JANUARY/FEBRUARY 2006

SPACE TIMES

THE MAGAZINE OF THE AMERICAN ASTRONAUTICAL SOCIETY

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American Astronautical Society
6352 Rolling Mill Place, Suite 102
Springfield, VA 22152-2354 U.S.A.
Phone: 703-866-0020 Fax: 703-866-3526
aas@astronautical.org www.astronautical.org

President's Message

The AAS Board of Directors at its November 2004 meeting approved a strategic plan for the Society. It was a bold and important step because it defines who we are, where we hope to go, and the difference we will strive to make. The plan was simple by design: about six hundred words in bulleted expressions on four pages. It was meant to be short, clear, and compelling. And most importantly, it was meant to be implemented. A mentor once told me that strategy without implementation is merely poetry. He wasn't denigrating poetry; he was extolling real strategy. Strategy exists to make something happen, to enable an enterprise to thrive in its environment by delivering value and meeting need. Our Board-approved strategy does that.

Our Vision: AAS – the *premier* network of professionals dedicated to advancing all space activities.

Our Mission: AAS harnesses the intellectual energies and diverse capabilities of its membership, both technical and non-technical, to:
- Strengthen the space community,
- Influence the development of space policy,
- Promote international dialogue on space activities, and
- Inspire students to undertake space-related careers while serving the professional needs and interests of its members, both individual and corporate.

Our Goals:
1. Enhance the robustness of the space community by broadening the capabilities of its members.
2. Play a more influential role in the development of space policy.
3. Increase our role in facilitating international understanding and cooperation in space activities.
4. Increase the Society's efforts to enhance the appeal of space as a career field.
5. Improve the service we provide for our members.
6. Improve stewardship of the Society.

Within our vision and mission, these goals and their derivative objectives will evolve with time to respond to change, need, and opportunity. We spent 2005 beginning implementation of the strategic plan. The Board of Directors reviewed progress at its November meeting and found that AAS had accomplished much, including holding record-breaking conferences, producing high-quality publications, forming the Houston Section, rebuilding the AAS website around members, strengthening our relationship with the Students for the Exploration and Development of Space (SEDS), facilitating timely dialogues on international cooperation, and issuing relevant public statements.

The year ahead is going to be an exciting one as we build on the momentum of 2005. I am particularly excited about 2006 opportunities to better serve our members and to inspire, mentor, and involve the next generation. I look forward to sharing strategic progress with you in the coming months and getting your feedback and ideas.

Mark Craig
mark.k.craig@saic.com

ON THE COVER

Inspired by the Hubble Space Telescope's Ultra Deep Field images, Italian artist Alessandro Gattuso has created this magnificent oil painting revealing the universe's billions of stars and galaxies in vibrant colors against the dramatic blackness of space. (Source: Alessandro Gattuso)

Colliding in Space: NASA, Astronomers, and

In the 1990s NASA asked the science community to set astronomy priorities for the agency. Now NASA is trying to take

by Brian D. Dewhurst

President George W. Bush's vision for space exploration has given new direction to the National Aeronautics and Space Administration (NASA) and the U.S. civil space program. It has been greeted, however, with skepticism and considerable concern in the scientific community, including in those disciplines – such as astronomy – that are major NASA stakeholders. In the case of the Hubble Space Telescope, this concern was escalated into open conflict, with potentially damaging consequences. The concern and conflict have been caused in part by a cultural clash between the scientific community and the agency. Both parties need to work together to find a middle ground that will enable the agency to pursue its new mandate while continuing to implement its successful and popular science program.

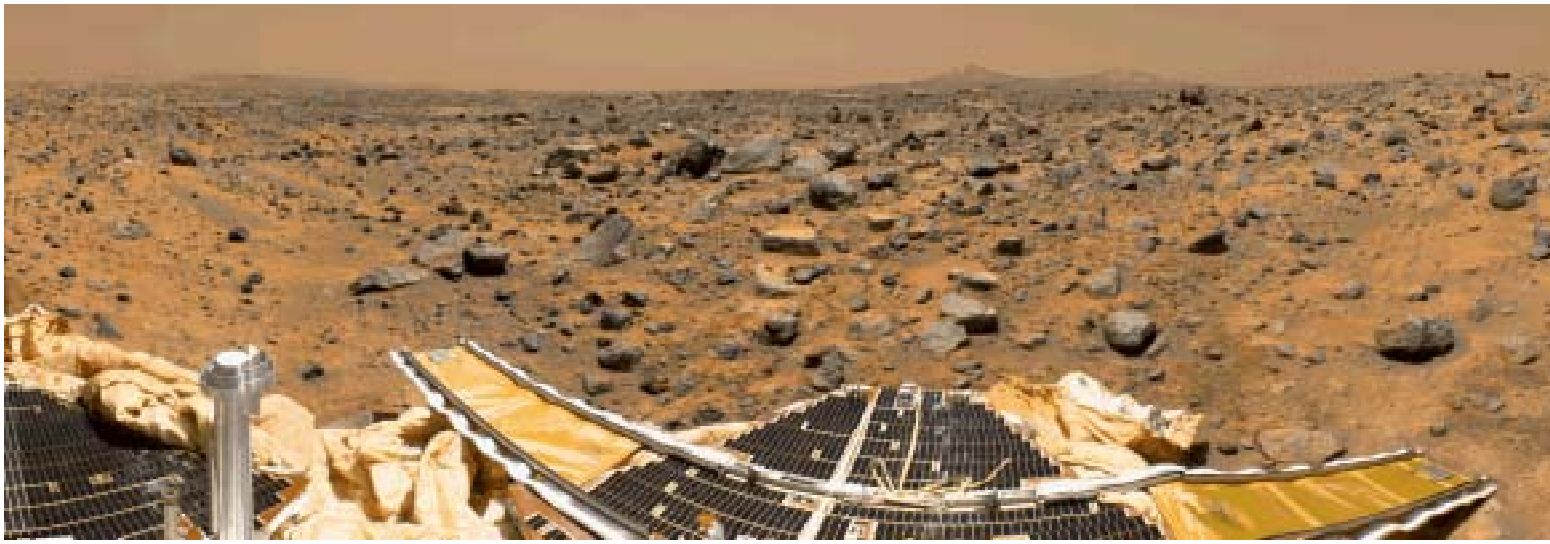
The Politics of Astronomy

Astronomers and astrophysicists have a long tradition of becoming enmeshed in politics, as the nature of their discipline makes such entanglements unavoidable. Astronomers study the universe around us and our place in it, which at times causes the scientific enterprise to run up against philosophical and religious schools that come at the same questions from other directions. Leaving aside these loftier concerns, however, there is a more practical explanation for the interactions of astronomy and government: astronomers need telescopes.

Observation time is the lifeblood of astronomers. Unlike physics or chemistry, astronomy is an observational science. Unable to create conditions for an experiment in a laboratory, astronomers must search the observable universe for instances of various phenomena. Therefore, progress in the field is largely driven by technological advances and their application in new generations of observing tools. The classical example is the invention of the telescope and Galileo's early observational work. A better example for these purposes, however, is the story of Tycho Brahe.

Tycho Brahe was a minor sixteenth century Danish noble with a strong interest in astronomical observations and instruments. Tycho's observations of the 1572 supernova brought him to the attention of the Danish king who, in 1576, granted him an island and a blank check to build his observatory. Tycho transformed the island of Hveen, which lies in the strait between modern-day Denmark and Sweden, into a state-of-the-art observatory with the most precise observational tools ever created. From this facility Tycho was able to make the most detailed astronomical observations of the pre-Galilean era. When Tycho set a young astronomer/mathematician named Johannes Kepler to the task of determining the orbit of Mars in 1601, it was the twenty-one years of high-quality data Tycho had collected which enabled Kepler to eventually succeed and, more importantly, defend his results. Kepler's determination of the elliptical orbit of Mars led to the development of his three laws of planetary motion – the beginnings of modern astrophysics. None of this would have been possible without the investment of the Danish king in Tycho's observatory on Hveen.

The successful landing in 1997 of the Mars Pathfinder rover, shown here observing Martian boulders, marked one of many successes for robotic sp



the Establishment of Research Priorities

decision-making back into its own purview.

Modern astronomy in the United States is quite similar. While there are some private observatories, most modern ground-based facilities are supported at least in part by the U.S. government through the National Science Foundation. For space-based observatories such as the Chandra X-ray Telescope or the Hubble Space Telescope, NASA is the only game in town. Today's space observatories are driving astronomy and astrophysics forward, and, therefore, the health of the field is largely tied to NASA's support for the current facilities and new missions that are in development. Clearly the space science piece of NASA is important to the astronomy community. But how is the astronomy community important to NASA?

From Mission to Science Agency…and Back

At the end of the George H. W. Bush administration, NASA was a rudderless agency. The Bush administration's Space Exploration Initiative had fallen flat, and its central program – the Freedom space station – was increasingly targeted by budget cutters looking to increase the "peace dividend" at the end of the Cold War. In June 1993 an amendment to eliminate the space station program was defeated by one vote on the floor of the House. While the addition of the Russians to the rechristened International Space Station program relieved some of the pressure, the agency was still casting about for a role for the program that would in part validate the cost of the station. Forbidden by the Clinton administration to talk about further goals such as a return to the Moon or a Mars mission, the agency turned to a scientific rationale. The space station began to be billed as a "world-class laboratory in space."

As the space station program limped along through the 1990s, robotic space science missions began to generate positive publicity for the agency. The Hubble Space Telescope observations of Comet Shoemaker-Levy hitting Jupiter in 1994, the successful arrival of the Galileo mission at Jupiter in 1995, the announcement by NASA researchers of potential Martian fossils in a meteorite in 1996, and the successful landing of the Mars Pathfinder rover on July 4, 1997, provided a string of major successes for the agency. NASA, realizing the value of these investigations, responded by increasing the budget for science. At the end of the George H.W. Bush administration, science in the agency was struggling to maintain its hold on one fifth of the NASA budget; by the end of the Clinton administration, science missions had grown to account for one third of the agency's spending. More importantly, the public identified NASA as a science agency – even the space shuttle program was selling itself on the strength of its scientific and educational accomplishments.

The transformation from a mission agency to a science agency had a dramatic effect on the way NASA operated. Both science and mission agencies can support scientific research, but the way in which they do so is different. Mission agencies, such as the Office of Naval Research or the National Cancer Institute, support basic research that can be tied to the goal of that agency – a better sonar system or

pace science missions and helped bolster the science budget at NASA during the Clinton Administration. (Source: NASA/Jet Propulsion Laboratory)

Astronauts Story Musgrave and Jeffrey Hoffman performed the first Hubble Space Telescope repair in 1993, as shown here. Although a fourth Hubble servicing mission is planned for late 2007 pending the shuttle's safe return to flight, some astronomers feel that the money required to remain ready for the space shuttle-based mission may be better spent elsewhere in astronomy. (Source: NASA)

a new cancer drug, for instance. The National Science Foundation, on the other hand, supports science for its own sake. It is designed to be reactive to new discoveries or new avenues of research. In short, it is the scientific community that advises science agencies about the areas in which they should invest. As science climbed in importance at NASA, the agency increasingly turned to the scientists for new projects to pursue.

In the wake of the Columbia accident, it was clear that NASA's human space flight activities were in need of a new rationale. On the other hand, critics charged that robots could do better science with both fewer dollars and a negligible risk to human life. In response to the accident and the need for a reinvigorated mission, the Bush administration released its vision for space exploration in January 2004. The first major Presidential direction that had been given to the agency since the failure of the Space Exploration Inititative, the vision and its sweeping set of goals became the focus of the agency. Accomplishing them would require NASA to change its culture. NASA could no longer be a science agency; it had to return to its mission-oriented roots.

Setting Science Priorities

Understanding how significant the change from science priorities to mission priorities is requires an understanding of how the scientific community sets priorities. Because astronomers are dependent on government support for new observatories, they have developed a sophisticated priority-setting system based on the scientific peer review process and the creativity of members of the community. The culmination of this process over the past forty years has been a series of survey reports on astronomy and astrophysics conducted by the National Academies.

Conducted roughly every ten years, these "decadal surveys" summarize the current state of knowledge in the field and then look ahead and identify the most important scientific questions to be addressed and the tools needed to address them. From a policy perspective, the key feature of these reports is a prioritized list of ground- and space-based observatories for federal investment. The process by which the survey is conducted is designed to sift and funnel the various proposals for new observatories into a single prioritized list for the government to implement.

The decadal survey process is of considerable value to both the astronomy community and to the science agencies. The survey process directly engages the community. For example, the decadal survey committee and panels that conducted the survey in 1999-2000 were comprised of 125 astronomers from around the nation, and dozens more participated through various information gathering sessions. By engaging such a large fraction of the nation's astronomers, the survey process is able to credibly represent the consensus of the community as a whole. Debates between members of the community are held inside the survey process, and the members of the community choose the winners and losers. When agencies fund the missions included on the decadal survey priority list, they are confident that the taxpayers' dollars are supporting the most valuable projects. Furthermore, the consensus nature of the reports can be used as a shield against lobbying on behalf of individual projects, saving agency officials and congressional staff from having to be the arbiters of scientific disputes – roles they may not be qualified to play.

Historically, the large majority of projects recommended in the decadal surveys has been completed, without messy public debates such as those which accompanied the Superconducting Supercollider. The result is a win-win situation for the astronomers and the government: the government is confident that it is investing in the most valuable observatories, and the astronomers are confident that their desires are being heard and acted upon. Perhaps the biggest testament to the value of the astronomy and astrophysics decadal surveys is that in the late 1990s NASA requested that the National Academies conduct decadal surveys for other scientific areas in NASA's portfolio.

Priorities in Conflict

NASA's request for additional decadal surveys shows how far the agency had swung towards the science agency culture. By requesting the surveys, NASA was asking the scientific communities to set the agency's science priorities for the coming decade. When the vision for space exploration was released with its own set of priorities for the agency, the competing priorities were set on a collision course. The former set of priorities was filtered from the bottom up, the latter set directed from the top down. NASA needs to find a way to reconcile the two sets of priorities in a decision-making process that keeps the best science while preparing the agency to complete its mission.

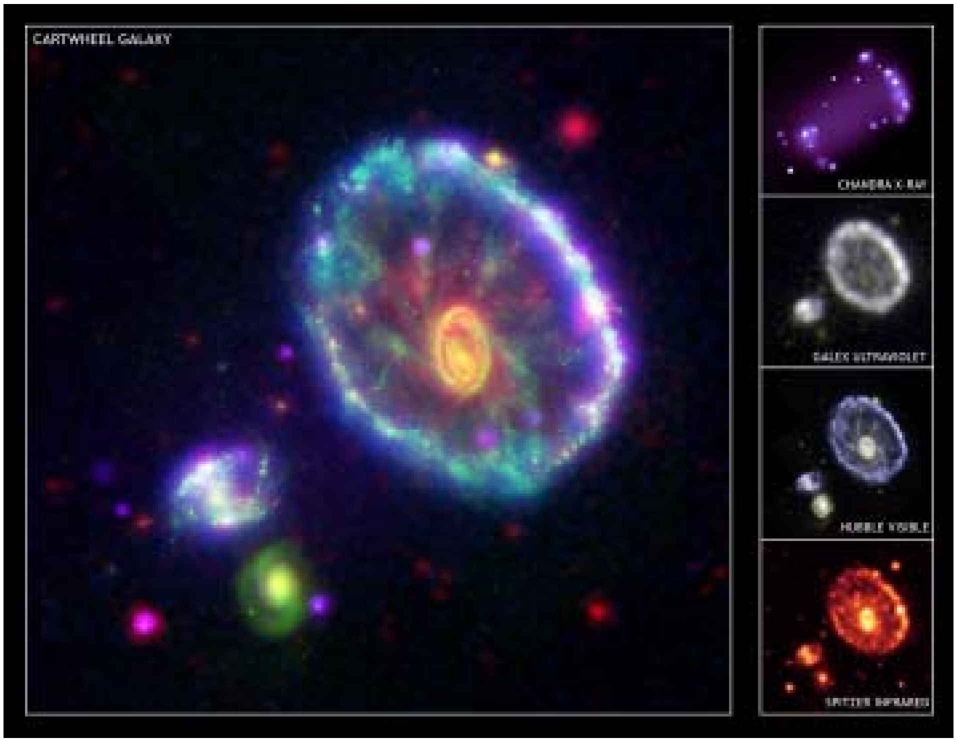
Unfortunately, the first steps in defining a new relationship between the science priorities of the stakeholders and the needs of NASA as a reinvigorated mission agency have not gone smoothly. In an attempt to reassert the mission agency culture, NASA's FY2005 budget request, released in February 2004, divided the agency's science portfolio into "exploration science" and "other science" categories. The agency proposed that funding for science in the "other" category would remain essentially flat until 2020, while exploration would roughly double in size over the same period. In astronomy, the tilt was incredibly pronounced. NASA proposed in mid-2004 to accelerate the third-ranked space observatory in the decadal survey, the Terrestrial Planet Finder, and to double its proposed scope. To fund this acceleration and expansion, the second-ranked priority and a suite of other missions the agency had been planning were postponed indefinitely. This decision was based on NASA's interpretation of the vision for space exploration and its determination that the Terrestrial Planet Finder mission was exploration-oriented and the other missions were not. In short, NASA was asserting its mission priorities over the astronomers' science priorities.

Had this change proven to be the sole reorientation involved in implementing the vision, the astronomy community might have been persuaded to accept the new ground rules and work with the agency. Unfortunately, the budget decisions were announced in the wake of then Administrator O'Keefe's decision to cancel Hubble servicing mission SM-4. The administrator made the decision without notifying or discussing it with the NASA Advisory Council and its scientific subcommittees – a marked change from past agency practice. The Hubble decision, combined with the reorientation of the program away from the community's priorities, portrayed an agency that was no longer willing to work with the astronomy community.

The astronomers began to search for other avenues to make their voice heard. In short order they found that Maryland Senator Barbara Mikulski was eager to help. The Space Telescope Science Institute and NASA Goddard Space Flight Center, the key institutions supporting Hubble, are both in Maryland. Furthermore, Senator Mikulski was the ranking member of the Senate subcommittee that controlled NASA's appropriations – putting her in a powerful position to change Hubble's fate. After months of wrangling it became clear that the senator was not going to allow NASA to eliminate the Hubble mission. By the next spring Administrator O'Keefe had resigned, and a new NASA administrator, Dr. Michael Griffin, had publicly committed to "saving" Hubble if the space shuttle's return to flight was successful.

By working through the political process, the astronomers had won a pyr-

Almost a year after the Space Shuttle Columbia disaster, President Bush, shown here during a memorial service for the Columbia astronauts at the Johnson Space Center, announced his new vision for space exploration and redirected the agency's focus to human and robotic exploration of the Moon and Mars. (Source: NASA)



Data from four space-based astronomical observatories – the Chandra, Hubble, Spitzer, and GALEX space telescopes – were combined to form this image of the Cartwheel Galaxy. NASA funded the development of all of these space telescopes and many others. (Source: NASA/Chandra X-ray Center/Smithsonian Astrophysical Observatory)

rhic victory. NASA was committed to conducting SM-4 once the space shuttle had returned safely to flight, but more than a year later the shuttle is still grounded. The astronomy program is spending well over $250 million per year on Hubble, a large fraction of which is spent merely keeping the agency ready to fly SM-4. That money might well be wasted if the agency is unable to fly before Hubble's batteries fail – assuming the shuttle returns safely to flight. Meanwhile, in this time of lean federal budgets, other NASA astronomy missions are being delayed or canceled. A conversation between NASA and the astronomy community about whether SM-4 is the best mission in which to invest could be beneficial to all involved, but because the astronomers sought a political solution such a conversation is very unlikely.

Even if such a conversation were possible, it is unclear how such a conversation might take place. Administrator Griffin chose to disband NASA's advisory committees until he could rework how they functioned. Historically, the advisory committees have been the venue in which the agency's top-down priorities and the community's bottom-up priorities have been brought together. At this time NASA has reestablished the NASA Advisory Council, but none of its scientific subcommittees are in place. Without these subcommittees, it is unclear how or whether the scientific community is able to have input into NASA's decision-making process. How the scientific community will communicate with the agency is unclear.

Moving forward, NASA's Science Mission Directorate needs to develop a mechanism to integrate the agency's mission priorities with the community's science priorities. NASA and the science community have come to depend on one another. The agency cannot return to an Apollo-like posture in which the science priorities are driven almost entirely by the needs of the human space flight program. On the other hand, the scientific community must realize that a healthy, vibrant exploration program is incomplete without a viable human space flight capability. By working together, NASA and the community should be able to maintain the remarkable success of the past decade while successfully implementing a new program of exploration. ■

***Brian D. Dewhurst* is a senior program associate for the National Academies' Board on Physics and Astronomy (http://www.nationalacademies.org/bpa/).**

American Astronautical Society

Charitable Giving and the AAS

A popular way to donate to an organization is to make a gift by means of a will, i.e., make a bequest. You may wish to consider either a general bequest to AAS or a bequest targeted to an existing or new AAS scholarship or award fund. Such bequests are deductible against estate and inheritance taxes. Of course, there are also tax advantages to making charitable donations to AAS while you're living. Such gifts could give tribute to the memory of someone who has passed away or honor a person still living. Special occasions offer other opportunities for gifts to be directed to the Society. As a final note, although AAS can provide suggestions for charitable giving, such actions should always be reviewed by your financial or legal advisor.

Astrometry's Next Leap

The European Space Agency is formulating a space-based mission that may revolutionize scientists' knowledge of stellar positions and motions and the formation and evolution of the Milky Way galaxy.

by Bruce Dorminey

Astrometry, first honed by the early Greeks and practiced to varying degrees of success by seafarers since the Phoenicians, was until recently looked upon as somewhat of an astronomical backwater. Astronomers anxious to break theoretical ground frequently turned elsewhere. Yet for decades, U.S. Naval Observatory (USNO) astronomers have faithfully provided the Department of Defense and the astronomical community at large with astrometric data listing relevant stellar positions, proper motions, and distance parallaxes. Even in this age of global positioning systems, the USNO's continually updated, billion-star catalogs remain the foundation for military ground-based navigation, satellite station-keeping, and amateur and professional astronomy. Today, the USNO also spends an average of a quarter of its observing time on purely scientific pursuits.

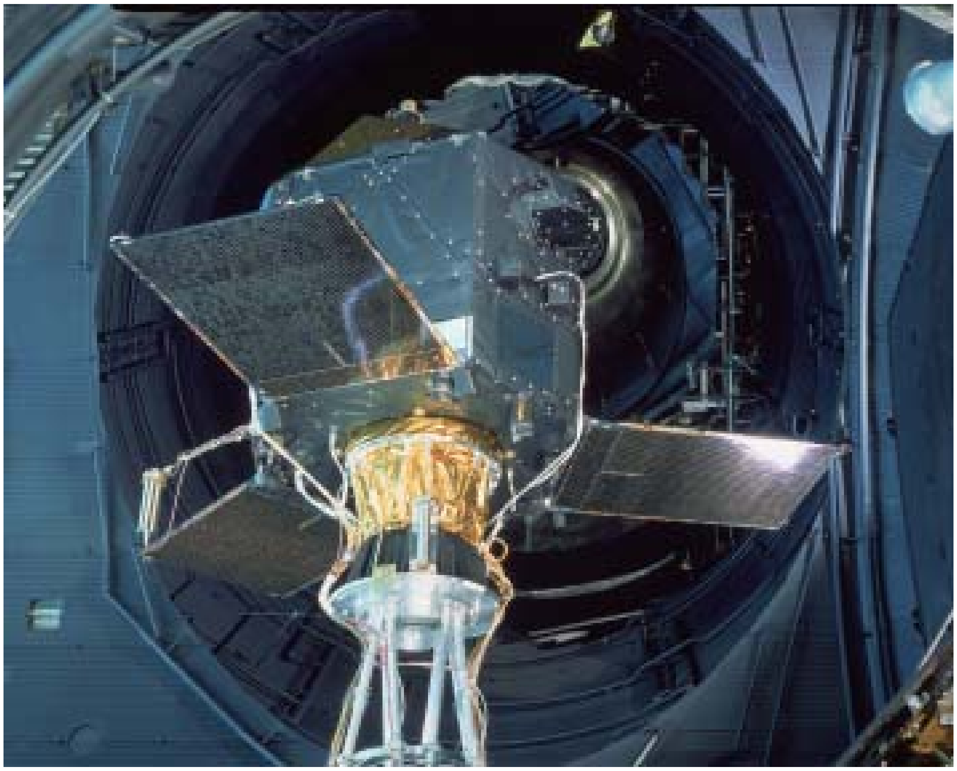
Even so, Europe gets credit for bringing astrometry into the space age, with the 1989 launch of the European Space Agency's (ESA) revolutionary geostationary Hipparcos (High Precision Parallax Collecting Satellite), an acronym honoring Hipparchus, the second century B.C. Greek observer who first cataloged one thousand stars. The satellite's 1997 catalog provided the biggest astrometrical leap in nearly four hundred years. Using Hipparcos data, astronomers cataloged 120,000 stars to an accuracy of approximately two milli-arcseconds and a million stars to an accuracy of some twenty milli-arcseconds. With Hipparcos, astrometry moved into pristine observational and theoretical territory.

Hipparcos project scientist Michael Perryman, together with Lennart Lindegren, an astronomer at Sweden's Lund Observatory, first proposed Gaia, a follow-on to Hipparcos, in 1994. Originally an acronym for Global Astrometric Interferometer for Astrophysics, the 520 million euro ($614 million) mission is currently due for liftoff on a Soyuz launcher in December 2011. Once it reaches the Earth-Sun L2 Lagrangian point, a semi-stable gravitational point from which Earth is always between a spacecraft positioned there and the Sun, its charge is to catalog more than a billion celestial objects.

Although Gaia is no longer an interferometry mission, its moniker stuck, and ESA approved the mission in 2000. But Perryman, now Gaia's project scientist, and much of the Gaia team spent a couple of anxious years wondering whether the Americans' Full-sky Astrometric Mapping Explorer (FAME) mission would cause postponement or even a cancellation of their own project.

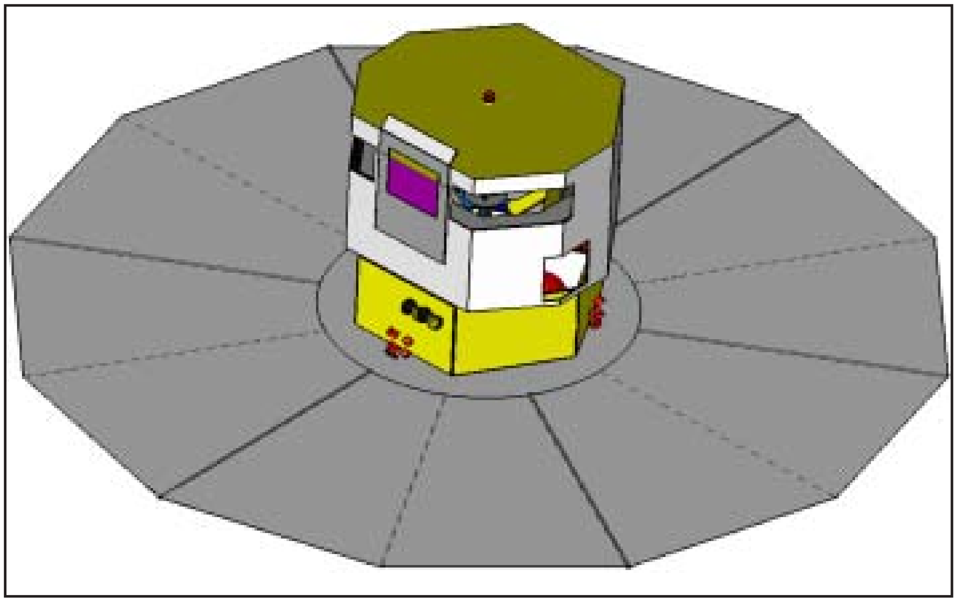
But FAME had its own problems. The USNO's long-awaited astrometric space-mission unfortunately met its demise only months after the National Aeronautics and Space Administration (NASA) gave it the go-ahead. FAME was to have been launched in 2004, measuring some forty million stars down to fifteenth magnitude (as a point of comparison, celestial objects are typically only visible with the naked eye down to sixth magnitude). During FAME's rollercoaster funding ride, ESA, meanwhile, had been developing its own plans for Gaia.

According to Ralph Gaume, an astronomer and the head of the USNO's astrometry department, FAME had diffi-

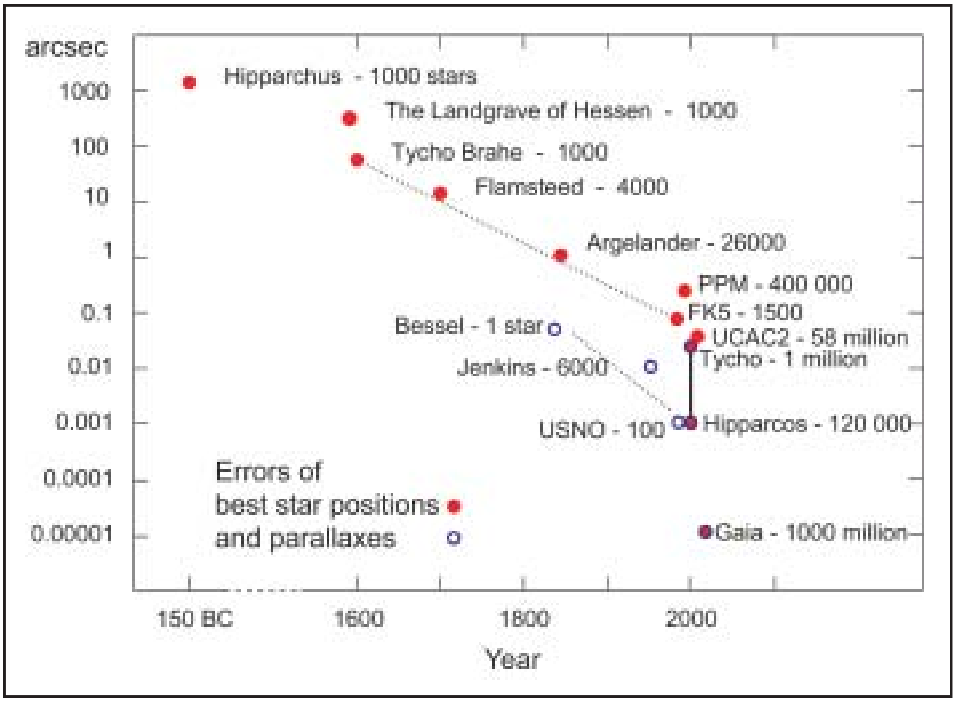


ESA's Hipparcos satellite, which launched in 1989, is credited with bringing astrometry into the space age. (Source: European Space Agency) culties with on-time delivery of some of its key components, which in turn drove up costs, causing NASA to bail out of the mission altogether.

"The FAME team made huge advances in a short time," according to Perryman, "but it faced big challenges, some of which are still with us. One big challenge will be to insure that the scientific goals of Gaia do not get relaxed over the next four to five years, as the real challenges of building the satellite become more evident. As a problem turns into a delay, then specifications get relaxed to preserve the schedule." Perryman says another challenge is readying Gaia's ground-based data-analysis system to meet the demands of handling up to a petabyte (10^{15} bytes) of raw scientific data. Gaia also faces some stiff computational challenges, and to that end, ESA has sought collaboration with Dell Computer Corporation.



ABOVE: *A schematic illustration of ESA's Gaia spacecraft, which will catalog millions of objects across the celestial sphere, scanning the sky in great circles. (Source: EADS Astrium)* ***BELOW:*** *The chart above shows how much progress has been made in a little over two thousand years of astrometry. With new space-based missions like Gaia, the science of astrometry is truly entering a golden era. (Source: Erik Hoeg)*



Mission Specs

Once the satellite has reached the Earth-Sun L2 point and finished three to four months of commissioning, time will be of the essence. The spacecraft will spend five years rotating on its axis every six hours, gathering data from three telescopes roughly scanning contiguous great circles on the sky in almost opposite directions from two different fields of view. With its three-axis motion, Gaia will orbit the Sun once each year, all the while keeping our own nearest star at a constant 50-degree angle. Two of its telescopes have primary rectangular mirrors (1.4 x 0.5 square meters) each to be separated by an angle of 106 degrees. Their images are to be combined into a single focal plane where their data will be collected by one hundred state-of-the-art charge coupled devices (CCD). And if all goes as planned, Gaia's nominal five-year lifetime could be given a one-year extension.

"The advantage of L2 is absence of Earth and Moon eclipses, contributing to the required thermal stability of the satellite and its payload," says Perryman. Aside from getting to L2 within a reasonable timeframe, he says, the main challenge is having enough transmitter power to effect a sufficiently efficient data return rate from L2's distance of 1.5 million kilometers from Earth.

ESA is considering two slightly different designs from two competing industrial teams — EADS-Astrium and Alenia/Alcatel — with the winner to be announced in early February 2006. Then there will be a period of about a year when the design details are optimized. At that point, Perryman says, final construction will begin. Some items, like Gaia's CCDs, are already being produced.

Gaume says that based on his experience with the FAME program, Gaia's biggest technical nemesis will be radiation damage to its highly sensitive CCD detectors, causing significant degradation to the telescopic payload's focal plane. If this occurs, Gaia might be stymied in its effort to get to the faintest planned magnitudes.

Even if the mission suffers from a bit of observational degradation due to radiation damage to its CCDs, its capability will be unprecedented. While Hipparcos observed one star at a time, an average of 2.5 stars per square degree, Gaia will observe some 25,000 stars per square degree or about 20,000 at any given time. Gaia's unbiased all-sky survey down to twentieth magnitude will reach best accuracies of seven micro-arcseconds and provide positions, proper motions, and parallaxes of any given celestial target.

Science

Gaia's main goal is its stereoscopic three-dimensional disentanglement of the formation and evolution of the Milky Way. It will shed new light on how our galaxy built itself up over time via the accretion of nearby dwarf galaxies. Gaia will observe millions of stars in both the Milky Way and neighboring Magellanic clouds (satellite "dwarf galaxies" of the Milky Way only visible from the southern hemisphere), allowing a detailed study of diverse stellar populations. The chemical makeup and movement of these distinct stellar populations offer clues to their origins. As with the Hipparcos mission, these new observations should provide astronomers with ancient stellar fingerprints. By observing how these older stellar interlopers have merged with the Milky Way's much more homogeneous stellar populations, theorists should better understand how the galaxy grew and evolved over time.

"I am excited about being able to construct a movie of the spatial extent and the motions of one billion stars," says Perryman, "then effectively being able to take a detailed look at how our galaxy is structured and how its constituent stars are moving."

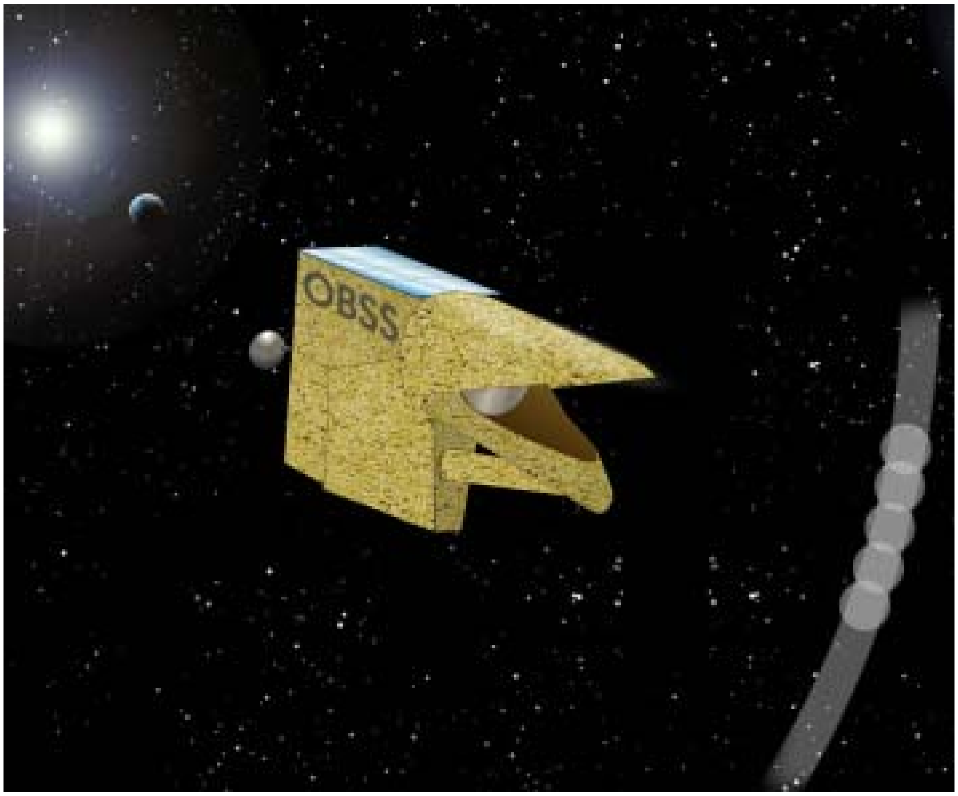
Gaia will be able to directly observe and catalog stars in the Andromeda galaxy, our nearest spiral neighbor. (Source: Robert Gendler)

Gaia's science payload will consist of three instruments to be mounted on a single optical bench – two astrometric telescopes that will be a combination radial velocity spectrometer to measure a celestial object's motion and break down its constituent spectra for chemical and kinematic analysis, and a photometer to chart an object's color and luminosity variations over time. Photometry is one of the keys to refining theories of stellar evolution.

The spectrometer will take radial velocity measurements for up to 250 million stars at a limit of seventeenth magnitude and with an accuracy of a few kilometers per second. Gaia's photometer will offer researchers information on absolute stellar luminosities, temperature, chemical composition, and surface gravity. Gaia will measure stars in the galactic center, for instance, with an absolute accuracy to 10 percent. Baade's Window, a region in the Milky Way's inner bulge, will be the highest density galactic region observed, containing some three million stars per square degree.

"Astrometry provides the infrastructure for doing a lot of astronomy," says Gaume. "For example, if you are following a gamma-ray burst, you have to be able to join the gamma-ray reference frame with the radio reference frame. Astronomers have found that there can be many arc minutes of offsets between different reference frames."

That's another area where Gaia will come into play, tying together diverse as-



The U.S. Naval Observatory's Origins Billion Star Survey spacecraft may succeed Gaia one day as the world's most advanced astrometry mission. (Source: Ralph Gaume)

tronomical reference frames so that no matter what part of the electromagnetic spectrum is being studied, ground-based observatories will be able to routinely cross-reference Gaia's new catalogs for help. The mission's first scientific papers will appear twelve to eighteen months after launch, with a final data wrap-up around 2020, some three years after the end of spacecraft operations.

In addition to quantifying and classifying stars, Gaia will detect thousands of hyper-dense remnants of dead stars known as "white dwarfs" and perhaps as many as 30 to 40,000 Jupiter-mass planets circling other stars, 20,000 supernovae, 50,000 low-mass, cool failed stars known as "brown dwarfs," half a million distant quasars, and ten million galaxies.

Ben Oppenheimer, astronomer and assistant curator in the department of astrophysics at the American Museum of Natural History in New York City, is interested in Gaia's detection of so-called "missing" white dwarfs in our galaxy's halo. He says that these missing white dwarfs have been proposed as the possible solution to the problem of missing baryonic, or ordinary, matter, which makes up about 4 percent of the mass of the universe. Oppenheimer notes that there may be enough white dwarfs in the halo to account for most or all of this missing matter.

Gaia will also help cosmologists further constrain their "distance ladders," or means of determining cosmological distances to both the local and distant universe. Astronomers routinely use observations of variable stars and their inherent period-luminosity relationships as "standard candles" to calculate the stars' absolute magnitude and luminosity. They then use these standard candles to extrapolate distances, both within our galaxy and to the neighboring Magellanic Clouds, the nearby Andromeda Galaxy (M31), and beyond. Gaia may detect up to eighteen million variable stars and make an almost complete census of galactic Cepheids and also lower-mass fainter RR Lyrae variable stars, to a distance of nearly 10,000 light years.

"Gaia will measure proper motions for many supergiant stars in Andromeda (M31), as well as in other Local Group galaxies," says Linnart Lindegren. "It should therefore provide an estimate of the Local Group rotation." As vast as our own Milky Way galaxy may seem, both our galaxy and Andromeda (M31) are dynamically bound up in a much larger cluster of galaxies known as the Local Group. Virtually nothing is known about the Local Group's rotation as a whole, but most of this cluster's mass can be attributed to M31 and our own Milky Way.

Lindegren further explains, "Knowing the relative orbits of M31 and the Milky Way will make it possible to predict if and when they are going to merge and form one giant elliptical galaxy. Gaia's observations of the present Milky Way halo will thus trace the formation history back in time. Gaia will also provide a lot of detailed information about the structure and motions in the Milky Way and other Local Group galaxies."

While the dynamics and velocities of the galaxies within the Local Group are misunderstood, there are also so-called hypervelocity stars whose movements and positions defy explanation. Most recently, the European Southern Observatory's (ESO) Very Large Telescope in Chile tracked a massive, young, speeding star far out in the halo of the Milky Way, moving at more than 2.6 million kilometers per hour. ESO researchers believe that the star may have been gravitationally "slung out" by a heretofore undetected massive black hole in the center of the nearby Large Magellanic Cloud.

What puzzles researchers is why such a massive star should be found out beyond the Milky Way's halo and not closer to the disc of our galaxy. Ralf Napiwotzki, an astronomer at the Center for Astrophysics Research at the University of Hertfordshire in the United Kingdom, says that Gaia's proper motion measurements will help us better understand where such hypervelocity stars may have originated.

Closer to home, Gaia will detect up to a million asteroids and comets within our own solar system. Because of its ability to observe within 40 degrees of the Sun, Gaia should also find a plethora of heretofore undetected Near-Earth Objects (NEOs). It is hoped that Gaia will determine orbits for all NEOs with diameters larger than a few hundred meters. And for anyone who questions the esoteric nature of much of Gaia's science, these findings might even save your life.

With the recent announcement that the 320-meter asteroid 99942 Apophis will make close approaches to Earth in 2029 and 2036, NASA and other groups are actively considering whether space-based reconnaissance and tracking may be used to determine if a future asteroid deflection mission is needed. "At the moment, the [likelihood of] this object hitting Earth is one in 5500," says Don Yeomans, an astronomer at the Jet Propulsion Laboratory in Pasadena, California, who routinely tracks and plots present and future NEO orbits. "On April 13, 2029, it will pass below some of our geosynchronous communications satellites. It will be a third magnitude naked-eye object, 36,350 kilometers from the Earth's center. We are anxious [to get] additional observations to refine its orbit."

Looking Ahead

Gaia's serendipitous NEO observations may not generate the kind of headlines ESA garnered after the spectacular success of its Huygens probe at Saturn's moon, Titan. Yet over ten years after Gaia's inception, ESA is to be lauded for its painstaking long view. Most of Gaia's science will require years of data reduction at an analytical pace not necessarily suited to a twenty-four-hour news cycle. Even so, perhaps because of the Huygens probe and ESA's new international recognition, it can be argued that ESA, if only inadvertently, may be assuming a portion of NASA's scientific mantle. But despite NASA's recent difficulties, Perryman notes, the American agency's funding is still a factor of ten times that of ESA's, so he doesn't envision ESA stealing the American agency's thunder anytime soon.

Continued on page 23

The MAPS Mission Concept

The USNO is also working on a more modest space-based astrometric micro-satellite concept. The $40-50-million Milli-Arcsecond Pathfinder Survey (MAPS) could be deployed in a 900-kilometer orbit around Earth by early 2009, more than two years ahead of Gaia's current launch schedule. The USNO is in discussions with the Department of Defense (DoD) and NASA about combining an astrometric mission that would help update and expand current catalogs while also enabling some innovative science surveys. Astronomer Ralph Gaume, head of the USNO's astrometry department, and other proponents at the USNO are in the process of pitching the idea to the astronomy community at large.

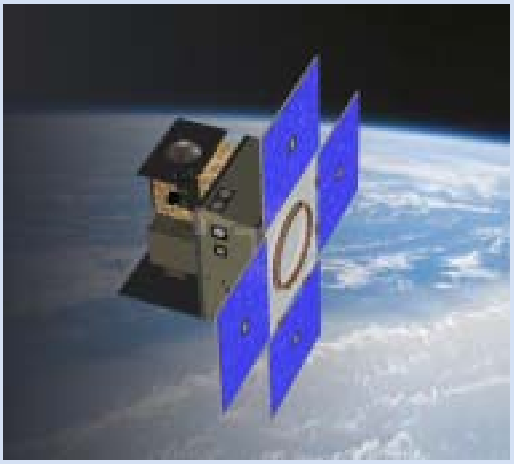
While Gaume remains pessimistic about NASA funding for another FAME-like astrometric mission in the immediate future, he hasn't given up on either the DoD or NASA funding a smaller-scale project. "Because the DoD has a real need for precise astrometry," says Gaume, "for the last year, we have been designing a mission specifically tailored to DoD astrometry needs. Not many people outside of DoD circles have heard of MAPS, but we've recently begun enumerating and elaborating basic science results that would be derived from MAPS." MAPS isn't fully funded as of yet, but Gaume says that the project has stirred significant interest within the DoD, and he believes NASA may underpin the project's science investigations.

In its current incarnation, MAPS would use a fifteen-centimeter visible and near-infrared telescope to gather positions, parallaxes, and proper motions over a one-square-degree field of view, with an average of two thousand stars within its sights at any given time. MAPS would observe some fifty million stars, from second to sixteenth magnitude, with ten million of the brightest stars observed at Hipparcos-like accuracies. But in contrast to Gaia's planned scanning mode, MAPS would use guide stars in a "step-stare" process of pointing and integrating the satellite toward one field of view at a time during a three-year mission.

MAPS science highlights would include searching for evidence of galactic mergers; fine-tuning the cosmic distance ladder, with new fixes on the Pleiades star cluster and other distance calibrators; and studying the origins of nearby stars like Beta Pictoris, a massive young star long known to harbor a planetary disk. MAPS would also help quantify whether long-period giant planets are circling nearby stars. In addition, it would help place age limits on the oldest binary systems, while giving new clues to the dynamics of the young star-forming regions nearest to Earth.

MAPS would look at the internal dynamics of star clusters younger than four hundred million years old and might even detect low-mass galactic black holes on long-period orbits around normal main-sequence, hydrogen-burning stars.

— Bruce Dorminey



MAPS satellite concept. (Source: U.S. Naval Observatory)

Report on the AAS National Conference and 52nd Annual Meeting

"Building Bridges to Exploration: The Role of the International Space Station"

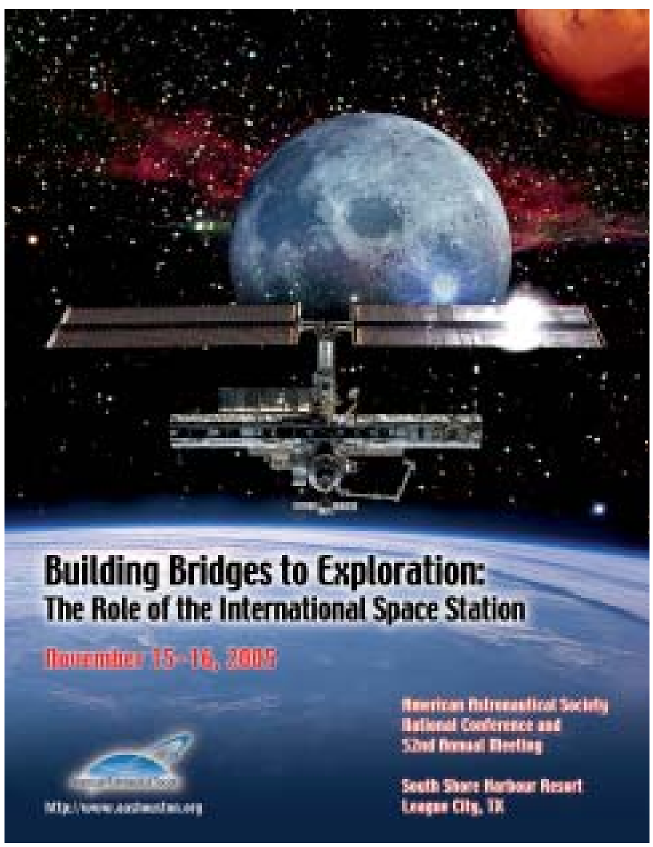
by Rick W. Sturdevant

The AAS National Conference and 52nd Annual Meeting at South Shore Harbour Resort, League City, Texas, during November 15-16, 2005, was a resounding success in terms of thematic coherence, topical relevance, and total attendance. Outgoing AAS President Jonathan Malay welcomed a standing-room-only crowd of approximately five hundred—one of the largest gatherings in AAS history—and introduced a videotaped greeting from International Space Station (ISS) Expedition 12 crew members Bill McArthur and Valery Tokarev, who wished everyone "all the best for a successful conference." Next, Jefferson Howell, Jr., director of Johnson Space Center (JSC), introduced National Aeronautics and Space Administration (NASA) Administrator Michael Griffin, who delivered the keynote address.

Griffin focused on how the ISS can contribute most usefully to accomplishment of the economic, political, and national security goals set forth in President George Bush's vision for space exploration. Viewing government as the "core provider of infrastructure," Griffin declared, "NASA will build the interstate highway to go to the Moon and Mars." To that end, the ISS provides a government-funded test bed for learning how to live and work in space and for promoting space commerce. Because American taxpayers cannot bear the financial burden alone, the government must foster more commercial space investment. Griffin described how NASA will spend $500 million over the next few years to cultivate commercial providers for such ISS services as crew transportation and cargo delivery. Long-term logistical support for a fully assembled, fully operational ISS is the first defined and sustainable market NASA is giving commercial space vendors.

Promotion of free-market competition might be crucial to success of the president's vision for space exploration, but we should not neglect public support. NASA Associate Administrator for Space Operations William Gerstenmaier explained how the "NASA Means Business" capstone program taps the knowledge, energy, and creativity of students from a broad range of academic disciplines to articulate effectively to the general public the value of space exploration and its potential contributions to improvement of life on Earth. The program, which began in 1998 under the agency's Mars program, has sponsored an annual competition ever since. Teams of graduate and undergraduate students from accredited U.S. higher education institutions generate short video, radio, print, or web-based productions. Winning public service announcement videos were shown before each session of the AAS conference.

Gerstenmaier, joined by William Panter and Kirk Shireman from JSC, presented the first session on achievements and challenges associated with assembly and utilization of the ISS in the Shuttle era and beyond. Touting the ISS as a test bed for development and demonstration of capabilities required for human missions to the Moon and Mars, Gerstenmaier admitted the station's current systems lack the robustness needed for the impending new age of space exploration. He speculated that older hardware, such as the shuttle's external tank and main engine or the Saturn launch vehicle, will contribute to launch and propulsion systems for lunar and Martian flights. Outlining the many engineering challenges associated with the ISS, Panter saw the largest as an effective logistical and maintenance strategy in the post-Shuttle era. From an ISS operational perspective, Shireman described challenges with assembly (e.g., shortages of spares and



planning for unknowns), international partnerships (e.g., differences in time zones, standards, and shared assets), and crew size (e.g., shortages of consumables when shuttle flights are curtailed). Despite the station's many problems and challenges, the panelists agreed "ISS is a springboard to many futures."

Tuesday's luncheon speaker, Courtney Stadd, former NASA chief of staff and current president of Capitol Solutions, sounded a less optimistic note concerning current space policy. He warned of a "tremendous noise-to-signal ratio" when trying to get anyone in Washington, D.C., interested in anything besides the war on terrorism. Despite the emergence of a new, extraordinarily competent NASA leadership team and a bipartisan legislative framework in Congress, several factors cloud prospects for a bright future: internal accounting problems that work against the validity of cost estimates at NASA; congressional committee realignments and rule changes on appropriations; a macro-political environment characterized by massive deficits; uncertainties about any presidential commitment to space after the 2008 elections; a "breathtakingly full dance card" for Administrator Griffin's team (i.e., Shuttle end of life, ISS assembly, and future crew and heavy-lift launchers); and the possibility that advocates of space exploration might be "out of phase" with American taxpayers' priorities. We can expect to see "Perils of Pauline" survival strategies for some years to come, warned Stadd, and any misstep could spell a very long hiatus in U.S. human space exploration. If the nation fails to respond successfully to this critical turning point in space history, Americans could witness a taikonaut landing on the Moon in 2018 and China, at least symbolically, supplanting U.S. preeminence in space.

A captivated audience enjoys a session of the two-day conference. (Source: AAS)

Session Two entailed an international discussion of ongoing and planned research aboard the ISS. NASA's Donald Thomas explained how the president's vision for space exploration has shifted U.S. priorities from diverse, multidisciplinary, fundamental research to the study of astronaut health and protection of crews on long-duration missions. Nicole Buckley from the Canadian Space Agency (CSA) described how her country's ISS experiments complement work in areas of the life and physical sciences where Canada already excels terrestrially. Canada's goal is to achieve a mixture of basic and applied research that will lead to improvement of life on Earth and safer space travel. Eric Istasse from the European Space Agency (ESA) categorized his organization's ISS research, which presently depends on U.S. and Russian willingness to share resources, as a mixture of one-third physics, one-third life sciences, and one-third planetary exploration. ESA also is harmonizing its ISS experiments with ongoing experimentation using drop towers, sounding rockets, and Russian Foton capsules. Finally, Masato Koyama from the Japan Aerospace Exploration Agency (JAXA) introduced the Japanese Experiment Module (JEM) "Kibo" and detailed his nation's five-phase, twenty-year research projection, including three internal experiment racks currently awaiting launch and three external payloads projected for launch in 2008.

Session Three concentrated on how ISS systems and operations might contribute directly to reduction of exploration risks. The Boeing Company's Anthony Majoros and Paul Jackson summarized how video-based "augmented reality," a technology that merges real-world images with computer-generated graphics, can enhance mission performance; it can guide a person step by step through a procedure, thereby decreasing time required to complete a task, reducing errors, and increasing overall safety. Pratt & Whitney Rocketdyne's Ed Gholdston reveled in the large areas available on ISS for testing electrical technologies related to power generation, storage, lighting, and propulsion. Honeywell's Carlos Garcia-Galan discussed how the success of long-duration missions will depend on handling system health or mission management problems tactically with an autonomous, spacecraft-based model rather than strategically with the traditional, ground-control model. In this regard, ISS can be a test bed for cultivating closer collaboration between technology implementation centers and operations centers in assessing the merits of specific automated health management proposals. To conclude, Boeing's Mark Wilson examined what the ISS experience has taught us about mitigating contamination of onboard water systems by microorganisms and why design and operational im-

Michael Malin (left), holding his 2005 Sagan Memorial Award, stands with AAS President Mark Craig. (Source: AAS)

provements are critically needed lest, to paraphrase Louis Pasteur, the microorganisms have the last word.

Moderator Stephen Johnson from the Institute for Science and Space Studies at the University of Colorado, Colorado Springs, introduced Session Four on integration challenges in a large-scale program like the ISS. His roundtable included Kuniaki Shiraki (JAXA), Alan Thirkettle (ESA), William Gerstenmaier (NASA), John Elbon (Boeing), Benoit Marcotte (CSA), and Nikolay Sevastiyanov (RSC-Energia). In one way or another, all participants identified the importance of deriving system requirements from a clearly defined, mutually understood end product or set of goals, and of remembering to maintain sufficient flexibility to adapt as funding levels, schedules, or priorities change. Several mentioned the need to orient configuration management to a documented baseline, to arrange communication among partners in ways that will ensure both accountability and the free flow of information, and to simplify as much as possible interfaces and other aspects of system integration. More than one acknowledged the benefits of international cooperation but pointed to problems caused by differences in language, culture, technical standards, time zones, and other barriers. Some stressed being able to "decompose" the program into self-contained, manageable elements or stages to avoid introduction of artificial problems; processes must be implemented to ensure all partners understand and adhere to the division of responsibilities. Shiraki touted the value of a building-block approach over the more traditional linear development program, and Thirkettle cautioned against developing new technology as an integral part of any critical path.

Johnson summarized the discussion by asserting that how we integrate the social aspects of what we do significantly affects a large-scale program's outcome. The introduction of systems engineering and integration reduced failure rates from 50 to 10 percent; now, the challenge is how to achieve an even lower failure rate of 1 or, perhaps, 0.1 percent. To accomplish this, he asserted, we must "use bureaucracy to fight bureaucracy." Because the repetitive nature of bureaucracy deadens minds and leads to failure, we must identify and implement ways to counter that phenomenon. He hinted thoughtfully that the key to overcoming bureaucracy's negative impact on large-scale programs might lie in answering the question, "Is a system of systems just another system, or is it something different?"

The awards banquet on Tuesday evening capped a very full day. Jack Stuster, vice president at Anacapa Sciences and author of *Bold Endeavors: Lessons from Polar and Space Exploration* (Naval Institute Press, 1996), delivered the address. Specializing in the measurement and enhancement of human performance in extreme environments, Stuster seeks to apply lessons about the psychological and behavioral effects of isolation, confinement, and other conditions historically associated with exploration to benefit crews on future lunar and Martian expeditions. Content analysis of records from the voyages of Columbus, journals from the Lewis and Clark expedition, logs and recollections from nearly a dozen polar expeditions during the nineteenth and early twentieth centuries, and diaries currently being kept by ISS crews suggests a dip in morale during the third quarter of any expedition, regardless of its length. Furthermore, research indicates that while conditions vary on any particular expedition, the types and relative importance of problems or issues remain fairly consistent, with group interaction being foremost.

To crown the evening, new AAS President Mark Craig presented the annual awards. Charles Elachi, Jet Propulsion Laboratory (JPL) director, received the prestigious Space Flight Award for application of synthetic aperture radar to Earth and planetary remote sensing. As the first pilot of a civilian craft, SpaceShipOne, into outer space, Michael Melvill of Scaled Composites earned the Flight Achievement Award. Thomas Gavin's extensive contributions to all robotic missions since 2001 brought him the W. Randolph Lovelace II Award, and Peter Teets's leadership of the National Reconnaissance Office led to his winning the Military Astronautics Award. The Dirk Brouwer Award went to F. Landis Markley for his technical expertise on spacecraft attitude and restoration, and the John F. Kennedy Astronautics Award was bestowed on John Logsdon for many years of helping the public appreciate and understand the importance of the nation's space programs. Ted Gavrilis, president of Lockheed Martin Commercial Space Systems, received the Industrial Leadership Award. For her book *Right Stuff, Wrong Sex: America's First Women in Space Program* (The Johns Hopkins University Press, 2004), Margaret Weitekamp won the Eugene M. Emme Astronautical Literature Award. Finally, three individuals became AAS Fellows: Christopher Hall, David Hull, and Srinivas Vadali.

Wednesday morning began with presentation of the Carl Sagan Memorial Award to geologist Michael Malin, president of Malin Space Science Systems. In his lecture on exploring Mars, the honoree explained how imagery from the Red Planet indicates a unique geologic morphology. It is a "complex, complicated place," said Malin. The layering, gullies, and other surface features provide evidence of what happened, but exactly how things happened remains mysterious. "All the interpretations you've heard at press conferences have been wrong," Malin charged, because the terminology associated with the geologic impact of water, wind, weather, and climate has been misused. We must ensure, he said, that people receive correct information and hear the best rationale for truly sustainable, systematic, and extensive robotic and human exploration of Mars. From Malin's perspective, the best rationale is not a search for life but, rather, to study the effects of weather and climate change on Martian geologic history.

He suggested Antarctic research as a "pretty good" model for justifying and scoping a Mars project because the former receives enormous Executive Branch support. If the U.S. presence in Antarctica has elevated national prestige through successful pursuit of knowledge, demonstration of technical capabilities, and promotion of international cooperation, exploration of the Red Planet could do the same. To answer those who might charge that human expeditions to Mars are too expensive, Malin speculated that the cost over a decade would be comparable to what the United States will spend on Antarctic research—about $3 billion, with up to 80 percent for infrastructure or logistical support and less than 20 percent going to scientific research.

AAS award recipients, from left to right: John Logsdon, Charles Elachi, Michael Malin, and Peter Teets. (Source: AAS)

In Session Five, teams of young engineers from JSC and JPL discussed challenges that human and robotic exploration have in common. Dividing those challenges into four categories—avionics; entry, descent, and landing (EDL); robotics; and mission operations—the discussants sought areas of current or potential JSC-JPL collaboration. For avionics, several recommendations emerged to expand beyond radiation research: opening communication via a NASA avionics conference, establishing a commonly accessible database for technological information, dedicating funds for continued collaborative efforts, piggybacking on tests, and employing inter-center liaisons on specific projects. The EDL team recommended creation of a NASA-wide EDL working group and found fertile ground for collaboration on blunt and slender lifting bodies, powered descent, inflatables, ballistic parachutes, navigation and guidance, simulation tools, and break-up or burn-up analysis for human casualty and hazard risk assessments. Robotics provides abundant opportunities for collaboration on mechanical, electrical, and software issues arising from the design, development, and testing of new interfaces or modules. Despite extensive cooperation on mission operations in the past, ample room exists for development, and demonstration through a series of integrated field tests, of a collaborative human-robotic approach to enhance crew performance on long-duration missions. JSC Deputy Director Robert Cabana concluded, "This exercise opened a channel of communication for future exploitation," and JPL's Andy Mishkin called for pursuing funds to implement the teams' suggestions. When Mishkin recommended making JSC-JPL collaborative sessions a regular part of the AAS national conference, new AAS President Mark Craig expressed strong support.

Wednesday's luncheon speaker, James Lewis from the Center for Strategic and International Studies, examined the "how and why" of Chinese human space flight. Led by American-trained rocket expert Tsien Hsue-shen, the Chinese first began planning for human missions in the late 1960s but terminated that effort a decade later due to its high cost. In 1992, China renewed its human space flight program with a target date for the first mission of 1999, the fiftieth anniversary of the country's Communist revolution. Russia agreed in 1995 to assist China with data and training, which surely reduced the risk and time it took the Chinese to succeed. Finally, in October 2003, China became the world's third nation independently capable of launching a human into space.

According to Lewis, the Chinese do not seek to compete with the United States in this arena but, rather, want to show the world generally and their neighbors specifically that "China has arrived." The primary driver behind China's well-funded program is political symbolism—to demonstrate technological self-reliance and thereby gain prestige and influence in the international community. Although China has invested immensely in training scientists and engineers and has progressed markedly in building a strong technological base, Lewis thinks its political culture, legal and financial system, along with programmatic compartmentalization, work against innovation and retard progress.

After lunch, Session Six focused on possible commercial participation in human space flight programs. Universal Space Network President Joseph Rothenberg emphasized that commercialization generally involves multiple providers offering products or services in a competitive market containing multiple customers. This is very different from privatization, where industry takes over a service from NASA and sells it back to NASA. According to Rothenberg, past experience reveals several challenges to commercialization in space: the government is an unreliable customer in terms of funding and scheduling; the government has limited experience in commercial contracting; and industry has a poor performance record when the government has sought services. Art Dula, chief executive officer of Excalibur Almaz Ltd., said two key questions—how to raise capital and how to mitigate risk—must be answered before commercial success can occur. If NASA would accept and follow the Commercial Space Act of 1998, he asserted, commercialization might work. Placing even stronger emphasis on risk mitigation, Charles Miller of Constellation Services International on the Isle of Man explained how his company, through proven performance on a privately funded, fixed-price deal with NASA for development of an ISS cargo-delivery concept, hopes to use NASA as an "anchor tenant" to attract other, more risk-averse customers. Echoing Rothenberg, Miller cautioned that the biggest challenge to commercial success is a "culture gap" between how companies do things to achieve a return on investment and how NASA normally procures things.

The sixth session continued with Michael Bain from SPACEHAB touting his company's success in solving—at one-fifth the government's estimated cost for a similar capability—NASA's problem of insufficient room for hundreds of experiments aboard the shuttle. Because approximately twenty flights since 1993 cost less than one-half the government's estimate for just the first four flights, SPACEHAB realized a significant return on its initial $184-million investment and managed to go public with fund raising. Although SPACEHAB envisions an expanded number of customers, Bain admitted that government customers—civil and military—currently are essential to the company's survival.

Chris Stott, chief executive officer of ManSat Ltd., a commercial satellite communications provider based on the Isle of Man, thinks the business model and the regulatory environment are most important to commercial success. Using the East India or Hudson's Bay Company model, ManSat has received the "sole and exclusive" contract to develop space for the Isle of Man government. The current regulatory environment for outer space is unfavorable for commercial ventures, however, and ought to move toward a "private property regime." Stott's company seeks support to establish that kind of regime in space law. Summarizing the session, Rothenberg observed that true integration of government and commercial interests in space exploration hinges on industry risking investment and on the government trusting commercial service providers.

Prospects for international cooperation on human space flight projects supplied the focus for Session Seven.

NASA Administrator Mike Griffin giving his keynote speech. (Source: NASA)

Peggy Finarelli from International Space University (ISU) and Ian Pryke from George Mason University, both of whom participated in the April 2005 Strasbourg Workshop on "Structuring Global International Cooperation in Space Exploration," pointed out obvious political, economic, and technological advantages to such partnering. They also found such disadvantages as greater management complexity and the possibility of one nation being held hostage to the broader foreign policy agendas of others. Because nations perceive their interests differently, they need not agree on a common rationale for cooperation, only on a common solution. Describing the workshop's outcome, Pryke said the traditional approach of negotiating roles and responsibilities at a project's outset will not suffice in future, cooperative efforts to explore the Moon and Mars. The latter will be a complex, open-ended set of activities, not a single project or monolithic program. Consequently, to advance human space flight beyond Earth orbit, he advocates a "program of programs" paradigm containing two tiers—individual national or multilateral exploration projects; and a broad, flexible, international coordination structure to integrate those efforts globally. This concept envisions a more genuine, egalitarian partnership—not one characterized by U.S. domination.

Picking up on the conference theme, ISU President Michael Simpson postulated that the real challenge lies in building "a bridge big enough for all of us." The past has taught us the bridge must be international, intercultural, and interdisciplinary. It also must be dynamic, continually renewed by elements of history yet to be made; it must be intergenerational, drawing on the wisdom of the past and the enthusiasm of the present to lead spacefarers toward a purposeful future. Education can bridge generations, and that is why ISU takes pride in having graduated 2,400 individuals from ninety-one countries during its eighteen-year existence.

The audience poses questions during the conference. (Source: AAS)

Two earlier speakers, Alan Thirkettle and Nikolay Sevastiyanov, also joined this session. Thirkettle identified the desire for independent access to human space flight as a force driving ESA toward cooperation with Roscosmos to produce the Kliper space shuttle, which could be launched from Baikonur or Kourou. Probing deeper into the nature of cooperation, Sevastiyanov perceived three structured ways it occurs: integrated international programs (e.g., ISS); independent national programs with international participation (e.g., European Automatic Transfer Vehicle and Kliper); and international commercial programs (e.g., Sea Launch International and RSC-Energia's Yamal communications satellite). Regardless of cooperative structures, he concluded that pooling political interests, economic resources and, above all, intellects will allow human exploration beyond Earth orbit.

In the final session, teams from the Students for the Exploration and Development of Space organization presented to the audience and a panel of NASA judges proposals for using the ISS as an exploration mission test bed in four technical areas—robotics, habitability, maintenance, and life support/medicine. The robotics team offered two concepts, an Advanced Robotic Maintenance System and an "Astrobot" network, to reduce human performance of simple tasks and to increase crew safety. For improving habitability, a second team articulated a "virtual Earth" concept that included a terrestrial-environment simulator, a "window" view, and family interaction. Another team proposed improving maintenance through data mining, increased inside vehicular activity, more reliance on robotic systems for extravehicular activity, reduction of spares inventory through standardization of some parts (e.g., fasteners) and on-station manufacture of others. The fourth team designed an easily scaleable, hydroponic system featuring hexagonal packing to double the ratio of surface area to volume and fiber-optic "curtains" for the collection and distribution of ambient solar light, along with a storage/fixation bay for preserving harvested plants. By a single point, the judges selected the life support/medicine team's proposal over the maintenance team's ideas.

While the judges were deliberating, Boeing geologist Kurt Klaus entertained the audience with tales from his "voluntary time in hell"—a fifteen-day simulated visit to the Red Planet by an engineering and science team at the Mars Desert Research Station (MDRS) near Hanksville, Utah. Seeking to better understand the environmental, engineering, psychological, and physiological challenges for humans during actual exploration of Mars, all-male (Leonardo) and all-female (Mona Lisa) crews ventured out in analog-pressurized rovers to explore the terrain, collect soil samples, photograph rocks, and observe cloud formations. Crewmembers reported their findings via e-mail to a command center staffed by Mars Society scientists. They also participated in a comparative study of behavioral characteristics in the Leonardo and Mona Lisa teams. Finally, they contributed to a study of the relative comfort levels of two types of spacesuits: the MDRS variety simulating gas-pressurization (as currently used by NASA astronauts) and the MarsSkin physical-compression suit. They also evaluated the utility of MDRS and MarsSkin helmets and gloves. All crewmembers found the MarsSkin suit more comfortable, with the gloves allowing especially good flexibility.

Briefly summarizing the conference, AAS President Mark Craig reminded listeners of its theme—Building Bridges to Exploration. He described Griffin's keynote address on Tuesday morning and the team reports in Session Eight as "anchors at each end of a bridge." The discussions between the anchors he perceived as "pylons" marking the entrance or approach to a new era in human space flight. ■

***Rick W. Sturdevant* is deputy command historian at Air Force Space Command in Colorado Springs, Colorado.**

44th Robert H. Goddard Memorial Symposium

(visit www.astronautical.org for program updates and online registration)

TUESDAY, MARCH 14, 2006

Welcome and Introduction: Mark Craig, SAIC - AAS President

Introduction of Keynote Speaker: Edward Weiler, Director, NASA Goddard Space Flight Center

Keynote Address: Michael Griffin, NASA Administrator

Session 1: Exploration and the Vision
The architecture to enable the vision for space exploration begins with a return to the Moon before the end of the next decade, going from sorties to full outposting. The Constellation program is the first step and core activity to implement the vision.

Luncheon Speaker: Senator Kay Bailey Hutchison, R-TX (invited)

Session 2: Exploring with Humans and Robots – The Synergy of Human and Robotic Exploration
Human and robotic exploration has made significant contributions to understanding our universe. This synergy is essential for enabling the vision for human exploration beyond low Earth orbit.

Session 3: Engineering the Exploration – The Challenge of Systems Engineering
The vision provides the long-term goals that will challenge our engineering systems to operate with a blend of proven and new technology. Learning from the past successes and failures of space exploration system engineering is essential to creating a robust exploration architecture to meet these goals.

Session 4: Engineering Innovation and the Vision
Even as we build upon and modify what has come before, the vision requires that we continually consider new ideas and alternate approaches to developing new technologies, systems, and missions.

Reception

WEDNESDAY, MARCH 15, 2006

Keynote Address: John H. Marburger, III, Director, Office of Science and Technology Policy (invited)

Session 5: Future Human Capital Needs of the Vision
It is important to identify the capabilities that will satisfy the human capital needs that ensure a future workforce to execute the vision. The human capital required to enable the vision encompasses committed leadership in government, academia, and industry.

Luncheon Speaker: Miles O'Brien, CNN Anchor (invited)

Session 6: Science is Exploration
Human exploration seeks the unknown. Robots take days where humans take minutes to make scientific measurements. Going where no human has gone before in the pursuit of science is the heart of the exploration vision.

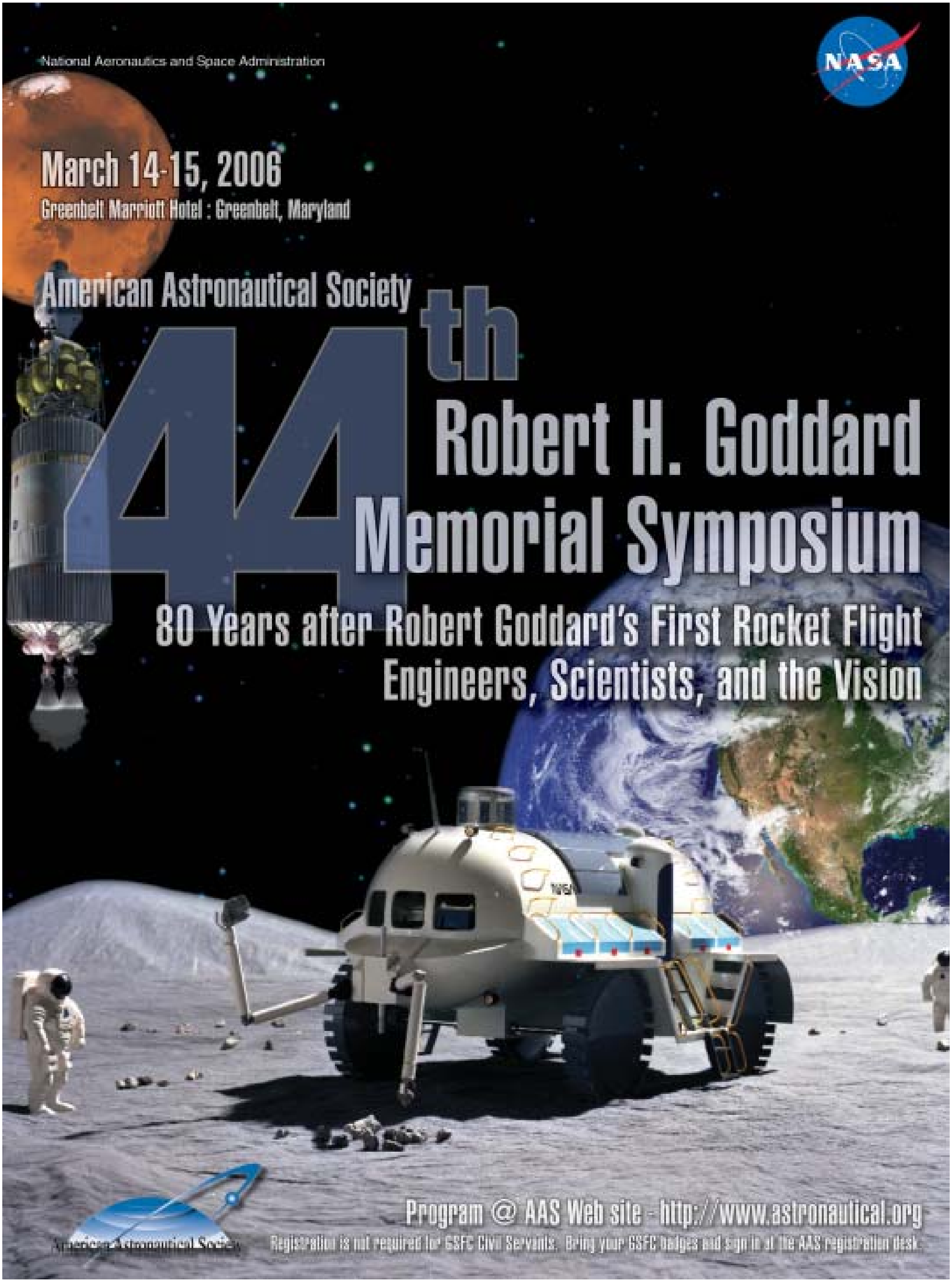
Session 7: Exploration is Science
Like science, exploration is an adventure in gaining new knowledge. Exploration provides strategic knowledge and capabilities that allow opportunities for science. As humans explore, we need to understand what we have found, where it came from, and how it relates to where we are in our Earth and space science research efforts.

Full Registration: includes all sessions, continental breakfasts, refreshment breaks, two luncheons, and reception.

AAS Member $350
Non-Member / Renewing Member $435
U.S. Government / Academia $275
One-Day Registration $220

Special Registration: includes all sessions, continental breakfasts, refreshment breaks, and reception. (Luncheons are not included, but tickets may be purchased for $40 each.)

Student (full-time) / Teacher (K-12) $30
Retired (over 65 and not employed full-time) $75
Press (with credentials) .... No Charge


National Aeronautics and Space Administration
NASA
March 14-15, 2006
Greenbelt Marriott Hotel : Greenbelt, Maryland
American Astronautical Society
44th
Robert H. Goddard
Memorial Symposium
80 Years after Robert Goddard's First Rocket Flight
Engineers, Scientists, and the Vision
Program @ AAS Web site - http://www.astronautical.org
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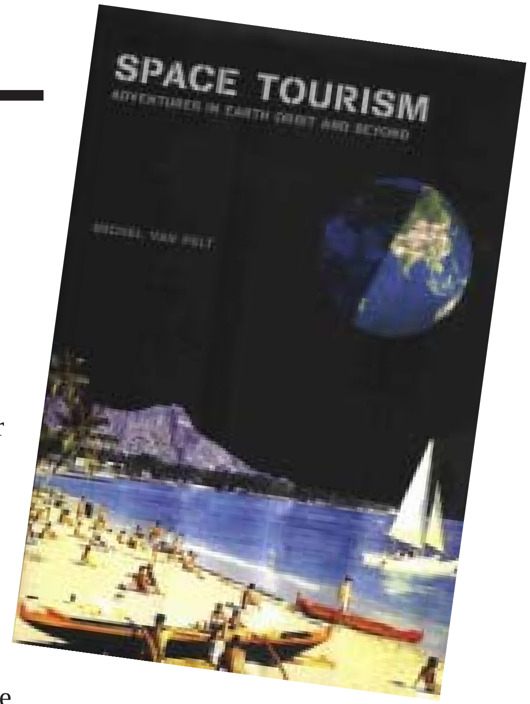
NOTES ON A NEW BOOK

Space Tourism: Adventures in Earth Orbit and Beyond

Reviewed by Mark Williamson



Space Tourism: Adventures in Earth Orbit and Beyond by Michel van Pelt. Chichester/New York: Praxis Publishing/ Copernicus Books, 2005. 217 pages. ISBN: 0-3874-0213-6. $27.50 (hardback).

With recent events such as the winning of the Ansari X Prize and the founding of new private human space flight companies, space tourism is becoming an accepted sub-genre in space book publishing. Written by Michel van Pelt, an engineer with some experience in designing – if not actually producing – reusable spaceplanes, *Space Tourism* is an indication of what to expect from this emerging area.

According to the author, the book is aimed at those who dream about circling the Earth and those who are curious to know why others do. Its non-technical nature should make it accessible to anyone. Indeed, some chapters are written in the form of a narrative describing the experience of space flight. These "imaginative scenarios" are printed in a different typeface and set in gray boxes to distinguish them from the rest of the book. In addition to black-and-white photos, the book includes an eight-page color insert.

The book begins, conventionally enough, with a section on selecting astronauts for space flight but quickly moves on to the recent history of space tourism and some of the proposals for new spacecraft. However, perhaps as an indication of the speed at which the market is developing, it contains no details of the recent agreement between Richard Branson's Virgin Galactic space tourism venture and Scaled Composites, developer of Ansari X Prize-winning spacecraft SpaceShipOne, as the book was written before the completion of the Ansari X Prize competition. And as far as pictures are concerned, it gives equal coverage to SpaceShipOne, the United Kingdom's Starchaser project, and the Xerus spaceplane from XCOR Aerospace, the latter two of which are so far unproven.

Predictably, much of the book refers to space history as opposed to "space future," contrasting the way things have been done in the past with the way they might be done in future. This is a good tactic to use for an audience which for the most part needs convincing that space tourism is possible, but it means that much of the book is not actually about space tourism. This indicates that the probable market for the book is not space professionals but the lay audience beyond.

Naturally enough, the author cannot resist the obligatory sections on eating, sleeping, and sex in space (which he heads "Space Loving"). The text here is littered with the usual euphemisms, such as "cosmonauts getting a bit too interactive" and "orbital lovers [experiencing] rendezvous and docking problems" – a habit that is bound to continue until the subject is given a proper airing. Indeed (at the risk of dwelling on the subject myself), natural human interest means that, one day, a manual of "recommended techniques" will have to be produced. According to the author, for example, the use of "special four-legged shorts" has already been suggested, while others propose a variety of straps, loops, and even "special furniture and fittings to help people to stay together." The mind boggles!

If nothing else, the inclusion of this relatively small section proves that space tourism is a human interest story. If you want an easy read on the general prospects for space tourism, then this could be a book for you. Personally, I look forward to a book about the systems, technologies, and policies for actual space tourism – and, of course, that all-important users' manual. ■

***Mark Williamson* is an independent space technology consultant and author.**

AAS Volunteers Needed

Your help is requested! Three important committees will meet later this year, and each is critical to the work of AAS. The awards committee reviews nominations for ten major AAS annual awards and selects worthy candidates for election by the Board. The Fellows committee reviews candidates for the annual Fellows election; 415 distinguished men and women have been chosen for this honor since 1954. Finally, the nominations committee develops a slate of officer and director candidates for election by the membership. Although the AAS president selects the committee chairs, membership of each is open to AAS members. If you are interested in serving as a committee member, please contact the AAS office at aas@astronautical.org.

Astrometry's Next Leap

Continued from page 13

For its part, the USNO has already gone back to the drawing board. In May 2005, the USNO submitted a proposal to NASA for a concept study for a mission it calls the Origins Billion Star Survey. As a follow-on to Gaia, the Origins survey would also position itself at L2, observing down to twenty-second magnitude, two magnitudes fainter than Gaia. Even so, the mission remains unfunded.

Perryman thinks astrometry's post-Gaia future may lie in an astrometry mission capable of detecting all Earth-mass planets out to some 320 light years. That sort of capability is years over the horizon. At present, there are only a few astrometric missions being planned or even being discussed. The Japanese have mentioned mounting an infrared astrometric mission to survey stars normally obscured by dust along the Milky Way's crowded galactic plane. But other than Gaia, the only funded space-based astrometric mission is NASA's Space Interferometry Mission (SIM), due for launch no earlier than 2013. SIM is primarily a planet-finding mission, yet it will also provide parallaxes of stars down to four micro-arcseconds at distances out to 80,000 light years. That's three arcseconds better than Gaia, and in a whole new paradigm from Hipparcos. A little astrometric rivalry never hurt anyone. ■

***Bruce Dorminey*, author of *Distant Wanderers: The Search for Planets beyond the Solar System* (Copernicus Books/Springer-Verlag, 2001), is a science journalist who covers aerospace and astronomy.**

2006 Space Events

March 5-8 – Earth & Space 2006 *"Engineering, Construction, and Operations in Challenging Environments"* at the South Shore Harbour Resort, Houston, Texas. www.asce.org/conference/space06

April 24-27 – 4th Responsive Space Conference *"Pulling It Together"* at the LAX Westin Hotel, Los Angeles, California. www.responsivespace.com

April 24-28 – Introductory Space Course at the International Space University campus, Strasbourg, France. www.isunet.edu

May 4-7 – International Space Development Conference sponsored by the National Space Society and The Planetary Society at the Sheraton Gateway Hotel, Los Angeles, California. www.isdc.nss.org/2006

May 20 – Team America Rocketry Challenge at The Plains, Virginia. www.aia-aerospace.org/aianews/features/team_america

July 17-21 – GPS/GNSS Symposium sponsored by the International Global Navigation Satellite Systems (IGNSS) Society at the Holiday Inn Surfers Paradise, Queensland, Australia. www.ignss.org

September 19-21 – Space 2006 Conference *"The Value Proposition for Space – Security, Discovery, Prosperity"* at the San Jose Convention Center, San Jose, California. www.space2006@aiaa.org

November 9-11 – Space Vision 2006 Students for the Exploration and Development of Space (SEDS) 3rd National Conference at the University of Central Florida in Orlando. www.seds.org

AAS Events Schedule

March 14–15, 2006
44th Robert H. Goddard Memorial Symposium
"Eighty Years After Robert Goddard's First Rocket Flight: Engineers, Scientists, and the Vision"
Greenbelt Mariott Hotel
Greenbelt, Maryland
www.astronautical.org

See pages 20-21 for details!

June 8–10, 2006
***Student CanSat Competition**
Washington, D.C., area
www.cansatcompetition.com

August 21–24, 2006
***AIAA/AAS Astrodynamics Specialist Conference and Exhibit**
Keystone Resort & Conference Center
Keystone, Colorado
www.aiaa.org

November 14–15, 2006
AAS National Conference and 53rd Annual Meeting
Pasadena Hilton
Pasadena, California
www.astronautical.org

January 28 – February 1, 2007
***AAS/AIAA Space Flight Mechanics Winter Meeting**
Hilton Sedona Resort & Spa
Sedona, Arizona
www.space-flight.org

January 31 – February 4, 2007
30th AAS Guidance and Control Conference
Beaver Run Resort
Breckenridge, Colorado
www.aas-rocky-mountain-section.org

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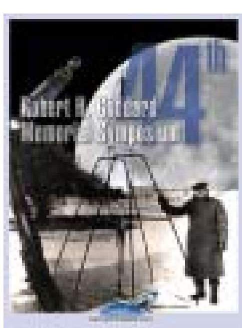

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