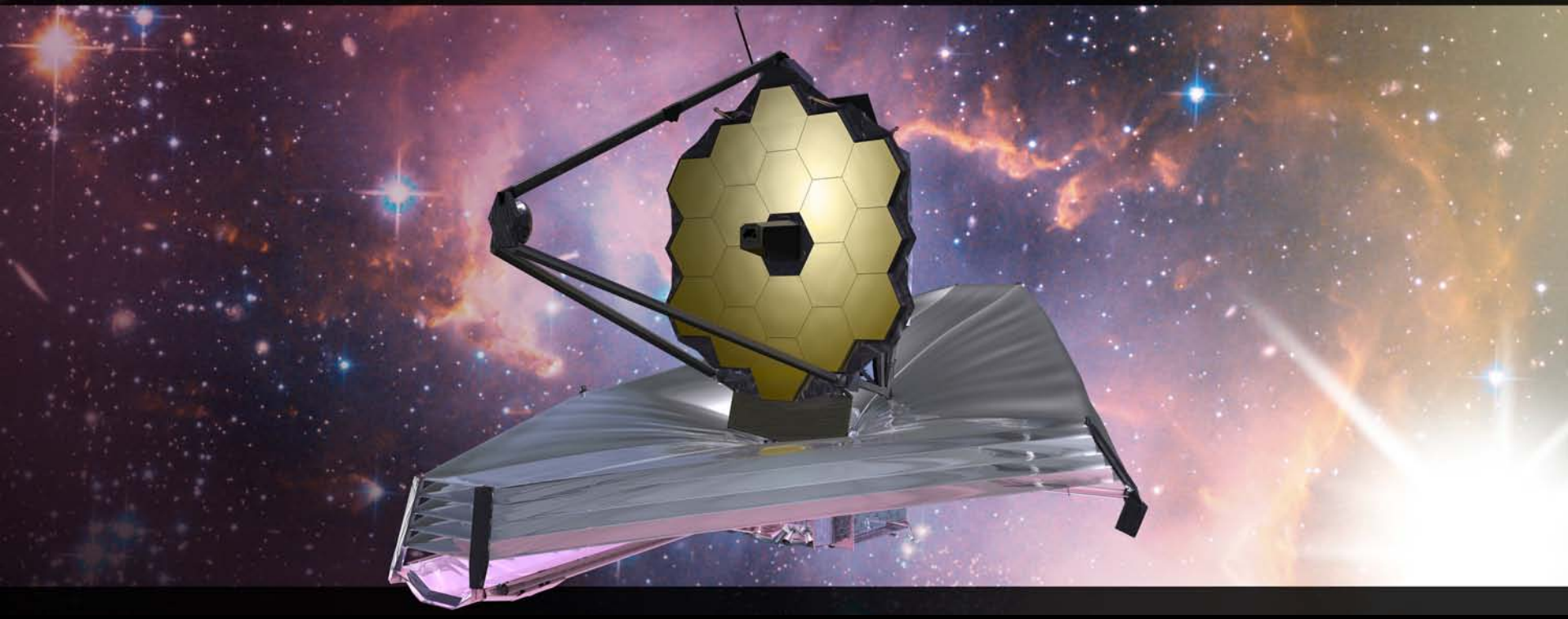
National Aeronautics and Space Administration



James Webb Space Telescope (JWST)

Program Status and Replan

Astrophysics Subcommittee
July 13-14, 2011

Rick Howard
JWST Program Director

Executive Summary

- NASA has made significant changes in the management of JWST
  - Elevated Program visibility, reporting, performance and cost control at HQ, GSFC, and contractors
  - All JWST senior management has been replaced
- NASA has developed a replan with an October 2018 launch date
  - Plan has adequate cost and schedule reserves consistent with an 80% confidence level
- JWST team has been making excellent progress in FY11, achieving milestones within cost and schedule
- Communications have greatly improved between HQ, Centers and contractors, especially at senior management levels
  - Open and honest dialogue, quick identification of issues and agreement on fixes
- Independent non-advocate assessment of alternatives against the replan baseline
  - Looked at broad range of options including ground-based, airborne, space-based and combinations and variants to the existing JWST baseline
  - None provided equivalent Level 1 science for a lower cost or earlier operational readiness

JWST Program Status

Summary of NASA's Response to ICRP Report

- ICRP confirmed that there are no technical issues on JWST
  - Have made significant progress since start, matured enabling technologies, has been well worth the $3B of taxpayers' money spent to date

- NASA agrees with all recommendations from the ICRP
  - Elevated Program visibility, reporting, performance assessment and cost control at GSFC, HQ, NGAS and subcontractors
  - All JWST senior management at GSFC and HQ have been replaced
  - At GSFC, JWST reports to Center Director
  - At HQ, JWST has been elevated to a division level in SMD (like Mars and HST in the past) and reports weekly to the NASA Associate Administrator
  - Used ICRP cost and schedule estimate as one of the inputs used to develop new baseline
  - NASA's Response to the ICRP Report is available on line:

http://www.jwst.nasa.gov/resources/JamesWebbSpaceTelescopeIndependentComprehensiveReviewPanelReport.pdf

Status on ICRP Recommendations (page 1)

1. Develop a new baseline cost and schedule plan-to-complete that incorporates adequate contingency and schedule reserve in each year. COMPLETED

2. Include a realistic allowance for all threats in the yearly budget submission. DONE

3. Budget at 80% cost confidence, and require 25% reserves in each year through launch. DONE

4. Commission a new ICE, reconcile the new plan with it, and update the plan appropriately. DONE (JCL was completed and reviewed by SRB)

5. Establish IPCE as the recognized Agency estimating capability, responsible for validating the most probable cost and schedule estimates. Agree, in work

6. Hold IPCE accountable for developing ICEs for major milestone reviews, reporting directly to the Agency PMC and not simply acting as a support organization to the SRB. DONE

Status on ICRP Recommendations (page 2)

7. Restructure the JWST Project Office at GSFC to ensure that the Project is managed with a focus on the LCC and LRD, as well as on meeting science requirements appropriate to the Implementation Phase. DONE

8. Fund all existing deferred work in FY 2011 to get the Project back on track. NOT DONE

9. Implement a threats and liens system that is consistently applied across all elements of the Project. DONE

10. Assess and track the likelihood of threats at the GSFC management level to more clearly delineate the process for transitioning from threats to liens. DONE

11. Manage and assess contingency in terms of its adequacy to cover unknown and as yet unrecognized threats using the industry standard process of assessing the dollarized EV of existing threats. DONE

12. Accelerate the spacecraft element schedule to more closely bring development into alignment with other Project elements. DONE

Status on ICRP Recommendations (page 3)

13. Move the JWST management and accountability from the Astrophysics Division to a new organizational entity at HQ having responsibility only for the management and execution of JWST. DONE

14. Revise the wording of the Agency's Center responsibilities document, NPD 1000.01a, to correctly and unambiguously reflect clear lines of authority, accountability, and responsibility for program execution. Administrator has already clarified, revision in process

15. Assign management and execution responsibility for the JWST Project to the GSFC Director, with accountability to the Science Mission Directorate Associate Administrator at HQ. DONE

16. Ensure that the Project Office, the Center, and the Agency are each held directly responsible for conducting in-depth analysis and projections of monthly JWST Project cost and schedule performance. DONE

17. Improve communications between the JWST Project and both GSFC management and NASA HQ SMD. DONE

Status on ICRP Recommendations (page 4)

18. Assign at least one senior GSFC project person to be resident at NGAS throughout the Project. Consider having an NGAS manager resident at GSFC. Agree, in work

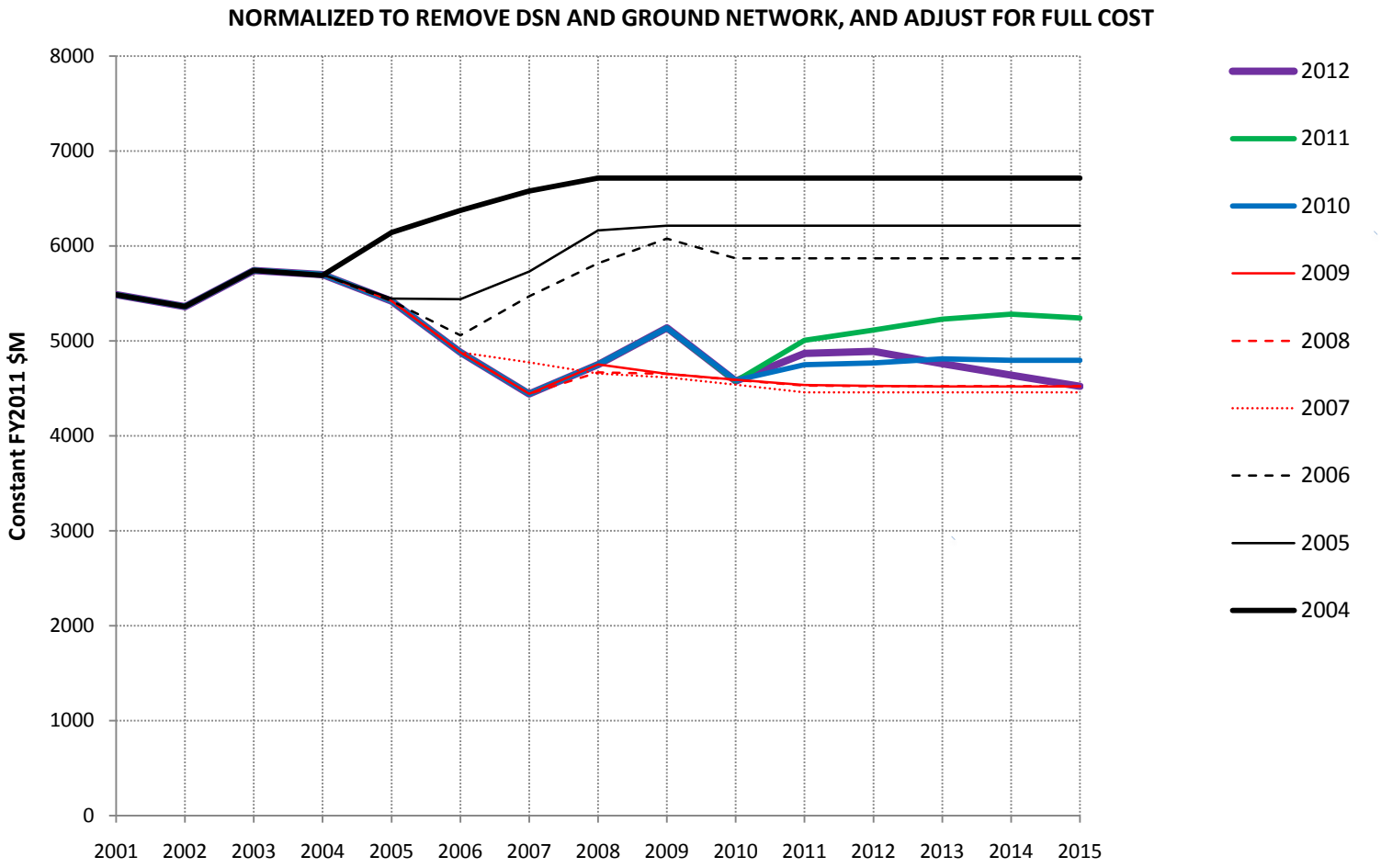
19. Conduct monthly or bi-monthly JWST Executive Project meetings, attended by the NASA Associate Administrator and the President of NGAS. DONE

20. Implement the TAT Report recommendations to substantially reduce the scheduled test time by running complementary testing off the critical path and by more effective sequencing of certain critical cryogenic and optical test segments. Agree, has been incorporated into new baseline

21. Establish a plan that provides the required level of experience and that involves the appropriate NGAS personnel before changing the system engineering accountability. DONE

22. Strengthen the role and the independent voice of the science team in the Project. DONE

SMD BUDGET



- Loss of flexibility - $10B over a five year period
- Lack of stability to support existing programs and plan for future
- Agency authority to reprogram funds in year of execution limited to $500K without OMB and Congressional approval

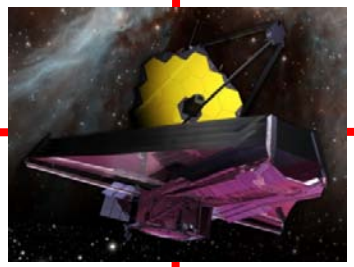
JWST Program Status

Telescope

- 18 flight (plus 1 spare) primary mirror segments are fully assembled
- 14 of 18 flight primary mirrors completed coating
- Final cryo testing of first 6 primary mirror segments has completed
- Flight Secondary Mirror completed coating
- Flight backplane structure under development
  - Telescope backplane pathfinder completed and delivered to NGAS

Science Instruments

- All instruments are in various stages of I&T
- Instrument deliveries to GSFC begin this fall
- Integrated Science Instrument Module (ISIM) structure completed this summer
- ISIM Integration and Test to begin in June



Sunshield

- 1/3rd-Scale Sunshield testing successfully complete (flight Sunshield verification test)
- Flight Mid-Boom tube fabrication is in process
- Membrane template manufacturing is well underway

Spacecraft

- Spacecraft design continues to mature
- Many components have completed Critical Design Reviews
- Engineering Model development underway/completed
- Flight solid state recorder to be completed this fall
- Flight Software development underway

JWST Program Status

JWST continues to make great progress toward as 2018 launch under new organization

- 75% (by mass) of the flight hardware is either ready to be fabricated, in fabrication, in test, or has been delivered

- Optical Telescope Team (NGAS, Ball, Tinsley, ATK & ITT) making progress on hardware developments
  - Should complete *all* primary mirror segment manufacturing in next 9 months (Tinsley & Ball)
  - Significant progress has been made on the support equipment to assemble the telescope (ITT)
  - Flight structure work continues with delivery of pathfinder and flight build continuing (ATK)

- Integrated Science Instrument Module (ISIM) Team making good progress on instrument developments and ISIM hardware
  - To begin ISIM-level Integration activities in FY11
  - Detector "hot-pixel" root cause hypothesis determined, improved design and manufacturing process being developed

- Sunshield engineering model work continues to finalize the flight design (NGAS)

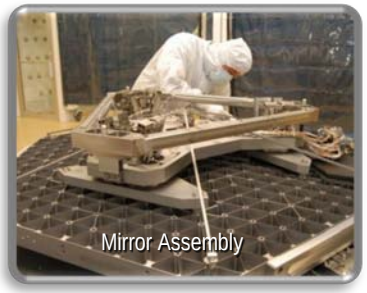
- Project Integration & Test Activities continue
  - Upgrades to JSC Chamber A making it the largest cryogenic vacuum chamber in the world continues

JWST FY11 Milestones

Month	Milestone	Comment
January ’11	Ship MIRI FPE to ESA (RAL) Ball's Flight Actuator Drive Unit S/W Test Review	Successfully Completed - 1/24 Successfully Completed – 1/20
February ’11	Deliver NRISpec flight spare detector to GSFC Pathfinder PMBSS delivered to NGAS Establish No-Earlier-Than LRD as part of replan Establish WBS for new GSFC responsibilities	Successfully Completed – 1/29 Pathfinder delivered to NGAS on 3/25 Based on current funding constraints a NET LRD of Oct. 2018 established, FY11 and FY12 schedule does not preclude an earlier date if deemed possible in the future – Completed 2/25 Successfully Completed – 2/28
March ’11	Complete flight IRSU Thermal Vacuum testing Deliver FGS ETU electronics to ISIM I&T Complete 2018 LRD budget details	Successfully Completed – 2/19 Successfully Completed – 2/24 Preliminary Budget was presented to Program Office and Center Management on 4/7
April ’11	Pathfinder PMSAs complete Deliver ICDH ETU to ISIM I&T Complete 2018 LRD project lead JCL	Successfully Completed - 4/25 Successfully Completed – 4/22 Initial JCL run completed – 4/28
May ‘’11	Start flight FGS environmental testing (instrument level) Complete SC SMS Cone Structure IDR 3/4	Successfully Completed - 5/4 Successfully completed – 4/20
June ’11	Complete CCTS Build 2.3 Start ISIM level I&T	Successfully completed – 4/13 Successfully Completed - 6/24 Began the ISIM Flight I&T with the integration of the Spacecraft Simulator 2A (SCSIM-2A) into the Flight Electrical Environment.
July ’11	Deliver ISIM Region 1 Harnesses Deliver ISIM Structure to ISIM I&T	
August ’11	S/C Flight S/W Build 1 TRR	Successfully Completed – 6/30
September ‘11	Deliver Flight IEC to ISIM I&T Deliver flight ICDH #1 to ISIM I&T	

JWST Hardware Status

Telescope

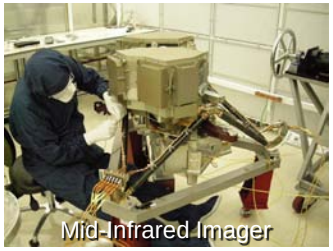

Mirror Assembly

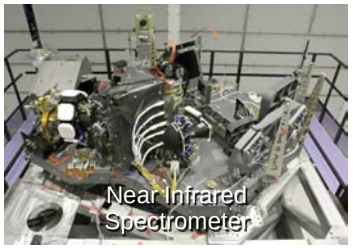

Secondary Mirror


Cryo Testing at MSFC


Telescope Backplane Pathfinder

Science Instruments


Mid-Infrared Imager

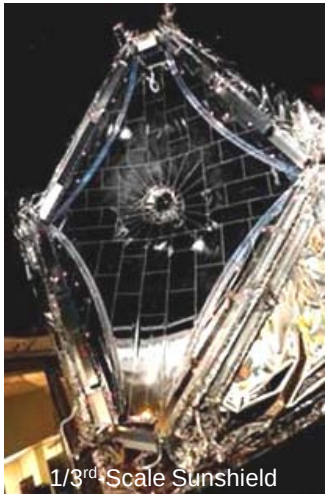

Near Infrared Spectrometer


Fine Guidance Sensor

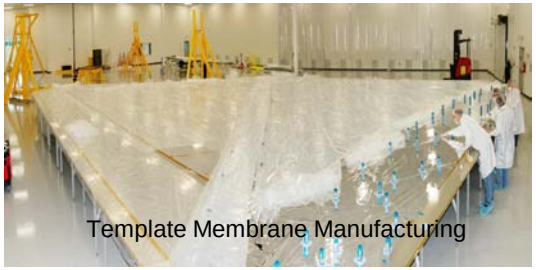

Near Infrared Camera Integration


Integrated Science Instrument Module

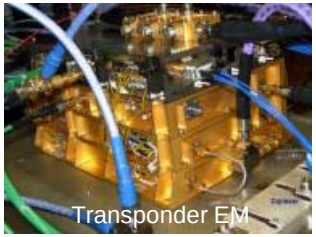
Sunshield


1/3rd-Scale Sunshield


Flight Mid-Boom Tube Fabrication


Template Membrane Manufacturing

Spacecraft

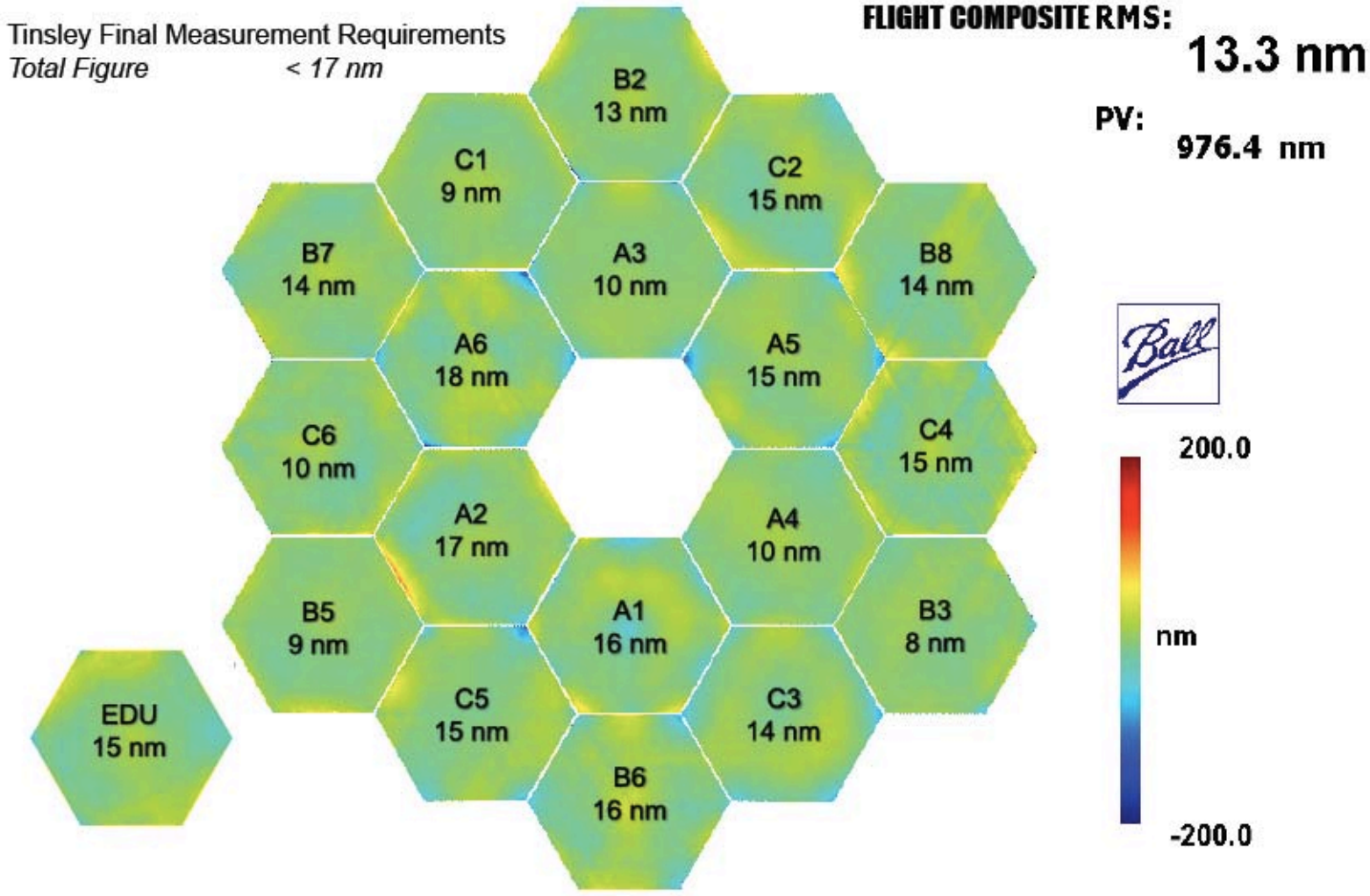

Transponder EM


Solid State Recorder EM


HGA Reflector


Flight Single Board Computer

JWST Flight Mirrors Have Completed Polishing



- Map of each mirror segment are of deviations from a perfect surface
- Blue areas below the ideal and yellow areas above the ideal
- 10 nanometers (nm) is ~1/10,000 the diameter of a human hair

All Mirror Polishing Is Complete At Tinsley

- On June 9, 2011 the final flight mirror completed polishing processing and testing at Tinsley
- All Tinsley operations are complete
- 18 of 18 flight Primary Mirrors are through final polishing
- Flight Secondary, Tertiary and Fine Steering Mirrors are complete

Hardware Fabrication Completion Percentages

Primary Mirror Segments

72%

Aft Optics System

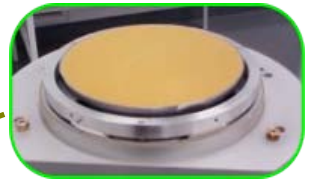
95%

Mirror Support Structure

75%

100% (Done!)

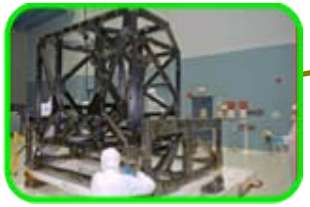
Tertiary Mirror



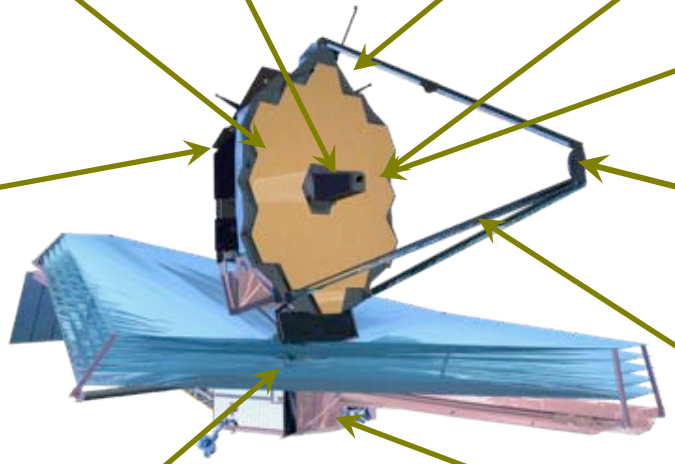
90%

Fine Steering Mirror

Science Instrument Module & Science Instruments



90%



85%

Secondary Mirror

Green borders denote actual spaceflight hardware images, red borders are test equipment

Secondary Mirror Supports

80%

10%

Sunshield Membranes

25%

Spacecraft Bus

As of 5/24/2011

JWST Replan

JWST Schedule to Support FY13 Budget Request

January 2011
- Replan budget guidelines provided to partners and contractors (FY11 and FY12 constrained)
  - Goal is to develop realistic cost and schedule baseline that supports earliest launch date
  - Use most recent, most detailed estimate from NGAS as starting point
- Develop bottom-ups cost estimates for in-house (GSFC) elements of project

February 2011
- Start work on bottoms-up estimates for contractor elements
- Review of replan liens and threats
- Develop “top-level” replan schedule and provide to the team

March 2011
- Start Joint cost and schedule Confidence Level (JCL)
- Project assessments of contractor, subcontractor inputs for replan

April 2011
- Complete assessments of replan, complete JCL, start internal and external review of JCL and replan

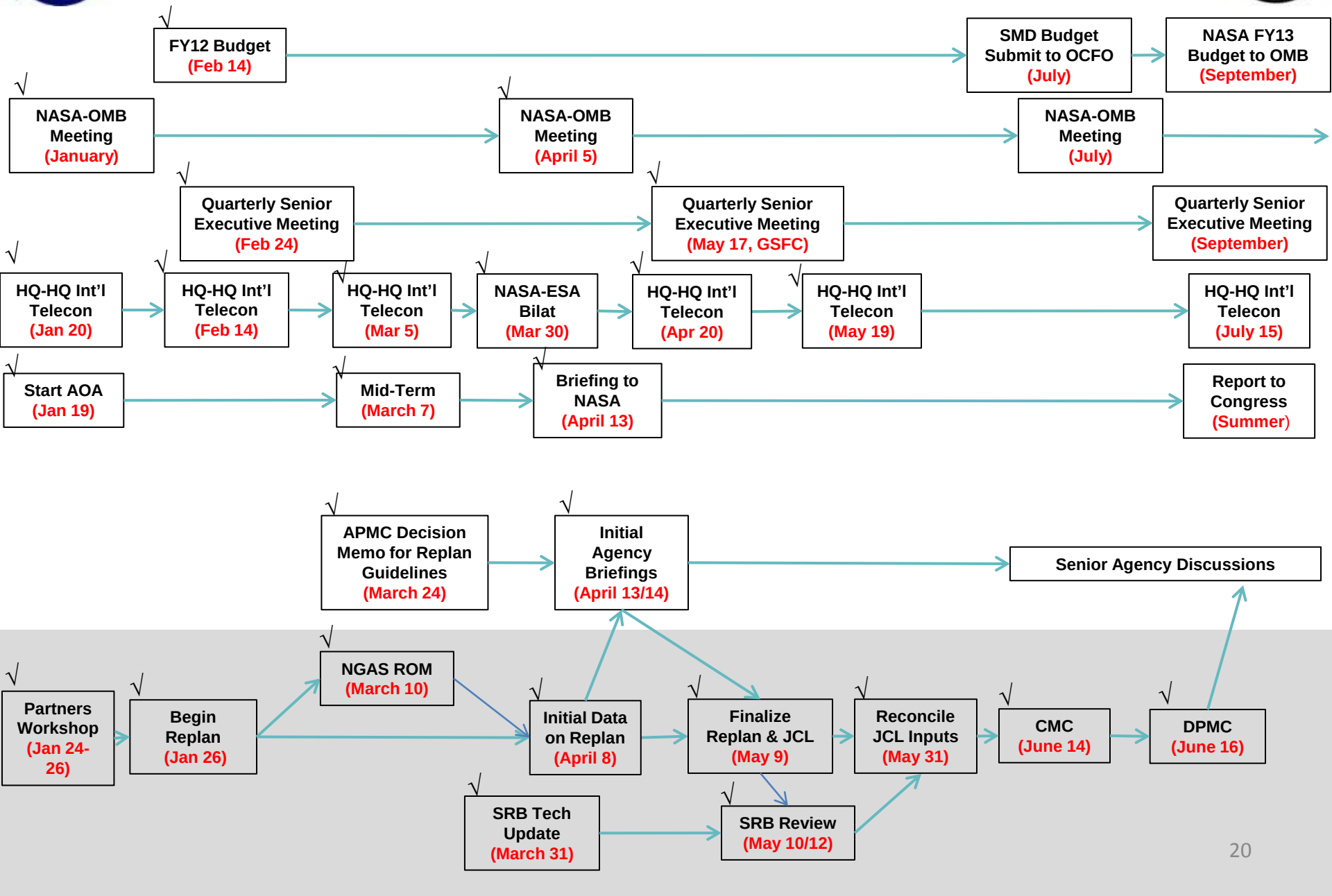
May 2011
- Finalize replan and hold Center and HQ reviews

June/July 2011
- Agency Program Management Council for approval of new baseline (LRD and LCC)

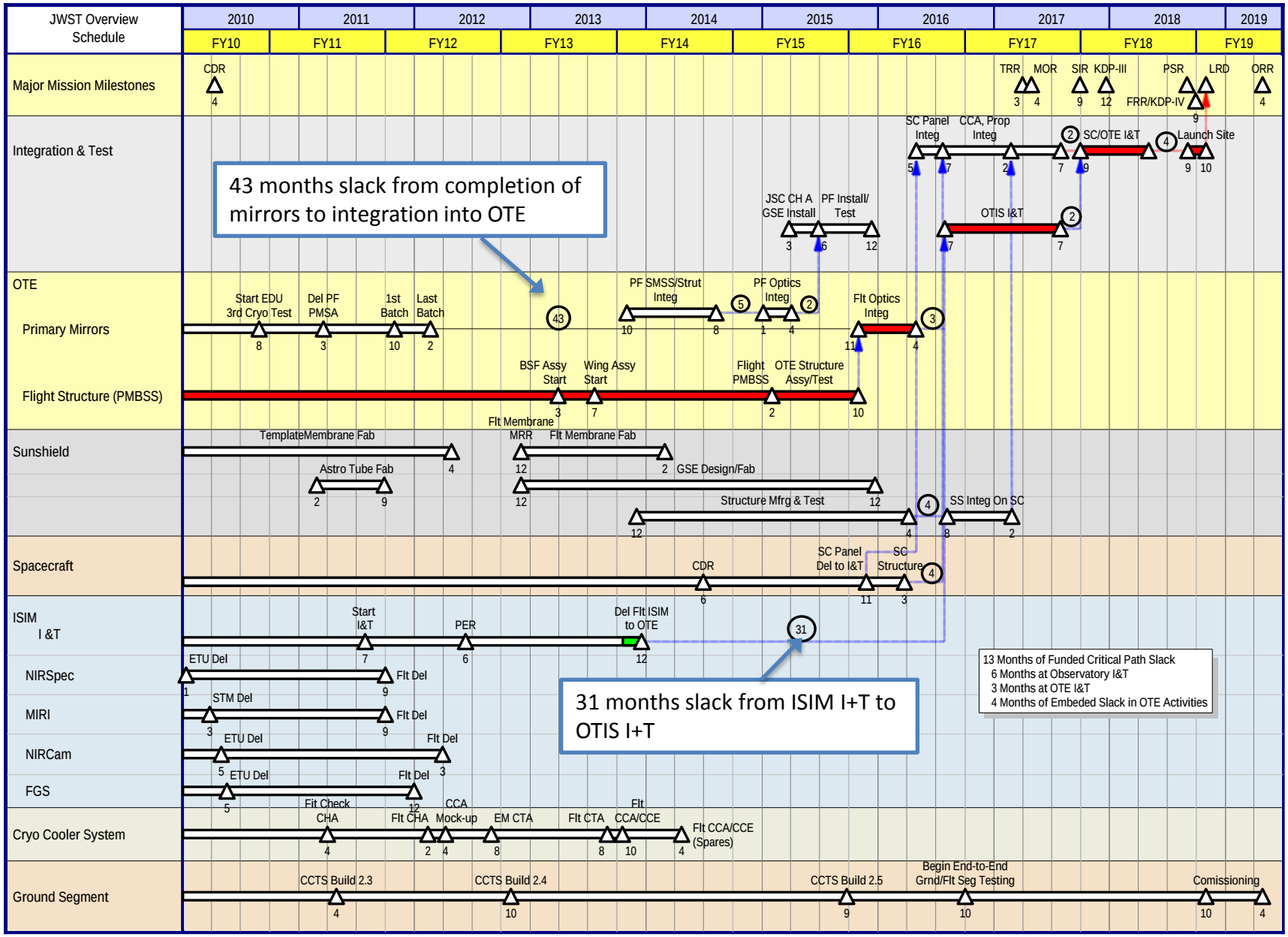
JWST Replan

- Replan developed by government and contractor team
  - Conducted bottoms-up estimate for cost and schedule to go
  - Assumed constrained budget in FY11 and FY12 ($471.2M & $374.7M, respectively), and unconstrained in FY13 forward
  - Developed a high confidence, realistic schedule with adequate reserves that launches JWST as soon as possible
- Resulting replan supports an October 2018 launch date
- A Joint Cost and Schedule Confidence Level (JCL) analysis was done
  - Replan consistent with 80% confidence level (within 1% on cost and 6% on schedule)
- Replan and JCL results have been reviewed by NASA's independent external review board – the JWST Standing Review Board (SRB)
- Replan has been presented to Agency management (both at GSFC and Headquarters)
- SRB findings and recommendations have been factored into the replan
- Funding for replan must fit within overall Agency's top line budget

Replan Flow


FY12 Budget (Feb 14)
SMD Budget Submit to OCFO (July)
NASA FY13 Budget to OMB (September)
NASA-OMB Meeting (January)
NASA-OMB Meeting (April 5)
NASA-OMB Meeting (July)
Quarterly Senior Executive Meeting (Feb 24)
Quarterly Senior Executive Meeting (May 17, GSFC)
Quarterly Senior Executive Meeting (September)
HQ-HQ Int'l Telecon (Jan 20)
HQ-HQ Int'l Telecon (Feb 14)
HQ-HQ Int'l Telecon (Mar 5)
NASA-ESA Bilat (Mar 30)
HQ-HQ Int'l Telecon (Apr 20)
HQ-HQ Int'l Telecon (May 19)
HQ-HQ Int'l Telecon (July 15)
Start AOA (Jan 19)
Mid-Term (March 7)
Briefing to NASA (April 13)
Report to Congress (Summer)
APMC Decision Memo for Replan Guidelines (March 24)
Initial Agency Briefings (April 13/14)
Senior Agency Discussions
Partners Workshop (Jan 24-26)
Begin Replan (Jan 26)
NGAS ROM (March 10)
Initial Data on Replan (April 8)
Finalize Replan & JCL (May 9)
Reconcile JCL Inputs (May 31)
CMC (June 14)
DPMC (June 16)
SRB Tech Update (March 31)
SRB Review (May 10/12)

Replan Schedule – October 2018 LRD



JWST Replan Schedule - Details

- Critical path is highlighted in red (with reserve months in black circles)
  - There are 13 months of funded critical path schedule reserve
    - 4 months prior to launch site activities
    - 2 months between completion of OTIS testing and Spacecraft and OTE integration
    - 3 months between the end of flight optics integration and OTIS I+T
    - 4 months within the Flight Structure (PMBSS) development line in FY13-FY15

- There are two major periods of subsystem inactivity in this schedule
    - 43 months between the completion of the Primary Mirror Segment Assembly final qualification cryo testing (for all eighteen mirror segments) and their integration into the flight Primary Mirror Support Structure
    - 31 months between the completion of the integration and testing of the instruments into the ISIM and the ISIM level testing and the integration of the ISIM for the OTE cryo testing at JSC
      - During this period, the new IR detectors will have to be integrated into three of the four instruments with additional instrument level and ISIM level testing

- The spacecraft and sunshield developments have 4 months of schedule slack prior to integration of the sunshield onto the spacecraft

Concerns

- Schedule stretch out to 2018
  - Potential loss of key government and contractor personnel due to periods of low or little activity
  - Long ISIM storage period
  - Long Mirror and Actuator storage period
  - Need to reevaluate sparing philosophy and parts aging/obsolescence

- NASA budget uncertainly for FY11 and out as a result of budget negotiations (recent House bill cut NASA FY12 by 9% compared to FY11 NASA budget)

- Need the JWST team to remain focused and motivated to keep the momentum of this year

Summary

- NASA has made significant changes in the management of JWST
- NASA has developed a replan with an October 2018 launch date
- Replan is on track to support the FY13 budget process
- Communications has greatly improved both with Centers and contractors, especially at senior management levels
- Assessment of alternatives completed – JWST remains is the best value

JWST continues to make great progress, achieving milestones within cost and schedule

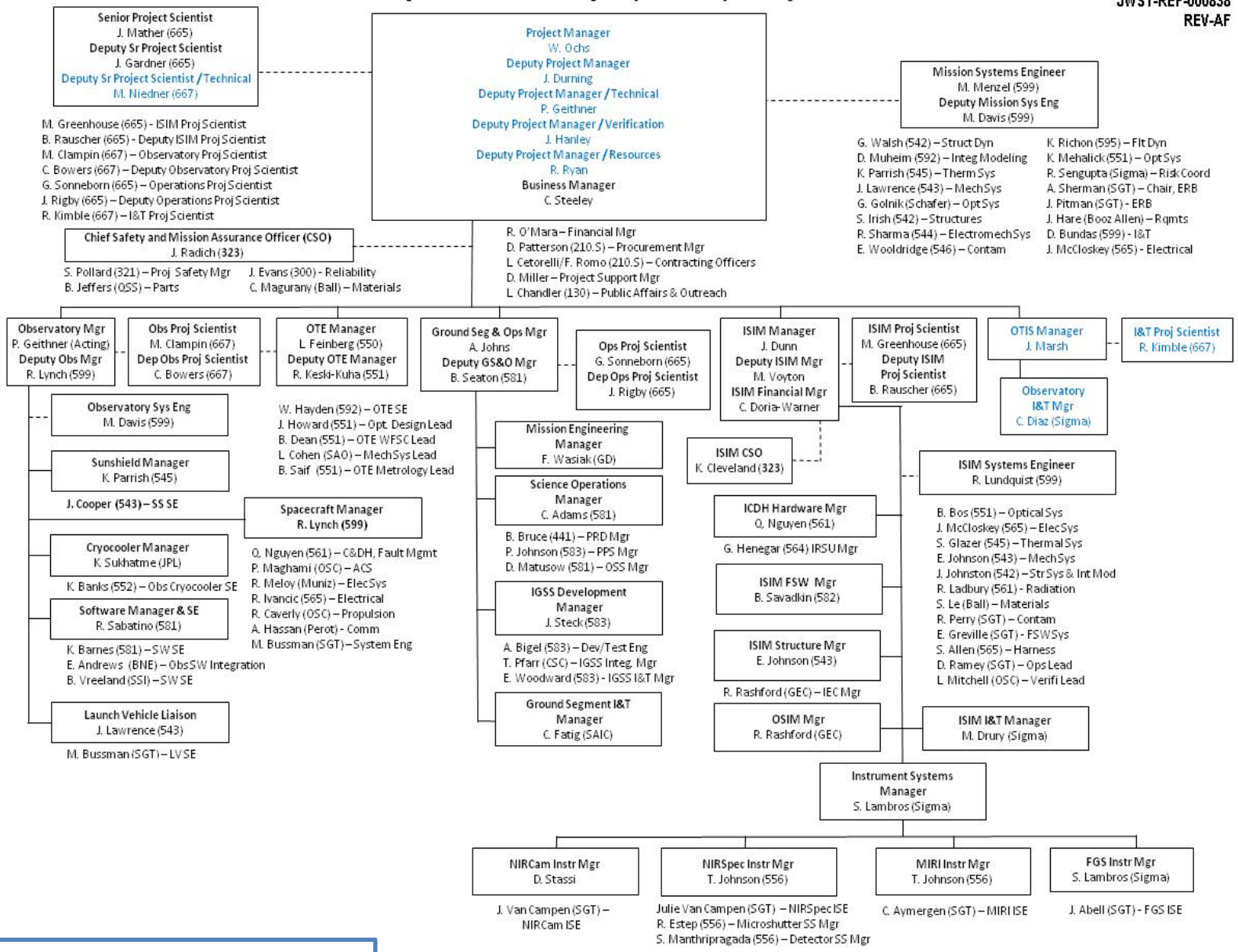
BACKUP

Changes Made at GSFC to Strengthen Project Team

- New Project Manager and Business Manager assigned.
- A resource analyst dedicated to the Integrated Science Instrument Module (ISIM) was added to the team.
- Project and Business Manager assessed the workload with respect to the resources team, identifying strengths and weaknesses in skills.
  - Have added two additional staff members
  - Further staff augmentations in discussion
- The Flight Projects Directorate and the Center will fully support additional manpower requirements as they are identified.
- JWST Project reports to Center Director

James Webb Space Telescope (JWST) Project – Code 443

JWST-REF-000838
REV-AF

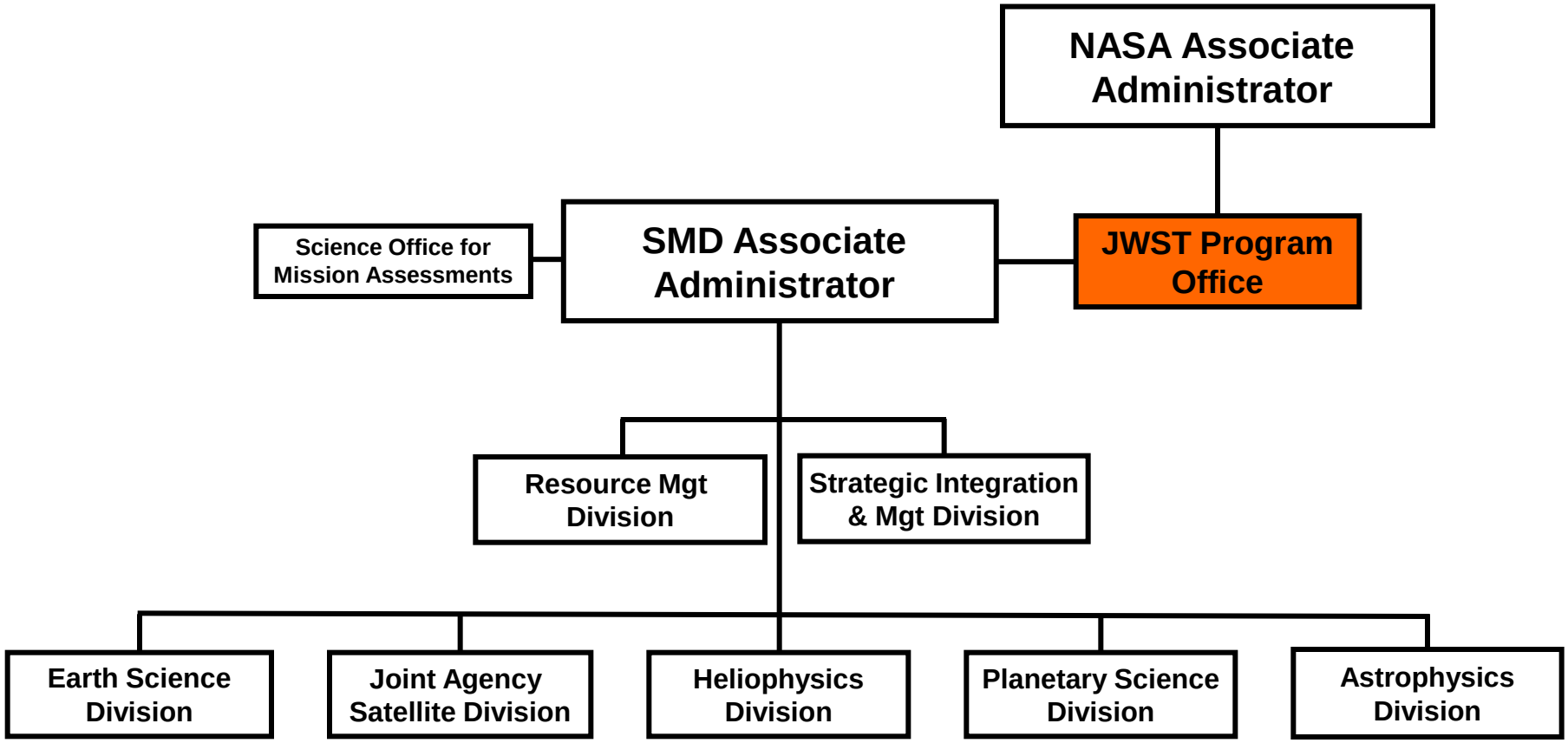


Blue indicates new personnel

Create a JWST Program Office at HQ

- Senior Manager and staff assigned to manage JWST at HQ
- Senior Manager assigned to lead test phase at JSC
- JWST elevated to a Program reporting directly to the SMD AA and NASA AA
- Similar to previous changes made to address major programmatic issues
  - NOAA civilian weather satellite program (~2010)
  - Mars program (~ 2000)
  - HST program (~1985)
- Budget will be managed independently from Astrophysics Division

Restructured JWST Headquarters Organization

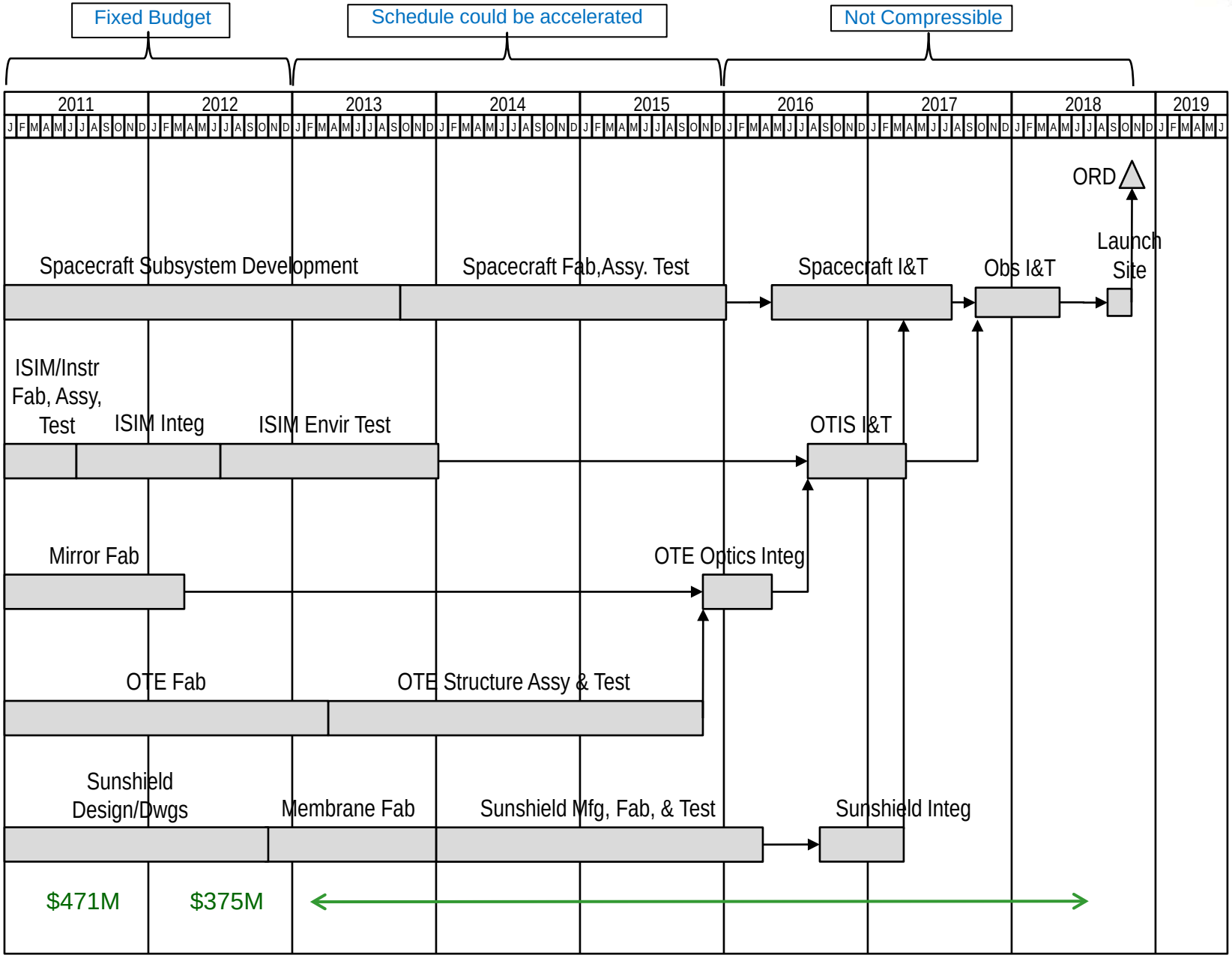


JWST Headquarters Program Office

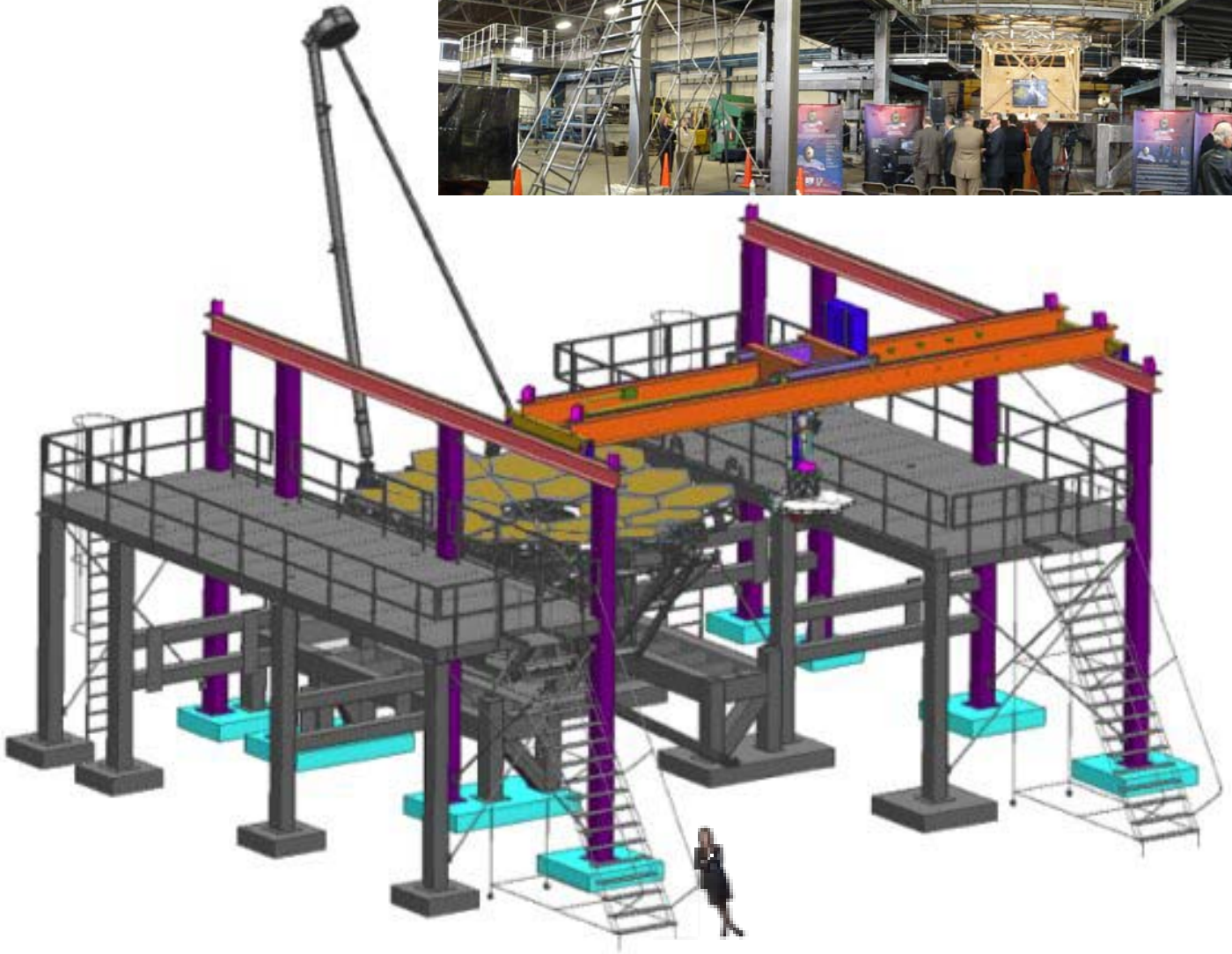
- Program Office includes:
  - JWST Program Director
  - JWST Dep. Program Director
  - JWST Program Manager
  - JWST Program Scientist (matrixed from Astrophysics Division)
  - Senior Resources Analyst specializing in program control
  - Support from Resource Management and Strategic Integration & Management Divisions

- Responsibilities include:
  - Discussions at least weekly with JWST Project Office at GSFC
  - Discussions at least weekly with GSFC senior management
  - Coordinate with other NASA Centers working on JWST
  - Coordinate with international partners (ESA and CSA)
  - Coordinate independent monthly analysis of JWST financial and schedule status with IPCE and SID
  - Coordinate assessments with Project and Center management
  - Present program status and analysis monthly at SMD Flight Program Review, SMD Monthly Status Reviews, and Agency BPR; present to PMCs as required
  - Conduct weekly status reviews with SMD AA and NASA AA
  - Elevate issues to SMD AA, NASA AA, and Administrator as necessary

JWST Replan Schedule

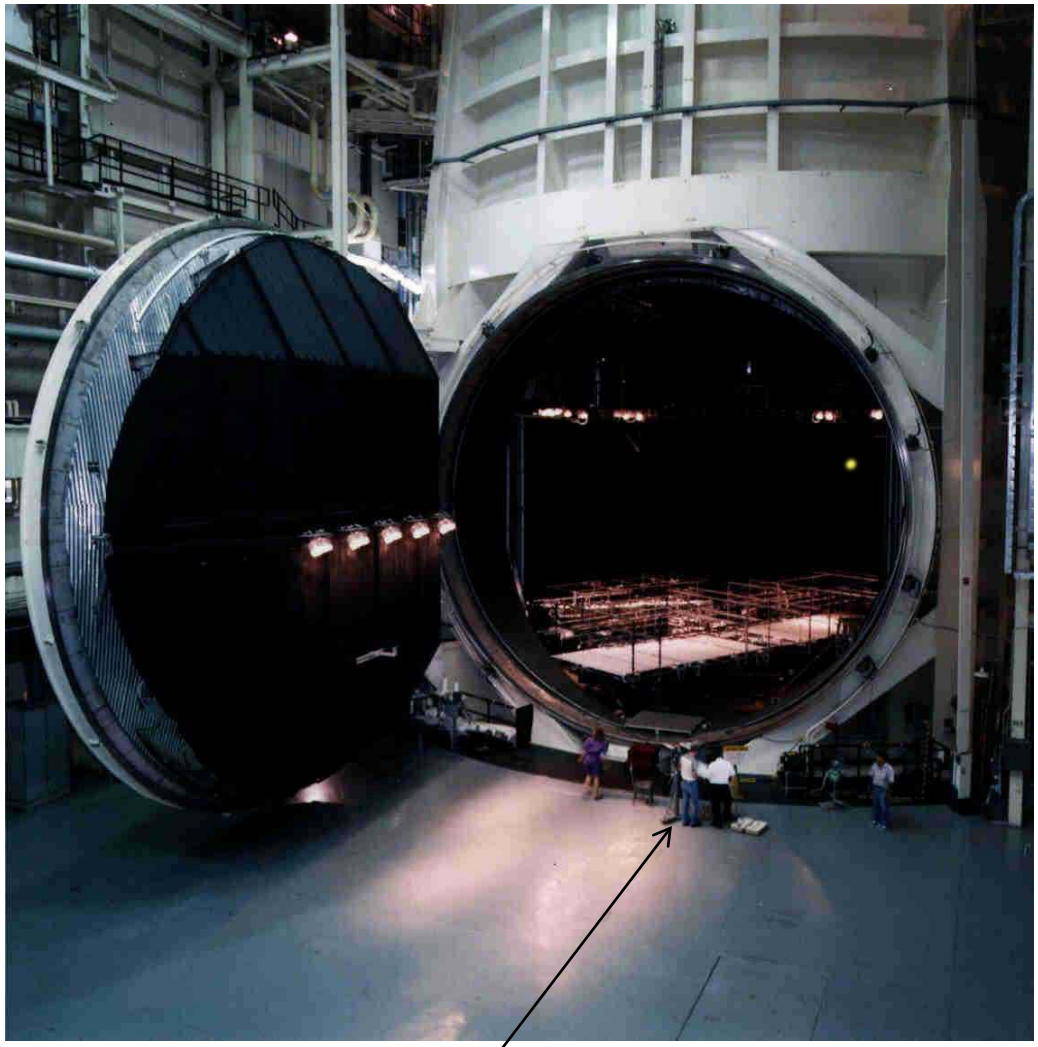


Completion of Ambient Optical Alignment Stand

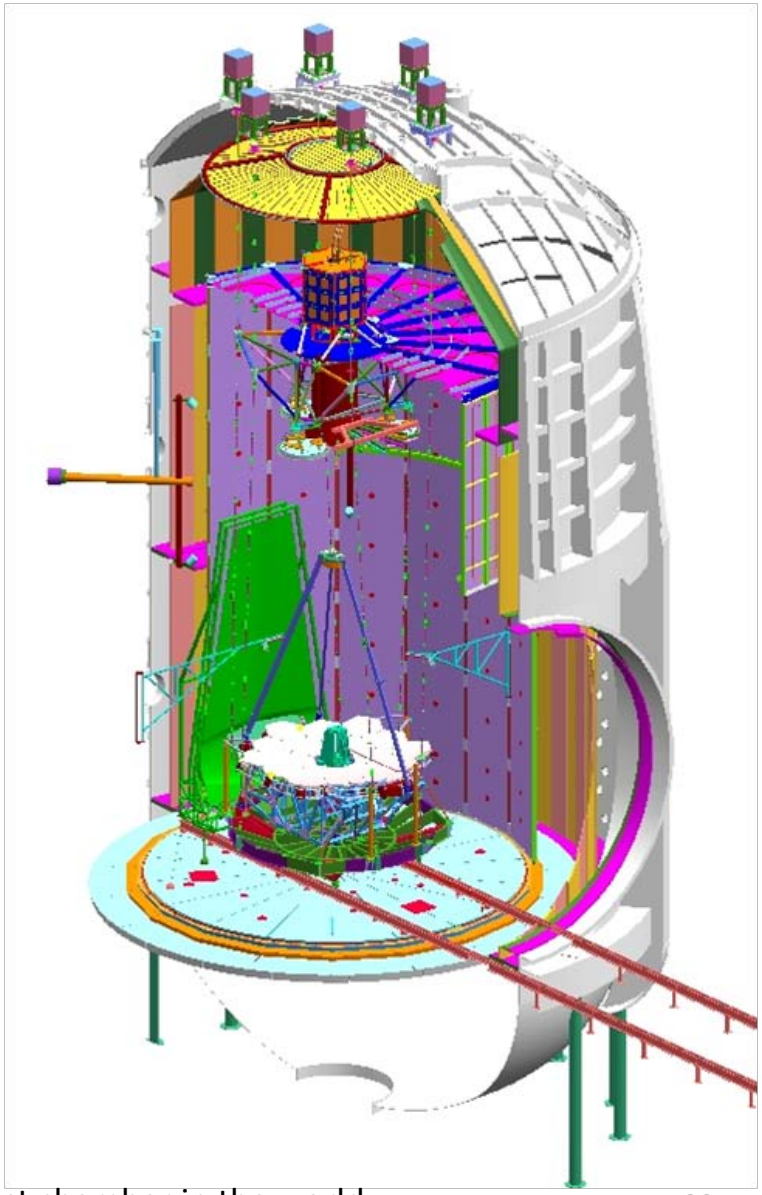


- Media event held at manufacturer in Syracuse, NY.
- Hardware now being shipped to NASA Goddard Space Flight Center test facility, Greenbelt, MD.

OTE Testing – Chamber A at JSC

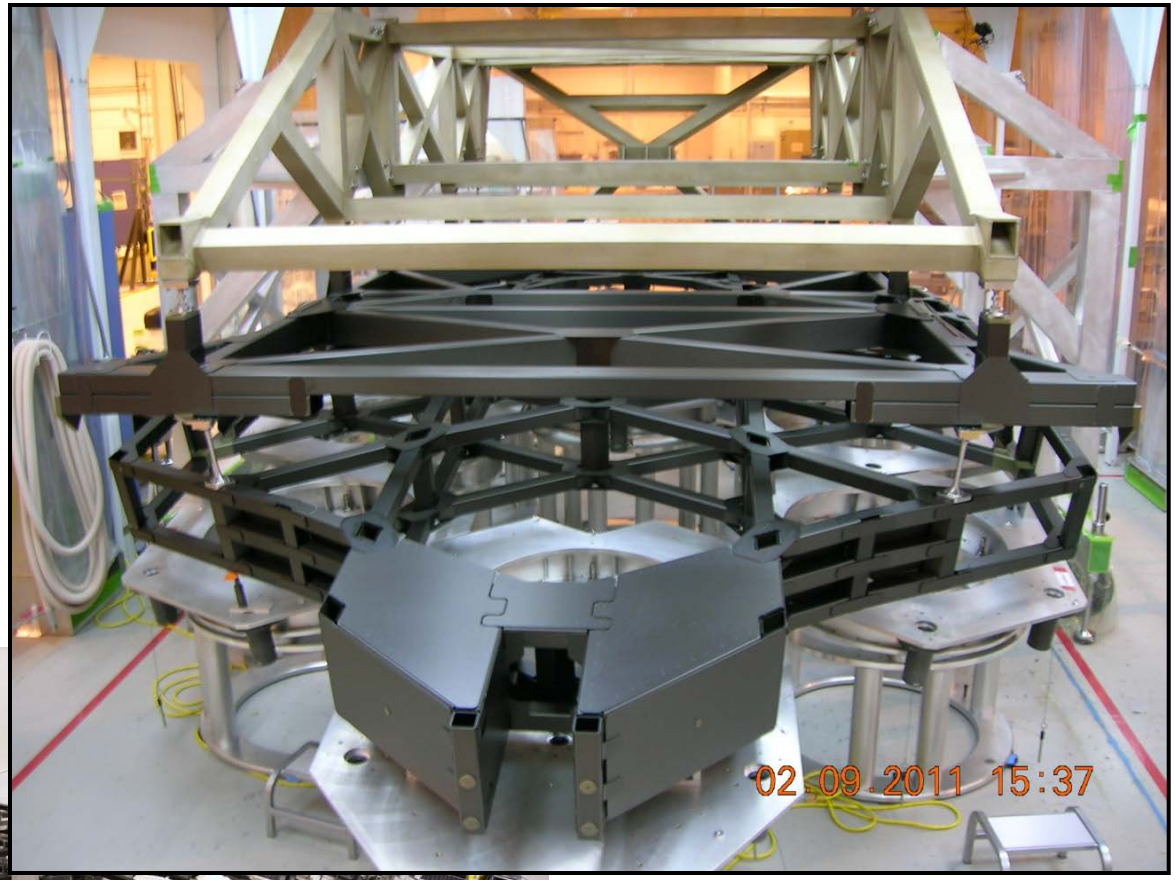


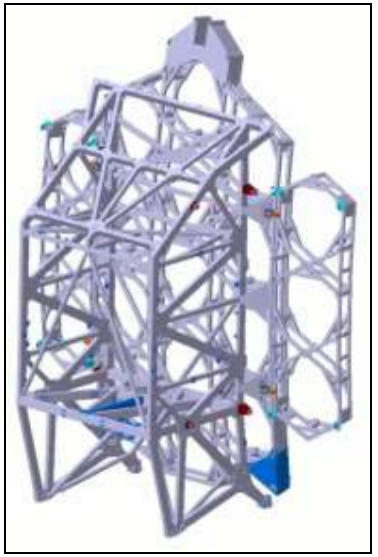
Notice people for scale

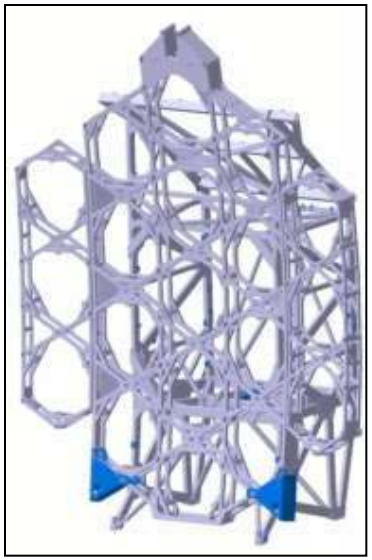


Will be the largest cryo vacuum test chamber in the world

Pathfinder PMBSS Complete
Delivered to NGAS March 25, 2011



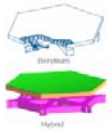




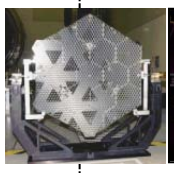
The Final Acceptance Test Completes a Decade plus Development Effort to Make JWST Mirrors

1996 1998 2000 2002 2004 2006 2008 2010 2012 2014

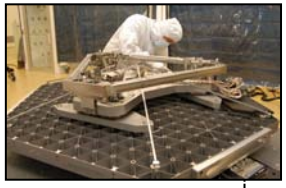
Advanced Mirror System Demonstrator (AMSD)
Collaboration among 3 government agencies
15Kg/m2, 1.2M diameter segments



Medium **Authority** Glass (ULE)



Low Authority **Beryllium**



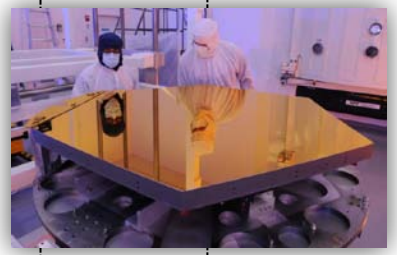
Technology Readiness Level-6 Demonstrated:
All key requirements and environments demonstrated

Onset of **James Webb Space Telescope**

AMSD Phase 1: 8 Mirror Designs

AMSD Phase 2: 3 mirrors developed

AMSD Phase 3/Six Sigma Study
Be manuf. and process improvements



OTE Optics Review (OOR): Beryllium Selected

Engineering Design Unit.

Subscale Beryllium Mirror Demonstrator (SBMD):
.5 meter diameter,

PM Manufacturing of 18 segments

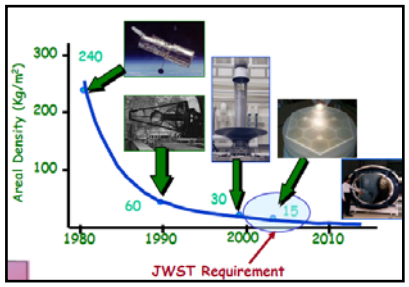
Primary Mirror Segment Assemblies Complete

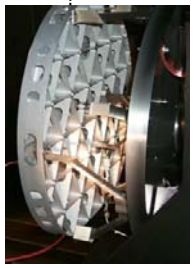
Machining Facility Complete

Cryo Testing

Polishing Facility Complete

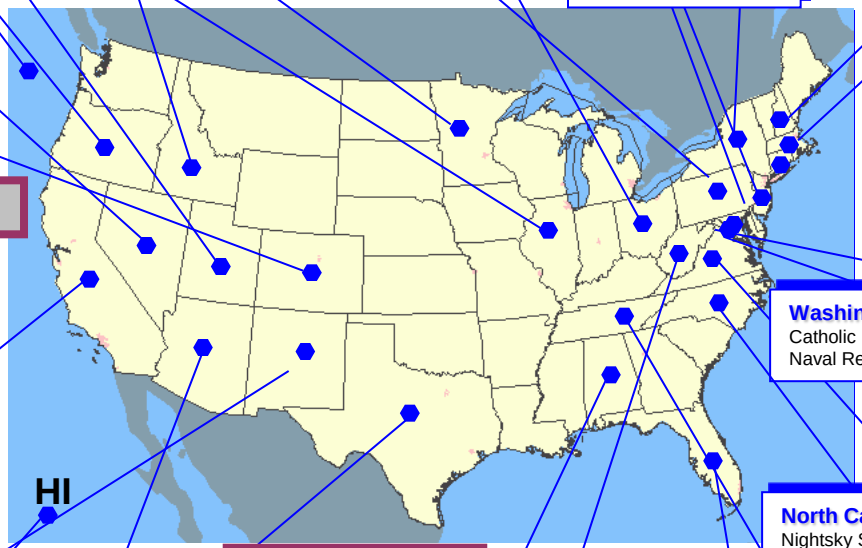
Low Areal Density Mirrors Identified as Key Enabling Technology for 25 Square Meter Space Telescope





JWST US Team Members

Total $M/FY10 FTEs



~$65 M/50 FTEs

Utah
ATK Aerospace Company
Space Dyamics Lab/ Utah St. U
Hexcel Corporation
Aerospace Machining

Idaho
University of Idaho

Minnesota
ION Corp
Minco Products, Inc.
Sheidahl CO.

Oregon
Precision Measurements & Instr.

Nevada
TRAX International Inc

Alaska
ASRC

Illinois
Boeing
Numerical Precision

~$330 M/80 FTEs

Colorado
ABSL Space Products
Ball Aerospace & Tech Corp
Blue Line Engineering
CTD
Raytheon Company
SEAKR Engineering, Inc
Space Science Institute

$1,750 M/~400FTEs

California
ATK Space Systems Inc
Composite Optics
Dow-Key Microwave Corp
Geologics Corp
Glenair
Hewlett Packard
JDS Uniphase
JPL
Lockheed Martin ATC
NEA electronics
Magna Tool
Maxwell Technologies
Moog
Newport Corporation
Northrop Grumman Aerospace Systems
Parsons Infrastructure & Technology
Raytheon Vision Systems
Rockwell Scientific
Sabritec
SAIC
St Systems USA, Inc
SVG Tinsley Laboratories
Sunrise Technologies, Inc
Synopsys, Inc
Tayco Engineering, Inc
Tavis Corp
University of California
Vacco
Ames Research Center

Hawaii
GL Scientific
Mauna Kea Engineering
University of Hawaii

~$23M

Ohio
Brush Wellman
Keithley
Lake Shore Cryotronics
Glenn Research Center

Pennsylvania
Tyco Engineered Systems

~$110M/40 FTEs

New York
Aeroflex
Cranetech Inc
Indium Corp of America
ITT Space Systems, LLC
JPW Structural Contracting, Inc
Moog Inc
Sigmaddyne
University of Rochester
ValveTech Inc

Connecticut
Zygo

~$20M

New Jersey
Newark Electronics
Quantum Coatings, Inc

New Hampshire
Optical Solutions Inc
Timkin Aerospace & Super Precision

Massachusetts
Appli-Tec Inc
Hypertronics Corporation

~$2,600M/~500 FTEs

Maryland
Bechdon Company, Inc.
Boeing
Computer Science Corporation
Conceptual Analytics
Curtis Management Co.
Energy Solutions International, LLC
General Dynamics
Genesis Engineering Co., LLC
Global Science & Technology
Goddard Space Flight Center
Hammers Company
Honeywell / HTSI
Jackson & Tull Chartered Engineers
Janis Research Company
Johns Hopkins University
Litton
Lockheed Martin
Lorr Company
Mega Engineering
Microtel
NGST Electronics
Northrop Grumman
Nu-Tek
QSS Group, Inc.
Raytheon
RSTX
Science Application International Corporation
SGT
Sigma
Space Telescope Science Institute
SRS Technologies
SSAI
University of Maryland
USRA
Wolcott Park

Washington DC
Catholic University
Naval Research Lab

North Carolina
Nightsky Systems

~$110M/40 FTEs

Texas
Muniz Engineering
National Instruments
Texas A&M University
Johnson Space Center

New Mexico
Cortez III Service Corp
DoE

West Virginia
NASA GSFC IV&V

Tennessee
Jacobs Technology

~$25M/10 FTEs

Arizona
Dynaco
Honeywell International, Inc
Optical Device Engineering Corp
University of Arizona
Arizona State University

~$77M/45 FTEs

Alabama
Axsys Technologies
Marshall Space Flight Center
SRI
Mantech - Nexolve

Florida
Advanced Quick Circuits
CDA InterCorp
Geodetic Services

~$40M/15 FTEs

Virginia
BAE Systems Information & Electronics Systems Integration
General Dynamics
Man Tech
National Research Initiatives
Orbital Sciences Corporation

JWST System Hierarchy

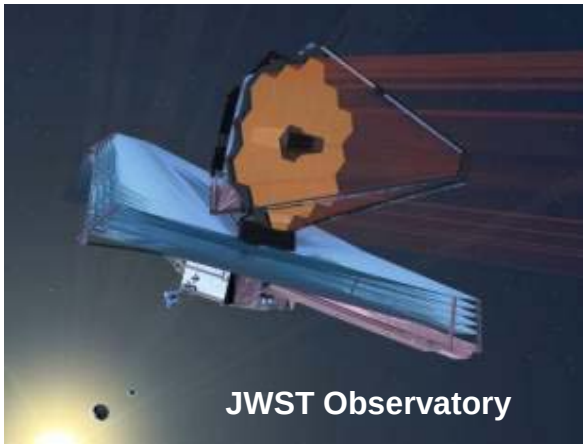
James Webb Space Telescope System

Launch Segment

Ariane Launcher

- Launch Vehicle
- Payload Adapter
- Launch Site Services

Observatory Segment



JWST Observatory

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

Ground Segment

Deep Space Network

Space Telescope Science Institute

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

Provided by NASA
Provided by NGST
Provided by STScI
Provided by ESA
Provided by CSA

International Partner Investment

- Both ESA and CSA have made significant investments in JWST
  - Based on a 2018 LRD:
    - CSA (FGS) has an approximate $150M USD investment
    - ESA (NIRSpec, MIRI, L/V, and Ops) has an approximate $790M USD investment
  - Total International Partner investment
    - ~ $940M USD