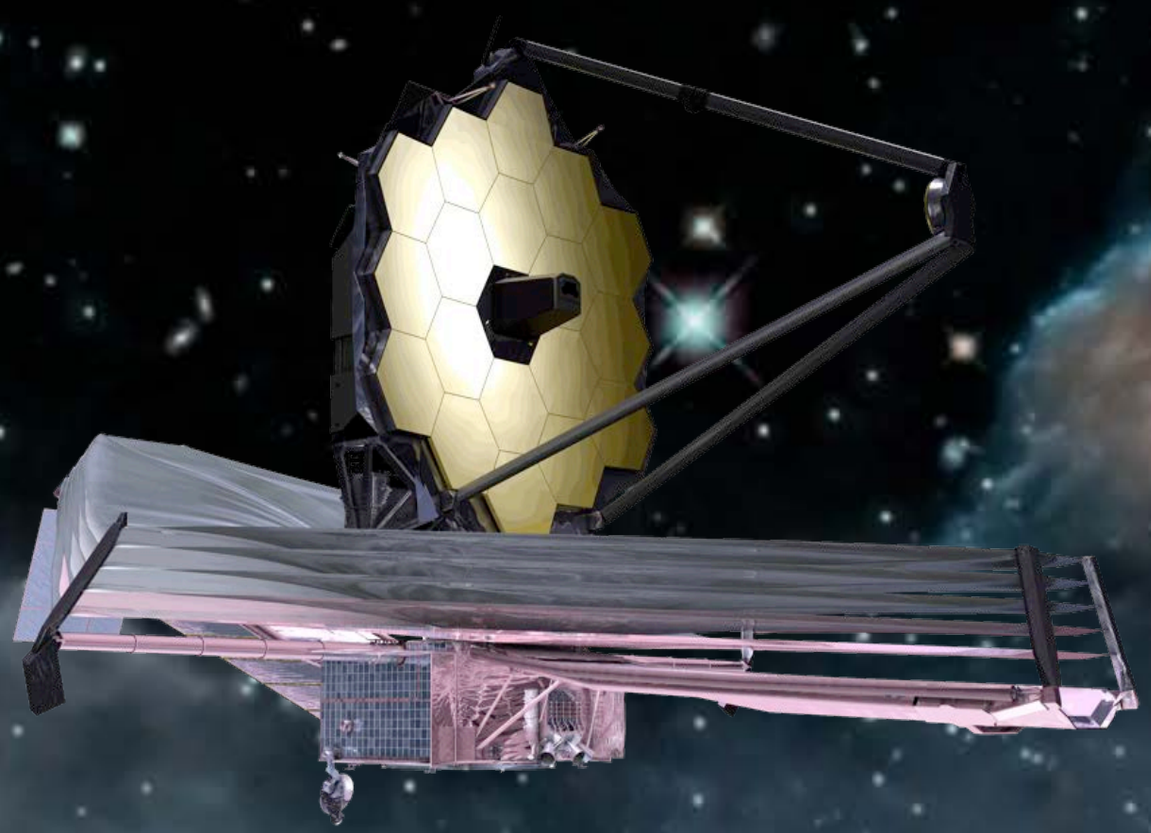
JWST Observatory Status



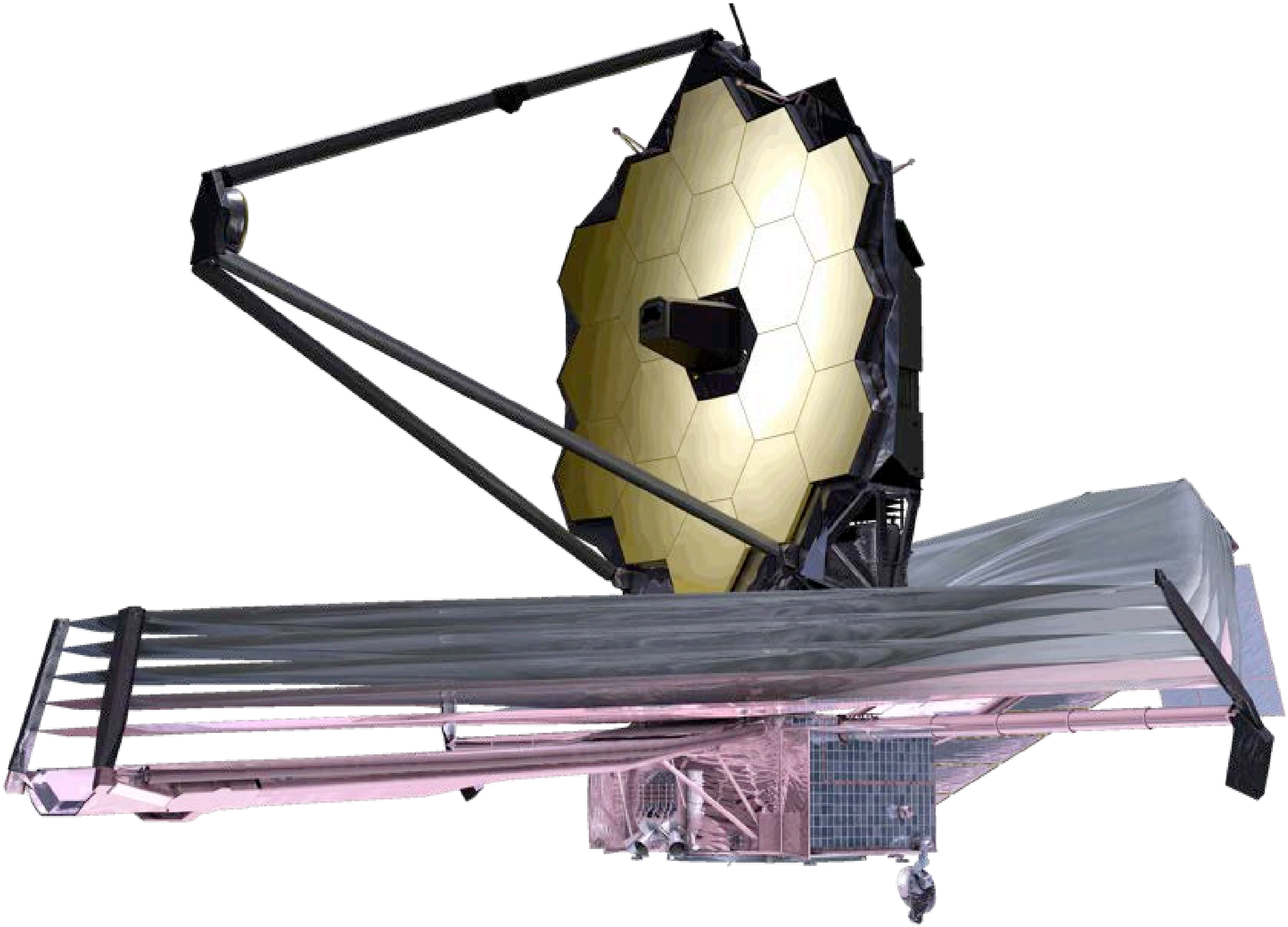
APS 16-17th July 2013

Mark Clampin - JWST Observatory Project Scientist

mark.clampin@nasa.gov

Goddard Space Flight Center

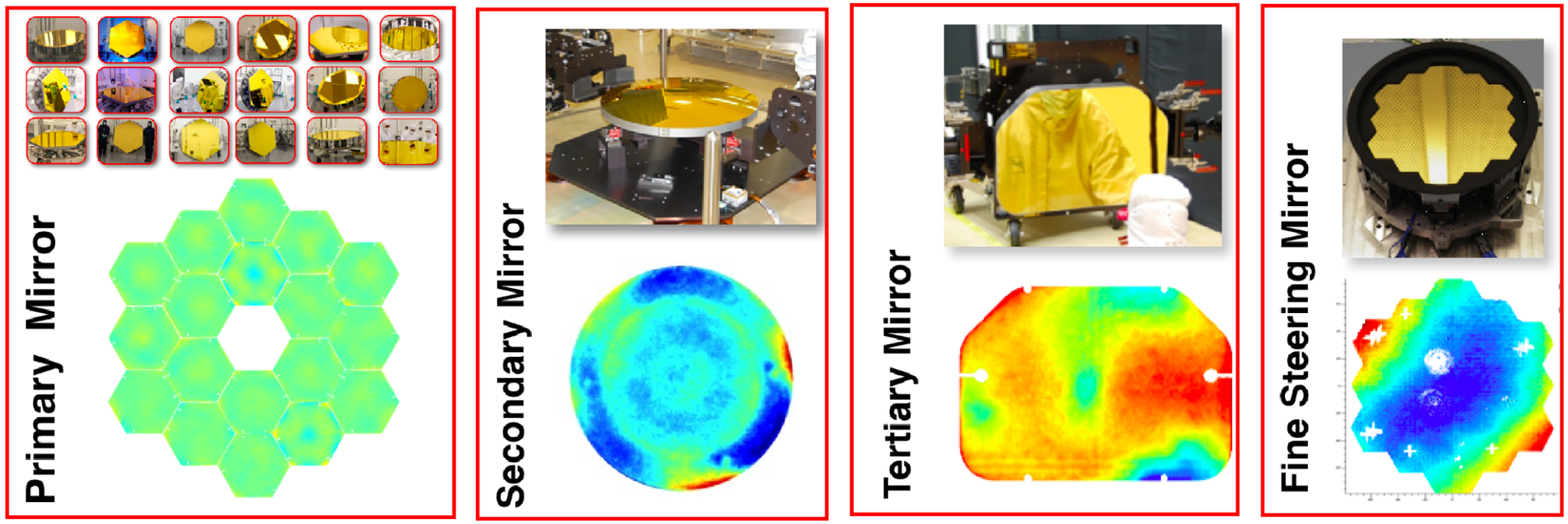
JWST Observatory



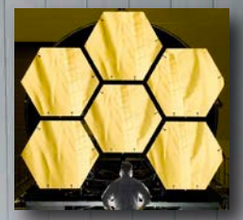
Optical Telescope Element: Optics

- **JWST flight mirrors are all completed: Optical requirements are met**

Mirror	Measured (RMS SFE)	Uncertainty (RMS SFE)	Total (RMS SFE)	Requirement (RMS SFE)
18 primary Segments (Composite Figure)	23.6	8.1	25.0	25.8
Secondary	14.7	13.2	19.8	23.5
Tertiary	18.1	9.5	20.5	23.2
FSM	13.9	4.9	14.7	18.7



- **Mirrors will have completed shipping to GSFC by year's end**

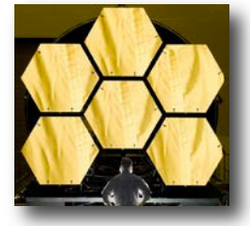


JWST

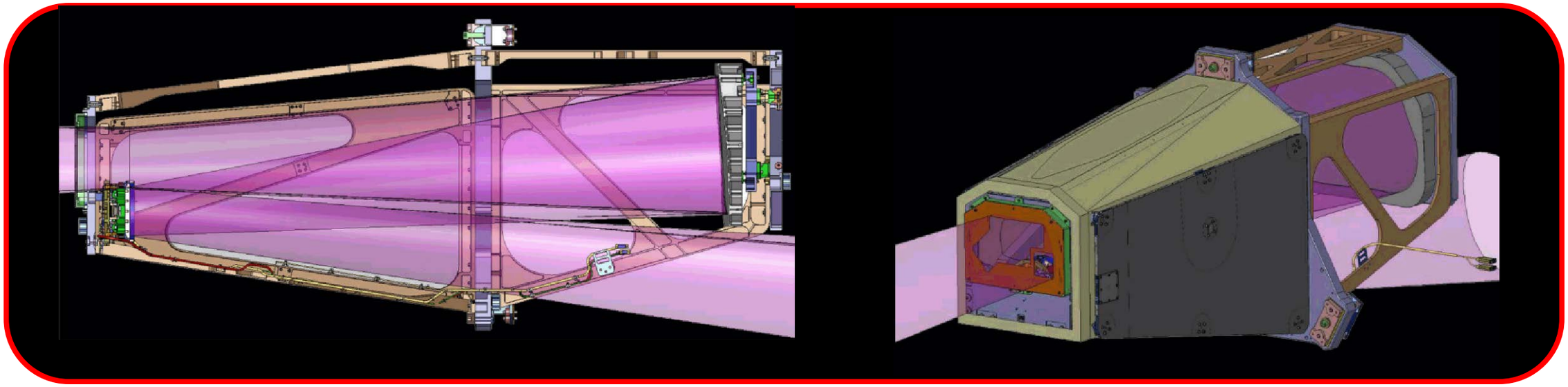
Clampin/GSFC

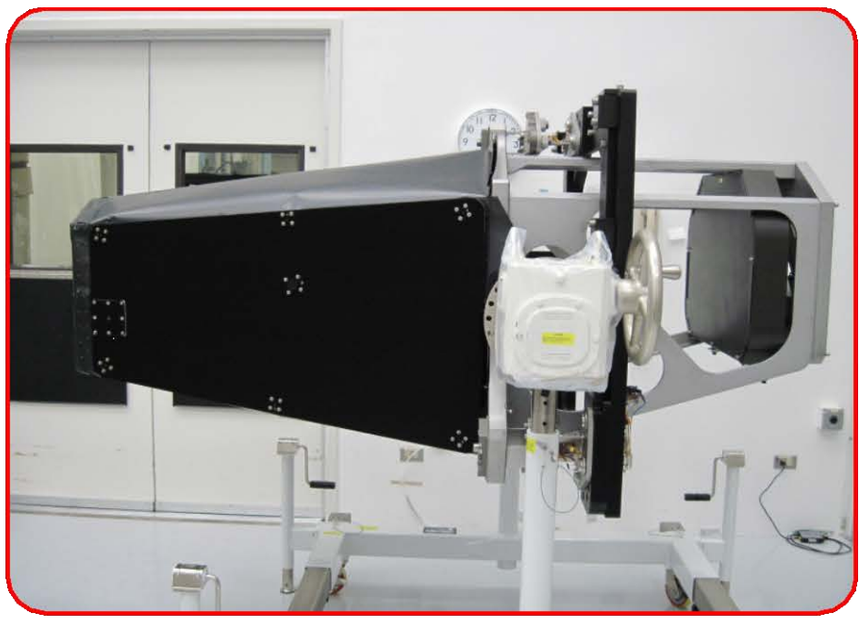

THIS SIDE UP
DO NOT STACK
CG
FORKLIFT

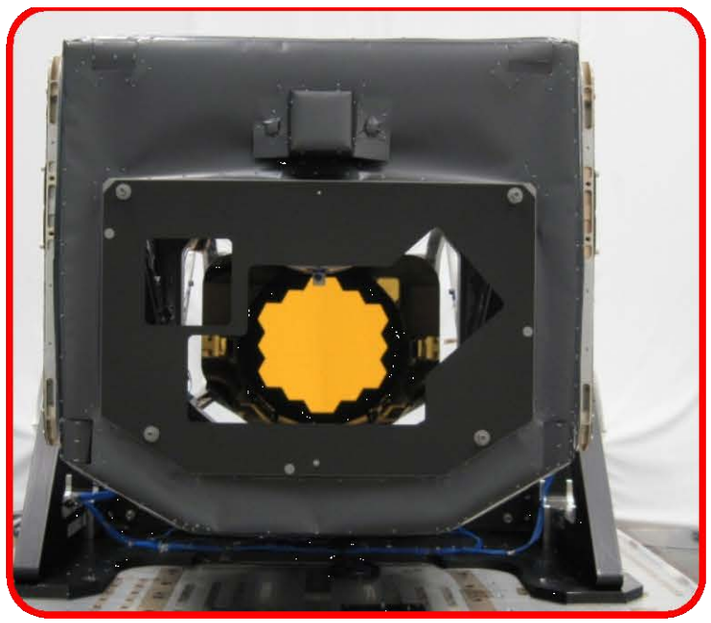
Aft-Optics System



- **Completed the Aft Optics System (w/Tertiary and Fine Steering Mirrors)**
  - ➡ **3 cryogenic cycles with alignment measurements completed.**
  - ➡ **Stored at Ball until 2015, when it will installed in the Pathfinder for tests**

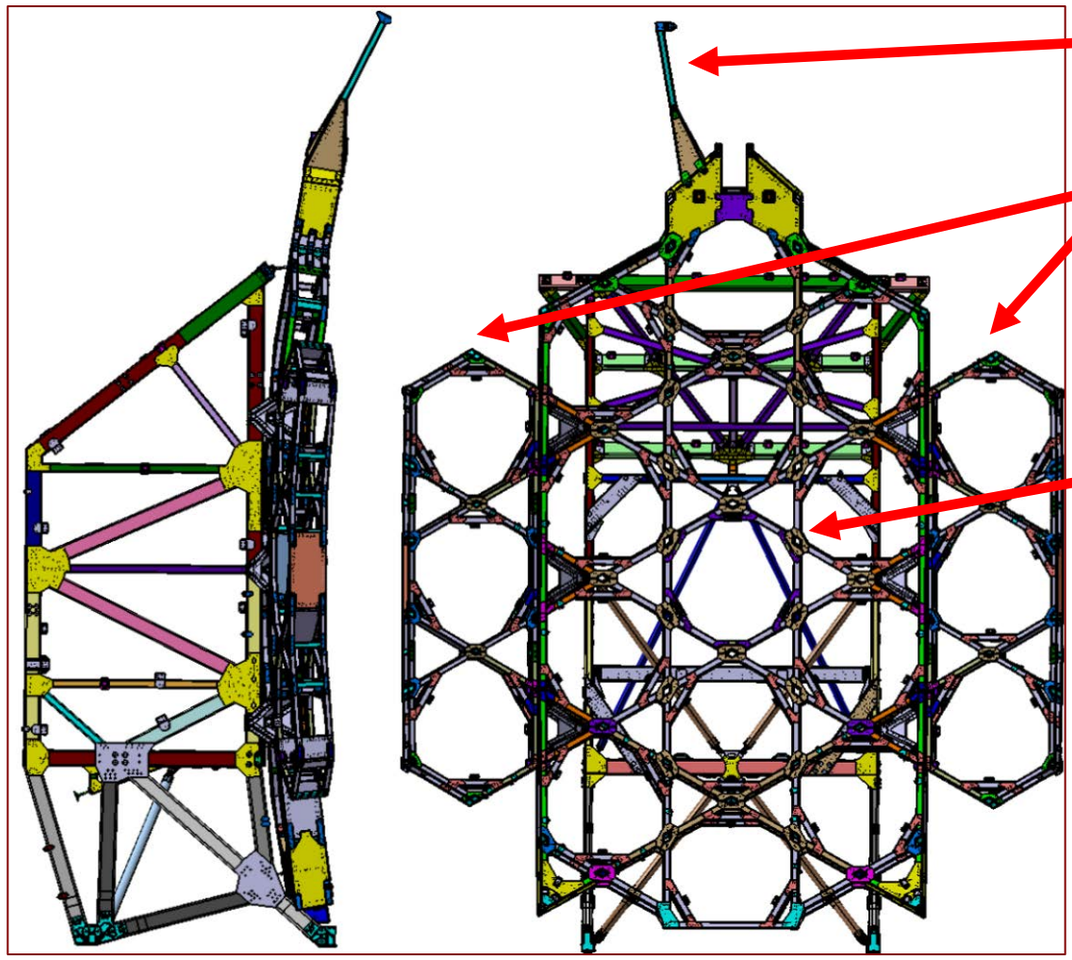






Optical Telescope Element: Backplane

- **Primary Mirror Backplane comprises four elements**
  - ➡ **Primary mirror backplane assembly (PMBA)**
    - ➡ **PMBA center section(CS) + 2 PMBA wings**
  - ➡ **Backplane Support fixture which houses ISIM and supports PMBA**



- **For JWST the critical path runs through the Optical Telescope Element and production of the telescope backplane.**

Optical Telescope Element: Backplane

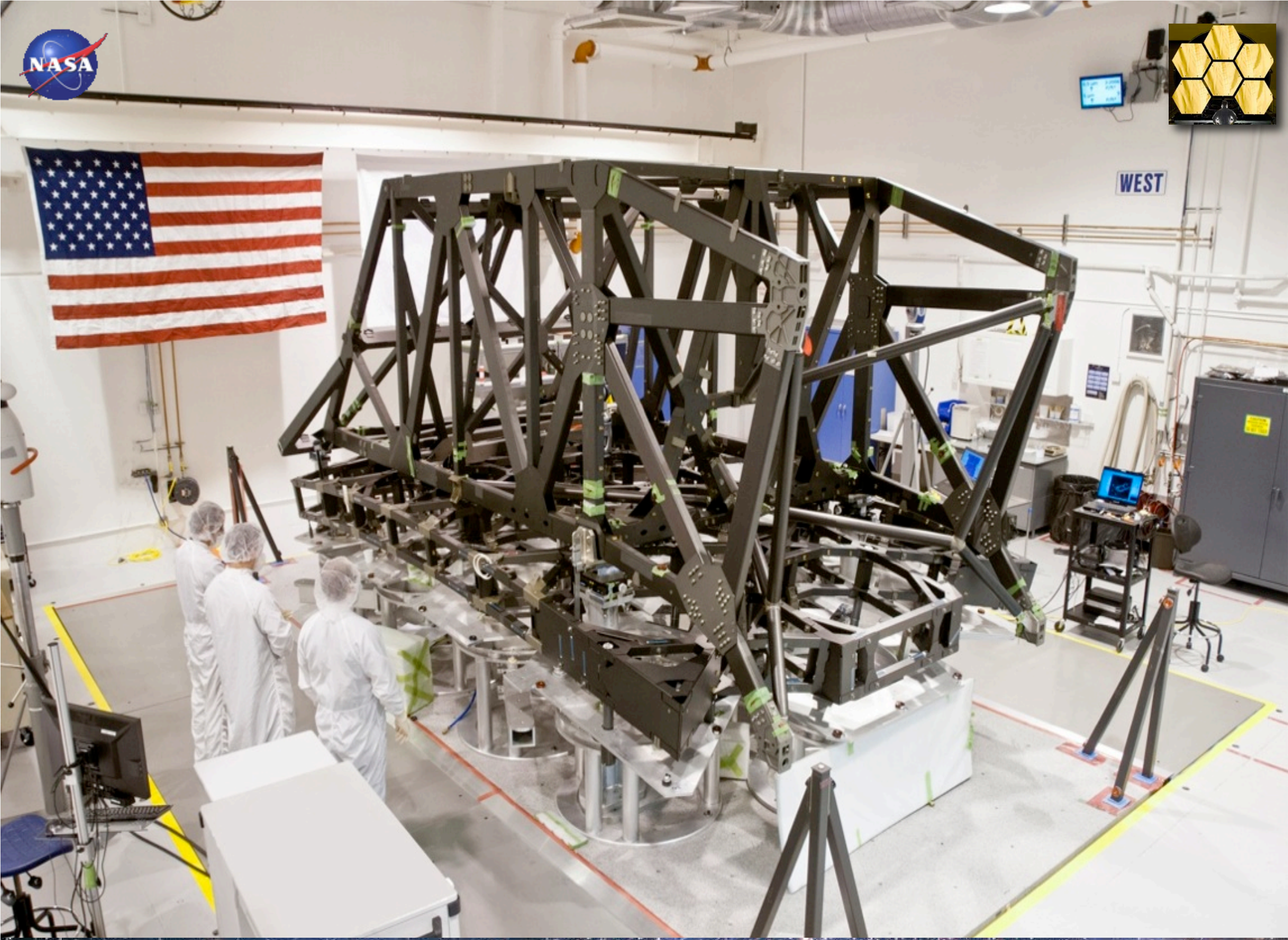
- **PMBA and BSF construction at ATK is complete**

- **PMBA wings have completed cryogenic cycling tests with Omni**
  - ➡ Tested in XRCF chamber: hardware achieved 23 K – 32K
  - ➡ Factoid: Mass difference of wings is 0.005 kg (50.130 kg vs 50.125 kg).
  - ➡ Currently undergoing post-test ultrasonic and visual inspection of joints.

- **PMBA center section (CS) has been mated with support fixture BSF**
  - ➡ Scheduled to begin cryocycle testing at XRCF ~September 2013

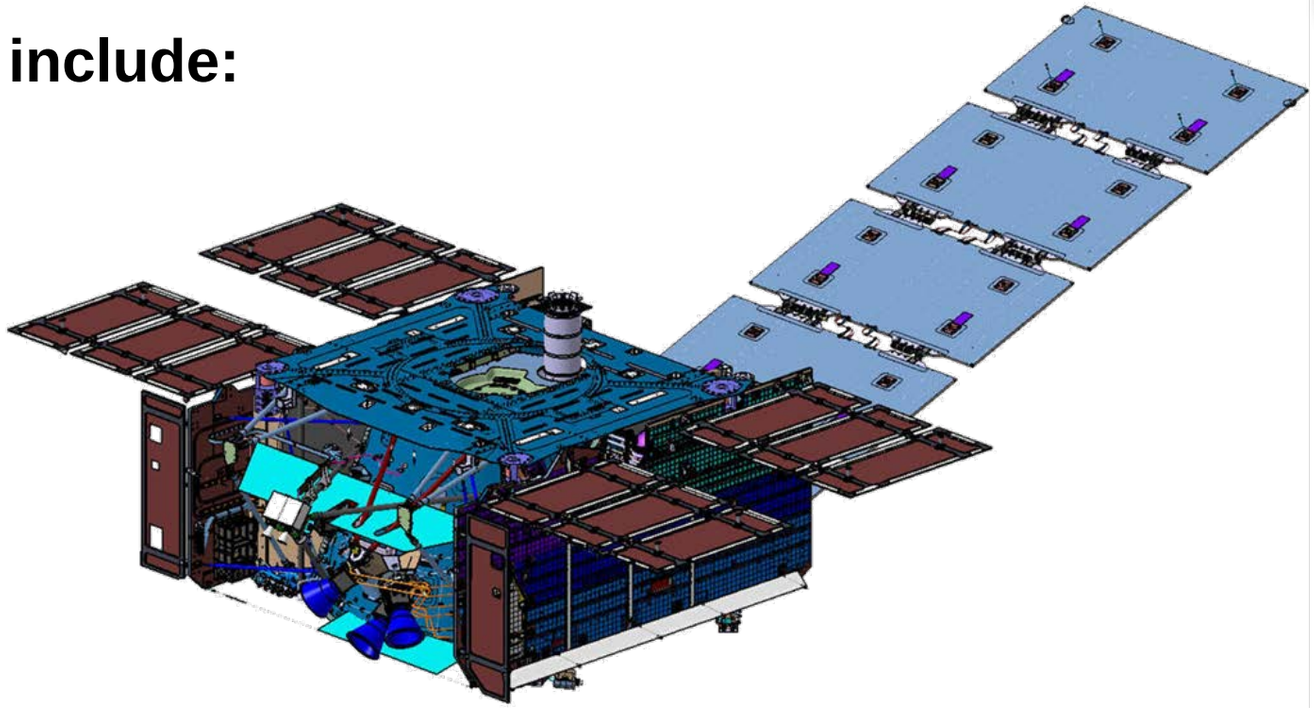
- **Ships to GSFC to begin telescope integration ~April 2015**

Mounting a dummy mirror segment using the robot arm


WEST

JWST's Spacecraft Bus

- **Spacecraft Bus systems include:**
  - ➡ Power/Electrical System
  - ➡ Attitude control systems
  - ➡ Propulsion
  - ➡ Communications
  - ➡ MIRI Cryocooler
  - ➡ OTE/Sunshield interface

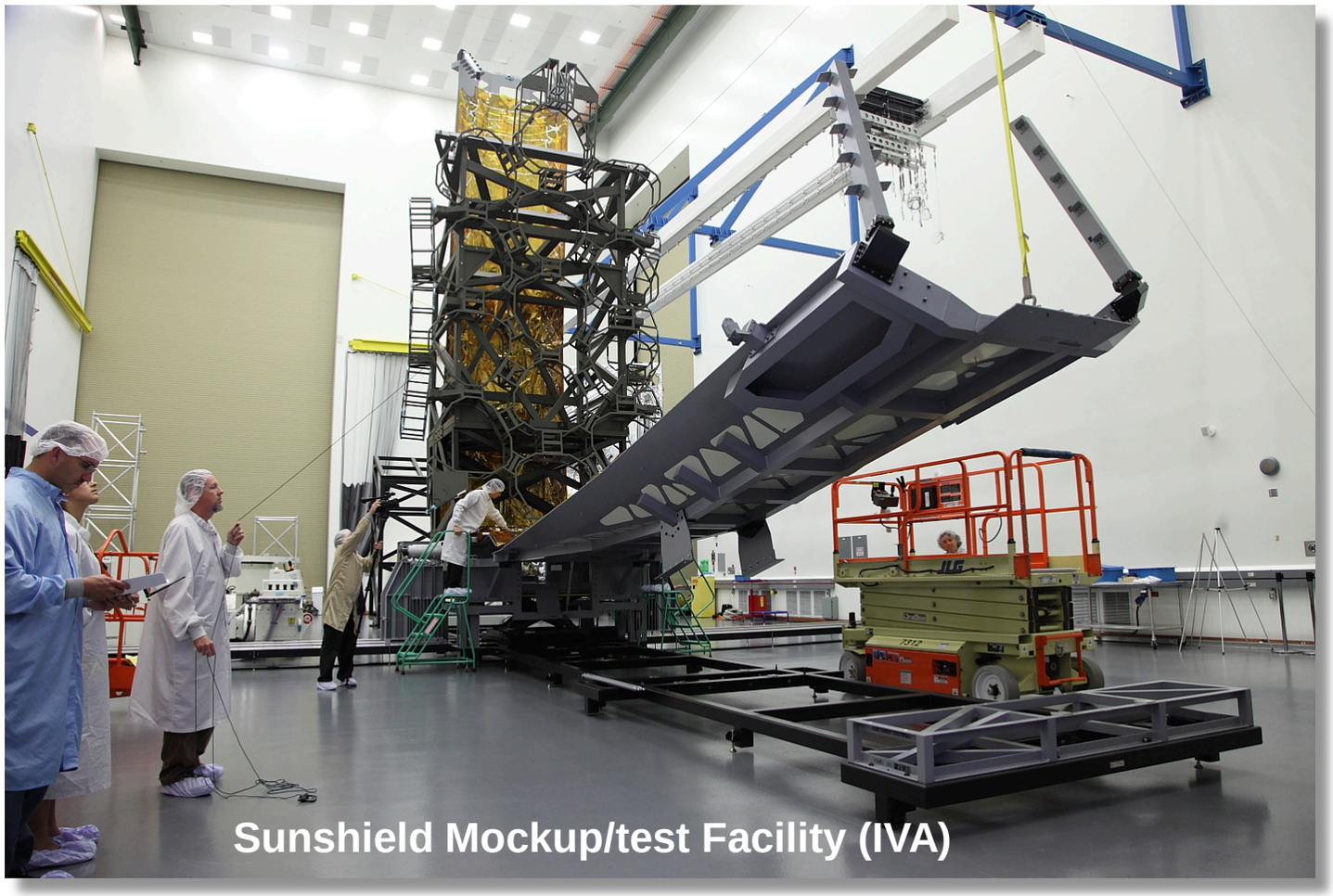


- **Key milestone for the Observatory is the Dec 2013 Critical Design Review**

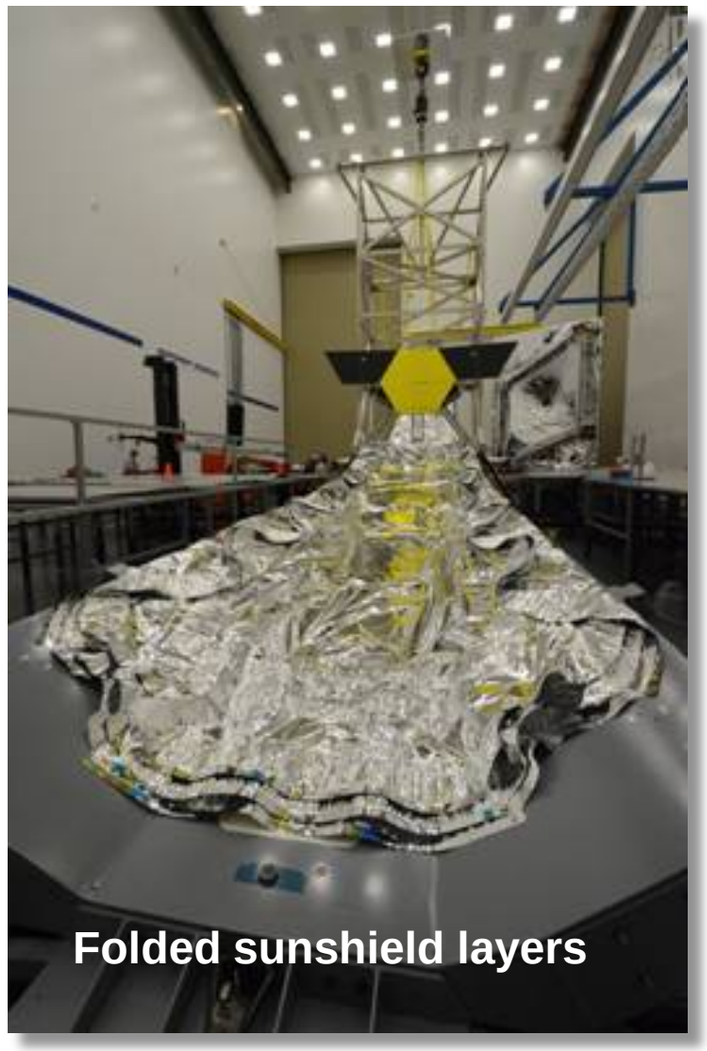
- **Spacecraft Cone is load-bearing structure for the bus**
  - ➡ Constructed from composite material
  - ➡ Preparing to cut harness/hardware pass-through apertures

Sunshield Status

- **Template (flight-like) constructed and delivered to NGAS: Major goals:**
  - ➡ **Verify 3-D shape for each layer under tension**
    - ➡ **repeat w/deployment fixtures on layer 5**
  - ➡ **Verify hole punching strategy & hole alignment concept**
  - ➡ **Verify folding/stowing concept on IVA facility**

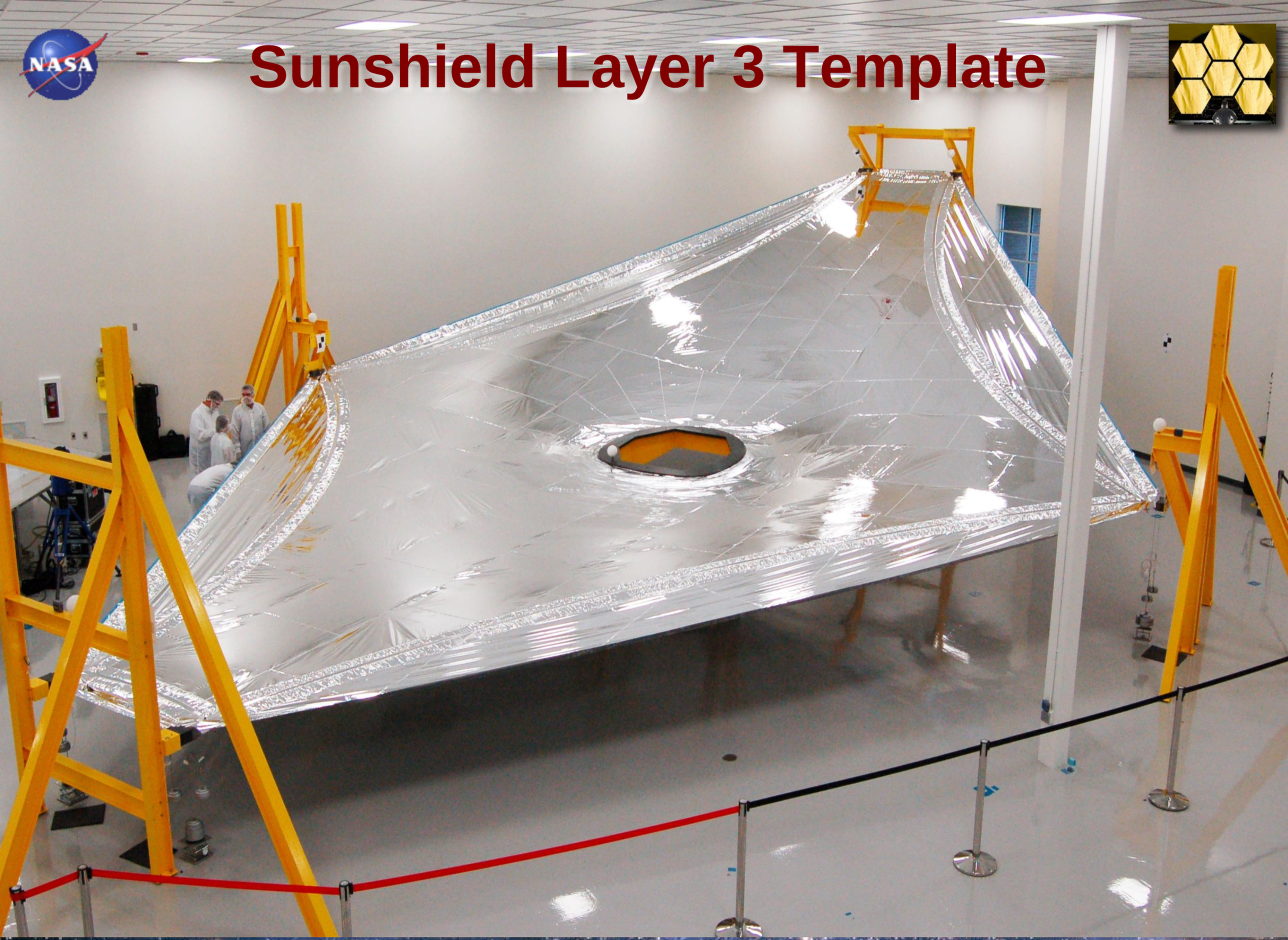


Sunshield Mockup/test Facility (IVA)



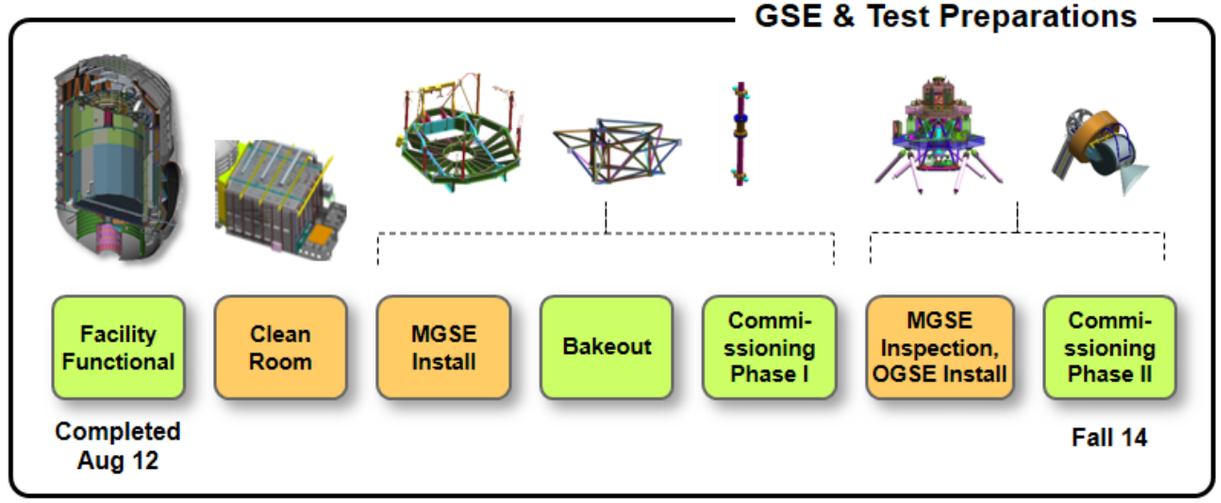
Folded sunshield layers

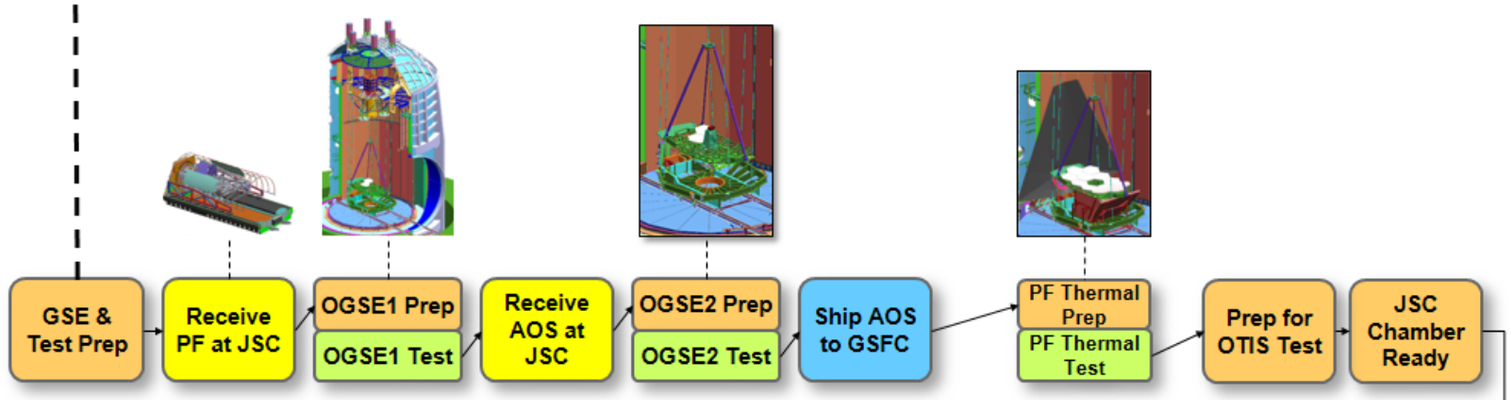
Sunshield Layer 3 Template



OTE/ISIM Integration & Test Flow

JWST OTIS Integration and Test





Acronyms

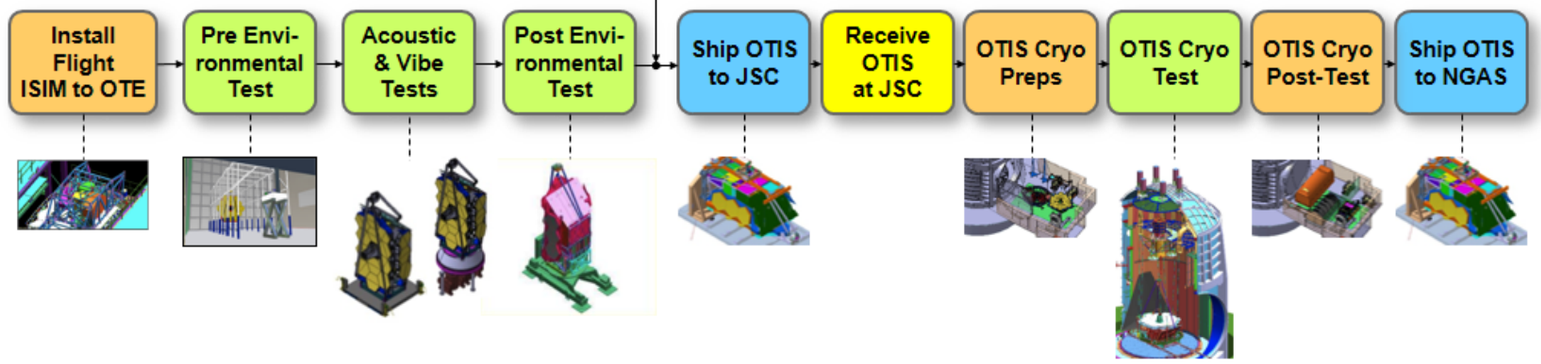
AOS	Aft-Optics Subsystem
GSE	Ground Support Equipment
MGSE	Mechanical Ground Support Equipment
NGAS	Northrop Grumman Aerospace Systems
OGSE	Optical Ground Support Equipment
PF	Pathfinder

Legend

Prep & Transport | Functional / Test | Assembly / Integration | Delivery

Risk Reduction Activities

Flight OTIS I&T



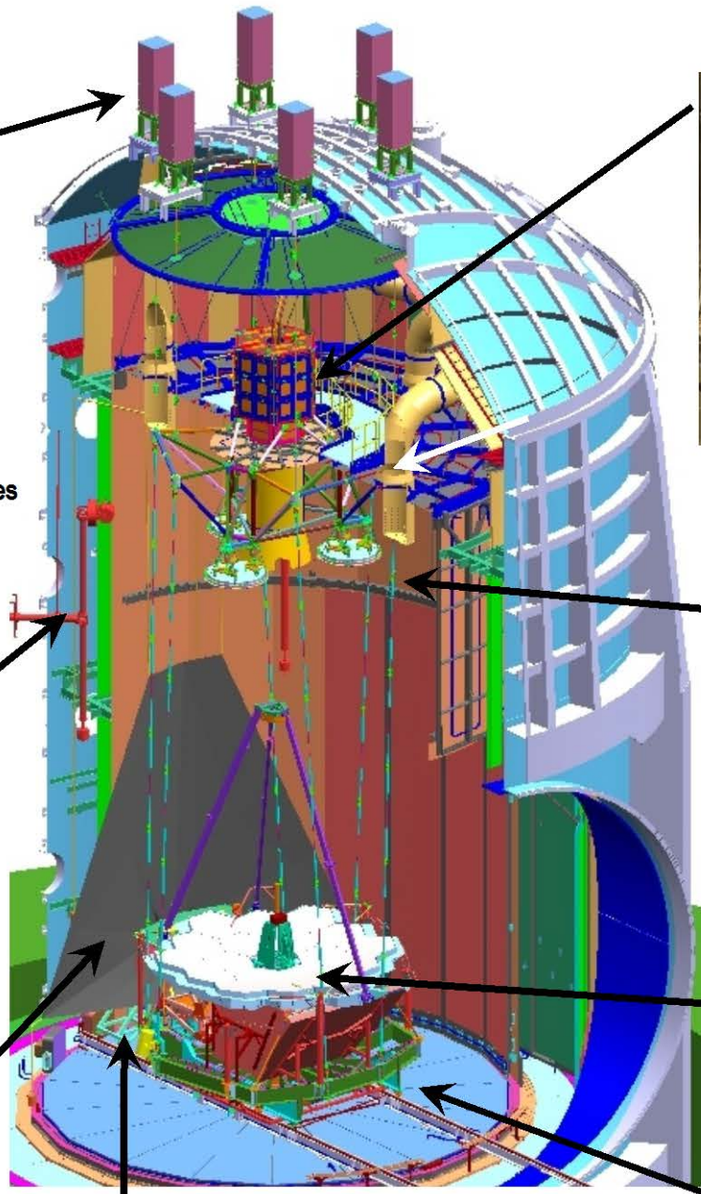
Chamber-A: OTIS Test Configuration

Chamber Isolator Units

Isolates the Ground Test from Seismic activities for Optical Testing

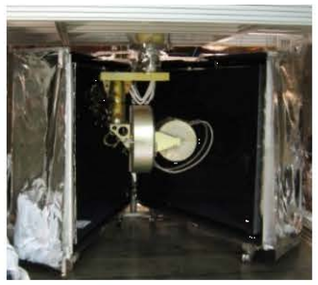
Center of Curvature Optical Assembly (COCOA)

- Multiwavelength interferometer (MWIF), null, calibration equipment, coarse/fine PM phasing tools, Displacement Measuring Interferometer
  - Build and Tested – in Storage at MSFC/XRCF



3 Auto Collimating Flat Mirrors (ACFs)

- Three - 1.5 meter mirrors and actuators for Pass and Half testing



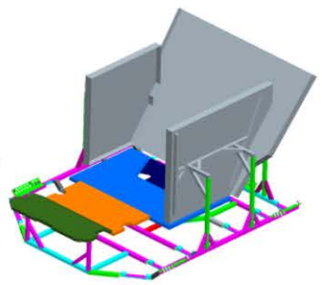
Cryo Position Metrology (CPM)
PG Cameras in canisters

AOS Source Plate and Cable Support

- Fiber optic sources for Field Testing and pas and Half Testing

Space Vehicle Thermal Simulator (SVTS) and Sunshield Simulator

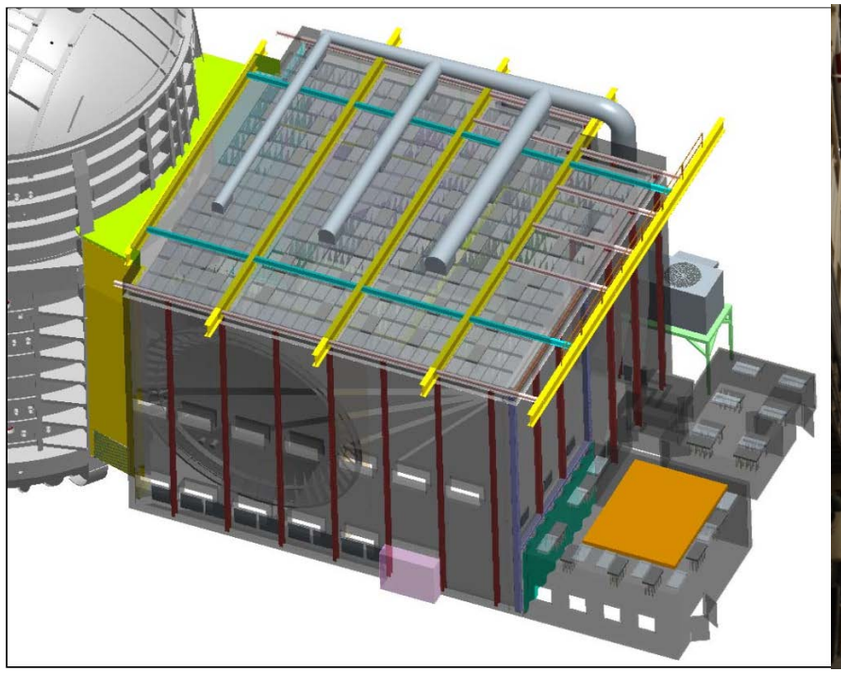
Absolute Distance Measurement Assembly (ADM)

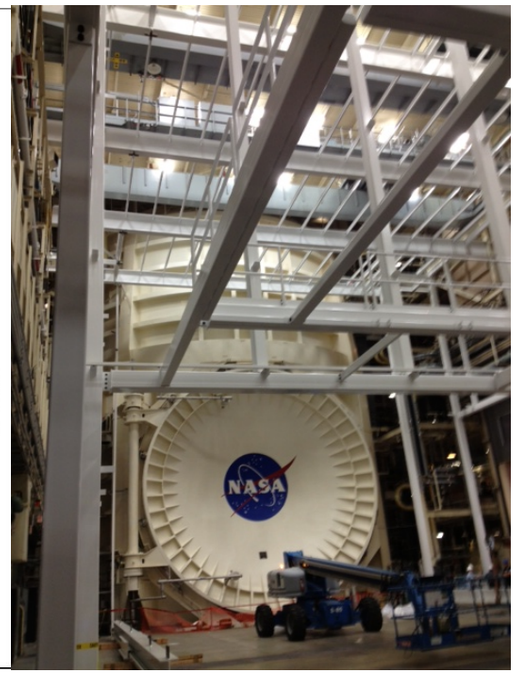


Deep Space Edge Radiation Sink (DSERS) – GSE
Radiators for collecting Flight Heat during the OTIS test

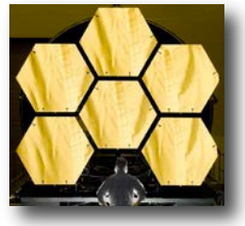
Chamber-A Refurbishment

- **Re-outfitting JSC's Chamber A to meet the testing requirements.**
- **Chamber functional modifications completed June 2012**
  - ➡ **Checked out with a chamber functional test (July – Aug. 2012)**
- **Cleanroom Assembly will be finished fall 2013**

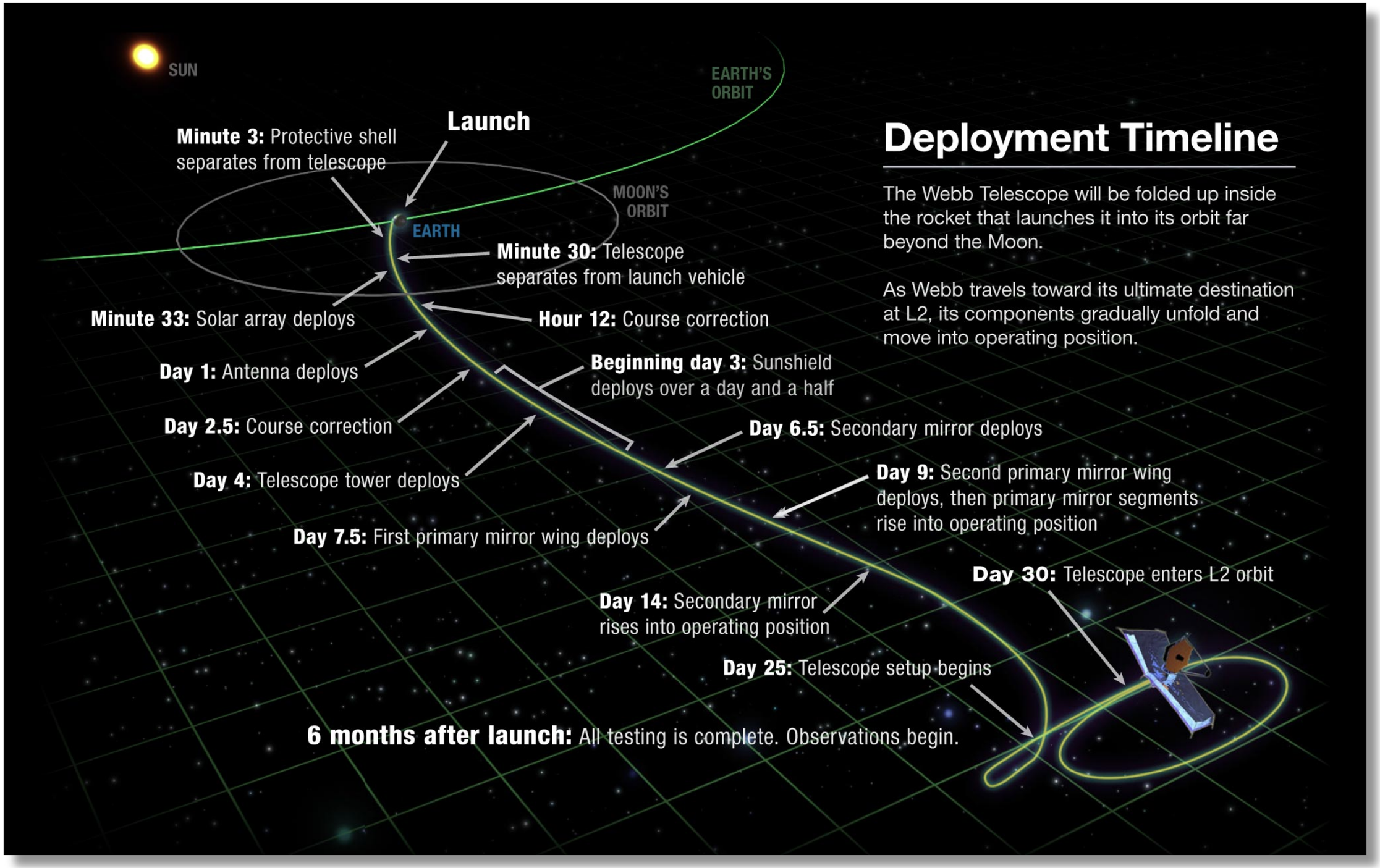




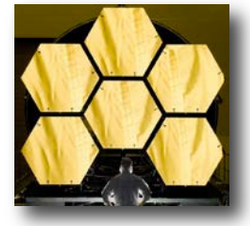
Deployment Concept



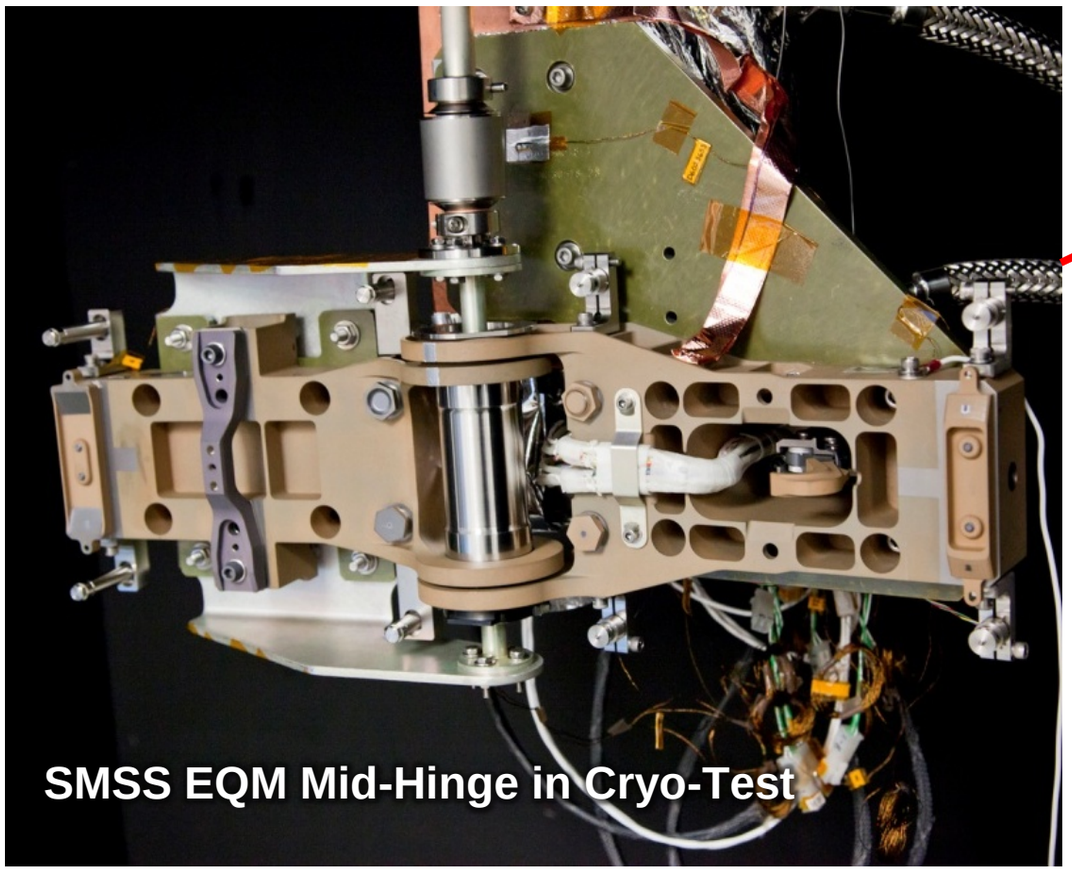
- **Deployment Review Team convened by NGAS to monitor implementation of JWST deployment at system-level**



OTE Deployment Hardware Testing



- **Completed Successful Qualification testing of the EQM SMSS Mid-Hinge Deployment Assembly**
- **Completed Cryo and Vibe-testing of the EQM SMSS In-Board Hinge (IBH) Deployment Mechanism**
- **Completed Initial Build and testing of EQM Primary Mirror Backplane Assembly (PMBA) Wing Deployment Mechanism**
- **Delivered EQM DTA to NGAS and began initial testing**

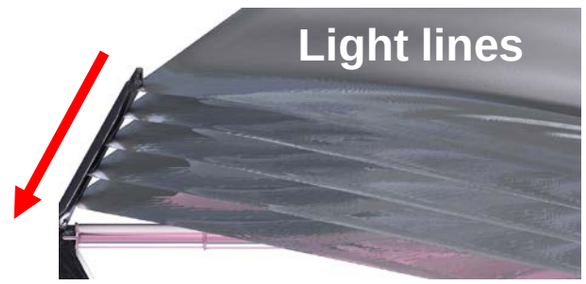


SMSS EQM Mid-Hinge in Cryo-Test

PMBA EQM Hinge

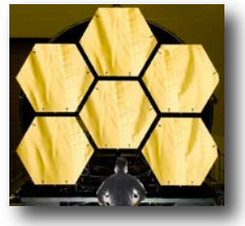
Project Scientist Watch List Examples

- **Observatory alignments are a focus area as we enter I&T phase**
  - ➡ **Thermal Stray Light (Telescope ➡ Spacecraft alignment):**
    - ➡ **Secondary mirror (SM) view to sunshield (known as Light lines)**
    - ➡ **Layers have to align so that SM only views the top (coldest) layer**
      - ➡ **Sunshield layer to layer alignment**
      - ➡ **SM alignment to the boresight**
  - ➡ **Star Tracker ➡ Telescope alignment**
    - ➡ Alignment relative to the observatory boresight
  - ➡ **Envelope: Design envelope requirements before/during deployment**



- **NIR and Stray Light**
  - ➡ **Focus on I&T and contamination control for NIR stray light control**
    - ➡ **Primary is particulate contamination on telescope optics**
- **Image Motion/Pointing: Focus on implementation to**

Deployment Testing



- **Observatory integration and deployment testing is complex, and bears directly upon science performance as well as deployment success**

- **First opportunity to exercise full system end-to-end**

  - ➡ **Approach**

    - ➡ **Sub-system to full scale deployments**

    - ➡ **Full scale deployments with flight hardware**

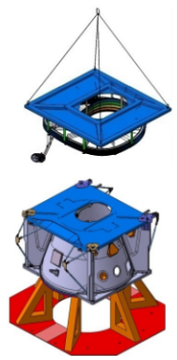
- **Early use of full-scale mockups and deployment tests**

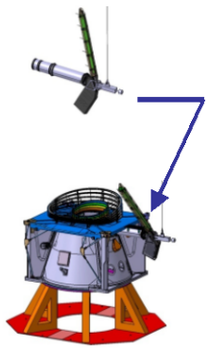
  - ➡ **investigate potential snags and clearances**

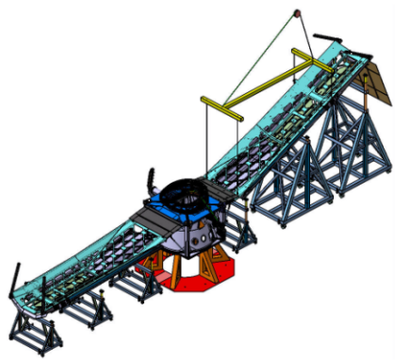
  - ➡ **alignment strategy**

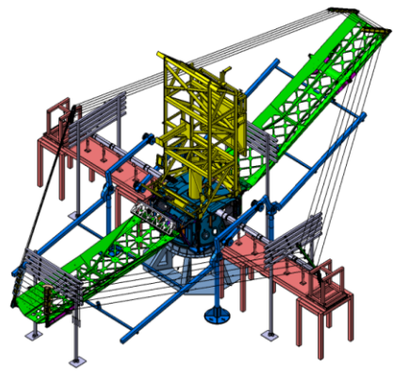
- **Multiple full scale deployments will exercise flight system**

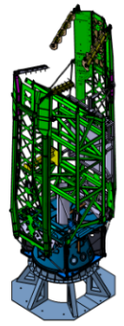
Spacecraft/Sunshield I&T

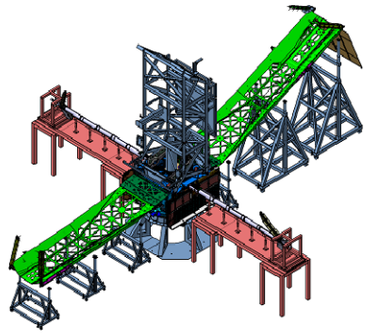












Install core to Bus

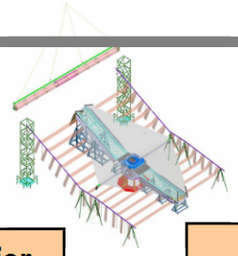
Install and Align Mid Booms

Install and Align Forward and Aft Structures

Skeleton Deployed Align and Shim Adjust

Skeleton Stow

Skeleton Deployment Test



Repeat for Layers 2-5

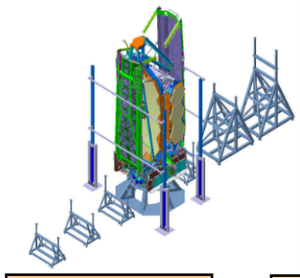
Prepare for Membrane Installation

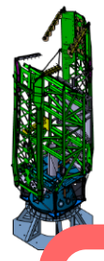
Membrane Installation

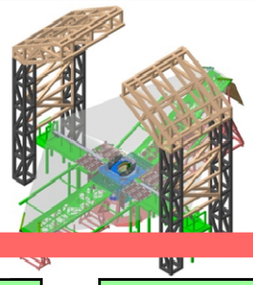
Membrane LIDAR Shape Check

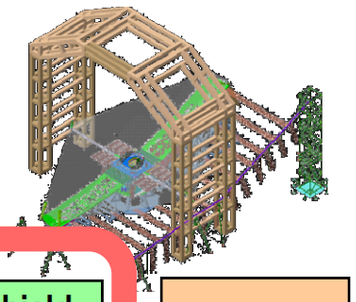
Connect Folding Assist Threads Between Layers

Fold Membranes









Transition to Deployed Config

Sunshield Stow

Stowed Align And Critical Clearances

Sunshield Deployment Test

Sunshield Alignment Verification

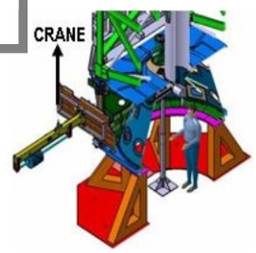
Fold Membranes

To SCE I&T

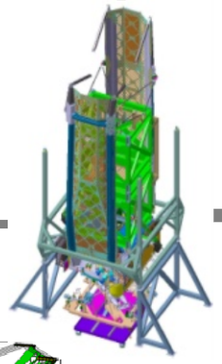
Spacecraft/Sunshield I&T

Propulsion Module

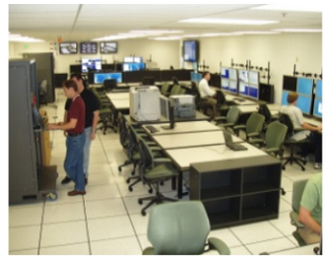
Integrate Cryocooler



Integrate Propulsion Module



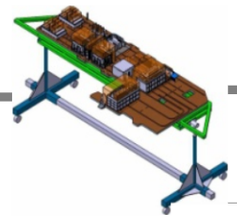
Integrate Equip & J2 Panels on Flight Structure

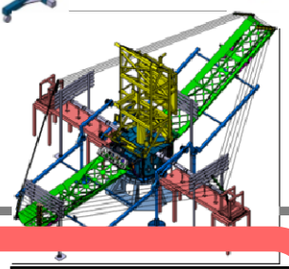


Ambient Test

- Validated FSW B2.1
- CST -1, GSEG-1
- DSN/TDRS RF Compatibility Vans
- SCE Stowed Alignments

J2 Panels Integration





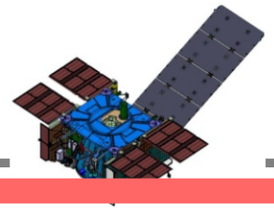
Radiator Shades

HG Antenna

Omni Antenna

Solar Array

MLI



Install Radiator Shades, SA, Antennas

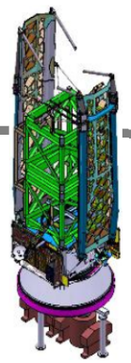
Offline 0-g deployments performed before installation

Pre-Env Deployments

- 1st Motion: GAA, RS, S
- SS Electrical Functional

Dynamics Tests

- Stowed Modal
- PF 3 Axis Sine Vibration
- Ariane Shogun Test



SCE Mass Properties

- Mass
- Lateral CG

Post Dynamics Deployment

1st Motion: GAA, RS, SA

- SA remove and offline deploy

Thermal Vacuum Test

- Hot & Cold TB
- Hot & Cold CSTs
- 4 thermal cycles

Post- Env Ambient Test

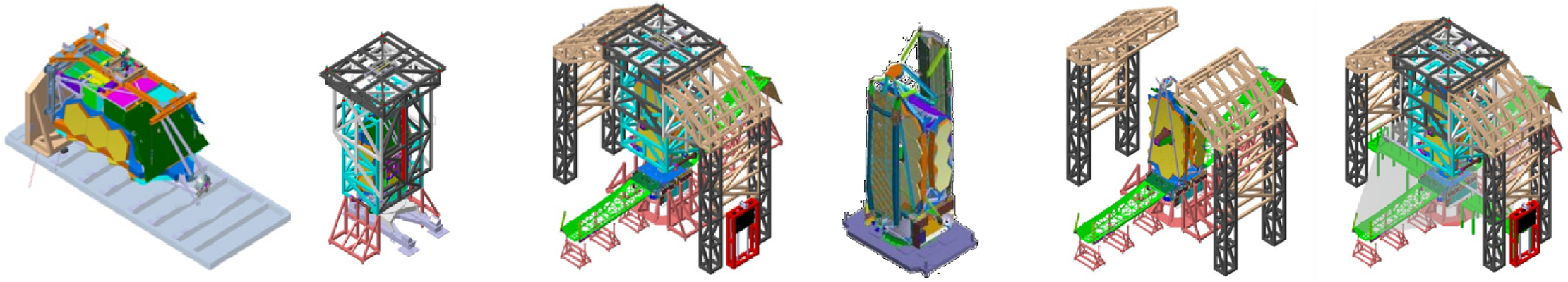
- Validated FSW B2.2
- GSEG-2
- ACS Polarity & Fault Modes

Post-Env Deployments

- SS Deployment

To Observatory I&T

Spacecraft/Sunshield I&T



Receive OTIS

Receive SCE

Integrate SCE and OTIS

- Mechanical Mate
- Electrical Integration
- Functional deployments
- Observatory Alignments

Ambient Test

- CST-2
- EMC
- GSEG-3

Dynamics Tests

- Reinstall SA
- Acceptance Acoustic
- Accept. Sine Vibe
- Separation Shock

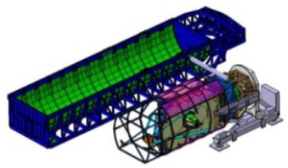
Post- Dynamics Deployments

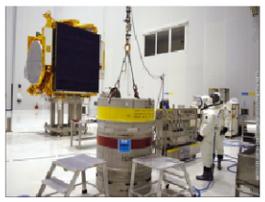
- GAA, SA, PS 1st Motion
- SMSS 1st Motion
- OTE Wing & DTA Deploy
- SS Deploy, Fold & Stow
- Deployed alignments

Post Dynamics Ambient Test

- CST-3
- GSEG-4
- Stowed Alignments

Receive LV PAF





Mass Props & Ship Preps

- Mass
- Lateral CG
- Move to container

Transport to CSG

- Space Park to LAX
- To Cayenne, French Guiana
- Rochambeau Airport to CSG

Configure Observatory in S5C

- Rotate to vertical
- Move into clean tent
- Remove contamination bag
- Post ship inspection

Limited Functional Test

- Limited Functional
- GSEG End-To-End Test

Fueling in S5B

- Air Barge to S5B
- Load propellants
- Mate to LV PAF

Mate to LV in BAF

- Red Tag /Green Tag
- CCU3 to BAF
- Mate to LV
- LVIF Test

Summary

- JWST Observatory is executing to Baseline

- Project Science closely integrated with major areas impacting scientific performance