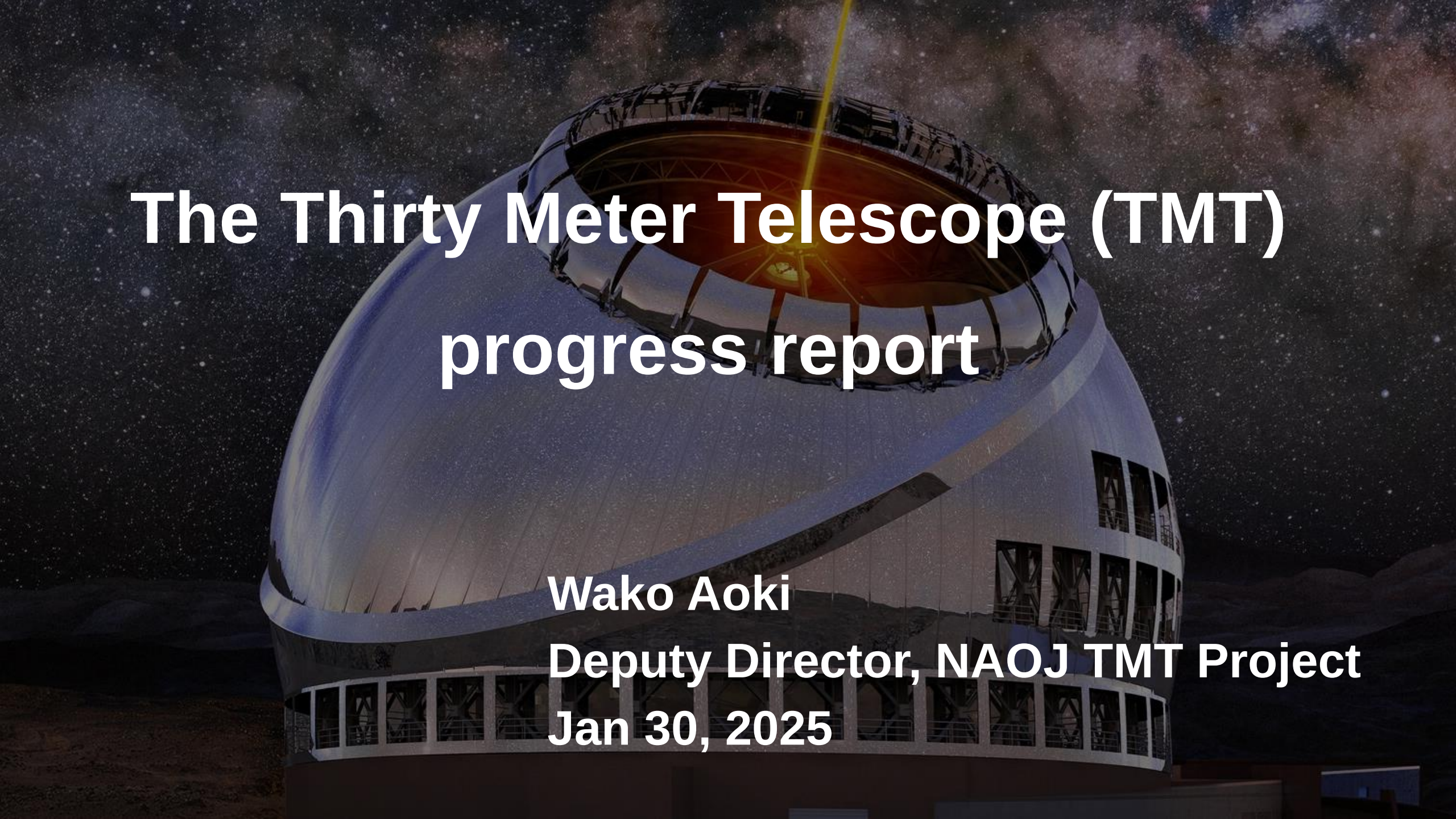


The Thirty Meter Telescope (TMT) progress report

Wako Aoki
Deputy Director, NAOJ TMT Project
Jan 30, 2025

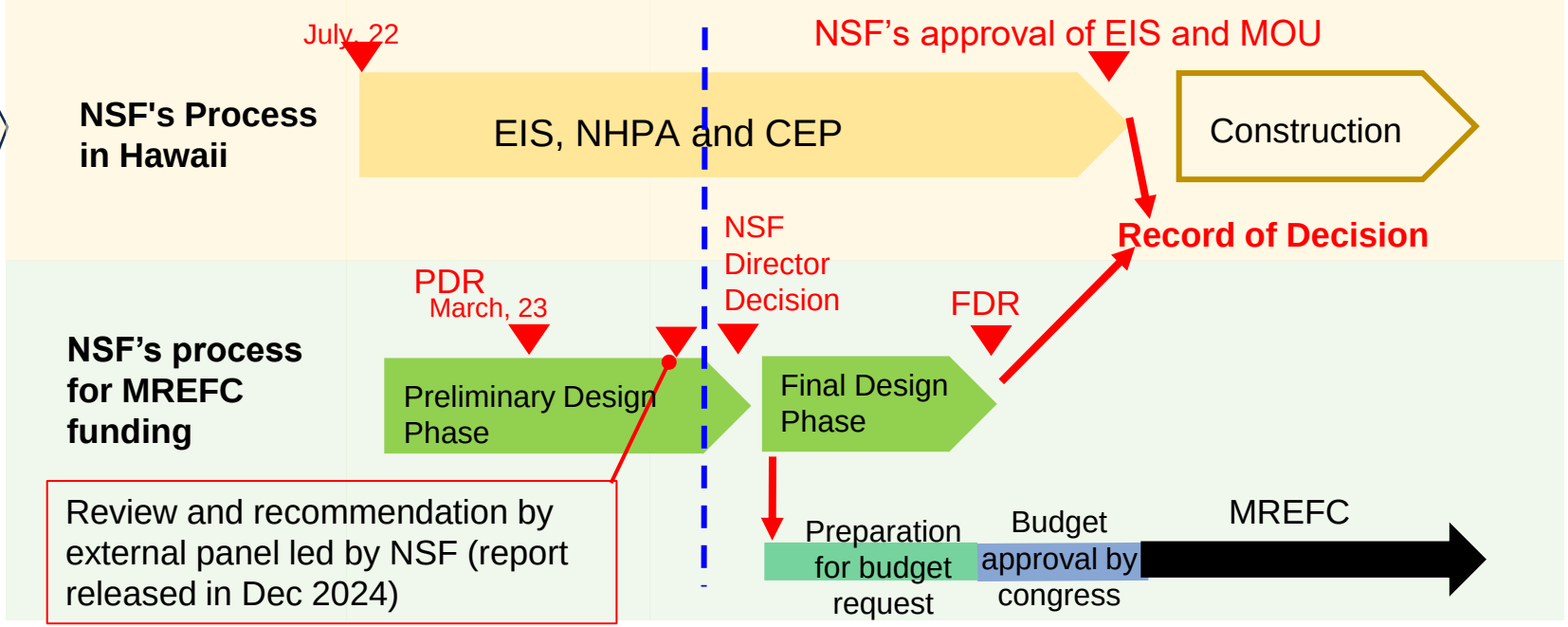
Status of the TMT project: NSF Process

TMT requires the participation of NSF with US government's funding for the construction. TMT project is under NSF's review as a part of the US-ELT program.

- **Status in Hawai'i:** NSF's environmental review and consultation process of National Historic Preservation Act in the community are ongoing. TIO continues direct dialogues and education activities in the local community that are significantly improving the atmosphere in the community.
- **Funding of US government:** NSF's external panel reviewed both TMT and GMT in 2024. The director will make a decision to proceed the project to the NSF's Final Design Phase and budget planning. The congress is reiterating the support for the US-ELT program with both TMT and GMT.

- ► Environment Impact Statement (EIS)
- ► National Historic Preservation Act (NHPA) section 106
- ► Community Engagement Plan (CEP)
- ► Completed by 2026

Approval of MKSOA is necessary for TMT construction.



Status of the TMT project: NSF funding process

In July 2024, NSF convened an external panel to assess the readiness of TMT and GMT to move into the major facility Final Design Phase (FDP). The panel report was released in December. The NSF director will make the decision on the projects to move into FDP.

Key points of the external panel report

- The report emphasizes that the US-ELTP is essential for US science. The panel evaluates that both projects have met the requirements to proceed to FDP, rather than selecting one of them. This is a very positive report for the US-ELTP.
- The problem is funding: “The panel emphasized the critical need for congressional support, noting that without additional appropriations, NSF may face challenges balancing these projects with other national priorities, risking US competitiveness in fundamental research” (executive summary).
- The panel recommends NSF 's careful consideration of its Risk Management Plans and the security of partnership commitments.
- The report points out the uncertainty of the construction site as a risk of TMT, mentioning “While it is possible to enter FDP with this level of uncertainty, it is impossible to participate in FDR before site selection has been fully resolved.” The site issue is a known risk. The relation between site selection and FDR needs to be confirmed, because NSF’s PDR report showed a different view from this panel report.

Status of the TMT project: Strong support of US congress for US-ELTP

The US congress that is responsible for passing appropriations bills reiterates support for the US-ELTP with TMT and GMT.

- FY2024 Commerce, Justice, Science, and Related Agencies Appropriations Act, 2024

  “The agreement* strongly encourages the NSB to ensure that the US-ELT Program includes a two-observatory footprint with a mechanism to guarantee robust community access.”

  *agreement between the Senate and House CSJ committees

- FY2025 senate appropriations bill (Commerce, Justice, Science, and Related Agencies Appropriations Bill, June 2024)

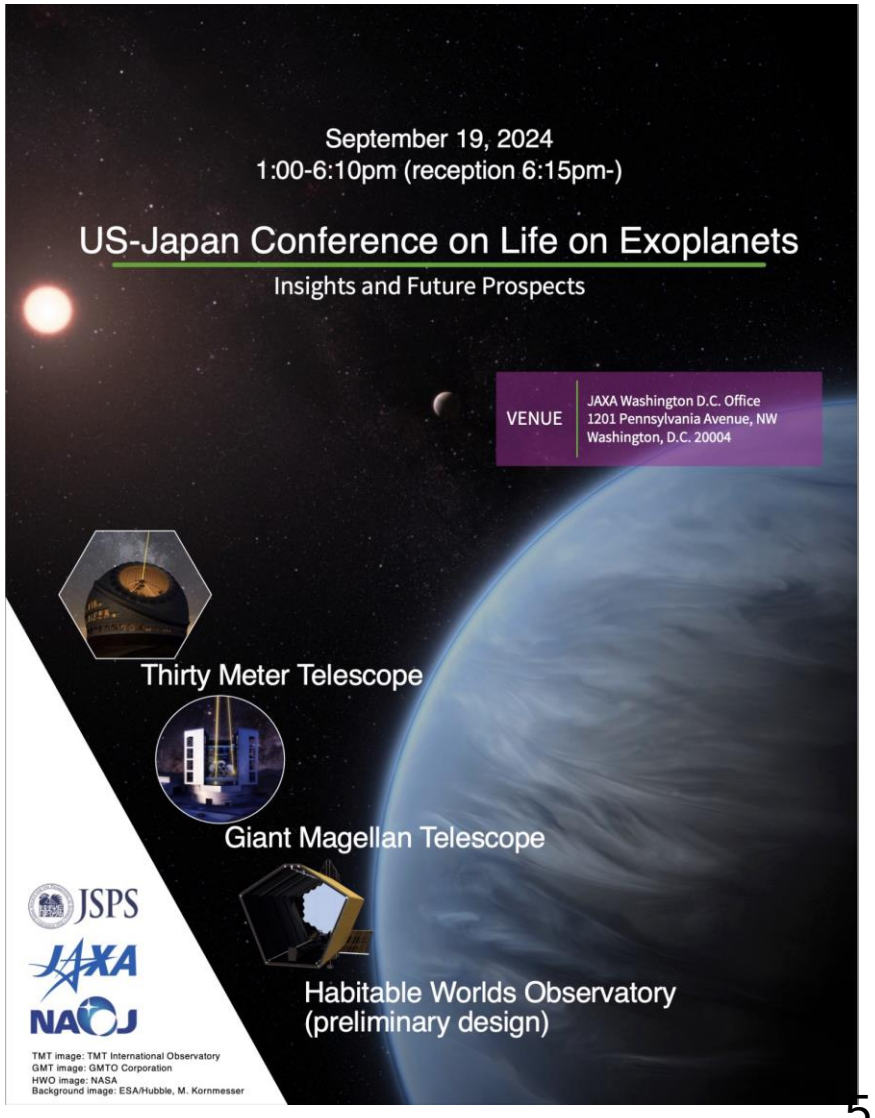
  “The Committee remains strongly supportive of a two-hemisphere, U.S. Extremely Large Telescope [US-ELT] program with a robust user support system and data archive to ensure broad U.S. community access.”

NAOJ is also promoting the significance of the US-ELT Program to US and Japanese policymakers, Congress, and media. (next page)

JSPS-JAXA-NAOJ Washington Conference
“US-Japan Conference on Life on Exoplanets”

Promoting the significance of the US-ELT Program to US and Japanese policymakers, Congress, and media.

- Sep 19, 2024 JAXA Washington Office
- 86 Participants (incl. NASA/NSF directors, US government officials)
- The conference aimed at enhancing the understanding of how impactful the US-Extremely Large Telescope Program (US-ELTP), consisting of TMT in Hawaii and GMT in Chile, and the HWO space telescope will be on science, technology, and society, as the year 2024 is of pivotal importance for advancing these projects into the next decades. The presentations were designed to elucidate how, with the latest observational technologies from the ground and space, these telescopes will address the critical question, “Are we alone?". Given their expected scientific delivery, they could change our worldview. Furthermore, the conference showcased what the telescopes will do for society.
- Speakers from Japan: Norio Narita, Yuri Aikawa (U Tokyo), Masaki Fujimoto (JAXA)



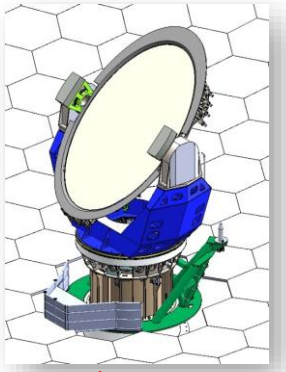
Status of the TMT project: Design and development in partners and TIO

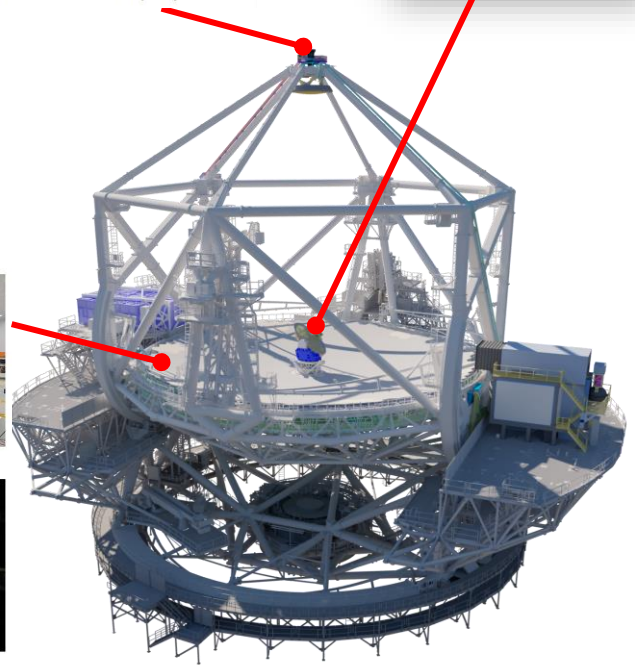
- **TIO's design work for optics by support of NSF's Design and Development budget in FY2023 and 2024 (total 13M USD)**
  - Design of secondary and tertiary mirrors by contract with AMOS
  - Design of alignment and phasing system based on the Keck's technology
- **Progress of primary mirror segments**
  - Steady progress of polishing and development of hex cutting in US
  - Development of polishing process in India

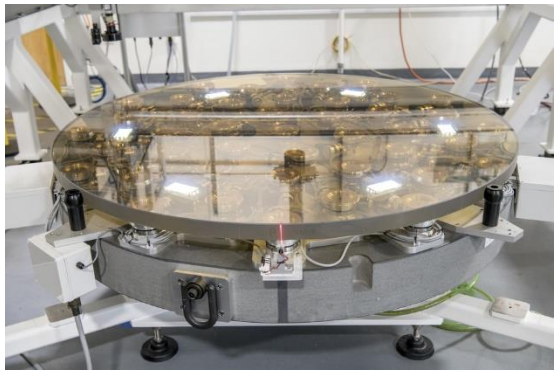
Secondary mirror

M2 Support & Positioner Concept by AMOS

Tertiary mirror







More than 100 Segments have been polished in US

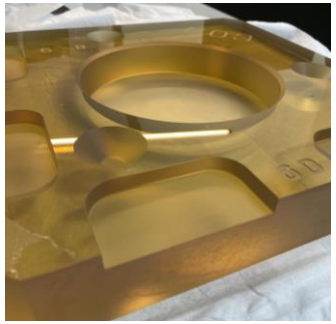
Polishing process developed in India

Status of the TMT project: Design and development in Japan

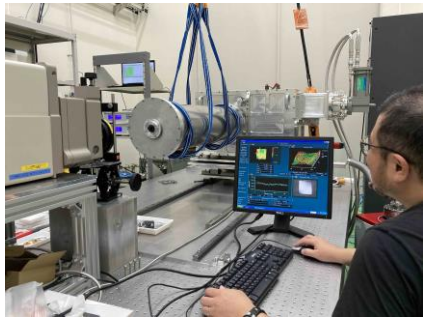
TMT is listed in the MEXT's Roadmap 2023. The NAOJ TMT project is working on the preparation for the fabrication of the telescope structure and the primary mirror segments, as well as the design and development of the first light instruments.

- **Primary mirror**
  - Verification of the capability of the melting furnace of Ohara for restarting fabrication of the mirror blank
  - Prototyping the hexing process (including making sensor pocket etc.) for the polished segments
- **Telescope structure (STR)**
  - Production Readiness Reviews (PRR1-3) for large components (Az/EL/Nasmyth) have been completed. The NAOJ STR team is working to close out the PRR actions, e.g., safety, risk analysis.
  - The STR team is supporting TIO's subsystem reviews (e.g., secondary mirror) concerning interface.
- **Instruments**
  - **IRIS** team is working for Final Design Review planned in Apr. 2025, e.g., mirror shape measurement with the protected silver coating at 77 K.
  - NAOJ is contributing designing IFU (Integral Field Units) for **WFOS** as a future upgrade path.

▲Verification of the mirror blank fabrication



◀Prototype of 30cm-square sample for hexing process



▲ Measurement of the effect of thermal shrink of the coating on the mirror shape at 77 K for IRIS design

Request to Subaru/TMT community

TMT, the unique extremely large telescope in the northern hemisphere, is necessary for future astronomy and related science. We would like to request the Subaru community's continuous understanding of the project, and to appeal the necessity of TMT with one voice at every opportunity.

Requests in this meeting:

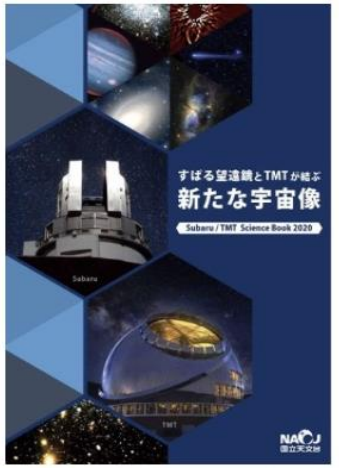
1. **Updating science cases with Subaru and TMT**
2. **Combining instrument development for Subaru and TMT**
3. **Science operations of Subaru and TMT under a common system**

➡ Poster P30 by C. Yasui

1. Update of science cases

Studies on the science with TMT and instrumentation are getting active since 2023 through international workshops on synergy between JWST and ELTs and update of TMT Detailed Science Dases (DSC).

- **Subaru/TMT Science Book 2020**

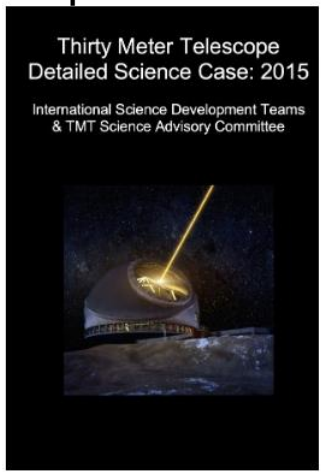


The book contains science synergies between Subaru and TMT in the 2020-2030's in Solar system, Exoplanets, Galaxies, Cosmology, and elaborates on the prospects of science instruments and operation.

Contribution from 80 scientists

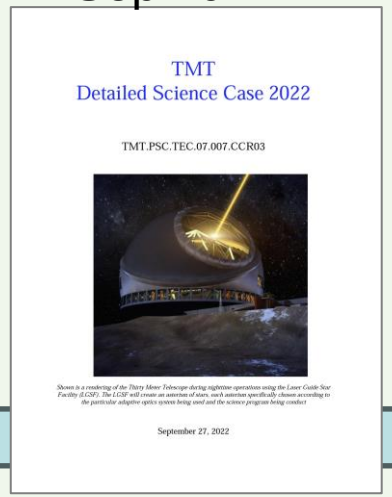
- **Update of TMT DSC by TIO with contributions of Japanese community**

April 2015



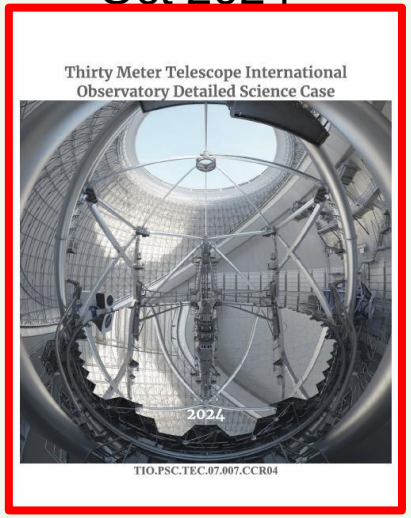
- Reflecting the rapid advancements in exoplanet research and multi-messenger astronomy
- MODHIS has been added to the 1st light instrument

Sep 2022



- Incorporated the latest results from ALMA, JWST, clarifying TMT's role.
- No changes made to the Top-Level Science Goals.
- Approved by SAC and released

Oct 2024



1. Update of science cases

ELT Science in Light of JWST - The scientific landscape for Extremely Large Telescopes in light of JWST

Part I. North America, Sep 2023, TIO Pasadena
Part II. Asia, June 2024, Tohoku University
Part III. Europe, 2025-2026

- Observations of exoplanet atmospheres with JWST and Gemini/Subaru
- Studies on the chemical composition of distant galaxies with JWST
- Detecting individual stars through micro-lensing

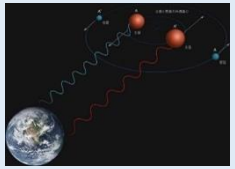
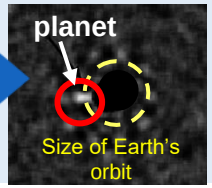
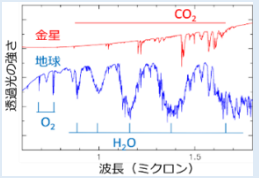
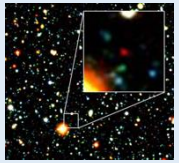
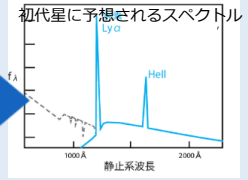
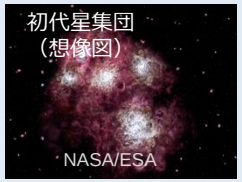
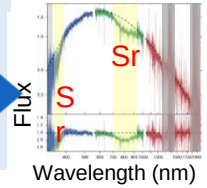
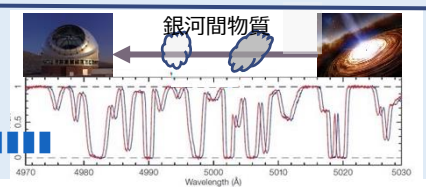
TMT eArly Career Centered, Engineers-Scientists Synergy II
June 2024, Tohoku University

- Workshop led by early-career researchers and engineers
- A total of 38 participants discussed the science to be pursued in the 2040s and the instruments needed to achieve it.
- **Next workshop: July 16-18, 2025 (NAOJ Mitaka) -> see poster**

TMT + Subaru 2-3: A Powerful Partnership at Maunakea

THIRTY METER TELESCOPE

National Astronomical Observatory of Japan

	Subaru 2-3 Ultra wide-field surveys	TMT High sensitivity and resolution
Exoplanet	**Search for Earth-like exoplanets by indirect method**  Identifying and characterizing a variety of Earth-like exoplanets. Providing candidates for direct imaging.	**Direct imaging/spectroscopy of Earth-like exoplanets**   Search for molecules related to life by transmission spectroscopy
Galaxy formation	**Search for first galaxy candidates by wide-field survey**  Exploring the era of rapid evolution of galaxies about 10 billion years ago. Infrared survey of early galaxies with ULTIMATE that is impossible by optical instruments.	**Detection of light from first stars**   Detecting the light from first stars (helium emission) to constrain the timescale of first star formation and their nature.
Multi-messenger astronomy	**Identifying optical/infrared counterpart of gravitational wave/neutrino sources by quick wide-field survey**  Following up a variety of gravitational wave sources to investigate synthesis of heavy elements. Identifying origins of high-energy events including neutrino sources.	**Spectroscopy of counterparts of GW/neutrino sources**   Exploring the explosion mechanisms and synthesis of elements in the Universe by spectroscopy for objects identified with Subaru etc.
Dark matter Dark energy	**Indirect measurement of the Universe's expansion by wide-field surveys**  Constraining the nature of dark matter and dark energy. Determining the mass of neutrino.	**Direct measurement of Universe's expansion**   Constraining the nature of dark energy that causes expansion of the Universe by a fully new approach.

2. Instrument development for Subaru and TMT

Development of TMT instruments takes long. Combination with the development of Subaru instruments is a key to promoting the activities for TMT instruments.

- Examples: ➡ two talks in this session
  IFU for FOCAS and TMT/WFOS ➡ Poster P20 by S. Ozaki
  SCExAO and TMT/PSI
- Keck's example:
  - LIGER (a Near-InfraRed IFS and Imager) uses the design of the IRIS spectrograph.
  - HISPEC (High-resolution Infrared Spectrograph for Exoplanet Characterization) is regarded as a prototype of MODHIS.

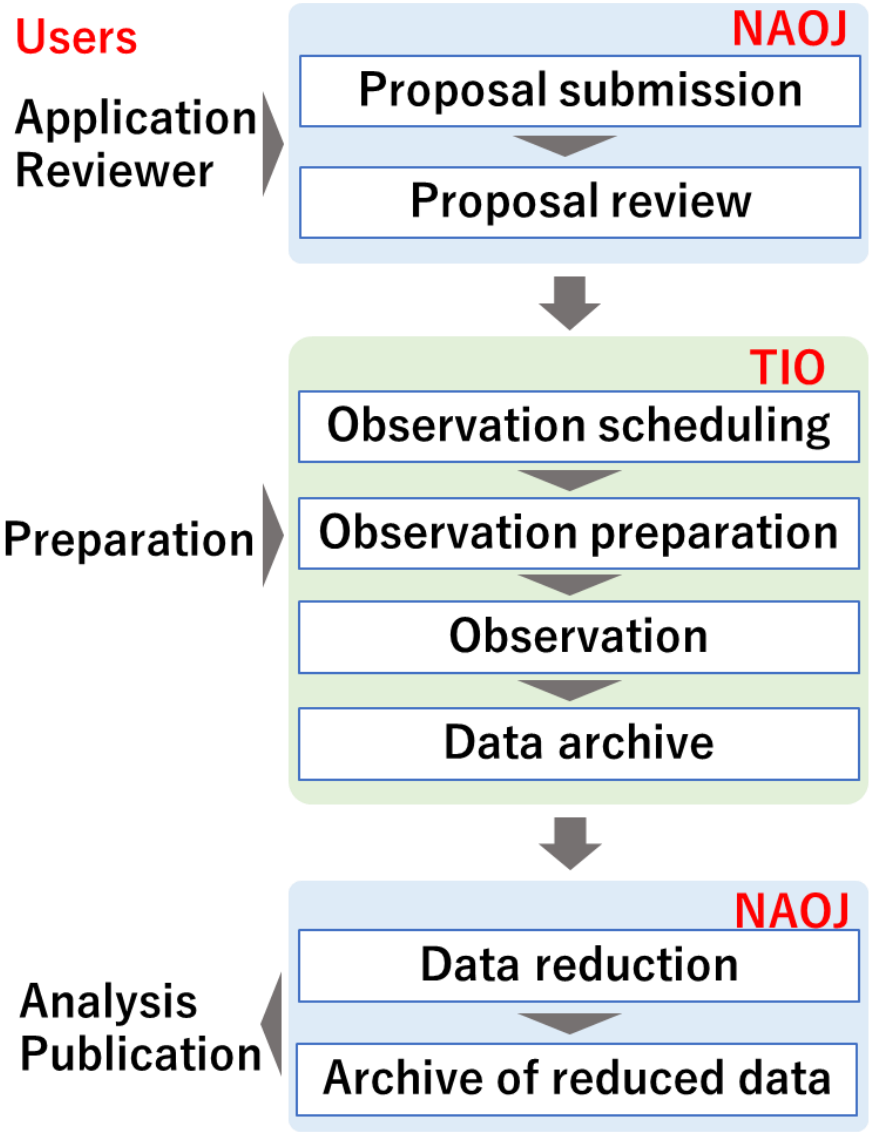
TMT

	First light inst.	2nd generation inst.	Targets of the 4 science goals
Optical	WFOS (Wide Field Spect.)		Galaxies, Multimessenger
		HROS (High-res spect.)	Exoplanet, Cosmology
Near Infrared	IRIS (Imager/Spect.)		Galaxies, Multimessengr
	MODHIS (High-res spect.)		Exoplanet
		PSI (High contrast)	Exoplanet (direct imaging)
Mid Infrared		MICHI (Imager/Spect.)	Exoplanet

3. Science operation of TMT and Subaru

Once operations begin, the TMT Observing time will become available to all members of the Japanese science community.

- TIO is responsible for the telescope operation, scheduling, observations, and archive of raw data. The archived data will become available to the world after a certain proprietary period.
- TMT partners are responsible for processing proposals and science data reduction and archive. **Tools and software developed by NOIRLab for the US-ELTP will be available to partners (next slide).**
- NAOJ will operate and manage the open use of the Japanese time. **The idea is to operate TMT and Subaru under a common system for proposal management, data analysis support and archive**, facilitating unique science with the two telescopes and increasing the operation efficiency at the NAOJ.



NOIRLab Program Platform (NPP)

- NOIRLab manages open access for the US astronomical community
- They develop, maintain, and manage a system to provide end-to-end support of the scientific discovery process; originally named the “US-ELT Program Platform” (UPP) but now called **“NOIRLab Program Platform” (NPP),** after recent guidance and financial support from US NSF.
- NOIRLab expects NPP to be “open source” and will share it with the worldwide astronomical community
- NOIRLab could also establish collaborations with other observatories and partners to enable tailored use of NPP on NOIRLab servers

►NPP will be used for Gemini’s proposal submission starting in 2026.
►Gemini users in Japan (e.g. through time exchange) will be using the NPP.
►Feedback will be greatly appreciated.

Discussion Points

1. **Updating the Subaru-TMT science case**
   - **What are the new findings since 2020?**
   - **What should be the timeline?**
2. **R&D (talks in this session)**
   - **What development items can be tested on Subaru and expandable to TMT?**
3. **TMT-Subaru Operation**
   - **What are the advantages and disadvantages of adopting NPP to TMT and Subaru.**