# James Webb Space Telescope
# Mission Status &
# Challenges Managing a Large Project

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# JWST System Hierarchy

## James Webb Space Telescope System

### Launch Segment


- Launch Vehicle
- Payload Adapter
- Launch Site Services

### Observatory Segment


- Optical Telescope Element (OTE)
- Integrated Science Instrument Module (ISIM)
  - NIRCam
  - MIRI
  - NIRSpec
  - FGS
- Spacecraft Element (SE)
  - Spacecraft Bus
  - Sunshield

### Ground Segment

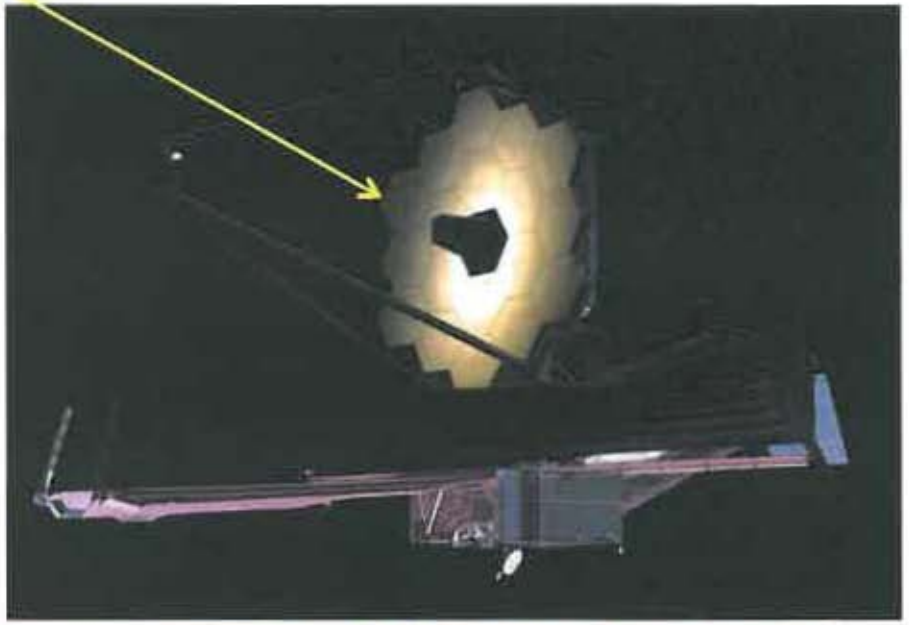


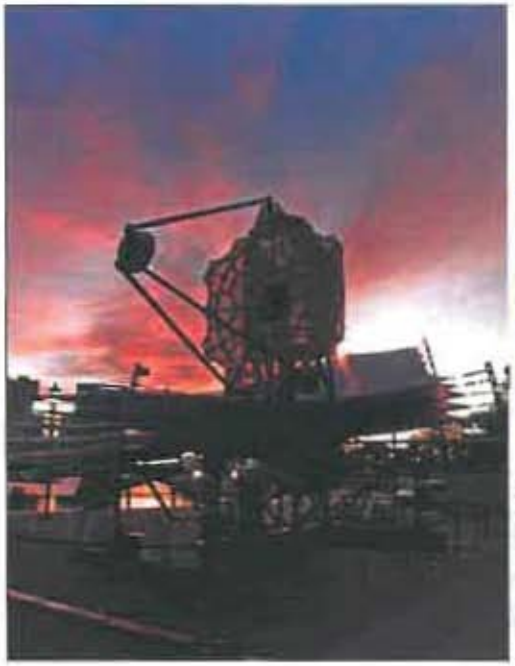
- Science and Operations Center (SOC)
- Institutional Systems
- Common Systems

Provided by NASA
Provided by NGAS
Provided by STScI
Provided by ESA
Provided by CSA

# Telescope

- **Optical Telescope Element (OTE)**
- **Sun Shield**
- **Integrated Science Instrument Module (ISIM)**
- **Spacecraft**





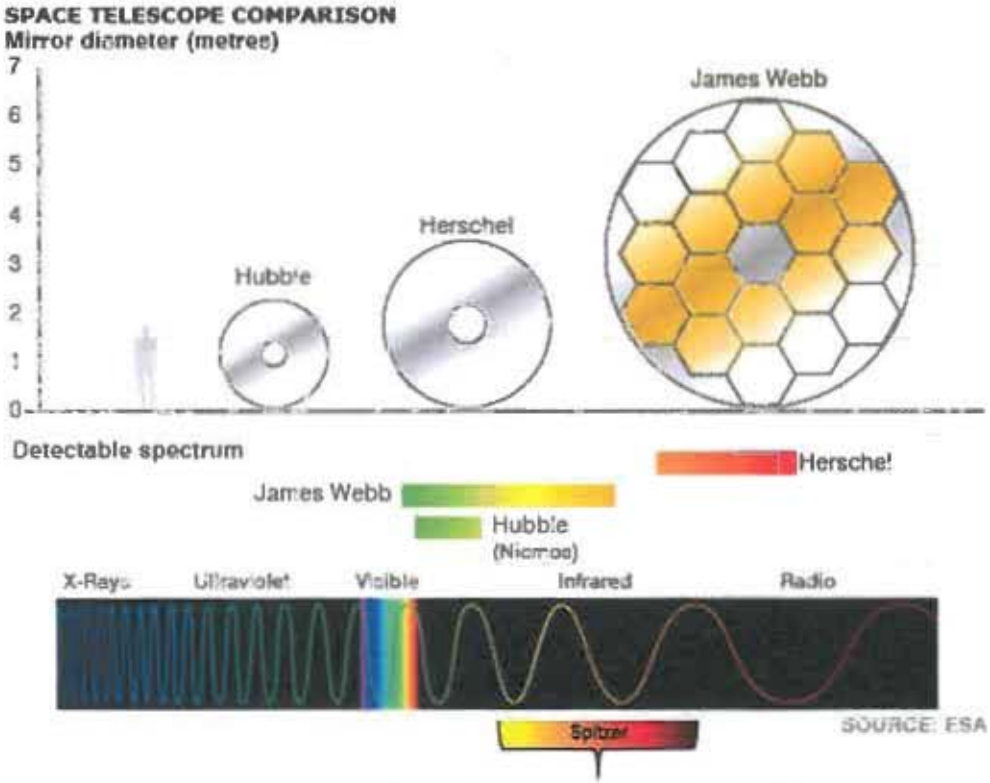
# JWST requires the largest cryogenic telescope ever constructed

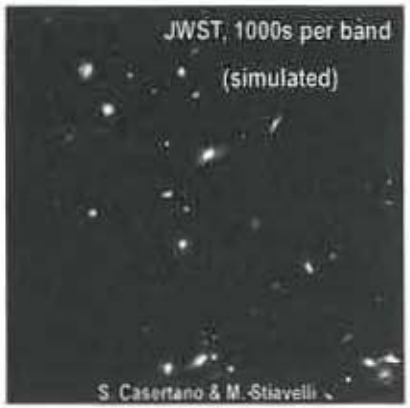
**To observe the early universe, the JWST mission requires:**

- 7X the light gathering capability of the Hubble Space Telescope
- similar angular resolution in the near-infrared spectrum
- wavelength coverage spanning the optical to mid-infrared spectrum

**As a consequence, the observatory requires:**

- a primary mirror that is larger in diameter than available rocket fairings
- a high stability 40-50K cryogenic operating temperature



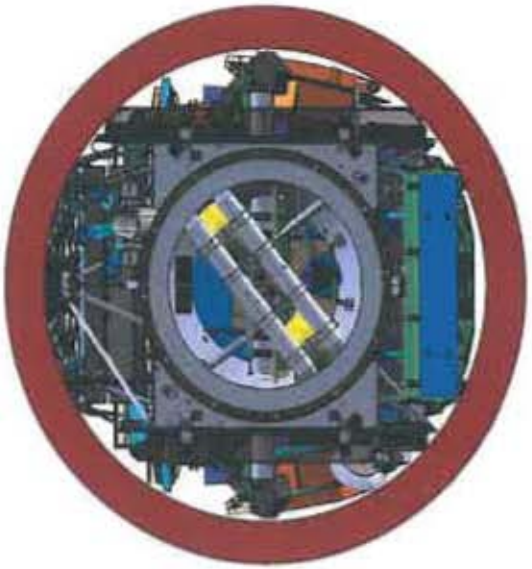

**1'x1' region in the UDF**

**3.5 to 5.8 um**

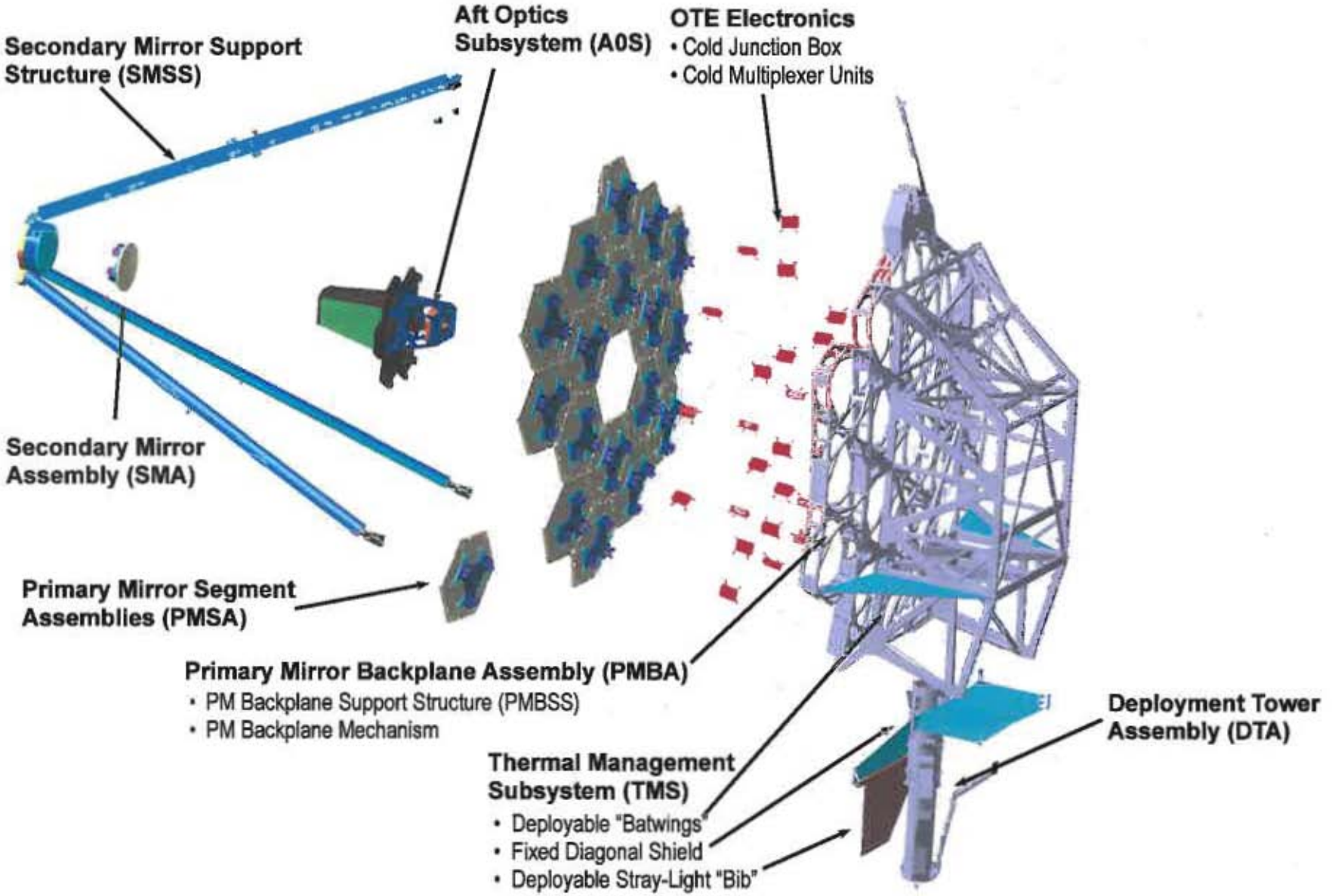
# JWST requires a segmented deployable primary mirror


Ariane 5 ECA


- JWST is designed to integrate with an Ariane V launch vehicle and 5 m diameter fairing
- Launch from Kourou Launch Center (French Guiana) with direct transfer to L2 point.
- Payload launched at ambient temperature with on orbit cooling to 50 K via passive thermal radiators
- JWST payload: 6330 kg



# Telescope Architecture Overview

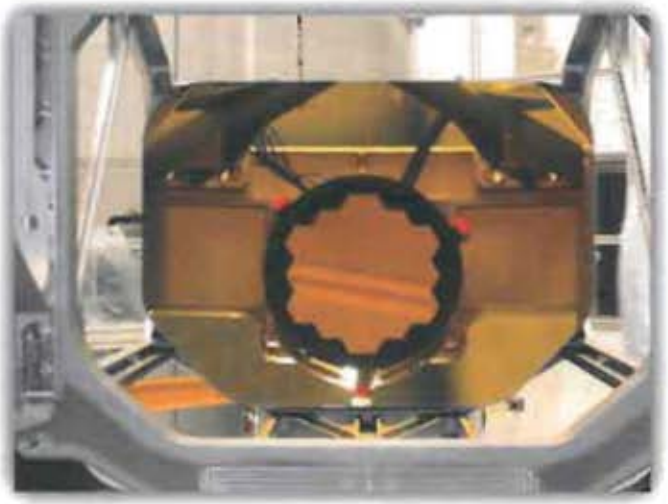


# JWST Mirror Manufacturing Team


**Each individual mirror makes 11 trips and travels ~*15,000 miles* before ever being integrated onto the observatory!**

# All Mirrors Are Complete!

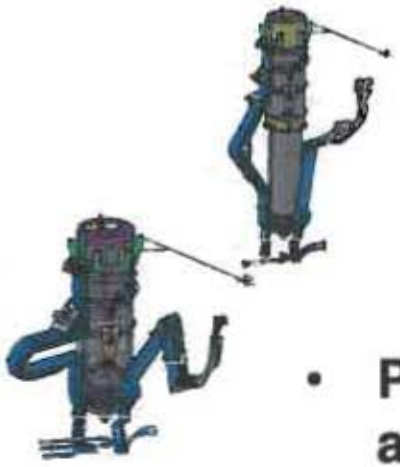
- Polished, coated, vibed, cryo tested
- Aft Optics Assembly (AOS) integration complete
- Flight Cryo Electronics on track for incremental deliveries over the next year



# Buildup of Telescope Flight Structure

## Assembly consists of ~3,200 bonded composite piece parts

Flight Deployable Tower Composite Pieces Almost Complete



- **PMBSS Center Section assembly is complete !**

Wing Structures being built on Tooling

Flight Backplane – Center Section

# Telescope Assembly Ground Support Equipment

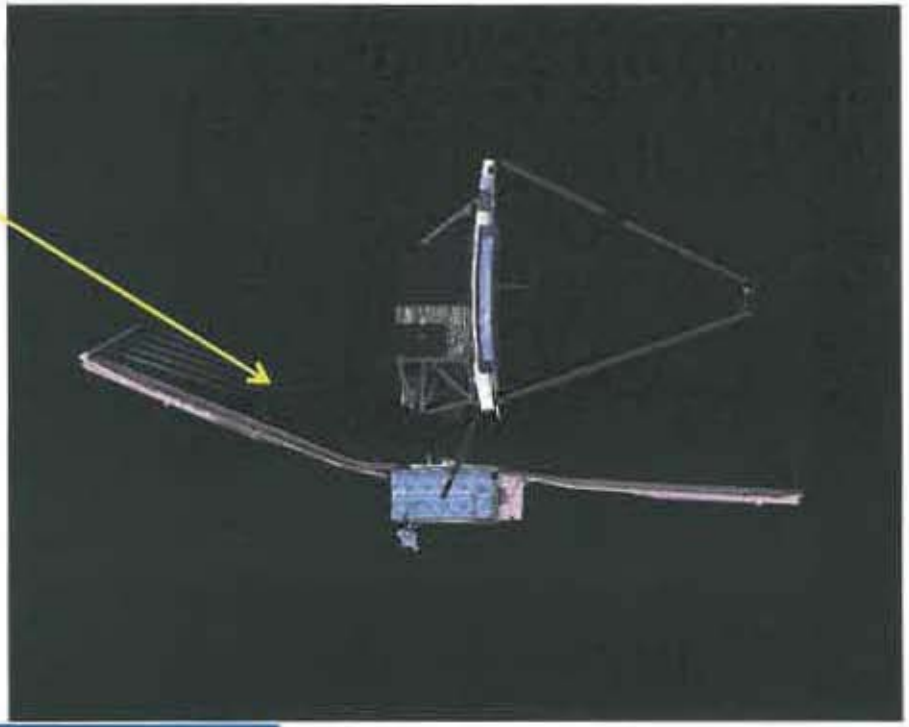
**139,000 lbs of GSE to install a 46 lb mirror segment!**

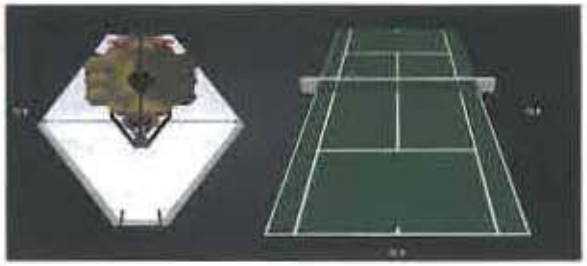
**Ambient Optical Alignment Stand Complete**

Landing a mirror onto backplane simulator

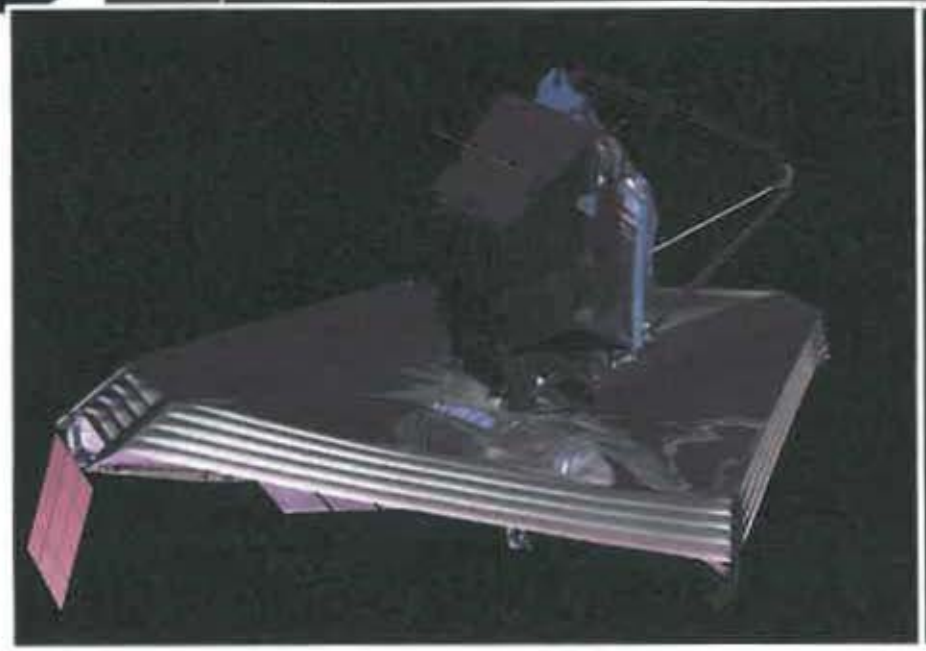
# Sunshield

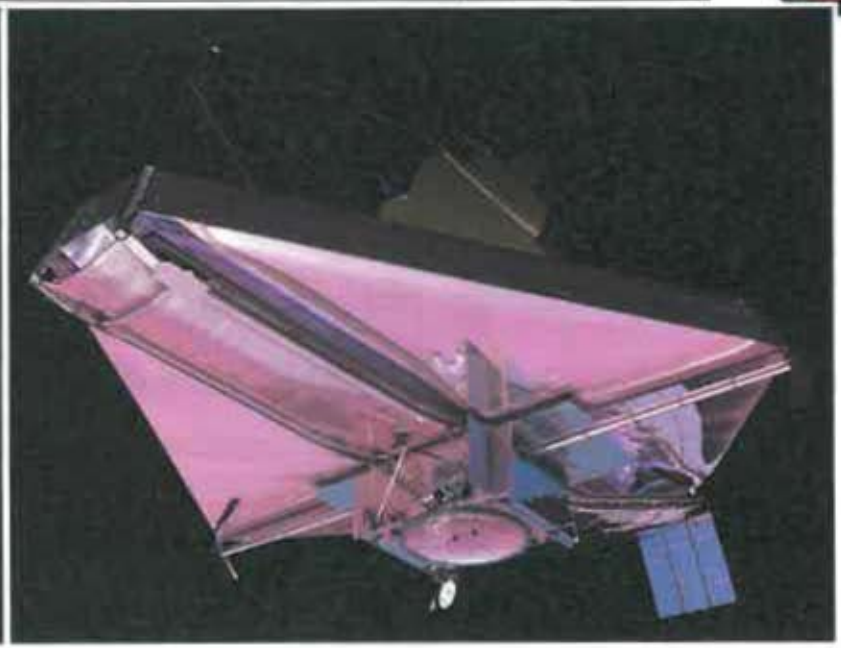
- Optical Telescope Element (OTE)
- **Sun Shield**
- Integrated Science Instrument Module (ISIM)
- Spacecraft





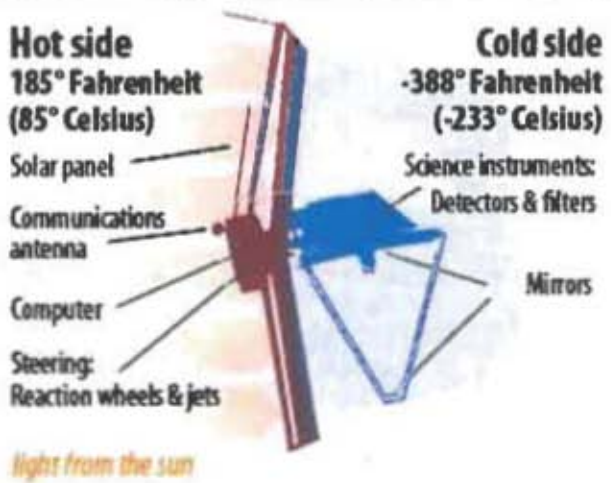
# JWST's 5 Layer Sunshield





## Sunshield Facts

- Measures 73 x 40 feet (about the size of a tennis court) and has 5 layers
- Contains 400 temperature sensors
- Sun side reaches 358 K (185° F)
- Dark side stays at 40 K (-388° F)



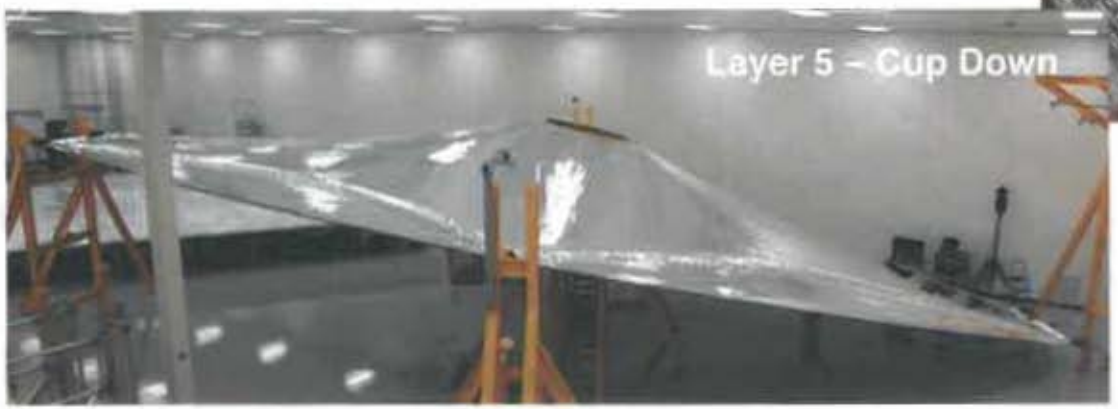
# Sunshield thermal performance has been validated by a 1/3 scale test in a space simulation chamber

# Sunshield Template Membrane Work On-Going

## Templates Verify Design Prior to Flight Build

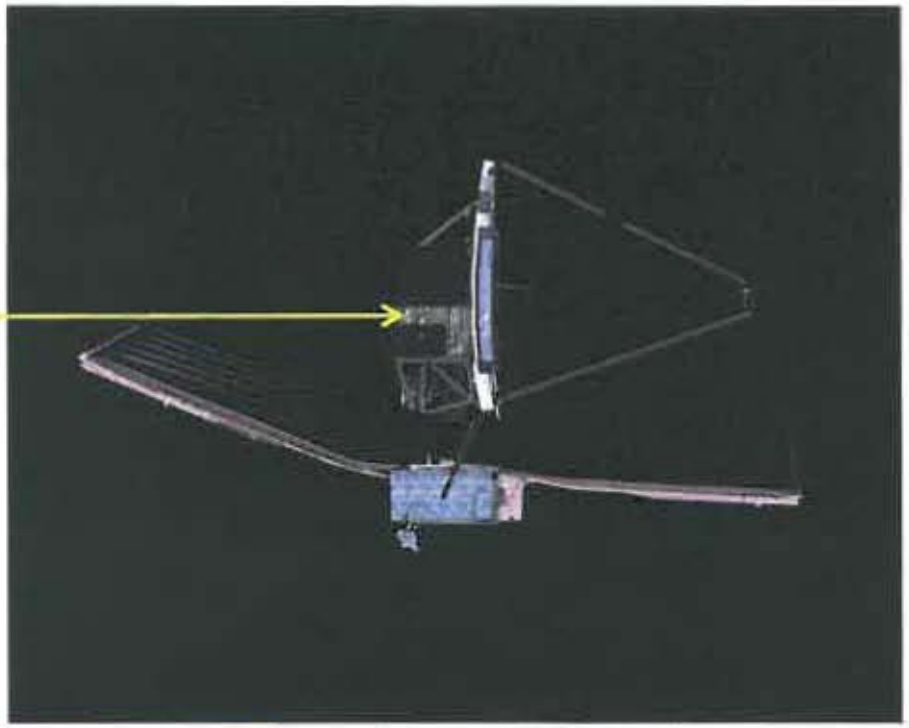
- **Template Layer 3 testing completed**
  - All shape measurement data looks good
  - Layer 3 hole punching on-going
- **Template Layer 5 - shape testing competed**
  - All shape measurement data looks good
- **Template Layer 4**
  - Shape testing completed and data delivered for analysis
- **Template Layer 2**
  - Manufacturing underway





# Integrated Science Instrument Module

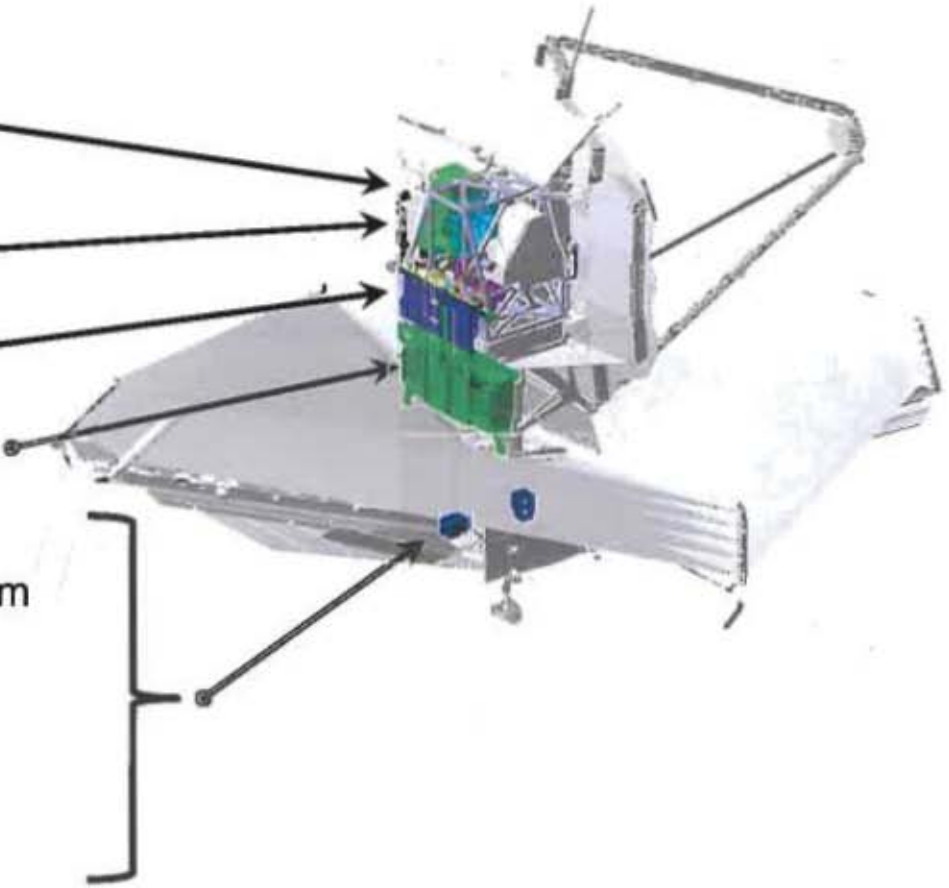
- Optical Telescope Element (OTE)
- Sun Shield
- **Integrated Science Instrument Module (ISIM)**
- Spacecraft



Flight ISIM Structure

# ISIM is the Science Instrument Payload of JWST

- **Approximately 1.4 metric tons, ~20% of JWST by mass**
- **The ISIM system consists of:**
  - Four science instruments
  - Nine instrument support systems:
    - Optical metering structure system
    - Electrical Harness System
    - Harness Radiator System
    - ISIM electronics compartment (IEC)
    - Cryogenic Thermal Control System
    - Command and Data Handling System (ICDH)
    - ISIM Remote Services Unit (IRSU)
    - Flight Software System
    - Operations Scripts System



# INSTRUMENTS

# NIRCam will provide the deepest near-infrared images ever and will identify primeval galaxy targets for NIRSpec

Module A

Module B

NIRCam Entering Chamber for Cryo Testing

- Developed by the University of Arizona with Lockheed Martin ATC
  - Operating wavelength: 0.6 – 5.0 microns
  - Supports OTE Wavefront Sensing
- Current Status
  - NIRCam: Module instrument level cryo testing has begun
- Delivery to I&T scheduled for Nov. 2012

# NIRSpec Will Acquire Spectra Of Up To 100 Galaxies In A Single Exposure

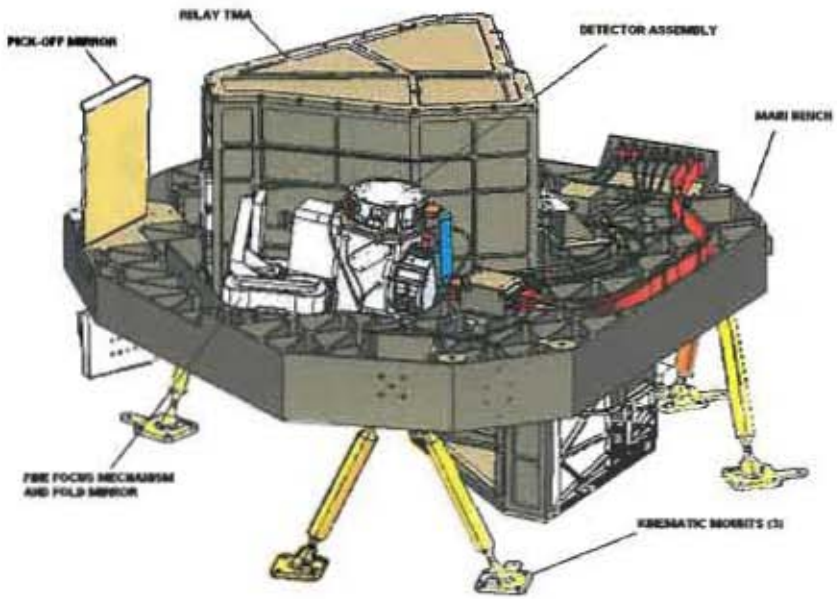
- **Developed by the European Space Technology Center (ESTEC) with Astrium GmbH and Goddard Space Flight Center**
  - Operating wavelength: 0.6 – 5.0 microns
  - Aperture control:
    - Programmable micro-shutters, 250,000 pixels
    - Fixed long slits & transit spectroscopy aperture
    - Image slicer (IFU) 3x3 arc sec
- **Current Status**
  - Integration of components on optical bench well underway
    - Flight optical bench had to be replace with spare after cracks found
- **Delivery to I&T scheduled for April 2013**
  - ISIM Cryo Vac Test 1 (of three) will use NIRSpec Engineering Test Unit

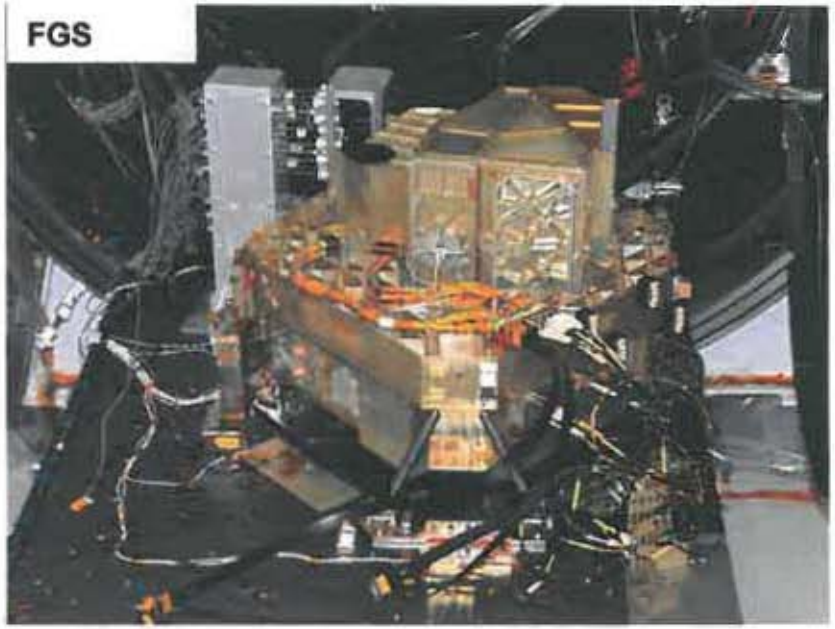
# MIRI will detect key discriminators that distinguish the earliest state of galaxy evolution from more evolved objects


MIRI in Clean Room at GSFC

- Developed by a European Consortium and JPL
  - Operating wavelength: 5 - 29 microns
  - Coronagraphic imager and Spectroscopy
- Current Progress
  - MIRI was delivered to GSFC on May 29th !
    - Completing post-ship functional test activities

# FGS provides imagery for telescope pointing control & imaging spectroscopy to reveal primeval galaxies and extra-solar planets



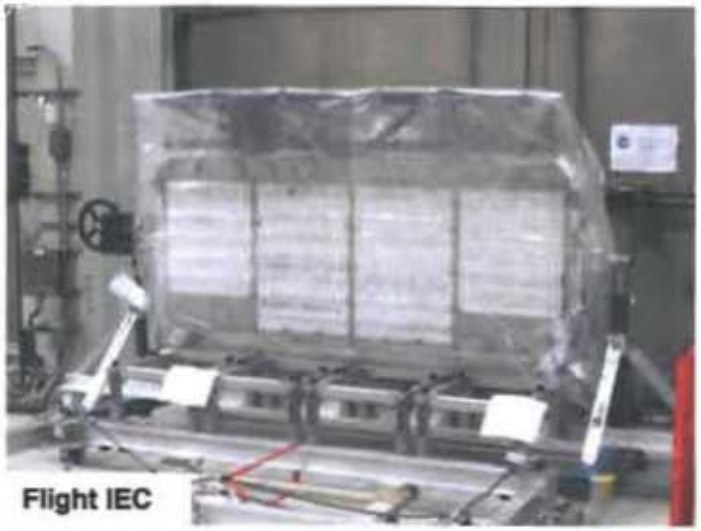




- **Developed by Canadian Space Agency with ComDev**
  - Operating wavelength: 0.8 – 4.8 microns
- **Current Progress**
  - Final integration and test underway
- **Delivery date: End of July 2012**

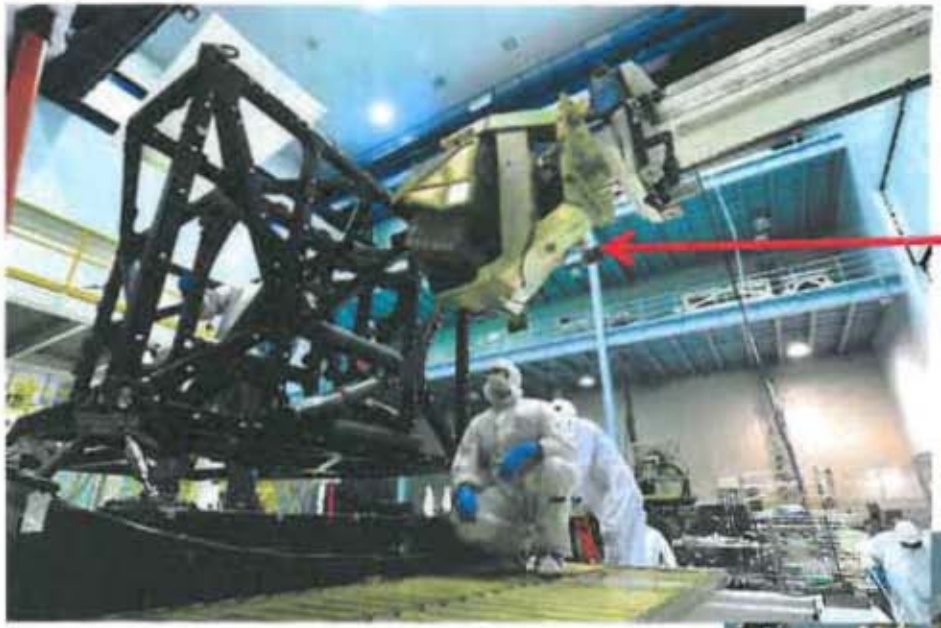
# ISIM Status

- **ISIM Structure - Completed**
- **ISIM Command & Data Handling Units (ICDHs) 1 & 2**
  - Delivered to ISIM I&T
- **ISIM Remote Servicing Unit (IRSU):**
  - Delivered to ISIM I&T
- **ISIM Electronics Compartment (IEC):**
  - Completed cryo and acoustics testing
  - Vibration testing in progress
- **ISIM Flight Software System**
  - Build completed to support ISIM Cryo-Vac 1

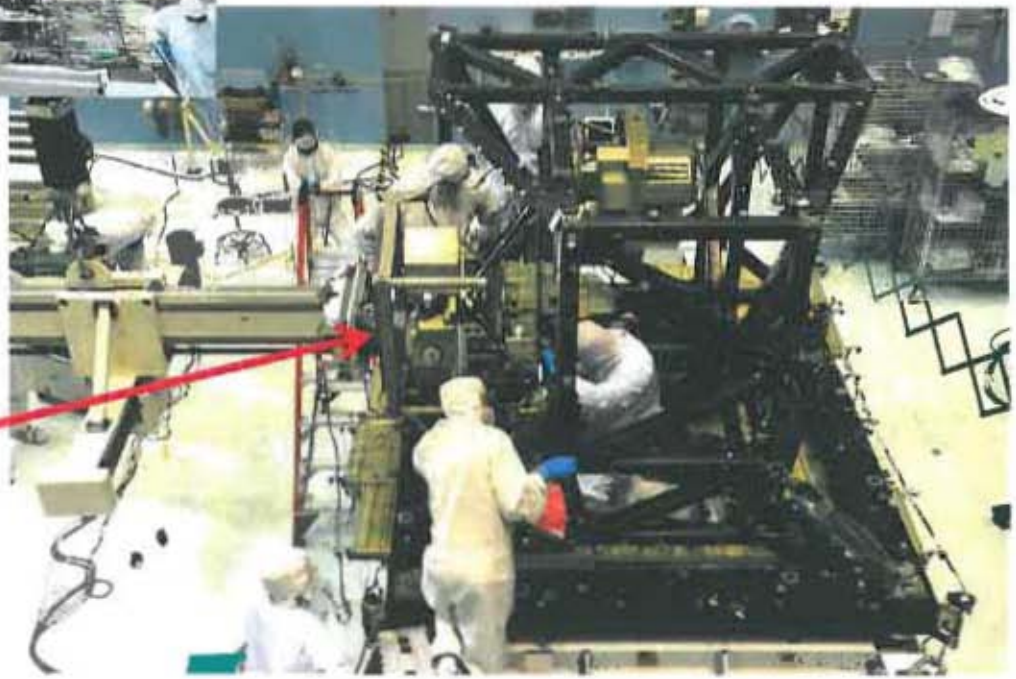


# ISIM Structure Instrument Fit Check



FGS ETU Being Installed Into
ISIM Flight Structure



MIRI STM Being Installed Into
ISIM Flight Structure

# Making sure ISIM all works .....

- **ISIM is flight qualified prior to delivery for integration with the Observatory element**

- **Primary ground support equipment:**

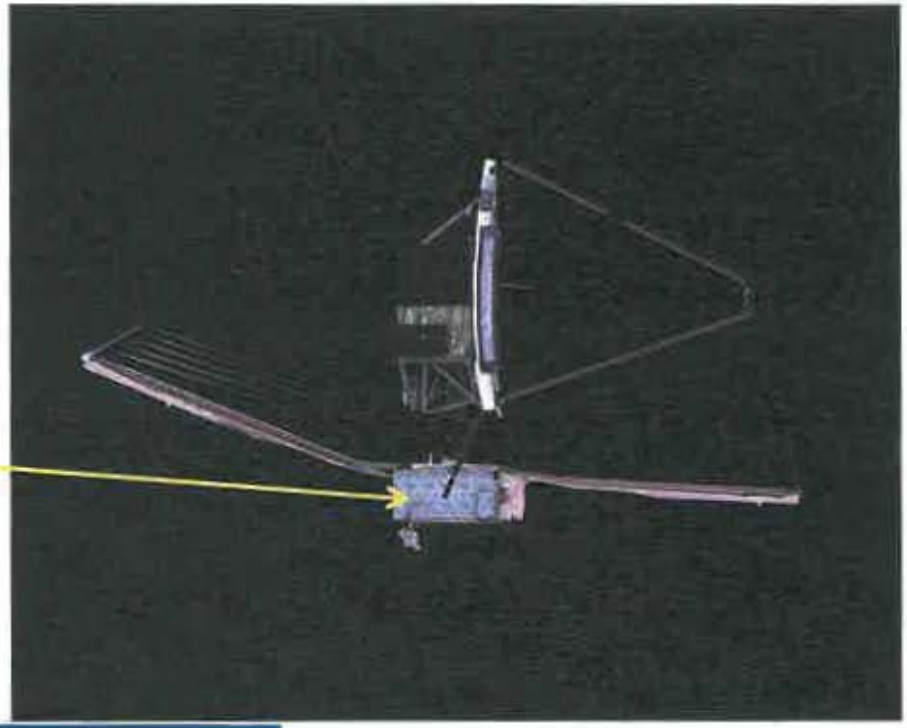
  - ✓ Space environment simulator LHe shroud
    - Enables ISIM testing at operating temperature
  - ✓ Cryogenic photogrammetry system
    - Enables metrology of ISIM structure at operating temperature
  - ✓ ISIM Test Platform (ITP)
    - Simulates OTE mechanical interface at cryogenic operating temperature
  - ✓ Ambient science instrument mechanical interface fixture (ASMIF)
    - Simulates ISIM structure mechanical interface for each instrument with high fidelity
  - ✓ Science instrument test sets (SITS)
    - Simulates ICDH for each instrument

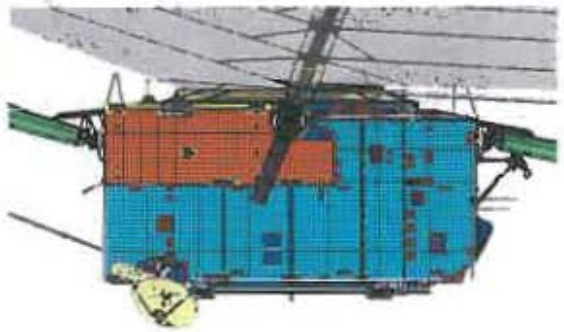
# ISIM Integration GSE

- **Optical Telescope Element (OTE) Simulator (OSIM)**
  - Simulates Optical Telescope Element (OTE) with high fidelity
  - Used to test optical performance of ISIM
    - Cryo Certification is in process

# Spacecraft

- Optical Telescope Element (OTE)
- Sun Shield
- Integrated Science Instrument Module (ISIM)
- Spacecraft

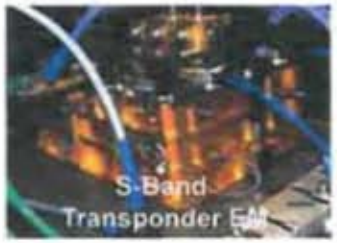




## Spacecraft Progress
## Component Level CDRs being conducted
## Various Flight and Engineering Model components are in fabrication















# OTE + ISIM = OTIS

# OTE/OTIS I&T Flow

**Receive OTE Structures at NGAS**
- PMBSS, Wings, DTA, Harnesses
- SMSS manufactured at NGAS

**Integrate Structure Deployment Tests**
- Install Wings, SMSS, DTA, harness
- Perform deployment & repeatability tests

**Modal Surveys**
- Install mass simulators
- Stowed Modal Survey
- Deployed Modal Survey

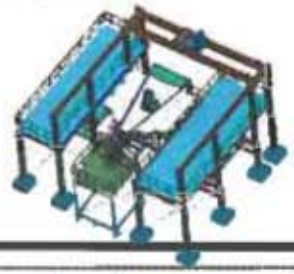
**Prep / Ship to GSFC OTE I&T**

**PMSA 1-18**

**AOS & SMA**

**Integrate Flight Optics**
- Walkout OTE for optical I&T
- Release SMSS at field joint

Begin TMS install



**Integrate Flight ISIM (Begin Obs. I&T)**
- Integrate Flight ISIM
- Integrate Flight IEC
- Integrate Radiators
- Complete TMS install

**Pre-Env. Test**
- COCI
- Alignment Metrology
- Electrical Functional

**Acoustic & Sine-Vibe Tests**

**Post Env. Test**
- Electrical Functional
- 1st Motion Checks
- COCI

**Ship to JSC/ CryoVac Prep**
- Electrical Functional
- SMSS Walkout
- Wing & DTA Deployment
- Configure OTE for cryovac test

**Observatory (OTIS) Cryo Optical Test**
- Verifies OTE-ISIM Alignment
- Cross check optical and thermal performance

**Prep/Ship To NGAS Observatory I&T**
- Obs. Level: CST, EMC,
- Acoustic, Shock Vibe, Deployment

Green=Test
Peach= Integration
Blue=Shipment

# OTE + ISIM = OTIS

- **Prior to final Observatory Integration the OTE + ISIM (OTIS) will be tested in a large chamber at JSC**
  - Chamber used for the Apollo missions
- **Modifications to Chamber A are nearing completion creating the world's largest Cryo-Vacuum Chamber**

# OTIS Status – Chamber A Modifcations



Before

After

Air Flow Management System: Large Bore Pipe Cleaning

# CHALLENGES MANAGING A LARGE PROJECT

# Management Challenges

- **Many challenges a large project faces are the same as smaller projects**
  - Exception is the "size" of the challenges and their complexity dependent on technical parameters and number of partners/contractors involved

- **Obvious keys to minimizing any impacts from these challenges:**
  - "High Confidence" Budget and Schedule
    - Appropriate cost and schedule reserves are required to provide the resources to proactively mitigate risks or have the ability absorb consequences of issues/ problems which could not be mitigated or avoided
    - Robust programmatic controls, monitoring and analysis helps ensure project is meeting programmatic requirements and has the reserves to tackle tough problems
      - Don't want to spend all your reserves on cost overruns due to poor management/ planning
    - Continually look for "opportunities" to reduce risk earlier, identify problems sooner, and increase schedule reserves (you'll always need it later)

# Management Challenges

- **Obvious keys to minimizing any impacts from these challenges (continued):**
  - Communications
    - Large programs that are geographically and culturally diverse such as JWST only emphasize the importance of communication
      - Communication needs to occur at all levels organization
        - » From daily or at least weekly at "working" level to at least weekly to monthly at higher management levels
      - Communications need to not only be formal but informal
        - » Must build personnel relationships with counterparts
        - » Good interpersonal relationships will only help the situation when things go wrong
    - Providing forums for face to face meetings
      - These can be monthly reviews, technical interchange meetings, etc.
      - For large geographically diverse teams, the whole team needs to meet face to face at least once or twice per year
        - » "Get everyone on the same page"
        - » Exchange ideas
        - » Work issues together in same room
        - » Provide opportunity to socialize to improve relationships

# Management Challenges

- **Obvious keys to minimizing any impacts from these challenges (continued):**
  - Robust Risk Management
    - At any phase of a project life cycle, good risk management is key to successfully maintaining progress and preserving cost/schedule reserves

- **One challenge which larger projects face which many smaller ones don't is "Visibility"**
  - Visibility includes internal to Agency and external entities such as stakeholders (US Congress) and media
  - High Visibility results in extra reviews, audits, media attacks, etc.
  - Mitigate impacts from high visibility
    - Ensure staffing levels can handle extra reviews, audits, etc.
    - Keep stakeholders informed
      - Goes back to good communication
    - Implement other key activities above and "do what you said you would do"
    - Don't worry about media attacks, can't do anything about them

# CLOSING REMARKS

# Closing Remarks

- **Excellent progress continues to be made on JWST!**
- **Challenges still lie ahead**
  - Schedule
    - Need to get all instruments in-house
    - Continuous risk mitigation in progress
      - "Always have work-arounds"
  - Technical
    - Backplane completion, completion of sun shield, etc.
  - Integration – "Put all the pieces together"
  - Testing
    - ISIM, OTIS, Observatory, etc.

**Project continues to execute to plan for 2018 Launch!**