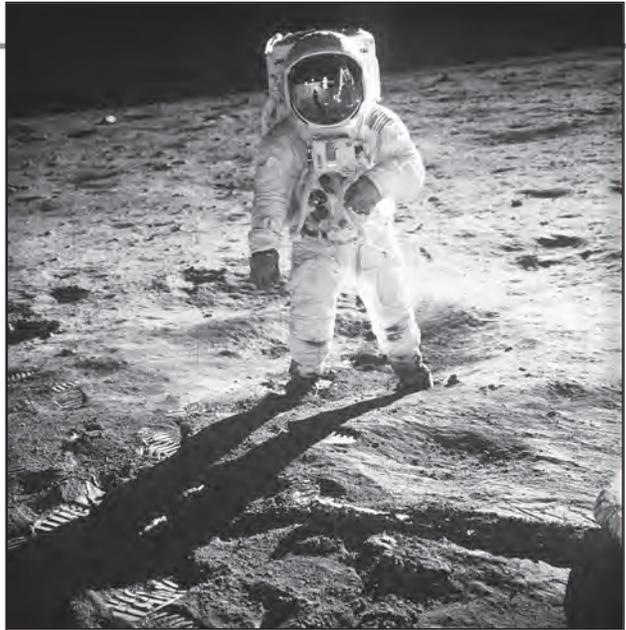




APOLLO  1969
2009

Forty years ago on July 20, the United States gained the lead in space exploration as the world watched the Apollo 11 Eagle land and Neil Armstrong take the first human step on the moon "...for the benefit of mankind." From a center leader, Dr. Abe Silverstein, who named the nation's lunar program, to pioneering technology that harnessed liquid hydrogen propulsion, NASA Glenn takes great pride in helping bring to life one of the most significant accomplishments in American history. In this issue, *AeroSpace Frontiers* will celebrate Apollo 11's success, highlight some of NASA Glenn's contributions to Apollo and will bring to life a new vision for exploration under the Constellation Program.



Right: Apollo 11's Lunar Module pilot Buzz Aldrin pauses for a picture taken by Ohio native Neil Armstrong, the first human to step on the moon.

C-2009-1340

Glenn Hardware

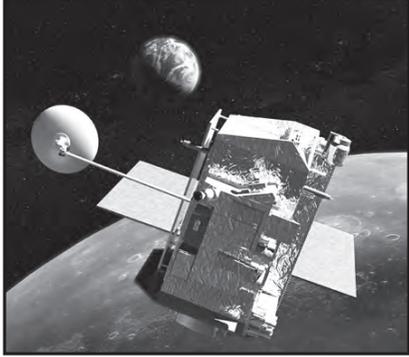
Traveling Wave Tube Amplifier Set to Make a World of Difference

A comprehensive atlas of the moon's prime real estate, its potential resources and a study of environment characteristics will soon be within reach on Earth due in large part to the higher power and increased efficiency of hardware provided by NASA Glenn.

The hardware, called the traveling wave tube amplifier (TWTA), is a critical part of the primary communication system of NASA's Lunar Reconnaissance Orbiter (LRO) that launched on June 18 as the first mission in NASA's Vision for Space Exploration.

Glenn's Advanced Capabilities Office oversaw manufacture of the TWTA for NASA's Goddard Space Flight Center, Greenbelt, Md. A number of design changes suggested by Glenn, including the amplifier's input drive power requirements, were incorporated in the

Continued on page 2



Left: An illustration of NASA's Lunar Reconnaissance Orbiter:

Inside

COLLIER TROPHY..... 2
Prestigious trophy recognizes greatest aeronautics or astronautics achievement

APOLLO 11 40th ANNIVERSARY ... 3-6
SPECIAL COLOR ISSUE: *AeroSpace Frontiers* looks back at NASA Glenn's rich contributions to the Apollo era and ahead as we prepare to return to the moon



PLANETS 8
Students at Lewis Little Folks get a closer look at the planets



Glenn Technology Sent To Space

Continued from page 1

construction of the amplifier built by L-3 Communications Electron Technologies, Torrance, Calif. Goddard manages the overall LRO spacecraft mission.

The LRO TWTA will allow significantly increased science data and video to be sent from the moon and other deep space destinations at much higher rates and reduced cost than previously possible with older technology.

"The Lunar Reconnaissance Orbiter TWTA advances Glenn-developed TWTA technology for Cassini (1997) by its higher power output and efficiency," explained Dr. Rainee Simons, chief of the Electron and Optoelectronic Device Branch. "Although the mass of the lunar traveling wave tube is twice that of Cassini, the output power has increased by a factor of four."

A traveling wave tube is an electronics device that is used to amplify microwave communications signals. It is needed for high frequency and high power applications such as deep space communications because of its higher power capability and efficiency when compared to solid-state devices.

This amplifier uses a new waveguide for input and output that adds strength to withstand mechanical shock and vibrations for enhanced reliability while traveling in the harsh environment of space.

In addition, the amplifier can be used to increase the rate of data transfer from Earth-orbiting satellites for improved weather forecasting and Earth observation for climate change. Possible future applications for the amplifier include air traffic control of transoceanic flights and tracking ships at sea.

Glenn's Advanced Capabilities Office manages the TWTA Project under NASA's Lunar Precursor Robotics Program, which is managed by NASA's

Marshall Space Flight Center, Huntsville, Ala. For more information on the LRO, visit http://www.nasa.gov/mission_pages/LRO/main/index.html.

—BY KATHERINE K. MARTIN

Flight TWTA being checked out in the LRO "Whiteroom" (clean room) while still on its shipping and handling plate.



Glenn Shares in Collier Trophy Award

On May 28, the National Aeronautics Association presented the 2008 Robert J. Collier Trophy to the Commercial Aviation Safety Team (CAST), an industry and government partnership that was established in 1997 with the goal of reducing the U.S. commercial aviation fatal accident rate by 80 percent in 10 years.

Mary Reveley, a researcher in Glenn's Multidisciplinary Design, Analysis and

award is named for Robert J. Collier, a prominent publisher, patriot, sportsman and aviator.

CAST represents thousands of people in public agencies and private industry "who have worked diligently since 1997 to produce the safest commercial aviation system in the world," according to the award nomination submitted by the Air Transport Association. Reveley represented NASA's Aviation Safety Program serving as a member of the CAST Joint Implementation Measurement and Data Analysis Team. Additionally, three researchers in Glenn's Icing Branch —Tom Ratvasky, Andy Reehorst and Tom Bond (currently with the Federal Aviation Administration)—served on the CAST Loss of Control Joint Safety Assessment Team.



Reveley receives Collier Trophy for her role in the award-winning CAST.

Optimization Branch, was one of eight key CAST members who received the coveted trophy. The trophy is presented annually for the greatest achievement in American aeronautics or astronautics, with respect to improving the performance, efficiency and safety of air or space vehicles demonstrated during the preceding year. The

Apollo 11 at the VC

On Saturday, July 18, Glenn's Visitor Center will celebrate the 40th Anniversary of Apollo 11. Visitors will learn about NASA's new spacecraft that will return humans to the moon and to Mars. Visitors can also tour the Glenn facilities that contributed to the Apollo missions. Admission will be first-come, first-served. No registration required. Contact 216-433-9653 for more information.



Glenn Made Numerous Contributions to Apollo Program

NASA Glenn (then Lewis Research Center) provided important early research as well as subsequent direct technical support to the Apollo program.

In 1958, when he was Associate Director of the center, Dr. Abe Silverstein was called to Washington to help organize NASA to be the nation's civilian agency for meeting the challenge of exploring space. Silverstein was appointed Headquarters' Director of Space Flight Programs with responsibility for developing and initiating all space missions.

Among the many missions conceived at that time was a manned journey to the moon and back. Silverstein himself named it "Apollo" after one of the most versatile of the Greek gods.

One of the most notable contributions this center made to the Apollo Program was our pioneering work with the cryogenic liquid hydrogen rocket fuel. This led to the development of liquid hydrogen rocket engines (RL-10 and J-2) and the use of liquid hydrogen fuel on the Centaur upper stage and Saturn V rocket that launched Apollo. In addition, the Glenn-led/managed Atlas Centaur expendable launch vehicle was used to launch the Surveyor robotic landers to the moon as a precursor to Apollo landings. The Surveyor missions helped determine the Apollo landing sites.

Glenn Contributions

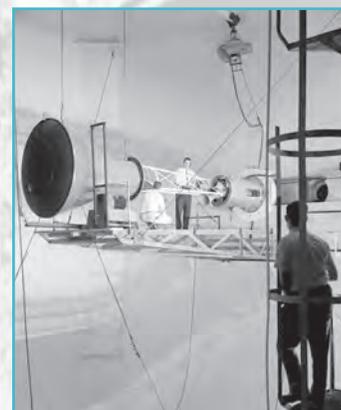
- Pioneering Rocket Research
- Engineering Studies
- Propellant Pump Designs
- Fabrication Support
- Zero-Gravity Research
- Fuel Cell Performance
- Rocket Engine Combustion
- Wind Tunnel Tests



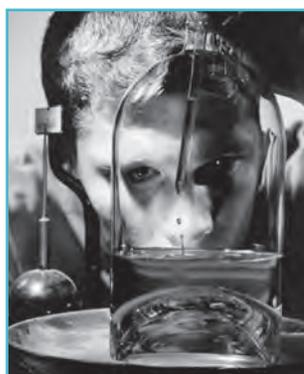
Centaur rocket construction at General Dynamics in 1962.



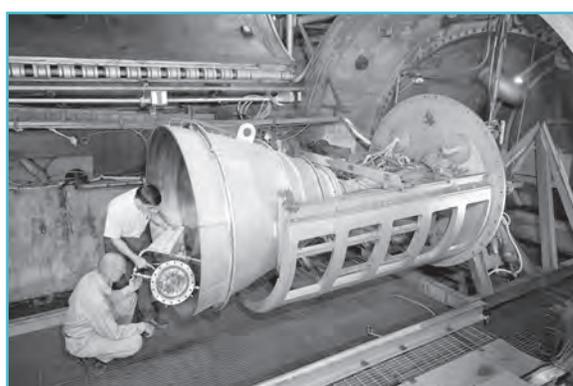
Assembly of "Big Joe" capsule in 1959 for Project Mercury.



Mercury escape rocket test in the Altitude Wind Tunnel in 1960.



Model of Centaur hydrogen tank used in Zero Gravity Drop Tower tests in 1964.



Apollo contour engine testing in 1964 in the Propulsion System Laboratory.





Constellation Focuses on Future Exploration

Building on the best of Apollo and shuttle technology, Glenn is continuing a legacy of space flight development contributions by using our world-class expertise and facilities to help design and build NASA's new space exploration fleet as part of the Constellation program. Here are a few examples of these efforts:



The new Reverberant Acoustic Vibration Facility for Space Environment Testing under construction in the Space Power Facility at Glenn's PBS.

- Reverberant Acoustic Vibration Facility installed in the Plum Brook Station (PBS) Space Power Facility for testing to reduce the effects of high acoustic loading

Ares I (the two-stage crew launch vehicle for Orion)



Glenn-developed Ares I-X test segments getting ready to mate to other parts of I-X vehicle in Kennedy's VAB.

Glenn leads the design of the electrical power system, including the battery and power distribution and control system for the rocket's entire upper stage:

- Designed and fabricated the Upper Stage Simulator of the Ares I-X flight test vehicle in Glenn's Ares Manufacturing Facility, building 50
- Designed the Thrust Vector Control system for the Upper Stage to steer the vehicle and keep it on the proper trajectory
- Designed a new Vehicle Motion Simulator for umbilical systems qualification testing conducted in the Launch Equipment Test Facility at NASA Kennedy
- Designed the development flight instrumentation system, sensors and the purge and hazardous gas detection system for the upper stage



Completed 2-axis Thrust Vector Control test rig in Building 333 for testing prototype system.

to provide a reliable source of electricity and water

- Developing lithium-ion battery technology, including the development of advanced anode technology enabling the EVA "Suit 2" (see pg. 4)
- Developing fission-powered system-technologies using free-piston Stirling engines or closed Brayton cycle engines, to enable the option for development of a fission power system that can generate up to 40 kW of power for the lunar outpost

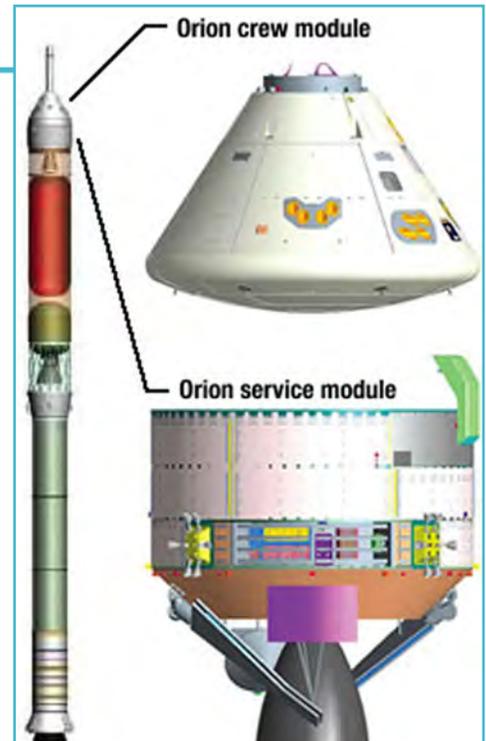
Ares V (cargo launch vehicle)

Glenn leads the earth departure stage design and definition, including power, thrust vector control and payload shroud development.

Power for Lunar Operations

Glenn leads the agency in developing advanced power and energy storage technologies for a lunar outpost:

- Developing regenerative fuel cells critical for the operation of an outpost during the lunar night, including the development of innovative fuel cell technology



Above: Ares I launch vehicle illustration showing location of the Orion crew exploration vehicle's crew module and service module.



Illustration of fission-powered system constructed for a lunar outpost.



Landing on the Moon . . . Again

When the United States returns to the moon, NASA plans to build an outpost where astronauts can stay for months. Altair will be the new moon lander for astronauts. Altair may look similar to the Lunar Module used for Apollo moon landings years ago, but is a completely different vehicle with significantly more capability. Altair can take four astronauts to the surface of the moon. It will have room for air and other supplies that will help astronauts stay there for one week. Altair will consist of two parts. The bottom part—the descent module—will have fuel and an engine to land on the moon. The upper part—the crew module—is where the astronauts will live. This crew module will also take the crew back into space to return to Earth when the mission is finished.

Forty years ago, Glenn's capabilities and facilities were called on to address crucial technological issues for the Apollo module. Today, Glenn's expertise is still in high demand as it tackles even more demanding challenges under the NASA Exploration Technology Development Program. Here are some of the areas where we're lending our expertise—then and now.

APOLLO

Fuel Cells: Proved fuel cell condensers work in microgravity and provided heat transfer data used for the spacecraft's electrical power subsystem simulation.

Propulsion & Cryogenics: Pioneered cryogenic liquid oxygen/liquid hydrogen propulsion systems development and test instrumentation; worked with a NASA team that tested and developed engines using these fuels.



Apollo Module

CONSTELLATION (Altair)

Fuel Cells: Leading the efforts to develop fuel cells critical for the Altair descent stage by reviving Gemini-era fuel cell technology infused with modern manufacturing and materials technology to provide a reliable, low mass system.

Batteries: Leading the efforts to develop advanced battery cells to provide greatly increased specific energy for Altair ascent stage.

Propulsion & Cryogenics: Leading power ascent propulsion subsystems design and development; leading propulsion and cryogenic fluid management technology development for descent and ascent; supporting Altair systems engineering and vehicle integration trade studies and analyses.



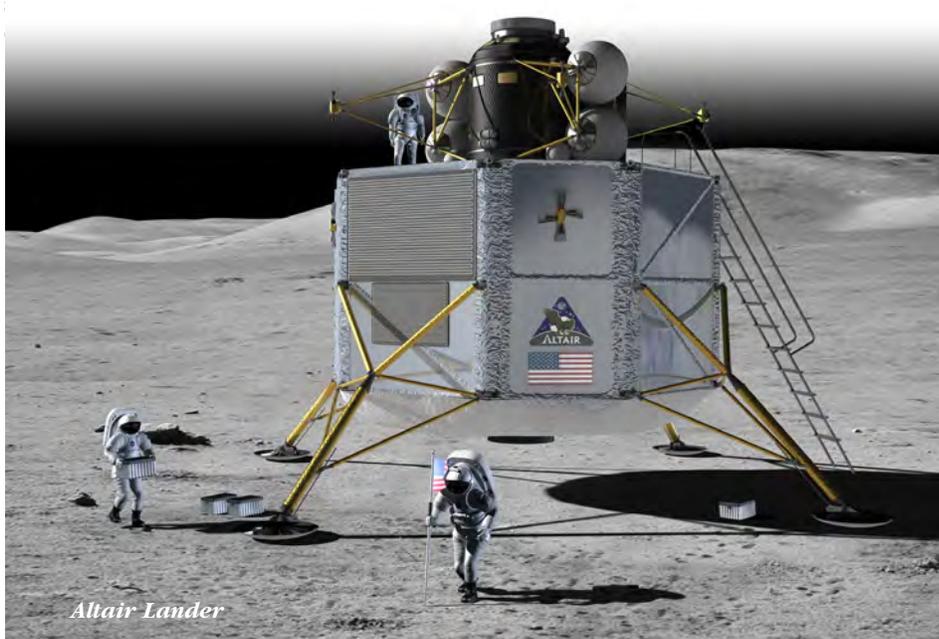
Pictured is the Apollo 1 capsule after the fire. Material flammability in low- and partial-gravity, evaluated at Glenn, will be an important consideration for Altair.

Fire Safety: Supporting Altair systems engineering trade studies on fire detection



Aerojet 100-lb liquid oxygen/liquid methane reaction control engine (RCE) during altitude test.

Glenn is leading lithium-ion battery technology development.



Altair Lander



Developing Technology for Spacesuit Safety

Although you may never see an astronaut competing on "Dancing With the Stars," many endure months of practice to perform the technically and physically demanding choreography of mission-critical Extravehicular Activities (EVAs).

The Apollo 11 mission and the majority of EVAs since then have been highly choreographed by ground control for precise execution of intricate steps and adherence to timelines. Today, Glenn is lead for NASA's new Constellation Program (CxP) spacesuit Power Communications Avionics and Informatics (PCAI) subsystem, aimed at developing a comprehensive system for astronauts to manage long-duration spacewalks.

The PCAI subsystem development is a collaborative effort pursued under the EVA Exploration Technology Development Program and the CxP EVA Systems Project Office. The PCAI subsystem team is led out of Glenn with support from NASA Johnson.

"The PCAI subsystem is the critical element that will allow our astronauts to perform EVAs with greater autonomy and efficiency on the moon," said Diane Malarik, Glenn's EVA lead, Constellation Office.

The PCAI portfolio includes developing a reliable source of power for an 8-hour EVA duration; an audio system integrated directly into the suit's upper torso to enhance crew comfort and logistics; advanced avionics displays and devices to perform numerous data display, processing and transfer functions; an EVA crewmember location determination system to aid walkback to the habitat and navigation to EVA sites; connectors and switches that operate reliably in the harsh environment of space; software systems that increase EVA task efficiency and provide more autonomous operations and less dependency on Earth-based mission control.

Glenn onsite laboratories, including the EVA software, audio and navigation labs in building 54, as well as the EVA Complex Electronics Laboratory in building 86, have enhanced the capabilities and safety of the future EVA spacesuit.

—BY S. JENISE VERIS



A cuff-mounted display and "Snoopy Cap" are among the developmental devices pursued in the PCAI portfolio.



Research Examined Lunar Dust on Spacesuits

Having trouble finding clothing that can withstand daily wear and the effects of the environment? Astronauts returning to the moon will have the same challenge.

Dust on Earth can be annoying but "lunar dust," tiny particles of rock on the moon's surface, is abrasive and sticks to objects like nails to a magnet. So living and working on the moon for extended periods of time will require clothing made of fabrics that can hold up in the harsh lunar environment.

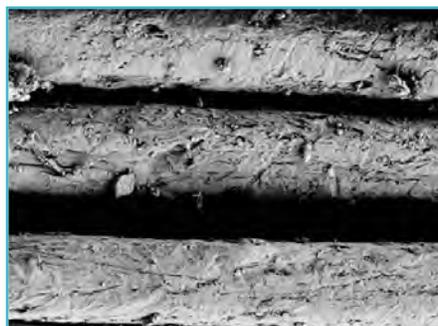
In a NASA study, *Lunar Dust Effects on Spacesuit Systems, Insights from the Apollo Suits*, Dr. Mary Ann Meador, Durability and Protective Coatings Branch, led research to determine the abrasive effects of lunar dust on spacesuits and recommend fabric alternatives for moon-bound apparel. Meador visited the Smithsonian Institute in Washington, DC to view several spacesuits worn by Apollo astronauts. She also examined samples of Apollo 12 astronaut Alan Bean's spacesuit here at the center.

"At first glance, the suits appear dirty and slightly worn," Meador explained, "but when we examined samples of Bean's suit under a microscope at high magnification, we discovered many frayed fibers on exposed areas of the suit."

Using in-house laboratory facilities, Meador and Dr. James Gaier of the Space Environment and Experiments Branch, subjected unused Apollo-era fabric to lunar dust-like particles in a simulated lunar environment to mimic the damage seen on the lunar exposed articles. They also studied various candidate fabrics for new suits to determine their level of damage and recommend alternative fabrics for future lunar missions. Material scientists and spacesuit designers at NASA Johnson are using this research as a basis for further testing and spacesuit design.

"This project was an exciting opportunity to examine, first hand, items of historical significance and discover something that could lead to better spacesuit designs in the future," Meador said. "It's rewarding to know that Glenn's efforts will be helpful in returning back to the moon."

—BY DOREEN B. ZUDELL



Pictured left: When viewed under a microscope with high magnification, these samples from the knee of Alan Bean's spacesuit show many frayed fibers.



People



Photo by Laurie Stauber

NEOSA's Brad Nellis, left, presents trophy to Glenn CIO Sasi Pillay, Falck, and Riehl

John Riehl (DRA), Waldy Sjauw and Robert Falck, in Glenn's Mission Design and Analysis Branch, and Stephen Paris, Boeing Research and Technology, received special recognition from the Northeast Ohio Software Association (NEOSA) for Best Software Product on May 19. The main application of the *Optimal Trajectories by Implicit Simulation Version 4* software is finding the optimal trajectories for aerospace and nonaerospace vehicles. Previously, this software received the prestigious 2008 NASA Software of the Year.

Tom Parkey, Office of the Chief Financial Officer's Cost and Economic Analysis Office, was selected the 2009 NASA Cost Estimator of the Year at the NASA Cost Workshop held in April at NASA Kennedy Space Center. The award is given annually to the estimator who has excelled in the technical merits of cost estimating at a specific center or at the agency level. Parkey was honored for his cost estimating support to the agency's Strategic Analysis Team—Lunar and Glenn Ares V Shroud and SCaN projects. He also developed a Glenn model for tracking earned value performance of in-house project activity.



Parkey

Dr. Mrityunjay Singh, OAI/Ceramics Branch, was elected a full member of the International Institute for the Science of Sintering (IISS), Serbia. IISS promotes achievements in sintering and related fields. Singh is one of only 65 IISS-elected members from



Dr. Singh

around the world. He also recently received the Lee Hsun Lecture award from the Chinese Academy of Sciences—Institute of Metal Research and Shenyang National Laboratory for Materials Science, China. Singh is renown for advanced ceramics and composites technologies benefitting crack repair materials for space shuttle thermal protection and the environment.

In Memory

Eleanor M. Langendorfer, 83, who retired in 1998 with 32 years of NASA service, died in April. Langendorfer worked for the NASA Exchange in Food Services and served as AFGE vice president representing Exchange employees. Her husband Paul, who retired from NASA in 1981, preceded her in death (2002).

Jerrold D. Wear, 95, who retired in 1987 with 45 years of NASA service, died April 19. Wear was a chemical engineer who began his NASA career working for the National Advisory Committee for Aeronautics at Langley. Prior to retiring, Wear served in NASA Lewis' (Glenn) Propulsion Systems Division. He worked on many projects, including turboprop development, ion engine research for deep space travel and the space shuttle program.

Dean D. Scheer, 77, who retired in 1988 with 26 years of NASA service, died April 30. Scheer was an expert in turbomachinery design, especially turbopumps—the most complex parts



Scheer

of liquid-propelled rocket engines. His expertise was critical to various NASA in-house studies, including the RL10A-3-3A Rocket Engine Modeling Project (1997). Scheer's legacy to the agency, however, lies in authorship of two turbopump design codes, developed later in his NASA career while supporting Glenn's Space Vehicle Propulsion Branch as a Sverdrup and NYMA contractor. The codes: PUMPDES, for preliminary prediction of centrifugal pump design point performance, and TURBDES, for preliminary prediction of design point performance of several types of rocket engine turbines, still guide turbopump design for rocket engines of the future. Scheer's colleagues recall him as a dedicated NASA team member who inspired them through his professionalism, courage and a wry sense of humor.

AeroSpace Frontiers is an official publication of Glenn Research Center, National Aeronautics and Space Administration. It is published the second Friday of each month by the Community and Media Relations Office in the interest of the Glenn workforce, retirees, government officials, business leaders and the general public. Circulation: 6,000.

Editor.....Doreen B. Zudell
SGT, Inc.
Assistant Editor.....S. Jenise Veris
SGT, Inc.
Managing Editor.....Kelly R. DiFrancesco

DEADLINES: News items and brief announcements for publication in the August issue is noon, July 24. Larger articles require at least 1 month notice. Submit contributions to the editor via e-mail, doreen.b.zudell@nasa.gov, fax 216-433-8143, phone 216-433-5317 or 216-433-2888, or MS 3-11. Ideas for news stories are welcome but will be published as space allows. View us online at <http://aerospacefrontiers.com>.

Calendar

IFPTE LOCAL 28, LESA MEETING: LESA will hold its next monthly membership meeting on Wednesday, August 5 at noon in the Small Dining Room of the Employee Center.

WOMEN RETIREE LUNCHEON: The next NASA Retired Women's Luncheon will be Thursday, August 20, at noon at Don's Pomeroy House in Strongsville. For Reservations, call Gerry Ziemba at 330-273-4850.

Display Brings Solar System Within Children's Reach

As the nation celebrates the 40th anniversary of the Apollo 11 moon landing, students at Lewis Little Folks (LLF) are getting a closer look at the moon and the other planets. On June 11, Center Director Dr. Woodrow Whitlow Jr. helped celebrate the installation of a solar system display that spans a 100-foot wall at the onsite child development center.

The three-dimensional model was made possible through a generous donation by an anonymous NASA Glenn contract employee who wanted to elevate NASA's connection to the child development center and encourage interest in science and engineering.

"The display is a great way to introduce the concept of space exploration to the children in a fun and interactive way," said Mike Blair, who headed a LLF parent-based committee to determine how best to use the funds. "The children and their parents can view and touch the planets,

Below: LLF students Adam Blair and Sanjana Katiyar explore the planets. Right: Center Director Dr. Whitlow cuts the ribbon.



opening up opportunities to discuss not only the solar system but also parents jobs at NASA Glenn."

The display, constructed by George Laurence, owner of the Museum Acrylics



Photos by Doreen B. Zudell

Company in New Philadelphia, Ohio, highlights the eight planets, the dwarf planet Pluto, and the four Galilean satellites and Saturn's moon Titan. The model is properly scaled along the length of the hallway. The planet Jupiter doubles as a miniature time capsule that contains a thumb drive with class photographs of the LLF children and staff for future generations to discover.

—BY DOREEN B. ZUDELL

National Aeronautics and Space Administration
John H. Glenn Research Center at Lewis Field
21000 Brookpark Road
Cleveland, Ohio 44135