

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)



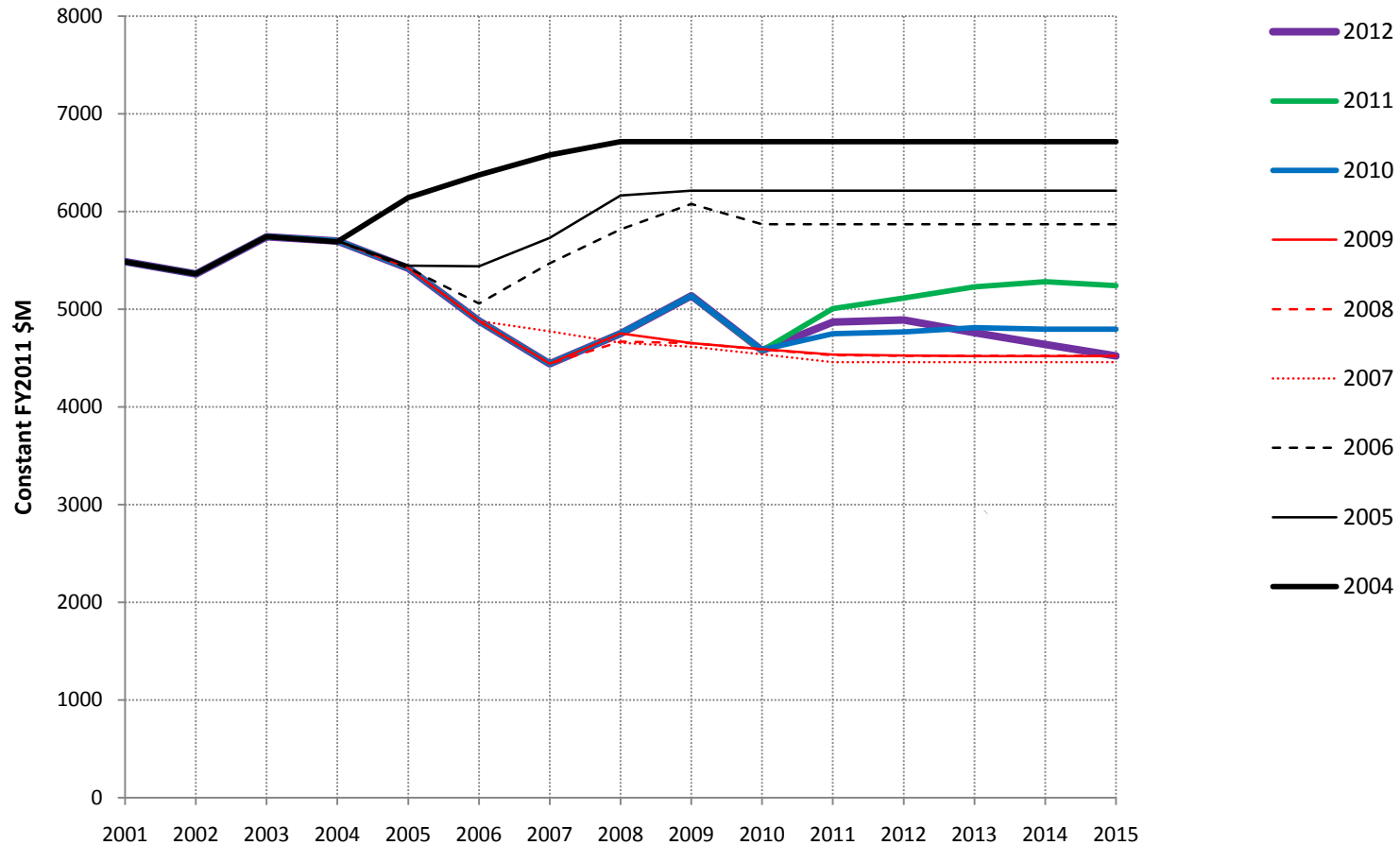
18. Assign at least one senior GSFC project person to be resident at NGAS throughout the Project. Consider having an NGAS manager resident at GSFC. **Agree, in work**
19. Conduct monthly or bi-monthly JWST Executive Project meetings, attended by the NASA Associate Administrator and the President of NGAS. **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

NORMALIZED TO REMOVE DSN AND GROUND NETWORK, AND ADJUST FOR FULL COST



- 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

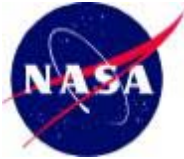


## Sunshield

- 1/3<sup>rd</sup>-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



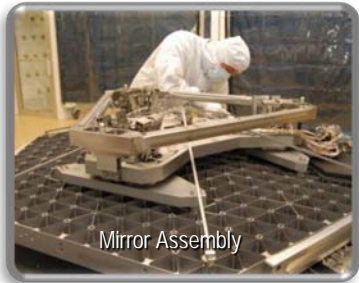
| Month         | Milestone   | Comment   |
|---------------|---|---|
| January '11   | Ship MIRI FPE to ESA (RAL)<br>Ball's Flight Actuator Drive Unit S/W Test Review   | Successfully Completed - 1/24<br>Successfully Completed – 1/20  |
| February '11  | Deliver NRISpec flight spare detector to GSFC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



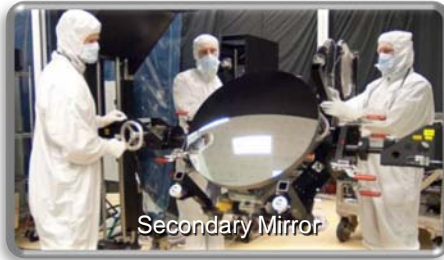
# JWST Hardware Status



## Telescope



Mirror Assembly



Secondary Mirror



Telescope Backplane  
Pathfinder

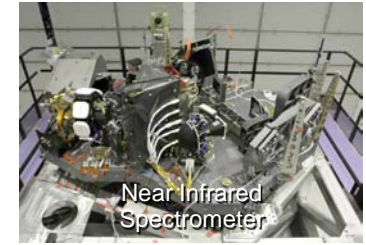


Cryo Testing at  
MSFC

## Science Instruments



Mid-Infrared Imager



Near Infrared  
Spectrometer



Fine Guidance Sensor

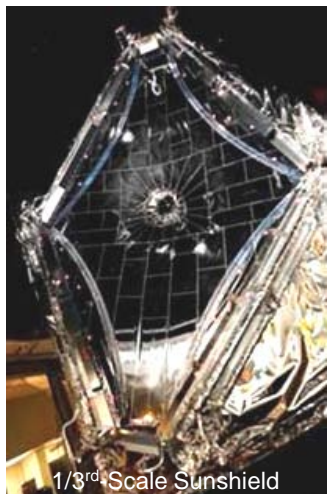


Near Infrared  
Camera Integration

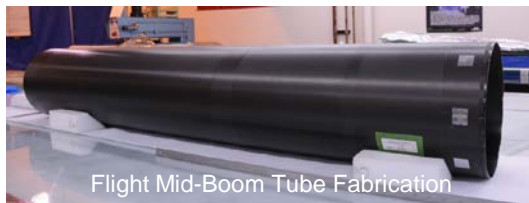


Integrated Science  
Instrument Module

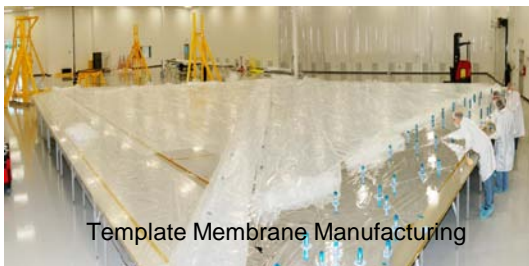
## Sunshield



1/3<sup>rd</sup> Scale Sunshield



Flight Mid-Boom Tube Fabrication



Template Membrane Manufacturing

## Spacecraft



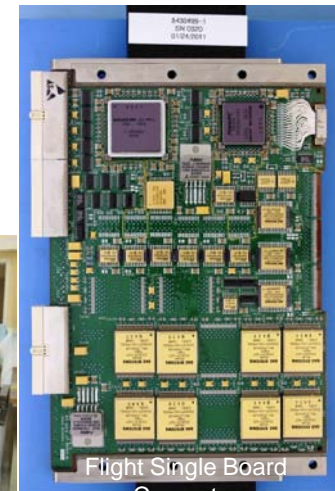
Transponder EM



Solid State Recorder  
EM



HGA Reflector



Flight Single Board  
Computer



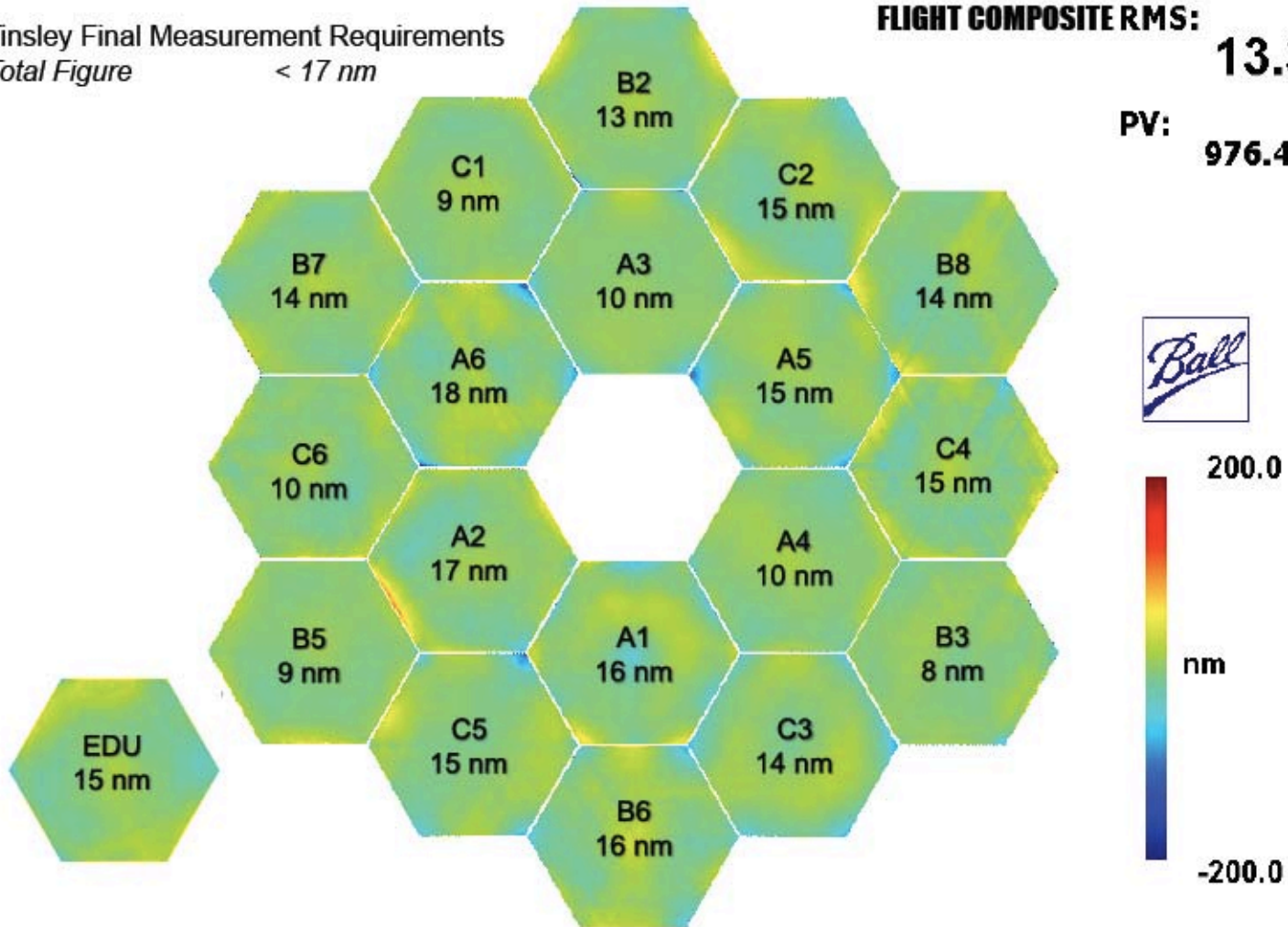
# JWST Flight Mirrors Have Completed Polishing



Tinsley Final Measurement Requirements  
Total Figure < 17 nm

FLIGHT COMPOSITE RMS: 13.3 nm

PV: 976.4 nm



- 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

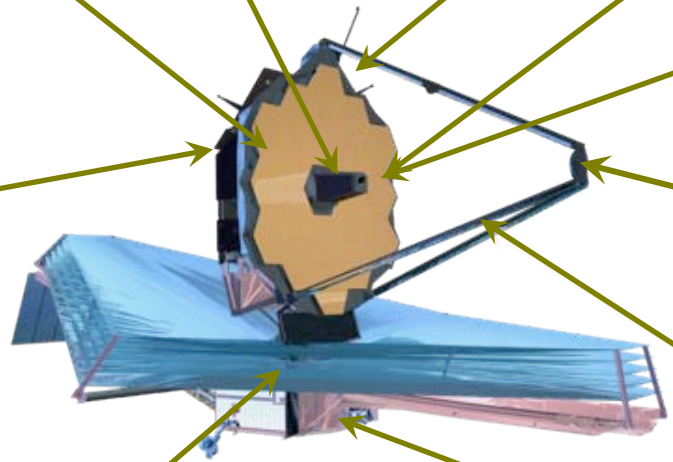


- On June 9, 2011 the final flight mirror completed polishing processing and testing at Tinsley
- All Tinsley operations are complete
- 18 of 18 flight Primary Mirrors are through final polishing
- Flight Secondary, Tertiary and Fine Steering Mirrors are complete





# Hardware Fabrication Completion Percentages

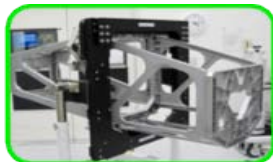


Primary Mirror Segments



72%

Aft Optics System



95%

Mirror Support Structure



75%



Tertiary Mirror

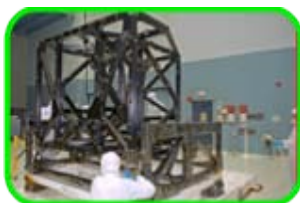
100%  
(Done!)



Fine Steering Mirror

90%

Science Instrument Module & Science Instruments



90%



Secondary Mirror

85%

Secondary Mirror Supports



80%



Spacecraft Bus

25%



Sunshield Membranes

10%

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





# 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

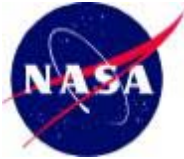
- Complete assessments of replan, complete JCL, start internal and external review of JCL and replan

## 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)



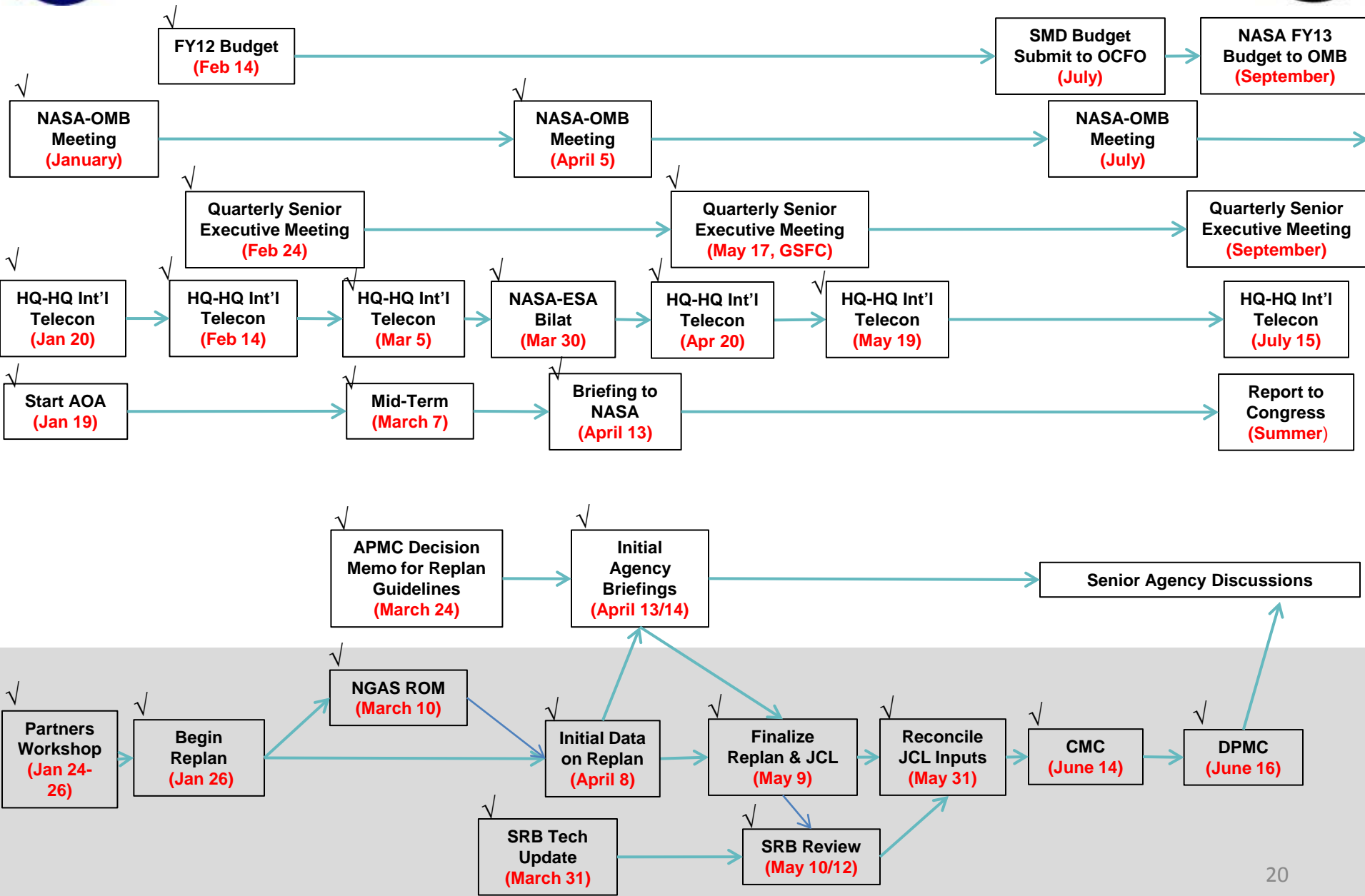
# JWST Replan



- 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

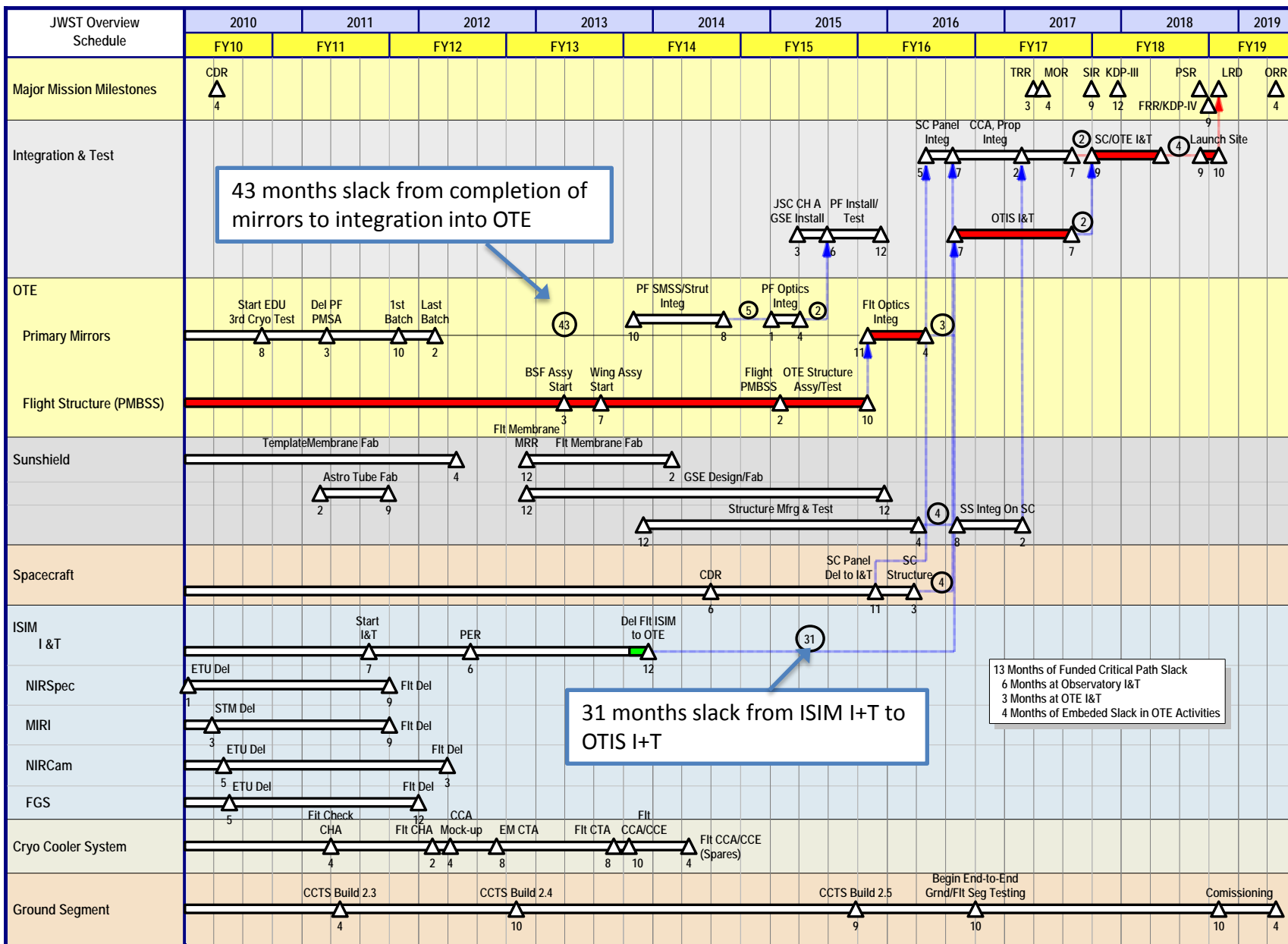


# Replan Flow





# 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

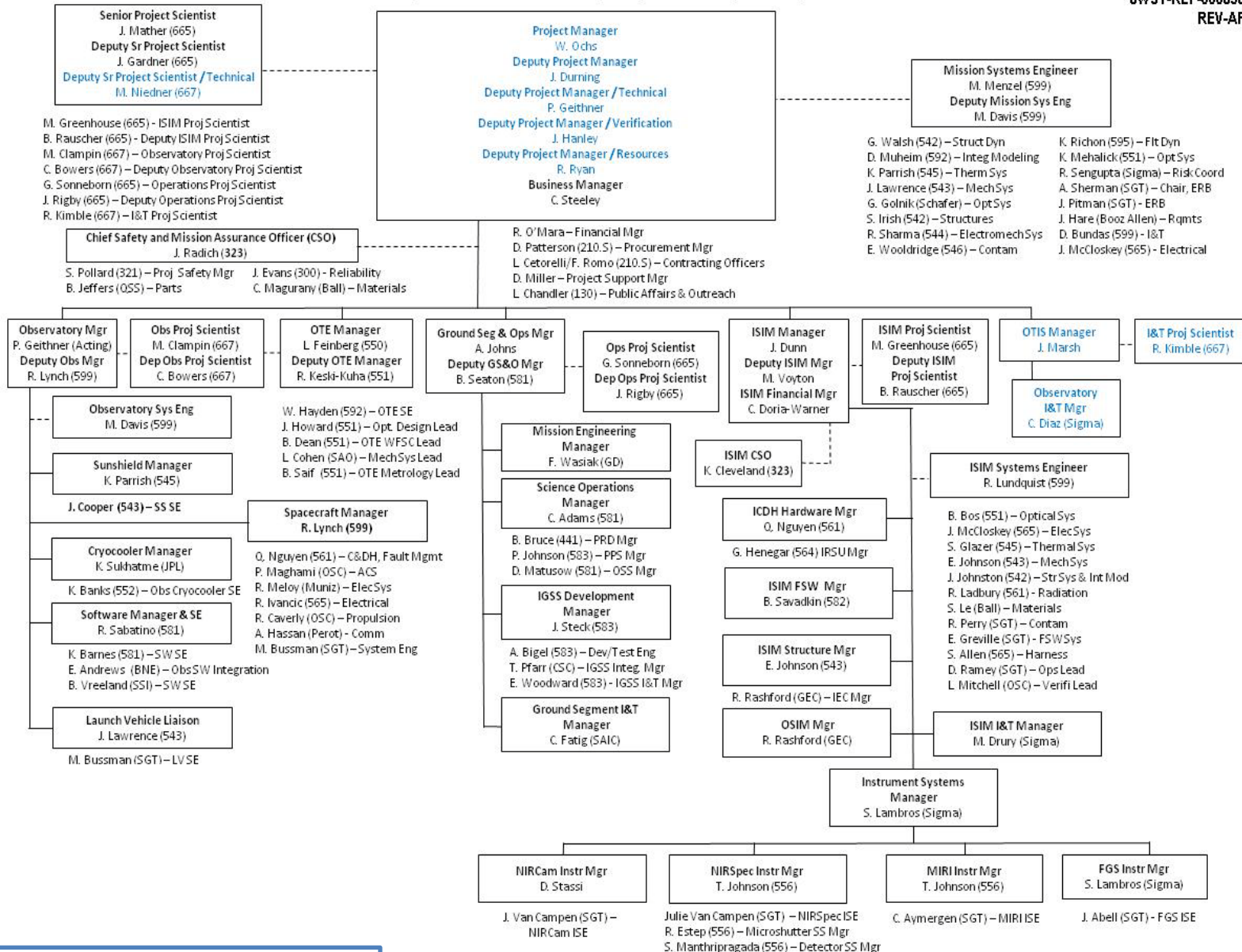


- New Project Manager and Business Manager assigned.
- A resource analyst dedicated to the Integrated Science Instrument Module (ISIM) was added to the team.
- Project and Business Manager assessed the workload with respect to the resources team, identifying strengths and weaknesses in skills.
  - Have 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



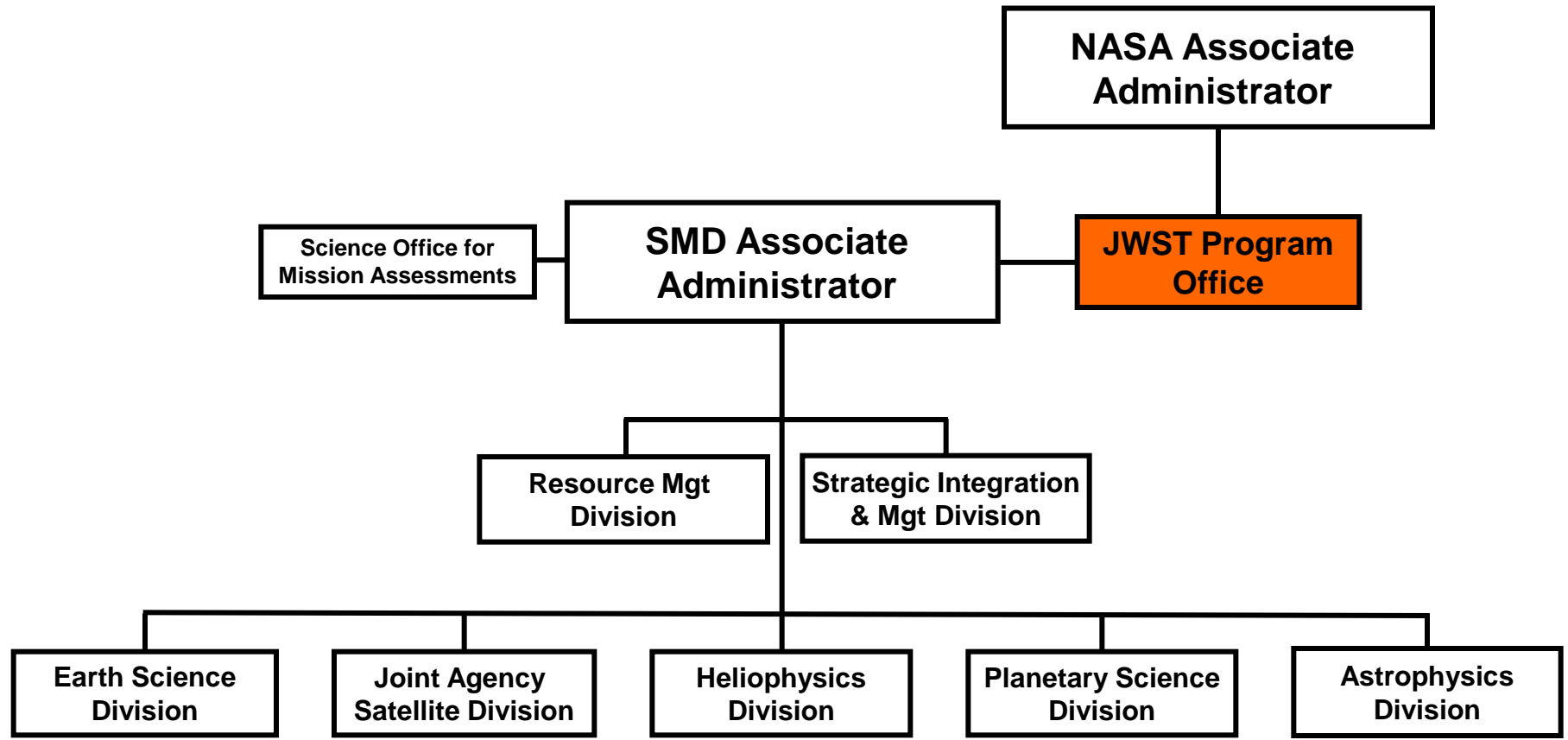
# Create a JWST Program Office at HQ



- 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





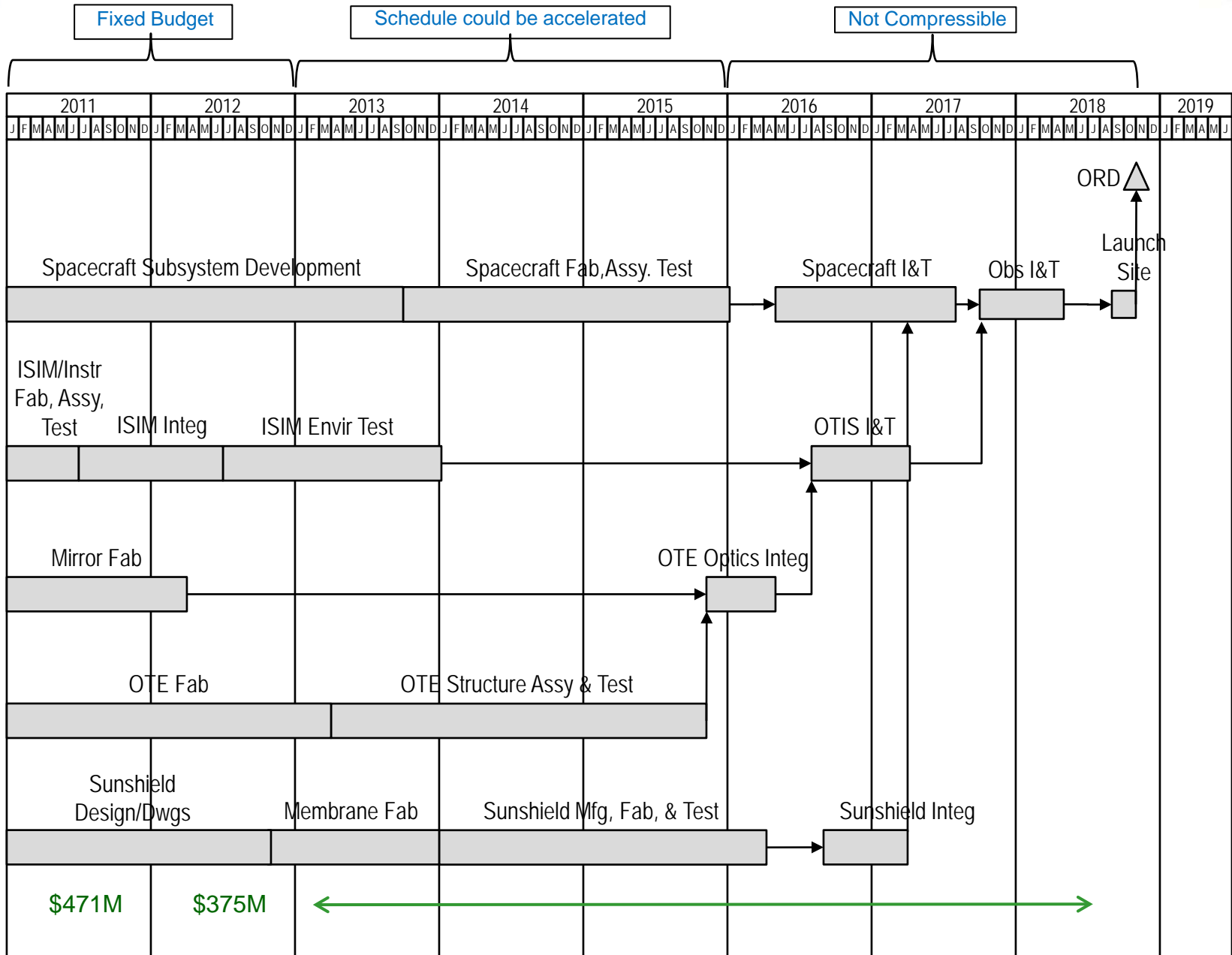
# JWST Headquarters Program Office



- 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

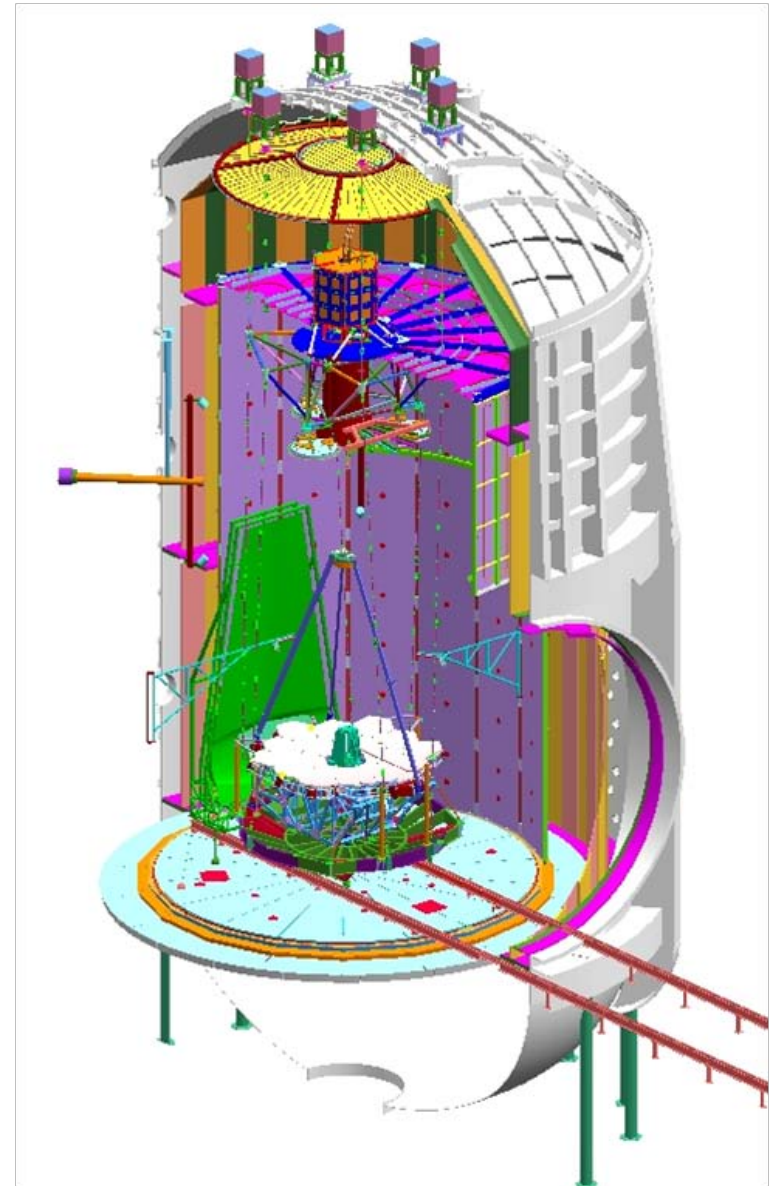
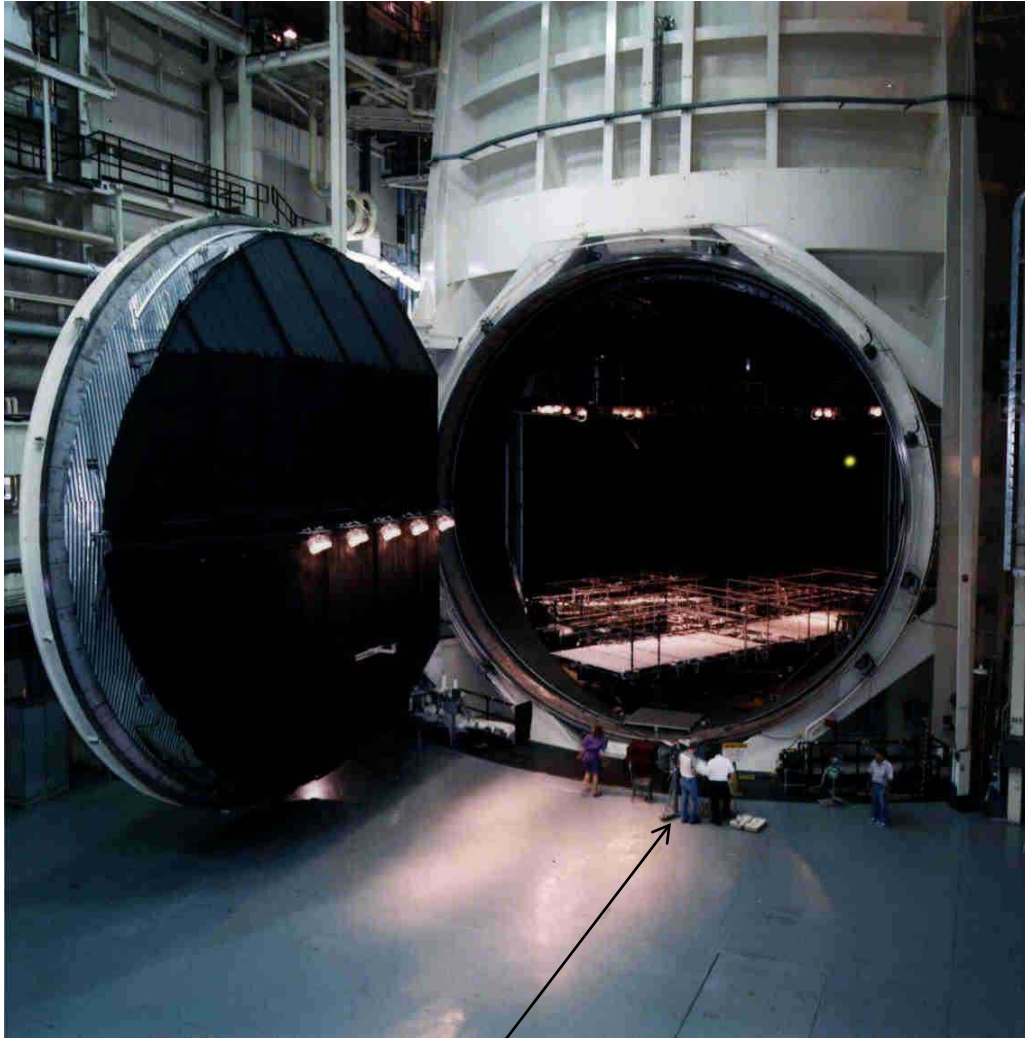


- Media event held at manufacturer in Syracuse, NY.
- Hardware now being shipped to NASA Goddard Space Flight Center test facility, Greenbelt, MD.





# OTE Testing – Chamber A at JSC

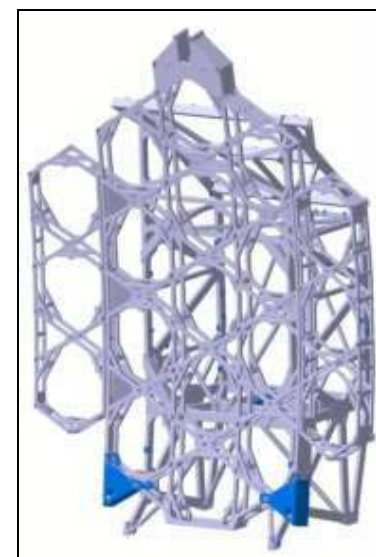
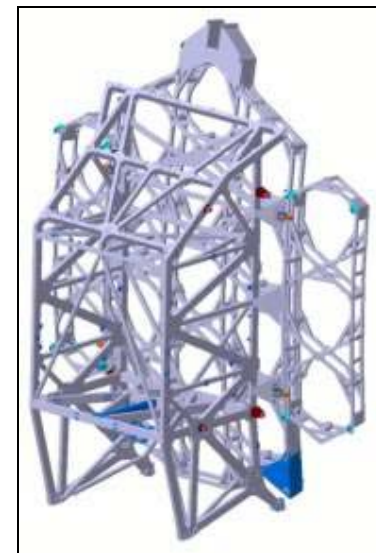
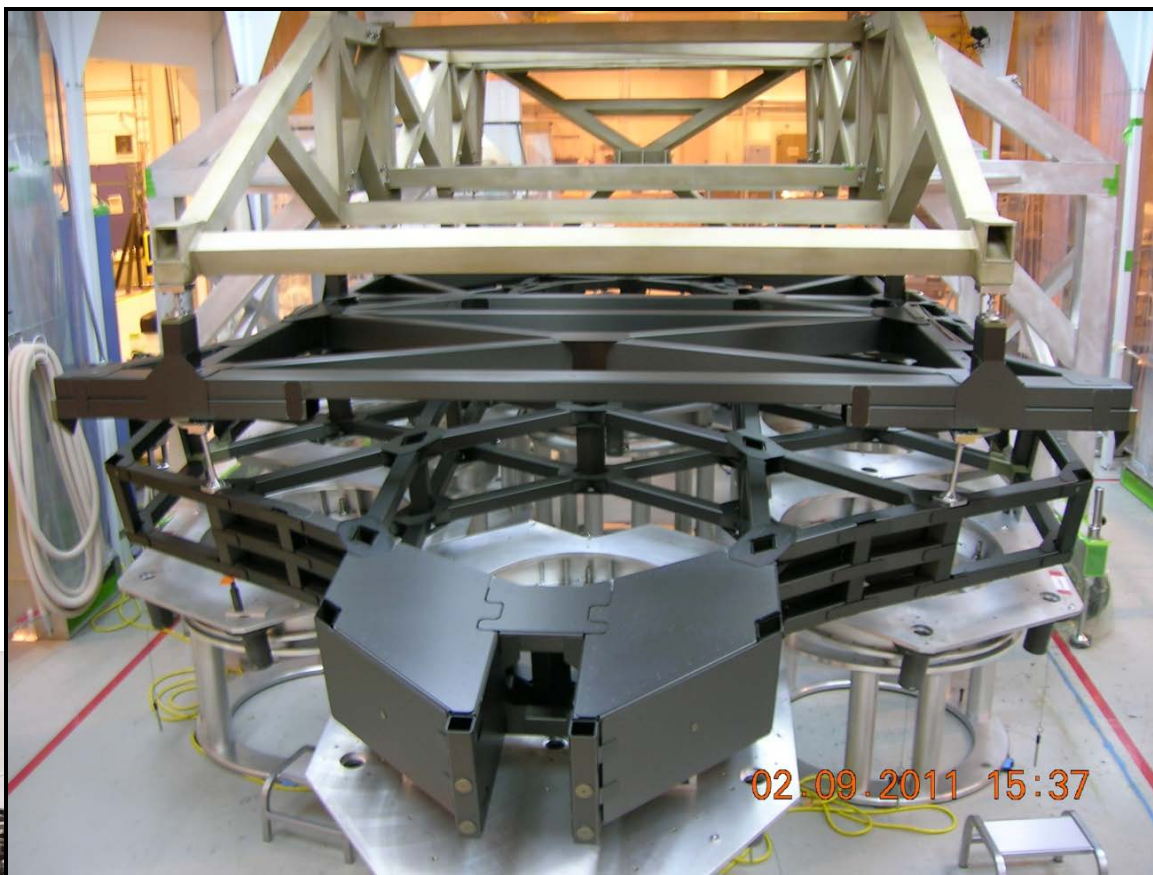


Notice people for scale

Will be the largest cryo vacuum test chamber in the world



# Pathfinder PMBSS Complete Delivered to NGAS March 25, 2011



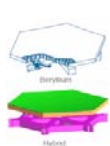


# The Final Acceptance Test Completes a Decade plus Development Effort to Make JWST Mirrors

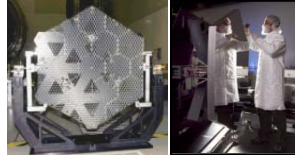
1996 1998 2000 2002 2004 2006 2008 2010 2012 2014

Onset of James Webb Space Telescope

Advanced Mirror System Demonstrator (AMSD)  
 Collaboration among 3 government agencies  
 15Kg/m<sup>2</sup>, 1.2M diameter segments

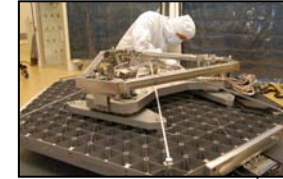


Medium Authority Glass (ULE)



Low Authority Beryllium

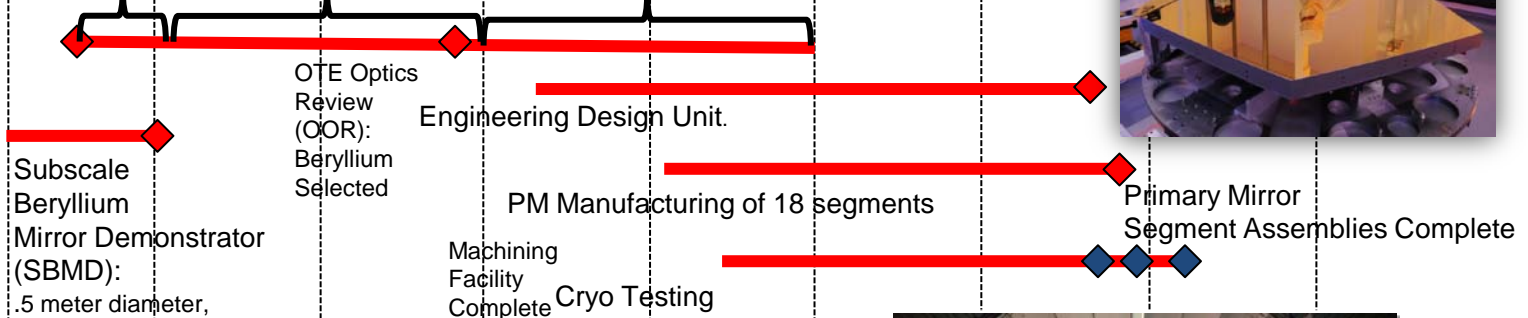
Technology Readiness  
 ◆ Level-6 Demonstrated:  
 All key requirements and environments demonstrated



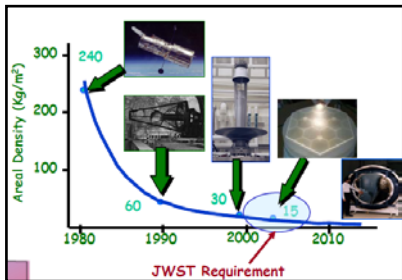
AMSD Phase 1: 8 Mirror Designs

AMSD Phase 2: 3 mirrors developed

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



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

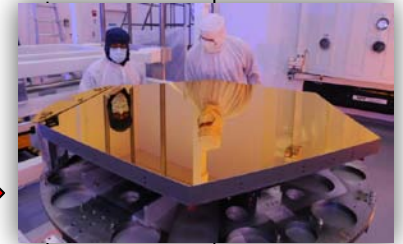


Engineering Design Unit.

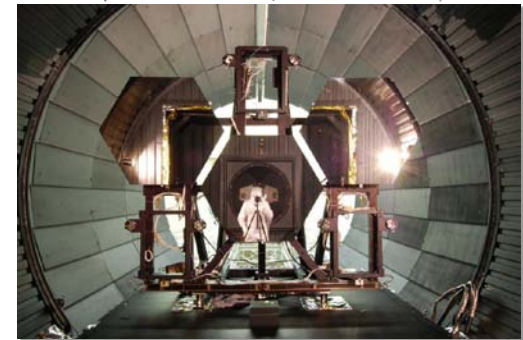
PM Manufacturing of 18 segments

Machining Facility Complete  
 Cryo Testing

Polishing Facility Complete



Primary Mirror Segment Assemblies Complete





# JWST US Team Members

Total \$M/FY10 FTEs



**Utah**  
 ~\$65 M/50 FTEs  
 ATK Aerospace Company  
 Space Dyamics Lab/ Utah St. U  
 Hexcel Corporation  
 Aerospace Machining

**Idaho**  
 University of Idaho

**Ohio**  
 ~\$23M  
 Brush Wellman  
 Keithley  
 Lake Shore Cryotronics  
 Glenn Research Center

**New York**  
 ~\$110M/40 FTEs  
 Aeroflex  
 Cranetech Inc  
 Indium Corp of America  
 ITT Space Systems, LLC  
 JPW Structural Contracting, Inc  
 Moog Inc  
 Sigmadyne  
 University of Rochester  
 ValveTech Inc

**New Hampshire**  
 Optical Solutions Inc  
 Timkin Aerospace & Super Precision

**Oregon**  
 Precision Measurements & Instr.

**Minnesota**  
 ION Corp  
 Minco Products, Inc.  
 Sheidahl CO.

**Massachusetts**  
 Appli-Tec Inc  
 Hypertronics Corporation

**Nevada**  
 TRAX International Inc

**Alaska**  
 ASRC

**Illinois**  
 Boeing  
 Numerical Precision

**Pennsylvania**  
 Tyco Engineered Systems

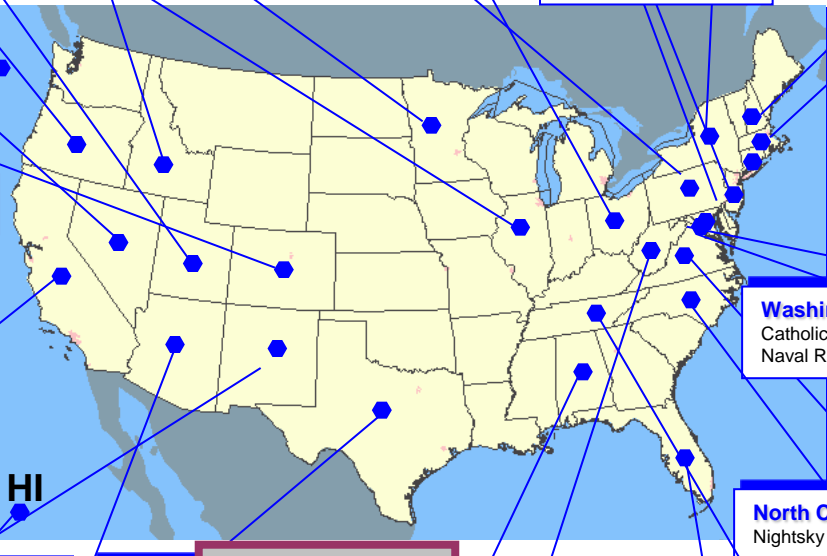
**Connecticut**  
 Zygo

**New Jersey**  
 ~\$20M  
 Newark Electronics  
 Quantum Coatings, Inc

**Maryland**  
 ~\$2,600M/~500 FTEs  
 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

**Colorado**  
 ~\$330 M/80 FTEs  
 ABSL Space Products  
 Ball Aerospace & Tech Corp  
 Blue Line Engineering  
 CTD  
 Raytheon Company  
 SEAKR Engineering, Inc  
 Space Science Institute

**California**  
 ~\$1,750 M/~400FTEs  
 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



**Washington DC**  
 Catholic University  
 Naval Research Lab

**North Carolina**  
 Nightsky Systems

**New Mexico**  
 Cortez III Service Corp  
 DoE

**Texas**  
 ~\$110M/40 FTEs  
 Muniz Engineering  
 National Instruments  
 Texas A&M University  
 Johnson Space Center

**West Virginia**  
 NASA GSFC IV&V

**Tennessee**  
 Jacobs Technology

**Arizona**  
 ~\$25M/10 FTEs  
 Dynaco  
 Honeywell International, Inc  
 Optical Device Engineering Corp  
 University of Arizona  
 Arizona State University

**Alabama**  
 ~\$77M/45 FTEs  
 Axsys Technologies  
 Marshall Space Flight Center  
 SRI  
 Mantech - Nexolve

**Florida**  
 Advanced Quick Circuits  
 CDA InterCorp  
 Geodetic Services

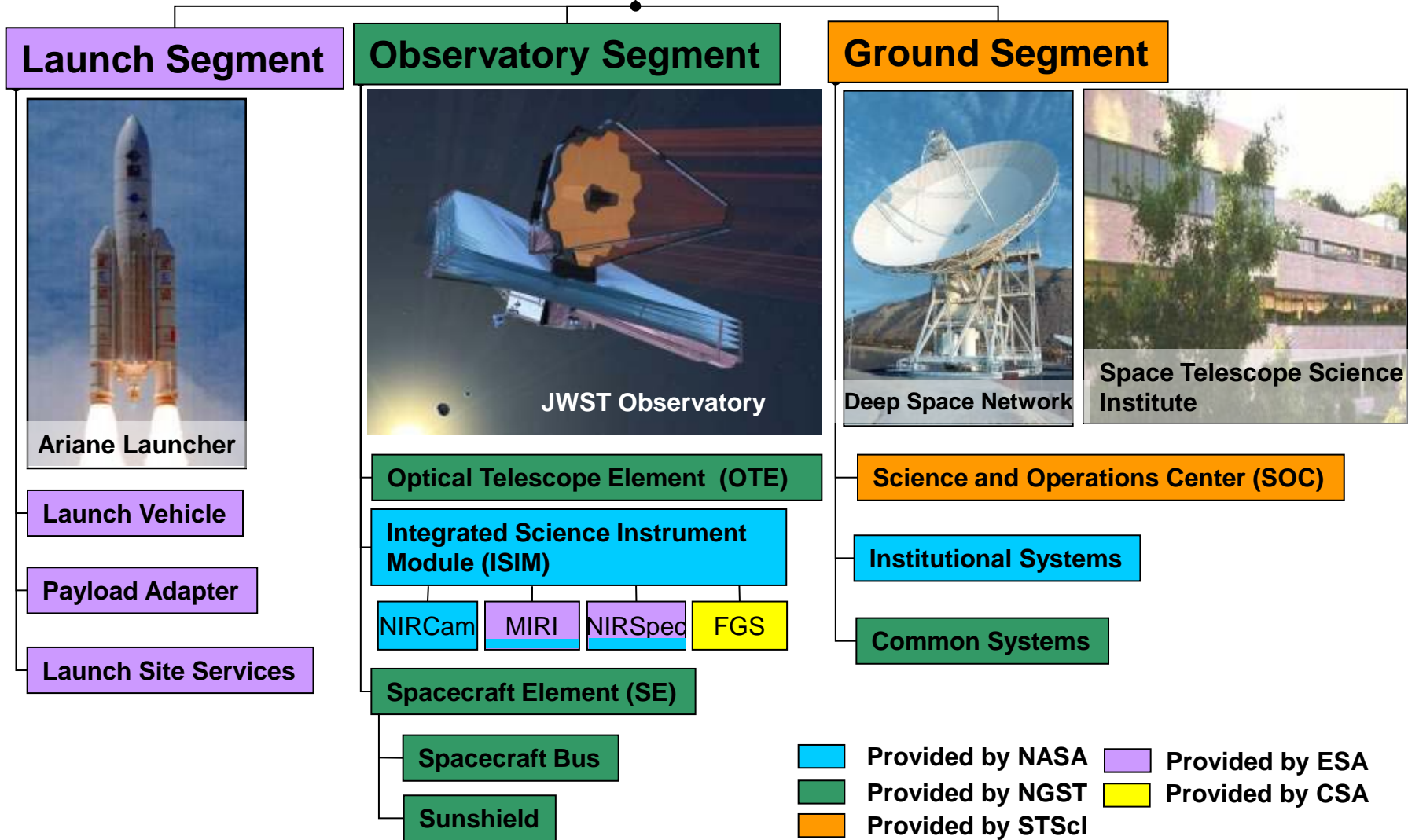
**Virginia**  
 ~\$40M/15 FTEs  
 BAE Systems Information & Electronics Systems Integration  
 General Dynamics  
 Man Tech  
 National Research Initiatives  
 Orbital Sciences Corporation

**Hawaii**  
 GL Scientific  
 Mauna Kea Engineering  
 University of Hawaii



# JWST System Hierarchy

## James Webb Space Telescope System





# 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