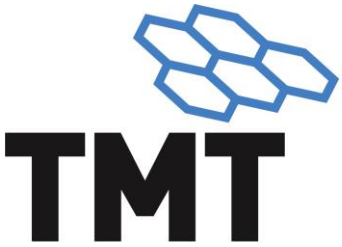

THIRTY METER TELESCOPE

Operations Requirement Document
(OPSRD)

TMT.OPS.MGT.07.002.CCR12

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DOCUMENT APPROVAL

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1. INTRODUCTION

This is the TMT Observatory Operations Requirement Document (OPSRD). It is one of the three systems engineering level one requirement documents, the others being the Observatory Requirements Document (ORD) (RD1), and the Observatory Architecture Document (OAD) (RD2).

The three documents are the project's response to the science requirements encapsulated in the Science Requirements Document (SRD) (RD3) and the Operations Plan (OpsPlan) (OPSPlan, RD4). The requirements in the OAD (RD2) will flow down to requirements for the observatory subsystems.

As necessary, new requirements implied by the current document flow down into OAD (RD2).

Site-specific implementation plans to fulfill these operational concepts are described in the TMT Operations Plan (OPSPlan) (RD4).

The requirements in this document are numbered in the form [REQ-X-Y-Z], where the placeholders X, Y and Z denote the level of the requirement, the document the requirement is associated with, and a unique number for the requirement. This numbering scheme allows for unambiguous reference to requirements.

1.1 PURPOSE

This document shall be used as guidance for the top level engineering function and performance requirements of the observatory.

The requirements documented in the OPSRD and the ORD (RD1) are intended to fully describe the top-level engineering and operational requirements to satisfy the criteria of the Science Requirements Document (SRD) (RD3) and Operations Plan (RD4). By this definition, the OPSRD will change in response to changes in the Operations Plan (RD4), but will not require modification when changes are made to the Observatory Requirements Document (ORD) (RD1), Observatory Architecture Document (OAD) (RD2), or to the Subsystem Requirements Documents.

The OPSRD shall also be used as guidance for the design and implementation of TMT operations processes and staffing plan.

1.2 SCOPE

This document contains high-level operations requirements in the following areas:

- General
- Science operations
- Technical operations (also known as engineering and technical services)

It is expected that each major TMT subsystem (e.g., AO systems, instruments, enclosure, APS) will have a separate operation concept definition document (OCDD) that describes operations, calibration, and maintenance processes.

1.3 REFERENCE DOCUMENTS

Reference documents contain information complementing, explaining, detailing, or otherwise supporting the information included in the current document.

RD1
Observatory Requirements Document (ORD)
TMT.SEN.DRD.05.001
https://docushare.tmt.org/docushare/dsweb/Get/Document-2688

RD2
Observatory Architecture Document (OAD)
TMT.SEN.DRD.05.002
https://docushare.tmt.org/docushare/dsweb/Get/Document-2689

RD3
Science Based Requirements Document (SRD)
TMT.PSC.DRD.05.001
https://docushare.tmt.org/docushare/dsweb/Get/Document-319

RD4
TMT Operations Plan (OpsPlan)
TMT.OPS.TEC.11.099
https://docushare.tmt.org/docushare/dsweb/Get/Document-21244

1.4 CHANGE RECORD

Version	Date	Modifications
CCR6	May 25, 2007	First release under change control (no change since Draft 5)
CCR7	March 26, 2009	Updates as per Level 1 DRD Change History Document TME.SEN.TEC.07.038.REL05
CCR8	April 27, 2010	Updated to include CR072 Updates as per Level 1 DRD Change History Document TMT.SEN.TEC.07.038.REL07
CCR9	September 23, 2012	Major revision as described in Change Request 095
CCR10	September 27, 2013	Update to incorporate SW requirements derived from TMT Operations Plan, as per change request 121
CCR11	October 24, 2014	Update to incorporate Change Requests 135 and 153
CCR12	February 29, 2016	Updated to incorporate Change Request CR174

1.5 ABBREVIATIONS AND ACRONYMS

AO	Adaptive Optics
APS	Alignment and Phasing System
CMMS	Computer Maintenance Management System
DIMM	Differential Image Motion Monitor
e.g.	exempli gratia (for example)
EPO	Education and Public Outreach
ES&H	Environment Safety and Health
FAQ	Frequently Asked Questions
GUI	Graphical User Interface
i.e.	id est (in other words)

IQ	Image Quality
LGS	Laser Guide Star
M1	Primary Mirror
M2	Secondary Mirror
M3	Tertiary Mirror
MASS	Multi-Aperture Scintillation Sensor
NFIRAOS	Narrow Field Infrared Adaptive Optics System
OAD	Observatory Architecture Document
OB	Observation Block
OCDD	Operation Concept Definition Document
OPSPlan	Operations Plan
OPSRD	Operations Requirement Document
ORD	Observatory Requirements Document
PI	Principal Investigator
RTC	Real Time Controller
SRD	Science Requirements Document
TAC	Technical Advisory Committee
TBC	To Be Confirmed
TBD	To Be Determined
TMT	Thirty Meter Telescope
US	United States
USA	United States of America
VO	Virtual Observatory
WFS	Wavefront Sensor

1.6 GLOSSARY

Early operations is defined as the period that starts when the first nontechnical facilities are accepted and continues until the observatory has reached steady-state operations.

Early science operations are expected to begin during the first 12 months after the M1 has been fully populated and phased for the first time.

Steady-state (science) operations is defined as the period that starts 36 (TBC) months after the M1 has been fully populated and phased for the first time. The intervening time is considered sufficient for tuning the performance and operational procedures to the level necessary to meet the requirements in this section.

Nighttime is defined as the time between the end of evening nautical twilight and the beginning of morning nautical twilight. At these points, the center of the sun is 12 degrees below the horizon. For Mauna Kea, this time interval corresponds to roughly 10 hours per 24-hour period in the mean.

1.7 VERB CONVENTION

Term	Definition
Shall	"Shall" denote requirements that are mandatory and will be the subject of specific acceptance testing and compliance verification. "Must" is not used.
Can/May/Should	"Can", "May", or "Should" indicate recommendations and are not subject to any requirement acceptance testing or compliance verification by the supplier. The supplier is free to propose alternative solutions.
Is/Will	"Is" or "Will" indicate a statement of fact or provide information and are not subject to any requirement acceptance testing or verification compliance by the supplier.

2. MOTIVATIONS: OPERATIONS SUCCESS METRICS

The development of TMT Observatory operational requirements is motivated by several key measurable metrics of success.

2.1 SCIENTIFIC SUCCESS METRICS

2.1.1 Primary Metric: Number of High-Impact Science Papers

The primary metric of scientific impact will be the number of high-impact science papers per unit time.

Conceptually, a high-impact paper contains transformational and/or unique scientific results. Quantitatively, high-impact papers lie in the upper 1% of all refereed papers ranked by number of citations.

The TMT Observatory will endeavor to maximize the production of high-impact science papers based on data obtained with the TMT. This metric will be evaluated per unit time (i.e. one year, TBC) and over the entire observatory lifetime.

2.1.2 Secondary Metrics

Several other secondary metrics of scientific impact will also be measured:

- The mean number of citations per refereed paper based on data obtained with the TMT, measured per unit time (i.e. one year, TBC) and over the entire observatory lifetime.
- The absolute number of papers published per year based on data obtained with the TMT.
- Citation decay rate as a function of time (a measure of impact longevity).

2.2 TECHNICAL SUCCESS METRICS

To maximize scientific success as measured by the metrics above, the TMT Observatory will strive for technical excellence as measured by the following technical success metrics.

2.2.1 Number of Unique Observatory Capabilities

High-impact papers often result from exploiting unique observatory capabilities. Such capabilities can lie in the areas of hardware (e.g. largest M1 collecting area, best science detectors), software (e.g. very efficient target acquisition system), or process (e.g. being the first of a new generation).

Conversely, it is well recognized that observatories that do not add new capabilities over time quickly become scientifically irrelevant, often limiting the overall scientific return on the original capital investment.

By design, the TMT Observatory will be first in its class in many areas at the start of operations.

To maintain its lead in as many areas as possible within available funding, the TMT Observatory will execute a vigorous development program during the operations phase. In particular, this program will endeavor to provide the TMT Observatory with a steady flow of new and unique instruments and AO systems commensurate with the evolving ambitions of the TMT user community.

2.2.2 Number of Science Integration Hours per Unit Time

As the number of science integration hours decreases, so does the potential for transformational observations.
The following metrics are directly related to the number of available science integration hours per unit time:

- Number of night time hours consumed by technical and process operational overheads
- Number of night time hours required for technical maintenance and performance tuning
- Number of night time hours required for commissioning of new observatory capabilities
- Number of night time hours required for instrument calibration
- Number of night time hours consumed by technical faults

These quantities must be minimized – by design as well as by an efficient operational process and a comprehensive maintenance program. More specific requirements and goals are discussed in Section 3.2, Technical Operations.

2.2.3 System Performance per Unit Time

As system performance degrades, so does the scientific grasp of TMT and hence its potential for transformational observations.

The following technical metrics are indirectly related to the number of available science integration hours per unit time:

- Delivered image quality during seeing-limited and AO-assisted observations
- Total system throughput (photons per second delivered to science detector)
- Total system background (photons per second delivered to the science detector)

These quantities must be optimized – by design as well as by a comprehensive monitoring and maintenance program. More specific requirements and goals are discussed in Section 3.2, Technical Operations.

2.2.4 User Process Efficiency per Unit Time

It is well known that many things contribute to user process efficiency but it is difficult to quantify and measure their impact directly. These things include:

- User preparation prior to observing run
- Easy-to-use and complete user interfaces
- High-quality user documentation in all areas
- Well-documented, self-documented science data
- Well-designed data processing software with good user documentation (both at cookbook and details level)
- Efficient user helpdesk process that delivers rapid turnaround support

3. SPECIFIC REQUIREMENTS

3.1 SCIENCE OPERATIONS

3.1.1 Time Allocation and Accounting

[REQ-1-OCD-2000] The TMT Observatory shall provide allocation process tools to be used by the partners.

[REQ-1-OCD-2001] The TMT Observatory shall provide partner-share time accounting tools to be used by the partners.

Discussion: The amount of time that each Partner can allocate is defined by the TMT Board.

Discussion: Only a preliminary 'Phase I' proposal tool will be provided as part of the construction project. See The Operations plan (RD4) sections 3.3.1 and 3.12.3 for further description of Phase I and Phase II tools.

Discussion: If required, TMT will provide technical feasibility evaluation at the proposal phase for individual instruments and AO systems, however it will be up to each partner to assess their observing proposals.

[REQ-1-OCD-2010] The TMT Observatory shall create and manage a master schedule based on output from partner-based TAC processes.

[REQ-1-OCD-2550] The TMT observatory shall support service observing and proposal process.

[REQ-1-OCD-2555] The TMT Observatory shall implement and manage a telescope scheduling process.

Discussion: This process will manage and track assignment of nights to specific activities and assignment of time to targets at specific celestial coordinates.

[REQ-1-OCD-4010] The TMT Observatory shall implement a time accounting process for each schedule program.

Discussion: This process will allow the time used for each observation to be automatically tracked and accounted to each partner's allocated time. Examples of time tracking policy are given in the discussion points below.

Discussion: The tracking will account for the amount of bright, gray and dark time used by each partner.

Discussion: Observations of astronomical objects necessary for performance monitoring will not be charged to individual users. As much as possible, such observations will be limited to nautical twilight at the beginning and ending of each night.

Discussion: Calibrations which are specific to an observing program and taken at night will be accounted in PI/partners time.

[REQ-1-OCD-4050] The TMT Observatory shall implement a proposal submission process that accommodates multi-partner collaborations and allows shared observing programs.

Discussion: These programs will require that observing planning tools allow secure access to single or multiple users and that time allocation and time used for single observations can be shared between partners.

3.1.2 Observing Modes

[REQ-1-OCD-4000] The TMT Observatory at the early light stage shall provide as a minimum two observing modes; PI Directed (Classical) Observing Mode and Pre-Planned Queue Service Observing.

[REQ-1-OCD-2050] The TMT Observatory in PI-Directed Observing Mode shall assign specific blocks of time that are no shorter than one half night.

Discussion: During their assigned time, PI-directed classical observing users will have complete responsibility for how they use and configure the telescope and instruments and may modify their observing program during the night as they require.

[REQ-1-OCD-2055] The TMT Observatory shall provide the following 2 observing scenarios: 1) remote observing (from headquarter or other physical location) and 2) physical presence, only when physical presence at the summit is essential.

[REQ-1-OCD-2060] The TMT Observatory shall support remote observing using hardware and software systems certified by TMT.

[REQ-1-OCD-2605] The TMT Observatory shall execute service queue observing on behalf of PIs from a combined list of observing blocks from all partners via a scheduling process over six month periods.

Discussion: An adaptive queue which dynamically adjusts to atmospheric conditions from a larger pool of partnership-wide observing programs will not be offered initially, however service queue processes and tools should not preclude this being offered later.

[REQ-1-OCD-4005] The TMT Observatory shall implement an adaptive scheduling process within a single partner's allocated observing time.

Discussion: These tools are not part of the TMT construction project.

[REQ-1-OCD-4020] The TMT Observatory shall implement an eavesdropping mode that allows the PI to connect remotely during their observation window.

[REQ-1-OCD-4030] The TMT Observatory shall provide a service queue mode that includes synoptic and cadence observations.

[REQ-1-OCD-4035] The TMT Observatory in PI Directed and Service Queue Observing Modes shall implement a Target of Opportunity Observation process.

Discussion: The Target of Opportunity observations will use pre-determined observing information and instrument configuration setup information stored in the observatory database. Section 3.7 of the Operations plan (RD4) contains further information about the implementation of these observations.

[REQ-1-OCD-4040] The TMT Observatory shall enable real-time selection and execution of observations with flexibility in response to changing conditions and ongoing observations.

[REQ-1-OCD-2620] The TMT Observatory OB shall contain all the user-specific information necessary for executing and scheduling an observation.

Discussion: The description of an individual service queue observation will be known as an observation block (OB). Each OB will contain all the information necessary for TMT Science Operations staff to configure the TMT system for observation execution, e.g. target coordinates, requested guide stars, instrument configuration, etc. Each OB also contains all the user-specified information necessary for scheduling, i.e. atmospheric conditions, lunar phase, etc.

Discussion: The process will allow for basic information to be entered into the observatory database (Phase I) with further details necessary to perform the observation entered via an on-line tool (Phase II). The data stored in the data base will be directly accessed to prepare the observing queue (ref. Operations Plan (RD4) section 3.3.1).

[REQ-1-OCD-2625] The TMT Observatory shall implement a process that allows an OB to be verified offline and prior to observing to determine that it is executable and compliant with standard TMT procedures.

[REQ-1-OCD-2626] The TMT observatory shall provide an observing process that enables the observer to check their OBs and observing scripts off-line before observing.

[REQ-1-OCD-4015] The TMT Observatory shall implement an observing backup process to prepare and execute backup programs for observations in the event that weather conditions or technical failures prevent the planned observation from taking place.

Discussion: Backup observing programs will be prepared for all TMT observing service queue programs in the event that weather conditions or technical failures prevent the execution of the primary science program.

3.1.3 Observing Efficiency and Availability

[REQ-1-OCD-3025] The TMT Observatory shall develop an automated target acquisition and system configuration process tailored for each instrument.

Discussion: The TMT target acquisition sequence will be automated and tailored to each mode of the TMT science instrument.

[REQ-1-OCD-3030] The TMT Observatory shall track and record times of target acquisition and system configuration.

Discussion: The budget and monitoring will cover all observatory activities including telescope and enclosure slewing.

[REQ-1-OCD-3085] The TMT Observatory in steady-state operations shall have no more than 3% unscheduled technical downtime between the end of evening nautical twilight and the start of morning nautical twilight during hours scheduled for science operations.

Discussion: Scheduled technical time will be publicly announced and taken into account when the observatory science operations schedule is constructed.

Discussion: All instruments declared to be operational are expected to have unscheduled technical downtimes commensurate with the above system level requirement. Any time loss due to failures of the telescope, instruments, adaptive optics systems or science observing software which prevent useful science observing with a reasonable efficiency and performance will be counted as unscheduled technical Downtime. Some technical faults may mean no science observing can be done, while for others there may be some degraded level of performance which is tolerable. The level of acceptable degraded performance for each sub-system will be defined and documented. Degraded performance may be slightly worse than the formal requirement.

Acceptable degraded performance will be set at a level which does not significantly impact the science for the type of observation being done and may include both quantitative performance losses (Strehl, throughput, etc.) or functional losses of particular observing modes (e.g. a particular filter or grating option).

[REQ-1-OCD-3094] The TMT Observatory available science time on the telescope for observing planning purposes shall be assumed to be 50% of time for seeing limited observations and 50% of the time for diffraction limited observations (using AO).

Discussion: Site weather statistics indicate that up to 70% of the time may be able to be used for AO LGS observing.

[REQ-1-OCD-4025] Unless undergoing maintenance or commissioning, TMT Observatory instruments shall be ready for use, including being powered and with their operating parameters including temperature in the required ranges.

[REQ-1-OCD-4065] The TMT Observatory shall monitor operational metrics to identify potential improvements and monitor observing efficiency and other telescope performance metrics.

Discussion: Operational metrics need to be defined, but they include as a minimum available science time, unplanned technical downtime, shutter open time, weather loss, commissioning time and scheduled engineering time.

Discussion: Details of these metrics are discussed in the Operations Plan (RD4) section 3.22.

[REQ-1-OCD-3185] The TMT Observatory shall monitor the delivered data quality and system throughput in focal plane of the science instruments as well as at other locations related to wavefront sensors and guiding units.

Discussion: Image quality measurements will be made on a regular basis as part of system-wide monitoring.

Discussion: Baseline image quality performance will be established during TMT integration and verification.

3.1.4 User Support

[REQ-1-OCD-2280] The TMT Observatory shall provide a proposal and observation process that at a minimum includes instrument simulators; exposure time calculators (including overheads); multi-object mask definition tool; data reduction software, calibration plan and AO simulator support.

Discussion: See section 3.8.1 of the TMT Operations Plan (RD4) for further details of these tools.

[REQ-1-OCD-2115] The TMT Observatory shall implement a Web portal for the purposes of organizing all information the observatory wishes to present to its user community.

Discussion: The Links from this portal will include the following:

* User-level documentation for instruments, AO systems, etc.
* Observation preparation support center
* System status report
* Site conditions report: current and forecast
* Site conditions statistics
* System quality control parameter statistics
* Sky almanac generator

* On line planning tool allowing observers to check object availability for the telescope on a given night

* Help desk access

* Gateway to a myTMT area that contains information tailored to a specific user. Access to that area will require user authentication.

Discussion: These tools are not a deliverable of the construction project. See section 3.8.1 of the TMT Operations Plan (RD4) for further details of these tools.

[REQ-1-OCD-2125] The TMT Observatory shall develop and maintain an electronic user helpdesk with the primary goal of helping users prepare and execute observations.

Discussion: Assistance with data calibration problems will be handled on a best-effort basis.

[REQ-1-OCD-2126] The TMT Observatory Helpdesk shall include at a minimum:

* A method for submitting questions to the TMT Observatory
* A system for managing and responding to questions submitted by users
* A Web-based, user-driven but staff monitored forum (discussion group) section
* A Frequently Asked Questions (FAQ) area

Discussion: For each instrument, the TMT Observatory will provide the following items (as appropriate for a particular instrument/AO system combination), Instrument handbook, Standard simulation software, Integration time calculators for all major modes,

Instrument and/or AO system configuration tools as appropriate (e.g. multi-object mask definition tools), Guide star definition tools Finding Chart Tool, Data reduction cookbooks,

Data processing applications.

Discussion: These tools are not a deliverable of the construction project. See sections 3.8.1 and 3.8.2 of the TMT Operations Plan (RD4) for further details of these tools.

Discussion: The TMT Observatory will be responsible for keeping this documentation and these tools up-to-date as TMT systems evolve.

3.1.5 Instrument Handbooks

[REQ-1-OCD-2200] The TMT Observatory instruments and associated AO systems shall be delivered with a user Handbook.

Discussion: These are handbooks for TMT science users. Other documentation will include technical operation and maintenance manuals.

3.1.6 User Interfaces

[REQ-1-OCD-2255] The TMT observatory shall provide Graphical user interfaces (GUIs) for all normal scientific and technical operations.

Discussion: All high-level interfaces need to have the same look-and-feel. It is desirable that all user observing tools have same or similar user interfaces to maximize user efficiency.

[REQ-1-OCD-2260] The TMT observatory shall provide observer interfaces that are as simple as possible.

Discussion: In particular, the number of windows (widgets) that must be accessed must be minimized.

[REQ-1-OCD-2265] In default mode, observers shall only need to provide high level observation description parameters.

Discussion: Examples of high-level observation description parameters include target/field coordinates, instrument configuration, desired dither patterns, etc. Such descriptions will be tailored to each major mode of every science instruments

[REQ-1-OCD-2270] The TMT observatory in steady operations shall not allow observers to modify low-level technical settings.

Discussion: Examples of low-level technical settings include dome ventilation configuration, detector voltages, AO system control parameters, etc.

[REQ-1-OCD-2285] The TMT observatory shall provide a master alarm monitor that shows TMT subsystem status.

Discussion: The TMT status will be in an easily interpretable form, e.g., a screen showing a red (alarm) or green (operational) bar for each major sub-system.

3.1.7 Science Data Stream and Data Archive

[REQ-1-OCD-4090] The TMT observatory shall digitally encode and record data delivered to the surface of the science detectors.

Discussion: The science data stream is defined to be all science instrument detector data and associated meta-data that must be captured and stored in the local observatory data store.

[REQ-1-OCD-2365] The TMT Observatory shall store science data in a searchable repository of raw observations, headers and metadata and it shall be made available on-line.

[REQ-1-OCD-3520] The TMT observatory storage systems shall provide sufficient storage to retain the science data and associated calibration data for the life of the observatory.

Discussion: If there are TMT external archives or data centers, the storage systems will be able to retain the most recent two years of science datasets.

[REQ-1-OCD-2915] The TMT observatory science data and metadata shall support enforcement of an 18 month (TBC) proprietary period after delivery to the PI.

[REQ-1-OCD-2916] The TMT observatory science data and metadata shall be made accessible to the worldwide community after the standard proprietary period is over.

[REQ-1-OCD-3310] The TMT observatory science data shall be compatible with, or transferrable to, Virtual Observatory (VO) standards and data structures.

[REQ-1-OCD-4055] The TMT observatory shall support access control and search criteria for planned use cases and the expected observatory user types.

Discussion: The science and associated data in the observatory database will be used by different groups of users (PIs, partner support personnel, TMT support staff, etc.). See Operations Plan (RD4) section 3.14 for details of the access and search user scenarios.

3.1.8 Data Processing

[REQ-1-OCD-2400] The TMT Observatory shall provide data reduction disk space and computing capability on remotely accessible observatory computers.

Discussion: Data reduction to a level suitable for scientific analysis will be the responsibility of the lead astronomer making use of generally available data reduction software combined with instrument specific software modules that shall be provided by TMT and instrument teams.

[REQ-1-OCD-2405] The TMT observatory science and/or calibration data shall be processed by TMT Observatory for the following reasons: to confirm target acquisition before observation begins; and to assess data quality (e.g. signal-to-noise ratio, delivered image quality in science instrument focal plane) during observation and as part of observatory system performance monitoring program.

[REQ-1-OCD-2410] The TMT observatory shall deliver for each instrument self-contained data processing software modules that meet the requirements of [REQ-1-OCD-2405].

Discussion: Self-contained in this context means that the modules will run without depending on observatory software.

[REQ-1-OCD-2950] The TMT Observatory processing pipelines shall use the data processing modules produced for each of the instruments.

[REQ-1-OCD-2951] The TMT Observatory processing pipelines shall be used for quick-look reductions, target acquisition during observing and system performance monitoring.

3.1.9 Instrument/AO Calibration

[REQ-1-OCD-3035] The TMT Observatory in steady-state science operations shall minimize the amount of night time needed for acquiring calibration data.

[REQ-1-OCD-3036] The TMT Observatory Day time calibrations shall be scheduled in conjunction with other technical work on the telescope and be unaffected by background lighting or other disturbances.

[REQ-1-OCD-3040] The TMT Observatory AO system night time calibration shall consume no more than 1% of the scheduled observing time.

[REQ-1-OCD-3045] The TMT Observatory shall perform during the daytime as many of the needed calibration activities for Instruments as possible.

Discussion: Attention must be given to making instruments mechanically rigid so that calibration data taken during the day can be applied to science observations acquired at night.

[REQ-1-OCD-2905] The TMT Observatory shall ensure that sufficient calibration data is obtained to meet minimum standards in the context of a scientifically useful archive.

Discussion: The minimum standards for calibrations will be described in the Instrument and Facility Calibration Plan.

These minimal calibration datasets may or may not be sufficient for some (or many) individual science programs. It will be the responsibility of the individual users (or teams) to review the on-going calibration program and decide whether or not to obtain additional calibration data tailored to their specific needs as part of their own observing programs.

[REQ-1-OCD-3050] Where possible, the TMT Observatory shall execute on-sky calibration between the beginning of nautical twilight sunrise and the sunset and the end of nautical twilight.

[REQ-1-OCD-3170] The TMT Observatory calibrations data shall be available to all users and have no proprietary period.

[REQ-1-OCD-3175] The TMT Observatory shall enable operations of multiple instruments in parallel for the purposes of instrument configuration and calibration.

[REQ-1-OCD-3176] The TMT Observatory performance monitoring on-sky calibrations shall be made available for science calibration and accounted under general technical time.

Discussion: Individual users may need to obtain additional calibration data. If so, they must request sufficient time for these calibrations as part of their original observing proposal. Time required to obtain such additional calibration data will be accounted to the observer.

[REQ-1-OCD-2220] The TMT Observatory additional calibration data shall be considered public information.

3.1.10 Site Monitoring and Forecasting

[REQ-1-OCD-2500] The TMT Observatory shall design, install and maintain a site condition monitoring system.

[REQ-1-OCD-3245] The TMT Observatory shall monitor and record external site conditions from at least one position outside within the TMT site sub-lease area.

Discussion: A location will be selected which is the least disturbed by the effects of the summit facilities for a majority of wind directions.

[REQ-1-OCD-3251] The TMT Observatory site monitoring shall measure as a minimum air temperature, humidity, pressure, wind speed, wind direction, cloud cover and IQ (DIMM/MASS seeing monitor).

[REQ-1-OCD-3255] The TMT Observatory shall provide TBD supplementary information about atmospheric conditions from the AO systems or on-board wavefront sensors (WFS).

[REQ-1-OCD-3260] The TMT Observatory site conditions data shall be made available locally in real-time at the summit and remote control rooms and stored in the observatory database.

[REQ-1-OCD-3261] The TMT Observatory current weather information shall be available to the wider community via a TMT Web portal and historical weather conditions stored in a public archive.

3.2 TECHNICAL OPERATIONS

3.2.1 Engineering Data

[REQ-1-OCD-2370] The TMT Observatory subsystems (including instruments) are required to produce status and diagnostic telemetry for the purposes of performance monitoring and failure analysis.

Discussion: To meet this requirement, the telemetry information needs to include both low-level (e.g. hydrostatic bearing pressures) and high-level (e.g. delivered image quality) information.

[REQ-1-OCD-2372] The TMT Observatory shall be capable of storing all technical data that is necessary for operations for the lifetime of the observatory.

[REQ-1-OCD-2374] The TMT Observatory in the construction phase shall provide technical data storage capacity and software capabilities for 5 years of operations.

[REQ-1-OCD-2376] The TMT Observatory shall maintain two (2) copies of the technical database with the prevision in mind that one copy will survive in the event of a local catastrophe.

Discussion: The technical data stream is defined to be any telemetry data produced by any TMT sub-system that must be captured and stored in the local observatory database.

[REQ-1-OCD-4120] The TMT Observatory shall define which telemetry data is stored.

Discussion: This can be done using filters and other means.

[REQ-1-OCD-4125] The TMT Observatory subsystems shall implement private data caches in the case they require large volume outside the data management system budget.

Discussion: This data caches can be very large, such as NFIRAOS RTC circular buffer.

[REQ-1-OCD-4130] The TMT Observatory shall provide persistent data storage for software subsystems.

[REQ-1-OCD-2375] The TMT Observatory shall be capable to capture and store duration bursts of high-bandwidth engineering telemetry data.

Discussion: The budgets for these data will be allocated in OAD (RD2).

[REQ-1-OCD-2380] The TMT Observatory engineering data archive shall allow remote search, retrieval, storage and analysis of data.

[REQ-1-OCD-2381] The TMT Observatory engineering data archive information shall be time-stamped to allow cross-referencing of parameters.

[REQ-1-OCD-2385] The TMT Observatory shall provide the capability to permit TMT Observatory staff to access all scientific and/or technical data.

Discussion: The TMT Observatory will reserve the right to access and review all scientific and technical data submitted to or generated by the TMT system. Such reviews will be necessary as needed to monitor system performance and/or diagnosis system problems.

3.2.2 Maintenance and Monitoring

[REQ-1-OCD-2300] The TMT Observatory shall monitor subsystems performance to detect abrupt or gradual changes in performance to enable timely corrective actions.

Discussion: The TMT observatory will provide regular reports to future users for planning purposes and previous users for analysis purposes.

[REQ-1-OCD-2305] The TMT Observatory shall update system performance information periodically as required to provide adequate monitoring.

Discussion: A sub-set of this system performance data will be made publicly available through the TMT Web portal.

[REQ-1-OCD-3015] The TMT Observatory shall implement a maintenance process that as a minimum shall include:

* Comprehensive problem reporting, tracking, and management system;

* Work order driven preventive maintenance support system (usually known as CMMS for Computerized Maintenance Management System);

* Warehouse inventory and property control;

* Document control center.

[REQ-1-OCD-3021] The TMT Observatory shall generate a set of automatic reports based on engineering telemetry for the purposes of monitoring technical performance.

[REQ-1-OCD-4070] The TMT Observatory shall be equipped with monitoring sensors and alarm systems that can remotely notify support staff in the event of any non-hazardous problem.

Discussion: An example of non-hazardous problem will be an engineering parameter that exceeds a predefined range, but is not a danger to the instrument, observatory, or personnel.

Discussion: Hazardous conditions will be reported and managed via the observatory safety system.

[REQ-1-OCD-4075] The TMT Observatory headquarters control room shall enable monitoring of subsystems and checks of equipment functionality at the summit.

[REQ-1-OCD-3055] The TMT Observatory in steady-state operation shall use no more than 24 nights per year for scheduled engineering time.

Discussion: These activities will include as a minimum: nighttime phasing and aligning after daytime segment exchange; extended shutdowns for M2 and M3 re-coating event; as well as nighttime calibrations to revise pointing models, control system look-up tables, and active and/or adaptive system performance tuning.

[REQ-1-OCD-3070] The TMT Observatory shall develop a system-wide budget for daytime and nighttime scheduled system maintenance and performance tuning activities including instrument calibration and preparations for science operations.

[REQ-1-OCD-3100] The TMT Observatory shall implement and maintain a comprehensive system-wide maintenance program, which includes both predictive and preventative maintenance.

[REQ-1-OCD-3110] The TMT Observatory shall develop a cost effective technical support model which can react to problems quickly in order to minimize time loss.

[REQ-1-OCD-3120] The TMT Observatory shall record the descriptions and time required to recover from each event for tracking and analysis purposes.

[REQ-1-OCD-3210] The TMT Observatory in steady-state operations, shall develop a segment exchange process that ensures no segments have their reflectivity degraded by more than 10% longward of 380nm and by 15% at shorter wavelengths when compared to a freshly coated segment.

[REQ-1-OCD-3220] The TMT Observatory M2 and M3 mirror coatings shall meet their mean net reflectivity requirements for at least 24 months.

[REQ-1-OCD-3530] The TMT Observatory shall be able to re-coat M2 and M3 within the same shutdown period window (Goal: 5 days maximum).

3.2.3 Systems Engineering

[REQ-1-OCD-3290] The TMT Observatory in steady operations will develop and maintain technical interface requirements.

Discussion: Examples of technical interface requirements include motion control (and controller) interface; command/control interface; data transport and archiving system interfaces; physical connectors; cabling; basic services (e.g. power, signal, coolant,…);

as well as the performance environmental constraints (e.g. mass, heat dissipation in enclosure, vibration…).

[REQ-1-OCD-3300] The TMT Observatory in steady operations shall establish and maintain a data interface requirement and definitions document.

3.3 INSTRUMENTATION

3.3.1 Development and Commissioning

Discussion: Instrument science commissioning will begin when all instrument modes have been demonstrated to meet their technical requirements, all software tools and interfaces are complete and robust, all documentation has been completed, and the instrument is ready for scientific use.

Instrument science commissioning activity will be executed by the observatory staff with support from the instrument team, under the responsibility of the designated observatory staff member.

Discussion: TMT Observatory will have responsibility for instrument maintenance, minor improvements and performance monitoring. As required, the instrument team will occasionally provide on-going support for more complex troubleshooting and problem solving.

Discussion: Instrument upgrades and enhancements will be undertaken by the instrument team or other organizations under contracts and managed by the observatory.

Discussion: In steady-state operations, the TMT Observatory will schedule no more than 15 nights per year for instrument commissioning (including both technical and science commissioning). This assumes no more than one (1) new major instrument per year and 2-3 multi-night runs.

3.3.2 Visitor Instruments

[REQ-1-OCD-4080] The TMT Observatory shall support a visitor instrument program.

Discussion: It is assumed that visitor instruments will comply with basic requirements and interface specifications that ensure operational safety is not compromised and that normal operations will not be affected by the instrument through effects such as vibration, network security, electromagnetic disturbances, etc.

[REQ-1-OCD-4085] The TMT Observatory visitor instruments shall be operated only in PI-Directed mode and will include their own data acquisition and storage capabilities.

Discussion: Visitor instrument data will not be stored or archived by TMT.

3.4 SUMMIT AND HEADQUARTERS FACILITIES

[REQ-1-OCD-1300] The TMT Observatory summit facility shall be collocated with the telescope and M1 spare segment storage facility.

[REQ-1-OCD-1305] The TMT Observatory headquarters Facility shall be established within two (2) hours drive of the summit.

[REQ-1-OCD-1310] The TMT Observatory Headquarters Facility shall support as a minimum administration and business services, human resources management, logistics,

local government interface management, and work space for TMT science operations staff performing off-site work.

[REQ-1-OCD-1315] The TMT Observatory Headquarters Facility shall have a remote observing center.

[REQ-1-OCD-1320] The TMT Observatory Headquarters Facility shall be located in Hilo, Hawaii, USA.

3.5 SAFETY

Discussion: The TMT ES&H program has the specific objectives to prevent personnel injury or loss of life during all phases of the TMT project and TMT operations; to prevent environmental contamination during the construction, shakedown or operation of TMT; to prevent damage to equipment caused by accidents during all phases of the project; to comply with all national, state and local laws, rules and regulations.

Discussion: During operations, the TMT ES&H program is the responsibility of the TMT Director. The Director has responsibility to insure that the TMT staff members identify specific ES&H issues and risks, and establish appropriate safeguards and procedures for addressing those risks. To accomplish detailed ES&H planning, documentation and surveillance, a TMT ES&H Officer shall be appointed. The ES&H Officer will be responsible for all ES&H program activities and report to the Director on matters pertaining to the ES&H program.

Discussion: Partner institutions manage their own safety programs. Activities at partner institutions will be governed by these programs. However, TMT systems will be designed and fabricated to safety standards established by the TMT Observatory.

[REQ-1-OCD-1020] The TMT Observatory hazard analysis and safety practices shall be governed by the following order of precedence:

- Design for Minimum Risk: The primary means for mitigation of risk will be to eliminate the hazard through design.
- Incorporate Safety Devices: Fixed, automatic or other protective devices shall be used in conjunction with the design features to attain an acceptable level of risk. Provisions will be made for periodic functional checks as applicable.
- Provide Warning Devices: When neither design nor safety items can effectively eliminate or reduce hazards, devices will be used to detect the condition, and to produce an adequate warning to alert personnel of a hazard. Devices may include audible or visual alarms, permanent signs or movable placards.
- Procedures and Training: Where it is impractical to substantially eliminate or reduce the hazard or where the condition of the hazard indicates additional emphasis, special operating procedures and training will be used.

3.6 ENVIRONMENTAL AND EPO

[REQ-1-OCD-1100] TMT Observatory operations shall be compliant with all State of Hawaii and US Federal environmental regulations.

[REQ-1-OCD-1110] The TMT observatory shall minimize the physical and visual impact in its environs.

[REQ-1-OCD-1115] The TMT Observatory shall minimize the emission of all electromagnetic radiation that might interfere with either itself or possible nearby future astronomical facilities.