JWST Observatory Status

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Goddard Space Flight Center
JWST Observatory
Optical Telescope Element: Optics

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

<table>
<thead>
<tr>
<th>Mirror</th>
<th>Measured (RMS SFE)</th>
<th>Uncertainty (RMS SFE)</th>
<th>Total (RMS SFE)</th>
<th>Requirement (RMS SFE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 primary Segments (Composite Figure)</td>
<td>23.6</td>
<td>8.1</td>
<td>25.0</td>
<td>25.8</td>
</tr>
<tr>
<td>Secondary</td>
<td>14.7</td>
<td>13.2</td>
<td>19.8</td>
<td>23.5</td>
</tr>
<tr>
<td>Tertiary</td>
<td>18.1</td>
<td>9.5</td>
<td>20.5</td>
<td>23.2</td>
</tr>
<tr>
<td>FSM</td>
<td>13.9</td>
<td>4.9</td>
<td>14.7</td>
<td>18.7</td>
</tr>
</tbody>
</table>

- Mirrors will have completed shipping to GSFC by year’s end
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 be 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
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
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
- OGS: Optical Ground Support Equipment
- PF: Pathfinder

Legend
- Prep & Transport
- Functional / Test
- Assembly / Integration
- Delivery

Risk Reduction Activities

Flight OTIS I&T

Install Flight ISIM to OTE
Pre Environmental Test
Acoustic & Vibe Tests
Post Environmental Test
Ship OTIS to JSC
Receive OTIS at JSC
OTIS Cryo Preps
OTIS Cryo Test
OTIS Cryo Post-Test
Ship OTIS to NGAS

GSE & Test Preparations
Completed Aug 12
Facility Functional
Clean Room
MGSE Install
Bakeout
Commissioning Phase I
MGSE Inspection, OGS Install
Commissioning Phase II
Fall 14

JSC Chamber Ready
Prep for OTIS Test
PF Thermal Test
Ship AOS to GSFC
OGSE2 Test
OGSE2 Prep
Receive AOS at JSC
OGSE1 Test
OGSE1 Prep
Receive PF at JSC
GSE & Test Prep
Fall 14

Clampin/GSFC
Chamber-A: OTIS Test Configuration

- Chamber Isolator Units: Isolates the Ground Test from Seismic activities for Optical Testing.
- Cryo Position Metrology (CPM): PG Cameras in canisters.
- Space Vehicle Thermal Simulator (SVTS) and Sunshield Simulator.
- Absolute Distance Measurement Assembly (ADM).
- 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.
- AOS Source Plate and Cable Support: Fiber optic sources for Field Testing and pass and Half Testing.
- 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

Deployment Timeline

The Webb Telescope will be folded up inside the rocket that launches it into its orbit far beyond the Moon.

As Webb travels toward its ultimate destination at L2, its components gradually unfold and move into operating position.

- Minute 3: Protective shell separates from telescope
- Minute 30: Telescope separates from launch vehicle
- Minute 33: Solar array deploys
- Day 1: Antenna deploys
- Day 2.5: Course correction
- Day 4: Telescope tower deploys
- Day 7.5: First primary mirror wing deploys
- Day 14: Secondary mirror rises into operating position
- Day 25: Telescope setup begins
- Day 6.5: Secondary mirror deploys
- Day 9: Second primary mirror wing deploys, then primary mirror segments rise into operating position
- Day 30: Telescope enters L2 orbit

6 months after launch: All testing is complete. Observations begin.
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
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

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

Radiator Shades
- HG Antenna
- Omni Antenna
- Solar Array
- MLI

Install Radiator Shades, SA, Antennas
- Off-site deployments
- 1st Motion: GM, DS, SS Electrical Functional

Pre-Env Deployments

Dynamics Tests
- Stowed Modal
- PF 3 Axis Sine Vibration
- Anane Shogun Test

SCE Mass Properties
- Mass
- Lateral CG

Post Dynamics Deployment
- 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
- GM Deployments

To Observatory I&T
Spacecraft/Sunshield I&T

Receive OTIS

Integrate SCE and OTIS
- Electrical Integration
- Functional deployments
- Observatory Alignments

Receive SCE

Ambient Test
- CST-2
- EMC
- GSEG-3

Receive LV PAF

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

Post-Dynamics Deployments
- SMSS 1st Motion
- OTE Wing & DTA Deploy
- SS Deploy, Fold & Slow
- Deployed alignments

Post Dynamics Ambient Test
- CST-3
- GSEG-4
- Stowed Alignments

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 SSC
- 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

Launch
Summary

• JWST Observatory is executing to Baseline

• Project Science closely integrated with major areas impacting scientific performance