James Webb Space Telescope (JWST)
Project Status for the AIAA Working Group on Space Simulation

Phil Sabelhaus
JWST Project Manager
September 2008
James Webb Space Telescope (JWST)

**Organization**
- Mission Lead: Goddard Space Flight Center
- International collaboration with ESA & CSA
- Prime Contractor: Northrop Grumman Space Technology
- Instruments:
  - Near Infrared Camera (NIRCam) – Univ. of Arizona
  - Near Infrared Spectrograph (NIRSpec) – ESA
  - Mid-Infrared Instrument (MIRI) – JPL/ESA
  - Fine Guidance Sensor (FGS) – CSA
- Operations: Space Telescope Science Institute

**Description**
- Deployable infrared telescope with 6.5 meter diameter segmented adjustable primary mirror
- Cryogenic temperature telescope and instruments for infrared performance
- Launch June 2013 on an ESA-supplied Ariane 5 rocket to Sun-Earth L2
- 5-year science mission (10-year goal)

www.JWST.nasa.gov

**JWST Science Themes**
- End of the dark ages: First light and reionization
- The assembly of galaxies
- Birth of stars and proto-planetary systems
- Planetary systems and the origin of life
JWST Full Scale Model at the GSFC
JWST Master Schedule

Major Mission Milestones

Integration & Test

OTE

JSC Activity

SSDIF Activity

Pathfinder Structure (PF)

Flight Structure (PMBSS)

Primary Mirrors (PMSA)

Sunshield (SS)

Membranes

Evolutionary Pathfinder (EPF)

Flight Sunshield

Spacecraft (SC)

SC & IES Simulators

Observatory FSW/EMTB

Build 1 & 2 V&V

ISIM

Integration & Test

NIRSpec

MIRI

NIRCam

FGS

Cooling System

Ground Segment

Rev. F
(Includes NGST Master Schedule - January 2008 & ISIM Master Schedule - Rev. F)
JWST Compared with other Telescopes

- Hubble Space Telescope (HST):
  - 2.7 x diameter, 2.7 x longer wavelength

- HST NICMOS:
  - 189 x FoV,
  - 38 x better sensitivity at K band, 8 x at H band

- Spitzer:
  - 8 x Spitzer diameter
  - Diffraction limited at 2 microns vs. 6 microns
  - 8 to 24 x better angular resolution
  - 10 x lower dark current supports R ~ 1000 at high redshift

- Ground:
  - JWST and GSMT are complementary where capabilities overlap:
    - HST: Keck diameter ratio ~ JWST:GSMT
    - Background ~1,000,000 x larger on ground at 5 microns
JWST System Architecture

Communications Coverage Provided For all Critical Events

Ariane 5 Upper Stage Injects JWST Into Direct Transfer Trajectory

Observatory – Upper Stage Separation

S-Band Tlm Link (2Kbps)
S-Band Cmd Link (0.25 Kbps)
S-Band Ranging

Ka-Band Science Link (Selectable 7, 14, 28 Mbps)
S-Band Tlm Link (Selectable 0.2 - 40 Kbps)
S-Band Cmd (Selectable 2 and 16 Kbps)
S-Band Ranging

Ariane 5 Launch System

Deep Space Network

Space Telescope Science Institute
Science & Operations Center

NASA Integrated Services Network

GSFC Flight Dynamics Facility

Observatory Deployments
- Solar Array
- High Gain/ Medium Antennas
- Sunshield
- Optical Telescope Element

Communications Services for Launch
(TDRS, ESA, ...)

Ariane PPF S5

L2 Point

L2 Lissajous Orbit

L2 Transfer Trajectory

Observatory Deployments
- Solar Array
- High Gain/ Medium Antennas
- Sunshield
- Optical Telescope Element
JWST Teams and Responsibilities

Integrated Science Instrument Module (ISIM) – GSFC
  • Structure – GSFC/ATK
  • MIRI - JPL & ESA/European Consortium
  • NIRSpec - ESA/Astrium
  • NIRCam – U of Arizona/LMATC
  • FGS/TFI – CSA/COM DEV

ISIM Radiators- NGST/Ball

Optical Telescope Element (OTE) – NGST/Ball

Backplane Structure – NGST/ATK

ISIM Electronics Compartment (IEC)- GSFC

Deployment Tower - NGST

Sunshield – NGST

Membrane – NGST/SRS

MIRI Cryocooler – JPL/NGST

Instrument C&DH - GSFC

Launch Vehicle & Adapter- ESA/Arianespace

Overall Observatory - NGST

Spacecraft - NGST
JWST Status
### Program Phases

#### Currently in Implementation (Phase C)
- Early emphasis on vigorous technology development to retire risk
  - ~50% of Phase A through D total invested so far
  - Pacing items (primary mirror, detectors) already in flight production
  - Successful Technology-Non Advocate Review (T-NAR) in January 2007

#### Mission PDR/Non-Advocate Review (NAR) completed last Spring
- Confirmation Review successfully held in July
All JWST Enabling Technologies Have Been Developed

Near IR Detectors
SIDECAR ASIC
Mid IR Detectors
Heat Switch
Sunshield Membrane
Mid IR Detectors Heat Switch
Primary Mirror
Wavefront Sensing & Control
Test Bed Telescope
Stable Large Cryogenic Structures
Backplane Stability Test Article (BSTA)
MIRI Cryocooler
Micro Shutter
Program Status and Recent Progress

- **General**
  - Successful Mission PDR, Non Advocate and Confirmation Reviews held
  - Preparations for mirror segment testing at MSFC XRCF facility are complete
  - Modifications to JSC Chamber A are underway

- **Science**
  - NASA HQ SMD has decided to add moving target tracking capability to JWST

- **Observatory**
  - First spacecraft simulator delivered to the ISIM software lab at GSFC
  - Sunshield PDR held in February 2008

- **Ground Segment**
  - Completed deliveries of all Science Instrument Integrated Test Sets (SITSs) and Science Instrument Development Units (SIDUs) to SI teams in the US, Canada and Europe
MSFC XRCF Test Chamber Complete

Test Stand on Flowtron waiting Integration into Chamber

Craning Test Stand in Place

Installing Test Stand into Chamber

Test Stand in Chamber waiting installation of final helium shroud
JSC Chamber A Modification Progress

External chamber modifications – removal of solar simulator structures
Mirrors and Optical Telescope Element (OTE)

- OTE Flight Backplane tube manufacturing continues at ATK
  - PMBSS bonding will probably occur no earlier than late September
- OTE Pathfinder backplane bonding continues at ATK
- Tinsley operations are continuing:
  - The A1 primary mirror (PM) was shipped to Ball in late August
  - The B3 and C3 PMs are currently in polishing and planned to be shipped to Ball in September
  - The remaining flight primary, secondary and tertiary mirrors are in various stages of rough polishing, smooth out and figure grinding
- Ball operations:
  - EDU PMSA build is underway
  - Scheduled to be shipped to the MSFC XRCF in September for pathfinder testing
- Successful OTE PDR at NGST in November 2007
- Preparations for PMSA testing at MSFC XRCF are going well
PM EDU in Optical Test at Ball
Recent Backplane and Space Vehicle Accomplishments

PF and Flight Backplane Assembly Tools
Complete and PF Bonding Started

Spacecraft Solar Array
Release and Reaction
Wheel Isolator
Development Articles

Soft Sunshield Membrane Covers
Decrease Mass and Stowed Volume
Integrated Science Instrument Module (ISIM)
- MIRI Verification Model achieved 6.2K operating temperature during its first cryo test last winter
  - Achieved first light!
- Completed CDR for NIRSpec Focal Plane Electronics and Software
- Selected flight detectors for MIRI
  - Held Cryo Cooler PDR
- Selected flight shortwave detectors for NIRCam
- Completed Microshutter CDR (part 1) covering Arrays and Quads
  - ESA concurred with priority ranking of Microshutter Flight Candidates
MIRI Verification Model prior to Cryo Vac Test
Integrated Science Instrument Module (ISIM) Continued:

- Successful ISIM Command and Data Handling (ICDH) CDR in October 2007
- Successful ISIM Flight Software CDR in April
- ISIM, ISIM Electronics Compartment (IEC) and ISIM Remote Services Unit (IRSU) PDR’s successfully completed
- Harness Radiator breadboard completed cryo-vac test
- Held FGS System CDR at COM DEV
- ISIM Structure bonding started in August
- Completed manufacturing of NIRSpec Qual Unit Optical Bench
- Completed bonding of the NIRCam ETU Optical Bench
  - ETU I&T began in July
NIRSpec Qual Unit Optical Bench Ready for Delivery
ISIM Structure Deck A Buildup
ETU Hardware Queuing Up for Instrument I&T

NIRSpec Focal Plane Assembly

NIRCam Shortwave Camera Triplet & Beamsplitter

NIRCam PIL Mechanism

NIRSpec Fore Optics
Additional ISIM Hardware

- NIRCam Qual Focal Plane Assembly
- NIRCam Focus Adjust Mechanism Actuators
- IEC Composite Mirror
- NIRSpec DM/ETU Optical Bench Proof Testing
- OSIM Primary Mirror
Project Status (continued)

- Upcoming events
  - OSIM PDR/CDR in October 2008 at GSFC
  - NIRSpec CDR in October 2008 at ESTEC
  - ISIM Structure CDR in December 2008 at GSFC
  - ISIM CDR in January 2009 at GSFC
  - Sunshield MMS IDR-2/PDR in January 2009 at NGST
  - Mission CDR scheduled for late Summer/Fall of 2009
Summary

- JWST is a flagship science mission; the highest priority large mission in astronomy and a worthy scientific successor to Hubble
- JWST is an engineering challenge, and the challenge is being met
  - All ten of our mission enabling technologies achieved Technology Readiness Level 6 by February 2007 – more than a year ahead of the NASA required date (mission PDR) and 6 years plus before launch
  - Engineering or Verification Models for all the instruments are being assembled and tested this year
- Mission Preliminary Design, Non-Advocate and Confirmation (KDP-C) Reviews successfully held this year
  - In phase C!
- Continuing to make good progress on critical path items
- JWST is well underway and on track for a launch in June 2013