James Webb Space Telescope
Mission Status

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NASA Goddard Space Flight Center

Goddard Contractors Association
Dec. 5, 2012
MISSION OVERVIEW AND STATUS
Telescope

- Optical Telescope Element (OTE)
- Sun Shield
- Integrated Science Instrument Module (ISIM)
- Spacecraft
- Ground System
Telescope Architecture Overview

Secondary Mirror Support Structure (SMSS)

Secondary Mirror Assembly (SMA)

Primary Mirror Segment Assemblies (PMSA)

Primary Mirror Backplane Assembly (PMBA)
- PM Backplane Support Structure (PMBSS)
- PM Backplane Mechanism

Aft Optics Subsystem (A0S)

OTE Electronics
- Cold Junction Box
- Cold Multiplexer Units

Thermal Management Subsystem (TMS)
- Deployable “Batwings”
- Fixed Diagonal Shield
- Deployable Stray-Light “Bib”

Deployment Tower Assembly (DTA)
All Mirrors Are Complete!

- Three flight primary mirror segments and the secondary mirror have been delivered to GSFC
- Aft Optics Assembly (AOS) integration and testing complete
- Flight Cryo Electronics
  - All 21 CMUs have been assembled & completed cryo testing
  - CJB has been assembled and has completed its acceptance testing
  - EM ADU has been delivered and flight ADU is in board-level testing
Buildup of Telescope Flight Structure

Assembly consists of ~3,200 bonded composite piece parts

Flight Backplane Center Section assembly is complete!

Flight Deployable Tower Integration Underway

Wing production continues
100% of composite parts are complete

BSF Assembly Initiated
99% of composite billets and 87% of composite parts and 91% of all invar fittings are complete
AOAS Hardware has been installed at GSFC
Primary Mirror Segment Assembly (PSMA) Installation Fixture (PAIF) delivered and installed on AOAS

- Demonstrations of placement of mirror mass model on BESTA completed
- Placement of engineering/flight spare mirror on BESTA scheduled for Jan.
Sunshield

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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 Template Membrane Work On-Going
Templates Verify Design/Manufacturing Prior to Flight Build

- Template Layer 3 - Completed & Delivered
- Template Layer 4 – Completed & Delivered
- Template Layer 5 – Completed & Delivered
- Template Layer 2
  - Manufacturing in process
- Template Layer 1
  - Manufacturing in process

Membrane Removed From Container
Membrane Installed Onto Rim And Deployed
Folded Sunshield Template Layer
Layer 3
Integrated Science Instrument Module

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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

- Developed by the University of Arizona with Lockheed Martin ATC
  - Operating wavelength: 0.6 – 5.0 microns
  - Supports OTE Wavefront Sensing

- Current Status
  - Cryo-Vac 1 testing has completed.
    - All objectives of test met
    - Stray light found in SW channel and light leak in LW channel.
    - Optical performance looks very good
  - Cryo-Vac 2 is underway
    - Temporary stray light fixes are in place for Cryo 2. Flight fixes to be installed following the test

- Delivery dates to GSFC for completion of environmental testing
  - Mid-Feb. to Early April depending on approach taken to test stray light and light leak fixes
  - Will not be included in ISIM Cryo Vac #1
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
  - Flight spare optical bench being utilized because of cracks in original flight bench
  - Completed instrument reintegration and end to end optical path verification
  - Held close-out meeting for the bench crack issue
  - Late discovery of fatigue issue with kinematic mounts (OBKs)
    - Will require replacement following the SI level cryotest in February
  - Successful PER conducted
  - MSA issue and detector debond

- Delivery to I&T scheduled for July 2013
  - ISIM Cryo Vac Test 1 will use NIRSpec Engineering Test Unit
MIRI will detect key discriminators that distinguish the earliest state of galaxy evolution from more evolved objects

- Developed by a European Consortium and JPL
  - Operating wavelength: 5 - 29 microns
  - Coronagraphic imager and Spectroscopy

- Current Progress
  - Delivered to GSFC at end of May
  - Post-ship functional testing and metrology successfully completed
  - ISIM flight electrical system testing (EICIT, IVT) complete.
    - FSW change required for ambient functional completion (2 days) in January
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
  - Delivered to GSFC at end of July
  - Post-ship functional testing and metrology successfully completed
  - FGS/ISIM Electrical Check-Out has initiated
ISIM Status

- 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)
  - Delivered to I&T August 14

- OTE Simulator (OSIM)
  - Cryo certification testing complete and out of SES Chamber
    - Test results review conducted October 15-16
  - OSIM delivered to ISIM I&T in Aug.
    - Cryo recertification process scheduled to start in Jan.
Spacecraft

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

- Component level designs reviews continue leading to S/C CDR in Dec. 2013 including:
  - Solar Array PDR
  - Reaction Wheel Assembly PDR
  - Deployment Unit Converter PDR
  - Propellant Management Device Concept Review
  - Command and Telemetry Processor CDR
  - Battery PDR
- S/C Mockup Completed
- Flight Solid State Recorder Delivered
- Flight Solar Cells Delivered
- Several Component level tests in progress including
  - CCU EQM in EMI/EMC testing
  - Flight TAU Vibration Testing
  - L2 Thermal Control Coating for LVIR Radiation Testing
  - EM Transponder functionality risk reduction testing
Spacecraft Progress
Various Flight and Engineering Model Components Are In Fabrication

Ka-band Modulator Engineering Model

Ka-Band Filter

Type-2A SCSim & IES

Command Control Unit EQM

S-Band Transponder EM

High Gain Antenna and Medium Gain Antenna

LVIR Forging

Star Tracker

SSR Flight Unit Delivered To I&T

Upgraded MRE-1 Thrusters with shunts

Instrumented MRE-1 Thruster
Spacecraft

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

Ground System
Ground Segment and Operations Status

- Majority of current effort is geared towards preparations for and support of ISIM I&T
  - STScI contributing test engineers, operations products (onboard scripts, project reference databases) and data analysis
  - NGAS contributing operations products (procedures, telemetry format tables), review of limitations and constraint implementation and simulator support
  - Releasing updates of Common Command and Telemetry System (CCTS), Flexible Image Transport System Writer (FITSWriter), science pipeline, NIRSpec noise reduction software as needed
  - Adding additional data storage capabilities at multiple testing locations to enable long-term archive of test data
    - Also supporting upgrade, relocation of various SITS, SIDU systems
  - Certification Lab being heavily utilized for operations product certification, test rehearsal
Ground Segment and Operations Status

- **Science and Operations Center (S&OC)**
  - General
    - Released updated version of Science Operations Design Reference Mission (SODRM)
  - Operations Scripts Subsystem (OSS)
    - Certified and delivered onboard scripts for MIRI ambient testing
    - Developing and testing onboard scripts for ISIM Cyro #1 testing
  - Project Reference Database Subsystem (PRDS)
    - Delivered multiple databases for ISIM I&T, spacecraft simulator (SCSim)
  - Proposal Planning Subsystem (PPS)
    - Release 1.5 of Exposure Time Calculator (ETC) prototype available to potential users on STScI website
  - Wavefront Sensing and Control (WFS&C) Software Subsystem (WSS)
    - Conducting testing of WSS Build 1.1
  - Data Management Subsystem (DMS)
    - Conducting System Design Review #2 December 6, 7
Ground Segment and Operations Status

- **Institutional Systems**
  - **Deep Space Network (DSN)**
    - Utilizing Solar Dynamics Observatory (SDO), Goldstone 34m antenna to collect performance data that will be indicative of Ka-band receiver implementation loss, antenna pointing loss for JWST
    - Performed successful testing of NGAS S-band transponder engineering model at GSFC RF lab
    - Updating documentation for TDRS, ESTRACK launch and ascent support
  - **Flight Dynamics (FD)**
    - Supporting multiple analyses for determining orbit box size, launch windows, mass savings
  - **Communications Service Office (CSO) [the former NISN]**
    - Supporting planning for JSC network configuration
OTE + ISIM = OTIS TESTING
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
- Slowed Modal Survey
- Deployed Modal Survey

Prep / Ship to GSFC OTE I&T

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

Prep/Ship To NGAS Observatory
PMSA 1-18

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
- Electrical Functional
- 1st Motion Checks
- COCI

Post Env. Test

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
Prior to final Observatory Integration the OTE + ISIM (OTIS) will be tested in a large chamber at JSC

Modifications to Chamber A are completed creating the world’s largest Cryo-Vacuum Chamber

Functional Testing Complete
• Overall functional operations finished on 8/20
• All primary objectives were met
OTIS Test GSE Architecture and Subsystems Status

Center of Curvature Optical Assembly (COCOA)
- Multiwavelength interferometer, null, calibration equipment, coarse/fine PM phasing tools, Displacement Measuring Interferometer
Testing at MSFC-XRCF
- Completed Cryo Vac Test - excellent optical and thermal results
- Contamination Cert. – complete @ 15X better than requirement
  - Being stored at XRCF

3 Autocollimating Flat Mirrors (ACFs)
- 1st unit complete. 2 & 3 polished

Cryo Position Metrology (CPM)
- 4 photogrammetry (PG) windmills in warm canisters
  - Canister delivered. Cryo test in progress.
- Absolute Distance Measurement (ADM) on HOSS
- Targets and codes
  - Cryo tested target
  - Tube holders at XRCF.
- Scale Bars
  - Post PDA

Hanging Configuration
- Down Rods
- Upper Suspension Frame (USF)
- Telescope Tension Rods
- Hardpoint Offloader Support Structure (HOSS)
  - Passed dCDA June 12, ’12
  - Contract in place. Manufacturing has started

Space Vehicle Thermal Simulator (SVTS) w/ cryo-cooler and electronics
- Concept

Chamber Isolator
- Contract in place for Isolators 2-6
  - Manufacturing has started

Deep Space Edge Radiation Sink (DSERS)
- Concept Verified

AOS Source Plate and cable w/ fishing pole support
- Concept

LN2 and Helium Cryogenic Shrouds and “barn door”
TRANSPORTATION
Space Telescope Transporter for Air, Road & Sea (STTARS)

STTARS Is Completed
SCHEDULE STATUS
### JWST Master Schedule

#### Major Mission Milestones
- **FY10**
  - CDR
- **FY11**
  - TRR
  - MOR
  - KOP
  - PSR
  - LRD
  - DRR

#### Integration & Test

##### OTE
- **Primary Mirrors**
  - Start EGU
  - Del PF
  - 1st Batch
  - Last Batch
  - PMIS
  - Gear Motor Requalification

##### Flight Structure (PMBSS)
- **Start EDU**
- **3rd Cryo Test**
- **Del PF**
- **PMSA**
- **3 Months at OTIS level**
- **7 Months of Slack at OTE level**
- **Baseline 5/24/12 Rev K**

#### Sunshield
- **Template Membrane Fab**
- **GSE Design/Fab**

#### Spacecraft
- **Cor**
- **SC Panel**
- **SC Panel Integ**

#### ISIM & I&T
- **ETU Del**
- **STM Del**
- **Del ISIM to OTIS**

#### NIRSpec
- **ETU Del**
- **CRD**

#### MIRI
- **ETU Del**
- **Del ISIM to OTIS**

#### NIRCam
- **ETU Del**
- **Del ISIM to OTIS**

#### FGS
- **ETU Del**
- **Del ISIM to OTIS**

#### Cryo Cooler System
- **CCTS 5.2**
- **CCTS 5.3**
- **CCTS 5.4**
- **CCTS 5.5**

#### Ground Segment
- **CCTS 5.6**
- **CCTS 5.7**
- **CCTS 5.8**
- **CCTS 5.9**
- **CCTS 5.10**
- **CCTS 5.11**
- **CCTS 5.12**
- **CCTS 5.13**
- **CCTS 5.14**
- **CCTS 5.15**

#### Launch Segment
- **LV Lift Perf. Verified**
- **Safety Submittal #2**
- **Flight Adapter for Elec/Mech Fittcheck**
- **Flight Adapter for Airman Adoption**
- **Safety Submittal #3**
- **Airman Adoption**
- **RAMF**
- **CC Release 2 (First)**
- **LV Readiness Review (RAM)**

*Project is actively seeking ways to recover lost schedule margin*
### JWST Master Schedule

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#### SC Subsystem Development
- ISIM & Instrument Fab/Assey/Test
  - Need SES For OSIM
  - SES Avail
- ISIM Integ
- ISIM Envir Test/Detector C/O

#### SC Fab/Assy/Test
- Spacecraft I&T
- OTIS I&T
- SC Panels To I&T
- SC Structure To I&T

#### Mirror Fab
- PMSA Gear Motor Rework

#### OTE Fab Assy & Test
- OTE
- Optics Integ

#### Sunshield Design/Dwgs
- Sunshield Mfg, Fab, & Test

#### Other
- LRD
- Obs I&T
- Launch Site

*Project is actively seeking ways to recover lost schedule margin*
### JWST FY12 Milestones


<table>
<thead>
<tr>
<th>Month</th>
<th>Milestone</th>
<th>Responsible</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Oct '11</td>
<td>Initiate Delivery of Ambient Alignment Optical Stand (AOAS) to GSFC</td>
<td>ITT</td>
<td>Completed 10/4</td>
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<tr>
<td>Nov '11</td>
<td>ISIM Electronics Simulator Engineering Model Test Bed Complete</td>
<td>ISIM, NGAS</td>
<td>Completed 11/15, 10/27</td>
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<td>Dec '11</td>
<td>JSC Helium (GHe) floor shroud installed</td>
<td>JSC, ESA</td>
<td>Completed 10/26, 12/15</td>
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<tr>
<td>Jan '12</td>
<td>Spacecraft-Optical Telescope Element (OTE) Vibration Isolation IDR 3/4 (CDR)</td>
<td>NGAS, ITT/GSFC, NGAS, ESA</td>
<td>Completed 12/15, 1/13, 12/1, 12/22, 1/28</td>
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<td>Feb '12</td>
<td>Complete assembly &amp; verification testing (MSFC testing) of Primary Mirror Segment Assemblies (PMSAs)</td>
<td>NGAS/Ball, JSC</td>
<td>Completed 12/19, 12/29</td>
</tr>
<tr>
<td>Mar '12</td>
<td>Complete System Engineering Team thermal margin assessment</td>
<td>GSFC, GSFC</td>
<td>Completed 3/19, 3/1</td>
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<td>Apr '12</td>
<td>ICDH Flt #2 delivered to ISIM I&amp;T</td>
<td>ISIM, ESA, NGAS, NGAS/ATK</td>
<td>Part failure in T/V. Corrected &amp; completed 5/16, 5/29, 3/21, 2/28</td>
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<td>May '12</td>
<td>Complete COCOA assessment at ITT</td>
<td>ITT/GSFC, NGAS/Nexolve, HQ/SRB</td>
<td>Completed 3/9, 4/23, 5/30</td>
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<td>Jun '12</td>
<td>JSC Chamber mods complete</td>
<td>JSC, NGAS, ITT/GSFC, NGAS</td>
<td>Completed 6/30, 6/13, 6/21, 6/28</td>
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<td>Jul '12</td>
<td>Program Office agreement on FY13 spending plan</td>
<td>HQ/GSFC, CSA, ISIM, NGAS/JPL, NGAS/ATK</td>
<td>Completed 7/10 - Approved by SMD AA, 7/30, 5/11, 6/14, 7/13</td>
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<tr>
<td>Aug '12</td>
<td>Order remaining Chamber A isolators from Minus K</td>
<td>ITT/GSFC</td>
<td>Completed 8/9</td>
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<td>Month</td>
<td>Milestone</td>
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<tr>
<td>October ‘12</td>
<td>Funding Direction per plan</td>
<td>HQ</td>
<td>Completed 9/15</td>
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<td>Battery PDA</td>
<td>NGAS</td>
<td>Completed 9/6</td>
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<td>Command &amp; Telemetry Processor (CTP) IDR4</td>
<td>NGAS</td>
<td>Completed 8/30</td>
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<td>Optical Ground Support Equipment #2 Audit</td>
<td>OTIS</td>
<td>Completed 10/17</td>
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<td>November ‘12</td>
<td>Bib &amp; Batwing PDA-2</td>
<td>NGAS</td>
<td>Completed 10/18</td>
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<td>Spacecraft J2 Equipment Panel IDR3/4</td>
<td>NGAS</td>
<td>Completed 10/4</td>
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<td>Complete integrated MIRI/ISIM electrical checkout</td>
<td>ISIM</td>
<td>Completed 11/19, 2 days of testing required in Jan. due to FSW bug (divide by zero)</td>
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<td>December ‘12</td>
<td>CTP Engineering Model #1 Delivered to Engineering Model Test Bed</td>
<td>NGAS</td>
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<td></td>
<td>Beam Image Analyzer re-integrated onto OSIM</td>
<td>ISIM</td>
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<td></td>
<td>Complete integrated FGS/ISIM electrical checkout</td>
<td>ISIM</td>
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<td>January ‘13</td>
<td>Aft Optical System Complete</td>
<td>NGAS</td>
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<td>Space Telescope Transporter for Air, Road &amp; Sea (STTARS) delivery</td>
<td>OTIS</td>
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<td></td>
<td>Data Management Subsystem System Design Review #2</td>
<td>STSci</td>
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<td></td>
<td>Deliver MIRI Shield to ISIM</td>
<td>ISIM</td>
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<td>February ‘13</td>
<td>Secondary Mirror Support Structure Floor Assembly Jig complete</td>
<td>NGAS</td>
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<td>Wing Assembly complete</td>
<td>NGAS</td>
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<td></td>
<td>Spacecraft Primary Structure Manufacturing Readiness Review (MRR)</td>
<td>NGAS</td>
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<td></td>
<td>OSIM Cryo Certification Test #2 Start</td>
<td>ISIM</td>
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<td>March ‘13</td>
<td>Funding Direction for remainder of the year (assuming a continuing resolution) Del</td>
<td>HQ</td>
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<td>iver last Cryo Multiplex Unit</td>
<td>NGAS</td>
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<tr>
<td></td>
<td>Fine Sun Sensor CDA</td>
<td>NGAS</td>
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<td>Space Vehicle Thermal Simulator SRR</td>
<td>OTIS</td>
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<td>Complete FGS &amp; MIRI integration onto ISIM</td>
<td>ISIM</td>
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<td>April ‘13</td>
<td>Sunshield Template Membrane Layer 2 fabrication complete</td>
<td>NGAS</td>
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<td>Communications Subsystem CDA</td>
<td>NGAS</td>
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<td>Wave Front Sensing &amp; Control Software Build 1.1</td>
<td>STSci</td>
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<td>May ‘13</td>
<td>Backplane Support Fixture (BSF) Assembly Complete</td>
<td>NGAS</td>
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<td>June ‘13</td>
<td>Spacecraft Thermal Control System CDA</td>
<td>NGAS</td>
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<td>Spacecraft Harness CDA</td>
<td>NGAS</td>
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<td></td>
<td>JSC Downrods &amp; Telescope Rod complete</td>
<td>OTIS</td>
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<td>ISIM Cryo-vacuum test #1 (Risk Reduction) start</td>
<td>ISIM</td>
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<td>July ‘13</td>
<td>Cryo-cooler flight Cold Head Assembly delivered to GSFC</td>
<td>JPL</td>
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<tr>
<td></td>
<td>Spacecraft FSW Build 2.1 Test Readiness Review</td>
<td>NGAS</td>
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<td>Program Office agreement on FY14 spending plan</td>
<td>HQ</td>
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<tr>
<td>August ‘13</td>
<td>NIRCam Delivered to ISIM I&amp;T</td>
<td>UoA/LMATC</td>
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<td>BSF/Center Section Integration complete</td>
<td>NGAS</td>
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<td>September ‘13</td>
<td>Flight NIRSpc delivered</td>
<td>ESA</td>
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<td>Sunshield Membrane Cover Assembly MRR</td>
<td>NGAS</td>
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<td>Mass margin return-to-green complete</td>
<td>NGAS</td>
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<td></td>
<td>ISIM Cryo-Vacuum test #1 complete</td>
<td>ISIM</td>
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<tr>
<td></td>
<td>Chamber A Upper Support Frame ready for paint</td>
<td>OTIS</td>
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CONCERNS
Thermal margins have experienced degradation since the Mission CDR due to a variety of sources (Liens) across the observatory elements:

- Design maturation
- Analysis latency (i.e. analysis catching up to design)
- Model errors

Issue is closed

- Cryogenic thermal margins have been brought back to acceptable levels without any impact to mass
- Thermal architecture modifications including Aft Deployed ISIM Radiator to increase the radiative cooling capability of the observatory have been completed
Concerns – Detector Degradation

- **Issue Closed**
  - Flight detector testing shows a degradation in pixel operability
    - Impacts NIRCam, NIRSpec, and FGS
  - Detector FRB complete
    - Found that detector degradation is caused by a design flaw which degraded its performance
    - Determined manufacturing and/or post-manufacture handling process changes are appropriate
    - Defined tests needed to screen-out degradation prone parts and insure the continued integrity of flight part
  - Manufacturing of Flight Detectors underway
    - 1st set off three shortwave SCAs detectors completed testing at Teledyne and are at Arizona
    - Next 3 shortwave SCAs have completed test and are expected to deliver to Arizona December 10.
      - Preliminary results on these parts look good
      - Another 3 parts will have begun testing at Teledyne
  - On Track for Detector Swap Out in 2014
  - 3rd ISIM Cryo Test Added
Concerns - Mass Margin Issue

- Unexpected mass increases for Pendings (Mass Liens) and Potentials (Mass Threats). Among them:
  - Spacecraft Bus increases primarily for harness (~ 112kg)
  - Mass impacts due to the recent Coupled Loads Analysis (~ 10kg)

- Although the Project is carrying 208.3 kg of mass reserve, these increases will decrease this to unacceptable levels if uncorrected.

- Coordinated efforts to improve the mass margin have been actively pursued by the Observatory and Systems Teams since March of 2012.
  - The pursuit of these opportunities is being coordinated and monitored as part of the Architecture Working Group (AWG).
  - These savings opportunities are to be implemented in time to have system level analysis completed in time for the Spacecraft Bus CDR currently scheduled for December 2013.
Concerns - Instrument Delivery Schedule and ISIM I&T

- **Instrument Schedules**
  - MIRI and FGS delivered
  - NIRCam and NIRSpec will arrive too late for 1st ISIM Cryo Test (CV-1)
    - NIRCam
      - Instrument Module level cryo-vacuum test #1 completed and cryo 2 has begun, but execution of cryo 1 was much longer than expected
      - Must resolve stray light and light leak issues
      - NIRCam will not be delivered in time for CV1
    - NIRSpec
      - Instrument integration is complete but deliver date has slipped to June 2013
      - Existing Optical Bench Kinematic (OBK) Mounts did not undergo sufficient thermal tempering and etching of the alpha layer. As a result, fracture toughness is marginal and may not meet requirements of ISIM pad motion load case and the ISIM vibration test
        » New OBKs are being manufactured
  - NIRCam and NIRSpec will be installed in ISIM for CV2

- **GPM SES Testing Impact on ISIM I&T**
  - ISIM was scheduled to start Jan. 1, but slips in GPM Thermal Vac have impacted ISIM start date in SES chamber
    - ISIM schedule reserves are impacted by GPM exit from the SES
      - GPM must be done with the chamber by end of Jan. to constrain reserve impact to only 1 month
        - Physical removal of GPM from the chamber does not equal facility readiness for ISIM. Chamber has to be clean, dry and empty for the next “customer”. Likely add 1-2 weeks from actual GPM removal
Why does JWST have a cryocooler?

- Telescope and instruments are passively-cooled behind sunshield. HgCdTe near-IR detectors in the three near-IR instruments operate at ~37K, and telescope operates at 50+K and below to limit background.
- The single mid-IR instrument (MIRI), which uses Si:As detectors requires further cooling to 6.7K.

JWST cryocooler is a combination of a pulse tube (PT) and a Joule-Thomson (JT) cooler. PT part has three stages, precooling from room temps to as low as ~14K, enabling JT to engage and operate down to 6.2K.

- Cooler compressors and control electronics reside in spacecraft bus, but MIRI heat exchange occurs several meters away inside ISIM.

Cryocooler challenges particular to JWST – cryocooler performance margin, heat loads, vibration isolation/attenuation, distributed integration.

- PT precooler must overcome heat loads to enable JT to operate.
  - Must have margin to cover uncertainties in heat loads and unknown-unknowns to ensure MIRI detectors will reach operating temperature.
- Cooling lines between compressors and MIRI must accommodate deployment and be secure for launch loads while being as decoupled thermally from rest of observatory as possible.
- Compressor vibration must be limited to enable diffraction-limited optical performance at 2 microns.
  - Requires vibration isolation between compressors and bus, as well as vibration attenuation of shorting path via cryocooler lines.
- Cooler hardware is delivered in pieces to different and separate integration and test activities (ISIM, OTE, S/C and OTIS).
Various issues have caused schedule delays (biggest risk), but progress is being seen

- **Flight valve production**
  - Cryo bypass valves for JT bypass during cooldown and for de-icing exterior of cooler lines are still in development
    - Difficulty meeting leak spec, especially given power/thermal dissipation limitations
    - Pursuing parallel valve developments

- **Electronics schedule**
  - Technical issues nearly resolved, but only 1 month schedule margin to need date in 2015
    - Examining ways to accelerate and add slack

- **Pulse Tube (PT) pre-cooler performance**
  - Modified flight design prototyping effort continues
    - Design adjustments being made to 2\textsuperscript{nd} and 3\textsuperscript{rd} PT stages to assure required performance
      » Flight prototype demonstration scheduled for early CY2013
Concerns – NIRSpec Micro-Shutters & Detector De-Bond Failure

**NIRSpec Micro-Shutters**

- During testing of the JWST Micro-shutter subsystem at IABG facility in Ottobrunn, Germany, anomalous behavior was witnessed in flight Micro-shutter Subsystem (MSS)
  - Micro-shutter Array Quadrants 1, 2 and 4 show a significant to severe increase in failed closed shutters
- Current theory is that during vibration or acoustic testing shutter shifts in plane and is pushed into the light shield where it is wedged closed
- Following root cause determination, assess both instrument and MSA design modifications to mitigate the problem
  - Acoustic testing currently underway has replicated the failure on an MSA test unit. Several more tests of this unit, both stand-alone as well as installed on the ETU NIRSpec, will be conducted in the next two months
- Production of a complete flight spare MSA is in process, with scheduled completion by mid-2014
  - Potential for replacement during the already planned detector swap-out activities

**Detector De-Bond Failure**

- A Flight FPA experienced a failure at the bond joint between the base of an SCA and its mounting structure
  - Spare FPA used for replacement in Flight NIRSpec
- Failure FPA was shipped back to GSFC for failure analysis
  - Evidence is mounting that the epoxy bond workmanship (contact area, adhesive batch strength, etc) was the failure cause
CLOSING REMARKS
Excellent progress has been made over the last year!

Challenges still lie ahead

- **Schedule**
  - Need to get rest of instruments in-house
  - Continuous risk mitigation in progress
    - “Always have work-arounds”
- **Technical**
  - Mass Recovery, Cryo cooler, detector swap, micro-shutters, etc.
- **Integration** – Starting “Put all the pieces together”
- **Testing**
  - ISIM, OTIS, Observatory, etc.

Project continues execute to baseline!
QUESTIONS