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JWST Commissioning Plan

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Commissioning Overview

- **Definition of Commissioning**
 - The collection of all flight activities required to assure that the Observatory is operational and ready to perform Cycle 1 science programs
- **Guidelines**
 - Activation and commissioning of primary units and paths only
 - Contingency procedures are not included in planned commissioning activities
 - No verification of requirements during commissioning
- **When does JWST commissioning occur?**
 - Begins at launch
 - The planned commissioning phase shall end no later than six months after launch (Level 2 requirement)
- **Observatory Commissioning Plan (JWST-PLAN-002040)**



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Commissioning Plan Development

- **Commissioning Activity Requests (CARs)**
 - Descriptions of all activities required for commissioning
- **Commissioning Timeline Working Group (now called the CAR Adjudication WG) Adjudicates CARs**
 - WG oversees, maintains, and controls all aspects of the timeline
 - CARs reviewed monthly by a CCB Controlled Board (since 2004)
- **Commissioning Timeline is produced**
 - Defines execution sequence of CARs
 - Initially (and currently) in Excel spreadsheet form
 - Eventually (and soon) as a Commissioning Activity Sequence Timeline
 - a set of instructions to be executed by command controllers in the MOC



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Commissioning Plan Implementation

- **Mission Ops Document (MOD) Squads**
 - Reviews details of sequence of events to perform each SC, Deployment and OTE Engineering CAR
 - Controlled by NGAS
- **Flight Product Reviews**
 - Reviews Standard Operating Procedures (SOPs) and Real Time Command Procedures (RTCPs)
 - Controlled by STScI instrument engineers
- **WFS&C Operations Working Group**
 - Refined & finalized ops plans and implementations
 - Core team of wavefront scientists who will carry out OTE commissioning
- **Proposal Implementation Team (PIT) Reviews**
 - Reviews CARs and APT files for Wavefront and SI activities
 - Controlled by STScI
- **Contingency Operations (COPS) WG**
 - Ensures all commissioning contingency scenarios have been addressed
 - Controlled by NGAS
- **Updates folded back into the Commissioning Timeline**

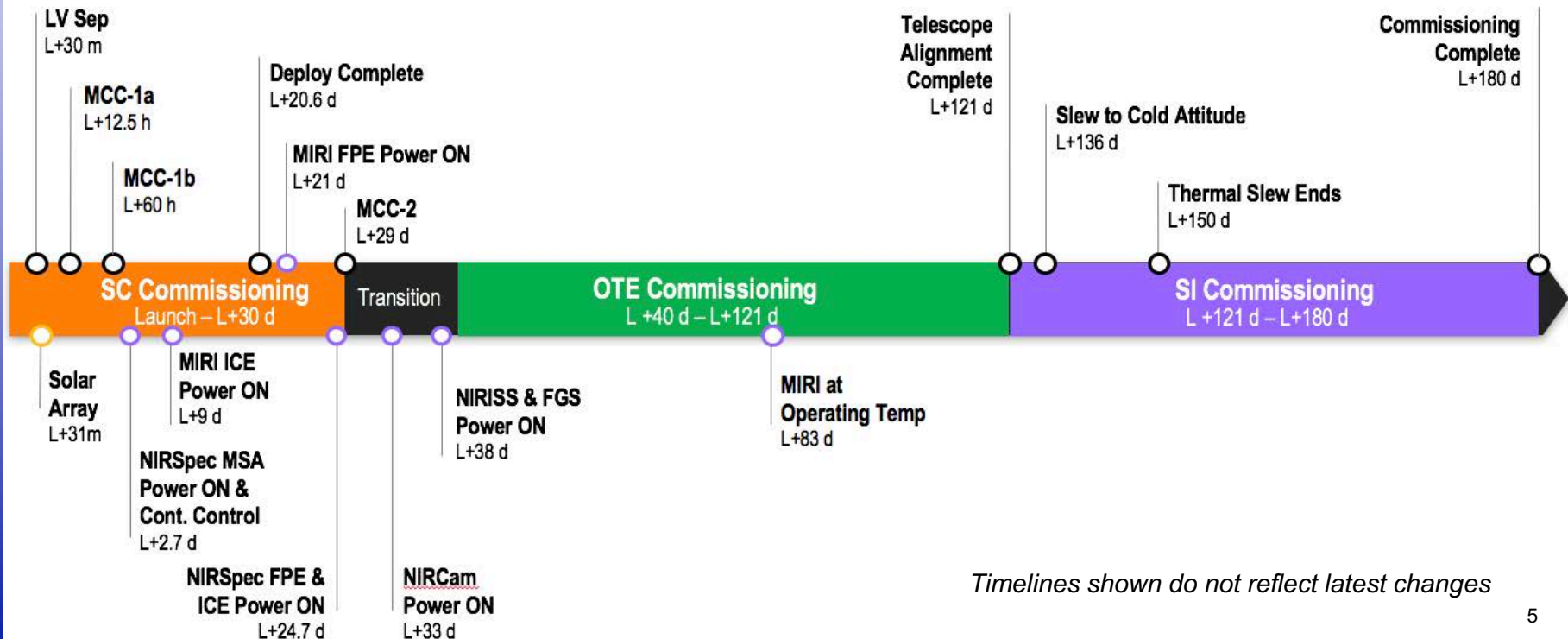


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Observatory Commissioning Phases

- **Spacecraft (SC) Commissioning**
 - Launch to Post MCC-2 burn activities (L+30d)
- **Thermal Cooldown**
 - Cooldown heaters enabled (L+45min) to MIRI reaching operating temp (L+83d)
- **Transition**
 - MOT shift cadence changes, OPE is activated and Observatory is transitioned to OPE control
- **Optical Telescope Element (OTE) Commissioning**
 - NIRCam reaches <80K (L+40d) to Telescope alignment (L+121d)
- **Science Instrument (SI) Commissioning**
 - Telescope alignment to completion of SI activities (L+166d)



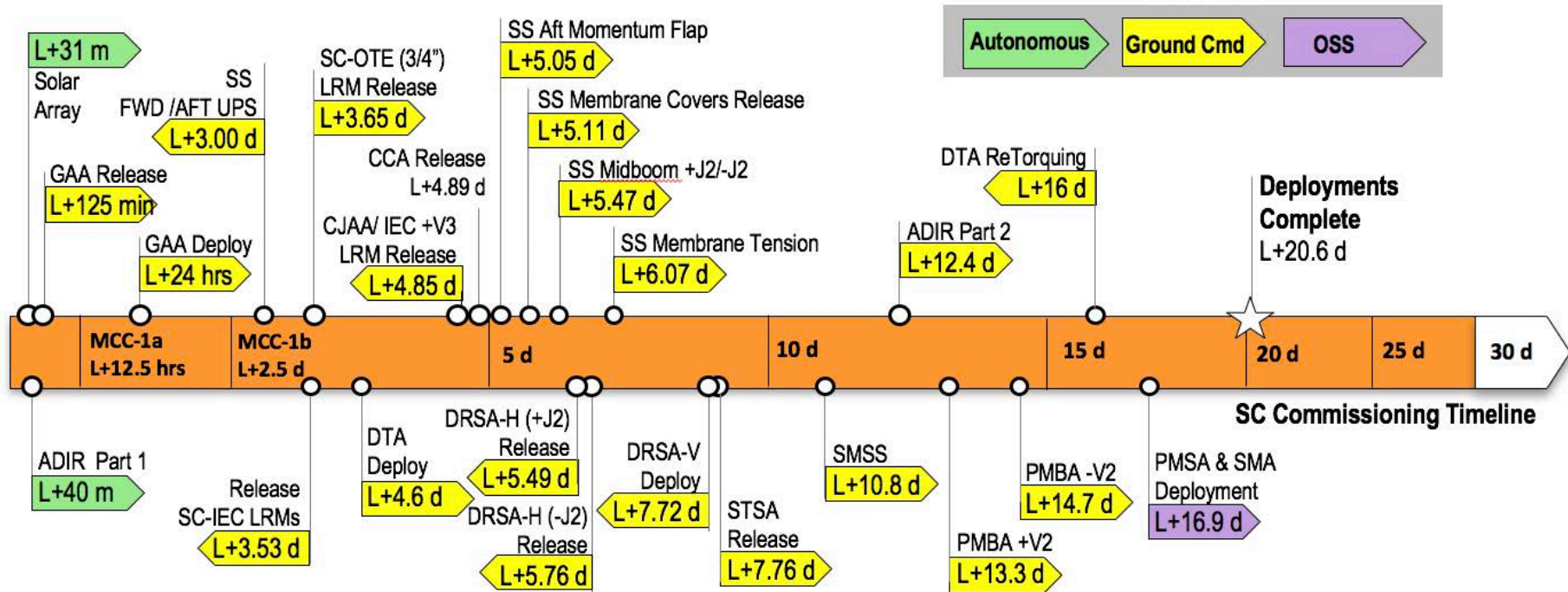


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Deployment Activities

- All deployments will be planned during continuous real-time contacts
- Momentum levels checked prior to starting each major deployment
- All commanding must withstand a break in the command sequence

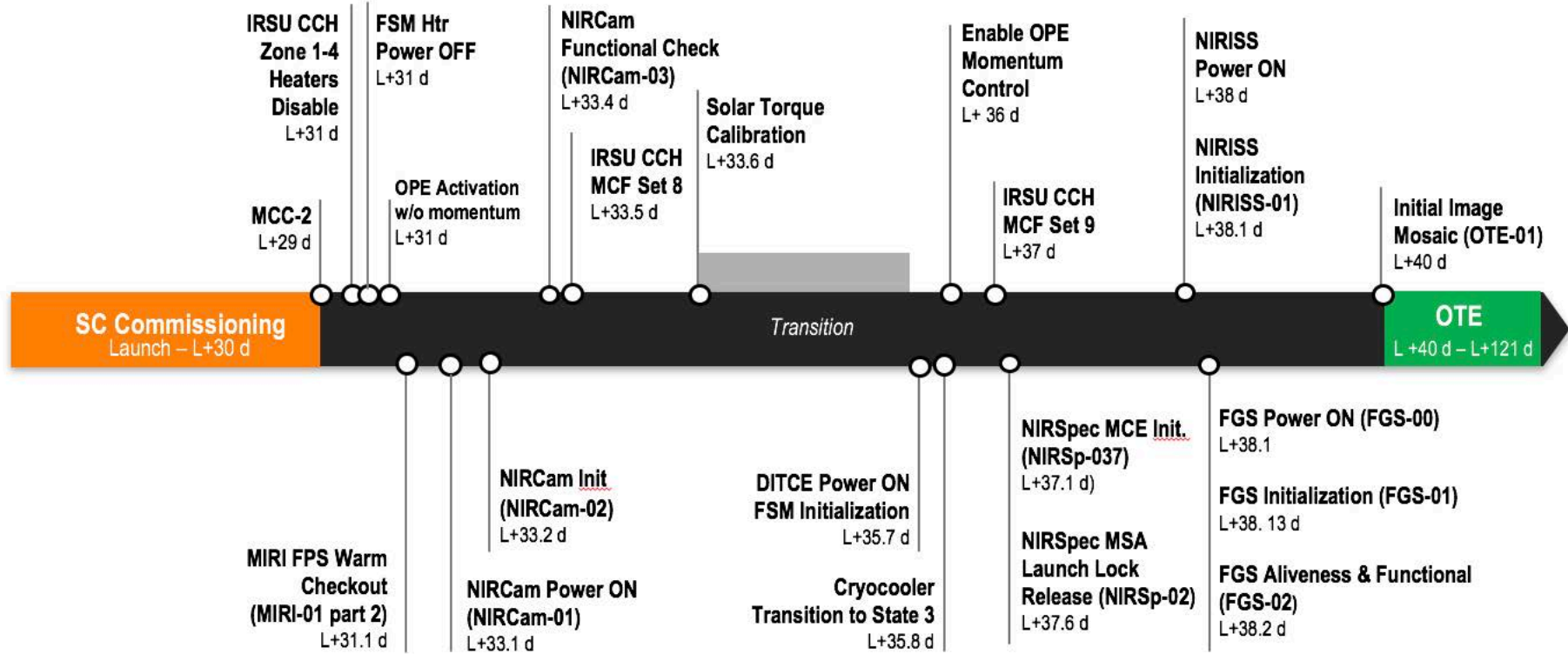




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Transition Period



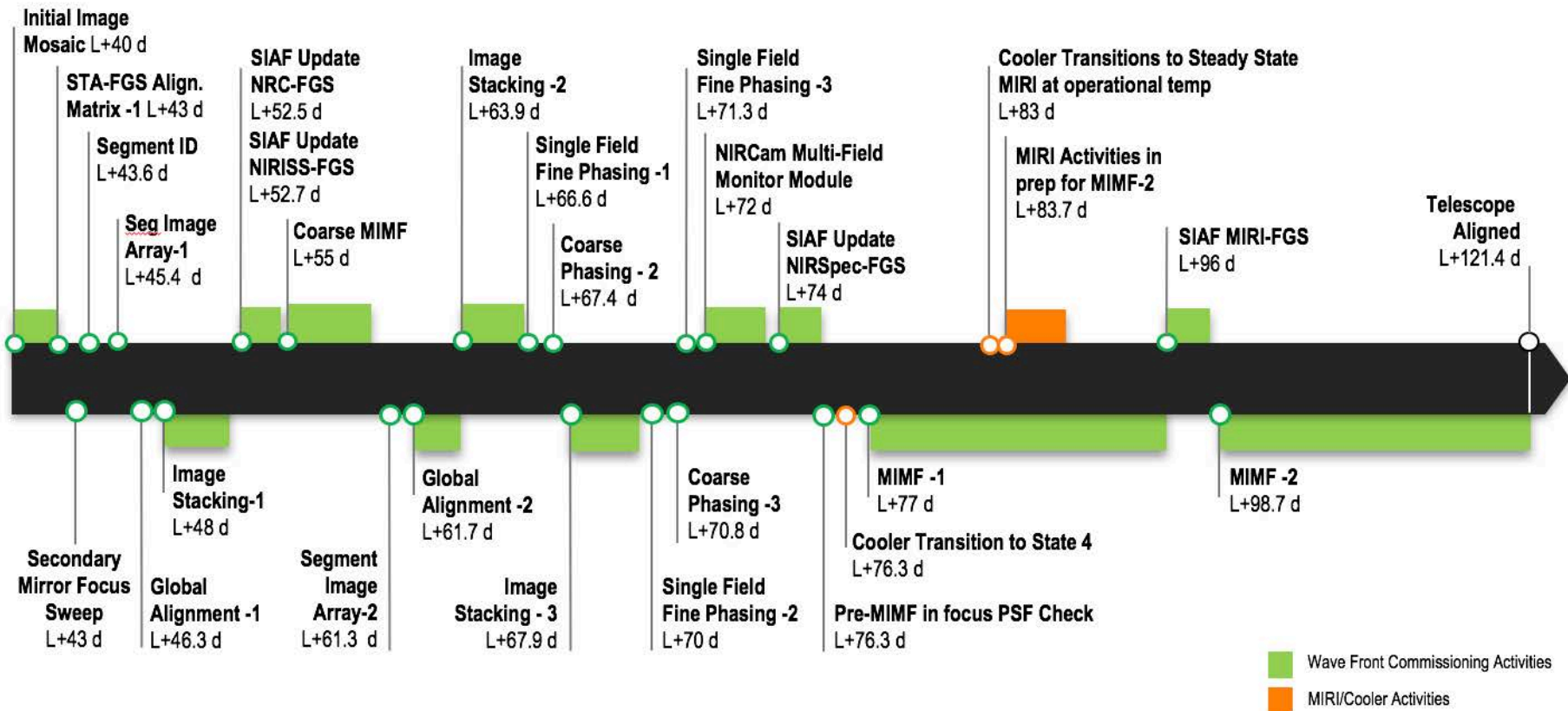


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OTE Commissioning

- **WFS&C activities are primarily (but not entirely) during OTE Commissioning phase**
 - Mirror deployments occur before that
 - Wavefront Maintenance continues after
- **WFS&C is interdependent on and interspersed with early steps of SI activation & commissioning**





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WFS&C Commissioning Major Stages

OTE Commissioning Stage	Goal	Timeline (days)
Segment Deployments	release segments from launch positions	<i>L+16 to 18</i>
Segment Location & Identification	determine rough positions post-deployments	<i>L+40 to 45</i>
Segment-level wavefront control	minimize wavefront error within each segment	<i>L+45 to 61</i>
Co-phasing the segments	bring segments to alignment as seen from NIRCam	<i>L+61 to 72</i>
Multi-Instrument Multi-Field	achieves good alignment as seen from all SIs	<i>L+72 to 81</i>
<i>Repeat last 3 stages above as necessary to iterate to convergence.</i>		<i>L+81 to 121</i>
Thermal Stability Assessment	starts characterizing on-orbit stability	<i>L+134 to 150</i>
Monitoring and Maintenance	ensures alignment over time	<i>rest of mission</i>

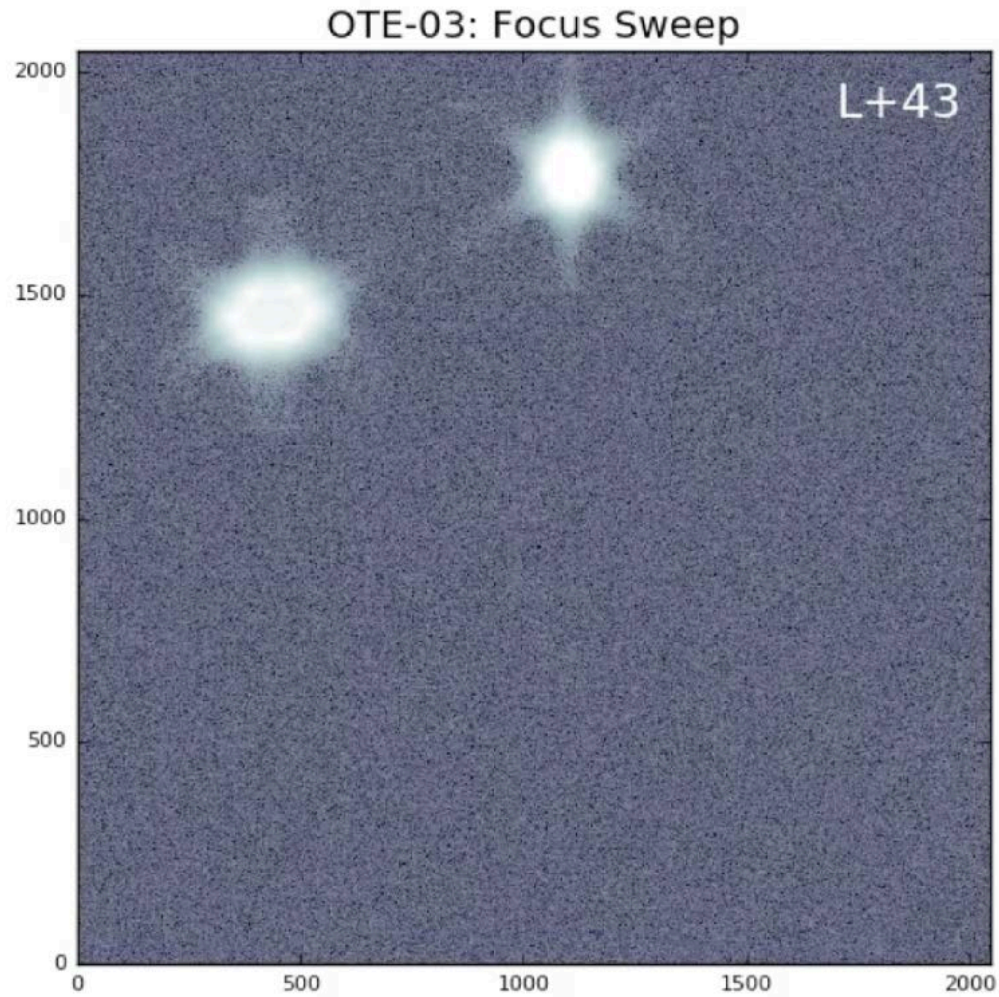
- **About two dozen distinct activities, most iterated multiple times, over approx. 80 days**
- **Interspersed with early steps of SI & FGS commissioning**
- **Timeline duration based on estimated iterations of each step derived from detailed optomechanical error budgets and simulations**
- **Maintenance and trending throughout mission to control wavefront error**
 - 2 day sensing cadence, 14 day nominal control cadence



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OTE Commissioning Simulation Movie



Example OTE commissioning sequence from Integrated Telescope Model simulations.
Only NIRCam SCA A3 shown for clarity.

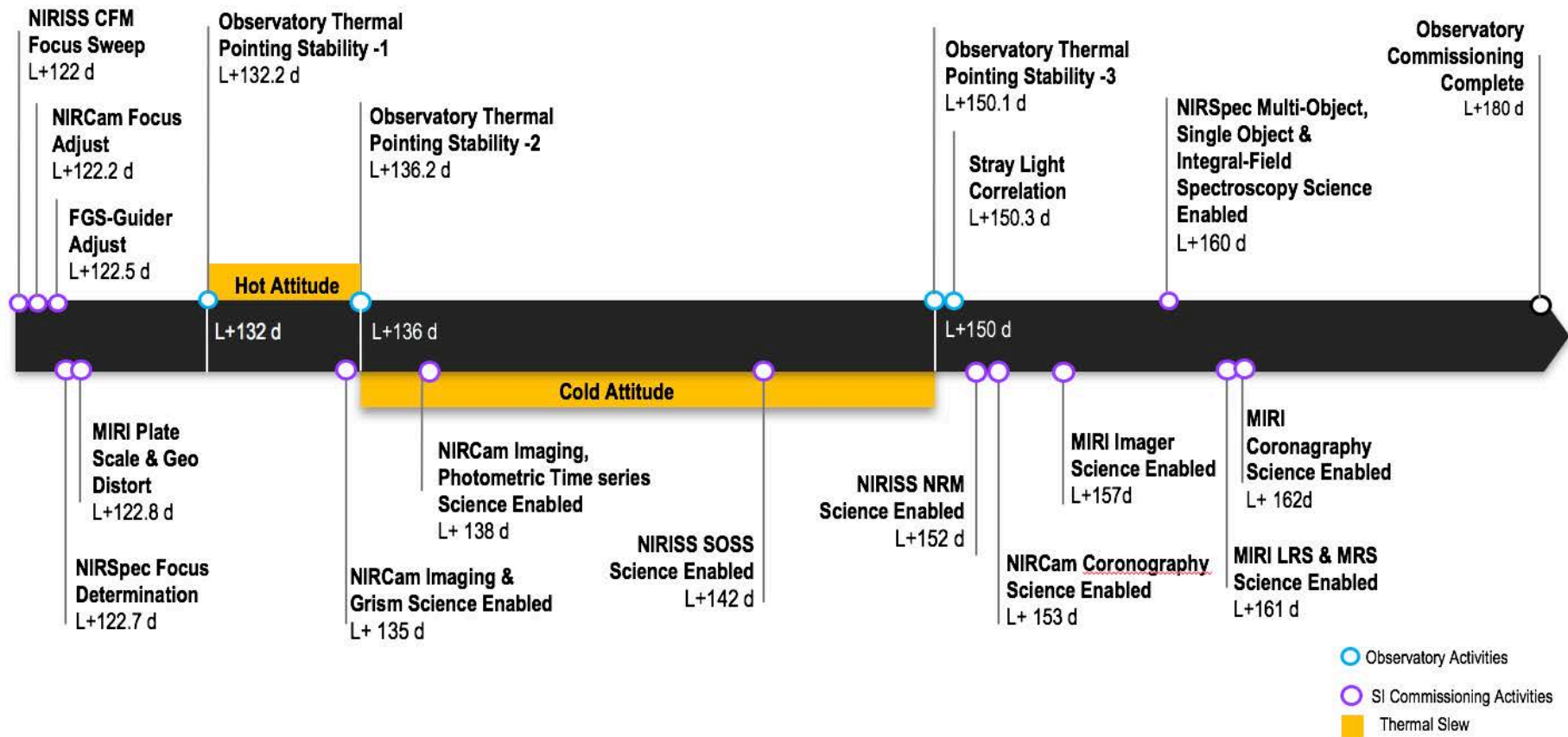


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Science Instrument Commissioning

- 136 SI Commissioning Activity Requests
- Cycle 1 science will start mode-by-mode
 - Some modes are hard and may take longer than other
- Some ground-derived calibration reference files will be in use as we enter Cycle 1
 - Full SI calibration/characterization executed in Cycle 1
 - Some calibration reference files cannot be obtained on ground



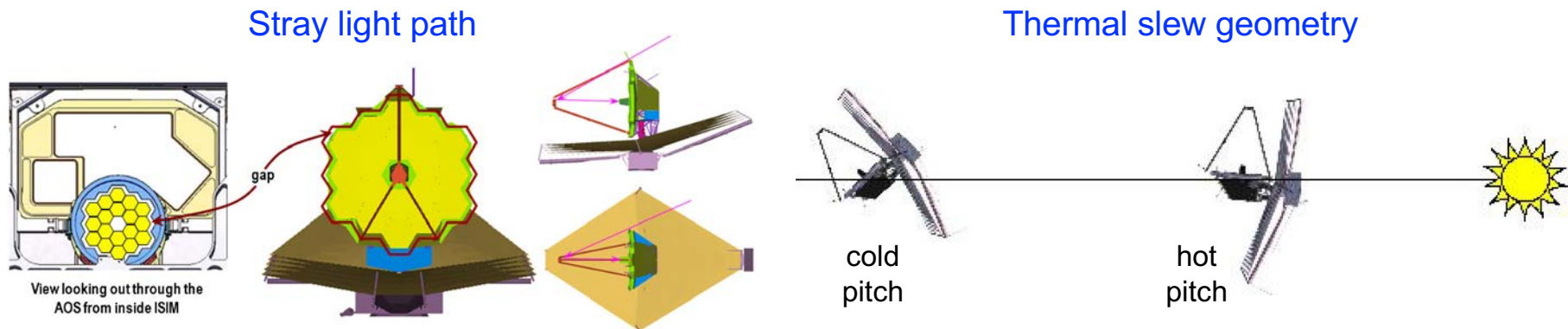


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Non-SI Specific CARs

- Moving targets
 - Required for solar system observations
- Stray light CAR
 - Characterize stray light backgrounds (zodiacal, galactic) and compare with models
- Thermal Slew CAR
 - correlates observatory thermal and telescope emission models
 - provides data to inform WFS&C cadence
- Stray light and thermal slew performance affects signal-to-noise of science observations





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Replans and Response to Problems

- APT/OSS/PRDB/VSS teams will support required changes
 - Small changes may take hours. Will assume 12 hour turnaround for planning purposes. Example: table update to change waveform driving the MIRI filter wheel.
 - Larger changes may take a few days. Example: change in end of visit instrument configuration.
- Commissioning leads are prepared to make rapid adjustments to timeline and disseminate the changes
- All plan changes must be approved by Ops CCB and all script changes tested on the Observatory Test Bed simulator



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Closing Thoughts

- **JWST commissioning plan is result of ~15 years of preparation**
- **By necessity, it involves all components of the observatory**
 - Spacecraft, OTE, science instruments, guiders, ISIM engineering
- **Our skill in operations will be a key to success**
 - Interactions with OTE & SI teams, PPS and command controllers
 - We must be adaptable to problems and changes
- **Wavefront Rehearsal will be an important test for commissioning team**
 - 8-day exercise in November
 - Most activities are WFS&C related but all SIs have some activities
 - Will test our interfaces and procedures