JWST Observatory & Commissioning

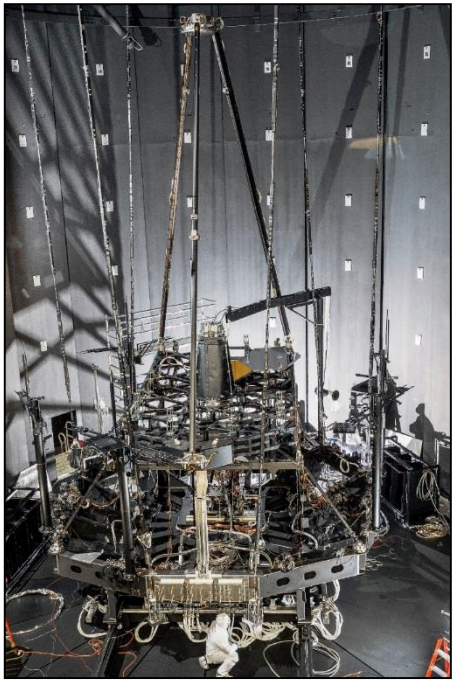
Michael McElwain & Chuck Bowers
JWST Observatory Project Scientist
March 18, 2016

Overview

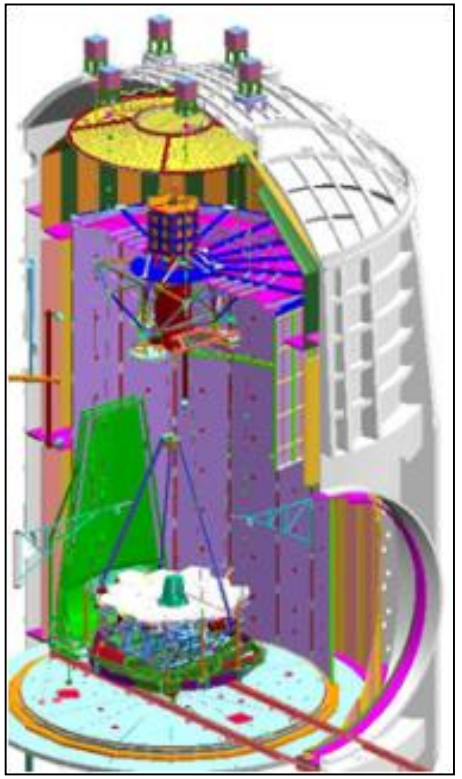
- Acrylic Adhesive Recap
- Reaction Wheel Update
- OTIS System Integration
- JWST Commissioning

Tertiary Cleaning & Adhesive Particles

- Flight tertiary mirror (TM), part of the AOS, was successfully cleaned following the OGSE-2 test.
- Comprehensive review of the the TM particulates led to identification of acrylic adhesive particles, which was not seen before.
- Several adhesive particle source containment efforts were successfully completed which then enabled the AOS installation.
- Observatory reach-across efforts underway to identify and mitigate future susceptibility to acrylic adhesive particulation.



JWST Pathfinder configuration for OGSE-2 inside JSC's Chamber A (2015)



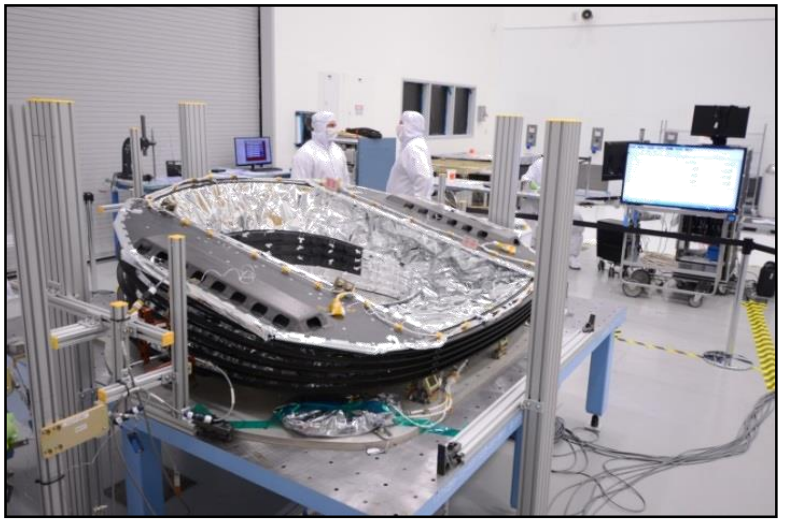
JWST configuration for OTIS cryo-test inside JSC's Chamber A (2017)

***See full adhesive review on NGIN here:**
https://ngin.jwst.nasa.gov/displaydoc.asp?RevisionNum=LATEST&doc=029351.pptx

Acrylic Adhesive Observatory Reach Across

- Cross-discipline NGAS team meeting twice per week to assess acrylic foreign object debris (FOD) across the Observatory
  - Hinge joints, sensors
  - Core2
- Detailed inspection of JSC facility on-going
  - ACF, USF, PG cameras, SMSS, CMUs
  - Thermal Pathfinder will be visually and photographically inspected before and after the test for adhesive fallout.

JWST Flight Core at NGAS/M2



OTE Cleanliness Reqs. Throughout I&T

Hardware Residing In/On Flight OTE	Initial Delivery to NGAS / I&T		Delivery to I&T at GSFC (SSDIF)		Delivery to OTIS I&T at SSDIF		Delivery to OTIS I&T at JSC		Delivery to Observatory I&T at NGAS		NGAS to NASA Handoff		EOL [8]	
	PAC	NVR [Å]	PAC	NVR [Å]	PAC	NVR [Å]	PAC	NVR [Å]	PAC	NVR [Å]	PAC	NVR [Å]	PAC	NVR [Å]
Optical Assemblies														
PM (PMSA Average) [1][12]	0.04	100	0.050	105	0.270	120	0.420	135	0.620	185	1.047	250	1.5	300
SMA [1]	0.04	100	0.050	105	0.090	120	0.140	135	0.240	185	0.455	250	0.5	300
AOS														
TMA [1]	0.04	100	0.15	125	0.190	140	0.240	155	0.340	205	0.455	250	0.5	300
FSM [1]	0.04	100	0.15	125	0.190	140	0.240	155	0.340	205	0.455	250	0.5	300
AOS Interior Surfaces	0.04	100	0.15	125	0.190	140	0.240	155	0.340	205	0.455	250	0.5	300
AOS Exterior Surfaces	0.04	100	0.050	105	0.270	120	0.420	135	0.620	185	1.047	250	1.5	300
Structure and Mechanisms (PMBA, SMSS)														
Structure Interior Surfaces	0.04	100	0.050	105	0.270	120	0.420	135	0.620	185	1.047	250	1.5	300
Structure Exterior Surfaces	0.04	100	0.050	105	0.270	120	0.420	135	0.620	185	1.047	250	1.5	300
Mechanisms [5]	0.04 [10]	100 [10]	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	N/A	N/A
DTA														
Structure Interior Surfaces	0.04	100	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	N/A	N/A
Structure Exterior Surfaces	0.04	100	0.050	105	0.270	120	0.420	135	0.620	185	1.047	250	1.5	300
Cable Trays	0.04	100	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	N/A	N/A
Mechanisms [5]	0.04 [10]	100 [10]	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	N/A	N/A
Cryocooler [2]														
Cryocooler RLDA Exterior	0.04	100	0.050	105	0.270	120	0.420	135	0.620	185	1.047	250	1.5	300
Cryocooler RTSA, HTSA	0.04	100	0.050	105	0.270	120	0.420	135	0.620	185	1.047	250	1.5	300
Thermal Management / TMS [6]														
Insulation, Blankets, Closeouts, PMBA Closeout, Shields, Bib, Doghouses, etc [1]	VC-UV	100	VC-UV	105	VC-UV	120	VC-UV	135	VC-UV	185	VC-UV	250	N/A	300
Radiators (ADIR, FIR, etc) [1]	0.04 [10]	100 [10]	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	N/A	N/A
Cryogenic Electronic Boxes/Assemblies [7]														
Interior Surfaces	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	N/A	N/A
Exterior Surfaces	0.04	100	0.050	105	0.270	120	0.420	135	0.620	185	1.047	250	1.5	300
Other OTE Hardware														
Cryogenic Harnesses/Cables [4]	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	N/A	N/A
S/C Far Omni Assembly [3]	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	VC-UV	N/A	N/A

OTE & ISIM Complete → On to OTIS

- The OTE integration now complete.
  - Flight OTE completed on March 8, 2016.
  - ISIM Pre-ship Review from March 8-10, 2016
- Primary mirror comprised of 18 segments completed on February 2, 2016
- Secondary mirror installed on February 29, 2016.
- Aft Optics Subsystem installed on March 6, 2016.

Secondary Mirror Installation

Aft Optics Subsystem

JWST OTE

JWST/OTIS Responsibilities

James Webb Space Telescope System

Mission Systems Engineering

Launch Segment

Ariane Launcher

- Launch Vehicle
- Payload Adapter
- Launch Site Services

Observatory Segment

JWST Observatory

- Optical Telescope Element (OTE)
- Integrated Science Instrument Module (ISIM)
  - NIRCam
  - MIRI
  - NIRSpec
  - FGS
- OTIS – Integrated OTE & ISIM
- Spacecraft Element (SE)
  - Spacecraft Bus
  - Sunshield
- Observatory I&T

Ground Segment

Deep Space Network

Space Telescope Science Institute

- Science and Operations Center (SOC)
- Institutional Systems
- Common Systems

Provided by NASA/GSFC
Provided by NGAS
Provided by STScI
Provided by ESA
Provided by CSA

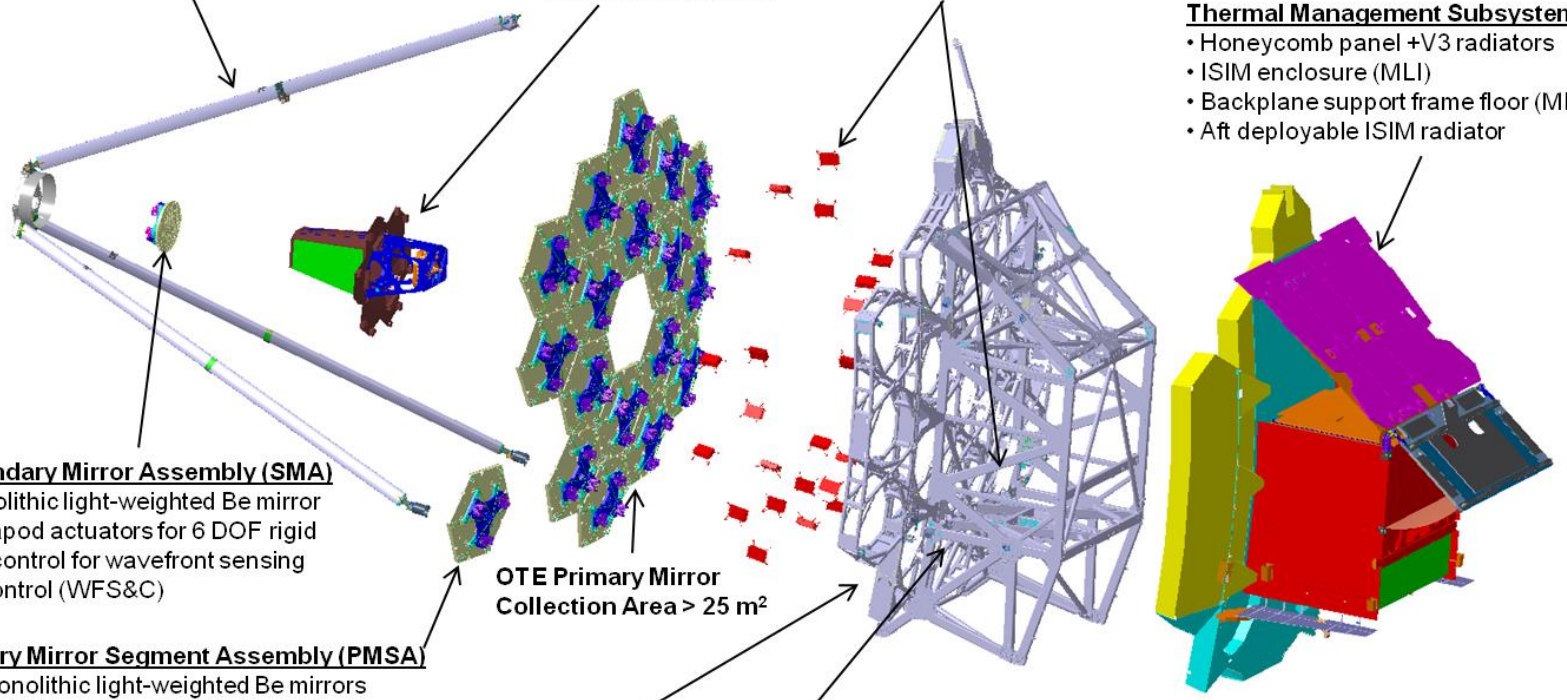
OTE Architecture

Secondary Mirror Support Structure (SMSS)
- Deployable four-bar linkage strut assembly
- M55J composite tube struts

Aft Optics Subsystem (AOS)
- Fixed tertiary mirror
- Fine steering mirror
- Baffle and pupil mask

Electrical Subsystem
- 21 cold multiplexer units
- Cold junction box
- Fine steering mirror control electronics

Thermal Management Subsystem (TMS)
- Honeycomb panel +V3 radiators
- ISIM enclosure (MLI)
- Backplane support frame floor (MLI)
- Aft deployable ISIM radiator



Secondary Mirror Assembly (SMA)
- Monolithic light-weighted Be mirror
- Hexapod actuators for 6 DOF rigid body control for wavefront sensing and control (WFS&C)

OTE Primary Mirror Collection Area > 25 m²

Primary Mirror Segment Assembly (PMSA)
- 18 monolithic light-weighted Be mirrors
- Hexapod actuators for 6 DOF rigid body control (WFS&C)
- Actuator for ROC control (WFS&C)

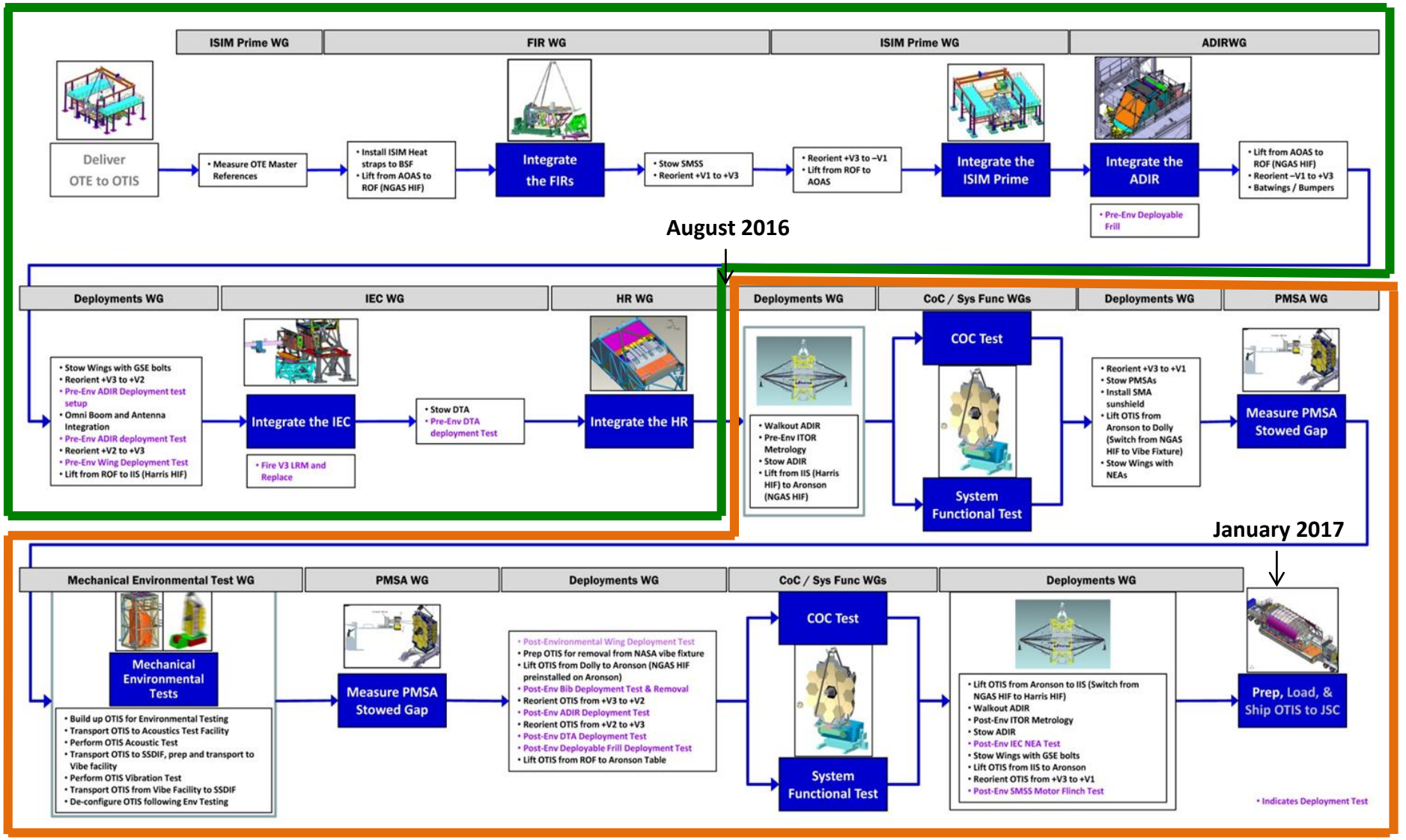
Primary Mirror Backplane Assembly (PMBA)
- M55J composite tube frame construction
- Fixed center section with torque box design
- Two deployable wings

Deployable Tower Assembly (DTA)
- Deployable telescoping tube
- Two deployable harness trays
- Cryocooler line accommodation

Thermal Management Subsystem
- Deployable "batwings"
- Fixed diagonal shield
- Deployable stray-light "bib"
- PMBA thermal management (SLI)

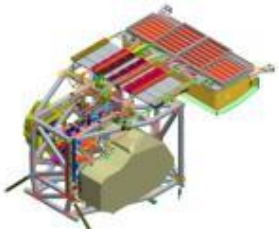
Isolator Assembly (IA)
- 1 Hz passive isolators
- Tower support

OTIS Integration & Test @ GSFC



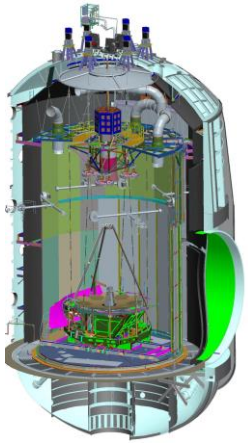
JWST Integration & Test Flow

We are here!



ISIM I&T
Completed

OTIS I&T
Cryo Optics Test
Completes 2017



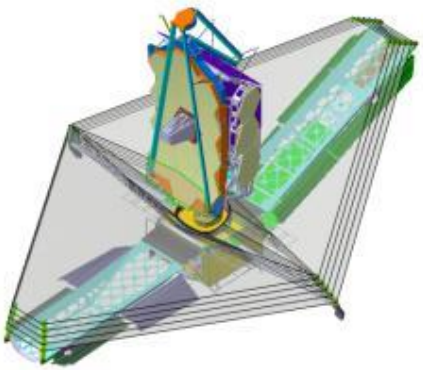
OTE Structure I&T
Completed

OTE I&T
Completed

OTE Pathfinder Structure
Completed

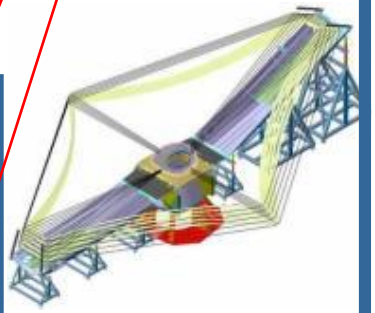
Pathfinder Optics Integration
Completed

Pathfinder Cryo Optics & Thermal Tests
Completes 2016



Observatory EM Test Bed (EMTB)
Completed

Propulsion Module I&T
Completed



Spacecraft Panel I&T
Completes 2016

✓ Sunshield Pathfinders (EPF/IVA)
Completed

Sunshield I&T
Completes 2017

Spacecraft Element I&T
Completes 2017

Complete Observatory I&T
Completes 2018

Launch Site I&T
Completes 2018

LV Integ

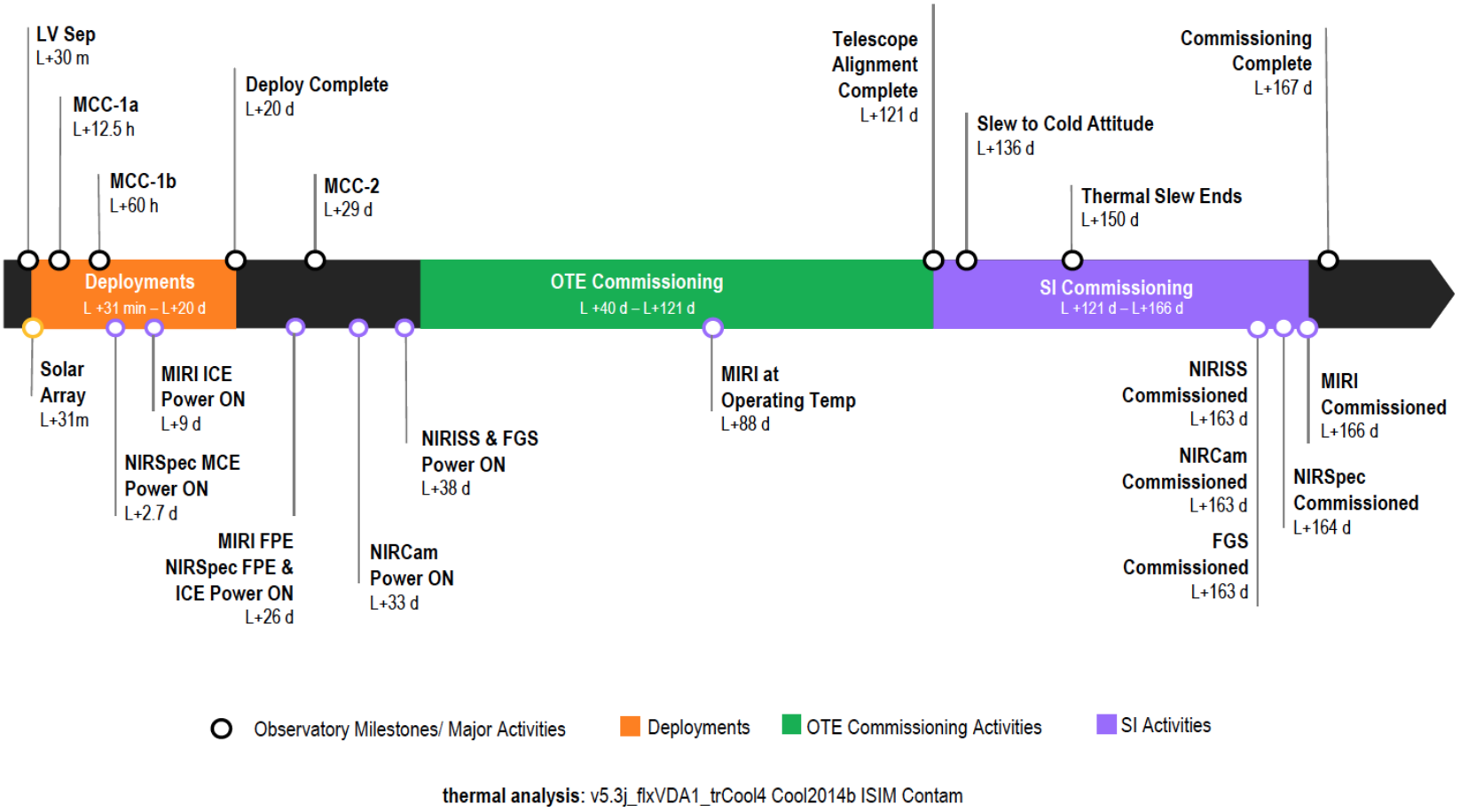
Launch

Oct. 2018

I&T Responsibility

	Execution	Facility
GSFC		
JSC	N/A	
NGAS		
ITT		
ESA / Arianespace		

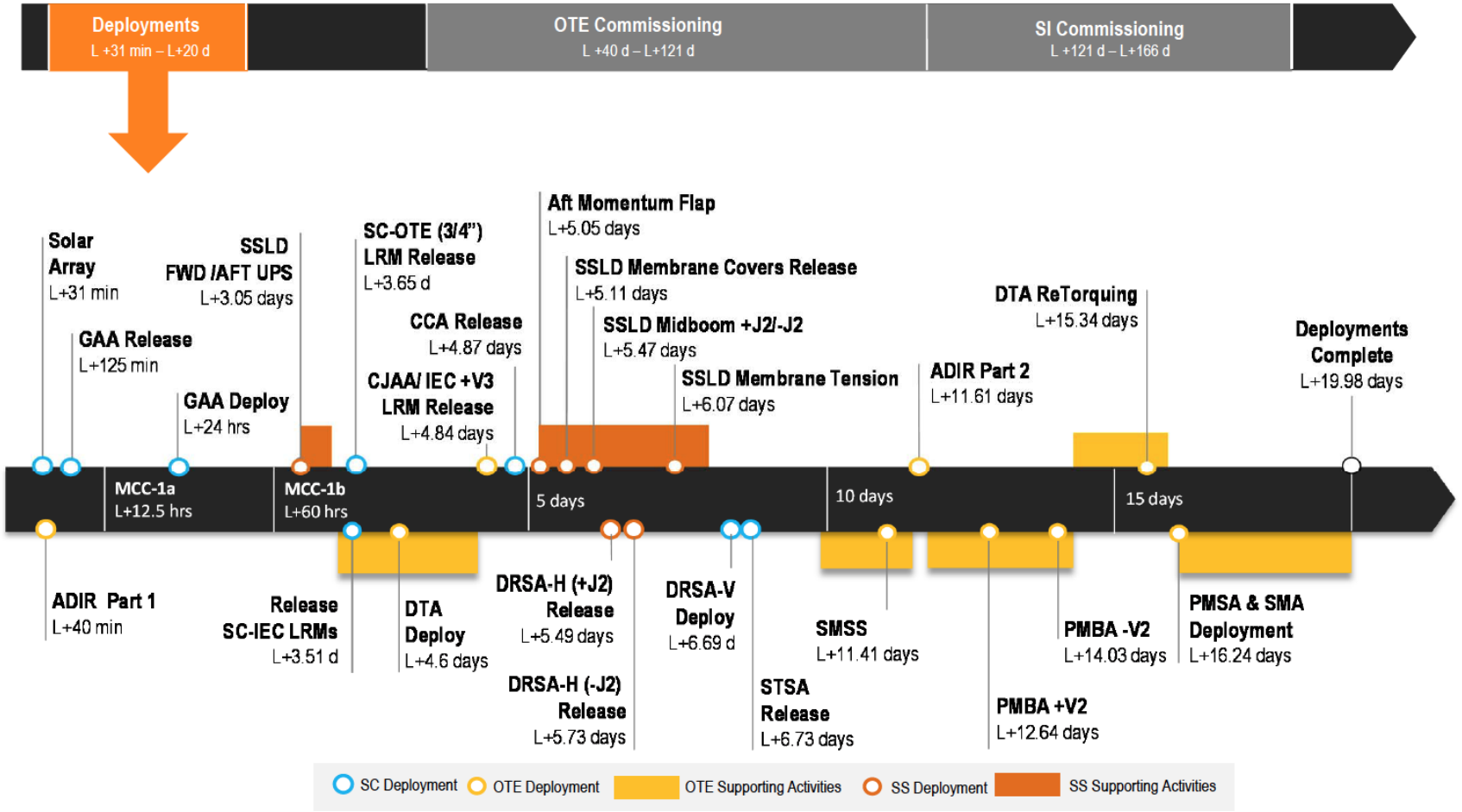
JWST Commissioning: 2015 Timeline



thermal analysis: v5.3j_flxVDA1_trCool4 Cool2014b ISIM Contam

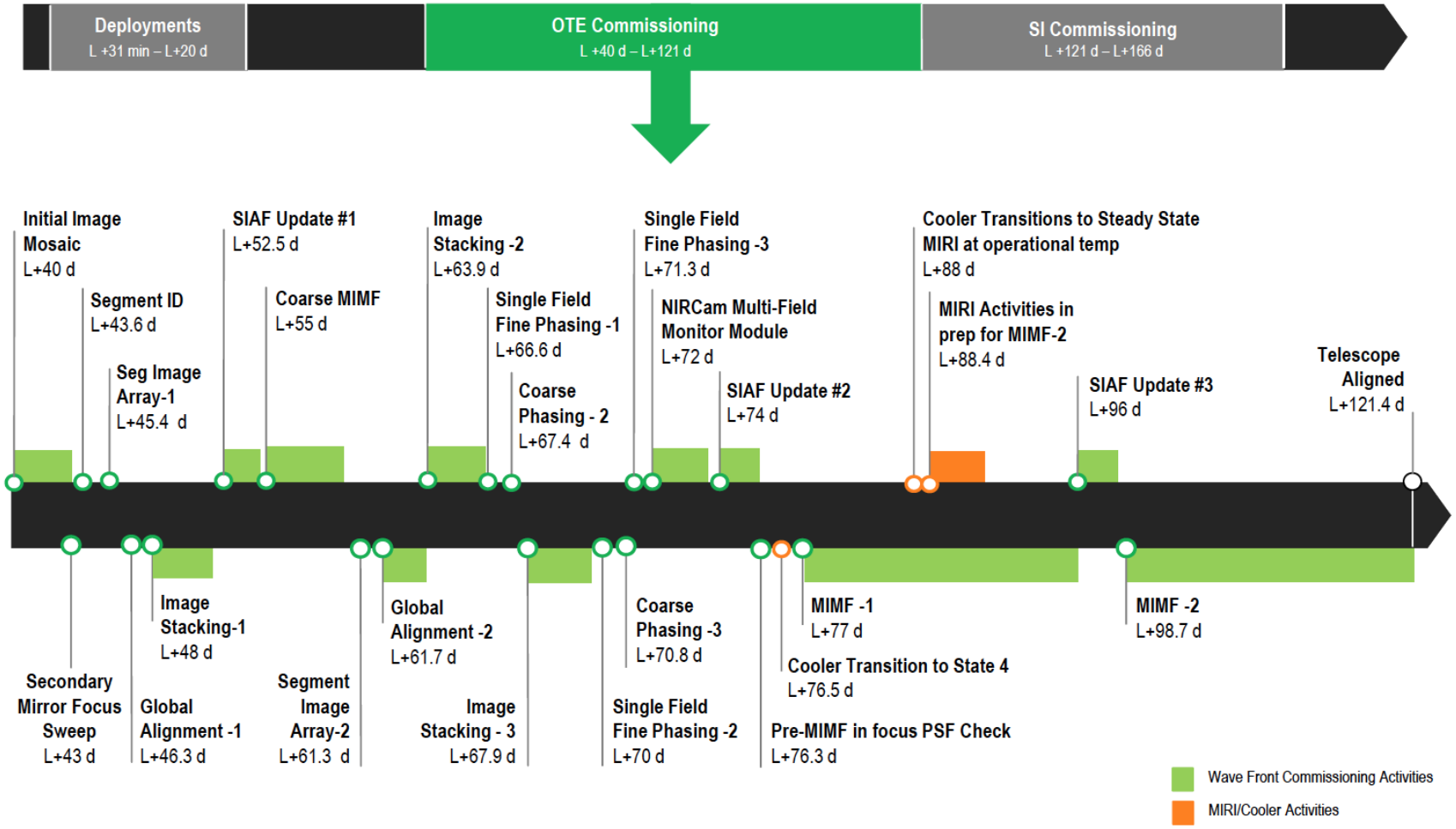
Commissioning Timeline Working Group Lead: Andria Welsh (NGAS)

JWST Commissioning: Deployments

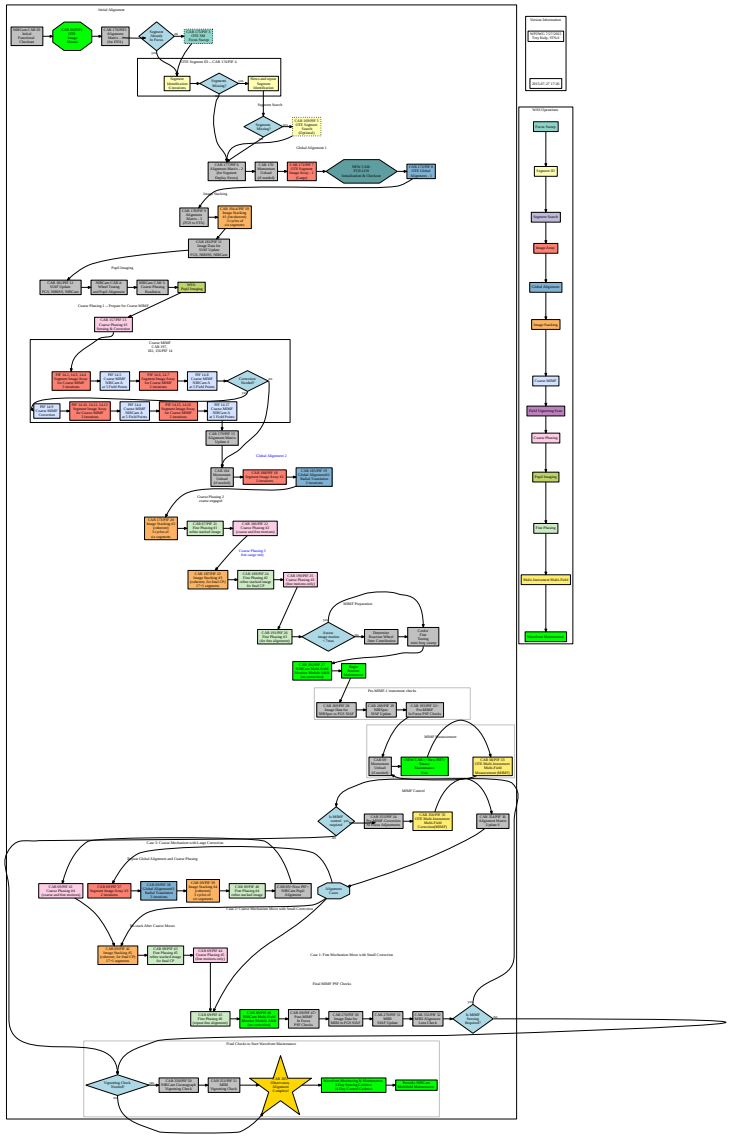


*See NGAS deployment video here: https://www.youtube.com/watch?v=bTxLAGchWnA

JWST Commissioning: OTE Baseline

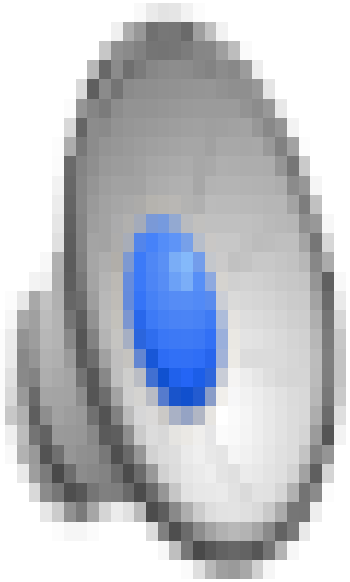


JWST Commissioning: OTE Flowchart



***Save image as .pdf to read text.**

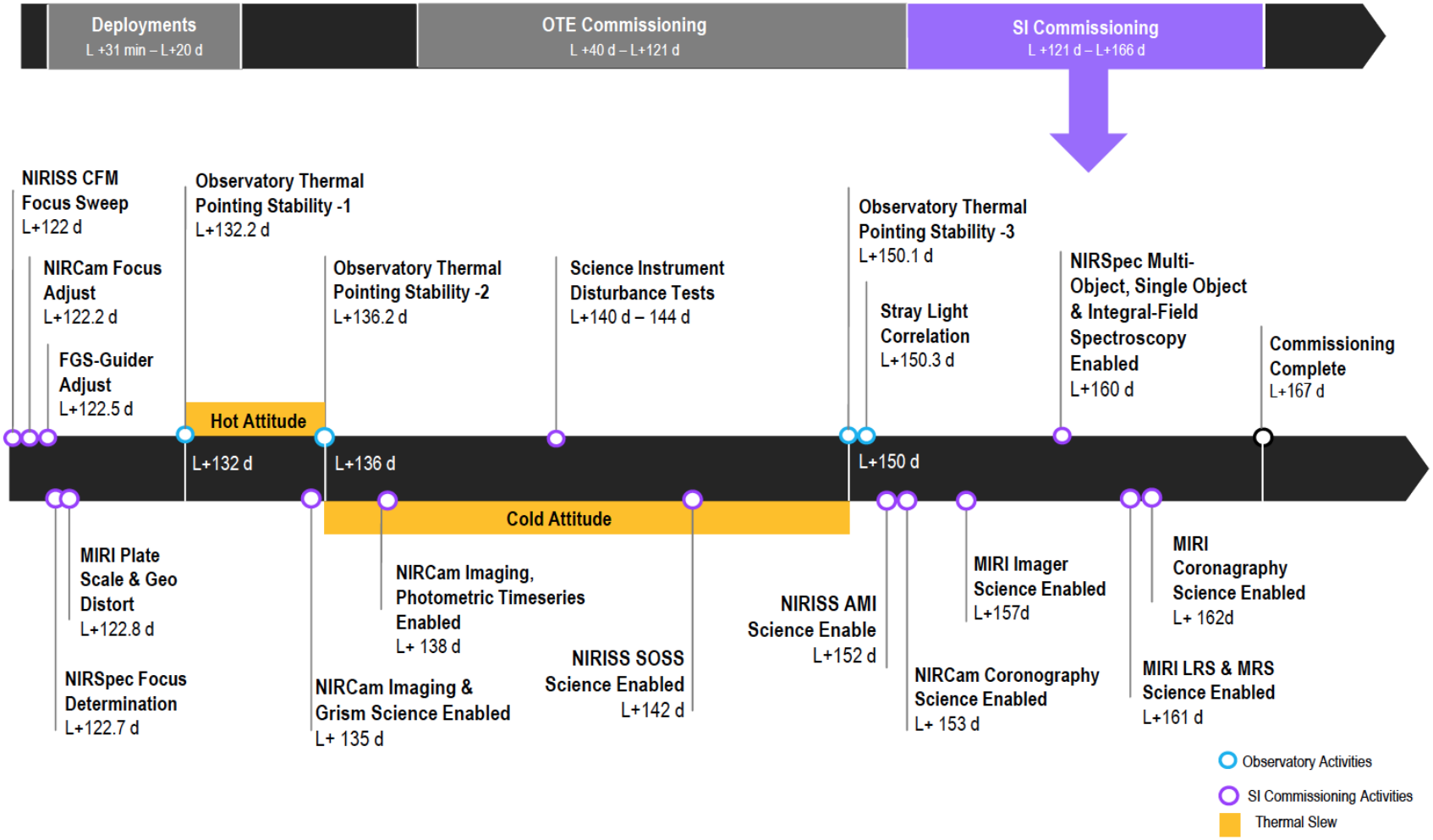
JWST Commissioning: ITM



OTE commissioning sequence as seen by NIRCam A3. This simulated data was made using the Ball Aerospace provided Integrated Telescope Model. These early OTE commissioning simulations are used to exercise the wavefront sensing and control software subsystem.

Movie credit: Charles-Philippe Lajoie (STScI)

JWST Commissioning: SI Commissioning



Thermal Slew CAR

- Objectives
  - Measure and characterize the JWST thermal profile to 1) validate observatory thermal models and 2) determine WFSC update expectations.
- Activity Description (~14 days, after MIMF)
  - Point in a hot/cold direction and thermally stabilize observatory (~4 days) followed by a large slew (~50 deg pitch) and monitor the observatory as it thermally stabilizes at the new cold/hot pointing (~14 days)
  - Observables: wavefront drift via NIRCam WFS, pointing stability from star tracker support assembly, telemetry data from the observatory, heater sensors, transient behaviors

http://www.stsci.edu/jwst/overview/design/field-of-regard