National Aeronautics and Space Administration

SPACE SHUTTLE MISSION

STS-128

Racking Up New Science

PRESS KIT/AUGUST 2009

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CONTENTS

STS-128 MISSION OVERVIEW

The STS-128 crew members take a break during a training session in the Space Vehicle Mockup Facility at NASA's Johnson Space Center. From the left are astronauts Rick Sturckow, commander; Patrick Forrester, European Space Agency (ESA) astronaut Christer Fuglesang, astronauts Nicole Stott, Jose Hernandez, John "Danny" Olivas, all mission specialists; and Kevin Ford, pilot. Stott is scheduled to join Expedition 20 as flight engineer after launching to the International Space Station with the STS-128 crew.

On the heels of the completion of the Japanese segment of the International Space Station, the shuttle Discovery is poised to blast off on a 13-day mission to deliver more than 7 tons of supplies, science racks and equipment, as well as additional environmental hardware to sustain six crew members on the orbital outpost.

Led by veteran shuttle Commander Rick Sturckow (STUR-coe) (Col., USMC), 48, Discovery is set for launch no earlier than 1:36:02 a.m. EDT Aug. 25 from Launch Pad 39-A at the Kennedy Space Center. This will be Sturckow's fourth flight into space. Kevin Ford (Col., USAF, ret.), 49, will serve as Discovery's pilot in his first flight into space. Patrick Forrester (Col., USA, ret.), 52, is making his third flight into space. The flight engineer for launch and landing is Jose Hernandez, 47. The son of an itinerant Mexican farming family, he did not learn English until he was 12 years old. Hernandez, on his first flight, will be involved in cargo transfer operations and the operation of the shuttle's robotic arm. Lead spacewalker John "Danny" Olivas (oh-LEE-vuhs), 44, is making his second flight into space, having also flown with Sturckow on his previous mission. Olivas will participate in all three of the mission's spacewalks. Christer Fuglesang (FYU-gel-sang) of the European Space Agency, 52, will conduct two spacewalks with Olivas in his second flight into space.

They are joined by NASA's Nicole Stott, 46, a former processing director for the shuttle Endeavour at the Kennedy Space Center, who replaces NASA astronaut Tim Kopra (CO-prah) (Col., USA), 46, as a long-duration crew member on the space station and a member of the Expedition 20 and 21 crews. Stott, who will conduct the mission's first spacewalk with Olivas, is scheduled to spend three months on the complex while Kopra returns home aboard Discovery. Stott plans to return in November on the shuttle Atlantis as part of the STS-129 crew.

The day after launch, Ford, Forrester and Hernandez will take turns at Discovery's aft flight deck as they maneuver the shuttle's robotic arm to reach over to the starboard sill of the orbiter to grapple the Orbiter Boom Sensor System, a 50-foot-long crane extension. The extension is equipped with sensors and lasers that will be used in the traditional daylong scan of Discovery's thermal protection heat shield and the reinforced carbon-carbon on the leading edges of the shuttle's wings. This initial inspection of the heat shield will provide imagery experts on the ground a close-up look at the tiles and blankets on the shuttle's skin to determine if the shuttle is ultimately safe to re-enter the Earth's atmosphere. A follow-up inspection will take place after Discovery undocks from the station.

While the inspection takes place, Olivas, Fuglesang and Stott will prepare the spacesuits they will wear for the three spacewalks to be conducted out of the Quest airlock at the station. Other predocking preparations will occupy the remainder of the crew's workday.

The following day, on the third day of the flight, Discovery will be flown by Sturckow and Ford on its approach for docking to the station. After a series of jet firings to fine-tune Discovery's path to the complex, the shuttle will arrive at a point about 600 feet directly below the station about an hour before docking. At that time, Sturckow will execute a one-degree-per-second rotational "backflip" to enable Expedtion 20 Commander Gennady Padalka and Flight Engineer Mike Barratt, using digital cameras with 400 and 800 millimeter lenses, to snap hundreds of detailed photos of the shuttle's heat shield and other areas of potential interest – another data point for imagery analysts to pore over in determining the health of the shuttle's thermal protection system.

Astronaut Nicole Stott, STS-128 mission specialist, attired in a training version of her Extravehicular Mobility Unit (EMU) spacesuit, is pictured during 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 Stott in her rehearsal, intended to help prepare her for work on the exterior of the International Space Station.

Once the rendezvous pitch maneuver is completed, Sturckow will fly Discovery to a point about 600 feet in front of the station before slowly closing in for a linkup to the forward docking port on the Harmony module. Less than two hours later, hatches will be opened between the two spacecraft to begin almost nine days of work between the two crews.

Discovery's arrival at the station two days after launch will again place 13 crew members on the complex. The shuttle crew will join Padalka of Russia, and flight engineers Barratt and Kopra of NASA, Roman Romanenko of Russia, Bob Thirsk of the Canadian Space Agency and Frank De Winne of the European Space Agency.

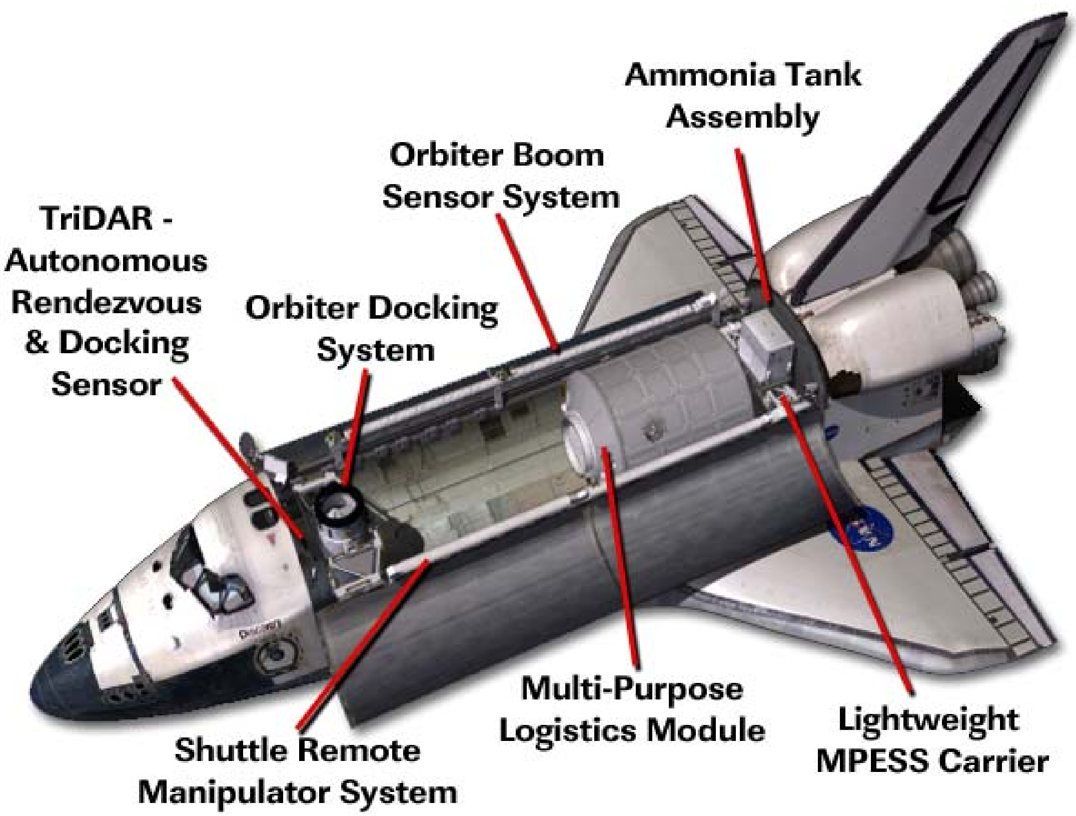
Aside from the delivery of Stott to join the station crew, the primary objective of the flight will be the transfer of the science and environmental racks to the complex to mark a quantum leap in the scientific capability of the orbital laboratory.

Housed for the ride to the station in the Leonardo Multi-Purpose Logistics Module in Discovery's payload bay are the Materials Science Research Rack (MSRR-1), the Minus Eighty Degree Laboratory Freezer for ISS (MELFI) and the Fluids Integration Rack (FIR). MSRR-1 will be used for basic materials research related to metals, alloys, polymers, semiconductors, ceramics, crystals and glasses in the microgravity environment. MELFI will be used for long-term storage of experiment samples that are to be returned to Earth for detailed analysis. The FIR is a fluid physics research facility designed to host investigations in areas such as colloids, gels, bubbles, wetting and capillary action, and phase changes, including boiling and cooling.

Attired in training versions of their shuttle launch and entry suits, astronauts Rick Sturckow (center), STS-128 commander; Patrick Forrester (left) and European Space Agency (ESA) astronaut Christer Fuglesang, both mission specialists, listen as a crew trainer (out of frame) briefs the crew in preparation for a training session in the Space Vehicle Mockup Facility at NASA's Johnson Space Center.

Leonardo, which serves as a large moving van for supplies and equipment back and forth from the station, also is carrying a new crew quarters to provide more sleeping space for the expanded station crew members and a new exercise device called the Combined Operational Load Bearing External Resistance Treadmill, or COLBERT, coined after late-night cable entertainment personality Stephen Colbert. COLBERT will be transferred to a temporary location in the Harmony node, but will ultimately reside in the new Node 3 module – Tranquility – that will be launched to the station in 2010 as a final connecting point for other modules on the U.S. segment of the complex, including the Cupola, a multi-windowed module to provide a vista-like view of the universe. COLBERT will not be checked out and activated until later this year.

In addition to the new treadmill, also referred to as "T2," the crew will transfer a new Air Revitalization System (ARS) rack to the station for use in Tranquility to maintain a pristine environment for the expanded six-person crew on the outpost. The system includes another carbon dioxide removal system bed similar to the Carbon Dioxide Removal Assembly (CDRA) that resides in the U.S. Destiny laboratory. The rack will be temporarily stowed in the Japanese segment of the station until Tranquility is in place to accept it on a permanent basis.



If the CDRA is operating when Discovery arrives at the station, the new ARS rack will be temporarily stowed in the Japanese Kibo module and not activated until it is installed in Tranquility next year. If a problem develops with the CDRA, however, the new rack could be temporarily installed in the Destiny lab in place of the current CDRA and activated to assist in the removal of carbon dioxide.

Ford and Barratt will hoist Leonardo out of Discovery's cargo bay using the station's Canadarm2 robotic arm on the fourth day of the flight and will berth it to the Earth-facing port on the Harmony module. Once leak checks are performed, the hatch to Leonardo will be opened to mark the start of transfer operations that will be supervised by Fuglesang and Hernandez.

Three spacewalks will be conducted on flight days 5, 7 and 9 during the docked phase of the mission.

Astronaut John "Danny" Olivas, STS-128 mission specialist, dons a training version of his Extravehicular Mobility Unit (EMU) spacesuit before being submerged in the waters of the Neutral Buoyancy Laboratory (NBL) near NASA's Johnson Space Center. Astronaut Jose Hernandez, mission specialist, assists Olivas.

The first spacewalk will see Olivas, who conducted two spacewalks on STS-117, and Stott venture outside to remove an empty ammonia tank from the port 1 (P1) truss of the station. The tank, which itself weighs about 1,800 pounds, contains 600 pounds of ammonia to provide the proper cooling for the thermal control system in the truss. Ammonia in the tank flows in the truss' Pump Module Assembly, which is the heart of the thermal control system. Olivas will work in tandem with Stott to remove the used tank that will be grappled by the Canadarm2 through a fixed grapple bar. The grapple bar will be attached to the tank before it is parked on a cargo carrying platform in Discovery's payload bay for the trip home. The tank that will be removed still will contain about 200 pounds of ammonia but is considered used and ready for replacement.

Olivas and Stott also will remove two experiments from the hull of the European Columbus module during the first spacewalk. The European Technology Exposure Facility, or EuTEF, was installed during the STS-122 mission in February 2008. EuTEF is a suite of nine experiments designed to collect data during its lengthy stay in the microgravity environment. The spacewalkers also will remove a materials science experiment called Materials International Space Station Experiment (MISSE), a device resembling an open suitcase that enables a variety of experiments to be exposed to the space environment. This latest in the series of MISSE experiments was moved to the outside of Columbus from a prior location on the station during the STS-123 mission in March 2008.

Olivas will be joined by Fuglesang for the second spacewalk. Fuglesang conducted three spacewalks on his first mission, STS-116. This excursion will be exclusively devoted to installing a new Ammonia Tank Assembly on the P1 truss and stowing the empty tank on the cargo carrying platform in Discovery's payload bay.

Olivas and Fuglesang team up for the final spacewalk two days later to begin preparations for the arrival of the Tranquility connecting module, Node 3, and its Cupola viewing port scheduled for launch next year.

Astronaut Jose Hernandez, STS-128 mission specialist, uses the virtual reality lab in the Space Vehicle Mockup Facility at NASA's Johnson Space Center to train for some of his duties aboard the space shuttle and space station. This type of computer interface, paired with virtual reality training hardware and software, helps to prepare the entire team for dealing with space station elements.

The spacewalkers will begin by completing a task that could not be accomplished during the STS-127 mission; i.e., the deployment of a payload attachment bracket on the starboard truss to which several critical spare parts will be attached during the STS-129 mission later this year. Next, Olivas and Fuglesang will route avionics systems cables from the S0 truss at the midpoint of the station's backbone to the port side of the complex where Tranquility will be permanently attached. After that, they will rig cables for heaters that will keep the berthing port warm on the port side of the Unity connecting module to which Tranquility will be mated.

They will replace a failed component on the S0 truss called a rate gyro assembly that works with the station's Global Positioning System (GPS) hardware to tell the station what its orientation is in relation to the Earth, replace a faulty power control module on the S0 that is used to route electricity to various components inside the complex and install two new GPS antennas on the S0 truss.

On the following day, flight day 10, the crew will enjoy some off-duty time and complete transfer operations before closing the hatch to Leonardo on flight day 11 so it can be unberthed from Harmony and returned to Discovery's payload bay. Ford and Hernandez will operate Canadarm2 from the robotics workstation on the station to demate Leonardo from its temporary parking spot and lower it onto latches in the shuttle's cargo bay.

Once the cargo module is berthed in Discovery, the two crews will say goodbye to one another and close the hatches between the shuttle and station to set the stage for undocking.

With Ford at the controls on flight day 12, Discovery will separate from the station. He will slowly back the shuttle away to a distance of about 400 feet from the station. At that point, he will conduct a radial flyaround of the complex before firing jets to depart the vicinity of the outpost.

With undocking complete, Ford, Forrester and Hernandez will use the shuttle's robotic arm and its Orbiter Boom Sensor System extension to conduct a "late" inspection of the orbiter's thermal heat shield – one more opportunity to ensure that it is in good shape to support landing.

Sturckow, Ford and Hernandez will conduct the traditional checkout of the shuttle's flight control systems and steering jets on flight day 13, setting Discovery up for its supersonic return to Earth on flight day 14. A special recumbent seat will be set up in the shuttle's lower deck for Kopra to ease his reorientation to a gravity environment for the first time in almost two months.

Finally, weather permitting, Sturckow and Ford will guide Discovery to a landing at the Kennedy Space Center on the evening of Sept. 6 to wrap up the 37th flight for the shuttle's fleet leader, the 128th mission in shuttle program history and the 30th shuttle visit to the International Space Station.

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TIMELINE OVERVIEW

Flight Day 1

- Launch
- Payload Bay Door Opening
- Ku-Band Antenna Deployment
- Shuttle Robotic Arm Activation and payload bay survey
- Umbilical Well and Handheld External Tank Photo and TV Downlink

Flight Day 2

- Discovery's Thermal Protection System Survey with Shuttle Robotic Arm/Orbiter Boom Sensor System (OBSS)
- Extravehicular Mobility Unit Checkout
- Centerline Camera Installation
- Orbiter Docking System Ring Extension
- Orbital Maneuvering System Pod Survey
- Rendezvous tools checkout

Flight Day 3

- Rendezvous with the International Space Station
- Rendezvous Pitch Maneuver Photography of Discovery's Thermal Protection System by Barratt and De Winne of the Expedition 20 Crew
- Docking to Harmony/Pressurized Mating Adapter-2
- Hatch Opening and Welcoming
- Stott and Kopra exchange Soyuz seatliners; Stott joins Expedition 20, Kopra joins the STS-128 crew

Flight Day 4

- Unberthing of the Leonardo Multi-Purpose Logistics Module (MPLM) from Discovery's cargo bay and installation on the Earth-facing port of the Harmony node
- Leonardo systems activation and hatch opening
- Spacewalk 1 Procedure Review
- Spacewalk 1 Campout in Quest airlock by Olivas and Stott

Flight Day 5

- Spacewalk 1 by Olivas and Stott (Preparation of P1 Truss Ammonia Tank Assembly for removal, EuTEF and MISSE experiment removal from the Columbus module)
- Rack transfers from Leonardo to the station; transfer of the COLBERT treadmill from Leonardo to the space station

Flight Day 6

- Focused inspection of Discovery's thermal heat shield by the shuttle robotic arm/OBSS, if necessary
- Rack and cargo transfers from Leonardo to the station

- Spacewalk 2 Procedure Review
- Spacewalk 2 Campout in Quest airlock by Olivas and Fuglesang

Flight Day 7

- Spacewalk 2 by Olivas and Fuglesang (Completion of Ammonia Tank Assembly swapout on P1 truss)
- Cargo transfer from Leonardo to space station

Flight Day 8

- Crew off-duty time
- Joint Crew News Conference
- Cargo transfer from Leonardo to the station
- Spacewalk 3 Procedure Review
- Spacewalk 3 Campout in Quest airlock by Olivas and Fuglesang

Flight Day 9

- Spacewalk 3 by Olivas and Fuglesang (Routing avionics cables for Tranquility Node 3 installation, replacement of Rate Gyro Assembly on the S0 truss, installation of two GPS antennas on the S0 truss)
- Cargo transfer from Leonardo to the station

Flight Day 10

- Cargo transfer from Leonardo to the station
- Crew off-duty time

Flight Day 11

- Final transfers
- Leonardo egress and systems deactivation
- Leonardo demating from Earth-facing port on Harmony node and berthing back in Discovery's cargo bay
- Farewells and Hatch Closure
- Rendezvous tools checkout

Flight Day 12

- Discovery undocking from station
- Flyaround of station and final separation
- Late inspection of Discovery's thermal protection system with the OBSS

Flight Day 13

- Flight Control System Checkout
- Reaction Control System hot-fire test
- Crew Deorbit Briefing
- Cabin Stowage
- Recumbent Seat Setup for Kopra

Flight Day 14

- Deorbit preparations
- Payload Bay Door closing
- Deorbit burn
- KSC Landing

MISSION PROFILE

CREW

Commander:	Rick Sturckow
Pilot:	Kevin Ford
Mission Specialist 1:	Patrick Forrester
Mission Specialist 2:	Jose Hernandez
Mission Specialist 3:	Danny Olivas
Mission Specialist 4:	Christer Fuglesang
Mission Specialist 5:	Nicole Stott (Up)
Mission Specialist 5:	Tim Kopra (Down)

LAUNCH

Orbiter:	Discovery (OV-103)
Launch Site:	Kennedy Space Center Launch Pad 39A
Launch Date:	No Earlier Than Aug. 25, 2009
Launch Time:	1:36:02 a.m. EDT (Preferred In-Plane launch time for 8/25)
Launch Window:	3 minutes
Altitude:	122 Nautical Miles (140 Miles) Orbital Insertion; 188 NM (213 Miles) Rendezvous
Inclination:	51.6 Degrees
Duration:	12 Days 19 Hours 04 Minutes

VEHICLE DATA

Shuttle Liftoff Weight:	4,522,852 pounds
Orbiter/Payload Liftoff Weight:	267,689 pounds
Orbiter/Payload Landing Weight:	225,860 pounds
Software Version:	OI-34

Space Shuttle Main Engines:

SSME 1:	2052
SSME 2:	2051
SSME 3:	2047
External Tank:	ET-132
SRB Set:	BI-139
RSRM Set:	107

SHUTTLE ABORTS

Abort Landing Sites

RTLS:	Kennedy Space Center Shuttle Landing Facility
TAL:	Primary – Zaragoza, Spain. Alternates – Moron, Spain and Istres, France
AOA:	Primary – Kennedy Space Center Shuttle Landing Facility. Alternate – White Sands Space Harbor

LANDING

Landing Date:	No Earlier Than Sept. 6, 2009
Landing Time:	8:40 p.m. EDT
Primary landing Site:	Kennedy Space Center Shuttle Landing Facility

PAYLOADS

Multi-Purpose Logistics Module (MPLM), Leonardo; Lightweight Multi-Purpose Carrier (LMC) with Ammonia Tank Assembly (ATA)

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MISSION OBJECTIVES

MAJOR OBJECTIVES

1. Dock Discovery to the International Space Station's Pressurized Mating Adaptor-2 port and perform mandatory crew safety briefing for all crew members.

2. Berth Multi-Purpose Logistics Module (MPLM) to the station's nadir port on the Harmony module using the station robotic arm, activate and check out MPLM.

3. Transfer mandatory quantities of water from Discovery to the space station.

4. Rotate Expedition 20 crew member Tim Kopra with Expedition 20/21 Flight Engineer Nicole Stott, transfer mandatory crew rotation equipment and perform mandatory tasks consisting of customized seatliner install and Sokol suit checkout.

5. Transfer and install Node 3 Air Revitalization System (ARS) rack.

6. Transfer Treadmill-2 (T2) rack and associated system components to the station and temporarily install in interim rack location.

7. Transfer and stow critical items.

8. Transfer and install remaining MPLM racks to the space station.

   – Deck Crew Quarters

   – Minus Eighty-Degree Laboratory Freezer for ISS-2 (MELFI-2)

   – Fluids Integration Rack (FIR)

   – Materials Science Research Rack (MSRR)

9. Transfer, remove, and replace Ammonia Tank Assembly (ATA) from the Lightweight Multi-Purpose Experiment Support Structure (MPESS) Carrier (LMC) to the P1 site using the station robotic arm.

10. Return empty P1 ATA to the LMC using the station robotic arm.

11. Return MPLM to Discovery's payload bay using the station robotic arm.

12. Transfer European Technology Exposure Facility (EuTEF)/Flight Support Equipment (FSE) Integrated Assembly (IA) from the station's Columbus Exposed Payload Facility (EPF) to the LMC using the station robotic arm.

13. Perform minimum crew handover of 12 hours per rotating crew member including crew safety handover.

14. Transfer Materials International Space Station Experiment (MISSE) 6a and 6b Passive Experiment Containers from the station's Columbus EPF to the Discovery's cargo bay using the station robotic arm.

15. Transfer remaining cargo items.

16. Remove and replace the S0 Rate Gyro Assembly (RGA).

17. Perform additional Node 3 (Tranquility) prep tasks.

    – Pre-route external channel 1/4 power and data cable and channel 2/3 power and data cables from S0 panel across Destiny to (Node 1) Unity.

    – Temporarily connect Node 1 port/PMA3 heater umbilical and install grounding on Node 1 nadir launch-to-activation connector.

    – Remove and replace RPCM S0-1A-D.

    – Remove Node 1 slidewire.

    – Reposition Zarya LAN connector on Node 1 port.

18. Perform Hydrogen ORU Calibration Kit (HOCK) verification on the OGS pressure sensor.

19. Perform daily station payload status checks as required.

20. Perform daily middeck activities to support payloads.

21. Perform station payload research operations tasks.

22. Remove MPLM Baseplate Ballast Assemblies (BBAs) and Lamp Housing Assemblies (LHAs) and transfer to the space station. If required, install the failed space station BBAs/LHAs back into MPLM.

23. Perform crew quarters outfitting and activation as required to support minimal crew habitation.

24. Perform TriDAR Automated Rendezvous and Docking Sensor DTO-701A activities.

25. Perform an additional four hours per rotating crew member of station crew handover (16 hours per crew member total).

26. The following spacewalk tasks are deemed to fit within the existing timelines; however, they may be deferred if the spacewalk is behind schedule. The spacewalk will not be extended to complete these tasks.

    – Install Global Positioning System AA No. 2 and No. 4 on S0

    – Install Node 1 micrometeoroid orbital debris shield

    – Install the station arm camera lens cover on Latching End Effector B wrist camera

27. Transfer oxygen from Discovery to the station airlock high-pressure gas tanks.

28. Perform water sampling for return for ground testing.

29. Perform program-approved intravehicular activity get-ahead tasks. The following intravehicular activity get-ahead tasks do not fit in the existing timelines; however, the team will be trained and ready to perform should the opportunity arise.

    – Complete remainder of crew quarters outfitting and activation as required to support full crew habitation

    – Perform Node 1 port bulkhead feed-through modifications (for 20A)

        – Potable Water (J33)

        – Waste Water (J30)

        – ARS Air Sample (J40)

        – Nitrogen (J44)

        – Oxygen (J45)

    – Perform coarse leaks checks of Node 1 port bulkhead feed-throughs using PMA-3 partial depressurization.

30. Perform program-approved spacewalk get-ahead tasks. The following get-ahead tasks do not fit in the existing spacewalk timelines; however, the spacewalk team will be trained and ready to perform should the opportunity arise.

    – Tuck down Lab/Node 2 cables.

    – Install a gap spanner on Node 2.

    – Relocate Fixed Grapple Bar in preparation of 19A ATA R&R.

    – Install Bootie/Grounding Connector Sleeves (launch in 17A MPLM).

    – Install station arm camera lens cover on station arm's elbow camera.

31. Perform payload of opportunity operations to support Shuttle Ionospheric Modification with Pulsed Localized Exhaust Experiments, Maui Analysis of Upper Atmospheric Injections (MAUI) and Shuttle Exhaust Ion Turbulence Experiments (SEITE).

32. Reboost the space station with the shuttle if mission resources allow and are consistent with station trajectory analysis and planning.

33. Perform imagery survey of the station exterior during orbiter flyaround after undock.

34. Perform SDTO 13005-U, ISS Structural Life Validation and Extension, during shuttle mated reboost.

35. Perform SDTO 13005-U, ISS Structural Life Validation and Extension, during 17A shuttle undocking, if crew time available.

36. Perform SDTO 13005-U, ISS Structural Life Validation and Extension for MPLM Berthing and Unberthing.

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MISSION PERSONNEL

KEY CONSOLE POSITIONS FOR STS-128 (DISCOVERY)

	Flt. Director	CAPCOM	PAO
Ascent	Richard Jones	Eric Boe TBD (Wx)	Rob Navias
Orbit 1 (Lead)	Tony Ceccacci	Chris Ferguson Tony Antonelli	Rob Navias
Orbit 2	Kwatsi Alibaruho	Stan Love	Josh Byerly
Planning	Gary Horlacher	Shannon Lucid	Nicole Cloutier
Entry	Richard Jones	Eric Boe TBD (Wx)	Rob Navias
Shuttle Team 4	Mike Sarafin	N/A	N/A
ISS Orbit 1	Ron Spencer	Chris Zajac	N/A
ISS Orbit 2 (Lead)	Heather Rarick	Robert Hanley	N/A
ISS Orbit 3	Royce Renfrew	Mike Jensen	N/A
Station Team 4	Derek Hassmann		

JSC PAO Representative at KSC for Launch – Lynnette Madison

KSC Launch Commentator – Mike Curie

KSC Launch Director – Pete Nickolenko

NASA Launch Test Director – Charlie Blackwell-Thompson

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STS-128 DISCOVERY CREW

The STS-128 patch symbolizes the 17A mission and represents the hardware, people and partner nations that contribute to the flight. The space shuttle Discovery is shown in the orbit configuration with the Multi-Purpose Logistics Module (MPLM) Leonardo in the payload bay. Earth and the International Space Station wrap around the Astronaut Office symbol reminding us of the continuous human presence in space. The names of the STS-128 crew members border the patch in an unfurled manner. Included in the names is the expedition crew member who will launch on STS-128 and remain on board the station, replacing another Expedition crew member who will return home with STS-128. The banner also completes the Astronaut Office symbol and contains the U.S. and Swedish flags representing the countries of the STS-128 crew.

Attired in training versions of their shuttle launch and entry suits, these seven astronauts take a break from training to pose for the STS-128 crew portrait. Seated are NASA astronauts Rick Sturckow (right), commander; and Kevin Ford, pilot. From the left (standing) are astronauts Jose Hernandez, John "Danny" Olivas, Nicole Stott, European Space Agency's Christer Fuglesang and Patrick Forrester, all mission specialists. Stott is scheduled to join Expedition 20 as flight engineer after launching to the International Space Station on STS-128.

Short biographical sketches of the crew follow with detailed background available at:

http://www.jsc.nasa.gov/Bios/

STS-128 CREW BIOGRAPHIES

Frederick Sturckow

Frederick Sturckow, a colonel in the U.S. Marine Corps, will lead the crew of STS-128. He served as pilot on STS-88 in 1998 (first International Space Station assembly mission) and STS-105 in 2001, and as commander of STS-117 in 2007. Sturckow has overall responsibility for the safety and execution of the mission, orbiter systems operations and flight operations, including landing. He also will fly Discovery through its rendezvous and docking to the International Space Station.

Kevin Ford

Astronaut Kevin Ford, a retired U.S. Air Force colonel, will serve as the pilot for Discovery. This will be his first journey into space. Selected by NASA in 2000, he has served in various shuttle technical jobs and as a CAPCOM. He will be responsible for orbiter systems operations, will assist Sturckow with rendezvous, and will fly the orbiter during undocking and the flyaround. He will be the primary operator of the space station robotic arm during docked operations, and will also assist with shuttle robotic operations during the thermal protection system inspections.

Patrick Forrester

Veteran astronaut Patrick Forrester will serve as a mission specialist for the space shuttle Discovery. He will choreograph the three planned spacewalks, as well as participate in robotics operations to inspect Discovery after launch and before re-entry. Forrester flew on STS-105 in 2001 and STS-117 in 2007. He has conducted four spacewalks totaling 25 hours, 22 minutes.

Jose Hernandez

This is the first spaceflight for Jose Hernandez. He was selected as a NASA astronaut in 2004 and completed his initial training in February 2006. He is slated to perform robotic operations to inspect Discovery after launch and assist with cargo transfer from shuttle to station.

Christer Fuglesang

An astronaut with the European Space Agency since 1992, Christer Fuglesang joined NASA in 1996 as a mission specialist. He will conduct two spacewalks with Olivas to assist with installation of a new Ammonia Tank Assembly (ATA) and make preparations for the arrival of the Tranquility connecting module. He will serve as the loadmaster for the Multi-Purpose Logistics Module during the mission. This will be Fuglesang's second spaceflight, the previous being STS-116 in 2006 that installed the P5 spacer truss segment.

Danny Olivas

Astronaut Danny Olivas will serve as the lead spacewalker for this mission. He will participate in all three spacewalks during the mission. Spacewalk tasks include installing a new ATA on the station's Port 1 truss and stowing the empty tank on the cargo carrying platform in Discovery's payload bay, retrieving two experiments from the hull of the European Columbus module and routing power cables for Tranquility (Node 3). Olivas also flew on STS-117 in 2007, which delivered the second starboard truss segment, third set of solar arrays, batteries and associated equipment.

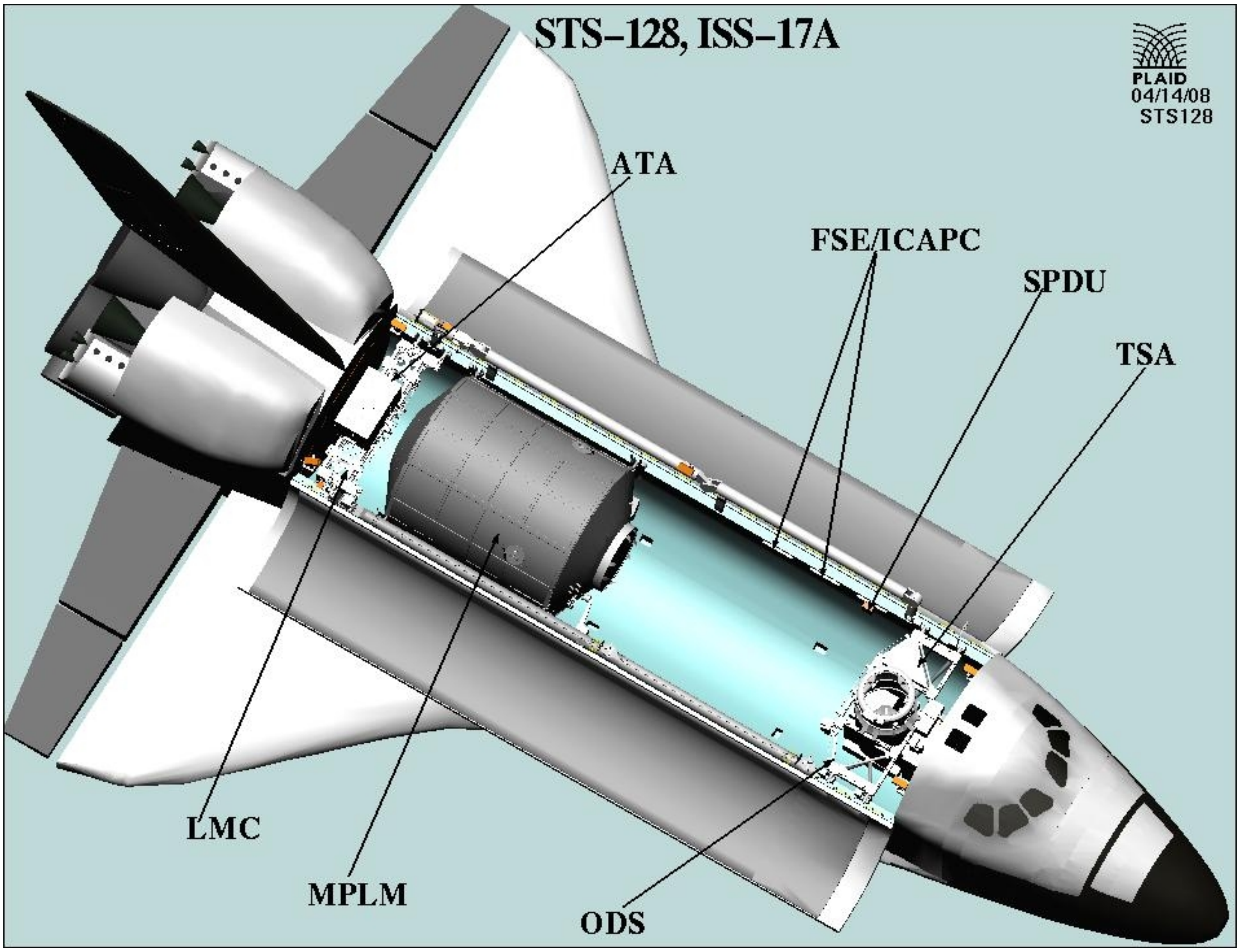
Nicole Stott

This will be the first spaceflight for Nicole Stott who will serve as flight engineer for Expedition 20 and 21 replacing Tim Kopra. Aside from serving as a long-duration crew member, along with Olivas she will conduct the first spacewalk of space shuttle Discovery's mission. Stott was selected as a NASA astronaut in 2000. She has worked technical aspects of station payloads, supported Expedition 10 and has served as a station CAPCOM. Stott will launch with the crew of STS-128 and return on STS-129.

Tim Kopra

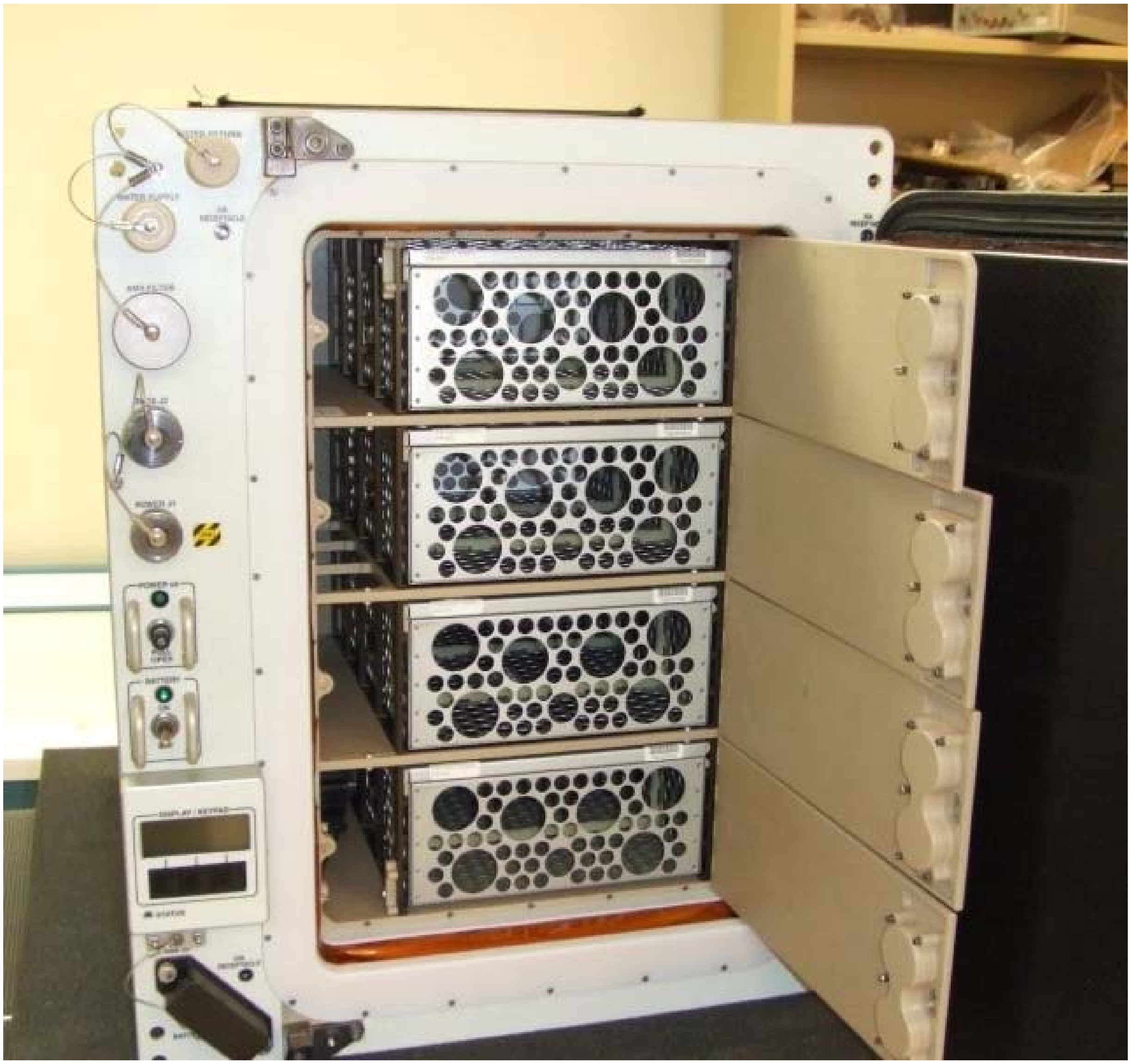
Tim Kopra, a colonel in the Army, has a history at NASA that precedes his joining the astronaut corps. Kopra was assigned to NASA at the Johnson Space Center in September 1998 as a vehicle integration test engineer. In this position, he served as an engineering liaison for space shuttle launch operations and space station hardware testing. He was selected as an astronaut in 2000. Since then, he has completed training at each of the international partner training sites and served as a backup crew member to Expeditions 16 and 17. Kopra launched to the station with the crew of STS-127 to replace Koichi Wakata as the Expedition 20 flight engineer. He will return with the STS-128 shuttle crew.

PAYLOAD OVERVIEW



The space shuttle payload will include the Leonardo Multi-Purpose Logistics Module (MPLM) and the Lightweight Multi-Purpose Experiment Support Structure Carrier (LMC). The total payload weight, not counting the middeck, is 31,694 pounds. The expected return weight is 19,053 pounds.

On the middeck of the space shuttle, it will carry GLACIER, a freezer designed to provide cryogenic transportation and preservation capability for samples. The unit is a double locker equivalent unit capable of transport and operation in the middeck and in-orbit operation in the EXPRESS Rack.



The space shuttle will carry on its middeck (ascent) the following items: GLACIER (Sortie) with refrigerated samples, NLP-Vaccine (Sortie), MDS & Support HDW, HRP Integrated Immune (SDBI 1900), HRP Sleep Short (SDBI 1634) and Sleep Long, JAXA Area Dosimeter (PADLES3), JAXA Space Seed, JAXA Payload Maintenance, JAXA Rad Silk Refrigerated Samples, ESA-CARD, and ESA SOLO. On its return, among the items carried on the middeck will be GLACIER (Sortie) with frozen samples, NLP-Vaccine (Sortie), ESA 3D-Space, Integrated Immune, Lada-VPU P3R root modules and frozen plant samples, HRP ISSMP frozen samples, JAXA Area Dosimeter (PADLES2), JAXA RAD Silk & Microbe refrigerated and frozen samples, and a double coldbag with refrigerated samples.

LEONARDO MULTI-PURPOSE LOGISTICS MODULE (MPLM) FLIGHT MODULE 1 (FM1)

The Leonardo Multi-Purpose Logistics Module (MPLM) is one of three differently named large, reusable pressurized elements, carried in the space shuttle's cargo bay, used to ferry cargo back and forth to the station. The STS-128 flight will be the second to the last time that Flight Module 1 (FM1) will be launched in its full configuration. After STS-128, FM1 will be modified to remove hardware to reduce the weight of the module so that more hardware can be launched on STS-131/Flight 19A. The cylindrical module includes components that provide life support, fire detection and suppression, electrical distribution and computers when it is attached to the station. The cylindrical logistics module acts as a "moving van" for the space station, carrying cargo, experiments and supplies for delivery to support the six-person crew on board the station, and to return spent materials, trash and unneeded hardware to Earth. The MPLM is designed to fit in the space shuttle cargo bay and can take up six bays. Each module is approximately 21 feet long and 15 feet in diameter.

On the STS-128 mission, Leonardo will carry two research racks, four station system racks, seven Resupply Stowage Platforms (RSPs), two Resupply Stowage Racks (RSRs), one Zero Stowage Rack (ZSR) and one Integrated Stowage Platform (ISP) and will include Aft Cone Stowage (first used on STS-126/ Flight Utilization Logistics Flight 2 on Nov. 14, 2008). The aft cone modification allows 12 additional cargo bags which are similar to the size of carry-on suitcases. In the aft endcone, additional Lithium Hydroxide (LiOH) canisters, which support the station's Environmental Control Life Support System (ECLSS), additional Remote Power Control Modules (RPCM), which support the Electrical Power System (EPS), as well as food containers and other hardware to support the crew will be flown.

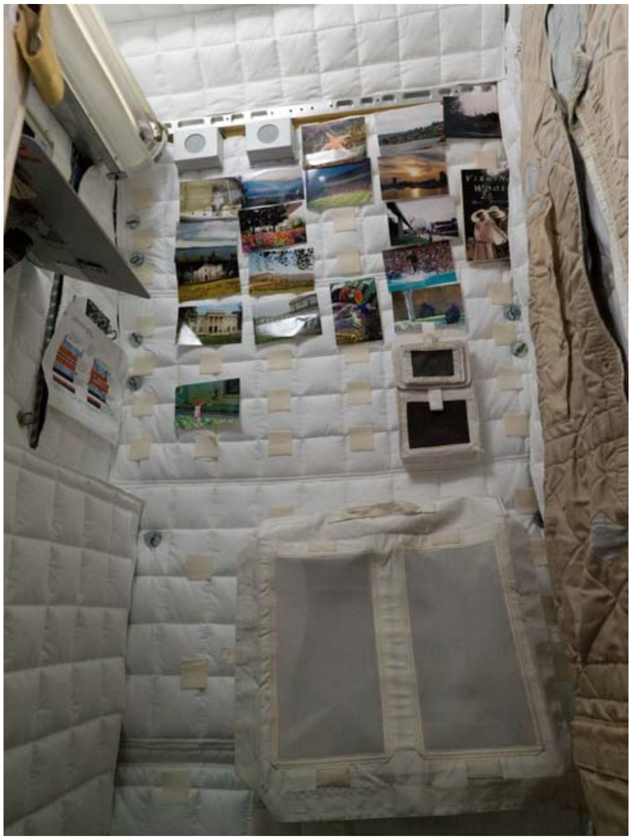
In addition, the sixth set of Materials International Space Station Experiment (MISSE) labeled 6a and 6b will be removed by the spacewalk crew from Columbus and transferred into the MPLM for return to Earth. MISSE is a series of experiments mounted externally on the station that investigate the effects of long-term exposure of materials to the harsh space environment. MISSE 6a and 6b were launched by space shuttle Endeavour during mission STS-123 on March 13, 2008, and contained more than 400 specimens of various materials.

The two research racks carried in Leonardo are: Fluid Integrated Rack (FIR) and Materials Science Research Rack (MSRR). The four station system racks are: Crew Quarters (CQ), Minus Eighty-Degree Laboratory Freezer for ISS-2 (MELFI-2), Node 3 Air Revitalization System Rack (ARS), and Treadmill 2, which was renamed Combined Operational Load Bearing External Resistance Treadmill or COLBERT for short by NASA.

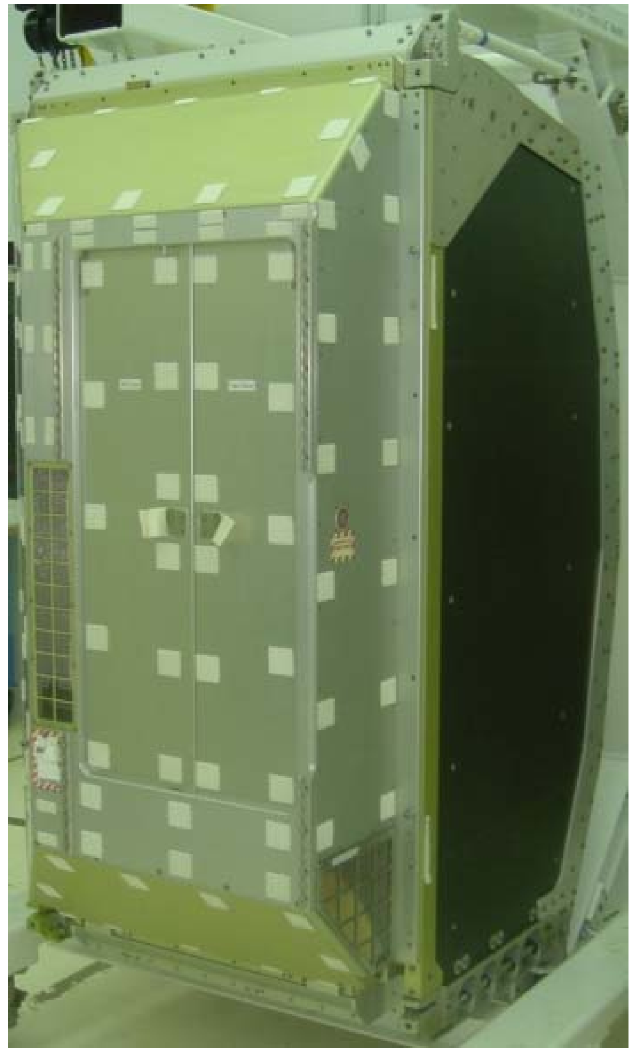
The following are more detailed descriptions on each of these racks:

Crew Quarters (CQ)

The crew quarters delivered on STS-128/17A will be installed in the Japanese Experiment Module (JEM) pressurized module. Two crew quarters are already installed in Node 2 and able to accommodate two crew members. The CQ provides private crew member space with enhanced acoustic noise mitigation, integrated radiation reduction material, controllable airflow, communication equipment, redundant electrical systems, and redundant caution and warning systems. The rack-sized CQ is a system with multiple crew member restraints, adjustable lighting, controllable ventilation, and interfaces that allow each crew member to personalize their CQ workspace.



Crew quarters (interior view)



Crew quarters (exterior view)

Fluids Integrated Rack (FIR)

The Fluids Integrated Rack (FIR) is a complementary fluid physics research facility designed to host investigations in areas such as colloids, gels, bubbles, wetting and capillary action, and phase changes including boiling and cooling. Fluids under microgravity conditions perform differently than those on Earth. Understanding how fluids react in these conditions will lead to improved designs on fuel tanks, water systems and other fluid-based systems.

The FIR features a large user-configurable volume for experiments. The volume resembles a laboratory optics bench. An experiment can be built up on the bench from components, or it can be attached as a self-contained package, or a combination. The FIR provides data acquisition and control, sensor interfaces, laser and white light sources, advanced imaging capabilities, power, cooling, and other resources. Astronauts can quickly mount and set up the experiment with final operations accomplished by remote control from the NASA Glenn Research Center's Telescience Support Center (TSC) in Cleveland or from the principal investigator home institution. The FIR offers the crew members easy access to the back of the optics bench for maintenance and experiment reconfiguration.

Materials Science Research Rack 1 (MSRR-1)

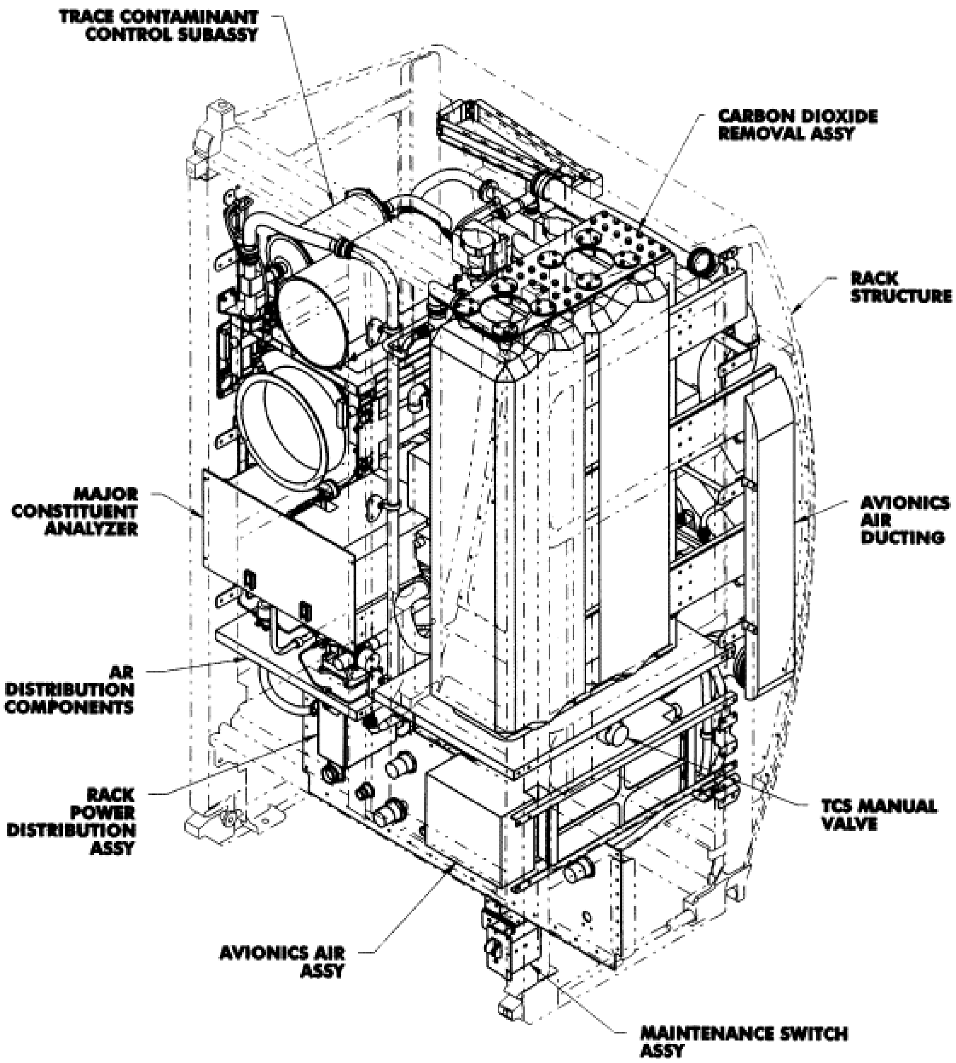
The Materials Science Research Rack-1 (MSRR-1) will be used for basic materials research in the microgravity environment of the station. MSRR-1 can accommodate and support diverse Experiment Modules (EMs). In this way many material types, such as metals, alloys, polymers, semiconductors, ceramics, crystals, and glasses, can be studied to discover new applications for existing materials and new or improved materials. Initially, the MSRR-1 will house the European Space Agency-developed Materials Science Laboratory (MSL) and the Low Gradient Furnace (LFG). Sample cartridge assemblies will be inserted into the furnace and heated, then cooled down to resolidify the sample material free from the effects of gravity. MSRR-1 will be moved by the crew from the MPLM to its rack location in the Destiny laboratory.

Minus Eighty-Degree Laboratory Freezer 2 (MELFI-2)

Minus Eighty-Degree Laboratory Freezer for ISS (MELFI) is a European Space Agency-built, NASA-operated freezer that allows samples to be stored on the station at temperatures as low as -80 degrees centigrade. It comprises four independent dewars which can be set to operate at different temperatures. Each dewar is a cylindrical vacuum-insulated 75-liter container and can accommodate samples of a variety of sizes and shapes. The total capacity of the unit is 300 liters. The first MELFI unit, FU-1, was flown to the station on STS-121, installed in the Destiny laboratory, and commissioned by Thomas Reiter. The MELFI was subsequently relocated to the "Kibo" Japanese Experiment Module. The second one will be installed in the U.S. laboratory.

Node 3 Air Revitalization System Rack (N3 ARS)

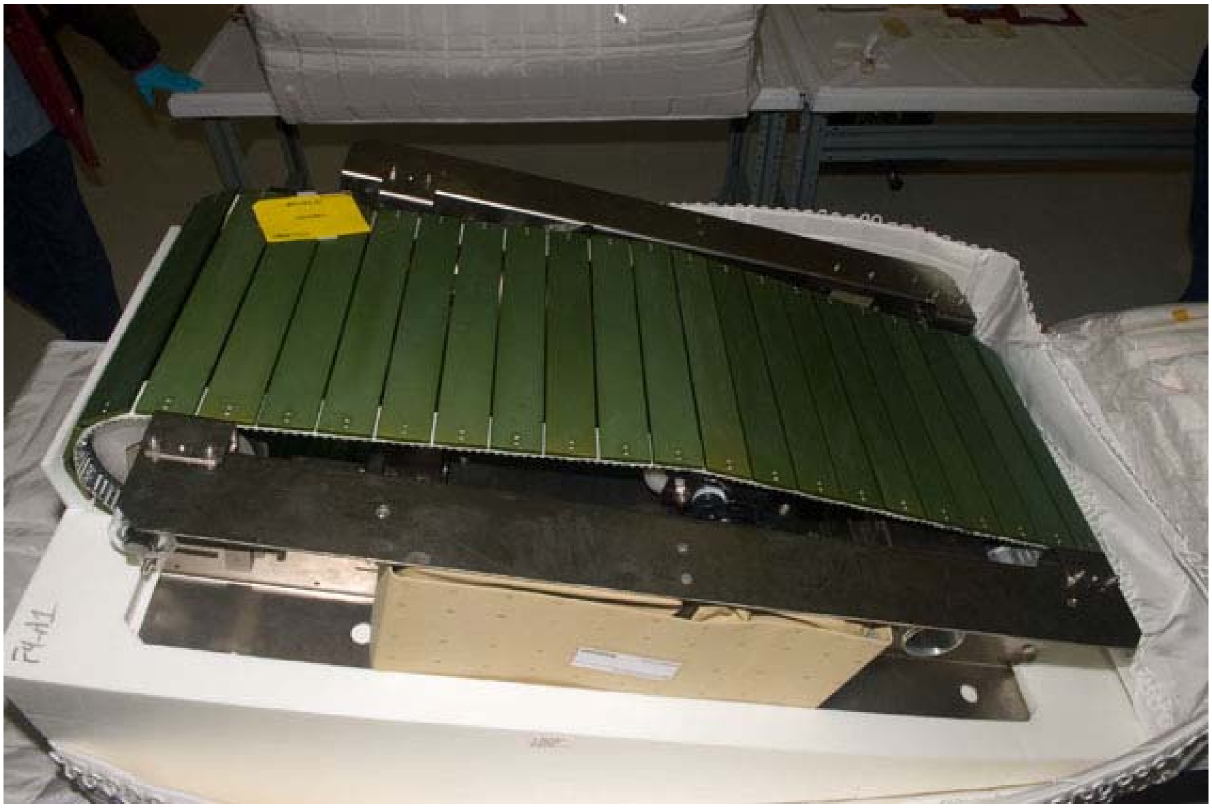
The N3 ARS will provide a Carbon Dioxide Removal Assembly (CDRA) to remove carbon dioxide from the cabin atmosphere in the International Space Station. The rack also contains a Trace Contaminant Control Subassembly (TCCS) that removes potentially hazardous trace contaminants from the cabin atmosphere. The third element contained in the rack is called a Major Constituent Analyzer (MCA), which monitors the cabin atmosphere for major constituents (N_2, O_2, CO_2, CH_4, H_2, and water vapor). The N3 ARS will be temporarily installed in the JEM pressurized module and eventually transferred to Node 3 when it arrives.



AR RACK FRONT ISOMETRIC VIEW

RACK FACEPLATES NOT SHOWN FOR CLARITY

COMBINED OPERATIONAL LOAD BEARING EXTERNAL RESISTANCE TREADMILL (COLBERT)



The Combined Operational Load Bearing External Resistance Treadmill (COLBERT) is packed and prepared for stowage aboard Discovery for its transport to the International Space Station.

Training for future exploration missions is a key goal for the International Space Station Program, and a new treadmill launching on STS-128 will help doctors determine just how important "training" is to humans on long-space journeys.

That's training as in exercise, and treadmill as in COLBERT, or the Combined Operational Load Bearing External Resistance Treadmill, so named for comedian Stephen Colbert of Comedy Central's "The Colbert Report."

The COLBERT will be the second treadmill on the space station, adding to a complement of six different exercise devices already in orbit that range from stationary bicycles to resistive exercise devices. First and foremost, the new treadmill is a critical countermeasure device that will be used to keep the international crew healthy while in orbit, and prepare them for return to Earth.

In addition, the COLBERT will feature data collection devices that will allow doctors and scientists to evaluate how effective the treadmill exercise is in reducing the amount of bone and muscle density loss due to life without gravity. Data on treadmill speed, session duration and body load of each crew member's exercise session will help scientists understand spaceflight-induced physiological changes in the cardiovascular, muscle, bone and sensorimotor systems.

The first experiment to use the COLBERT will be the Functional Task Test (FTT), a multidisciplinary study designed to identify the key underlying physiological factors that contribute to performance of functional tests that are representative of critical mission tasks for lunar and Mars operations. FTT's principal investigator is Jacob Bloomberg of NASA's Johnson Space Center (JSC), Houston.

This is not the first treadmill on the station. Station residents currently are using the Treadmill with Vibration Isolation System (TVIS) that's recessed in the floor of the Zvezda service module. Expedition 20 flight engineers Mike Barratt and Koichi Wakata just performed a complete overhaul of that treadmill to extend its life. Both treadmills will continue to be used, which will nearly double the availability of this critical work-out device for six-person crews.

While the purpose and general functionality of TVIS and COLBERT will be the same, there are a couple of significant differences.

First, the actual treadmill for COLBERT was purchased from Woodway USA, Waukesha, Wis., while TVIS was developed in-house at JSC. The COLBERT and supporting subsystems (power, cooling, etc.) will be housed in an International Standard Payloads Rack (ISPR). The entire assembly will be housed initially in the station's Harmony module, then be moved to the Tranquility module after it is launched in early 2010. Tranquility is a pressurized module that will provide room for many of the space station's life support systems. Attached to the node is a cupola, which is a unique workstation with six windows on the sides and one on top.

Second, the two use different methods to keep the vibrations generated by runners from shaking the sensitive microgravity experiments on the station. TVIS uses an active system of throw masses that sense running forces and "throw" a counterweight in the opposite direction to counteract the vibrations. TVIS also uses some light tethers and a gyroscope. COLBERT was designed to be heavy, so that its inertial mass will be the primary method for dampening the vibrations. The total weight of the COLBERT rack is 2,200 pounds fully configured in orbit. Launch weight is around 1,600 pounds. Individual treadmill weighs about 300 pounds. The entire rack will have a modified Passive Rack Isolation System (PaRIS) that uses two-stage isolators, or springs, to dampen different vibration frequencies.

The main reasons for the different approach were to simplify the system, making it easier and less costly to maintain. The simpler design also is expected to result in higher reliability, making the new treadmill consistently available to the crew, which must work out daily to counteract the loss of bone and muscle density that is a side effect of long-duration stays in orbit. If all goes as expected, the COLBERT will have a five-year service life.

There are a number of COLBERT and TVIS similarities. Both have running surfaces made of aluminum. The COLBERT treadmill surface uses the exact same aluminum as a commercial treadmill, but a rubber coating is stripped off the top of the treads and that aluminum is anodized to provide surface roughness and protection.

Both treadmills meet the payload requirements for vibration isolation. COLBERT and TVIS are very close in most frequencies, but each is able to dampen some frequencies better than the other.

COLBERT's maximum speed is 12.4 miles an hour, but don't expect crew members to run that fast because 12.4 miles an hour is faster than the Olympic 100-meter race record. An average person runs 7- to- 8 miles an hour, and most crew members will run about 4- to- 8 miles an hour.

Another improvement is that COLBERT is designed so that ground experts tracking crew health in orbit can create individual exercise prescriptions and uplink them to the crew as a profile. COLBERT will use the same control interface as that used for the Advanced Resistive Exercise Device (ARED) so that crew members won't have to learn a new interface. The interface is modeled on commercial treadmills and looks nearly identical to what you'd find in many gyms on Earth. The standard rack connection device, the same seat tracks used in Boeing airliners, will provide locations where the crew can mount devices such as laptop computers so they can entertain themselves while exercising.

Each crew member is required to work out a total of two and a half hours a day, about an hour of that on the treadmill. Astronauts are expected to burn between 250 and 500 calories while working out on COLBERT, which has instrumented load cells and three-axis accelerometers that can measure the foot force of running. Ground experts will be able to use this information to determine how well they are being conditioned or losing their deconditioning, and adjust exercise prescriptions accordingly.

Setting up for an exercise session on COLBERT should be fairly simple. The first runner of the day will turn it on by flipping the rack power switch. After waiting a couple minutes for all systems to activate, they'll position the control interface to a location comfortable for them. They'll connect bungee cords to provide a load that will generate the foot force necessary to give the astronaut's bones and muscles a workout in the absence of gravity. They'll put on the harness that connects them to the bungees, set the desired load and verify that they agree with their prescription. Then, they'll log into the system, pick a profile, hit start and go. In the future, a new load system being developed by the European Space Agency will provide highly accurate, continuous force that's closer to a full one-gravity body weight.

The two treadmills provide side benefits for the entire crew, because as humans exercise they respire (breathe) and perspire (sweat) and that moisture is reclaimed by the station's systems that recycle moisture from the station's atmosphere.

NASA chose the acronym COLBERT after the television comedian's campaign for write-in votes to name the next module after himself. NASA chose to name the module Tranquility instead, in honor of the 40th anniversary of the first Apollo landing on the moon. Expedition 14 and 15 astronaut Suni Williams made the announcement on "The Colbert Report" two years after running the Boston Marathon in space.

The COLBERT rack, treadmill and support hardware will launch in the Leonardo Multi-purpose Logistics Module and be transferred to the station on flight day 5. The new workout machine will be set up and used after the shuttle Discovery departs.

MPLM BACKGROUND INFORMATION

Leonardo

The Italian-built, U.S.-owned logistics modules are capable of ferrying more than 7.5 tons (15,000 pounds) of cargo, spares and supplies. This is the equivalent of a semi-truck trailer full of station gear bringing equipment to and from the space station. Return equipment includes container racks with science equipment, science experiments from NASA and its international partners, assembly and spare parts; other return hardware items include completed experiments, system racks, station hardware that needs repair and refuse from the approximately 220-mile-high outpost. Some of these items are for disposal on Earth while others are for analysis and data collection by hardware providers and scientists.

Including STS-128, the MPLMs in total have flown nine times since 2001. This will be the sixth flight for Leonardo. Of the three MPLM modules, only two remain in active service to NASA for future flights. The space shuttle flies logistics modules in its cargo bay when a large quantity of hardware has to be ferried to the orbiting habitat at one time. The modules are attached to the inside of the bay for launch and landing. When in the cargo bay, the module is independent of the shuttle cabin, and there is no passageway for shuttle crew members to travel from the shuttle cabin to the module. After the shuttle has docked to the outpost, typically on the fourth flight day after shuttle launch, Leonardo is mated to the station using the station's robotic arm to the Node 2 nadir port. In the event of a failure or issue which may prevent the successful latching of the MPLM to the nadir port, the Zenith port can be used to mate the MPLM to the station. Nodes are modules that connect the elements to the station, and Unity was the first element to the station to connect the U.S. and Russian segments of the outpost. For its return trip to Earth, Leonardo will be detached from the station and positioned back into the shuttle's cargo bay.

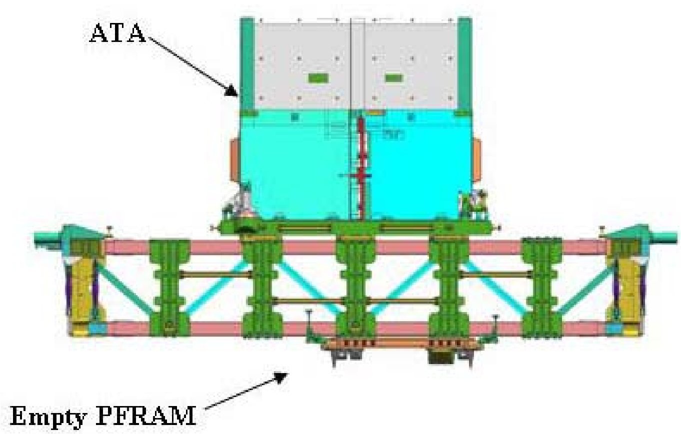
LEONARDO SPECIFICATIONS	
Dimensions:	Length: 21 feet Diameter: 15 feet
Payload Mass (launch):	27,510 lbs
Payload Mass (return):	16,268 lbs
Empty Weight:	9,810 lbs

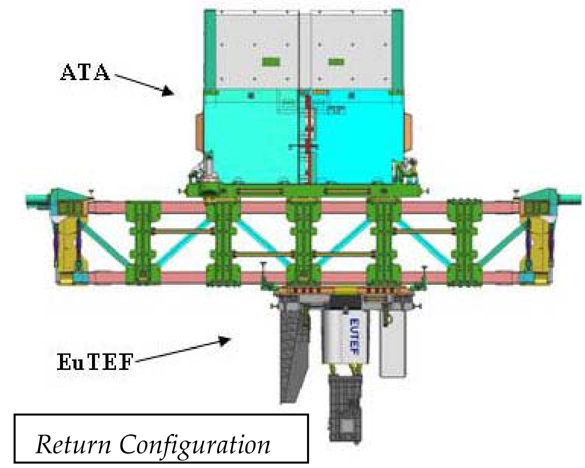
NASA solely owns the modules which were acquired in a bartered agreement between NASA and the Italian Space Agency for using the modules in exchange for allowing the Italians to have crew time on board station.

Leonardo is named after the Italian inventor and scientist Leonardo da Vinci. It was the first MPLM to deliver supplies to the station. The two other modules are named Raffaello, after master painter and architect Raffaello Sanzio, and Donatello, for one of the founders of modern sculpture, Donato di Niccolo Di Betto Bardi. Raffaello has flown three times. Leonardo has flown the most because it is equipped with programmable heater thermostats on the outside of the module that allow for more mission flexibility. Donatello is not currently on the shuttle manifest to fly because of the cost associated with getting the module up to flight status code. There is only one more MPLM flight scheduled on STS-131/19A before the station is complete and space shuttle retires in 2010.

Under its Checkout, Assembly and Payload Processing Services (CAPPS) contract with NASA, Boeing processes every major payload that flies on all space shuttle flights, and the team performs all aspects of payload support, including the planning and receiving of payloads, payload processing, maintenance of associated payload ground systems, logistics support, integration of payloads with the space shuttle, launch support and space shuttle post-landing payload activities. On this particular mission, Leonardo's micrometeoroid panel bolts were inspected by Boeing technicians at the recommendation of the Marshall Space Flight Center MPLM project office and the chief engineer's office. All 290 bolts were inspected and 16 were replaced on 68 debris shields.

THE LIGHTWEIGHT MULTI-PURPOSE EXPERIMENT SUPPORT STRUCTURE CARRIER (LMC)





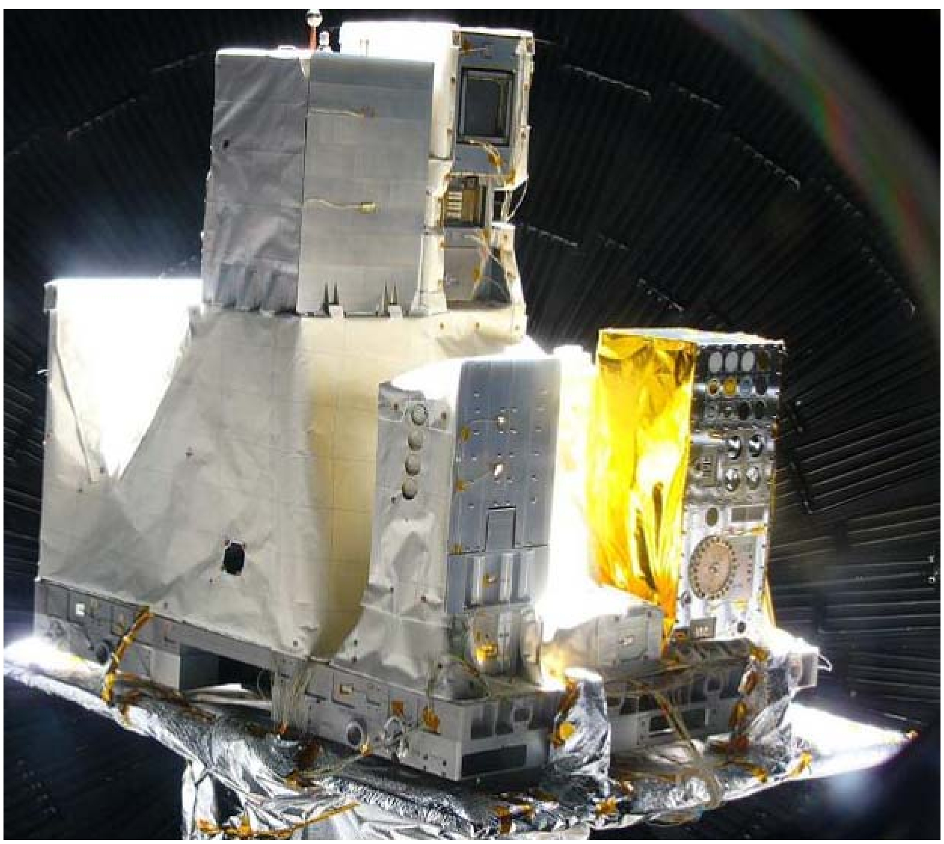
Located behind Leonardo in the space shuttle payload is the Lightweight Multi-Purpose Experiment Support Structure Carrier (LMC), a non-deployable cross-bay carrier providing launch and landing transportation. The LMC is a light-weight shuttle stowage platform that is maintained by the Goddard Space Flight Center and ATK Space for NASA and has flown on four previous missions (STS-108/UF-1, STS-114/LF1, STS-121/ULF1.1 and STS-126/ULF2). The LMC weighs 1,108 pounds. The launch weight of the integrated LMC is 3,926 pounds and the return weight will be 4,146 pounds.

The LMC is the platform which carries the Ammonia Tank Assembly (ATA), a critical spare Orbital Replacement Unit (ORU), in the space shuttle payload bay to the International Space Station and returns with a spent ATA, as well as the European Technology Exposure Facility (EuTEF).

The LMC will be carrying a replacement ATA. The tank, installed on the port one truss, is part of the station's cooling system for the electronic components. The ATA that the space shuttle returns with will have about 30 percent of its ammonia remaining in its tank.

EuTEF will be removed from its orbital mounting platform outside of the Columbus module. There will be a special Contingency Pin Kit (CPK) carried on the LMC. The CPK provides the EVA crew with frontside access to the backside release mechanism of the Passive Flight Releasable Attach Mechanism (PFRAM) to Orbital Replacement Unit (ORU) restraint system if required for safe return of an ORU on the LMC.

In the Space Station Processing Facility at NASA's Kennedy Space Center in Florida, STS-128 Mission Specialists John "Danny" Olivas (left) and Christer Fuglesang (far right) inspect the ATA.



EuTEF carries a suite of 13 different experiments in the fields of exobiology, fundamental physics, and technology requiring exposure to the space environment. The experiments and facility infrastructure are accommodated on the Columbus External Payload Adaptor (CEPA), consisting of an adapter plate, the Active Flight Releasable Attachment Mechanism and the connectors and harness. The experiments are mounted either directly on the adapter plate or an intermediate support structure that elevates them for optimum exposure to the direction of flight or pointing away from the Earth.

The suite of experiments on EuTEF consists of:

- Exposure Experiment (Expose): Exobiological organic samples exposure facility
- Dosimetric Telescope (DOSTEL): cosmic radiation environment measurement
- EuTEF Thermometer (EuTEMP): EuTEF's thermal environment measurement
- Earth Viewing Camera (EVC): Earth observing camera
- DEBris In-orbit Evaluator (DEBIE-2): Micrometeoroid and orbital debris detector
- Flux (Phi) Probe EXperiment (FIPEX): Atomic oxygen detector
- Material Exposure and Degradation Experiment (MEDET): Materials degradation examination
- Plasma Electron Gun Payload (PLEGPAY): Plasma discharge in orbit
- Experiments on Space Tribology (Tribolab): Testbed for tribology (study of friction on moving parts) and properties of materials

RENDEZVOUS & DOCKING

The above image depicts space shuttle Discovery's final docking approach with the International Space Station.

When Discovery launches on the STS-128 mission, it will fly on a trajectory to chase the International Space Station. A series of engine firings during the first two days of the mission will bring the shuttle to a point about 50,000 feet behind the station. Once there, Discovery will start its final approach. About 2.5 hours before docking, the shuttle's jets will be fired during what is called the terminal initiation burn. The shuttle will cover the final miles to the station during the next orbit.

As Discovery moves closer to the station, its rendezvous radar system and trajectory control sensor will provide the crew with range and closing-rate data. Several small correction burns will place the shuttle about 1,000 feet below the station.

Commander Rick Sturckow, with help from Pilot Kevin Ford and other crew members, will manually fly the shuttle for the remainder of the approach and docking.

Sturckow will stop Discovery about 600 feet below the station. Once he determines there is proper lighting, he will maneuver the shuttle through a 9-minute backflip called the Rendezvous Pitch Maneuver. During this maneuver, station crew members Mike Barratt and Gennady Padalka will use digital cameras with 400 mm and 800 mm lenses to photograph Discovery's upper and bottom surfaces through windows of the Zvezda Service Module. The 400 mm lens provides up to 3-inch resolution and the 800 mm lens up to 1-inch resolution. Padalka will use the 400 mm and Barratt will use the 800 mm.

The photography is one of several techniques used to inspect the shuttle's thermal protection system for possible damage. Areas of special interest include the thermal protection tiles, the reinforced carbon-carbon of the nose and leading edges of the wings, landing gear doors and the elevon cove. The photos will be downlinked through the station's Ku-band communications system for analysis by systems engineers and mission managers.

When Discovery completes its backflip, it will be back where it started, with its payload bay facing the station. Sturckow then will fly the shuttle through a quarter circle to a position about 400 feet directly in front of the station. From that point, he will begin the final approach to docking to the Pressurized Mating Adapter 2 at the forward end of the Harmony node.

The shuttle crew members will operate laptop computers that process the navigational data, the laser range systems and Discovery's docking mechanism.

Using a video camera mounted in the center of the Orbiter Docking System, Sturckow will line up the docking ports of the two spacecraft. If necessary, he will pause the shuttle 30 feet from the station to ensure proper alignment of the docking mechanisms. He will maintain the shuttle's speed relative to the station at about one-tenth of a foot per second, while both Discovery and the station are moving at about 17,500 mph. Sturckow will keep the docking mechanisms aligned to a tolerance of 3 inches.

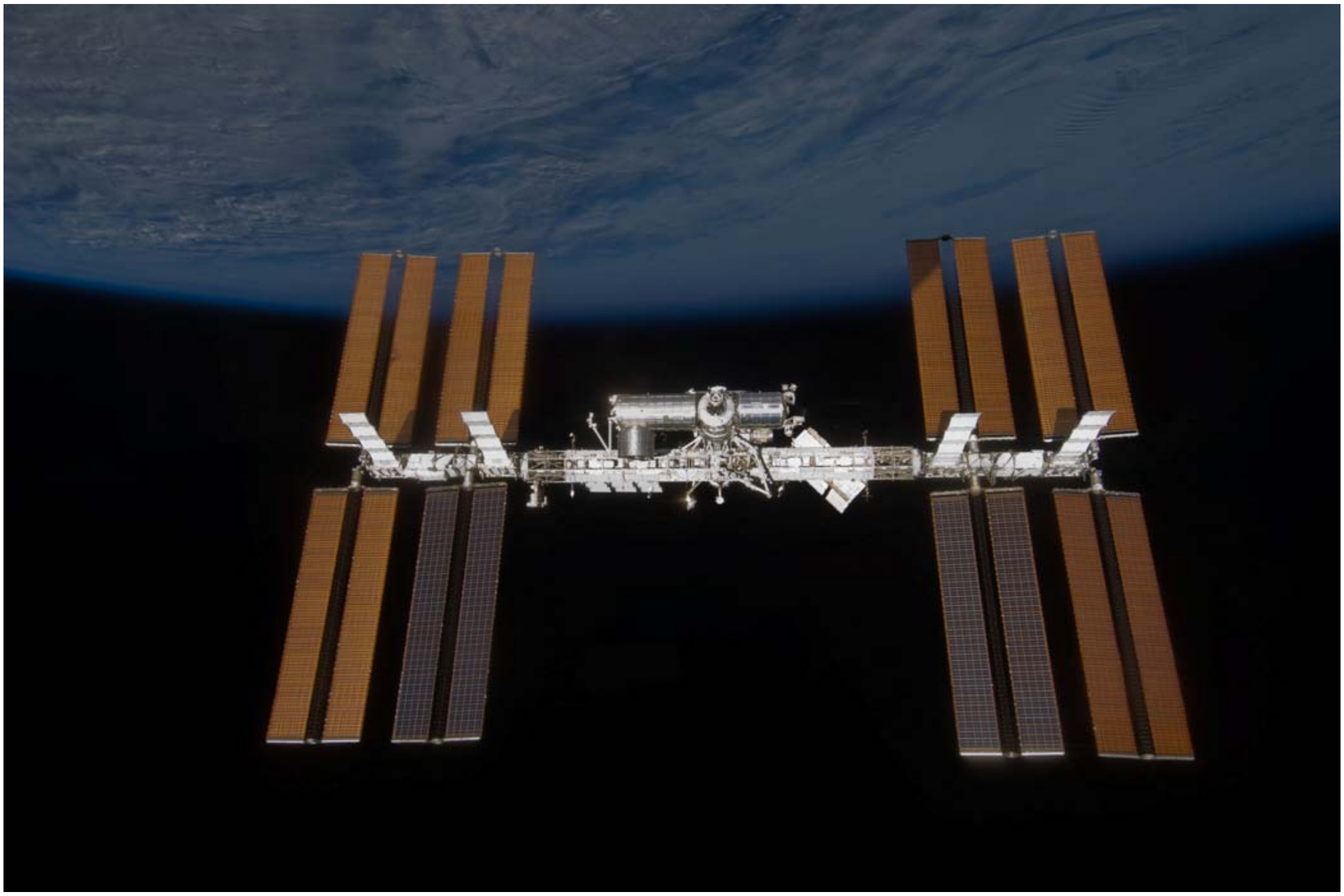
When Discovery makes contact with the station, preliminary latches will automatically attach the two spacecraft. The shuttle's steering jets will be deactivated to reduce the forces acting at the docking interface. Shock absorber springs in the docking mechanism will dampen any relative motion between the shuttle and station.

Once motion between the shuttle and the station has been stopped, the docking ring will be retracted to close a final set of latches between the two vehicles.

UNDOCKING, SEPARATION AND DEPARTURE

At undocking time, the hooks and latches will be opened and springs will push the shuttle away from the station. Discovery's steering jets will be shut off to avoid any inadvertent firings during the initial separation.

Once the shuttle is about 2 feet from the station and the docking devices are clear of one another, Ford will turn the steering jets back on and will manually control Discovery within a tight corridor as the shuttle separates from the station.



Backdropped by the blackness of space and Earth's horizon, the International Space Station is seen from space shuttle Discovery as the two spacecraft begin their relative separation.

Discovery will move to a distance of about 450 feet, where Ford will begin to fly around the station. Ford will circle the shuttle around the station at a distance of 600-700 feet. This will only be done if propellant margins and mission timeline activities permit.

Once the shuttle completes 1.5 revolutions of the complex, Ford will fire Discovery's jets to leave the area. The shuttle will begin to increase its distance from the station with each trip around the Earth, while ground teams analyze data from the late inspection of the shuttle's heat shield. However, the distance will be close enough to allow the shuttle to return to the station in the unlikely event that the heat shield is damaged, preventing the shuttle's safe re-entry.

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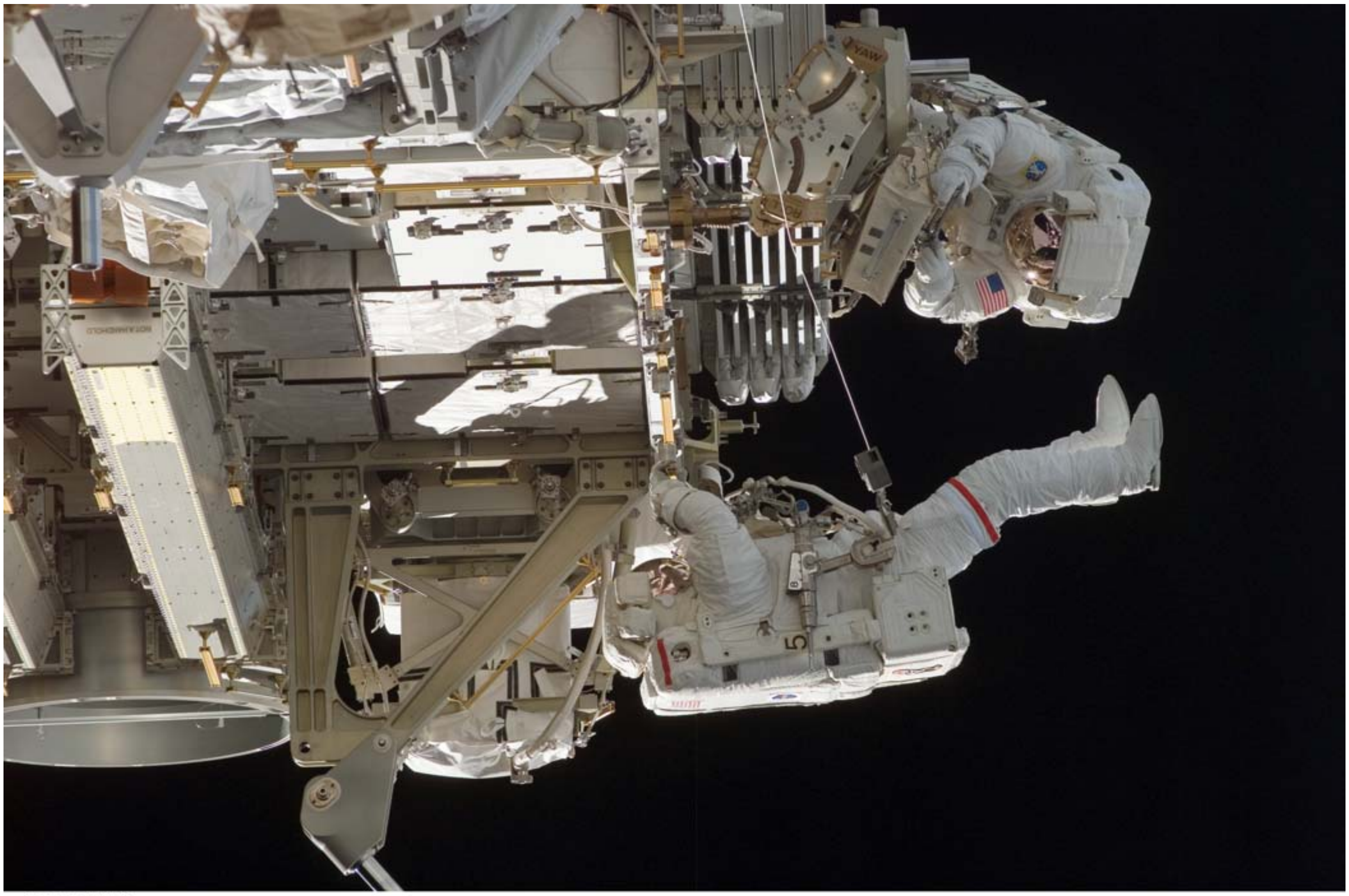
SPACEWALKS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Astronauts Jim Reilly (bottom) and John "Danny" Olivas (top right), both STS-117 mission specialists, participate in the mission's first planned session of extravehicular activity (EVA), as construction resumes on the International Space Station.

There are three spacewalks scheduled for the STS-128 mission.

Mission Specialists John "Danny" Olivas, Christer Fuglesang and Nicole Stott will spend a combined total of 19.5 hours outside the station on flight days 5, 7 and 9. Olivas, the lead spacewalker for the mission, will suit up for all three spacewalks in a spacesuit marked with solid red stripes. He is a veteran spacewalker with two extravehicular activities, or EVAs, performed during the STS-117 mission in 2007.

European Space Agency astronaut Fuglesang will be participating in the second and third spacewalks, adding to the more than 18 hours of spacewalking time that he built up over three EVAs during the STS-116 mission in 2006. He will wear an all white spacesuit.

Stott, who will be staying behind as a station crew member, whose first spacewalk will also be the first of the mission, will wear a spacesuit with broken red stripes.

On each EVA day, a spacewalker inside the station will act as the intravehicular officer, or spacewalk choreographer. The first and second spacewalks will require at least two crew members inside the station or shuttle to be at the controls of the station's 58-foot-long robotic arm to carry and maneuver equipment and spacewalkers.

Preparations will start the night before each spacewalk, when the astronauts spend time in the station's Quest Airlock. This practice is called the campout prebreathe protocol and is used to purge nitrogen from the spacewalkers' systems and prevent decompression sickness, also known as "the bends."

During the campout, the two astronauts performing the spacewalk will isolate themselves inside the airlock while the air pressure is lowered to 10.2 pounds per square inch, or psi. The station is kept at the near-sea-level pressure of 14.7 psi. The morning of the spacewalk, the astronauts will wear oxygen masks while the airlock's pressure is raised back to 14.7 psi for an hour and the hatch between the airlock and the rest of the station is opened. That allows the spacewalkers to perform their morning routines before returning to the airlock, where the air pressure is lowered again. Approximately 50 minutes after the spacewalkers don their spacesuits, the prebreathe protocol will be complete.

The procedure enables spacewalks to begin earlier in the crew's day than was possible before the protocol was adopted.

EVA-1

Duration: 6 hours, 30 minutes
Crew: Olivas and Stott
IV Crew: Forrester
Robotic Arm Operators: Ford and Thirsk

EVA Operations

- Old ammonia tank assembly removal
- EuTEF removal
- MISSE 6 removal

The work to replace the ammonia tank assembly on the first port segment of the station's truss – P1 – will begin on the first spacewalk of the mission. Olivas and Stott will be removing the depleted tank from the truss, so that it may be picked up by the station's robotic arm for storage until after the second spacewalk.

To remove it from the station's truss, Olivas and Stott will disconnect two lines used to transfer its ammonia, two lines which provide nitrogen for pressurization, and two electrical connections and release four bolts. They'll then work together to lift the tank away from the truss and maneuver it into position for the robotic arm to latch onto.

While the arm is still holding the tank assembly, Stott will install a foot restraint on it as well, which she'll then climb into for the removal of the European Technology Exposure Facility, or EuTEF. While Stott gets into place, Olivas will document the experiment's condition by taking some photographs. Olivas will then detach the experiment by releasing one bolt, and Stott will lift it away from its place on the Columbus laboratory. From there, Ford and Thirsk will drive her via the robotic arm to the shuttle's cargo bay, where she'll work with Olivas to store it on a cargo carrier for transport back to Earth. One bolt will be used to attach it to the carrier.

The spacewalkers' final task will be the removal of the sixth Materials International Space Station Experiment – or MISSE. Stott will climb out of the robotic arm's foot restraint and meet Olivas back at Columbus. (Although MISSE is a NASA experiment, it is located on the exterior of the Columbus laboratory.) While he waits for Stott to arrive, Olivas will close the passive experiment containers in which the two parts of the MISSE experiment are housed, and disconnect two cables. Olivas will then remove the first of the containers and pass it on to Stott for installation in a storage location. The second will be removed and stowed by Olvias.

EVA-2

Duration: 6 hours, 30 minutes
Crew: Olivas and Fuglesang
IV Crew: Forrester
Robotic Arm Operators: Ford and Stott

EVA Operations

- New ammonia tank assembly installation
- Old ammonia tank assembly storage

The entire second spacewalk of the mission will focus on completing the ammonia tank assembly swap. Olivas will begin by removing insulation on the new ammonia tank while Fuglesang gets into position in the robotic arm's foot restraint. He and Olivas will then work together to release the four bolts securing the assembly to the cargo carrier inside the shuttle's cargo bay. Ford and Stott will then drive the robotic arm – carrying Fuglesang and both ammonia tanks – to the installation site on the P1 truss segment.

Olivas will meet Fuglesang there, and together they'll drive the four bolts that will hold it in place. Olivas will then connect two electrical cables and four fluid lines.

With the new tank assembly installed, Olivas and Fuglesang will prepare for the storage of the old tank assembly, still latched to the robotic arm. Olivas will tether the old tank assembly to himself and then give Ford and Stott the OK to command the robotic arm to release it. Then Fuglesang will attach his tether to the assembly and Olivas will remove his tether, allowing Fuglesang and the old tank to make their way back to the shuttle's cargo bay via robotic arm.

Once there, Olivas and Fuglesang will install it on the cargo carrier with four bolts.

EVA-3

Duration: 6 hours, 30 minutes
Crew: Olivas and Fuglesang
IV Crew: Forrester
Robotic Arm Operators: None

EVA Operations:

- S3 upper, outboard payload attachment system deploy
- S0 rate gyro assembly replacement
- S0 remote power control module replacement
- Pressurized mating adapter 3 heater cable connection
- Tranquility node avionics cable routing
- Unity node slidewire removal
- Robotic arm camera and light assembly insulation installation

The first tasks of the final spacewalk of the mission will finish work left by the previous space shuttle mission. The STS-127 spacewalkers completed the deployment of the one cargo attachment system on the P1 truss segment, but had to leave the set up of similar systems on S3 for future missions. On STS-119 a jammed detent pin on the first of the systems prevented them from deploying the P1 system. A special tool was built to assist with the deployment. The STS-127 spacewalkers were successful in clearing the jam. Olivas and Fuglesang will have the same tool on hand for use if needed.

If the detent pin does not jam, however, the cargo attachment system will be set up by removing brackets and pins holding it in place, moving it into its correct position and then reinstalling the brackets and pins.

Once that's complete, Olivas and Fuglesang will work together to remove and replace a failed rate gyro assembly in the center of the station's truss. To remove the failed assembly, Olivas will disconnect two cables and remove two bolts. Fuglesang will remove the final two holding the assembly in place, and then Olivas will remove it and temporarily store it nearby. To install the new one, Olivas and Fuglesang will each drive four bolts, and Olivas will then connect its two cables before moving on to the next task.

At this point in the spacewalk, Olivas and Fuglesang will split up. Olivas will set up heater cables that will be used to keep the PMA 3 berthing port between the Unity and the coming Tranquility node warm so it can be pressurized. This will allow the station crew to prepare the vestibule for Tranquility node's arrival. That will involve disconnecting four cables and wire-tying them into place along a handrails on the Unity node. One of them will be connected to an outlet on Unity, the rest will have caps installed on them.

Meanwhile, Fuglesang will replace a failed remote power control module on the center segment of the station's truss. To remove the failed module, he'll simply release one bolt. To install the new unit, he'll slide it into place on a guide rail and then secure it using one bolt. He'll follow that up by installing an insulation sleeve on a cable inside the truss.

With those tasks done, Fuglesang and Olivas will come together again in the center of the truss to route avionics systems cables. They'll be using wire ties to secure two cable bundles to handrails along the truss system and the Unity node, and then a panel on the truss.

Olivas will wrap up the spacewalk by removing a damaged slidewire from a stanchion on Unity, while Fuglesang installs a lens cover on a camera and light assembly on the space station's robotic arm.

EXPERIMENTS

The space shuttle and International Space Station have an integrated research program that optimizes the use of shuttle crew members and long-duration space station crew members to address research questions in a variety of disciplines.

For information on science on the station, visit:

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

or

http://iss-science.jsc.nasa.gov/index.cfm

Detailed information is located at:

http://www.nasa.gov/mission_pages/station/science/experiments/Expedition.html

DETAILED TEST OBJECTIVES AND DETAILED SUPPLEMENTARY OBJECTIVES

Detailed Test Objectives (DTOs) are aimed at testing, evaluating, documenting systems or hardware, and proposing improvements to hardware, systems, and operations. Many of the DTOs on this mission are to provide additional information for engineers working for the Constellation Program as they develop requirements for the rocket and crew module that will return humans to the moon.

DTO 695 Thrust Oscillation Seat Accelerometer/SBDI-1904 Effects of Vibration on Visual Performance during Launch

For this test, accelerometers are being placed on crew seats in the orbiter to gather information on the seat vibration environment during launch. This DTO is being done in conjunction with another test that will measure crew visual performance during launch to help determine how the design of the Orion crew displays might be improved.

Three crew seats -- the same seats that were instrumented for the test on STS-119 in March 2009 and STS-125 in May 2009 -- will be instrumented for this flight.

During ascent, this DTO will measure the vibration of shuttle flight deck seat three and middeck seats five and six. Each seat will have a total of three triaxial accelerometers, each placed on the seat pan, the backrest, and the headrest.

Although the Seat DTO data alone are important in terms of providing a measure of vibration, human performance data are required to fully interpret the operational impact of the vibration values collected.

These human factors data will be provided by the Visual Performance test that has been designed for participation of the shuttle middeck crew members in seats five, six and seven over the course of two flights (STS-119 and STS-128).

Participating crew members will be requested to view a placard attached with Velcro to the middeck lockers directly in front of them. The placard will depict a representative Orion display format in each of four quadrants (i.e., four numbered display formats per placard). Each display format will depict a different effective font size, for a total of four tested font sizes. There will also be displays containing different color schemes.

Crew members will indicate using a response card included in their kneeboard or flight notebook, by which quadrant had the minimum readable font size, and to rate the readability of the various display schemes, during the launch phase of the flight. Once vibration has subsided, after solid rocket booster separation and before main engine cut-off, the crew members will respond to a brief questionnaire. A post-flight debrief will be held with crew members to elaborate on their experience. When practical within mission constraints, a video camera will record the motion of the middeck crew for correlation with seat vibration.

For additional information, follow this link:

http://www.nasa.gov/mission_pages/station/science/experiments/Visual_Performance.html

DTO 696 Grab Sample Container (GSC) Redesign for Shuttle

Successfully sustaining life in space requires closely monitoring the environment to ensure the health and performance of the crew. Astronauts can be more sensitive to air pollutants because of the closed environment, and the health effects of pollutants are magnified in space exploration because the astronauts' exposure is continuous. One hazard is the off-gassing of vapors from plastics and other inorganic materials aboard the vehicle.

To monitor air contaminant levels, crew members use devices called grab sample canisters. The containers to be flown on this mission have been redesigned so that they minimize overall size and volume. Three of the new GSCs will fit into the packing volume previously needed for one GSC. The smaller GSCs will also be used on the space station and evaluated during this mission.

DTO 701A TriDAR Sensor (Triangulation and LIDAR Automated Rendezvous and Docking)

The TriDAR Sensor is a 3D autonomous rendezvous and docking system that will be integrated into the space shuttle orbiter to demonstrate that technology in low Earth orbit. The complete vision system will incorporate scanning laser ranging and imaging capability, along with software to perform real-time tracking and six degrees of freedom pose calculation, to allow spacecraft rendezvous and docking without typical target markers. Future applications include using TriDAR for multifunction sensor robotic operations, potentially assisting with lander guidance, rover navigation, vehicle inspection, and exploration science.

Such flexible capability in a single sensor will be critical in future exploration missions where size, weight, and power limits are small.

Developed by Canada's Neptec Design Company, TriDAR is a dual sensing, multi-purpose scanner capable of full pose – six degrees of freedom – and sensors for long range rendezvous, vehicle inspection and hazard avoidance. It is a hybrid scanner combining features of the Orbiter Boom Sensor System Laser Camera System with a long-range Time of Flight or LIDAR system. Unlike pure LIDAR system, the TriDAR operates at distances ranging from 0.5 meters to more than 2,000 meters.

TriDAR uses its random access capability to rapidly acquire 3D data. Model-based tracking algorithms then calculate the six degrees of freedom relative pose of the target spacecraft from the acquired data in real-time. The system relies only on the vehicle's geometry and does not require cooperative target. The sensor can also perform high-resolution inspection scans or low-resolution range and bearing determination.

Triangulation is typically used for high-resolution virtualization of objects for a variety of purposes including video games, movies, reverse engineering, inspection, archiving of historic artifacts. LIDARs are most often used for airborne or ground-based imaging such as geological surveys, forestry, urban planning, and automatic target recognition.

DTO 854 Boundary Layer Transition (BLT) Flight Experiment

Tested successfully in arc jet facilities, the Boundary Layer Transition (BLT) flight experiment will gather information on the effect of high Mach number boundary layer transition caused by a protuberance on the space shuttle during the re-entry trajectory.

The experiment is designed to demonstrate that a protuberance on an orbiter BRI-18 tile is safe to fly. BRI-18 is a tile originally developed as a potential heat shield upgrade on the orbiters and is now being considered for use on the Orion crew exploration vehicles. Due to Orion's geometry, the tiles could experience re-entry heating temperatures up to 3,400 degrees Fahrenheit, about 500 degrees higher than the 2,900 degrees experienced by an orbiter during re-entry.

STS-128 will be the second phase of the flight experiment. The BLT flight experiment on STS-119, which flew in March 2009, provided temperature data on a 0.25-inch protuberance near Mach 16. That information is still being assessed. The goal for STS-128 is to gather data on a 0.35-inch protuberance at Mach 18 speed.

Boundary layer transition is a disruption of the smooth, laminar flow of supersonic air across the shuttle's belly and occurs normally when the shuttle's velocity has dropped to around 8 to 10 times the speed of sound, starting toward the back of the heat shield and moving forward. Known as "tripping the boundary layer," this phenomenon can create eddies of turbulence that, in turn, result in higher downstream heating.

For the experiment, a heat shield tile with a "speed bump" on it was installed under Discovery's left wing to intentionally disturb the airflow in a controlled manner and make the airflow turbulent. The bump is four inches long and 0.3-inch wide. Ten thermocouples will be installed on the tile with the protuberance and on tiles downstream to capture test data.

The experiment will receive additional support from a U.S. Navy aircraft that will check the orbiter's exterior temperatures. A Navy NP-3D Orion will fly below Discovery during re-entry and use a long-range infrared camera to remotely monitor heating to the shuttle's lower surface. The imagery captured and recorded will complement the information collected by the onboard instruments. Both will be used to verify and improve design efforts for future spacecraft.

Hypersonic Thermodynamic Infrared Measurements (HYTHIRM)

(Not a DTO but associated with the BLT flight experiment)

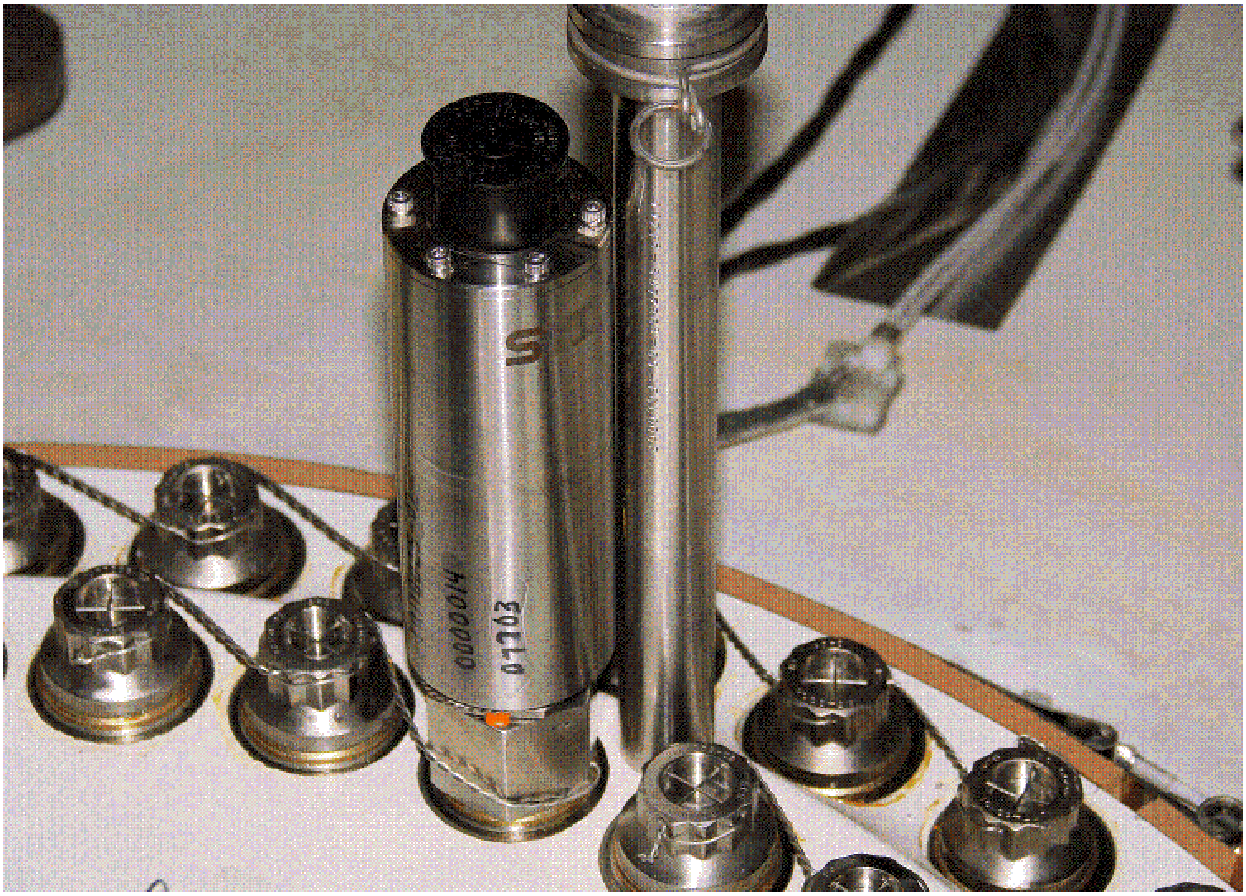
Hypersonic Thermodynamic Infrared Measurements (HYTHIRM) will take advantage of the shuttle BLT flight experiment on STS-128 to continue a study of heating patterns of the space shuttle on re-entry. Temperature increases from a protuberance purposely placed on the orbiter's lower left (port) wing will be imaged by the HYTHIRM team with the help of a U.S. Navy NP-3D Orion aircraft. Equipped with a long-range infrared optical system called "Cast Glance," the aircraft will fly 25 to 35 miles under Discovery as it returns to Earth at speeds 18 times the speed of a bullet. The Cast Glance system, as used during STS-119 and STS-125, will remotely monitor and record heating to the shuttle's lower surface using a long-range infrared camera. HYTHIRM imagery will provide ancillary flight data to the BLT Detailed Test Objective by complementing its onboard instruments. Both sets of data will be used to verify and improve design efforts for future spacecraft. HYTHIRM is managed by NASA's Langley Research Center, Hampton, Va.

DTO 900 Solid Rocket Booster Thrust Oscillation

The Space Shuttle Program is gathering data on five shuttle flights, beginning with STS-126, to gain a greater understanding of the pressure oscillation, or periodic variation, phenomena that regularly occurs within solid rocket motors. The pressure oscillation that is observed in solid rocket motors is similar to the hum made when blowing into a bottle. At 1.5 psi, or pounds per square inch, a pressure wave will move up and down the motor from the front to the rear, generating acoustic noise as well as physical loads in the structure. These data are necessary to help propulsion engineers confirm modeling techniques of pressure oscillations and the loads they create. As NASA engineers develop alternate propulsion designs for use in NASA, they will take advantage of current designs from which they can learn and measure. In an effort to obtain data to correlate pressure oscillation with the loads it can generate, the shuttle program is using two data systems to gather detailed information. Both systems are located on the top of the solid rocket motors inside the forward skirt.

The Intelligent Pressure Transducer, or IPT, is a standalone pressure transducer with an internal data acquisition system that will record pressure data to an internal memory chip. The data will be downloaded to a computer after the booster has been recovered and returned to the Solid Rocket Booster Assembly and Refurbishment Facility at NASA's Kennedy Space Center, Fla. This system has been used on numerous full-scale static test motors in Utah and will provide engineers with a common base to compare flight data to ground test data.

The Enhanced Data Acquisition System, or EDAS, is a data acquisition system that will record pressure data from one of the Reusable Solid Rocket Booster Operational Pressure Transducers, or OPT, and from accelerometers and strain gages placed on the forward skirt walls. These data will provide engineers with time synchronized data that will allow them to determine the accelerations and loads that are transferred through the structure due to the pressure oscillation forces.



Intelligent Pressure Transducer

Detailed Supplementary Objectives (DSOs) are space and life science investigations. Their purpose is to determine the extent of physiological deconditioning resulting from spaceflight, to test countermeasures to those changes and to characterize the space environment relative to crew health.

DSO 640 Physiological Factors

Astronauts experience alterations in multiple physiological systems due to exposure to the microgravity conditions of spaceflight. These physiological changes include sensorimotor disturbances, cardiovascular deconditioning, and loss of muscle mass and strength. These changes may lead to a disruption in the ability to walk and perform functional tasks during the initial reintroduction to gravity following prolonged spaceflight, and may cause significant impairments in performance of operational tasks immediately following landing.

The objective of this study is to identify the key underlying physiological factors that contribute to changes in performance of a set of functional tasks that are representative of critical mission tasks for lunar and Mars operations. Astronauts will be tested on an integrated suite of functional and interdisciplinary physiological tests before and after short- and long-duration spaceflight. Using this strategy, the investigators will be able to: 1) identify critical mission tasks that may be impacted by alterations in physiological responses; 2) map physiological changes to alterations in functional performance; and 3) design and implement countermeasures that specifically target the physiological systems responsible for impaired functional performance.

For more information, follow these links:

https://rlsda.jsc.nasa.gov/scripts/experiment/exper.cfm?exp_index=1448

https://rlsda.jsc.nasa.gov/docs/research/research_detail.cfm?experiment_type_code=35&researchtype

SHORT-DURATION RESEARCH AND STATION EXPERIMENTS

The STS-128 space shuttle mission marks the start of the transition from assembling the International Space Station to using it for continuous scientific research. 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 will enable a measured increase in time devoted to research as a national and multinational laboratory.

Two major additions to the research facilities aboard the station – the Materials Science Research Rack-1 and the Fluids Integrated Rack – will be delivered by Discovery's crew inside the Leonardo Multi-Purpose Logistics Module.

A host of short-duration experiments investigating the causes of and potential solutions to the harmful effects of long-duration spaceflight on the human body, technology development work for future human space exploration and the physical and biological sciences are planned.

In addition, a second treadmill, the Combined Operational Load Bearing External Resistance Treadmill (COLBERT), will provide medical researchers with new insight into the effectiveness of exercise as a countermeasure for bone and muscle density loss due to spaceflight.

New Facilities Delivered by STS-128/17A

Materials Science Research Rack-1 (MSRR-1) is used for basic materials research in the microgravity environment of the station. MSRR-1 can accommodate and support diverse Experiment Modules (EMs). In this way many material types, such as metals, alloys, polymers, semiconductors, ceramics, crystals, and glasses, can be studied to discover new applications for existing materials and new or improved materials

The Fluids Integrated Rack (FIR) is a complementary fluid physics research facility designed to host investigations in areas such as colloids, gels, bubbles, wetting and capillary action, and phase changes, including boiling and cooling.

Short-Duration Research to Be Completed During STS-128/17A

The space shuttle and International Space Station have an integrated research program that optimizes use of shuttle crew members and long-duration space station crew members in addressing research questions in a variety of disciplines.

Human Research and Countermeasure Development for Exploration

Sleep-Wake Actigraphy and Light Exposure during Spaceflight – Short (Sleep-Short) examines the effects of spaceflight on the sleep-wake cycles of the astronauts during 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. (NASA)

Validation of Procedures for Monitoring Crew Member Immune Function – Short Duration Biological Investigation (Integrated Immune-SDBI) assesses 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 spaceflight. (NASA)

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. (NASA)

Human Factors Assessment of Vibration Effects on Visual Performance During Launch (Visual Performance) determines the visual performance limits during operational vibration and g-loads on the space shuttle, specifically through the determination of minimum readable font size during ascent using planned Orion display formats. (NASA)

National Lab Pathfinder-Vaccine-5 (NLP-Vaccine-5) is a commercial payload serving as a pathfinder for the use of the International Space Station as a National Laboratory after station assembly is complete. It contains several different pathogenic (disease causing) organisms. This research is investigating the use of spaceflight to develop potential vaccines for the prevention of different infections caused by these pathogens on Earth and in microgravity. (NASA)

Studies on Microbiota On Board the International Space Station and Their Relationship to Health Problem (Microbe-I) examines the microbial (bacteria and fungi) environment on board the International Space Station. This investigation uses samples from surfaces and air to determine the variety of microbes through culture analysis. (JAXA)

The Study of Lower Back Pain in Crew Members During Space Flight (Mus) will study the details on development of Low Back Pain (LBP) during flight in astronauts/ cosmonauts. According to biomechanical model, strain on the ilio-lumbar ligaments increases with backward tilt of the pelvis in conjunction with forward flexion of the spine. This is what astronauts may experience due to loss of curvature. The objective is to assess astronaut deep muscle corset atrophy in response to microgravity exposure. (ESA)

Technology Development

Maui Analysis of Upper Atmospheric Injections (MAUI) observes the space shuttle engine exhaust plumes from the Maui Space Surveillance Site in Hawaii. As the shuttle flies over the Maui site, a telescope and all-sky imagers capture images and data when the shuttle engines fire at night or twilight. The data collected is analyzed to determine the interaction between the spacecraft exhaust plume and the upper atmosphere. (NASA)

Shuttle Exhaust Ion Turbulence Experiments (SEITE) uses space-based sensors to detect the ionospheric turbulence inferred from the radar observation from a previous space shuttle Orbital Maneuvering System (OMS) burn experiment using ground-based radar. (NASA)

The Shuttle Ionospheric Modification with Pulsed Localized Exhaust Experiments (SIMPLEX) investigates plasma turbulence driven by rocket exhaust in the ionosphere using ground-based radars. (NASA)

New Facilities and Experiments Delivered by STS-128/17A

Facilities

Materials Science Research Rack-1 (MSRR-1) is used for basic materials research in the microgravity environment of the station. MSRR-1 can accommodate and support diverse Experiment Modules (EMs). In this way, many material types, such as metals, alloys, polymers, semiconductors, ceramics, crystals, and glasses, can be studied to discover new applications for existing materials and new or improved materials.

The Fluids Integrated Rack (FIR) is a complementary fluid physics research facility designed to host investigations in areas such as colloids, gels, bubbles, wetting and capillary action, and phase changes including, boiling and cooling.

Human Research and Countermeasure Development for Exploration

Neutron Field Study (RaDI-N) will characterize the neutron environment of the station to develop risk countermeasures for crew members living and working in space. (CSA)

Physical and Biological Sciences in Microgravity

The Materials Science Laboratory – Columnar-to-Equiaxed Transition in Solidification Processing and Microstructure Formation in Casting of Technical Alloys under Diffusive and Magnetically Controlled Convective Conditions (MSL-CETSOL and MICAST) are two investigations that support research into metallurgical solidification, semiconductor crystal growth (Bridgman and zone melting) and measurement of thermo-physical properties of materials. This is a cooperative investigation with the European Space Agency (ESA) and NASA for accommodation and operation aboard the International Space Station.

Mice Drawer System (MDS) is an Italian Space Agency investigation that will use a validated mouse model to investigate the genetic mechanisms underlying bone mass loss in microgravity. Research conducted with the MDS is an analog to the Human Research Program, which has the objective to extend the human presence safely beyond low Earth orbit.

Constrained Vapor Bubble (CVB) consists of a remotely controlled microscope and a small, wickless heat pipe, or heat exchanger, operating on an evaporation/condensation cycle. The objective is to better understand the physics of evaporation and condensation as they affect heat transfer processes in a heat exchanger designed for cooling critical, high heat output components in microgravity. (NASA)

DEvice for the Study of Critical LIquids and Crystallization (DECLIC) is a multi-user facility consisting of three investigations, DECLIC – Alice Like Insert (DECLIC-ALI), DECLIC – High Temperature Insert (DECLIC-HTI) and DECLIC – Directional Solidification Insert (DECLIC-DSI) to study transparent media and their phase transitions in microgravity on board the station. (NASA/CNES)

Selectable Optical Diagnostics Instrument – Influence of Vibration on Diffusion of Liquids (SODI-IVIDIL) will study the influence of controlled vibration stimulus (slow shaking) on diffusion between different liquids in absence of convection induced by the gravity field. Such investigation will help scientists to model numerically this physical phenomenon. (ESA)

Life Cycle of Higher Plants under Microgravity Conditions (Space Seed) uses *Arabidopsis thaliana* to determine if the life cycle of this plant can be achieved in microgravity. Additionally, this study will examine the specific genes in the cell wall of the plant that do not activate in microgravity that normally activate in 1-g conditions. (JAXA)

Integrated Assessment of Long-term Cosmic Radiation Through Biological Responses of the Silkworm, *Bombyx mori*, in Space (RadSilk) examines the effects of radiation exposure in microgravity on silkworms. (JAXA)

Observing the Earth and Educational Activities

Space Education Project of Leave a nest C. Ltd (Leaveanest Seed Project) is a commercial venture between the JAXA and the Leave a nest C. Ltd. For this educational activity, Bonsai Tomato and MicroTom seeds are brought to the station and then returned for distribution. (JAXA)

Technology Development for Exploration

Autonomous Robotic Operations Performed from the ISS (Avatar Explore) is a technology demonstration used to develop remote communications for robot autonomy software. This experiment uses the amateur HAM radio on board the station to interact with a rover on Earth in a Mars exploration scenario.

Space Dynamically Responding Ultrasonic Matrix System (SpaceDRUMS) is a suite of hardware that enables containerless processing of experimental materials without ever touching a container wall. Using a collection of 20 acoustic beam emitters, SpaceDRUMS can completely suspend a baseball-sized solid or liquid sample during combustion or heat-based synthesis. Because the samples never contact the container walls, materials can be produced in microgravity with an unparalleled quality of shape and composition. The goal of the SpaceDRUMS hardware is to assist with the development of advanced materials of a commercial quantity and quality, using the space-based experiments to guide development of manufacturing processes on Earth. (NASA)

ISS Research Samples Returned on STS-128/17A

Human Research and Countermeasure Development for Exploration

Nutritional Status Assessment (Nutrition) is the most comprehensive inflight study done by NASA to date of human physiologic changes during long-duration spaceflight; this includes measures of bone metabolism, oxidative damage, nutritional assessments, and hormonal changes. This study will impact both the definition of nutritional requirements and development of food systems for future space exploration missions to the moon and Mars. This experiment will also help to understand the impact of countermeasures (exercise and pharmaceuticals) on nutritional status and nutrient requirements for astronauts. (NASA)

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. Biological samples from the International Space Station, including blood and urine, will be collected, processed and archived during the preflight, inflight and postflight phases of station missions. This investigation has been developed to archive biosamples for use as a resource for future spaceflight-related research. (NASA)

Validation of Procedures for Monitoring Crew Member Immune Function (Integrated Immune) assesses the clinical risks resulting from the adverse effects of spaceflight on the human immune system and will validate a flight-compatible immune monitoring strategy. Researchers collect and analyze blood, urine and saliva samples from crew members before, during and after spaceflight to monitor changes in the immune system. Changes in the immune system are monitored by collecting and analyzing blood and saliva samples from crew members during flight and blood, urine, and saliva samples before and after spaceflight. (NASA)

Bisphosphonates as a Countermeasure to Space Flight Induced Bone Loss (Bisphosphonates) determines whether antiresorptive agents (help reduce bone loss), in conjunction with the routine inflight exercise program, will protect station crew members from the regional decreases in bone mineral density documented on previous station missions. (NASA)

A Comprehensive Characterization of Microorganisms and Allergens in Spacecraft (SWAB) will use advanced molecular techniques to comprehensively evaluate microbes on board the space station, including pathogens (organisms that may cause disease). It also will track changes in the microbial community as spacecraft visit the station and new station modules are added. This study will allow an assessment of the risk of microbes to the crew and the spacecraft. (NASA)

Cardiovascular and Cerebrovascular Control on Return from ISS (CCISS) will study the effects of long-duration spaceflight on crew members' heart functions and their blood vessels that supply the brain. Learning more about the cardiovascular and cerebrovascular systems could lead to specific countermeasures that might better protect future space travelers. This experiment is collaborative effort with the Canadian Space Agency. (NASA/CSA)

Passive Dosimeter for Life Science Experiment in Space (PADLES) measures radiation exposure levels on board the International Space Station. PADLES uses passive and integrating dosimeters to detect radiation levels. These dosimeters are located near the biological experiment facilities and on the end of the Japanese Experiment Module, Kibo. The proposed research seeks to survey the radiation environment inside the Kibo by using Area dosimeter. Area dosimeter and the analysis system have been developed in JAXA as a system for space radiation dosimetry. The dosimeters measure absorbed doses, equivalent doses and Liner Energy Transfer (LET) distributions. (JAXA)

Mental Representation of Spatial Cues During Space Flight (3D-Space) experiment investigates the effects of exposure to microgravity on the mental representation of spatial cues by astronauts during and after spaceflight. The absence of the gravitational frame of reference during spaceflight could be responsible for disturbances in the mental representation of spatial cues, such as the perception of horizontal and vertical lines, the perception of objects' depth and the perception of targets' distance. (ESA)

Physical and Biological Science in Microgravity

Integrated Assessment of Long-term Cosmic Radiation Through Biological Responses of the Silkworm, *Bombyx mori*, in Space (RadSilk) examines the effects of radiation exposure in microgravity on silkworms. (JAXA)

Validating Vegetable Production Unit (VPU) Plants, Protocols, Procedures and Requirements (P3R) Using Currently Existing Flight Resources (Lada-VPU-P3R) is a study to advance the technology required for plant growth in microgravity and to research related food safety issues. Lada-VPU-P3R also investigates the non-nutritional value to the flight crew of developing plants in orbit. The Lada-VPU-P3R uses the Lada hardware on the station and falls under a cooperative agreement between the National Aeronautics and Space Administration (NASA) and the Russian Federal Space Agency (FSA). (NASA/FSA)

Technology Development

Materials International Space Station Experiment – 6A and 6B (MISSE-6A and 6B) is a sample box attached to the outside of the International Space Station; it is used for testing the effects of exposure to the space environment on small samples of new materials. These samples will be evaluated for their reaction to atomic oxygen erosion, direct sunlight, radiation, and extremes of heat and cold. Results will provide a better understanding of the durability of various materials, with important applications in the design of future spacecraft. (NASA)

European Technology Exposure Facility (EuTEF) is a platform that provides power, data, thermal control and structural support to payloads mounted on the Columbus External Payload Facility. During its time in orbit, EuTEF supported the following nine experiments:

– **DEBris In-orbit Evaluator (DEBIE-2):** Micrometeoroid and orbital debris detector

- **Dosimetric Telescope (DOSTEL):** Measuring the radiation environment
- **EuTEF Thermometer (EuTEMP):** Measure EuTEF's thermal environment
- **Earth Viewing Camera (EVC):** Earth observing camera
- **Exposure Experiment (Expose):** An exobiological exposure facility
- **Flux(Phi) Probe EXperiment (FIPEX):** Atomic oxygen detector
- **Material Exposure and Degradation Experiment (MEDET):** Examine material degradation
- **Plasma Electron Gun Payload (PLEGPAY):** Plasma discharge in orbit
- **An Experiment on Space Tribology Experiment (Tribolab):** Testbed for the tribology (study of friction on moving parts) properties of materials

Additional Station Research from Now Until the End of Expedition 20

Human Research and Countermeasure Development for Exploration

Cardiovascular and Cerebrovascular Control on Return from ISS (CCISS) will study the effects of long-duration spaceflight on crew members' heart functions and their blood vessels that supply the brain. Learning more about the cardiovascular and cerebrovascular systems could lead to specific countermeasures that might better protect future space travelers. This experiment is collaborative effort with the Canadian Space Agency. (NASA/CSA)

Sleep-Wake Actigraphy and Light Exposure During Spaceflight-Long (Sleep-Long) examines the effects of spaceflight and ambient light exposure on the sleep-wake cycles of the crew members during long-duration stays on the space station. (NASA)

Nutritional Status Assessment (Nutrition) is the most comprehensive inflight study done by NASA to date of human physiologic changes during long-duration spaceflight; this includes measures of bone metabolism, oxidative damage, nutritional assessments, and hormonal changes. This study will impact both the definition of nutritional requirements and development of food systems for future space exploration missions to the moon and Mars. This experiment will also help to understand the impact of countermeasures (exercise and pharmaceuticals) on nutritional status and nutrient requirements for astronauts. (NASA)

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. Biological samples from the International Space Station, including blood and urine, will be collected, processed and archived during the preflight, inflight and postflight phases of station missions. This investigation has been developed to archive biosamples for use as a resource for future spaceflight-related research. (NASA)

Validation of Procedures for Monitoring Crew Member Immune Function (Integrated Immune) assesses the clinical risks resulting from the adverse effects of spaceflight on the human immune system and will validate a flight-compatible immune monitoring strategy.

Researchers collect and analyze blood, urine and saliva samples from crew members before, during and after spaceflight to monitor changes in the immune system. Changes in the immune system are monitored by collecting and analyzing blood and saliva samples from crew members during flight and blood, urine, and saliva samples before and after spaceflight. (NASA)

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) will quantify the extent, time course and clinical significance of cardiac atrophy (decrease in the size of the heart muscle) associated with long-duration spaceflight. This experiment will also identify the mechanisms of this atrophy and the functional consequences for crew members who will spend extended periods of time in space. (NASA)

Bisphosphonates as a Countermeasure to Space Flight Induced Bone Loss (Bisphosphonates) determines whether antiresorptive agents (help reduce bone loss), in conjunction with the routine inflight exercise program, will protect station crew members from the regional decreases in bone mineral density documented on previous station missions. (NASA)

The Effect of Long-Term Microgravity Exposure on Cardiac Autonomic Function by Analyzing 24-hours Electrocardiogram (Biological Rhythms) examines the effect of long-term microgravity exposure on cardiac autonomic function by analyzing 24-hour electrocardiogram. (JAXA)

SOdium LOading in Microgravity (SOLO) is a continuation of extensive research into the mechanisms of fluid and salt retention in the body during bed rest and spaceflights. It is a metabolically-controlled study. During long-term space missions, astronauts will participate in two study phases, five days each. Subjects follow a diet of constant either low or normal sodium intake, fairly high fluid consumption and isocaloric nutrition.

Observing the Earth and Educational Activities

Crew Earth Observations (CEO) takes advantage of the crew in space to observe and 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.

Education Payload Operation – Demonstrations (EPO-Demos) are recorded video education demonstrations performed on the International Space Station by crew members using hardware already on board the station. EPO-Demos are videotaped, edited, and used to enhance existing NASA education resources and programs for educators and students in grades K-12. EPO-Demos are designed to support the NASA mission to inspire the next generation of explorers

Technology Development

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 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. (NASA)

Space Dynamically Responding Ultrasonic Matrix System (SpaceDRUMS) comprises a suite of hardware that enables containerless processing (samples of experimental materials can be processed without ever touching a container wall). Using a collection of 20 acoustic beam emitters, SpaceDRUMS can completely suspend a baseball-sized solid or liquid sample during combustion or heat-based synthesis. Because the samples never contact the container walls, materials can be produced in microgravity with an unparalleled quality of shape and composition. The ultimate goal of the SpaceDRUMS hardware is to assist with the development of advanced materials of a commercial quantity and quality, using the space-based experiments to guide development of manufacturing processes on Earth.

Microgravity Acceleration Measurement System (MAMS) and Space Acceleration Measurement System (SAMS-II) measure vibration and quasi-steady accelerations that result from vehicle control burns, docking and undocking activities. The two different equipment packages measure vibrations at different frequencies.

SHUTTLE REFERENCE DATA

SHUTTLE ABORT MODES

Redundant Sequence Launch Sequencer (RSLS) Aborts

These occur when the on-board shuttle computers detect a problem and command a halt in the launch sequence after taking over from the ground launch sequencer and before solid rocket booster ignition.

Ascent Aborts

Selection of an ascent abort mode may become necessary if there is a failure that affects vehicle performance, such as the failure of a space shuttle main engine or an orbital maneuvering system engine. Other failures requiring early termination of a flight, such as a cabin leak, might also require the selection of an abort mode. There are two basic types of ascent abort modes for space shuttle missions: intact aborts and contingency aborts. Intact aborts are designed to provide a safe return of the orbiter to a planned landing site. Contingency aborts are designed to permit flight crew survival following more severe failures when an intact abort is not possible. A contingency abort would generally result in a ditch operation.

Intact Aborts

There are four types of intact aborts: abort to orbit (ATO), abort once around (AOA), transoceanic abort landing (TAL) and return to launch site (RTLS).

Return to Launch Site

The RTLS abort mode is designed to allow the return of the orbiter, crew, and payload to the launch site, KSC, approximately 25 minutes after liftoff.

The RTLS profile is designed to accommodate the loss of thrust from one space shuttle main engine between liftoff and approximately four minutes 20 seconds, after which not enough main propulsion system propellant remains to return to the launch site. An RTLS can be considered to consist of three stages – a powered stage, during which the space shuttle main engines are still thrusting; an external tank separation phase; and the glide phase, during which the orbiter glides to a landing at the KSC. The powered RTLS phase begins with the crew selection of the RTLS abort, after solid rocket booster separation. The crew selects the abort mode by positioning the abort rotary switch to RTLS and depressing the abort push button. The time at which the RTLS is selected depends on the reason for the abort. For example, a three-engine RTLS is selected at the last moment, about 3 minutes, 34 seconds into the mission; whereas an RTLS chosen due to an engine out at liftoff is selected at the earliest time, about 2 minutes, 20 seconds into the mission (after solid rocket booster separation).

After RTLS is selected, the vehicle continues downrange to dissipate excess main propulsion system propellant. The goal is to leave only enough main propulsion system propellant to be able to turn the vehicle around, fly back toward the KSC and achieve the proper main engine cutoff conditions so the vehicle can glide to the KSC after external tank separation. During the downrange phase, a pitch-around maneuver is initiated (the time depends in part on the time of a space shuttle main engine failure) to orient the orbiter/external tank configuration to a heads-up attitude, pointing toward the launch site. At this time, the vehicle is still moving away from the launch site, but the space shuttle main engines are now thrusting to null the downrange velocity. In addition, excess orbital maneuvering system and reaction control system propellants are dumped by continuous orbital maneuvering system and reaction control system engine thrustings to improve the orbiter weight and center of gravity for the glide phase and landing.

The vehicle will reach the desired main engine cutoff point with less than 2 percent excess propellant remaining in the external tank. At main engine cutoff minus 20 seconds, a pitch down maneuver (called powered pitch-down) takes the mated vehicle to the required external tank separation attitude and pitch rate. After main engine cutoff has been commanded, the external tank separation sequence begins, including a reaction control system maneuver that ensures that the orbiter does not recontact the external tank and that the orbiter has achieved the necessary pitch attitude to begin the glide phase of the RTLS.

After the reaction control system maneuver has been completed, the glide phase of the RTLS begins. From then on, the RTLS is handled similarly to a normal entry.

Transoceanic Abort Landing

The TAL abort mode was developed to improve the options available when a space shuttle main engine fails after the last RTLS opportunity but before the first time that an AOA can be accomplished with only two space shuttle main engines or when a major orbiter system failure, for example, a large cabin pressure leak or cooling system failure, occurs after the last RTLS opportunity, making it imperative to land as quickly as possible.

In a TAL abort, the vehicle continues on a ballistic trajectory across the Atlantic Ocean to land at a predetermined runway. Landing occurs about 45 minutes after launch. The landing site is selected near the normal ascent ground track of the orbiter to make the most efficient use of space shuttle main engine propellant. The landing site also must have the necessary runway length, weather conditions and U.S. State Department approval. The three landing sites that have been identified for a launch are Zaragoza, Spain; Moron, Spain; and Istres, France.

To select the TAL abort mode, the crew must place the abort rotary switch in the TAL/AOA position and depress the abort push button before main engine cutoff (depressing it after main engine cutoff selects the AOA abort mode). The TAL abort mode begins sending commands to steer the vehicle toward the plane of the landing site. It also rolls the vehicle heads up before main engine cutoff and sends commands to begin an orbital maneuvering system propellant dump (by burning the propellants through the orbital maneuvering system engines and the reaction control system engines). This dump is necessary to increase vehicle performance (by decreasing weight) to place the center of gravity in the proper place for vehicle control and to decrease the vehicle's landing weight. TAL is handled like a normal entry.

Abort to Orbit

An ATO is an abort mode used to boost the orbiter to a safe orbital altitude when performance has been lost and it is impossible to reach the planned orbital altitude. If a space shuttle main engine fails in a region that results in a main engine cutoff under speed, the MCC will determine that an abort mode is necessary and will inform the crew. The orbital maneuvering system engines would be used to place the orbiter in a circular orbit.

Abort Once Around

The AOA abort mode is used in cases in which vehicle performance has been lost to such an extent that either it is impossible to achieve a viable orbit or not enough orbital maneuvering system propellant is available to accomplish the orbital maneuvering system thrusting maneuver to place the orbiter on orbit and the deorbit thrusting maneuver. In addition, an AOA is used in cases in which a major systems problem (cabin leak, loss of cooling) makes it necessary to land quickly. In the AOA abort mode, one orbital maneuvering system thrusting sequence is made to adjust the post-main engine cutoff orbit so a second orbital maneuvering system thrusting sequence will result in the vehicle deorbiting and landing at the AOA landing site (White Sands, N.M.; Edwards Air Force Base, Calif.; or the Kennedy Space Center, Fla). Thus, an AOA results in the orbiter circling the Earth once and landing about 90 minutes after liftoff.

After the deorbit thrusting sequence has been executed, the flight crew flies to a landing at the planned site much as it would for a nominal entry.

Contingency Aborts

Contingency aborts are caused by loss of more than one main engine or failures in other systems. Loss of one main engine while another is stuck at a low thrust setting also may necessitate a contingency abort. Such an abort would maintain orbiter integrity for in-flight crew escape if a landing cannot be achieved at a suitable landing field.

Contingency aborts due to system failures other than those involving the main engines would normally result in an intact recovery of vehicle and crew. Loss of more than one main engine may, depending on engine failure times, result in a safe runway landing. However, in most three-engine-out cases during ascent, the orbiter would have to be ditched. The inflight crew escape system would be used before ditching the orbiter.

Abort Decisions

There is a definite order of preference for the various abort modes. The type of failure and the time of the failure determine which type of abort is selected. In cases where performance loss is the only factor, the preferred modes are ATO, AOA, TAL and RTLS, in that order. The mode chosen is the highest one that can be completed with the remaining vehicle performance.

In the case of some support system failures, such as cabin leaks or vehicle cooling problems, the preferred mode might be the one that will end the mission most quickly. In these cases, TAL or RTLS might be preferable to AOA or ATO. A contingency abort is never chosen if another abort option exists.

Mission Control Houston is prime for calling these aborts because it has a more precise knowledge of the orbiter's position than the crew can obtain from on-board systems. Before main engine cutoff, Mission Control makes periodic calls to the crew to identify which abort mode is (or is not) available. If ground communications are lost, the flight crew has onboard methods, such as cue cards, dedicated displays and display information, to determine the abort region. Which abort mode is selected depends on the cause and timing of the failure causing the abort and which mode is safest or improves mission success. If the problem is a space shuttle main engine failure, the flight crew and Mission Control Center select the best option available at the time a main engine fails.

If the problem is a system failure that jeopardizes the vehicle, the fastest abort mode that results in the earliest vehicle landing is chosen. RTLS and TAL are the quickest options (35 minutes), whereas an AOA requires about 90 minutes. Which of these is selected depends on the time of the failure with three good space shuttle main engines.

The flight crew selects the abort mode by positioning an abort mode switch and depressing an abort push button.

SHUTTLE ABORT HISTORY

RSLS Abort History

(STS-41 D) June 26, 1984

The countdown for the second launch attempt for Discovery's maiden flight ended at T-4 seconds when the orbiter's computers detected a sluggish valve in main engine No. 3. The main engine was replaced and Discovery was finally launched on Aug. 30, 1984.

(STS-51 F) July 12, 1985

The countdown for Challenger's launch was halted at T-3 seconds when onboard computers detected a problem with a coolant valve on main engine No. 2. The valve was replaced and Challenger was launched on July 29, 1985.

(STS-55) March 22, 1993

The countdown for Columbia's launch was halted by onboard computers at T-3 seconds following a problem with purge pressure readings in the oxidizer preburner on main engine No. 2. Columbia's three main engines were replaced on the launch pad, and the flight was rescheduled behind Discovery's launch on STS-56. Columbia finally launched on April 26, 1993.

(STS-51) Aug. 12, 1993

The countdown for Discovery's third launch attempt ended at the T-3 second mark when onboard computers detected the failure of one of four sensors in main engine No. 2 which monitor the flow of hydrogen fuel to the engine. All of Discovery's main engines were ordered replaced on the launch pad, delaying the shuttle's fourth launch attempt until Sept. 12, 1993.

(STS-68) Aug. 18, 1994

The countdown for Endeavour's first launch attempt ended 1.9 seconds before liftoff when onboard computers detected higher than acceptable readings in one channel of a sensor monitoring the discharge temperature of the high pressure oxidizer turbopump in main engine No. 3. A test firing of the engine at the Stennis Space Center in Mississippi on September 2nd confirmed that a slight drift in a fuel flow meter in the engine caused a slight increase in the turbopump's temperature. The test firing also confirmed a slightly slower start for main engine No. 3 during the pad abort, which could have contributed to the higher temperatures. After Endeavour was brought back to the Vehicle Assembly Building to be outfitted with three replacement engines, NASA managers set Oct. 2 as the date for Endeavour's second launch attempt.

Abort to Orbit History

(STS-51 F) July 29, 1985

After an RSLS abort on July 12, 1985, Challenger was launched on July 29, 1985. Five minutes and 45 seconds after launch, a sensor problem resulted in the shutdown of center engine No. 1, resulting in a safe "abort to orbit" and successful completion of the mission.

SPACE SHUTTLE MAIN ENGINES

Developed in the 1970s by NASA's Marshall Space Flight Center, MSFC in Huntsville, Ala., the space shuttle main engine is the most advanced liquid-fueled rocket engine ever built. Every space shuttle main engine is tested and proven flight worthy at NASA's Stennis Space Center in south Mississippi, before installation on an orbiter. Its main features include variable thrust, high performance reusability, high redundancy and a fully integrated engine controller.

The shuttle's three main engines are mounted on the orbiter aft fuselage in a triangular pattern. Spaced so that they are movable during launch, the engines are used, in conjunction with the solid rocket boosters, to steer the shuttle vehicle.

Each of these powerful main engines is 14 feet long, weighs about 7,000 pounds and is 7.5 feet in diameter at the end of its nozzle.

The engines operate for about 8.5 minutes during liftoff and ascent, burning more than 500,000 gallons of super-cold liquid hydrogen and liquid oxygen propellants stored in the external tank attached to the underside of the shuttle. The engines shut down just before the shuttle, traveling at about 17,000 miles per hour, reaches orbit.

The main engine operates at greater temperature extremes than any mechanical system in common use today. The fuel, liquefied hydrogen at -423 degrees Fahrenheit, is the second coldest liquid on Earth. When it and the liquid oxygen are combusted, the temperature in the main combustion chamber is 6,000 degrees Fahrenheit, hotter than the boiling point of iron.

The main engines use a staged combustion cycle so that all propellants entering the engines are used to produce thrust, or power, more efficiently than any previous rocket engine. In a staged combustion cycle, propellants are first burned partially at high pressure and relatively low temperature, and then burned completely at high temperature and pressure in the main combustion chamber. The rapid mixing of the propellants under these conditions is so complete that 99 percent of the fuel is burned.

At normal operating level, each engine generates 490,847 pounds of thrust, measured in a vacuum. Full power is 512,900 pounds of thrust; minimum power is 316,100 pounds of thrust.

The engine can be throttled by varying the output of the preburners, thus varying the speed of the high-pressure turbopumps and, therefore, the flow of the propellant.

At about 26 seconds into ascent, the main engines are throttled down to 316,000 pounds of thrust to keep the dynamic pressure on the vehicle below a specified level, about 580 pounds per square foot, known as max q. Then, the engines are throttled back up to normal operating level at about 60 seconds. This reduces stress on the vehicle. The main engines are throttled down again at about seven minutes, 40 seconds into the mission to maintain three g's, three times the Earth's gravitational pull, reducing stress on the crew and the vehicle. This acceleration level is about one-third the acceleration experienced on previous crewed space vehicles.

About 10 seconds before main engine cutoff, or MECO, the cutoff sequence begins. About three seconds later the main engines are commanded to begin throttling at 10 percent thrust per second until they achieve 65 percent thrust. This is held for about 6.7 seconds, and the engines are shut down.

The engine performance has the highest thrust for its weight of any engine yet developed. In fact, one space shuttle main engine generates sufficient thrust to maintain the flight of two and one-half Boeing 747 airplanes.

The space shuttle main engine also is the first rocket engine to use a built-in electronic digital controller, or computer. The controller accepts commands from the orbiter for engine start, change in throttle, shutdown and monitoring of engine operation.

NASA continues to increase the reliability and safety of shuttle flights through a series of enhancements to the space shuttle main engines. The engines were modified in 1988, 1995, 1998, 2001 and 2007. Modifications include new high-pressure fuel and oxidizer turbopumps that reduce maintenance and operating costs of the engine, a two-duct powerhead that reduces pressure and turbulence in the engine, and a single-coil heat exchanger that lowers the number of post flight inspections required. Another modification incorporates a large-throat main combustion chamber that improves the engine's reliability by reducing pressure and temperature in the chamber.

The most recent engine enhancement is the Advanced Health Management System, or AHMS, which made its first flight in 2007. AHMS is a controller upgrade that provides new monitoring and insight into the health of the two most complex components of the space shuttle main engine – the high pressure fuel turbopump and the high pressure oxidizer turbopump. New advanced digital signal processors monitor engine vibration and have the ability to shut down an engine if vibration exceeds safe limits. AHMS was developed by engineers at Marshall.

After the orbiter lands, the engines are removed and returned to a processing facility at Kennedy Space Center, Fla., where they are rechecked and readied for the next flight. Some components are returned to the main engine's prime contractor, Pratt & Whitney Rocketdyne, West Palm Beach, Fla., for regular maintenance. The main engines are designed to operate for 7.5 accumulated hours.

SPACE SHUTTLE SOLID ROCKET BOOSTERS (SRB)

The two solid rocket boosters required for a space shuttle launch and first two minutes of powered flight boast the largest solid-propellant motors ever flown. They are the first large rockets designed for reuse and are the only solid rocket motors rated for human flight. The SRBs have the capacity to carry the entire weight of the external tank, or ET, and orbiter, and to transmit the weight load through their structure to the mobile launch platform, or MLP.

The SRBs provide 71.4 percent of the thrust required to lift the space shuttle off the launch pad and during first-stage ascent to an altitude of about 150,000 feet, or 28 miles. At launch, each booster has a sea level thrust of approximately 3.3 million pounds and is ignited after the ignition and verification of the three space shuttle main engines, or SSMEs.

SRB apogee occurs at an altitude of about 230,000 feet, or 43 miles, 75 seconds after separation from the main vehicle. At booster separation, the space shuttle orbiter has reached an altitude of 24 miles and is traveling at a speed in excess of 3,000 miles per hour.

The primary elements of each booster are nose cap, housing the pilot and drogue parachute; frustum, housing the three main parachutes in a cluster; forward skirt, housing the booster flight avionics, altitude sensing, recovery avionics, parachute cameras and range safety destruct system; four motor segments, containing the solid propellant; motor nozzle; and aft skirt, housing the nozzle and thrust vector control systems required for guidance. Each SRB possesses its own redundant auxiliary power units and hydraulic pumps.

SRB impact occurs in the ocean approximately 140 miles downrange. SRB retrieval is provided after each flight by specifically designed and built ships. The frustums, drogue and main parachutes are loaded onto the ships along with the boosters and towed back to the Kennedy Space Center, where they are disassembled and refurbished for reuse. Before retirement, each booster can be used as many as 20 times.

Each booster is just over 149 feet long and 12.17 feet in diameter. Both boosters have a combined weight of 1,303,314 pounds at lift-off. They are attached to the ET at the SRB aft attach ring by an upper and lower attach strut and a diagonal attach strut. The forward end of each SRB is affixed to the ET by one attach bolt and ET ball fitting on the forward skirt. While positioned on the launch pad, the space shuttle is attached to the MLP by four bolts and explosive nuts equally spaced around each SRB. After ignition of the solid rocket motors, the nuts are severed by small explosives that allow the space shuttle vehicle to perform lift off.

United Space Alliance (USA)

USA, at KSC facilities, is responsible for all SRB operations except the motor and nozzle portions. In conjunction with maintaining sole responsibility for manufacturing and processing of the non-motor hardware and vehicle integration, USA provides the service of retrieval, post flight inspection and analysis, disassembly and refurbishment of the hardware. USA also exclusively retains comprehensive responsibility for the orbiter.

The reusable solid rocket motor segments are shipped from ATK Launch Systems in Utah to KSC, where they are mated by USA personnel to the other structural components – the forward assembly, aft skirt, frustum and nose cap – in the Vehicle Assembly Building. Work involves the complete disassembly and refurbishment of the major SRB structures – the aft skirts, frustums, forward skirts and all ancillary hardware – required to complete an SRB stack and mate to the ET. Work then proceeds to ET/SRB mate, mate with the orbiter and finally, space shuttle close out operations. After hardware restoration concerning flight configuration is complete, automated checkout and hot fire are performed early in hardware flow to ensure that the refurbished components satisfy all flight performance requirements.

ATK Launch Systems (ATK)

ATK Launch Systems of Brigham City, Utah, manufactures space shuttle reusable solid rocket motors, or RSRMs, at their Utah facility. Each RSRM – just over 126 feet long and 12 feet in diameter – consists of four rocket motor segments and an aft exit cone assembly is. From ignition to end of burn, each RSRM generates an average thrust of 2.6 million pounds and burns for approximately 123 seconds. Of the motor's total weight of 1.25 million pounds, propellant accounts for 1.1 million pounds. The four motor segments are matched by loading each from the same batches of propellant ingredients to minimize any thrust imbalance. The segmented casing design assures maximum flexibility in fabrication and ease of transportation and handling. Each segment is shipped to KSC on a heavy-duty rail car with a specialty built cover.

SRB Hardware Design Summary

Hold-Down Posts

Each SRB has four hold-down posts that fit into corresponding support posts on the MLP. Hold-down bolts secure the SRB and MLP posts together. Each bolt has a nut at each end, but the top nut is frangible, or breakable. The top nut contains two NASA Standard detonators, or NSDs, that, when ignited at solid rocket motor ignition command, split the upper nut in half.

Splitting the upper nuts allow the hold-down bolts to be released and travel downward because of NSD gas pressure, gravity and the release of tension in the bolt, which is pretensioned before launch. The bolt is stopped by the stud deceleration stand which contains sand to absorb the shock of the bolt dropping down several feet. The SRB bolt is 28 inches long, 3.5 inches in diameter and weighs approximately 90 pounds. The frangible nut is captured in a blast container on the aft skirt specifically designed to absorb the impact and prevent pieces of the nut from liberating and becoming debris that could damage the space shuttle.

Integrated Electronic Assembly (IEA)

The aft IEA, mounted in the ET/SRB attach ring, provides the electrical interface between the SRB systems and the obiter. The aft IEA receives data, commands, and electrical power from the orbiter and distributes these inputs throughout each SRB. Components located in the forward assemblies of each SRB are powered by the aft IEA through the forward IEA, except for those utilizing the recovery and range safety batteries located in the forward assemblies. The forward IEA communicates with and receives power from the orbiter through the aft IEA, but has no direct electrical connection to the orbiter.

Electrical Power Distribution

Electrical power distribution in each SRB consists of orbiter-supplied main dc bus power to each SRB via SRB buses A, B and C. Orbiter main dc buses A, B and C supply main dc bus power to corresponding SRB buses A, B and C. In addition, orbiter main dc, bus C supplies backup power to SRB buses A and B, and orbiter bus B supplies backup power to SRB bus C. This electrical power distribution arrangement allows all SRB buses to remain powered in the event one orbiter main bus fails.

The nominal dc voltage is 28 V dc, with an upper limit of 32 V dc and a lower limit of 24 V dc.

Hydraulic Power Units (HPUs)

There are two self-contained, independent HPUs on each SRB. Each HPU consists of an auxiliary power unit, or APU; Fuel Supply Module, or FSM; hydraulic pump; hydraulic reservoir; and hydraulic fluid manifold assembly. The APUs are fueled by hydrazine and generate mechanical shaft power to a hydraulic pump that produces hydraulic pressure for the SRB hydraulic system. The APU controller electronics are located in the SRB aft integrated electronic assemblies on the aft ET attach rings. The two separate HPUs and two hydraulic systems are located inside the aft skirt of each SRB between the SRB nozzle and skirt. The HPU components are mounted on the aft skirt between the rock and tilt actuators. The two systems operate from T minus 28 seconds until SRB separation from the orbiter and ET. The two independent hydraulic systems are connected to the rock and tilt servoactuators.

The HPUs and their fuel systems are isolated from each other. Each fuel supply module, or tank, contains 22 pounds of hydrazine. The fuel tank is pressurized with gaseous nitrogen at 400 psi to provide the force to expel via positive expulsion the fuel from the tank to the fuel distribution line. A positive fuel supply to the APU throughout its operation is maintained.

The fuel isolation valve is opened at APU startup to allow fuel to flow to the APU fuel pump and control valves and then to the gas generator. The gas generator's catalytic action decomposes the fuel and creates a hot gas. It feeds the hot gas exhaust product to the APU two-stage gas turbine. Fuel flows primarily through the startup bypass line until the APU speed is such that the fuel pump outlet pressure is greater than the bypass line's, at which point all the fuel is supplied to the fuel pump.

The APU turbine assembly provides mechanical power to the APU gearbox, which drives the APU fuel pump, hydraulic pump and lube oil pump. The APU lube oil pump lubricates the gearbox. The turbine exhaust of each APU flows over the exterior of the gas generator, cooling it and directing it overboard through an exhaust duct.

When the APU speed reaches 100 percent, the APU primary control valve closes and the APU speed is controlled by the APU controller electronics. If the primary control valve logic fails to the open state, the secondary control valve assumes control of the APU at 112 percent speed. Each HPU on an SRB is connected to both servoactuators. One HPU serves as the primary hydraulic source for the servoactuator and the other HPU serves as the secondary hydraulics for the servoactuator. Each servoactuator has a switching valve that allows the secondary hydraulics to power the actuator if the primary hydraulic pressure drops below 2,050 psi. A switch contact on the switching valve will close when the valve is in the secondary position. When the valve is closed, a signal is sent to the APU controller that inhibits the 100 percent APU speed control logic and enables the 112 percent APU speed control logic. The 100 percent APU speed enables one APU/HPU to supply sufficient operating hydraulic pressure to both servoactuators of that SRB.

The APU 100 percent speed corresponds to 72,000 rpm, 110 percent to 79,200 rpm and 112 percent to 80,640 rpm.

The hydraulic pump speed is 3,600 rpm and supplies hydraulic pressure of 3,050, plus or minus 50 psi. A high-pressure relief valve provides overpressure protection to the hydraulic system and relieves at 3,750 psi.

The APUs/HPUs and hydraulic systems are reusable for 20 missions.

Thrust Vector Control (TVC)

Each SRB has two hydraulic gimbal servoactuators: one for rock and one for tilt. The servoactuators provide the force and control to gimbal the nozzle for TVC. The all-axis gimbaling capability is 8 degrees. Each nozzle has a carbon cloth liner that erodes and chars during firing. The nozzle is a convergent-divergent, movable design in which an aft pivot-point flexible bearing is the gimbal mechanism.

The space shuttle ascent TVC portion of the flight control system directs the thrust of the three SSMEs and the two SRB nozzles to control shuttle attitude and trajectory during liftoff and ascent. Commands from the guidance system are transmitted to the ascent TVC, or ATVC, drivers, which transmit signals proportional to the commands to each servoactuator of the main engines and SRBs. Four independent flight control system channels and four ATVC channels control six main engine and four SRB ATVC drivers, with each driver controlling one hydraulic port on each main and SRB servoactuator.

Each SRB servoactuator consists of four independent, two-stage servovalves that receive signals from the drivers. Each servovalve controls one power spool in each actuator, which positions an actuator ram and the nozzle to control the direction of thrust.

The four servovalves in each actuator provide a force-summed majority voting arrangement to position the power spool. With four identical commands to the four servovalves, the actuator force-sum action prevents a single erroneous command from affecting power ram motion. If the erroneous command persists for more than a predetermined time, differential pressure sensing activates a selector valve to isolate and remove the defective servovalve hydraulic pressure. This permits the remaining channels and servovalves to control the actuator ram spool.

Failure monitors are provided for each channel to indicate which channel has been bypassed. An isolation valve on each channel provides the capability of resetting a failed or bypassed channel.

Each actuator ram is equipped with transducers for position feedback to the thrust vector control system. Within each servoactuator ram is a splashdown load relief assembly to cushion the nozzle at water splashdown and prevent damage to the nozzle flexible bearing.

SRB Rate Gyro Assemblies (RGAs)

Each SRB contains two RGAs mounted in the forward skirt watertight compartment. Each RGA contains two orthogonally mounted gyroscopes – pitch and yaw axes. In conjunction with the orbiter roll rate gyros, they provide angular rate information that describes the inertial motion of the vehicle cluster to the orbiter computers and the guidance, navigation and control system during first stage ascent to SRB separation. At SRB separation, all guidance control data is handed off from the SRB RGAs to the orbiter RGAs. The RGAs are designed and qualified for 20 missions.

Propellant

The propellant mixture in each SRB motor consists of ammonium perchlorate, an oxidizer, 69.6 percent by weight; aluminum, a fuel, 16 percent by weight; iron oxide, a catalyst, 0.4 percent by weight; polymer, a binder that holds the mixture together, 12.04 percent by weight; and epoxy curing agent, 1.96 percent by weight. The propellant is an 11-point star-shaped perforation in the forward motor segment and a double truncated cone perforation in each of the aft segments and aft closure. This configuration provides high thrust at ignition and then reduces the thrust by about one-third 50 seconds after liftoff to prevent overstressing the vehicle during maximum dynamic pressure.

SRB Ignition

SRB ignition can occur only when a manual lock pin from each SRB safe and arm device has been removed by the ground crew during prelaunch activities. At T minus 5 minutes, the SRB safe and arm device is rotated to the arm position. The solid rocket motor ignition commands are issued when the three SSMEs are at or above 90 percent rated thrust; no SSME fail and/or SRB ignition pyrotechnic initiator controller, or PIC low voltage is indicated; and there are no holds from the launch processing system, or LPS.

The solid rocket motor ignition commands are sent by the orbiter computers through the master events controllers, or MECs, to the NSDs installed in the safe and arm device in each SRB. A pyrotechnic initiation controller, or PIC, is a single-channel capacitor discharge device that controls the firing of each pyrotechnic device. Three signals must be present simultaneously for the PIC to generate the pyro firing output. These signals – arm, fire 1 and fire 2 – originate in the orbiter general-purpose computers and are transmitted to the MECs. The MECs reformat them to 28 V dc signals for the PICs. The arm signal charges the PIC capacitor to 40 V dc, minimum 20 V dc.

The fire 2 commands cause the redundant NSDs to fire through a thin barrier seal down a flame tunnel. This ignites a pyro booster charge, which is retained in the safe and arm device behind a perforated plate. The booster charge ignites the propellant in the igniter initiator; and combustion products of this propellant ignite the solid rocket motor igniter, which fires down the length of the solid rocket motor igniting the solid rocket motor propellant.

The general purpose computer, or GPC, launch sequence also controls certain critical main propulsion system valves and monitors the engine-ready indications from the SSMEs. The main propulsion system, or MPS, start commands are issued by the on-board computers at T minus 6.6 seconds. There is a staggered start – engine three, engine two, engine one – within 0.25 of a second, and the sequence monitors the thrust buildup of each engine. All three SSMEs must reach the required 90 percent thrust within three seconds; otherwise, an orderly shutdown is commanded and safing functions are initiated.

Normal thrust buildup to the required 90 percent thrust level will result in the SSMEs being commanded to the liftoff position at T minus 3 seconds as well as the fire 1 command being issued to arm the SRBs. At T minus three seconds, the vehicle base bending load modes are allowed to initialize.

At T minus 0, the two SRBs are ignited by the four orbiter on-board computers; commands are sent to release the SRBs; the two T-0 umbilicals, one on each side of the spacecraft, are retracted; the on-board master timing unit, event timer and mission event timers are started; the three SSMEs are at 100 percent; and the ground launch sequence is terminated.

SRB Separation

The SRB/ET separation subsystem provides for separation of the SRBs from the orbiter/ET without damage to or recontact of the elements – SRBs, orbiter/ET – during or after separation for nominal modes. SRB separation is initiated when the three solid rocket motor chamber pressure transducers are processed in the redundancy management middle value select and the head end chamber pressure of both SRBs is less than or equal to 50 psi. A backup cue is the time elapsed from booster ignition.

The separation sequence is initiated, commanding the thrust vector control actuators to the null position and putting the main propulsion system into a second-stage configuration 0.8 second from sequence initialization, which ensures the thrust of each SRB is less than 100,000 pounds. Orbiter yaw attitude is held for four seconds and SRB thrust drops to less than 60,000 pounds. The SRBs separate from the ET within 30 milliseconds of the ordnance firing command.

The forward attachment point consists of a ball on the SRB and socket on the ET, held together by one bolt. The bolt contains one NSD pressure cartridge at each end. The forward attachment point also carries the range safety system cross-strap wiring connecting each SRB range safety system, or RSS, and the ET RSS with each other.

The aft attachment points consist of three separate struts: upper, diagonal, and lower. Each strut contains one bolt with an NSD pressure cartridge at each end. The upper strut also carries the umbilical interface between its SRB and the external tank and on to the orbiter.

Redesigned Booster Separation Motors (RBSM)

Eight Booster Separation Motors, or BSMs, are located on each booster – four on the forward section and four on the aft skirt. BSMs provide the force required to push the SRBs away from the orbiter/ET at separation. Each BSM weighs approximately 165 pounds and is 31.1 inches long and 12.8 inches in diameter. Once the SRBs have completed their flight, the BSMs are fired to jettison the SRBs away from the orbiter and external tank, allowing the boosters to parachute to Earth and be reused. The BSMs in each cluster of four are ignited by firing redundant NSD pressure cartridges into redundant confined detonating fuse manifolds. The separation commands issued from the orbiter by the SRB separation sequence initiate the redundant NSD pressure cartridge in each bolt and ignite the BSMs to effect a clean separation.

Redesigned BSMs flew for the first time in both forward and aft locations on STS-125. As a result of vendor viability and manifest support issues, space shuttle BSMs are now being manufactured by ATK. The igniter has been redesigned and other changes include material upgrades driven by obsolescence issues and improvements to process and inspection techniques.

SRB Cameras

Each SRB flies with a complement of four cameras, three mounted for exterior views during launch, separation and descent; and one mounted internal to the forward dome for main parachute performance assessment during descent.

The ET observation camera is mounted on the SRB forward skirt and provides a wide-angle view of the ET intertank area. The camera is activated at lift off by a G-switch and records for 350 seconds, after which the recorder is switched to a similar camera in the forward skirt dome to view the deployment and performance of the main parachutes to splash down. These cameras share a digital tape recorder located within the data acquisition system.

The ET ring camera is mounted on the ET attach ring and provides a view up the stacked vehicle on the orbiter underside and the bipod strut attach point.

The forward skirt camera is mounted on the external surface of the SRB forward skirt and provides a view aft down the stacked vehicle of the orbiter underside and the wing leading edge reinforced carbon-carbon, or RCC, panels.

The ET attach ring camera and forward skirt camera are activated by a global positioning system command at approximately T minus 1 minute 56 seconds to begin recording at approximately T minus 50 seconds. The camera images are recorded through splash down. These cameras each have a dedicated recorder and are recorded in a digital format. The cameras were designed, qualified, and implemented by USA after Columbia to provide enhanced imagery capabilities to capture potential debris liberation beginning with main engine start and continuing through SRB separation.

The camera videos are available for engineering review approximately 24 hours following the arrival of the boosters at KSC.

Range Safety Systems (RSS)

The RSS consists of two antenna couplers; command receivers/decoders; a dual distributor; a safe and arm device with two NSDs; two confined detonating fuse manifolds; seven confined detonator fuse, or CDF assemblies; and one linear-shaped charge.

The RSS provides for destruction of a rocket or part of it with on-board explosives by remote command if the rocket is out of control, to limit danger to people on the ground from crashing pieces, explosions, fire, and poisonous substances.

The space shuttle has two RSSs, one in each SRB. Both are capable of receiving two command messages – arm and fire – which are transmitted from the ground station. The RSS is only used when the space shuttle violates a launch trajectory red line.

The antenna couplers provide the proper impedance for radio frequency and ground support equipment commands. The command receivers are tuned to RSS command frequencies and provide the input signal to the distributors when an RSS command is sent. The command decoders use a code plug to prevent any command signal other than the proper command signal from getting into the distributors. The distributors contain the logic to supply valid destruct commands to the RSS pyrotechnics.

The NSDs provide the spark to ignite the CDF that in turn ignites the linear shaped charge for space shuttle destruction. The safe and arm device provides mechanical isolation between the NSDs and the CDF before launch and during the SRB separation sequence.

The first message, called arm, allows the onboard logic to enable a destruct and illuminates a light on the flight deck display and control panel at the commander and pilot station. The second message transmitted is the fire command. The SRB distributors in the SRBs are cross-strapped together. Thus, if one SRB received an arm or destruct signal, the signal would also be sent to the other SRB.

Electrical power from the RSS battery in each SRB is routed to RSS system A. The recovery battery in each SRB is used to power RSS system B as well as the recovery system in the SRB. The SRB RSS is powered down during the separation sequence, and the SRB recovery system is powered up.

Descent and Recovery

After separation and at specified altitudes, the SRB forward avionics system initiates the release of the nose cap, which houses a pilot parachute and drogue parachute; and the frustum, which houses the three main parachutes. Jettison of the nose cap at 15,700 feet deploys a small pilot parachute and begins to slow the SRB decent. At an altitude of 15,200 feet the pilot parachute pulls the drogue parachute from the frustum. The drogue parachute fully inflates in stages, and at 5,500 feet pulls the frustum away from the SRB, which initiates the deployment of the three main parachutes. The parachutes also inflate in stages and further slow the decent of the SRBs to their final velocity at splashdown. The parachutes slow each SRB from 368 mph at first deployment to 52 mph at splashdown, allowing for the recovery and reuse of the boosters.

Two 176-foot recovery ships, Freedom Star and Liberty Star, are on station at the splashdown zone to retrieve the frustums with drogue parachutes attached, the main parachutes and the SRBs. The SRB nose caps and solid rocket motor nozzle extensions are not recovered. The SRBs are dewatered using an enhanced diver operating plug to facilitate tow back. These plugs are inserted into the motor nozzle and air is pumped into the booster, causing it to lay flat in the water to allow it to be easily towed. The boosters are then towed back to the refurbishment facilities. Each booster is removed from the water and components are disassembled and washed with fresh and deionized water to limit saltwater corrosion. The motor segments, igniter and nozzle are shipped back to ATK in Utah for refurbishment. The nonmotor components and structures are disassembled by USA and are refurbished to like-new condition at both KSC and equipment manufacturers across the country.

SPACE SHUTTLE SUPER LIGHT WEIGHT TANK (SLWT)

The super lightweight external tank (SLWT) made its first shuttle flight June 2, 1998, on mission STS-91. The SLWT is 7,500 pounds lighter than the standard external tank. The lighter weight tank allows the shuttle to deliver

International Space Station elements (such as the service module) into the proper orbit.

The SLWT is the same size as the previous design. But the liquid hydrogen tank and the liquid oxygen tank are made of aluminum lithium, a lighter, stronger material than the metal alloy used for the shuttle's current tank. The tank's structural design has also been improved, making it 30 percent stronger and 5 percent less dense.

The SLWT, like the standard tank, is manufactured at Michoud Assembly, near New Orleans, by Lockheed Martin.

The 154-foot-long external tank is the largest single component of the space shuttle. It stands taller than a 15-story building and has a diameter of about 27 feet. The external tank holds over 530,000 gallons of liquid hydrogen and liquid oxygen in two separate tanks. The hydrogen (fuel) and liquid oxygen (oxidizer) are used as propellants for the shuttle's three main engines.

EXTERNAL TANK

The 154-foot-long external tank is the largest single component of the space shuttle. It stands taller than a 15-story building and has a diameter of about 27 feet. The external tank holds more than 530,000 gallons of liquid hydrogen and liquid oxygen in two separate tanks, the forward liquid oxygen tank and the aft liquid hydrogen tank. An unpressurized intertank unites the two propellant tanks.

Liquid hydrogen (fuel) and liquid oxygen (oxidizer) are used as propellants for the shuttle's three main engines. The external tank weighs 58,500 pounds empty and 1,668,500 pounds when filled with propellants.

The external tank is the "backbone" of the shuttle during launch, providing structural support for attachment with the solid rocket boosters and orbiter. It is the only component of the shuttle that is not reused. Approximately 8.5 minutes after reaching orbit, with its propellant used, the tank is jettisoned and falls in a preplanned trajectory. Most of the tank disintegrates in the atmosphere, and the remainder falls into the ocean.

The external tank is manufactured at NASA's Michoud Assembly Facility in New Orleans by Lockheed Martin Space Systems.

Foam Facts

The external tank is covered with spray-on foam insulation that insulates the tank before and during launch. More than 90 percent of the tank's foam is applied using an automated system, leaving less than 10 percent to be applied manually.

There are two types of foam on the external tank, known as the Thermal Protection System, or TPS. One is low-density, closed-cell foam on the tank acreage and is known as Spray-On-Foam-Insulation, often referred to by its acronym, SOFI. Most of the tank is covered by either an automated or manually applied SOFI. Most areas around protuberances, such as brackets and structural elements, are applied by pouring foam ingredients into part-specific molds. The other is a denser composite material made of silicone resins and cork and called ablator. An ablator is a material that dissipates heat by eroding. It is used on areas of the external tank subjected to extreme heat, such as the aft dome near the engine exhaust, and remaining protuberances, such as the cable trays. These areas are exposed to extreme aerodynamic heating.

Closed-cell foam used on the tank was developed to keep the propellants that fuel the shuttle's three main engines at optimum temperature. It keeps the shuttle's liquid hydrogen fuel at -423 degrees Fahrenheit and the liquid oxygen tank at near -297 degrees Fahrenheit, even as the tank sits under the hot Florida sun. At the same time, the foam prevents a buildup of ice on the outside of the tank.

The foam insulation must be durable enough to endure a 180-day stay at the launch pad, withstand temperatures up to 115 degrees Fahrenheit, humidity as high as 100 percent, and resist sand, salt, fog, rain, solar radiation and even fungus. Then, during launch, the foam must tolerate temperatures as high as 2,200 degrees Fahrenheit generated by aerodynamic friction and radiant heating from the 3,000 degrees Fahrenheit main engine plumes. Finally, when the external tank begins reentry into the Earth's atmosphere about 30 minutes after launch, the foam maintains the tank's structural temperatures and allows it to safely disintegrate over a remote ocean location.

Though the foam insulation on the majority of the tank is only 1-inch thick, it adds 4,823 pounds to the tank's weight. In the areas of the tank subjected to the highest heating, insulation is somewhat thicker, between 1.5 to 3 inches thick. Though the foam's density varies with the type, an average density is about 2.4 pounds per cubic foot.

Application of the foam, whether automated by computer or hand-sprayed, is designed to meet NASA's requirements for finish, thickness, roughness, density, strength and adhesion. As in most assembly production situations, the foam is applied in specially designed, environmentally controlled spray cells and applied in several phases, often over a period of several weeks. Before spraying, the foam's raw material and mechanical properties are tested to ensure they meet NASA specifications. Multiple visual inspections of all foam surfaces are performed after the spraying is complete.

Most of the foam is applied at NASA's Michoud Assembly Facility in New Orleans when the tank is manufactured, including most of the "closeout" areas, or final areas applied. These closeouts are done either by hand pouring or manual spraying. Additional closeouts are completed once the tank reaches Kennedy Space Center, Fla.

The super lightweight external tank, or SLWT, made its first shuttle flight in June 1998 on mission STS-91. The SLWT is 7,500 pounds lighter than previously flown tanks. The SLWT is the same size as the previous design, but the liquid hydrogen tank and the liquid oxygen tank are made of aluminum lithium, a lighter, stronger material than the metal alloy used previously.

Beginning with the first Return to Flight mission, STS-114 in June 2005, several improvements were made to improve safety and flight reliability.

Forward Bipod

The external tank's forward shuttle attach fitting, called the bipod, was redesigned to eliminate the large insulating foam ramps as a source of debris. Each external tank has two bipod fittings that connect the tank to the orbiter through the shuttle's two forward attachment struts. Four rod heaters were placed below each forward bipod, replacing the large insulated foam Protuberance Airload, or PAL, ramps.

Liquid Hydrogen Tank & Liquid Oxygen Intertank Flange Closeouts

The liquid hydrogen tank flange located at the bottom of the intertank and the liquid oxygen tank flange located at the top of the intertank provide joining mechanisms with the intertank. After each of these three component tanks, liquid oxygen, intertank and liquid hydrogen, are joined mechanically, the flanges at both ends are insulated with foam. An enhanced closeout, or finishing, procedure was added to improve foam application to the stringer, or intertank ribbing, and to the upper and lower area of both the liquid hydrogen and liquid oxygen intertank flanges.

Liquid Oxygen Feedline Bellows

The liquid oxygen feedline bellows were reshaped to include a "drip lip" that allows condensate moisture to run off and prevent freezing. A strip heater was added to the forward bellow to further reduce the potential of high density ice or frost formation. Joints on the liquid oxygen feedline assembly allow the feedline to move during installation and during liquid hydrogen tank fill. Because it must flex, it cannot be insulated with foam like the remainder of the tank.

Other tank improvements include:

Liquid Oxygen & Liquid Hydrogen Protuberance Airload (PAL) Ramps

External tank ET-119, which flew on the second Return to Flight mission, STS-121, in July 2006, was the first tank to fly without PAL ramps along portions of the liquid oxygen and liquid hydrogen tanks. These PAL ramps were extensively studied and determined to not be necessary for their original purpose, which was to protect cable trays from aeroelastic instability during ascent. Extensive tests were conducted to verify the shuttle could fly safely without these particular PAL ramps. Extensions were added to the ice frost ramps for the pressline and cable tray brackets, where these PAL ramps were removed to make the geometry of the ramps consistent with other locations on the tank and thereby provide consistent aerodynamic flow. Nine extensions were added, six on the liquid hydrogen tank and three on the liquid oxygen tank.

Engine Cutoff (ECO) Sensor Modification

Beginning with STS-122, ET-125, which launched on Feb. 7, 2008, the ECO sensor system feed through connector on the liquid hydrogen tank was modified by soldering the connector's pins and sockets to address false readings in the system. All subsequent tanks after ET-125 have the same modification.

Liquid Hydrogen Tank Ice Frost Ramps

ET-128, which flew on the STS-124 shuttle mission, May 31, 2008, was the first tank to fly with redesigned liquid hydrogen tank ice frost ramps. Design changes were incorporated at all 17 ice frost ramp locations on the liquid hydrogen tank, stations 1151 through 2057, to reduce foam loss. Although the redesigned ramps appear identical to the previous design, several changes were made. PDL* and NCFI foam have been replaced with BX* manual spray foam in the ramp's base cutout to reduce debonding and cracking; Pressline and cable tray bracket feet corners have been rounded to reduce stresses; shear pin holes have been sealed to reduce leak paths; isolators were primed to promote adhesion; isolator corners were rounded to help reduce thermal protection system foam stresses; BX manual spray was applied in bracket pockets to reduce geometric voids.

*BX is a type of foam used on the tank's "loseout," or final finished areas; it is applied manually or hand-sprayed. PDL is an acronym for Product Development Laboratory, the first supplier of the foam during the early days of the external tank's development. PDL is applied by pouring foam ingredients into a mold. NCFI foam is used on the aft dome, or bottom, of the liquid hydrogen tank.

Liquid Oxygen Feedline Brackets

ET-128 also was the first tank to fly with redesigned liquid oxygen feedline brackets. Titanium brackets, much less thermally conductive than aluminum, replaced aluminum brackets at four locations, XT 1129, XT 1377, Xt 1624 and Xt 1871. This change minimizes ice formation in under-insulated areas, and reduces the amount of foam required to cover the brackets and the propensity for ice development. Zero-gap/slip plane Teflon material was added to the upper outboard monoball attachment to eliminate ice adhesion. Additional foam has been added to the liquid oxygen feedline to further minimize ice formation along the length of the feedline.

LAUNCH AND LANDING

LAUNCH

As with all previous space shuttle launches, Discovery has several options to abort its ascent if needed after engine failures or other systems problems. Shuttle launch abort philosophy is intended to facilitate safe recovery of the flight crew and intact recovery of the orbiter and its payload.

Abort modes include:

ABORT-TO-ORBIT (ATO)

This mode is used if there is a partial loss of main engine thrust late enough to permit reaching a minimal 105 by 85 nautical mile orbit with the orbital maneuvering system engines. The engines boost the shuttle to a safe orbital altitude when it is impossible to reach the planned orbital altitude.

TRANSATLANTIC ABORT LANDING (TAL)

The loss of one or more main engines midway through powered flight would force a landing at either Zaragoza, Spain; Moron, Spain; or Istres, France. For launch to proceed, weather conditions must be acceptable at one of these TAL sites.

RETURN-TO-LAUNCH-SITE (RTLS)

If one or more engines shut down early and there is not enough energy to reach Zaragoza, the shuttle would pitch around toward Kennedy until within gliding distance of the Shuttle Landing Facility. For launch to proceed, weather conditions must be forecast to be acceptable for a possible RTLS landing at KSC about 20 minutes after liftoff.

ABORT ONCE AROUND (AOA)

An AOA is selected if the vehicle cannot achieve a viable orbit or will not have enough propellant to perform a deorbit burn, but has enough energy to circle the Earth once and land about 90 minutes after liftoff.

LANDING

The primary landing site for Discovery on STS-128 is the Kennedy Space Center's Shuttle Landing Facility. Alternate landing sites that could be used if needed because of weather conditions or systems failures are at Edwards Air Force Base, Calif., and White Sands Space Harbor, N.M.

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ACRONYMS AND ABBREVIATIONS

A/G	Alignment Guides
A/L	Airlock
AAA	Avionics Air Assembly
ABC	Audio Bus Controller
ACBM	Active Common Berthing Mechanism
ACDU	Airlock Control and Display Unit
ACO	Assembly Checkout Officer
ACS	Atmosphere Control and Supply
ACU	Arm Control Unit
ADS	Audio Distribution System
AE	Approach Ellipsoid
AEP	Airlock Electronics Package
AI	Approach Initiation
AJIS	Alpha Joint Interface Structure
AM	Atmosphere Monitoring
AMOS	Air Force Maui Optical and Supercomputing Site
AOH	Assembly Operations Handbook
APAS	Androgynous Peripheral Attachment
APCU	Assembly Power Converter Unit
APE	Antenna Pointing Electronics
	Audio Pointing Equipment
APFR	Articulating Portable Foot Restraint
APM	Antenna Pointing Mechanism
APS	Automated Payload Switch
APV	Automated Procedure Viewer
AR	Atmosphere Revitalization
ARCU	American-to-Russian Converter Unit
ARS	Air Revitalization System
	Atmosphere Revitalization System
ASW	Application Software
ATA	Ammonia Tank Assembly
ATCS	Active Thermal Control System
ATU	Audio Terminal Unit
BAD	Broadcast Ancillary Data
BC	Bus Controller
BCDU	Battery Charge/Discharge Unit
	Berthing Mechanism Control and Display Unit
BEP	Berthing Mechanism Electronics Package

BGA	Beta Gimbal Assembly
BIC	Bus Interface Controller
BIT	Built-In Test
BM	Berthing Mechanism
BOS	BIC Operations Software
BSS	Basic Software
BSTS	Basic Standard Support Software
C&C	Command and Control
C&DH	Command and Data Handling
C&T	Communication and Tracking
C&W	Caution and Warning
C/L	Crew Lock
C/O	Checkout
CAM	Collision Avoidance Maneuver
CAPE	Canister for All Payload Ejections
CAS	Common Attach System
CB	Control Bus
CBCS	Centerline Berthing Camera System
CBM	Common Berthing Mechanism
CCA	Circuit Card Assembly
CCAA	Common Cabin Air Assembly
CCHA	Crew Communication Headset Assembly
CCP	Camera Control Panel
CCT	Communication Configuration Table
CCTV	Closed-Circuit Television
CDR	Space Shuttle Commander
CDRA	Carbon Dioxide Removal Assembly
CETA	Crew Equipment Translation Aid
CHeCS	Crew Health Care System
CHX	Cabin Heat Exchanger
CISC	Complicated Instruction Set Computer
CLA	Camera Light Assembly
CLPA	Camera Light Pan Tilt Assembly
CMG	Control Moment Gyro
COLBERT	Combined Operational Load Bearing External Resistance Treadmill
COTS	Commercial Off the Shelf
CPA	Control Panel Assembly
CPB	Camera Power Box
CR	Change Request
CRT	Cathode-Ray Tube
CSA	Canadian Space Agency

CSA-CP	Compound Specific Analyzer
CVIU	Common Video Interface Unit
CVT	Current Value Table
CZ	Communication Zone
DB	Data Book
DC	Docking Compartment
DCSU	Direct Current Switching Unit
DDCU	DC-to-DC Converter Unit
DEM	Demodulator
DFL	Decommutation Format Load
DIU	Data Interface Unit
DMS	Data Management System
DMS-R	Data Management System-Russian
DPG	Differential Pressure Gauge
DPU	Baseband Data Processing Unit
DRTS	Japanese Data Relay Satellite
DYF	Display Frame
E/L	Equipment Lock
EATCS	External Active Thermal Control System
EBCS	External Berthing Camera System
ECC	Error Correction Code
ECLSS	Environmental Control and Life Support System
ECS	Environmental Control System
ECU	Electronic Control Unit
EDSU	External Data Storage Unit
EDU	EEU Driver Unit
EE	End Effector
EETCS	Early External Thermal Control System
EEU	Experiment Exchange Unit
EF	Exposed Facility
EFBM	Exposed Facility Berthing Mechanism
EFHX	Exposed Facility Heat Exchanger
EFU	Exposed Facility Unit
EGIL	Electrical, General Instrumentation, and Lighting
EIU	Ethernet Interface Unit
ELM-ES	Japanese Experiment Logistics Module – Exposed Section
ELM-PS	Japanese Experiment Logistics Module – Pressurized Section
ELPS	Emergency Lighting Power Supply
EMGF	Electric Mechanical Grapple Fixture
EMI	Electro-Magnetic Imaging

EMU	Extravehicular Mobility Unit
E-ORU	EVA Essential ORU
EP	Exposed Pallet
EPS	Electrical Power System
ES	Exposed Section
ESA	European Space Agency
ESC	JEF System Controller
ESW	Extended Support Software
ET	External Tank
ETCS	External Thermal Control System
ETI	Elapsed Time Indicator
ETRS	EVA Temporary Rail Stop
ETVCG	External Television Camera Group
EuTEF	European Technology Exposure Facility
EV	Extravehicular
EVA	Extravehicular Activity
EXP-D	Experiment-D
EXT	External

FA	Fluid Accumulator
FAS	Flight Application Software
FCT	Flight Control Team
FD	Flight Day
FDDI	Fiber Distributed Data Interface
FDIR	Fault Detection, Isolation, and Recovery
FDS	Fire Detection System
FE	Flight Engineer
FET-SW	Field Effect Transistor Switch
FGB	Functional Cargo Block
FIR	Fluids Integration Rack
FOR	Frame of Reference
FPP	Fluid Pump Package
FR	Flight Rule
FRD	Flight Requirements Document
FRGF	Flight Releasable Grapple Fixture
FRM	Functional Redundancy Mode
FSE	Flight Support Equipment
FSEGF	Flight Support Equipment Grapple Fixture
FSW	Flight Software

GAS	Get-Away Special
GCA	Ground Control Assist
GLA	General Lighting Assemblies
	General Luminaire Assembly
GLONASS	Global Navigational Satellite System
GNC	Guidance, Navigation, and Control
GPC	General Purpose Computer
GPS	Global Positioning System
GPSR	Global Positioning System Receiver
GUI	Graphical User Interface
H&S	Health and Status
HCE	Heater Control Equipment
HCTL	Heater Controller
HEPA	High Efficiency Particulate Acquisition
HPA	High Power Amplifier
HPP	Hard Point Plates
HRDR	High Rate Data Recorder
HREL	Hold/Release Electronics
HRFM	High Rate Frame Multiplexer
HRM	Hold Release Mechanism
HRMS	High Rate Multiplexer and Switcher
HTV	H-II Transfer Vehicle
HTVCC	HTV Control Center
HTV Prox	HTV Proximity
HX	Heat Exchanger
I/F	Interface
IAA	Intravehicular Antenna Assembly
IAC	Internal Audio Controller
IBM	International Business Machines
ICB	Inner Capture Box
ICC	Integrated Cargo Carrier
ICS	Interorbit Communication System
ICS-EF	Interorbit Communication System – Exposed Facility
IDRD	Increment Definition and Requirements Document
IELK	Individual Equipment Liner Kit
IFHX	Interface Heat Exchanger
IMCS	Integrated Mission Control System
IMCU	Image Compressor Unit
IMV	Intermodule Ventilation
INCO	Instrumentation and Communication Officer

IP	International Partner
IP-PCDU	ICS-PM Power Control and Distribution Unit
IP-PDB	Payload Power Distribution Box
ISP	International Standard Payload
ISPR	International Standard Payload Rack
ISS	International Space Station
ISSSH	International Space Station Systems Handbook
ITCS	Internal Thermal Control System
ITS	Integrated Truss Segment
IVA	Intravehicular Activity
IVSU	Internal Video Switch Unit
JAXA	Japan Aerospace Exploration Agency
JCP	JEM Control Processor
JEF	JEM Exposed Facility
JEM	Japanese Experiment Module
JEMAL	JEM Airlock
JEM-EF	Japanese Experiment Module Exposed Facility
JEM-PM	Japanese Experiment Module – Pressurized Module
JEMRMS	Japanese Experiment Module Remote Manipulator System
JEUS	Joint Expedited Undocking and Separation
JFCT	Japanese Flight Control Team
JLE	Japanese Experiment Logistics Module – Exposed Section
JLP	Japanese Experiment Logistics Module – Pressurized Section
JLP-EDU	JLP-EFU Driver Unit
JLP-EFU	JLP Exposed Facility Unit
JPM	Japanese Pressurized Module
JPM WS	JEM Pressurized Module Workstation
JSC	Johnson Space Center
JTVE	JEM Television Equipment
Kbps	Kilobit per second
KOS	Keep Out Sphere
LB	Local Bus
LCA	LAB Cradle Assembly
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LEE	Latching End Effector
LMC	Lightweight MPESS Carrier Lightweight Multipurpose Carrier
LSW	Light Switch

LTA	Launch-to-Activation
LTAB	Launch-to-Activation Box
LTL	Low Temperature Loop
MA	Main Arm
MAUI	Main Analysis of Upper-Atmospheric Injections
Mb	Megabit
Mbps	Megabit per second
MBS	Mobile Base System
MBSU	Main Bus Switching Unit
MCA	Major Constituent Analyzer
MCC	Mission Control Center
MCC-H	Mission Control Center – Houston
MCC-M	Mission Control Center – Moscow
MCDS	Multifunction Cathode-Ray Tube Display System
MCS	Mission Control System
MDA	MacDonald, Dettwiler and Associates Ltd.
MDM	Multiplexer/Demultiplexer
MDP	Management Data Processor
MELFI	Minus Eighty-Degree Laboratory Freezer for ISS
MGB	Middle Grapple Box
MIP	Mission Integration Plan
MISSE	Materials International Space Station Experiment
MKAM	Minimum Keep Alive Monitor
MLE	Middeck Locker Equivalent
MLI	Multi-layer Insulation
MLM	Multipurpose Laboratory Module
MMOD	Micrometeoroid/Orbital Debris
MOD	Modulator
MON	Television Monitor
MPC	Main Processing Controller
MPESS	Multipurpose Experiment Support Structure
MPEV	Manual Pressure Equalization Valve
MPL	Manipulator Retention Latch
MPLM	Multi-Purpose Logistics Module
MPM	Manipulator Positioning Mechanism
MPV	Manual Procedure Viewer
MSD	Mass Storage Device
MSFC	Marshall Space Flight Center
MSP	Maintenance Switch Panel
MSRR	Materials Science Research Rack
MSS	Mobile Servicing System

MT	Mobile Tracker
MTL	Moderate Temperature Loop
MUX	Data Multiplexer
n.mi.	nautical mile
NASA	National Aeronautics and Space Administration
NBL	Neutral Buoyancy Laboratory
NCS	Node Control Software
NET	No Earlier Than
NLT	No Less Than
NPRV	Negative Pressure Relief Valve
NSV	Network Service
NTA	Nitrogen Tank Assembly
NTSC	National Television Standard Committee
OBSS	Orbiter Boom Sensor System
OCA	Orbital Communications Adapter
OCAD	Operational Control Agreement Document
OCAS	Operator Commanded Automatic Sequence
ODF	Operations Data File
ODS	Orbiter Docking System
OI	Orbiter Interface
OIU	Orbiter Interface Unit
OMS	Orbital Maneuvering System
OODT	Onboard Operation Data Table
ORCA	Oxygen Recharge Compressor Assembly
ORU	Orbital Replacement Unit
OS	Operating System
OSA	Orbiter-based Station Avionics
OSE	Orbital Support Equipment
OTCM	ORU and Tool Changeout Mechanism
OTP	ORU and Tool Platform
P/L	Payload
PAL	Planning and Authorization Letter
PAM	Payload Attach Mechanism
PAO	Public Affairs Office
PBA	Portable Breathing Apparatus
PCA	Pressure Control Assembly
PCBM	Passive Common Berthing Mechanism
PCN	Page Change Notice
PCS	Portable Computer System

PCU	Power Control Unit
PDA	Payload Disconnect Assembly
PDB	Power Distribution Box
PDGF	Power and Data Grapple Fixture
PDH	Payload Data Handling unit
PDRS	Payload Deployment Retrieval System
PDU	Power Distribution Unit
PEC	Passive Experiment Container
PEHG	Payload Ethernet Hub Gateway
PFE	Portable Fire Extinguisher
PGSC	Payload General Support Computer
PIB	Power Interface Box
PIU	Payload Interface Unit
PLB	Payload Bay
PLBD	Payload Bay Door
PLC	Pressurized Logistics Carrier
PLT	Payload Laptop Terminal
	Space Shuttle Pilot
PM	Pressurized Module
PMA	Pressurized Mating Adapter
PMCU	Power Management Control Unit
POA	Payload ORU Accommodation
POR	Point of Resolution
PPRV	Positive Pressure Relief Valve
PRCS	Primary Reaction Control System
PREX	Procedure Executor
PRLA	Payload Retention Latch Assembly
PROX	Proximity Communications Center
psia	Pounds per Square Inch Absolute
PSP	Payload Signal Processor
PSRR	Pressurized Section Resupply Rack
PTCS	Passive Thermal Control System
PTR	Port Thermal Radiator
PTU	Pan/Tilt Unit
PVCU	Photovoltaic Controller Unit
PVM	Photovoltaic Module
PVR	Photovoltaic Radiator
PVTCS	Photovoltaic Thermal Control System
QD	Quick Disconnect

R&MA	Restraint and Mobility Aid
RACU	Russian-to-American Converter Unit
RAM	Read Access Memory
RBVM	Radiator Beam Valve Module
RCC	Range Control Center
RCT	Rack Configuration Table
RF	Radio Frequency
RGA	Rate Gyro Assemblies
RHC	Rotational Hand Controller
RIGEX	Rigidizable Inflatable Get-Away Special Experiment
RIP	Remote Interface Panel
RLF	Robotic Language File
RLT	Robotic Laptop Terminal
RMS	Remote Manipulator System
ROEU	Remotely Operated Electrical Umbilical
ROM	Read Only Memory
R-ORU	Robotics Compatible Orbital Replacement Unit
ROS	Russian Orbital Segment
RPC	Remote Power Controller
RPCM	Remote Power Controller Module
RPDA	Remote Power Distribution Assembly
RPM	Roll Pitch Maneuver
RS	Russian Segment
RSP	Return Stowage Platform
RSR	Resupply Stowage Rack
RT	Remote Terminal
RTAS	Rocketdyne Truss Attachment System
RVFS	Rendezvous Flight Software
RWS	Robotics Workstation
SAFER	Simplified Aid for EVA Rescue
SAM	SFA Airlock Attachment Mechanism
SARJ	Solar Alpha Rotary Joint
SCU	Sync and Control Unit
SD	Smoke Detector
SDS	Sample Distribution System
SEDA	Space Environment Data Acquisition equipment
SEDA-AP	Space Environment Data Acquisition equipment - Attached Payload
SELS	SpaceOps Electronic Library System
SEU	Single Event Upset
SFA	Small Fine Arm
SFAE	SFA Electronics

SI	Smoke Indicator
SLM	Structural Latch Mechanism
SLP-D	Spacelab Pallet – D
SLP-D1	Spacelab Pallet – Deployable
SLP-D2	Spacelab Pallet – D2
SLT	Station Laptop Terminal
	System Laptop Terminal
SM	Service Module
SMDP	Service Module Debris Panel
SOC	System Operation Control
SODF	Space Operations Data File
SPA	Small Payload Attachment
SPB	Survival Power Distribution Box
SPDA	Secondary Power Distribution Assembly
SPDM	Special Purpose Dexterous Manipulator
SPEC	Specialist
SRAM	Static RAM
SRB	Solid Rocket Booster
SRMS	Shuttle Remote Manipulator System
SSAS	Segment-to-Segment Attach System
SSC	Station Support Computer
SSCB	Space Station Control Board
SSE	Small Fine Arm Storage Equipment
SSIPC	Space Station Integration and Promotion Center
SSME	Space Shuttle Main Engine
SSOR	Space-to-Space Orbiter Radio
SSP	Standard Switch Panel
SSPTS	Station-to-Shuttle Power Transfer System
SSRMS	Space Station Remote Manipulator System
STC	Small Fire Arm Transportation Container
STR	Starboard Thermal Radiator
STS	Space Transfer System
STVC	SFA Television Camera
SVS	Space Vision System
TA	Thruster Assist
TAC	TCS Assembly Controller
TAC-M	TCS Assembly Controller – M
TCA	Thermal Control System Assembly
TCB	Total Capture Box
TCCS	Trace Contaminant Control System
TCCV	Temperature Control and Check Valve

TCS	Thermal Control System
TCV	Temperature Control Valve
TDK	Transportation Device Kit
TDRS	Tracking and Data Relay Satellite
THA	Tool Holder Assembly
THC	Temperature and Humidity Control
	Translational Hand Controller
THCU	Temperature and Humidity Control Unit
TIU	Thermal Interface Unit
TKSC	Tsukuba Space Center (Japan)
TLM	Telemetry
TMA	Russian vehicle designation
TMR	Triple Modular Redundancy
TPL	Transfer Priority List
TRRJ	Thermal Radiator Rotary Joint
TUS	Trailing Umbilical System
TVC	Television Camera
UCCAS	Unpressurized Cargo Carrier Attach System
UCM	Umbilical Connect Mechanism
UCM-E	UCM – Exposed Section Half
UCM-P	UCM – Payload Half
UHF	Ultrahigh Frequency
UIL	User Interface Language
ULC	Unpressurized Logistics Carrier
UMA	Umbilical Mating Adapter
UOP	Utility Outlet Panel
UPC	Up Converter
USA	United Space Alliance
US LAB	United States Laboratory
USOS	United States On-Orbit Segment
VAJ	Vacuum Access Jumper
VBSP	Video Baseband Signal Processor
VCU	Video Control Unit
VDS	Video Distribution System
VLU	Video Light Unit
VRA	Vent Relief Assembly
VRCS	Vernier Reaction Control System
VRCV	Vent Relief Control Valve
VRIV	Vent Relief Isolation Valve

VSU	Video Switcher Unit
VSW	Video Switcher
WAICO	Waiving and Coiling
WCL	Water Cooling Loop
WETA	Wireless Video System External Transceiver Assembly
WIF	Work Interface
WRM	Water Recovery and Management
WRS	Water Recovery System
WS	Water Separator
	Work Site
	Work Station
WVA	Water Vent Assembly
ZSR	Zero-g Stowage Rack

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MEDIA ASSISTANCE

NASA TELEVISION TRANSMISSION

NASA Television is carried on an MPEG-2 digital signal accessed via satellite AMC-6, at 72 degrees west longitude, transponder 17C, 4040 MHz, vertical polarization. For those in Alaska or Hawaii, NASA Television will be seen on AMC-7, at 137 degrees west longitude, transponder 18C, at 4060 MHz, horizontal polarization. In both instances, a Digital Video Broadcast, or DVB-compliant Integrated Receiver Decoder, or IRD, with modulation of QPSK/DBV, data rate of 36.86 and FEC 3/4 will be needed for reception. The NASA Television schedule and links to streaming video are available at:

http://www.nasa.gov/ntv

NASA TV's digital conversion will require members of the broadcast media to upgrade with an "addressable" Integrated Receiver De-coder, or IRD, to participate in live news events and interviews, media briefings and receive NASA's Video File news feeds on a dedicated Media Services channel. NASA mission coverage will air on a digital NASA Public Services "Free to Air" channel, for which only a basic IRD will be needed.

Television Schedule

A schedule of key in-orbit 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 on launch countdown and mission progress, in-orbit activities and landing operations will be posted at:

http://www.nasa.gov/shuttle

This site also contains information on the crew and will be updated regularly with photos and video clips throughout the flight.

More Internet Information

Information on the ISS is available at:

http://www.nasa.gov/station

Information on safety enhancements made since the Columbia accident is available at:

http://www.nasa.gov/returntoflight/system/index.html

Information on other current NASA activities is available at:

http://www.nasa.gov

Resources for educators can be found at the following address:

http://education.nasa.gov

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