From the Sun to Pluto: Inspiring the Next Generation of Explorers

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The APL Space Department's Education and Public Outreach (E/PO) Office strives to excite and inspire the next generation of space explorers by creating hands-on, minds-on learning experiences. The E/PO programs provide training and materials to teachers to enhance their classroom activities and develop and implement activities that directly engage students and members of the general public. This article offers a brief overview of the many E/PO Office efforts, illustrating the programs' wide range of educational activities, diverse audiences, and venues including schools, museums, and science centers.

WE ARE ALL EXPLORERS

The Space Department's Education and Public Outreach E/PO Office provides unique opportunities for students, educators, museums, science centers, and the general public to share in the excitement of APL's current missions for NASA. The office's responsibilities include creating informational materials that increase a mission's visibility and highlight its capabilities, representing APL's Space Department and its missions and instruments at professional and educator conferences through exhibits and workshops, and developing working relationships and joint activities using the NASA education and public outreach infrastructure. In addition, the office liaises with NASA, private industry, educational partners, and the general public and designs and implements printed and web-based materials, such as brochures, fact sheets, educational curricula, frequently asked questions, graphics, exhibits and displays, mission animations, videos, and web sites.

From the Sun to Pluto, the APL Space Department is engineering the future of space exploration—exploring Earth's near-space environment, the Sun, planetary bodies, and the outer solar system (Fig. 1). With the January 2006 launch of NASA's New Horizons mission to Pluto and the upcoming STEREO launch to image the Sun in 3-D, this is an exciting time for space exploration.

The E/PO Office offers a unique glimpse into the Space Department's "end-to-end" approach to mission design and execution. APL designs, manages, fabricates, integrates, tests, and operates interplanetary space and Earth science missions and instruments. The department is also charged with the scientific challenge of capturing and analyzing mission and instrument data, leading to new scientific findings. Spacecraft and remote sensing instruments designed and built by APL are used in the study of astrophysics, planetary magnetospheres and geology, oceanography, atmospheric sciences, and

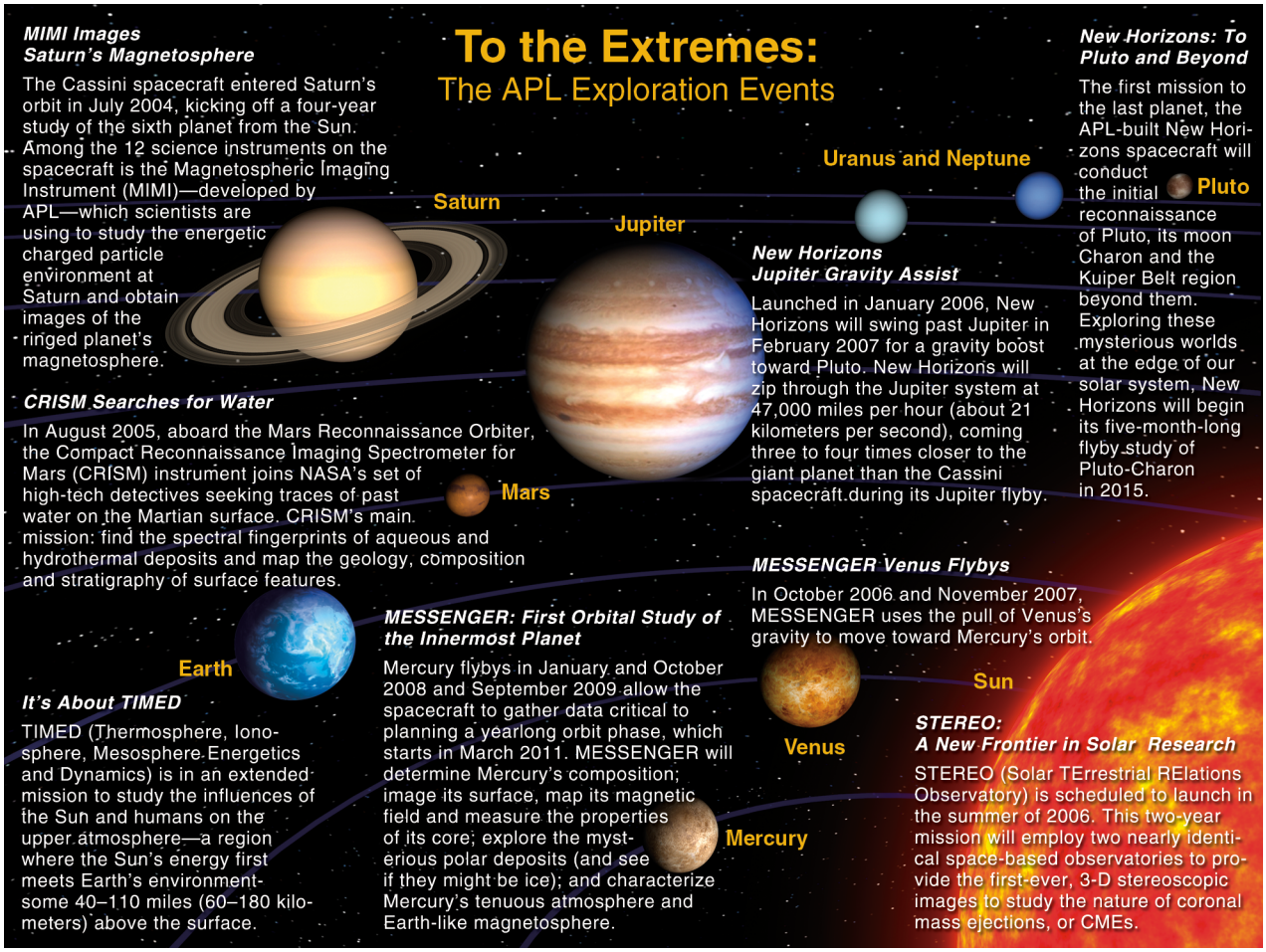

Figure 1. From the Sun to Pluto, the APL Space Department is engineering the future of space exploration.

solar terrestrial physics. Since 1959, APL engineers and scientists have designed, built, and launched 62 spacecraft and more than 150 instruments.

Current, exciting activities in the Space Department include, but are not limited to, the following initiatives.

- New Horizons will be the first mission to perform the initial reconnaissance of Pluto-Charon and the Kuiper Belt—sent out to explore the mysterious worlds at the edge of our solar system (http://pluto.jhuapl.edu/). Dr. Alan Stern of the Southwest Research Institute is the Principal Investigator for the mission and leads the science team. APL manages the mission for NASA's Science Mission Directorate and is operating the spacecraft in flight. The mission team also includes Ball Aerospace Corp., the Boeing Co., NASA Goddard Space Flight Center (GSFC), NASA Jet Propulsion Laboratory, Stanford University, KinetX Inc., Lockheed Martin, the University of Colorado, the U.S. Department of Energy, and a number of other firms, NASA centers, and university partners.
- TIMED (Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics) provides an opportunity for students of all ages to explore one of the last frontiers in Earth's atmosphere. TIMED is the first mission in NASA's Solar Terrestrial Probes Program (http://www.timed.jhuapl.edu/). APL leads the project's science effort and manages the mission's Science Data Center for NASA. NASA's GSFC, in Greenbelt, Maryland, oversees the TIMED mission for NASA Headquarters in Washington, D.C.
- STEREO (Solar TErrestrial RElations Observatory) offers a new perspective on solar eruptions by simultaneously imaging coronal mass ejections and background events from two nearly identical observatories (http://stereo.jhuapl.edu/). STEREO is the third mission in NASA's Solar Terrestrial Probes Program and is sponsored by the agency's Science Mission Directorate, Washington, D.C. NASA GSFC's Solar Terrestrial Probes Program Office manages the mission, instruments, and Science Center. APL designed, built, and will operate the twin observatories for NASA during the mission.
- CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) is an instrument that joins NASA's set of high-tech detectives seeking traces

of past water on the Martian surface (http://crism.jhuapl.edu/). Led by APL, CRISM is onboard the Mars Reconnaissance Orbiter mission managed by the Mars Exploration Program at the Jet Propulsion Laboratory for NASA's Office of Space Science, Washington, D.C.

- MESSENGER (MErcury Surface, Space ENvironment, GEochemistry, and Ranging), set to become the first spacecraft to orbit the planet Mercury (http://messenger.jhuapl.edu/), is the seventh mission in NASA's Discovery Program of lower-cost, scientifically focused exploration projects. Dr. Sean Solomon of the Carnegie Institution of Washington leads the mission as Principal Investigator. APL built MESSENGER, operates the spacecraft, and manages the mission for NASA.
- NEAR (Near Earth Asteroid Rendezvous) was the first mission to orbit and land on an asteroid (http://near.jhuapl.edu/). NEAR, the first launch in NASA's Discovery Program, was built and managed by APL.
- Space Academy—launched in 2000 by APL, Comcast Cable, and the Discovery Channel—takes students behind the scenes of actual space missions and introduces them to engineers and scientists working on some of NASA's most exciting projects (http://www.spaceacademy.jhuapl.edu/).

E/PO programs are aligned with the science and engineering objectives of NASA's Science Mission Directorate and are managed by the E/PO Office in collaboration with each of the mission and instrument teams. These programs also are aligned to the National Science Education Standards (NRC, 1996) and the NASA Implementation Strategy (NASA, 1996).

This E/PO approach, as noted previously, involves a variety of interdisciplinary classroom activities, teacher training, workshops, posters, fact sheets, and websites, as well as a multimedia component. High-leverage partnerships across the country have been key to the success of widely disseminated, award winning E/PO programs. E/PO partners participate in tasks such as program design, development, dissemination, implementation, and evaluation. The educational programs are regularly evaluated by external professional evaluators. Data collected on all of the Space Department E/PO programs are also reported directly to NASA.

The E/PO Office works closely with the APL Office of Communications and Public Affairs to provide a comprehensive and robust public information campaign. This multidepartmental team develops products serving the campaign's target audiences.

FORMAL EDUCATION

The E/PO formal education (K–12) programs are designed to inspire the next generation of explorers and to promote careers in science, technology, engineering, and mathematics, fusing a pipeline of future scientists and engineers with a science-literate community. Many of these programs create opportunities that allow students and teachers direct access to real-time data though hands-on participation. Higher education programs offer undergraduate and graduate students opportunities ranging from designing and building a flight instrument to interning during integration and test phases of missions and instruments. Many of these opportunities focus on students from Historically Black Colleges and Universities and Minority Serving Institutions. The following are highlights of the formal education programs.

Opportunities for Educators

Teachers across the country can integrate APL-led mission and instrument science and engineering into their curriculum, exposing students to exploration initiatives and encouraging them to follow up-to-date results from year to year.

Many E/PO programs have a cadre of educators who teach specific mission and instrument materials to other educators in the form of teacher workshops in their home states. Besides aligning mission and instrument science and engineering to the national standards cited above, these efforts develop examples and target implementation plans, including how teachers can incorporate specific topics into their classrooms. Professional development workshops also teach educators how to disseminate these materials and models via print media, workshops, and new communication technologies.

For example, the cadre of New Horizons teachers converged on APL for a 3-day workshop in August 2005 at the Kennedy Space Center (Fig. 2) and then again during launch in January 2006. These K–12 master educators were trained on mission science and engineering goals as well as New Horizons curriculum materials and lesson plans and will carry out their own regional teacher workshops on the mission. The APL workshop

Figure 2. The cadre of New Horizons K–12 educators visit with the engineering team and interns during their workshop.

included an opportunity to see the New Horizons spacecraft while it was in testing at NASA GSFC and to participate in several discussions with key mission scientists and engineers. These teachers also led the New Horizons National Teacher Workshop at Kennedy Space Center during launch week.

Teachers participating in such activities are encouraged to submit proposals to hold workshops at conferences such as those held by their state or regional Science Teachers Association, allowing them to reach a greater number of educators from a wide demographic area. Cadre team members follow up with their workshop participants to facilitate the integration of mission and instrument materials into the classroom.

The E/PO Office also manages an on-site Teacher Internship Program. Teachers are paired with mentors that represent the many disciplines involved in a mission, and together they develop curricula related to the mission. The E/PO Office and mentors make lesson plans available via the mission and instrument websites for use in their classrooms. Teacher interns are also encouraged to conduct workshops at educator conferences to introduce their curricula to classrooms across the nation.

Experiences for Students

Student-Built Instruments

The Student Dust Counter (SDC) on New Horizons is an example of how students can become actively involved in a NASA mission through E/PO programs. Students not only participate in the mission but are also key members of the engineering and science teams.

The SDC was designed by students at the University of Colorado at Boulder. The instrument had a clear development schedule and while separate from the baseline science investigation was held to the same criteria as the other flight instruments. The device will detect dust grains produced by collisions between asteroids, comets, and Kuiper Belt objects during New Horizons' journey. It is the first science instrument on a NASA planetary mission to be designed, built, and "flown" by students.

Participation by Underserved and Underrepresented Groups

The E/PO programs also seek opportunities to engage minorities and women in science and engineering associated with NASA space science investigations. A key example has been the New Horizons' E/PO program partnership with NASA's Minority University-Space Interdisciplinary Network (MU-SPIN). New Horizons and MU-SPIN are providing internship opportunities for college students to help train the next generation of NASA's minority scientists and engineers (Fig. 3). These programs serve America's Historically Black Colleges and Universities (HBCUs), Hispanic Serving Institutions (HSIs), and Tribal Colleges.

Figure 3. NASA's Minority University-Space Interdisciplinary Network (MU-SPIN) interns experience a "summer on Pluto" working with the New Horizons team during integration and test.

Many of these students experienced a "Summer on Pluto" by participating in internships during the integration and test phase of the New Horizons mission during the summer of 2005. Students came from the MU-SPIN and NASA Academy programs. Each student worked closely with a mission team "mentor" for 10 weeks.

One of the activities for this E/PO program was supporting the environmental testing phase of the New Horizons mission where the entire spacecraft was tested under flight-like conditions. Other examples include developing software for presenting, receiving, and distributing spacecraft operational and scientific data; tools for manipulating spacecraft data; graphical user interfaces for existing command line applications; and documentation and testing of new and existing ground system applications.

Space Academy

The E/PO Office created the Space Academy series in which students go behind the scenes of current space missions and are introduced to scientists and engineers working on these projects (Fig. 4). Space Academy is sponsored by Comcast, the Discovery Networks, and APL. These programs, which are based on a mission, instrument, or specific science theme, give middle school students a close-up look at NASA's work being done by APL. Events include a student press conference in which students play the role of reporters and interview APL panelists. The event is also moderated by an APL public relations representative.

After learning why spacecraft engineers wear white outfits called "clean-room suits" during spacecraft construction and testing, students don suits of their own to tour APL's space facilities. Spacecraft and instrument team members lead student groups through a series of

Figure 4. Students go behind the scenes of NASA's missions during the Space Academy program.

"exploration stations" that include a mission operations center used to control spacecraft and a satellite communications facility. They witness spacecraft and instruments being assembled and participate in a variety of mission-related science demonstrations. To prepare for their visit, students learn about the featured mission and space-related careers through a series of classroom activities and videos developed by the Discovery Networks and APL. After their visit, the students engage in follow-up activities on the mission and on their Space Academy experience.

Maryland Summer Center for Space Science

APL offers an exciting environment for the study of space missions by hosting the annual Maryland Summer Center for Space Science sponsored by the Maryland State Department of Education. During this event, rising 6th- and 7th-grade students learn to harness the power of technology and keep pace with the expanding knowledge of space science. The E/PO Office ensures the 2-week experience focuses on the latest and most exciting activities in the Space Department—from tours to talks with key scientists and engineers directly responsible for carrying out APL-led missions.

Students experience firsthand planning a mission, designing and fabricating instrumentation, and launching spacecraft. They are an integral part of a simulated mission team tasked to build a scale-model spacecraft complete with instrumentation. The experience culminates in a presentation to their peers covering the full mission overview (Fig. 5).

TEAMing for Success

The Space Department E/PO Office hosts an annual middle school robotics competition. Armed with dozens of robots, nearly 300 students from a number of Maryland schools participate in the TEAMS (Technology Alliance with Middle Schools) science and technology competition. The goal is to give students a fun, competitive experience combining math, science, technology and engineering.

The robotics competition is sponsored by APL, the Odyssey School, NASA GSFC, a.i. solutions, Computer Sciences Corp., the Maryland Space Business Roundtable, AIAA/Baltimore Section, the Washington Academy of Sciences, the Marion I. and Henry J. Knott Foundation, and Honeywell.

Educational Resources

Space Department E/PO efforts create educational resources that complement today's curricula (Fig. 6). For example, the New Horizons curriculum provides a unique opportunity for students of all ages to "grow up with the mission" because of the mission's long duration with launch in 2006 and Pluto flyby in 2015. The overarching goal of the curriculum is to capitalize on the excitement generated by going to uncharted territories and visiting an unexplored planet and new region of the solar system.

The following are examples of the prelaunch lesson plans for New Horizons.

- *Charting the Progress of New Horizons* (grades K–5): With the help of a New Horizons poster depicting a scale drawing of the solar system, students track the progress of the spacecraft.
- *Where Are We Going?* (grades K–5): Students take imaginary trips through the solar system on a space bus and use math skills to find the next space bus stop.

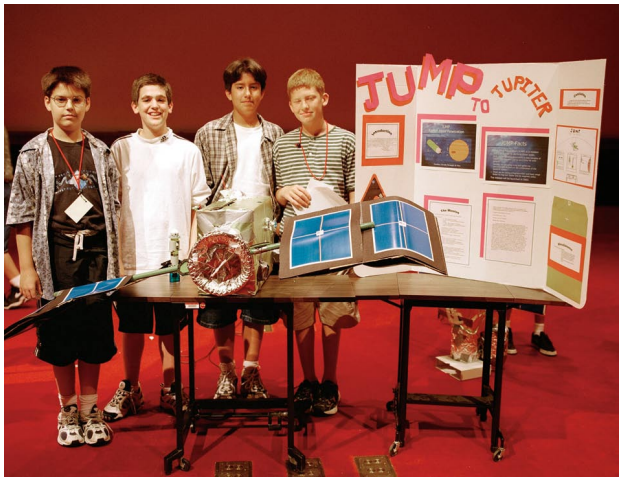

Figure 5. Students participating in the Maryland Summer Center for Space Science design their own Discovery-class missions.

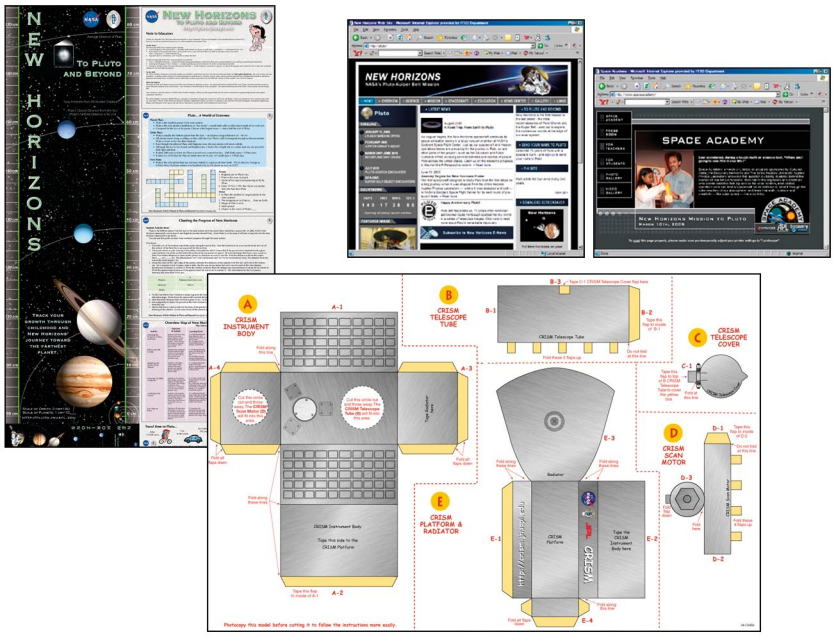

Figure 6. Examples of educational resources designed to inspire the next generation of explorers.

- *Modeling the Orbits of the Planets* (grades K–5): Students make a scale model of the orbits of the outer planets and explore the peculiarities of Pluto's orbit.
- *Growing up with a Mission* (grades K–5): Using a growth chart, students measure their own height and the heights of classmates to predict these measurements at the time New Horizons flies by Pluto.
- *Looking to the Future* (grades K–5): Students examine aspects of their lives and predict what the future will be like when New Horizons passes by Pluto.
- *Last Year on Pluto* (grades K–5): Students determine the length of 1 year on the nine planets and match historical events that occurred on Earth 1 year ago on these planets.
- *Orbit and Spin* (grades 3–5): A whole-body activity that explores the relative sizes, distances, orbits, and spins of the Sun, Earth, and Moon.
- *Discovering Planet "X"* (grades 3–5): Students explore parallax and then simulate the discovery of Pluto with a blink comparator via an online interactive program.
- *Appearance Can Be Deceiving!* (grades 6–8): Students explore the relationships among angular width, actual size, and distance by using their finger, thumb, and fist as units of angular measurement.

INFORMAL EDUCATION: ENGAGING THE PUBLIC

Partnerships

The E/PO Office's programs also engage the public in the experience of exploration. These programs provide public access to real-time data, milestone events, and general mission and instrument information in informal settings across the country such as museums, science centers and libraries, planetaria and broadcast television with the goal of contributing to the overall advancement of the nation's scientific, technical, engineering, and mathematics awareness. Services range from full exhibits with spacecraft models and artwork, to guest speakers and lectures, to the development of planetarium shows.

A local example of these partnerships is the Maryland Science Center's SpaceLink. A combination of media center, discovery room, and newsroom, SpaceLink focuses on the "latest and greatest" in space science and astronomy. APL Space Department scientists and engineers provide workshops, monthly credited seminars for educators (Teachers' Thursdays), a menu of classroom programs on request, distance learning teacher presentations, and special live events to highlight mission milestones and space-related anniversaries. These events complement the Space Department's mission and instrument exhibits that are permanently housed at the Maryland Science Center.

The E/PO Office also partners with NASA's Space Place, a program covering a wide range of educational activities that reach a national audience. The Space Place website (http://www.spaceplace.nasa.gov) for elementary-age children features many activities regarding the New Horizons mission. The Laboratory also has joined in a Space Place partnership with the International Technology Education Association's (ITEA) and its *Technology Teacher Journal*. APL-specific New Horizons curriculum supplements have been created, reaching the 8,000 ITEA members. Space Place also displays APL mission/instrument materials through a network of over 220 museums and libraries in 49 states, with an exposure to a potential audience of more than 27 million.

Another significant E/PO activity is the partnership with the NASA Solar System Ambassador public outreach effort designed to work with motivated volunteers across the nation. These volunteers communicate information about NASA's space exploration missions and recent discoveries to people in their local communities. Currently there are 459 ambassadors in 50 states and Puerto Rico that are trained on a number of APL-led missions and instruments.

Multimedia

Documentaries

The highly successful New Horizons E/PO product, *Passport to Pluto*, includes the behind-the-scenes look at how the New Horizons mission was put together. The documentary was aired on Discovery Science Channel as well as NASA TV. It was also distributed to science centers, museums, and educators across the country. *Passport to Pluto* allows viewers to embark on a deep-space adventure with the New Horizons team as it prepares for the first-ever mission to the ninth planet. It takes them inside this historic NASA endeavor, a story that begins with Pluto's discovery at Lowell Observatory in 1930 and continues with preparations to launch the New Horizons spacecraft from Cape Canaveral Air Force Station in Florida.

Over 75 years our view of Pluto has evolved from a telescopic dot in the heavens into a very real world with three moons, a complex atmosphere, an exotic surface, and an extended "family" of thousands of icy, rocky companions. In the next decade, New Horizons will provide even greater understanding of this strange planet.

Figure 7. The quarterly *Explorer* newsletter and DVD created for sponsor engagement.

Videos

Why would NASA want two spacecraft to study the Sun? How will engineers build these probes to operate in the extreme conditions of outer space? How do you launch two spacecraft on one rocket? Using a broadcast news approach, a 6-minute video, *Solar News Network: NASA Gets a Double Dose of the Sun*, answers these and other questions. STEREO is employing two nearly identical space-based observatories to provide the first-ever 3-D "stereo" images of the Sun to study the nature of coronal mass ejections.

The E/PO Office also managed production of the *Civilian Space Video*, which offers a unique glimpse at APL's "end-to-end" approach to mission design and execution (Fig. 7). The video, along with additional information about APL's civilian space activities, can be found at http://civspace.jhuapl.edu. (The E/PO-managed Civilian Space newsletter, *Explorer*, can also be accessed at this website.)

These are just a few examples of the many videos created by the E/PO Office for audiences ranging from students to museums, science centers, and potential customers.

MAKING AN IMPACT

The Space Department's E/PO program uses mission and instrument science and engineering to enhance the nation's formal education system and to contribute to the public understanding of science, mathematics, and technology. The E/PO team strives to create space exploration adventures for students of all ages and has a continued commitment to develop new opportunities to carry the message across the nation—We are all explorers!

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Kerri B. Beisser, APL's E/PO Office Lead since 1999, is a member of the Senior Professional Staff. She received a B.A. in government with a minor in astronomy from Franklin and Marshall College in 1996. She is currently completing her M.S. in aeronautical science, with a concentration in space studies, from Embry Riddle Aeronautical University. Before joining APL, Ms. Beisser was a Project Manager for the Challenger Center for Space Science Education, where she created national Educator Fellowship programs for the Cassini, Stardust, and Galileo Europa missions. She also worked at the U.S. Space and Rocket Center & Space Camp in Huntsville, Alabama, where she trained students and teachers in the history of the space program and developed activities in the fields of aerospace engineering and technology, and the space station/space shuttle. She also conducted corporate training programs and special events for the Space Camp. Ms. Beisser is currently the APL E/PO Manager for the following missions and instruments: NEAR, TIMED, New Horizons, CRISM, and the Interstellar Innovative Explorer. She also leads the E/PO effort for the STEREO twin observatories and develops the plans for NASA mission and instrument package proposal efforts and E/PO grants. She also manages the Civilian Space newsletter, *Explorer*. Her e-mail address is kerri.beisser@jhuapl.edu.