to provide the core wireless capability
  - Payloads/Users
    - Characterization of a wireless solution for the payloads/users to integrate and provide piece parts to the developers
- **External Wireless users can connect using two methods:**
  - Use an IEEE 802.11n Network Interface Card in their device
    - The NIC can be integrated directly into the Payload. (e.g. a PCI card)
    - NASA can provide a USB NIC to a user that can be integrated into the Payload.
  - Provide an IEEE 802.3 wired Ethernet interface and connect to Wireless Media Converter
    - NASA is investigating providing a hardware (circuit card with wired Ethernet port and antenna out port) solution that will allow a Payload to use a standard wired Ethernet port and this hardware perform the wired to wireless conversion
    - This hardware will be "smart" and require some configuration by the Payload in order to access the network
    - Radiation testing on candidate hardware is being performed January 16 – 18

USOS System Enhancements

- In an effort to increase the utilization of Commercial off the Shelf (COTS) hardware with limited or no modifications to support on-orbit operations, the ISS Program worked with commercial industry to develop a power inverter which converts the DC power generated from the ISS solar arrays to AC power just as you would find in your home.
- The provision of AC power allows ISS systems and payload developers to simplify and reduce the schedule and cost for the development, integration and delivery hardware into the ISS.
- The ISS power inverter (pictured below) comes in two models: 120Vdc-to120Vac and 28Vdc-to-120Vac respectively to support the primary power input voltages provided throughout the ISS (USOS and Russian Segments) and payload power interfaces.
- The 120Vdc-to120Vac power inverter provides power AC power provides: four (4) standard three prong AC power outlets and is capable of providing a total of 750W @ 60hz.
- The 28Vdc-to120Vac power inverter provides power AC power provides: four (4) standard three prong AC power outlets and is capable of providing a total of 400W @ 60hz.

Use of ISS to Prepare for Exploration

Four main focus areas

– ***Exploration technology demonstrations***

  » *On-orbit demonstration or validation of technologies that enable or enhance exploration mission readiness*

– ***Maturing critical systems***

  » *Driving evolution in capabilities supporting the ISS today to meet future challenges - high reliability, high efficiency, low mass, low power*

– ***Human health management for long duration space travel***

  » *Research to understand the main risks to human health and performance*

  » *Validation of strategies for keeping the crew healthy and productive*

– ***Ops simulations and operations technique demonstrations***

  » *Furthering our understanding of future operations challenges*

  » *Gaining information which will enable efficient and effective mission design and operations approaches*

Current, Planned, or Proposed ISS Technology Demonstrations, Nov 2012

Italic = NRC High Priority Technology that would benefit from ISS access
Underline = NRC High Priority Technology (focus for next 5 years)

Robotics

- *Next Gen Canadarm testing (CSA)*
- *Robotic Assisted EVA's (Robonaut, NASA)*
- METERON (ESA) and Surface Telerobotics
- Delay Tolerant Network Robotic Systems
- *Robotic Refueling Mission (CSA, NASA)*
- <u>*Robotic assembly to optical tolerances (OPTIIX, NASA)*</u>

Comm and Nav

- OPALS – Optical Communication
- X-Ray Navigation, (NICER/SEXTANT, NASA)
- *Software Defined Radio (CoNNeCT/SCAN, NASA)*
- Delay tolerant space networks
- <u>*Autonomous Rendezvous & Docking advancements (ESA/JAXA)*</u>
- <u>*Advanced optical metrology (sensing/mat'ls)*</u>

Power

- Regenerative fuel cells
- <u>*Advanced solar array designs [FAST, IBIS, or other]*</u>
- <u>*Advanced photovoltaic materials*</u>
- *Battery and energy storage advancements [Li-Ion or other]*

Thermal Control

- High efficiency radiators
- <u>*Cryogenic propellant storage & transfer*</u>
- Advanced materials testing

Closed Loop ECLSS

- Atmospheric monitoring: ANITA2 (ESA), MIDASS (ESA), AQM (NASA)
- <u>*Air Revitalization: Oxygen production, Next Gen OGA [Vapor Feed or other] (NASA)*</u>
- <u>*Contaminated gas removal*</u>
- <u>*Carbon Dioxide recovery: Amine swingbed and CDRA bed advancements*</u>
- <u>*Advanced Closed-loop Life Support ACLS (ESA), MELiSSA (ESA),*</u>
- <u>*Water/Waste: Electrochemical disinfection, Cascade Distillation System, Calcium Remediation, [Electrodialysis Metathesis or other]*</u>

Other

- *Spacecraft Fire Safety Demonstration*
- <u>*Radiation protection/mitigation/monitoring*</u>
- On-board parts repair and manufacturing
- <u>*Inflatable Module (BEAM)*</u>

Use of ISS to Prepare for Exploration

Maturing Critical Systems

- Radiation Environment Monitor - (NASA) *demonstration of first generation of operational active personal space radiation dosimeters*
- Amine Swingbed - (NASA) *provide for environmental control of the habitable volume for human-rated spacecraft by removing metabolically-produced carbon dioxide, and minimizing losses of ullage air and humidity*
- Air Quality Monitor (AQM) – (NASA) *volatile organic compound analyzer to be used to monitor the ISS environment*
- Disruption Tolerant Networking for Space Operations (DTN) - (NASA) *long-term, readily accessible communications test-bed, DTN is the comm standard for future spacecraft*
- DOSIS-3D – (ESA) *Determination of the radiation field parameters absorbed dose and dose equivalent inside the ISS with various active and passive radiation detector devices provided by ESA, JAXA and Russia. Aiming for a concise three dimensional dose distribution (3D) map of all the segments of the ISS.*
- Exploration EVA Suit – *(NASA) Could fly exploration suit as early as 2019. Will demonstrate and mature suit on ISS prior to use beyond LEO*
- NASA Docking System - (NASA) *Based on International specs agreed to by partners for exploration ISS will utilize and mature the system on ISS starting in 2015 with arrival of passive port.*

Human Health and Performance Risks, Coordinated Across All Partners	**Mission**			
	ISS 6 mo	Lunar 6 mo	NEA (1yr)	Mars (3yr)
Musculoskeletal: Long-Term health risk of Early Onset Osteoporosis Mission risk of reduced muscle strength and aerobic capacity	Green	Green	Yellow	Red
Sensorimotor: mission Risk of sensory changes/dysfunctions	Green	Yellow	Green	Yellow
Ocular Syndrome: Mission and long-term health risk of Microgravity-Induced Visual Impairment and/or elevated Intracranial Pressure (VIIP)	Yellow	Yellow	Red	Red
Nutrition: Mission risk of behavioral and nutritional health due to inability to provide appropriate quantity, quality and variety of food	Green	Green	Yellow	Red
Autonomous Medical Care: Mission and long-term health risk due to inability to provide adequate medical care throughout the mission (Includes onboard training, diagnosis, treatment, and presence/absence of onboard physician)	Green	Yellow	Red	Red
Behavioral Health and Performance: Mission and long-term behavioral health risk.	Green	Yellow	Red	Red
Radiation: Long-term risk of carcinogenesis and degenerative tissue disease due to radiation exposure – Largely addressed with ground-based research -	Green	Yellow	Red	Red
Toxicity: Mission risk of exposure to a toxic environment without adequate monitoring, warning systems or understanding of potential toxicity (dust, chemicals, infectious agents)	Yellow	Yellow	Red	Red
Autonomous emergency response: Medical risks due to life support system failure and other emergencies (fire, depressurization, toxic atmosphere, etc.), crew rescue scenarios	Yellow	Yellow	Red	Red
Hypogravity: Long-term risk associated with adaptation during IVA and EVA on the Moon, asteroids, Mars (vestibular and performance dysfunctions) and postflight rehabilitation	Green	Green	Yellow	Red

Green	Yellow	Red
Not mission limiting **GO**	Not mission limiting, but increased risk **GO**	Mission limiting **NO GO**

Use of ISS to Prepare for Exploration

Human Health Management for Long Duration Space Travel

- **Weightlessness**: greatest emphasis on understanding long-term physiological effects of most unusual spaceflight factor, including newly identified risk affecting visual function
  - Hypogravity: 7 investigations from CSA, ESA, JAXA and NASA
  - Musculoskeletal: 6 investigations from ESA and NASA
  - Sensorimotor: 2 investigations from ESA and NASA
  - Ocular Syndrome: 1 investigation from NASA
  - Nutrition: 1 investigation from NASA
- **Internal and external environments**: factors related to mechanics of spaceflight inside closed vehicle in dangerous natural environment
  - Toxicity: 2 investigations from NASA and ESA
  - Radiation: 1 investigation from CSA which supplements a major ground-based research program
- **Operational medical issues**: development of medical solutions to problems caused by physiological and environmental factors, with special attention to psychosocial effects of high autonomy at extreme distance from Earth
  - Behavioral Health and Performance: 4 investigations from ESA and NASA
  - Autonomous Medical Care and Autonomous Emergency Response: 2 investigations from ESA

Use of ISS to Prepare for Exploration

Ops Simulations and Operations Technique Demonstrations

Started

- Autonomous Procedure Execution – (NASA) Modification of several existing procedures to make more autonomously executable (add notes, troubleshooting steps, video, constraints, crew commanding)
- Crew User Interface System Enhancements (CRUISE) – (ESA) Voice activated procedure viewer

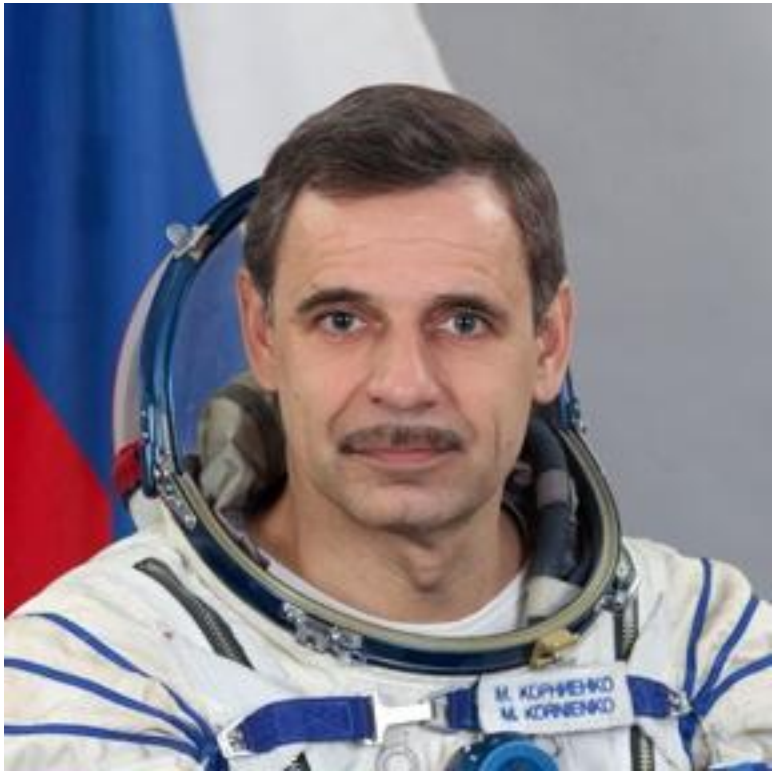
Future

- Instant Messaging (IM) Texting (countermeasure for voice communication delay) (NASA) (Summer 2013)
- Crew Self Scheduling/Replanning on ISS (NASA and Roskosmos) (Summer 2013)
- Communication delay testing - (NASA) Testing of voice communication delay implications to crew/ground behavior and task execution (start date TBD)
- Crew procedures interaction (NASA and ESA) - Using system telemetry embedded in procedures (start date TBD)
- Advanced Exploration Systems (AES)/Autonomous Mission Ops (AMO) – (NASA) Automating crew systems management (start date TBD)

One-Year ISS Mission crewmembers

Scott Kelly
STS-103 in 1999, STS-118 in 2007,
ISS 25/26 in 2011

Mikhail Kornienko
ISS 23/24 in 2010.



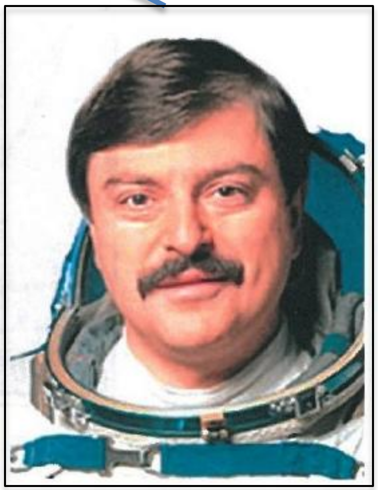
Previous one-year fliers

Months	14	13	12	11	10
#	1	1	2	1	1
Year	1994-1995	1998-1999	1987-1988	1987-1988	1992


Valeri Polyakov


Sergei Avdeyev


Vladimir Titov


Musa Manarov

Joint Biomedical Research Program for Russian-US One-Year ISS Mission

Categories of Biomedical Investigations

- Risks currently not resolved
- Evaluation of countermeasures
- Physiological research on cost of adaptation to spaceflight
- Behavior and performance

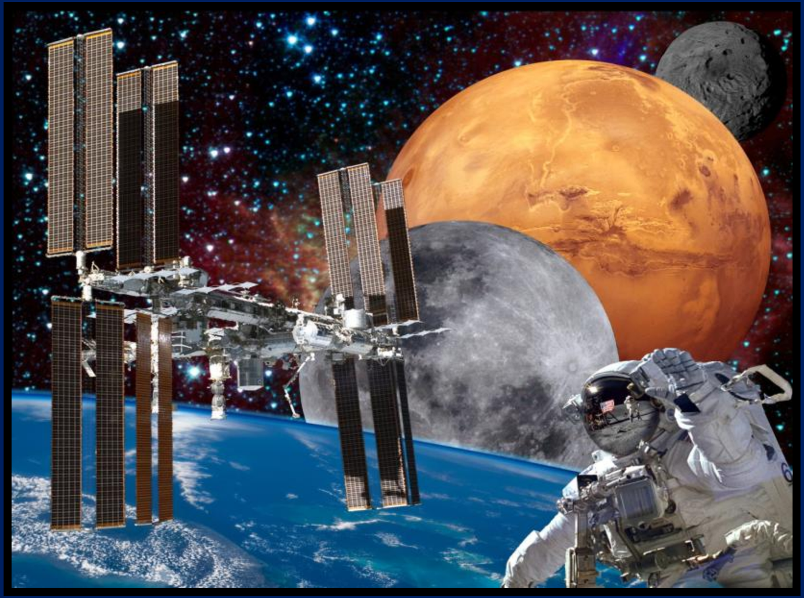
Selection of Biomedical Investigations

- Prioritization will consider (not in rank order)
  - ✓ Highest criticality for Mars
  - ✓ Coordination with Russian investigations
  - ✓ Heritage from previous flights
  - ❑ Compatibility among candidate investigations for co-manifesting on same crewmember(s)
  - ❑ Efficiencies from data-sharing with other investigations and medical requirements
  - ❑ Resources — including mass, power, volume and crewmember time (pre-, in-, post-flight) — for combinations of candidate investigations
  - ❑ Logistics required, especially for post-flight data collection

ISS Vision and Mission

ISS Vision

A world renowned laboratory in space enabling discoveries in science and technology that benefit life on Earth and exploration of the universe



ISS Mission

To advance science and technology research, expand human knowledge, inspire and educate the next generation, foster the commercial development of space and demonstrate capabilities to enable future exploration missions beyond low Earth orbit

Revised ISS Goals

Goal 1: **Maximize Science and Technology Research** **and development on the ISS to realize its full potential**

Goal 2: **Achieve Operational and Cost Efficiency** **with a high performance ISS team working in an optimal and inclusive Program structure**

Goal 3: **Raise Awareness of the ISS**, **its relevance and benefits in our daily lives and our future**

Goal 4: **Provide Global Leadership**, **strategic alliances and partnerships to fully utilize ISS capabilities to further research and exploration**

Goal 5: **Demonstrate capabilities that Benefit Space Exploration and** **Expand Our Reach Beyond Low Earth Orbit (LEO)**

Goal 6: **Use the ISS to** **Catalyze Commercial Development and Operations in Space**