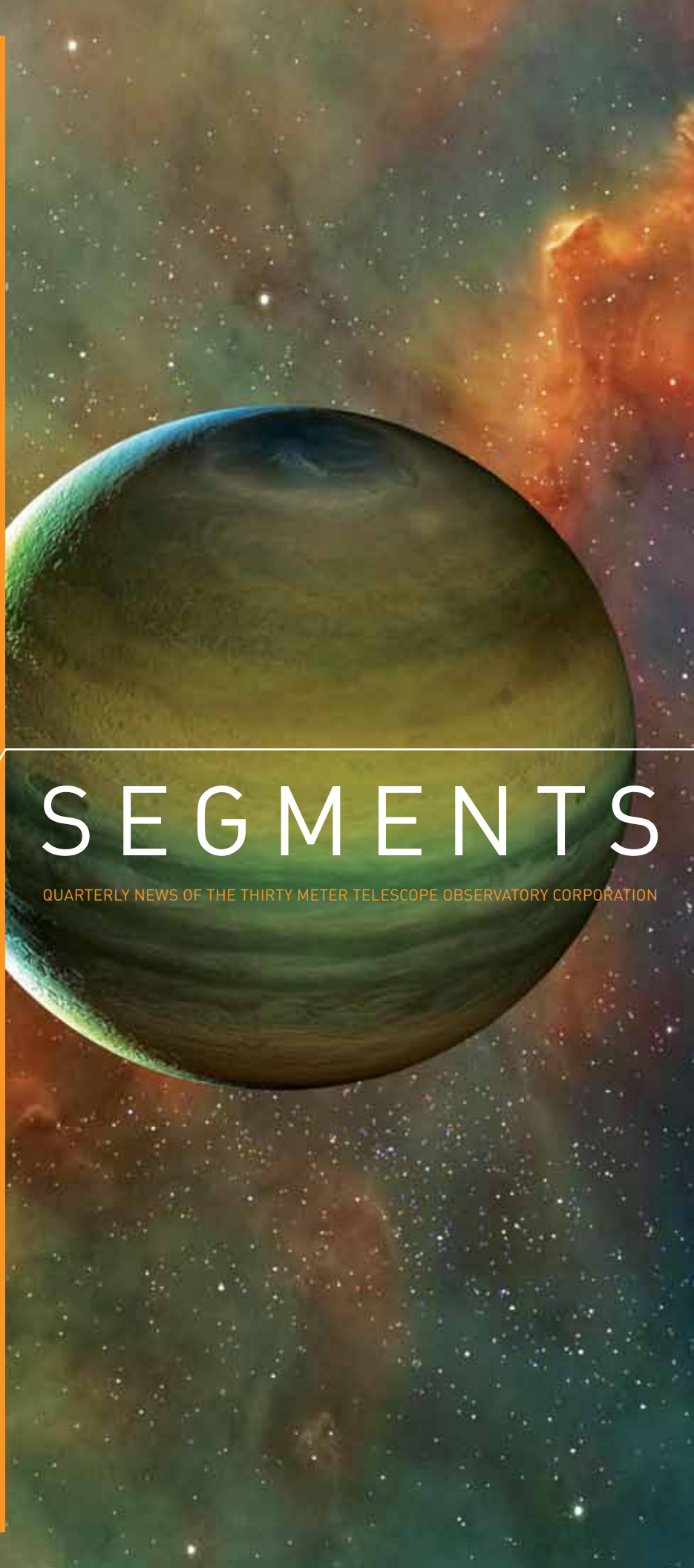

ISSUE 04
NOVEMBER 2010

TMT SEGMENTS

QUARTERLY NEWS OF THE THIRTY METER TELESCOPE OBSERVATORY CORPORATION

IN THIS ISSUE

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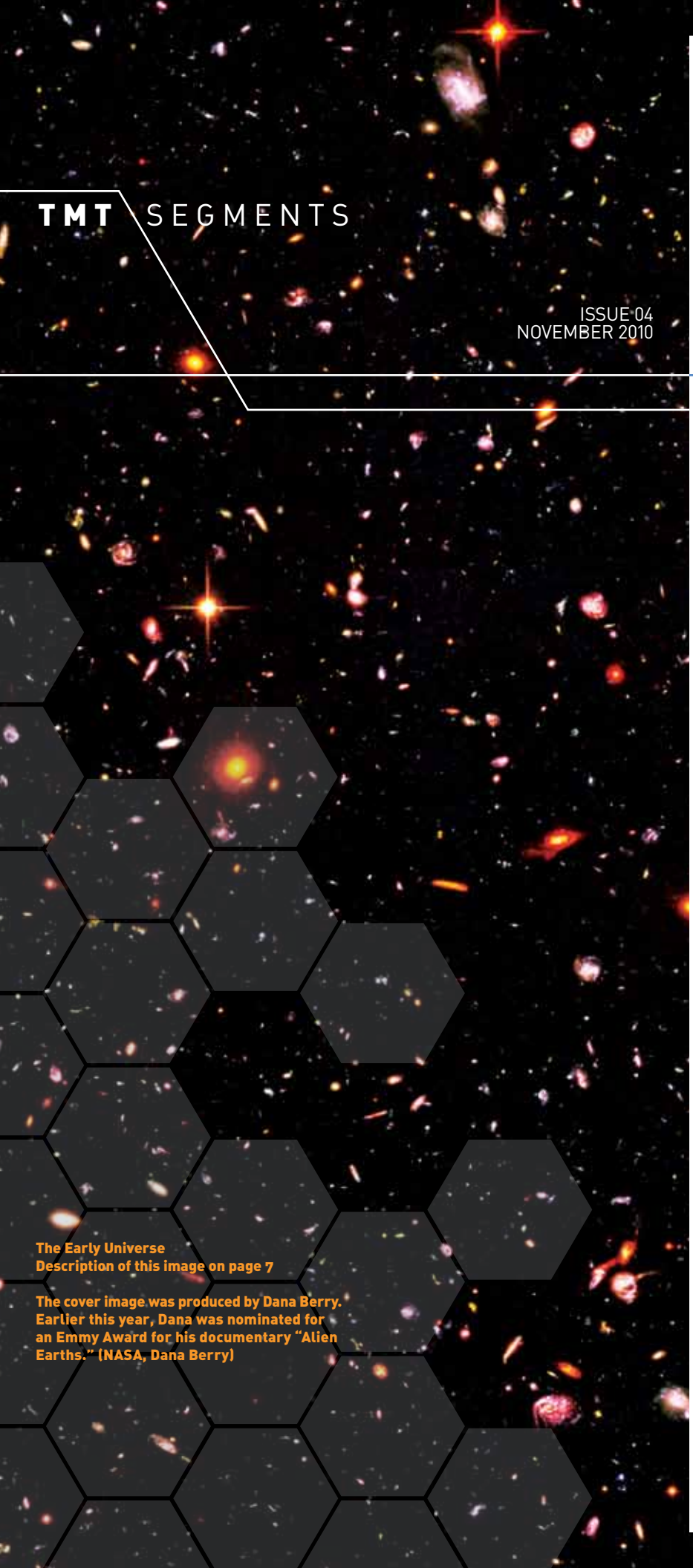

The Early Universe
Description of this image on page 7

The cover image was produced by Dana Berry. Earlier this year, Dana was nominated for an Emmy Award for his documentary "Alien Earths." (NASA, Dana Berry)

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PROJECT MANAGER'S CORNER: TMT INDIA

Gary Sanders, *TMT Project Manager*

It is a long way from Pondicherry to Pasadena. I traveled back from Pondicherry to Chennai to Delhi to Chicago and to Los Angeles recently. It is a long way.

This air trek capped a very gratifying week of meeting with TMT's new Indian colleagues (www.tmt.org/news-center/india-joins-thirty-meter-telescope-project) and with several industries in India. After decades of working in global science projects, I still find it gratifying to travel so far and to move through very different streets and cities and cuisines and customs and find that the working meetings are in a familiar and universal language of engineering and science. A discussion of finite element analysis or high spatial frequency figure errors or common services software or telescope control bandwidth is the same in Pondicherry or Pasadena. Long distances do not influence the focus on the technical challenge or how to produce a part at a lower cost.

That bit of air travel took 30 hours. But today, our team is in a follow up video conference early in the California morning with our Indian colleagues who are staying late. 12.5 hour time zone differences can be dealt with. It takes some effort but the teams are focused. The goals and challenges beckon and after hours electronic conferences are part of shrinking the globe to fit inside our collaboration.

Our week in India explored TMT observatory software. India is where a large fraction of the commercial software in the world is written. India's powerful IT industries can play a major role in TMT software, including control of the observatory systems and processing of the data that will be generated.

But India also carries out an extensive space program and has a well developed nuclear industry. Quantity production of automobiles and other products is well established in India. Precision, automation, special materials processing, advanced optics and quality are evident in the Indian industrial community. First rate technical universities and well developed physics and astronomy programs underpin and power these capabilities as well as aspirations of future research with large telescopes such as TMT.

Big science facilities are national and global assets. Increasingly, they require global talent and resources but they support scientific reach on a global scale. They present implementation challenges in geography, management and coordination and in diverse ways to carry out the work. But science has paved the way with many examples of global scientific projects. The Large Hadron Collider caps more than a half century of transnational and global scientific effort in high-energy physics. Projects like TMT, with participation in the United States, Canada, Japan, China, and India, are translating that experience into the next chapter in astronomy.

FEATURE: GUIDING THE TMT DESIGN BY STUDYING TODAY'S LARGEST TELESCOPES

By Warren Skidmore,
TMT Scientist

The Keck Dome during the day. ***Photo courtesy of Keck Observatory***

The Thirty Meter Telescope's (TMT) primary mirror has much in common with the 10-meter mirrors on the Keck telescopes.

They all have a segmented design and use edge sensors and actuators to keep the segments in perfect alignment (see Technology Corner, page 8). They also need to compensate for a host of environmental conditions that could affect the performance of the telescope.

As the Keck telescopes operate, they are constantly jostled by things like wind, vibrations from machinery, and changes in temperature and humidity. All of these environmental conditions affect the ability of the telescope structure and control systems to maintain optical alignment and accurate telescope pointing.

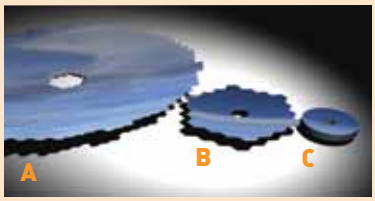
On the scale of the Keck telescopes, some of these factors are negligible while others can be easily corrected. However, environmental effects that don't cause a problem for present-day telescopes can have very serious consequences for the larger telescopes like the TMT.

For example, TMT scientists earlier discovered subtle effects of high humidity on the edge sensors for Keck's mirror segments. When scaled up to the size of the TMT, these same conditions, if not addressed, would compromise the performance of the telescope. But, by understanding the problem in advance, the TMT's mirror control system will be designed to compensate for humidity variations, avoiding a potentially serious problem.

Also, small vibrations caused by pumps, compressors, and other machinery on or around telescopes could pose problems. Once again the Keck Observatory was used to help understand how the TMT would perform under similar circumstances. For the TMT, potential sources of vibrations were located away from the telescope and engineers developed other vibration dampening techniques. When combined, these measures will ensure that even though the TMT will be much larger than the Keck, its vibration environment will be lower and its ability to alleviate the effects of vibrations will be higher.

These comparative investigations continue. Throughout 2010, a team of engineers has been measuring and monitoring a number of critical environmental conditions on the Keck telescopes. First, the team has been working to characterize the entire observatory environment, documenting all the possible internal and external forces and factors that could potentially impact telescope performance. Second, the TMT engineering team has been measuring the response of

A) TMT's 30-meter, 492 segment mirror
B) Keck's 10-meter, 36 segment mirror
C) Palomar's 200-inch single mirror



Left image: The dome of one of the Keck telescopes at dusk.
Bottom image: Tony Travouillon, TMT Environmental Control Scientist, checking testing equipment on the Keck II dome. ***Photos courtesy of Keck Observatory***

the telescope and its many control systems to all possible environmental disturbances.

These measurements were made after installing wind and air temperature sensors on the telescope and at the top of one of the Keck domes. With data from these instruments, the team has been better able to characterize the environmental conditions around the telescope. This information was also used to estimate the atmospheric turbulence in the dome, which directly impacts the optical performance. The computer modeling tools being used to estimate the dome seeing at Keck are the same tools being applied to the TMT design. Measurements inside the Keck dome taken with an instrument called a laser scintillometer are also providing important tests for those turbulence estimates.

The ultimate goal is to ensure that the TMT will deliver the best possible image quality.

Additional research is now underway on the wind-induced motions of the Keck telescope and the ability of the control system to mitigate those motions, minimizing image jitters.

Critical elements of the TMT design are being supported by measurements made at operating telescopes that share many design and environmental aspects with TMT. The ultimate goal is to ensure that the TMT will deliver the best possible image quality while operating in the harsh environment of Mauna Kea.

Segmented Primary Mirror

TMT, with its 30-meter (nearly 100-foot) diameter mirror, will have nine times the light-gathering power of today's best telescopes. When compared to the Hubble Space Telescope, TMT will have 156 times the collecting area and more than 10 times its resolution at certain wavelengths.

TMT will use a segmented primary mirror, which was successfully pioneered on the Keck telescopes. This design is essential for extremely large telescopes. A single 30-meter diameter mirror would be too large to build and transport. TMT's smaller segments, less than two meters across, can be more easily made, transported, and replaced if necessary.

Photo illustration: Todd Mason

Chilean Student Completes TMT Research Scholarship

The Thirty Meter Telescope (TMT) and the Universidad Catolica Del Norte (UCN) in Chile joined together earlier this year to offer a new undergraduate scholarship to a UCN student. The TMT and UCN earlier collaborated on the successful site testing campaign for Armazones, Chile. More than 20 students applied for several projects under the new scholarship. After a selection process involving TMT and UCN faculty, the winner, Andrea Paz, came to Pasadena in April 2010 to work on data analysis of turbulence profiles. Her strong interest in the topic led her to choose this work as a basis for her undergraduate thesis, which she successfully presented on July 30. This is the first thesis co-supervised by TMT, which is a testament to the potential of the project for education.

TMT Hawaii Update

The 60-day state challenge period for the Thirty Meter Telescope's (TMT) Final Environmental Impact Statement (EIS) ended on August 8. No challenges were filed and the EIS process is now complete. The TMT must now complete the Conservation District Use Application (CDUA) process. The process was initiated by the approval on September 1 of the draft CDUA by the Mauna Kea Management Board. The application was then approved by the Department of Land and Natural Resources (DLNR) and will be open for public comment until November 23. DLNR will hold public hearings in early December before deciding whether or not to grant a permit to build on Mauna Kea.

Photos courtesy of Dana Berry, Inge Heyer, Andrea Paz, and TMT

Outreach Activities

The Thirty Meter Telescope participated in North Hawaii's second annual Solar System Walk on August 7. The event featured a half-mile scale model of our Solar System beginning with the Sun at Keck Observatory headquarters and extending to the Kuiper Belt at Canada-France-Hawaii Telescope headquarters. TMT volunteers represented the planet Uranus.

Also, the Thirty Meter Telescope was one of the sponsors of the first Hawaii International Micro Robot Conference and Tournament hosted by the 'Imiloa Astronomy Center. The event was held in July to stimulate high technology education. The conference included student and teacher participants from Hawaii high schools, and students from the University of Hawaii College of Engineering.

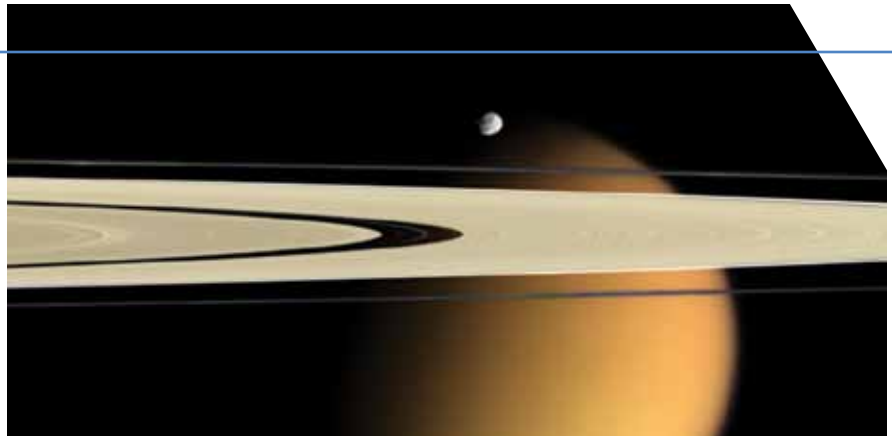
TMT Moving Headquarters

As of November 1, 2010, the headquarters for the Thirty Meter Telescope will have a new address: 1111 South Arroyo Parkway, Suite 200, Pasadena, Calif. The TMT will occupy approximately 15,000 square feet of an existing office building located near the entrance of the 110 freeway in Pasadena, between Old Town Pasadena and South Pasadena. The new office is in close proximity to restaurants, shopping, and other retail amenities. It's also within walking distance of the Gold Line commuter railway system.

TMT Animation Artist Honored by Hollywood

Dana Berry (on the right, co-author Ray Villard on the left), the artist who produced TMT's new animations, images, and promotional video, was nominated this year for an Emmy Award for his documentary "Alien Earths." Though the award went to another production, the nomination was a remarkable achievement. The cover image of this issue of Segments is a still from that program, and all previous covers are renderings from Dana. To see more of Dana's work, visit www.tmt.org.

Cassini delivers this stunning vista showing small, battered Epimetheus and smog-enshrouded Titan, with Saturn's A and F rings stretching across the scene. *Courtesy of NASA/JPL/Space Science Institute*



TMT TO EXPLORE OUR SOLAR SYSTEM

By Mike Brown, Division of Geological and Planetary Sciences, California Institute of Technology

While the Thirty Meter Telescope (TMT) will spend much of its time examining the outer reaches of the universe, studying galaxies as they form and the coalescence of supermassive black holes, viewing photons that originated billions of years ago, occasionally the focus will be much much closer, and astronomers will be examining light emitted not from the distant past, but, perhaps, from earlier that very afternoon: our own solar system is on the cusp of an exploration renaissance that will be assisted by the TMT.

Earlier this decade new discoveries in the outer solar system led to the realization that large dynamically important planets in our system are overwhelmingly outnumbered by a vast array of icy dwarf planets. In many ways, these dwarf planets provide a much higher fidelity recording of the evolution of the solar system than their larger cousins. The smaller sizes of these dwarf planets prevents much of the geochemical processing that occurs in the true planets, while the vast distances and low temperatures of these icy dwarfs allows many of the initial chemical constituents to remain undisturbed.

The largest of these icy dwarf planets—Pluto, Eris, Haumea, Makemake, and Quaoar—have been studied intensively with the current generation of 8-10 meter telescopes, and astronomers have learned of their extreme seasonal cycling, the outgassing of their tenuous atmospheres, the loss and retention of cosmochemically important volatile constituents on their frost surfaces. The more important even smaller objects remain just beyond the reach of the even the largest current telescopes, however. The TMT will instantly open this new window into the chemical and physical composition of our early solar system.

Even closer to home, the high spatial resolution of the TMT will provide the unprecedented ability to examine and monitor the giant moons of the solar system. Saturn's moon Titan, in particular, is an object of particularly intensive study with NASA's Cassini spacecraft. Cassini will crash into Saturn at about the time of TMT first light, and we will, in many ways, lose our view into the only other world in the solar system with an active hydrological and meteorological cycle. The view of Titan from the TMT, however, will be better than that from Cassini except for a day from Cassini closest approach. More importantly for understanding dynamical processes like weather and hydrology, the TMT will be able to monitor and follow a body like Titan at will, unconstrained by spacecraft dynamics. Likewise, the ubiquitous volcanoes on Jupiter's moon Io, slated to be visited by a NASA spacecraft in 20 years, will be able to be studied in unprecedented detail well before spacecraft arrival.

The solar system, though closer than anything else studied in the astronomical universe, is equally full of mystery and opportunity for discovery. The TMT will provide a vessel for exploration of these new horizons.

Science Case for TMT: The Early Universe

TMT will allow astronomers to directly explore the early Universe, from the end of the cosmic dark ages through the formation of the first stars and reionization and into the epoch of galaxy formation. The signatures of the chemically unevolved Population III sources and studies of the resulting chemical enrichment of the young Universe are within reach of the TMT. The epoch of first assembly of matter and stars into proto-galaxies, the first appearance of quasars and the processes of reionization of the intergalactic medium will be observable by the TMT. TMT also will make important contributions to the study of dark energy by pushing supernovae observations to the highest possible redshifts and measuring the dark energy density as a function of cosmic time.
Image courtesy of HubbleSite

TECHNOLOGY CORNER

Primary Mirror Position Actuators Pass Major Milestone

One of TMT's key technologies has passed a major development milestone. The second-generation Primary Mirror Position Actuator prototype has been built and successfully tested.

When completed, the TMT will rely on 1,476 of these actuators, three for each of TMT's 492 mirror segments. Actuators with nanometer precision are necessary to position the segments so they form the equivalent of a single 30-meter diameter mirror. In addition to operating with extreme precision, the Primary Mirror Position Actuators also need to be very stiff. This ensures that the segments remain stable when wind blows on the primary mirror. The actuators also help isolate the segments from unwanted vibrations coming from pumps, fans, and motors within the observatory facility.

TMT's Primary Mirror Position Actuators are based on "voice coil" technology. This is similar to the technology commonly used in everyday loudspeakers. A voice coil is an electromagnetic device that produces force when a current is applied. Position sensors and embedded computers enable the actuators to maintain the mirror segments in their correct position. A mechanism called an offloader is used to minimize the power required by the actuator, which in turn minimizes the undesirable effects caused by heat released behind the primary mirror.

After additional reliability testing, a third-generation actuator prototype will be built, which will pave the way toward full scale production.

TMT's Primary Mirror Position Actuators were developed jointly by Marjan Research and the Jet Propulsion Laboratory (JPL), a division of the California Institute of Technology. For more information on the TMT Primary Mirror Position Actuators contact Mark Sirota at msirota@tmt.org.

By Mark Sirota,
Telescope Controls Group Leader

Want to learn more?

Find us on the web at: **www.tmt.org**

Find us on Facebook (look for the "official" TMT page) and TMTHawaii on Twitter.

UPCOMING EVENTS

Decadal Survey Town Hall
November 29, 2010
Univ. of California, Berkeley

To foster community understanding of and support for the recommendations of the Astro 2010 Decadal Survey, "New Worlds, New Horizons," the AAS has coordinated a series of Town Halls with regional hosts so that a Decadal Survey member can present the results in a forum that enables questions and discussion at the individual level. The local host for the UC Berkeley event is Imke de Pater. For information contact Barbara Hoversten, bhovers@astro.berkeley.edu.

217th AAS Meeting
January 7–13, 2011
Seattle, Washington

The Thirty Meter Telescope will once again sponsor an exhibit at the Winter Meeting of the American Astronomical Society. Details on the meeting are available from the AAS here: aas.org/meetings/aas217.