

TESTIMONY
OF
EDWARD C. STONE

My name is Edward C. Stone and I am the Executive Director of TMT International Observatory LLC.

I received my undergraduate education at Iowa's Burlington Junior College, I earned an M.S. and Ph.D in physics at the University of Chicago. I joined the staff of Caltech as a research fellow, and became a full faculty member in 1967, was named professor of physics in 1976, and chair of the Division of Physics, Mathematics, and Astronomy from 1983 to 1988. I also served as vice president for Astronomical Facilities from 1988 to 1990 and as director of Jet Propulsion Laboratory in Pasadena, California from 1991 to 2001. In the late 1980s through 2009, I also served as chairman and vice chairman of the Board of Directors of the California Association for Research in Astronomy, which has been responsible for building and operating the W.M. Keck Observatory with its two ten-meter telescopes on Mauna Kea, Hawaii.

I joined the Thirty Meter Telescope Corporation in 2004 and served as chairman and vice-chairman until May 2014 when I became Executive Director of the newly-founded TMT International Observatory (TIO) that was established to carry out the construction and operation phases of the TMT Project. The current Members of TIO are Caltech, UC, the National Institutes of Natural Science of Japan, the National Astronomical Observatories of the Chinese Academy of Sciences, the Canadian National Research Council and the Indian Department of Science and Technology. Major funding has been provided by the Gordon & Betty Moore Foundation.

Each of these Members or their affiliates had been associated with the TMT Observatory Corporation prior to the formation of TIO, had participated and collaborated in the planning for the TMT Project, had spent funds on the design of the TMT, and had expressed interest in forming an international partnership once the site at Mauna Kea received its Conservation District Use Permit. TIO was thus formed with these members in May 2014. It is important to note that all of these members or their affiliates had been associated with TMT Observatory Corporation for several years.

TIO will pursue its purposes by designing, developing, constructing, and operating an observatory on Mauna Kea with a "state-of-the-art" thirty-meter, world class telescope, and in doing so, foster academic and scientific interaction among educational and other research institutions on a global basis.

TIO is organized exclusively for exempt purposes under Section 501(c)(3) of the Internal Revenue Code. TIO may not carry out activities that are not permitted by Section 501 (c)(3) of the Code. TIO is operated exclusively to further the charitable educational and/or scientific purposes within the meaning of Section 501 (c)(3). TIO is specifically organized and operated to provide for the observation and collection of images and information from deep space to advance human knowledge of astronomy and the origins of the universe by and through the TMT Project. TIO and its members seek to develop, design, finance, construct, commission, operate and decommission a next generation segmented mirror telescope and associated observatory on Mauna Kea in Hawaii.

Background

This has been a long journey for us. In spring 2003, we began a partnership to design and built a next generation large telescope. We developed a preliminary design for a segmented 30-meter-diameter astronomical telescope that is patterned after the twin Keck telescopes. We hoped then that our journey could be expanded to include not only the preliminary design phase, but also the final design, construction, commissioning, and operation of the observatory.

Value of the TMT Observatory

The critical need for an optical/infrared¹ telescope² with a 30-meter primary mirror to continue the scientific advancement of the last decades was identified by the U.S. scientific community and assigned a priority by the Canadian scientific community. In response to this need, the TMT Corporation was formed to manage initial planning, and then the design, development, and operation of the TMT Observatory,³ which will house a 30-meter primary mirror telescope.

¹ Optical or visual light encompasses the wavelengths from 320 nanometers (blue/ultra-violet) to 950 nanometers (red) (0.32 to 0.95 microns) including the U, B, V R, I, and Z bands in astronomy.

Infrared can be divided into near, mid, and far infrared wavelengths, generally as follows:
Near – 1,000 to 2,200 nanometers (1.0 to 2.2 micrometers or microns); includes the J, H, and K bands in astronomy.
Mid – 2,500 to 30,000 nanometers (2.5 to 30 microns); includes L M, N and Q astronomy bands.
Far – 30,000 to 400,000 nanometers (30 to 400 microns); also referred to as submillimeter.

² A telescope is defined as a movable structure and optics and/or reflectors used to select a viewing position on the sky, capture the radiation (visible light, infrared, or radio) from astronomical objects and focus that radiation into a focal plane.

³ An observatory includes the telescope(s), the dome(s) that contain the telescope(s), and the instrumentation and support facilities for the telescope(s) that fall under a common ownership.

The TMT Project's primary purpose is to provide a much more advanced and powerful ground-based observatory than currently exists, one that will enable discoveries about the nature and origins of the physical world, from the first formation of galaxies in the distant past and remote regions of the Universe to the formation of planets and planetary systems today in our Milky Way Galaxy.

The United States has been the leader in astronomical research for the last 150 years, and locating the TMT Observatory in Hawai'i will maintain the United States' leadership in astronomical research, discovery, and innovation. The TMT Project will help to maintain this leadership by leveraging the capability of the existing observatories on Mauna Kea, including the W. M. Keck Observatory, the Canada-France-Hawai'i Telescope (CFHT), and the Subaru Telescope. While these observatories are world-leading observatories today, their future scientific productivity would be increased by the co-location of a next generation observatory, such as the TMT Observatory. Additionally, by bringing the TMT Project to Hawai'i, the potential significant socioeconomic benefits, including employment and education, of the TMT Project will be realized by the people of Hawai'i.

The quest to answer fundamental questions about the nature and workings of the Universe has been pursued through the ages, and continues today. The TMT Project will continue this quest. The TMT concept was developed to address the need to overcome the limitations of existing astronomical facilities. An observatory similar to the TMT Observatory has been envisioned by the scientific community for some time. It has been referred to generically as a Next Generation Large Telescope (NGLT) or Giant Segmented Mirror Telescope (GSMT) in various plans and surveys for the last 15 years.

With the TMT Observatory, observations of the first stars and galaxies formed after the Big Bang will be possible and the epoch of "First Light" in the Universe could be unveiled. Understanding the subsequent evolution of galaxies from this early time to the current era is another major research area for which TMT Observatory will provide a giant step forward. The combination of great sensitivity and unique spatial resolution of the TMT Observatory will be vital to learning more about the recently discovered phenomenon in which galaxy evolution and the growth of supermassive black holes in galaxy cores are tightly coupled. The combination of great sensitivity and unique spatial resolution will also make the TMT Observatory an extremely powerful observatory for the discovery and characterization of planets orbiting other stars.

Since 2003, work has greatly progressed on the design of the telescope, instruments and all aspects of the Observatory. The project has been named the Thirty Meter Telescope (TMT) and the effort has included the government agencies of Canada, China, Japan, India, and the University of California and the California Institute of Technology.

On July 21, 2009, after a multiyear evaluation of different sites and intensive visits and discussions with the various stakeholders in Hawaii, TMT collaborators selected Mauna Kea on Hawaii Island as the location of the telescope. In May 2010 a Final EIS for the Project was completed and accepted by the Governor of Hawaii. In September 2010, the UH applied for a Conservation District Use Permit to build the TMT Observatory in the Mauna Kea Science Reserve. In April 2013 following a lengthy contested case proceeding, this Board granted a Conservation District Use Permit to build and operate the TMT on Mauna Kea. In February 2014, the Board of Regents for the University of Hawaii approved the terms of a sublease to the TIO for the Project site. On December 2, 2015 the Hawaii Supreme Court ruled that the Board did not follow the correct procedure and should have held the contested case prior to their vote to grant the permit. The Supreme Court remanded the circuit court to further remand to the Board so that a new contested case hearing could be conducted.

In addition to the very large technical effort of observatory design, there have been concerted efforts in many other areas over the past seven years. These include the engagement of the Hawaii community in support of astronomy and in determining how TMT could more meaningfully involve and connect Hawaii Island residents with astronomy. In addition to the rent to be provided under the Sublease, TIO on its own initiative has committed to providing significant funding for education, outreach and training for STEM positions benefiting the Hawaiian community.

Pre-Construction and Construction at Mauna Kea

The TIO members have spent approximately \$327 million through June 30, 2016, and have agreements, budget and/or plans for funding of the construction phase at \$1.4 billion. Already the government of Japan has initiated procurement of telescope mirror blanks in Japan.

Following the approval of a permit, construction on the TMT Observatory at Mauna Kea is slated to begin in April 2018, with completion of the TMT enclosure and telescope structure expected in 2024 and initial operations three years later.

Decommissioning

In 2000, UH adopted the Mauna Kea Science Reserve Master Plan, which establishes the management structure for UH's stewardship of the areas it manages on Mauna Kea. In 2009 and 2010, UH adopted, and BLNR approved, the Mauna Kea Comprehensive Management Plan ("CMP") and its subplans; the Cultural Resources Plan, Natural Resources Management Plan, Public Access Plan, and Decommissioning Plan. These plans commit UH to exercise responsible stewardship of Mauna Kea and to ensure that astronomical activities are conducted in a manner that respects the cultural significance of Mauna Kea, protects the environment, and is responsive to the needs and concerns of Native Hawaiians and the public. In May 2010, UH completed an Environmental Impact Statement for the TMT.

Once the TMT Project has expended its useful life, it will be decommissioned and the site will be restored as directed by OMKM. This is a requirement of the CMP and its subplans.

A Decommissioning Funding Plan (DFP) is also a requirement of the Office of Mauna Kea Management's ("OMKM's") Decommissioning Plan. The DFP contains a cost estimate for decommissioning, a description of the method for assuring that funds are available, and the method for adjusting the cost estimate and funding level over the life of the sublease. The DFP describes and documents the sublessee's assurance that a prescribed amount of funding is secured for decommissioning and site restoration. Initially this is based on a conceptual cost estimate and plan to fulfill these requirements. TIO provided to OMKM its initial DFP in 2014.

Summary

The TMT Observatory in Hawaii will not only provide scientists, researchers, and students access to a new telescope with greatly increased power that will provide currently unrivaled opportunities for exciting discoveries, but will highlight Hawaii as an outstanding platform for international collaborations with the largest nations and economies around the Pacific Rim. TMT will also provide opportunities for training, education and jobs in STEM fields.