National Aeronautics and Space Administration

SPACE STATION MISSION
EXPEDITION 27-28

PRESS KIT/April 2011

Stocking the Station

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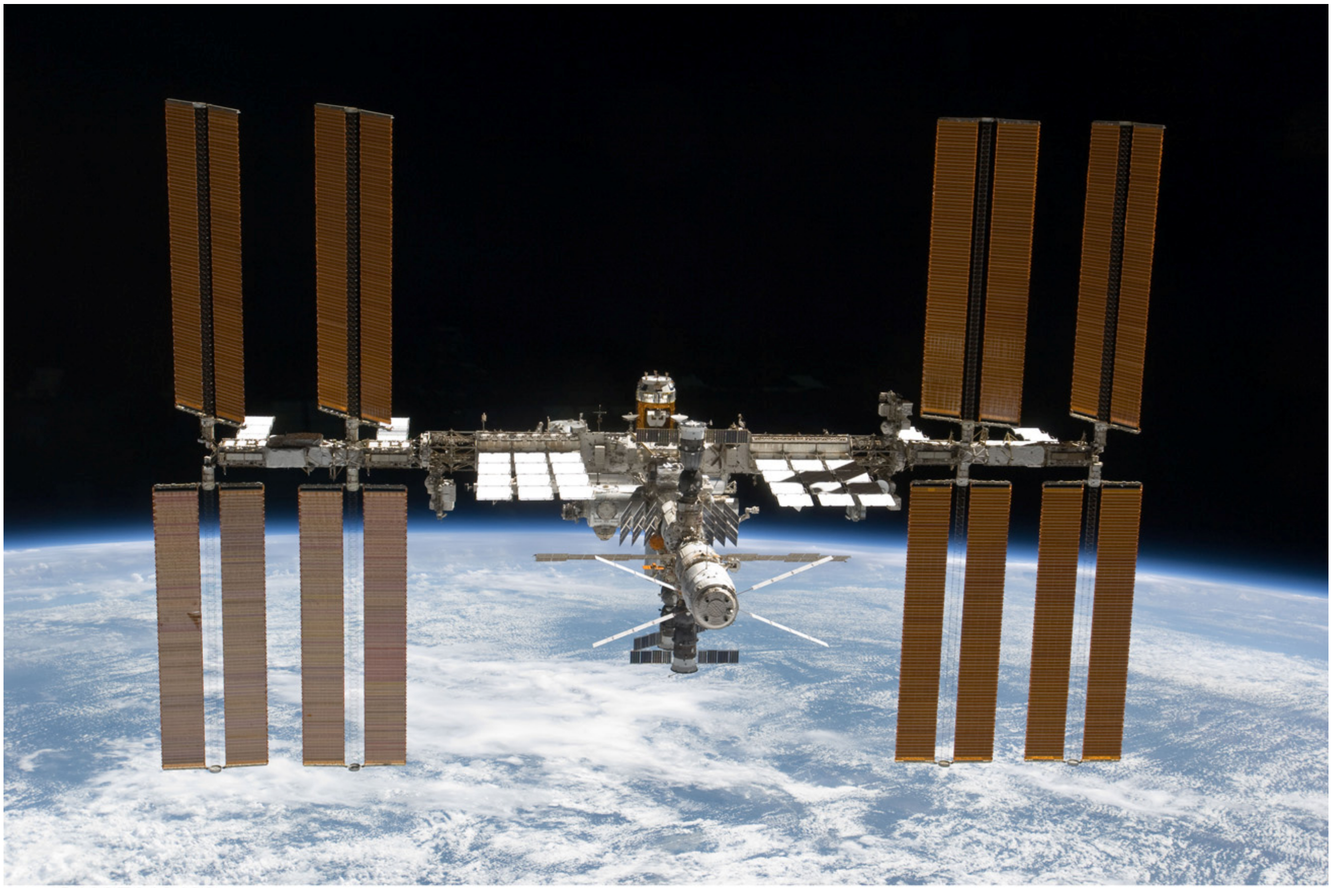
Mission Overview

Expeditions 27 and 28



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The International Space Station is featured in this image photographed by an STS-133 crew member on space shuttle Discovery after the station and shuttle began their post-undocking relative separation. Undocking of the two spacecraft occurred at 7 a.m. (EST) on March 7, 2011. Discovery spent eight days, 16 hours, and 46 minutes attached to the orbiting laboratory. Photo credit: NASA

The primary goals of Expedition 27 and 28 are to continue world-class research while preparing the International Space Station (ISS) for a future without space shuttles, provisioning it with enough supplies and spare parts to support the orbiting outpost until all of its new resupply spacecraft are ready.

The comings and goings of the final two space shuttle missions, STS-134 and STS-135, will keep the station’s six-person crew busy for much of the summer, while the departure of four cargo ships turned trash trucks and the activation of Robonaut 2 fill the rest of its busy schedule.

The Expedition 27 and 28 crews, comprised of a total of nine residents over a span of seven months, will continue to support research into the effects of microgravity on the human body, biology, physics and materials, and expand its scope to the mysteries of the cosmos with the Alpha Magnetic Spectrometer.

As Expedition 26 Commander Scott Kelly and Flight Engineers Alexander Kaleri and Oleg Skripochka departed in mid-March, cosmonaut Dmitry Kondratyev became commander of the three-person Expedition 27 crew that also includes NASA's Catherine Coleman and the European Space Agency's Paolo Nespoli. For about two weeks, the trio maintained station operations and research before being joined by another American and two more Russians.

NASA's Ron Garan and Russians Andrey Borisenko and Alexander Samokutyaev joined Kondratyev, Coleman and Nespoli when their Soyuz TMA-21 spacecraft docked with the station April 6, following an April 4 launch from the Baikonur Cosmodrome in Kazakhstan. United, they comprise the full Expedition 27 crew. Kondtatyev, Coleman and Nespoli launched to the station Dec. 15, 2010, aboard the Soyuz TMA-20 spacecraft.

Less than two weeks after the arrival of Garan, Borisenko and Samokutyaev, the six-person crew celebrated the 50th anniversary of the first human spaceflight and the 30th anniversary of the first space shuttle flight. Russian cosmonaut Yuri Gagarin's flight lifted off from the same launch pad as Garan, Borisenko and Samukotyaev on April 12, 1961, while NASA astronauts John Young and Robert Crippen launched from Kennedy Space Center on STS-1 on April 12, 1981, aboard space shuttle Columbia.

Coleman, a retired U.S. Air Force colonel, has been on the space station since Dec. 17, 2010. She was a mission specialist on STS-73 in 1995 and STS-93 in 1999, a mission that deployed the Chandra X-Ray Observatory. She also served as the backup U.S. crew member for Expeditions 19, 20, and 21.

Kondratyev, selected as a test-cosmonaut candidate of the Gagarin Cosmonaut Training Center Cosmonaut Office in December 1997, trained as a backup crew member for Expedition 5 and Expedition 20. He also served as the Russian Space Agency director of operations stationed at the Johnson Space Center from May 2006 through April 2007. He conducted two spacewalks in January and February.

Nespoli was selected as an astronaut by the Italian space agency in July 1998 and one month later joined ESA's European astronaut corps. He flew as a mission specialist on STS-120 in October 2007, which delivered the Italian-built Harmony module to the space station. Prior to this mission, Nespoli had accumulated more than 15 days of spaceflight experience.

Expedition 27 crew members from top, Russian cosmonaut Andrey Borisenko, NASA astronaut Ron Garan, and cosmonaut and Soyuz commander Alexander Samokutyaev wave farewell from the bottom of the Soyuz rocket prior to their launch to the ISS from the Baikonur Cosmodrome in Baikonur, Kazakhstan, on April 5, 2011 (Kazakhstan time). The Soyuz, which has been dubbed "Gagarin," is launching one week shy of the 50th anniversary of the launch of Yuri Gagarin from the same launch pad in Baikonur on April 12, 1961 to become the first human to fly in space. Photo credit: NASA/Carla Cioffi

Garan, 49, is embarking on the second mission of his NASA career. Garan completed his first spaceflight in 2008 on STS-124 as a mission specialist and has logged more than 13 days in space and 20 hours and 32 minutes of extravehicular activity in three spacewalks. Garan is a retired colonel in the U.S. Air Force and has degrees from the SUNY College at Oneonta, Embry-Riddle Aeronautical University and the University of Florida.

Samokutyaev, 41, flight engineer for Expeditions 27 and 28, is on his first mission. Before becoming a cosmonaut, Samokutyaev flew as a pilot, senior pilot and deputy commander of air squadron. Samokutyaev has logged 680 hours of flight time and performed 250 parachute jumps. He is a Class 3 Air Force pilot and a qualified diver. Since December 2008, he has trained as an Expedition 23/24 backup crew member, Soyuz commander and Expedition 24 flight engineer.

Borisenko, 46, graduated from the Leningrad Physics and Mathematics School No. 30 and, working in a military unit, started his career at RSC Energia in 1989 where he was responsible for the Mir motion control system and took part in the Borisenko was a shift flight director at the MCC-M starting in 1999, first for the Mir space station and then for the International Space Station. Borisenko will serve as a flight engineer on Expedition 27 and commander on Expedition 28.

The Expedition 27 and 28 crews will work with some 111 experiments involving approximately 200 researchers across a variety of fields, including human life sciences, physical sciences and Earth observation, and conduct technology demonstrations ranging from recycling to robotics. Seventy-three of these experiments are sponsored by NASA, including 22 under the auspices of the U.S. National Laboratory program, and 38 are sponsored by international partners. More than 540 hours of research are planned. As with prior expeditions, many experiments 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 systems with plan for future exploration missions.

Aside from research, Expeditions 27 and 28 are all about making room for the supplies and equipment to be delivered on the final shuttle missions by putting as much trash and packing material as possible into departing cargo vehicles. The emptied Japan Aerospace Exploration Agency-provided Konotouri2, or H-II Transfer Vehicle (HTV2) departed the station on March 28. The 41st Russian Progress cargo craft is scheduled to undock on April 22. The European Space Agency-launched Johannes Kepler Automated Transfer Vehicle 2 (ATV2) is slated to depart on June 20. The 43rd Russian Progress cargo craft is scheduled to undock on Aug. 29. All four will be commanded to make fiery re-entries that destroy the spacecraft and the refuse inside as they fall back to Earth.

Before Johannes Kepler departs, its thrusters and propellant will be used to boost the space station to its normal planned altitude of 248 miles, or 400 kilometers. The main reason for increasing the standard orbit from 220 statute miles, or about 350 kilometers, is to cut the amount of fuel needed to keep it there by more than half.

Even though the space station orbits in what most people on Earth would consider to be the “vacuum of space,” there are still enough atmospheric molecules contacting the station’s surfaces to change its speed, or velocity. The station is so large (as big as a football field with the end zones included) that the cumulative effect of these tiny contacts reduces its speed and causes a minute but continuous lowering of its altitude, or height above the Earth. To fight this tendency, thrusters on the space station or visiting vehicles such as the space shuttle, Progress resupply vehicles, or ATVs, are fired periodically to “reboost” the station. These reboosts, however, come at the cost of propellant, that must be launched from Earth at significant cost. Raising the space station’s altitude means that visiting vehicles will not be able to carry as much cargo as they could if they were launching to the station at a lower altitude, but it also means that not as much of that cargo needs to be propellant.

NASA astronaut Mike Fossum (right foreground), Expedition 28 flight engineer and Expedition 29 commander; Japan Aerospace Exploration Agency (JAXA) astronaut Satoshi Furukawa (center foreground), Expedition 28/29 flight engineer; NASA astronaut Ron Garan (left background), Expedition 27/28 flight engineer; and NASA astronaut Chris Ferguson (right background), STS-135 commander, participate in a training session in an ISS mock-up/trainer in the Space Vehicle Mock-up Facility at NASA’s Johnson Space Center. Fossum and Garan are attired in training versions of the Extravehicular Mobility Unit (EMU) spacesuit. Photo credit: NASA

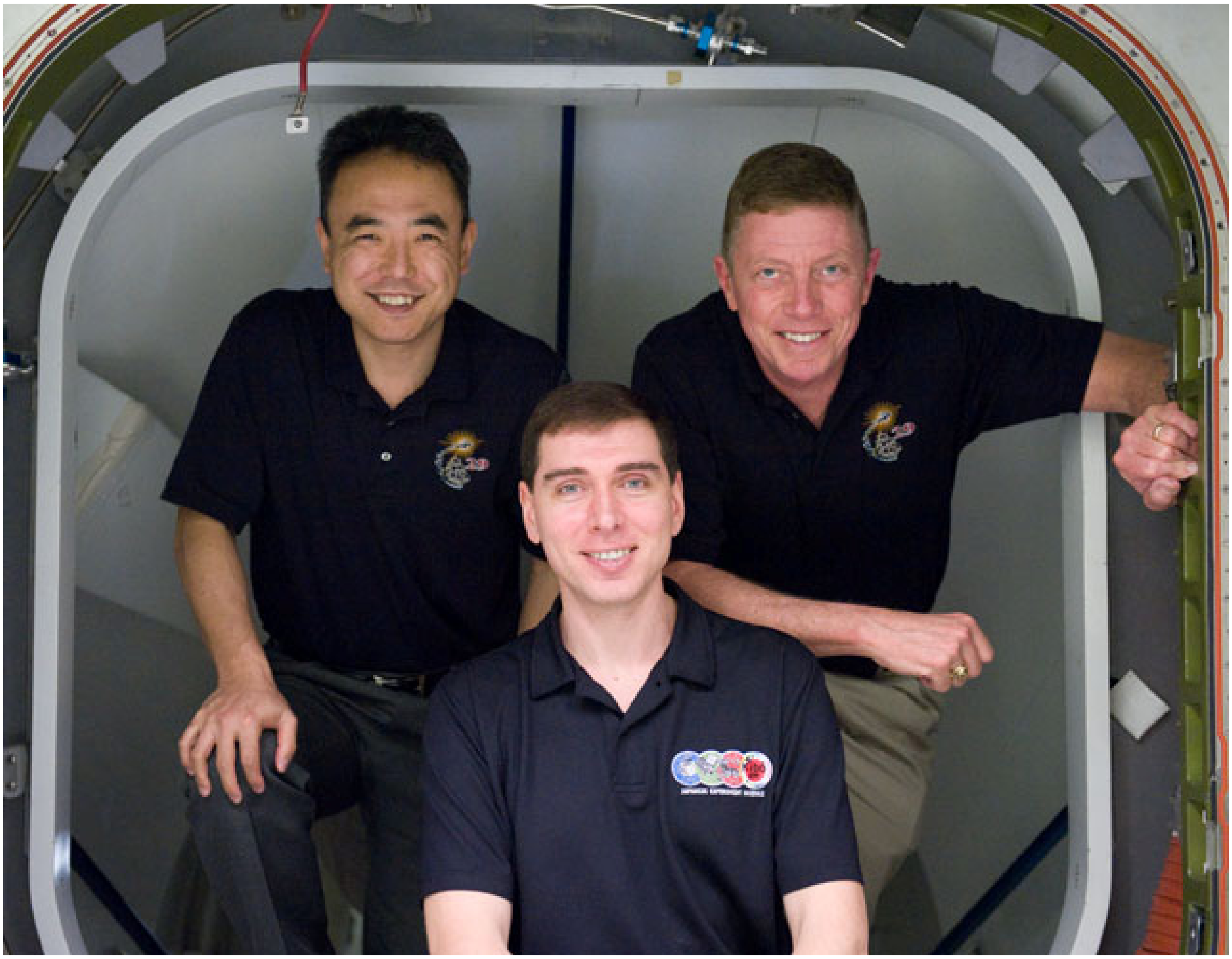
At its current altitude, the space station uses about 19,000 pounds (8.6 kilograms of propellant a year to maintain a consistent orbit. At the new, slightly higher altitude, the station is expected to expend about 8,000 pounds (3.6 kilograms) of propellant a year. And that will translate to a significant amount of food, water, clothing, research instruments and samples, and spare parts that can be flown on the cargo vehicles that will keep the station operational until 2020 and beyond.

Another important task for the new crew will be to install infrastructure upgrades to the station's command and control computers and its communications systems. The year-long upgrade process started during Expedition 26. Upgrading the computers and communications network will double the speed of data that can be transferred to and from the station, and add two additional video and two additional audio channels. The upgrades will help transmit scientific experiment data to researchers through control centers around the world, and help share the crew's activities with the public. The goal is to increase the high-speed downlink levels from 150 to 300 megabits a second, which will allow the station to almost continually downlink telemetry data on all of its systems. The upgrade also will standardize the video system at high-definition television quality levels.

Endeavour's final mission, STS-134/ULF6, also known as Utilization and Logistics Flight 6, is scheduled to launch April 29, and will deliver the Alpha Magnetic Spectrometer (AMS). The AMS will be mounted to the station's truss structure where it will use the power generated by the station's solar arrays to support observations of cosmic rays. Looking at various types of unusual matter found in the universe will allow AMS researchers to study the formation of the universe and search for evidence of dark matter and antimatter.

In addition, STS-134 will deliver ExPRESS Logistics Carrier 3 (ELC-3), which will hold a variety of spare parts. The STS-134 mission will include four spacewalks to lubricate the port Solar Alpha Rotary Joints (SARJs) that allow the station's solar arrays to track the sun as they generate electricity, install ammonia jumper hoses for the station's cooling system, stow the Orbiter Boom Sensor System outside the station for future use as an inspection tool, and retrieve a set of materials exposure experiments for return to Earth.

The final flight of the space shuttle fleet, STS-135/ULF7, is scheduled to launch June 28, and dock to the station three days later. Also known as Utilization and Logistics Flight 7, Atlantis' last mission will carry the Raffaello Multi-Purpose Logistics Module to deliver supplies, logistics and spare parts to the station. The four-person shuttle crew also will fly a system to investigate the potential for remote-controlled robot refueling of satellites and spacecraft in orbit and return a failed ammonia pump module to help NASA better understand the failure mechanism and improve pump designs for future systems.



NASA astronaut Mike Fossum (right), Expedition 28 flight engineer and Expedition 29 commander; along with Russian cosmonaut Sergei Volkov (center) and Japan Aerospace Exploration Agency (JAXA) astronaut Satoshi Furukawa, both Expedition 28/29 flight engineers, pose for a photo during a docking timeline simulation training session in the Space Vehicle Mock-up Facility at NASA's Johnson Space Center. Photo credit: NASA

Two Progress resupply craft are scheduled to deliver about two tons of supplies, equipment, fuel and other consumables during the summer. Progress 42 is scheduled to launch from the Baikonur Cosmodrome on April 27 and dock with the station’s Pirs port two days later, and Progress 43 is scheduled to launch from Kazakhstan on June 21, and dock on June 23 to the aft port of Zvezda, which will be vacated by ATV2. Progress 43’s stay is expected to be relatively brief, with Progress 44 scheduled to launch Aug. 30 and dock to the same Zvezda port on Sept. 1.

One flight of the new commercial resupply vehicles, named Dragon, designed and tested for station support by Space Exploration Technologies Corp. (SpaceX), is scheduled to pass within a few miles of the station during the summer. The demonstration flight is part of NASA’s Commercial Crew and Cargo Program, which also involves future demonstration flights by Orbital Sciences Corp.’s Cygnus spacecraft. Once the test flights demonstrate the capabilities of the new commercial spacecraft, they will begin flying routine cargo missions to the station.

The six-person Expedition 27 crew will spend about two months together before Kondratyev, Coleman and Nespoli climb into their Soyuz, undock and head for a late May landing in Kazakhstan. That will leave Borisenko, Garan and Samokutayev as the sole occupants of the station for about two weeks as the first set of three crewmembers that make up Expedition 28. Borisenko will become the Expedition 28 commander when Kondratyev departs. The rest of the Expedition 28 crew – NASA’s Mike Fossum, JAXA’s Satoshi Furukawa and Russia’s Sergei Volkov – arrive approximately two weeks after Kondratyev, Coleman and Nespoli depart. They are scheduled to launch June 7 aboard the Soyuz TMA-02M spacecraft from Baikonur and be a part of the six-person crew for the rest of the summer until Borisenko, Garan and Samokutayev depart on Sept. 16. Fossum will become Expedition 29 commander when Borisenko leaves for home.

Attired in Russian Sokol launch and entry suits, Russian cosmonaut Andrey Borisenko (right), Expedition 27 flight engineer and Expedition 28 commander; along with Russian cosmonaut Alexander Samokutyaev (center) and NASA astronaut Ron Garan, both Expedition 27/28 flight engineers, take a break from training in Star City, Russia to pose for a portrait. Photo credit: Gagarin Cosmonaut Training Center

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Expedition 27/28 Crew

Expedition 27

Expedition 27 Patch

The Expedition 27 patch depicts the International Space Station prominently orbiting Earth, continuing its mission for science, technology and education. The space station is an ever-present reminder of the cooperation between the United States, Russia, Japan, Canada and the European Space Agency – and of the scientific, technical and cultural achievements that have resulted from that unique teamwork. The station is shown in its completed status with the latest addition of the Alpha Magnetic Spectrometer and with two resupply vehicles docked at each end of the station. The Southern Cross Constellation is also shown in the foreground and its five stars, along with the sun, symbolize the six international crew members who live and work on the space station. The Southern Cross is one of the smallest modern constellations, and also one of the most distinctive. It has cultural significance all over the world and inspires teams to push the boundaries of their worlds, both in space and on the ground.

Expedition 27 crew members take a break from training at NASA's Johnson Space Center to pose for a crew portrait. Pictured from the right are Russian cosmonaut Dmitry Kondratyev, commander; Russian cosmonaut Andrey Borisenko; NASA astronaut Catherine Coleman; Russian cosmonaut Alexander Samokutyaev; European Space Agency (ESA) astronaut Paolo Nespoli; and NASA astronaut Ron Garan, all flight engineers. Photo credit: NASA

Expedition 28

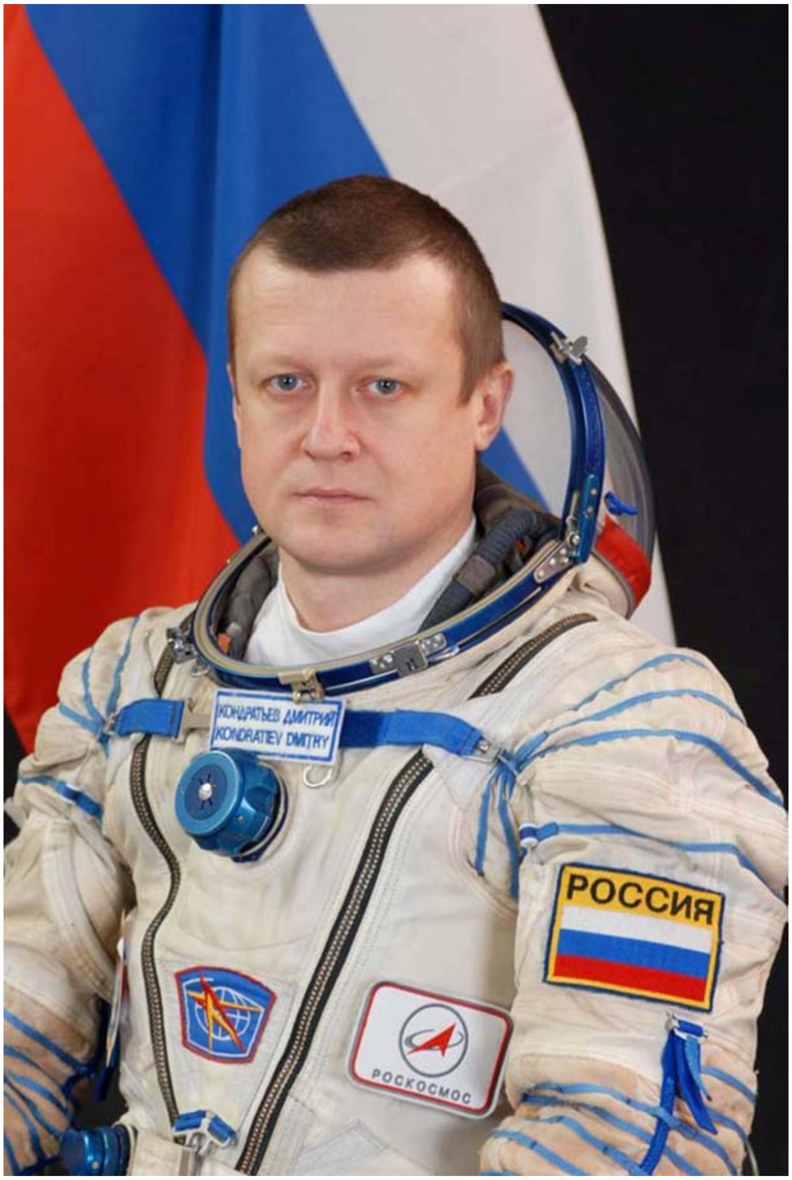
Expedition 28 Patch

In the foreground of the Expedition 28 patch, the International Space Station is prominently displayed to acknowledge the efforts of the entire International Space Station team – both the crews who have assembled and operated it, and the team of scientists, engineers and support personnel on Earth who have provided a foundation for each successful mission. Their efforts and accomplishments have demonstrated the space station's capabilities as a technology test bed and a science laboratory, as well as a path to the human exploration of our solar system and beyond. This Expedition 28 patch represents the teamwork among the international partners – USA, Russia, Japan, Canada and the ESA – and the ongoing commitment from each partner to build, improve and use the space station. Prominently displayed in the background is our home planet, Earth – the focus of much of our exploration and research on our outpost in space. Also prominently displayed in the background is the moon. The moon is included in the design to stress the importance of our planet's closest neighbor to the future of our world. Expedition 28 is scheduled to occur during the timeframe of the 50th anniversary of both the first human in space, Russian cosmonaut Yuri Gagarin, and the first American in space, astronaut Alan Shepard. To acknowledge the significant milestone of 50 years of human spaceflight, the names "Гагарин" and "Shepard" as well as "50 Years" are included in the patch design.

Expedition 28 crew members take a break from training at NASA's Johnson Space Center to pose for a crew portrait. Pictured from the right (front row) are Russian cosmonaut Andrey Borisenko, commander; Russian cosmonaut Alexander Samokutyaev and NASA astronaut Mike Fossum, both flight engineers. Pictured from the left (back row) are Japan Aerospace Exploration Agency (JAXA) astronaut Satoshi Furukawa, NASA astronaut Ron Garan and Russian cosmonaut Sergei Volkov, all flight engineers. Photo credit: NASA

Short biographical sketches of the crew follow with detailed background available at the following Web site: http://www.jsc.nasa.gov/Bios/

Expedition 27



Dmitry Kondratyev

Dmitry Kondratyev, 41, will serve as the Soyuz commander for the December Soyuz launch and landing in May. He will join the Expedition 26 crew as a flight engineer and then transition to Expedition 27 as the crew commander. Kondratyev was selected as a test-cosmonaut candidate of the Gagarin Cosmonaut Training Center Cosmonaut Office in December 1997. He trained as a backup crew member for Expedition 5 and Expedition 20. He also served as the Russian Space Agency director of operations stationed at the Johnson Space Center from May 2006 through April 2007.

Cady Coleman

This is the third spaceflight mission for NASA astronaut Cady Coleman, 49, a retired U.S. Air Force colonel. Coleman and her crewmates launched to the space station on Dec. 13, 2010. She will serve as a flight engineer for both Expedition 26 and Expedition 27. Coleman has logged more than 500 hours in space. She was a mission specialist on STS-73 in 1995 and STS-93 in 1999, a mission which deployed the Chandra X-Ray Observatory. She also served as the backup U.S. crew member for Expeditions 19, 20 and 21.

Páolo Néspoli

European Space Agency astronaut Páolo Néspoli, 53, will serve as a flight engineer for Expedition 26 and 27, his second spaceflight mission. Néspoli was selected as an astronaut by the Italian space agency in July 1998 and one month later joined ESA’s European astronaut corps. He flew as a mission specialist on STS-120 in October 2007. During the mission, which delivered the Italian-built Node 2 Harmony to the space station, Néspoli accumulated more than 15 days of spaceflight experience.

Expedition 28

Alexander Samokutyaev

Alexander Samokutyaev, 41, flight engineer for Expeditions 27 and 28, is on his first mission. Before becoming a cosmonaut, Samokutyaev flew as a pilot, senior pilot and deputy commander of air squadron. Samokutyaev has logged 680 hours of flight time and performed 250 parachute jumps. He is a Class 3 Air Force pilot and a qualified diver. Since December 2008, he has trained as an International Space Station 23/24 backup crew member, Soyuz commander and 24 flight engineer.

Andrey Borisenko

This will be the first spaceflight for Andrey Borisenko, 46. After graduating from the Leningrad Physics and Mathematics School No. 30 and working in a military unit, Borisenko started his career at RSC Energia in 1989 where he was responsible for the Mir motion control system and took part in the MCC-M onboard systems operation analysis board. Borisenko was a shift flight director at the MCC-M starting in 1999, first for the Mir space station and then for the International Space Station.

Borisenko will serve as a flight engineer on Expedition 27 and commander on Expedition 28.

Ron Garan Jr.

Ron Garan, 49, will be embarking on the second mission of his NASA career. Garan completed his first spaceflight in 2008 on STS-124 as mission specialist 2 (flight engineer for ascent and entry) and has logged more than 13 days in space and 20 hours and 32 minutes of extravehicular activity in three spacewalks. Garan is a retired colonel in the U.S. Air Force and has degrees from the SUNY College at Oneonta, Embry-Riddle Aeronautical University and the University of Florida.

Sergei Volkov

Volkov, 38, a colonel in the Russian Air Force, was selected as a test-cosmonaut candidate of the Gagarin Cosmonaut Training Center Cosmonaut Office in December 1997. Volkov's first spaceflight was the Soyuz 12 as commander and International Space Station commander where he logged 12 hours, 15 minutes of extravehicular activity time in two spacewalks and 199 days in space. He will be serving as a flight engineer in Expedition 28 on Soyuz 27.

Mike Fossum

Fossum, 53, a colonel in the USAF, was selected as an astronaut in June 1998. Before Fossum was selected, he served as a flight test engineer on the X-38, a prototype crew escape vehicle for the new space station, and supported the Astronaut Office as a technical assistant for the space shuttle. Fossum is now a veteran of two spaceflights, STS-121 in 2006 and STS-124 in 2008. On those two flights Fossum logged more than 636 hours in space, including more than 42 hours in six spacewalks. He has been assigned to a six-month stay on the space station, serving as flight engineer on Expedition 28 and commander on Expedition 29.

Satoshi Furukawa

Furukawa, 47, will be serving his first spaceflight as a crew member on Expedition 28 in Soyuz 27 to the International Space Station. In 1999, Furukawa was selected by the National Space Development Agency of Japan (NASDA) as one of three Japanese astronaut candidates for the International Space Station. He was certified as an astronaut in January 2001. Since 2001, Furukawa has been participating in space station advanced training, as well as supporting the development of the hardware and operation of the Japanese Experiment Module "Kibo."

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EXPEDITION 27 AND 28 MILESTONES

April 26	41 Progress undocks from the Pirs docking compartment 1
April 27	42 Progress launches from the Baikonur Cosmodrome, Kazakhstan
April 29	42 Progress docks to the Pirs docking compartment 1
May 5	50th anniversary of the first American human spaceflight, Freedom 7, by astronaut Alan Shepard
May 15	Expedition 28 begins when 25 Soyuz/TMA-20 undocks from the Rassvet mini research module 1 and then lands (May 16 Kazakhstan time)
May 23	Expedition 27 undocking from Rassvet Module/MRM1; Soyuz TMA-20/ 25 Soyuz (Kondratyev, Coleman, Nespoli) (6:06 pm CT, 3:06 a.m. Moscow time on May 24)
May 23	Expedition 27 Landing; Soyuz TMA-20 / 25 Soyuz (Kondratyev, Coleman, Nespoli) (8:37 p.m. CT, 5:37 a.m. Moscow time on May 24)
June 1	27 Soyuz/TMA-02M docks to the Rassvet Mini Research Module 1
June 7	Expedition 28 Launch; 27 Soyuz/TMA-02M launches from the Baikonur Cosmodrome, Kazakhstan
June 9	Expedition 28 Docking to Rassvet Module (3:59 p.m. CT)
June 20	The European Johannes Kepler Automated Transfer Vehicle (ATV2) undocks from the aft of the Zvezda service module
June 21	43 Progress launches from the Baikonur Cosmodrome, Kazakhstan
June 23	43 Progress docks to the aft of the Zvezda service module
July 26	Russian spacewalk No. 29
Aug. 29	43 Progress undocks from the aft of the Zvezda service module
Aug. 30	44 Progress launches from the Baikonur Cosmodrome, Kazakhstan
Sept. 1	44 Progress docks to the aft of the Zvezda service module
Sept. 16	Expedition 29 begins when 26 Soyuz/TMA-21 undocks from the Poisk MRM 2 and then lands

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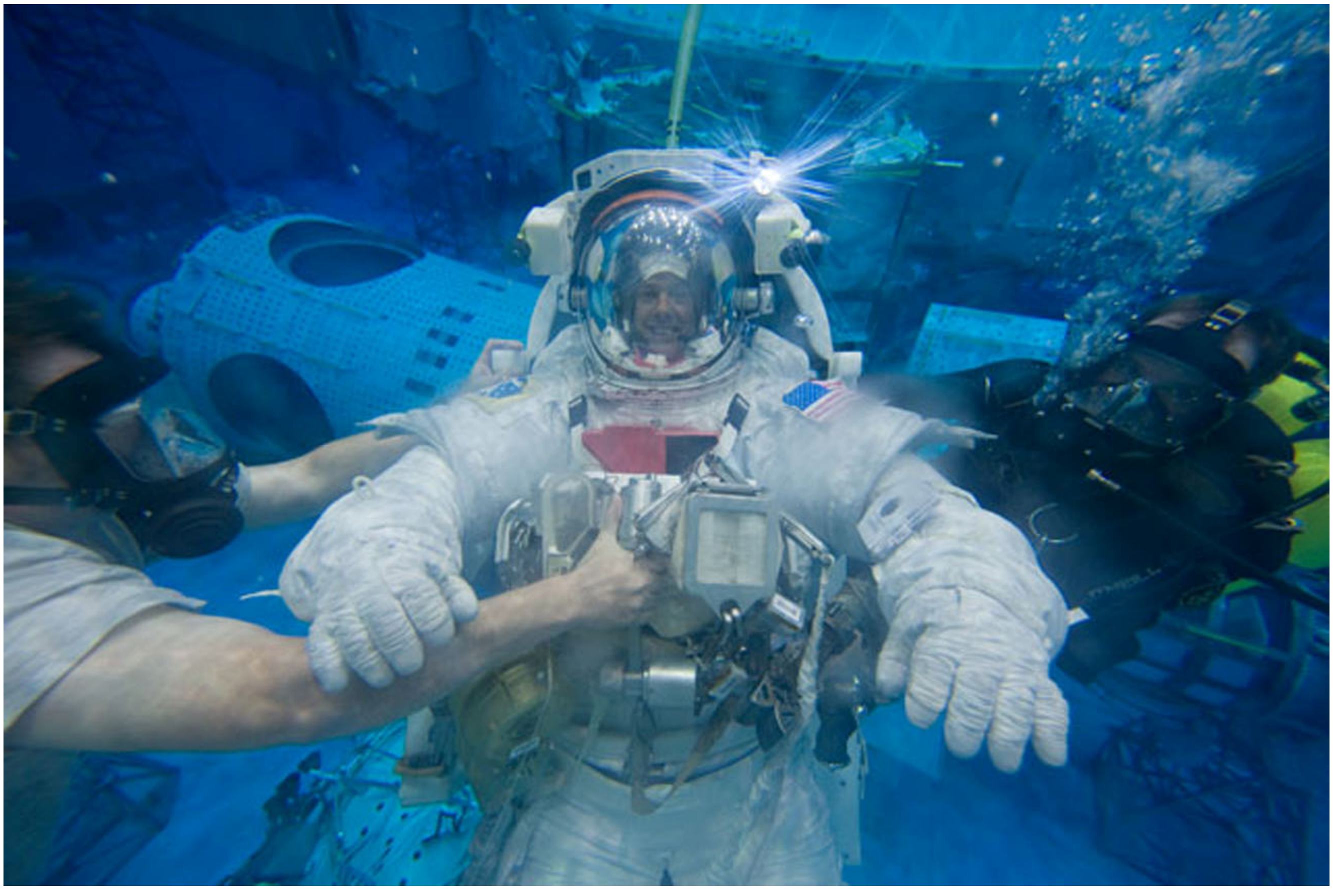
Expedition 27/28 Spacewalks



Attired in a training version of his Extravehicular Mobility Unit (EMU) spacesuit, NASA astronaut Ron Garan, Expedition 27/28 flight engineer, participates in a spacewalk training session in the waters of the Neutral Buoyancy Laboratory (NBL) near NASA's Johnson Space Center. Divers are in the water to assist Garan in his rehearsal, which is intended to help prepare him for work on the exterior of the International Space Station. Photo credit: NASA

There are no U.S.-based spacewalks currently scheduled for Expedition 27 or 28, though Flight Engineers Ron Garan and Mike Fossum will perform one during the STS-135 mission. However, Flight Engineer Sergi Volkov and Commander Andrey Borisienko will don Russian Orlan spacesuits for the station's 29th Russian spacewalk. Volkov has 12 hours and 15 minutes of spacewalk experience from the two spacewalks he performed on Expedition 17 in 2008. Borisienko will perform his first spacewalk.

Spacewalks 29 is currently planned for July, though the date is subject to change.

The focus of the spacewalk – Russian spacewalk 29 – will be the relocation of one of the two Russian Strela cargo booms from the Pirs docking compartment to the Poisk mini research module, in preparation for the deorbiting of the Pirs in late 2012.

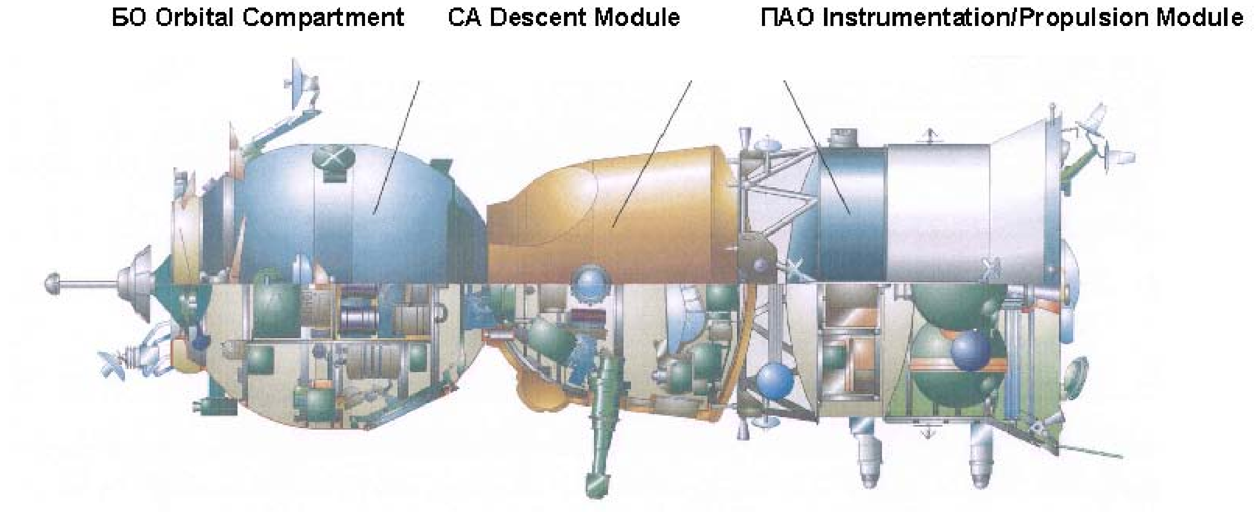
Another task on the spacewalkers' agenda will be the installation of an onboard laser communications terminal on the Zvezda service module. This terminal will transmit information from the space station to the ground using optical communication channel assets. They will also install a platform with three Biorisk experiment containers onto the Pirs docking compartment. Biorisk studies the effect of the space environment on various biological materials during long-term exposure, particularly the way organisms like bacteria and fungi might adapt or change.

In addition to all this, the cosmonauts will deploy an experiment called ARISSat-1, or Radioskaf-V, a 57-pound nanosatellite that houses congratulatory messages commemorating the 50th anniversary in April 2011 of Yuri Gagarin's launch to become the first human in space.

The ham radio transmitter will enable communications with amateur radio operators around the world for three to six months. It is one of a series of educational satellites being developed in a partnership with the Radio Amateur Satellite Corp.; the NASA Office of Education International Space Station National Lab Project; the Amateur Radio on the International Space Station working group; and RSC-Energia.

NASA astronaut Mike Fossum, Expedition 28 flight engineer and Expedition 29 commander, attired in a training version of the Extravehicular Mobility Unit (EMU) spacesuit, awaits the start of a spacewalk training session in the waters of the Neutral Buoyancy Laboratory (NBL) near NASA's Johnson Space Center.
Photo credit: NASA

Russian Soyuz



The Soyuz-TMA spacecraft is designed to serve as the International Space 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 the 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 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, Moscow, 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

A Soyuz TMA spacecraft launches from the Baikonur Cosmodrome in Kazakhstan on Oct. 12, 2008 carrying a new crew 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 at three hours before the liftoff time.

Rendezvous to Docking

A Soyuz spacecraft generally takes two days 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

Prelaunch Countdown Timeline (concluded)

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
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

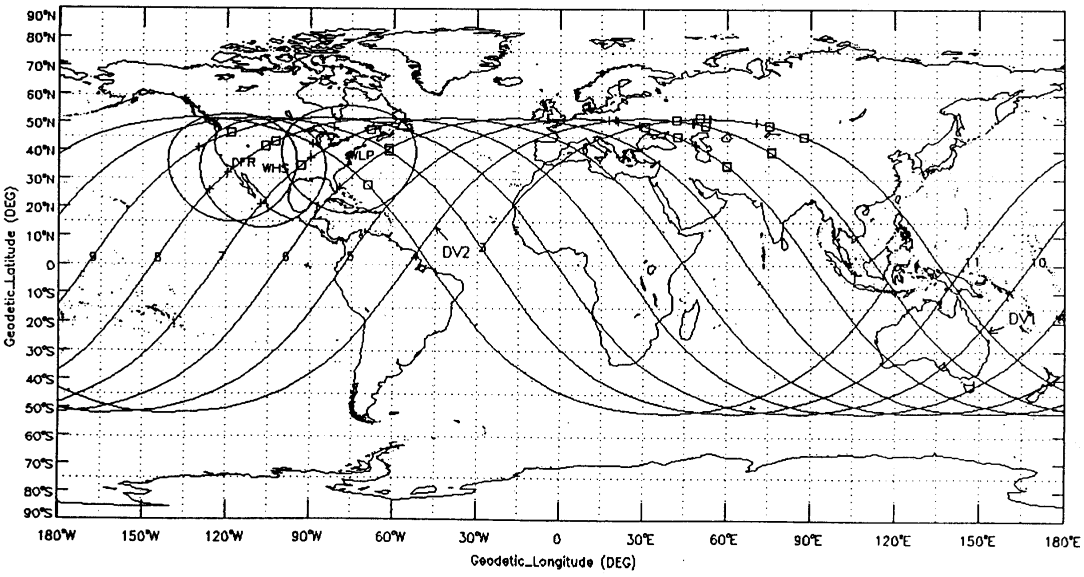
FLIGHT DAY 1 OVERVIEW	
Orbit 1	**Post insertion: Deployment of solar panels, antennas and docking probe**
	- Crew monitors all deployments
	- Crew reports on pressurization of OMS/RCS and ECLSS systems and crew health. Entry thermal sensors are manually deactivated
	- Ground provides initial orbital 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

FLIGHT DAY 1 OVERVIEW (CONTINUED)	
Orbit 4 (continued)	**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
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

FLIGHT DAY 2 OVERVIEW (CONTINUED)	
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
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

FLIGHT DAY 3 AUTO RENDEZVOUS SEQUENCE (CONCLUDED)	
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
	- 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-18 spacecraft is seen as it lands with Expedition 24 commander Alexander Skvortsov and flight engineers Tracy Caldwell Dyson and Mikhail Kornienko near the town of Arkalyk, Kazakhstan on Sept. 25, 2010. Photo Credit: NASA/Bill Ingalls

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, the Soyuz commander will conduct a separation maneuver, 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.

Expedition 27/28 Science Overview

NASA astronaut Mike Fossum (left background), Expedition 28 flight engineer and Expedition 29 commander; along with Russian cosmonaut Sergei Volkov (right background) and Japan Aerospace Exploration Agency (JAXA) astronaut Satoshi Furukawa (left foreground), both Expedition 28/29 flight engineers, participate in a docking timeline simulation training session in the Space Vehicle Mock-up Facility at NASA's Johnson Space Center. A crew instructor assisted the crew members. Photo credit: NASA

Expedition 27 and 28 will take advantage of a bonus storage and science facility, the final new experiment rack and the first human-like robot ever to move its head and stretch its arms in microgravity. These research and technology development activities will continue the transition of the International Space Station from construction site to full-time laboratory, putting the potential of space to work for the people of Earth.

The Expedition 27 and 28 crews will work with 111 experiments involving approximately 200 researchers across a variety of fields, including human life sciences, physical sciences and Earth observation, and conduct technology demonstrations ranging from recycling to robotics. Seventy-three of these experiments are sponsored by NASA, including 22 under the auspices of the U.S. National Laboratory program, and 38 are sponsored by international partners. More than 540 hours of research are planned. As with prior expeditions, many experiments 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 systems with plan for future exploration missions.

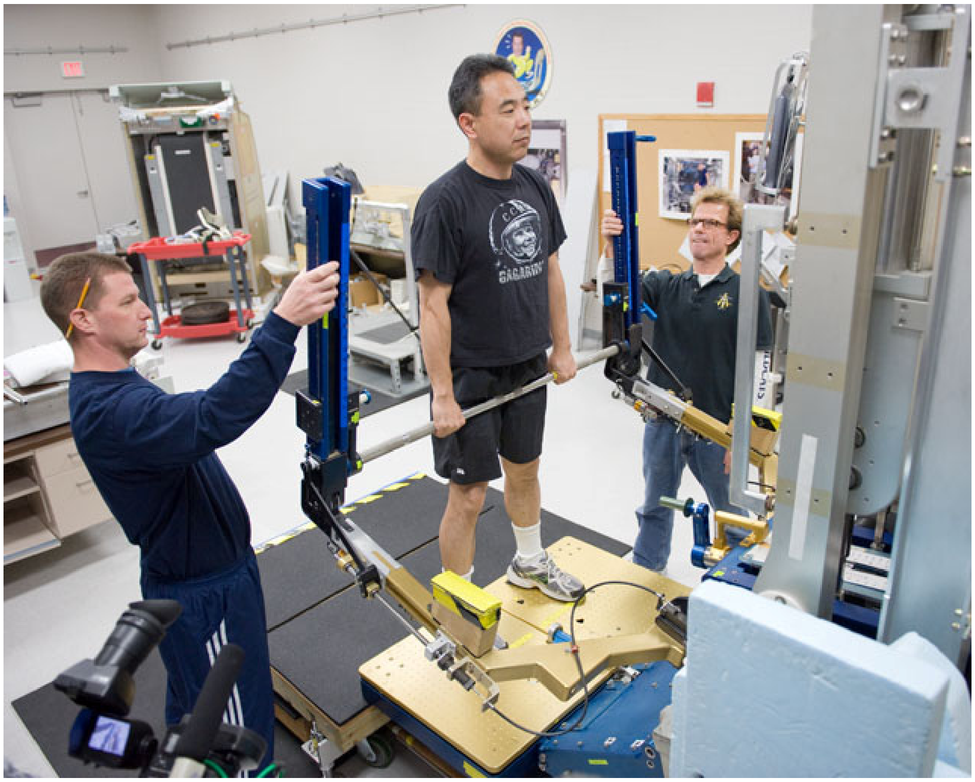
An important new instrument, the Alpha Magnetic Spectrometer (AMS-02), will be delivered to the station by the space shuttle Endeavour on the STS-134 mission. AMS-02 is a state-of-the-art particle physics detector constructed, tested and operated by an international team composed of 60 institutes from 16 countries and organized under the United States Department of Energy (DOE) sponsorship. It will use 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.

Experimental evidence indicates that our galaxy is made of matter; however, there are more than 100 million galaxies in the universe and the Big Bang theory of the origin of the universe requires equal amounts of matter and antimatter. Theories that explain this apparent asymmetry violate other measurements. Whether or not there is significant antimatter is one of the fundamental questions of the origin and nature of the universe.

AMS-02 will operate on the space station's external truss structure for three years, gathering an immense amount of accurate data and allowing measurements of the long-term variation of the cosmic ray flux over a wide energy range, for nuclei from protons to ions. After the nominal mission, AMS-02 may continue to provide cosmic ray measurements that will help researchers understand what radiation protection is needed for human interplanetary flight.

The arrival of the Permanent Multipurpose Facility, an Italian-built converted pressurized cargo carrier named Leonardo, has added 2,700 cubic feet of pressurized volume to the orbiting laboratory, increasing the total habitable volume of the station to 13,846 cubic feet.

Robonaut 2 will be installed in the U.S. Destiny Laboratory, providing scientists and engineers on the ground and crews on the station an opportunity to test how humans and human-like robots can work shoulder to shoulder in microgravity. Once this has been demonstrated inside the station, software upgrades and lower bodies can be added, potentially allowing Robonaut 2 to move around inside the station and eventually work outside in the vacuum of space. This will help NASA understand robotic capabilities for future deep space missions.



Japan Aerospace Exploration Agency (JAXA) astronaut Satoshi Furukawa, Expedition 28/29 flight engineer, participates in an advanced Resistive Exercise Device (aRED) training session in the Center for Human Spaceflight Performance and Research at NASA's Johnson Space Center. Crew instructors Robert Tweedy (right) and Bruce Nieschwitz assisted Furukawa. Photo credit: NASA

Three science facilities recently delivered or activated on the station will be used in a variety of investigations: the Boiling Experiment Facility (BXF) is supporting microgravity experiments on the heat transfer and vapor removal processes in boiling. The eighth Expedite the Processing of Experiments to Space Station (ExPRESS) rack was delivered and installed on the STS-133 space shuttle mission and is being activated to support a variety of experiments in the Destiny Laboratory module. The Light Microscopy Module (LMM) is undergoing initial testing as a device to examine samples from experiments without requiring that they be returned to Earth, experiencing the effects of re-entry from orbit. The microscope is isolated from vibrations on the station, allowing it to obtain clear, high-resolution images of microorganisms and individual cells of plants and animals, including humans. The biological samples for the LMM were launched on space shuttle Discovery's STS-133 mission, and included eight fixed slides containing yeast; bacteria; a leaf; a fly; a butterfly wing; tissue sections and blood; six containers of live C. elegans worms, an organism biologists commonly study; a typed letter "r" and a piece of fluorescent plastic. Some of the worms are descendants of those that survived the space shuttle Columbia (STS-107) accident; and others are modified to fluoresce.

A Japanese experiment will continue to look at one factor in the way fluid moves, called Marangoni convection. This type of convection is manifested on Earth in the way that “legs” or “tears of wine” form on the inside of a glass. This ring of clear liquid that forms near the top of a glass above the surface of wine, then forms rivulets that fall back into the liquid, illustrates the tendency for heat and mass to travel to areas of higher surface tension within a liquid. To study how heat and mass move within a fluid in microgravity, investigators are using a larger bridge of silicone oil between two discs. In microgravity on the space station, warm air does not rise and cold air does not sink, which allows investigators to heat one disc more than the other to induce Marangoni convection in that bridge of silicone oil to learn more about how heat is transferred in microgravity.

A suite of European Space Agency experiments will look at other convection processes large and small, using aluminum alloys, a standard cast metal used in a number of automotive and transportation applications. The Materials Science Laboratory – Columnar-to-Equiaxed Transition in Solidification Processing (CETSOL) and Microstructure Formation in Casting of Technical Alloys under Diffusive and Magnetically Controlled Convective Conditions (MICAST) are two investigations that will examine different growth patterns and evolution of microstructures during crystallization of metallic alloys in microgravity. CETSOL will give industry confidence in the reliability of the numerical tools used in casting, while MICAST will study microstructure formation during casting under diffusive and magnetically controlled convective conditions, and the Solidification along a Eutectic path in Ternary Alloys (SETA) experiment will look into a specific type of growth in alloys of aluminum manganese and silicon.

Another interesting investigation is the Shape Memory Foam experiment, which will evaluate the recovery of shape memory epoxy foam in microgravity. The investigation will study the shape memory properties needed to manufacture a new-concept actuator that can transform energy to other forms of energy.

As with prior expeditions, many experiments 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 systems while planning for future exploration missions.

The investigations cover human research; biological and physical sciences; technology development; Earth observation, and education. In the past, assembly and maintenance activities have dominated the available time for crew work. But, as completion of the orbiting laboratory nears, additional facilities and the crew members to operate them are enabling a measured increase in time devoted to research as a national and multi-national laboratory.

NASA astronaut Mike Fossum (left), Expedition 28 flight engineer and Expedition 29 commander; along with Russian cosmonaut Sergei Volkov (center) and Japan Aerospace Exploration Agency (JAXA) astronaut Satoshi Furukawa, both Expedition 28/29 flight engineers, participate in a docking timeline simulation training session in the Space Vehicle Mock-up Facility at NASA's Johnson Space Center. Photo credit: NASA

Also on tap in the area of technology demonstration is the resumption of work with a recycling device known as Sabatier, designed to help wring additional water from excess hydrogen not yet being reclaimed by the station's water recovery system.

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 space shuttles or other 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 27/28 experiments and payload operations, visit the following Web site:

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

Research Experiments

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
HYPERSOLE	Cutaneous Hypersensitivity and Balance Control in Humans	CSA	Human Research and Counter-measures Development	HYPERSOLE will determine the change in skin sensitivity post spaceflight for the application to balance control, specifically changes in skin sensitivity of the sole of the foot and which receptors may be influenced following a period of non-loading	Leah R. Bent, Ph.D., University of Guelph, Guelph, Ontario, Canada	Pre and Post-flight (Shuttle)	None
VASCULAR	Health consequences of Long-Duration 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 and will link this with functional and health consequences that parallel changes that occur with the aging process	Richard Lee Hughson, Ph.D., University of Waterloo, Waterloo, Ontario, Canada	ISS	Columbus
3D SPACE	Mental Representation of Spatial Cues During Spaceflight	ESA	Human Research and Counter-measures Development	3D Space involves comparison of pre-flight, flight and post-flight perceptions and mental imagery with special reference to spaceflight-related decreases in vertical percepts	France: G. Clement USA: C. E. Lathan	ISS	Columbus
ALTEA-SHIELD	Anomalous Long-Term Effects in Astronauts – Radiation Shielding	ESA	Radiation Dosimetry	ALTEA-SHIELD aims at obtaining a better under-standing of the light flash phenomenon, and more generally the interaction between cosmic rays and brain function, as well as testing different types of shielding material	Italy: L. Narici, F. Ballarini, G. Battistoni, M. Casolini, A. Ottolenghi, P. Picozza, W. Sannita, S. Villari USA: E. Benton, J. Miller, M. Shavers	ISS	Destiny
Batch-2A CETSOL-2	Columnar-to-Equiaxed Transition in Solidification Processing	ESA	Physical Sciences in Microgravity	CETSOL-2 carries out research into 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 Batch-2A MICAST-2 and SETA-2)	France: A Gandin, B. Billia, Y. Fautrelle Germany: G. Zimmerman Ireland: D. Browne USA: D. Poirier	ISS	Destiny
Batch-2A MICAST-2	Microstructure Formation in Casting of Technical Alloys Under Diffusive and Magnetically Controlled Convective Conditions	ESA	Physical Sciences in Microgravity	MICAST carries out research into the formation of microstructures during the solidification of metallic alloys under diffusive and magnetically controlled convective conditions. (See also Batch-2A CETSOL-2 and SETA-2)	Germany: L. Ratke, G. Mueller, G. Zimmerman France: Y. Fautrelle, J. Lacaze Hungary: A. Roosz Canada: S. Dost USA: D. Poirier	ISS	Destiny
Batch-2A SETA-2	Solidification Along an Eutectic Path in Ternary Alloys	ESA	Physical Sciences in Microgravity	Dedicated to the study of a particular type of eutectic growth namely symbiotic growth in hypoeutectic metallic alloys. (See also Batch-2A CETSOL-2 and MICAST-2)	Germany: S. Rex, U. Hecht, L. Ratke France: G. Faivre Belgium: L. Froyen	ISS	Destiny

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
CARD	CARD	ESA	Human Research and Counter-measures Development	The main aims of CARD are to understand how weightlessness affects the regulation of blood pressure and establish how some hormones responsible for regulating the cardiovascular system are affected by long-term exposure to weightlessness	Switzerland: A. Ferrari; Germany: H. Iwase, D. Schardt; Japan: T. Sato; Sweden: L. Sihver	ISS	Columbus
CARD - (Sympatho)	Sympatho-adrenal activity in humans during spaceflight	ESA	Human Research and Counter-measures Development	SYMPATHO, which forms part of the CARD experiment is an ongoing study of adrenal activity of the sympathetic nervous system in weightlessness	Denmark: N.J. Christensen, P. Norsk	ISS	Merged protocol with CARD
CFS-A	Coloured Fungi in Space (Part A)	ESA	Biological Sciences in Microgravity	CFS-A will undertake an examination of the survival and growth of different coloured fungi species, which can be relevant to spacecraft contamination, panspermia and planetary protection issues	Romania: D. Hasegan, O. Maris, G. Mogildea, M. Mogildea	Sortie. Shuttle/ ISS	Columbus
DOBIES	Dosimetry for Biological Experiments in Space	ESA	Radiation Dosimetry	The objective of DOBIES is to develop a standard dosimetric method to measure absorbed and equivalent doses for biological samples as a contribution to the continuing DOSIS experiment, as well as the EXPOSE-E and EXPOSE-R payloads that have finished on-orbit activities	Belgium: F. Vanhaever, et al	ISS	Columbus
DOSIS	Dose Distribution Inside the ISS	ESA	Radiation Dosimetry	DOSIS maps the actual nature and distribution of the radiation field inside Columbus using different detectors placed around the European laboratory	Germany: G. Reitz et al.	ISS	Columbus
EDOS	Early Detection of Osteoporosis	ESA	Human Research and Counter-measures Development	This is a study into the mechanisms underlying the reduction in bone mass, which occurs in astronauts in weightlessness and will evaluate bone structure pre and post-flight	France: C .Alexandre, L. Braak, L. Vico Switzerland: P. Ruegsegger Germany: M. Heer	Pre/Post flight	Ground-based
EKE	Assessment of endurance capacity by gas exchange and heart rate kinetics during Physical Training	ESA	Human Research and Counter-measures Development	EKE will make an assessment of endurance capacity and heart rate kinetics during physical training of ISS Expedition crew members	Germany: U. Hoffman, S. Fasoulas, D. Essfeld, T. Drager	Pre/Post flight	Ground-based. Data sharing with NASA VO2max protocol
ERB-2	Erasmus Recording Binocular 2	ESA	Technology Demonstration	The ERB-2 is a high definition 3D stereoscopic video camera which will be used for taking footage inside the ISS to develop narrated video material for promotional and educational purposes	Netherlands: M. Sabbatini, ESA/ESTEC	ISS	Columbus
Geoflow-2	Geoflow-2	ESA	Physical Sciences in Microgravity	Geoflow-2 investigates the flow of an incompressible viscous fluid held between two concentric spheres rotating about a common axis as a representation of a planet. This is of importance for astrophysical and geophysical problems	Germany: Ch. Egbers France: P. Chossat	ISS	Columbus
IMMUNO	Neuroendo-crine and immune responses in humans during and after a long-term stay on the ISS	ESA	Human Research and Counter-measures Development	The aim of this experiment is to determine changes in hormone production and immune response during and after an ISS mission	Germany: A. Chouker, F. Christ, M. Thiel, I. Kaufmann, Russia: B. Morukov	ISS	Russian Segment

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
MARES	The Muscle Atrophy Research and Exercise System	ESA	Human Research and Countermeasures Development	MARES will carry out research on musculo-skeletal, bio-mechanical, and neuro-muscular human physiology. Results will provide a better understanding of the effects of microgravity on the muscular system and an evaluation of relevant countermeasures	Netherlands: J. Ngo-Anh, J. Castellsaguer, ESA/ ESTEC	ISS	Columbus
OTOLITH	Otolith assessment during post-flight re-adaptation	ESA	Human Research and Countermeasures Development	The otolith organs in the inner ear play an important role in our balance system as detectors of vertical and horizontal acceleration. This experiment will make an assessment of otolith function before and after short-term spaceflight	Germany: A Clarke USA: S. Wood	Pre and Post-flight (Shuttle)	Ground-based
PASSAGES	Scaling Body-related Actions in the Absence of Gravity	ESA	Human Research and Countermeasures Development	PASSAGES is designed to test how astronauts interpret visual information due to exposure to weightlessness with a focus on the possible decrease in use of the “Eye-Height” strategy	France: M. Luyat, J. McIntyre	ISS	Columbus
SOLAR	SOLAR	ESA	Solar Physics	In orbit since February 2008, the Solar facility consists of three instruments and continues to study the Sun’s irradiation with unprecedented accuracy across most of its spectral range	Germany: G. Schmidtke France: G. Thuillier Switzerland: C. Frohlich	ISS	Columbus
SOLO	Sodium Loading in Microgravity	ESA	Human Research and Countermeasures Development	SOLO is carrying out research into salt retention in space and related human physiology effects	Germany: P. Frings-Meuthen, M. Heer, N. Kamps, F. Baisch Denmark: P. Norsk	ISS	Columbus
SPIN	SPIN	ESA	Human Research and Countermeasures Development	SPIN is a comparison between pre-flight and post-flight testing of astronaut subjects using a centrifuge and a standardized tilt test to link orthostatic tolerance with otolith-ocular function	Belgium: F. Wuyts, N. Pattyn USA: S. Moore, B. Cohen, A. Diedrich Australia: H. MacDougall France: G. Clement	Pre/Post flight	Ground-based
THERMOLAB	Thermoregulation in humans during long-term spaceflight	ESA	Human Research and Countermeasures Development	THERMOLAB is looking into core temperature changes in astronauts performed before during and after exercise on the ISS to investigate thermoregulatory and cardiovascular adaptations during long-duration spaceflight	Germany: H.C. Gunga, K. Kirsch, E. Koralewski, J. Cornier, H.-V. Heyer, P. Hoffman, J. Koch, F. Sattler France: P. Arbeille	ISS	Destiny
Vessel ID System	Vessel ID System	ESA	Technology Demonstration	The Vessel ID System is demonstrating the space-based capability of identification of maritime vessels and also test the ability of an external grappling adaptor to accommodate small payloads	Norway: R.B. Olsen Luxembourg: G. Ruy	ISS	Columbus
Vessel Imaging	Vascular Echography	ESA	Human Research and Countermeasures Development	The main objective of Vessel Imaging is to evaluate the changes in the peripheral blood vessel wall properties (thickness and compliance) and cross sectional areas during long-term spaceflight	France: P. Arbeille	ISS	Columbus

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
ZAG	Z-axis Aligned Gravito-inertial force	ESA	Human Research and Counter-measures Development	This is an investigation into the effect weightlessness has on an astronaut's perception of motion and tilt and his level of performance before and immediately after spaceflight	France: G. Clement USA: S. Wood, D. Harm, A. Rupert	Pre and Post-flight (Shuttle)	Ground-based
2D Nanotemplate	2D Nanotemplate	JAXA	Applied Research	The 2D Nanotemplate will evaluate gravitational effects on a new nanomaterial quantitatively during its chemical reaction process. To prepare the two-dimensional template with nanoditches for electronic devices, it is prepared via an isothermal reaction upon mixing of peptides and alkali water. Microgravity is needed to prevent sedimentation and convective flow	Takatoshi Kinoshita, Nagoya Institute of Technology, Naokiyo Koshikawa, JAXA	ISS	US Lab
PADLES	Passive Dosimeter for Life Science Experiments in Space	JAXA	Human Spaceflight Technology Development	Area PADLES project surveys the space radiation environment inside Kibo using the PADLES analysis system and passive and integrating dosimeter developed by JAXA for measuring absorbed dose, LET distributions, and dose equivalents. Ultimate goals of this program are to support risk assessment and dose management for Japanese astronauts, and to update radiation assessment models for human spaceflight in the next generation. The 17 Area PADLES dosimeters have been installed in Kibo's Pressurized Module (PM) and Kibo's Experiment Logistics Module-Pressurized Section (ELM-PS). These are replaced in each expedition. This series of experiment has begun since Expedition 17	Keiji Murakami, Akiko Nagamatsu, JAXA	ISS	Kibo
BioRyhthsm	The effect of long-term microgravity exposure on cardiac autonomic function by analyzing 24-hours electrocardiogram	JAXA	Human Spaceflight Technology Development	ECG data of ISS crew members will be recorded continuously through 24-hour by a commercial Holter ECG recorder in this Biological Rhythms project. The recordings will be performed once in pre-flight time, three times in flight and once in post-flight. The data from the flight time will be downlinked to the ground after measurement. With these data, cardiovascular and autonomic functions are analyzed, and also be used to evaluate Biological Rhythm fluctuations and crew members' heart resting quality while they sleep on board the ISS. The results come from this experiment will be applied to improving health care technologies for the ISS crew	Chiaki MUKAI, Japan	ISS	Kibo
CsPINs	Dynamism of auxin efflux facilitators, CsPINs, responsible for gravity-regulated growth and development in cucumber	JAXA	Life Science	It has been hypothesized that an auxin efflux facilitator, CsPIN1, plays an important role in regulation of gravity-dependent auxin redistribution and controls gravimorphogenesis of cucumber (Cucmis sativus L.) seedlings. In addition, gravitropism interferes with hydrotropism in cucumber roots on the ground, in which CsPIN5 may play a role. In this space experiment, we will use cucumber seedlings to analyze the effect of gravity on the localization of CsPIN1 protein and unravel its contribution to peg formation. At the same time, we will differentiate hydrotropism from gravitropism in cucumber roots and investigate the localization of CsPIN5 protein to figure out the interacting mechanism between the two tropisms	Kazuyuki Wakabayashi, Osaka City University	ISS	Kibo

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
Marangoni EXP	Chaos, Turbulence and its Transition Process in Marangoni Convection	JAXA	Fluid Science	Marangoni EXP is an experiment of Marangoni convection led by Koichi Nishino of Yokohama National University, and performed using the Fluid Physics Experiment Facility (FPEF) in the RYUTAI rack in Kibo. Within a silicone oil liquid bridge formed into a pair of disks, convection is induced by imposing a temperature difference between the disks. The flow and temperature fields in each stage (e.g., steady, oscillatory, and chaotic flow) are observed using several visualization techniques to determine the transition process. The experimental data and images will be downlinked in real time and also recorded for detailed analysis. The cells for this experiment have been delivered to the ISS on the HTV-1 Mission	Koichi Nishino, Yokohama National University	ISS	Kibo
Evaluation of Onboard Diagnostic kit	Evaluation of Onboard Diagnostic kit	JAXA	Human Research	Onboard Diagnostic Kit is total telemedicine system, e.g., stethoscope, electroencephalography and etc. This system is capable of measuring, storing and analyzing crew's medical data. In addition, the medical data will be downlinked to the ground in real time in order to diagnose a crew's disorder by doctor. Onboard Diagnostic Kit will be evaluated, and confirmed its operability and accuracy of the measured data	JAXA	ISS	Kibo
Hair	Biomedical analyses of human hair exposed long-term space flight	JAXA	Human Spaceflight Technology Development	Hair is a target to study about effects of long-term exposure into the space environment against gene expression and mineral metabolism in it. Human hair is one of the most suitable biological specimens for a space experiment since there are no special requirements for handling, nor use of hardware. Hair matrix cells divide to a hair follicles actively while these cell divisions reflect physical conditions sensitively. The hair shaft records the information of the astronauts' metabolic conditions. These samples give us useful physiological information to examine the effects of spaceflight on astronauts participating in long-duration spaceflight missions. In the experiment, two different analyses will be performed using the ISS crew members' hair:1) Nucleic Acids (RNA and mitochondrial DNA) and proteins in the hair root and 2) Minerals in the hair shaft	Chiaki MUKAI, Japan	ISS	Kibo
Hicari	Growth of Homogeneous SiGe Crystals in Microgravity by the TLZ Method	JAXA	Crystallization	Hicari experiment aims to verify the crystal-growth theory, and to produce high-quality crystals of SiGe semiconductor, and performed by the Gradient Heating Furnace (GHF). The experimental cartridge containing SiGe samples is heated at the planned temperature profile in the GHF. After the cartridges are set in GHF, the experiment will be conducted by ground operations. The cartridges of this experiment will be delivered to Kibo, ISS on HTV-2	Kyoichi Kinoshita, JAXA	ISS	Kibo

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
JAXA PCG	High-Quality Protein Crystallization Research	JAXA	Applied Research	JAXA PCG project has been exploring to grow crystals of biological macromolecules using the counter diffusion technique. The main scientific objective of the JAXA PCG experiment is to produce fine-quality protein crystals in microgravity. The crystals will be grown in the JAXA PCG Canister using the Protein Crystallization Research Facility (PCRF) in the RYUTAI rack. The space-grown crystals will be applied to structural biology and pharmaceutical activities. This experiment is a JAXA-ROSCOSMOS science collaboration. JAXA is performing the onboard experiments, including samples from the Russian research group, and ROSCOSMOS is operating the launch and retrieval	Masaru Sato, JAXA (The samples are supplied from researchers in company, university, and national laboratory)	ISS	Kibo
MAXI	Monitor of All-sky X-ray Image	JAXA	X-ray Astronomy	MAXI is an external observatory operated on the EF. MAXI was launched and installed on Kibo's EF during the STS-127 Mission. MAXI has been monitoring X-ray variability more than 1,000 its sources covering the entire sky. MAXI consists of two types of highly sensitive X-ray slit cameras: the Gas Slit Camera (GSC) and the Solid-state Slit Camera (SSC). The GSC uses a gas proportional counter for X-ray detection, and the SSC uses Peltier-cooled CCDs for X-ray detection. MAXI is equipped with 12 GSCs and 2 SSCs. The discoveries of X-ray novae and gamma-ray bursts with MAXI are to be distributed worldwide via the Internet, so that astronomical observatories may conduct follow-up and detailed observations with telescopes or astronomical satellites	Masaru Matsuoka, JAXA	ISS	Kibo
SEDA-AP	Space Environment Data Acquisition Equipment-Attached Payload	JAXA	Astrophysics/ Earth Observation	SEDA-AP is an external experiment conducted on the Exposed Facility (EF). SEDA-AP was launched and installed on Kibo's Exposed Facility (EF) during the STS-127 Mission, and it has been collecting space environment data ever since then. It consists of common bus equipment, a mast that extends the neutron monitor sensor into space, and seven measurement units that measure space environment data. The measurement units are (1) Neutron Monitor (NEM), (2) Heavy Ion Telescope (HIT), (3) Plasma Monitor (PLAM), (4) Standard Dose Monitor (SDOM), (5) Atomic Oxygen Monitor (AOM), and (6) Electronic Device Evaluation Equipment (EDEE). Micro-Particles Capture (MPAC) and Space Environment Exposure Device (SEED) were removed by EVA and recovered by STS-131	Tateo Goka, JAXA	ISS	Kibo

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
Myco	Mycological evaluation of crew member exposure to ISS ambient air	JAXA	Human Spaceflight Technology Development	Myco1 project will investigate and evaluate the risk of inhalation and adhesion of microorganisms to astronauts who are exposed to ambient air on board the ISS during long-duration missions. The ultimate goal of this experiment is to develop medically effective countermeasures to protect ISS crew members living in a closed environment of microgravity against the living environmental risks caused by microorganisms. Normal human flora is thought to be strongly affected by the living environment. The environment on board the ISS would progressively be contaminated by microorganisms since various microorganisms are brought up to the station along with commodities and or crew members themselves. Some of them are possible allergens in our living environment. To mitigate the risk of microbial contamination on board, it is necessary to take some countermeasures against microbial contaminations	Chiaki MUKAI, Japan	ISS	Kibo
AMS-02	Alpha Magnetic Spectrometer – 02	NASA	Earth and Space Science	The Alpha Magnetic Spectrometer – 02 (AMS-02) is 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	Spokesperson: Samuel Ting, Ph.D., Massachusetts Institute of Technology, Cambridge, Mass.	ISS External	
BCAT-3	Binary Colloidal Alloy Test – 3	NASA	Physical Sciences	Binary Colloidal Alloy Test – 3 (BCAT-3) investigates the long-term behavior of colloids – a system of fine particles suspended in a fluid – in a microgravity environment, where the effects of sedimentation and convection are removed. Results will help scientists develop fundamental physics concepts previously masked by the effects of gravity	David A. Weitz, Ph.D., Harvard University, Cambridge, Mass. Peter Lu, Ph.D., Harvard University, Cambridge, Mass.	ISS Inflight	
BCAT-4	Binary Colloidal Alloy Test – 4	NASA	Physical Sciences	Binary Colloidal Alloy Test – 4 (BCAT-4) is part of the BCAT suite of experiments studying colloids – a system of fine particles suspended in a fluid. Results from this study may lead to new colloid materials with applications in the communications and computer industries for switches, displays and optical devices with properties that could rival those of lasers	Paul M. Chaikin, Ph.D., Princeton University, Princeton, NJ and New York University, New York	ISS Inflight	

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
BCAT-5	Binary Colloidal Alloy Test – 5	NASA	Physical Sciences	Binary Colloidal Alloy Test – 5 (BCAT-5) is a suite of four investigations which will photograph randomized colloidal samples onboard the International Space Station to determine their resulting structure over time. The use of EarthKAM software and hardware will allow the scientists to capture the kinetics, or evolution, of their samples, as well as the final equilibrium state of each sample	Arjun Yodh, Ph.D., University of Pennsylvania, University Park Barbara Frisken, Ph.D., Simon Fraser University, Burnaby, British Columbia, Canada Matthew Lynch, Ph.D., Procter and Gamble, Cincinnati David Weitz, Ph.D., Harvard University, Cambridge, Mass. Paul Chaikin, Ph.D., New York University, New York	ISS Inflight	
BCAT-6	Binary Colloidal Alloy Test – 6	NASA	Physical Sciences	Binary Colloidal Alloy Test – 6 (BCAT-6) is a suite of four investigations which will photograph randomized colloidal samples onboard the International Space Station to determine their resulting structure over time. The use of EarthKAM software and hardware will allow the scientists to capture the kinetics, or evolution, of their samples, as well as the final equilibrium state of each sample	Paul Chaikin, Ph.D., New York University, New York Arjun Yodh, Ph.D., University of Pennsylvania, University ParkMatthew Lynch, Ph.D., Procter and Gamble, Cincinnati David Weitz, Ph.D., Harvard University, Cambridge, Mass.	ISS Inflight	
BIOKIS	BIOKon In Space	NASA	Biology and Biotechnology	BIOKon In Space (BIOKIS) involves the investigation of seven experiments sponsored by the Italian Space Agency (ASI-Agenzia Spaziale Italiana) in the areas of cellular biology, radiation and radioprotection, aging, germination and plant growth. These experiments will aim to evaluate various biological species to determine genetic distinctions following short-duration space flight; also, BIOKIS will utilize a variety of dosimeters to monitor radiation	Pier Luigi Ganga, Kayser Italia s.r.l., Livorno, Italy	ISS Inflight	

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
Bio	Biology	NASA	Physical Sciences	Biology (Bio) is a NASA Rapid Turn Around (RTA) engineering proof-of-concept proposal in preparation for Advanced Colloids Experiment (ACE). In Bio, crew members image three-dimensional biological sample particles, tissue samples and live organisms. The goal of this experiment is to indicate the microscope's capabilities for viewing biological specimens	Jacob Cohen, Ph.D., Ames Research Center, Moffett Field, Calif.	ISS Inflight	
Bisphosphonates	Bisphosphonates as a Countermeasure to Space Flight Induced Bone Loss	NASA	Human Research	Bisphosphonates as a Countermeasure to Space Flight Induced Bone Loss (Bisphosphonates) determines whether anti-resorptive agents (help reduce bone loss), in conjunction with the routine in-flight exercise program, protects International Space Station (ISS) crew members from the regional decreases in bone mineral density documented on previous ISS missions	Adrian LeBlanc, Ph.D., Division of Space Life Sciences, Universities Space Research Association, Houston	ISS Inflight	
CBTM-3	Commercial Biomedical Test Module – 3	NASA	Human Research	Commercial Biomedical Test Module – 3 (CBTM-3) will use a validated mouse model to examine the effectiveness of an experimental therapeutic as a possible countermeasure for muscle atrophy. Combined with exercise, this experimental therapeutic developed by Amgen could one day form the basis for a treatment that will help maintain a high level of physical fitness in future flight crews. Also, through an extensive tissue sharing program several additional investigations will be performed on the effects of microgravity on the skeletal, cardiovascular, immune systems, liver and kidney function as well as other physiological systems	Louis Stodieck, Ph.D., BioServe Space Technologies, University of Colorado – Boulder	Sortie	
CCF	Capillary Channel Flow	NASA	Physical Sciences	Capillary Channel Flow (CCF) yields results to contribute to the improvement of future spacecraft fuel tanks. Currently, spacecraft fuel tanks rely on additional reservoirs to prevent ingestion of gas into the engines during firing to attain optimal engine performance. By understanding capillary fluid flow rates in microgravity, current models for spacecraft fuel tanks could be updated to use capillary vanes to supply gas-free propellant to spacecraft thrusters instead of reservoirs, resulting in reduced cost and weight, and improved reliability	Michael Dreyer, Ph.D., University of Bremen, Germany	ISS Inflight	
CEO	Crew Earth Observations	NASA	Earth and Space Science	In Crew Earth Observations (CEO), the crew on the International Space Station (ISS) photograph natural and human-made changes 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 better understand the planet	Susan Runco, Johnson Space Center, Houston	ISS Inflight	
CFE-2	Capillary Flow Experiment – 2	NASA	Physical Sciences	Capillary Flow Experiments – 2 (CFE-2) is a suite of fluid physics experiments that investigate capillary flows and flows of fluids in containers with complex geometries. The experiments have led to changes in computer models of low-gravity fluid systems, which achieve better results, and may lead to improvements in fluid-transfer systems in future spacecraft designs	Mark M. Weislogel, Ph.D., Portland State University, Portland, Ore.	ISS Inflight	

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
CSI-05	Commercial Generic Bioprocessing Apparatus Science Insert – 05	NASA	Educational Activities	(CSI-05) Commercial Generic Bioprocessing Apparatus Science Insert – 05 (CSI-05) is part of the CSI program series and provides the K-12 community opportunities to utilize the unique microgravity environment of the International 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 – Boulder, BioServe Space Technologies, Boulder	ISS Inflight	
CVB	Constrained Vapor Bubble	NASA	Physical Sciences	Constrained Vapor Bubble (CVB) operates a miniature wickless heat pipe (heat exchanger) to understand the physics of evaporation and condensation as they affect heat transfer processes in microgravity	Peter C. Wayner, Jr., Ph.D., Rensselaer Polytechnic Institute, Troy, New York	ISS Inflight	
DTN	Delay Tolerant Networking	NASA	Technology	The Delay Tolerant Networking (DTN) tests communication protocols with the Commercial Generic Bioprocessing Apparatus (CGBA) onboard the International Space Station. The primary purpose is to rapidly mature the DTN technology for use in NASA's exploration missions and space communications architecture	Kevin Gifford, Ph.D., University of Colorado, Boulder	ISS Inflight	
ENOS	Electronic NOse for Space exploration	NASA	Technology	Electronic NOse for Space exploration (ENOS) is a study involving air quality monitoring and the search for possible anomalies in the internal on-orbit atmosphere utilizing a network of three sensorial ENOS units	Eugenio Martinelli, University of Rome Tor Vergata, Rome, Italy Arnaldo D Amico, University of Rome Tor Vergata, Rome, Italy Corrado Di Natale, University of Rome Tor Vergata, Rome, Italy	ISS Inflight	
EPO-Demos	Education Payload Operation – Demonstrations	NASA	Educational Activities	Education Payload Operation – Demonstrations (EPO-Demos) records video education demonstrations performed on the International Space Station (ISS) by crew members using hardware already onboard the ISS. EPO-Demos enhance existing NASA education resources and programs for educators and students in grades K-12. EPO-Demos support the NASA mission to inspire the next generation of explorers	Matthew Keil, Johnson Space Center, Houston	ISS Inflight	
EarthKAM	Earth Knowledge Acquired by Middle School Students	NASA	Educational Activities	Earth Knowledge Acquired by Middle School Students (EarthKAM), an education activity, allows middle school students to program a digital camera on board the International Space Station to photograph a variety of geographical targets for study in the classroom. Photos are made available on the world wide web for viewing and study by participating schools around the world. Educators use the images for projects involving Earth Science, geography, physics, and social science	Sally Ride, Ph.D., University of California – San Diego	ISS Inflight	

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
Functional Task Test	Physiological Factors Contributing to Changes in Postflight Functional Performance	NASA	Human Research	The Physiological Factors Contributing to Changes in Postflight Functional Performance (Functional Task Test) payload tests 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	Pre/ Postflight	
HREP-HICO	HICO and RAIDS Experiment Payload – Hyperspectral Imager for the Coastal Ocean	NASA	Earth and Space Science	HICO and RAIDS Experiment Payload – Hyperspectral Imager for the Coastal Ocean (HREP-HICO) operates a visible and near-infrared (VNIR) Maritime Hyperspectral Imaging (MHSI) system, to detect, identify and quantify coastal geophysical features from the International Space Station. The experiment analyzes the water clarity, chlorophyll content, water depth, and ocean or sea floor composition for civilian and naval purposes	Mike Corson, Naval Research Laboratory, Washington	ISS External	
HREP-RAIDS	HICO and RAIDS Experiment Payload – Remote Atmospheric and Ionospheric Detection System (RAIDS)	NASA	Earth and Space Science	The HICO and RAIDS Experiment Payload – Remote Atmospheric and Ionospheric Detection System (HREP-RAIDS) experiment 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 International Space Station (ISS) 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 95 - 300 kilometers	Scott Budzien, Naval Research Laboratory, Washington	ISS External	
ISSAC	International Space Station Agricultural Camera	NASA	Earth and Space Science	The International Space Station Agricultural Camera (ISSAC) will take frequent images, in visible and infrared light, of vegetated areas on the Earth, principally of growing crops, rangeland, grasslands, forests, and wetlands in the northern Great Plains and Rocky Mountain regions of the United States. Images will be delivered directly to requesting farmers, ranchers, foresters, natural resource managers and tribal officials to help improve their environmental stewardship of the land. Images will also be shared with educators for classroom use	George A. Seielstad, Ph.D., University of North Dakota, Grand Forks	ISS Inflight	
ISS Ham Radio	International Space Station Ham Radio	NASA	Educational Activities	Utilizing ham radios, International Space Station Ham Radio (ISS Ham Radio) gets students interested in space exploration by allowing them to talk directly with the crews living and working aboard the ISS	Kenneth Ransom, Johnson Space Center, Houston	ISS Inflight	
InSPACE-3	Investigating the Structure of Paramagnetic Aggregates from Colloidal Emulsions – 3	NASA	Physical Sciences	Investigating the Structure of Paramagnetic Aggregates from Colloidal Emulsions – 3 (InSPACE-3) obtains data on fluids that change their physical properties in response to magnetic fields	Eric M. Furst, Ph.D., University of Delaware, Newark	ISS Inflight	

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
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	Cardiac Atrophy and Diastolic Dysfunction During and After Long Duration Spaceflight: Functional Consequences for Orthostatic Intolerance, Exercise Capability and Risk for Cardiac Arrhythmias (Integrated Cardiovascular) quantifies the extent, time course and clinical significance of cardiac atrophy (decrease in the size of the heart muscle) associated with long-duration space flight. This experiment identifies the mechanisms of this atrophy and the functional consequences for crew members who will 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	ISS Inflight	
Integrated Immune	Validation of Procedures for Monitoring Crew member Immune Function	NASA	Human Research	Validation of Procedures for Monitoring Crew Member Immune Function (Integrated Immune) will assess the clinical risks resulting from the adverse effects of space flight on the human immune system and will validate a flight-compatible immune monitoring strategy. To monitor changes in the immune system, researchers collect and analyze blood, urine and saliva samples from crew members before, during and after space flight	Clarence Sams, Ph.D, Johnson Space Center, Houston	ISS Inflight	
Integrated Immune-SDBI	Validation of Procedures for Monitoring Crew member Immune Function – Short Duration Biological Investigation	NASA	Human Research	Validation of Procedures for Monitoring Crew Member Immune Function – Short Duration Biological Investigation (Integrated Immune-SDBI) will assess the clinical risks resulting from the adverse effects of space flight on the human immune system and will validate a flight-compatible immune monitoring strategy. Immune system changes will be monitored by collecting and analyzing blood, urine and saliva samples from crew members before, during and after space flight	Clarence Sams, Ph.D, Johnson Space Center, Houston	Sortie	
Kids In Micro-g-2	Kids In Microgravity-2	NASA	Educational Activities	Kids In Micro-gravity – 2 (Kids in Micro-g-2) provides students in grades 5 - 8 a hands-on opportunity to design an experiment or simple demonstration that could be performed both in the classroom and aboard the International Space Station (ISS)	Deborah Biggs, Johnson Space Center, Houston	ISS Inflight	
Lego Bricks	Lego Bricks	NASA	Educational Activities	The Lego Bricks payload is a series of toy Lego kits that are assembled on orbit and used to demonstrate scientific concepts. Some of these models include satellites, a space shuttle orbiter, and a scale model of the International Space Station (ISS)	The Lego Group, Billund, Denmark	ISS Inflight	
MAMS	Microgravity Acceleration Measurement System	NASA	Technology	Microgravity Acceleration Measurement System (MAMS studies the small forces, or vibrations and accelerations, on the International Space Station (ISS) that result from the operation of hardware, crew activities, dockings and maneuvering. Results are used to generalize the types of vibrations affecting vibration-sensitive experiments. Investigators seek to better understand the vibration environment on the space station	Project Manager: Robert Hawersaat, Glenn Research Center, Cleveland	ISS Inflight	

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
MAUI	Maui Analysis of Upper Atmospheric Injections	NASA	Technology	Maui Analysis of Upper Atmospheric Injections (MAUI) observes the Space Shuttle engine exhaust plumes from the Maui Space Surveillance Site in Hawaii. The observations occur when the Space Shuttle fires its engines at night or twilight. A telescope and all-sky imagers take images and data while the Space Shuttle flies over the Maui site. The images are analyzed to better understand the interaction between the spacecraft plume and the upper atmosphere of Earth	Rainer A. Dressler, Ph.D., Hanscom Air Force Base, Lexington, Mass.	Descent Only	
MDCA-FLEX-2	Multi-User Droplet Combustion Apparatus – Flame Extinguishment Experiment – 2	NASA	Physical Sciences	The Multi-User Droplet Combustion Apparatus – Flame Extinguishment Experiment – 2 (MDCA-FLEX-2) assesses the effectiveness of fire suppressants in microgravity and quantify the effect of different possible crew exploration atmospheres on fire suppression. The goal of this research is to provide definition and direction for large scale fire suppression tests and selection of the fire suppressant for next generation crew exploration vehicles	Forman A. Williams, University of California, San Diego	ISS Inflight	
MISSE-7	Materials International Space Station Experiment – 7	NASA	Physical Sciences	The Materials International Space Station Experiment – 7 (MISSE-7) is a test bed for materials and coatings attached to the outside of the International Space Station 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 to better withstand the rigors of space environment. Results will provide a better understanding of the durability of various materials when they are exposed to the space environment with applications in the design of future spacecraft	Robert Walters, Ph.D., Naval Research Laboratory, Washington	ISS External	
MISSE-8	Materials International Space Station Experiment – 8	NASA		The Materials on International Space Station Experiment – 8 (MISSE-8) is a test bed for materials and computing elements attached to the outside of the International 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	ISS External	
NLO-Education-1	National Laboratory Office – Education – 1	NASA	Educational Activities			ISS Inflight	

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
NLP-Cells-6	National Laboratory Pathfinder – Cells – 6: Jatropha – 3	NASA	Biology and Biotechnology	National Lab Pathfinder – Cells – 6: Jatropha – 3 (NLP-Cells-6) assesses the effects of microgravity on formation, establishment and multiplication of undifferentiated cells of the Jatropha (Jatropha curcas), a biofuel plant, using different tissues as explant sources from different genotypes of Jatropha. Specific goals include the evaluation of changes in cell structure, growth and development, genetic changes, and differential gene expression. Postflight analysis identifies significant changes that occur in microgravity which could contribute to accelerating the breeding process for the development of new cultivars of this biofuel plant	Wagner Vendrame, Ph.D., Tropical Research and Education Center, Gainesville, Fla.	ISS Inflight	
NLP-Cells-7	National Laboratory Pathfinder – Cells – 7	NASA	Biology and Biotechnology	National Lab Pathfinder – Cells – 7 (NLP-Cells-7) is a commercial payload serving as a pathfinder for the use of the International Space Station (ISS) as a National Laboratory after ISS assembly complete. It contains several different experiments that examine cellular replication and differentiation of cells. This research is investigating the use of space flight to enhance or improve cellular growth processes utilized in ground based research	Louis Stodieck, Ph.D., BioServe Space Technologies, University of Colorado – Boulder	ISS Inflight	
NLP-Vaccine	National Laboratory Pathfinder – Vaccine	NASA	Biology and Biotechnology	The National Laboratory Pathfinder – Vaccine (NLP-Vaccine) is a commercial investigation serving as a pathfinder for the use of the International Space Station (ISS) as a National Laboratory after ISS assembly is complete. NLP-Vaccine uses microgravity to examine pathogenic (disease-causing) organisms to develop a potential vaccine for the prevention of infection on Earth and in microgravity	Timothy Hammond, M.B.B.S., Durham Veterans Affairs Medical Center, Durham, N.C.	Sortie	
NanoRacks-CubeLabs Module-6	NanoRacks-CubeLabs_Module-6	NASA	Multipurpose	The NanoRacks-CubeLabs Module-6 is a 3-Dimensional video camera for International Space Station (ISS) crew members. NanoRacks-CubeLabs Module-6 supports future NanoRacks-CubeLabs investigations onboard the ISS			
NanoRacks-CubeLabs Module-7	NanoRacks-CubeLabs Module-7	NASA	Human Research	The NanoRacks-CubeLabs Module-7 mixes samples of two or three liquids in microgravity. The science goals for NanoRacks-CubeLabs Module-7 are proprietary. The client base is international, with researchers from North America and Israel involved in using the hardware and forms the basis for future space station research	Jeffrey Manber, NanoRacks, LLC, Laguna Woods, Calif.	ISS Inflight	
NanoRacks-CubeLabs Module-8	NanoRacks-CubeLabs_Module-8	NASA	Biology and Biotechnology	The NanoRacks-CubeLabs Module-8 processes biological samples in microgravity. The science goals for NanoRacks-CubeLabs Module-8 are proprietary	Jeffrey Manber, NanoRacks, LLC, Laguna Woods, Calif.	Sortie	
Night Vision	Eyespots and Macular Pigments Extracted from Algal Organisms Immobilized in Organic Matrix with the Purpose to Protect Astronaut's Retina	NASA	Biology and Biotechnology	Eyespots and Macular Pigments Extracted from Algal Organisms Immobilized in Organic Matrix with the Purpose to Protect Astronaut's Retina (Night Vision) is a study on the response of microalgae strains (that contain eye spots similar to the human retina) to space radiation in order to obtain results applicable to future nutrition programs for astronauts	Maria Teresa Giardi, Ph.D., Institute of Crystallography, Rome, Italy	Sortie	

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
Nutrition	Nutritional Status Assessment	NASA	Human Research	Nutritional Status Assessment (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 space exploration missions. This experiment 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	ISS Inflight	
PACE-2	Preliminary Advanced Colloids Experiment – 2: 3D Particle Test	NASA	Technology	Preliminary Advanced Colloids Experiment – 2 (PACE-2) characterizes the resolution of the high magnification colloid experiments with the Light Microscopy Module (LMM) to determine the minimum size of the particles that can be resolved by the Advanced Colloids Experiment (ACE). There is a direct relationship between magnification, particle size, test duration and on-orbit vibration that is quantified	Jacob N. Cohen, Ph.D., Ames Research Center, Moffett Field, Calif.	ISS Inflight	
Plant Signaling	Plant Signaling	NASA	Biology and Biotechnology	The Plant Signaling experiment studies the effects of microgravity on the growth of plants. The experiment is performed on board the International Space Station (ISS) in collaboration with the European Space Agency (ESA). Images of the plants are captured and down-linked to Earth. Samples of the plants are harvested and returned to Earth for scientific analysis. The results of this experiment can lead to information that will aid in food production during future long duration space missions, as well as data to enhance crop production on Earth	Imara Perera, Ph.D., North Carolina State University, Raleigh		
Pro K	Dietary Intake Can Predict and Protect Against Changes in Bone Metabolism during Spaceflight and Recovery	NASA	Human Research	The Dietary Intake Can Predict and Protect Against Changes in Bone Metabolism during Spaceflight and Recovery (Pro K) investigation is NASAs 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 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	ISS Inflight	

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
RAMBO-2	Ram Burn Observations – 2	NASA	Technology	Ram Burn Observations – 2 (RAMBO-2) is an experiment in which the Department of Defense uses a satellite to observe space shuttle orbital maneuvering system engine burns. Its purpose is to improve plume models, which predict the direction the plume, or rising column of exhaust, will move as the shuttle maneuvers on orbit. Understanding the direction in which the spacecraft engine plume, or exhaust flows could be significant to the safe arrival and departure of spacecraft on current and future exploration missions	William L. Dimpfl, Ph.D., Aerospace Corporation, Los Angeles	Descent Only	
REBR	ReEntry Breakup Recorder	NASA	Technology	Reentry Breakup Recorder (REBR) will test a cost-effective system that can ride a reentering vehicle, record data during the reentry and breakup of the vehicle, and return data for analysis	William Ailor, Ph.D., The Aerospace Corporation, El Segundo, Calif.	Sortie	
Reaction Self Test	Psychomotor Vigilance Self Test on the International Space Station	NASA	Human Research	The Psychomotor Vigilance Self Test on the International Space Station (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 International Space Station (ISS)	David F. Dinges, Ph.D., University of Pennsylvania School of Medicine, Philadelphia	ISS Inflight	
Repository	National Aeronautics and Space Administration Biological Specimen Repository	NASA	Human Research	The National Aeronautics and Space Administration Biological Specimen Repository (Repository) is a storage bank that is used to maintain biological specimens over extended periods of time and under well-controlled conditions. This repository supports scientific discovery that contributes to our fundamental knowledge in the area of human physiological changes and adaptation to a microgravity environment and provides unique opportunities to study longitudinal changes in human physiology spanning many missions. Samples from the International Space Station (ISS), including blood and urine, are collected, processed and archived during the preflight, in-flight and postflight phases of ISS missions. This investigation archives biosamples for use as a resource for future space flight related research	Kathleen A. McMonigal, M.D., Johnson Space Center, Houston	ISS Inflight	
Robonaut	Robonaut	NASA	Technology	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	ISS Inflight	
SAMS-II	Space Acceleration Measurement System-II	NASA	Technology	Space Acceleration Measurement System-II (SAMS-II) is an ongoing study of the small forces (vibrations and accelerations) on the International Space Station (ISS) resulting from the operation of hardware, crew activities, dockings and maneuvering. Results generalize the types of vibrations affecting vibration-sensitive experiments. Investigators seek to better understand the vibration environment on the ISS	Project Manager: Robert Hawersaat, Glenn Research Center, Cleveland	ISS Inflight	

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
SEITE	Shuttle Exhaust Ion Turbulence Experiments	NASA	Technology	Shuttle Exhaust Ion Turbulence Experiments (SEITE) uses space-based sensors to detect the ionospheric turbulence inferred from the radar observations from a previous Space Shuttle Orbital Maneuvering System (OMS) burn experiment using ground-based radar	Paul A. Bernhardt, Ph.D., Naval Research Laboratory, Washington	Descent Only	
SHERE-II	Shear History Extensional Rheology Experiment – II	NASA	Physical Sciences	The Shear History Extensional Rheology Experiment – II (SHERE-II) investigation involves a non-Newtonian fluid that will undergo preshearing (rotation) for a specified period of time, followed by stretching. This combination of shearing and extensional deformations is common in many earth-based polymer processing and manufacturing operations such as extrusion, blow-molding and fiber spinning. However, in order to accurately predict the flow behaviour of polymeric fluids under such deformation histories, an accurate knowledge of the extensional viscosity of a polymer system and its variation with strain rate is critical and will be measured during this experiment. The fundamental understanding and measurement of these complex fluids is important for containerless processing, a key operation for fabrication of parts, such as adhesives or fillers, using elastomeric materials on future exploration missions	Gareth McKinley, Ph.D., Massachusetts Institute of Technology, Cambridge, Mass.	ISS Inflight	
SLICE	Structure and Liftoff In Combustion Experiment	NASA	Physical Sciences	Structure and Liftoff In Combustion Experiment (SLICE) investigates the structure of lifting and lifted flames; whereby the flame detaches from the nozzle and stabilizes at a downstream position	Marshall B. Long, Ph.D., Yale University, New Haven, Conn.	ISS Inflight	
SNFM	Serial Network Flow Monitor	NASA	Technology	Using a commercial software CD, Serial Network Flow Monitor (SNFM) monitors 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	ISS Inflight	
SPHERES	Synchronized Position Hold, Engage, Reorient, Experimental Satellites	NASA	Technology	Synchronized Position Hold, Engage, Reorient, Experimental Satellites (SPHERES) are bowling-ball sized spherical satellites. They are used inside the space station to test a set of well-defined instructions for spacecraft performing autonomous rendezvous and docking maneuvers. Three free-flying spheres fly within the cabin of the Space Station, performing flight formations. Each satellite is self-contained with power, propulsion, computers and navigation equipment. The results are important for satellite servicing, vehicle assembly and formation flying spacecraft configurations	David W. Miller, Ph.D., Massachusetts Institute of Technology, Cambridge, Mass.	ISS Inflight	
STP-H3-Canary	Space Test Program – Houston 3 – Canary	NASA	Technology	Space Test Program – Houston 3 – Canary (STP-H3-Canary) investigates the interaction of ions with the background plasma environment around the ISS	Geoff Mcharg, Ph.D., United States Air Force Academy, Colorado Springs, Colo.	ISS External	

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
STP-H3-DISC	Space Test Program – Houston 3 – Digital Imaging Star Camera	NASA	Technology	Space Test Program – Houston 3 – Digital Imaging Star Camera (STP-H3-DISC) captures images of star fields for analysis by ground algorithms to determine the attitude of the ISS. The results will lead to the creation of more robust and capable satellites to be used by ground systems for Earth-bound communications	Andrew Williams, Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio	ISS External	
STP-H3-MHTEX	Space Test Program – Houston 3 – Massive Heat Transfer Experiment	NASA	Technology	Space Test Program – Houston 3 – Massive Heat Transfer Experiment (STP-H3-MHTEX) is 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 Williams, Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio	ISS External	
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	Space Test Program – Houston 3 – Variable emissivity radiator Aerogel insulation blanket Dual zone thermal control Experiment suite for Responsive space (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 Williams, Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio	ISS External	
Shape Memory Foam	Shape Memory Foam	NASA	Physical Sciences	The Shape Memory Foam experiment will evaluate the recovery of shape memory epoxy foam in microgravity obtained by solid-state foaming on ground consisting of various geometric complexities shaped on ground. This investigation is expected to study the shape memory properties required to manufacture a new concept actuator (a device that transforms energy to other forms of energy)	Professor Loredana Santo, University of Rome Tor Vergata, Rome, Italy	Pre/Postflight	
Sleep-Short	Sleep-Wake Actigraphy and Light Exposure During Spaceflight-Short	NASA	Human Research	Sleep-Wake Actigraphy and Light Exposure During Spaceflight-Short (Sleep-Short) examines how spaceflight affects astronauts' sleep patterns during Space Shuttle missions. Advancing state-of-the-art technology for monitoring, diagnosing and assessing treatment of sleep patterns is vital to treating insomnia on Earth and in space	Charles A. Czeisler, M.D., Ph.D., Brigham and Women's Hospital, Harvard Medical School, Boston	Sortie	
Spinal Elongation	Spinal Elongation and its Effects on Seated Height in a Microgravity Environment	NASA	Human Research	The Spinal Elongation and its Effects on Seated Height in a Microgravity Environment (Spinal Elongation) study provides quantitative data as to the amount of change that occurs in the seated height due to spinal elongation in microgravity	Sudhakar Rajulu, Ph.D., Johnson Space Center, Houston	Sortie	
Sprint	Integrated Resistance and Aerobic Training Study	NASA	Human Research	Sprint (Integrated Resistance and Aerobic Training Study) evaluates the use of high intensity, low volume exercise training to minimize loss of muscle, bone, and cardiovascular function in ISS crew members during long-duration missions	Lori Ploutz-Snyder, Ph.D., Universities Space Research Association, Houston	ISS Inflight	

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
Treadmill Kinematics	Biomechanical Analysis of Treadmill Exercise on the International Space Station	NASA	Human Research	The Biomechanical Analysis of Treadmill Exercise on the International Space Station (Treadmill Kinematics) experiment is the first rigorous investigation to quantify the biomechanics of treadmill exercise conditions during long duration spaceflight on the ISS. Exercise prescriptions have been developed under the assumption that walking and running in microgravity have the same training effects as during normal gravity. However, if locomotion kinematics and kinetics differ between microgravity and normal gravity, understanding these mechanisms will allow the development of appropriate exercise prescriptions to increase exercise benefits to crew health and well-being	John De Witt, Ph.D., Wyle Integrated Sciences and Engineering Group, Exercise Physiology and Counter-measures Project, NASA Johnson Space Center	ISS Inflight	
VCAM	Vehicle Cabin Atmosphere Monitor	NASA	Technology	Vehicle Cabin Atmosphere Monitor (VCAM) identifies gases that are present in minute quantities in the International Space Station breathing air that could harm the crew's health. If successful, instruments like VCAM could accompany crew members during long-duration exploration missions	Ara Chutjian, Ph.D., California Institute of Technology, Pasadena, CA and Jet Propulsion Laboratory, Pasadena, Calif.	ISS Inflight	
VIABLE ISS	eValuatIon And monitoring of microBiofiLms insidE International Space Station	NASA	Physical Sciences	The eValuatIon And monitoring of microBiaL biofilms insidE ISS (VIABLE ISS) study involves the evaluation of the microbial biofilm development on space materials. Both metallic and textile space materials, either conventional or innovative, will be located inside and on the cover of Nomex pouches that will be placed inside the International Space Station (ISS)	Francesco Canganella, Department of Agrobiology and Agrochemistry, University of Tuscia, Viterbo, Italy	ISS Inflight	
VO2max	Evaluation of Maximal Oxygen Uptake and Submaximal Estimates of VO$_2$max Before, During, and After Long Duration International Space Station Missions	NASA	Human Research		Alan D. Moore, Jr., Ph.D., Johnson Space Center, Houston	ISS Inflight	
TXH-9	Kristallizator (Crystallizer)	RSA	Physico-chemical processes and material in condition of cosmos	Biological macromolecules crystallization and obtaining bio-crystal films under microgravity conditions		ISS Inflight	JAXA PCG complex
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		ISS Inflight	MRM2
КПТ-16	Zone-К	RSA	Physico-chemical processes and material in condition of cosmos	Study termokapilarnoe to convections of the fluid zone in condition the microgravity		ISS Inflight	MRM1
КПТ-17	Sloiy -К	RSA	Physico-chemical processes and material in condition of cosmos	Study termokapilarnoe to convections in laminated liquid system in condition the microgravity		ISS Inflight	MRM1

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
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		ISS Inflight	
ГФИ-8	Uragan	RSA	Geophysics and located beside land outer space	Experimental verification of the ground and space-based system for predicting natural and man-made disasters, mitigating the damage caused, and facilitating recovery		ISS Inflight	
ГФИ-11	Obstanovka (Situation) (Step 1)	RSA	Geophysics and located beside land outer space	Studies in the surface zone ISS plasma-wave interaction processes Superlarge spacecraft and the ionosphere		ISS Inflight	EVA
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		ISS Inflight	
ГФИ-17	Molnija- Gamma (Lightning-Gamma)	RSA	Geophysics and located beside land outer space	Study atmospheric hits gamma and optical radiation in condition of the storm activity		ISS Inflight	EVA
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		ISS Inflight	
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”		ISS Inflight	Progress
МБИ-12	Sonokard	RSA	Biomedical studies	Integrated study of physiological functions during sleep period throughout a long space flight		ISS Inflight	
МБИ-16	Vzaimodeistvie (Interaction)	RSA	Biomedical studies	Monitoring of the group crew activities under space flight conditions		ISS Inflight	
МБИ-20	Tipologia	RSA	Biomedical studies	Researching for typological features of the activities of the ISS crews as operators activities in long term space flight phases		ISS Inflight	
МБИ-21	Pneumocard	RSA	Biomedical studies	Study of space flight factors impacts on vegetative regulation of blood circulation, respiration and contractile heart function during long space flights		ISS Inflight	
МБИ-24	Sprut-2	RSA	Biomedical studies	Investigation of the dynamics of body composition and distribution of human body fluids during prolonged space flight		ISS Inflight	
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		ISS Inflight	
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		ISS Inflight	EVA
БИО-5	Rasteniya	RSA	Biomedical studies	Study of the space flight effect on the growth and development of higher plants		ISS Inflight	
ДЗЗ-12	Rusalka	RSA	Remote flexing the Land	Testing of the procedure to determine the carbon dioxide and methane content in the Earth atmosphere to understand a role of natural processes in human activity		ISS Inflight	

Research Experiments (continued)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
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		ISS Inflight	
ДЗЗ-14	СВЧ – radiometry Microwave radiometry	RSA	Remote flexing the Land	Investigation of the underlying surface, ocean and atmosphere		ISS Inflight	
КПТ-3	Econ	RSA	Remote flexing the Land	Experimental researching of ISS RS resources estimating for ecological investigation of areas		ISS Inflight	
ИКЛ-2В	BTN-Neutron	RSA	Study of the Solar system	Study of fast and thermal neutrons fluxes		ISS Inflight	
БТХ-5	Laktolen	RSA	Cosmic biotechnology	Effect produced by space flight factors on Laktolen producing strain		ISS Inflight	
БТХ-6	ARIL	RSA	Cosmic biotechnology	Effect produced by SFFs on expression of strains producing interleukins 1α, 1β, “ARIL”		ISS Inflight	
БТХ-7	OChB	RSA	Cosmic biotechnology	Effect produced by SFFs on strain producing superoxidodismutase (SOD)		ISS Inflight	
БТХ-8	Biotrack	RSA	Cosmic biotechnology	Study of space radiation heavy charged particles fluxes influence on genetic properties of bioactive substances cells-producers		ISS Inflight	
БТХ-10	Kon’yugatsiya (Conjugation)	RSA	Cosmic biotechnology	Working through the process of genetic material transmission using bacteria conjugation method		ISS Inflight	
БТХ-11	Biodegradatsiya	RSA	Cosmic biotechnology	Assessment of the initial stages of biodegradation and biodeterioration of the surfaces of structural materials		ISS Inflight	
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		ISS Inflight	
БТХ-26	Cascad (cascade)	RSA	Cosmic biotechnology	Study of various types cells cultivation processes		ISS Inflight	
БТХ-29	Zhenshen’-2 (Ginseng-2)	RSA	Cosmic biotechnology	Study of the possibility to increase the ginseng biological activity		ISS Inflight	
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 membran мембран		ISS Inflight	MRM2
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		ISS Inflight	MRM1
БТХ-40	BIF (bifidobacterias)	RSA	Cosmic biotechnology	Study of the influence factor space flight on technological and биомедицинские of the feature bifidobacterias		ISS Inflight	
БТХ-41	Bakteriofag	RSA	Cosmic biotechnology	Study of the influence factor space flight on bakteriofages		ISS Inflight	
БТХ-42	Structure	RSA	Cosmic biotechnology	Reception high-quality crystal рекомбинантных squirrel		ISS Inflight	
БТХ-43	Constant	RSA	Cosmic biotechnology	Study of the influence factor space flight on activity ferment		ISS Inflight	
ТЕХ-14 (SDTO 12002-R)	Vektor-T	RSA	Technical studies and experiments	Study of a high-precision system for ISS motion prediction		ISS Inflight	
ТЕХ-15 (SDTO 13002-R)	Izgib	RSA	Technical studies and experiments	Study of the relationship between the onboard systems operating modes and ISS flight conditions		ISS Inflight	

Research Experiments (concluded)

Acronym	Title	Agency	Category	Summary	Principal Investigator	ISS/ Sortie	Ops Location
ТЕХ-22	Identifikatsiya	RSA	Technical studies and experiments	Identification of disturbance sources when the microgravity conditions on the ISS are disrupted		ISS Inflight	
ТЕХ-38	Veterok	RSA	Technical studies and experiments	Otrabotka new technology to optimization of the gas ambience in inhabited compartment ISS RS		ISS Inflight	
ТЕХ-39	SLS (System lazer relationship)	RSA	Technical studies and experiments	Otrabotka systems lazer relationship for issue greater array to information from target equipment		ISS Inflight	EVA
ТЕХ-44	Sreda-ISS (Environment)	RSA	Technical studies and experiments	Studying ISS characteristics as researching environment		ISS Inflight	
ТЕХ-50	Contur (Sidebar)	RSA	Technical studies and experiments	Development of the methods of management through Internet robot-manipulator on ISS		ISS Inflight	
ТЕХ-51	VIRU	RSA	Technical studies and experiments	Virtual Guide		ISS Inflight	
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		ISS Inflight	
РБО-3	Matryeshka-R	RSA	Study of the physical conditions in outer spaces on orbit ISS	Study of radiation environment dynamics along the ISS RS flight path and in ISS compartments, and dose accumulation in anthropomorphous phantom, located inside and outside ISS		ISS Inflight	
ОБР-3	MAI-75	RSA	Formation and popularization cosmic studies	Spacecraft and up-to-date technologies for personal communications		ISS Inflight	
КПТ-14	Ten' – Mayak (Shadow – Beacon)	RSA	Formation and popularization cosmic studies	Working-out of the method for radio probing of board-ground space for supporting preparation of "Ten" ("Shadow") plasma experiment on ISS RS		ISS Inflight	
КПТ-10	Kulonovskiy crystal	RSA	Formation and popularization cosmic studies	System speaker Study of the charged particles in magnetic field in condition the microgravity		ISS Inflight	MRM2

NASA’s Commercial Orbital Transportation Services (COTS)

Through a revolutionary program begun in 2006, NASA’s Commercial Crew and Cargo Program is investing financial and technical resources to stimulate efforts within the private sector to develop and demonstrate safe, reliable, and cost-effective space transportation capabilities. In a multi-phase strategy, the program is helping spur the innovation and development of new spacecraft and launch vehicles from the commercial industry, creating a new way of delivering cargo – and possibly crew – to low-Earth orbit and the International Space Station.

As NASA sets its sights on exploring once again beyond low-Earth orbit, the ability for private industry to take on the task of providing routine access to space and the International Space Station is of vital importance. NASA’s Commercial Crew and Cargo Program is the catalyst for this expanding new industry.

The first phase of this strategy is known as Commercial Orbital Transportation Services (COTS). Under COTS, NASA is helping commercial industry develop and demonstrate its 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.

Two companies have funded COTS agreements with NASA: Space Exploration Technologies (SpaceX) and Orbital Sciences Corporation (Orbital). Since their competitive selection, these two companies have been working vigorously to develop technologies and capabilities to complete orbital space flight demonstrations in 2010 and 2011. The International Space Station Program has already purchased future cargo delivery services from both of these companies to resupply the station through 2015.

Orbital Sciences Corporation

Just 100 miles up the coast from where the Wright brothers first flew their airplane at Kitty Hawk, North Carolina, Orbital is planning to launch its new COTS system at the Mid-Atlantic Regional Spaceport (MARS), located at NASA’s Wallops Flight Facility in Virginia. Founded in 1982 with the goal of making space technology more affordable, accessible, and useful, Orbital has grown to become a leading developer and manufacturer of space and rocket systems. Orbital’s COTS system design is based on the new Taurus II rocket with a liquid oxygen (LOX)/kerosene (RP-1) first stage powered by two Aerojet AJ-26 engines. The Taurus II second stage is ATK’s Castor 30 solid propellant motor derived from their flight-proven Castor 120. The spacecraft, known as Cygnus, is derived from Orbital’s heritage DAWN and STAR spacecraft projects and International Space Station pressurized cargo carriers.

Space Exploration Technologies (SpaceX)

At Florida’s Cape Canaveral, within sight of where every NASA human spaceflight mission has launched, SpaceX is planning to launch its new COTS system. Established in 2002, SpaceX is well into the development of a new family of launch vehicles, and has already established an extensive launch manifest. SpaceX is based on the philosophy that simplicity, low cost, and reliability go hand in hand. SpaceX personnel have a rich history of launch vehicle and engine experience, and are developing their Dragon cargo and crew capsule and the Falcon family of rockets from the ground up, including main- and upper-stage engines, cryogenic tank structure, avionics, guidance and control software, and ground support equipment. In December 2010, SpaceX completed the first COTS demonstration mission and became the first commercial company in history to successfully launch and recover a spacecraft to and from low-Earth orbit.

Media Assistance

NASA Television and Internet

The digital NASA Television system provides higher quality images and better use of satellite bandwidth, meaning multiple channels from multiple NASA program sources at the same time.

Digital NASA TV has the following four digital channels:

1. NASA Public Channel (“Free to Air”), featuring documentaries, archival programming, and coverage of NASA missions and events.
2. NASA Education Channel (“Free to Air/Addressable”), dedicated to providing educational programming to schools, educational institutions and museums.
3. NASA Media Channel (“Addressable”), for broadcast news organizations.
4. NASA Mission Channel (Internal Only), provides high-definition imagery from science and human spaceflight missions and special events.

Digital NASA TV channels may not always have programming on every channel simultaneously.

NASA Television Now in High Definition

NASA TV now has a full-time High Definition (HD) Channel available at no cost to cable and satellite service providers. Live coverage of space shuttle missions; on-orbit video of Earth captured by astronauts aboard the International Space Station; and rocket launches of advanced scientific spacecraft are among the programming offered on NASA HD. Also available are imagery from NASA’s vast array of space satellites, as well as media briefings, presentations by expert lecturers, astronaut interviews and other special events, all in the improved detail and clarity of HD.

Getting NASA TV via satellite (AMC3 Transponder 15C)

In continental North America, Alaska and Hawaii, NASA Television’s Public, Education, Media and HD channels are MPEG-2 digital C-band signals carried by QPSK/DVB-S modulation on satellite AMC-3, transponder 15C, at 87 degrees west longitude. Downlink frequency is 4000 MHz, horizontal polarization, with a data rate of 38.86 Mhz, symbol rate of 28.1115 Ms/s, and 3/4 FEC. A Digital Video Broadcast (DVB) compliant Integrated Receiver Decoder (IRD) is needed for reception.

Effective Sept. 1, 2010, NASA TV changed the primary audio configuration for each of its four channels to AC-3, making each channel’s secondary audio MPEG 1 Layer II.

For NASA TV downlink information, schedules and links to streaming video, visit **http://www.nasa.gov/ntv**

Television Schedule

A schedule of key mission events and media briefings during the mission will be detailed in a NASA TV schedule posted at the link above. The schedule will be updated as necessary and will also be available at **http://www.nasa.gov/multimedia/nasatv/mission_schedule.html**

Status Reports

Status reports and timely updates on launch countdown, mission progress, and landing operations will be posted at: **http://www.nasa.gov/shuttle**

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**
or
http://www.nasa.gov/newsinfo/index.html

Information on the International Space Station is available at: **http://www.nasa.gov/station**

The NASA Human Space Flight Web contains an up-to-date archive of mission imagery, video and audio at: **http://spaceflight.nasa.gov**

Resources for educators can be found at: **http://education.nasa.gov**

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