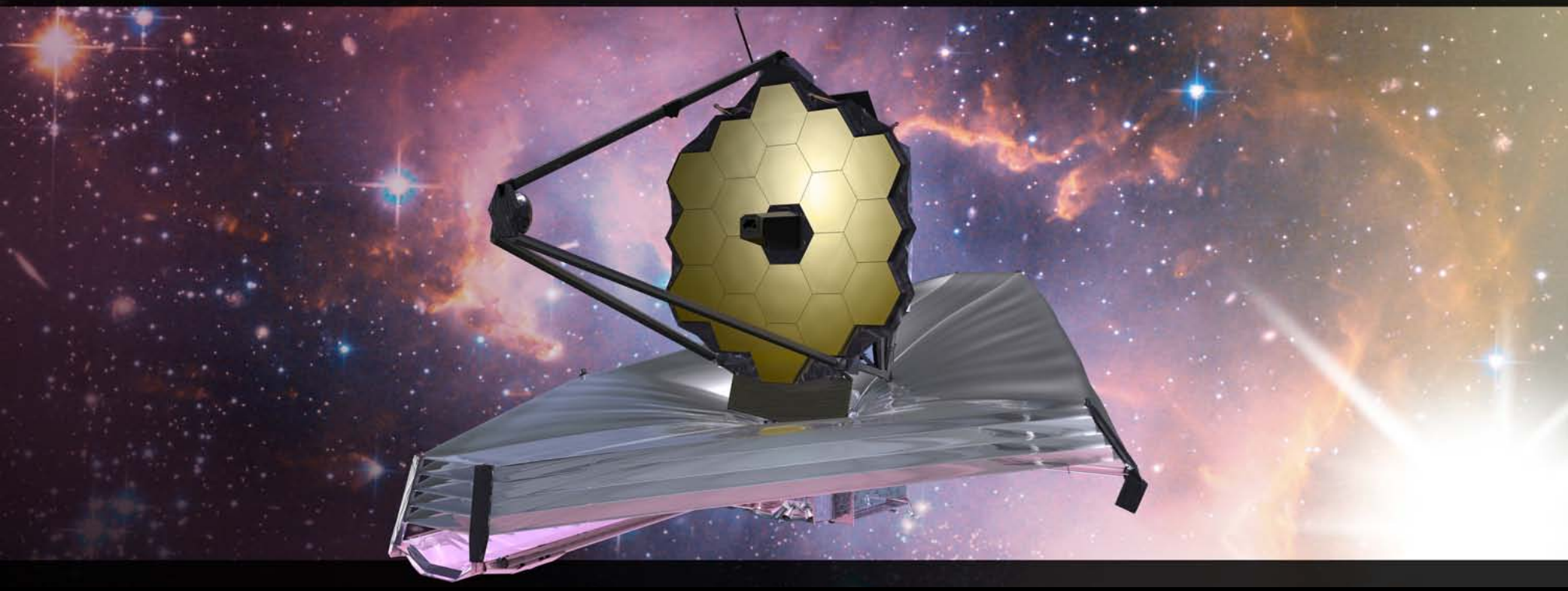
National Aeronautics and Space Administration



James Webb Space Telescope (JWST)

Program Status

Rick Howard

October 19, 2011

JWST on a new path

- **NASA has made significant changes in the management of JWST**
  - Response to ICRP report (http://www.ngst.nasa.gov/resources/JamesWebbSpaceTelescopeIndependentComprehensiveReviewPanelReport.pdf)
- **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
- **Assessment of alternatives completed**
- **Completed a replan (9/23/2011) with an October 2018 launch date**
  - Plan has adequate cost and schedule reserves consistent with an 80% confidence level
  - Replan is on track to support the FY13 budget process

JWST made great progress in FY2011, achieving milestones within cost and schedule

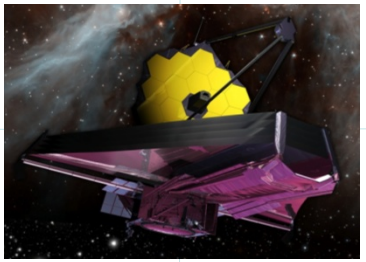
JWST Status

Telescope

- 18 flight (plus 1 spare) primary mirror segments are fully assembled
- All flight optics completed coating and vibration testing
- Final cryo testing of first 12 primary mirror segments has completed
- Final 6 primary segments begin last cryo test 10/24
- Flight backplane structure under development, center section nearing completion

Science Instruments

- MIRI completed all pre-ship tests
- ISIM Integration and Test underway, harness and ISIM command and data handling computer #1 also delivered to ISIM I&T
- Instrument deliveries to GSFC begin Spring 2012
- NIRSpec optical bench cracks delaying that instrument



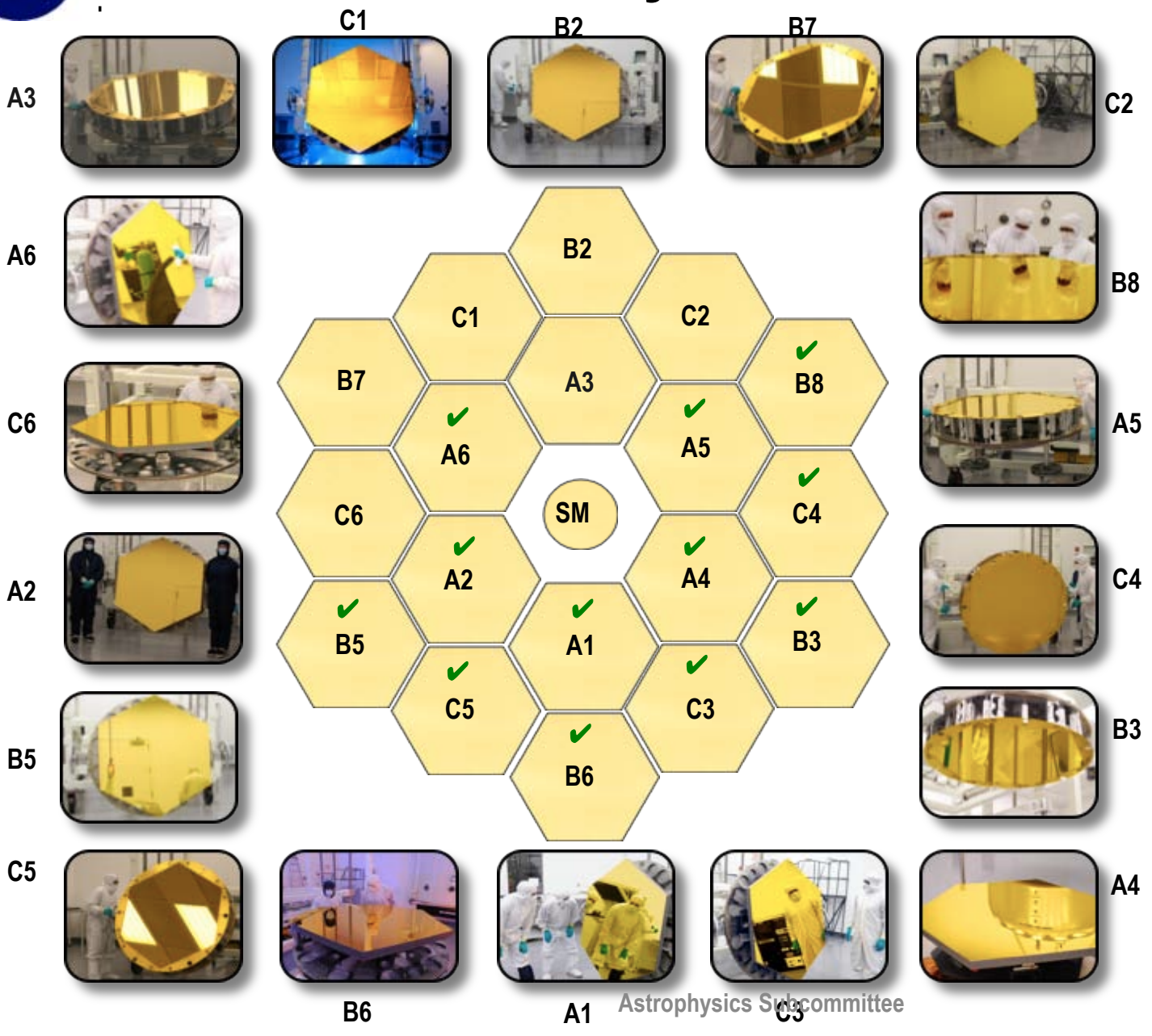
Sunshield

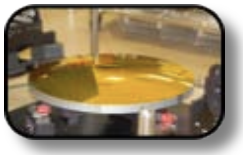
- 1/3rd-Scale Sunshield testing successfully complete (flight Sunshield verification test)
- Engineering Development Unit for layer #3 in test now in AL. Initial shape-under-tension measurements are good.
- All sunshield material for test units and flight layers in house.

Spacecraft

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

Family Portrait





Secondary

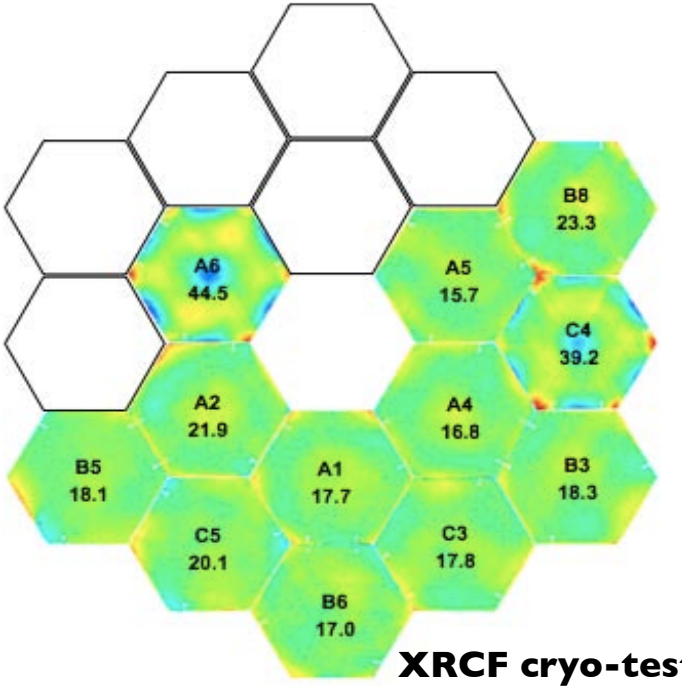
Tertiary ✔

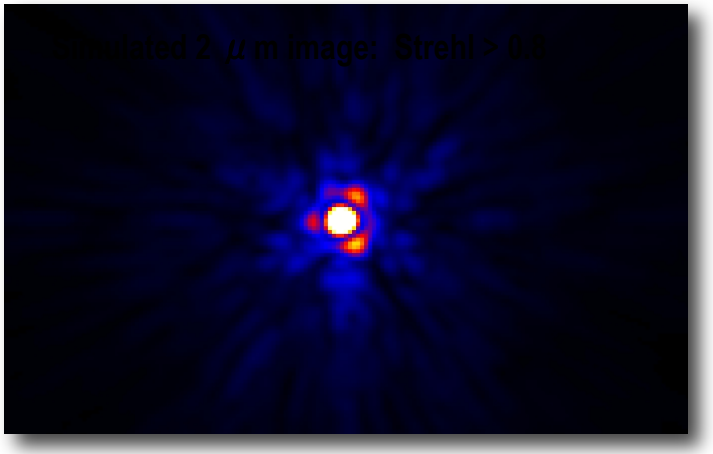
Fine Steering ✔

✔ Mirror segment has completed all thermal testing

Mirror Cryo-Optical Testing

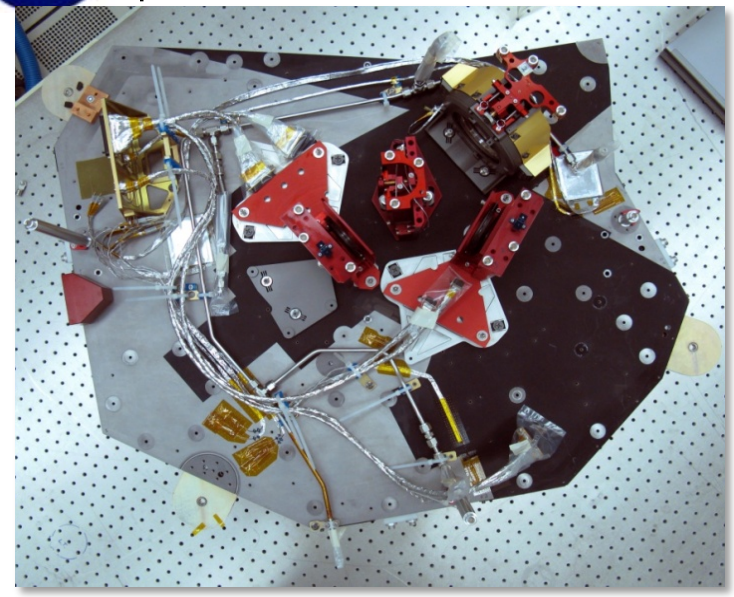
- **XRCF testing of the second batch of 6 PMSAs is complete**
- **Overall surface figure error (SFE) with 12 segments is 24.2 nm RMS**
  - Primary Mirror (18 segment) SFE requirement is = 25.8 nm RMS
  - Projected SFE for 18 segment primary Mirror is ≤ 24.6 nm
  - A6 and C4 PMSA segments do not meet their individual SFE specification, but that is accommodated by allocated margin at the primary mirror level.





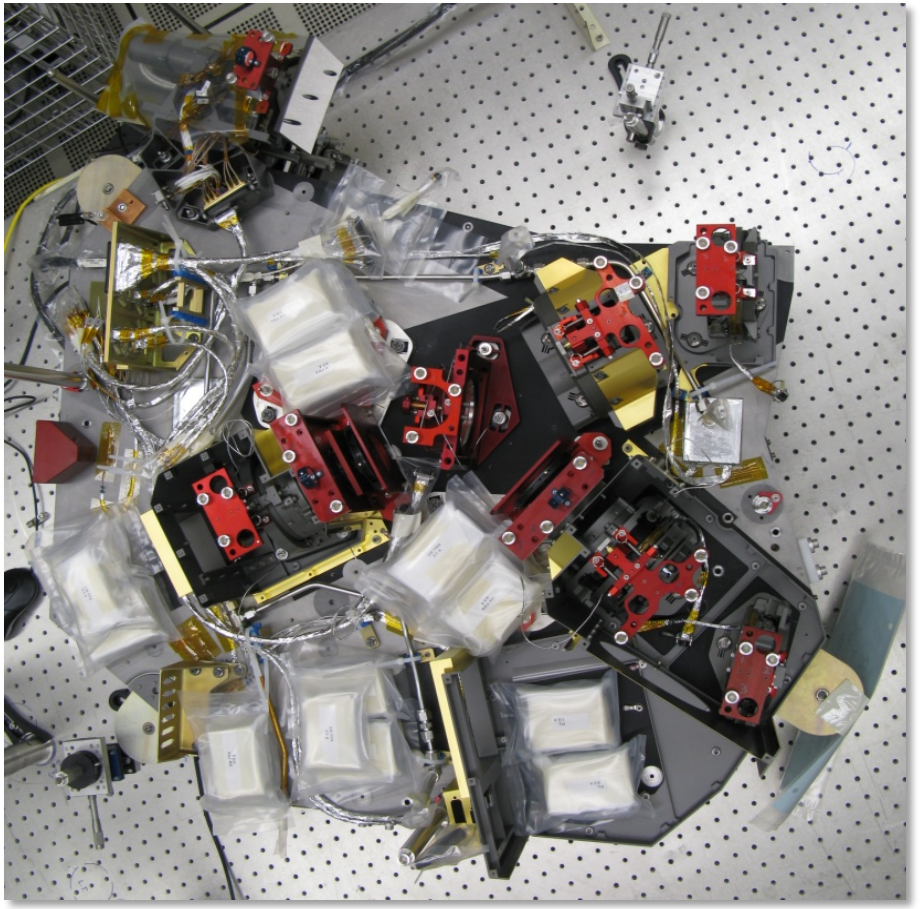
XRCF cryo-test results

NIRCam Status



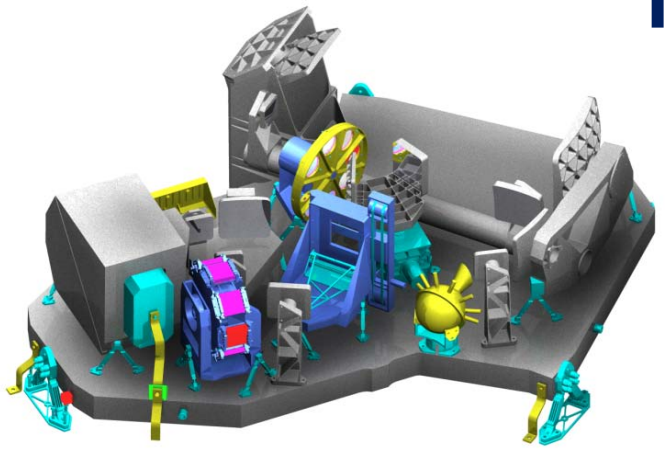
Module A Optical Bench Assembly
February 2011

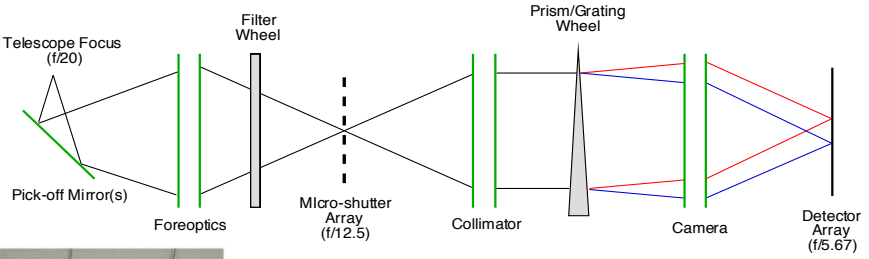
- Installed Short Wave/Pupil Img. Lens Baffle (A)
- Installed Short Wave Camera (A)
- Installed Short Wave Fold Mirror (A)
- Installed Long Wave Camera Baffle (A)
- Installed Long Wave Camera (A)
- Installed First Fold Mirror (A&B)
- Installed Focus Alignment Mechanism (A)
- Installed Harnesses (A&B)

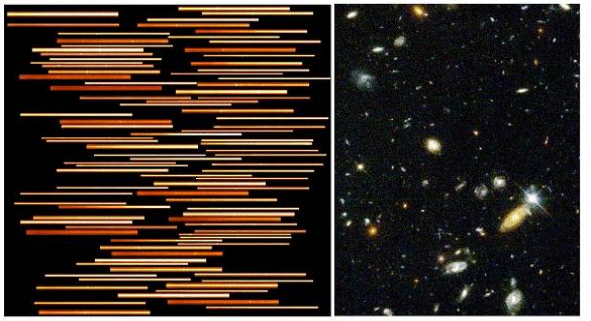


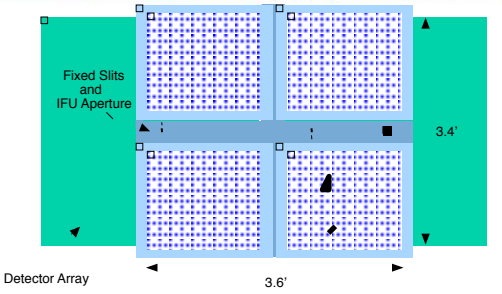
Module A Optical Bench Assembly, September 14, 2011

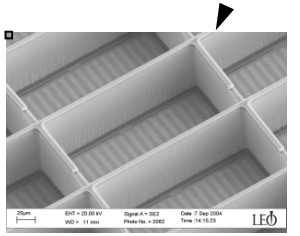
NIRSpec Status





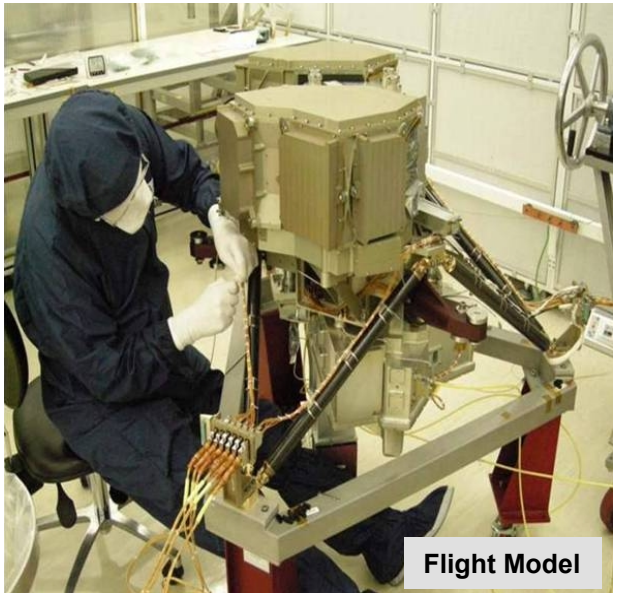


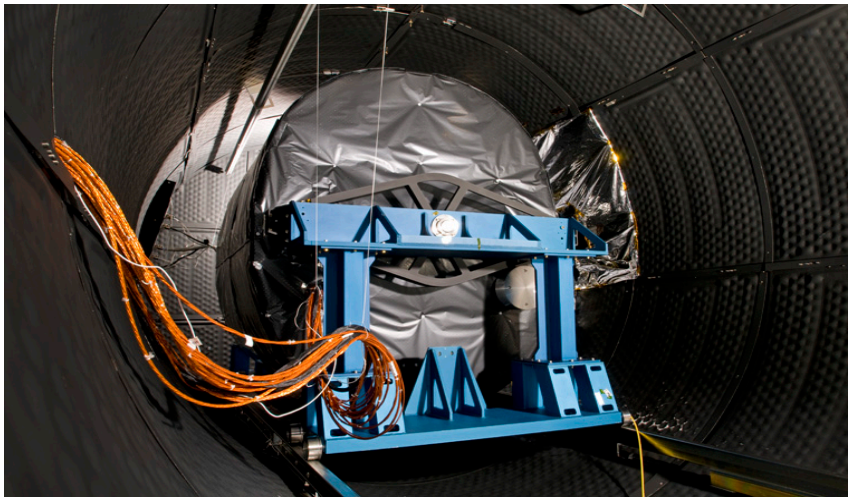




- **Developed by the European Space Technology Center (ESTEC) with Astrium GmbH and Goddard Space Flight Center (Sept 2012 delivery scheduled)**
- **Current Status**
  - Integration, vibration, EMC, first cryo cycle completed:
    - Instrument mechanical, electrical and optical behavior is “as designed”
  - Issue: Discovered cracks in the bench while inspecting harness tie-down chip-out repairs.

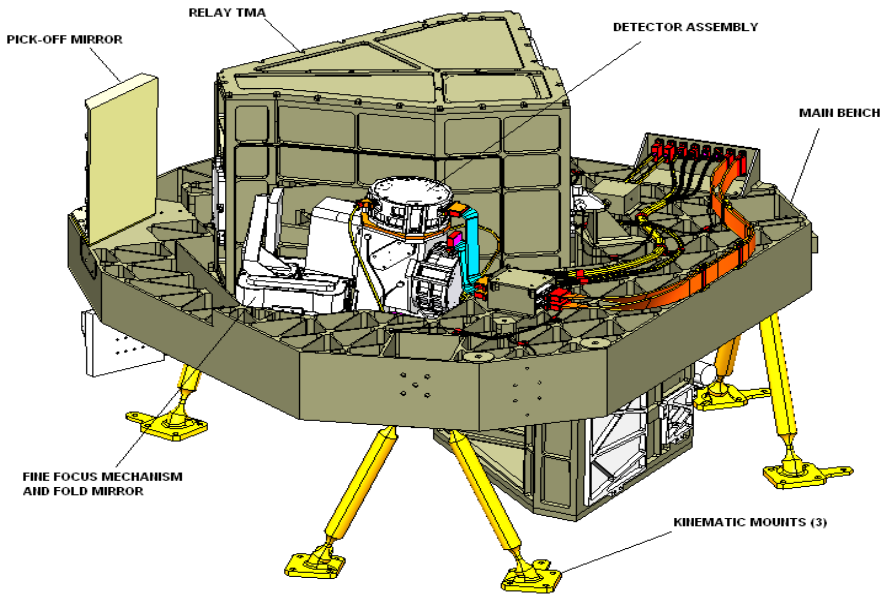
MIRI Status

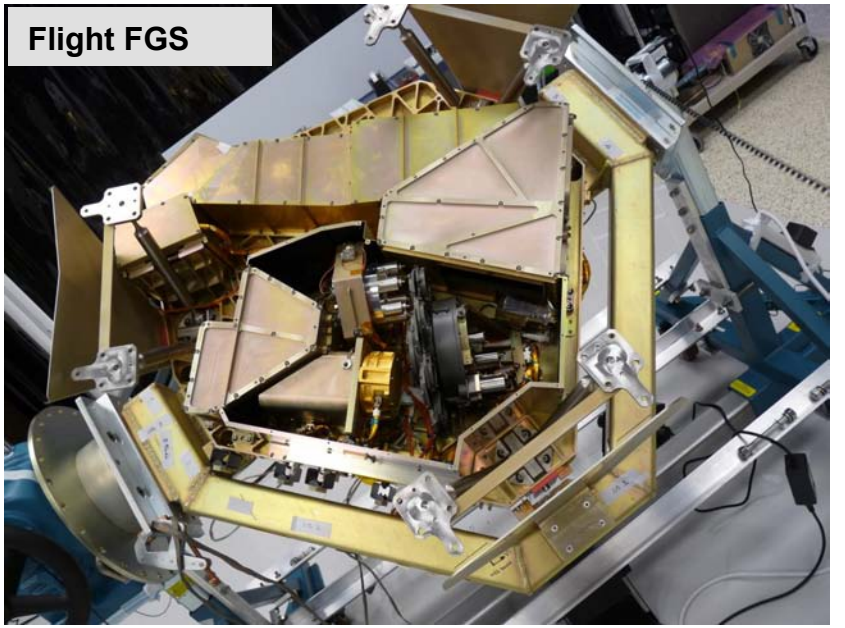

Flight Model


MIRI emerging from the Test Chamber, 17th August

- Developed by a European Consortium and JPL
- Current Progress
  - Optical Module (OM) vibration, alignment, and final cryo-vacuum testing completed!
    - 86 days of cold testing at RAL at 6.5 K
    - 2,465 test scripts run successfully
  - Data analysis in process
- Current delivery date April 2012

FGS Status

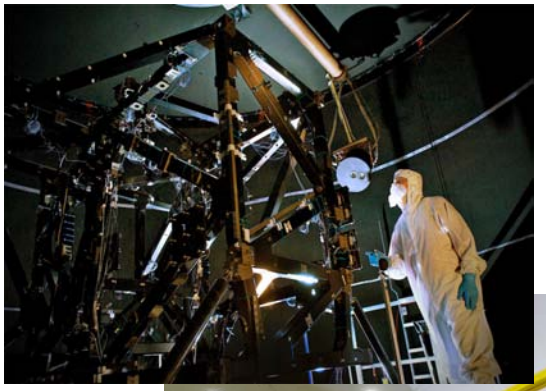




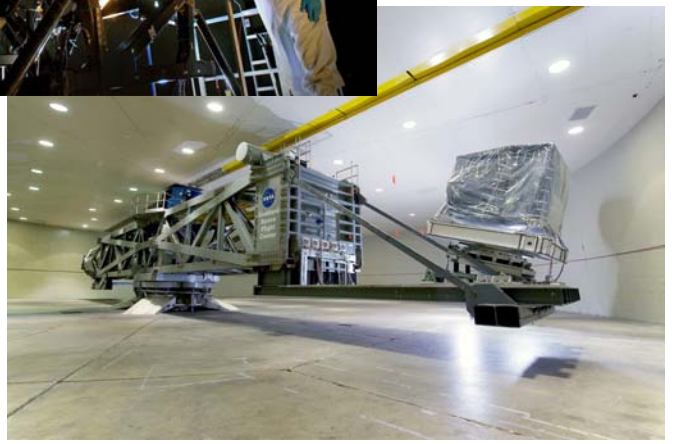
- Developed by the Canadian Space Agency with ComDev
- Current Progress
  - Successfully completed flight instrument vibration
  - Preparing for flight EMI/EMC testing this month
  - Technical development issues on the Tunable Filter have resulted in an alternate means of gathering worthy science without the tunable filter
    - New concept NIRISS (Near Infrared Imager and Slitless Spectrograph) was presented to and ultimately endorsed by the JWST Science Working Group
    - NIRISS CDR scheduled for October 19-20
- New delivery date: July 2012 with a month of reserve

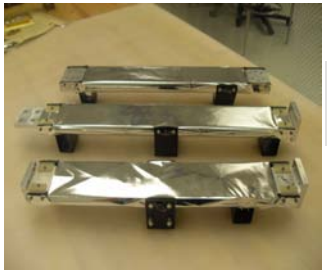
Instrument Support Systems

- **ISIM instrument support systems:**
  - Optical metering structure system
    - Primary structure now flight qualified and ready for I&T
  - Electrical Harness System
    - Finishing up final builds for NIRCam, then moving on to ISIM I&T needs
  - Harness Radiator System and ISIM electronics compartment (IEC)
    - Flight Builds in Progress
  - Cryogenic Thermal Control System
    - On track to meet heat lift and temperature requirements
    - Flight Builds in Progress



ISIM Flight Structure

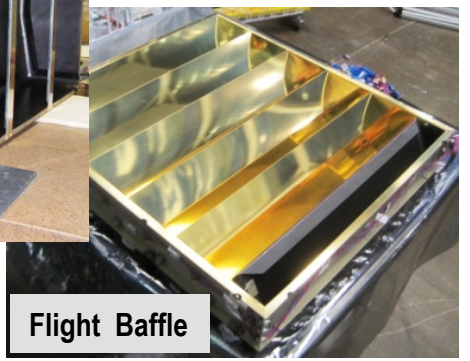




Flight high purity aluminum heat strap assemblies

Flight Shell

IEC Flight Build



Flight Baffle

Instrument Support Systems

- **ISIM instrument support systems (continued):**
  - ISIM Command and Data Handling System (ICDH)
    - Flight model box #1 completed
  - ISIM Remote Services Unit (IRSU)
    - Flight IRSU Delivered to I&T
  - Flight Software System
    - On track to support ISIM cryo-vac testing
    - Build 12 of 13 in test
      - 100% complete ICDH functionality
    - Remaining development centered on integration of SI-provided applications
  - Operations Scripts System
    - On track to support ISIM cryo-vac testing
    - Completed CDR Dec 2010
    - Expecting build 1 delivery during early 2012


Flight ICDH


Flight IRSU

Sunshield

- **Template membrane build to flight-like requirements for verification of:**
  - Shape under tension to verify gradients and light line locations
  - Hole punching & hole alignment for membrane restraint devices (MRD)

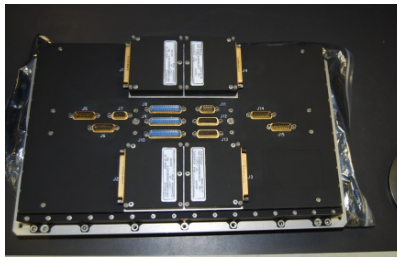
←Layer-3 template membrane under tension for 3-D shape measurements at Mantech

Full-scale JWST mockup with sunshield pallette ↓

Progress Continues on the Spacecraft

- Completed Primary Structure Critical Design Review (CDR)
- Solar Array Regulator (SAR) and Telemetry Acquisition Unit (TAU) EQM Functional (ambient) Testing Complete
- Launch Vehicle Interface Ring (LVIR) Forgings (2) delivered
- Completed Star Tracker CDR
- Completed S-band Transponder CDR
- Completed RF Switch CDR
- Ka-band filter Engineering Qualification Model build completed and testing started
- Build 1 Flight Software verification complete

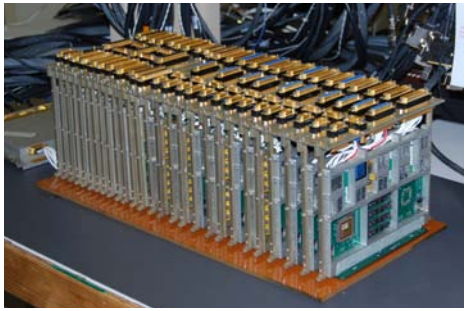
HGA Reflector



SAR EQM

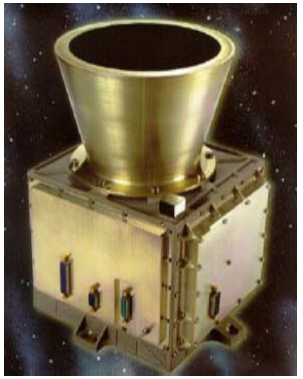
Ka Filter EQM parts

LVIR Forging

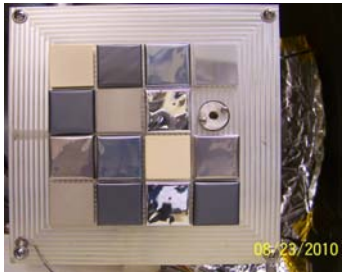


TAU EQM

Ka-Band Filter



Star Tracker



HGA/MGA Radiation samples

Integration and Testing at GSFC

Building 29 Clean Room

Flight Integrated Science Instrument Module (ISIM)

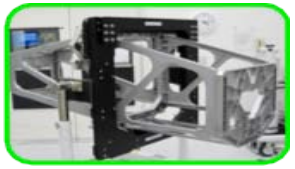
Ambient Optical Assembly Stand
Under construction

Hardware Fabrication Completion Percentages

Primary Mirror Segments

100%

Aft Optics System Bench



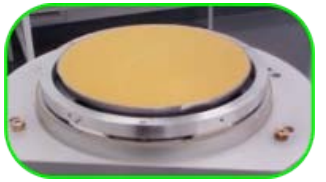
100%

Primary Mirror Support Structure

75%

100%

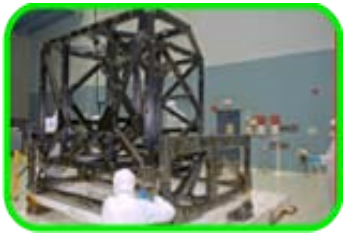
Tertiary Mirror



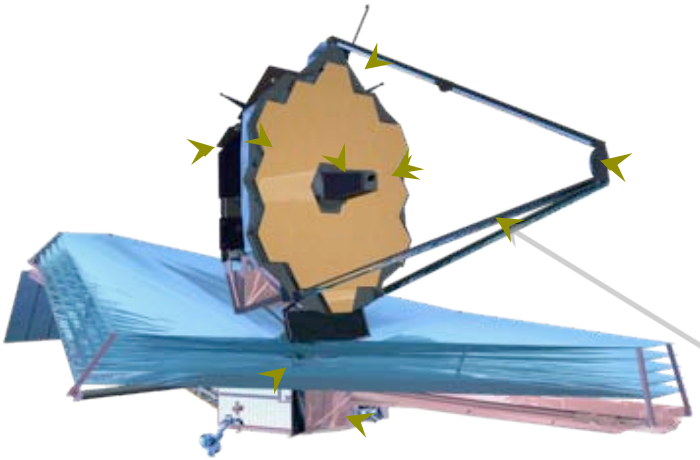
100%

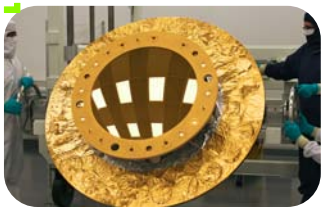
Fine Steering Mirror

Science Instrument Module & Science Instruments



90%





95%

Secondary Mirror

Secondary Mirror Supports

90%

25%

Spacecraft Bus

40%

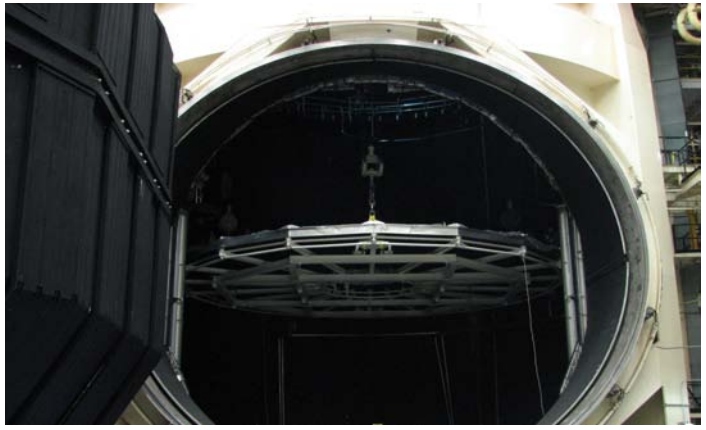
Sunshield Membranes

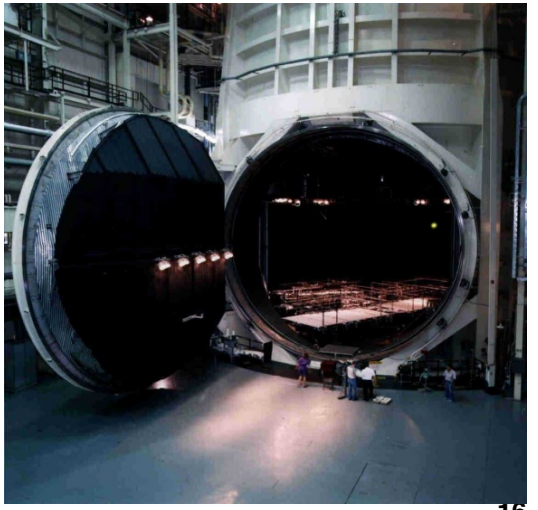
Green borders denote actual spaceflight hardware images, red borders are test equipment

As of 10/10/2011

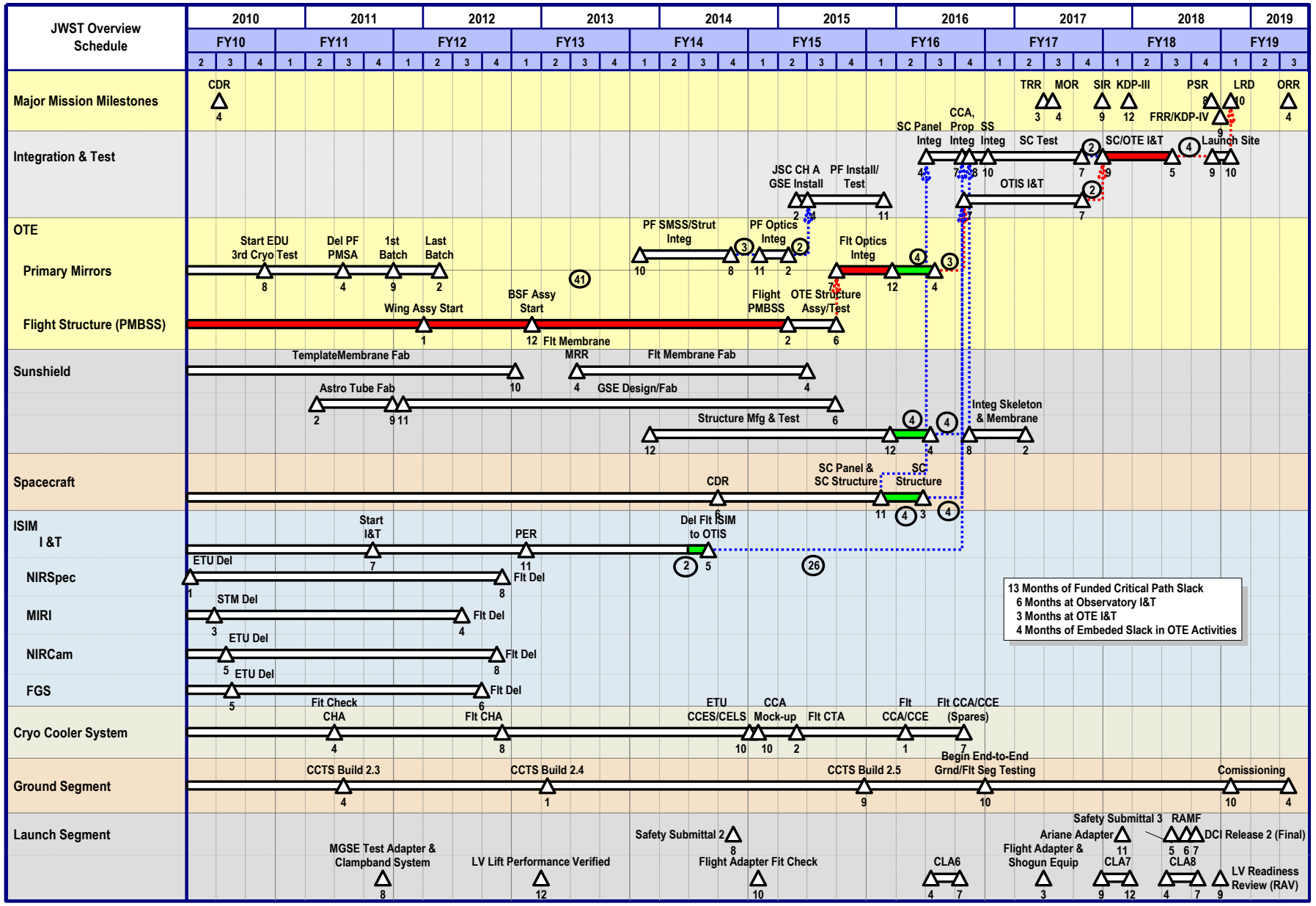
OTE + ISIM = OTIS

- **OTIS planning and risk mitigation continues to proceed**
- **All Ground Support Equipment is in various stages of design and fabrication**
- **Modifications to Johnson Space Center Chamber are progressing**
  - Distribution system for LN2 and GHe system under way
  - GHe refrigeration system installation completed
  - Installation of ceiling shroud completed
  - Floor shroud fabrication completed with installation under way
  - Wall shroud fabrication completed with installation beginning after the floor installation
  - Make-up air units for airflow management systems installed





JWST Master Schedule



NASA's Proposed Offsets to support JWST 2018 Replan

Total additional funds required FY2012-2016: $1208 M

- **FY2012 additional requirement: $156M**
  - 50% from the Science Mission Directorate (SMD)
    - No funds from Earth Science
  - 50% from Agency's institutional support budget

- **FY2013-2016 additional requirement: $1055M**
  - Details still being assessed

JWST Near Term Program/Project Office Efforts

- **Provide Report to Congress under Sec 103(d)(2) of PL 109-155 ("Breach Report")**
  - Projected cost and schedule for completing the program
  - Assessment of broad range of alternatives to the program
- **Capitalize on new plan as we transition from re-planning to building**
  - Already have accelerated final tests of 6 remaining Primary Mirror Segment Arrays at the XRCF. Will start 10/24 and complete before year end.
  - Letter sent to Northrop-Grumman instructing them to pull in schedule on Primary Mirror Backplane Assembly by ~6-8 months.
  - Discussions underway to accelerate spacecraft Critical Design Review [CDR] (last remaining major element not past it's CDR) by 4-6 months.

ANSWERS TO QUESTIONS

Questions

1. Documentation about recent (within the past three years) studies of de-scope/re-scope options
2. Documentation about studies of alternative means of achieving the scientific goals of JWST
3. The history of project status reports (green/yellow/red) for the last three years
4. Estimates of what percentage by cost (not mass) of JWST's parts have already been fabricated or are in the process of being fabricated."

1. Descopes

JWST Descopes Taken To-Date

Date	Descope	Science	I&T	Mission Phase
Dec-02	**Primary mirror diameter from ~7m to 6.5m**	X		A
Jan-03	Tunable Filter descoped from NIRCam	X		
Jun-04	Stray Light relaxation: 0.013 MJ/Sr to 0.041 MJ/Sr at 2 microns	X		B
Jan-06	Elimination of cryogenic heat switching in the ISIM TCS		X	
Jun-06	OTE "Cup down" to "Cup up" testing		X	
Jun-06	Elimination of 2nd Tunable Filter Fabry-Perot Etalon	X		
Jun-06	**Elimination of 1µm encircled energy req.**	X		
Jun-06	Scattered light req. relaxation (cleanliness)	X		
Jun-06	Observatory OTE stability req. from 30 days to 7-10 days	X		
Jun-06	Elimination of image anisotropy requirement	X		
2007/2008	Eliminated double-pass and the cones of light at JSC and went to “pass and a half” and with SI’s used for the test sensors		X	
2007/2008	Eliminated ISIM Egineering Test Unit test		X	
2007/2008	Eliminated OTE alone test		X	
Jun-08	Re-balanced contamination allocations for PM and SM mirrors providing relief on I&T: no requirement relief but loss of margin on stray light	X		
Apr-10	Changes to Mirror polishing specification to speed polishing. Had the potential for some mirrors to exceed single mirror specification	X		C/D
Jun-10	Multi-Instrument Multi-Field calibration points reduction	X		
Jun-10	OTIS verification to 3 µm only (instead of 2 µm)	X		
Aug-10	Testing Assessment Team related descopes		X	
May-11	Encircled Energy stability relaxation for 24 hours and 14 days	X		
May-11	Field Of Regard (FOR) relaxation to accommodate sunshield light line change. Slight reduction in FOR.	X		
May-11	NIRCam Strehl requirement applies to 80% Field of View, relaxed from 95%	X		
Aug-11	**Removal of Fabry-Perot element from CSA instrument**	X		

Acronyms
ISIM = Integrated Science Instrument Module
JSC = Johnson Space Center
OTE = Otpical Telescope Element
OTIS = OTE & ISIM Integration and Test at Johnson Space Flight Center
PM, SM = Primary Mirror, Secondary Mirror
SI = Science Instrument
TCS = Thermal Control System
Bold font indicates changes to Level 1 science requirements.

See also, SAT (http://www.stsci.edu/jwst/news/2005/SAT-final-report.pdf) and TAT (http://www.ngst.nasa.gov/resources/JWST_TAT_Final_Report_100907.pdf) reports

2. Alternatives Analysis

- Analysis completed April 18, 2011 during replanning process
- Release of information awaiting submission to Congress which will occur as part of the “Breach report”

3. Stoplight History

JWST Project/Program Stoplight History

Date	Technical		Schedule		Cost		Programmatic	Overall		Events
	Project	Program	Project	Program	Project	Program	Program	Project	Program	
Jul-08	🟡	🟡	🟢	🟢	🟢	🟢	🟢	🟢	🟡	PDR, Primary Mirror Segment grind & polish begins
Aug-08	🟡	🟡	🟢	🟢	🟡	🟡	🟡	🟢	🟡	NGST Contract value increase
Sep-08	🟡	🟡	🟢	🟢	🟡	🟡	🟡	🟢	🟡	
Oct-08	🟡	🟡	🟢	🟡	🟡	🟡	🟡	🟢	🟡	NIRCam WFE issues reported
Nov-08	🟡	🟡	🟢	🟡	🟡	🟡	🟡	🟡	🟡	
Dec-08	🟡	🟡	🟢	🟡	🟡	🟡	🟡	🟡	🟡	NAS: Initial meeting for Astro2010
Jan-09	🟡	🟡	🟢	🟡	🟡	🟡	🟡	🟡	🟡	
Feb-09	🟡	🟡	🟢	🟡	🟡	🔴	🔴	🟡	🟡	Low FY09 & FY10 budget reserves
Mar-09	🟡	🟡	🟢	🟡	🔴	🔴	🔴	🟡	🟡	
Apr-09	🟡	🟡	🟡	🟡	🔴	🔴	🔴	🟡	🟡	Project unable to meet internal 2013 LRD from PDR
May-09	🟡	🟡	🟡	🟡	🔴	🔴	🔴	🟡	🟡	
Jun-09	🟡	🟡	🟢	🟢	🟡	🟡	🔴	🟡	🟡	Project told to plan to 2014 LRD
Jul-09	🟡	🟡	🟢	🟡	🟡	🟡	🔴	🟡	🟡	
Aug-09	🟡	🟡	🟢	🟡	🟡	🟡	🔴	🟡	🟡	
Sep-09	🟡	🟡	🟢	🟡	🟡	🟡	🔴	🟡	🟡	
Oct-09	🟡	🟡	🟢	🟡	🟡	🟡	🔴	🟡	🟡	NAS: Program Prioritization Panel final meeting
Nov-09	🟡	🟡	🟢	🟡	🟡	🟡	🔴	🟡	🟡	
Dec-09	🟡	🟡	🟢	🟡	🟡	🟡	🔴	🟡	🟡	
Jan-10	🟡	🟡	🟢	🟡	🟡	🟡	🔴	🟡	🟡	
Feb-10	🟡	🟡	🟢	🟡	🟢	🟢	🟡	🟢	🟡	FY11 budget increase ($52M), NAS: Panel reports to reviewers
Mar-10	🟡	🟡	🟢	🟡	🟢	🟢	🟡	🟢	🟡	
Apr-10	🟡	🟡	🟢	🟡	🟢	🟡	🔴	🟢	🔴	Technical CDR
May-10	🟡	🟡	🔴	🔴	🔴	🔴	🔴	🔴	🔴	Programmatic CDR, NAS: Survey report to reviewers, Start TAT discussion
Jun-10	🟡	🟡	🔴	🔴	🔴	🔴	🔴	🔴	🔴	TAT begins work
Jul-10	🟡	🟡	🔴	🔴	🔴	🔴	🔴	🔴	🔴	
Aug-10	🟢	🟡	🔴	🔴	🔴	🔴	🔴	🔴	🔴	TAT Report, NAS: Decadal survey release, ICRP begins
Sep-10	🟢	🟡	🔴	🔴	🔴	🔴	🔴	🔴	🔴	SMD's JWST budget rebaseline submission
Oct-10	🟢	🟢	🔴	🔴	🔴	🔴	🔴	🔴	🔴	Several technical problems resolved*
Nov-10	No Project/Program reporting									ICRP Report, Program restructuring
Dec-10	🟢	🟡	🔴	🔴	🔴	🔴	🔴	🔴	🔴	SMD's JWST budget rebaseline rejected
Jan-11	🟢	N/A	🔴	🔴	🔴	🔴	🔴	🔴	🔴	Replan begins
Feb-11	🟢	🟡	🔴	🔴	🔴	🔴	🔴	🔴	🔴	
Mar-11	🟢	🟡	🔴	🔴	🔴	🔴	🔴	🔴	🔴	
Apr-11	🟢	🟡	🔴	🔴	🔴	🔴	🔴	🔴	🔴	
May-11	🟢	🟡	🔴	🔴	🔴	🔴	🔴	🔴	🔴	Replan concludes, review of replan begins
Jun-11	🟢	🟡	🔴	🔴	🔴	🔴	🔴	🔴	🔴	
Jul-11	🟢	🟡	🔴	🔴	🔴	🔴	🔴	🔴	🔴	
Aug-11	🟢	🟡	🔴	🔴	🔴	🔴	🔴	🔴	🔴	Primary Mirror Segment production completes, TF removed from FGS
Sep-11	No Program/Project reporting									
Oct-11										

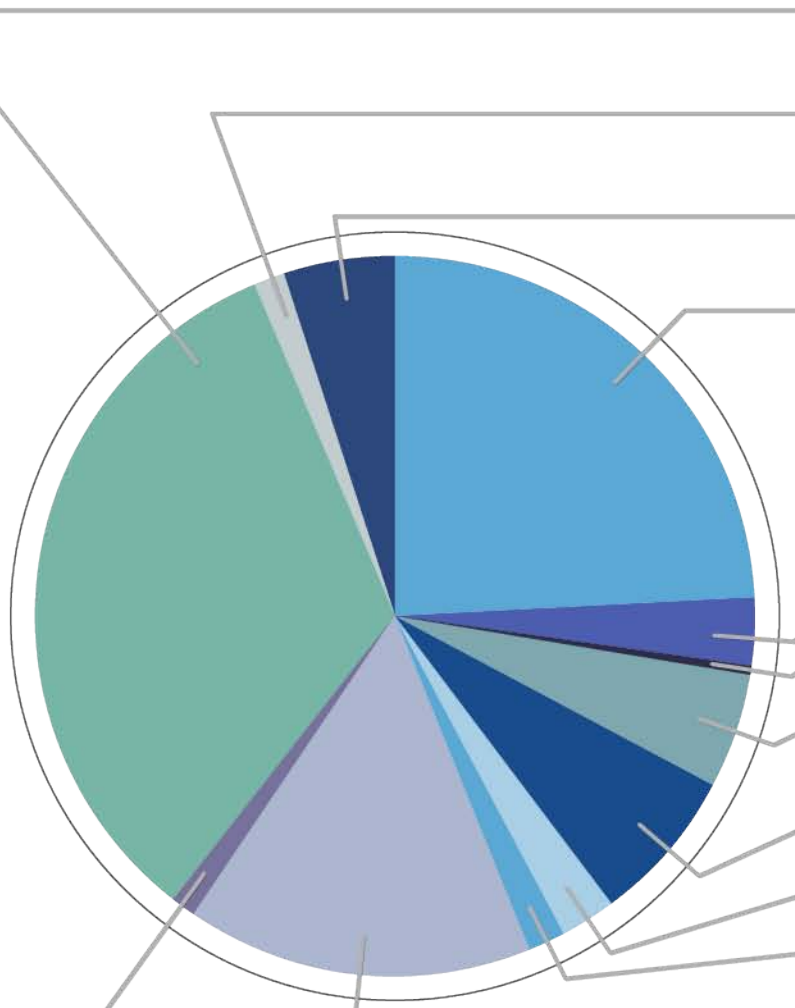
🟢 Progress according to plan, all commitments can be met

🟡 Area of concern, problem can be resolved within reporting organization resources

🔴 Significant Problem, Solution not identified, Needs action/help beyond reporting organization

* Delivery of microshutters to ESA, NIRCam design modifications completed, positive news on NIRSpec detectors

4. Cost Breakdown by Element through FY11 ($3.5B total)



33.2%	Northrop-Grumman	40% spent
1.3%	Misc. Observatory Support	86% spent
4.9%	Ground System	24% spent
24.2%	ISIM and Science Instruments	78% spent
3.2%	Technology Development	100% spent
0.3%	Science Working Group	32% spent
5.2%	Miscellaneous	50% spent
7.1%	Civil Service Labor	56% spent
2.5%	I&T test chamber	70% spent
1.6%	MIRI cryocooler	65% spent
15.4%	Mirrors (Ball Aerospace)	79% spent
1.1%	System Level I&T	15% spent