

**Office of the President**

**TO MEMBERS OF THE COMMITTEE ON EDUCATION POLICY:**

**DISCUSSION ITEM**

*For Meeting of January 22, 2014*

**DEVELOPMENTS REGARDING THE THIRTY METER TELESCOPE AND THE PARTICIPATION OF THE UNIVERSITY OF CALIFORNIA**

**EXECUTIVE SUMMARY**

In May 2003, the Regents authorized the President to partner with the California Institute of Technology (CalTech) to form a new nonprofit public benefit corporation to develop the design for the California Extremely Large Telescope project, now known as the Thirty Meter Telescope (TMT), first of the next generation of giant ground-based telescopes. The TMT is based on innovative technology invented by UC faculty and demonstrated with the Keck Observatory telescopes, in partnership with Caltech. Participation in the project continues the UC tradition of involvement in world-leading astronomy observatories.

The TMT project has evolved from the original partnership between UC and Caltech to include scientific agencies from the nations of Canada, Japan, China, and India. The University of California has vibrant Astronomy and Astrophysics programs on eight campuses and is at the forefront in the development of new knowledge and discoveries in this area. These programs have produced outstanding graduates, both undergraduate and graduate students, many of whom have gone on to leadership positions in research and astronomy throughout the United States and the world.

A TMT Master Agreement, which establishes the framework for the project's governance, has been developed and signed by the Scientific Authorities for each partner and is ready for signature by the partners' Financial Authorities. President Yudof signed the Agreement representing the University of California's scientific authority in July 2013. The TMT Master Agreement will be put forward to President Napolitano for signature as University of California's financial authority in the coming months. The Regents will be asked to approve certain elements of the project at a future meeting prior to determination on the Notice to Proceed.

UC participation in the project has been made possible by a gift/pledge of \$250 million from the Gordon and Betty Moore Foundation, shared on a 50-50 basis between UC and Caltech. UC and Caltech are in the process of raising an additional \$100 million, on a 50-50 basis, to match the Moore Foundation gift.

## BACKGROUND

In spring 2003, the UC Regents approved the University of California's partnership in a consortium with the California Institute of Technology to design and build the California Extremely Large Telescope (CELT). The Regents authorized the development of a preliminary design for a segmented 30-meter-diameter astronomical telescope "that is patterned after the twin Keck telescopes. (UC and Caltech have been responsible for the creation and operation of the W.M. Keck Observatory in Hawaii.)" The Regents' approval stated that "the mission may be broadened to include not only the preliminary design phase, but also a final design, construction, and commissioning and operation of the observatory."

Since 2003, work has greatly progressed on the design of the telescope, instruments, and all aspects of the Observatory. The project has been renamed the Thirty Meter Telescope (TMT) and additional partners have joined the consortium. The current partnership is UC, Caltech and:

- Association of Canadian Universities for Research in Astronomy as the Scientific Authority and the Government of Canada, acting by and through the National Research Council of Canada as the Financial Authority (collectively "Canada")
- Japanese astronomy institutions, acting by and through the National Astronomical Observatory of Japan as the Scientific Authority and the National Institutes of Natural Sciences as the Financial Authority (collectively "Japan")
- People's Republic of China, acting by and through the National Astronomical Observatories of Chinese Academy of Sciences as the Scientific Authority on behalf of the Chinese Academy of Sciences, and the Ministry of Science and Technology as the Financial Authority (collectively "China")
- Republic of India, acting by and through the Department of Science and Technology in the dual capacity as the Scientific and Financial Authority (collectively "India")

UC has played a leadership role since the beginning of the TMT project, in collaboration with Caltech. Chancellor Yang has been Chairman of the TMT Corporation Board (which is made up of six members, three each from UC and Caltech) and the TMT Collaborative Board with three members from each of the TMT partners since 2008. Dr. Edward Stone of Caltech has been the Vice Chair of these two Boards. The Project Scientist since the beginning of the project has been Dr. Jerry Nelson of UCSC. Dr. Nelson is the originator of the segmented-mirror technology that made the Keck Observatory such a great success and which is the scientific basis of the TMT design.

On July 21, 2009, the TMT Board, after a multiyear evaluation of different sites and intensive visits and negotiations with the various stakeholders in Hawaii, jointly led by TMT Chair Chancellor Yang and Caltech President Jean-Lou Chameau, selected Mauna Kea on Hawaii Island as the location for the telescope. In February 2011, the University of Hawaii, as a proxy for the consortium, applied for and was granted a Conservation District Use Permit to build and operate the TMT on Mauna Kea. The permit was granted by the Board of Land and Natural

Resources of Hawaii's Department of Land and Natural Resources. The TMT consortium will lease the land from the University of Hawaii.

In addition to the very large technical effort on observatory design, there have been concerted efforts in many other areas over the past five years. These include the completion of the Environmental Impact Statement, the engagement of the Hawaiian community to support the TMT, and many other associated activities that led to the issuance of a Conservation District Use Permit at Mauna Kea for the TMT at Mauna Kea. The recruitment of the international partners, Japan, China, and India required many trips to these countries and strategic discussions with audiences ranging from the scientific communities up to the highest levels of government. A Cooperative Agreement with the U.S. National Science Foundation (NSF) was also granted in 2013, and much effort was required to engage the NSF. These activities have been led for the most part by the UC and Caltech TMT Board members with Board Chair Chancellor Yang playing a key role.

On July 25, 2013, the TMT partners signed a Master Agreement, which brings together the TMT partners for the purpose of developing, designing, financing, constructing, commissioning, operating, and decommissioning a next-generation, 30-meter-class astronomical observatory. The Master Agreement establishes a formal agreement among the international parties defining the project goals, establishing a governance structure, and defining member party rights, obligations, and benefits. President Yudof signed the Master Agreement on behalf the University of California.

The next step will be for the Financial Authorities of each of the partners to sign the document and finalize the funding plan. It is anticipated that President Napolitano will sign for the University of California in the coming months.

Following execution of the Master Agreement by the partners' Financial Authorities, the project will be reviewed for readiness. The partners will then vote on a "decision to proceed." Upon an affirmative vote, each of the partners will then be bound to deliver their contributions to the construction and operation of the observatory.

Construction of TMT is slated to begin in 2014, with completion of the TMT enclosure and structure expected in 2020. Based on the current schedule, scientific operations are to be initiated in 2022.

Funding for the project during the preliminary design and preconstruction phase has come primarily from a \$250 million gift from the Gordon and Betty Moore Foundation and shared by UC and Caltech on a 50-50 basis. Intel cofounder Gordon Moore and his wife, Betty, established the foundation to support bold ideas that create enduring impact in the areas of science, environmental conservation, and patient care. They believe that TMT is a transformative scientific tool. Another \$100 million in matching funds to the Moore gift is being jointly raised by UC and Caltech; UC's \$50-million share is being raised by campus leaders through philanthropic support, building on relationships between the University and generous donors. A fund-raising plan developed by Chancellor Yang has been submitted to the Moore Foundation.

The current cost estimate for the construction phase is \$1.21 billion (with a 2012 U.S. dollar base year). With inflation, if the project is started in April 2014 and concludes as planned in late 2022, the inflated cost in then-year U.S. dollars is \$1.49 billion. UC's ownership share is expected to be 12.3 percent of the total shares. It is expected that the construction will take eight years, and the facilities will be in full operation in 2022.

UC will be responsible for 12.3 percent (its ownership share) of the operating costs of TMT. The operational monies will become available with the scheduled reduction of the UC portion of the W.M. Keck Observatory's operating costs. As of March 31, 2018, UC will have put in, through annual operation costs, the equivalent of the original Keck gift to Caltech that funded construction of the observatory. The agreement between UC and Caltech for management and operation of the Keck Observatory stipulates that starting April 1, 2018, Caltech will be responsible for sharing half of the Keck operation costs, and the UC obligation will be reduced by that amount. For no additional operating funding, UC will retain its current access to the Keck Observatory and gain access to the TMT.

### *Importance of TMT to the UC*

UC has been a world leader in astronomy and astrophysics research for more than 125 years. The Lick (1888) and Keck (1993) observatories have created opportunities for research and partnerships in the fields of astronomy and astrophysics research. There are vibrant and growing Astronomy and Astrophysics programs on eight of the UC campuses.

Discoveries by UC researchers using the Lick and Keck Observatories include the development of a new branch of science discovering and characterizing planets orbiting stars other than the Sun, the measurement of the acceleration of the expansion of the Universe and unexpected inference of Dark Energy, verification of predictions of the Hot Big Bang model for the original of the Universe, the mapping of galaxy evolution over cosmic time, and the discovery of a supermassive black hole at the center of our own Milky Way Galaxy.

Access to the two UC observatories has brought outstanding faculty to UC and outstanding graduate students from all over the world. The excellence of UC programs in this research area can be seen in the remarkable record of national and international prizes awarded to UC astronomers (table below). Data obtained with the Keck telescopes have been the basis for more than 125 UC Ph.D. student dissertations since 1993; this is among the most productive facilities in the world for training the next generation of astronomers.

Awards won by UC astronomers and departments:

**International**

- Nobel Prize in Physics
- 31% of all Shaw Prizes in Astronomy
- 25% of all Kavli Astrophysics Prizes
- 20% of all Crafoord Prizes in Astronomy

**National**

- 22% of all American Astronomical Society Awards since 1982
- National Medal of Science

The TMT partnership and location of the telescope in Hawaii will not only provide UC scientists, researchers and students access to the world's most powerful telescope for unrivaled opportunities for new discoveries, but will also create an outstanding platform to develop international collaborations with our largest Pacific Rim partners.

This simple recipe for success of guaranteeing UC faculty, researchers, and students access to the most capable observatories will be continued for decades into the future by UC participation in the TMT.

***TMT Overview***

The TMT is a ground-based telescope with a primary mirror composed of 492 segments that act as a single giant mirror 30 meters in diameter. When completed, it will be one of the great scientific facilities of this century. The TMT will allow astronomers to analyze the light from the first stars born after the Big Bang, directly observe the formation and evolution of galaxies, see planets around nearby stars, and make observations that test fundamental laws of physics. Advanced adaptive optics capabilities will allow observations at 12.5 times sharper spatial resolution than is provided by the Hubble Space Telescope.

The combination of great light-gathering capability and very high special resolution will enable groundbreaking advances in a wide range of scientific areas, from the most distant reaches of the universe to the Earth's own solar system. Powerful new facilities have often opened up unimagined areas of research and made important but unanticipated discoveries. It is expected that the situation with TMT will be no different. and UC researchers look forward to a rich and diverse mix of both expected and unexpected scientific results.