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

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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.
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.
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.
Using Monte-Carlo simulation on our behavior model:

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

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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