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Systems Engineering of TMT

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Goals of this Presentation

- Communicate TMT Project Systems Engineering Processes to Partners
- Raise awareness of expectations on subsystem teams to conduct systems engineering as part of the design and development process
- Provide information about where TMT systems engineering documentation is located

- This is an initial step. Expect much more interaction in the future.

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What is Systems Engineering?

- The function of systems engineering is to **guide** the **engineering** of **complex systems**.
- A **system** is "a set of interrelated components working together toward some common objective".
- TMT is a **complex system**, in that the elements of the system are diverse and have intricate relationships with one another.
- Qualities of systems engineering:
  - Focuses on the system as a whole, emphasizing total operation.
  - Systems engineers play a key role in the design of the system.
  - Systems engineering bridges the traditional engineering disciplines.
- Reference: "Systems Engineering Principles and Practice, Kossiakoff & Sweet, Published by Wiley".

TMT Systems Engineering Responsibilities

- Maintaining the configuration of the system
  - Documentation
  - Geometric models
  - Engineering & Performance Models
- Requirements
- Interfaces
- Engineering Budgets
- Modeling and Performance Simulation
- System Tests and Technical Verification
- Risk Management
- Technical Oversight / Conducting Design Reviews

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Overview (1/2)

- Summary of Information Available on TMT Systems Engineering Wiki Pages
- Design phases
  - TMT Design Phase Definitions
  - Design Review Process
- Product Data Deliverables
- Requirements and Interfaces
  - TMT Systems Decomposition (WBS and Product Tree)
  - Interface Control
  - Requirements flow-down
- Requirement Verification

Overview (2/2)

- Risk Management
  - Subsystem and System Risk Register
- Configuration Control and Change Control Process
  - Documentation
  - CAD Geometry / Space Envelopes
  - Configuration Index Document
- Systems Engineering Organization Within TMT

Systems Engineering Processes and Documentation References: Wiki Pages

Systems Engineering Wiki Pages on TMT Document Control Center

- A TMT Document Control Center (DCC) account is required to view the TMT Wiki pages.
- Contact Holly Novack (hnovack@tmt.org) to obtain and account.
- Main Page is:

  https://docushare.tmt.org/docushare/dsweb/View/Wiki-66

System Engineering Wiki: Processes

System Engineering Processes

Templates and Forms

Templates for system engineering documents including DRD, ICD, CID.

Documentation and Configuration Control

Configuration Control standards, processes and related collections.

Design reviews, plans, processes and links to previous reviews

Links to system and subsystem design review collections and committee reports.

Verification

Links to system and subsystem level verification plans and processes.

Assessment of Compliance with Requirements

Links to system and subsystem level compliance assessment.

Risk Management

Links to project and subsystem risk register, and project guidelines for risk management

Systems Engineering Issue Tracker

Link to Issue Tracker

Issue Tracker Wiki Page

CAD Drawing Standards and Digital Mock-Up

Documents related to the TMT CAD Standards and Digital Mock-Up.

Systems Engineering Wiki:
Requirements, Interfaces, Architectures, Budgets

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Requirements, Specifications, Architectures, Interfaces, Budgets and Performance Models

System and Subsystem Requirements

Links to system and subsystem level requirements documents.

Specification Documents

Specification Documents Listed as References or Applicable Documents in DRDs and ICDs

System Architectures

Wavefront Control Architecture and the Telescope Optical Feedback System (TOFS)

Architectural design for Wavefront Control, Power, Cooling, Communications, Compressed Air

System Decomposition

Description of the TMT Subsystem Product Tree, and the Mapping of WBS elements to Subsystems

Interface Control Documents

Links to the interface N-squared diagram and related documents

Engineering Budgets

Links to error budgets and engineering allocations

Performance Modeling

Links and documents related to performance modeling of the observatory

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Design and Development Phases

Instrumentation Design and Development Phases (1/2)

- TMT Design and Development phases:
  - **Feasibility Study:** Explores whether there are feasible instrument designs that fulfill the desired science capabilities?
  - **Conceptual Design (CoD Phase):** Defines the instrument requirements, identifies critical technologies, identifies problem areas and risks. Initial cost and schedule developed.
  - **Preliminary Design (PD Phase):** Development of design to show that requirements and interfaces are met, enabling technologies developed, major risks retired, bottom-up cost estimate, fabrication and construction schedule developed.
  - **Final Design (FD Phase):** Production ready design, work scopes for subcontracts and procurements, key technologies industrialized, show compliance with requirements and interfaces and plans for test and verification, quality, safety, hazard/risk assessment, operations and maintenance plans, refined cost and schedule.

Instrumentation Design and Development Phases (1/2)

- TMT Design and Development phases (Continued):
  - **Production Readiness Review (PRR):** Manufacturing plans finalized (facilities, equipment, tools, procedures, shipping, packing, storage), Integration (vendor site) and AIV (observatory) plans, quality and safety processes in place, verification plan and procedures finalized, final budget and schedule.
  - **Pre-Shipment Review (PSR):** Demonstrate that the implemented system at the vendor/partner site meets design requirements and interfaces (review verification reports, material certifications), Assembly Integration and Verification plan is finalized, shipping / packaging / storage plans are finalized.
  - **Final Acceptance Review (FAR):** Demonstrate completeness of assembly and integration at the TMT site, performance in observatory conditions, and on-sky. Operations and maintenance plans are finalized.

Product Data Deliverables

Document Deliverables
Product Data Definition Document

- At set of deliverables is defined for each phase of the work. The deliverables are defined in the work package document, and follow the guidelines in the TMT Product Data Definition Document (PDD).
- The PDD document lists all expected documentation deliverables, and their state of development at each review.

Section	Title	Description	CoDR	PDR	FDR	PRR	PSR	FAR (EIDP)
Requirements – sub-system requirements	Level 2 DRD	Contains the design requirements for the level 2 sub-system	R	C	C	C	C	C
	Level 3 DRDs	Contains the design requirements for key level 3 assemblies that make up the level 2 sub-system (as agreed with Systems Engineering)		C	C	C	C	C
Requirements - Interfaces	ICDs*	Contains numbered interface statements for each interface between the sub-system and other level 2 sub-systems identified in the TMT N^2 diagram. Similar documents to be produced within sub-system for internal interfaces between level 3 components that make up the sub-system.		C[1]	C	C[2]	C[2]	C[2]

Documentation Deliverables (1/3)

Section	Document Title / Description
Requirements – Subsystem	- Level 2 and Level 3 DRDs
Requirements – Interfaces	- ICDs
Design – Design Description	- Design Description Document - Configuration Index Document - Assembly Drawings - Bill of Materials - Software Detailed Design - Schematics and Diagrams
Design – Analysis and Modeling	- CAD Models - Structural, Optical, Dynamic/Control, Thermal, CFD, FE Model Descriptions
Design - Safety	- Safety Plan - Hazard/Risk Assessment
Design - Reliability	- Failure Modes and Effects Analysis (FMEA) - Reliability Prediction Report

Documentation Deliverables (2/3)

Section	Document Title / Description
Design – Fabrication	- Fabrication and Integration Plan (Activities at partner / vendor site) - Assembly and Integration Plan (Activities at Observatory)
Design – Operations and Maintenance	- Operational Concept Definition Document - Maintenance Plan - User Guide / Software Operator's Manual - Instrument Handbook - Spares List - Standard Operating Procedures / Maintenance Procedures - Shipping and Packaging Plan
Design Verification	- Compliance and Verification Matrix - Verification Plan - Verification Procedures / Reports - Acceptance Test Procedures (for multiple items)

Documentation Deliverables (3/3)

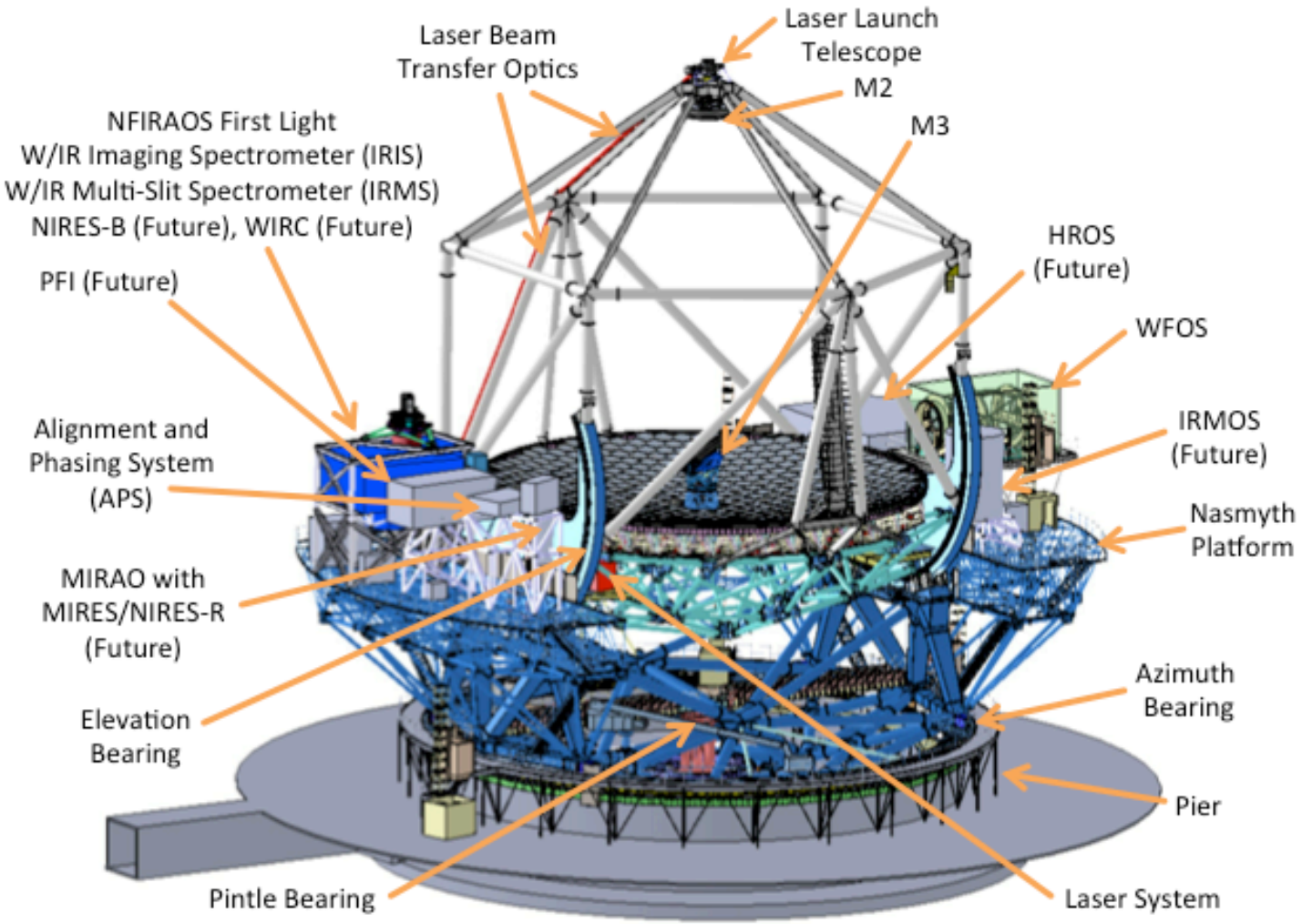
Section	Document Title / Description
Design – Quality	- Quality Assurance Plan - Certificate of Compliance - Acceptance Test Report - Waivers - Proof Test Report - Interface Verification - Dimensional Data Verification - Material Certification - Process Certification
Project Management	- Project Management Plan - Schedule - Cost Estimate - Risk Register

Requirements and Interfaces

Requirements and Interface Definitions and Usage in TMT

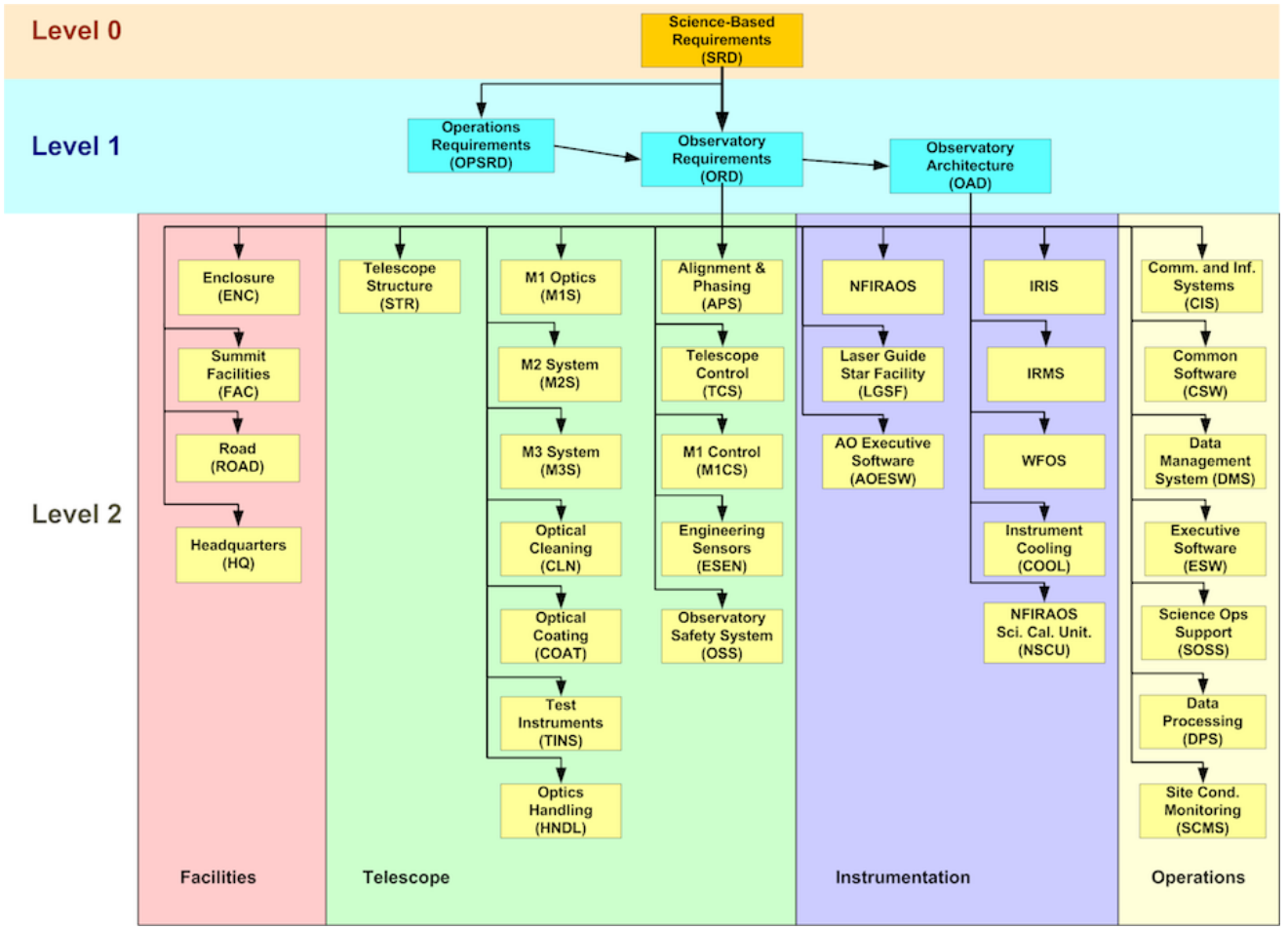
- Requirements:
  - Are the “shall statement” definition of the system in statements of functional, performance, hardware and software behavior. Includes science, engineering, and operations.
  - Are the basis for guiding, evaluating, verifying and accepting the technical design and implementation of TMT systems.
  - TMT has requirements documents for the system and for each subsystem of the observatory.
- Interfaces:
  - Describe the interaction and mutual interdependence between TMT subsystems. Can be optical, mechanical, electrical, thermal, software, control etc.
  - In TMT there are separate Interface Control Documents (ICDs) for each pair of subsystems (for example WFOS to the Telescope Structure).
  - The teams on each side of the interface must negotiate / agree the interface.

Requirements and Interfaces: TMT System and Subsystems



Requirements and Interfaces: Subsystem Decomposition

- TMT consists of 32 Level 2 Subsystems:



Requirements and Interfaces Subsystem Decomposition

- Each subsystem is defined by the Work Breakdown Structure (WBS) elements that it encompasses. These are defined in the Observatory Architecture Document.
- For example, NFIRAOS consists of:

2.2.2.19 Narrow Field Near Infrared On-Axis AO System (NFIRAOS)

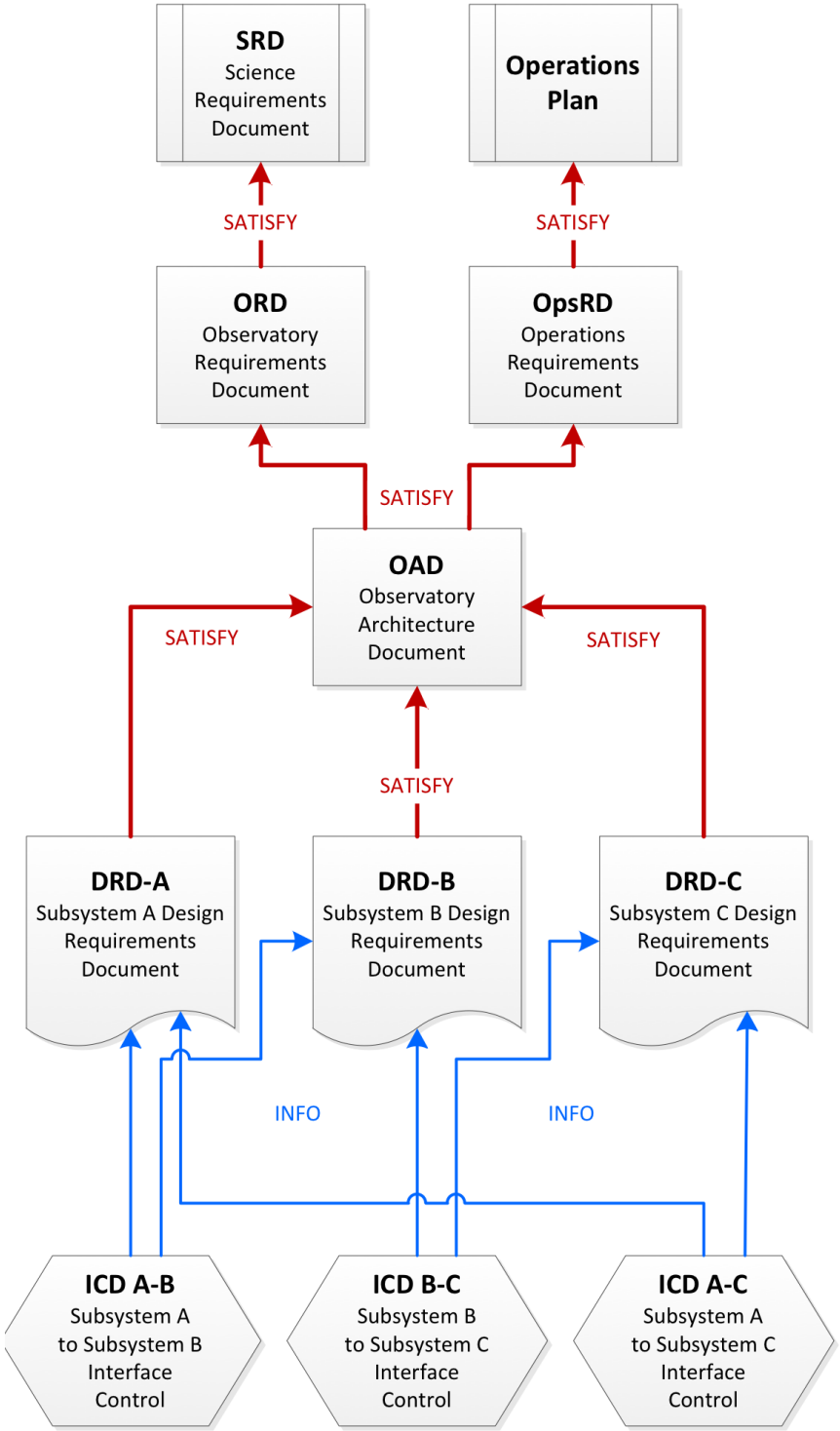
[REQ-1-OAD-0194] The NFIRAOS system decomposition element is defined as follows:

Associated WBS element(s): TMT.INS.AO.NFIRAOS, TMT.INS.AO.COMP.VCAM.NFIRAOS, TMT.INS.AO.COMP.RTC.NFIRAOS, TMT.INS.AO.COMP.WC.NFIRAOS

NFIRAOS is a Laser Guide Star, Multi-conjugate Adaptive Optics System (LGS MCAO) system intended to provide atmospheric turbulence compensation in the near IR over a 2' FOV for up to 3 instruments working in the near IR. Near-diffraction-limited performance is provided over the central 10-30" FOV. NFIRAOS includes several optical tables, 6 LGS WFS, 1 NGS WFS, 1 TWFS, 2 DMs and a tip/tilt stage (TTS), a source simulator (for natural objects and laser beacons) and all associated entrance windows, beamsplitters, fore-optics, opto-mechanical devices, cooling, electronics and computing systems. It also includes test equipment, which is composed of a high-resolution wavefront sensor, an acquisition camera, and miscellaneous fixtures. It also includes the real time computer. It also includes local e-stops and any sensors and wiring that interface with the Observatory Safety System. Instrument rotators, cable wraps, Science ADCs, on-instrument TTF WFSs, rotating lip seals and windows at NFIRAOS exit ports are included in the NFIRAOS-fed instruments and not in NFIRAOS. Also excluded are instrument wavelength and flat field calibration sources.

Work and Product Breakdown Structures

- The TMT Product Breakdown Structure (into Subsystems) is used to define the structure of **independently testable subsystems**, their **design requirements documents**, and **interfaces** between these subsystems.
- The **WBS** and its elements are used to define, assign, schedule and control tasks.
- The WBS and PBS are closely related, in that the work to produce the TMT Subsystems is defined by the WBS elements that they encompass.
- If more than one vendor or team work to produce a single subsystem, the agreement on the division of work is by WBS element.



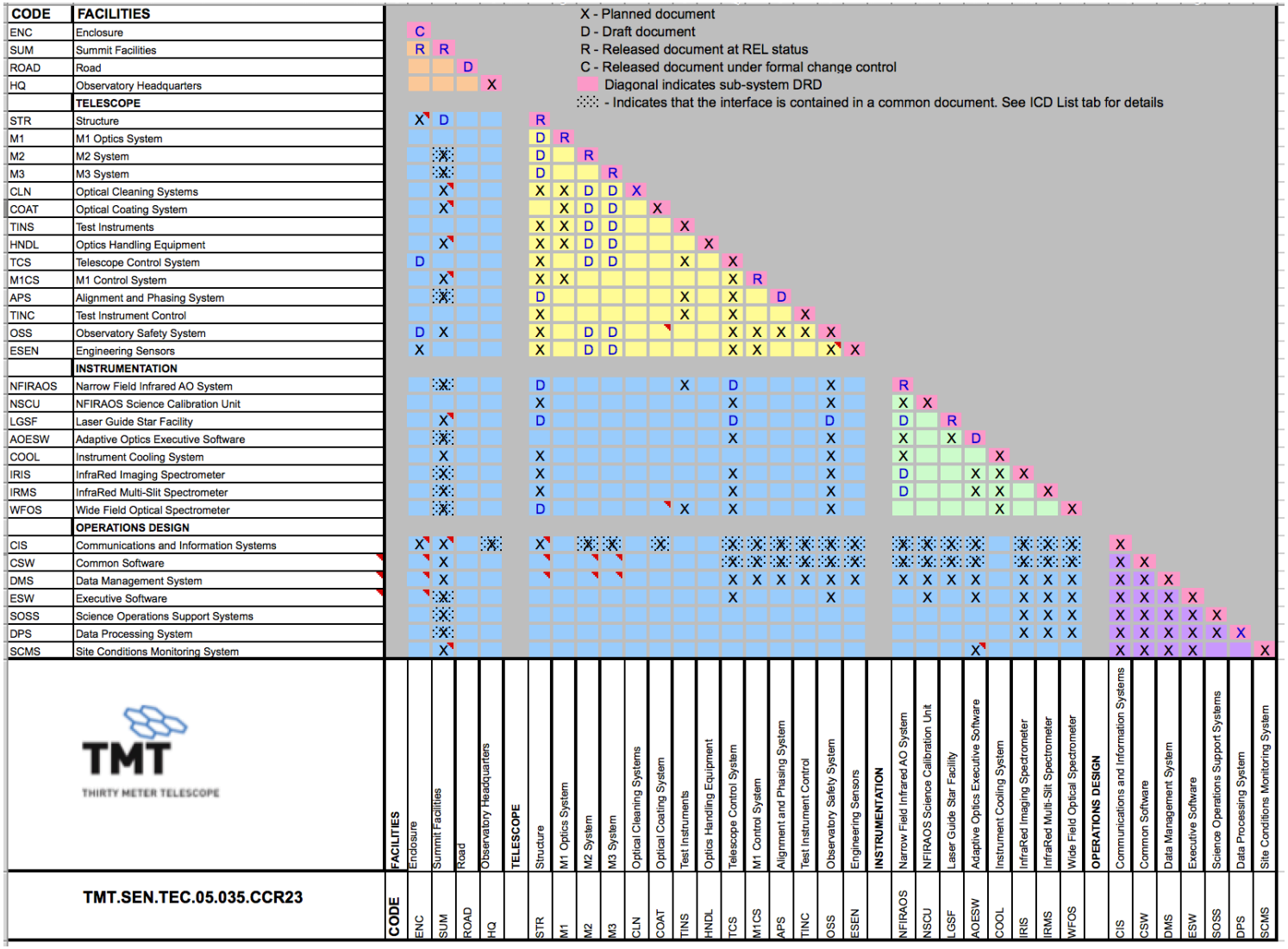
Requirements Traceability

- SRD
  - Requirements directly linked to science capabilities
- Operations Plan
  - Highest Level Statement of TMT operations plan
- OpsRD
  - Requirements that science and technical operations place on observatory design
- ORD
  - Requirements defining the observatory system
- OAD
  - High level (architectural) design
  - Subsystem definitions (high level requirements)
  - Coordination between subsystems (high level interfaces)
  - Reflects evolution of design
- DRDs
  - Requirements defining the individual subsystems
- ICDs
  - Interfaces trace to subsystem requirements

Interface Management

Key subsystem interfaces defined in OAD

- 186 Interfaces identified between 32 subsystems in n-squared diagram



Requirements and Interface Numbering

- Requirement Format is: REQ-[Level]-[Identifier]-[Unique Number]
  - REQ identifies the statement as a requirement
  - Level indicates:
    - 0: Science Level
    - 1: System Engineering Level
    - 2: Subsystem Level
    - 3: Component Level
  - Identifier indicates:
    - At Level 0 or 1, a document (SRD, ORD, OAD for example)
    - At Level 2, a Subsystem (WFOS, IRIS, IRMS for example)
    - At Level 3, a Component (M1CS Actuators for example)
- Interface Format is: INT-[SYS1]-[SYS2]-[Unique Number]
  - SYS1 and SYS2 identify TMT Subsystems. The correct order of listing SYS1 and SYS2 is provided in the **Configuration Control Plan Document**.

Requirement and Interface Examples:

- **Level 1:** [REQ-1-ORD-1805] The system shall be capable of coordinating all observatory activity so that the complete target acquisition sequence (e.g. telescope configuration, enclosure configuration, instrument configuration, AO system configuration, and guide star acquisition), can be completed in five (5) minutes if an instrument change is not needed.

- **Level 2:** [REQ-2-ENC-0450] For thermal purposes, the IR emissivity of the internal surface of the enclosure shall be < 0.4.

  [REQ-2-STR-0360] Flexure of the mirror cell structure over the zenith angle range specified in [REQ-2-STR-0050] caused by the STR System shall not require a M1CS actuator travel of more than 1.8 mm peak-to-peak to maintain phasing of the M1 mirror. This allocation does not include the effects of thermal distortion, which are budgeted separately.

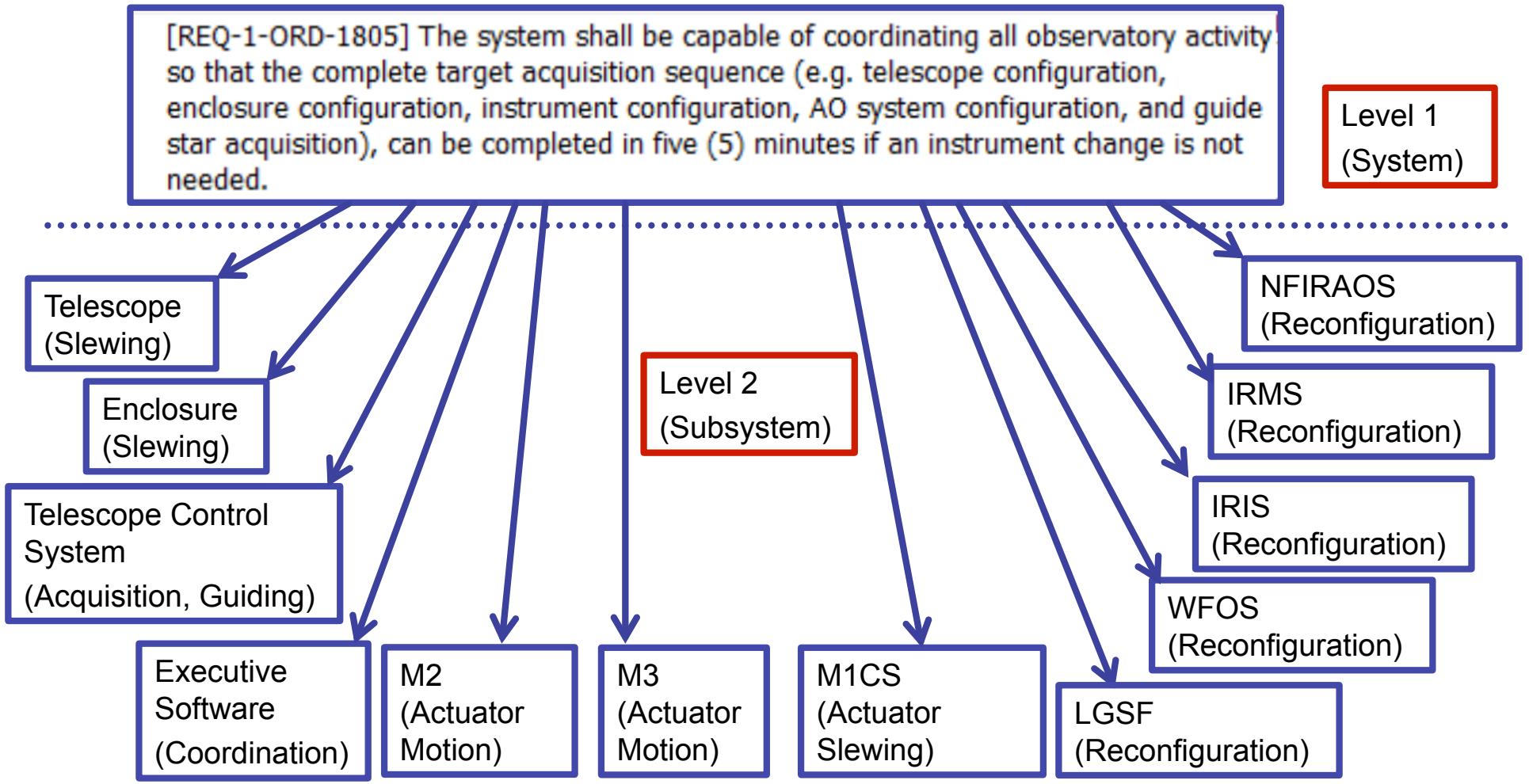
- **Level 3** **[REQ-3-M1CS.ACT-0160]** The actuator, when de-energized, shall maintain its position with a deadband of 0.8 mm [TBC] for all elevation angles and the full range of loads in REQ-2-M1CS-1020. [REQ-2-M1CS-0840,-0430]

- **Interface:**

  [INT-STR-LGSF-0050] The Laser Units envelope and location on the telescope elevation structure shall be as illustrated in the drawing TMT.INS.AO.LGSF.LAS-ENV.PDF [AD1].

Requirement Flow-Down Example
Target Acquisition

- Requirements are traceable in a Parent-Child relationship:

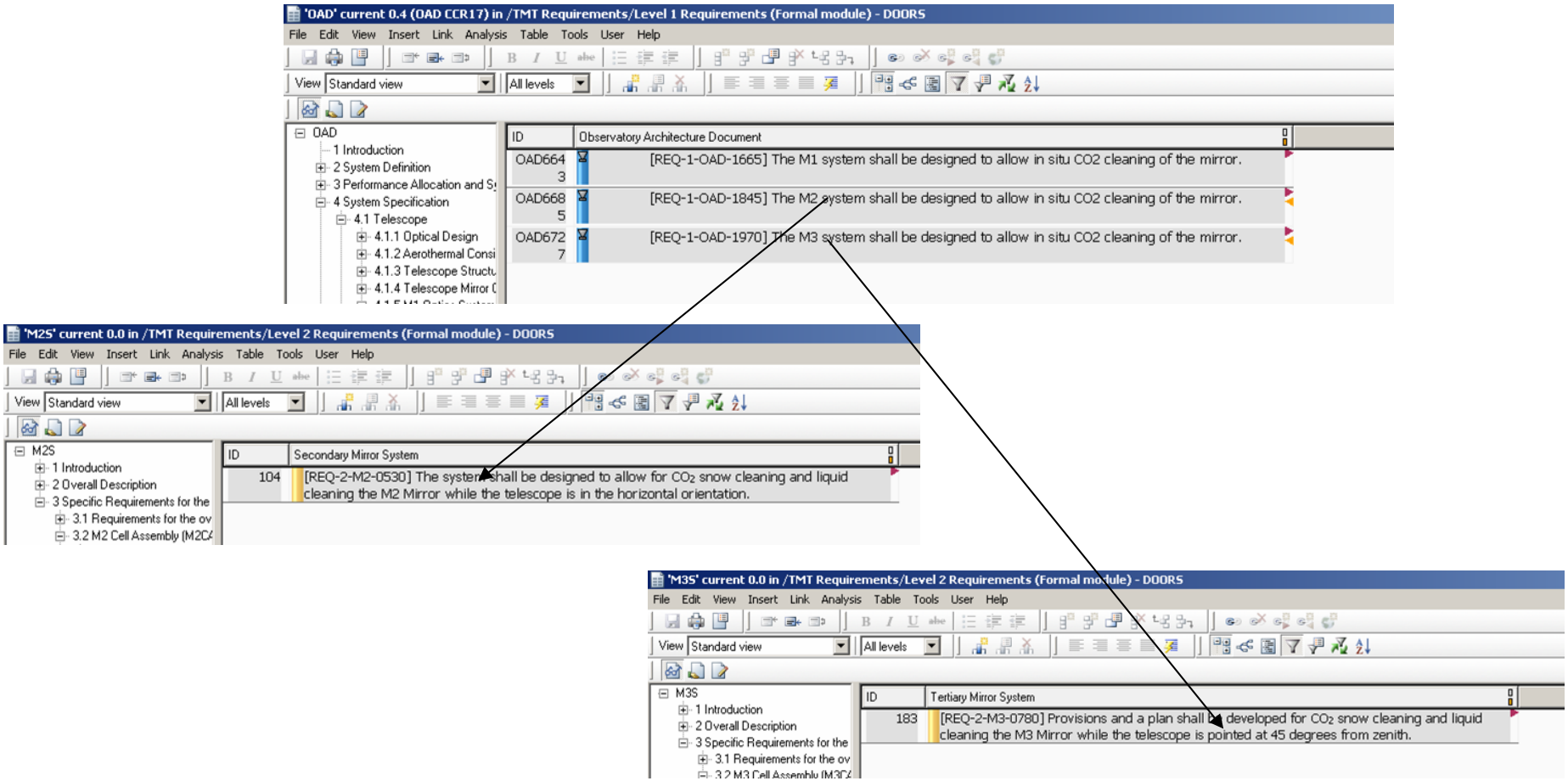


Requirement Flow-Down Example
Target Acquisition (2/2)

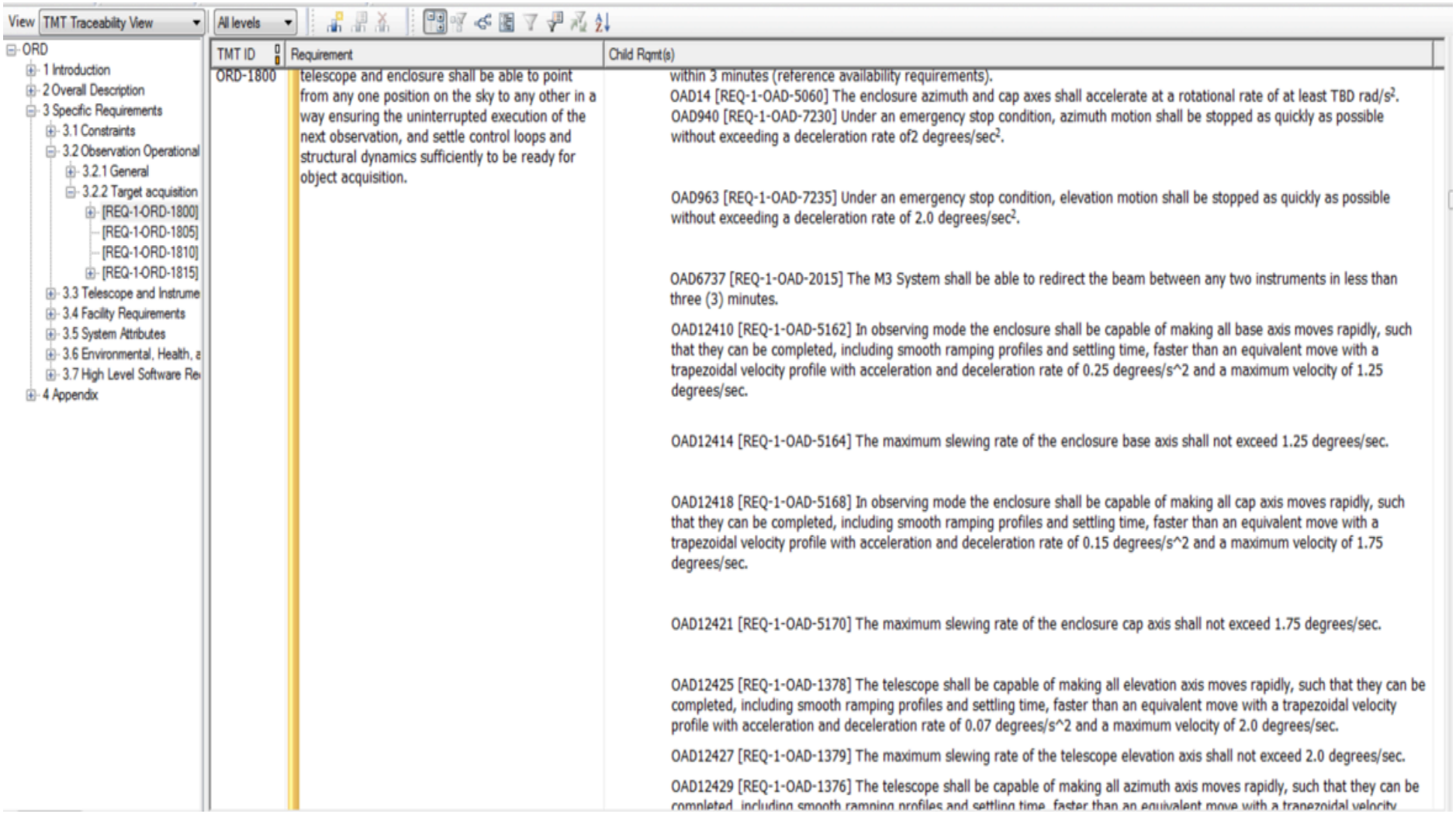
- Considering only the WFOS requirements, flow down will include requirements on:
  - Time to read out detectors
  - Time to re-position Wavefront Sensors and Guiders
  - Time to change slit masks
  - Time to reconfigure Atmospheric Dispersion Compensator
  - Time to change gratings
  - Time to change filters
  - Time to move instrument rotator
- Supporting analysis documents are needed to show that the coordination of these activities meets the top level requirement (some activities may be in parallel and some in series, with dependencies on other systems)

Configuration Control: DOORS Requirements Database

- DOORS = "Dynamic Object Oriented Requirements System"
- Industry standard tool to develop, manage and review requirements data



Standard DOORS Traceability Report



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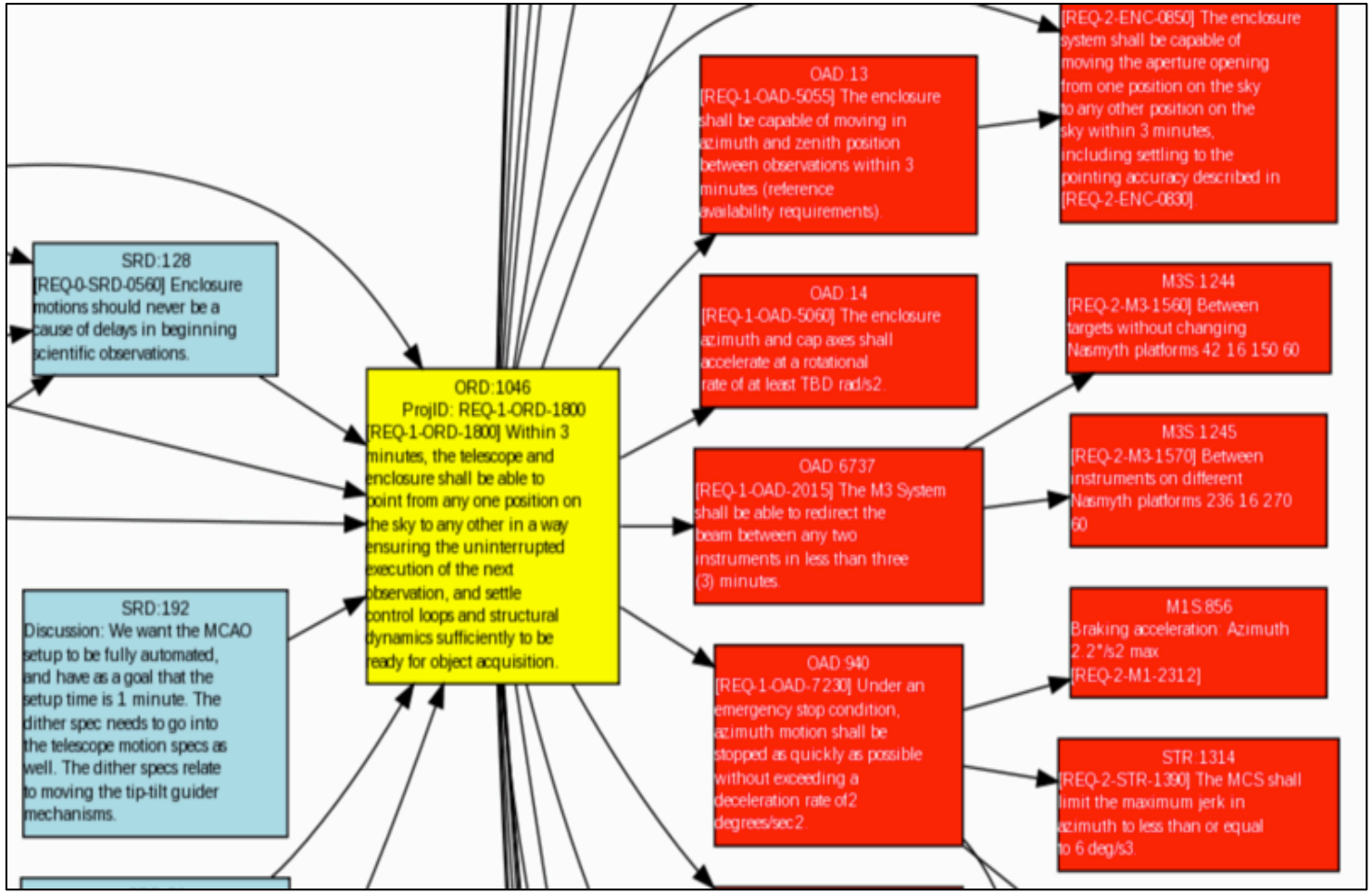
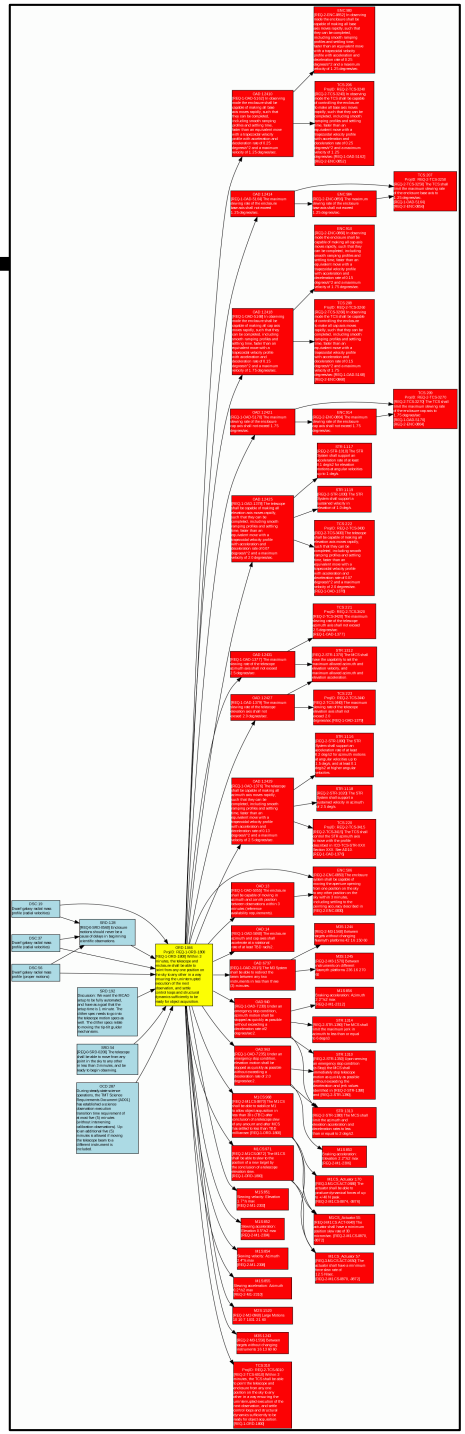
JPL TraceTree Tool





- Web based, DXL interface to DOORS, run daily, available to entire project

Requirement Verification

Verification - Overview

- TMT uses an incremental approach to Verification that is spread throughout project phases
  - Tests are complemented by design review, engineering analysis and lower level results
    - Many design-related verifications can be done prior to system assembly
    - Some verifications can be split into detailed low-level tests or analysis followed by a simpler high-level check
  - This on-going verification provides earlier confidence that requirements will be met
  - Reduces the number of complex, difficult to interpret, system level tests occurring on the critical path
  - Method depends on strong system configuration control to ensure that results obtained at lower levels of assembly are still valid at later stages of integration

Verification - Nomenclature

- Verification Method
  - One of five possible verification methods: Design, Inspection, Demonstration, Test, or Analysis
- Verification Activity
  - The act of performing one of the above methods of verification
- Verification Procedure
  - The sequence of documented steps that constitute a Verification Activity
- Verification Milestone
  - A logical grouping of verification activities in time (e.g. FDR, Telescope First Motion)

Verification: Subsystem Document Deliverables

- Verification Cross-Reference Matrix
  - A list of each requirement from a requirements document providing an associated Verification Method and links to Verification Procedures at one or more Verification Events
- Verification Plan
  - A document written for each requirements document which contains a description of the equipment and sequence of tests and how they map to the Verification Procedures associated to each requirement
- Verification Procedures Document
  - Procedures for each verification activity at a Verification Event.
  - Verification Procedures documents will be grouped by Verification Event, e.g. “Telescope First Motion Verification Procedures”
- Verification Test
  - An instance of a test of verification activity procedure. Result may be assessed as Passed, Failed, Partial or Invalid.
- Verification Reports
  - Completed Procedures documents for a Verification Milestone will become the Verification Reports for that Event

Verification – VCRM example

Enclosure DRD	Overall Verification Method	Verification at FDR	Verification at EAT	Verification Description
[REQ-2-ENC-0020] All mechanical and electrical components with lifetimes of less than 50 years shall be documented in the Enclosure Maintenance Plan. The maintenance plan for each such item shall be agreed with TMT.	Analysis	Inspection	Analysis	Verification by Inspection at FDR and again at EAT. However to reach agreement with TMT on particular items may require Design, Test or Analysis work for those specific parts.
[REQ-2-ENC-0050] The enclosure downtime shall not exceed 0.17% (TBD hours) of the scheduled science time between the end of evening nautical twilight and the start of morning nautical twilight	Analysis	Design	Analysis	Generally by Design, but some parts may require life test data to show compliance, similarly the times required for some repair operations may need to be proven.
[REQ-2-ENC-0070] The maximum duration for the enclosure scheduled maintenance shall not exceed 6 elapsed hours (TBC) on any given day.	Analysis	Design	Demonstration	Largely by Design report at FDR. Maintenance Plan at FDR (draft at PDR), EAT may include some demonstration of particular operations.
[REQ-2-ENC-0080] The average duration for the enclosure daily scheduled maintenance shall not exceed 1.5 elapsed hours (TBC).	Analysis	Design	Demonstration	Largely by Design report at FDR. Maintenance Plan at FDR (draft at PDR), EAT may include some demonstration of particular operations.
[REQ-2-ENC-0090] The total enclosure scheduled maintenance time shall not exceed 2,000 person-hours per year (TBC)	Analysis	Design	Demonstration	Largely by Design report at FDR. Maintenance Plan at FDR (draft at PDR), EAT may include some demonstration of particular operations.
[REQ-2-ENC-0100] The process of removal of ice and snow accumulation from critical areas affecting safe observing shall be accomplished with a crew of TBD people within an 8 hour daytime period. An area is considered critical if snow, ice, or water can reach the inside of the enclosure from that area through an open observing slit or vent.	Analysis	Design	Demonstration	Design at FDR, some development tests and then limited demonstration of function at EAT.
[REQ-2-ENC-0110] The serviceable enclosure components, such as drives, encoders, and local controls, shall be easily accessible from the interior of the enclosure for maintenance.	Demonstration		Demonstration	Largely by Design at FDR, some Demonstation may be required at ENC first motion.
[REQ-2-ENC-0120] All normal maintenance shall be performed with the enclosure shutter and vents closed and all interior systems protected at all times. The exception to this requirement is normal maintenance of the aperture flaps system that may need to be performed while the flaps are open.	Design	Design		By Design at FDR, review Enclosure Operations and Maintenance Plan

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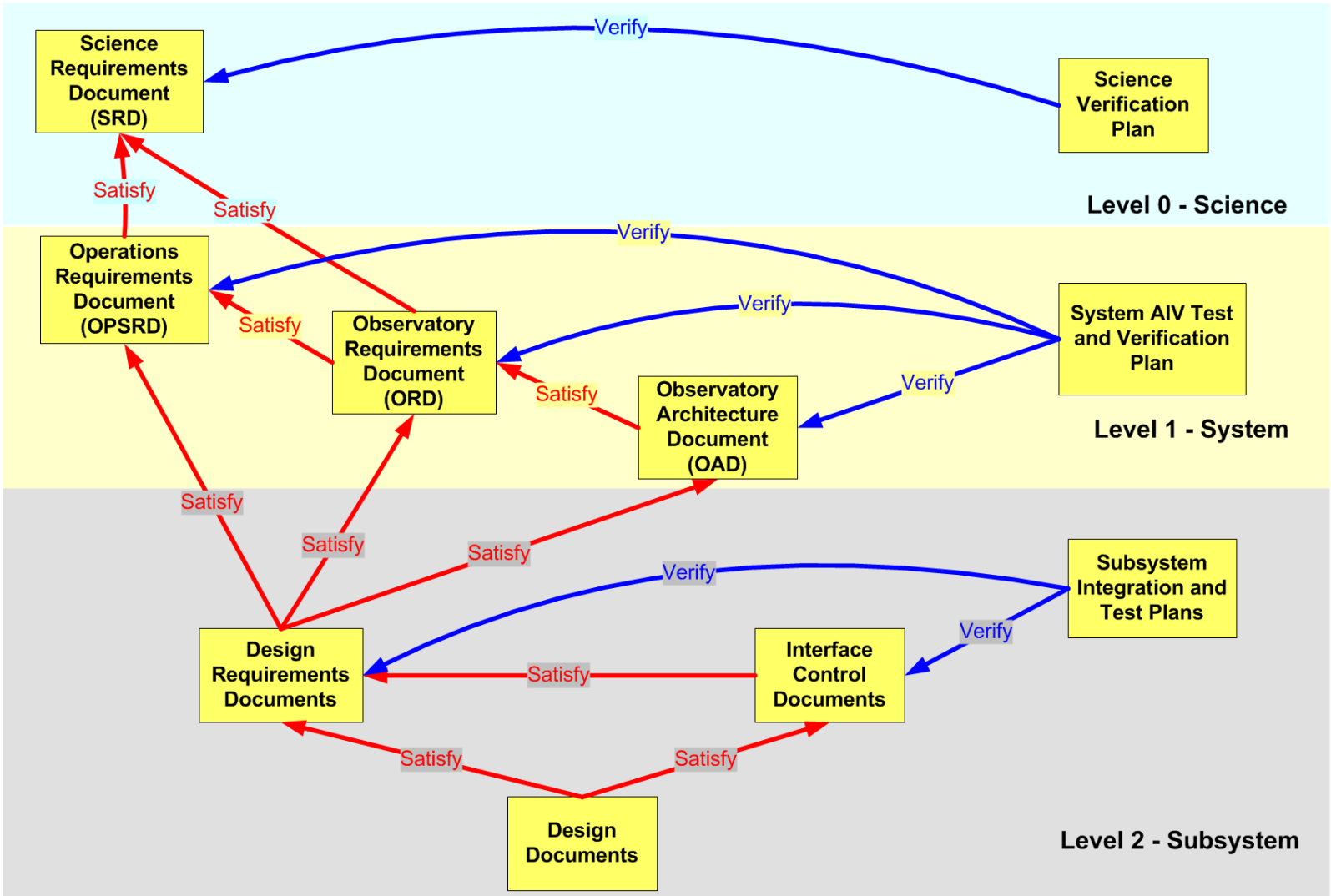
Verification 'Milestones'

- Verification milestones are logical groupings of verification procedures that are executed when enough data, or system components, or test equipment are available.
- Verification milestones are often closely associated to design, integration and test milestones, but the verification activities are not necessarily the milestone completion criteria.
- This decoupling can be very valuable in efficiently proceeding with the project while simultaneously building a "rolling wave" of verified requirements.

TMT Systems Engineering: Requirements, Interfaces, Test and Verification

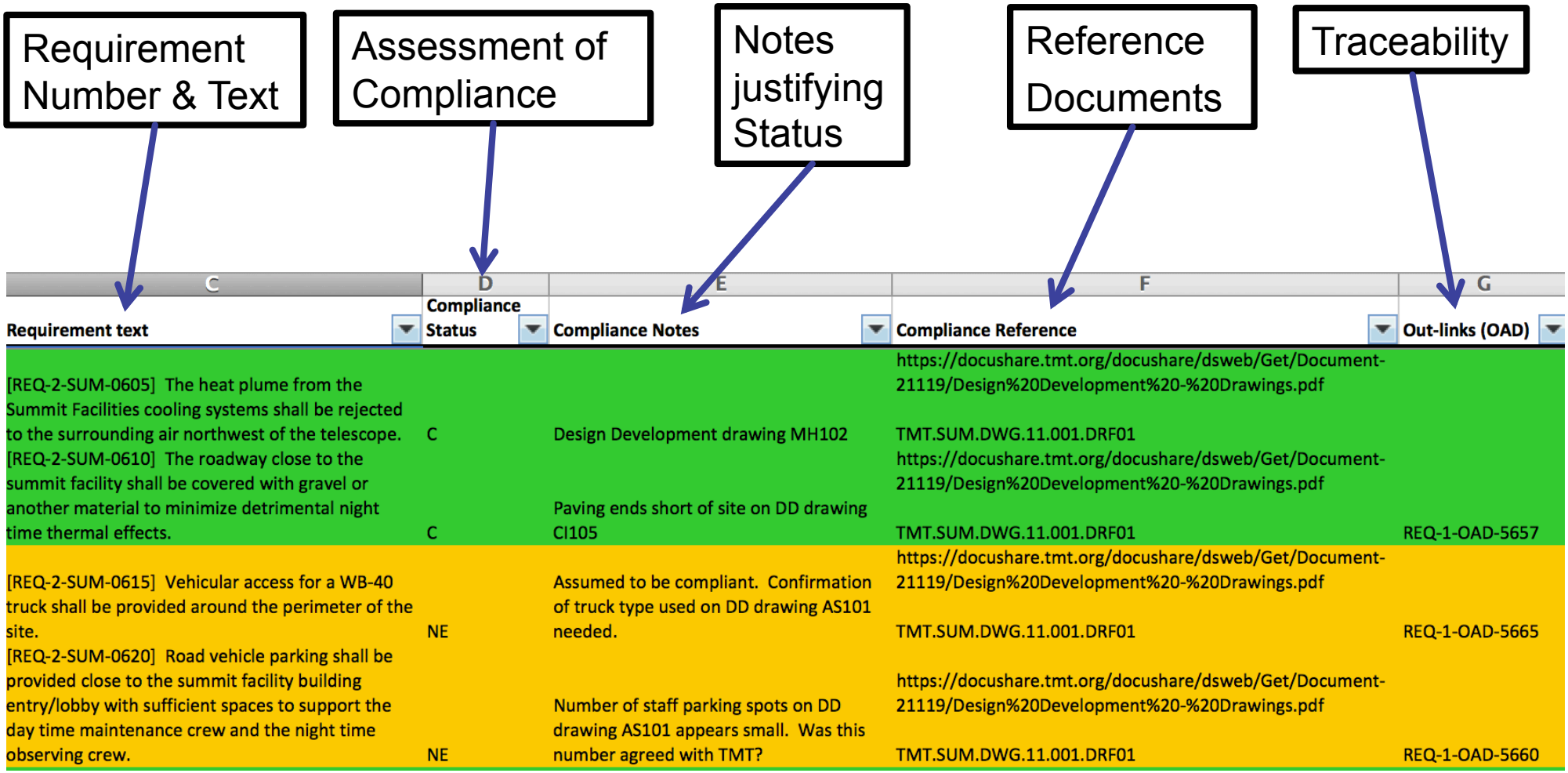


Design Compliance with Requirements

Requirement Compliance Assessment

- Subsystems are expected to assess the compliance of their design against each substem requirement, as either **compliant**, **partially compliant**, or **non-compliant**.
- Brief notes that explain why the component or sub-system is judged to compliant (or not) with the requirement. Examples could be:
  - similarity to existing designs
  - discussion of supporting tests or analysis
  - discussion of design features that enable requirement to be met
- Where appropriate, include title and URL link to any document on the DCC that supports the compliance status.
- A template for reporting compliance and additional guidance can be found on the systems engineering wiki pages.

Compliance Report Example



C	D	E	F	G
Requirement text	**Compliance Status**	**Compliance Notes**	**Compliance Reference**	**Out-links (OAD)**
[REQ-2-SUM-0605] The heat plume from the Summit Facilities cooling systems shall be rejected to the surrounding air northwest of the telescope.	C	Design Development drawing MH102	https://docushare.tmt.org/docushare/dsweb/Get/Document-21119/Design%20Development%20-%20Drawings.pdf TMT.SUM.DWG.11.001.DRF01	
[REQ-2-SUM-0610] The roadway close to the summit facility shall be covered with gravel or another material to minimize detrimental night time thermal effects.	C	Paving ends short of site on DD drawing CI105	https://docushare.tmt.org/docushare/dsweb/Get/Document-21119/Design%20Development%20-%20Drawings.pdf TMT.SUM.DWG.11.001.DRF01	REQ-1-OAD-5657
[REQ-2-SUM-0615] Vehicular access for a WB-40 truck shall be provided around the perimeter of the site.	NE	Assumed to be compliant. Confirmation of truck type used on DD drawing AS101 needed.	https://docushare.tmt.org/docushare/dsweb/Get/Document-21119/Design%20Development%20-%20Drawings.pdf TMT.SUM.DWG.11.001.DRF01	REQ-1-OAD-5665
[REQ-2-SUM-0620] Road vehicle parking shall be provided close to the summit facility building entry/lobby with sufficient spaces to support the day time maintenance crew and the night time observing crew.	NE	Number of staff parking spots on DD drawing AS101 appears small. Was this number agreed with TMT?	https://docushare.tmt.org/docushare/dsweb/Get/Document-21119/Design%20Development%20-%20Drawings.pdf TMT.SUM.DWG.11.001.DRF01	REQ-1-OAD-5660

Risk Management (Risk Registers)

Risk Management Overview

- TMT formalizes the management of risk in the following three ways:
  - Risk analysis at lowest level of WBS in the **cost estimate** to generate risk adjustment. The rationale for the included risk adjustment is included as a narrative in the cost book.
  - Risk analysis in **schedule** development to address critical paths and other schedule risks.
  - A **Risk Register** employed for formal project-wide system level risk identification, assessment and retirement.
- This presentation addresses the 3rd item, Risk Registers at the System and Subsystem Level

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Project Risk Register

Main Menu | My Risks | All Risks | New Risk | Log Out

Expand a section below to view details of the risks, change log, and new risk submissions. Follow links to view entry details.

Risk Register Elements (comprehensive list of all 213 elements)

ID	Risk ID	Description	Overall	Status	Last Updated
1	AIV-01	TMT Science Commission Plans not yet fully defined. Not in present project scope as it is planned to be done during Early Operations, therefore as yet no clear responsibility.	3	Active	12/13/2010
2	AIV-02	Limited number of high-level TMT staff available to handle simultaneou the integration and troubleshooting of multiple complex leading-edge su systems during the peak AIV activity.			
3	AIV-03	Construction delays and non-availability of Summit Facility buildings ar infrastructure affecting AIV working conditions. Limited size of summit facility and lack of nearby office/technical work areas on Mauna Kea.			
4	AIV-04	Large number of parallel interdependent AIV activities during final phase of TMT AIV. High likelihood of slippage of some tasks when problems are encountered.	2	Active	12/13/2010
5	AIV-05	Long time span and staff turnover during project construction and AIV will make it difficult to retain the detailed technical knowledge and historical background for complex troubleshooting of final systems.	3	Active	06/16/2011
6	AIV-06	TMT is a very complex system and will be a significant challenge for the project staff to install, debug and calibrate many interacting subsystems. Without a highly experienced knowledgeable project staff, full performance will be difficult to achieve.	3	Active	12/13/2010

Risk Register contains ~ 200 entries

Over 550 change requests have been processed

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Project Risk Register

Static ID: 178
Risk ID: SYS-10

Description: Plant machinery located in the summit facility building on Mauna Kea will produce vibrations that will degrade the science performance of the observatory.

Consequences: Degradation of the science capability of the observatory.

WBS Elements: TMT.PM.SE.CTRL, TMT.PM.SE.PERF

Mitigation: The risk is that equipment has not been specified sufficiently for vibration. Have to pay for a fix to either isolate or replace equipment. Specify systems and their mountings to minimize the effect of vibration. Carry out thorough simulations of these effects to understand the consequences of design choices.

Probability: 1 (Highly Likely)
Severity: 2 (Moderate Severity)
Overall: 1 (High Risk)

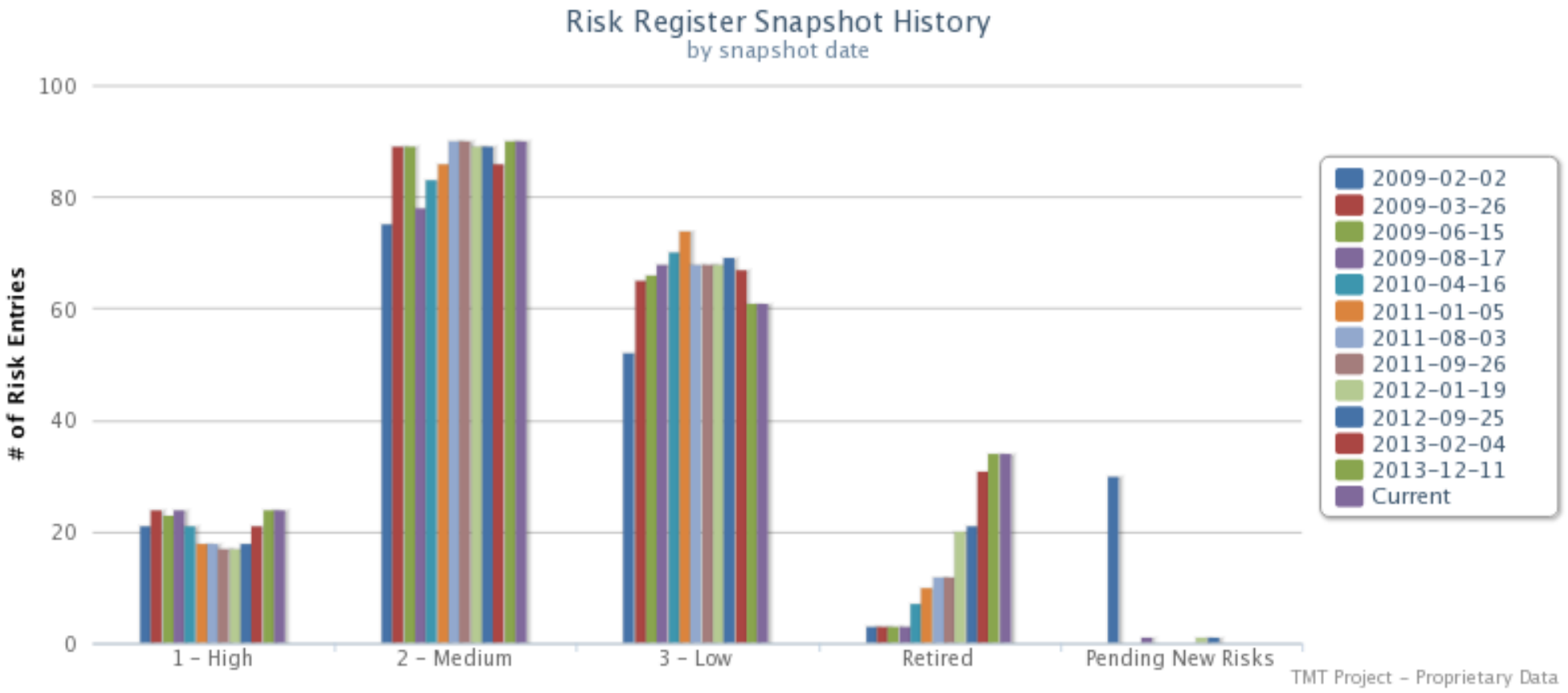
Status: Active
Owner: Scott Roberts
Group: SYS

Comments: See also risk FAC-03. PG 20090130: changed Overall M to H.
SR 20130127: Changed probability M to H, Overall M to H. Updated mitigation text.
SR 20130130: Removed heat aspect of this risk. Created new risk SYS-16 to cover utility room heat risk.

Submitted by: Scott Roberts on 01/29/2009
Last Updated: 01/30/2013

Edit this risk
View My Risks
View All Risks

System Risk Progression



Subsystem Risk Registers

- Subsystems teams are expected to conduct risk management as part of their design and development process. A deliverable of this process is a subsystem risk register that is reviewed regularly by the TMT project.
- Often this is a document in Excel format (Template available)
- The TMT project regularly holds meetings to review and update the project risk register. Subsystems are encouraged to provide input to these meetings, including identification of subsystem risks that may be candidates for inclusion into the system risk register.
- Risks may be promoted from Subsystem Risk registers to the Project Risk Register, Retired, or Demoted back down to the Subsystem Registers.
- See the following systems engineering Wiki page for more information on TMT Risk Management:
  - https://docushare.tmt.org/docushare/dsweb/View/Wiki-66/Risk

Subsystem Risk Register Example

- Some examples of risk categories include technical Issues, compliance with requirements or interfaces, procurement, management, schedule, cost.
- Can be risks from internal or external sources.

NFIRAOS Subsystem Risk Register TMT.AOS.TEC.11.082.REL01

Risk ID	Risk Description	Additional Details	Mitigation	Probability of Occurance	Severity	Overall Rating
1	HIA may not have an integration facility built in time for NFIRAOS integration.	Funding is needed from NRC to build this facility.	Rental of a large facility building in the Victoria area. Staff would have to travel between the observatory and the integration facility.	2	2	2
2	NFIRAOS may not be able to withstand updated estimates for seismic loads during 200- or 1000-year return-period earthquakes.	The TMT structures group is currently analyzing the seismic response of the telescope and will provide the NFIRAOS team with updated inputs, probably in early 2012. Initial indications are that seismic loads may be higher than previously thought.	Explore increased robustness of the structural design. Consider isolating the NFIRAOS structure from the telescope through use of dampers.	2	1	2
3	Seismic activity may breach the cold enclosure's walls, causing moist air to damage optical coatings and DMs.		In design phase we will perform finite-element analysis of the enclosure walls; add sensors to shut off high-voltage DM-drive electronics in case of seismic activity. The implementation of NFIRAOS will have built in safety features such as disabling the high voltage to the DMs if there is an incursion of humid air to the enclosure.	2	2	2
4	Uncertainty in the amount of labour required to integrate and provide systems engineering for NFIRAOS.		Review and update cost estimates as integration plans evolve. Seek review by other teams who have implemented complex AO systems.	2	2	2

Configuration Control

Configuration Control

- Goals of Configuration Control:
  - Define the configuration of the TMT system, both current and past
  - Manage Configuration Items (CIs), ensuring efficient & appropriate definition, review and authorization of change
  - Provide auditable evidence of stakeholder review and approval of CIs via signatures
- TMT configuration control plan adopted project wide in 2014 with the formation of the TMT International Observatory Organization
- Other key supporting documents include:
  - Product Data Package Definition
  - Change Control Role Assignment
  - Document Approval Matrix (indicates signatures required for approval)
  - TMT Reviews: Definitions, Guidelines and Procedures

Document Approval Matrix

Title	Database Source	DCC Document Designat	CCB Action Req'd	TMT PM	Proj. Science	Assoc. PM	Bus. Mgr.	Sys Eng	ES&H	Quality	TMT Dept. Head	TMT WP Man	Partner WP Man.	Partner PM	Review Chair
Project Standards and Policies		SPE	YES	**YES**			YES	YES	YES	YES					
Work Package Agreements / SOWs		CON		**YES**			YES	YES	YES	YES	YES	YES	YES	YES	
TMT Project Management Plan		MGT		**YES**			YES	YES	YES	YES	YES				
Review Plan		MGT		**YES**				YES			YES	YES	YES	YES	YES
Review Report Response		MGT		**YES**				YES	YES	YES	YES	YES	YES	YES	
Work Breakdown Structure (WBS)	PMCS	MGT		**YES**			YES	YES							
IPS Schedule	Open Plan	SCH	YES	**YES**											
TMT Project Cost Book	PMCS	CST	YES	**YES**											
TMT Project Budgeted Cost of Work Scheduled (BCWS)	TIO Financial System	CST	YES	**YES**											
Change Control Role Assignment		MGT		**YES**											
Level 0 DRDs (SRD)	DOORS	DRD	YES	**YES**	YES										
Level 1 DRDs (ORD, OAD, OPSRD)	DOORS	DRD	YES	**YES**	YES			YES	YES						
Level 2 DRDs (Subsystems)	DOORS	DRD		**FDP**				PDP	PDP		**PDP**	PDP	PDP		
Level 3 DRDs (Assemblies)	DOORS	DRD						PDP			**FDP**	**YES**	YES		

Configuration Index Document Example

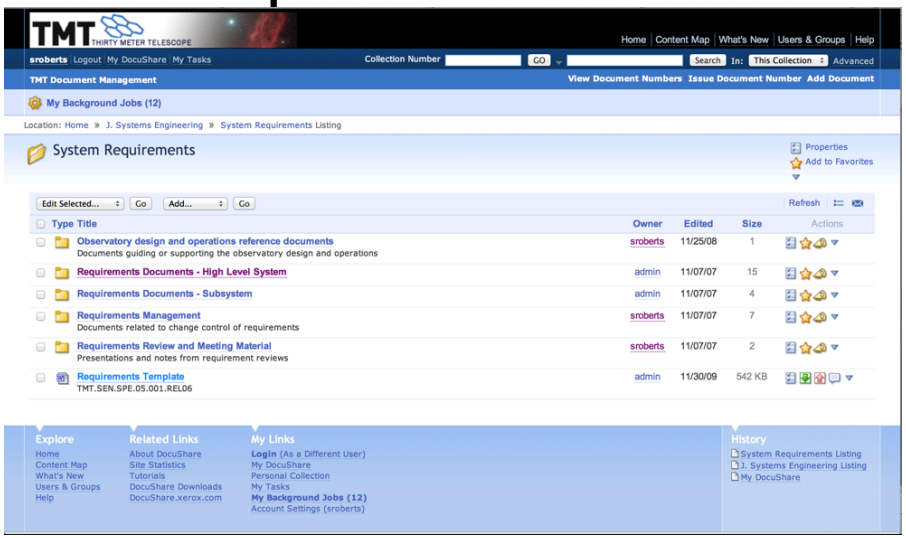
- CID Links are to a specific document version, so that even after a document is updated, the CID version will still point to the version in use for that configuration.

2. SYSTEM CONFIGURATION INDEX

System Name	*TMT Observatory*		
WBS	*TMT*		
System Configuration	*DRF01*		
Linked to Milestone	*2013 Cost Review*		
REQUIREMENTS			
Level 0 Science Requirements			
Document Title	**Document/Drawing Reference**	**Revision**	**Notes**
Science Based Requirements Document	TMT.PSC.DRD.05.001	**CCR18**	
ORD/OCD Traceability to SRD	TMT.SEN.TEC.09.036	**REL07**	
Level 1 Observatory Requirements			
Document Title	**Document/Drawing Reference**	**Revision**	**Notes**
OAD	TMT.SEN.DRD.05.002	CCR26	*OAD updated to CCR26 immediately following 2013 cost review to capture any WBS changes made as result of cost estimate process*

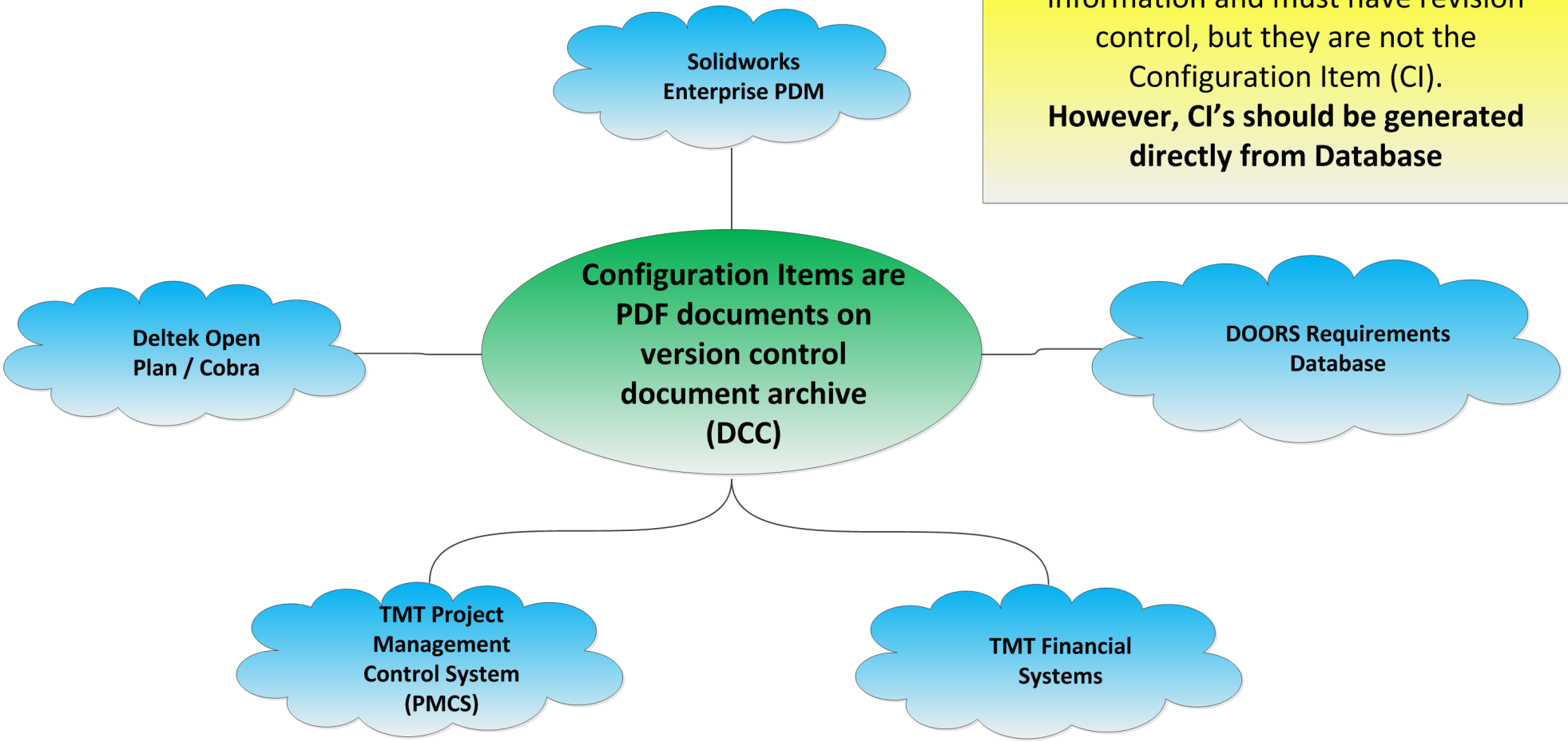
Configuration Control: Document Control Center (DCC)

- DocuShare database
  - ~450 users, ~24,000 documents, ~6,800 collections
- Unique document numbering
- Search capabilities
- Each and every project document captured
  - Requirements documents
  - Interface control documents
  - Design documents
  - Specifications
  - Contracts
  - Budgets
  - Technical notes
  - Change control requests
  - Presentations, other media files
  - Published documents (papers, etc.)
  - Project standards, guidelines, and templates
  - Correspondence (memos, meeting minutes, etc.)



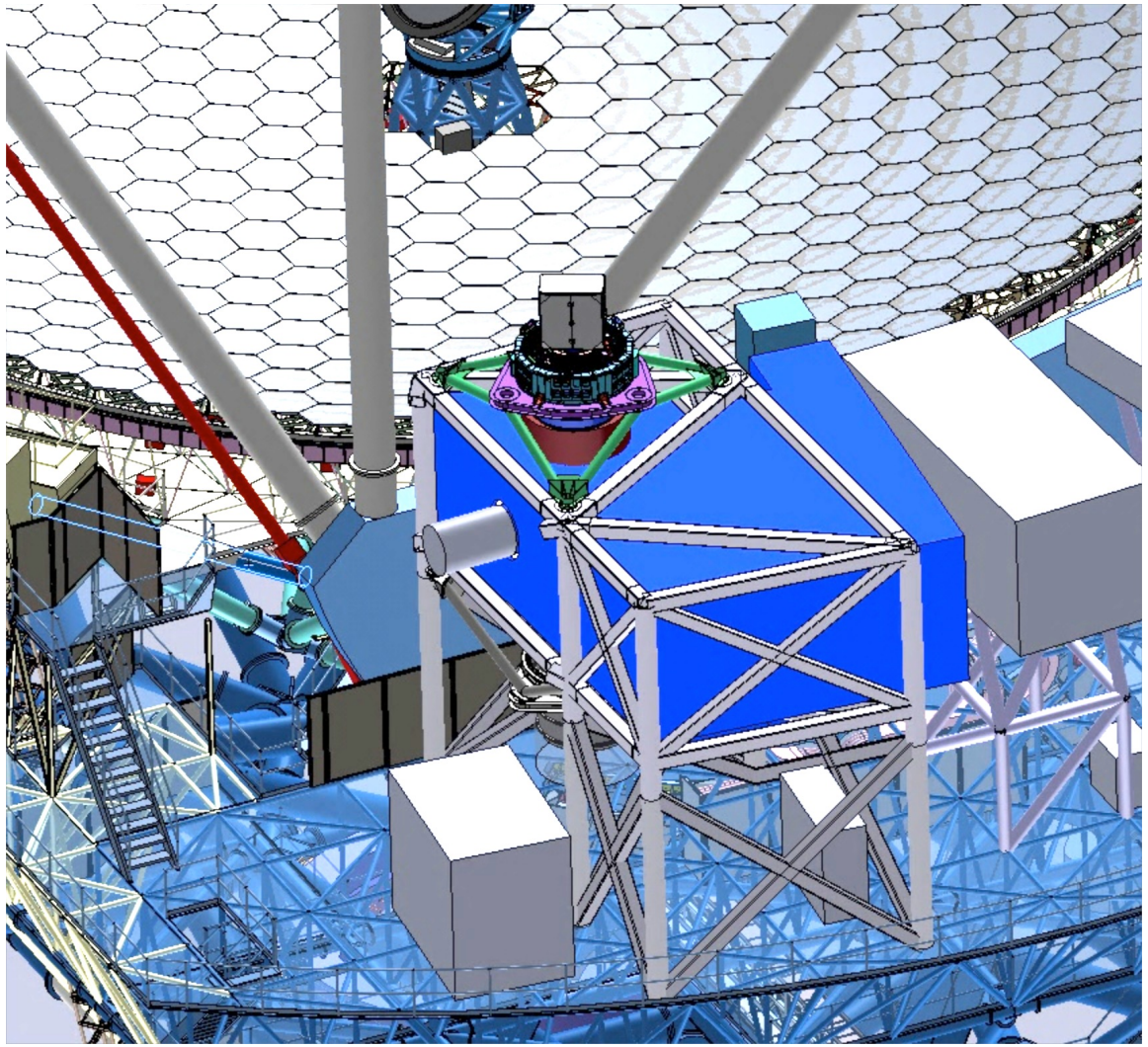
Clarity of Configuration Control: Configuration Items vs. Source Databases

Databases contain source information and must have revision control, but they are not the Configuration Item (CI).
However, CI's should be generated directly from Database



Configuration Control: CAD Database (Drawings and Models)

- A fundamental configuration control aid
  - Under strict revision control
    - May trigger change control requests
- SolidWorks Master Model (***Digital Mock-Up***) of the observatory
  - Interface control tool
    - Mechanical interfaces
    - Space envelopes, swept volumes
  - Design support tool
    - Architectures and trade studies (like access and handling)
- Solid model database SW/HW
  - Enterprise PDM (EPDM)



Configuration Control: Configuration Index Document (CID)

- Snapshot of design
  - By reference (which document is the relevant and current one)
  - A separate Index for each subsystem, as well as one for the entire system
  - Mandatory at major milestones (CoDR, PDR, FDR, PSR, FAR, EIDP)
  - Evolves as the design matures and construction proceeds – documents and details added
- Includes
  - Requirements and interfaces
  - Design documents
    - Design description (architectural design)
    - Detailed design (drawings, specifications, bill of materials, schematics, etc.)
    - Models and analyses (CAD, FEM, optical, thermal, control, etc.)
    - Safety (Safety Plan, Hazard Risk Assessment, etc.)
    - Reliability (FMEA, Reliability Prediction Report)
    - Manufacturing
    - Assembly and integration
    - Operations and maintenance (Operational Concepts, Maintenance Plan, etc.)
    - Verification (VCRM, Verification Plan and Report)

Configuration Index Document Example

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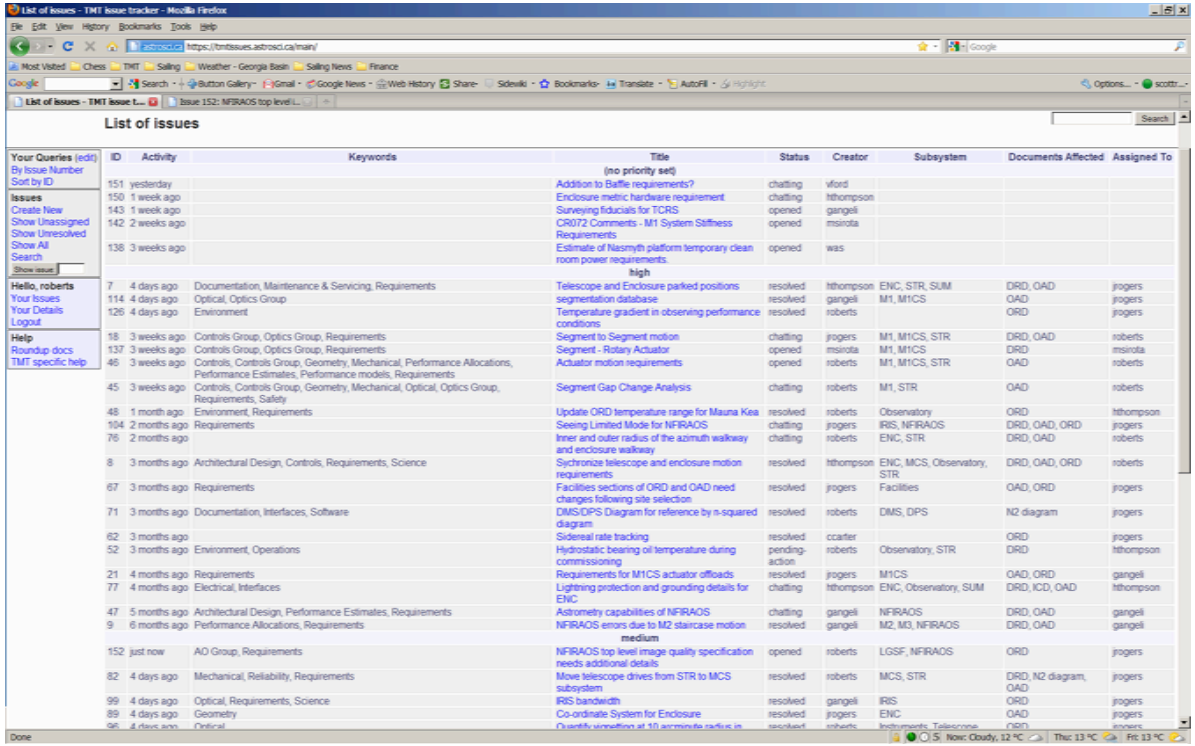
Configuration Control: Systems Engineering Issue Tracker

- Implemented to track engineering tasks with system engineering involvement
- Web based with E-mail functionality
- Searchable meta-data
- Issue states, lifecycle
- Currently 238 issues



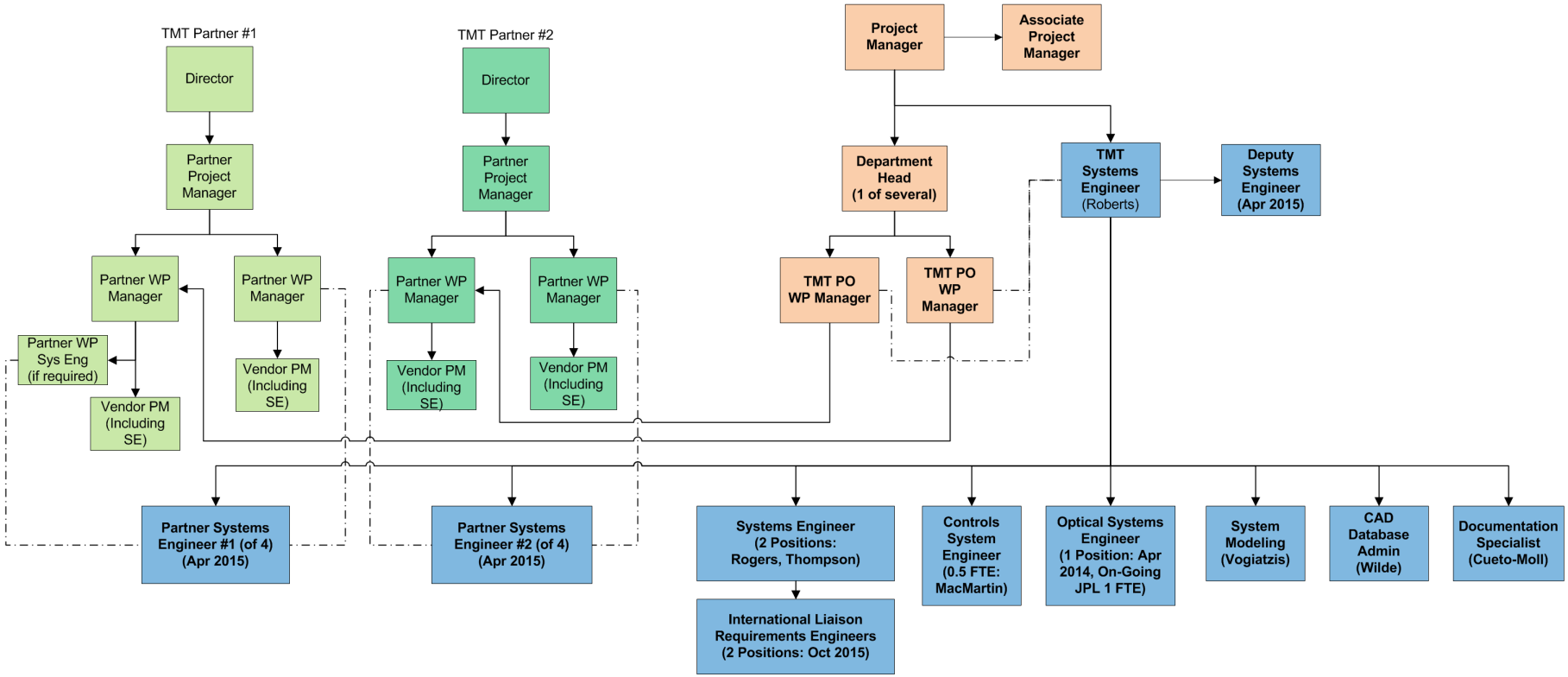
TMT Systems Engineering Organization

Systems Engineering Organization within TMT

- Project Systems Engineering provides guidance and coordinates with subsystem teams on systems engineering deliverables.
- Subsystems are responsible for their own systems engineering processes and deliverables.
- The subsystems team should be structured and enough resources should be allocated to perform the systems engineering tasks, and provide the deliverables as specified in the Product Data Package Definition Document.

SE Organization

- Systems Engineering of subsystems is conducted within the subsystem team in coordination with the TMT Systems Engineering Group
- Clear reporting lines are maintained between the TMT and Partner Work Package managers



TMT
THIRTY METER TELESCOPE

Acknowledgments

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