

# CATAC report to CASCA Board

May 9, 2022

## Executive Summary

- The USELTP has still not entered the MREFC (Large Facilities) queue. Once it does, this will trigger several activities, including a Preliminary Design Review, an Environmental Impact Statement, and Section 106 process. The earliest construction could begin is 2025, assuming the MREFC process starts soon. Further delays to the start will only push the construction date later.
- Legislation for a new Management Authority for Maunakea has been approved by the Hawai'i legislature and now goes to the governor for final approval, or veto. This legislation would transfer management authority from UH after a transition period of five years. No leases or subleases can be initiated or renewed during the transition period.
- The construction permit for the alternative site, at ORM, was revoked following an appeal by Ben Magec. That decision has been appealed by TIO, IAC and the Cabildo. A ruling has been made but it is not yet public.
- CATAC is working with the GAC to provide considered advice if our first choice for VLOT access - TMT - becomes impossible to realize for any reason.
- CATAC has reviewed the instrumentation plans and status for TMT, ELT and GMT. We provide a current summary comparing timelines and capabilities over approximately the first decade of operations.
- CATAC is hosting a webinar for CASCA members on 12 May to update them on the status of the TMT project. The focus will be on the procedures and milestones to expect over the next couple of years. There will also be a presentation from the Project Manager, who will provide a project update and a focus on developments in Hawaii.
- The TMT Science forum will now take place in Vancouver, June 18-21 2023.

## Project update

The TMT Executive Director (ED), Ed Stone, is retiring. Robert Kirschner will become the new ED as of May 15, 2022. Further details are available [here](#).

## The process following Astro2020

Following the recommendation of the US Decadal report released last November, the next major milestone awaiting the US Extremely Large Telescope Project (USELTP) is acceptance by the NSF into the Major Research Equipment and Facilities Construction (MREFC) queue. This potential involvement by the NSF is welcome and important to TMT, as it could both mitigate the significant financial needs of the project, and help identify whether or not there is a path to construction on Maunakea on a reasonable timescale.

Acceptance into the MREFC queue requires a recommendation from the NSF Director, on receipt of an appropriate memo from the AST Division Director. This has not happened yet, though the process is well underway. As soon as it does, an NSF Preliminary Design Review (PDR) will be launched. This will be a comprehensive review of all aspects of the project, including cost, technical readiness, site readiness, operations and governance. In particular the PDR will likely result in a proposed governance model for the USELTP. Given all the preparatory work that has been done, it is possible that the PDR could still be completed by the end of 2022, though further delay to the MREFC start will surely push this into 2023. Should the PDR be successful, the project could be approved to enter the Final Design phase. This process would likely take about 1.5 years; the Final Design Review (FDR) would include a Final Cost Review, for which a firm governance model and site selection would be required.

## Site implications

Once the project enters the MREFC queue it becomes an official federal project; as such it constitutes a Federal Action that triggers compliance with the National Environmental Policy Act (NEPA), the National Historic Preservation Act (NHPA), and the Endangered Species Act. As described by the [Advisory Council on Historic Preservation](#), “the NHPA and NEPA are two separate laws which require federal agencies to ‘stop, look, and listen’ before making decisions that impact historic properties and the human environment”. NEPA compliance will require a federal Environmental Impact Statement (EIS) that includes consideration of the cultural impact of construction. Section 106 of the NHPA requires federal agencies to identify historic properties, assess effects to historic properties, consider alternatives to avoid, minimize, or mitigate any adverse effects, and document their resolution. Agencies are required to facilitate a stakeholder engagement process known as consultation – discussing and considering the views of consulting parties, including State Historic Preservation Officers (SHPOs) and/or Tribal Historic Preservation Officers (THPOs), Indian tribes, Native Hawaiian organizations, and others, while also providing opportunities for public input. These two processes - the EIS and Section 106 - are expected to take about two years to complete, and could begin as soon as the project enters the MREFC queue.

## Funding implications

The US Decadal survey has recommended that NSF participate in the USELTP as either a 25% partner of both telescopes, or a 50% partner of one. This requires an extraordinary contribution from NSF, and ultimately from Congress which is the body that appropriates funds. The NSF will first be able to request funding for the USELTP after the PDR. The request would then have to be included in the President’s budget, which would be considered by Congress.

## Construction Timeline

Upon successful FDR and demonstrated NEPA/NHPA compliance through the EIS and Section 106 processes, NSF can issue a Record of Decision (RoD). Construction approval would require both a successful RoD and fund appropriation, so could begin no sooner than some time in 2025. The MREFC process is rigorous and well defined in the [Large Facilities](#)

[Manual](#). Further delay in the addition of the USELTP to the MREFC queue will certainly push any possible construction start farther into the future.

## Site Developments

### Maunakea

An important development in Hawai'i over the past months has been the progress of House Bill 2024 (HB2024), proposing new legislation for the management of Maunakea. The original version of the bill was based on the report of the Mauna Kea working group described in our earlier reports, and proposed a new Management Authority, including a majority of Native Hawaiians and with no University of Hawaii (UH) or astronomy representation. The bill received significant amendments at both the House and Senate, and a joint Conference Committee recommended a new version ([CD1](#)) that was recently approved. This version proposes a five year transition period, during which UH will jointly manage Mauna Kea lands with the new Authority. No leases or subleases may be initiated or renewed during this transition period. This bill still requires the governor's approval to become law. We note that this is an election year, and that Governor Ige will not be running for reelection this November. TMT construction is still a highly visible issue and is expected to feature in the candidates' platforms.

Whatever the outcome, an important aspect of this development is that it demonstrates engagement at both the community and government level to find a new way of managing the mountain. It is notable that the Maunakea Observatories (MKO) stated in their testimony that they would be willing to work collaboratively with whichever Authority is established, whether or not it includes UH.

### Roque de los Muchachos Observatory (ORM)

In our last report we noted that the TMT construction permit on ORM had been revoked, following a successful appeal by the environmental group Ben Magec. The TMT International Observatory (TIO), Instituto de Astrofisica (IAC) and the Cabildo (local government body) appealed this decision. At the time of writing, the court has made their ruling, but it has not yet been made public.

In addition to the site access difficulties is uncertainty about the required funding. There may be a significant challenge in obtaining congressional support for a USELT where neither telescope is built on US soil, and where one is in a location with no other US infrastructure. The geopolitical situation continues to evolve rapidly and of course CATAC does not have sufficient information to predict what the NSF or US congress would do. We only reiterate that both the TMT SAC and CATAC have concluded that building TMT on ORM would be scientifically acceptable; but it is not at all clear that this alternative site significantly alleviates either the site access or funding problems that face TMT on Maunakea.

# Canada Long Range Planning

If NSF initiates PDR in 2022, a technically-paced (i.e. assuming no funding- or political-related slowdowns) schedule will lead to TMT first light in 2032-2034, with full science operations starting 1-2 years after that. This will be several years behind ELT, but the difference (especially considering the fuzzy boundary that is “first light”) is not one we consider significant in the context of the observatory’s anticipated lifetime. TMT - on either Maunakea or ORM - remains a scientifically exciting and competitive project that will enable Canadian researchers to remain at the forefront of astronomy research for the foreseeable future. We note, however, that there is no scope to accelerate construction; so any and all further delays will push first light farther into the future.

Until both the site and full funding are secured, however, the future of TMT remains uncertain. Fulfilment of the LRP recommendations requires significant participation in a VLOT, including possibly interim access before TMT is built. At the moment there are still too many possible outcomes from the NSF processes and the rapidly evolving situation in Hawai’i to present a clear decision point for Canadians. However, there are two broad considerations that will require guidance from CASCA and the community of astronomers:

1. The LRP makes strong recommendations about developing guiding principles for the construction of large astronomy facilities in which Canada participates. The NSF has its own processes for assessing the environmental and cultural impact of its projects (via NEPA and NHPA). It is important to continue good communication between international partners so the expectations of the Canadian community are known and taken into account. We look forward to the processes being developed by CASCA, and LCRIC specifically, to ensure our continued partnership in TMT respects the guiding principles expressed in the LRP.
2. The uncertainty around TMT means it is prudent to continue careful consideration of the international and domestic astronomy landscape, so that the recommendations of the LRP can be fulfilled, whatever the outcome. CATAC is working with the GAC to provide considered advice if our first choice for VLOT access - TMT - becomes impossible to realize for any reason.

## TMT Instrumentation Update

In July 2019, CATAC published a [document](#) considering the status of TMT’s post-first light instrumentation suite. Over the past few months we revisited this information to consider any updates and significant developments. Here we summarize how the first-light and post-first light instrumentation planning compares for TMT, GMT and ELT. The GMT instrumentation status has been updated following a meeting with the Project Manager and Project Scientist, and the ELT instrumentation status is based on the ESO Messenger report by [Ramsay et al. \(2021\)](#).

## TMT

The technical definition of first-light at TMT means light reflecting off a fully filled and phased primary mirror, passing through the AO system (NFIRAOS) and reaching the detector of the NIR imager, IRIS (there is no constraint on achieved Strehl ratio). In addition, the wide-field optical spectrograph WFOS is planned to be ready for near first light. The high resolution NIR spectrograph MODHIS has been “fast-tracked” to be available as soon as possible after first light, in particular to try and achieve some unique (relative to early GMT and ELT capability) exoplanet science goals. The instrument status described at [www.tmt.org](http://www.tmt.org) is mostly up-to-date; we summarize some of the latest developments, here.

**NFIRAOS** is the facility AO system, and is being developed at the HAA. It offers natural guide star and laser guide star modes. NFIRAOS is now in the procurement and fabrication stage. Last year the laser guide star system passed the first phase of its PDR.

**IRIS** is the facility NIR imager and IFU, with wavelength coverage from 0.8 to 2.5 $\mu$ m. IRIS is designed to be used with NFIRAOS, and will deliver diffraction-limited performance longwards of 1 $\mu$ m. The instrument is now in the final design review (FDR) stage. The first elements of the FDR process were passed last year, and work to complete the design is on-going.

**WFOS** entered the Preliminary Design Phase on April 1, 2022. After a long and somewhat turbulent history, this instrument is now progressing quite well. It remains a large, expensive, and challenging instrument. As a workhorse, seeing-limited instrument it represents a critical capability that we expect will be heavily used by Canadians.

**MODHIS** is undergoing a detailed science case/traceability matrix and top-level instrument requirements discussion. An NSF MRI proposal to fund the precursor HISPEC instrument for Keck was turned down last year because it did not fit within the expected MRI envelope. The proposal was very positively reviewed by the NSF, however, and a revised proposal for a smaller subset of the HISPEC package was submitted to the NSF in January. The funding complement is being sought from private sources, and has already been partly secured to maintain the project development pace.

## GMT

The technically-paced estimate for GMT first light is early 2031, with the first science observations occurring later that year. The high-resolution spectrograph, G-CLEF, is in construction and planned for first light. It promises to be a powerful instrument that has no first-light analog on TMT. This would be followed first by a wide field, optical multi-object spectrograph (GMACS), currently in Preliminary Design. The final two instruments in this suite will be a near-IR AO assisted imager and IFU (GMTIFS) and an echelle spectrometer (GMTNIRS). Both of these instruments are also in the Preliminary Design Phase.

GMT has a very different AO system from TMT and ELT. The telescope consists of seven primary mirror segments, and each is precisely paired with its own adaptive secondary mirror (ASM). Each ASM is 1.1m in diameter, so smaller than the TMT segments, and corrects the wavefront over a single primary mirror. The GMT pupil is easy to baffle; thus,

while it has an unusual shape, it is particularly clean. At first light, the telescope will have only a fast-steering mirror (FSM); the ASM will be installed later, and the FSM will be retained as a backup system (e.g. for recoatings). It is expected that the ASM will be commissioned and providing diffraction limited resolution, and ground-layer corrected performance for seeing-limited resolution, when science operations begin.

## ELT

The current state of ELT instrumentation development is taken primarily from the update in ESO Messenger, [Ramsay et al. \(2021\)](#). The construction of MICADO, HARMONI and METIS is part of the project construction proposal. Technical first light for ELT is currently expected for early 2027, with the first science observations occurring about six months after that. All four instruments (including the AO system, MAORY) are expected to be operational within three years of first light, i.e. 2030. The optical/NIR high resolution spectrometer has been renamed ANDES (from HIRES), and also has an anticipated first light date of around 2030.

## Comparison of capabilities and timelines

The table below shows an approximate grouping of instruments by capability, colour-coded according to their estimated launch date. These are notional, technically-paced estimates based on public information.

Key:

2030-2033	2033-2035	>2035
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Type of Instrument		TMT	GMT	E-ELT
AO system		<b>NFIRAOS</b>	<b>Deformable M2</b>	<b>MAORY</b>
Optical	Multi-Object Spectrometer	<b>WFOS</b> Preliminary Design	<b>GMACS</b> Preliminary Design	<b>MOSAIC</b>
	High-resolution Spectrometer	<b>HROS</b>	<b>G-CLEF</b> Fabrication	<b>ANDES</b> Phase A
Near-IR	AO-assisted Imager	<b>IRIS</b> Final design	<b>GMTIFS</b> Preliminary Design	<b>MICADO</b> Final design

	IFU spectroscopy			<b>HARMONI</b> Final design
	Multi-object	<b>TIRMOS</b> Pathfinder: GIRMOS		<b>MOSAIC</b>
	AO-assisted Echelle Spectrometer	<b>MODHIS</b> Conceptual design	<b>GMTNIRS</b> Preliminary Design	<b>ANDES</b> Phase A
		<b>NIRES-B</b> Pathfinder: NIRPS		
<b>Mid-IR</b>	AO-assisted Echelle Spectrometer	<b>b-MICHI</b>		<b>METIS</b> Final design
	Extreme AO	<b>PSI</b>	<b>G-AOX</b>	<b>PCS</b>

In the context of TMT instrumentation planning, we note the following:

- Despite the delays in the project, the technically-paced schedule for TMT will realize an instrument suite in its first five years that is competitive.
- Adaptive optics is an essential, defining characteristic of VLOTs. All three telescopes have very different AO designs, which will come with their own advantages and disadvantages.
- WFOS covers similar parameter space to GMACS. The optical design of GMT makes wide field instruments like this easier (and cheaper) to build. Of course Canadians do not have access to GMACS, so it is essential that we continue to support WFOS development on TMT.
- High resolution optical spectroscopy is a very powerful workhorse capability. Canada's experience here (Gemini vs Keck) was not good. Currently, both ELT and GMT are ahead of TMT in their development of this capability.
- As has been well documented, TMT on Maunakea would have a strong advantage in the MIR given the low water vapour. In particular, GMT has no instrumentation planned that operates at wavelengths  $>5\mu\text{m}$ .
- MODHIS and WFOS give TMT first light capabilities distinct from E-ELT. Though ANDES and possibly MOSAIC could still be on-sky before TMT.

# Science forum in 2023

The TMT Science forum has been postponed until June 18-21, 2023, and will be held in Vancouver.

## Consultations

To obtain more information about the developments in Hawai'i, specifically around HB2024, CATAC met with Doug Simons (IfA Director) on Feb 16, and with Hilton Lewis (Keck Director) and Rich Matsuda (Keck Observatory, and member of the MKWG) on March 23. The CATAC Chair met with James Fanson (Project Manager) and Rebecca Bernstein (Project Scientist) from GMT to learn more about the instrumentation development status and plans for that facility.

CATAC is hosting a webinar for CASCA members, on Thursday, May 12. This will include a 25 minute summary from the CATAC Chair, followed by a 40 minute presentation by the Project Manager, Fengchuan Liu. There will be 25 minutes for discussion. We will make the final slide deck publicly available on our website.

## Membership

Michael Balogh (University of Waterloo), Chair Jan 2017 -

### **CASCA appointees**

Bob Abraham (University of Toronto; TIO SAC) Nov 2018 -  
Laura Ferrarese (NRC) Nov 2018-  
David Lafrenière (Université de Montréal) Jan 2017-April 2022

### **ACURA appointees**

Stefi Baum (University of Manitoba) Jan 2017 -  
Harvey Richer (UBC) Jan 2017-  
Kristine Spekkens (RMC) Sept 2017-April 2022

### **Ex-officio members**

Luc Simard (Director General of NRC-HAA)  
Don Brooks (Executive Director of ACURA)  
Rob Thacker (CASCA President)  
Stan Metchev (TIO SAC)  
Tim Davidge (TIO SAC Canadian co-chair; NRC, observer)  
Greg Fahlman (NRC, observer)

According to the ToR for this committee, term limits are three years, renewable. Kristine Spekkens (ACURA appointment) and David Lafrenière (CASCA appointment) have requested to be replaced on this committee so they can focus on other commitments. We request that all others be renewed, retroactively. The next renewals would then be expected in Jan 2023, when the second terms of Balogh, Baum and Richer will expire.



