The James Webb Space Telescope: Observatory Status and Preparations for Launch

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JWST Observatory Project Scientist

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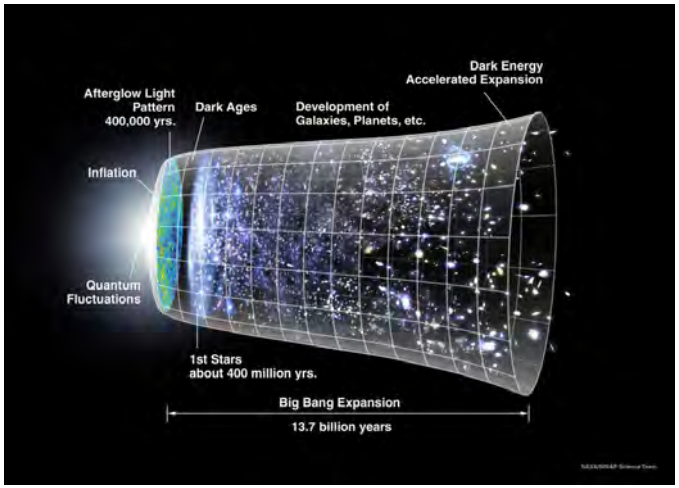
June 19, 2018

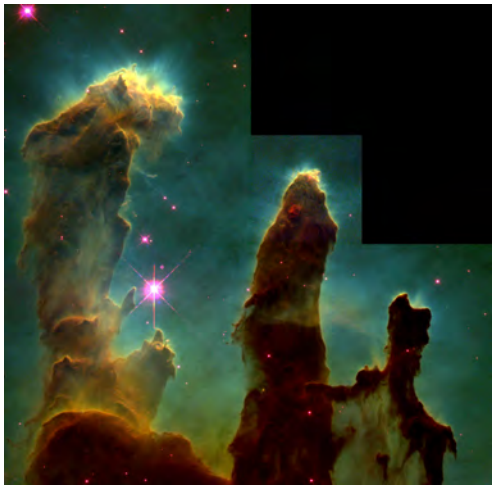
JWST Science Themes

First Light & Reionization

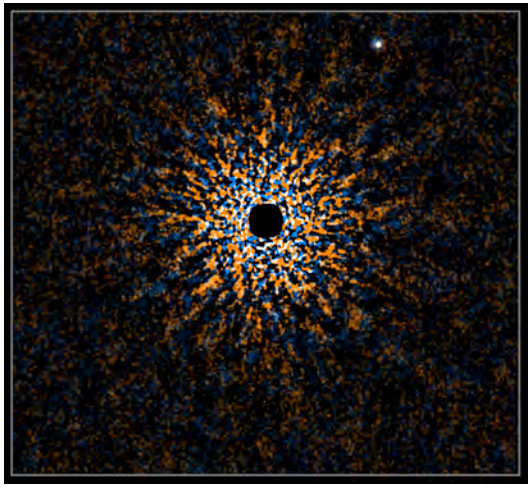


Assembly of Galaxies

Birth of Stars and Protoplanetary Systems



Planets and the Origins of Life



JWST Team

Organizations

- Mission Lead: Goddard Space Flight Center
- Project Scientist: Dr. John Mather (Nobel Laureate)
- International Partners: ESA & CSA
- Observatory Contractor: Northrop Grumman Aerospace Systems
- Operations Center: Space Telescope Science Institute

Instruments

- NIRCam (Near Infrared Camera) – Univ. of Arizona
- NIRSpec (Near Infrared Spectrograph) – ESA
- MIRI (Mid-Infrared Instrument) – ESA/JPL
- Fine Guidance Sensor/Near Infrared Imager and Slitless Spectrograph – (FGS/NIRISS) – CSA

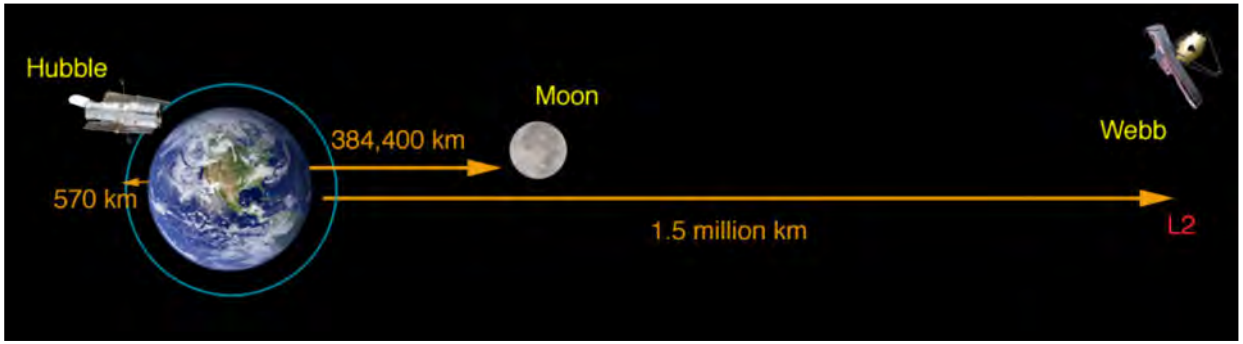
How JWST Works

Ariane 5 Launch Vehicle

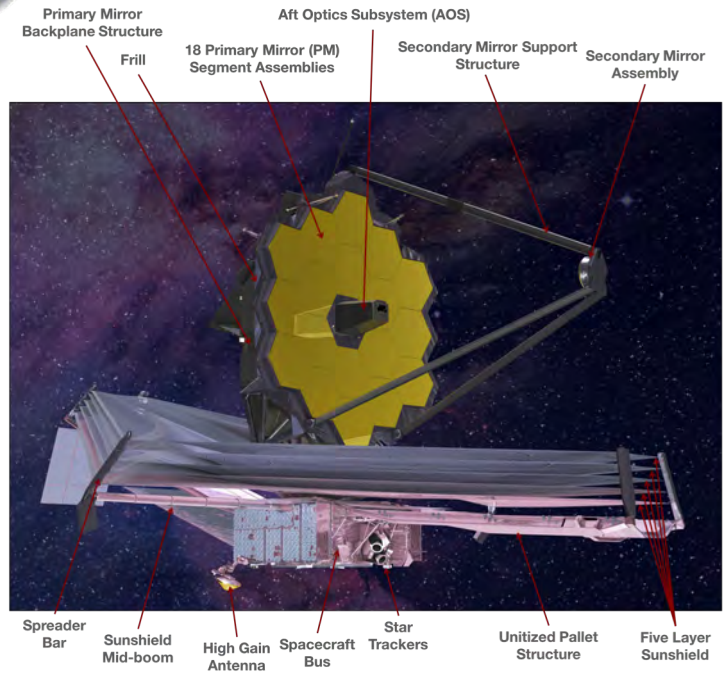
JWST is folded and stowed for launch

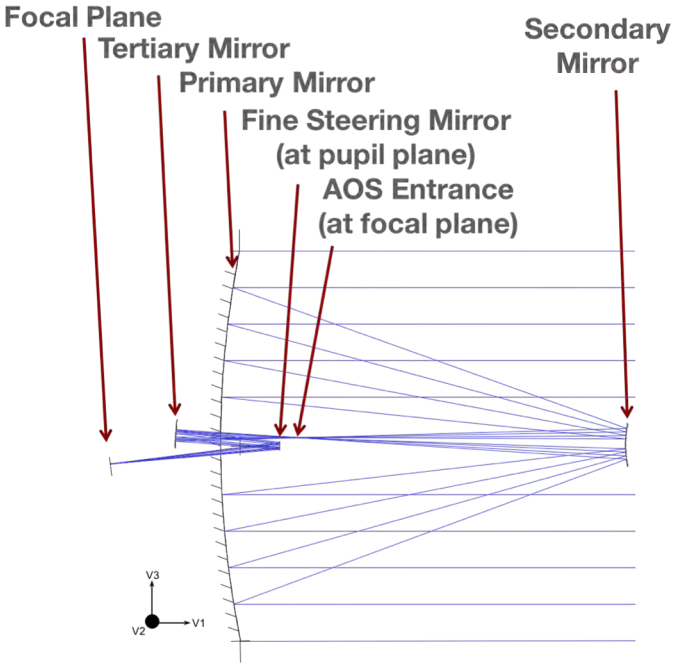
JWST Deployed

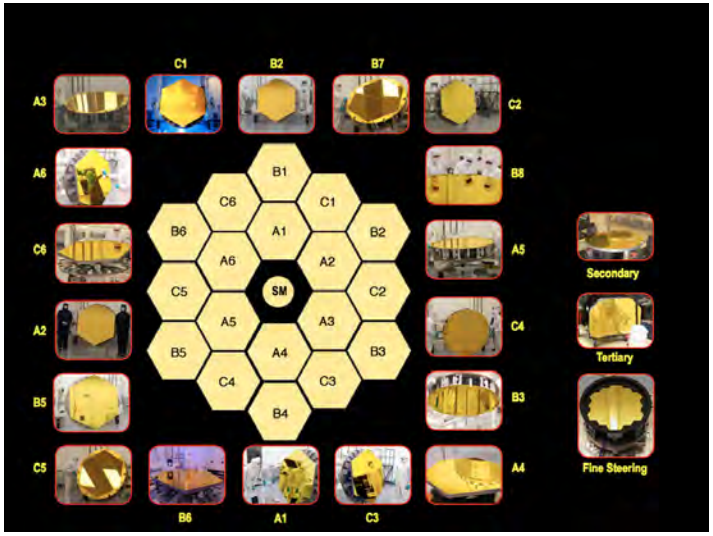
L2 Halo Orbit



Optical Telescope Element (OTE)





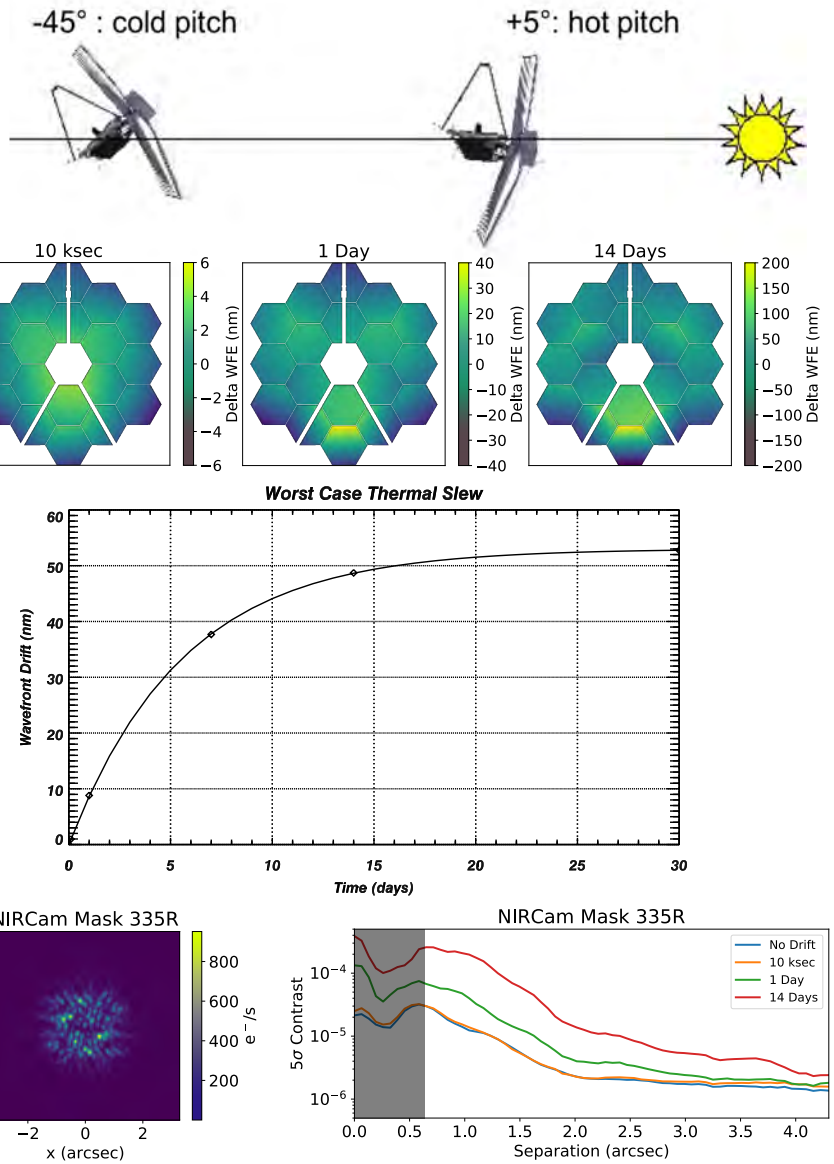


SI Field Location	Requirement (RMS WFE, nm)	Measured (RMS WFE nm)
NIRCam	131	114
NIRSpec	131	119
MIRI	131	117
NIRISS	150	119

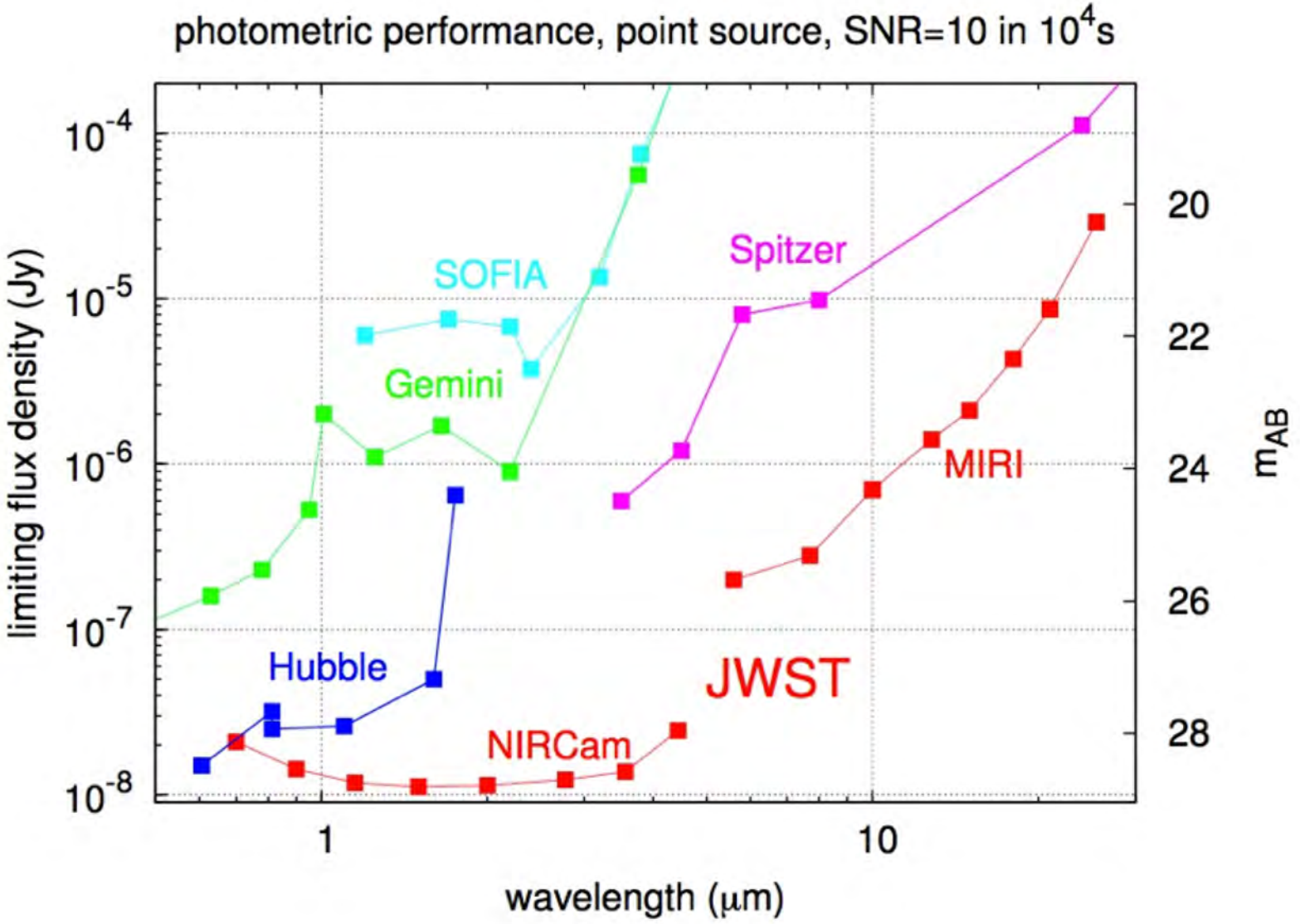
See Lightsey 10698-3

Verifying JWST's Performance

- JWST imaging quality and stability were defined for the end to end Observatory optical system.
- Optical system must meet these requirements with both the static and dynamic errors.
- **Ground testing** where possible, with component level testing, ISIM level testing, and OTIS level testing.
- **Integrated modeling** where testing is not feasible. A software package called the Integrated Telescope Model (ITM) generates PSF based on ground test data and uses integrated modeling analysis for thermal distortion, deployed dynamics, and pointing control.
- **Commissioning activities** will validate the performance for primary metrics such as image quality and stability.



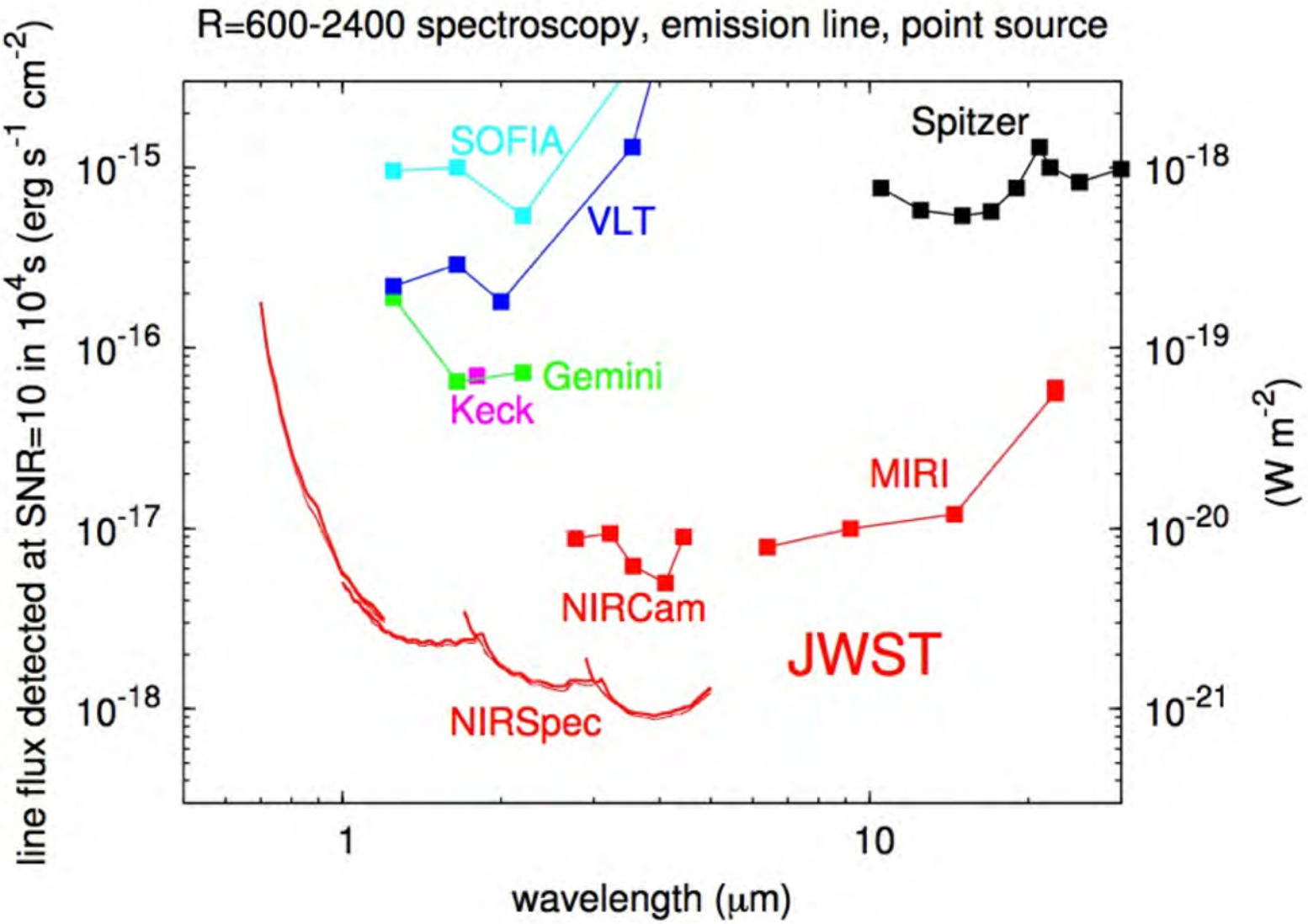
Observatory Sensitivity: Imaging



See https://jwst.stsci.edu/science-planning/

Courtesy of Jane Rigby

Observatory Sensitivity: Spectroscopy



See https://jwst.stsci.edu/science-planning/

Courtesy of Jane Rigby

JWST Integration & Test Flow

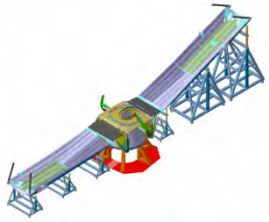
SC Avionics Tests → SC Panel I&T

SC Core Structure I&T

SC Propulsion I&T

Sunshield Component Tests

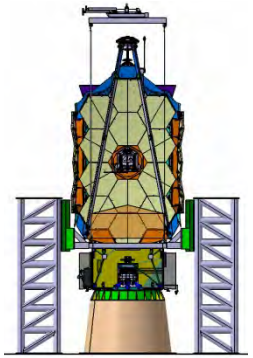
EP Sunshield Observatory Core & Sub-Scale Sunshield Thermal Tests



Spacecraft Bus /Sunshield I&T (NGAS)

2018

Cryo-Cooler I&T



Observatory I&T (NGAS)

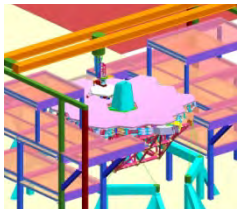
2019

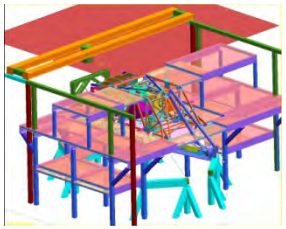
Pathfinder OTE I&T

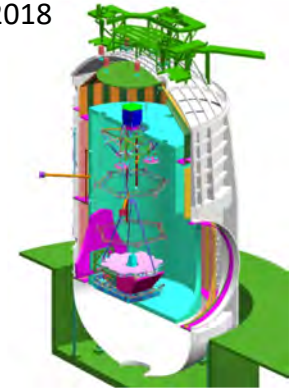
AOS I&T

SMA I&T

PMSA I&T

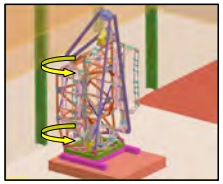






DTA I&T

SMSS I&T



Flight OTE Structural I&T (NGAS)

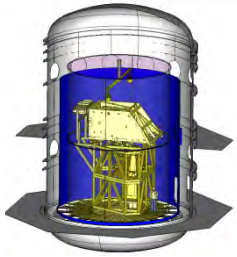
Flight OTE Ambient I&T (GSFC)

OTIS I&T (GSFC)

2016

OTIS Cryogenic Testing (JSC)

2017



Cryo-Cooler I&T

Science Instrument I&T

2012

ISIM Structure

IEC I&T

ISIM I&T

2014

Observatory I&T Activity

Spacecraft Element I&T Activity

OTIS (OTE+ISIM) I&T Activity

Optical Telescope Element I&T Activity

ISIM Element I&T Activity

Cryo-Cooler I&T Activity

OTE + ISIM = OTIS

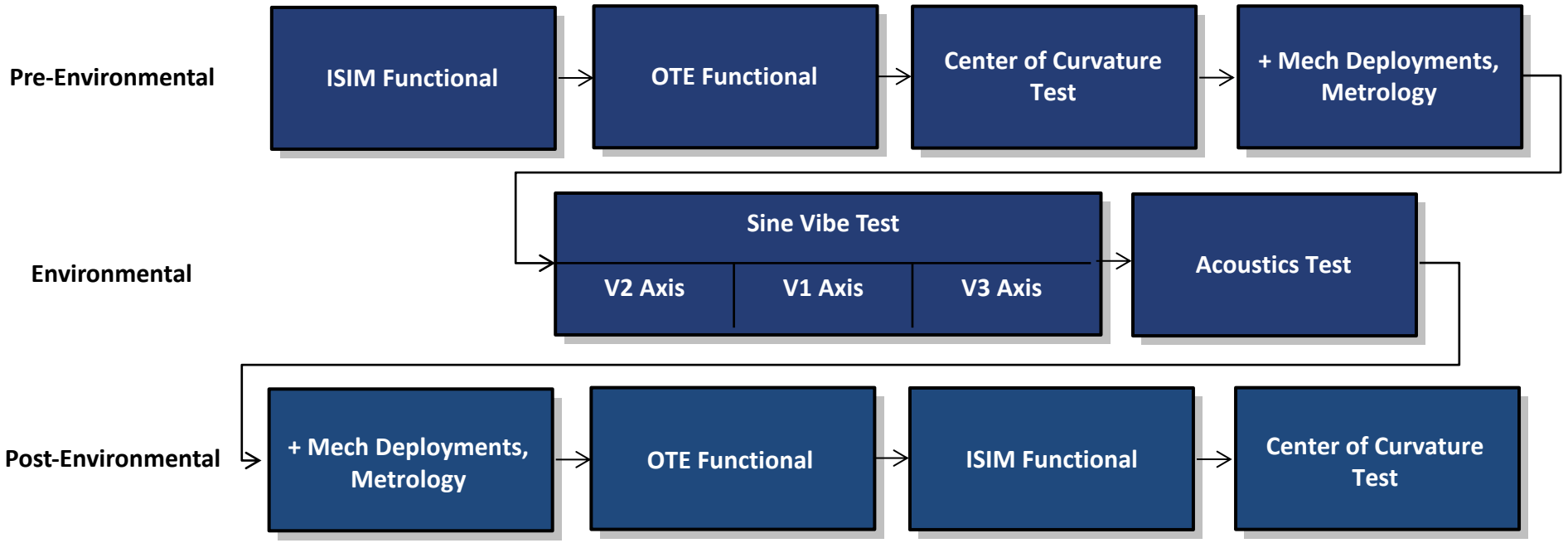
JWST OTE –V1, ISIM Installation

ISIM Installation from AOAS

*Circa SPIE AT+I 2016 Edinburgh

OTIS Ambient Test Program

- Following the integration of the OTIS assembly, the payload executed the ambient test program at Goddard.



- Assorted mechanism deployments (e.g., ADIR, bib, wings, DTA, IEC, frill first motion), PMSA gap tests and alignment measurements were sprinkled in among these electrical functional test activities.
- Post-environmental deployment tests included actuation of the Launch Restraint Mechanisms.

See Keski-Kuha 10698-125

OTIS Vibration Testing

- Starting in Nov. 2016, the OTIS vibration test was carried out in three axes, with V2/V1 on a horizontal shaker and V3 on a vertical shaker.
- For each axis, the team gradually increased sine sweep test levels from -24 dB through -18, -12, -9, -6, -3dB, where 0dB is the final “protoflight” level.
- V2 vibe anomaly identified as gapping in a launch restraint mechanism (LRM). The V1 and V3 did not have any anomalies.
- OTIS was measured to have a higher stiffness and lower damping than the mechanical models predicted.
- Ancillary tests showed LRM preload degradation from dynamic exposure, which is being evaluated.
- Lessons learned from OTIS Sine Vibe Testing presented to and incorporated in the Spacecraft Element sine vibe test planning.

Moving OTIS from V2/V1 to V3 shaker table

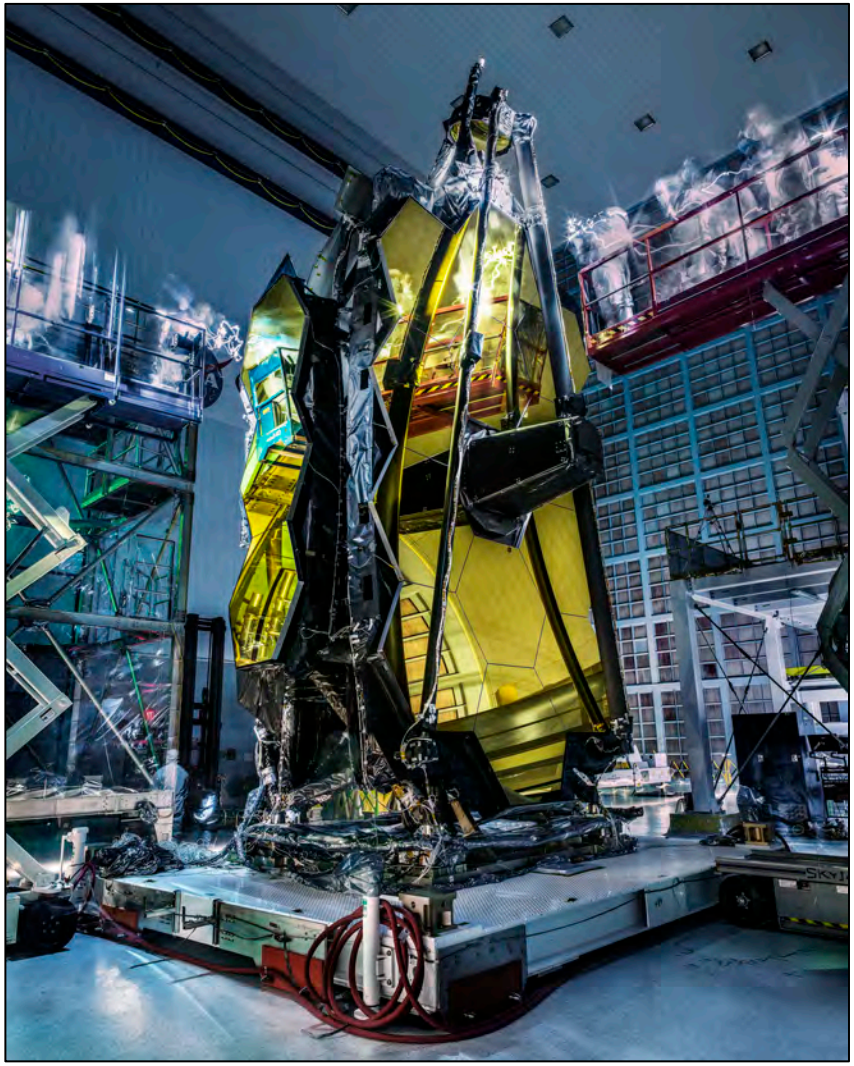
OTIS Acoustic Testing

- Prior to the acoustic test, OTIS temporarily moved to SSDIF to make adjustments to the tent.
- The acoustic test increased the levels from -18, -12, -6, -3 up to 0 dB, where 0 dB is the final “protoflight” level.
- Temporary hold at -6 dB during the acoustic progression to assess the stress and fatigue on a primary mirror segment flexure. It was deemed safe to proceed and the test completed successfully.
- Acoustic test went well and met all protoflight minimum specifications at all octave bands.
- The microshutter array (MSA) is sensitive to acoustic exposure. The test set-up was adjusted to reduce the high frequency acoustic exposure that was most problematic for the MSA. Post-acoustic test imaging inspections suggest the MSA was not affected by this test.

Moving OTIS into the Acoustic Chamber

OTIS Ambient Testing - Results

- ***OTIS completed the vigorous ambient test program and is in excellent health.***
- All mirror actuators operated successfully on both A and B sides.
- Mirror figures consistent with pre-environmental measurements.
- Post-vibe launch restraint mechanisms (LRMs) released properly.
- Test vibe levels were reduced at a few resonant frequencies that had a higher dynamic response than anticipated. This will be mitigated by adding particle dampers following the cryotest at the Johnson Space Center and before the Observatory-level vibe testing.
- Measured contamination levels are well within budgets at this phase of integration and test.



Post-Environmental "Lights-Out" Contamination Inspection

JWST Integration & Test Flow

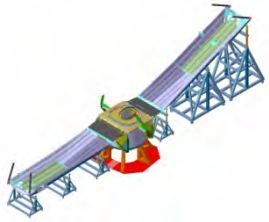
SC Avionics Tests → SC Panel I&T

SC Core Structure I&T

SC Propulsion I&T

Sunshield Component Tests

EP Sunshield Observatory Core & Sub-Scale Sunshield Thermal Tests



Spacecraft Bus /Sunshield I&T (NGAS)

2017

Cryo-Cooler I&T

Pathfinder OTE I&T

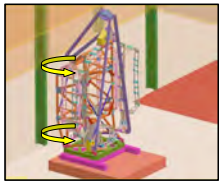
AOS I&T

SMA I&T

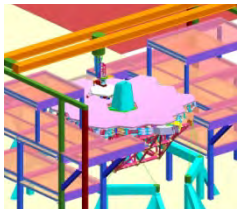
PMSA I&T

DTA I&T

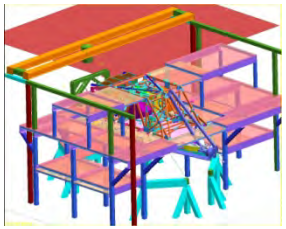
SMSS I&T



Flight OTE Structural I&T (NGAS)

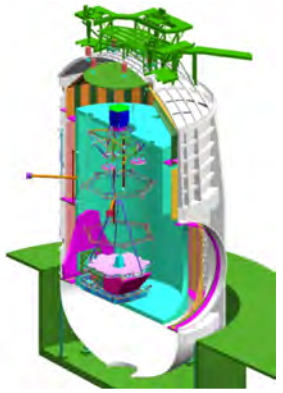


Flight OTE Ambient I&T (GSFC)



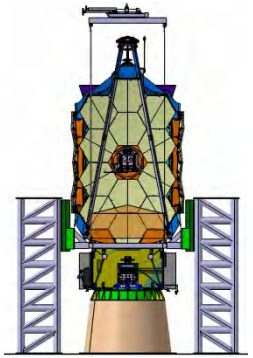
OTIS I&T (GSFC)

2016



OTIS Cryogenic Testing (JSC)

2017



Observatory I&T (NGAS)

2018

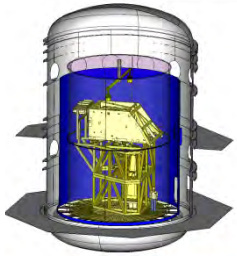
Cryo-Cooler I&T

Science Instrument I&T

ISIM Structure

IEC I&T

2012



ISIM I&T

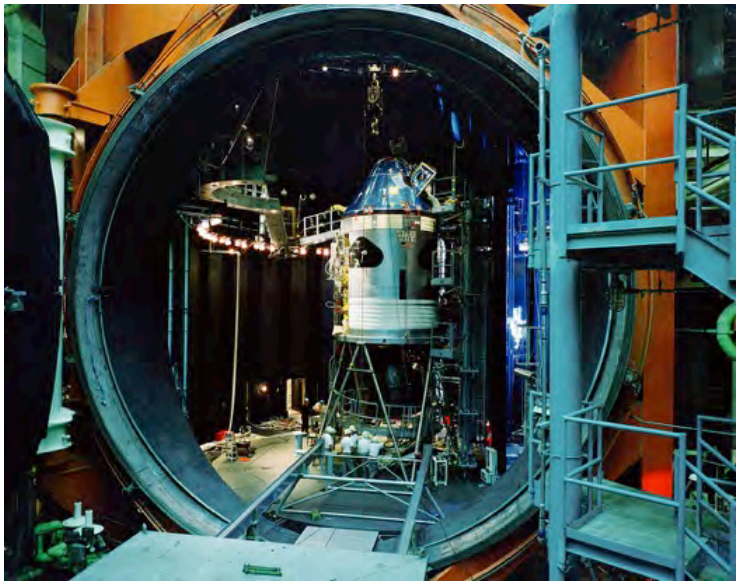
2014

- Observatory I&T Activity
- Spacecraft Element I&T Activity
- OTIS (OTE+ISIM) I&T Activity
- Optical Telescope Element I&T Activity
- ISIM Element I&T Activity
- Cryo-Cooler I&T Activity

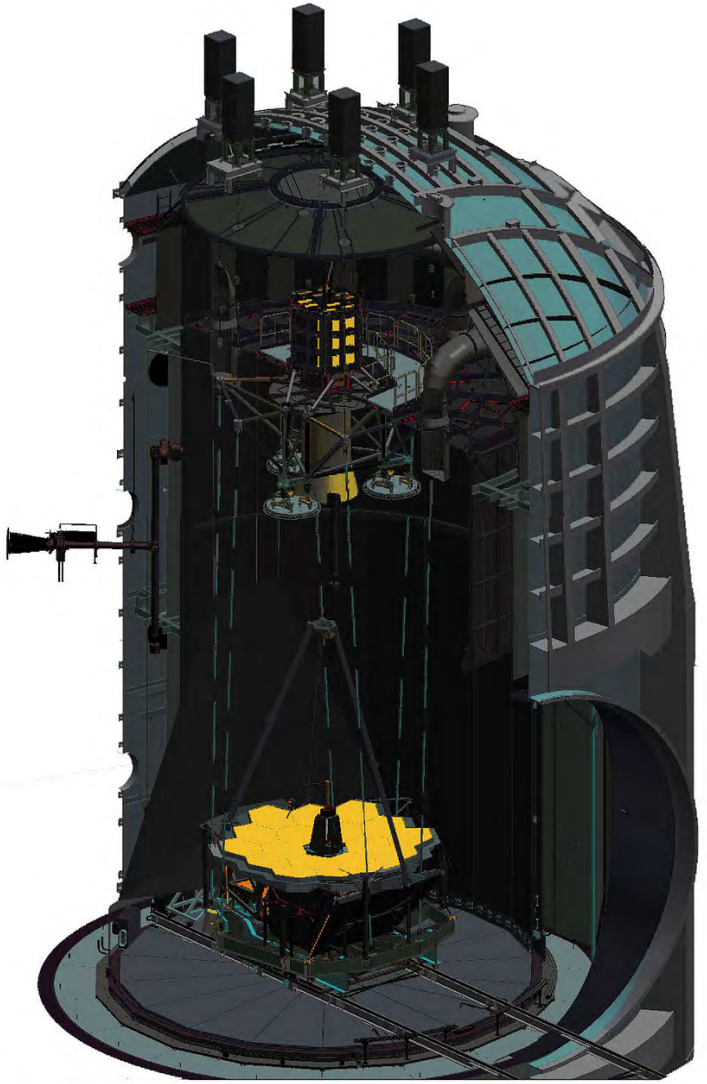
Johnson Space Center Chamber A

JWST Space Telescope Transporter for Air, Road and Sea (STTARS)

Apollo command module test in JSC's Chamber A (1968)



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



See Kimble 10698-3

JWST Integration & Test Flow

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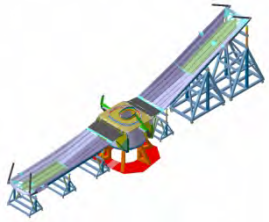
SC Propulsion I&T

Sunshield Component Tests

EP Sunshield Observatory Core & Sub-Scale Sunshield Thermal Tests



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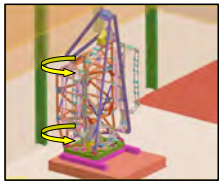
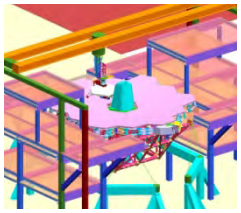
DTA I&T

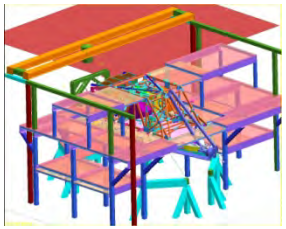
SMSS I&T



Flight OTE Structural I&T (NGAS)

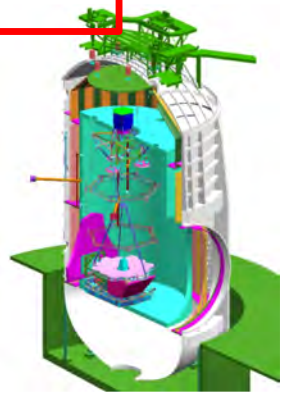


Flight OTE Ambient I&T (GSFC)



OTIS I&T (GSFC)

2016



OTIS Cryogenic Testing (JSC)

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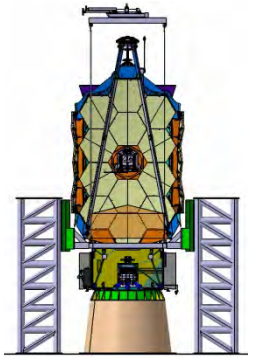


Observatory I&T (NGAS)

2019

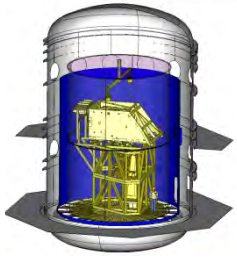
Cryo-Cooler I&T

Science Instrument I&T

ISIM Structure

IEC I&T

2012



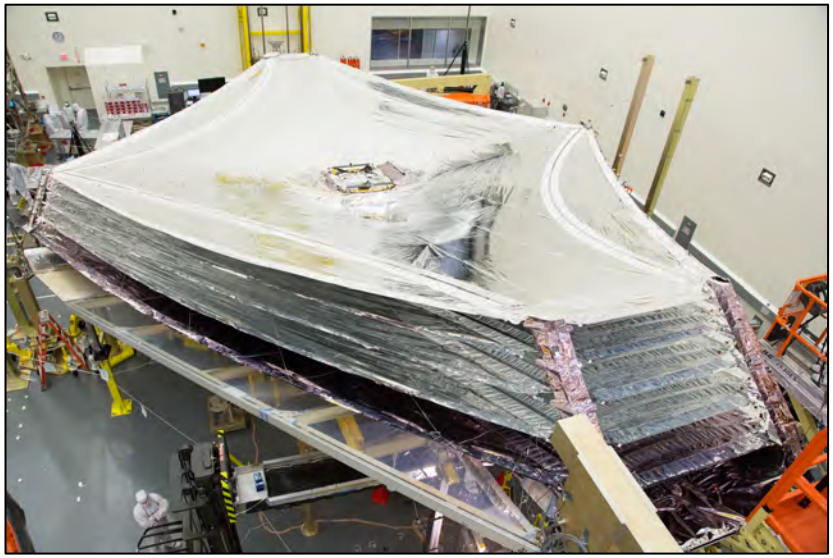
ISIM I&T

2014

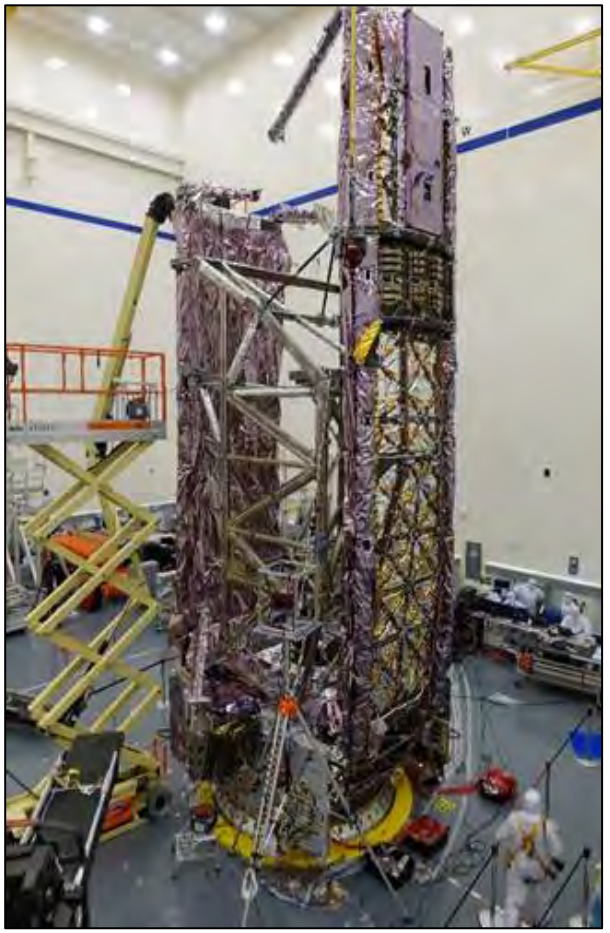
Observatory I&T Activity
Spacecraft Element I&T Activity
OTIS (OTE+ISIM) I&T Activity
Optical Telescope Element I&T Activity
ISIM Element I&T Activity
Cryo-Cooler I&T Activity

Sunshield/Spacecraft Status

- Sunshield and spacecraft fully integrated.
- Successfully completed pre-environmental deployments.
- Successful spacecraft compatibility testing with TDRSS and the Deep Space Network.
- Spacecraft element environmental tests (e.g., acoustic, vibration, thermal vacuum) this year.



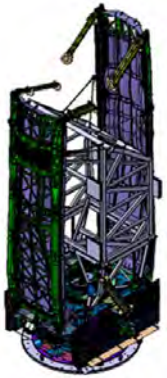
Spacecraft Element in Deployed Configuration



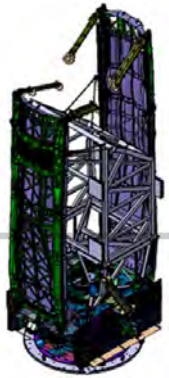
Spacecraft Element in Stowed Configuration

OTIS Arrival in Northrop's Highbay

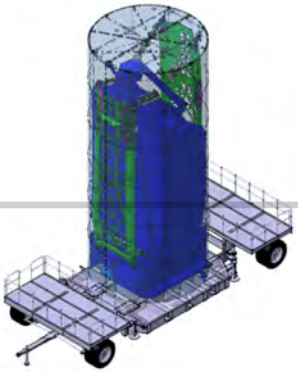
SCE Environmental Test Flow Overview



M8/Stowed SCE with OTIS Simulator



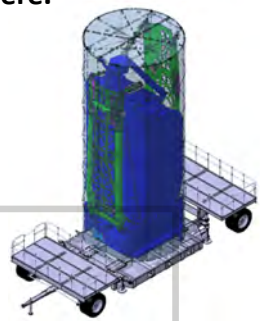
PAS Shock Test (Mechanical Only)



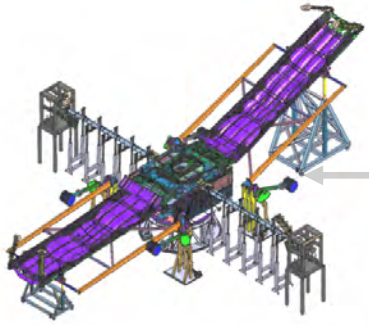
Transport to M1/LATF

Acoustics @ Protoflight

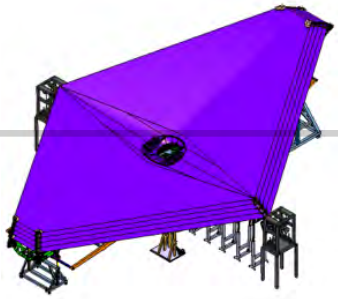
We are here.



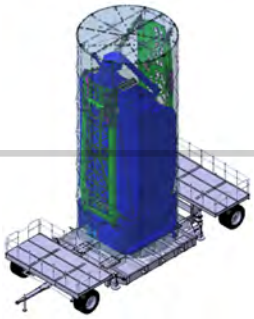
Transport to M4



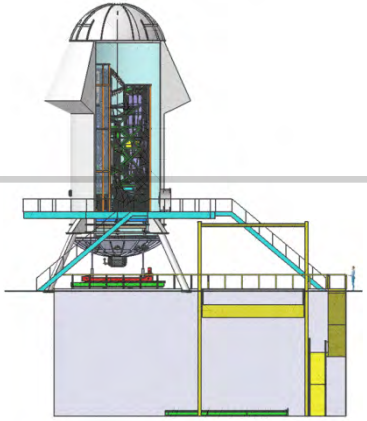
Stow for OTIS Install (3rd fold)



Full SCE Deployment (2nd deploy)



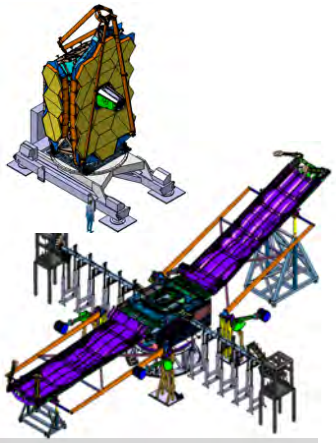
Transport to M8



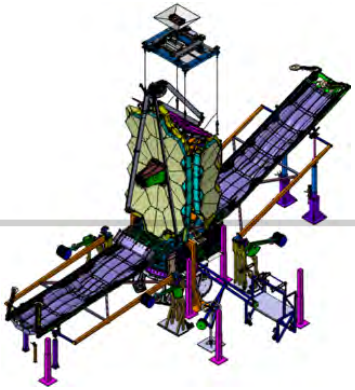
Thermal Vacuum

3-axis Vibe @ Protoflight

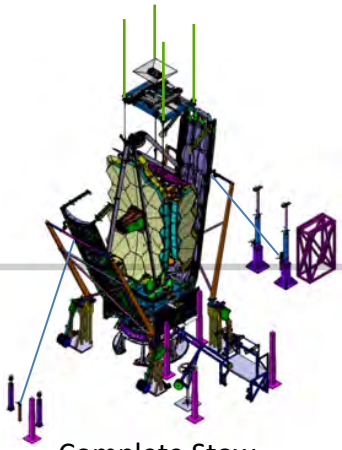
Observatory I&T Flow Overview



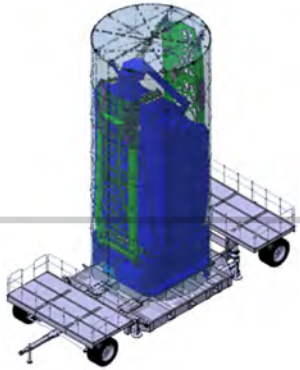
Observatory I&T Start



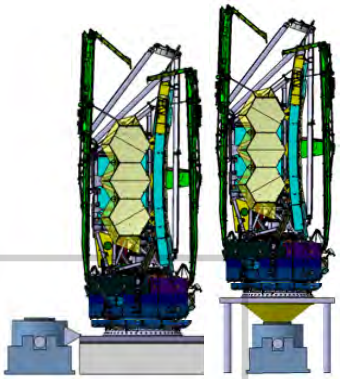
OTIS Install and DTA Deploy
*Risk reduction activities underway



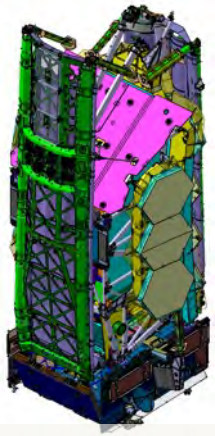
Complete Stow



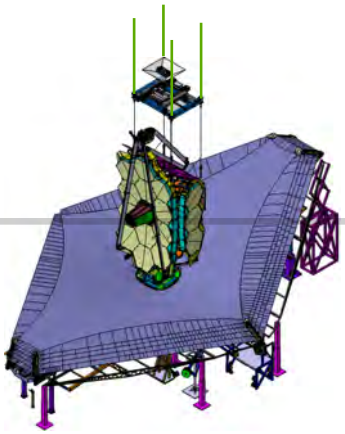
Transport to Vibe Facility



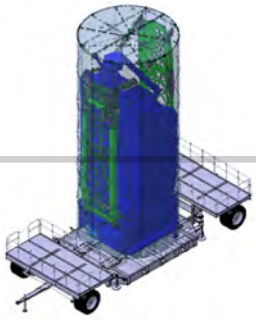
Vibe @ Acceptance



Stow and Ready to Ship

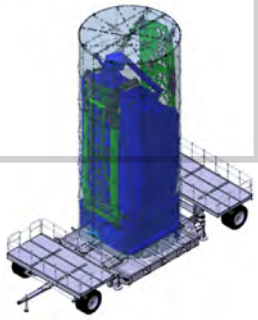


Full Observatory Deployments



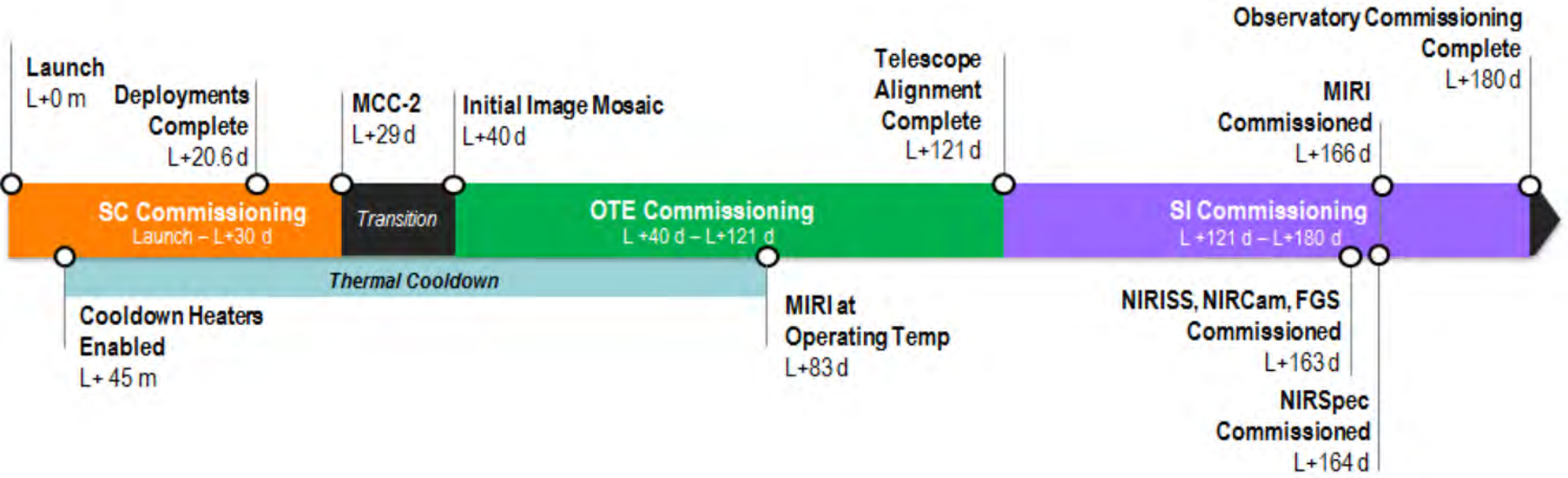
Transport to Highbay

Acoustics @ Acceptance



Transport to LATF

JWST Commissioning



- JWST commissioning is “the collection of flight activities required to activate, checkout, and calibrate the Observatory subsystems, including the science instruments to perform Cycle 1 science.”
- The flight operations team is in place and has been going through various training programs and rehearsals in preparation for commissioning.

Summary

- JWST will carry out transformative science from the very early universe and across cosmic time.
- JWST OTE and ISIM have been combined to form OTIS, which completed its test program at NASA Goddard and Johnson. It is now delivered to Northrop's Space Park.
- The spacecraft element has completed its integration activities and is currently in its environmental test program.
- To date, JWST testing and analysis suggests that all performance requirements can be achieved.

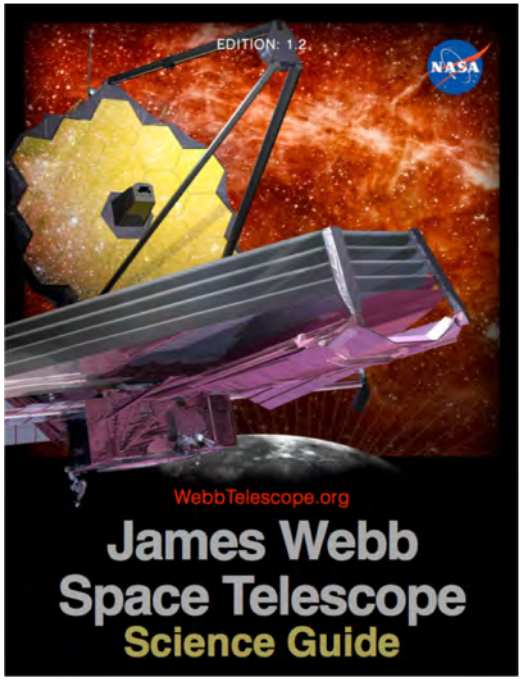
Following JWST

Webpages

www.jwst.nasa.gov

webbtelescope.org/

Webb e-book



Webcam

www.jwst.nasa.gov/webcam.html

Social Media