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Designing a Systems Engineering Process and Toolset for the Giant Magellan Telescope

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GIANT MAGELLAN TELESCOPE

Overview

- Introduction to the Giant Magellan Telescope (GMT)
- Description of the Systems Engineering process at GMT
  - Identification of the architecture
  - Optimization of products and interfaces
  - Functional Decomposition into deliverable work packages
- Management of the Systems Engineering process
  - Selection of the tool (Cockpit)
  - Cockpit User Experience
  - Management of information
- Lessons learned
- Future plans

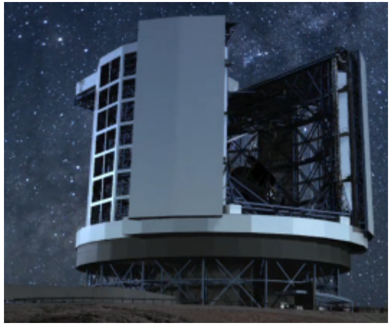
Introduction to the GMT

The Giant Magellan Telescope

Complexity of the GMT

- The GMT is no different than other complex systems

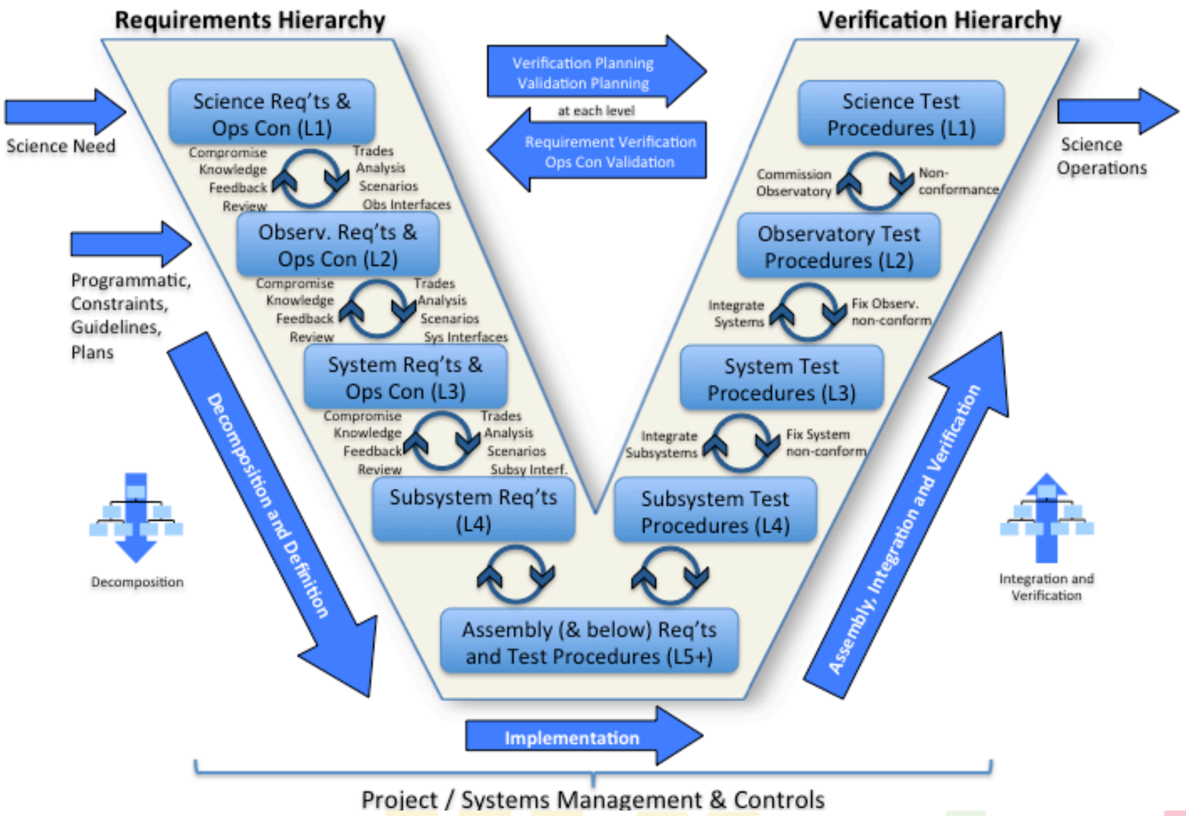


- We still apply core Systems Engineering processes
- Difference: Community is historically unfamiliar with Systems Engineering processes

Description of the Systems Engineering Process at GMT

GMT Systems Engineering Process



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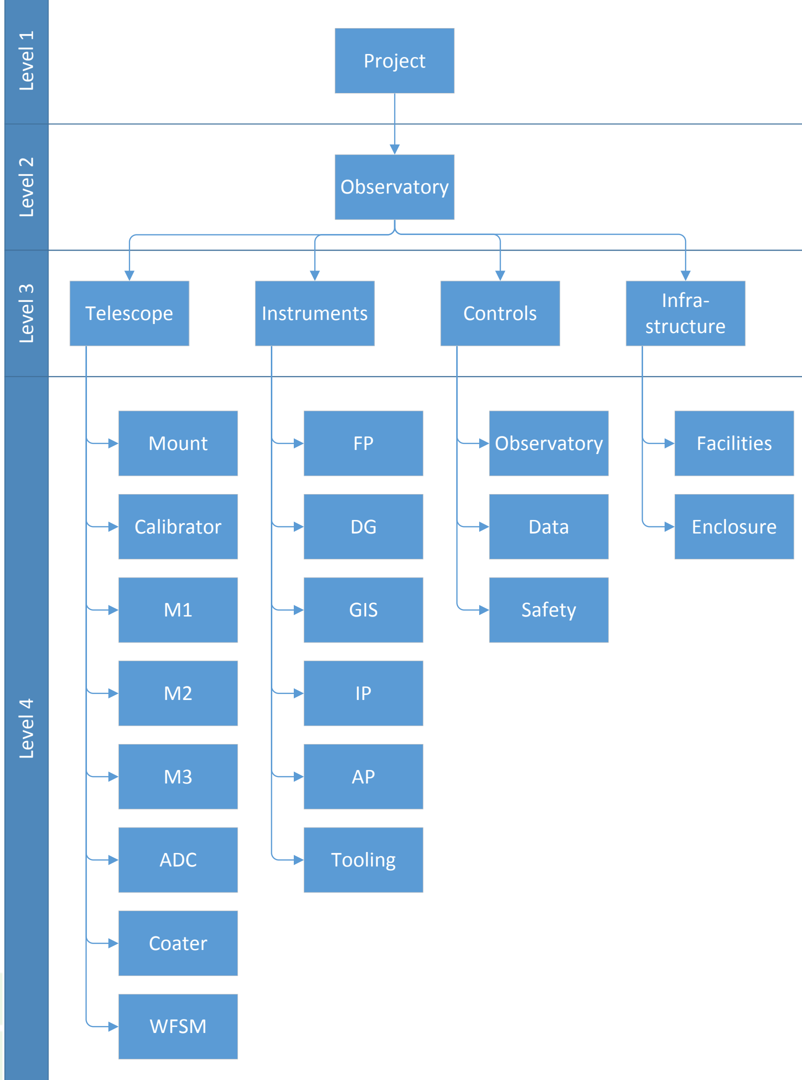
GMT Architecture

- A high-level architecture and functional allocation was developed based on legacy designs
- 4 major systems:
  - Telescope
  - Instruments
  - Controls
  - Infrastructure
- After further decomposition and optimization, 19 subsystems were identified



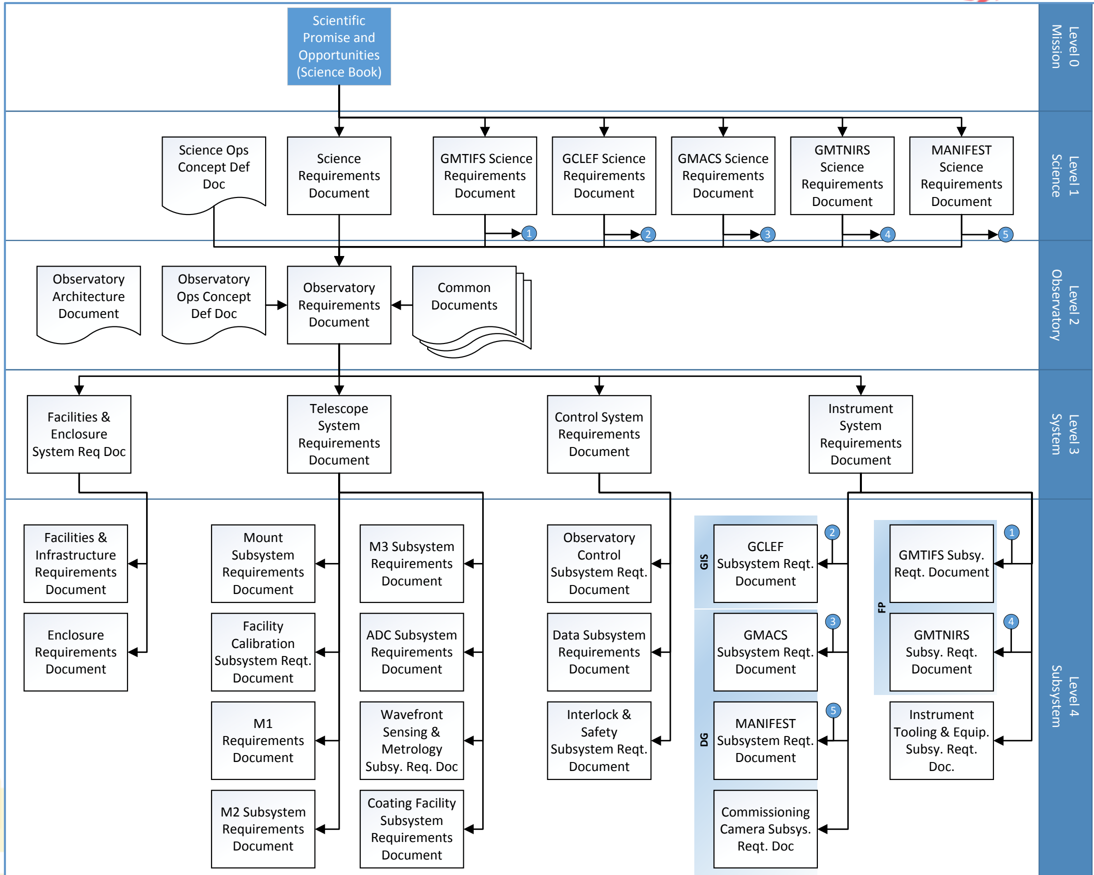
Optimizing GMT Products: Requirements and Interfaces

- Optimized architecture products based on common functionalities and procurement feasibility
- Requirements
  - Dark pink boxes
- Interfaces
  - Yellow, blue, green, pink boxes

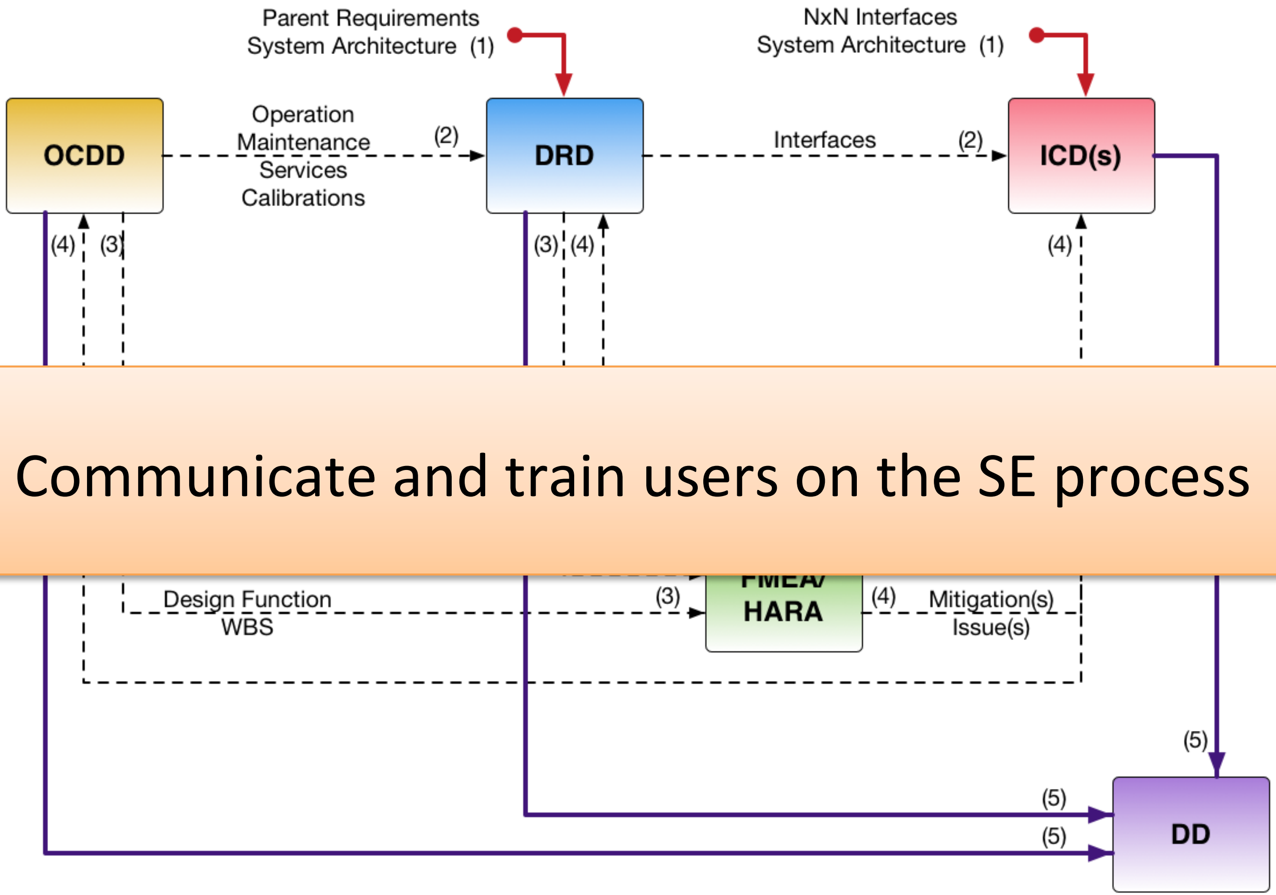
	Telescope	Mount	Calibrater	M1	M2	M3	ADC	Coater	WFSM	Instruments	FP	DG	GIS	IP	AP	Tooling	Controls	Observatory	Data	Safety	Infrastructure	Facilities	Enclosure
Telescope	•																						
Mount		•																					
Calibrater		•	•																				
M1		•		•																			
M2		•	•		•																		
M3		•				•																	
ADC		•				•	•																
Coater				•	•	•		•															
WFSM		•	•						•														
Instruments			•							•													
FP	•										•												
DG	•										•	•											
GIS	•											•	•										
IP	•											•											
AP	•											•											
Tooling	•									•						•							
Controls																	•						
Observatory	•									•								•					
Data	•									•								•	•				
Safety	•									•								•		•			
Infrastructure																				•			
Facilities	•									•												•	
Enclosure	•							•		•								•				•	•

GMT Requirements Hierarchy

- Using the optimized architecture, a requirements hierarchy was developed
- This finalized the GMT deliverables and scoped information needed for:
  - Internal work packages
  - External work packages (procurements)
  - Verification



GMT Functional Decomposition Process



Communicate and train users on the SE process

Management of the Systems Engineering Process

Now What?

- Too many inputs to track efficiently and effectively
- Paper documents hard to maintain and not current
- Expected ~10K requirement and interface items

A database was needed to capture this information, facilitate the SE processes, and manage traceability between design inputs

Selection of Management Tool

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GMT Project acquired Cognition Cockpit™, a real-time requirements, interfaces, FMEA and HARA management tool database

- Provides a web-based user interface
- Easy to configure
- Learning curve appeared less steep than other options

COCKPIT take control.

Capability to link all requirements, interfaces, operations concepts, failure modes, and hazards in one database

Tailoring the Management Tool

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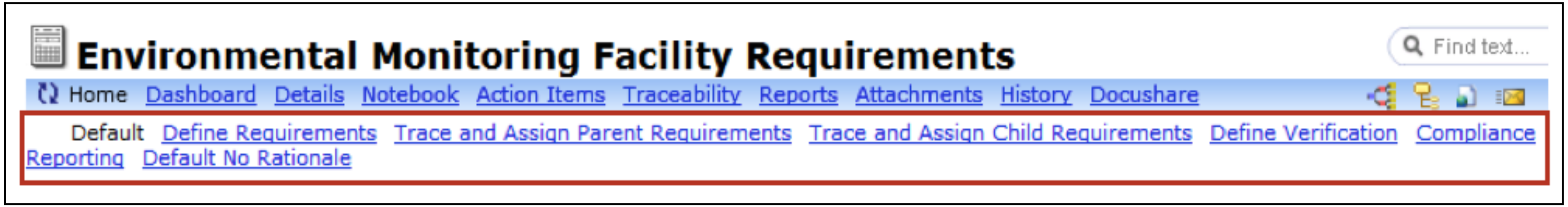
- Cockpit was tailored to accommodate all users by creating *View Definitions* to facilitate **data entry, traceability and documentation exports**



- Applied *View Definitions* to standard GMT templates for requirement, OCDD, ICD, FMEA and HARA documents

User Experience – e.g. Requirement and Interface Management

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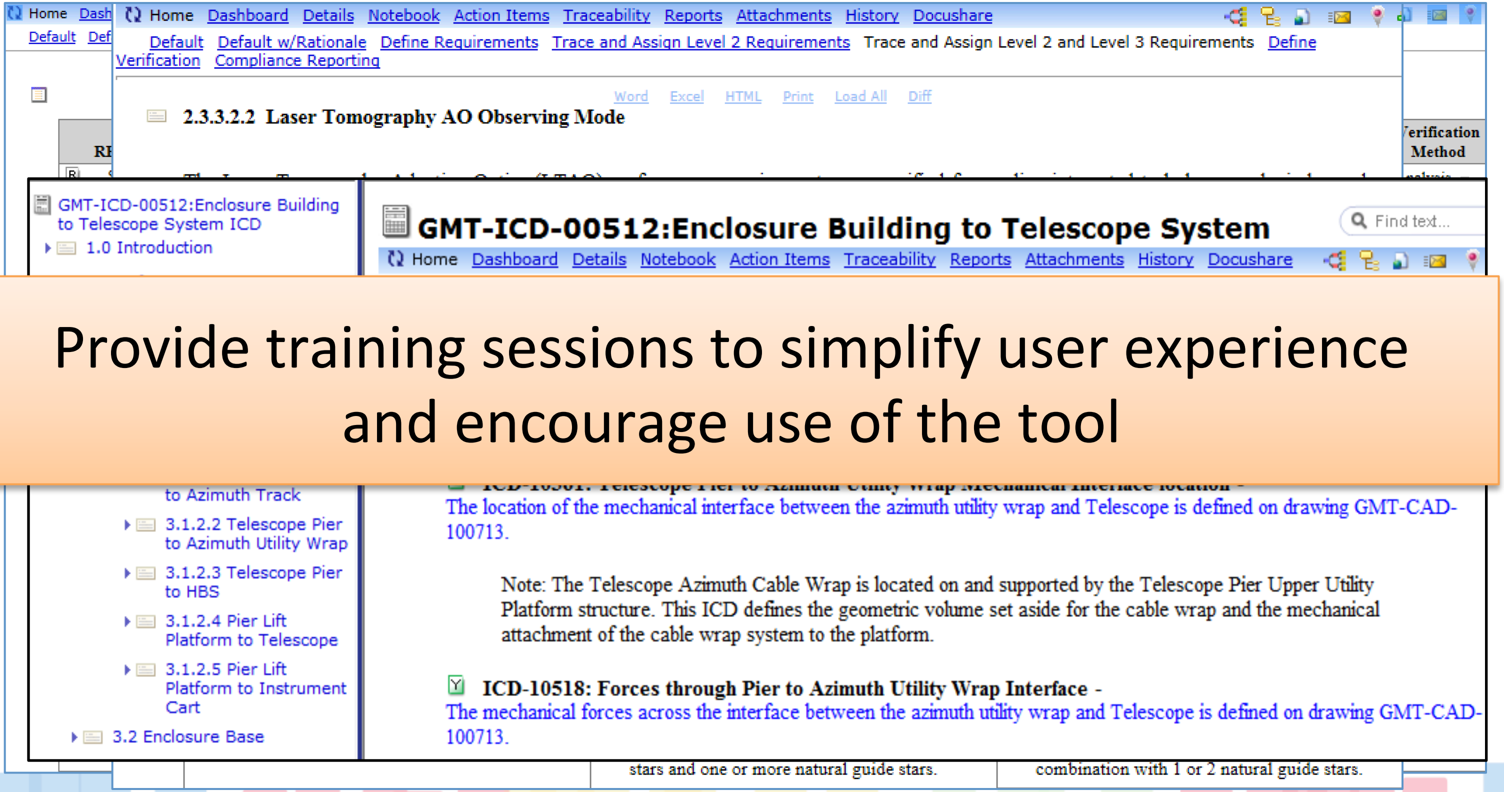

Provide training sessions to simplify user experience and encourage use of the tool

User Experience – e.g. FMEA and HARA

- Analyses recorded using the template provided by Cockpit
- Mitigations defined as a result of the analyses are linked as parents to new requirements

Hazard(s)	Effect(s) of Hazard	S	Cause(s) of Hazard	O	Action Owner	SxO	Final Risk Control Measure(s)
RISK-0362: Laser beam is propagated outdoors … hits aircra…	RISK-0365: Possible eye/skin injury for aircraft …	4	RISK-0368: Aircraft Avoidance System is …	3	Gelys Trancho	12	MIT-0187: Design AAS to reduce probability … probable;
							…t laser propagation … is BAD
RISK-0363… outdoors … hits satelli…							…o reduce probability … probable;
							MIT-0190: LIS to prevent laser propagation to sky when AAS health is BAD
RISK-0364: Laser beam is propagated when LTCS is malfunctioning, within field of view of neighbor telescope	RISK-0367: Neighbor telescope data is corrupted	2	RISK-0370: Laser Traffic Control System is malfunctioning	3	Gelys Trancho	6	MIT-0191: Design LTCS to reduce probability of failure to remote or improbable

Provide training sessions to simplify user experience and encourage use of the tool

Managing the Information

To manage the wealth of information in the tool, we leveraged the out-of-the-box reporting features of Cockpit with custom reports

Document Title	Revision Status	Owner	# of Reqs	# Reqs w/o Target	# Reqs w/o Rationale	# Reqs w/o Ver Method	# Reqs with TBx	# Reqs w/o Parents	# Reqs w/o Children
Telescope System Requirements	B	Eric Pearce	250	0	1	62	28	9	99
Adaptive Optics System Requirements	B	Antonin Bouchez	188	0	2	4	7	19	33
[illegible] Infrastructure/Utilities Requirements	[illegible]	[illegible]	247	0	1	6	11	4	242
Software & Controls System Requirements	DRAFT	Josema Filgueira	218	0	0	1	16	8	217
Instrumentation Requirements	A	Brian Walls	139	0	0	0	21	13	35

Generate progress reports for periodic requirement reviews

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Managing the Information

- Reports were used to understand the level of requirement satisfaction for a specified document, displayed either as a pie chart or table.
- They could also be applied to a requirements flowdown

Parameter/Type/Units	Target/Rationale	Current Value/Comments	Status
SCI-1884: LTAO Imaging with Moderate Sky Coverage - GMT-SCI-REQ-00001 Numeric Strehl@1.65um	The GMT shall support high angular resolution extragalactic science with an LTAO observing mode that delivers an on-axis H band (1.65 μm) Strehl ratio of **no less than 0.30** over at least 20% of the sky at the galactic pole, over a 120 s integration (goal: 50% at the galactic pole). This will support high angular resolution observations of extragalactic targets and faint or obscured	0.30	Margin -.37 %
Shake PSD - GMT-TEL-REQ-00158 Pass/Fail	equal or better than the figures below, when pointed into the wind, 75th Percentile (~9.8 m/s) and with the enclosure set to 50% open. PSDs worse than this would degrade the image motion requirements. The FSM requirements are set for these PSDs. This is for "Case C" 50% open vents with 10m/sec external wind.	Refer Telescope PDR Report 6-164.	
TS-MNT-7183: Mount - Wind Shake 50% Open - GMT-TEL-REQ-00506 Pass/Fail	The Mount shall deliver to the Direct Gregorian Port focal plane, an image motion Power Spectral Density equal or better than the figures below, when pointed into the wind, 75th Percentile (~9.8 m/s) and with the Enclosure Vents set to 50% open. Derived analysis contained in GMT-TEL-DOC-TBD.		Current value not set

Generate satisfaction reports for periodic requirement reviews

Lessons Learned

What We Have Learned!

Simple, simple, simple!

- Cultivate technical and management engagement one process at a time, don't try to implement everything at once

Training, training, training!

Essential for the entire team to understand, communicate, and follow SE processes in order for a tool to be effective and useful

the tool

Balance, balance, balance!

- Document processes and configurations before tailoring
- Find balance between supporting users and doing the work for them

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Future Plans

What's Next: Hybrid Approach

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Traditional SE

- Clear, defined deliverables
- Easily accessible
- Shallow learning curve
- Simple traceability

MBSE

- Understanding behaviors of a system
- "Rich" capability to represent complex systems

Exploit the advantages of each approach

Questions?

Thank you!