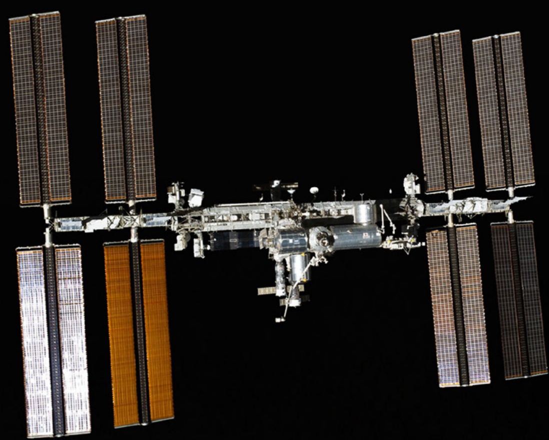
National Aeronautics and Space Administration



SPACE STATION EXPEDITION 35-36

PRESS KIT/March 2013

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BOEING

Prime Contractor to the International Space Station

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MISSION OVERVIEW

Expeditions 35 and 36

The International Space Station is featured in this image photographed by an STS-134 crew member on the space shuttle Endeavour after the shuttle undocked May 29, 2011. Photo credit: NASA

Expeditions 35 and 36 aboard the International Space Station span March 15 through Sept. 11, 2013, and will be filled with numerous international and commercial cargo flights, spacewalks and research investigations involving numerous scientific areas.

Expedition 35 began on March 15 when Kevin Ford, Oleg Novitskiy and Evgeny Tarelkin undocked from the station and came back to Earth. They completed 144 days in space—142 aboard the space station. Before they departed the orbiting complex, Ford handed over command of the station to Chris Hadfield. Hadfield will remain on board with Tom Marshburn and Roman Romanenko.

Chris Cassidy, Alexander Misurkin and Pavel Vinogradov will launch aboard a Russian Soyuz spacecraft on March 28 to join Expedition 35 in progress. This will be the first time a crewed vehicle has launched and docked with the space station on the same day, just six hours after launch. This accelerated rendezvous technique was tested during the past three Progress cargo craft flights.

Hadfield, Marshburn and Romanenko will depart the station on May 14, signaling the beginning of Expedition 36. Cassidy, Misurkin and Vinogradov will remain on board the station as a three-person crew until the end of the month when they will be joined by Karen Nyberg, Fiyodor Yurchikhin and Luca Parmitano. Nyberg, Yurchikin and Parmitano will launch aboard a Russian Soyuz spacecraft May 28.

Four Russian spacewalks are planned during Expeditions 35 and 36 focusing on retrieving science experiments, deploying other experiments and conducting preparatory work to discard the Pirs docking compartment later this year. Pirs will be replaced by the Multipurpose Laboratory Module (MLM), a large Russian airlock, docking port and laboratory to be launched on a Proton rocket at the end of the year. The first of these spacewalks will be conducted by Pavel Vinogradov and Roman Romanenko. The last three will be performed by Fyodor Yurchikhin and Alexander Misurkin.

Two U.S. spacewalks are planned by NASA's Chris Cassidy and ESA's Luca Parmitano. These will be focused on routing power and communication cables for the Russian MLM module, replacing a faulty electronics box for the station's Ku-band communication system, staging spacewalk tools and equipment, including a pair of radiator grapple bars, and completing a number of routine maintenance tasks deferred from previous spacewalks.

EXPEDITION 35 AND 36 CREWS

Expedition 35

Expedition 35 Patch

Emblazoned with a bold 35 for the 35th expedition to the International Space Station, this patch portrays a natural moonlit view of Earth from the International Space Station at the moment of sunrise, one of the 16 that occur each day at orbital velocity, with glowing bands of Earth's atmosphere dispersing the sun's bright light into primary colors. The Earth is depicted as it often appears from space, without recognizable coastlines or boundaries—just as the international endeavor of living and working together in space blurs technical and cultural boundaries between nations. The space station is the unseen central figure of the image, since the view is from a window of the station itself, commemorating full use of the station as a long-duration dwelling from which humans can develop techniques and technologies to explore further. As the crew points out, "The arc of the Earth's horizon with the sun's arrows of light imply a bow shooting the imagination to Mars and the cosmos where our species may one day thrive." Photo credit: NASA

Expedition 35 crew members take a break from training at NASA's Johnson Space Center to pose for a crew portrait. Pictured on the front row are Canadian Space Agency astronaut Chris Hadfield (right), commander; and Russian cosmonaut Pavel Vinogradov, flight engineer. Pictured from the left (back row) are Russian cosmonaut Alexander Misurkin, NASA astronaut Chris Cassidy, Russian cosmonaut Roman Romanenko and NASA astronaut Tom Marshburn, all flight engineers.
Photo credit: NASA

Expedition 36

Expedition 36 Patch

The dynamic design of the Expedition 36 patch portrays the International Space Station's iconic solar arrays. The slanted angles denote a kinetic energy leading from Earth in the lower right to the upper left tip of the triangular shape of the patch, representing the infinite scientific research, education and long-duration spaceflight capabilities the space station provides with each mission, as well as our goal for future exploration beyond the station. The numbers 3 and 6 harmoniously intertwine to form expedition number 36 and its gray coloration signifies the unity and neutrality among all of the international partners of the space station. The blue and gold color scheme of the patch represents the subtle way the central gold orbit wraps around the number 36 to form a trident at its lower right tip. The trident also symbolizes the sea, air and land, all of which make up Earth from where the trident originates in the design. Photo credit: NASA

Expedition 36 crew members take a break from training at NASA's Johnson Space Center to pose for a crew portrait. Pictured on the front row are Russian cosmonauts Pavel Vinogradov (left), commander; and Fyodor Yurchikhin, flight engineer. Pictured from the left (back row) are Russian cosmonaut Alexander Misurkin, NASA astronaut Chris Cassidy, European Space Agency astronaut Luca Parmitano and NASA astronaut Karen Nyberg, all flight engineers. Photo credit: NASA

Chris Hadfield

This is the third space mission for Canadian Space Agency astronaut Chris Hadfield, 52, a retired colonel in the Canadian Air Force. His first mission was on STS-74 to the Mir station in 1995. His second mission was to the International Space Station on STS-100 in 2001 where he performed two spacewalks. Hadfield will serve as commander on Expedition 35.

Thomas Marshburn

For former NASA flight surgeon Dr. Thomas Marshburn, 51, this is his second space mission. His first mission was on STS-127 in 2009 which delivered the Japanese-built Exposed Facility and the Experiment Logistics Module Exposed Section to the International Space Station. On that mission Marshburn performed three spacewalks. Marshburn will serve as a flight engineer for Expedition 35.

Roman Romanenko

A major in the Russian Air Force, Roman Romanenko, 40, is making his second long-duration expedition. He was a member of the Expedition 20 and 21 crews. He was selected as a cosmonaut candidate in 1997 and qualified as a test-cosmonaut in 1999. Romanenko will serve as the Soyuz commander and as a flight engineer for Expedition 35.

Chris Cassidy

This will be the second space mission for Chris Cassidy, 43, a commander in the United States Navy. His first mission was on STS-127 to the International Space Station in 2009. During that mission he performed three spacewalks, spending more than 18 hours outside the orbiting complex. Cassidy will serve as a flight engineer for Expeditions 35 and 36.

Pavel Vinogradov

This will be the third space mission for Pavel Vinogradov, a former design engineer. He joined the cosmonaut corps in 1992 and underwent two years of training before certification as a test cosmonaut in 1994. In his previous spaceflights Vinogradov was a crew member aboard space station Mir for 197 days in1997-98, and lived aboard the International Space Station for 182 days in 2006. Vinogradov will serve as flight engineer for Expedition 35 and commander of Expedition 36.

Aleksandr Misurkin

A retired lieutenant colonel in the Russian Air Force, Aleksandr Misurkin, 35, will be making his first spaceflight. He was selected as a cosmonaut candidate in 2006 and qualified as a test-cosmonaut in 2009. Misurkin will serve as a flight engineer for Expeditions 35 and 36.

Karen Nyberg

This will be the second space mission for Karen Nyberg, 43, who holds a doctorate in mechanical engineering. Her first mission was on STS-124 to the International Space Station in 2008. Nyberg will serve as a flight engineer on Expeditions 36 and 37.

Fyodor Yurchikhin

For former Russian engineer Fyodor Yurchikhin, 54, this will be his fourth space mission. His first mission was on STS-112 in 2002, followed by two long-duration missions to the International Space Station in 2007 as a crew member of Expedition 15, and as a crew member of Expedition 24/25 in 2010. Yurchikhin has performed five spacewalks and spent more than 371 days in space. Yurchikhin will serve as a flight engineer for Expedition 36 and commander of Expedition 37.

Luca Parmitano

A major in the Italian Air Force, Luca Parmitano, 36, will be making his first spaceflight. The European Space Agency selected him as an astronaut candidate in 2009. Following two years of training, Parmitano was certified as an astronaut in 2011. Parmitano will serve as a flight engineer for Expeditions 36 and 37.

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EXPEDITION 35 AND 36 SPACEWALKS

There are six spacewalks planned for the Expedition 35 and 36 increments – Russian spacewalks 32, 33, 34 and 35 and U.S. spacewalks 21 and 22.

NASA astronaut Chris Cassidy and European Space Agency astronaut Luca Parmitano will participate in both of the planned U.S. spacewalks targeted for early July.

Russian spacewalk 32 will be performed by cosmonauts Pavel Vinogradov and Roman Romanenko and is planned to occur April 19. Russian spacewalks 33, 34 and 35 will be conducted by cosmonauts Fyodor Yurchikhin and Alexander Misurkin with the first planned to occur in late June and the next pair in August.

The first spacewalk – Russian spacewalk 32 by Vinogradov and Romanenko - will focus on setting up and connecting the Obstanovka plasma wave experiment, a Russian investigation into space weather in Earth’s upper atmosphere. This task includes the planned jettison of two probe containers and a cable reel.

They will then remove a container from the Russian experiment Biorisk, which looks at the effects of microbial bacteria and fungus on structural materials used in spacecraft construction. If time permits, they also will remove the first sample panel from the Russian Vynoslivost experiment, an ongoing research study into identifying the effects of space environment factors on strain, strength and fatigue characteristics on various materials.

The focus of the second spacewalk – Russian spacewalk 33 by Yurchikhin and Misurkin – will be replacing a fluid flow regulator on the Russian segment’s Zarya module. They also will remove the Photon-Gamma unit of the Molina-Gamma experiment, which measures gamma splashes and optical radiation during terrestrial lightning and thunder conditions, from a portable workstation on Zvezda. A test of the station’s KURS equipment, which is used to control the automatic docking of Russian Progress resupply ships, also will be conducted. Additional tasks will include photographing the multilayer insulation (MLI) protecting the Russian segment from micrometeoroids and taking samples from the exterior surface of the pressure hull underneath the MLI to identify signs of pressure hull material microscopic deterioration.

The third spacewalk – U.S. spacewalk 21 – will focus on routing power cables in preparation for the planned Russian Multipurpose Laboratory Module (MLM), which will replace the Pirs Docking Compartment in late 2013. Cassidy and Parmitano will remove and replace a Space-to-Ground Transmitter Receiver Controller, install a radiator grapple bar and retrieve a mast camera from the Mobile Base System. They also will install the first of two jumper cables on the Z1 truss. Their final tasks will include the retrieval of samples from the Materials International Space Station Experiment and the Optical Reflector Materials Experiment. If time permits, a variety of “get-ahead” tasks could be performed, including temporary cable stowage, releasing clamps on the S1 truss and relocating an articulating portable foot restraint.

Just days later, the fourth spacewalk – U.S. spacewalk 22 – will see Cassidy and Parmitano work to remove alignment guides from the radiator grapple bars and move them to External Stowage Platform-2. Next they will work to route networking cables to the upcoming MLM location and remove insulation from one of the station’s Main Bus Switching Units. After installing a second Z1 truss jumper cable, the two astronauts will work to replace a camera on the Japanese Experiment Module Exposed Facility and install cables for the fixed grapple bar’s module’s power and data grapple fixture. Their final task will be to relocate the Wireless External Transceiver Assembly and the Video Stanchion Support Assembly from Camera Port 8 to Camera Port 11 on the truss. If time permits, the two spacewalkers will work to finish up get-ahead tasks from the previous spacewalk including the release of clamps on the S1 truss and relocating an articulating portable foot restraint.

The fifth spacewalk – Russian spacewalk 34 with Yurchikhin and Misurkin – will focus on routing four power feeders from the Zarya module's pressurized adapter to the Poisk module to transfer power from the U.S. segment to the new MLM. They also will route and connect the networking cables for the MLM from Zarya's pressurized adapter over to Poisk. Their final task will be setting up a panel for the Vynoslivost experiment.

The final spacewalk – Russian spacewalk 35 by Yurchikhin and Misurkin – will see the cosmonauts set up a portable workstation and targeting platform on the large diameter working compartment on Zvezda. They will then remove the Onboard Laser Communications Terminal hardware from the working compartment as well as the docking target from Pirs. The crew will then photograph insulation on the Russian segment, if time permits.

NASA astronaut Chris Cassidy, Expedition 35/36 flight engineer, gets help making final touches on a training version of his Extravehicular Mobility Unit spacesuit in preparation for a spacewalk training session in the waters of the Neutral Buoyancy Laboratory near NASA's Johnson Space Center in Houston.

H-II TRANSFER VEHICLE-4

The H-II Transfer Vehicle (HTV) nicknamed “KOUNOTORI” is Japan’s uncrewed cargo transfer spacecraft that delivers internal and external equipment and experiments to the International Space Station. The HTV successfully completed its missions in 2009, 2011 and 2012. It is scheduled to be flown once annually. HTV4 is scheduled for launch this summer.

Specifications

Length	9.8 m (10 yards)
Diameter	4.4 m (4 yards)
Dry Mass	10,500 kg (23,148 lbs)
Cargo Capacity for Supply	Total 6,000 kg (13,227 lbs)
	(Pressurized Cargo) 5,200 kg (11,464 lbs)
	(Unpressurized Cargo) 1,500 kg (3,306 lbs)
Cargo Capacity for Trash	Up to 6,000 kg (13,227 lbs)

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<u>The major mission of HTV4</u>

- **Transportation of supplies**
  - A maximum 6 tons of supplies (including the loaded racks) will be transported to the station.
  - The Pressurized Logistics Carrier (PLC) will carry water bags, food, experimental samples, among other items
  - The Exposed Pallet (EP) will carry three NASA exposed payloads.
    - Main Bus Switching Unit (MBSU)【ORU *1】 (NASA)
    - UTA (Utility Transfer Assembly) 【ORU *1】 (NASA)
    - STP-H4 (Space Test Program-Houston 4) (NASA)

- **Waste disposal**
  - Pressurized waste materials used/spent on the station will be loaded onto and disposed with the HTV4.
  - STP-H3 (Space Test Program-Houston 3) (NASA)
- **Confirmation of reflecting the results of the HTV3**

HTV4 Cargo

2.1 Pressurized cargo

The HTV4 will transport water bags, experimental samples, food and daily commodities using eight HTV Resupply Racks (HRRs).

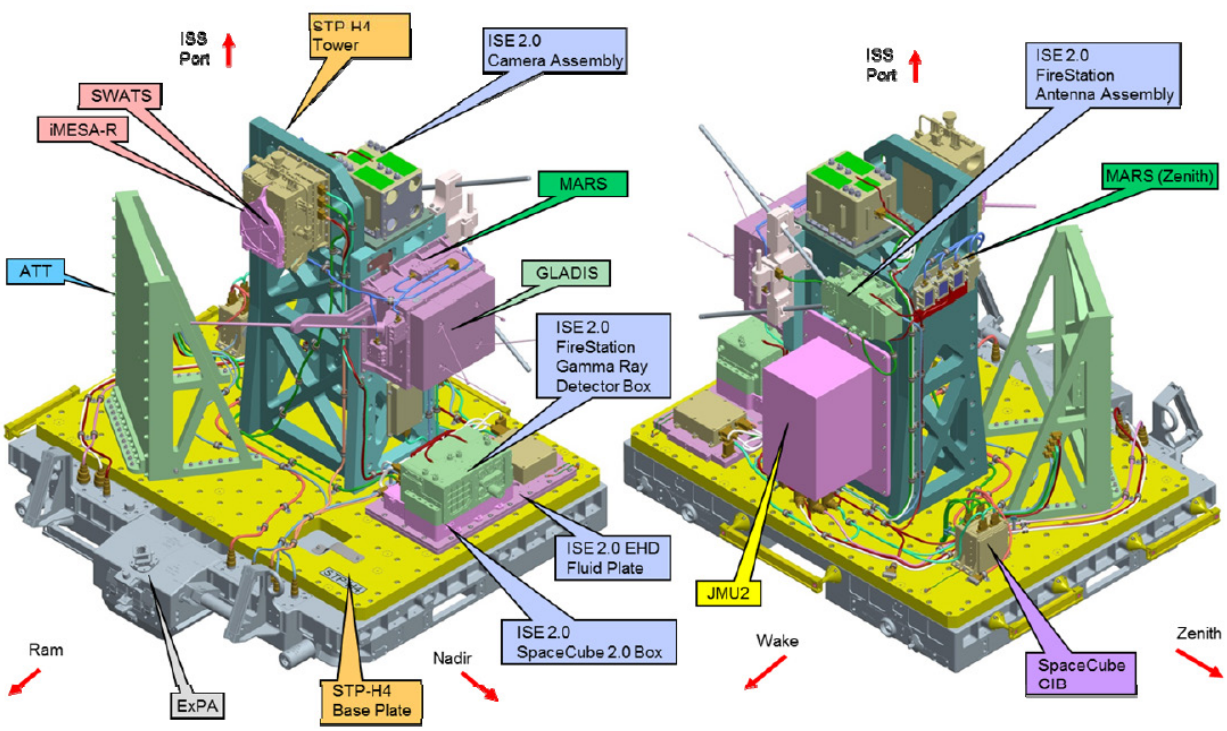
2.2 Unpressurized cargo

The HTV4 will transport three sets of unpressurized cargo on the EP-MP and dispose of one set of unpressurized waste cargo. (The HTV4 will be the first space transfer vehicle to carry three sets of unpressurized cargo and also the first to dispose of a pressurized cargo on re-entry.)

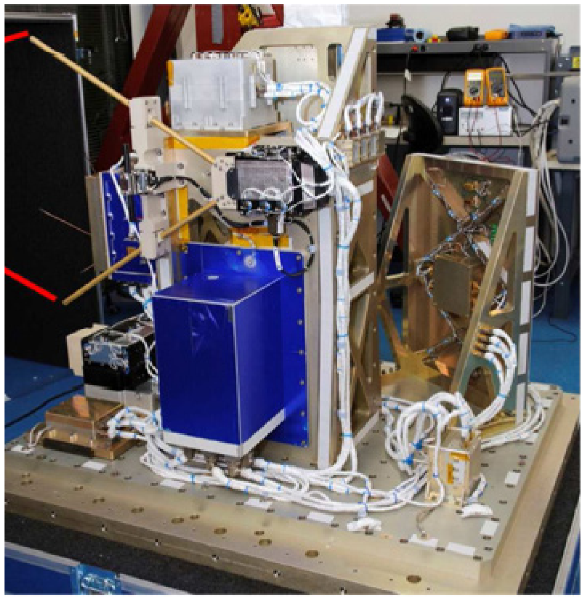
Cargo scheduled to be loaded

- **STP-H4 (Space Test Program – Houston 4)**

  STP-H4, an experiment payload including several pieces of experimental equipment (eight in total), will be launched in one of the sets of HTV4 unpressurized cargo.



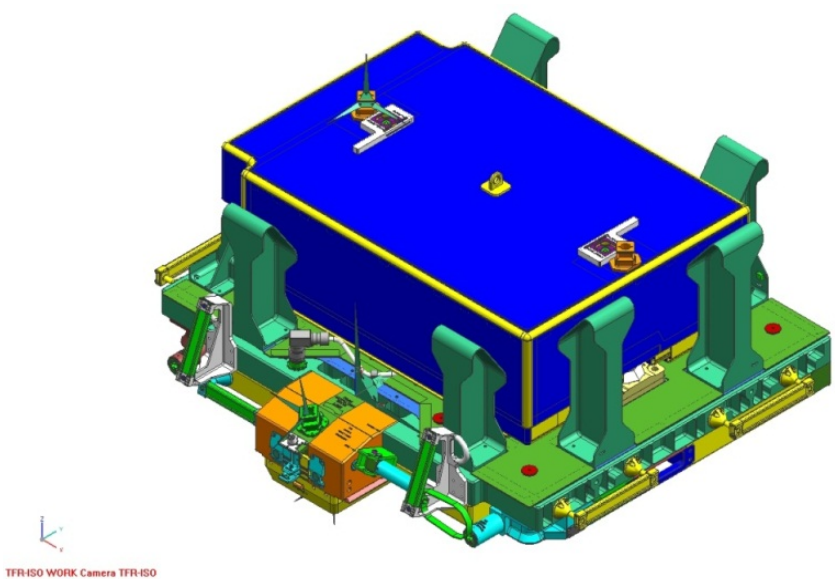
Exterior of the STP-H4



Space Test Program - Houston 4

- **Main Bus Switching Unit**

  The Main Bus Switching Unit (MBSU) is a device used to switch the main bus power system of the station: each MBSU receiving electricity from two power channels distributes it to the experimental modules, DDCU on the truss, and the Russian module. This is one of the station's spare items.

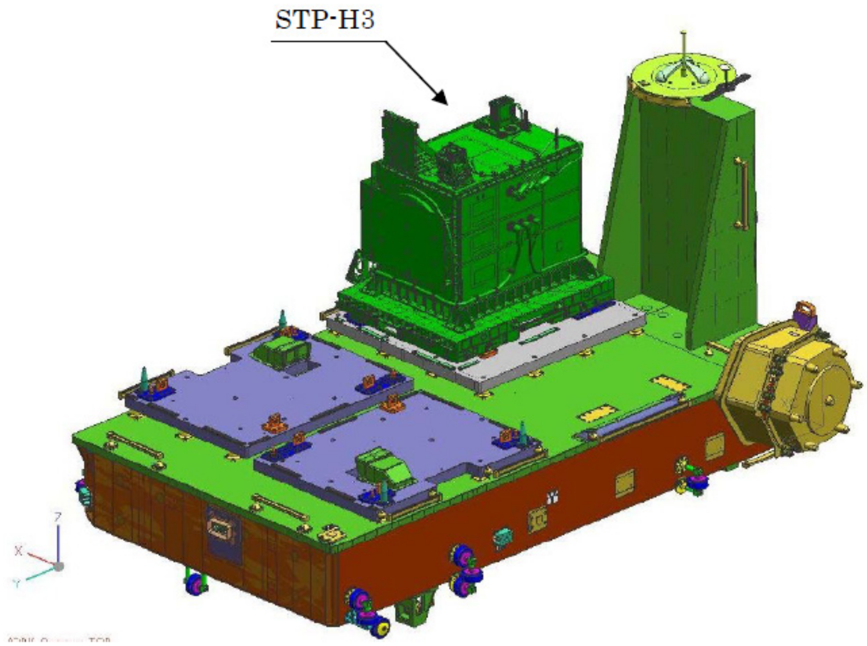


- **Utility Transfer Assembly**

  The Utility Transfer Assembly (UTA), at the core of the SARJ structure, provides power and a communications interface. This is also one of the station's spare items.

Waste cargo

- **STP-H3 (Space Test Program – Houston 3)**



Waste cargo on the Exposed Pallet (on return)

Re-entry observation equipment

- Following the HTV3, the re-entry of the HTV4 will be observed to assess the dispersion of the destruction altitude of the HTVs.
- This assessment will be used to minimize the HTV fall and dispersion area in future.
- Along with the re-entry observation, data contributing to research and development regarding future re-entry vehicles will be acquired.
- The acquired re-entry observation data will be shared with that concerning transportation.
- The HTV4 carries i-Ball, the technology of which was verified on the HTV3. With a fundamental specification equivalent to that at the HTV3, the following optional specifications for improvements and supplements will be employed:
  - Improvement in the acquired acceleration/angular velocity data rate (1 → 10 Hz or more)
  - Pressure/temperature measurement in the Pressurized Logistics Carrier

i-Ball (Container and capsule)

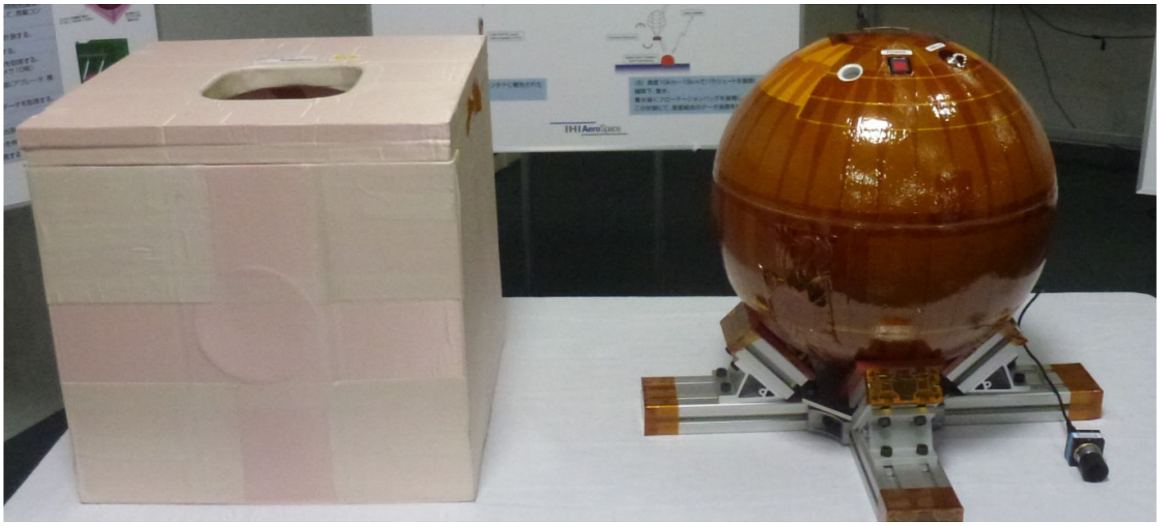


Image acquired with HTV3 i-Ball

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AUTOMATED TRANSFER VEHICLE-4

Mission Overview

Automated Transfer Vehicle-4: The Flight of Albert Einstein

One of the most reliable and complex spacecraft ever built in Europe is set for another trip to the International Space Station. Named after Albert Einstein, the fourth Automated Transfer Vehicle (ATV-4) contributes to keep the station and its permanent crew of six working at full capacity.

ATV-4 will take off from Europe's Spaceport in Kourou, French Guiana, on top of an Ariane 5 ES launcher. Launch is targeted for early June.

The spacecraft plays a vital role in station logistics: it serves as cargo carrier, storage facility and "space tug." Just as its predecessors, the objectives of this mission are to deliver 6.6 tons of cargo and maintain the station's orbit for six months.

ATV has the largest cargo capability of all vehicles that visit the International Space Station. The fourth in the series carries more dry cargo than any ATV to date, increasing its contribution to the station.

It is loaded with 2,380 kg (5,247 pounds) of propellant to function as a space tug. ATV-4's reboosts help counteract atmospheric drag that causes the station to lose up to 100 m (109 yards) of altitude each day. ATV can even push the station to avoid space debris. It also provides attitude control when other spacecraft are approaching the station.

As a space freighter, ATV carries 2,700 kg (5,952 pounds) of dry cargo such as scientific equipment, spare parts, food and clothes for the astronauts. It also delivers 100 kg (220 pounds) of gas, more than 500 liters (132 gallons) of drinking water and about 800 kg (1,763 pounds) of propellant − all pumped into the station's tanks.

The station's needs change with every mission, and there are always last-minute requests of every kind. A new Late Cargo Access Means lift will be used to load larger and heavier bags during the last weeks before launch. This allows for greater flexibility when ATV is already on top of its Ariane 5 rocket.

Russian cosmonaut Pavel Vinogradov will be the prime operator monitoring Albert Einstein as it approaches the station. The 20-ton vehicle is able to navigate on its own and dock automatically with the station.

Once attached, ATV-4 is used as an extra module by the crew members on board. After about six months, it will undock from the station filled with a few tons of waste water, materials and equipment. ATV-4 last journey will be a controlled and destructive re-entry into Earth's atmosphere.

Automated Transfer Vehicle-2, called Johannes Kepler, is seen attached to the International Space Station.

RUSSIAN SOYUZ

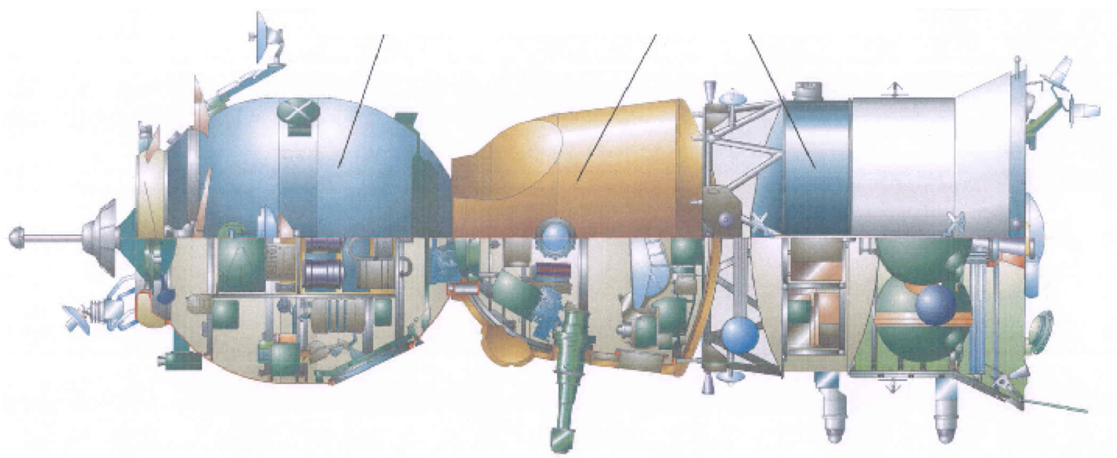


Diagram of the Soyuz-TMA spacecraft

The Soyuz-TMA spacecraft is designed to serve as the station's crew return vehicle, acting as a lifeboat in the unlikely event an emergency would require the crew to leave the station. A new Soyuz capsule is normally delivered to the station by a Soyuz crew every six months, replacing an older Soyuz capsule already docked to the space station.

The Soyuz spacecraft is launched to the space station from the Baikonur Cosmodrome in Kazakhstan aboard a Soyuz rocket. It consists of an orbital module, a descent module, and an instrumentation/propulsion module.

Orbital Module

This portion of the Soyuz spacecraft is used by the crew while in orbit during free flight. It has a volume of 230 cubic feet, with a docking mechanism, hatch and rendezvous antennas located at the front end. The docking mechanism is used to dock with the space station and the hatch allows entry into the station. The rendezvous antennae are used by the automated docking system − a radar-based system − to maneuver toward the station for docking. There is also a window in the module.

The opposite end of the orbital module connects to the descent module via a pressurized hatch. Before returning to Earth, the orbital module separates from the descent module − after the deorbit maneuver − and burns up upon re-entry into the atmosphere.

Descent Module

The descent module is where the cosmonauts and astronauts sit for launch, re-entry and landing. All the necessary controls and displays of the Soyuz are located here. The module also contains life support supplies and batteries used during descent, as well as the primary and backup parachutes and landing rockets. It also contains custom-fitted seat liners for each crew member's couch/seat, which are individually molded to fit each person's body − this ensures a tight, comfortable fit when the module lands on Earth.

The module has a periscope, which allows the crew to view the docking target on the station or Earth below. The eight hydrogen peroxide thrusters on the module are used to control the spacecraft's orientation, or attitude, during the descent until parachute deployment. It also has a Guidance, Navigation, and Control (GNC) system to maneuver the vehicle during the descent phase of the mission.

This module weighs 6,393 pounds, with a habitable volume of 141 cubic feet. Approximately 110 pounds of payload can be returned to Earth in this module and up to 331 pounds if only two crew members are present. The descent module is the only portion of the Soyuz that survives the return to Earth.

Instrumentation/Propulsion Module

This module contains three compartments: intermediate, instrumentation and propulsion.

The intermediate compartment is where the module connects to the descent module. It also contains oxygen storage tanks and the attitude control thrusters, as well as electronics, communications and control equipment. The primary guidance, navigation, control and computer systems of the Soyuz are in the instrumentation compartment, which is a sealed container filled with circulating nitrogen gas to cool the avionics equipment. The propulsion compartment contains the primary thermal control system and the Soyuz radiator, which has a cooling area of 86 square feet. The propulsion system, batteries, solar arrays, radiator and structural connection to the Soyuz launch rocket are located in this compartment.

The propulsion compartment contains the system that is used to perform any maneuvers while in orbit, including rendezvous and docking with the space station and the deorbit burns necessary to return to Earth. The propellants are nitrogen tetroxide and unsymmetric- dimethylhydrazine. The main propulsion system and the smaller reaction control system, used for attitude changes while in space, share the same propellant tanks.

The two Soyuz solar arrays are attached to either side of the rear section of the instrumentation/propulsion module and are linked to rechargeable batteries. Like the orbital module, the intermediate section of the instrumentation/propulsion module separates from the descent module after the final deorbit maneuver and burns up in the atmosphere upon re-entry.

TMA Improvements and Testing

The Soyuz TMA-01M spacecraft is the first to incorporate both newer, more powerful computer avionics systems and new digital displays for use by the crew. The new computer systems will allow the Soyuz computers to interface with the onboard computers in the Russian segment of the station once docking is complete.

Both Soyuz TMA-15, which launched to the station in May 2009, and Soyuz TMA-18, which launched in April 2010, incorporated the new digital "Neptune" display panels, and seven Progress resupply vehicles have used the new avionics computer systems.

The Soyuz TMA-01M vehicle integrates those systems. The majority of updated components are housed in the Soyuz instrumentation module.

For launch, the new avionics systems reduce the weight of the spacecraft by approximately 150 pounds, which allows a small increase in cargo-carrying capacity. Soyuz spacecraft are capable of carrying a limited amount of supplies for the crew's use. This will increase the weight of supplies the spacecraft is capable of carrying, but will not provide any additional volume for bulky items.

Once Soyuz is docked to the station, the new digital data communications system will simplify life for the crew. Previous versions of the spacecraft, including both the Soyuz TM, which was used from 1986 to 2002, and the Soyuz TMA in use since 2002, required Mission Control Center-Moscow (MCC-M), to turn on the Soyuz computer systems periodically so that a partial set of parameters on the health of the vehicle could be downlinked for review. In addition, in the case of an emergency undocking and deorbit, crew members were required to manually input undocking and deorbit data parameters. The new system will eliminate the need for the crew to perform these checks and data updates, with the necessary data being automatically transferred from the space station to the Soyuz.

The updates required some structural modifications to the Soyuz, including the installation of cold plates and an improved thermal system pump capable of rejecting the additional heat generated by the new computer systems.

The majority of Soyuz TMA systems remain unchanged. In use since 2002, the TMA increased safety, especially in descent and landing. It has smaller and more efficient computers and improved displays. In addition, the Soyuz TMA accommodates individuals as large as 6 feet, 3 inches tall and 209 pounds, compared to 6 feet and 187 pounds in the earlier TM. Minimum crew member size for the TMA is 4 feet, 11 inches and 110 pounds, compared to 5 feet, 4 inches and 123 pounds for the TM.

Two new engines reduced landing speed and forces felt by crew members by 15 to 30 percent, and a new entry control system and three-axis accelerometer increase landing accuracy. Instrumentation improvements included a color “glass cockpit,” which is easier to use and gives the crew more information, with hand controllers that can be secured under an instrument panel. All the new components in the Soyuz TMA can spend up to one year in space.

New components and the entire TMA were rigorously tested on the ground, in hangar-drop tests, in airdrop tests and in space before the spacecraft was declared flight-ready. For example, the accelerometer and associated software, as well as modified boosters (incorporated to cope with the TMA’s additional mass), were tested on flights of Progress, the unpiloted supply spacecraft, while the new cooling system was tested on two Soyuz TM flights.

Descent module structural modifications, seats and seat shock absorbers were tested in hangar drop tests. Landing system modifications, including associated software upgrades, were tested in a series of air drop tests. Additionally, extensive tests of systems and components were conducted on the ground.

Soyuz Launcher

The Soyuz TMA-04M rocket launches from the Baikonur Cosmodrome in Kazakhstan on May 15, 2012, carrying Expedition 31 Soyuz Commander Gennady Padalka of Russia, Flight Engineer Joseph Acaba of NASA and Flight Engineer Sergei Revin of Russia, to the International Space Station. Photo credit: NASA/Bill Ingalls

Throughout history, more than 1,500 launches have been made with Soyuz launchers to orbit satellites for telecommunications, Earth observation, weather, and scientific missions, as well as for human space flights.

The basic Soyuz vehicle is considered a three-stage launcher in Russian terms and is composed of the following:

- A lower portion consisting of four boosters (first stage) and a central core (second stage).
- An upper portion, consisting of the third stage, payload adapter and payload fairing.
- Liquid oxygen and kerosene are used as propellants in all three Soyuz stages.

First Stage Boosters

The first stage's four boosters are assembled laterally around the second stage central core. The boosters are identical and cylindrical-conic in shape with the oxygen tank in the cone-shaped portion and the kerosene tank in the cylindrical portion.

An NPO Energomash RD 107 engine with four main chambers and two gimbaled vernier thrusters is used in each booster. The vernier thrusters provide three-axis flight control.

Ignition of the first stage boosters and the second stage central core occur simultaneously on the ground. When the boosters have completed their powered flight during ascent, they are separated and the core second stage continues to function.

First stage booster separation occurs when the predefined velocity is reached, which is about 118 seconds after liftoff.

Second Stage

An NPO Energomash RD 108 engine powers the Soyuz second stage. This engine differs from those of the boosters by the presence of four vernier thrusters, which are necessary for three-axis flight control of the launcher after the first stage boosters have separated.

An equipment bay located atop the second stage operates during the entire flight of the first and second stages.

Third Stage

The third stage is linked to the Soyuz second stage by a latticework structure. When the second stage's powered flight is complete, the third stage engine is ignited. Separation of the two stages occurs by the direct ignition forces of the third stage engine.

A single-turbopump RD 0110 engine from KB KhA powers the Soyuz third stage.

The third stage engine is fired for about 240 seconds, and cutoff occurs when the calculated velocity increment is reached. After cutoff and separation, the third stage performs an avoidance maneuver by opening an outgassing valve in the liquid oxygen tank.

Launcher Telemetry Tracking & Flight Safety Systems

Soyuz launcher tracking and telemetry is provided through systems in the second and third stages. These two stages have their own radar transponders for ground tracking. Individual telemetry transmitters are in each stage. Launcher health status is downlinked to ground stations along the flight path. Telemetry and tracking data are transmitted to the mission control center, where the incoming data flow is recorded. Partial real-time data processing and plotting is performed for flight following an initial performance assessment. All flight data is analyzed and documented within a few hours after launch.

Baikonur Cosmodrome Launch Operations

Soyuz missions use the Baikonur Cosmodrome's proven infrastructure, and launches are performed by trained personnel with extensive operational experience.

Baikonur Cosmodrome is in the Republic of Kazakhstan in Central Asia between 45 degrees and 46 degrees North latitude and 63 degrees East longitude. Two launch pads are dedicated to Soyuz missions.

Final Launch Preparations

The assembled launch vehicle is moved to the launch pad on a horizontal railcar. Transfer to the launch zone occurs two days before launch, during which the vehicle is erected and a launch rehearsal is performed that includes activation of all electrical and mechanical equipment.

On launch day, the vehicle is loaded with propellant and the final countdown sequence is started three hours before the liftoff time.

Rendezvous to Docking

A Soyuz spacecraft generally takes a single day after launch to reach the space station. The rendezvous and docking are both automated, though once the spacecraft is within 492 feet of the station, the Russian Mission Control Center just outside Moscow monitors the approach and docking. The Soyuz crew has the capability to manually intervene or execute these operations.

Soyuz Booster Rocket Characteristics

First Stage Data - Blocks B, V, G, D	
Engine	RD-107
Propellants	LOX/Kerosene
Thrust (tons)	102
Burn time (sec)	122
Specific impulse	314
Length (meters)	19.8
Diameter (meters)	2.68
Dry mass (tons)	3.45
Propellant mass (tons)	39.63
Second Stage Data - Block A	
Engine	RD-108
Propellants	LOX/Kerosene
Thrust (tons)	96
Burn time (sec)	314
Specific impulse	315
Length (meters)	28.75
Diameter (meters)	2.95
Dry mass (tons)	6.51
Propellant mass (tons)	95.7
Third Stage Data - Block I	
Engine	RD-461
Propellants	LOX/Kerosene
Thrust (tons)	30
Burn time (sec)	240
Specific impulse	330
Length (meters)	8.1
Diameter (meters)	2.66
Dry mass (tons)	2.4
Propellant mass (tons)	21.3
PAYLOAD MASS (tons)	6.8
SHROUD MASS (tons)	4.5
LAUNCH MASS (tons)	309.53
TOTAL LENGTH (meters)	49.3

Prelaunch Countdown Timeline

T- 34 Hours	Booster is prepared for fuel loading
T- 6:00:00	Batteries are installed in booster
T- 5:30:00	State commission gives go to take launch vehicle
T- 5:15:00	Crew arrives at site 254
T- 5:00:00	Tanking begins
T- 4:20:00	Spacesuit donning
T- 4:00:00	Booster is loaded with liquid oxygen
T- 3:40:00	Crew meets delegations
T- 3:10:00	Reports to the State commission
T- 3:05:00	Transfer to the launch pad
T- 3:00:00	Vehicle 1st and 2nd stage oxidizer fueling complete
T- 2:35:00	Crew arrives at launch vehicle
T- 2:30:00	Crew ingress through orbital module side hatch
T- 2:00:00	Crew in re-entry vehicle
T- 1:45:00	Re-entry vehicle hardware tested; suits are ventilated
T- 1:30:00	Launch command monitoring and supply unit prepared
	Orbital compartment hatch tested for sealing
T- 1:00:00	Launch vehicle control system prepared for use; gyro instruments activated
T- :45:00	Launch pad service structure halves are lowered
T- :40:00	Re-entry vehicle hardware testing complete; leak checks performed on suits
T- :30:00	Emergency escape system armed; launch command supply unit activated
T- :25:00	Service towers withdrawn
T- :15:00	Suit leak tests complete; crew engages personal escape hardware auto mode
T- :10:00	Launch gyro instruments uncaged; crew activates onboard recorders
T- 7:00	All prelaunch operations are complete
T- 6:15	Key to launch command given at the launch site
	Automatic program of final launch operations is activated
T- 6:00	All launch complex and vehicle systems ready for launch
T- 5:00	Onboard systems switched to onboard control
	Ground measurement system activated by RUN 1 command
	Commander's controls activated
	Crew switches to suit air by closing helmets
	Launch key inserted in launch bunker
T- 3:15	Combustion chambers of side and central engine pods purged with nitrogen
T- 2:30	Booster propellant tank pressurization starts
	Onboard measurement system activated by RUN 2 command
	Prelaunch pressurization of all tanks with nitrogen begins
T- 2:15	Oxidizer and fuel drain and safety valves of launch vehicle are closed
	Ground filling of oxidizer and nitrogen to the launch vehicle is terminated

Prelaunch Countdown Timeline (concluded)

T- 1:00	Vehicle on internal power
	Automatic sequencer on
	First umbilical tower separates from booster
T- :40	Ground power supply umbilical to third stage is disconnected
T- :20	Launch command given at the launch position
	Central and side pod engines are turned on
T- :15	Second umbilical tower separates from booster
T- :10	Engine turbopumps at flight speed
T- :05	First stage engines at maximum thrust
T- :00	Fueling tower separates
	Lift off

Ascent/Insertion Timeline

T- :00	Lift off
T+ 1:10	Booster velocity is 1,640 ft/sec
T+ 1:58	Stage 1 (strap-on boosters) separation
T+ 2:00	Booster velocity is 4,921 ft/sec
T+ 2:40	Escape tower and launch shroud jettison
T+ 4:58	Core booster separates at 105.65 statute miles
	Third stage ignites
T+ 7:30	Velocity is 19,685 ft/sec
T+ 9:00	Third stage cut-off
	Soyuz separates
	Antennas and solar panels deploy
	Flight control switches to Mission Control, Korolev

Orbital Insertion to Docking Timeline

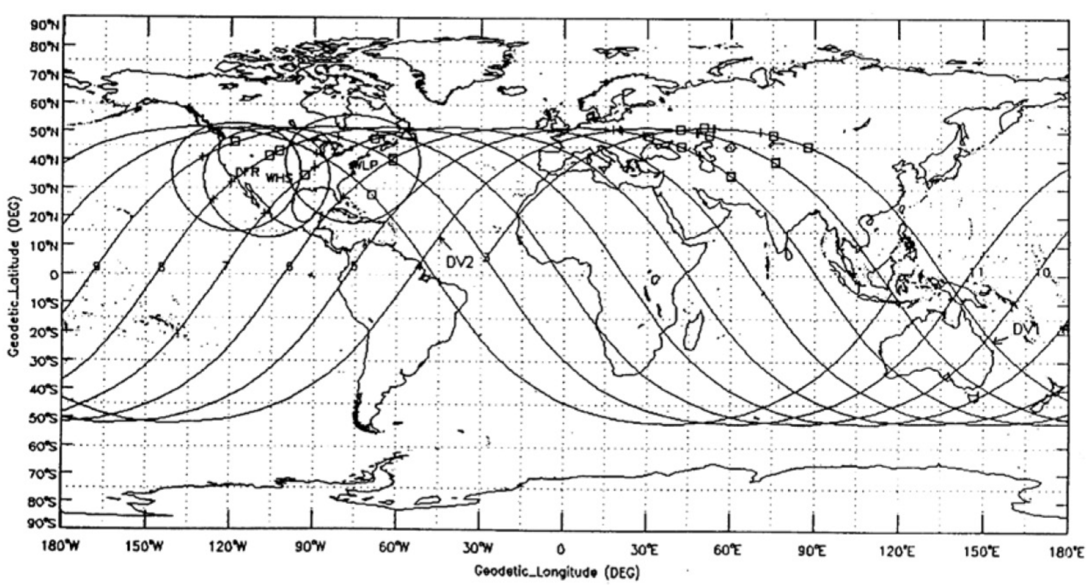
FLIGHT DAY 1 OVERVIEW	
Orbit 1	**Post insertion: Deployment of solar panels, antennas and docking probe**
	• Crew monitors all deployments
	• Crew reports on pressurization of OMS/RCS and ECLSS systems and crew health. Entry thermal sensors are manually deactivated
	• Ground provides initial orbital insertion data from tracking
Orbit 2	**Systems Checkout: IR Att Sensors, Kurs, Angular Accels, "Display" TV Downlink System, OMS engine control system, Manual Attitude Control Test**
	• Crew monitors all systems tests and confirms onboard indications
	• Crew performs manual RHC stick inputs for attitude control test
	• Ingress into HM, activate HM CO2 scrubber and doff Sokols
	• A/G, R/T and Recorded TLM and Display TV downlink
	• Radar and radio transponder tracking
	Manual maneuver to +Y to Sun and initiate a 2 deg/sec yaw rotation. MCS is deactivated after rate is established
Orbit 3	**Terminate +Y solar rotation, reactivate MCS and establish LVLH attitude reference (auto maneuver sequence)**
	• Crew monitors LVLH attitude reference build up
	• Burn data command upload for DV1 and DV2 (attitude, TIG Delta Vs)
	• Form 14 preburn emergency deorbit pad read up
	• A/G, R/T and Recorded TLM and Display TV downlink
	• Radar and radio transponder tracking
	Auto maneuver to DV1 burn attitude (TIG - 8 minutes) while LOS
	• Crew monitor only, no manual action nominally required
	DV1 phasing burn while LOS
	• Crew monitor only, no manual action nominally required
Orbit 4	**Auto maneuver to DV2 burn attitude (TIG - 8 minutes) while LOS**
	• Crew monitor only, no manual action nominally required
	DV2 phasing burn while LOS
	• Crew monitor only, no manual action nominally required
	Crew report on burn performance upon AOS
	• HM and DM pressure checks read down
	• Post burn Form 23 (AOS/LOS pad), Form 14 and "Globe" corrections voiced up
	• A/G, R/T and Recorded TLM and Display TV downlink
	• Radar and radio transponder tracking
	Manual maneuver to +Y to Sun and initiate a 2 deg/sec yaw rotation. MCS is deactivated after rate is established
	External boresight TV camera ops check (while LOS)
	Meal

FLIGHT DAY 1 OVERVIEW (CONTINUED)	
Orbit 5	**Last pass on Russian tracking range for Flight Day 1**
	Report on TV camera test and crew health
	Sokol suit clean up
	• A/G, R/T and Recorded TLM and Display TV downlink
	• Radar and radio transponder tracking
Orbit 6-12	**Crew Sleep, off of Russian tracking range**
	• Emergency VHF2 comm available through NASA VHF Network
FLIGHT DAY 2 OVERVIEW	
Orbit 13	**Post sleep activity, report on HM/DM Pressures**
	Form 14 revisions voiced up
	• A/G, R/T and Recorded TLM and Display TV downlink
	• Radar and radio transponder tracking
Orbit 14	**Configuration of RHC-2/THC-2 work station in the HM**
	• A/G, R/T and Recorded TLM and Display TV downlink
	• Radar and radio transponder tracking
Orbit 15	**THC-2 (HM) manual control test**
	• A/G, R/T and Recorded TLM and Display TV downlink
	• Radar and radio transponder tracking
Orbit 16	**Lunch**
	• A/G, R/T and Recorded TLM and Display TV downlink
	• Radar and radio transponder tracking
Orbit 17 (1)	**Terminate +Y solar rotation, reactivate MCS and establish LVLH attitude reference (auto maneuver sequence)**
	RHC-2 (HM) Test
	• Burn data uplink (TIG, attitude, delta V)
	• A/G, R/T and Recorded TLM and Display TV downlink
	• Radar and radio transponder tracking
	Auto maneuver to burn attitude (TIG - 8 min) while LOS
	Rendezvous burn while LOS
	Manual maneuver to +Y to Sun and initiate a 2 deg/sec yaw rotation. MCS is deactivated after rate is established
Orbit 18 (2)	**Post burn and manual maneuver to +Y Sun report when AOS**
	• HM/DM pressures read down
	• Post burn Form 23, Form 14 and Form 2 (Globe correction) voiced up
	• A/G, R/T and Recorded TLM and Display TV downlink
	• Radar and radio transponder tracking
Orbit 19 (3)	**CO2 scrubber cartridge change out**
	Free time
	• A/G, R/T and Recorded TLM and Display TV downlink
	• Radar and radio transponder tracking

FLIGHT DAY 2 OVERVIEW (CONTINUED)	
Orbit 20 (4)	**Free time**
	• A/G, R/T and Recorded TLM and Display TV downlink
	• Radar and radio transponder tracking
Orbit 21 (5)	**Last pass on Russian tracking range for Flight Day 2**
	Free time
	• A/G, R/T and Recorded TLM and Display TV downlink
	• Radar and radio transponder tracking
Orbit 22 (6) - 27 (11)	**Crew sleep, off of Russian tracking range**
	• Emergency VHF2 comm available through NASA VHF Network
FLIGHT DAY 3 OVERVIEW	
Orbit 28 (12)	**Post sleep activity**
	• A/G, R/T and Recorded TLM and Display TV downlink
	• Radar and radio transponder tracking
Orbit 29 (13)	**Free time, report on HM/DM pressures**
	• Read up of predicted post burn Form 23 and Form 14
	• A/G, R/T and Recorded TLM and Display TV downlink
	• Radar and radio transponder tracking
Orbit 30 (14)	**Free time, read up of Form 2 "Globe Correction," lunch**
	• Uplink of auto rendezvous command timeline
	• A/G, R/T and Recorded TLM and Display TV downlink
	• Radar and radio transponder tracking
FLIGHT DAY 3 AUTO RENDEZVOUS SEQUENCE	
Orbit 31 (15)	**Don Sokol spacesuits, ingress DM, close DM/HM hatch**
	• Active and passive vehicle state vector uplinks
	• A/G, R/T and Recorded TLM and Display TV downlink
	• Radio transponder tracking
Orbit 32 (16)	**Terminate +Y solar rotation, reactivate MCS and establish LVLH attitude reference (auto maneuver sequence)**
	Begin auto rendezvous sequence
	• Crew monitoring of LVLH reference build and auto rendezvous timeline execution
	• A/G, R/T and Recorded TLM and Display TV downlink
	• Radio transponder tracking
FLIGHT DAY 3 FINAL APPROACH AND DOCKING	
Orbit 33 (1)	**Auto Rendezvous sequence continues, flyaround and station keeping**
	• Crew monitor
	• Comm relays via SM through Altair established
	• Form 23 and Form 14 updates
	• Fly around and station keeping initiated near end of orbit

FLIGHT DAY 3 FINAL APPROACH AND DOCKING (CONTINUED)	
Orbit 33 (1) (continued)	• A/G (gnd stations and Altair), R/T TLM (gnd stations), Display TV downlink (gnd stations and Altair)
	• Radio transponder tracking
Orbit 34 (2)	**Final Approach and docking**
	• Capture to “docking sequence complete” 20 minutes, typically
	• Monitor docking interface pressure seal
	• Transfer to HM, doff Sokol suits
	• A/G (gnd stations and Altair), R/T TLM (gnd stations), Display TV downlink (gnd stations and Altair)
	• Radio transponder tracking
FLIGHT DAY 3 STATION INGRESS	
Orbit 35 (3)	**Station/Soyuz pressure equalization**
	• Report all pressures
	• Open transfer hatch, ingress station
	• A/G, R/T and playback telemetry
	• Radio transponder tracking

Typical Soyuz Ground Track



Soyuz Landing

The Soyuz TMA-04M spacecraft is seen as it lands with Expedition 32 Commander Gennady Padalka of Russia, NASA Flight Engineer Joe Acaba and Russian Flight Engineer Sergei Revin in a remote area near the town of Arkalyk, Kazakhstan, on Sept. 17, 2012 (Kazakhstan time). Padalka, Acaba and Revin returned from five months onboard the International Space Station where they served as members of the Expedition 31 and 32 crews. Photo credit: NASA/Carla Cioffi

After about six months in space, the departing crew members from the International Space Station will board their Soyuz spacecraft capsule for undocking and a one-hour descent back to Earth.

About three hours before undocking, the crew will bid farewell to the other three crew members who will remain on the station awaiting the launch of a new trio of astronauts and cosmonauts from the Baikonur Cosmodrome in Kazakhstan about 17 days later.

The departing crew will climb into its Soyuz vehicle and close the hatch between Soyuz and its docking port. The Soyuz commander will be seated in the center seat of the Soyuz' descent module, flanked by his two crewmates.

After activating Soyuz systems and getting approval from flight controllers at the Russian Mission Control Center outside Moscow, the Soyuz commander will send commands to open hooks and latches between Soyuz and the docking port.

He will then fire the Soyuz thrusters to back away from the docking port. Six minutes after undocking, with the Soyuz about 66 feet away from the station, a burn is performed automatically by the vehicle, firing the Soyuz jets for about 15 seconds to begin to depart the vicinity of the complex.

About 2.5 hours after undocking, at a distance of about 12 miles from the station, Soyuz computers will initiate a deorbit burn braking maneuver. The 4.5-minute maneuver to slow the spacecraft will enable it to drop out of orbit and begin its re-entry to Earth.

About 30 minutes later, just above the first traces of the Earth’s atmosphere, computers will command the pyrotechnic separation of the three modules of the Soyuz vehicle. With the crew strapped in the centermost descent module, the uppermost orbital module, containing the docking mechanism and rendezvous antennas, and the lower instrumentation and propulsion module at the rear, which houses the engines and avionics, will separate and burn up in the atmosphere.

The descent module’s computers will orient the capsule with its ablative heat shield pointing forward to repel the buildup of heat as it plunges into the atmosphere. The crew will feel the first effects of gravity about three minutes after module separation at the point called entry interface, when the module is about 400,000 feet above the Earth.

About eight minutes later, at an altitude of about 33,000 feet, traveling at about 722 feet per second, the Soyuz will begin a computer-commanded sequence for the deployment of the capsule’s parachutes. First, two “pilot” parachutes will be deployed, extracting a larger drogue parachute, which stretches out over an area of 79 square feet. Within 16 seconds, the Soyuz’ descent will slow to about 262 feet per second.

The initiation of the parachute deployment will create a gentle spin for the Soyuz as it dangles underneath the drogue chute, assisting in the capsule’s stability in the final minutes before touchdown.

A few minutes before touchdown, the drogue chute will be jettisoned, allowing the main parachute to be deployed. Connected to the descent module by two harnesses, the main parachute covers an area of about 3,281 feet. The deployment of the main parachute slows the descent module to a velocity of about 23 feet per second. Initially, the descent module will hang underneath the main parachute at a 30-degree angle with respect to the horizon for aerodynamic stability. The bottommost harness will be severed a few minutes before landing, allowing the descent module to right itself to a vertical position through touchdown.

At an altitude of a little more than 16,000 feet, the crew will monitor the jettison of the descent module’s heat shield, which will be followed by the termination of the aerodynamic spin cycle and the dissipation of any residual propellant from the Soyuz. Also, computers will arm the module’s seat shock absorbers in preparation for landing.

When the capsule’s heat shield is jettisoned, the Soyuz altimeter is exposed to the surface of the Earth. Signals are bounced to the ground from the Soyuz and reflected back, providing the capsule’s computers updated information on altitude and rate of descent.

At an altitude of about 39 feet, cockpit displays will tell the commander to prepare for the soft landing engine firing. Just three feet above the surface, and just seconds before touchdown, the six solid propellant engines will be fired in a final braking maneuver. This will enable the Soyuz to settle down to a velocity of about five feet per second and land, completing its mission.

As always is the case, teams of Russian engineers, flight surgeons and technicians in fleets of MI-8 helicopters will be poised near the normal and "ballistic" landing zones, and midway in between, to enact the swift recovery of the crew once the capsule touches down.

A portable medical tent will be set up near the capsule in which the crew can change out of its launch and entry suits. Russian technicians will open the module's hatch and begin to remove the crew members. The crew will be seated in special reclining chairs near the capsule for initial medical tests and to begin readapting to Earth's gravity.

About two hours after landing, the crew will be assisted to the recovery helicopters for a flight back to a staging site in northern Kazakhstan, where local officials will welcome them. The crew will then return to Chkalovsky Airfield adjacent to the Gagarin Cosmonaut Training Center in Star City, Russia, or to Ellington Field in Houston where their families can meet them.

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INTERNATIONAL SPACE STATION RESEARCH AND TECHNOLOGY DEVELOPMENT OVERVIEW

Expedition 35/36 continues to expand the scope of research aboard the International Space Station, operating with a predominantly six-person crew. The research mission of the station is to develop knowledge that strengthens our economy and improves life on Earth, advances future exploration beyond Earth orbit, and uses this unique laboratory for scientific discovery.

During the approximate six-month timeframe of Expedition 35/36, 137 investigations will be performed on the U.S. operating segment of the station, and 44 on the Russian segment. More than 430 investigators from around the world are involved in the research. The investigations cover human research, biological and physical sciences, technology development, Earth observation, and education.

Benefits to Life On Earth

Research results from space studies provide advantages to many areas of our lives here on Earth – health and telemedicine, pharmaceuticals, physical science, engineering safety, better consumer goods, and Earth science and observation.

The International Space Station provides a global platform by which to observe our home planet. Through a unique combination of hands-on and automated instruments, the station enables observation of significant natural events and changes in global climate and environmental conditions. Within the station, an automated investigation called the International Space Station SERVIR Environmental Research and Visualization System (ISERV), is a pathfinder investigation designed to gain experience in automated data acquisition of Earth imagery. The knowledge captured from this investigation will lead to the development of enhanced capabilities that will provide useful images to support monitoring and assessment of significant natural events and environmental decision making. ISERV is a joint venture between NASA and the U.S. Agency for International Development.

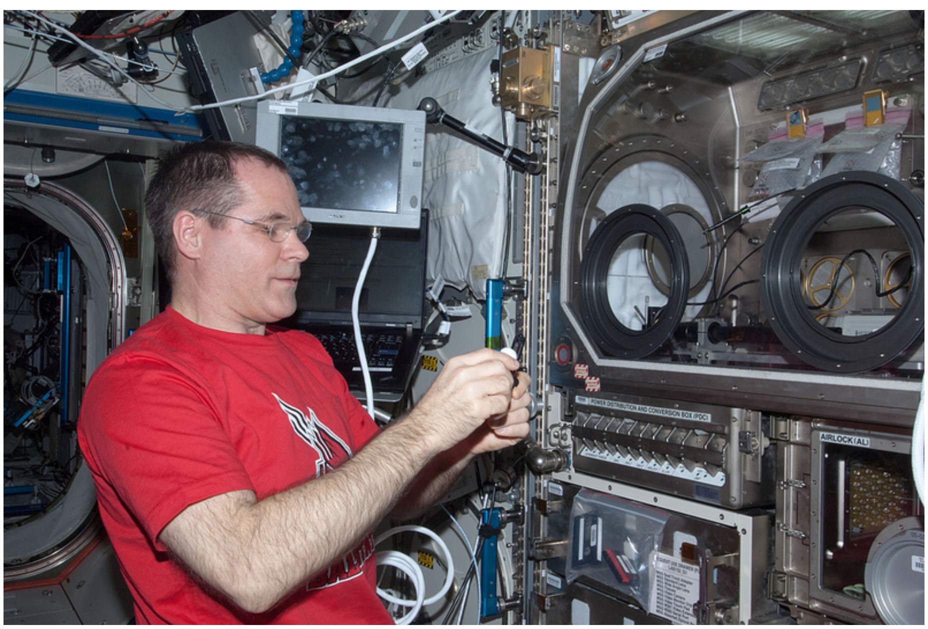
A wide variety of Earth-observation payloads can be attached to the exposed facilities on the station's exterior, one of the first of these is the NASA-sponsored Hyperspectral Imager for the Coastal Ocean (HICO). HICO uses a specialized visible and near-infrared camera to detect, identify, and quantify coastal features from the space station, originally built by the Naval Research Lab. It is now a facility open to NASA and International Space Station National Lab users, such as the Environmental Protection Agency, for collecting coastal data that includes parameters such as water depth and clarity, chlorophyll content, and sea floor composition. This kind of information can tell us about conditions of the coastal ocean that impacts the local environment and its surrounding wildlife.

While these are just a few examples of Earth observation capabilities currently being implemented on the station, efforts are underway for the development of increasingly complex instruments that will be delivered to the space station in the future.

Physical science investigations during this expedition include Investigating the Structure of Paramagnetic Aggregates from Colloidal Emulsions – 3 (InSPACE-3). NASA is studying fluids containing ellipsoid-shaped particles that change the physical properties of the fluids in response to magnetic fields. These fluids are classified as smart materials, known as magnetorheological fluids, which transition to a solid-like state by the formation and cross-linking of microstructures in the presence of a magnetic field. On Earth, these materials could be used for vibration damping systems for bridges and buildings to better withstand earthquake forces.

Canadian Space Agency astronaut Chris Hadfield, Expedition 34 flight engineer, sets up the International Space Station SERVIR Environmental Research and Visualization System (ISERV) in the Destiny laboratory of the International Space Station. ISERV is a fully automated image data acquisition system that flies aboard the space station and deploys in the Window Observational Research Facility (WORF) rack in Destiny. The study is expected to provide useful images for use in disaster monitoring and assessment and environmental decision making.

View of the Hyperspectral Imager for Coastal Oceans (HICO) and Remote Atmospheric and Ionospheric Detection System (RAIDS) Experiment Payload (HREP) installed on the Japanese Experiment Module - Exposed Facility and the port side solar array wings. Photo taken from a JEM Pressurized Module window.



NASA astronaut Kevin Ford, Expedition 34 commander, works with the InSPACE-3 hardware inside the Microgravity Science Glovebox in the Destiny laboratory of the International Space Station. InSPACE-3 applies different magnetic fields to vials of colloids, or liquids with microscopic particles, and observes how fluids can behave like a solid. Results may improve the strength and design of materials for stronger buildings and bridges.

In typical NASA and international partner fashion, there are many educational activities and investigations planned to teach and inspire students of all ages. The Synchronized Position Hold, Engage, Reorient, Experimental Satellites - Zero - Robotics (SPHERES-Zero-Robotics) is another ongoing activity providing students an opportunity to design research for the station, using their math skills to write algorithms while allowing them to act as ground controllers. This activity concludes with a competition.

With their feet anchored in floor restraints, NASA astronauts Kevin Ford (left), Expedition 34 commander, and Tom Marshburn, flight engineer, conduct a session of the Synchronized Position Hold, Engage, Reorient, Experimental Satellites Zero Robotics (SPHERES ZR) program in the Kibo laboratory of the International Space Station.

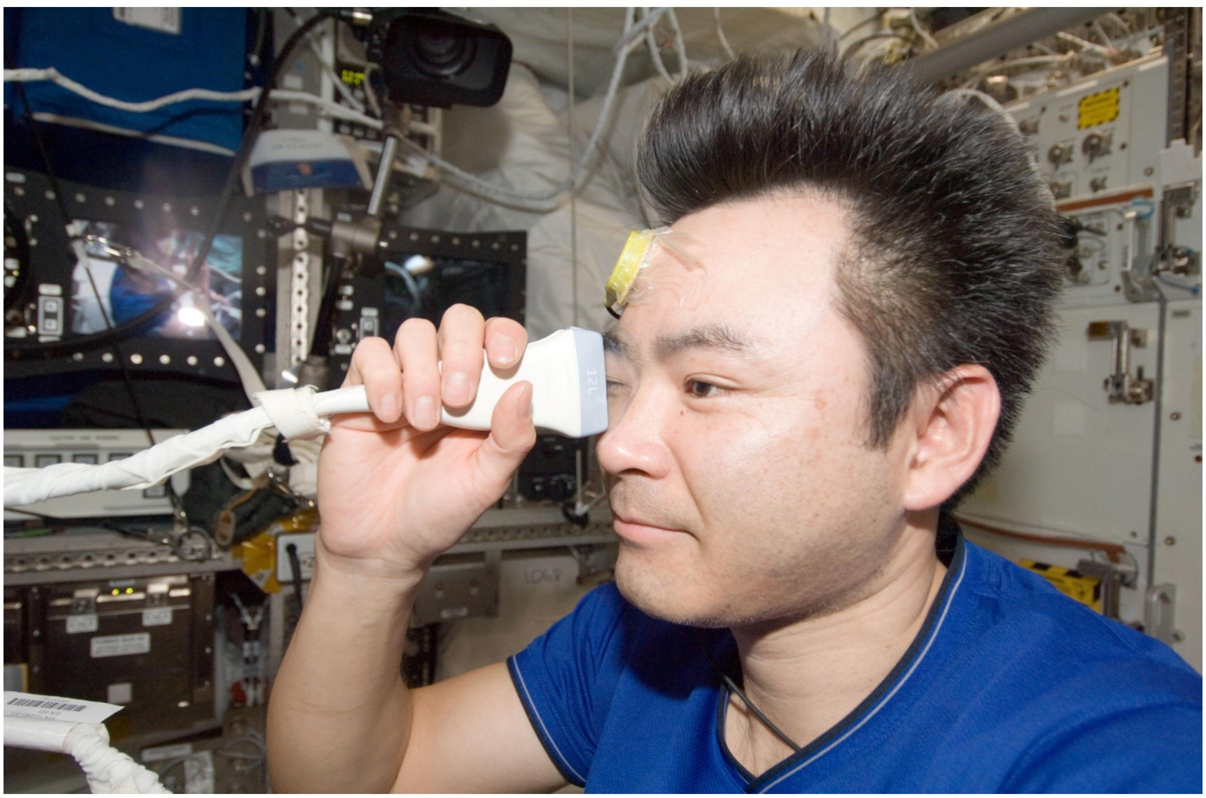
Technology demonstrations are also an important component to station research. The Canadian Space Agency (CSA) is continuing performance testing on a miniaturized flow cytometer, with Microflow-1. Using a small amount of liquid (blood or other body fluids) in a small fiber-optic structure enables researchers to quantify the components and monitor physiological and cellular activity – allowing for real-time analysis of blood cells, infections, cancer markers, and other molecular and cellular physical and chemical properties. The goal of this testing in microgravity is to develop a smaller and safer operational instrument that may be certified for real-time medical care and monitoring during space flight. This technology brings the power of molecular biology not only to the space environment, but also can help reduce health care costs in remote regions on Earth. Agriculture and food processing plants may be able to use this technology for onsite quality-control inspections and tests.

Benefits to Future Space Exploration

The station is a unique test bed for future exploration, and benefits from these types of investigations are important to NASA, our international partners, and humankind. Data and experience from space exploration investigations benefits and furthers our ability to travel to and explore the unknown, testing our boundaries. Leaving low-Earth orbit is the next step to expand our horizons, exploring Mars, or an asteroid for instance. Ensuring the health and safety of the crew and vehicle, along with completion of mission goals, is of utmost importance.

Many investigations are designed to gather information about the effects of long-duration spaceflight on the human body, which will help us understand complicated processes such as immune and skeletal systems with plans for future human exploration missions. Human research investigations work to address these concerns, while information taken away is applied to similar health issues on Earth when applicable.

Currently, the top human spaceflight risk under investigation is the vision issues syndrome reported by astronauts following long-term stays on the station. Several studies have been done in response to this issue, with several more planned. The Prospective Observational Study of Ocular Health in International Space Station Crews (Ocular Health) is one of many new investigations continuing to systematically study the effects of microgravity on astronaut vision. This study will collect data from test subjects before, during, and after a visit to the orbiting lab, using a multitude of screening, measurement, testing, and imaging protocols.



Japan Aerospace Exploration Agency astronaut Aki Hoshide, Expedition 33 flight engineer, performs ultrasound eye imaging in the Columbus laboratory of the International Space Station as part of the Ocular Health investigation.

Sonographic Astronaut Vertebral Examination (Spinal Ultrasound), a NASA study, is using ultrasound imaging aboard the station to track spinal changes experienced by crew members. These images, combined with pre- and post-flight MRI, will be used to track and determine risk of intervertebral disk damage resulting from extended microgravity exposure, launch or landing forces, or other unidentified causes such as radiation or nutrition/metabolism. This technology adds capabilities for health tracking and illness/injury detection during long-duration spaceflight missions. This technology, with its continued expanded usage, will help people Earth-bound who do not have access to advanced imaging like MRI.

NASA's Ultrasonic Background Noise Test (UBNT) will monitor high frequency noise levels generated by station hardware and equipment operating within the U.S. Lab and the Node 3 modules. Information gained from this investigation will assist in developing an automated leak location detection system based on the ultrasonic, or high frequency, noise generated by air leaking through a space structure's pressure wall. Information learned from this research can be used as a new approach to validate the structural integrity of pressurized systems across a broad spectrum of industries – from the station to future space travel vessels and nuclear and chemical industries using high pressure systems and vacuum vessels.

NASA astronaut Kevin Ford, Expedition 34 commander, installs a Ultra-Sonic Background Noise Tests (UBNT) sensor kit behind a rack in the Destiny of the International Space Station.

Benefits to Scientific Discovery

Fundamental scientific discovery benefits all of humanity by advancing our understanding of the world around us. The information gleaned from these discoveries may change the primary knowledge base regarding basic concepts and understanding, along with enhancing emerging technologies. Two excellent examples of this are the Alpha Magnetic Spectrometer-02 (AMS) and Robonaut-2, both ongoing investigations. The AMS continues to collect a vast amount of data – measuring almost double the amount researchers expected, at a rate of about 1.2 billion particles per month. The testing of Robonaut's capabilities and movement continues as planned – working through a progression of tests.

In the International Space Station's Destiny laboratory, Robonaut 2 is pictured during a round of testing for the first humanoid robot in space. Ground teams put Robonaut through its paces as they remotely commanded it to operate valves on a task board. Robonaut is a testbed for exploring new robotic capabilities in space, and its form and dexterity allow it to use the same tools and control panels as its human counterparts do aboard the station.

A human microbiome is the collection of microbes that live in and on the human body at any given time and plays an important role to health, as research has established. The Study of the Impact of Long-Term Space Travel on the Astronauts' Microbiome (Microbiome) is a first-flight investigation for NASA studying the importance of microbiomes to human health and immune systems and potential impact on crew member health, along with microbiome changes associated with exposures to stressful conditions like g-forces, radiation, microgravity, and anxiety.

Another first-time study involves Italian principal investigators studying evaporation and combustion of renewable liquid fuels with the Italian Combustion Experiment for Green Air (ICE-GA) experiment. Tests varying pressure and oxygen content of two selected fuels (biofuels or surrogates) will assist in developing combustion models and possible acceleration of adoption of eco-friendly renewable fuels.

Managing the Science

Managing the international laboratory's scientific assets, as well as the time and space required to accommodate experiments and programs from a host of private, commercial, industry and government agencies nationwide, makes the job of coordinating space station research critical. Teams of controllers and scientists on the ground continuously plan, monitor, and remotely operate experiments from control centers around the globe. Controllers staff payload operations centers around the world, effectively providing for researchers and the station crew around the clock, seven days a week. State-of-the-art computers and communications equipment deliver up-to-the-minute reports about experiment facilities and investigations between science outposts across the United States and around the world. The payload operations team also synchronizes the payload timelines among international partners, ensuring the best use of valuable resources and crew time.

The control centers of NASA and its partners are

- NASA Payload Operations Center (POC), Marshall Space Flight Center in Huntsville, Ala.
- RSA Center for Control of Spaceflights ("TsUP" in Russian) in Korolev, Russia
- JAXA Space Station Integration and Promotion Center (SSIPC) in Tskuba, Japan
- ESA Columbus Control Center (Col-CC) in Oberpfaffenhofen, Germany
- CSA Payloads Operations Telesciences Center, St. Hubert, Quebec, Canada

NASA's POC serves as a hub for coordinating much of the work related to delivery of research facilities and experiments to the space station, as they are rotated in and out periodically when vehicles make deliveries and return completed experiments and samples to Earth.

The payload operations director leads the POC's main flight control team, known as the "cadre," and approves all science plans in coordination with Mission Control at NASA's Johnson Space Center in Houston, the international partner control centers and the station crew.

On the Internet

For fact sheets, imagery and more on Expedition 35/36 experiments and payload operations, visit the following Web site:

http://www.nasa.gov/mission_pages/station/science/

Expedition 35 and 36 Science Table

Research Experiments

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
BCAT-C1	Binary Colloidal Alloy Test – Canadian 1	CSA	Physical Science	BCAT-C1 will probe three-phase separation kinetics and the competition between phase separation and crystallization in colloid-polymer mixtures. This regime remains virtually uncharacterized in any type of material including molecular fluids or complex mixtures. BCAT-C1 takes advantage of a substantial opportunity to fill a gap in the knowledge of these fundamental processes. By examining the kinetics in seven samples of different composition, we intend to show that significant quantitative differences in kinetics occur even though the resulting phases are similar.	Dr. Barbara Frisken, Simon Fraser University, British Columbia, Canada	JEM	Earth Discovery
BP-Reg	A Simple In-flight Method to Test the Risk of Fainting on Return to Earth After Long-Duration Space Flights	CSA	Human Research	BP-Reg will test the efficacy of an in-flight manipulation of arterial blood pressure (BP) as an indicator of post-flight response to a brief stand test. Space flight negatively impacts the regulation of BP on return to upright posture on earth. A Leg Cuff test will challenge BP regulation by inducing a brief drop in BP following the release of a short occlusion of blood flow to the legs. The change in BP from pre- to in-flight will be used to predict those astronauts who will experience the greatest drop in BP in the post-flight stand test.	Dr Richard L. Hughson, University of Waterloo, Waterloo, Ontario, Canada	Columbus	Earth Space
MicroFlow1	MicroFlow1	CSA	Technology Demonstration	Microflow1 is a first time test of the performance of a miniaturized flow cytometer in the station environment. Flow cytometry enables scientists and physicians to quantify molecules (such as hormones) and cells in blood or other body fluids. This demonstration will use samples prepared on the ground to test whether Microflow1 works in the space environment. A successful demonstration of the Microflow1 platform can become the first step into providing future capacity to perform real-time medical care of crew members, as well as an essential tool for research in physiology and biology.	Luchino Cohen, Canadian Space Agency Payload Developer: Ozzy Mermut, Institut National d'Optique, Québec City	US Lab	Earth Space
MVIS	Microgravity Vibration Isolation Subsystem	CSA	Physical Science	MVIS is used to isolate Fluids Science Laboratory (FSL) experiments from the vibrations present on the station. It is equipped with high performance acceleration measurement devices. The data produced by these devices will be available to supplement information acquired by the European Space Agency Geoflow science team.	Canadian Space Agency	Columbus	Space
RaDI-N-2	Radi-N 2 Neutron Field Study	CSA (in collaboration with Russian Institute of Biomedical Problems)	Operational Research – Radiation Health	Radi-N 2 Neutron Field Study objective is to characterize the neutron radiation environment aboard the station. The study uses neutron monitors called bubble detectors produced by a Canadian company, Bubble Technology Industries. The data from this and the Radi-N Study flown aboard Increment 20/21 will be used to better define the risk posed to the astronauts' health by neutron radiation and will eventually help in development of better protective measures.	Martin Smith, Bubble Technology Industries Inc.	Russian Segment, US Lab, Columbus, JEM, Node2	Space

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
TOMATOSPHERE III	TOMATOSPHERE III	CSA	Education Activity	TOMATOSPHERE III primary objectives are to increase student interest in space science and horticultural technology and to increase student familiarity and experience with research methodology. Following exposure of the tomato seeds to weightlessness, they will be distributed to approximately 14,000 classrooms across Canada and the United States. Students in grades 3-10 will plant the seeds, make observations, record data and investigate the effect of spaceflight on seed germination rate, seedling vigor and other growth parameters.	Dr. Michael Dixon, University of Guelph, Ontario, Canada	None	Earth
VASCULAR	Cardiovascular Health Consequences of Long-Duration Space Flight	CSA	Human Research and Counter-measures Development	Health Consequences of Long-Duration Flight (VASCULAR) will conduct an integrated investigation of mechanisms responsible for changes in blood vessel structure with long-duration space flight, linking this with functional and health consequences that parallel changes with that occur the aging process.	Richard Lee Hughson, Ph.D., University of Waterloo, Waterloo, Ontario, Canada	Columbus	Earth Space
Cartilage	Cartilage	ESA	Human Research and Counter-measures Development	Investigate the effects of weightlessness on articular cartilage health and cartilage metabolism to assess the risk of cartilage degeneration during space mission.	Germany: G.P. Brueggemann, A. Niehoff, A.M. Liphardt, A. Mundermann, J. Mester W. Bloch South Korea: S. Koo Austria: F. Eckstein		Space
Circadian Rhythms	Circadian Rhythms	ESA	Human Research and Counter-measures Development	Aims to get a better understanding of alterations in circadian rhythms (and the autonomic nervous system) during long-term space flight.	Germany: H.C. Gunga A. Stahn A. Werner D. Kunz M. Steinach J. Koch O. Opatz Austria: V. Leichtfried W. Schoberberger	USOS	Space
Cruise	Cruise	ESA	Technology Demonstration	Technology demonstrator for performing station system operations. Analysis of pre-, in- and post-flight metrics will pave the way for operational use of building block technologies for station and future exploration missions.	Netherlands: M. Wolff ESA/ESTEC Germany: P. Nespoli ESA/EAC Astrium et al; USA: NASA/JSC support from MOD's ODF and IDAGS groups, and Life Science	USOS	Space

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
DOSIS-3D	Dose Distribution Inside the International Space Station - 3D	ESA	Radiation Dosimetry	Will determine the nature and distribution of the radiation field inside the station using different active and passive detectors spread around the Columbus laboratory and will build on data by combining it with station partner data gathered in other modules.	Germany: T. Berger, G. Reitz S.Burmeister B. Heber, USA: E. Benton, E. Yukihara N. Zapp Poland: P. Bilski, Austria: M. Hajek Hungary: A. Hirn J. Pálfalvi P. Szanto Japan: A.Nagamatsu Y. Uchihori N. Yasuda Ireland: D.O´Sullivan Russia: V. Petrov V.Shurshakov Czech Republic: I.Ambrožová Belgium: F. Vanhavere	Columbus	Space
ENERGY	Astronaut's Energy Requirements for Long-Term Spaceflight.	ESA	Human Research and Counter-measures Development	ENERGY measures changes in energy balance/expenditure due to long term spaceflight; and derives an equation for astronaut's energy requirements.	France: S. Blanc, A. Zahariev, M. Caloin, F. Crampes USA: D. Schoeller	Columbus	Space
EPO – Space Robotics	Luca Parmitano Space Robotics Competition (Take Your Classroom Into Space)	ESA	Education	Aims to teach students (11-20 years old) about various aspects of robotics and basics about how ESA operates with regards to industry.	Netherlands: N. Savage (ESA/ESTEC)	Columbus	Earth
EPO – Mission X	Mission X: Train Like An Astronaut 2013	ESA	Education	NASA-led project using strict astronaut training activities to emphasise importance of exercise and healthy eating to children (ages 8-12) globally.	Netherlands: N. Savage (ESA/ESTEC)	Columbus	Earth
EPO – SCRIPTS - Slinky	EPO – SCRIPTS - Slinky	ESA	Education	Demonstrating harmonic oscillation, longitudinal waves transverse wave direction of energy transport, spectra etc. in order to produce an educational video.	Netherlands: N. Savage (ESA/ESTEC)	Columbus	Earth
EPO – SCRIPTS – "Space In Bytes"	EPO – SCRIPTS – "Space In Bytes"	All Inter-national Partners	Education	"Space in Bytes" will record educational photography and video supporting the "Space Robotics" themes within Luca Parmitano's mission.	Netherlands: N. Savage (ESA/ESTEC)	Columbus	Earth

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
FASES	Fundamental and Applied Studies of Emulsion Stability	ESA	Physical Sciences in Microgravity	Aims to establish links between emulsion stability and physico-chemical characteristics of droplet interfaces, which is of great importance for the generation of emulsion dynamics models for use in industrial applications.	Italy: L. Liggieri, G. Loglio, ENI France: M. Antoni, D. Clausse, ARCOFLUID Germany: R. Miller, SINTERFACE Greece: T.Karapantsios Netherlands: V. Dutschk, Spain: R. G. Rubio Russia: B. Noskov	Columbus	Earth Discovery
FASTER	Facility for Adsorption and Surface Tension	ESA	Physical Sciences in Microgravity	FASTER will study the links between emulsion stability and physicochemical characteristics of droplet interfaces. On the basis of these studies, a model of emulsion dynamics will be generated to be transferred to industrial applications.	Italy: L. Liggieri G. Loglio Germany: R. Miller France: M. Antoni D. Clausse Greece: T.Karapantsios Netherlands: V. Dutschk Greece: R. G. Rubio Russia: B. Noskov USA: J. Ferri Canada: J. Elliott	Columbus	Earth Discovery
HAM Video	HAM Video	ESA/NASA	Education	HAM Video payload will transmit over amateur radio frequencies video and audio signals from the Station.	Netherlands: E. Celton (ESA/ESTEC)	Columbus	Earth
IMMUNO	Neuroendocrine and Immune Responses in Humans During and After a Long-Term Stay on the International Space Station	ESA	Human Research and Counter-measures Development	IMMUNO aims to determine changes in hormone production and immune response during and after a space station mission.	Germany: A. Chouker, F. Christ, M. Thiel, I. Kaufmann, Russia: B. Morukov	Russian Segment (with Russian cosmonauts only)	Space
MSL Batch-2A CETSOL-2	Columnar-to-Equiaxed Transition in Solidification Processing	ESA	Physical Sciences in Microgravity	CETSOL-2 researches the formation of microstructures during the solidification of metallic alloys, specifically the transition from columnar growth to equiaxed growth when crystals start to nucleate in the melt. Results will help to optimize industrial casting processes. (See also MSL Batch-2A MICAST-2 and SETA-2).	France: C.A. Gandin, B. Billia, Y. Fautrelle Germany: G. Zimmerman Ireland: D. Browne USA: D. Poirier, C. Beckermann	Destiny	Earth Discovery

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
MSL Batch-2A MICAST-2	Microstructure Formation in Casting of Technical Alloys Under Diffusive and Magnetically Controlled Convective Conditions	ESA	Physical Sciences in Microgravity	MICAST researches the formation of microstructures during the solidification of metallic alloys under diffusive and magnetically controlled convective conditions. (See also MSL Batch-2A CETSOL-2 and SETA-2).	Germany: L. Ratke, G. Zimmerman France: Y. Fautrelle, J. Lacaze Hungary: A. Roosz Canada: S. Dost USA: D. Poirier	Destiny	Earth Discovery
MSL Batch-2A SETA-2	Solidification Along an Eutectic Path in Ternary Alloys	ESA	Physical Sciences in Microgravity	SETA-2 is dedicated to the study of a particular type of eutectic growth namely symbiotic growth in hypoeutectic metallic alloys. (See also MSL Batch-2A CETSOL-2 and MICAST-2)	Germany: S. Rex, U. Hecht L. Ratke France: G. Faivre Belgium: L. Froyen USA: R.Napolitano	Destiny	Earth Discovery
NEUROSPAT : NEUROCOG-2	Effect of Gravitational Context on Brain Processing: A study of Sensorimotor Integration Using Event Related EEG Dynamics	ESA	Human Research and Counter-measures Development	This project will study brain activity that underlies cognitive processes involved in four different tasks that humans and astronauts may encounter on a daily basis. The roles played by gravity on neural processes will be analyzed by different methods such as EEG during virtual reality stimulation.	Belgium: G. Cheron, C. Desadeleer, A. Cebolla, A. Bengoetxea France: A. Berthoz, J. Mc Intyre	Columbus	Space
NEUROSPAT: PRESPAT	Prefrontal Brain Function and Spatial Cognition	ESA	Human Research and Counter-measures Development	Prespat will use physiological and behavioral measures to assess changes in general activation, prefrontal brain function and perceptual reorganization. It is funded as part of the European Commission The International Space Station: a Unique REsearch Infrastructure (SURE) project.	Hungary: L. Balazs, I. Czigler, G. Karmos, M. Molnar, E. Nagy Poland: J.Achimowicz	Columbus	Space
Reversible Figures	Reversible Figures	ESA	Human Research and Counter-measures Development	Reversible Figures investigates whether the perception of ambiguous figures is affected by microgravity.	France: G.Clement ISU team Canada: R. Thirsk	USOS	Space
Sarcolab	Myotendi-nous and neuro-muscular adaptation to long-term spaceflight: determinants and time courses	ESA	Human Research and Counter-measures Development	The first goal of this project is to investigate the myotendinous structural and functional determinants of loss of muscle mass, function and motor control in weightlessness. The second goal of this project is to characterize reflex excitability of the disused muscles.	Italy: P. Cerretelli, M. Narici, R. Bottinelli, C. Gelfi France: C. Pérot, C. Marque, F. Canon, D. Gamet, S.Boudaoud, D. Lambertz. UK: M. Fluck, C.Maganaris, J. Rittweger, O. Seynnes	Columbus	Space

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
Seedling Growth-2	Effects of red light stimulation on cell growth and proliferation under spaceflight conditions in Arabidopsis thaliana (LICEA)	ESA/NASA	Biological Sciences in Microgravity	The experiment aims to understand the combined influence of light and gravity on plant development through the identification of changes in the mechanisms and regulation of essential cellular functions.	Spain: F.J. Medina, R. Herranz, USA: J.Z. Kiss, R. Edelmann France: E. Carnero-Diaz, E. Boucheron-Dubuisson J. Saez-Vasquez	Columbus	Earth Space Discovery
Skin-B	Study of skin aging in microgravity to develop a mathematical model of aging skin.	ESA	Human Research and Counter-measures Development	Aims to increase the scientific knowledge of skin physiology and the skin “aging” process, and use those parameters to develop a skin mathematical model.	Germany: U. Heinrich, H. Tronnier, N. Gerlach, M.Wiebusch, Slovenia: T. Rodič, T. Šuštar, A. Grm, P. Šuštarič, J. Langus	USOS	Earth
SOLAR: SOLSPEC	SOLSPEC	ESA	Solar Physics	SOLSPEC will measure the solar spectrum irradiance from 207 miles (333 kilometers) to 3452 miles (5555 kilometers). The goals of this investigation are the study of solar variability at short and long term and the achievement of absolute measurements.	France: G. Thuillier, T. Foujols	Columbus	Earth Space
SOLAR: SOLACES	Solar Auto-Calibrating Extreme UV-Spectrometer	ESA	Solar Physics	The goal of the experiment is to measure the solar spectral irradiance of the full disk from 19.5 miles (31 kilometers) to 253 miles (407 kilometers) at 0.5 miles (0.8 kilometers) to 2.3 miles (3.7 kilometers) spectral resolution.	Germany: G.Schmidtke R. Brunner	Columbus	Earth Space
SPACE HEADACHES	Space Headaches	ESA	Human Research and Counter-measures Development	Studies the incidence and prevalence of headaches during a stay aboard the space station. Headache characteristics are analyzed and classified according to International Classification of Headache Disorders.	Netherlands: A. Vein, M. Terwindt, M.D. Ferrari	Columbus	Space
TRITEL	3D Silicon Detector Telescope	ESA	Radiation Dosimetry	TRITEL will investigate the radiation environment of the station and estimate the absorbed dose and dose equivalent burden on astronauts aboard the space station.	Hungary: A. Hirn, T. Pázmándi, S. Deme, I. Apáthy, L. Bodnár, V. Nagy, C. Buday, J.K. Pálfalvi, J. Szabó, B. Dudás, P. Szántó, Germany: G. Reitz, S. Burmeister	Columbus	Space
Vessel ID System	Vessel ID System	ESA	Technology Demonstration	The Vessel ID System demonstrates the space-based capability of identification of maritime vessels and also tests the ability of an external grappling adaptor to accommodate small payloads.	Norway: R.B. Olsen, O. Helleren, A. Nordmo Skauen, T. Eriksen, S. Christiansen, H. Rosshaug, F. Storesund	Columbus	Earth Space

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
Vessel Imaging	Vascular Echography	ESA	Human Research and Counter-measures Development	Vessel Imaging will evaluate changes in the peripheral blood vessel wall properties (thickness and compliance) and cross sectional areas during long-term spaceflight.	France: P. Arbeille	Columbus	Space
AQH Microscope Checkout	Aquatic Habitat Microscope Checkout	JAXA	Biology and Biotechnology	The microscope observation system is a remotely-controlled microscope for various biological experiments, especially aquatic experiments with medaka or zebrafish. Initial checkout for subsequent science experiments will be performed.	Satoko Uchida, Kyoto University, Institute for Frontier Medical Sciences, Sakyoku, Kyoto	Kibo	Discovery
Area PADLES	Passive Dosimeter for Life Science Experiments in Space	JAXA	Technology Development and Demonstration	Area PADLES will measure the space radiation environment inside the KIBO module. The dosimeters, having been exposed to the space environment for six months, are returned to the ground for analysis. The measured data will be utilized for planning future life science experiments and updating radiation assessment models for human spaceflight in the next generation.	Keiji Murakami, Akiko Nagamatsu, JAXA	Kibo	Space
Biological Rhythms	The Effect of Long-term Microgravity Exposure on Cardiac Autonomic Function by Analyzing 48-Hours Electrocardiogram	JAXA	Human Research	Biological Rhythms examines the effect of long-term microgravity exposure on cardiac autonomic function by analyzing 48-hour electrocardiogram of long-duration space station crew members.	Chiaki Mukai, M.D., Ph.D., Japan Aerospace Exploration Agency, Tsukuba, Japan	Kibo	Space
Cell Mechanosensing	Identification of Gravity-Transducers in Skeletal Muscle Cells: Physiological Relevance of Tension Fluctuations in Plasma Membrane	JAXA	Biology and Biotechnology	Cell Mechanosensing examines the mechanical stress changes in tension fluctuation in cell membrane, resulting in activation of channels and/or proteases on membrane surface. The experiment will clarify the mechanism how the tension fluctuation in cell membrane regulate activities of such transducers during microgravity conditions.	Masahiro Sokabe, Nagoya University Graduate School of Medicine	Kibo	Space Discovery
Dynamic Surf	Experimental Assessment of Dynamic Surface Deformation Effects in Transition to Oscillatory Thermo-capillary Flow in Liquid Bridge of High Prandtl Number Fluid	JAXA	Physical Science	Marangoni convection is the flow driven by the presence of a surface tension gradient which can be produced by temperature difference at a liquid/gas interface. The convection in liquid bridge of silicone oil is generated by heating the one disc higher than the other. Scientists are observing flow patterns of how fluids move to learn more about how heat is transferred in microgravity.	Yasuhiro, Kamotani, Case Western Reserve University, Cleveland, OH	Kibo	Discovery
JAXA-Commercial	Japan Aerospace Exploration Agency - Commercial Payload Program	JAXA	Educational Activity and Outreach	JAXA-Commercial Payload Program consists of commercial items sponsored by JAXA sent to the station to experience the microgravity environment.	Secured (anonymous)	Kibo	Earth
MAXI	Monitor of All-sky X-ray Image	JAXA	Earth and Space Science	MAXI is a highly sensitive X-ray slit camera for the continuous monitoring of more than 1000 X-ray sources in space over an energy band range of 0.5 to 30 kiloelectron volt (keV). Besides the goal of performing a complete sky survey, this research helps to address fundamental astrophysics questions and allows researchers to better understand the current state and evolution of our Universe.	Masaru Matsuoka, Ph.D., Institute of Space and Astronautical Science (ISAS) International Space Station Science Project Office, Japan Aerospace Exploration Agency, Tsukuba, Japan	Kibo	Discovery

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
MCE	Multi-Mission Consolidated Equipment	JAXA	Earth and Space Science	The Multi-mission Consolidated Equipment (MCE) investigation consists of five small unique instruments that are located at Equipment Exchange Unit (EER) site 8 on the Japanese Experiment Module - Exposed Facility (JEF). IMAP: Observes the rim of atmosphere, between space and the earth, with visible light spectrometer for no less than one continuous year. GLIMS: Observes lightning and plasma phenomena during night time for no less than one continuous year. SIMPLE: Demonstrates the usefulness of the inflatable space structures in orbit including extendable mast, space terrarium and material panel. REXJ: Demonstrates the robot manipulation in orbit from ground. The robot moves around within an envelope by adjusting length of tethers and a telescopic arm. HDTV: Demonstrates utilization of Commercial-off-the-Shelf (COTS)-HDTV in an exposed environment in orbit.	Hirohisa Oda, Japan Aerospace Exploration Agency, Tsukuba, Japan	Kibo	Space
Medaka Osteoclast 2	Effect of Micrograwity on Osteoclasts and the Analysis of the Gravity Sensing System in Medaka	JAXA	Biology and Biotechnology	Enhancement of the osteoclast (bone resorption cell) is assumed to cause the decrease of bone mineral density in space. Medaka fish is a model animal for life science research, and JAXA plans to study the effects of microgravity on the osteoclast activity and the gravity sensing system of the vertebrate using Medaka fish onboard the Kibo Module.	Akira Kudo, Professor, Department of Biological Information, Tokyo Institute of Technology	Kibo	Earth Space Discovery
Microbe-A1	On-board Micro-organism Monitoring in Spacecrafts	JAXA	Biology and Biotechnology	The purpose of this experiment is to provide a rapid and effective on board monitoring system for the crew to monitor microorganisms in the station's cabin environment, taking countermeasures immediately against microbial contamination on board. Also passive sampling continues from "Microbe I/II/III" experiment to continue time sequential monitoring from KIBO construction.	Takashi Yamazaki, Ph.D., Japan Aerospace and Exploration Agency, Tsukuba	Kibo	Space
OSTEOPONTIN	Examination of the "Osteopontin Hypothesis"	JAXA	Biology and Biotechnology	To clarify whether osteopontin is an important factor regulating microgravity induced bone loss, researchers will evaluate the osteoblastic differentiation of bone marrow stromal cells obtained from osteopontin-deficient mice and wild type control mice, by culturing with minerarizing condition in the space.	Professor Masaki Noda, Tokyo Medical and Dental University, Tokyo	Kibo	Earth Space
Resist Tubule	Mechanisms of Gravity Resistance in Plants From Signal Transformation and Transduction to Response	JAXA	Biology and Biotechnology	Resist Tubule clarifies the mechanisms of gravity resistance. Gravity resistance is a principal gravity response in plants and plays an important role in the transition of plant ancestors from an aquatic environment to a terrestrial environment (about 450 million years ago) and in the consequent establishment of land plants. The present study will clarify the mechanisms of gravity resistance, in particular the processes from signal transformation and transduction to response.	Takayuki Hoson, Ph.D., Osaka City University, Osaka	Kibo	Earth Space Discovery

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
SEDA-AP	Space Environment Data Acquisition Equipment - Attached Payload	JAXA	Technology Development and Demonstration	SEDA-AP investigation consists of seven small instruments designed to measure the space environment around the station from the Exposed Facility (EF) of the Japanese Experimental Module (JEM) “Kibo” on the station. SEDA-AP instruments include five radiation and particle monitors and two electronic device performance monitors. Characterizing and understanding the environment around space vehicles though this unique combination of instruments allows researchers to develop and design more robust, safe and protective spacecraft in the future.	Kiyokazu Koga, Japan Aerospace Exploration Agency, Japan	Kibo	Space
SMILES	Superconducting Submillimeter-Wave Limb-Emission Sounder	JAXA	Earth and Space Science	SMILES is a highly sensitive, cryogenically cooled, radio wave receiver that measures atmospheric limb emissions. Located at Equipment Exchange Unit (EER) site 3 on the Japanese Experiment Module - Exposed Facility (JEF), the SMILES instrument monitors and maps the global distributions of the high altitude trace gases and constituents related to the chemistry of the ozone layer. Observing and understanding the properties and evolution of the upper atmosphere allows researchers to better model Earth’s atmosphere and possibly detect or predict environmental changes.	Masato Shiotani, Kyoto University, Kyoto, Japan	Kibo	Earth
SSAF2013	Space Seeds for Asian Future 2013	JAXA	Educational Activities and Outreach	This is a simple plant culture experiment for education, training and basic science. Variety of plant seeds originated from Asian countries will be packed and launched, then deploy in a small "greenhouse" in the JEM. Seeds will be watered and monitored for germination, growth and hopefully bloom. High quality images will be downlinked and distributed to participating Asian countries.	Muneo Takaoki, Space Environment Utilization Center, Human Space Systems and Utilization Mission Directorate, Tsukuba-City	Kibo	Earth
Space Pup	Effect of Space Environment on Mammalian Reproduction	JAXA	Biology and Biotechnology	We examine the effects of cosmic radiation on spermatozoa using freeze-dried samples. These freeze-dried spermatozoa will be kept on board the station in the Japanese Experiment Module "Kibo" and exposed to cosmic radiation for several months (about 1 month, 12 months, 24 months). After this sample returns to the ground, we will try to make offspring from them and examine the effects of cosmic radiation on sperm DNA.	Teruhiko Wakayama, Riken Center for Developmental Biology	Kibo	Discovery
Stem Cells	Study on the Effect of Space Environment to Embryonic Stem Cells to Their Development	JAXA	Biology and Biotechnology	Stem Cells examines the development of embryonic stem cells that have flown on the space station. The cells are launched frozen and, after returning to Earth, are micro-injected into mouse-8-cell embryos in order to analyze the influence of the space environment on the development and growth of adult mice. It is extremely important to estimate space radiation effects in order to defend the human body from those influences, especially the possibility of reproductive and developmental issues resulting from a long-term stay in space.	Professor Takashi Morita, Osaka City University, Osaka	Kibo	Space Discovery

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
TEM	Transport Environment Monitor Packages	JAXA	Technology Development and Demonstration	The TEM investigation monitors temperatures inside cargo vehicles bound for the International Space Station. Environmental conditions during transportation are very important for biological specimens and reagents for life-science experiments. This investigation uses temperature data loggers to record the environmental conditions near investigations launched on cargo vehicles.	M. Masukawa	Kibo	Space
Tanpopo	Astrobiology Exposure and Micrometeoroid Capture Experiments	JAXA	Biology and Biotechnology	Blocks of soft-solid material called aerogel will be exposed outside of the station to collect particles. We will also expose terrestrial microbes and organic compounds to the space and analyze the survival after bringing them back to Earth. Researchers expect to know the possibility of transport of organic compounds from space to the earth and interplanetary migration of microbes.	Akihiko Yamagishi, Tokyo University of Pharmacy and Life Sciences, Tokyo	Kibo	Space
V-C REFLEX	Plastic Alteration of Vestibulo-Cardiovascular Reflex and Its Countermeasure	JAXA	Human Research	The vestibular system plays an important role in controlling arterial pressure upon posture change (vestibulo-cardiovascular reflex), although this system is highly plastic, i.e., the sensitivity of the vestibulo-cardiovascular reflex is altered if subjects are exposed to a different gravitational environment. Thus, it is possible that the sensitivity of vestibulo-cardiovascular reflex is diminished after spaceflight, and then orthostatic hypotension is induced. To test this hypothesis, the role of the vestibulo-cardiovascular reflex in maintaining arterial pressure upon posture change is examined before and after spaceflight.	Hironobu Morita, Ph.D., M. D., Gifu University Graduate School of Medicine	Kibo	Space
3DA1 Camcorder	Panasonic 3D Camera	NASA	Technology Development and Demonstration	3DA1 Camcorder is a unique all-in-one design, three-dimensional high-definition television (3D HDTV) camcorder that records video as files on standard definition (SD) memory cards. The camera tests the performance of a file-based video camcorder versus recording on tapes, and provides useful data regarding the performance of the camera's complementary metal oxide semiconductor (CMOS) imaging sensors. The 3D HD video also provides a unique virtual experience for outreach to the public. As part of a Fully Reimbursable Space Act Agreement with Panasonic Solutions Company, the camera provides a unique outlet for outreach involving the space station.	Rodney Grubbs, Marshall Space Flight Center, Huntsville, AL		Earth

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
ACE-1	Advanced Colloids Experiment-1	NASA	Physical Science	ACE-1 is the first in a series of microscopic imaging investigations of materials which contain small colloidal particles, which have the specific characteristic of remaining evenly dispersed and distributed within the material. This investigation takes advantage of the unique environment onboard the space station in order to separate the effects induced by Earth's gravity in order to examine flow characteristics and the evolution and ordering effects within these colloidal materials. Engineering, manipulation and the fundamental understanding of materials of this nature potentially enhances our ability to produce, store, and manipulate materials which rely on similar physical properties.	P. Chaikin, Ph.D., New York University, New York, NY; Matthew Lynch, Ph.D., Procter and Gamble, Cincinnati, OH; David A. Weitz, Ph.D., Harvard University, Cambridge, MA; Arjun Yodh, Ph.D., University of Pennsylvania, University Park, PA;Dr. Stefano Buzzaccaro, ESA		Earth Discovery
AMS-02	Alpha Magnetic Spectrometer - 02	NASA	Earth and Space Science	A state-of-the-art particle physics detector constructed, tested and operated by an international team, the AMS-02 uses the unique environment of space to advance knowledge of the universe and lead to the understanding of the universe's origin by searching for antimatter, dark matter and measuring cosmic rays.	Samuel Ting, Ph.D., Massachusetts Institute of Technology, Cambridge, MA		Space Discovery
APEX-02-1	Advanced Plant EXperiments 02-1	NASA	Biology and Biotechnology	The APEX-02-1 investigation utilizes the Advanced Biological Research System (ABRS) facility on the station. This investigation focuses on the growth and development of Arabidopsis thaliana seedlings in the spaceflight environment and the effects of the spaceflight environment on root development and cell wall architecture. Specimens are harvested on-orbit, preserved with a chemical fixative, and returned to the ground for post-flight evaluation.	Elison Blancaflor, Ph.D., Samuel Roberts Noble Foundation Incorporated, Ardmore, OK		Earth Space Discovery
APEX-02-2	Advanced Plant EXperiments-02-2	NASA	Biology and Biotechnology	The APEX-02-2 investigation utilizes the Advanced Biological Research System (ABRS) facility on the station. The investigation aims to learn how cells adapt to the unique aspects of the space environment, using the model eukaryotic organism, Saccharomyces cerevisiae (yeast). By identifying specific mechanisms which are regulated within the regions of genes that respond to growth in microgravity, researchers will be able to identify factors associated with how genetic information is transferred and the associated signaling pathways that are involved in microbial growth and physiological responses in the space environment.	Timothy G Hammond, M.B.B.S., Durham Veterans Affairs Medical Center, Durham, NC		Earth Space Discovery
Amine Swingbed	Amine Swingbed	NASA	Technology Development and Demonstration	The Amine Swingbed will determine if a vacuum-regenerated amine system can effectively remove carbon dioxide (CO_2) from the station atmosphere using a smaller more efficient vacuum regeneration system.	John Graf, Ph.D., Johnson Space Center, Houston, TX		Space

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
BASS	Burning and Suppression of Solids	NASA	Physical Science	BASS examines the burning and extinction characteristics of a wide variety of fuel samples in microgravity, guiding strategies for extinguishing accidental fires in microgravity. BASS results contribute to the combustion computational models used in the design of fire detection and suppression systems in microgravity and on Earth.	Paul Ferkul, Ph.D., National Center for Space Exploration Research, Cleveland, OH		Earth Space Discovery
BCAT-3-4-CP	Binary Colloidal Alloy Test 3 and 4: Critical Point	NASA	Physical Science	Depending on their relative distances and energies, with respect to one another, atoms and molecules organize themselves to form gases, liquids, and solids. BCAT-3-4-CP studies the critical point of these systems, which is defined where gases and liquids no longer exist as separate entities and a new state of matter forms which is known as the critical point. The application of this experiment in the near term is to enhance the shelf life of everyday products and in the longer term, the development of revolutionary materials for electronics and medicine.	David A. Weitz, Ph.D., Harvard University, Cambridge, MA		Earth Discovery
BCAT-4-Poly	Binodal Colloidal Aggregation Test - 4: Polydispersion	NASA	Physical Science	BCAT-4-Poly involves two samples containing microscopic spheres suspended in a liquid, which are designed to determine how crystals can form from the samples after they have been well mixed. The two samples have the same average sphere size but one of them has a wider range (more polydisperse) of sizes in order to demonstrate the dependence of crystallization on particle size range. Results from these experiments help scientists develop fundamental physics concepts which will enable the development of a wide range of next generation technologies, such as in high speed computers and advanced optical devices.	Paul Chaikin, Ph.D., New York University, New York, NY		Earth Discovery
BCAT-5-3D-Melt	Binary Colloidal Alloy Test - 5: Three-Dimensional Melt	NASA	Physical Science	BCAT-5-3D-Melt involves crew members photographing specially designed microscopic particles (colloids) suspended in a liquid over a period of time. The particles are designed to melt when temperatures warm above a specific temperature (when the station is warmed by sun) and crystallize when the temperatures drop below a specific temperature (when the Earth blocks the sun). The results help scientists develop fundamental physics concepts which are important in developing next generation technologies in computers and advanced optics.	Arjun Yodh, Ph.D., University of Pennsylvania, University Park, PA		Earth Discovery

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
BCAT-6-Colloidal Disks	Binary Colloidal Alloy Test - 6: Colloidal Disks	NASA	Physical Science	BCAT-6-Colloidal Disks use microscopic particles (known as colloids) as models for studying the fundamental physics of a theoretically predicted, but until now unseen, liquid crystal phase. Liquid crystals have many useful physical properties, such as being useful for switching colors (light) on and off in the thin-screen monitors used for many computers, tablets, and cell phones. The use of anisotropic (asymmetric) particles, like the colloidal disks used in this experiment, should produce a new material (cubatic) phase that is predicted to have orientational (directional) order, but no translational (position dependent) order.	Arjun Yodh, Ph.D., University of Pennsylvania, University Park, PA		Earth Discovery
BCAT-6-PS-DNA	Binary Colloidal Alloy Test - 6: Polystyrene - Deoxyribonucleic Acid	NASA	Physical Science	BCAT-6-PS-DNA attempts to produce crystals in microgravity where the components of the crystals are held together by deoxyribonucleic acid (DNA). The crystals in this experiment are created from DNA coated spherical polymer particles. The experiment has applications in the design of new revolutionary nanomaterials.	Paul Chaikin, Ph.D., New York University, New York, NY		Earth Discovery
BCAT-6-Phase Separation	Binary Colloidal Alloy Test - 6: Phase Separation	NASA	Physical Science	BCAT-6-Phase Separation will provide unique insights into how gas and liquid phases separate and come together in microgravity. These fundamental studies on the underlying physics of fluids could provide the understanding needed to enable the development of less expensive, longer shelf-life household products, foods, and medicines.	Matthew Lynch, Ph.D., Procter and Gamble, Cincinnati, OH		Earth Discovery
Biotube-MICRO	Biotube-Magnetophoretically Induced Curvature in Roots	NASA	Biology and Biotechnology	The Biotube-MICRO research is designed to provide insight into the organization and operation of the gravity sensing systems of plants. The experiment uses magnetic fields to determine whether the distribution of subcellular starch grains, called amyloplasts, or their position in columella cells, predicts the direction in which roots will grow in microgravity. This study contributes to an improved understanding of how plants grow and has important implications for improving plant growth and productivity on Earth.	Karl H Hasenstein, Ph.D., University of Louisiana, Lafayette, LA		Earth Space Discovery
Bisphosphonates	Bisphosphonates as a Countermeasure to Space Flight Induced Bone Loss	NASA	Human Research	Bisphosphonates will determine whether an antiresorptive agent, in conjunction with the routine in-flight exercise program, protects space station crew members from the regional decreases in bone mineral density documented on previous station missions.	Adrian Leblanc, Ph.D., Baylor College of Medicine, Houston, TX		Space
BRIC-18	Biological Research in Canisters-18	NASA	Biology and Biotechnology	BRIC hardware has supported a variety of plant growth investigations. The BRIC-18 investigation will focus on the growth and development of seedlings in microgravity. Seedlings will be preserved with a chemical fixative and returned to the ground for post-flight evaluation.	TBD		Earth Space Discovery

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
CARA (Petri Plants)	Characterizing Arabidopsis Root Attractions	NASA	Biology and Biotechnology	The CARA investigation focuses on the growth and development of Arabidopsis thaliana seedlings in the spaceflight environment, with a specific focus on how a root knows which direction to grow in when gravity is absent. Plants are grown in agar, a nutrient solution with a gelatin-like consistency, and exposed to light or dark conditions. Plants are harvested on-orbit, preserved with a chemical preservative, and returned to the ground for post-flight evaluation.	Anna-Lisa Paul, Ph.D., University of Florida, Gainesville, FL		Earth Space Discovery
CEO	Crew Earth Observations	NASA	Earth and Space Science	CEO involves the station crew to photograph natural and human-made events on Earth. The photographs record the Earth's surface changes over time, along with dynamic events such as storms, floods, fires and volcanic eruptions. These images provide researchers on Earth with key data to understand the planet from the perspective of the space station.	Susan Runco, Johnson Space Center, Houston, TX		Earth
CFE-2	Capillary Flow Experiment - 2	NASA	Physical Science	CFE-2 is a suite of fluid physics experiments that investigates how fluids move up surfaces in microgravity. The results could improve current computer models used by designers of low gravity fluid systems, and may improve fluid transfer systems for water on future spacecraft.	Mark M. Weislogel, Ph.D., Portland State University, Portland, OR		Earth Space Discovery
CSI-06	Commercial Generic Bioprocessing Apparatus Science Insert - 06	NASA	Educational Activity and Outreach	CSI-06 is one investigation in the CSI program series. The CSI program provides the K-12 community opportunities to utilize the unique microgravity environment of the space station as part of the regular classroom to encourage learning and interest in science, technology, engineering and math.	Louis Stodieck, Ph.D., University of Colorado, BioServe Space Technologies, Boulder, CO		Earth
Comm Delay Assessment	Assessing the Impact of Communication Delay on Behavioral Health and Performance: An Examination of Autonomous Operations Utilizing the International Space Station	NASA	Human Research	The overall aim of this investigation is to determine whether the communications delays likely to be experienced on a mission to and from Mars will result in clinically or operationally significant negative impacts in crew behavior and performance, and where in that changing communication delay is the critical point that behavioral and task performance is most affected.			Space
DECLIC-DSI-R	Device for the Study of Critical Liquids and Crystallization - Directional Solidification Insert – Reflight	NASA	Physical Science	DECLIC-DSI provides a better understanding of the relationship between micro- and macrostructure formation during solidification processes.	Nathalie Bergeon, Ph.D., Universit Paul Czanne (Aix-Marseille III), Marseille, France		Earth Discovery
DECLIC-HTI-R	Device for the Study of Critical Liquids and Crystallization - High Temperature Insert - Reflight	NASA	Physical Science	DECLIC-HTI studies liquids just beyond the verge of boiling. The flow of heat during boiling events is different in microgravity than it is on Earth. Understanding how heat flows in fluids at the verge of boiling will help scientists develop cooling systems for use in microgravity.	Yves Garrabos, Ph.D., Institut de Chimie de la Matire Condense de Bordeaux, Bordeaux, France		Space Discovery

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
DOD-SPHERES-RINGS	Department of Defense Synchronized Position, Hold, Engage, Reorient, Experimental Satellites-RINGS (DoD SPHERES-RINGS)	NASA	Technology Development and Demonstration	DOD SPHERES-RINGS uses the SPHERES facility and is designed to demonstrate and test, in a complex environment, enhanced technologies and techniques related to micro electromagnetic formation flight (EMFF) and wireless inductive power transfer. By advancing the knowledge base with regards to inter-satellite attitude control and wireless power transfer, future systems can expect enhanced attitude control performance between separate satellites and potentially the ability to efficiently transfer power at a distance, possibly alleviating the need for alternate or expendable (i.e., batteries) power sources.	Melissa Wright, Defense Advanced Research Projects Agency, Washington, DC		Space
DTM DIAPASON	DTM DIAPASON	NASA	Technology Development and Demonstration	The experiment tests a simple instrument (DTM DIAPASON) for the study of nano-particles migration and capture, achieved by very small thermal gradients. The particles range from 2 nm to 1 micron. This range allows the monitoring of combustion-generated pollution, the analysis of hostile environments, and the identification of atmospheric contaminants.	Ferdinando Cassese		Earth
DTN	Disruption Tolerant Networking for Space Operations	NASA	Technology Development and Demonstration	DTN establishes a long-term, readily accessible communications test-bed onboard the space station. Two Commercial Generic Bioprocessing Apparatus (CGBA), CGBA-5 and CGBA-4, will serve as communications test computers that transmit messages between station and ground Mission Control Centers. All data will be monitored and controlled at the BioServe remote Payload Operations Control Center (POCC) located on the Engineering Center premises at the University of Colorado - Boulder.	Kevin Gifford, Ph.D., University of Colorado, Boulder, CO		Space
EarthKAM	Earth Knowledge Acquired by Middle School Students	NASA	Educational Activity and Outreach	EarthKAM is a NASA education program that enables thousands of students to photograph and examine Earth from a space crew's perspective. Using the Internet, the students control a special digital camera mounted on-board the International Space Station. This enables them to photograph the Earth's coastlines, mountain ranges and other geographic items of interest from the unique vantage point of space. The team at EarthKAM then posts these photographs on the Internet for the public and participating classrooms around the world to view.	Sally Ride, Ph.D., University of California - San Diego, San Diego, CA		Earth
EPO-Demos	Education Payload Operation - Demonstrations	NASA	Educational Activity and Outreach	EPO-Demos records video education demonstrations performed on the space station by crew members using hardware already onboard. EPO-Demos enhance existing NASA education resources and programs for educators and students in grades K-12, in support of the NASA mission to inspire the next generation of explorers.	Trinesha Dixon, Johnson Space Center, Houston, TX		Earth

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
FLEX-2	Flame Extinguishment Experiment - 2	NASA	Physical Science	FLEX-2 is the second investigation on the station which uses small droplets of fuel to study the special burning characteristics of fire in space. FLEX-2 will study the rate and manner in which fuel is burned, the conditions that are necessary for soot to form, and the way in which a mixture of fuels evaporate before burning. The results from the FLEX experiments will give scientists a better understanding of how fires behave in space, providing important information that will be useful in increasing the fuel efficiency of engines using liquid fuels.	Forman A. Williams, University of California, San Diego, San Diego, CA		Earth Space Discovery
Functional Task Test	Physiological Factors Contributing to Changes in Postflight Functional Performance	NASA	Human Research	Functional Task Test will test crew members on an integrated suite of functional and physiological tests before and after short- and long-duration space flight. The study identifies critical mission tasks that may be impacted, maps physiological changes to alterations in physical performance, and aids in the design of countermeasures that specifically target the physiological systems responsible for impaired functional performance.	Jacob Bloomberg, Ph.D., Johnson Space Center, Houston, TX		Space
HDEV	High Definition Earth Viewing	NASA	Technology Development and Demonstration	HDEV payload incorporates four commercially available high definition (HD) cameras to provide high definition views of the Earth. HDEV uses four different camera types which have shown potential in early ground based testing and studies to best survive the radiation and space environment. In addition to providing Earth viewing images, the payload also demonstrates the longevity of these cameras in the space environment, in order to provide data and reduce risk in the selection of cameras that could be considered for future use on NASA spacecraft.	Susan Runco, M.S., Johnson Space Center, Houston, TX		
HET-Smartphone	Human Exploration Telerobotics Smartphone	NASA	Technology Development and Demonstration	HET-Smartphone demonstrates and assesses intravehicular activity (IVA) free-flyer telerobotic operations using SPHERES and remote operation of SPHERES by ground control and crew. HET-Smartphone assesses telerobotic operations in order to increase crew efficiency and productivity for future human exploration missions.	Terry Fong, NASA Ames Research Center, Moffett Field, CA		Space
HiMassSEE	Spacecraft Single Event Environments at High Shielding Mass	NASA	Technology Development and Demonstration	HiMassSEE measures space radiation interactions with spacecraft structure and shielding using several passive track detector technologies to provide a more accurate definition of space station payload accommodation.	Steven Koontz, Ph.D.		Space
Hip QCT	Feasibility Study: QCT Modality for Risk Surveillance of Bone - Effects of In-flight Countermeasures on Sub-regions of the Hip Bone	NASA	Human Research	Hip QCT aims to use quantitative computed tomography (QCT) as a surveillance technology to monitor changes in hip bone structure in response to in-flight bone countermeasures. The regions of bone being measured are determinants of fracture risk and will help define the response of hip bone structure to spaceflight, to countermeasures and after return to earth.	Jean Sibonga, Ph.D., Johnson Space Center, Houston, TX		Space

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
HREP-HICO	HICO and RAIDS Experiment Payload - Hyperspectral Imager for the Coastal Ocean	NASA	Earth and Space Science	HREP-HICO operates a specialized visible and near-infrared camera to detect, identify and quantify coastal features from the space station. The experiment demonstrates the retrieval of coastal products including the water depth, the water clarity, chlorophyll content, and sea floor composition for civilian and naval purposes. The EPA also is using HICO to collect data.	Mike Corson, Naval Research Laboratory, Washington, D.C.		Earth
HREP-RAIDS	HICO and RAIDS Experiment Payload - Remote Atmospheric and Ionospheric Detection System (RAIDS)	NASA	Technology Development and Demonstration	HREP-RAIDS provides atmospheric scientists with a complete description of the major constituents of the thermosphere and ionosphere. The thermosphere is the layer of the Earth's atmosphere where the space station orbits the Earth, and the ionosphere is the portion of the upper atmosphere that affects radio waves. RAIDS provides density, composition, temperature and electron density profiles at altitudes between 59 miles (95 kilometers) – 186 miles (300 kilometers).	Scott Budzien, Naval Research Laboratory, Washington, D.C.		Earth
ICE-GA	Italian Combustion Experiment for Green Air	NASA	Physical Science	Study of the evaporation and combustion regimes of renewable liquid fuels. Single droplet imaging is used to perform the study. The experiments are carried out on two selected fuels by varying the pressure (0.1 MPa, 0.3 MPa, 0.6 MPa) and the oxygen content (21%, 10%, 0 -pure pyrolysis). The fuels are second/third generation biofuels or fundamental biofuel surrogates.	Research Director Patrizio Massoli, Dr, Istituto Motori, National Council of Research, Naples		Space Earth
International Space Station Ham Radio	International Space Station Ham Radio	NASA	Educational Activity and Outreach	Ham (amateur) radios are utilized to increase student interest in space exploration by allowing them to talk directly with crew members living and working aboard the space station.	Kenneth Ransom, Johnson Space Center, Houston, TX		Earth
International Space Station High Efficiency Particle Filter Analysis	International Space Station High Efficiency Particle Filter Analysis	NASA	Biology and Biotechnology	Microbes are the most abundant life forms on earth, but the least well characterized and understood. International Space Station High Efficiency Particle Filter Analysis studies the microbes present in the air of the space station by examining those trapped on the station air filter. The goal is to characterize the enormous diversity of microbes that are normally present in indoor environments.	Robert Friedman, J. Craig Venter Institute, San Diego, CA		Space
International Space Station Medical Monitoring	International Space Station Medical Monitoring	NASA	Human Research	International Space Station Medical Monitoring involves the collection of health data at regular intervals from long-duration station crew members. Crew health before, during and following space flight is essential to overall station mission success. All of the partner agencies recognize the importance of crew health to mission success and are dedicated to maintaining the health of all crew members throughout all phases of station missions.			Space
InSPACE-3	Investigating the Structure of Paramagnetic Aggregates from Colloidal Emulsions - 3	NASA	Physical Science	InSPACE-3 obtains data on fluids containing ellipsoid-shaped particles that change the physical properties of the fluids in response to magnetic fields.	Eric M. Furst, Ph.D., University of Delaware, Newark, DE		Earth Discovery

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
Integrated Cardiovascular	Cardiac Atrophy and Diastolic Dysfunction During and After Long Duration Spaceflight: Functional Consequences for Orthostatic Intolerance, Exercise Capability and Risk for Cardiac Arrhythmias	NASA	Human Research	Integrated Cardiovascular aims to quantify the extent, time course and clinical significance of cardiac atrophy (decrease in the size of the heart muscle) associated with long-duration space flight, identifying the mechanisms of this atrophy and the functional consequences for crew members who spend extended periods of time in space.	Benjamin D. Levine, M.D., Institute for Exercise and Environmental Medicine, Presbyterian Hospital and University of Texas Southwestern Medical Center at Dallas, Dallas, TX		Space
Intervertebral Disc Damage	Risk of Intervertebral Disc Damage after Prolonged Space Flight	NASA	Human Research	This study will use state-of-the-art imaging technologies to comprehensibly characterize and quantify space-flight induced changes in disc morphology, biochemistry, metabolism, and kinematics. Subjects will be imaged before and after prolonged spaceflight. This data will be correlated with low back pain that spontaneously arises in space so as to establish pain and disc damage mechanisms that will serve as a basis for future countermeasure development.	Alan Hargens, Ph.D., UCSD Medical Center, San Diego, CA		Space
ISERV	International Space Station SERVIR Environmental Research and Visualization System	NASA	Earth and Space Science	ISERV is an automated system designed to acquire images of the Earth's surface from the space station. It is primarily a means to gain experience and expertise in automated data acquisition from station, although it is expected to provide useful images for use in disaster monitoring and assessment, and environmental decision making.	Burgess Howell, National Space Science and Technology Center, Huntsville, AL		Earth
Journals	Behavioral Issues Associated With Isolation and Confinement: Review and Analysis of Astronaut Journals	NASA	Human Research	Journals obtains information on behavioral and human issues that are relevant to the design of equipment and procedures and sustained human performance during extended-duration missions. Study results will provide information to help prepare for future missions to low-Earth orbit and beyond.	Jack W. Stuster, Ph.D., CPE, Anacapa Sciences, Inc., Santa Barbara, CA		Earth
Manual Control	Assessment of Operator Proficiency Following Long-Duration Space Flight	NASA	Human Research	Lack of gravity causes sensorimotor deficits post-landing. This experiment's comprehensive cognitive/sensorimotor test battery will determine the relative contribution of specific mechanisms (including sleepiness and fatigue) underlying decrements in post-flight operator proficiency. These results will be critical in determining whether sensorimotor countermeasures are required for piloted landings and early surface operations, and what functional areas countermeasures should target.	Steven Moore, Ph.D., Mount Sinai School of Medicine, New York, NY, Hamish MacDougall, Ph.D., University of Sydney, Scott J. Wood, Ph.D., Universities Space Research Association, Houston, TX	Pre- and Post-flight	Space
Micro-5	Investigation of Host-Pathogen Interactions, Conserved Cellular Responses, and Countermeasure Efficacy During Spaceflight Using the Human Surrogate Model Caenorhabditis Elegans	NASA	Biology and Biotechnology	Micro-5 aims to better understand the risks of in-flight infections in space explorers during long-term space flight using the model organism Caenorhabditis elegans (roundworm) with the microbe Salmonella typhimurium (causes food poisoning in humans).	Cheryl A. Nickerson, Ph.D., Arizona State University, Tempe, AZ		Space

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
Micro-7	miRNA Expression Profiles in Cultured Human Fibroblast in Space	NASA	Biology and Biotechnology	The majority of the cells in the human body are non-dividing cells that provide critical physiological functions required to sustain life; however, these types of cells have never been directly studied in the space flight environment. Micro-7 will study how the gene expression and morphology of non-dividing cells are affected in the space flight environment. An understanding of how the space flight environment affects gene and protein expression and their regulation in non-dividing cell cultures is an important step towards understanding the root causes of changes to tissues, organs, and whole body cellular system in the microgravity environment.	Honglu Wu, Ph.D., Kelsey Seybold, Houston, TX		Space
Microbiome	Study of the Impact of Long-Term Space Travel on the Astronauts' Microbiome	NASA	Human Research	The Microbiome experiment investigates the impact of space travel on both the human immune system and an individual's microbiomes (the collection of microbes that live in and on the human body at any given time). To monitor the status of crew members' microbiome and their immune system and their interaction with the unique environment of the station, Periodic samples from different parts of the body and the surrounding station environment will be taken. As part of this study, the likelihood and consequences of alterations in the microbiome due to extreme environments, and the related human health risk, will be assessed.	Assistant Professor Hernan Lorenzi, J Craig Venter Institute, Rockville, MD		Space
MISSE-8	Materials International Space Station Experiment - 8	NASA	Technology Development and Demonstration	MISSE-8 is a test bed for materials and computing elements attached to the outside of the space station. These materials and computing elements are being evaluated for the effects of atomic oxygen, ultraviolet, direct sunlight, radiation, and extremes of heat and cold. This experiment allows the development and testing of new materials and computing elements that can better withstand the rigors of space environments. Results will provide a better understanding of the durability of various materials and computing elements when they are exposed to the space environment, with applications in the design of future spacecraft.	Robert Walters, Ph.D., Naval Research Laboratory, Washington, DC		Space
Nutrition	Nutritional Status Assessment	NASA	Human Research	Nutrition is a comprehensive in-flight study designed to understand changes in human physiology during long-duration space flight. This study includes measures of bone metabolism, oxidative damage, and chemistry and hormonal changes; as well as assessments of the nutritional status of the crew members participating in the study. The results have an impact on the definition of nutritional requirements and development of food systems for future exploration missions beyond low-Earth orbit. This study also helps researchers understand the effectiveness of measures taken to counteract the effects of space flight, as well as the impact of exercise and pharmaceutical countermeasures on nutritional status and nutrient requirements for crew members.	Scott M. Smith, Ph.D., Johnson Space Center, Houston, TX		Earth Space

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
OPALS	Optical PAyload for Lasercomm Science	NASA	Technology Development and Demonstration	OPALS aims to demonstrate and test optical communications technologies from a space based platform. This is accomplished by transferring video data from the OPALS hardware on the station to a ground receiver at the Jet Propulsion Laboratory's (JPL's) Optical Communications Telescope Laboratory (OCTL) in Wrightwood, CA. Optical communication is an emerging technology where the data is modulated onto laser beams, which offers the promise of much higher data rates than what is achievable with radio-frequency (RF) transmissions.	Baris I. Erkmen, Caltech/JPL, Pasadena, CA		Space
Ocular Health	Prospective Observational Study of Ocular Health in International Space Station Crews	NASA		Ocular Health protocol aims to systematically gather physiological data to characterize the risk of microgravity-induced visual impairment/intracranial pressure on crew members assigned to a six-month station increment. The data collected will mirror Medical Requirements Integration Documents (MRID) requirements and testing performed during annual medical exams with an increase in the frequency of in-flight and post-flight testing to more accurately assess changes that occur in the visual, vascular, and central nervous systems upon exposure to microgravity and the resulting fluid shifts. Monitoring in-flight visual changes, in addition to post-flight recovery, is the main focus of this protocol.	Christian Otto, Universities Space Research Association (USRA), Houston, TX		Earth Space
PPOD	Poly Pico satellite Orbital Deployer	NASA	Technology Development and Demonstration	NASA has agreed to sponsor the deployment of various CubeSat payloads through PPOD launchers on SpaceX launch vehicles with available mass.			Space
Pro K	Dietary Intake Can Predict and Protect Against Changes in Bone Metabolism During Spaceflight and Recovery	NASA	Human Research	Pro K is NASA's first evaluation of a dietary countermeasure to lessen bone loss of astronauts. Pro K proposes that a flight diet with a decreased ratio of animal protein to potassium will lead to decreased loss of bone mineral. Pro K has impacts on the definition of nutritional requirements and development of food systems for future exploration missions, and could yield a method of counteracting bone loss that would have virtually no risk of side effects.	Scott M. Smith, Ph.D., Johnson Space Center, Houston, TX		Space
Quantification of In-flight Physical Changes	Quantification of In-flight Physical Changes - Anthropometry and Neutral Body Posture (NBP)	NASA	Technology Development and Demonstration	Determine the change in anthropometric (body) measurements due to the effects of microgravity, spinal elongation growth, fluid shifts, etc. Determine and establish the crew dependent in-flight neutral body postures (NBP) and the associated spinal elongation effect on NBP during extended exposure to microgravity. Use data to determine implications for tasks, mobility aids, and equipment design.	Sudhakar Rajulu, Ph.D., Johnson Space Center, Houston, TX		Space
Reaction Self Test	Psychomotor Vigilance Self Test on the International Space Station	NASA	Human Research	Reaction Self Test is a portable five-minute reaction time task that will allow the crew members to monitor the daily effects of fatigue on performance while on board the space station.	David F. Dinges, Ph.D., University of Pennsylvania School of Medicine, Philadelphia, PA		Space

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
REBR	ReEntry Breakup Recorder	NASA	Technology Development and Demonstration	REBR tests a cost-effective system that rides a re-entering space vehicle, records data during the re-entry and breakup of the vehicle, and returns the data for analysis.	William Ailor, Ph.D., The Aerospace Corporation, El Segundo, CA		Earth Space
Robonaut and Robonaut-2	Robonaut	NASA	Technology Development and Demonstration	Robonaut serves as a spring board to help evolve new robotic capabilities in space. Robonaut demonstrates that a dexterous robot can launch and operate in a space vehicle, manipulate mechanisms in a microgravity environment, operate for an extended duration within the space environment, assist with tasks, and eventually interact with the crew members.	Myron A. Diftler, Ph.D., Johnson Space Center, Houston, TX		Space
RRM P2	Robotic Refueling Mission Phase 2	NASA	Technology Development and Demonstration	RRM demonstrates and tests the tools, technologies and techniques needed to robotically refuel satellites in space, even satellites not designed to be serviced. RRM is expected to reduce risks and lay the foundation for future robotic servicing missions in microgravity. The Robotic Refueling Mission Phase 2 (RRM-P2) consists of installing 2 new modular task boards onto the existing RRM experiment that was installed on the International Space Station ELC4 in August 2011. The modular task boards are designed to mimic satellite interfaces that can be used in robotic servicing. The task boards also feature various mechanical adapters to actuate these satellite interfaces that are manipulated by the existing RRM Multi-Function Tool (MFT) stowed within the RRM experiment. The robot that will perform the demonstrations is the Special Purpose Dexterous Manipulator (SPDM, also known as "Dextre") that operates in an environment equivalent to a robotic servicing mission. The demonstrations on the task boards will reduce risks, refine techniques, and increase the reliability and technical proficiency of future robotic servicing missions. RRM-P2 operations will be remotely controlled by flight controllers at NASAs Goddard Space Flight Center in Greenbelt, MD, Johnson Space Center in Houston, TX, Marshall Space Flight Center in Huntsville, AL, and the Canadian Space Agency (CSA) in St. Hubert, Quebec.	Frank Cepollina, Goddard Space Flight Center, Greenbelt, MD		Space
Radiation Environment Monitor	Radiation Environment Monitor	NASA	Technology Development and Demonstration	The Radiation Environment Monitor is a demonstration of the Medipix technology, which has evolved from work at the European Organization for Nuclear Research (CERN) in Geneva, Switzerland. The device has the capabilities necessary and is sufficiently developed to become the basis for the first generation of operational active personal space radiation dosimeters. The desired outcome is a successful demonstration of the measurement capabilities with sufficient data to allow the initiation of a follow-on design effort to produce operational hardware and embedded software.	Edward Semones, Johnson Space Center, Houston, TX		Space

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
SCAN Testbed	Space Communications and Navigation Testbed	NASA	Technology Development and Demonstration	SCAN Testbed will be a station-based experimental facility investigating reprogrammable, software defined radio (SDR) technology during space missions. The experiments will advance a common SDR architecture standard, and demonstrate advanced communications, navigation, and networking applications. The Testbed includes three software defined radios communicating with Tracking and Data Relay Satellite System (TDRSS) constellation at S-band and Ka-band, direct to ground at S-band, and receive L-band (GPS) signals. The SCAN Testbed will advance many technologies to enhance future human and robotic missions including high data rate transmission and reception, new data coding and modulation, adaptive cognitive applications, real-time networking including disruptive tolerant networking, and precise navigation at current and emerging GPS frequencies. The testbed will also host SDR investigations by other government agencies, commercial and academic users.	Richard C. Reinhart, Glenn Research Center, Cleveland, OH		Space
SNFM	Serial Network Flow Monitor	NASA	Technology Development and Demonstration	SNFM, using a commercial software CD, will monitor the payload local area network (LAN) to analyze and troubleshoot LAN data traffic. Validating LAN traffic models may allow for faster and more reliable computer networks to sustain systems and science on future space missions.	Carl Konkel, Boeing, Houston, TX		Space
SpaceDRUMS	Space Dynamically Responding Ultrasonic Matrix System	NASA	Physical Science	SpaceDRUMS will provide a suite of hardware capable of facilitating containerless advanced materials science, including combustion synthesis and fluid physics. That is, inside SpaceDRUMS samples of experimental materials can be processed without ever touching a container wall.	Jacques Guigne, Ph.D., Guigne Space Systems, Incorporated, Paradise, Newfoundland, Canada		Space
SPHERES-Fluid Slosh	SPHERES-Slosh	NASA	Technology Development and Demonstration	Slosh examines the way liquids move inside containers in a microgravity environment. The phenomena and mechanics associated with such liquid movement are still not well understood and are very different than our common experiences with a cup of coffee on Earth. Rockets deliver satellites to space using liquid fuels as a power source, and this investigation plans to improve our understanding of how propellants within rockets behave in order to increase the safety and efficiency of future engine designs.	Dr Paul Schallhorn, Aerospace Supervisor, Kennedy Space Center, FL		Space
SPHERES-VERTIGO	Synchronized Position Hold, Engage, Reorient, Experimental Satellites - Vertigo	NASA	Technology Development and Demonstration	VERTIGO will demonstrate - in a realistic test environment - critical technologies in the area of visual inspection/navigation. This effort will develop hardware and software to enable one or two SPHERES to construct a 3D model of another object (likely a third SPHERE, but applicable to any object) and perform relative navigation solely by reference to this 3D model.	Roger Hall, Defense Advanced Research Projects Agency, Washington, D.C.; Maj. Matt Moye, Department of Defense Space Test Program, Houston, TX		Space

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
SPHERES-Zero-Robotics	Synchronized Position Hold, Engage, Reorient, Experimental Satellites-Zero-Robotics	NASA	Educational Activity and Outreach	SPHERES-Zero-Robotics establishes an opportunity for high school students to design research for the space station. As part of a competition, students write algorithms for the SPHERES satellites to accomplish tasks relevant to future space missions. The algorithms are tested by the SPHERES team and the best designs are selected for the competition to operate the SPHERES satellites on board the station.	David W. Miller, Ph.D., Massachusetts Institute of Technology, Cambridge, MA		Earth
Spinal Ultrasound	Sonographic Astronaut Vertebral Examination	NASA	Human Research	Spinal Ultrasound aims to use ground and space-based studies to fully characterize spinal changes during and after spaceflight. Ground based pre- and post-flight MRI and high fidelity ultrasound, combined with in-flight ultrasound, will be used to characterize and assign a mission health risk to microgravity-associated spinal alterations for back pain and potential injury. This research will determine the accuracy of MRI and musculoskeletal ultrasound in characterizing the anatomy/composition of the vertebral unit and develop training methodologies.	Scott A Dulchavsky, Ph.D., M.D., Henry Ford Health System, Detroit, MI;		Earth Space
STP-H3-Canary	Space Test Program - Houston 3 - Canary	NASA	Technology Development and Demonstration	STP-H3-Canary investigates the interaction of ions with the background plasma environment around the station.	Geoff Mcharg, Ph.D., US Air Force Academy, CO		Space
STP-H3-DISC	Space Test Program - Houston 3 - Digital Imaging Star Camera	NASA	Technology Development and Demonstration	STP-H3-DISC captures images of star fields for analysis by ground algorithms to determine the attitude of the station. The results will lead to the creation of more robust and capable satellites to be used by ground systems for Earth-bound communications.	Andrew Nicholas, Naval Research Laboratory, Washington, DC		Earth Space
STP-H3-MHTEX	Space Test Program - Houston 3 - Massive Heat Transfer Experiment	NASA	Technology Development and Demonstration	STP-H3-MHTEX tests capillary pumped loop heat transfer equipment, which operates by continuous fluid flow to transfer heat from multiple spacecraft sources to an external vehicle surface to improve the understanding of two-phase flow microgravity performance.	Andrew Nicholas, Naval Research Laboratory, Washington, DC		Space Discovery
STP-H3-VADER	Space Test Program - Houston 3 - Variable Emissivity Radiator Aerogel Insulation Blanket Dual Zone Thermal Control Experiment Suite for Responsive Space	NASA	Technology Development and Demonstration	STP-H3-VADER tests a new form of multilayer insulation that uses Aerogel as the thermal isolator to protect spacecraft from the harsh extremes of the space environment.	Andrew Nicholas, Naval Research Laboratory, Washington, DC		Space
STP-H4-ATT	Space Test Program-Houston 4-Active Thermal Tile	NASA	Technology Development and Demonstration	ATT consists of a series of variable conductance thermal interface tiles. The objective of the ATT experiment is to measure the on-orbit performance of the ATT string and measure its on-orbit degradation in the combined effects of the space environment. The variable conductance is achieved with thermo-electric devices (TEDs) that are used as a heat pump.	Andrew Williams, Air Force Research Laboratory, Wright-Patterson Air Force Base, OH; Maj. Matt Moye, Department of Defense Space Test Program, Houston, TX; Rick Caldwell, Department of Defense Space Test Program, Houston, TX		Space

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
STP-H4-GLADIS	Space Test Program - Houston 4 - Global Awareness Data-Exfiltration International Satellite	NASA	Technology Development and Demonstration	GLADIS will validate the performance of a dual channel Ultra High Frequency (UHF) and Very High Frequency (VHF) data-extraction payload in a nanosatellite form factor. GLADIS will receive Automatic Identification System (AIS) vessel tracking signals and simultaneously provide two way communications to widely distributed Maritime Domain Awareness sensor arrays via the Ocean Data Telemetry Microsat Link (ODTML).	Rick Caldwell, Department of Defense Space Test Program, Houston, TX; Jay Middour, Naval Research Lab; Maj. Matt Moye, Department of Defense Space Test Program, Houston, TX		Space
STP-H4-ISE 2.0	Space Test Program-Houston 4-International Space Station SpaceCube Experiment 2.0	NASA	Technology Development and Demonstration	ISE 2.0 will demonstrate NASA/GSFC SpaceCube 2.0 technology in low Earth orbit, using commercial Xilinx Virtex-5 FPGAs and Goddard Space Flight Center (GSFC) "radiation hardened by software" (RHBS) technology, and continue the RHBS technology development initiated during the SpaceCube 1.0 (commercial Virtex-4) experiment in the MISSE7 payload. ISE 2.0 will also serve as an on-orbit test bed to further develop Earth science and robotic servicing applications being developed in collaboration with the GSFC Science and Exploration Directorate and the Jet Propulsion Laboratory (JPL). ISE 2.0 will also include a thermal plate prototype to demonstrate Electro Hydro-Dynamic (EHD) pumping of liquids in micro-channels for advanced thermal control, and instrumentation (i.e., FireStation) to detect and measure terrestrial gamma-ray flashes from lightning/thunderstorms, which will be used to demonstrate real-time on-board science data processing.	Tom Farley, Goddard Space Flight Center, Greenbelt, MD; Rick Caldwell, Department of Defense Space Test Program, Houston, TX; Maj. Matt Moye, Department of Defense Space Test Program, Houston, TX		Earth Space
STP-H4-MARS	Space Test Program-H4-Miniature Array of Radiation Sensors	NASA	Technology Development and Demonstration	MARS will monitor the total dose radiation on a host spacecraft (in the case of STP-H4 the host spacecraft will be the GLADIS experiment) for 3-D radiation modeling with an array of persistent, ubiquitous micro dosimeter sensors. A MARS sensor node consists of a hybrid microcircuit which directly measures accumulated total ionizing dose in a silicon test mass, starting at power-up.	Rick Caldwell, Department of Defense Space Test Program, Houston, TX; Maj. Matt Moye, Department of Defense Space Test Program, Houston, TX		Space
STP-H4-SWATS	Space Test Program-Houston 4-Small Wind and Temperature Spectrometer	NASA	Technology Development and Demonstration	SWATS will demonstrate a low Size, Weight and Power (SWaP) space weather sensor. SWATS will acquire simultaneous co-located, in-situ measurements of atmospheric density, composition, temperature and winds.	Rick Caldwell, Department of Defense Space Test Program, Houston, TX; Maj. Matt Moye, Department of Defense Space Test Program, Houston, TX		Earth
Surface Telerobotics	Surface Telerobotics	NASA	Technology Development and Demonstration	Surface Telerobotics will examine how the crew can effectively tele-operate ground robots from orbit while constrained by factors related to the space environment, crew vehicle resources and communications.	Terry Fong, NASA Ames Research Center, Moffett Field, CA		Space

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
T-Cell Act in Aging	T-Cell Activation in Aging	NASA	Biology and Biotechnology	The main objective of TCELLSUP is to e activation, specifically T-cell activation, during microgravity exposure to characterize the role of the candidate molecular regulatory factors and cellular factors in the inhibition of T-cell activation. Space flight T-cell specimens will be obtained from mid-age adults (ages 30 – 55) and ground study T-cells will be from older adults (over 65). The comparison of T-cell activation data between these two groups will provide scientists with further insight into understanding and identifying specific factors that may play a critical role in immune function loss during aging. The discoveries from the TCELLSUP may lead to development of medical treatments that can be used to maintain normal immune function throughout life on Earth and in space.	Millie Hughes-Fulford, Ph.D., University of California, San Francisco, San Francisco, CA		Earth Space
UBNT	Ultrasonic Background Noise Test	NASA	Technology Development and Demonstration	UBNT will obtain the high frequency noise levels generated by space station hardware and equipment operating within the U.S. Lab and the Node 3 structures. This information is necessary in order to develop an automated leak location system for current and future manned space systems that is based on the ultrasonic noise generated by an air leak through a space structure’s pressure wall. An understanding of the background noises generated by non-leak sources will allow a leak detection system to deal with extraneous noise sources.	Eric Madaras, Ph.D, Langley Research Center, Hampton, VA		Space
VIABLE ISS	Evaluation and Monitoring of Microbiofilms Inside International Space Station	NASA	Biology and Biotechnology	VIABLE ISS involves the evaluation of the microbial biofilm development on space materials. Both metallic and textile space materials, either conventional or innovative, are located inside and on the cover of Nomex pouches that are placed inside the space station.	Francesco Canganella, Universita della Tuscia, Viterbo, Italy		Space
ТХН-9	Kristallizator (Crystallizer)	RSA	Physico-chemical processes and material in condition of cosmos	Biological macromolecules crystallization and obtaining bio-crystal films under microgravity conditions.		Kibo	Space
КПТ-21(ТЕХ-20)	Plazmennyi Kristall (Plasma Crystal)	RSA	Physico-chemical processes and material in condition of cosmos	Study of the plasma-dust crystals and fluids under microgravity.		MRM2	Discovery
ГФИ-1	Relaksatsiya	RSA	Geophysics and located beside land outer space	Study of chemiluminescent chemical reactions and atmospheric light phenomena that occur during high-velocity interaction between the exhaust products from spacecraft propulsion systems and the Earth atmosphere at orbital altitudes and during the entry of space vehicles into the Earth upper atmosphere.			Earth Space
ГФИ-16	Vsplesk (Burst)	RSA	Geophysics and located beside land outer space	Seismic effects monitoring. Researching high-energy particles streams in near-Earth space environment.			Earth
ГФИ-28	Microsatellite	RSA	Geophysics and located beside land outer space	Testing of run in automatic mode microsatellite Chibis-M using the cargo ship “Progress.”		Progress	Space

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
КПТ-23	Radar-Progres	RSA	Geophysics and located beside land outer space	Investigation of ground-based observations of reflection characteristics of plasma irregularities in the ionosphere generated by the onboard engines of the Progress.			Earth
МБИ-16	Vzaimodeistvie (Interaction)	RSA	Biomedical studies	Monitoring of the group crew activities under space flight conditions.			Space
МБИ-20	Tipologia	RSA	Biomedical studies	Researching for typological features of the activities of the station crews as operators activities in long term space flight phases.			Space
МБИ-24	Sprut-2	RSA	Biomedical studies	Investigation of the dynamics of body composition and distribution of human body fluids during prolonged space flight.			Space
МБИ-26	Motokard	RSA	Biomedical studies	Mechanisms of sensorimotor coordination in weightlessness.			Space
МБИ-28	Chromatomassspekt r M (GC spectrum)	RSA	Biomedical studies	Evaluation of microbiological status of the person using GC-MS.			Space
МБИ-29	Immuno	RSA	Biomedical studies	The study of neuro-endocrine and immune responses in humans during and after the flight to the space station.			Space
БИО-1	Poligen	RSA	Biomedical studies	Detection of genotypic features (experimental object – Drozophila midge), determining individual characteristics of resistance to the long-duration flight factors.			Space
БИО-2	Biorisk	RSA	Biomedical studies	Study of space flight impact on microorganisms-substrates systems state related to space technique ecological safety and planetary quarantine problem.		EVA	Space
БИО-8	Plazmida	RSA	Biomedical studies	Investigation of microgravity effect on the rate of transfer and mobilization of bacteria plasmids.			Space
ДЗЗ-13	Seyener	RSA	Remote flexing the Land	Experimental methods of the interaction of the crews to cosmic station with court Fishing in process of searching for and mastering commercial-productive region of the World ocean.			Earth
КПТ-22	Econ-M	RSA	Remote flexing the Land	Information for the Environmental Survey areas of different objects using the space station RS.			Earth
ИКЛ-2В	BTN-Neutron	RSA	Study of the Solar system	Study of fast and thermal neutrons fluxes.			Discovery
БТХ-5	Laktolen	RSA	Cosmic biotechnology	Effect produced by space flight factors on Laktolen producing strain.			Discovery
БТХ-6	ARIL	RSA	Cosmic biotechnology	Effect produced by SFFs on expression of strains producing interleukins 1α, 1β, "ARIL."			Discovery
БТХ-10	Kon'yugatsiya (Conjugation)	RSA	Cosmic biotechnology	Working through the process of genetic material transmission using bacteria conjugation method.			Discovery
БТХ-11	Biodegradatsiya	RSA	Cosmic biotechnology	Assessment of the initial stages of biodegradation and biodeterioration of the surfaces of structural materials.			Space
БТХ-14	Bioemulsiya (Bioemulsion)	RSA	Cosmic biotechnology	Study and improvement of closed-type autonomous reactor for obtaining biomass of microorganisms and bioactive substance without additional ingredients input and metabolism products removal.			Space
БТХ-29	Zhenshen'-2 (Ginseng-2)	RSA	Cosmic biotechnology	Study of the possibility to increase the ginseng biological activity.			Earth
БТХ-35	Membrane	RSA	Cosmic biotechnology	Study of the possibility of the reception in principal new пористых material with regular structure for use as filter and membrane.		MRM2	Discovery

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	Ops Location	Benefits Provided
БТХ-39	Asepsises	RSA	Cosmic biotechnology	Development of the methods and on-board technical facilities of the ensuring the aseptic conditions of the undertaking BTH - an experiment in condition of the space flight.		MRM1	Space
БТХ-40	BIF (Bifidobacterias)	RSA	Cosmic biotechnology	Study of the influence factor space flight on technological and биомедицинские of the feature bifidobacterias.			Space
БТХ-41	Bakteriofag	RSA	Cosmic biotechnology	Study of the influence factor space flight on bakteriofages.			Space
БТХ-42	Structure	RSA	Cosmic biotechnology	Reception high-quality crystal рекомбинантных squirrel.			Earth Discovery
БТХ-44	Calcium	RSA	Cosmic biotechnology	Studies on the effect of microgravity on the solubility of calcium phosphates in the water.			Discovery
ТЕХ-19	Otklik	RSA	Technical studies and experiments	Register meteor strikes, and man-made particles in the outer elements of the design of the station with the help of piezoelectric sensors.			Space
ТЕХ-22 (SDTO 13001-R)	Identifikatsiya	RSA	Technical studies and experiments	Identification of disturbance sources when the microgravity conditions on the station are disrupted.			Space
ТЕХ-39	SLS (System lazer relationship)	RSA	Technical studies and experiments	Otrabotka systems laser relationship for issue greater array to information from target equipment.		EVA	Space
ТЕХ-44	Sreda-ISS (Environment)	RSA	Technical studies and experiments	Studying space station characteristics as researching environment.			Space
ТЕХ-51	Viru	RSA	Technical studies and experiments	Virtual guide			Space
ТЕХ-52	Visir (Sight)	RSA	Technical studies and experiments	Investigation of methods for detecting the current position and orientation of the portable scientific equipment manned space complexes.			Space
ТЕХ-58	Vinoslivost (Endurance)	RSA	Technical studies and experiments	Investigation of the influence of space factors on the mechanical properties of materials for space purposes.			Space
ТЕХ-62	Albedo	RSA	Technical studies and experiments	Investigation of the characteristics of the radiation of the Earth and development of their use in the power system model of the space station RS.			Space
КПТ-2	Bar	RSA	Technical studies and experiments	Testing of principles and methods for the space station leak area control, selection of the sensor design and configuration.			Space
РБО-3	Matryeshka-R	RSA	Study of the physical conditions in outer spaces on station orbit	Study of radiation environment dynamics along the space station RS flight path and in station compartments, and dose accumulation in anthropomorphous phantom, located inside and outside the station.		SM, MRM1, Kibo	Space
КПТ-14	Ten' - Mayak (Shadow – Beacon)	RSA	Formation and popularization cosmic studies	Working-out the method for radio probing of board-ground space for supporting preparation of "Ten" ("Shadow") plasma experiment on the station RS.			Space
КПТ-10	Kulonovskiy crystal	RSA	Formation and popularization cosmic studies	System speaker study of the charged particles in magnetic field in the condition of microgravity.		MRM2	Space Discovery
ОБР-3	MAI-75	RSA	Formation and popularization cosmic studies	Spacecraft and up-to-date technologies for personal communications.			Space
ОБР-5	Great Start	RSA	Formation and popularization cosmic studies	Popularize the achievements of Soviet manned space flight.			Earth Space

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NASA'S COMMERCIAL ORBITAL TRANSPORTATION SERVICES (COTS)

Cygnus (Orbital Sciences Corp.)

Just 100 miles up the coast from where the Wright brothers first flew their airplane at Kitty Hawk, North Carolina, Orbital plans to launch its new system at the Mid-Atlantic Regional Spaceport (MARS), located at NASA's Wallops Flight Facility in Virginia.

Founded in 1982, Orbital's spacecraft design is based on the new Antares rocket with a liquid oxygen (LOX)/kerosene (RP-1) first stage powered by two Aerojet AJ-26 engines. The Antares second stage uses ATK's Castor 30 solid-propellant motor derived from its flight-proven Castor 120. The cargo spacecraft, known as Cygnus, is derived from Orbital's heritage DAWN and STAR projects and space station cargo carriers.

Cygnus will approach the station and will be grappled by the crew using the station's robotic arm. It will then be installed on the bottom side of the station's Harmony node. After delivering cargo to the space station, Cygnus destructively re-enters Earth's atmosphere.

Both Orbital Sciences and SpaceX took part in NASA's Commercial Orbital Transportation Services (COTS) Program. Under COTS, NASA is helping commercial partners develop and demonstrate their own cargo space transportation capabilities to serve the U.S. government and other potential customers. The companies lead and direct their own efforts, with NASA providing technical and financial assistance.

Orbital will conduct a test flight of the Antares rocket from Wallops, followed by a full demonstration flight to the International Space Station. Once those are completed, cargo flights will begin.

For more information, visit: www.orbital.com

Artist rendering of Antares on launch pad

Artist rendering of Cygnus spacecraft approaching the International Space Station

Dragon (Space Exploration Technologies)

At Florida's Cape Canaveral, within sight of the launch locations of every NASA human spaceflight mission to date, SpaceX launches its Falcon 9 rocket and Dragon spacecraft.

Founded in 2002, SpaceX has designed these systems from the ground up using the best of modern technology. The Falcon 9, which launches the Dragon to low Earth orbit, uses SpaceX-designed Merlin LOX/RP-1 engines, with nine in the first stage and one in the second stage. Dragon is designed not only to take cargo to the space station, but also to bring back cargo and experiment samples to Earth. It is the only cargo craft that can do that.

Both Orbital Sciences and SpaceX took part in NASA's Commercial Orbital Transportation Services (COTS) Program. Under COTS, NASA is helping commercial partners develop and demonstrate their own cargo space transportation capabilities to serve the U.S. government and other potential customers. The companies lead and direct their own efforts, with NASA providing technical and financial assistance.

After conducting a successful test flight to the space station, SpaceX began routine cargo flights in 2012. SpaceX is now flying under the Commercial Resupply Services Program.

For more information, visit: www.spacex.com

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DIGITAL NASA TELEVISION

NASA Television Is On Satellite AMC-18C

NASA TV is available in continental North America, Alaska and Hawaii on AMC-18C. A Digital Video Broadcast (DVB) compliant Integrated Receiver Decoder (IRD) is needed for reception. Below are parameters for each channel:

Uplink provider = AMC 18 C
Transponder = 3C
105 degrees W
C-Band
Downlink Frequency: 3760 MHz
Downlink Polarity: Vertical
Transmission Format = DVB-S, 4:2:0
FEC = ¾
Data Rate = 38.80 Mbps
Symbol Rate = 28.0681
Modulation: QPSK/DVB-S

For NASA TV downlink information, schedules and links to streaming video, visit:

http://www.nasa.gov/ntv

Internet Information

Information on NASA and its programs is available through the NASA Home Page and the NASA Public Affairs Home Page:

http://www.nasa.gov

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