NASA Facts

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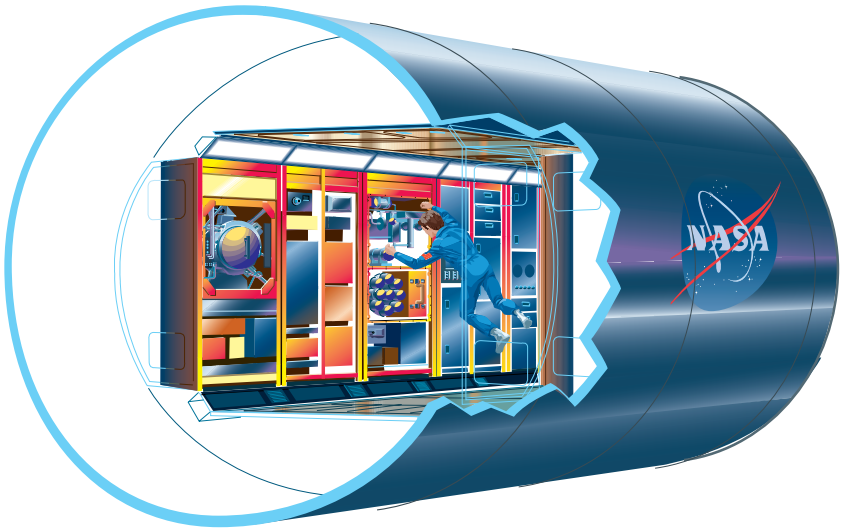
Unlocking Mysteries in Microgravity

NASA Glenn Provides the Keys With the Fluids and Combustion Facility

What Is Microgravity?

Gravity is a force that governs motion throughout the universe. It holds us to the ground and keeps the Earth in orbit around the Sun. Microgravity describes the environment in orbital space flight, which has very weak gravitational effects (one-millionth of what is felt on Earth) and which is sometimes referred to as a state of "weightlessness." The condition of microgravity occurs when an object is in "free fall." In free fall, an object falls faster and faster, accelerating with exactly the speed of attraction caused by gravity. Objects travelling around the Earth in a state of continuous free fall, or orbit, are essentially weightless even though their mass remains the same.



The International Space Station's (ISS) Fluid and Combustion Facility (FCF).

Conducting research in a microgravity environment gives researchers a unique opportunity to study the true nature of processes and materials without having to consider the effects of Earth's gravity. Thus, physics theories can be tested at levels of accuracy that are impossible on Earth. Microgravity experiments uncover the mystery of how gravity affects processes such as combustion science and fluid physics. This knowledge can then help to improve the way we do things on Earth.

A World-Class Orbiting Laboratory

The term "microgravity" will become more commonplace when the International Space Station (ISS) is fully operational. The ISS will be the largest orbiting space structure and the largest international scientific and technological endeavor in history. So far 16 countries, including the United States, are participating in this recordbreaking project. The ISS will be a permanent laboratory in space where studies can be performed without the effects of gravity.

The Space Station will provide researchers with all the laboratory space and equipment and electrical power needed for safe, long-term research by human beings in space. The ISS will enable larger and longer experiments than are possible on the typical two-week space shuttle mission. This will give scientists time for more detailed observation in the microgravity environment.

The knowledge gained from ISS microgravity experiments will benefit research on Earth in many fields. Our understanding of theories relevant to everything from high-temperature superconductivity to weather prediction will be advanced. New insights into areas such as human health and disease prevention and treatment will be achieved. In addition, scientists will use the microgravity environment to uncover other, more subtle forces and interactions in fluids and materials. By essentially taking gravitational effects out of the equation, researchers will be able to study as primary characteristics what would have been secondary behaviors on Earth.

Simple investigations of fluid interfaces and combustion processes can be addressed in small, contained experiments, such as the shuttle Glovebox experiments. However, more complex and challenging investigations require dedicated facilities to contain fluids and products of combustion in a controlled and safe environment.

The ISS Fluids and Combustion Facility

The United States Laboratory Module on the ISS will contain the Fluids and Combustion Facility (FCF), designed and built at NASA Glenn Research Center in Cleveland, Ohio. The FCF is being developed to accommodate the unique challenges of working with fluids and combustion processes in microgravity, as well as to provide services and capabilities comparable to those found in traditional Earth-based laboratories.

Glenn researchers working on FCF components.

Glenn was an ideal choice for this project because of their reputation for award-winning research, particularly in the areas of fluids and combustion, as well as their long-standing experience in developing experiment hardware and world-class test facilities. Glenn engineers and scientists have been involved in designing, producing, and managing space-based hardware and facilities since the 1960's. As pioneers in rocket research, they had tested high-energy propellants even before the United States officially entered into the space business. Glenn Research Center advanced the propulsion technology that helped make space travel possible.

The Center's unique Zero Gravity Research Facility and other drop towers and laboratories were the source of foundational work in microgravity research. NASA's Zero Gravity Trainer aircraft, the KC-135, operates out of NASA Glenn several weeks each year in support of Glenn's ground-based microgravity research. Some flights include astronauts participating in crew training so they can have low-gravity experience with experiment hardware and materials prior to shuttle missions. In all, these facilities give Glenn a unique ability to develop and test microgravity experiments.

Glenn Research Center is NASA's center of excellence for fluid physics and combustion science and has been responsible for 153 experiments on 47 flights. In addition to providing the new Fluids and Combustion Facility, they will be a major contributor to the investigations onboard the FCF, in gloveboxes, and in other ISS facilities. A forerunner of the FCF, the Glenn-developed Combustion Module-1 (CM-1), which flew onboard the Shuttle Columbia, STS-83, in April, 1997, laid the groundwork for the combustion portion of the new Fluids and Combustion Facility with several hardware innovations.

The FCF will usher in a new era of fluids and combustion research. It is a modular, multi-user, permanent microgravity science laboratory that is capable of accommodating a minimum of 10 combustion and fluids science investigations per year over an expected 10-year life cycle. The FCF will make it possible for researchers on the ground, with the assistance of the astronauts in space, to schedule and perform studies of how fluids and flames behave in the absence of gravity at a cost that's not out of this world.

The FCF will occupy three powered ISS racks and an equivalent amount of storage space and have rack closure doors and structural interfaces with the ISS. The racks will be launched separately beginning in 2003. The first rack will be the Combustion Integrated Rack.

The second rack is the Fluids Integrated Rack, scheduled to launch in 2003. In 2006, the Fluids and Combustion Facility will be complete with the addition of the third rack, the Shared Accommodations Rack, which will add more science experiment capabilities. The three racks together will provide the basic physical and functional framework required to perform combustion science, fluid physics, and associated science onboard the ISS. The environmental control subsystems will provide temperature and pressure control for air and water systems, as well as safety measures and fire detection.

The end result is true facility operations with all of the capabilities that serious researchers expect on the ground without the effects of gravity.

Combustion Science

Combustion, or burning, is a process in which a substance reacts with oxygen to give off heat and light. Combustion meets almost 85% of the U.S. energy needs. While it does a good job of powering how we live on Earth, combustion is a major contributor to air pollution.

The cost of combustion energy is about $450 billion each year in the U.S. In any area of the economy where a huge amount of money is spent, even the smallest improvements in efficiency can mean savings of very large amounts of money. A mere 1 percent increase in fuel efficiency, like improving your gas mileage from 25 miles per gallon to 25.25 miles per gallon, would translate into a savings to America of nearly 100 million barrels of oil a year (roughly $5.5 million per day at today's cost). Although today combustion is vital to transportation, materials processing, hazardous waste disposal, and many other areas, there is still only limited understanding of many of its fundamental characteristics.

There are over 2,500 fatalities and tens of billions of dollars in property damage each year in accidental fires. Combustion research in microgravity can lead to advances in fire prevention, detection, and fighting. In addition, combustion research in microgravity can lead to more efficient use of energy, reduced pollution, and improved processes for making high-technology materials. Glenn Research Center's experience with jet engines provides a solid background in combustion and Glenn scientists have already begun to study combustion in space.

A simple example of microgravity's effect in combustion is the behavior of flames in space. On Earth, hot air

Flame in microgravity.

rises around a candle flame, which causes the flame to flicker and take on an elongated shape. In microgravity, however, no such distortion takes place. The flame, without the effects of gravity, has a steady, spherical, shape. The FCF allows researchers to study aspects of combustion, such as flame behavior, that are impossible to observe on the ground. Their research will lead to a better understanding of whole processes, such as soot production, which will aid development of improvements in fire fighting and pollution reduction.

Fluid Physics

Of the four states of matter — solid, liquid, gas, and plasma — three are fluid, meaning they flow in response to an applied force. An understanding of fluid physics is not only vital to advancing aircraft and spacecraft applications, such as air flow and propellant management, but is also essential to understanding the human body, aspects of everyday life, and many industrial processes. In microgravity, fluid positioning and flow characteristics can be studied from a new perspective.

Scientists at NASA Glenn Research Center have played an important role in fluid physics research since the 1940's. With orbiting spacecraft, microgravity fluid physics became an important research area in which NASA Glenn has always played a leading role. Glenn is currently focusing its research on the enabling technology for space exploration (water and fuel flow, life support systems, temperature control, etc.) as well as on using the space environment (reduced gravity) to provide insight into phenomena that are important for Earth-based applications. A recent spinoff of the special nonintrusive instruments and techniques developed to perform the fluid experiments is a dynamic light scattering (DLS) probe and Hruby lens holder that make early detection of cataracts and other eye diagnoses easier.

Glenn researchers have also experimented with the behavior of colloidal suspensions. A colloid is a system of fine particles suspended in a fluid. Italian salad dressing provides a simple illustration of the effects of microgravity on the behavior of colloidal suspensions. In space you would need to shake the dressing only once, rather than between uses, which is needed on Earth. Paint, ink, milk, and orange juice are also common examples. Though these products are routinely produced and used, scientists know little about the underlying structure of colloidal systems because they are difficult to study in ground-based laboratories. Understanding their structures may allow scientists to manipulate the physical properties of colloids for the creation of new materials and products or to improve the manufacturing of known products.

Experiments by Remote Control

While the astronauts perform their roles in experiment setup, operation, observation, evaluation, and feedback, the FCF will be teleoperated from the NASA Glenn Research Center. Operation of experiments via remote control is coordinated through the Telescience Support Center (TSC) at Glenn. Telescience is the systematic monitoring, command, and control of an experiment from a remote location and has already

Telescience support center.

been implemented successfully by NASA on the Shuttle/Spacelab and the Russian Mir Space Station. In concert with the work performed by the astronauts in space and the Cleveland-based operations team, the FCF Principle Investigator's experiment will be remotely monitored and controlled from the PI's home site through Glenn's TSC.

The concept of telescience offers several advantages. Typically, the development of an experiment takes years and involves a varied group of scientists, engineers, and support personnel. Only a few of these people would be on the operations team that travels to a NASA center to support actual mission operations. A major benefit of remote operations is that the entire team that developed and built the experiment can be connected to the operations team to support data analysis, command decisions, anomaly resolution, and other real-time considerations. Also, some facilities that are not physically located at NASA centers can be included (e.g., colleges, universities, and industrial labs). Additional benefits are reductions in travel requirements and increases in the amount of science data acquired.

The Sky is Not the Limit!

At the dawn of the new millennium, the International Space Station is underway. The newest star in the night sky will continue to grow brighter, demonstrating to the world that its nations can work together in peace.

Researchers at NASA Glenn Research Center, world leaders in microgravity science, continuously define scientific requirements and develop hardware for microgravity space experiments that will eventually have an impact on many areas of life here on Earth. Microgravity research aboard the International Space Station's Fluids and Combustion Facility, developed by NASA Glenn, will be helping to improve industrial processes, increase fundamental knowledge, advance our health care technologies, and make space exploration easier and safer. This research will help create new ideas for tomorrow's products, today.

Microgravity research on the International Space Station will be showing life on Earth to us in ways we've never seen before. The sky is not the limit at NASA Glenn Research Center.

For more information, visit the NASA Glenn Microgravity Science Web Site at

http://microgravity.grc.nasa.gov/

or contact the

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