WFIRST FSWG Meeting

Integrated Modeling

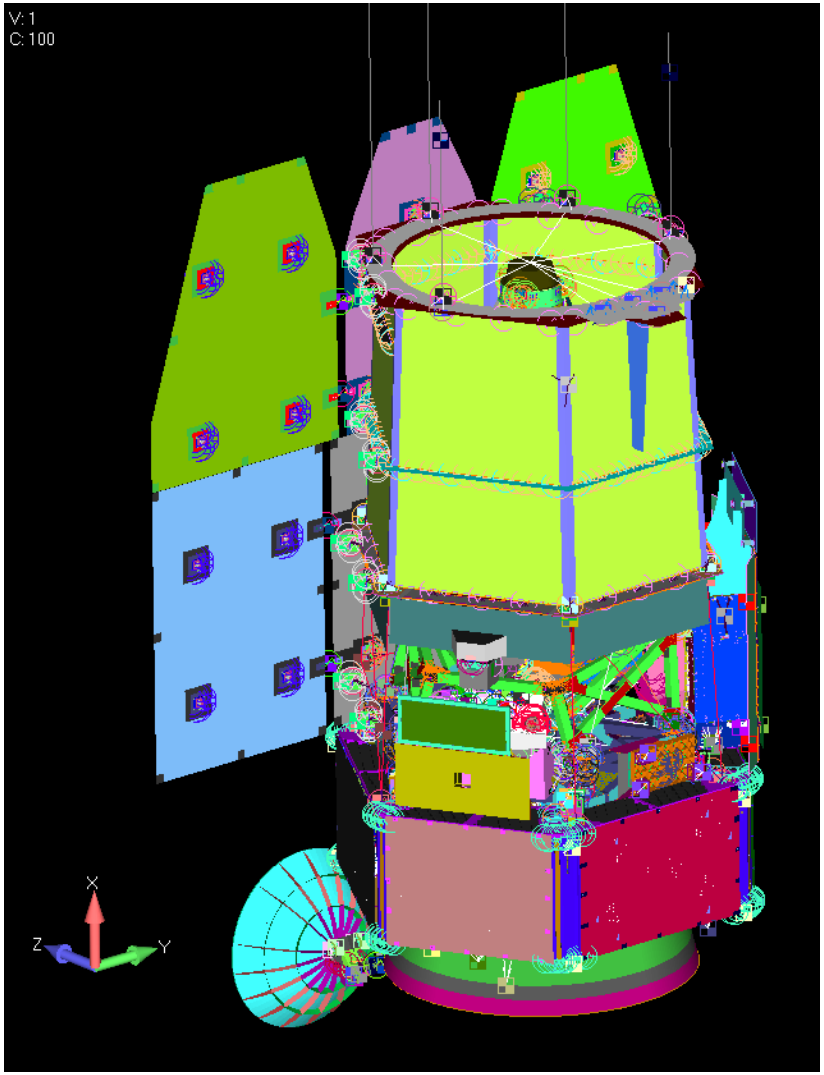
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WFIRST IM Team

Agenda

- Integrated Modeling (IM) Status
- Changes that Affect Stability Performance
- Stability Sensitivity Summary
- Jitter Analysis and Updates
- Structural-Thermal-Optical-Performance (STOP) Analysis
- Summary and Future Work

Integrated Modeling (IM) Status

- Completed optical, structural, and thermal model integration and checks for performing PDR IM analyses
  - Completed preliminary jitter analyses
  - Working on thermal distortion, moisture desorption, gravity release, and material stability analyses
- Held Model Validation Plan Peer Review 6/13 - 6/14
  - Successfully passed review with positive feedback from the review panel
  - Currently working on addressing RFAs/advisories
- Selected Honeywell for Launch Lock and Vibration Isolation System (LLVIS) procurement
- Completed reaction wheel isolation system and high gain antenna damper studies with potential vendors
- Hold IM pre-PDR Engineering Peer Review on 9/26-9/27



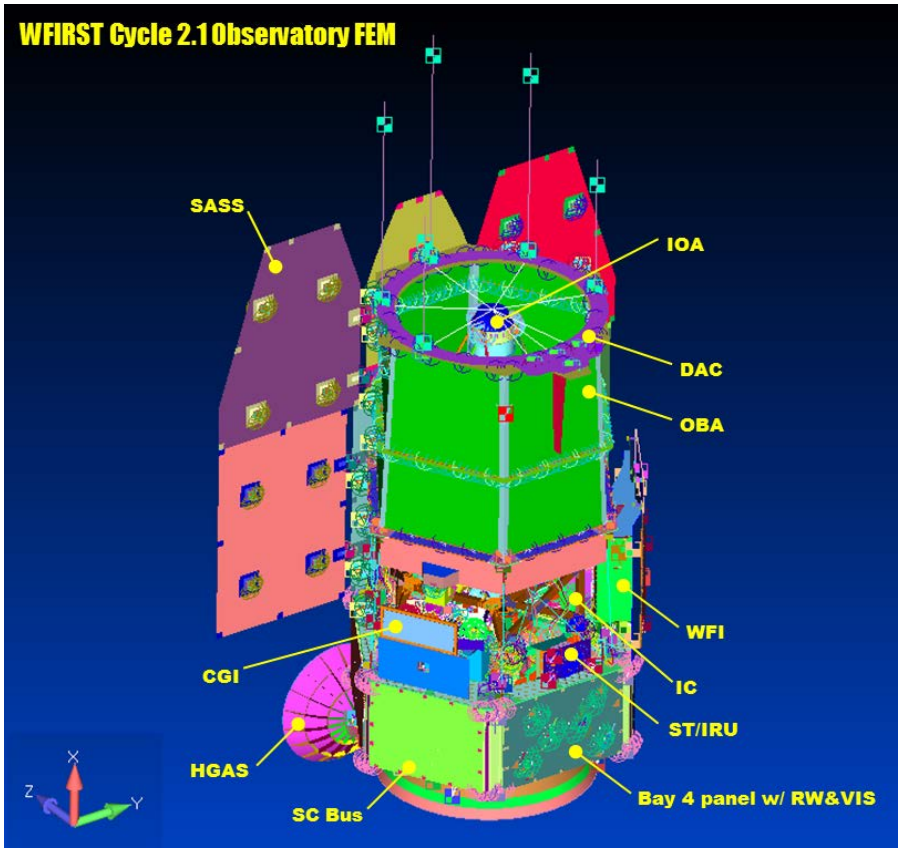
Changes from Phase A that Impact Stability

- Instrument Carrier (IC)
  - Added IC heaters to avoid violating cold and survival limits
    - Currently performing trade study on IC heater options
  - Baselined new LLVIS instead of using inherited WFIRST D-struts
- Optical Telescope Assembly (OTA)
  - Build new secondary mirror support tubes (SMSTs) to have near zero CTE near operating temperature
  - Addition of new Optical Barrel Assembly (OBA) temperature requirements to S/C team
- Wide Field Instrument (WFI)
  - Many design changes occurred since SRR from GSFC in-house Cold Sensing Module (CSM) design to latest Ball CSM design
  - Facility cryo radiator (FCR) eliminated in favor of Mosaic Plate Radiator (MPR)
- Coronagraph Instrument (CGI)
  - Updated optical bench to be more alignment friendly (open top)
  - Undergoing structural redesign with instrument mounting interfaces moved to CGI
- Spacecraft (S/C)
  - OBA no long supports FCR; changed from mechanical thermostat to software control heaters (constant + trim heaters)
  - Composite bus with heat pipes to aluminum Isogrid bus

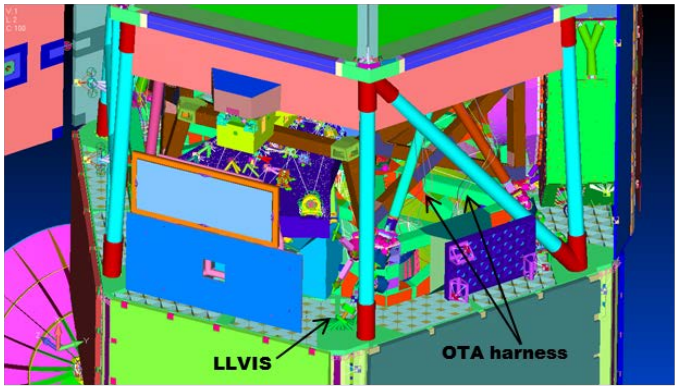
Optical Stability Sensitivity Summary

- WFE stability is dominated by primary mirror (PM) stability and relative stability between secondary mirror and PM
  - Provide thermally stable environment for the telescope drives Optical Barrel Assembly (OBA) temperature stability
  - Maintain telescope optical stability drives Optical Telescope Assembly (OTA) thermal stability and thermoelastic sensitivity
  - Provide dynamic stable environment for the telescope drives Spacecraft and Instrument Carrier (IC) isolation and damping system designs
- Wide Field focus stability can be significantly affected by the index of refraction change due to temperature gradient changes (dn/dT effects)
  - Provide thermally stabile environment for the filters drives element wheel thermal design
  - Working on methods to mitigate this effect
- Both WFE and pupil shear stability are influenced by IC thermal stability since IC can introduce distortion through the FOA struts to the OTA, and through the interface flexures to the instruments
  - Currently performing trade study on IC heater options

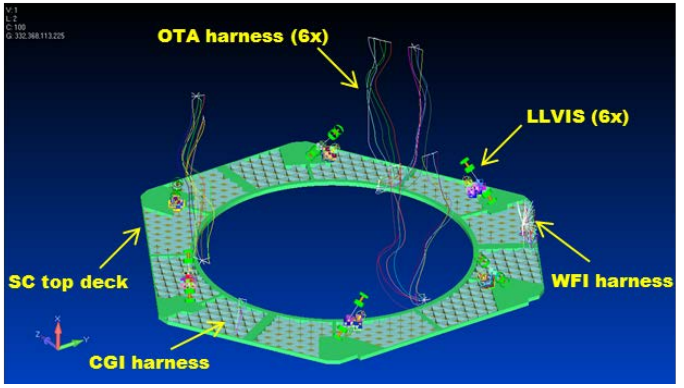
WFIRST Deployed Observatory FEM



Zoom-in view showing locations of LLVIS & harness



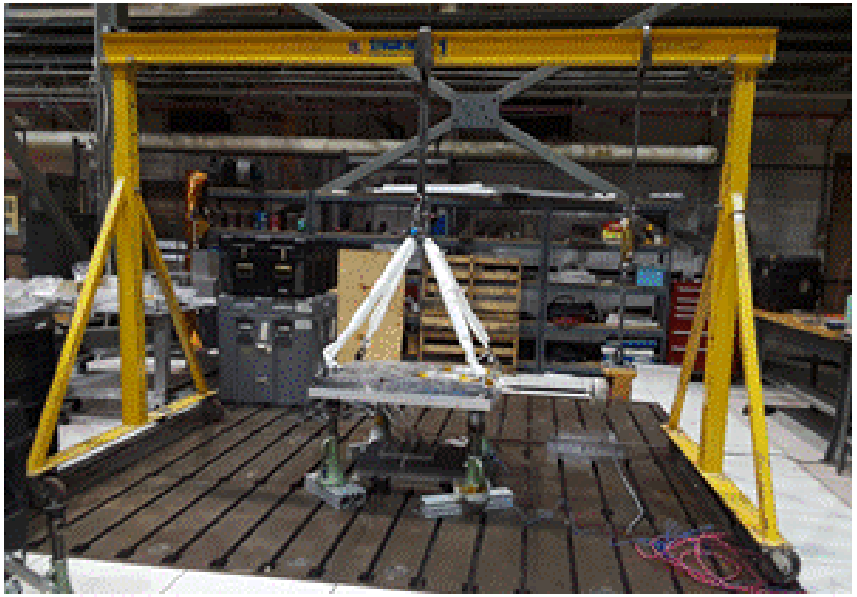
LLVIS & harness models w/ SC top deck



- Key features in jitter model:
  - Reaction wheel & reaction wheel vibration isolation system models in Spacecraft Bay 4
  - High gain antenna system actuator drive model
  - Transition harness models between Payload and Spacecraft based on current design layout & measured JWST harness properties

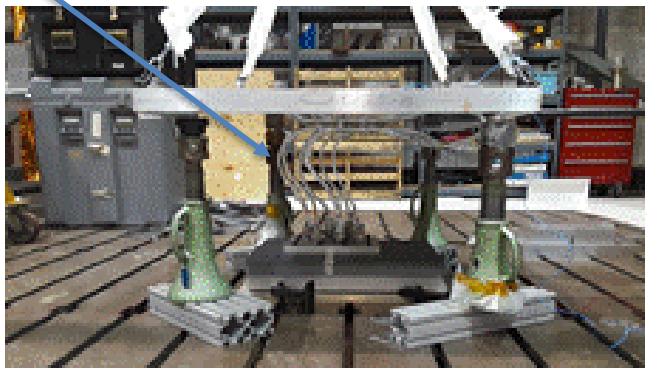
Harness Transmissibility Testing

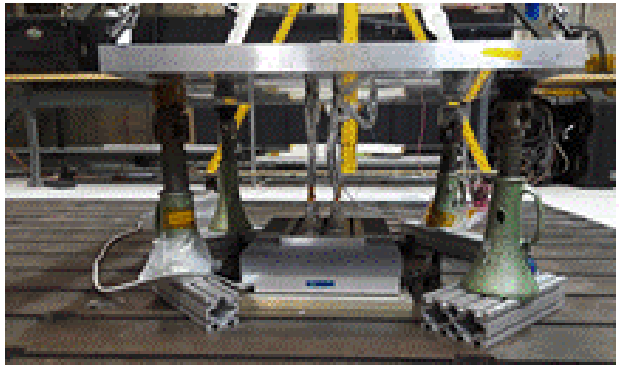
- Completed first round of Harness transmissibility testing
- Working on harness model correlation to test data



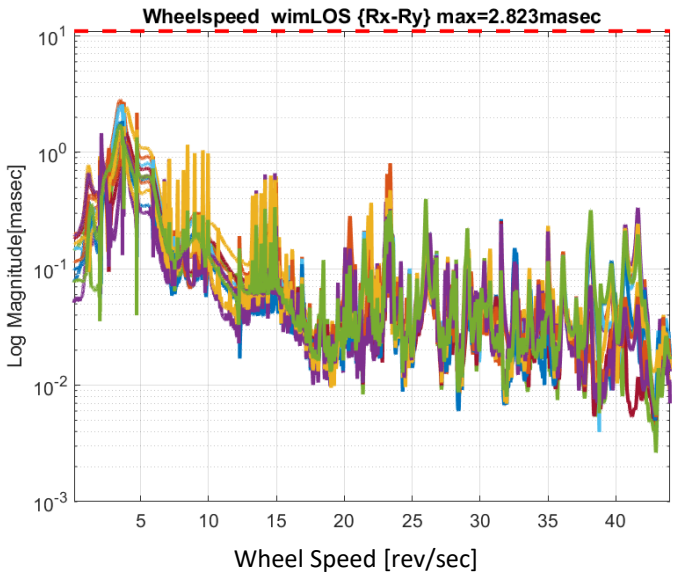
Test data provides harness model correlation information to allow IM team to accurately model WFIRST harness behavior

Test includes flight-like cable bundles

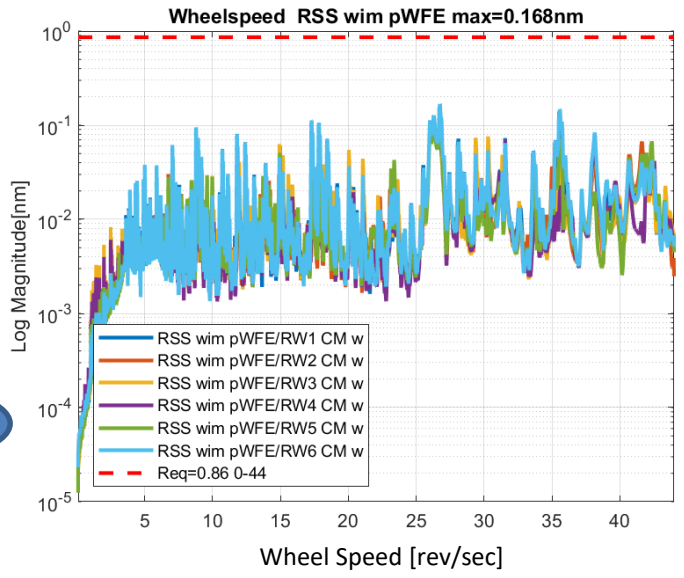


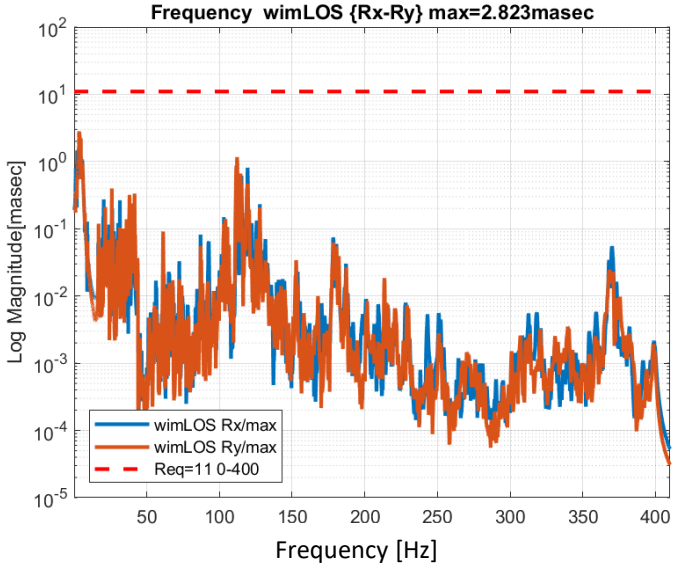


Cycle 2.0 Wide Field Reaction Wheel Jitter

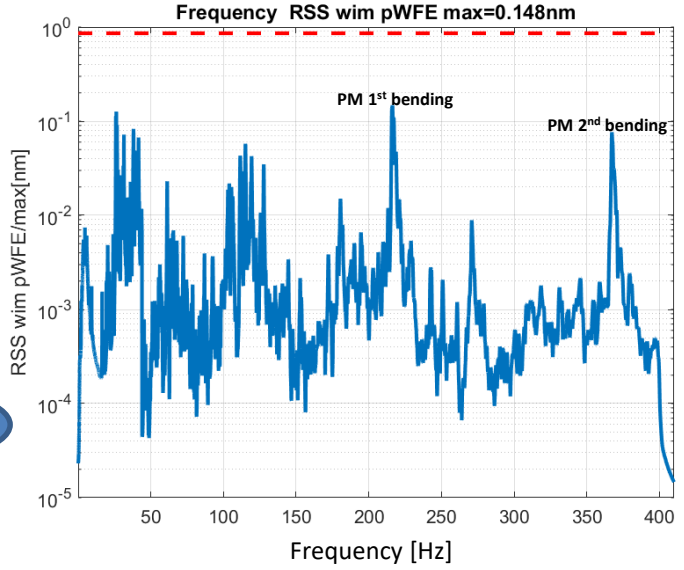


vs wheel speed



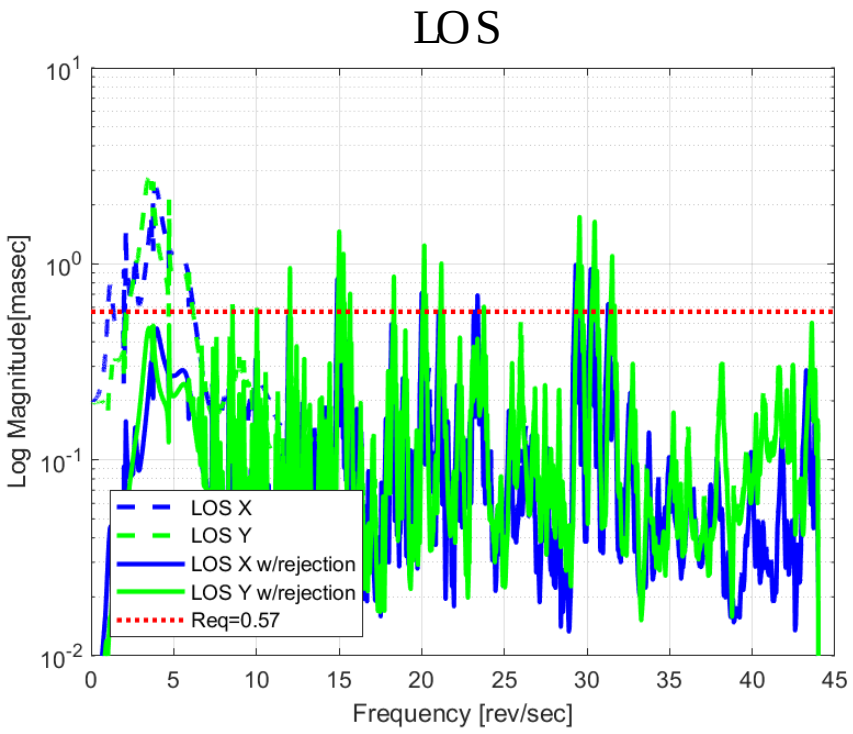


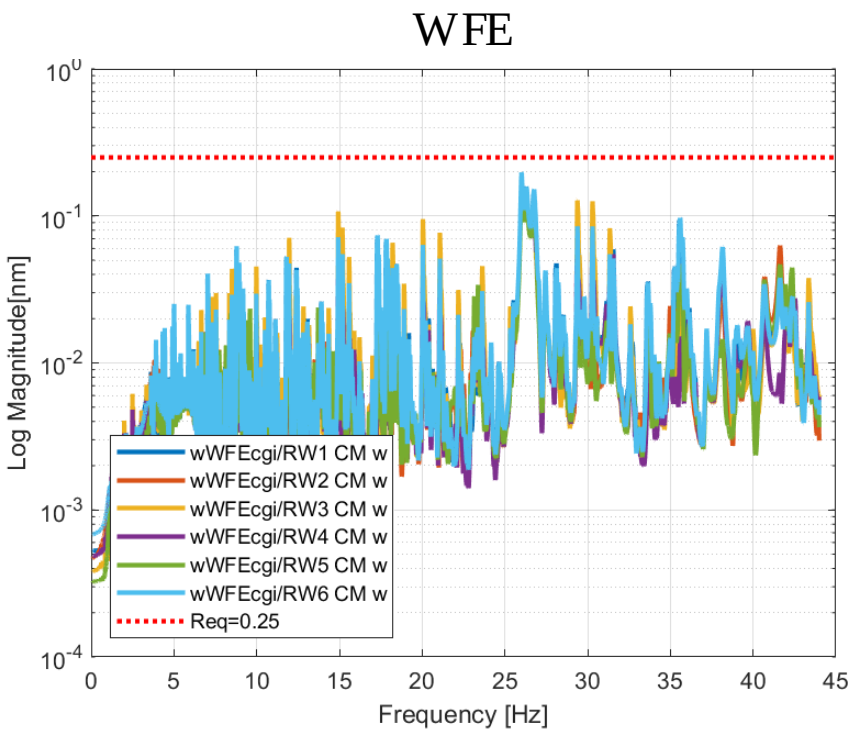
vs frequency



- Wide Field jitter requirements are met with Phase A model uncertainty factor applied

CGI Jitter

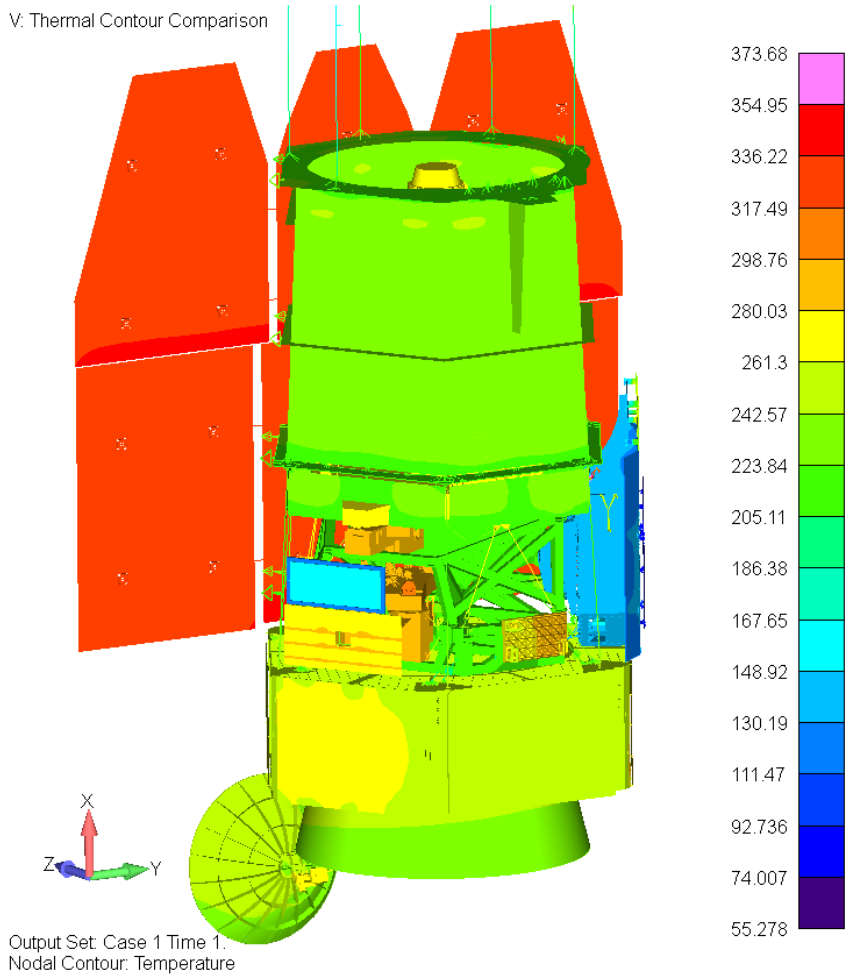




- CGI jitter results include Phase A model uncertainty factor
- LOS jitter requirement can be met if wheel speeds are kept below ~12 rev/sec
- WFE jitter requirement can be met over all wheel speeds

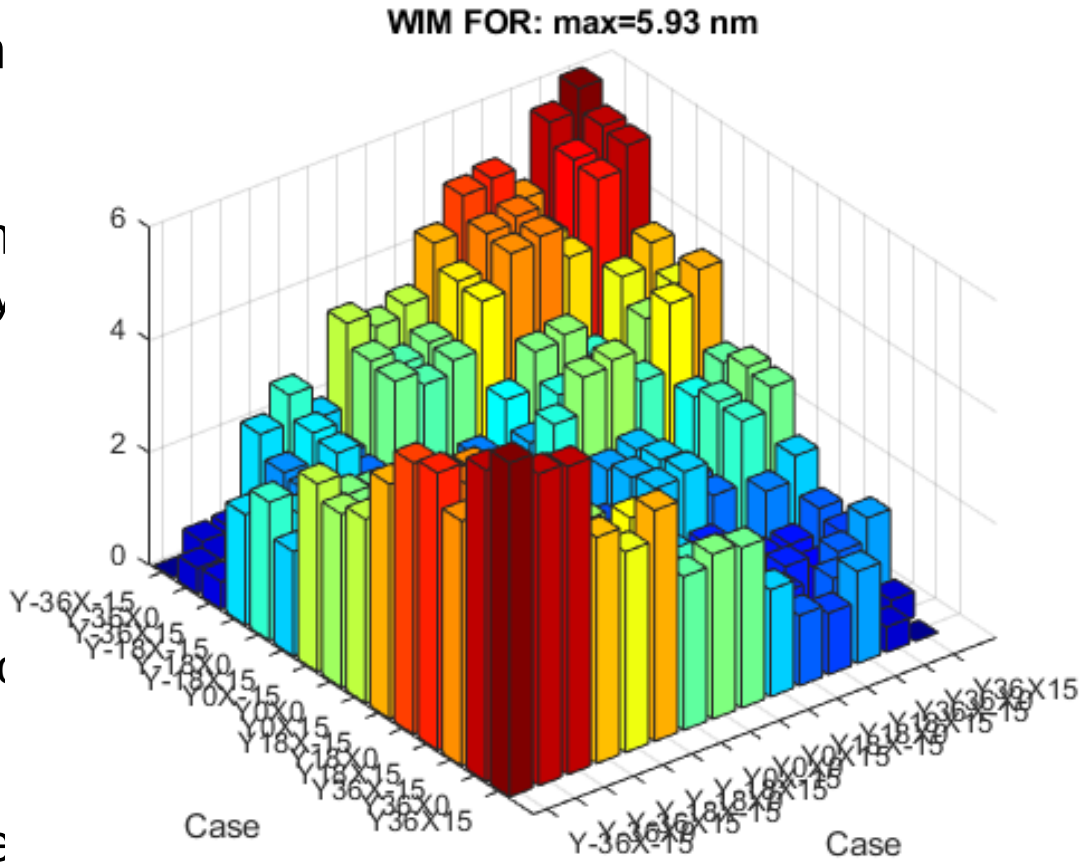
WFIRST Structural-Thermal-Optical-Performance (STOP) Status

- Integrated optical, structural, and thermal models from elements into observatory models, and performed appropriate model checks
- Completed thermal to structural temperature mapping checks
- Completed Wide Field FOR analysis
- Currently running Wide Field worst-case slew and CGI Operation Scenario-8 (OS-8) cases
  - Perform study on $\delta n/\delta T$ (change in filter/Prism/Grism index of refraction with respect to change in temperature gradient)



Wide Field STOP: Field of Regard Results

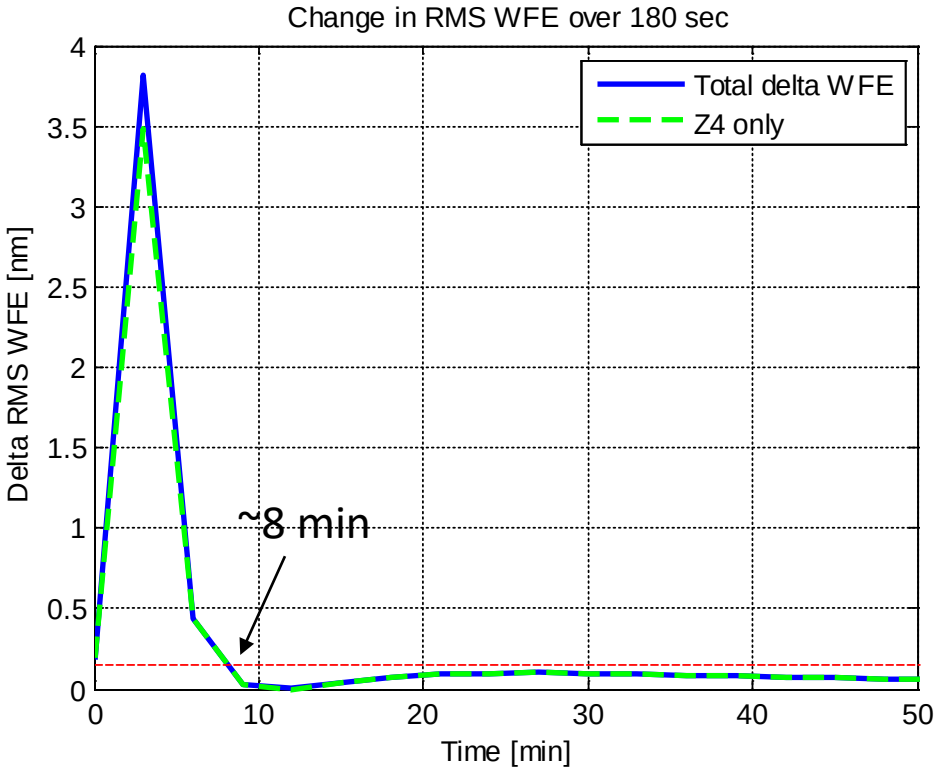
- Select 15 attitude configurations (Y=+/-36, +/-18, and 0 deg, X = +/-15 an 0 deg) to cover the field of regard (FOR)
- Run STOP analysis at each attitude to determine steady state WFE
  - Cooldown compensated
- Determine worst-case slew by differencing 15 steady-state WFE cases
  - Largest change: Y36X15 t Y-36X-15
- Preliminary results show steady-state to steady-state change in FOR introduces small change in WFE



WFI WFE Stability

- WFI wavefront (WFE) stability exceeds current allocation for about 8 min after rotating the filter from stowed to operational position
  - Filter temperature gradient in the non-operational position does not match the gradient developed in the operational position (warm AOM in front and cold detector in back)
  - Change in temperature gradient causes change in index of refraction and introduces mostly focus error

- It may be possible to enhance fitting algorithm to calibrate out the focus error but can significantly complicate fitting algorithm development
- If requirement violation duration can be kept small, it is simpler to ignore the first few exposures after filter is rotated into operational position for Weak Lensing science only
  - WFE stability requirement shall be met for at least 95% of exposures, not all the time
- Working with Ball/WFI on improving WFE stability performance, including reduction of requirement violation time with “reasonable” design changes



Summary and Future Work

- IM analysis work has been progressing well and is on track to support Mission PDR
- Optical performance requirements that are verified by IM have been clearly identified
  - Model validation plans were peer reviewed in June 2019
- Focus going forward is on completing Monte Carlo analyses to validate model uncertainty factors (MUFs) that are applied to all IM results
- Working on completing PDR analyses and presenting results at IM pre-PDR Engineering Peer Review to be held on 9/26-9/27
  - Jitter, STOP (short term and long term performance)
  - WFI filter/Grism/Prism dn/dT effects
  - Gravity release, moisture desorption, and invar growth