



# Committee on Astronomy and Astrophysics

## **James Webb Space Telescope (JWST)**

### **Discussion**

**Eric P. Smith**

**Astrophysics Division, Science Mission Directorate**

# Contents



- Status, Replan and Special Review Context
- Special Review Summary
  - Slides with blue background are verbatim from review team
- Four Community Concerns

# Questions Cross Reference



Question	Where Answered
1) Is it reasonable for the JWST spending profile to follow the current plan allowing a wedge to open up in 2009 or will it be much longer before other projects can start?	Phil Sabelhaus
2) Are you really already in a situation when there is no feasible large descope, and further cost increases, if they happened, would lead to a stark choice for NASA - find the money or cancel?	Eric Smith
3-1) What is the schedule of major components for the mission (e.g., instrument deliveries, ISIM delivery, spacecraft delivery, telescope assembly delivery, etc.)? 3-5) What are the key milestones that will inform you about whether you are on schedule (through to the 2013 launch)?	Phil Sabelhaus
3-2) What is the development status of the major hardware components?	Mark Clampin
3-3) What are your three greatest technical and three greatest programmatic concerns? 3-4) What is the risk mitigation strategy for each of them?	Phil Sabelhaus
3-6) What are the budget, schedule, and technical reserves at this point (the last including mass, power, fuel, radiative cooling, etc.)?	Phil Sabelhaus
3-7) How much of the JWST budget is being spent on the mission itself, and how much goes to other factors like GSFC overhead, HQ taxes, etc?	Phil Sabelhaus
3-8) What is the probability of mission success at this time?	Phil Sabelhaus
3-9) Many NASA missions are required to have a written specific minimum science criteria. Does JWST have such a criteria formally defined? If so, what is it and how was it developed?	John Mather
4) Discussion about what lessons NASA has learned from previous large missions, and how those lessons influenced the program strategy for JWST at the outset and as the project has progressed	Phil Sabelhaus



# JWST Status

- Program is in Phase B, preliminary design, confirmation to Phase C: March 2008
- Cost-to-launch (April 2006 projection) ~\$2.5B (FY06)
- European contribution defined (value ~\$0.5B) , industrial partners under contract
- Project on track for January 2007 technology non-advocate review, beginning of mission confirmation process
- Cost Comparison (FY06, design, develop and construction only, full-costed) with other Great Observatories:

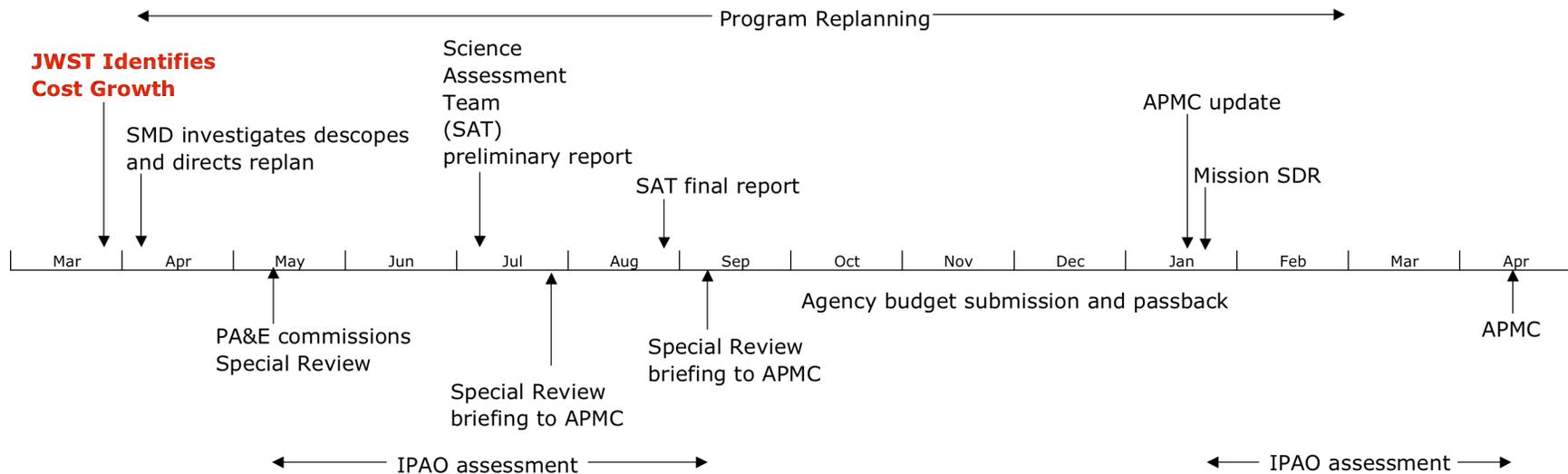
	<u>Collecting Area</u>	<u>Launch Mass</u>
– JWST:	\$0.1B/m <sup>2</sup>	\$0.5M/kg (projected)
– Spitzer:	\$1.4B/m <sup>2</sup>	\$0.8M/kg
– Chandra:	\$0.2B/m <sup>2</sup> *	\$0.6M/kg
– HST:	\$0.9B/m <sup>2</sup>	\$0.4M/kg

\*Chandra's grazing incidence optics not directly analogous to other great observatory's normal incidence optics

# Replan and Special Review Context



- JWST reports growth in development cost - Mar'05
- Science Mission Directorate (SMD) investigates descopes, commissions independent Science Assessment Team (SAT), directs replanning - Apr'05
- PA&E commissions independent special review - May'05
  - Interim special Agency Program Management Council (APMC) meetings - Jul'05, Sep'05, Jan'06
- Replanning completed - Mar'06
- Special Review Completed - Apr'06
  - Final special APMC meeting - Apr'06



# Special Review Team

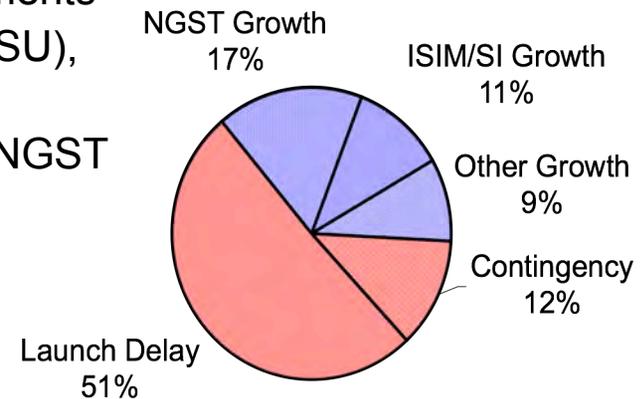


<u>Name</u>	<u>Expertise</u>	<u>Affiliation</u>
<b>Jeff Jones:</b> Manager	Management	NASA IPAO
<b>Jean Olivier:</b> Chair	Project Management, Systems Engineering ( <i>Chandra, HST</i> )	Consultant (SAIC), retired NASA
<b>Mohan Aswani</b>	I&T, Structures, Materials	The Aerospace Corporation
<b>Richard Capps</b>	Technology Development, Space Systems	NASA JPL
<b>Glenn Cunningham</b>	Operations, Software	Consultant (SAIC), retired NASA
<b>Hamilton Fernandez</b>	Cost Analysis	NASA IPAO
<b>Dave Gilmore</b>	Thermal, Cryo Systems	The Aerospace Corporation
<b>Randy VanValkenburg</b>	Software	NASA LaRC
<b>Gus Guastaferrro</b>	Management, Spacecraft Systems	Consultant (SAIC), retired NASA, retired Lockheed Martin
<b>John Mangus</b>	Cryogenic Optics ( <i>HST, COBE</i> )	Consultant (SAIC), retired NASA
<b>Carl Rice</b>	Science Instruments, Space Systems	The Aerospace Corporation
<b>Ken Sizemore</b>	Management, Systems Engineering, Instruments	Consultant (SAIC), retired NASA
<b>Bill Taylor</b>	Management, Systems Engineering ( <i>HST</i> )	Consultant (SAIC), retired NASA
<b>Mike Werner</b>	Science, Cryo Missions ( <i>Spitzer</i> )	NASA JPL
<b>Jaime Belitz</b>	Schedule Analysis	SWALES
<b>Cheryl Malloy</b>	Launch Vehicles	NASA KSC

# JWST Cost Growth Today



- ~\$1B net cost growth from POP-04; No change since September 2005
  - ~\$530M for 22 month launch slip to June 2013.
    - Launch vehicle uncertainty and lack of TAA
    - Budget profile limitations in FY06 and 07
    - Previous budget cuts
    - Schedule reduction risk
  - ~\$177M at NGST
    - Reevaluation of I&T effort, additional launcher-related testing requirements, additional ISIM resources, etc
  - ~\$125M of recommended added contingency funding
    - Contingency levels on cost-to-go 19%
  - ~\$113M in instruments and instrument-related elements
    - Change in content (cryo-cooler, IEC, ASIC, IRSU), growth in Microshutter and detector cost, etc
  - ~\$96M in JWST project growth other than ISIM or NGST
    - JSC Chamber modifications, ITA pool, etc



# Special Review Process

- Many SRT members have prior experience on JWST or relevant experience on other systems
- Team attended System Definition Review at GSFC January 23-27, 2006
- Site meetings held at GSFC February 15-17, 2006, and at NGST March 12-18, 2006
- Special in-depth site/telecon reviews were held at:
  - GSFC (Mission Systems Engineering) - telecon
  - NGST (Sunshield, Backplane, Thermal Testing)
  - Tinsley Corp. (Primary Mirror Segments)
  - GSFC (ISIM Structures, Micro-shutter Array, Program Schedules)
  - STScI (Mission Operations) – telecon
  - Observer on Optical Product Integrity Team (PIT)
- Independent Cost Estimate (ICE) developed
- Out-briefing Process:
  - April 7, 2006, GSFC Management Review
  - April 12, 2006, Science Mission Directorate Program Management Council
  - April 13, 2006, Agency Program Management Council

# Executive Summary

- Scientific performance meets the expectations of the science community
- Technical content is complete and sound
- GSFC and Contractor teams are effective
- Early year funding constraints are the major re-plan issue



# SMD Observations & Plans

- FY07 JWST budget submit is consistent with replan
  - Accomplished by rebalancing between programs within Astrophysics Division
- Results of Special Review Team (SRT) consistent w/ expectations
  - Solid development plan that includes prudent risk mitigations
  - Outstanding team of people
  - Low percentage of funding for contingencies up-front (through FY10) is a issue that will to be addressed as part of POP process this year
    - However, Chandra had similar contingency at similar stage
    - No need to change cost-to-launch, “rephasing of contingency”
- Agency is conducting internal dialog on the remaining contingency issue for JWST
  - Seeking workable solution with adequate levels of contingency and appropriate programmatic mix within the division portfolio
  - Solution promised to NASA Administrator in mid-June in time for FY08 budget process.

# “JWST is Eating My Lunch”



- Current fiscal pressure within Astrophysics Division has multiple causes
  - Removal of ~\$3B from Science Mission Directorate funding for other higher priority programs
    - Astrophysics Division lost \$382M in FY07-FY011 budget
  - Congressionally directed spending outside planned program
    - Approximately 4% of SMD budget directed to Congressionally mandated activities (~\$200M)
  - Delay in HST SM4
    - Original SM4 date, 2002, last budgeted launch date (*i.e.*, before FY07 budget) Nov 2004
  - Program cost increases/other problems (launch ordered)
    - SOFIA, GLAST, *Kepler*, JWST

# “Why Can’t JWST Give Up Just \$X M to Help Other Missions/Programs?”



- Budget cuts now would cause delay and increase run out costs (see chart 7, note cause of largest pie segment) and create problems starting other missions
  - Low contingency (as noted by SRT) levels for project argue against budget cuts
  - Division must balance budget year-by-year for 5 years, single year solutions cause problems downstream
- When programs are making progress, have good plans, and are well managed (cf., SRT report) the best solution to minimizing their impact on other division elements budgets is to proceed to launch

# “JWST’s Never Had to Descope”



- Primary Mirror Aperture Diameter
  - Sep 1997: 8m diameter (40m<sup>2</sup>)
  - Aug 2001: ~7m diameter proposed by NGST (29.7m<sup>2</sup>)
  - Sep 2003: “diameter no less than 6m and be mostly filled” (25m<sup>2</sup>)
- Instruments simplified (now only 1.5 out of 4 are U.S.)
  - Aug 2001: NIRCams US & Canadian partnership, >50 Megapixels
  - Dec 2002: US only instrument, no US tunable filter, 42 Megapixels
  - Aug 2005: One Canadian tunable filter module removed
- Requirements Relaxation & Elimination (Summer 2005)
  - Shortwave sensitivity has been relaxed to enable greatly simplified Integration & Test
    - “Cup-up” I&T at JSC (elimination of 600,000 lb thermal vac/cryo testing tower)
    - Achievable Contamination levels
  - Visible/Shortwave IR wavelength requirements removed ( $\lambda < 1.7 \mu\text{m}$ )
  - PSF Anisotropy requirement removed

# “You Should Cost Cap JWST”



- NASA Authorization Act of 2005:
  - S1281 Section 103: Baselines and Cost Controls
  - Parts (d) (e), 15 and 30% projected increases above development costs require for (15%) notification of House Committee on Science plus description of why the increases occurred and the plan forward or (30%) no further spending on the program may occur unless the Congress has subsequently authorized continuation of the program by law.
- JWST (and all future missions >\$250M) cost regulated by LAW!

# Summary

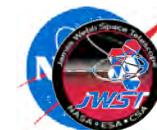


- NASA is building the next Great Observatory that will be widely used by the majority of our colleagues. It will very likely be the only U.S. general-user space observatory operating in the next decade
- Two Independent Reviews Have Concluded:
  - JWST is even more important today than when it was top priority in the 2000 decadal survey
  - Mission Science goals met by replanned program
  - Technology developments on track
  - Project is being managed effectively
- Program has many reviews and milestones coming up that permit careful monitoring and Project has plans for mitigating cost growth
- HQ working with Project and astronomical community to solve contingency concerns and programmatic mix within Astrophysics Division
- Best fiscal, programmatic, and science decision is to press with present plans and schedule to technology non-advocate review in January 2007



# Backup Material

# James Webb Space Telescope (JWST)



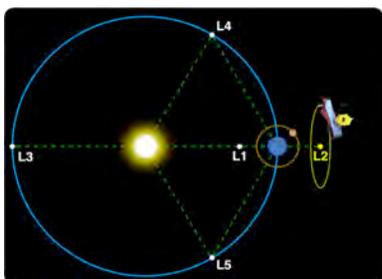
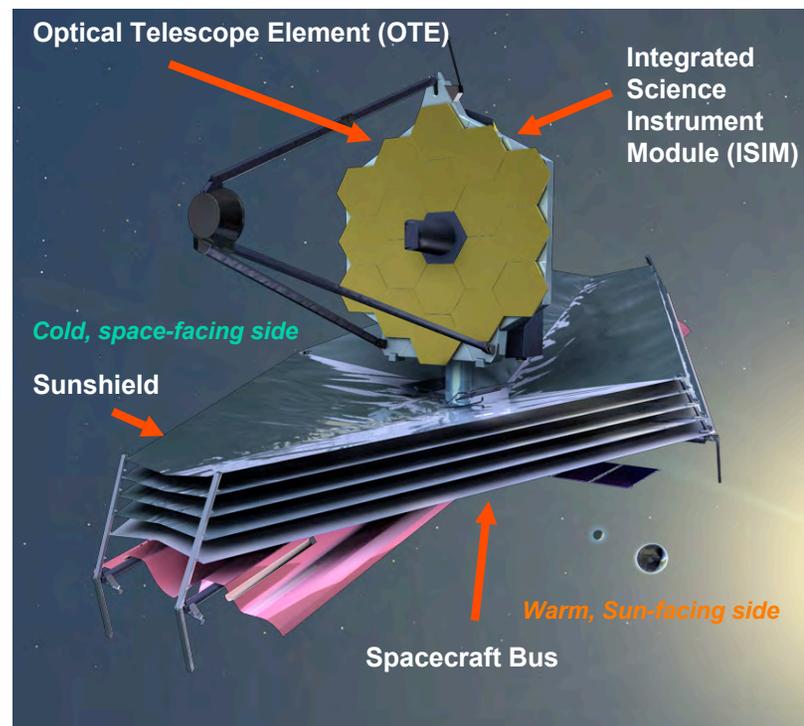
## Mission

- First light and reionization
- The assembly of galaxies
- The birth of stars and protoplanetary systems
- Planetary systems and the origins of life

*Optimized for infrared observations (0.6 – 28 μm)*

## Organization

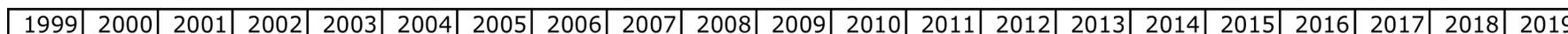
- Mission Lead: Goddard Space Flight Center
- International collaboration with ESA & CSA
- Prime Contractor: Northrop Grumman Space Technology
- Instruments:
  - Near Infrared Camera (NIRCam) – Univ. of Arizona
  - Near Infrared Spectrograph (NIRSpec) – ESA
  - Mid-Infrared Instrument (MIRI) – JPL/ESA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



## Description

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

[www.JWST.nasa.gov](http://www.JWST.nasa.gov)



Phase A

Formulation/20/06  
Authorization



Phase B

ICR  
(PNAR)



T-NAR



NAR

Phase C/D

CAA, Washington, DC



Phase E

Launch

# Science Assessment Team



<b>Name</b>	<b>Expertise</b>	<b>Affiliation</b>
<b>Matt Mountain:</b> Co-chair	Large Optics, Science Management, Adaptive Optics	Gemini Director/STScI Director
<b>Peter Stockman:</b> Co-Chair	Observatory operations	STScI
<b>Malcolm Longair</b>	Cosmology, active galaxies, galactic evolution	University of Cambridge
<b>Kathryn Flanagan</b>	X-ray instrumentation, Astrophysics Division roadmap lead	MIT
<b>Christopher McKee</b>	Astrophysical Theory / ISM, Decadal Survey co-author	UC, Berkeley
<b>Roberto Abraham</b>	Galaxy morphology and evolution	University of Toronto
<b>Bob Gehrz</b>	Infrared astronomy and instrumentation	University of Minnesota
<b>Sara Seager</b>	Extra-solar planets / Giant planets	Carnegie Institution of Washington/DTM
<b>Alan Dressler</b>	Clusters of galaxies, galaxy distributions, extra-galactic astronomy	Observatories of the Carnegie Institution of Washington