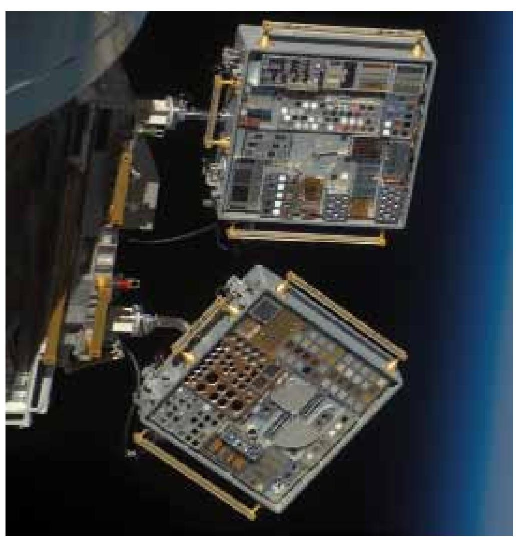
A New Era for Science

Research on the International Space Station

BY CLIFFORD R. MCMURRAY

From the time the first crew settled in aboard the International Space Station (ISS), it has been an operational research platform. But until recently, scientific experiment and commercial utilization took a back seat to the heavy time demands of the assembly process. Now the decade of construction for the International Space Station is ending, and ISS will come into its own as a center of technology development and scientific research for all the nations that have partnered to build it. ISS is now at its planned permanent crew level of six astronauts. The amount of crew time devoted to research activity has jumped from about 15 hours per week to about 60 hours per week, and continues to increase.

ISS has several obvious advantages over other space-based research platforms. Unlike the Shuttle or Soyuz, whose operations are limited to a few weeks at most, ISS can run, monitor, and adjust experiments over periods of many months. Unlike purely robotic platforms, whose power supply is limited to a few hundred watts, its large solar arrays provide up to 120 kilowatts for powering larger instruments such as the 25,000 pound Alpha Mass Spectrometer. And with its high-inclination orbit of 51.6 degrees, ISS passes overhead of 95% of the Earth's population every day, making it an excellent Earth observation platform.



It's been eight years since the first Materials International Space Station Experiment, or MISSE, arrived at the orbiting laboratory. During that time, more than 4,000 materials samples have been placed outside the space station to test how they react to the harsh environment of space.

The reevaluation of NASA's human spaceflight program that followed the loss of Columbia has caused a shift in emphasis for American ISS-based experiments. NASA's research is now focused on medical studies and technology demonstrations in support of the longer flights that will come when astronauts once again venture beyond low Earth orbit. Even with two hours of exercise per day, astronauts lose one percent of bone mass per month in microgravity – and that's a straight linear graph, with no reduction in the loss rate up to fourteen months (the maximum anyone has spent in space so far). Flights to Mars take up to three years, so there is keen interest in finding a way to slow bone atrophy, by some combination of exercise and drug therapy.

ISS also offers an ideal location to test new components and systems. The water recycling system aboard ISS, for instance, is an important first step in closing the life support loop and reducing the need to haul consumables up from Earth.

NASA-funded research is not the only American-sponsored work aboard ISS, however. With the NASA 2005 Authorization Act, Congress designated the U.S. portion of the space station as a national laboratory, directing NASA to support the use of ISS by other government agencies as well as commercial research and development. The Naval Research Laboratory and the Air Force currently have experiments on ISS, paid for by their own budgets. The National Institutes of Health is also soliciting proposals for ISS-based research. NASA calls the first commercial experiments National Lab Pathfinder missions; two examples are an attempt by Astrogenetix Inc. to develop a vaccine for salmonella, and a materials processing chamber called the Space Dynamically Responding Ultrasonic Matrix System (Space-DRUMS). Developed by Guigne Space

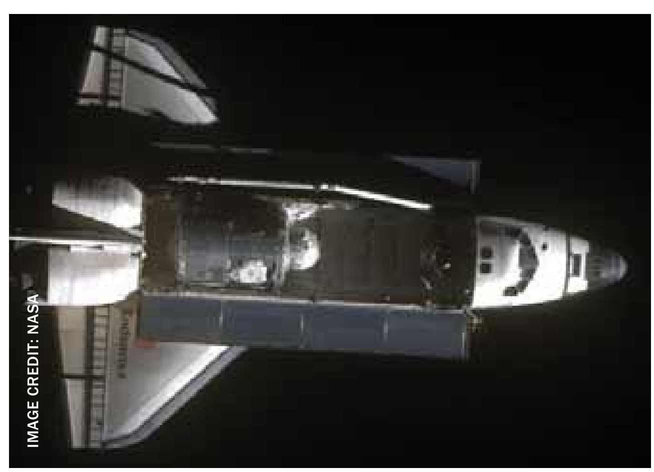
Russian cosmonauts Oleg Kotov and Maxim Suraev (out of frame), both Expedition 22 flight engineers, participate in a session of extravehicular activity (EVA) as maintenance and construction continue on the International Space Station. During the spacewalk, Kotov and Suraev prepared the Mini-Research Module 2 (MRM2), known as Poisk, for future Russian vehicle dockings.

Systems Inc., Space-DRUMS uses beams of sound energy to push materials away from the walls of a container in microgravity. The samples so produced will be ultra-pure and concentrated, and much larger than materials previously produced in space. A single sample might be worth hundreds of thousands of dollars.

The United States is, of course, only one of the nations in the ISS partnership. The other partners have contributed research modules and other hardware, and have a share in the research time budget. In addition to the Destiny laboratory built by NASA, ISS contains the Columbus lab from the European Space Agency and the Kibo lab contributed by the Japanese Aerospace Exploration Agency. Together, these modules currently accommodate 21 refrigerator-sized experiment racks. Although the labs each have a ground station in their country of origin (the Tsukuba Space Center for Kibo; the Columbus Control Center in Oberpfaffenhofen, Germany for Columbus; and the Payload Operations Center in Huntsville, Alabama for Destiny), these ground stations only monitor the lab hardware and their own experiments. ISS is managed by the partners as an integrated laboratory, so any given experiment is housed in whichever laboratory has the appropriate equipment, regardless of national origin. Coordination of the workload is done both on an agency level and by international work groups within a given specialty.

Not all the experiments aboard ISS take place within the pressurized modules. Some experiments are attached to the outside of the space station for exposure to vacuum. The MISSE (Materials International Space Station Experiment) packages, for instance, are suitcase-sized racks containing samples of construction materials, biological samples such as seeds and spores, and actual hardware components such as switches and sensors. Analysis of these samples after long exposure to the harsh space environment will help develop better hardware for both robotic and crewed spacecraft. There are 18 external power and data ports for unpressurized experiments, with four more to be added this year.

As an Earth observation platform, ISS provides photos with resolution comparable to that of Earth resources satellites. Destiny has a special



Backdropped by the blackness of space, Space Shuttle Endeavour was photographed by the Expedition 22 crew as the Shuttle approached the International Space Station during STS-130 rendezvous and docking operations on February 9, 2010. The Tranquility node can be seen in the Shuttle's payload bay.

The Soyuz TMA-17 spacecraft approaches the International Space Station, carrying Russian cosmonaut Oleg Kotov, Soyuz commander and Expedition 22 flight engineer; along with NASA astronaut T.J. Creamer and Japan Aerospace Exploration Agency astronaut Soichi Noguchi, both flight engineers. Docking to the Zarya nadir port occurred at 4:48 p.m. (CST) on December 22, 2009. The trio launched aboard the Soyuz TMA-17 spacecraft at 3:52 p.m. on December 20 from the Baikonur Cosmodrome in Kazakhstan. A docked Russian spacecraft is at top left.

optical-quality window for photography, although the crew also takes pictures from the many other windows aboard. A noteworthy long-term project in this area is EarthKAM (Earth Knowledge Acquired by Middle School Students), which allows high school students to use a dedicated, remotely operated camera. The students' target requests are coordinated by college students at the University of California in San Diego, uplinked to a computer controlling the camera, and the resulting images are downlinked to the world wide web. As of 2006, more than 65,000 students in more than 1,000 schools in the U.S. and 12 other countries had used EarthKAM in geography and Earth science projects of their own formulation.

Many lines of investigation – physiological, biological, crystal growth, plant growth, fluid behavior, combustion experiments, technology development, Earth observation, education, and others – will continue aboard ISS in the decade ahead. The trickle of experiments has turned into a stream, and the space community can look forward to a flood of new knowledge as the result of this new era in space science.

International Space Station INTERNET RESOURCES

The NASA Website lists more than 400 research projects that have flown on ISS so far. Readers wishing to see more information may visit the following sites:

- Find details of all the experiments flown on ISS to date at http://www.nasa.gov/mission_pages/station/science/experiments/List.html.
- Find a summary of the research performed aboard ISS through 2008 at http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20090029998_2009030907.pdf.
- Find more about EarthKAM and how schools can sign up to use it at http://earthkam.ucsd.edu.
- Find an archive of photos of the Earth taken by astronauts, including more than 430,000 photos from ISS at http://eol.jsc.nasa.gov.

IMAGE CREDIT: NASA