

# Analyzing the Operational Behavior of NFIRAOS LGS MCAO on the Thirty Meter Telescope using SysML

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# Requirements

In the new era of Extreme large Telescopes (ELT) performances requirements, e.g, TMT,

**[REQ-0-SRD-0820]** Tilt-removed RMS wavefront error should be less than 173 nm on axis, in median seeing conditions, for NFIRAOS with a goal of less than 120nm for NFIRAOS upgrade

**[REQ-0-SRD-0825]** Tilt-removed RMS WFE should be less than 190nm over a 30 arcsec field of view, in median seeing conditions, for NFIRAOS with a goal of less than 133nm for NFIRAOS upgrade.

**[REQ-0-SRD-0850]** Sky coverage should be  $> 50\%$  at the galactic poles, with  $< 2$  mas rms tip-tilt jitter.

**are not the only** critical parameters in the design table.

# Requirements

Others requirements such as **acquisition times, observing efficiencies and operational behavior** of systems can influence the design significantly.

e.g.

**[REQ-1-ORD-1800]** Within 3 minutes, the telescope and enclosure shall be able to point from any one position on the sky to any other in a way ensuring the uninterrupted execution of the next observation, and settle control loops and structural dynamics sufficiently to be ready for object acquisition.

**[REQ-1-ORD-1805]** The TMT Observatory shall perform the complete target acquisition sequence in less than 5 minutes when an instrument change is not needed.

**[REQ-1-ORD-2656]** The TMT Observatory average slew time between science targets shall be less than 60 seconds.

# Solution: MBSE

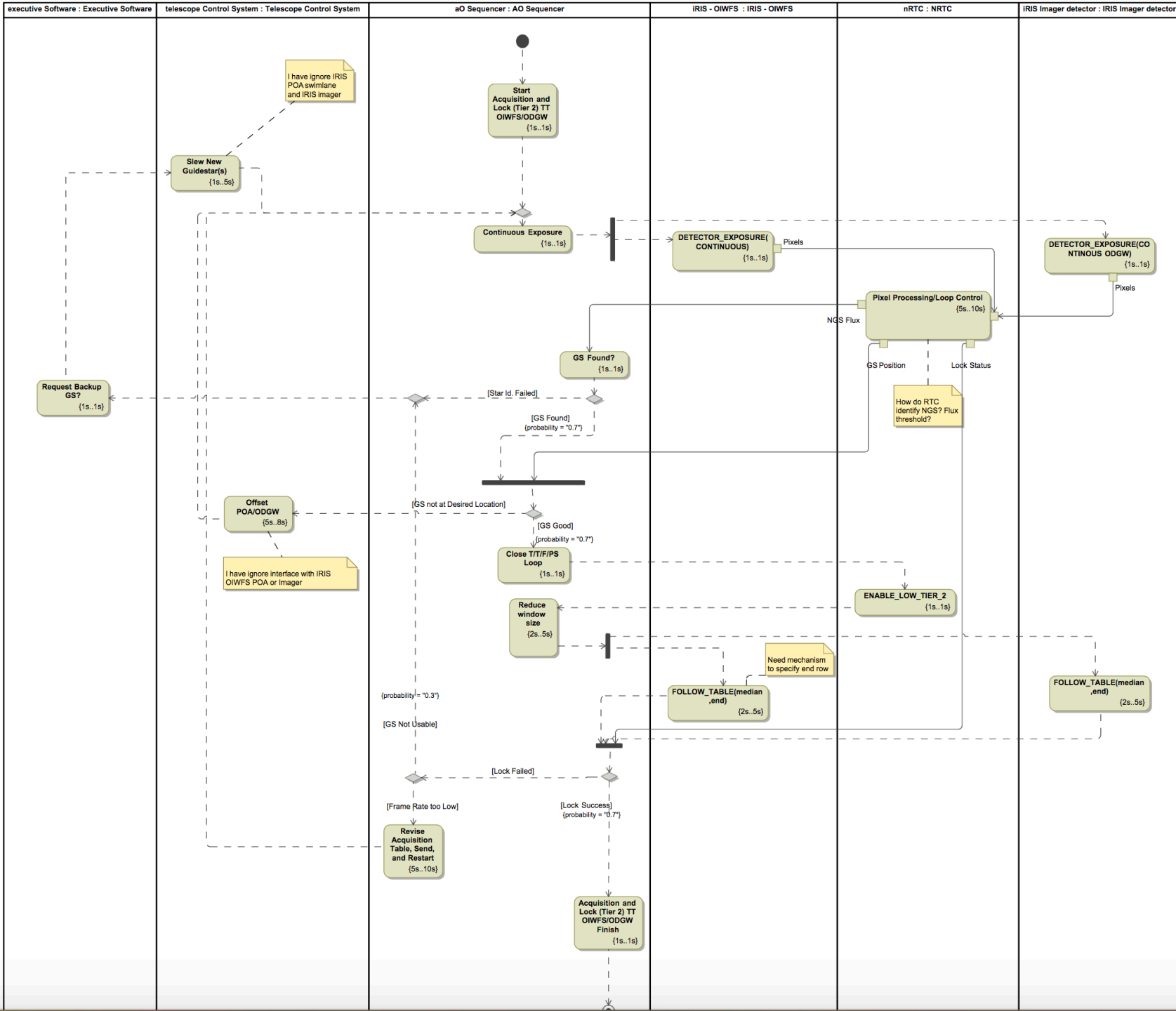
In an effort to address this challenge, TMT/JPL have created a system model, which captures:

- The functional and physical structure
- Behavior
- Requirements
- Parametric relationships

Specifically, capturing the Slew, Acquisition and Observing sequence behavior and use case scenarios for the purpose of verifying requirements on timing through system-level simulation:

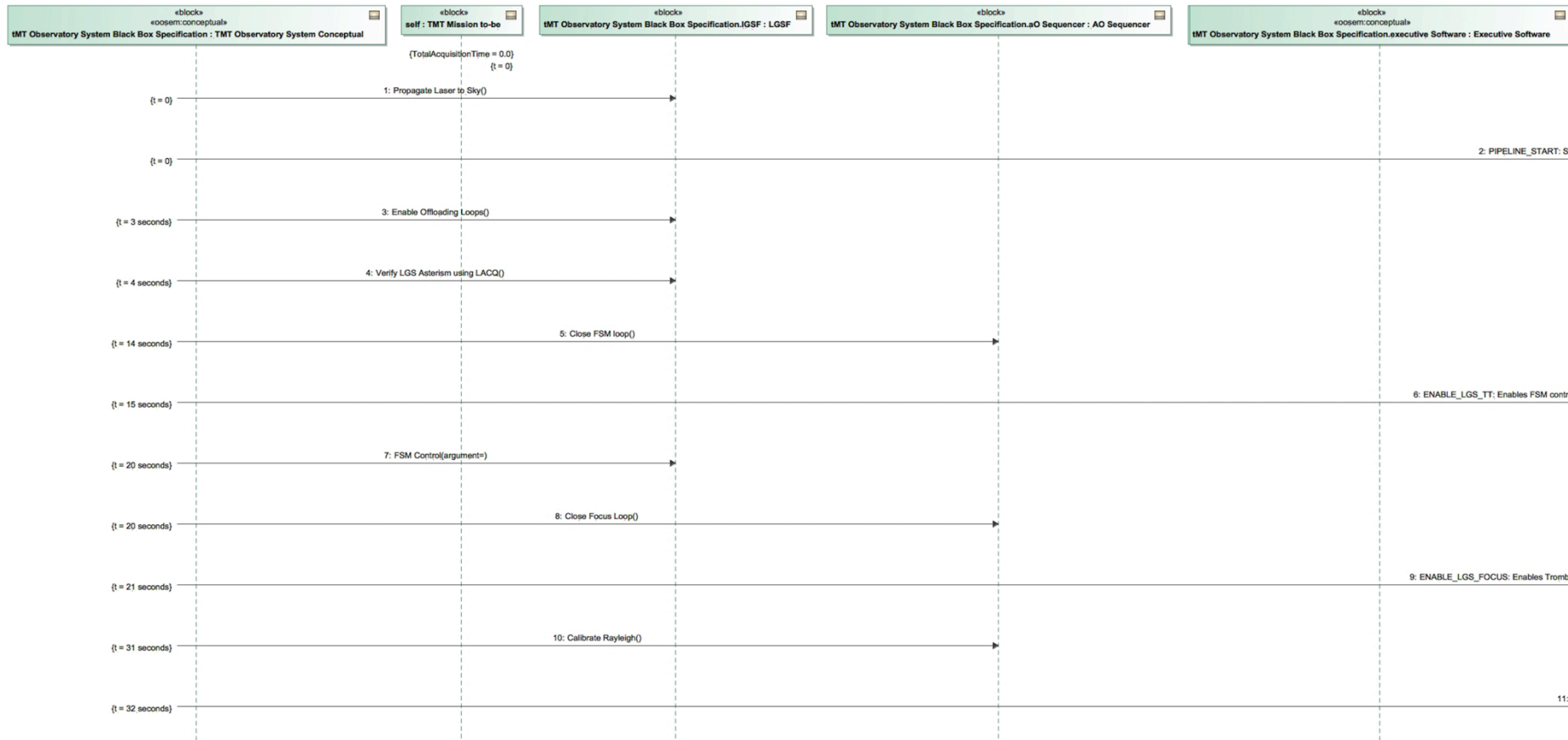
- Operating modes and behavior are modeled using activity diagrams.
- Scenarios are captured primarily using sequence and activity diagrams.
- Verifiable requirements are formally captured using constraints on properties.

This type of modeling can prove to be particularly useful when wanting to investigate the effect of parallelizing, identify Interfaces issues or re-ordering sequence acquisition tasks





# Analysis



# Analysis

Using Monte-Carlo simulation on our behavior model:

- we can estimate if we've achieved REQ,
- what do we need to change or parallelize

**Instance Table**

#	TMT Observatory System Black Box Specification	Name	Total Acquisition Time	Total Acq Time Acq Tel Point	Total Acq Time BTOOP	Total Acq Time Chk Laser Pro	Total Acq Time Acq Lck LGS	Total Acq Time Acq Pwfs Firs	Total Acq Time Acq TTFOIWF	Total Acq Time Acq Pwfs Secor	Total Acq Time Acq TTOIWFSDGW	Total Acq Time Truth ODGWOIWF
99	tmt mission to-be group3.tmt observatory system conceptual33 : TMT Observatory System Conceptual	tmt mission to-be group3 at 2017.02.20 10.27	204				56		25	10		113
101	tmt mission to-be group3.tmt observatory system conceptual34 : TMT Observatory System Conceptual	tmt mission to-be group3 at 2017.02.20 10.27	163				53		22	10		78
103	tmt mission to-be group3.tmt observatory system conceptual35 : TMT Observatory System Conceptual	tmt mission to-be group3 at 2017.02.20 10.27	187				58		71	10		48
105	tmt mission to-be group3.tmt observatory system conceptual36 : TMT Observatory System Conceptual	tmt mission to-be group3 at 2017.02.20 10.27	128				58		40	10		20
107	tmt mission to-be group3.tmt observatory system conceptual37 : TMT Observatory System Conceptual	tmt mission to-be group3 at 2017.02.20 10.27	159				51		24	28		56
109	tmt mission to-be group3.tmt observatory system conceptual38 : TMT Observatory System Conceptual	tmt mission to-be group3 at 2017.02.20 10.27	124				50		21	29		24
111	tmt mission to-be group3.tmt observatory system conceptual39 : TMT Observatory System Conceptual	tmt mission to-be group3 at 2017.02.20 10.28	157				52		23	23		59
113	tmt mission to-be group3.tmt observatory system conceptual40 : TMT Observatory System Conceptual	tmt mission to-be group3 at	139				56		46	10		27

# Communication Tool

We use the model swimlanes activities diagrams to communicate and discuss possible scenarios or new ideas

We redlines or add notes of possible issues, to follow up

It has help to put different stakeholder in the same page: Software Engineer, System Architect, System Engineers, Work package and Astronomers

Allow different type of user to have a common language and one reference

→ We use all this and we update Requirements and Interfaces



# The Model

DEMO