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JAMES WEBB SPACE TELESCOPE PROGRAM / PROJECT PLAN

IN PROCESS
As of
31 October 2007

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2 section required:
3.1.8 Descope Plans
JSC Facility Mods

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

CM FOREWORD

This document is a James Webb Space Telescope (JWST) Project Configuration Management (CM)-controlled document. Changes to this document require prior approval of the applicable CCB Chairperson or designee. Proposed changes shall be submitted to the JWST CM Office (CMO), along with supportive material justifying the proposed change. Changes to this document will be made by complete revision.

Questions or comments concerning this document should be addressed to:

JWST Configuration Manager
JWST Configuration Management Office
Mail Stop 443
Goddard Space Flight Center
Greenbelt, Maryland 20771

JAMES WEBB SPACE TELESCOPE

PROGRAM/PROJECT PLAN

Signature Page

Approved by:

S. Alan Stern Associate Administrator, Science Mission Directorate NASA Headquarters	Date
Edward J. Weiler Director Goddard Space Flight Center	Date
Phillip A. Sabelhaus Associate Director, Flight Projects Directorate JWST Program/Project Manager Goddard Space Flight Center	Date

JAMES WEBB SPACE TELESCOPE PROJECT

DOCUMENT CHANGE RECORD

REV LEVEL	DESCRIPTION OF CHANGE	APPROVED BY	DATE APPROVED
Basic	Released per JWST-CCR-000095	P. Geithner	11/20/2003
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PREFACE

As James Webb Space Telescope Program is a single-project program, this document is prepared as a combined Program and Project Plan, as delineated in the NASA Space Flight Program and Project Management Requirements (NPR 7120.5D), section 4.1.2 b(1) and includes all content required in the Program and Project Plan templates.

1.0 PROGRAM / PROJECT OVERVIEW

1.1 INTRODUCTION

The James Webb Space Telescope (JWST) is a 6-m class infrared (IR) telescope to study and answer fundamental astrophysical questions ranging from the formation and structure of the Universe to the origin of planetary systems and the origins of life. A scientific successor to the Hubble Space Telescope (HST) and the Space Infrared Telescope Facility (SIRTF), JWST will be used by international teams of astronomers to conduct imaging and spectroscopic observations in the wavelength range 0.6-27 µm. The Observatory will be located in an orbit near the second Lagrange point (L2), approximately 1.5 million km from Earth. The telescope and instruments will be cold (~30K) and shielded from the heat of the Sun by a large Sunshield. As a result of the low background, the Observatory will achieve unprecedented sensitivity over its entire wavelength range.

A telescope with a segmented primary mirror will deliver IR light to the Fine Guidance Sensor (FGS) for both "guide-star" acquisition and fine pointing updates to the Observatory and to the four scientific instruments of the Observatory:

- A wide-field Near-Infrared Camera (NIRCam), providing wide-field medium and narrow-band imaging from a 0.6-5µ.
- A 0.6 to 5 µm wide-field multi-object Near-Infrared Spectrograph (NIRSpec)
- A Mid-Infrared Instrument (MIRI) that combines a mid-infrared imager and integral field spectrograph, for the wavelength range 5 to 27 µm
- An FGS-Tunable Filter (FGS-TF), a wide field, narrow-band camera that provides imagery over a wavelength range of 1.6 to 4.9 µm, with a gap between 2.6 and 3.1 µm.

1.1.1 Program/Project History

In its report, "HST and Beyond," a blue ribbon committee appointed by the Association of Universities for Research in Astronomy (AURA) recommended a follow-on mission to the HST. The report urged the development of a general-purpose, near-infrared observatory equipped with a primary mirror larger than 4 meters. It was recommended that the observatory be able to maintain a cool temperature of 70K or lower so as to be up to 1,000 times more sensitive than any existing or planned facility in the 1 to 5 micron region. To further enhance its performance, the report recommended that the observatory be placed as far from the Earth-Moon system as possible to reduce stray light and to maintain the telescope's relatively cool temperature.

During the pre-Phase-A Concept Studies, NASA and its industry and academic partners studied three approaches:

1. Deployable 8-meter segmented primary mirror telescope and erectable sunshield, deployed at Sun-Earth Lagrange (L2) Orbit

2. Monolithic 6-meter thin shell primary mirror telescope and fixed sunshade, in an interplanetary orbit beyond that of Mars
3. Deployable 8-meter segmented primary mirror telescope and inflatable sunshield, in a halo orbit at L2

All three concepts shared certain design features, including adjustable thin mirrors, deep space orbits, fast-steering mirrors for fine guidance, infrequent contact with the ground and a mass of about 2800 kg. They differed in the areas of mirror construction, materials and deployment, detector types, sunshield types, vibration control and launch vehicles.

The most important and difficult part of the mission was determined to be designing and building the primary mirror. While the primary mirror would be the largest ever flown on a space-borne observatory, it would have to remain relatively lightweight to meet the mass requirements. The mirrors will be incorporated into optical assemblies, mounted on the telescope structure, and subjected to a series of tests at cryogenic temperatures, individually and as an integrated system.

The selected Observatory design features an approximately 6-meter diameter primary mirror, comprised of 18 hexagonal shaped beryllium segments and a deployable sunshield to be placed in a halo orbit at L2. The primary mirror will be 2.5 times the diameter, yet weigh only one-quarter as much, as the primary mirror on the HST.

In 2001, The National Research Council report, Astronomy and Astrophysics in the New Millennium, Chapter 3 The New Initiatives: Building On The Current Program stated:

> "…The committee's top recommendations for this decade are to dramatically increase the capability of {Ultra Violet, Optical, and Infrared} observations with the Next Generation Space Telescope (NGST) in space and the Giant Segmented Mirror Telescope (GSMT) on the ground. Both of these telescopes have filled apertures and are very substantial improvements on HST and Keck, respectively. Their large mirrors must be segmented, and fast-responding actuators must bring the segments into nearly perfect alignment…NGST consists of a passively cooled, segmented telescope that will deploy to its full diameter of about 8 m once it is in space. It will orbit the Sun roughly a million miles from Earth. At present, its planned wavelength range is 0.6 to 27 µm. NGST will be far more capable than its space predecessors HST and SIRTF and its airborne predecessor SOFIA. … the sensitivity of NGST … at low spectral resolving power, … is appropriate in searches for distant galaxies and faint stellar objects. Much of its increase in sensitivity compared with previous space telescopes comes from its large aperture, which not only gathers more photons from each source but also reduces the number of photons from the background by virtue of its greater angular resolution. Astronomical capability is defined in the 1991 survey, *The Decade of Discovery in Astronomy and Astrophysics* (NRC, 1991), in terms of the speed of an observation. Improvements in sensitivity and angular resolution make NGST roughly 1,000 times more capable than HST and SIRTF; its low temperature makes it up to a million times more capable than similar-size ground-based telescopes. The discovery potential of NGST is enormous. Having NGST's sensitivity extend to 27 µm would substantially improve its ability to study Kuiper Belt objects (KBOs) in the solar system, star formation and planet formation in our galaxy, and dust emission in galaxies out to a redshift of 3. Not only would this extension take full advantage of the effort to cool the instrument, but NGST would also gain its greatest advantage over any ground-based telescope at the longer infrared wavelengths

In early 2005, as a result of budgetary concerns, the NASA HQ Science Missions Directorate commissioned an independent Science Assessment Team (SAT) to perform an evaluation of the JWST Mission Science Requirements and the planned implementation approach. The SAT focused on the JWST science capabilities that were deemed to be: (a) redundant; (b) no longer considered uniquely competitive in 2015-2020; (c) significantly driving mission risk and had the potential for future cost escalation. The SAT recommendations were recorded in three documents:

SAT Preliminary Report (8 July 2005)	JWST-RPT-005460
SAT Interim Report (26 July 2005)	JWST-RPT-005464
SAT Final Report (23 August 2005)	JWST-RPT-005466

The Project implemented the SAT recommendations.

Concurrent with the SAT evaluation, the Independent Program Analysis Office performed an assessment of the Project's plan leading to a not-earlier-than launch in June 2013. This review had the following conclusions:

- Scientific performance meets the expectations of the science community
- Technical content is complete and sound
  - The plan effectively prioritizes the critical elements:
    - Advanced technology development
    - Telescope elements
    - ISIM development
    - Sunshield development
  - Critical system interfaces and analyses are prioritized to reduce risk in hardware development and fabrication
- The GSFC and Contractor team is well integrated, organized, experienced and has strong institutional management support
- Early year funding constraints, specifically low early year contingency are the major issue.
  -- To address the low early year contingency, the Project proposed a modest rephasing of contingency from FY11-12 to FY08-09 as part of the POP 06-1 submittal. There was *no* increase in the estimate at complete, i.e. the total project cost remained the same as at the inception of the review process.

The JWST Program entered the Program Life Cycle Implementation Phase (Project Life Cycle Preliminary Design and Technology Completion (Phase-B)) as it completed the Program/Project System Definition Review in January 2006.

The transition to "Project Implementation" (Phase-C) is planned to occur in March/April 2008 with the presentation of the Program/Project Preliminary Design Review and Non-Advocate Review.

1.1.2 Program/Project Category/Risk Classification

Whereas the JWST Program/Project has a life cycle cost of $\geq$$1B and a risk classification "A" [as determined from Risk Classifications for NASA Payloads (NPR8705.4), Appendix A], the JWST Program/Project is classified as a Category 1 Program/Project, as determined using the schema shown in Table 2-1 of the NASA Program and Project Management Processes and Requirements (NPR 7120.5D)

1.2 GOALS AND OBJECTIVES

1.2.1 Program Level

The mission of the JWST Program/Project is to develop, launch, and operate a state-of-the-art observatory for use by the international astronomy community to address NASA Strategic Plan goals in understanding; the origin and destiny of the universe, the creation and evolution of the first stars and galaxies to form after the Big Bang, the formation of stars and planetary systems within the Galaxy, and characteristics of planetary systems including our own. To address these goals the JWST mission divides its science program into four themes:

1. The End of the Dark Ages - First Light and Reionization: Identify the first luminous sources to form and determine the ionization history of the early universe.
2. The Assembly of Galaxies: Determine how galaxies and the dark matter, gas, stars, metals, morphological structures, and active nuclei within them evolved from the epoch of reionization to the present day
3. The Birth of Stars and Protoplanetary Systems: Unravel the birth and early evolution of stars, from infall on to dust-enshrouded protostars to the genesis of planetary systems
4. The Planetary Systems and the Origins of Life: Determine the physical and chemical properties of planetary systems including our own, and investigate the potential for the origins of life in those systems

The Level 1 mission requirements for the JWST mission are defined in section 2.1 of this plan. To verify achievement of its overall scientific objectives, the science requirements for full mission success for the JWST are defined in section 2.1.1.1 and the science requirements for minimum mission success are defined in section 2.1.1.2 of this plan.

1.2.2 Project Level

1.2.2.1 Performance Objectives

The Project (Level 2) performance requirements for the JWST mission are addressed in the JWST Project Mission Requirements Document (MRD) (JWST-RQMT-000634).

This document draws from four sources:

1) The Level 1 mission requirements for the JWST mission defined in section 2.1
2) The detailed/derived scientific objectives of the JWST as delineated in the JWST Science Requirements Document (SRD) (JWST-RQMT-002558). These objectives of the four themes are addresses in the following section of the SRD:
    a. SRD Section 3.0: The End of the Dark Ages: First Light and Reionization
    b. SRD Section 4.0: The Assembly of Galaxies
    c. SRD Section 5.0: The Birth of Stars and Protoplanetary Systems
    d. SRD Section 6.0: Planetary Systems and the Origins of Life
3) The mission operations as defined in the JWST Mission Operations Concept Document (JWST-OPS-002018), and

4) The Project performance assurance requirements as defined in the JWST Project Performance Assurance Requirements for the JWST Observatory (JWST-RQMT-000650).

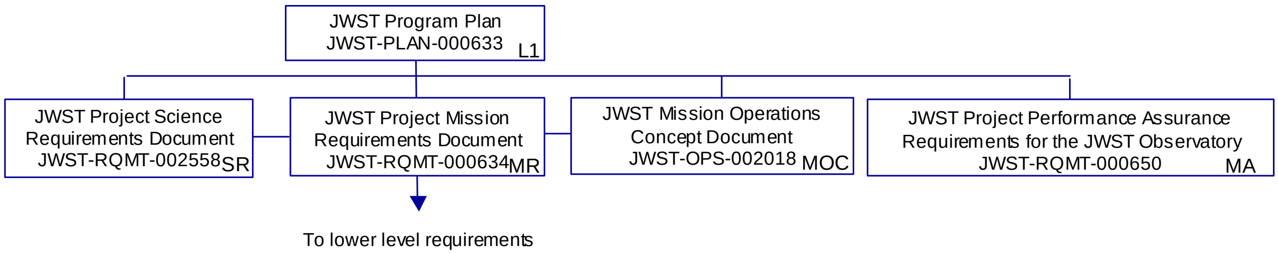


Figure 1-1 JWST "Top Level" Requirements Flow-Down

Requirements flow down from the MRD to the mission segments and elements has been established and is documented in the JWST Requirements Flowdown Document (JWST-TREE-004618).

1.2.2.2 Schedule

The planned launch for the JWST Observatory is FY 2013.

1.2.2.3 Cost

The JWST Program is a cooperative effort between the NASA, ESA, and CSA. Each of these entities provides their own funding with no exchange for funds between entities.

The JWST NASA Life Cycle Cost Plan, is shown in Table 1-1

Table 1-1 JWST NASA Life Cycle Cost Plan (as of Oct 2007)

	TOTAL	Phase-A thru FY03 NOA	Phase-B FY04 thru 50% of FY08	Phase-C 50% of FY08 and 75% of FY09	Phase-D 25% of FY09 thru FY14	Phase-E starts FY14
Cost	4,358.4	325.2	1,465.0	502.7	1,177.1	888.4
Reserves	546.4	n/a	46.7	29.6	416.5	53.6
TOTAL	4,904.8	325.2	1,511.7	532.3	1,593.6	942.0

1.2.2.4 Technology Development

JWST identified ten “enabling” technologies (delineated in section 3.5 of this plan) which required development for the mission. These technologies are those, which essentially required new “inventions” (advancements in the state-or-the-art) to achieve the performance needed to achieve the JWST science mission.

1 Near Infrared Detectors
2 Mid-Infrared Detectors
3 Sunshield Materials
4 Lightweight Cryogenic Mirrors
5 Micro-shutter Arrays
6 Cryogenic Detector Readout ASICs
7 Cryogenic Heat Switches
8 Large, Precision Cryogenic Structure

9 Wavefront Sensing and Control
10 Cryocooler

JWST placed the development of these critical enabling technologies on an accelerated schedule, making an early and significant investment to achieve Technology Readiness Level 6 (TRL-6), i.e., prototype hardware tested in the relevant JWST flight environments. The program/project opted to hold an early review of technology at a Technology Non-Advocate Review (T-NAR) in January. 2007. This gave NASA Headquarters chartered independent reviewers the opportunity to assess the readiness of these critical technologies over a year before the traditional Preliminary Design Review / Non-Advocate Review, and over 6 years before the Launch Readiness Date (LRD) of June 2013.

The review committee reported their findings as follows:

- The Project and Development Teams have made impressive progress in the maturation of the ten enabling technologies herein reviewed.
- This activity has retired a significant amount of JWST Program Risk.
- As of the review committee's final report (17 April 2007) TRL-6 has been achieved on all ten items

1.3 ARCHITECTURE

1.3.1 Program Components

The JWST Program is a cooperative effort with and between the NASA, the European Space Agency (ESA), and the Canadian Space Agency (CSA). Each agency has established a JWST Project office to provide the management of their respective programmatic contributions.

The NASA provides the overall program management for the JWST mission

1.3.2 Summary Technical Description

As shown in Figure 1-2, JWST System is an amalgam of three distinct Segments; the Observatory Segment, the Ground Segment, and the Launch Segment. Each of these Segments is further delineated as Elements.

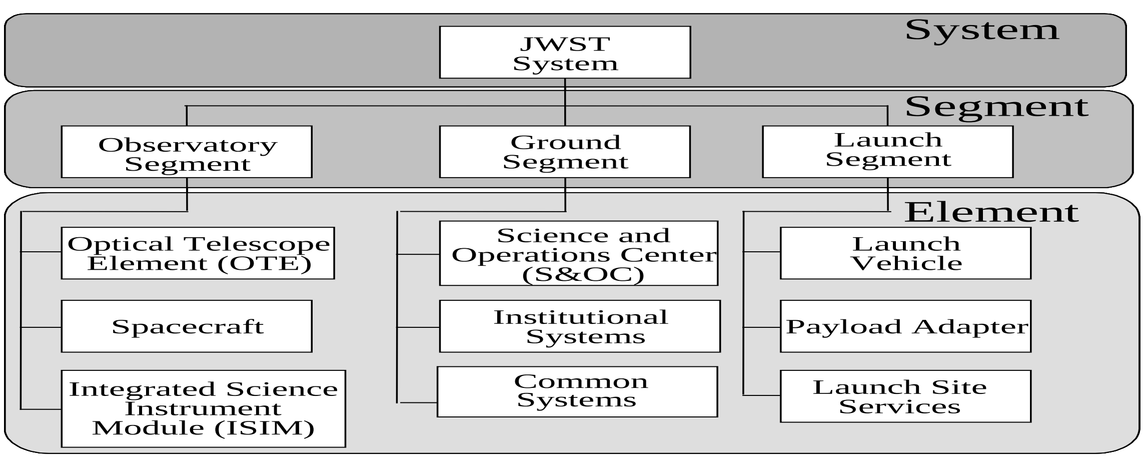


Figure 1-2 JWST System Hierarchy

Within the Observatory Segment, the NASA is providing the OTE, Spacecraft and ISIM. The ESA and the CSA are providing instruments to be installed in the ISIM.

The NASA is providing the Ground Segment of the JWST Program.

The ESA is providing the Launch Segment of the JWST Program.

1.3.3 Organizational Relationships

The execution of the program/project is carried out by an extensive team of domestic and international partners that includes the National Aeronautics and Space Administration (NASA) and its centers at the Goddard Space Flight Center (GSFC), Jet Propulsion Laboratory (JPL), Marshall Space Flight Center (MSFC), Johnson Space Center (JSC), Ames Research Center (ARC), Glenn Research Center (GRC), and the Kennedy Space Flight Center (KSC); international partners, including the European Space Agency (ESA) and the Canadian Space Agency (CSA); and domestic universities and industry

1.3.3.1 NASA Centers

1.3.3.1.1 Goddard Space Flight Center

In addition to having the overall responsibility the JWST mission, GSFC provides technical, financial, and contractual management for all domestic efforts. GSFC also provides systems engineering coordination and management for all aspects of the project, as well as the science oversight for the mission.

The GSFC is responsible for developing the Integrated Science Instrument Module (ISIM), which will be delivered to the JWST prime contractor, Northrop Grumman Space Technology (NGST), as Government Furnished Equipment (GFE).

The GSFC is responsible for coordinating delivery of all science instruments and for the development of the NIRSpec Detector and Micro-shutter Subsystems.

The GSFC is responsible for providing the facility in which the observatory prime contractor will perform integration of the Optical Telescope Element (OTE).

1.3.3.1.2 Jet Propulsion Laboratory

The JPL leads the management and systems engineering team that is responsible for the development of the Mid-Infrared Instrument (MIRI). The team includes JPL, ESA and the European Consortium (EC). The JPL will provide the MIRI Detector, Flight Software, and Cooling Subsystems. The ESA/EC will provide the MIRI Optical Bench Assembly (OBA).

The JPL provides the management of the Deep Space Network, which will be used for uplink and downlink communications with the JWST Observatory.

1.3.3.1.3 Marshall Space Flight Center

Optical Telescope Element Support

The MSFC provided the lead in the Project's Pre-Phase-A and Phase-A observatory primary mirror technology development efforts. This effort included managing the JWST Mirror Systems Demonstrator and Advanced Mirror Systems Demonstrator (AMSD) program.

For the Project Phase-B/C/D efforts, MSFC is a member of the Mirror Support Team (MST) that provides insight and oversight of all telescope optics. In addition, building on the expertise and test facilities developed for the AMSD program, MSFC will be the site where the OTE primary mirror segments are cryotested during the mirror fabrication efforts. The same facility was used to cryogenically test the OTE Backplane Structure Test Article, a lightweight composite technology validation article, and the ISIM structure concept validation model.

Other Support

Marshall Space Flight Center is the NASA center of excellent for the plasma environment. NASA Headquarters funded the development of the most authoritative model of the Space Plasma Charge Particles Effects at L2. MSFC has provided detailed tables for the plasma environment at L2 which directly affects JWST. MSFC also has excellent facilities for testing material with electron sources in vacuum at cryo temperatures. For JWST, MSFC provides testing of JWST cables and materials which are subject to potential ESD threats. Mitigation techniques to this environment are analyzed and tested in a vacuum chamber with control dosage of plasma to achieve this goal.

MSFC also has developed micro meteorite models for the L2 orbit. They tested the JWST sunshield material for effects from micrometers.

1.3.3.1.4 Johnson Space Center

The JSC will be the site where OTE/ISIM integrated thermal vacuum performance testing and verification is to be performed.

1.3.3.1.5 Ames Research Center

The ARC provided the lead in the Project's Pre-Phase-A and Phase-A development of the 2048 x 2048 Low-Noise Cryogenic Near-Infrared Sensor Chip Assembly (SCA) and the 1024 x 1024Mid-Infrared SCA technology development efforts.

For the flight SCAs, the ARC is providing consultative services and radiation test of the Mid-infrared SCAs.

1.3.3.1.6 Kennedy Space Flight Center

Kennedy Space Flight Center provides support to the Program Manager for technical evaluation, recommendations and risk assessments for analysis and documentation, test plan and procedure review and support, trade studies, launch site processing, launch campaign management and support, launch segment reviews, anomaly reviews and meetings concerning the interface between the ESA-provided Launch Segment and the JWST Observatory.

1.3.3.2 European Space Agency

Under the provisions of the Memorandum of Understanding (MOU) (JWST-MOU-001211) between NASA and ESA to conduct the JWST mission, the ESA will provide the following:

- Near-Infrared Spectrograph (NIRSpec) science instrument
- The Optical Bench Assembly (OBA) of the MIRI, in association with the European Consortium (EC)
- Launch of the JWST by means of an Ariane 5 Expendable Launch Vehicle (ELV)
- Assist in the operation of the JWST and related facilities, and arrange for participation of ESA-sponsored astronomers in the observation program.

The James Webb Space Telescope Project National Aeronautics and Space Administration Goddard Space Flight Center and European Space Agency Joint Project Implementation Plan (JWST-PLAN-004414) defines the individual and joint responsibilities of the GSFC JWST Project and the ESA JWST Project to meet the provisions of the MOU.

1.3.3.2.1 European Consortium

The design, fabrication and test of the OBA of the MIRI is to be carried out by a Consortium of European institutions and companies. The UK is the lead nation, headed up by the European Principal Investigator. The other nations are France, Germany, Netherlands, Sweden, Ireland, Denmark, Switzerland, Belgium and Spain.

The Consortium has distributed effort according to the skills in the participating institutes and reflecting the areas of national interest in MIRI. This also ensures that a broad spectrum of recent and appropriate technical design expertise is brought to bear on the design, construction and test of the MIRI-OBA.

Details of the Consortium are documented in the JWST MIRI European Consortium Programme Management Plan (MIRI-PL-00003-AEU).

1.3.3.3 Canadian Space Agency

Under the provisions of the Memorandum of Understanding (MOU) (JWST-MOU-001212) between NASA and CSA to conduct the JWST mission, the CSA will design, develop, assemble, test, and qualify the FGS, as well as providing requisite ground and flight software packages.

The James Webb Space Telescope Project National Aeronautics and Space Administration Goddard Space Flight Center and Canadian Space Agency Joint Project Implementation Plan (JWST-PLAN-003273) defines the individual and joint responsibilities of the GSFC JWST Project and the CSA JWST Project to meet the provisions of the MOU.

1.3.3.4 US University and Industry Partners

1.3.3.4.1 Northrop Grumman Space Technology

The JWST observatory prime contractor, Northrop Grumman Space Technology (NGST), under contract with NASA through the GSFC, will design and develop the Optical Telescope Element, the spacecraft and the sunshield, and integrate, test, qualify, and support launch and commissioning of the JWST Observatory.

NGST is leading a team including three major sub-contractors: Ball Aerospace, ITT, and Alliant Techsystems. The three principal beryllium mirror subcontractors to Ball Aerospace are Tinsley Laboratories; Axsys Technologies; and Brush Wellman Inc.

1.3.3.4.2 Space Telescope Science Institute

The Association of Universities for Research in Astronomy (AURA) operates the Space Telescope Science Institute (STScI) which, under contract with NASA through the GSFC, will develop the JWST Ground Segment. The Ground Segment consists of two major elements, the Science and Operations Center and the Communications Elements. The STScI will have responsibility for combined science and mission operations.

1.3.3.4.3 University of Arizona

The University or Arizona and industry partners, under contract with NASA through the GSFC, will be responsible for development of the Near-Infrared Camera (NIRCam) science instrument.

1.3.3.5 Program/Project Agreements

There are several major agreements that define the relationship between the JWST Project and its domestic and international partners.

1.3.3.5.1 NASA "Internal" Agreements

a. Agreements with other NASA centers
   - **ARC**
     - MIRI Science Team: Statement of Work, Thomas P Green Principal Investigator on the proposal, "Participation in the MIRI Science Team" (AO-01-05-OSS-006)
   - **JPL**
     - Memorandum of Understanding (MOU) Between NASA Office of Space Science, GSFC and Jet Propulsion Laboratory Regarding Large Space Observatories (JWST-MOU-001651)
     - Memorandum of Agreement between NASA/GSFC, California Institute of Technology, JPL concerning Program Managing Center/Project Managing Center/Instrument Provider Responsibilities (JWST-MOA-008844)
     - MIRI Phase-B/C/D (Task Plan 70-7930)
     - JWST Deep Space mission System Service Agreement (JWST-RQMT-005999)
   - **JSC**
     - Memorandum of Understanding Between the Johnson Space Center's Engineering Directorate and the James Webb Space Telescope Project (JWST-MOU-008809)
     - JWST Observatory to NASA JCS Test Facility IRCD (JWST-IRCD-003577)
   - **KSC**
     - Memorandum of Understanding Between the James Webb Space Telescope Project and the Launch Services Program (JWST-MOU-008183)
   - **MSFC**
     -
   - **Software Independent Verification and Validation Center**
     - Memorandum of Agreement Between the NASA GSFC Software Independent Verification and Validation Center And GSFC JWST Project (JWST-MOA-003482)

b. A negotiated and jointly signed System Implementation Plan (SIP) functions as the internal GSFC agreement between the Project and other GSFC organizations. The SIPs address all aspects of a subsystem or area of responsibility including technical performance, cost, and schedule.

1.3.3.5.2 NASA "External" Agreements

c. Agreements with domestic organizations

- Request for use of the National Reconnaissance Office Shipping Container is in process. Formal agreement to be negotiated.

d. International Agreements

1) European Space Agency

- Memorandum of Understanding Between the the National Aeronautics and Space Administration of the United States of America and the European Space Agency concerning the James Webb Space Telescope (JWST-MOU-001211) – dated 18 June 2007
- JWST Project National Aeronautics and Space Administration Goddard Space Flight Center and European Space Agency Joint Project Implementation Plan (JWST-PLAN-004414)
- James Webb Space Telescope Project National Aeronautics and Space Administration/Goddard Space Flight Center and European Space Agency Near-Infrared Spectrograph Joint Project Implementation Plan (JWST-PLAN-003310)
- James Webb Space Telescope Project National Aeronautics and Space Administration/Goddard Space Flight Center and European Space Agency Mid-Infrared Instrument Joint Project Implementation Plan (JWST-PLAN-002823)
- James Webb Space Telescope National Aeronautics and Space Administration/Goddard Space Flight Center and European Space Agency Project Launch Segment Joint Project Implementation Plan (JWST-PLAN-003468)
- JWST Project National Aeronautics and Space Administration/Goddard Space Flight Center and European Space Agency Operations Joint Project Implementation Plan (JWST-PLAN-004432) [Note: this plan is in draft form, the plan will be finalized/issued no later than 6 months prior to the Mission Operations Review.]

2) Canadian Space Agency

- Agreement Between United States National Aeronautics and Space Administration and the Canadian Space Agency for Cooperation on the James Webb Space Telescope Program -- (JWST-MOU-001212), dated 16 July 2007
- Canadian Space Agency and National Aeronautics and Space Administration/Goddard Space Flight Center JWST Fine Guidance Sensor Joint Project Implementation Plan -- (JWST-PLAN-003273)
- JWST Project National Aeronautics and Space Administration/Goddard Space Flight Center and Canadian Space Agency Operations Joint Project

Implementation Plan (JWST-PLAN-00xxxx) [Note: this plan will be prepared/issued no later than 6 months prior to the Mission Operations Review.]

1.4 MISSION DESCRIPTION AND TECHNICAL APPROACH

1.4.1 Mission Description

The JWST Mission will be divided into four operational phases: Launch, Deployment and Trajectory Correction, Cruise and Commissioning, and Operations.

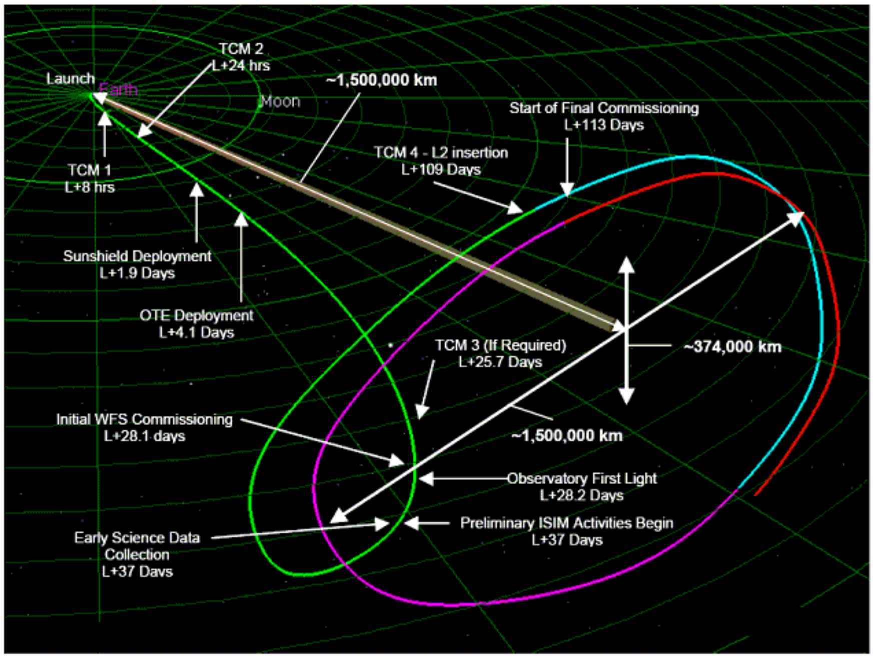


Figure 1-3 Launch Trajectory and Final Orbit for JWST at Sun-Earth Lagrange (L2) Orbit

1.4.1.1 Launch Phase

The Launch phase begins with launch on an Ariane 5 and ends when attitude stabilization is achieved using thrusters after upper stage stabilization. During this time, JWST will be launched on a trajectory to L2; the payload fairing will be jettisoned; low rate communications will be established, and the JWST propulsion system will be activated

1.4.1.2 Deployment and Trajectory Correction Phase

The Deployment and Trajectory Correction phase begins with thruster-based attitude stabilization and ends with the mirror deployed and with the mirror actuators at the nominal positions for beginning the co-phasing of the segmented mirror. It includes the deployment of the solar arrays, the high gain antenna, and the optical telescope element as well as initial trajectory correction maneuvers. During this phase, high data rate communications will be established, wheel-based attitude control will be established, and the Observatory Reaction Control System (RCS) will be verified.

1.4.1.3 Cruise and Commissioning Phase

The Cruise and Commissioning phase begins at the point of initial alignment and phasing of the mirror and ends after L2 insertion when JWST, including the science instruments, has been commissioned for science operations. It includes the initial alignment and co-phasing of the telescope, the determination that the optical performance requirements for the telescope can be met using the fine steering mirror and NIRCam, and the successful checkout of the science instruments and all other subsystems needed to conduct science operations. As delineated in the Data Requirements Document for the JWST Observatory Contract NAS5-02200 (JWST-RQMT-000636), the Observatory Prime Contractor, NGST, is to prepare the Observatory Commissioning Plan (OPS-01) to document the specific plans for directing the early phases of the JWST mission (launch, deployment and trajectory correction, and cruise and commissioning).

1.4.1.4 Operations Phase

The Operations phase begins when the Observatory is declared ready to execute its science mission and continues for the duration of the mission. This phase is planned to commence 6 months post launch and includes the actual execution of the science program as well as the maintenance, calibration and recovery activities needed to preserve the ability of JWST to conduct the science program.

The JWST Mission Operations Concept Document (MOCD) (JWST-OPS-002018) provides an overview for the operation of JWST as a whole and provides a framework for more detailed description of operations of individual portions of JWST as detailed in the following documents:

- JWST NIRCam Operations Concept Document (JWST-OPS-002843)
- JWST NIRSpec Operations Concept Document (JWST-OPS-003212)
- JWST MIRI Operations Concept Document (JWST-OPS-003492)
- JWST FGS-Guider Operations Concept Document (JWST-OPS-004818)
- JWST FGS-Tunable Filter Operations Concept Document (JWST-OPS-004819)
- JWST Science and Operations Center Operations Concept Document (JWST-OPS-002636)

The Mission Operations are delineated in sections 5, 6, and 7 of the MOCD. The table of contents for these sections is provided herein for reference.

7.3 Ground System Fault Detection and Recovery

Upon completion of the JWST mission, the observatory will be decommissioned and, with the use of residual orbit station keeping fuel, will be "removed" from the L2 orbit and placed in a deep space coast orbit.

1.4.2 Technical Approach

As shown in Figure 1-2, JWST System is an amalgam of three distinct Segments; the Observatory Segment, the Ground Segment, and the Launch Segment. Each of these Segments is further delineated as Elements.

1.4.2.1 Observatory Segment

Figure 1-4 defines the JWST Observatory Segment architecture, its three elements, and their principal subsystems/assemblies.

Optical Telescope Element (OTE)	Spacecraft Element	Integrated Science Instrument Module (ISIM)
Primary Mirror Subsystem	**Spacecraft Bus**	**Science Instruments**
Primary Mirror Segment Assembly	Attitude Control Subsystem	Near Infrared Camera (NIRCam)
Primary Mirror Backplane Assembly	Command and Data Handling Subsystem	Near Infrared Spectrograph (NIRSpec)
Secondary Mirror Subsystem	Communications Subsystem	Mid Infrared Instrument (MIRI)
Secondary Mirror Assembly	Electrical Power Subsystem	Fine Guidance Sensor (FGS)
Secondary Mirror Support Structure	ISIM Electronics Compartment	FGS – Tunable Filter (FGS-TF)
Aft Optics Subsystem	Propulsion Subsystem	**ISIM Infrastructure**
Deployment Tower Subsystem	Spacecraft Flight Software	ISIM Structure
ISIM Enclosure Subsystem	Structure Subsystem	ISIM Thermal Control System
	Thermal Control Subsystem	ISIM Flight Software
	Sunshield Subsystem	ISIM Harness Assemblies
	Thermal Membranes	ISIM Command & Data Handling
	Deployment Hardware	

Figure 1-4 JWST Observatory Architecture

Figure 1-5 provides a pictorial concept of the JWST Observatory.

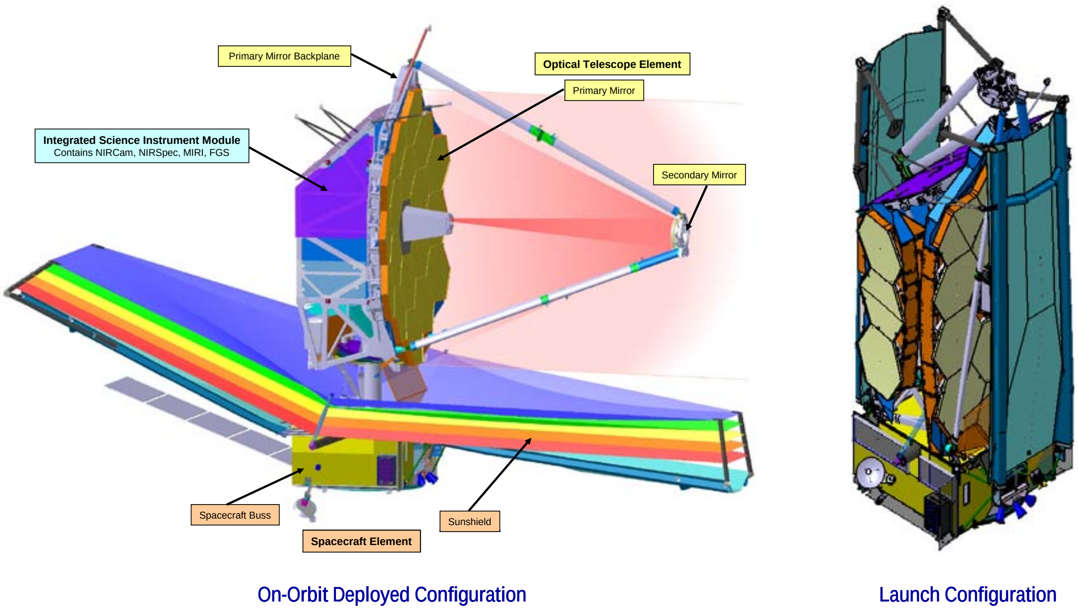


Figure 1-5 JWST Observatory Concept

Detailed description of the architecture may be found in the JWST Architecture Description Document (JWST-ARCH-004617)

1.4.2.1.1 Optical Telescope Element

The OTE is an approximately 25 square meter deployable optical system with diffraction-limited performance at 2 µm and a stable Point Spread Function (PSF). The OTE provides a low emission and scatter background to the Science Instrument (SI) payload.

The OTE is a three mirror antistigmat mirror system; it includes three mirrors, known as the primary mirror, the secondary mirror, and the tertiary mirror. The OTE has 2 other components: the Fine Steering Mirror (FSM) and the structure pieces to hold everything together [the secondary mirror support structure (SMSS) and the primary mirror backplane assembly (PMBA)]. The OTE tertiary mirror and the fine steering mirror are both contained within the OTE Aft Optics Subsystem. The PMBA, in addition to holding the OTE together will be where the science instruments, in the Integrated Science Instrument Module (ISIM), are installed in the Observatory.

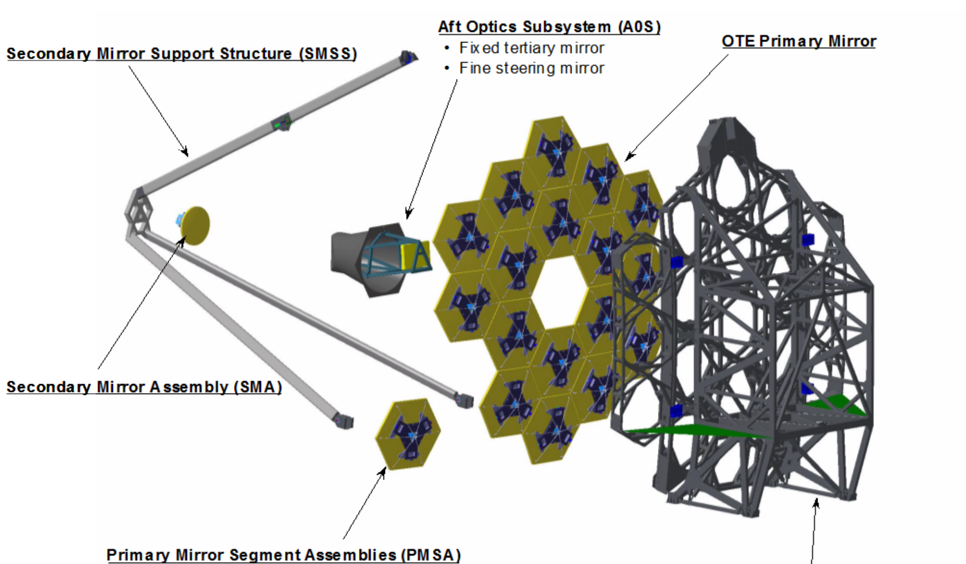


Figure 1-6 Optical Telescope Assembly Components

As there is no launch vehicle large enough to hold a 6.5-meter mirror if it was all one piece. The OTE is 18 hexagonal primary mirror assembly segments which can be folded up to fit into the launch vehicle and then unfold after launch. So that the segments work together as a single large mirror, the 18 segments have been divided into 3 groups of six mirrors, each group having a slightly different shape (prescription) and a system known as Wavefront Sensing & Control has been developed.

1.4.2.1.2 Integrated Science Instrument Module

The ISIM is the Payload of the JWST. The ISIM includes the following instruments:

- Near-Infrared Camera (NIRCam) – provided by the University of Arizona
- Near-Infrared Spectrograph (NIRSpec) – provided by ESA
- Mid-Infrared Instrument (MIRI) – provided by the European Consortium (EC) (with the European Space Agency (ESA)) and the NASA Jet Propulsion Laboratory (JPL)
- Fine Guidance Sensor (FGS) – provided by the Canadian Space Agency (CSA). The FGS contains a dedicated Guider (FGS-Guider) and an FGS-Tunable Filter Camera (FGS-TF).

The Goddard Space Flight Center provides the ISIM infrastructure subsystems required for operation of the Instruments. These items include the following:

- ISIM Structure Subsystem
- ISIM Electronics Compartment
- ISIM Thermal Control Subsystem
- ISIM Control and Data Handling (ICDH) Subsystem
- ISIM Flight Software (IFSW)
- ISIM Harness Assemblies

The ISIM is distributed across the three regions of the Observatory.

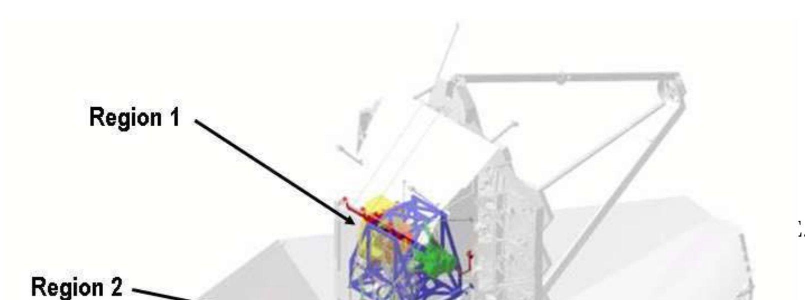
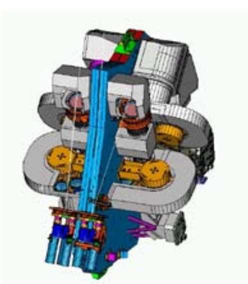


Figure 1-7 ISIM Overview

- The Region 1 component is the cryogenic instrument module comprised of the SI and FGS optics assemblies mounted to the ISIM Structure. The instrument module is integrated with the OTE Backplane Support Fixture (BSF) and is enclosed within the ISIM/OTE Thermal Management Subsystem. The ISIM/OTE Thermal Management Subsystem provides passive cooling of the cryogenic instrument module to a nominal operating temperature of 39K.
- The Region 2 component is the ISIM Electronics Compartment (IEC) that provides the mounting surfaces and ambient thermally controlled environment for the instrument control electronics. The IEC is integrated to the OTE BSF in close proximity to the cryogenic instrument module.
- The Region 3 component, located within the Spacecraft Bus, is the ISIM Command and Data Handling (ICDH) subsystem, with integral ISIM flight Software (IFSW), and the MIRI cryocooler compressor and control electronics.

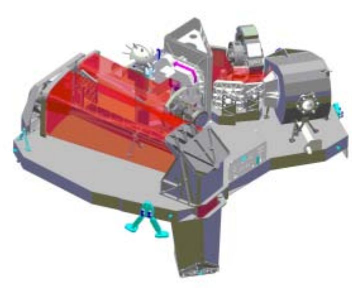
1.4.2.1.2.1 Near Infrared Camera



The Near Infrared Camera (NIRCam) is a large Field of View (FOV) broadband, high angular resolution imager and serves as both a science instrument and the Optical Telescope Element wavefront sensor. The NIRCam covers a spectral range of 0.6-5 micrometers utilizing a complement of 10 Mercury Cadmium Telluride (HgCdTe) detector arrays.

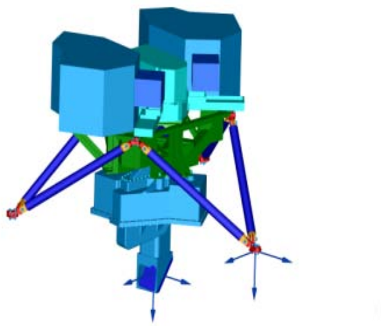
1.4.2.1.2.2 Near Infrared Spectrograph

The Near Infrared Spectrograph (NIRSpec) provides users of JWST with the ability to obtain simultaneous spectra of more than



100 objects in a 9 square arc-minute field of view. The NIRSpec employs a Micro-electromechanical System (MEMS) Micro-Shutter Array (MSA) for aperture control. The NIRSpec utilizes a complement of 2 HgCdTe detector arrays. This instrument provides medium resolution (R in the range of 1000 – 3000) spectroscopy over a wavelength range of 1 - 5 micrometers and low resolution (R ~ 100) spectroscopy over 0.6 - 5 micrometers.

1.4.2.1.2.3 Mid-Infrared Instrument

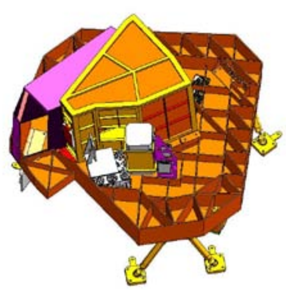


The Mid-Infrared Instrument (MIRI) is an imager/spectrograph that covers the spectral range of 5 - 27 micrometers in both functions with a goal of spectroscopic coverage to 29 micrometers. The MIRI utilizes a complement of 3 Arsenic doped Silicon (Si:As) detector arrays. The camera module provides wide field broadband (R~4) imagery and the spectrograph module provides medium resolution (R~3000) integral field spectroscopy over a small FOV relative to the imager.

The nominal operating temperature for the MIRI is 7K. This level of cooling cannot be attained using the passive cooling provided by the ISIM/OTE Thermal Management Subsystem, thus active cooling, using a cryocooler system will provide the added cooling capabilities required. The cryocooler system is comprised of a Pulse Tube (PT) precooler to attain 18K. Subsequently, a Jules- Thomson Loop (JT) heat exchanger provides the final stage of cooling to bring the instrument to the nominal 7K operating temperature. The cryocooler compressor assembly and control electronics are housed in the Spacecraft Bus. A cold head assembly is mounted on the MIRI. Coolant lines link these two assemblies.

1.4.2.1.2.4 Fine Guidance Sensor

The Fine Guidance Sensor - Guider (FGS-Guider) is a very broadband guide camera that is incorporated into the cryogenic instrument payload in order to meet the image motion requirements of the JWST. The FGS is used for both "guide-star" acquisition and fine pointing. The FGS operates over a wavelength range of 1-5 micrometers utilizing a complement of 2 HgCdTe detector arrays . Its FOV is sufficient to provide a 95% probability of acquiring a guide star for any valid pointing direction. During normal observations, the FGS provides the pointing error signal used by the OTE and SC to maintain a stable and accurate optical LOS.



The FGS-Tunable Filter Camera (FGS-TF) is a wide field, narrow-band (R~100) camera that provides imagery over a wavelength range of 1.6 to 4.9 micrometers, with a gap between 2.6 and 3.1 micrometers, via tunable Fabry-Perot etalons that are configured to illuminate the detector array with a single order of interference at a user selected wavelength. The FGS-TF utilizes a single HgCdTe detector array.

1.4.2.1.3 <u>Spacecraft Element</u>

The Spacecraft Element has 2 components, the spacecraft bus and the sunshield.

1.4.2.1.3.1 Spacecraft Bus

The spacecraft bus provides a highly stable pointing platform and housekeeping functions for the Observatory.

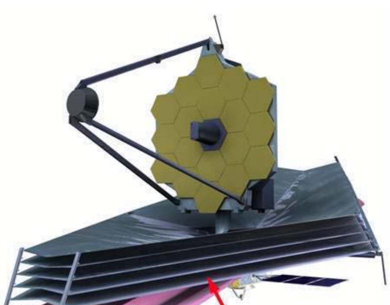
The bus is comprised of six major subsystems:

- Electrical Power Subsystem -- converts sunlight shining on the solar array panels into the power needed to operate the other subsystems in the bus as well as the Science Instrument Payload
- Attitude Control Subsystem -- senses the orientation of the Observatory, maintains the Observatory in a stable orbit, and provides the coarse pointing of the Observatory to the area on the sky that the Science Instruments want to observe
- Communication Subsystem -- receives instructions (commands) from the Operations Control Center and sends (transmits) the science and status data and to the OCC
- Command and Data Handling Subsystem -- the system has a computer, the Command Telemetry Processor (CTP) that takes in the commands from the Communications System and directs them to the appropriate recipient. The C&DH also has the memory/data storage device for the Observatory, the Solid State Recorder (SSR). The CTP will control the interaction between the Science Instruments, the SSR and the Communications System
- Propulsion Subsystem -- contains the fuel tanks and the thrusters that, when directed by the Attitude Control System, are fired to maintain the orbit
- Thermal Control Subsystem -- Maintains the operating temperature of the spacecraft bus.

Additionally, the Spacecraft Bus houses the ISIM control and data handling electronics and the MIRI cryocooler compressors and control electronics.

1.4.2.1.3.2 Sunshield

Science and other top-level JWST requirements drive the need for a deployable, low areal density, high thermal performance efficiency (effective emittance, of 1E-4 to 1E-5) Sunshield to passively cool the Observatory telescope elements and Integrated Science Instruments Module (OTE/ISIM). The thermal performance dictated the need for a Sunshield consisting of multiple, space membrane layers such that the ~200 kW of sun's energy impinging on the sun-facing layer would be attenuated such that the heat emitted from the rear or OTE-facing membrane would be <1W. This would enable the OTE/ISIM to operate at cryogenic temperature levels (<50K) and have a temperature stability of 0.1 to 0.2K over the field-of-regard pointing re-alignments. From the above top-level mission requirement evolved a Sunshield with 5 membrane layers with pitch and dihedral separation angles of 1.6 and 2 degrees, respectively. Through the use of a low solar absorptance-to-emittance ratio (α_s/ε_H) coating on the sun-facing surface (layer 1) and an infrared highly reflective coating on the majority of the other membranes' surfaces, the sun's heat load absorbed by the sun-facing membrane is reduced and the resulting infrared energy reemitted to the other layers would be reflected laterally out the open sides of the Sunshield, thus greatly attenuating the residual infrared energy emitted by the OTE/SIM-facing membrane surface (layer 5).



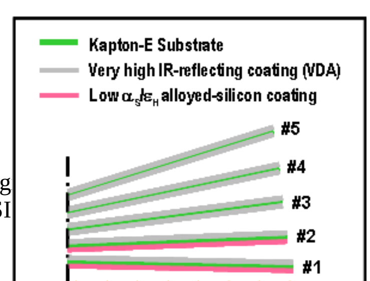


Figure 1-8 Sunshield Overview

From a variety of trade studies the Sunshield evolved into a 5-membraneassembly, with membranes 140 to 150m^2 in size that are supported by spreader bar/boom assemblies and are lightly tensioned in a deployed configuration by constant-force spring-loaded catenary cable assemblies attached to the periphery of each membrane. The coating selected for the sun-facing surface of membrane 1 (and layer 2 to provide a redundant layer to layer 1) was an alloyed-silicon, semi-conductive material; the coating selected for the other membrane surface was a infrared highly reflective metallic coating, vacuum-deposited aluminum (VDA). For the bulk membrane material, because of the need for reduced weight and excellent mechanical properties under the extreme L2 mission environments, thin, 25 and 50 μm (1-mil, 2-mil), unreinforced polymide Kapton E was chosen.

When fully deployed, the sunshield will be roughly 15 meters x 19 meters..

1.4.2.2 Ground Segment

Figure 1-9 defines the Ground Segment architecture, its three elements, and their principal subsystems.

Science and Operations Center S&OC	Institutional systems	Common Systems
Proposal Planning Subsystem	Deep Space Network	Project Reference Database
Flight Operations Subsystem	JWST Network Support System	Common Command and Telemetry System
Data Management Subsystem	Flight Dynamics Facility	
Project Reference Database Subsystem	Wavefront Sensing and Control Executive Subsystem	

Figure 1-9 Ground Segment Architecture

Figure 1-10 shows the interaction of the Ground Segment elements internal to the Ground Segment as well as with the Observatory during the Operations Phase of the mission.

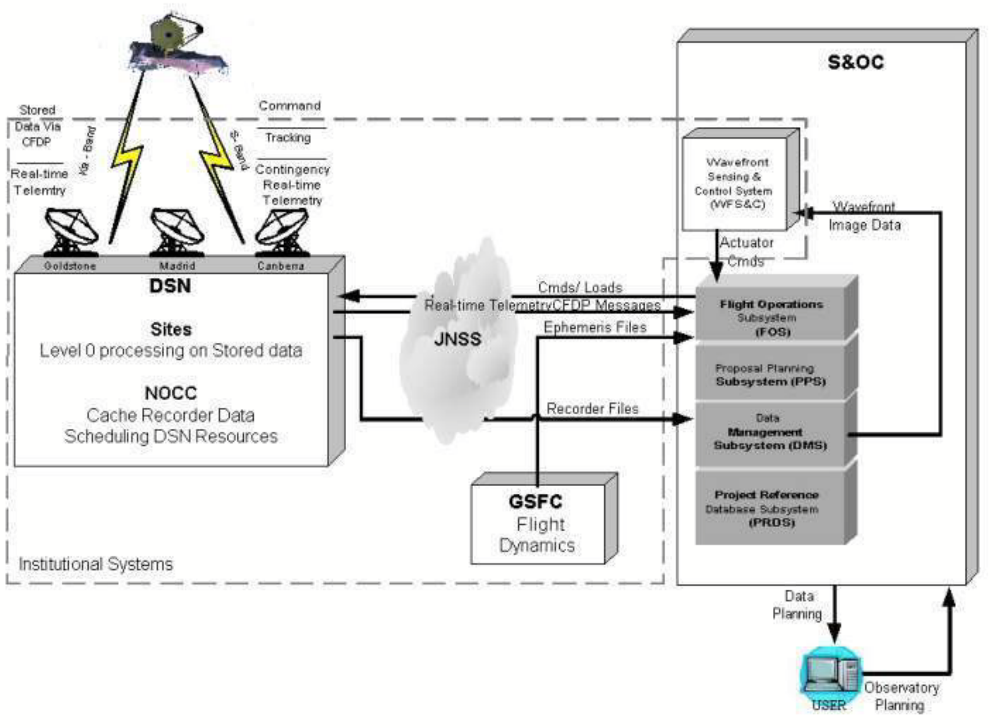


Figure 1-10 Ground Segment Interaction

The requirements for the ground segment are delineated in the JWST Ground Segment Requirements Document (JWST-RQMT-001056).

1.4.2.2.1 Science and Operations Center

The S&OC, located at the Space Telescope Science Institute (STScI), is responsible for operating the JWST Observatory and enables the scientists to plan and complete their scientific investigations. These activities are accomplished via the S&OC's subsystems. The major subsystems of the S&OC include the Proposal Planning Subsystem (PPS), Data Management Subsystem (DMS), Project Reference Database Subsystem (PRDS) and Flight Operations Subsystem (FOS).

The PPS provides the proposal solicitation, processing and planning functions required to generate the science program and generate the Observation Plan. This subsystem also provides for submitting and administering grants.

The FOS provides the command data uplink and telemetry capture functions, performs telemetry processing necessary to monitor Observatory status, monitors Observatory and Ground status, and detects and notifies operations personnel in the event of an anomaly (Observatory or Ground). It contains the Common Command and Telemetry System (CCTS), which was originally a part of the Common Systems element.

The DMS provides the data processing, archive, catalog, calibration, distribution and analysis functions required to support the science program and maintenance of Observatory performance.

The PRDS is comprised of the Project Reference Database (PRD) and database tools. It is the repository for all JWST data and information required for Observatory operations, such as telemetry descriptors, commands, parameters, algorithms, and characteristics. It provides the configuration management, change process management, and data distribution functions required to provide operational data to the S&OC systems.

The S&OC also houses other components, developed by other elements, such as the Wavefront Sensing and Control (WFSC) Executive Subsystem and Observatory simulators.

1.4.2.2.2 Institutional Systems

The Ground Segment's Institutional Systems is made up of government resources including the Deep Space Network (DSN), GSFC Flight Dynamics Facility (FDF), the JWST Network Support System (JNSS) and the Wavefront Sensing and Control (WFSC) Executive Subsystem.

The Deep Space Network (DSN) along with the Deep Space Mission Systems (DSMS) Office is responsible for the flight to ground communications portion of the mission. All flight to ground communications go through the DSN. Its major components are the Network Operations Control Center (NOCC) at the Jet Propulsion Laboratory (JPL) and the Signal Processing Centers at Goldstone Ca, Madrid Spain and Canberra Australia. DSN performs Level-0 processing on the recorded Observatory data prior to forwarding it to the S&OC.

The FDF is responsible for the mission's orbit determination and tracking and ranging support. It interacts with the S&OC and supports the validation of on-board navigation systems, design and implementation of orbit maneuvers through all phases of the mission. After insertion into the L2 orbit, ranging information will provide the basis for planning of the Delta-V maneuvers required to maintain the orbit, and for monitoring the results of such maneuvers. Tracking and ranging services are also required for accurate and efficient acquisition of the DSN ground stations by JWST.

The JNSS provides the telecommunication services needed for the transmission of data between the DSN and the S&OC.

The WFSC Executive Subsystem will store and process science and engineering data obtained to measure wavefront error. The Executive Services portion of the subsystem is developed at the STScI and falls under Institutional Systems. It provides the user interface and performs such functions as data management and process control. It also houses the WFSC algorithms and mirror control software that are developed by Ball Aerospace under contract to Northrop Grumman Space Technologies (NGST). The algorithms are developed and provided by the Optical Telescope Element. Wavefront control output products (i.e., actuator commands) are produced that will be uplinked to correct the optical figure of the telescope.

1.4.2.2.3 Common Systems

The Common Systems element of the Ground Segment is comprised of subsystems, Common Command and Telemetry System (CCTS) and the Project Reference Database (PRD), that are used for Project I&T activities and subsequently as foundations for S&OC operational subsystems.

The CCTS is the real-time command and telemetry system used to communicate with the Observatory. Real-time commanding and health and safety monitoring are accomplished via the CCTS as are the loading of on-board tables and files. The CCTS provides an interface for the operator to the command and telemetry database.

The PRD is the configuration-controlled source of command and telemetry formats and definitions used during development, integration & test and operations of the JWST Observatory and Ground Segment. The PRD includes definitions and descriptions of commands, command parameters, health and safety limitations, related telemetry verifiers, and command sequences and scripts. Also included are definitions and formats of telemetry monitors, location in telemetry stream, parameters for conversion to engineering units, health and safety limits, and display page formats. The PRD includes constants that define spacecraft characteristics, ground system characteristics, and constants that define constraints, restrictions and operational limitations. The PRD will contain any constant data that is needed for operation of the Observatory or Ground Segment.

1.4.2.3 Launch Segment

The JWST launch segment has 3 elements: 1) Launch Vehicle, 2) Payload Adapter, and 3) Launch Services.

1.4.2.3.1 Launch Vehicle

The baseline launch vehicle is the Ariane 5 ECA Expendable Launch Vehicle (ELV) to be provided by the ESA under the provisions of the Memorandum of Understanding (MOU) (JWST-MOU-001211) between NASA and ESA to conduct the JWST mission.

In compliance with NPD 8610.7 (Launch Services Risk Mitigation Policy for NASA-Owned and/or NASA-Sponsored Payloads/Missions), a LSP risk assessment has revealed that no launch vehicle certification is required for JWST due to an appropriate balance between mission criticality and launch vehicle maturity and flight history, based on the following:

- The long successful history of the Ariane
- The announced (as of March 2007) 8 consecutive successful flights of the ECA configuration.

ESA is responsible for the overall success of the ESA contribution of the JWST mission.

- Under contract with ESA, Arianespace is the JWST Launch Vehicle Provider and is responsible for the overall success of the Launch Vehicle Contract.

1.4.2.3.2 Payload Adapter

In accordance with the James Webb Space Telescope National Aeronautics and Space Administration/Goddard Space Flight Center and European Space Agency Project Launch Segment Joint Project Implementation Plan (JWST-PLAN-003468), ESA/Arianespace will provide a standard adapter for JWST.

1.4.2.3.3 Launch Services

Under the provisions of the MOU, ESA will provide the "standard" Ariane 5 launch services.

Under the provisions of the MOU and delineated in the JWST Launch Segment JPIP, NASA will provide those non standard services (NSS) as agreed between NASA and ESA as being the responsibility of NASA. The NSS may include, but possibly not be limited to, the following:

- Payload Fairing customization for Observatory Access
- Launch Campaign Duration in excess of 30 days
- Extraordinary *(or supplementary)* Contamination Control
- Multiple Launch Programs (i.e., trajectory optimization(s) for given launch dates and/or times)

1.4.2.4 Operations Concept

In order to address the system efficiency requirements, JWST has adopted an "Event-Driven" approach to operations. Event-driven means that there is a queue of activities that are executed sequentially. An activity is started and returns a flag or message indicating successful or unsuccessful completion of the activity. When the first activity ends, the next activity begins. Exact times that the first activity has to begin and end are not pre-ordained, the only option the S/W has is to start or skip the next activity in a list of activities.

The queue is specified by the Observation Plan, a list of the high level activities/visits/pointings. The Observations Plan is processed by a master (Java) script called the Observation Plan Executive (OPE) resident in the ISIM C&DH. The OPE calls lower level scripts stored in the IC&DH based on detailed information in visit files

1.5 AUTHORITY, GOVERNANCE, AND MANAGEMENT STRUCTURE

1.5.1 <u>Management Structure</u>

1.5.1.1 Program Management

The NASA HQ organization programmatically responsible for the JWST is the Science Missions Directorate, Universe Division. Program authority is delegated from the NASA HQ Associate Administrator (AA) for the SMD to the JWST Program/Project Manager, located at the Goddard Space Flight Center (GSFC). The SMD provides the JWST Program/Project with Mission Requirements, Program/Project Schedule (launch readiness date), and budget authority to procure and manage the development of the JWST System (Observatory Segment, Ground Segment, and Launch Segment).

The JWST Program is a cooperative effort with and between the NASA, the European Space Agency (ESA), and the Canadian Space Agency (CSA). Each agency has established a JWST Project office to provide the management of their respective programmatic contributions. The NASA JWST Program/Project Manager provides overall program management for the JWST mission.

The NASA JWST Program/Project Manager and the ESA JWST Project Manager will be the single points of contact for programmatic requirements and NASA/ESA issues at the project level.

The NASA JWST Program/Project Manager and the CSA JWST Project Manager will be the single points of contact for programmatic requirements and NASA/CSA issues at the project level.

The flow of programmatic authority for the JWST Program/Project is shown in Figure 1-11.

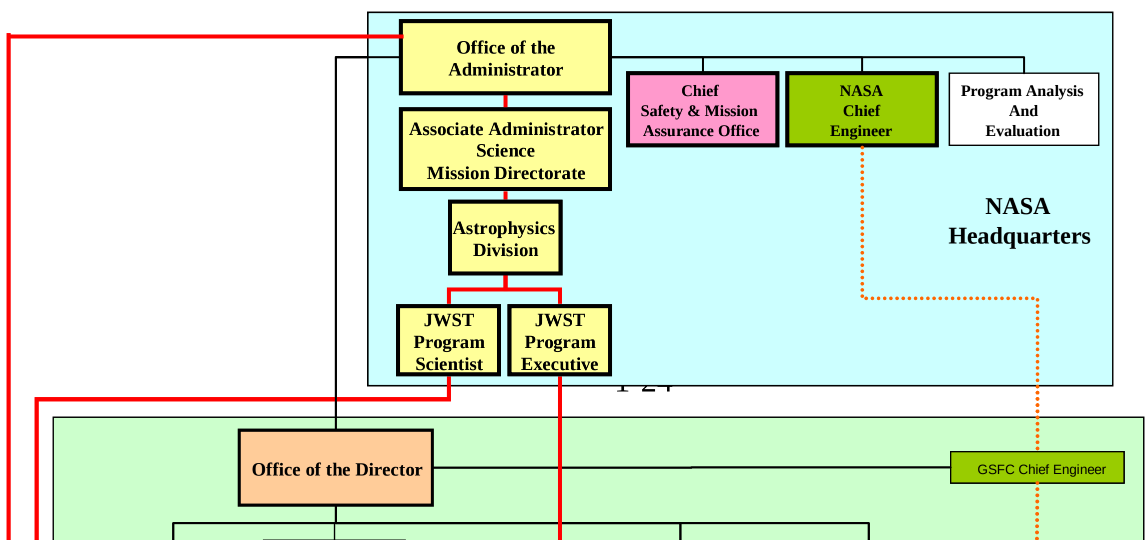


Figure 1-11 JWST Governance / Programmatic Authority Flow

The JWST Program/Project Office is located at the Goddard Space Flight Center (GSFC) within the Flight Projects Directorate. The GSFC provides the JWST Program/Project Manager requisite infrastructure and staffing. The JWST Project staff interfaces with functional GSFC directorates and facilities to plan, implement, and coordinate development of the JWST System.

All management responsibilities are delineated according to the JWST Project Work Breakdown Structure and Work Breakdown Structure Dictionary (JWST-WBS-000776).

1.5.1.2 Project Management

The organizational structure of the JWST Project is shown in Figure 1-12.

The GSFC JWST Program/Project Manager manages the JWST Project.

The current revision of the JWST Project organization chart (JWST-REF-000869) may be found on the JWST Project management website, known as the Next Generation Integrated Network (NGIN) (https://ngin.jwst.nasa.gov).

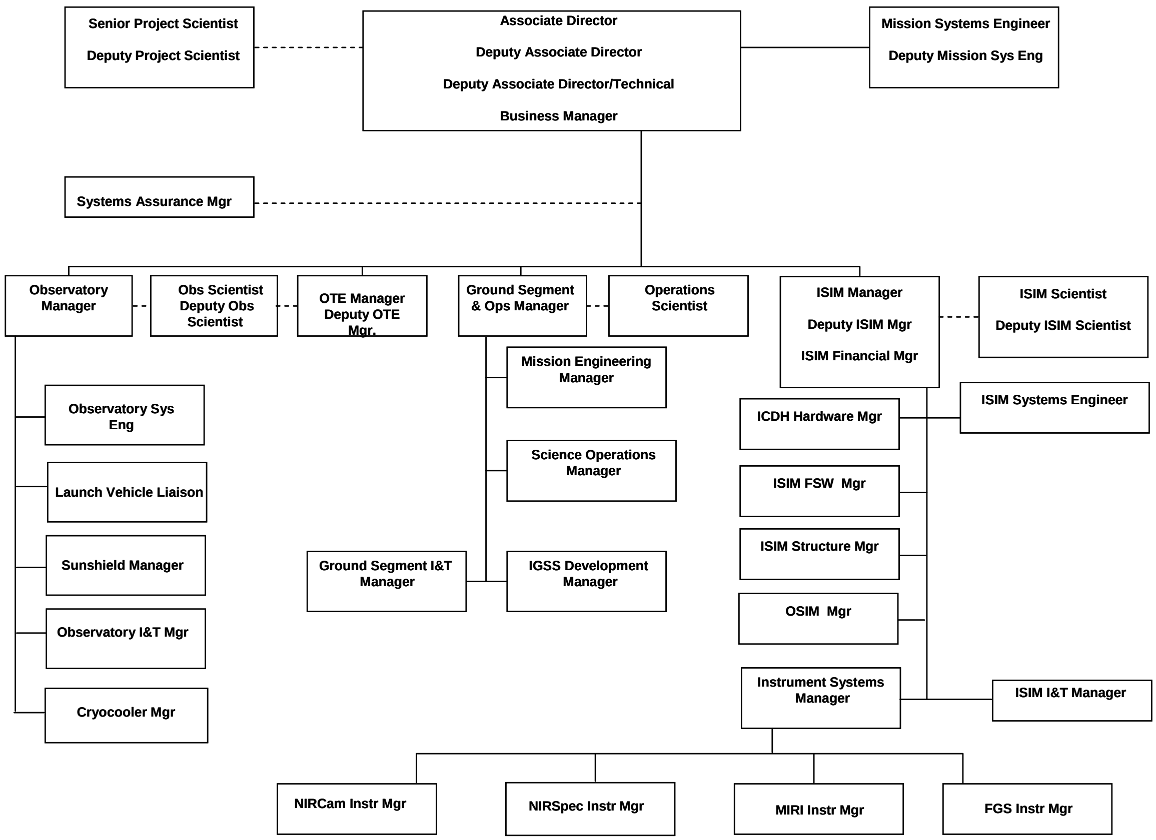


Figure 1-12 JWST Project Organization

1.5.2 Partner Organizations

The JWST Program is a cooperative effort with and between the NASA, the European Space Agency (ESA), and the Canadian Space Agency (CSA).

1.5.2.1 European Space Agency

Under the provisions of the Memorandum of Understanding (MOU) (JWST-MOU-001211) between NASA and ESA to conduct the JWST mission, the ESA will provide the following:

- Near-Infrared Spectrograph (NIRSpec) science instrument
- The Optical Bench Assembly (OBA) of the MIRI, in association with the European Consortium (EC)
- Launch of the JWST by means of an Ariane 5 Expendable Launch Vehicle (ELV)
- Assist in the operation of the JWST and related facilities, and arrange for participation of ESA-sponsored astronomers in the observation program.

1.5.2.2 Canadian Space Agency

Under the provisions of the Memorandum of Understanding (MOU) (JWST-MOU-001212) between NASA and CSA to conduct the JWST mission, the CSA will design, develop, assemble, test, and qualify the FGS, as well as providing requisite ground and flight software packages.

1.5.3 Special Boards and Committees

1.5.3.1 Science Working Group

The Science Working Group (SWG) is chartered by and reports to the JWST Program Scientist at NASA HQ. It is the main scientific coordination body of the Program. It is chaired by the JWST Senior Project Scientist and advises the Project Manager on a regular basis.

The SWG membership comprises the Scientific Instrument Principal Investigators (PIs), Telescope Scientist, Interdisciplinary Scientists (two of the JWST Interdisciplinary Scientists are from ESA member states), ESA's designated lead scientists for the NIRSpec and MIRI, Project Scientists from NASA (Senior and Deputy Project Scientist, ISIM and Observatory Project Scientists), ESA, CSA, and the AURA/STScI. The external members of the SWG are competitively selected through the NASA Announcement of Opportunity (AO) process.

The two JWST Interdisciplinary Scientists from ESA member states are sponsored by ESA in the sense that ESA covers their travel expenses when attending SWG and related meetings. ESA also covers the travel expenses of the European MIRI Consortium Principal Investigator and the NIRSpec Science Representative when attending SWG meetings. NASA (or CSA) covers the expenses of the remaining members of the SWG.

The SWG will work in collaboration with the, JWST Project, NASA HQ Program, AURA/STScI and the astronomical community to advise the Project Scientist and Project Manager on all project-wide scientific issues; provide coherent scientific leadership during the formulation, design, construction, launch, and early scientific operation of the JWST; refine science requirements and performance metrics and objectives for the JWST telescope, instrumentation, software, operations, and other aspects of the program; participate in negotiations involving the Observatory/science interfaces; participate in refining the mission design; review the work of the Program from beginning to end, by participating in JWST Program reviews; assist the JWST project in mission decisions by assessing the scientific implications of design concepts and implementation plans; recommend solutions to technical and resource problems during the development and implementation phases of the mission; as a liaison to the astronomy community, assist NASA in the dissemination of information about JWST; prepare materials for review by external scientific advisory groups and oversight committees.

1.5.3.2 Optical Product Integrity Team

The purpose of the Optical Product Integrity Team (PIT) is to provide world-class optics technical expertise to the JWST project. The PIT will help the JWST Project identify and prioritize potential technical problems early in the program and will help resolve key technical issues, results and problems as they arise.

Members of the PIT have expertise in areas that include optical testing, optical design, optical modeling, wavefront sensing and control, cryo-optics, segmented optics, error budgeting, optical fabrication, optical alignment, and opto-mechanical/stability issues

PIT members will participate in peer reviews or formal design reviews as appropriate.

PIT members are selected and their activities funded by the NASA/GSFC JWST Project.

1.5.3.3 Sunshield Independent Review Team

The purpose of the Sunshield Independent Review Team (SIRT) is to provide world-class technical expertise to the JWST project. The SIRT will help the JWST Project identify and prioritize potential technical problems early in the program and will help resolve key technical issues, results and problems as they arise. SIRT team members are selected based on their expertise in mechanical structures, deployment systems, mechanisms, materials, thermal design, and space system engineering.

The SIRT team acts in conjunction with an independent review team internal to the Sunshield Prime Contractor.

SIRT members will participate in peer reviews or formal design reviews as appropriate.

SIRT members are selected and their activities funded by the NASA/GSFC JWST Project.

1.5.3.4 Thermal System Verification Advisory Team (TVAT)

The purpose of the Thermal System Verification Advisory Team (TVAT) is to provide world-class thermal testing technical expertise to the JWST project. The TVAT is a standing review team that continually reviews thermal test plans and associated thermal and cryogenic analyses as they mature. The TVAT will help the JWST Project identify and prioritize potential problems early in the test planning process and will help resolve key testing technical issues and problems as they arise.

TVAT members consist of experts in the fields of cryogenic and thermal design and testing.

TVAT meetings will occur on a regular basis and TVAT members will participate in peer reviews or formal design and reviews as appropriate.

TVAT members are selected and their activities funded by the NASA/GSFC JWST Project.

1.5.3.5 NASA Resident Office(s)

The Project will establish resident offices at the Observatory Prime Contractor facilities during the observatory integration and test phases.

The Project will establish resident office(s) at the Science Instrument contractor facilities during the instrument integration and test phases.

Due to the close proximity of the AURA/STScI facility to the GSFC Project Office, the Project does not plan to establish a resident office at the AURA/STScI facility.

1.5.4 <u>Program/Project Lines of Communication</u>

The program/project is encouraging (requiring) "full and open communications" between all parties. The communications are for both technical and managerial topics. The lines of communication are illustrated in Figure 1-13.

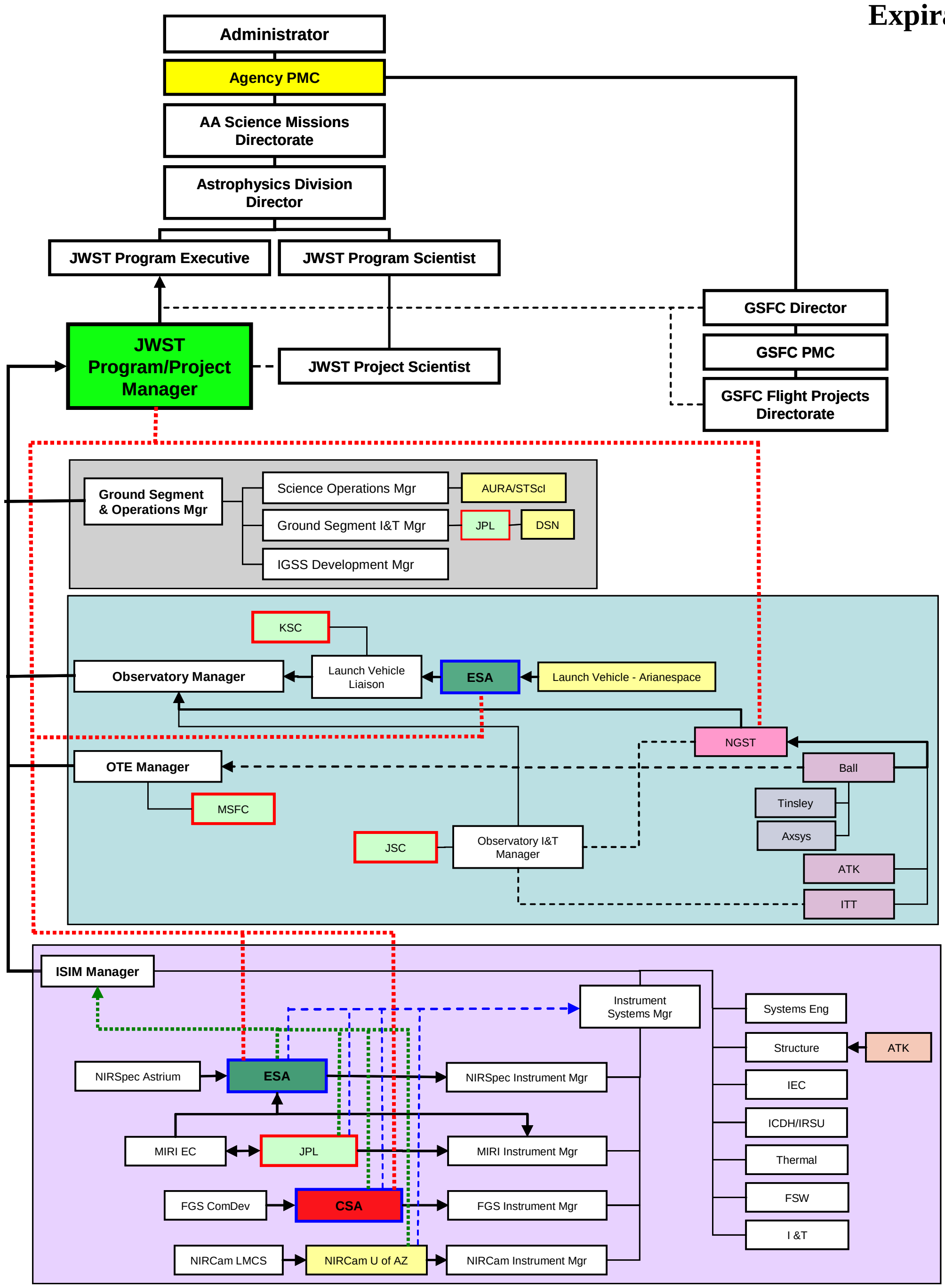


Figure 1-13 Program / Project Lines of Communication

Table 1-2 is a partial/illustrative listing of the "standing" meetings that have been established to foster the communications on the program/project.

Table 1-2 JWST Program / Project "Standing" Meetings

Weekly Meetings		
Title	**Mgmt**	**Tech**
MIRI Systems Telecom		X
NIRCam Tech Telecom		X
Optical-Mechanical WG		X
MIRI JPL/GSFC Telecom		X
MIRI Mgmt Team Telecom	X	
ASIC Status	X	X
Optical Systems		X
Simulator Working Group		X
WFSC Telecom		X
OTE-ISIM IF		X
Ground Systems and Operation Senior Staff	X	X
Ground Systems and Operation General Staff	X	X
Integrated Ground Support System Discrepancy Review Board		X
Integrated Ground Support System WG		X
Information Technology/Computer Security Status	X	X
NGST/Raytheon Telecon	X	X
ISIM Systems		X
ICDH-FPE I/F Telecom		X
ISIM Electrical EMC WG		X
ISIM Harness WG		X
Integrated Modeling WG		X
Architecture WG		X
Thermal WG		X
Sunshield WG	X	X
IEC Working Group		X
ISIM Staff	X	X
ISIM-Observatory Tag Up	X	
OTE-ISIM IF Telecom		X
ESA-NASA Telecom	X	X
ISIM Subsystem Cost and Schedule Reviews	X	
Heat Strap WG		X
Project Manager Systems Engineering "Tag Up"	X	
Project Manager Observatory "Tag Up"	X	
Project Manager ISIM "Tag Up"	X	
Project Manager Resources "Tag Up"	X	
JWST Senior Staff	X	
JWST General Staff	X	
Center Director Project "Tag Up"	X	X
Observatory Trade Status and Top 10	X	X

Observatory Contract Management Videocon	X	
Bi-Weekly Meetings		
Title	**Mgmt**	**Tech**
FGS Systems Tag-Up		X
ISIM I&T Planning		X
FGS Mgmt Telecom	X	
S&OC Management/Contract Status	X	
S&OC Technical Exchange		X
Project Reference Database (PRD) Working Group		X
Mission Operations and Mission Services (MOMS) Tagup	X	
Science Working Group Telecom		X
Science Leads Telecom		X
Target Acquisition WG		X
Monthly Meetings		
Title	**Mgmt**	**Tech**
Contractor Monthly Status Review(s)	X	X
JWST/ISIM Project Monthly Status Review	X	
Contamination WG		X
Line of Sight WG		X
S&OC Monthly	X	
Mission Operations Working Group (MOWG)	X	X
NIRSpec Detector Subsystem Champions Meeting	X	X
NIRSpec Micro Shutter Subsystem Champion Team	X	X
Other Periodic Meetings		
Title	**Mgmt**	**Tech**
JWST Partners Workshop	X	X
NISN Customer Forum	X	X
Science Working Group	X	X
Town Hall Session @American Astronomical Society		X
JWST Session @ Society of Photo-Optical Instrumentation Engineers meeting on large telescopes		X

1.6 IMPLEMENTATION APPROACH

1.6.1 Programmatic Approach

The JWST Project is following the standard Program/Project Phases:

- JWST Mission Formulation
  - Conceptual Design Studies (Pre-Phase-A) – wherein a broad spectrum of ideas and alternatives for the mission were developed. An initial translation of the mission objectives into top-level technical requirements was made. These initial top-level requirements of the program/project were allocated to the various team members for further evaluation. For contractor team members, agreements are reached between the Program/Project office and

the performing organization for the cost, schedule, risk level, technical requirements, and products for each activity
  - Preliminary Design Development (Phase-A) – wherein the determination of the feasibility and desirability of JWST system and its compatibility with NASA's strategic plans was made. This phase culminated in the JWST Mission Definition Review, December 2001.

- JWST Observatory Implementation
  - Detailed Design Development – (Phases-B/C)
    - Phase-B – wherein the initial program/project baseline, which includes "a formal flow-down of the project-level performance requirements to a complete set of system and subsystem design specifications for both “flight and ground elements" and "corresponding preliminary designs is established to a sufficient level of detail so as to establish firm schedule and cost estimates for the program/project. Phase-B will culminate in the presentation of the Mission Preliminary Design Review and the Non-Advocate Review.
    - Phase-C – wherein a complete design (“build-to" baseline) that is ready to fabricate, integrate, and verify has been prepared. During this phase, technical parameters, schedules, and budgets are closely tracked to ensure that undesirable trends are recognized early enough to take corrective action. Phase C will culminate in the Mission Critical Design Review.
  - Production, Integration, and Test (Phase-D) – wherein the build and verification of the system designed in the previous phase, deployment/launch, and preparation for operations/on-orbit commissioning is to be performed.

- JWST Observatory Operations
  - Post commissioning operation of the JWST Observatory
  - Data processing and delivery

1.6.2 Acquisition Strategy

Implementation of the JWST is a collaborative effort between NASA, international partners (ESA and CSA), and domestic universities and industry.

1.6.2.1 Observatory Segment

The JWST observatory prime contractor, Northrop Grumman Space Technology (NGST), under contract with NASA through the GSFC, will design and develop the Optical Telescope Element, the spacecraft and the sunshield, and integrate, test, qualify, and support launch and commissioning of the JWST Observatory. NGST is leading a team including three major sub-contractors: Ball Aerospace, ITT, and Alliant Techsystems. The three principal beryllium mirror subcontractors to Ball Aerospace are Tinsley Laboratories; Axsys Technologies; and Brush Wellman Inc.

The ISIM is the Payload of the JWST. The Goddard Space Flight Center provides the ISIM infrastructure subsystems. Two of the subsystems are procured: the ISIM Structure Subsystem – contracted to Alliant Techsystems and the ISIM Thermal Control Subsystem – contracted to Space Dynamics Laboratory. The remaining subsystems are provided as “in-house” efforts: the ISIM Control Data Handling (ICDH) Subsystem, the ISIM Flight Software (IFSW), and the ISIM Harness Assemblies.

The ISIM includes the following instruments:

- Near-Infrared Camera (NIRCam) – provided by the University of Arizona
- Near-Infrared Spectrograph (NIRSpec) – provided by ESA
- Mid-Infrared Instrument (MIRI) – provided by the European Consortium (EC) (with the European Space Agency (ESA)) and the NASA Jet Propulsion Laboratory (JPL)
- Fine Guidance Sensor (FGS) – provided by the Canadian Space Agency (CSA). The FGS contains a dedicated Guider (FGS-Guider) and an FGS-Tunable Filter Camera (FGS-TF).

Figure 1-14 illustrates the roles and responsibilities of the organizations contributing to the Observatory Segment.

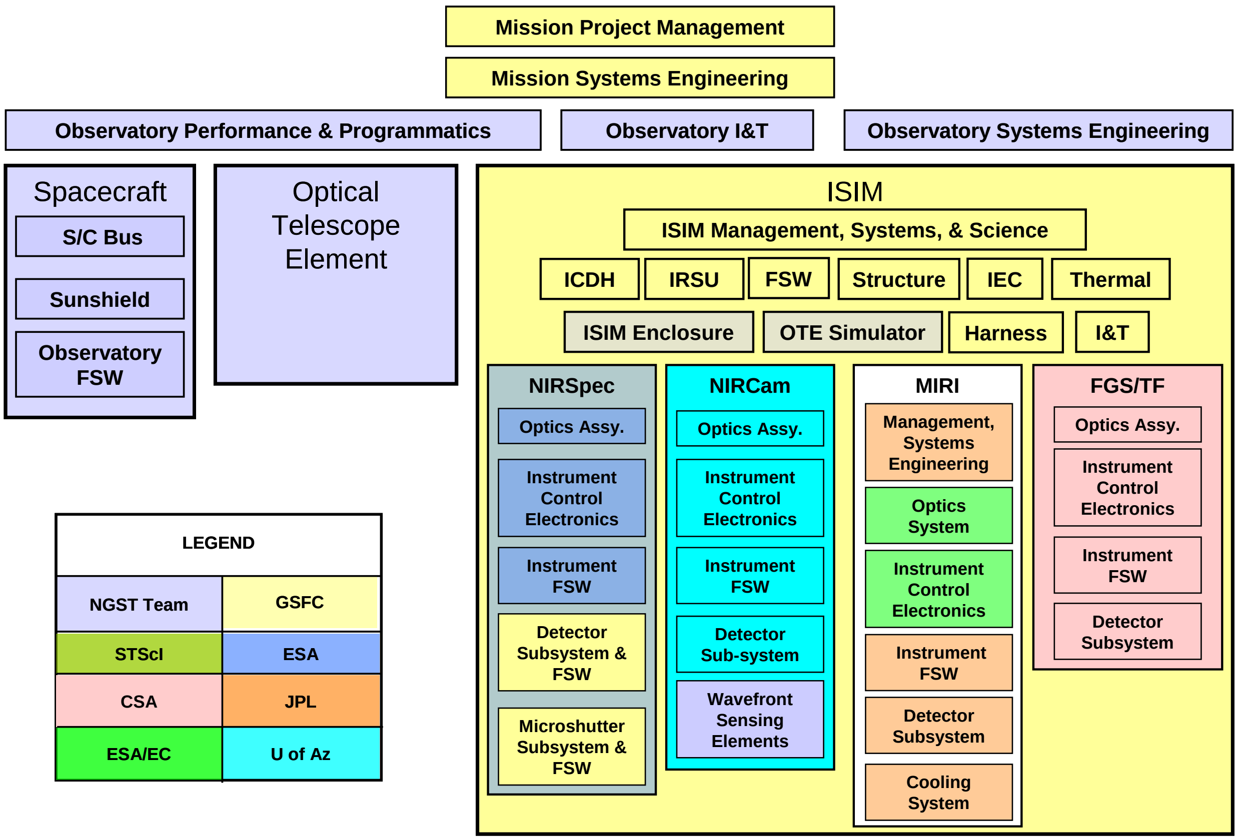


Figure 1-14 Observatory Segment Partner Rolls

1.6.2.2 Ground Segment

The Ground Segment will be the responsibility of the AURA/STScI through a contract with NASA, administered by the GSFC. The Ground Segment consists of two major elements, the S&OC and the Communications Element.

1.6.2.3 Launch Segment

The launch segment is provided by ESA with GSFC and NGST interface coordination activities.

1.6.3 Program/Project Dependencies

There are significant advantages to promoting partnerships, both domestic and international, during the development of the JWST observatory. Partnerships allow the costs of developing a spacecraft as technologically ambitious as JWST to be distributed across several entities and the benefits to be shared by all. There will be an increase in observatory scientific capability and productivity, as well as increased project contingency.

The JWST Project has both upstream and downstream dependencies within NASA as well as with industrial and international partners and external committees.

1.6.3.1 Related NASA Activities

JWST follows in the scientific footsteps of the 'Great Observatories' including HST, GRO, AXAF and SIRTF.

Other NASA Centers that play a significant role in JWST development are JPL (development of the MIRI), MSFC (AMSD development), ARC (detector technology), and JSC (large cryogenic vacuum test facility).

1.6.3.2 Related Non-NASA Activities

Major international partners include ESA and CSA, who will make significant technological contributions to the development of the science instruments. US university and industrial partners will also have a role in the development of the NIRCam instrument.

The STScI is a major partner, having responsibility for the development of the ground system as well as coordination of both science operations and flight operations.

The project is dependent on the support of the international scientific user community as well as the SWG.

1.7 STAKEHOLDER DEFINITION

The JWST Program/Project mission customers are the international public and astronomical community, as well as each of the partnering agencies.

1.7.1 International Public

The JWST Project will develop a plan that will establish the outreach responsibilities and coordination of the partnering agencies. In general, public releases during the development and commissioning phase will be the responsibility of the appropriate partner agency but will be coordinated with the other partners sufficiently in advance that common or simultaneous releases are encouraged and conflicting or erroneous releases are avoided. NASA will be the lead agency for public releases during the pre-launch through commissioning phase and will be responsible for informing the press prior to and following all major activities.

During the operations phase, the partnering agencies will coordinate their releases and assist astronomers within their nations in communicating the exciting scientific results of their observations. Within the U.S., the Space Telescope Science Institute (STScI) Science and Operations Center (S&OC) will assist astronomers in preparing and presenting their work to the public and will coordinate all releases with the JWST Project and NASA HQ. NASA HQ will be responsible for the development of educational materials based upon JWST discoveries using established organization such as the Origins Forum at the STScI.

1.7.2 International Astronomers

The international astronomical community desires access to the unique capabilities of the JWST observatory and to data within its archives. During the development phase, the scientific communities advising the partnering agencies will be vitally interested in decisions and progress made by the respective space agencies. Several processes will facilitate the communications among these communities:

The Space Telescope Institute Council (or equivalent) will oversee the development of the S&OC and the observatory and advises NASA and AURA.

The Science Working Group (SWG) will work directly with the NASA Project during development.

The individual instrument science teams will advise their Principal Investigators (PIs).

The S&OC, in coordination with international organizations such as the Space Telescope – European Coordinating Facility (ST-ECF) will communicate regularly with the astronomical community through newsletters, national, and international meetings.

During the operations phase, the S&OC will manage the international solicitation and review of scientific proposals to use the JWST. The peer review committees will be international, with non-US members supported by the respective international partner. In the same fashion, the S&OC will create an international JWST Users Committee to advise the S&OC on the desires and priorities of the user community. A similar structure already exists for the Multi-mission Archive at Space Telescope (MAST), the likely repository and distribution point for JWST data.

1.7.3 Partnering Space Agencies

Each of the partnering space agencies is a customer of the JWST mission. The deployment of a world-class scientific observatory for use by their scientific customers, the development of new technologies and strategic capabilities, and the communication of agency success to the public are equally important goals for the three agencies. The intra-agency process for communicating progress within NASA Centers, HQ, and the international counterparts is well established and is addressed in the remainder of this plan. As an international collaboration, the JWST partnering projects will work closely and cooperatively to share information for use within other partnering agencies.

1.7.4 Data Products

All scientific data from the instruments will be calibrated at the S&OC and released first to the selected investigators and after a suitable time, to the science user community

2.0 PROGRAM / PROJECT BASELINE

2.1 REQUIREMENTS BASELINE

These requirements constitute the James Webb Space Telescope (JWST) Level 1 requirements.

2.1.1 Science Requirements

2.1.1.1 Baseline Science Requirements

The following constitute the **baseline** mission success criteria for the JWST.

2.1.1.1.1 Density of Galaxies

L1-1 Measure the space density of galaxies to a 2 micrometer flux density limit of 1.0 x 10^{-34} $Wm^{-2}Hz^{-1}$ via imagery within the 0.6 to 27 micrometers spectral band to enable the determination of how this density varies as a function of their age and evolutionary state.

2.1.1.1.2 Spectra of Galaxies

L1-2 Measure the spectra of at least 2500 galaxies with spectral resolutions of approximately 100 (over 0.6 to 5 micrometers) and 1000 (over 1 to 5 micrometers) and to a 2 micrometer emission line flux limit of $5.2x10^{-22}$ Wm^{-2} to enable determination of their redshift, metallicity, star formation rate, and ionization state of the intergalactic medium.

2.1.1.1.3 Physical and Chemical Properties of Young Stellar Objects

L1-3 Measure the physical and chemical properties of young stellar objects, circumstellar debris disks, extra-solar giant planets, and Solar System objects via spectroscopy, and imagery within the 0.6 to 27 micrometers spectral band to enable determination of how planetary systems form and evolve.

2.1.1.1.4 Observing Time

L1-4 Enable, within a 5-year mission, a total observing time of at least $1.1x10^{8}$ seconds on targets located at any position on the celestial sphere.

2.1.1.2 Minimum Science Requirements

The following constitute the **minimum** mission success criteria for the JWST.

2.1.1.2.1 Density of Galaxies

L1-5 Measure the space density of galaxies to a 2 micrometer flux density limit of 1.0 x 10^{-34} W $m^{-2}Hz^{-1}$ via imagery within the 1.7 to 10 micrometers spectral band to enable determination of how this density varies as a function of their age and evolutionary state.

2.1.1.2.2 Spectra of Galaxies

L1-6 Measure the spectra of at least 1000 galaxies with spectral resolutions of approximately 100 (over 1.7 to 5 micrometers) and 1000 (over 1.7 to 5 micrometers) and to a 2 micrometer emission line flux limit of $5.2x10^{-22}$ Wm^{-2} to enable determination of their redshift, metallicity, star formation rate, and ionization state of the intergalactic medium.

2.1.1.2.3 Physical and Chemical Properties of Young Stellar Objects

L1-7 Measure the physical and chemical properties of young stellar objects, circumstellar debris disks, extra-solar giant planets, and Solar System objects via spectroscopy, and imagery within the 1.7 to 10 micrometers spectral band to enable determination of how planetary systems form.

2.1.1.2.4 Observing Time

L1-8 Enable a total observing time of at least $5.5x10^{7}$ seconds on targets located at any position on the celestial sphere.

2.1.2 Mission And Spacecraft Performance Requirements

To support the realization of the **baseline** science requirements the following requirements are placed on the JWST. The L1-XX number indicates the Dynamic Object Oriented Requirements System (DOORS) Database Identifier for each requirement.

2.1.2.1 Lifetime

L1-9 The JWST Spacecraft, telescope and instruments shall be designed for at least a 5-year lifetime. Level 1 performance shall be achieved for a minimum of 5 years.

2.1.2.2 Telemetry

L1-10 The operational JWST system shall deliver to the Science and Operations Center (SOC) a minimum of 95 percent of all real-time telemetry and stored data.

2.1.3 Launch Requirements

2.1.3.1 Date

L1-11 The JWST Project shall plan for a launch date as early as June 2013.

2.1.3.2 Orbit

L1-12 The JWST shall orbit the Sun-Earth second Lagrange point (L2 point).

2.1.4 Observatory Requirements

2.1.4.1 Telescope

L1-13 The JWST Optical Telescope Element (OTE) shall have a primary mirror whose unobscured light collecting area is no less than 25 square meters.

2.1.4.2 Strehl Ratio

L1-14 The Observatory, over the field of view (FOV) of the Near-Infrared Camera (NIRCam) shall be diffraction limited at 2 micrometers defined as having a Strehl Ratio greater than or equal to 0.8.

2.1.4.3 Thermal Environment

L1-16 The JWST Observatory shall provide the thermal environment needed to permit the imaging science instruments to be Zodiacal light background limited over the wavelength range 1.7 to 10 micrometers.

2.1.5 Baseline Science Instruments Requirements

L1-17 The Integrated Science Instrument Module (ISIM) shall contain the following science instruments, a NIRCam, a Near-Infrared Spectrograph (NIRSpec), and a Mid-Infrared Instrument (MIRI).

2.1.5.1 Near-Infrared Camera

L1-18 The NIRCam shall be capable of operating over the wavelength range 0.6-5 micrometers, and producing images with spectral resolution less than 100.

2.1.5.2 Near-Infrared Spectrograph

L1-19 The NIRSpec shall be capable of operating over the wavelength range 0.6-5 micrometers and producing spectra with spectral resolutions of order 100 and 1000.

2.1.5.3 Mid-Infrared Instrument

L1-20 The MIRI shall be capable operating over the wavelengths range 5-27 micrometers and producing both images (spectral resolution less than 100) and spectra (spectral resolution of order 1000).

2.1.6 Ground System Requirements

L1-21 During a normal operations contact, the JWST shall be capable of down linking, and the Ground Segment capable of capturing and processing 229 Gigabits of science data, compressed from 458 Gigabits

2.2 WBS BASELINE

The JWST WBS and WBS Dictionary, at level 2, are shown in Table 2-1 below.

Table 2-1 JWST Level 2 WBS & WBS Dictionary

WBS #	WBS TITLE	WBS DESCRIPTION
1.0	JWST PROJECT MANAGEMENT	This element encompasses the Goddard Space Flight Center (GSFC) Project Office coordination and oversight of the overall JWST Project, both in-house GSFC and contractors
2.0	SYSTEMS ENGINEERING	This element encompasses the activities of the GSFC Mission System Engineer (MSE) and the JWST Systems Engineering Team (SET). The MSE/SET employs an interdisciplinary approach encompassing the entire technical effort containing a balanced set of system personnel, products, and processes that satisfy Project goals and objectives.

WBS #	WBS TITLE	WBS DESCRIPTION
3.0	SAFETY AND MISSION ASSURANCE	Within this element, the requirements of a performance and quality assurance program for the Project are developed and implemented. The program includes performance verification, safety, electrical, electronic, and electromechanical (EEE) parts control, materials and processes control, fasteners control, reliability assurance, quality assurance, contamination control, and support to logistics. Performance/quality assurance specialists perform surveillance/monitoring of compliance with the program requirements.
4.0	SCIENCE / TECHNOLOGY	This element covers three activities: (1) the NASA funded portions of the JWST Science Working Group (SWG), (2) the activities of the JWST Senior Project Scientist, Deputy Project Scientist, Observatory Scientist, ISIM Scientist, and Deputy ISIM Scientist., and (3) leading, managing, and performing technology demonstration elements of the Project:
5.0	INTEGRATED SCIENCE INSTRUMENT MODULE	This element provides all the NASA funded activities for the management, systems engineering, development, fabrication, integration and test of the JWST Observatory Payload.
6.0	JWST OBSERVATORY	(1) This element encompasses the efforts of the JWST observatory prime contractor, and a team of three major sub-contractors:, to design and develop the Optical Telescope Element, the Spacecraft and the Sunshield, and integrate, test, qualify, and support launch and commissioning of the JWST Observatory. (2) This element encompasses GSFC JWST Project coordination and oversight of the Observatory prime contractor's performance and the provision of Government technical support
7.0	MISSION OPERATIONS	This element is RESERVED for Mission Operations year(s) two through Observatory decommissioning and will be defined prior to the Mission Operations Review. Mission Operations year one is incorporated in the Science and Operations Center contract (WBS element 9).
8.0	LAUNCH VEHICLE / SERVICES	The launch vehicle for the JWST Observatory is JWST Partner (European Space Agency) provided/funded. This element encompasses the GSFC JWST Project responsibilities for the launch vehicle as delineated in section 4.2-paragraph 7 of the National Aeronautics and Space Administration Goddard Space Flight Center and European Space Agency Preliminary Joint Project Implementation Plan,
9.0	GROUND SYSTEMS	(1) This element encompasses the efforts of the Association of Universities for Research in Astronomy (AURA), through the Space Telescope Science Institute (STScI), to develop the JWST Science and Operations Center (S&OC) and to perform the first year of Mission Operations (2) This element encompasses the GSFC JWST Project coordination and oversight of the Science and Operations Contractor performance, coordination and oversight of the Mission Operations and Mission Services (MOMS) Contract, and Management and Oversight of the NASA institutional elements, including the Deep Space Network (DSN), the Flight Dynamics Facility (FDF), and the NASA Institutional Support Network (NISN)
10.0	SYSTEMS INTEGRATION & TEST	This element encompasses provision of the Integrated Science Instrument Module integration and test facilities, GSFC JWST Project coordination and oversight of the Observatory Integration and Test Program, Optical Telescope Element integration and test facilities that are provided to the Observatory Contractor as Government Furnished Equipment and Provision of Observatory transportation
11.0	EDUCATION & PUBLIC OUTREACH	This element encompasses the JWST Project effort to prepare and disseminate information about the JWST Observatory to the world science community and to the general public.

The JWST WBS is delineated in the JWST Project Work Breakdown Structure (WBS) and WBS Dictionary (JWST-WBS-000776). This document provides the WBS and WBS definitions for the activities performed by or under direct contract to the GSFC JWST Project Office [Northrop Grumman Space Technologies (NGST), Association of Universities for Research in Astronomy/Space Telescope Science Institute Organization (AURA/STScI)].

The WBS is also the basis for allocating responsibility for all JWST configuration items and formal documents. The Systems Engineering organization will use the WBS to evaluate the work within each partner's responsibility and across interfaces for a comprehensive, systems-level assessment of the status and adjustments required during the JWST lifecycle. All resources management and analyses (e.g. properties, workforce, budgets) are allocated and managed within this WBS framework.

The JWST WBS is under formal configuration control at the Project level (Level 2)

2.3 SCHEDULE BASELINE

The JWST Project Master Schedule (JWST-SCHED-004215) summarizes the overall Project (Observatory Prime Contract, ISIM, Ground Segment, and Launch Operations). This Master Schedule is maintained under formal configuration management control at the project level. The approved revisions are maintained on the JWST web site (https://ngin/jwst/nasa/gov).

Figure 2-1 provides an overview/summary of the critical milestones, major events, interdependencies, and Program/Project reviews as delineated in the Project Master Schedule. Refer to the JWST web site for the most current schedule.

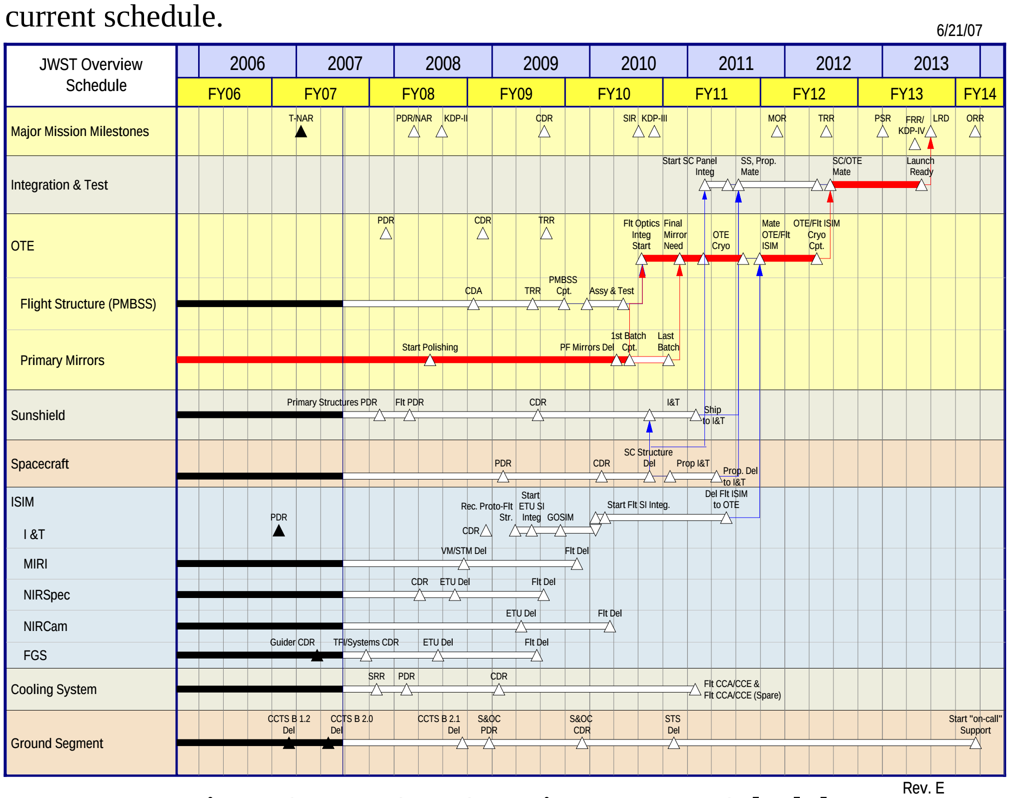


Figure 2-1 JWST "Overview" Master Schedule

2.4 RESOURCES BASELINE

2.4.1 Funding Requirements

The NASA Life Cycle Cost Plan, (FY 2008 OMB Submit) is shown in Table 1-1

The JWST Project fiscal resource requirements are defined in the GSFC Program Operating Plan (POP) budget submittal. The POP process is conducted on an annual basis and requires concurrence from the GSFC management.

2.4.2 Workforce Requirements

The civil servant and contractor workforce requirements are identified in the annual GSFC Manpower Process. The JWST Project's institutional manpower requirements are contained in the GSFC Workforce Integrated Strategic Plan (WISP). Manpower requirements are derived for GSFC's Statement of Work process. These requirements are updated annually as a result of the workforce call. Results of the manpower exercise are recorded and tracked in a center-wide manpower database. Manpower status is reported monthly in the Pre-Monthly Status Review (Pre-MSR) to the FPD as part of the JWST monthly reporting.

2.4.3 Infrastructure Requirements

The facility infrastructure requirements identified herein are unique to the JWST Project and cannot be met thru any synergistic means with other programs and projects.

The JWST Project ISIM effort requires no new infrastructure development and will use existing facilities at GSFC for the development, integration and test of the ISIM, its instruments and components.

NGST will use GFE facilities at GSFC for the OTE integration and mechanical test. The GSFC vibration facility will be upgraded for the OTE vibe.

NGST will use GFE facilities at JSC for the OTE thermal/vacuum test and qualification and for the integrated OTE/ISIM testing. The JWST project has overall Project Management responsibilities for the JSC Chamber A facility accommodations as delineated in the JSC IRCD. The IRCD document will detail the exact specifications of the facility for the test configurations. It is mutually agreed upon by all parties (JSC, JWST and NGST) and then placed in configuration control at GSFC. Requisite facility modifications that will have to take place prior to the OTE test hardware arriving at JSC are delineated in the IRCD.

NGST fabrication and test of the OTE mirror segments has requierd upgrades at the mirror vendor facilities (Axsys, Tinsley) and at the MSFC XRCF

- Axsys: New building dedicated to JWST Be mirror manufacturing operation. Equipment housed in the new facility:
  - 8 Horizontal Machining Centers
  - Coordinate Measuring Machine (CMM)
  - Heat Treat Furnace
  - Scrubber (acid etch)
  - Chemical Lab and Zyglo Equipment

  - Uninterrupted Power Supplies
  - Vapor Degreaser Equipment.
  - Granite plate
- Tinsley: Remodeled building to be dedicated to JWST Be mirror production. Following major equipment is housed in the remodeled facility:
  - 9 Computer Controlled Optical Surfacing (CCOS) Machining Stations
  - 2 Profilometers (modified Leitz CMM machines)
  - 2 Shack-Hartman Wavefront Sensors
  - 2 Interferometers
  - 2 Thermal Chambers
  - 2 Cryogenic Chambers
- XRCF at MSFC
  - New cryo shroud for segment level cryo testing at XRCF

Using existing technology, the JWST Project has undertaken development of an integrated information management tool known as the Next Generation Integrated Network. NGIN is a suite of project management tools deployed in a private website accessible by JWST project personnel worldwide.

3.0 PROGRAM / PROJECT CONTROL PLANS

3.1 TECHNICAL, SCHEDULE, AND COST CONTROL PLAN

The surveillance and control of the project by the program is primarily accomplished through the maintenance and review of the integrated cost, schedule, and technical performance data products.

The formulation and implementation of the JWST mission will include Integrated Independent Reviews as specified in GPR 8700.4E. The project attends and receives the findings of these reviews.

3.1.1 Technical Control

All changes impacting the JWST Project objectives are reviewed and controlled in accordance with the JWST Configuration Management Procedure, JWST-PROC-000654. The JWST CM process satisfies the requirements of GPR 1410.2, Configuration Management.

All technical performance, cost, or schedule trade-offs not impacting the JWST PCA are under the control of the JWST Project Manager and will be handled in accordance with the JWST CM Procedure.

The JWST Project Manager (or designee) chairs the Configuration Control Board (CCB), with representation on the CCB by all major project elements, including science, spacecraft, instruments, and ground system. The CCB is responsible for all changes affecting mission objectives, total program cost, scheduled launch date, mission component interfaces, and MOU requirements.

3.1.2 Performance Measures

The JWST Observatory key performance parameters (KPP) have been established as listed in Table 3-1

Table 3-1. Key Performance Parameters

PARAMETER
Observatory Mass Margin
Observatory Power Margin
Observing Efficiency
OTE Wavefront Error
Wavefront Error Stability
Strehl Ratio
Encircled Energy
Sensitivity
Image Motion
Stray Light Levels
Cryogenic Thermal Margin
Commissioning Duration
Data Volume / Link Margin
Momentum Accumulation

The KPPs are monitored at various frequencies from once a month to once every 4 months.

Minimum margins / reaction limits for many of these KPPs are taken from GSFC-STD-1000 (aka "The Gold Rules") as a primary source. If guidance is not provided by this source then one of these are used:

- Interpolation / extrapolation of GSFC-STD-1000
- Other Standard Aerospace Sources or common industry practice
- JWST specific risk / uncertainty assessment

Margins are defined as (Requirement – Estimate) / (Estimate)

Cryogenic Thermal Rejection Margin = (T^4Required – T^4Predicted) / T^4Predicted where T is temperature measured at the cryogenic radiators

Both the established quantitative value and the "current" status for each KPP are documented in the monthly report from the observatory prime contractor (NGST).

3.1.3 Earned Value Management Implementation

The JWST Project will follow an Earned Value Management System (EVMS), in accordance with current (2006) NASA policies, to control costs. Costs are tracked against initial baseline projections and monthly cost reports are generated to ensure that costs are closely monitored.

Detailed business metrics have been developed to ensure reliable processes are followed throughout the life cycle of the project.

3.1.3.1 In-House Metrics

The in-house effort encompasses the Applied Engineering and Technology Directorate (AETD) build for ISIM, including the ICDH and flight software, as well as discipline support for out-of-house oversight. Metrics include:

Branch-level working agreements

Baselines and management systems will be established within the first 6 months of agreement (procurement plans, CM audits, reporting, etc.)

Management interactions such as monthly and quarterly reviews, peer reviews, support to external reviews

Vertically integrated schedules

In-house resources including budgets, procurement and parts progress, work force and hiring, commitment/obligation/cost, labor charge-backs, and space management.

EVMS will associate scope, schedule, work force, cost, and progress.

Full-cost accounting

3.1.3.2 Out-of-House Metrics

The out-of-house effort encompasses the prime contractor and major subcontracts for WFSC Executive (JPL), S&OC (AURA), flight detectors, FPAs, and MIRI (JPL), and the launch vehicle. Metrics include:

Contracts and working agreements (will evolve with final international MOU negotiations)

Baseline established within the first 6 months of award (EVMS, CM audits, reporting, etc.)

Management interactions such as monthly and quarterly reviews, quarterly executive dialogues, and roundtables

Vertically integrated schedules and electronic updates

Contractor Financial Management Reports (Form 533) monthly/quarterly meetings on budget, work force, and funding

EVMS to address NGST, S&OC/AURA, NIRCam, and MIRI

Award fee plans and evaluations (NGST, S&OC/AURA, NIRCam, and MIRI)

Specialized formats as needed, e.g., procurement milestones, change order status, weekly staffing, timecard audit, subcontractor status, IRAD, semi-annual process meetings (for S&OC)

3.1.3.3 International Metrics

The international partnerships encompass limited oversight of NIRSpec (ESA), MIRI (ESA), and the FGS (CSA). Metrics include:

Baseline of major milestones and delivery dates between partners

Determination of US accommodations costs and likely value of contributions as a guide for NASA planning

Coordination and optimization of management systems, international CM, web-based risk management, etc.

Determination of reporting and interchange meeting schedules and possible Resident Office support

Sharing of expert control knowledge and incorporation of such information into procurement and logistics plans

3.1.4 Schedule Control

The JWST Project has established a hierarchy of schedules to permit management and control of the work effort at a level of detail commensurate with the focus of management responsibility. This hierarchy of interlocking schedule baselines includes the Master, Intermediate, and Detailed Schedules.

- Master Schedule -- The Master Schedule represents the flow-up (summarization) of the subsystem detailed data which combines key program milestones, internal/external schedule dependencies, and controlled project trigger events.
- Intermediate Schedules -- The Intermediate Schedules represent a summary of the detailed data contained within a Subsystem. Intermediate Schedules will be rolled-up into the Master Schedule.
- Detailed Schedules -- Detailed Schedule contains the backbone of events and activities that make-up the content of that subsystem and reflect the significant events in sufficient detail to permit adequate monitoring of work progress. Detailed Schedules will be rolled-up into the Intermediate Schedules.

The JWST Project has standardized on an automated time phased Planning and Scheduling Software tool called Microsoft Project Professional that will be linked to a dedicated project schedule sever.

Each JWST Segment, Element and Subsystem shall maintain, under configuration management, project schedules for their responsible portion of the project using the above hierarchy.

The JWST Project will use these schedules and their agreed upon key milestones, linked to WBS and cost account, for evaluating, managing, and reporting project performance with respect to baseline plans.

3.1.4.1 Project Master Schedule

The JWST Project Master Schedule (JWST-SCHED004215), which summarizes the overall Project (Observatory Prime Contract, ISIM, Ground Segment, Launch Operations), is the responsibility of the NASA/GSFC JWST Project. This Master Schedule is maintained under formal configuration management control at the project level. The approved revisions are maintained on the JWST web site (https://ngin/jwst/nasa/gov).

In addition to providing a summary of the overall project plan/status, the Project Master Schedule delineates the major project milestones:

- Mission System Requirements Review (SRR)
- Mission System Definition Review (SDR)
- Technology Non-Advocate Review (T-NAR)
- Mission Preliminary Design Review (PDR)
- Non-Advocate Review (NAR)
- Mission Critical Design Review (CDR)
- Mission Operations Review (MOR)
- Observatory Test Readiness Review (TRR)
- Observatory Pre-Ship Review (PSR)
- Flight Readiness Review (FRR)
- Launch Readiness Review (LRR)
- Launch
- Operations Readiness Review (ORR)

3.1.4.2 Project Intermediate Schedules

The project intermediate schedules represent a summary of the subsystems within a JWST Element. These intermediate schedules are updated on a monthly and/or as required basis.

The Observatory prime contractor, NGST, is responsible for the preparation/reporting the overall status for Contract NAS5-02200. The Observatory Summary Schedule is an input to the JWST Project Master Schedule.

The AURA/STScI is responsible for the preparation/reporting the schedules for the Ground Segment & Operations. The Ground Segment/Operations Schedule is an input to the JWST Project Master Schedule

The JWST ISIM Top Level Schedule (JWST-SCHED-004165), which summarizes the activities incumbent to the ISIM (ISIM infrastructure, Science Instruments, Integration and Test), is the responsibility of the NASA/GSFC JWST Project. The ISIM Top Level Schedule is an input to the JWST Project Master Schedule.

The ESA Launch Segment Schedule is the responsibility of the ESA JWST Project. The Launch Segment Schedule is an input to the JWST Project Master Schedule.

3.1.4.3 Project Detail Schedules

The Observatory prime contractor, NGST, is responsible for the preparation/reporting the detail status for the following:

- Observatory I&T
- Optical Telescope Element
- Sunshield
- Spacecraft

These schedules are an input to the Observatory Summary Schedule.

The Near-Infrared Spectrograph Schedule is the responsibility of the ESA JWST Project. The NIRSpec Schedule is an input to the ISIM Top Level Schedule.

The Mid-Infrared Instrument (EC Provided Elements) Schedule is the responsibility of the ESA JWST Project. The MIRI (EC Provided Elements) Schedule is an input to the MIRI Schedule (maintained by JPL) that is in then an input to the ISIM Top Level Schedule.

The Near-Infrared Camera Schedule is the responsibility of the University of Arizona. The NIRCam Schedule is an input to the ISIM Top Level Schedule.

The Fine Guidance Sensor Schedule is the responsibility of the CSA JWST Project. The FGS Schedule is an input to the ISIM Top Level Schedule.

The ISIM infrastructure (ICDH, ISIM Structure, ISIM Thermal Control, ISIM Flight Software, and ISIM ETU/Flight I&T) schedules are the responsibility of the GSFC JWST Project. These schedules are inputs to the ISIM Top Level Schedule.

In addition, the Near-Infrared Instrument Detector Subsystem and Micro-shutter Subsystem schedules are the responsibility of the GSFC JWST Project. These subsystem schedules are an input to the ESA JWST Project Near-Infrared Spectrograph Schedule.

3.1.4.4 Program Control Milestones

Program Control Milestones (PCM), a set of milestones within and between Segments, Elements and/or Subsystems, will be agreed between the “giver” and the “receiver” and will be placed under Project Configuration Change Board (CCB) control.

The Observatory Prime Contractor required milestones and the hardware and software deliverables to the JWST Project are delineated in Contract NAS5-02200, Article B-1.

The JWST/ISIM hardware and software deliverables to the Observatory Prime Contractor are delineated in the James Webb Space Telescope Project Government-Furnished Equipment List and Schedule for Contract NAS5-02200 (JWST-LIST-000638).

The Science and Operations Center required milestones and the hardware and software deliverables to the JWST Project are delineated in Contract NAS5-03127, Clause G-11.

The JWST/ISIM hardware and software deliverables to/from the Science IDTs are delineated in the indicated/applicable DILS or Government-Furnished Equipment (GFE) List:

NIRCAM	JWST- LIST-002571	James Webb Space Telescope Project Integrated Science Instrument Module Near-Infrared Camera Government-Furnished Property List for Contract NAS5-02105
NIRSpec	JWST-LIST-000823	James Webb Space Telescope Integrated Science Instrument Module Near-Infrared Spectrograph Deliverable Items List and Schedule
MIRI	JWST-LIST-000824	James Webb Space Telescope Integrated Science Instrument Module Mid-Infrared Instrument Deliverable Items List and Schedule
FGS	JWST- LIST-000825	James Webb Space Telescope Integrated Science Instrument Module Fine Guidance Sensor Deliverable Items List and Schedule

The JWST/ISIM hardware and software deliverables from one ISIM component to another ISIM component are delineated in the component Subsystem Implementation Plan(s) and the ISIM Top Level Schedule (JWST-SCHED-004165).

3.1.5 Reserves Control

3.1.5.1 Technical Reserves Control

Program/Project technical reserves are under the purview/control of the Mission Systems Engineer (MSE). As delineated in section 3.1.2 of this plan, key performance parameters (KPP) have been established as listed in Table 3-1. For each KPP a set of allocations and reserves has been established. For each of the allocations, minimum margins / reaction limits have been established and are tracked on a periodic basis. As the reaction limits are approached, the MSE, in conjunction with the discipline/product systems engineer and design engineers, initiates the performance of tradeoff studies to recover the minimum margin. In those instances where recovery can not be achieved, a “KPP Control Board: (e.g., Mass control board, Power control Board, etc) is convened wherein the KPP allocations and margins are reassessed and reserves are released as required.

3.1.5.2 Schedule Reserves Control

The Program/Project schedules are reported to /reviewed by the Program/Project management on a monthly basis. Release/allocation of schedule reserves is controlled through the JWST Program/Project configuration control process.

3.1.5.3 Cost Reserves Control

Cost reserves are managed via a document controlled system under the auspices of the Program/Project Business Manager. On a periodic basis, the Business Manager meets with the Program/Project Manger to discuss the cost status and present IPT lead requests for reserves disbursement/allocation. The Program/Project Manager holds approval/disapproval authority for these requests.

3.1.6 Reporting

The JWST Project reports to senior NASA management in the forums listed in Table 3-2. Special discussion topics, as detailed in this plan, shall be included in these forums: i.e., Risk Management, Budgets, Program Master Schedule, etc.

Table 3-2 Reporting Forums

Forum	Report	Schedule
GSFC Flight Projects Directorate	Electronic Weekly Progress Report	Weekly
GSFC Center Director	Weekly Progress Report	Weekly
GSFC PMC	Technical Progress, Cost, Schedule	Monthly
GSFC PMC	Technical Progress, Cost, Schedule	Quarterly
JWST Program Operating Plan	Technical Progress, Cost, Schedule	Once a Year
SMD Weekly Status Reports	Electronic Weekly Progress Report	Weekly (post CDR)

3.1.7 Waiver Control

Waivers and deviations are controlled in accordance with section 4.10 of the JWST Configuration Management Procedure (JWST-PROC-000654). The table of contents for this section is provided herein for reference.

3.1.8 Descope Plans

TBS

3.1.9 Systems Engineering Organization/Structure

The JWST Systems Engineering Team (SET), shown in Figures 3-1and 3-2, is comprised of the Mission Systems Engineer (MSE), product systems engineers, and discipline systems engineers from the program/project organizations.

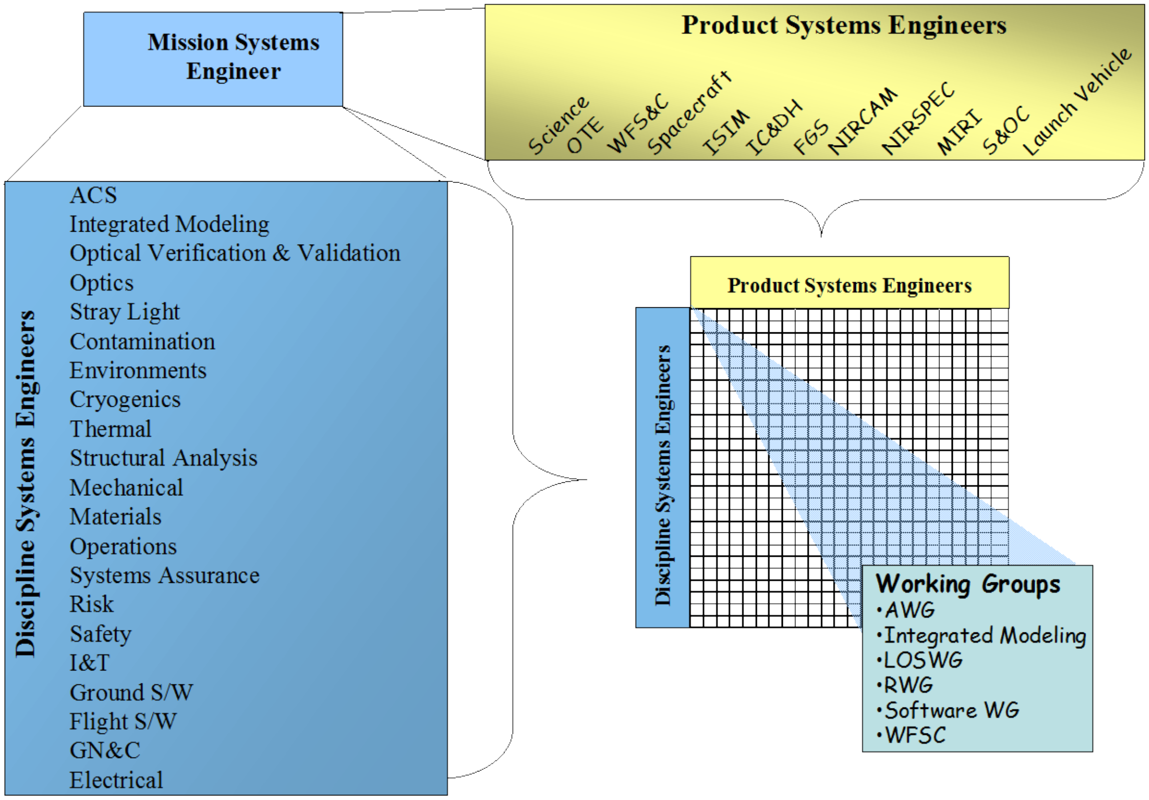


Figure 3-1 JWST Program/Project Systems Engineering Team

The discipline systems engineers and product systems engineers are the key to systems engineering on JWST. The product systems engineers are aligned with the traditional product-based decomposition of the JWST system. They provide systems engineering support associated directly with the production of the product. Product systems engineers work with each of the discipline engineers to obtain the best product possible. The discipline systems engineers work for each of the product systems engineers and product managers. The discipline systems engineers strive to integrate their discipline across all products to achieve an optimal system.

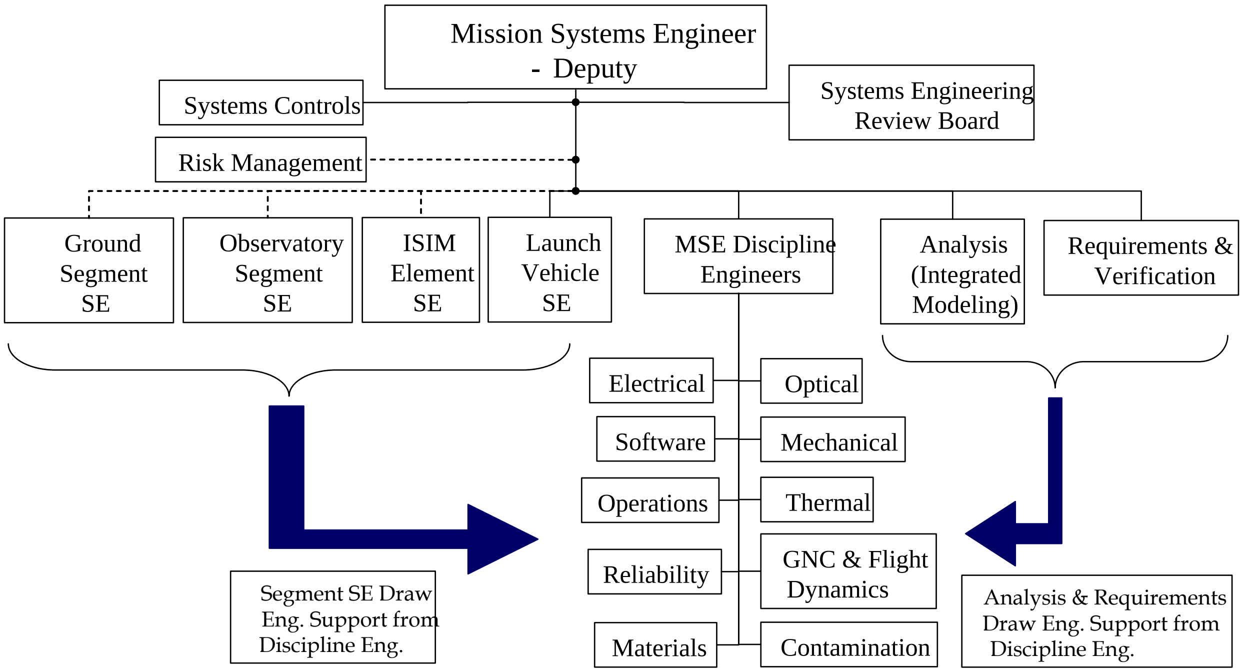


Figure 3-2 Program / Project Systems Engineering Organization

The SET interacts with Project management on all levels. The MSE works directly for the JWST Project Manager and with each product manager.

The SET interacts with representatives from the appropriate Program/Project scheduling/planning, quality, system safety, data management, and CM organizations to ensure recommended changes in the technical baseline can be efficiently presented to Project management for implementation.

Within the SET, responsibility is partitioned according to the system (mission), segment, and element levels shown in Figure 1-2. The MSE is responsible for systems engineering at the mission level. At the segment and element levels, systems engineering responsibility is divided among the Prime, GSFC, and STScI for the Observatory, Integrated Science Instrument Module (ISIM), and Ground Segment, respectively.

3.1.10 Termination Review Criteria

Provide the technical, scientific, schedule, cost, and other criteria, which will be utilized in the consideration of a termination review.

The JWST Project will be subject to a Termination Review conducted by the GSFC PMC if it falls into any of the following categories. Findings will be submitted to the SMD AA for review. The SMD will submit recommendations to the HQ PMC and will update the PCA accordingly. The Program Plan will be subsequently changed to reflect these recommendations. The categories are:

a. Fails to meet baseline (level 1) requirements as defined by the SMD.
b. Delays or is projected to delay launch readiness by 15 percent (based on timeframe between MCR or its equivalent and Launch Readiness Date as defined at MCR or its equivalent).
c. Exceeds or is projected to exceed by more than 10 percent the total development run-out cost identified at MCR, or its equivalent. (Reference: Section 300, OMB Circular A11.)

d. Exceeds or is projected to exceed the NASA mission cost cap identified at MDR or its equivalent.

3.2 SAFETY AND MISSION ASSURANCE

3.2.1 General

The System Assurance Manager (SAM), assigned to the JWST Project by the GSFC Office of Systems Safety and Mission Assurance, is the focal point for all mission assurance and safety related activities and documentation. From early in the design phase, the SAM is responsible for documenting requirements and how they will be met during the life cycle of the project. The SAM has direct access to project and science managers with the functional freedom and authority to interact with other elements of the JWST Project. The SAM also has reporting responsibilities directly to Code 300, thereby assuring independence in the safety and mission assurance activities.

NASA/GSFC will manage their quality assurance program according to its established procedures as documented in the James Webb Space Telescope Project Mission Assurance Requirements (MAR) for the JWST Observatory, Phase 2 (JWST-RQMT-000650) and the James Webb Space Telescope Project Mission Assurance Requirements (MAR) for the JWST Instruments (JWST-RQMT-002363). These requirements are based upon the policy and requirements contained in 300-PG-7120.2.2, Mission Assurance Guidelines for Tailoring to the Needs of GSFC Projects.

A Performance Assurance Implementation Plan will detail the individual developers' plans for meeting the mission-specific requirements throughout the design, fabrication, and testing of the instruments and spacecraft. Other mission-level documents will define how the instruments will be integrated and tested with the spacecraft.

3.2.2 Safety

The safety procedures and requirements to be followed in implementing the JWST Project are in response to and in accordance with the policies and guidelines set forth in GPD 8715.1, GSFC Safety Policy, and the general GSFC policy of avoiding injury to people and property loss to the maximum extent practical.

The JWST Flight Systems Safety Engineer is responsible for all safety-related activities and documentation and coordinates his/her activities with the JWST SAM.

The JWST Project will implement all project-related activities in accordance with the JWST Systems Safety Project Plan, JWST-PLAN-001000 and the JWST ISIM System Safety Program Plan, JWST-PLAN-001001.

3.2.3 Reliability

The JWST SAM will coordinate the work of a reliability engineer on the project. The Reliability Engineer will be responsible for reviewing all reliability and risk analyses and assessments, test data, and associated documentation. These include, but are not limited to, the failure modes and effects analyses (FMEAs), "critical-items" lists, worst-case analyses, probabilistic risk assessments, and fault tree analyses which will be approved by the JWST Project Office.

3.2.4 Quality Assurance

The Quality Assurance (QA) program for JWST will be based on GPR 8730.3, GSFC Quality Manual. Standard documented work practices will be monitored for compliance to both the document and the project requirements. Where a conflict exists, the project documentation will take precedence. All departures from either documentation will be recorded and entered into the NCR/CA system for disposition.

Figure 3-3 illustrates the flowdown/interrelationship of the NASA and the international partners quality standards.

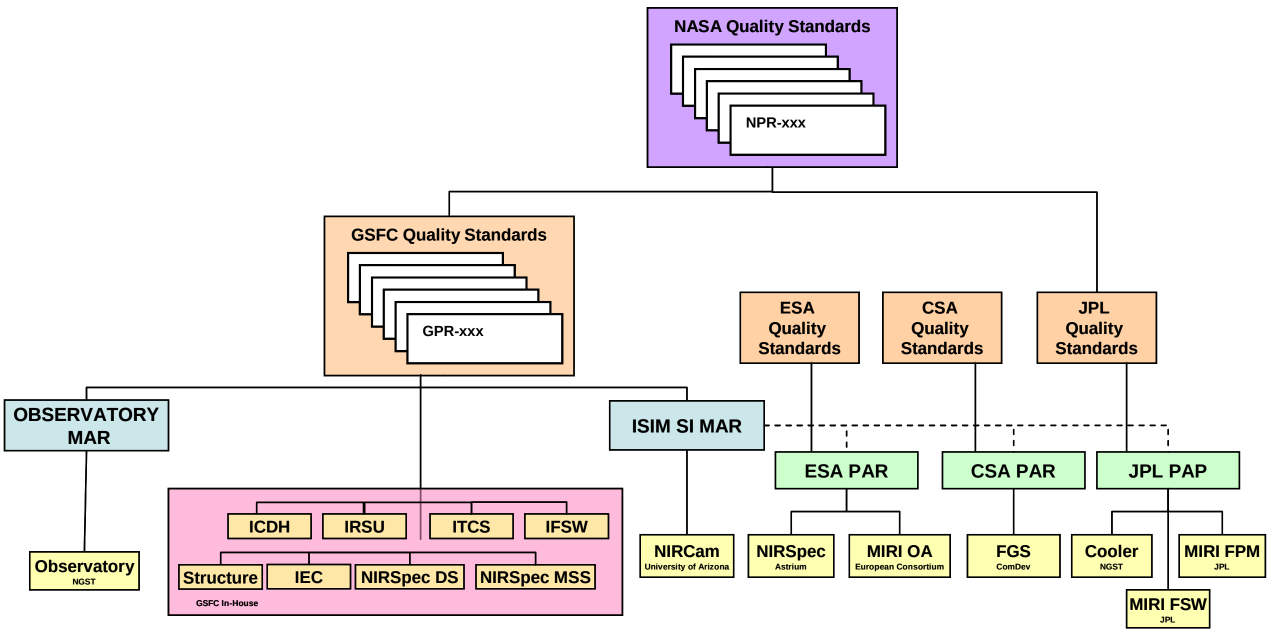


Figure 3-3 Program Quality Standards Flowdown

For the work performed by our partners (ESA, CSA, and JPL), our partner counterparts are responsible for maintaining their own mission assurance verification and surveillance. The SAM will ensure that our partners' product assurance requirements documents are equal to or exceed the Instrument MAR. NASA's insight into our partner's will include the following:

- Reviewing all partner's Performance Assurance Requirements (PAR) (including revisions) to ensure that they meet the requirements of Program/Project Mission Assurance Requirements
- Reviewing waiver and deviation requests submitted by partner contractors against the partner's PAR
- Participating at major design reviews
- Holding regular communication with our partner's counterparts.

The Hardware Quality Engineers (QEs) assigned to the JWST Program/Project will monitor the design, fabrication, and testing activities throughout the life of the project. Hardware QEs will report on all activities to the SAM. Audits will to be performed at periodic intervals to verify the quality system functions as designed. Records of these audits are to be captured per the JWST CM Procedure, JWST-PROC-000654, and GPR 5100.4, Supplier Quality Audits.

3.2.5 Performance Verification

The JWST Project will have a performance verification plan in place and controlled by the CM Office. The SAM, in coordination with the I&T Manager, will assure that the verification plan, the implementation, and the results are documented and that the records provide accurate traceability from mission specification requirements to launch and on-orbit capability.

The JWST mission verification process will employ a series of requirements database audits, functional tests, analyses, inspections, physical measurements, and environmental tests to ensure all verifiable requirements have been accounted for and verified. The Verification Program shall begin with functional testing at the component level of assembly and shall continue through functional and environmental testing at the subsystem, instrument, spacecraft and observatory levels of assembly, supported by appropriate analyses as necessary. The program shall conclude with end-to-end testing of the entire operational hardware/software system at the observatory level including the instruments, the ground control center, and the appropriate network elements.

3.2.5.1 Observatory Validation and Verification

The observatory prime contractor (NGST) is responsible for all observatory-level verification. These activities will be conducted in accordance with the JWST System Verification Plan (JWST-PLAN-002027).

Flight software for the JWST mission will be developed in accordance with the JWST Software Management Plan (JWST-PLAN-000653).

3.2.5.2 ISIM Element Validation and Verification

The ISIM Systems Engineering team is responsible for all ISIM Element Validation and Verification activities. This activity will be conducted in accordance with the JWST ISIM Verification Plan (JWST-PLAN-003019).

3.2.5.3 Flight Software Independent Verification and Validation

The JWST Project has established a Memorandum of Understanding between itself and the NASA GSFC Software Independent Verification and Validation Center (JWST-MOA-003482) for the IV&V of the Mission Flight Software.

3.2.6 Software Quality Assurance

The JWST Software QE will monitor the JWST ground and flight software programs including testing activities throughout the life of the project. The Software QE will report on all activities to the SAM.

The JWST Project will have a Software Quality Management System (SQMS) that is applied to flight software and firmware, ground support equipment, key parameter and orbital checkout software, and any software developed under contract that is relative to flight mission operations.

3.2.7 Orbital Debris

The JWST observatory shall be designed to minimize generation of orbital debris in accordance with NASA Policy Directive (NPD) 8710.3, NASA Policy for Limiting Orbital Debris Generation.

3.2.8 Failure Resolution and Reporting

The JWST Project shall use the GSFC Nonconformance Reporting/Corrective Action System to document any failures during the implementation of the JWST mission.

3.3 RISK MANAGEMENT PLAN

The James Webb Space Telescope (JWST) Project has established a Continuous Risk Management Plan (CRMP) (JWST-PLAN-000651). The plan governs how technical, cost, schedule and other forms of risk will be determined, analyzed, managed and communicated. Risk management activities conducted by other NASA organizations, and Contractors working on the JWST Project must be planned and conducted in a manner compatible with the Plan.

The goal of risk management on the JWST Project is to identify risks and to manage the efforts and resources necessary to avoid occurrence of the risks. The JWST CRMP describe the overall process, procedures, organizational roles, and the tool that are used to support this effort.

The plan governs the management of risks that may be encountered during the formulation, design, implementation, and operation of the entire JWST System. The JWST System is itself comprised of the Launch, Observatory and Ground Segments and their constituent Elements and Subsystems. The scope also includes risks associated with the use of Project and Contractor financial resources, facilities, procedures, equipment, and personnel that have been allocated to the JWST Mission.

The scope of risks addressed also includes joint risks related to the use of dedicated facilities and resources at other NASA Centers and international agencies, such as the ESA and the CSA, which have entered into partnership with the JWST Project in support of the JWST Mission. Whereas such joint risks and proposed mitigations will be considered within the context of JWST Project risk management, and tracked within the JWST Project Risk Management database, the actual addressing of joint risks will be implemented with the respective partner Organization, in accordance with existing agreements.

The latest NASA Risk Management Policies for Projects are stated in NASA Procedures and Guidelines, NASA Project and Project Management Processes and Requirements *(*NPG 7120.5). These policies are elaborated in the NASA Integrated Action Team (NIAT) Report (see Section 1.2.2, Ref. 6). The governing document for this Plan is the Risk Management GSFC Procedures and Guidelines (GPG) 7120.4

Project level risk board meetings are conducted on a regular basis. The project manager chairs the risk board meetings. The Risk Board evaluates the risks for the cost, schedule, performance, and probability of occurrence. Element and subsystem managers lead the risk effort for their areas of responsibility and report their top risks to the project.

Mission System Engineer (MSE) leads the technical risk process.

Failure Modes and Effects Analysis (FMEA), Fault Tree Analysis (FTA), and Probabilistic Risk Assessment (PRA) shall be conducted as part of system design, analysis and trade study activities.

An automated Risk Management Tool (RMT) has been custom developed satisfying all NPR requirements as well as unique project requirements. The RMT is located on the JWST NGIN website. A risk list will be maintained throughout the project life cycle. Risk database is open to the entire team. Training was provided to the senior management and members of the project on CRM and the Risk Tool.

3.4 ACQUISITION PLAN

3.4.1 Acquisition Strategy Meeting Minutes

- Observatory and Instruments
  - Archived in the Contracting Officer's file for Contract NAS5-02200
- Science and Operations Center
  - Archived in the Contracting Officer's file for Contract

3.4.2 Major JWST Acquisitions Summary

Table 3-3 JWST Project Acquisition Strategy

Element/Subsystem	Prime Contractor	Major Subcontractor(s)	Procurement Method	Contract Type
Observatory OTE Spacecraft Sunshield	Northrop Grumman Space Technologies	• Ball Aerospace • ITT • Alliant Techsystems	Competitive	CPAF
NIRCam	University of Arizona	Lockheed Martin Applied Technologies Center	NASA HQ Announcement of Opportunity (AO)	CNF
NIRSpec	ESA	EADS/Astrium GmbH	Memorandum of Understanding	
NIRSpec Detector Subsystem	GSFC In-house	Rockwell	Sole Source	CPIF
NIRSpec Microshutter Subsystem	GSFC In-house			
MIRI Optics Assembly	ESA	European Consortium	Memorandum of Understanding	
MIRI Management	JPL		NASA HQ AO	Sub-allot
MIRI Detector Subsystem	JPL	Raytheon Vision Systems	Competitive	CPFF
MIRI Cooling System	JPL	Northrop Grumman Space Technologies	Competitive	Phase A&B: CPFF, Phase C/D: CPIF
FGS	CSA	Com/Dev	Memorandum of Understanding	
ISIM Structure	GSFC In-house	Alliant Techsystems	Sole Source	CPAF
ISIM Command and Data Handling	GSFC In-house	BAE Systems	Competitive	FFP
Launch Vehicle	ESA	Arianespace	Memorandum of Understanding	
S&OC	AURA/STScI	STScI	Phase 1: follow-on to an existing HST contract Phase 2: cost- contract through Launch +1 year (L+1), with a fixed (science) and award fee (development) structure Phase 3: Cooperation Agreement (CA) Phase E MO&DA	CNF

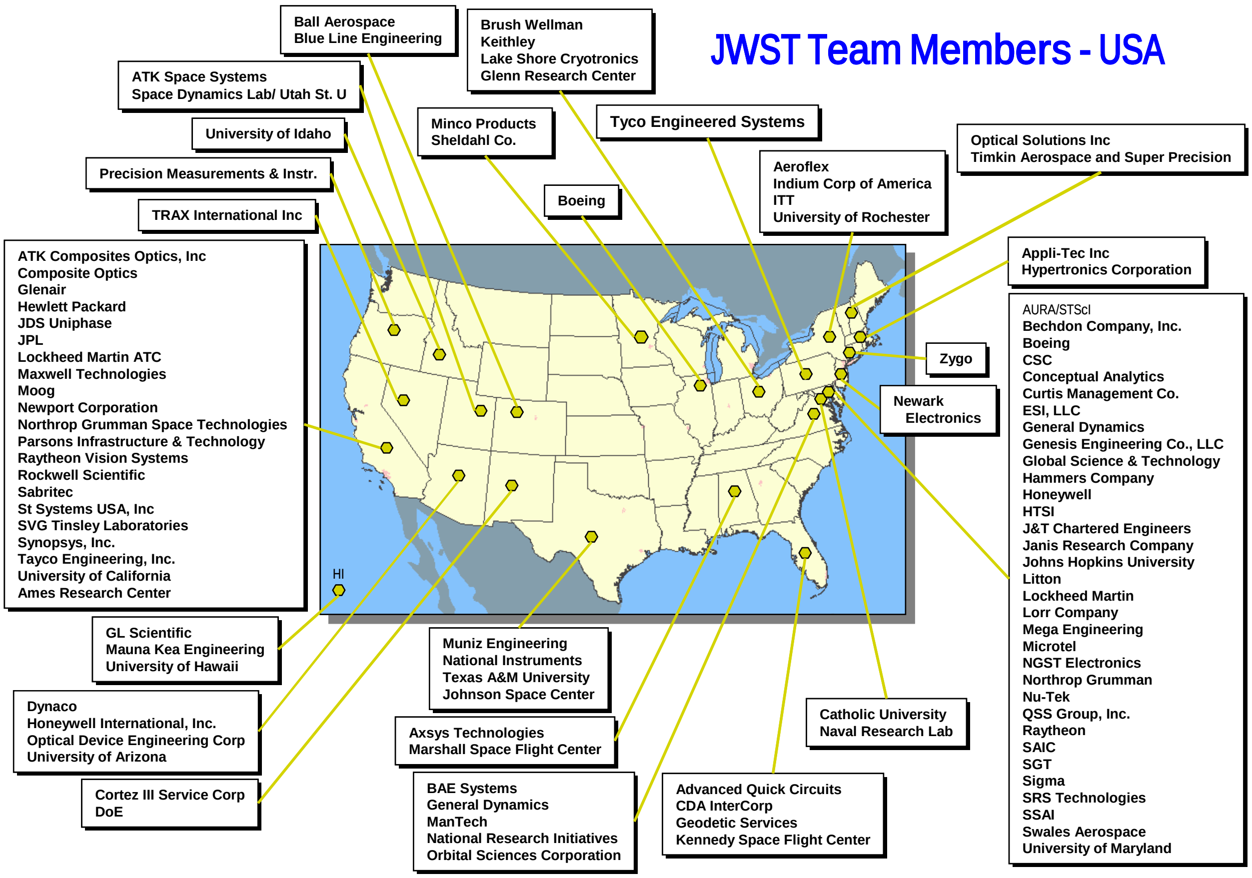


Figure 3-4 JWST Team Members – Observatory/ISIM – USA

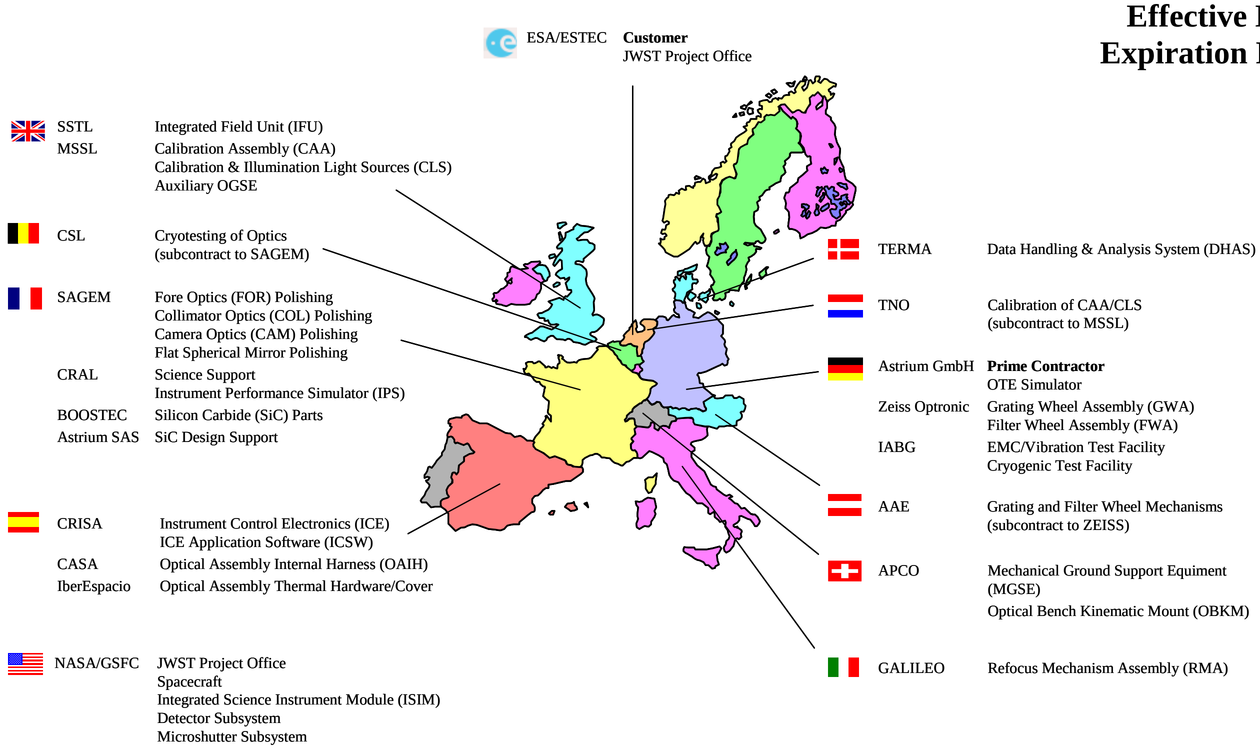


Figure 3-5 JWST Team Members – Europe / NIRSpec

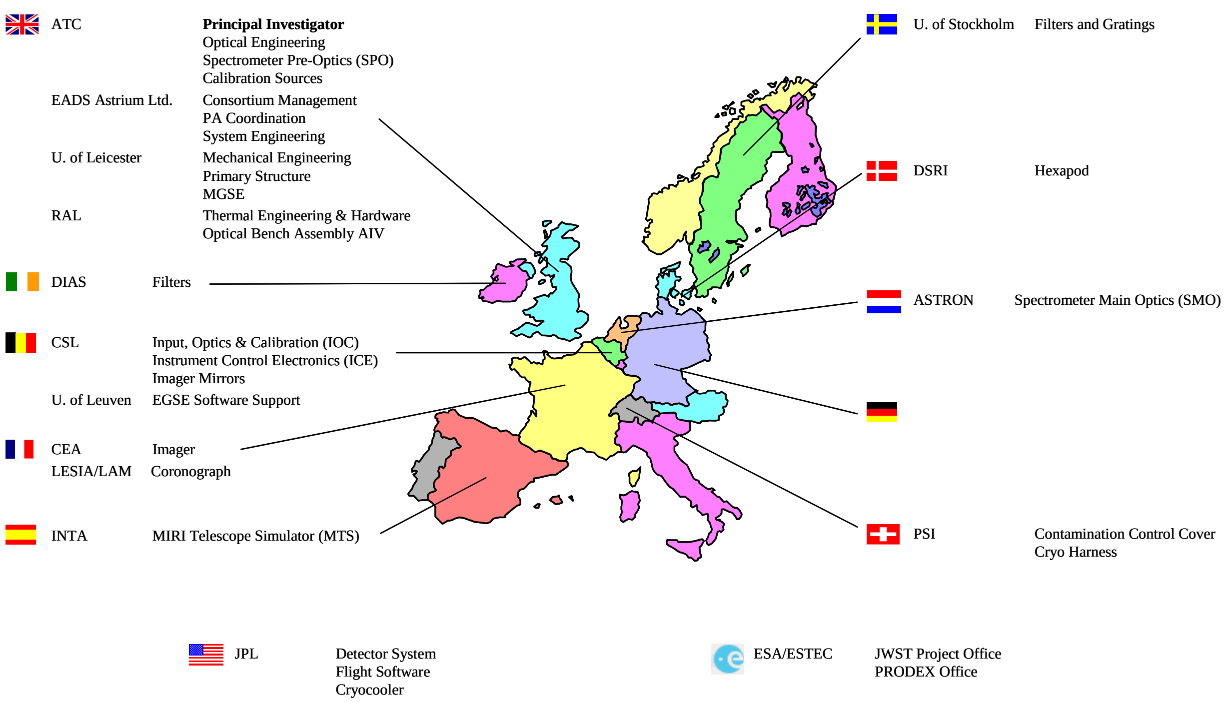


Figure 3-6 JWST Team Members -- Europe / MIRI

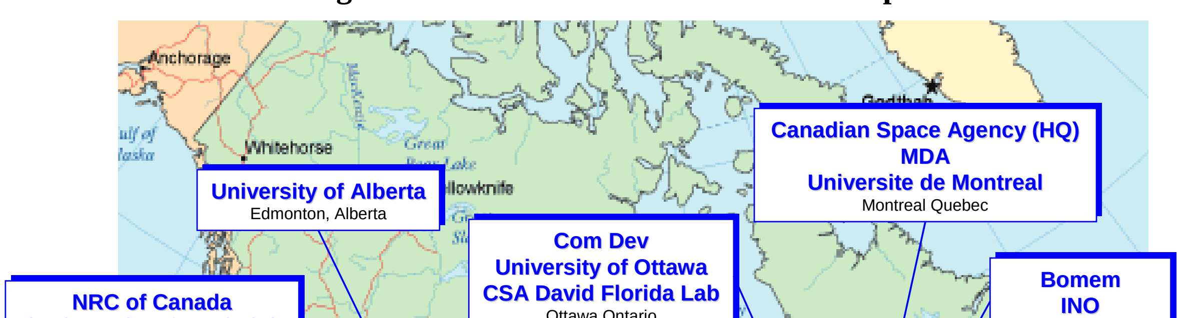


Figure 3-7 JWST Team Members -- FGS

3.5 TECHNOLOGY DEVELOPMENT PLAN

3.5.1 Technologies Development

JWST identified ten enabling technologies required for the mission. These technologies are those, which essentially require new "inventions" (advancements in the state-or-the-art) to achieve the performance needed to achieve the JWST science mission. JWST placed the development of these critical enabling technologies on an accelerated schedule, making an early and significant investment to achieve Technology Readiness Level 6 (TRL-6), i.e., prototype hardware tested in the relevant JWST flight environments, by the end of CY 2006.

The project held a review of technology at a Technology Non-Advocate Review (T-NAR) in January. 2007. This gave NASA independent reviewers the opportunity to assess the readiness of these critical technologies over a year before the traditional Preliminary Design Review / Non-Advocate Review, and over 6 years before the Launch Readiness Date (LRD) of June 2013.

The review committee reported their findings as follows:

- The Project and Development Teams have made impressive progress in the maturation of the ten enabling technologies herein reviewed.
- This activity has retired a significant amount of JWST Program Risk.

- At time of the review committee's final report (17 April 2007) TRL-6 has been achieved on all ten items

The JWST enabling technologies are described below.

1) Near Infrared Detectors

Existing Near Infrared detector arrays did not meet JWST sensitivity and format requirements. The JWST Near Infrared detectors significantly advanced the state of the art in a number of areas, including: total noise, 2048×2048 pixel format for space, and λ=0.6-5 mm mercury-cadmium-telluride (HgCdTe) sensor chip assemblies (SCAs) at T=37 K

The Teledyne Imaging Systems (TIS; formerly Rockwell) HAWAII-2RG SCA was developed for JWST

The Near Infrared detector effort is documented in the following report: Near-Infrared Detectors TRL-6 Demonstration (JWST-RPT-007977)

2) Mid-Infrared Detectors

The Mid Infrared detectors are closely related to the arsenic-doped silicon (Si:As) Spitzer/IRAC arrays. While the JWST Mid Infrared detector layers are developed using exactly the same processes as the Spitzer devices and the readouts, while implementing a slightly different design, use the same Integrated Circuit design rules and foundry processes it has been 10 years since the Spitzer production. The JWST arrays vary from the Spitzer arrays as noted in below.

Property	Spitzer/IRAC	JWST
Pixel Format	256x256	1024x1024
Dark Current	< 10 e-/s (1-4 e-/s)	< 0.03 e-/s
Read Noise	< 20 e- (15 e-)	< 19 e-
QE	> 23% @ 6.3 µm	> 50%

The Mid Infrared detector effort is documented in the following report: Report on the TRL-6 Status of the MIRI Sensor Chip Assemblies (JWST-RPT-008013)

3) Sunshield Materials

The JWST telescope and instruments must be cooled below 50K. The JWST design includes a lightweight deployable five layer sunshield which enables passive cooling of JWST telescope and instruments to stable, cryogenic temperature levels. Layers one and two of material system that meets the thermal, electrical, mechanical, and contamination performance requirements over the JWST lifetime. Existing technology coatings could not meet JWST requirements: conductive paints are too thick and incompatible with folded thin membranes, metallic coatings have $\alpha S/\varepsilon H > 1$, brittle ITO coatings cannot maintain surface conductivity, ITO-SiO2-VDA has brittleness/contamination problems, and Germanium coating corrodes in humid environment. An alloyed-silicon based coated Kapton was selected/developed for sun-facing surface of layers 1 and 2

The sunshield materials effort is documented in the following report: TRL-6 Report, Sunshield Membrane Materials and Coatings (JWST-RPT-008033)

4) Lightweight Cryogenic Mirrors

To achieve the science requirements, JWST has a 25 square-meter primary mirror constructed of 18 primary mirror segment assemblies (PMSA), which are aligned on-orbit to form a single optical surface. The challenge is to make the mirrors lightweight for launch, but nearly distortion-free for excellent image quality. A pre-Phase-A/Phase-A Advanced Mirror System Demonstrator (AMSD) Technology Development program demonstrated that beryllium mirrors can be made to meet the JWST mass and wavefront requirements. The TRL-6 effort was to perform further testing for demonstration of mirror survival through exposure to launch-load testing of a full integrated PMSA.

The PMSA effort is documented in the following report: JWST Mirror Technology (Report) (JWST-RPT-008057)

5) Micro-shutter Arrays

The NIRSpec instrument is to perform spectroscopy on up to 100 targets simultaneously. Previously flown spectrometers had fixed slits which only permitted the viewing of one object at a time. A fixed slit spectrometer would not meet the JWST Level 1 requirement of 2500 galaxies in 5.5 years. The Microshutter arrays are a controllable and reconfigurable aperture-mask (arrays of 171 x 365 100x200 micron-wide cells with "lids" that open and close in response to the application of a magnetic field) to allow multi-object optical transmission to a spectrograph. No flight cryogenic technology existed for this application prior to this development.

The Microshutter effort is documented in the following report: Micro Shutter Array (MSA) Technology Readiness Level (TRL) – 6 Final Test Report (JWST-RPT-007859)

6) Cryogenic Detector Readout ASICs

The JWST observatory architecture is such that the analog signals from the near infrared detectors would need to be transmitted from the cold detector side to the warm electronics side over 4 meter harnesses. A low noise analog signal transmitted over such distances runs the risk of cross talk among different Science Instrument (SI) harnesses and perhaps other observatory harnessing/electronics. To digitize the analog signals from the detectors, JWST is employing a low-noise, cryogenic application specific integrated circuit (ASIC). This ASIC advances the state of art for such devices by delivering a micro-processor with extremely low power dissipation and a 16 bit analog-to-digital converter with noise comparable to conventional warm electronics.

The cryo-ASIC effort is documented in the following report: System for Image Digitization, Enhancement, Control and Retrieval (SIDECAR) Application Specific Integrated Circuit (ASIC) TRL-6 Final Report (JWST-RPT-007999)

7) Cryogenic Heat Switches

The need to protect instruments from contamination during cool-down, and to decontaminate them in the event of an anomaly, requires the capability to warm the instruments. JWST uses heat switches to temporarily break the thermal path from the instruments to their radiators, allowing power-efficient warming of the instruments. The JWST heat switches are tailored for high conductance at 40K when closed.

The cryogenic heat switches effort is documented in the following report: Overview of Heat Switch TRL-6 Development Program (Summary Report) (JWST-RPT-008028)

8) Large, Precision Cryogenic Structure

The composite structure that holds the JWST primary mirror must be exquisitely stable to keep the segments in alignment. While cryogenic, thermally stable telescope structures much smaller than JWST were produced for SIRTF and other missions and thermally stable structures operating at room temperature had been produced the size of HST, prior to JWST, there were no thermally stable, cryogenic, large scale, composite structures produced. The thermal stability requirements (to tens of nanometers) are also more stringent, as JWST is the first mission to utilize a segmented Primary Mirror riding on a Backplane.

To demonstrate the required performance, JWST built a 1/6th full-scale cutout of the flight backplane structure using the manufacturing techniques that will be used for the flight structure and subjected it to cryogenic stability tests.

The Large, Precision Cryogenic Structure effort is documented in the following report: TRL-6 for JWST Large Cryogenic Stable Structures (JWST-RPT-008059)

9) Wavefront Sensing and Control

Wavefront Sensing and Control (WFSC) is the process used to align the JWST mirror segments. Through WFSC, the position of each mirror segment is measured and then each is adjusted to its correct position to produce a very low telescope wavefront error. Taking images of a star with a science instrument, and then processing the images through algorithms that calculate the necessary mirror adjustments accomplish WFSC. The WFSC algorithms have been proven through computer simulations and breadboard demonstrations that replicate a portion of the primary mirror. Successful algorithm tests were also conducted on the Keck Observatory segmented mirror. The final demonstration was accomplished using a subscale WFSC testbed that simulates all 132 degrees of freedom in the JWST telescope.

The WFSC effort is documented in the following report: TRL-6 for JWST Wavefront Sensing and Control (JWST-RPT-008039).

10) Cryocooler

The mid-IR detectors must operate at 7K to detect thermal emissions at wavelengths out to 29 microns. A high-efficiency pulse-tube cryocooler is being developed to provide this cooling capability. The JWST cryocooler is unique in that it provides cooling remotely: the cold head is close to the mid-IR detectors which are located 10 to 15 meters from the cryocooler compressor and electronics. None of the existing flight technologies for ~6K cooling are directly applicable to the JWST application.

The cryocooler effort, as of the T-NAR, is documented in the following report: MIRI Cooler TRL-6 Summary Report (JWST-RPT-008019). At the time of the T-NAR, the cryocooler had not demonstrated achievement of the requisite heat lift versus DC input power. This effort was completed in February 2007 and is documented in the following presentation to the NAR Review Team: JWST-PRES-008679.

3.5.2 Commercialization Opportunities

The JWST Program/Project Office's current and new business strategy will include coordination with the GSFC Technology Management Office and the GSFC Office of Technology Transfer to report and new or unique product of process developed with program/project funds.

3.6 SYSTEMS ENGINEERING MANAGEMENT PLAN

The JWST Program/Project has established a Systems Engineering Team (SET) comprised of the Mission Systems Engineer (MSE), product systems engineers, and discipline systems engineers from the various program/project organizations. The purpose of the SET is to provide technical recommendations to the JWST Project Manager.

The discipline systems engineers and product systems engineers are the key to systems engineering on JWST. The product systems engineers are aligned with the traditional product-based decomposition of the JWST system. They provide systems engineering support associated directly with the production of the product. Product systems engineers work with each of the discipline engineers to obtain the best product possible. The discipline systems engineers work for each of the product systems engineers and product managers. The discipline systems engineers strive to integrate their discipline across all products to achieve an optimal system.

In order to ensure engagement of the discipline system engineers and product systems engineers, they will meet on a weekly basis with the MCE to discuss system-wide issues. This ensures that the entire SET is fully engaged.

The MSE looks to the discipline and product systems engineers as the "gate keepers" for their discipline or product. The discipline and product systems engineers are responsible for auditing, via peer reviews, their discipline or product and for making pass/fail recommendations to the MSE. Recommendations from discipline systems engineers, and product systems engineers provide the MSE with a balanced technical view of the JWST Project. The MSE can then provide optimized recommendations, based on the principles outlined previously, to the JWST Program/Project Manager.

The SET is responsible for the fundamental systems engineering activities of: requirements analysis, functional analysis and allocation, design synthesis, verification, and system analysis and control (Figure 3-8). This responsibility includes, but is not limited to, requirements identification and development, interface requirements, validation and verification; system definition, system design, control of technical budgets, integration and test, technical risk management and the definition of operations concepts. The SET is also responsible for establishing requirements for tests and test-beds and the implementation of tests and test-beds necessary for model validation, verification, and Mission and Segment level technical risk management.

The basic activities shown in Figure 3-8 are iterative in nature and repeated through the various phases of the project lifecycle

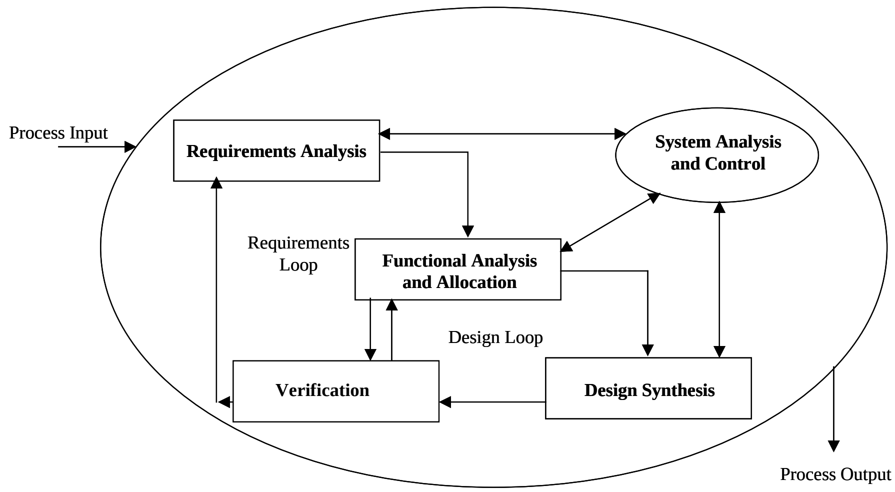


Figure 3-8 JWST Systems Engineering Process

The SET interacts with Project management on all levels. The MSE works directly for the JWST Project Manager and with each product manager.

The SET interacts with representatives from the appropriate Program/Project scheduling/planning, quality, system safety, data management, and CM organizations to ensure recommended changes in the technical baseline can be efficiently presented to Project management for implementation.

Within the SET, responsibility is partitioned according to the system (mission), segment, and element levels shown in Figure 1-2. The MSE is responsible for systems engineering at the mission level. At the segment and element levels, systems engineering responsibility is divided among the Prime, GSFC, and STScI for the Observatory, Integrated Science Instrument Module (ISIM), and Ground Segment, respectively.

The systems engineering scope and approach implemented on the JWST Program/Project are defined in the JWST Systems Engineering Management Plan (SEMP) (JWST-PLAN-000872).

3.7 SOFTWARE MANAGEMENT PLAN

The JWST Software Management Plan (SMP) (JWST-PLAN-000653) establishes the Project's goals, organization, and management processes, for the acquisition of all software products to be provided to the Project to satisfy its requirements. This includes the development and integration of software for both the flight and ground segments, and for laboratory, test, and development tools and environments. The term "software" as used in this document includes code, documentation, and associated data.

This SMP contains requirements to be satisfied by the providers of all software purchased, contractually acquired, developed or maintained for the support or execution of the mission. It defines standards, procedures and organizational relationships for all software activities associated with the Project. Its provisions apply to all Government organizations, in-house activities and contractors providing software capabilities to the Project.

The SMP does not describe the details of JWST software development. This type of information is provided in documents, such as the Observatory Flight Software Product Plan (JWST-PLAN-002504), Integrated Science Instrument Module (ISIM) Flight Software Product Plans (JWST-PLAN-00002762), Near-Infrared Camera Flight Software Product Plan (JWST-PLAN-002051), and the Near Infrared Spectrograph Micro-Shutter Subsystem Flight Software Product Plan (JWST-PLAN-007249).

The Project SMP provides a model for provider SMPs or Product Plans and is intended to be referenced where appropriate to reduce effort and minimize redundancy. Providers' proprietary processes are acceptable if they meet the intent of the Project SMP.

3.8 REVIEW PLAN

3.8.1 Technical Reviews

The JWST mission's independent review plan is defined in the JWST Integrated Independent Review Plan (IIRP) (JWST-PLAN-001402). The independent reviews will be supported by a comprehensive set of peer reviews, as appropriate. The JWST Project will perform Engineering Peer Reviews, as documented in the JWST Project Engineering Peer Review Plan (JWST-PLAN-000912).

Technical reviews will be conducted throughout the program/project life cycle by review boards whose members are independent of the program and project. Through the planned series of reviews, the review boards will provide expert assessment of the technical approach, risk posture, and progress against the program/project baseline. When appropriate, the review boards will offer recommendations to the program/project to improve performance and/or reduce risk. Board members are chosen based on their technical, safety and mission assurance expertise, their objectivity, and their ability to make a broad assessment of the implementation of the program/project that employs numerous engineering and other disciplines.

The program/project has instituted a tiered review system that reflects the JWST System Hierarchy (Figure 1-2) as follows:

- JWST System level reviews and selected Segment level reviews will be conducted by the Standing Review Board.
- Segment, Element, and selected Subsystem level reviews will be conducted by the GSFC Systems Review Office
- Subsystem and lower levels (component and assemblies) will be subject to peer reviews conducted by the applicable "next higher level of assembly" systems engineering/programmatics entity.

Table 3-4 defines the formal technical reviews that have been completed / are planned. The schedule for performance of those reviews yet to be performed is maintained as part of the JWST Project Master Schedule (JWST-SCHED-004215).

Table 3-4 JWST Program / Project Technical Reviews

7120.5D Required Program/Project Reviews	JWST Review Titles	JWST Hierarchy Level	Description	System Schedule
Mission Concept Review (MCR)	Concept Review	System	The MCR affirms the mission need and examines the proposed mission's objectives and the concept for meeting those objectives. Key technologies are identified and assessed	Completed
Mission System Requirements Review (SRR)	System Requirements Review (SRR)	System Segment Element Subsystem	The SRR examines the functional and performance requirements defined for the system and ensures that the requirements and the selected concept will satisfy the mission.	Completed
Mission Definition Review (MDR)	Mission Definition Review (MDR)	System	The MDR (or SDR) examines the proposed requirements, the mission/system architecture, and the flow down to all functional elements of the system.	Completed
Mission System Definition Review (SDR)	System Definition Review (SDR)	System		Completed
Mission Preliminary Design Review (PDR)	Preliminary Design Review (PDR)	System Segment Element Subsystem	The PDR demonstrates that the preliminary design meets all system requirements with acceptable risk and within the cost and schedule constraints and establishes the basis for proceeding with detailed design. It shows that the correct design option has been selected, interfaces have been identified, verification methods have been described, risk assessments, and metrics are presented.	March/April 2008
Mission Critical Design Review (CDR)	Critical Design Review (CDR)	System Segment Element Subsystem	The CDR demonstrates that the maturity of the design is appropriate to support proceeding with full scale fabrication, assembly, integration, and test, and that the technical effort is on track to complete the flight and ground system development and mission operations in order to meet mission performance requirements. Risk assessments are presented.	July 2009
Production Readiness Review (PRR)	Manufacturing Readiness Review(s) (MRR)	Subsystem	The PRR is held for projects developing or acquiring multiple similar or identical flight and/or ground support systems. The purpose of the PRR is to determine the readiness of the system developer(s) to efficiently produce (build, integrate, test, and launch) the required number of systems. The PRR also evaluates how well the production plans address the system's operational support requirements.	As Required
System Integration Review (SIR)	Observatory Test Readiness Review (TRR)	System Segment Element Subsystem	The SIR evaluates the readiness of the project to start flight system assembly, test, and launch operations. V&V plans, integration plans, and test plans are reviewed. Test articles (hardware/software), test facilities, support personnel, and test procedures are ready for testing and data acquisition, reduction, and control.	July 2010

7120.5D Required Program/Project Reviews	JWST Review Titles	JWST Hierarchy Level	Description	System Schedule
System Acceptance Review (SAR)	Pre-Ship Review (PSR)	System Segment Element Subsystem	The SAR verifies the completeness of the specific end item with respect to the expected maturity level and to assess compliance to stakeholder expectations. The SAR examines the system, its end items and documentation, and test data and analyses that support verification. It also ensures that the system has sufficient technical maturity to authorize its shipment to the designated operational facility or launch site.	January 2013
Mission Operations Review (MOR)	Mission Operations Review (MOR)	System Segment	The ORR examines the actual system characteristics and the procedures used in the system or product's operation and ensure that all system and support (flight and ground) hardware, software, personnel, and procedures are ready for operations and that user documentation accurately reflects the deployed state of the system.	December 2011
Mission Flight Readiness Review (FRR)	Mission Flight Readiness Review (FRR)	System	The FRR examines tests, demonstrations, analyses, and audits that determine the system's readiness for a safe and successful flight/launch and for subsequent flight operations. It also ensures that all flight and ground hardware, software, personnel, and procedures are operationally ready.	May 2013
Operations Readiness Review (ORR)	(Ground Segment) Operations Readiness Review	System	The ORR examines the actual system characteristics and the procedures used in the system or product's operation, and ensure that all system and support (flight and ground) hardware, software, personnel, and procedures are ready for operations and that user documentation accurately reflects the deployed state of the system.	TBD
Launch Readiness Review (LRR)	Launch Readiness Review (French acronym: RAL)	System	Final review prior to actual launch in order to verify that Launch System and Spacecraft/Payloads are ready for launch.	May 2013
Post-Launch Assessment Review (PLAR)	Operations Readiness Review (ORR)	System	Assessment of system post checkout and commissioning in-flight performance and an assessment of readiness to enter into mission operational status	December 2014
Critical Event Readiness Review (CERR)		System	Review to confirm readiness to execute a critical event during flight operations.	As Required
Decommissioning Review (DR)		System	The purpose of the DR is to confirm the decision to terminate or decommission the system and assess the readiness for the safe decommissioning and disposal of system assets.	TBD

3.8.2 Program / Project Programmatic Reviews

In addition to the technical reviews described above, the following Program/ Project programmatic reviews have been completed / are planned: The schedule for performance of those reviews yet to be performed is maintained as part of the JWST Project Master Schedule (JWST-SCHED-004215).

Table 3-5 JWST Program / Project Programmatic Reviews

7120.5D Required Program/Project Reviews	JWST Review Titles	JWST Hierarchy Level	Description	System Schedule
Preliminary Program Approval Review (PPAR)	System Requirements Review (SRR)	System	The PPAR is conducted as part of the Program/System Requirements Review. ROM budgets and schedules are presented. The review is to ensure that major issues are understood and resolved early and to provide Agency management with an independent assessment of the readiness of the program to continue with formulation.	Completed
Program Approval Review (PAR)	Mission Definition Review (MDR)	System	The PAR is conducted as part of the Program/System Definition Review to provide Agency management with an independent assessment of the readiness of the program to proceed into implementation. The proposed program's objectives and the concept for meeting those objectives are assessed. Key technologies and other risks are identified and assessed. The baseline Program Plan, budgets, and schedules are presented.	Completed
Preliminary Non-Advocate Review (PNAR)	Preliminary Non-Advocate Review (PNAR)	System	The PNAR is conducted as part of the Mission Definition Review to provide Agency management with an independent assessment of the readiness of the project to proceed to Phase B.	Completed
n/a	Technologies Non-Advocate Review (T-NAR)	System	JWST identified ten "enabling" technologies required for the mission (see section 3.5). The TNAR provides all concerned parties the opportunity to identify, plan mitigation for, and retire – if possible – technology risks, prior to mission PDR. The TNAR scope will be limited to the assessment of technology readiness (TRL-6) of the specified technology items	Completed
Non-Advocate Review (NAR)	Non-Advocate Review (NAR)	System	The NAR is conducted as part of the System Preliminary Design Review to provide Agency management with an independent assessment of the readiness of the project to proceed to implementation. Full baseline cost and schedules, as well as risk assessments, management systems, and metrics are presented.	April 2008

7120.5D Required Program/Project Reviews	JWST Review Titles	JWST Hierarchy Level	Description	System Schedule
Program Status Review (PSR) Program Implementation Review (PIR)		System	PSRs are conducted by the program to examine the program's continuing relevance to the Agency's Strategic Plan, the progress to date against the approved baseline, the implementation plans for current and upcoming work, budget, schedule, and all risks and their mitigation plans. PSRs are to be performed on two year centers following completion of the System PDR/NAR. For JWST, the PSRs will be incorporated as a part of System Level Technical Reviews. If required, a "stand alone" PSR will be held two years after the previous System Technical Review/PSR. PIRs are conducted as part of this review to provide Agency management with an independent assessment of the readiness of the program to continue with implementation.	In conjunction with Mission Technical reviews
	Monthly Project Status Review	System	Internal to the JWST Project. Each major area of the Project reports to the Project Manager, identifying significant events since last month's review; accomplishments; budget; technical progress, identified risks, schedule status; and risk issues.	
	Monthly Status Review (MSR)	System	With the GSFC Program Management Council (GPMC). The technical, schedule, and financial status of the Project are presented.	
	Pre-MSR	System	Presentation to the Director of Code 400. The technical, schedule, and financial status of the Project are presented preparatory to the MSR.	
	Semi-Annual Mission-level Review (Partner's Workshop)		With participation by all JWST Mission partners. This is used to identify significant events since the last review and to assess technical progress, identified risks, schedule status; and risk issues.	

3.9 MISSION OPERATIONS PLAN

The Mission Operations Plan (MOP) will be developed as specified in GSFC Rule 1.02 (Development & Implementation of Mission Operations Concept). The draft MOP will be developed in Phase C and reviewed at CDR. It will be baselined in Phase D and reviewed at the MOR. The MOP will describe the Project plan to implement the Ground Segment elements with the necessary hardware, software and procedures. Other required contents will be captured at a high level, with details contained in other specified documents as follows:

- Activities required to launch, operate, and decommission the flight system will be contained in the Mission Operations Concept Document.
- Mission operation plans, rules, and constraints will be documented in the Observatory Operations Requirements Allocation Document.
- The Mission Operations and Ground Data Systems training requirements will be documented in the Flight Operations Training Plan.

- Procedures to ensure reliable, consistent, and controlled operations, incorporating integration and test lessons learned will be contained in the Flight Operations Handbook.
- Facilities requirements will be documented in the Facilities Plan.
- Mission Operations and Ground Data Systems hardware and software descriptions will be captured in the S&OC Architecture Document and associated documentation.

3.10 ENVIRONMENTAL MANAGEMENT PLAN

3.10.1 Purpose and Scope

The purpose of the Environmental Management Plan is to define how the James Webb Space Telescope mission will comply with NPR 8580.1, Implementing the National Environmental Policy Act (NEPA) and Executive Order (EO) 12114. This plan identifies the steps and schedule of events for compliance with NEPA and other environmental regulations.

The GSFC JWST Project Manager has the overall responsibility for ensuring that the project is carried out in compliance with the letter and spirit of NEPA and other applicable environmental laws and regulations.

3.10.2 National Environmental Policy Act

The National Environmental Policy Act is the national policy for protecting the human environment. NEPA sets the Nation's goals for enhancing and preserving the environment. NEPA also provides the procedural requirements to ensure compliance by all Federal agencies. NEPA compliance can be a critical path item in project or mission implementation.

NEPA requires all Federal agencies to consider the environmental impacts of an action during the planning phase. NEPA directs agencies to consider alternatives to their proposed activities. In essence, NEPA requires NASA decision makers to consider environmental, technical, and economic factors. NEPA is also an environmental disclosure statute. It requires that available information be adequately addressed and made available to NASA decision makers in a timely manner so they can consider the environmental consequences of the proposed action or activity. Environmental information must also be made available to the public as well as to other Federal, State, and local agencies.

NEPA does not require that the proposed action or activity be free of environmental impacts, be the most environmentally benign of potential alternatives, or be the most environmentally wise decision. NEPA requires the decision maker to consider environmental impacts as one factor in the decision to implement an action.

EO 121114 was issued January 4, 1979, to establish internal procedures for Federal Agencies to consider the significant effects of their actions on the environment outside of the United States, its territories, and possessions. Its purpose is to enable decision makers to be informed of environmental considerations and factor such considerations in their decisions.

3.10.3 The JWST Mission NEPA Process

The JWST Mission involves a launch from a foreign launch site, French Guiana. Because of this, the JWST mission will follow the procedures established under NPR 8580.1 for EO 12114 to satisfy the requirements of the executive order. The JWST Mission will implement the following steps:

1) Complete the Environmental Checklist, Flight Projects (GSFC Form 23-75).
*JWST Project Manager (***completed 8/10/2007)**

2) Perform environmental evaluation to determine environmental compliance requirements.
*GSFC NEPA Program Manager (***completed 8/2007)**

3) Contact the Radiation Safety Officer (RSO) at GSFC (6-0280) to initiate the launch approval process for the radioactive source on the MIRI instrument. The RSO must also be contacted prior to arrival of the source at GSFC.
JWST Project Manager

4) Prepare EO 12114 Memorandum for the Record (MFR)/Record of Environmental Consideration (REC).
GSFC NEPA Program Manager and JWST Project Manager

5) Project Review of MFR/REC.
JWST Project Manager

6) Coordination with Headquarters and foreign country.
GSFC NEPA Program Manager and JWST Project Manager

7) Route for signature to NASA HQ Science Mission Directorate Director of Astrophysics Division
JWST Project Manager

8) Retain in files
GSFC NEPA Program Manager and JWST Project Manager

9) Notify NEPA Program Manager of any changes which may affect NEPA compliance and environmental impacts.
JWST Project Manager

3.10.4 Decision-Maker

The NASA HQ Science Mission Directorate Director of Astrophysics Division is the designated decision-maker for the JWST Mission and will approve the EO 12114 MFR/REC.

3.10.5 Administrative Record

The GSFC NEPA Program Manager will maintain the administrative record in support of the NEPA process. The Project shall maintain mission-related records and copies of the decision record, the EO 12114 MFR/REC.

3.10.6 NEPA Noncompliance

Compliance with NEPA is subject to judicial review. It is imperative that NEPA procedural requirements be satisfied. Failure to comply with NEPA can result in the Project being slowed down or stopped until the NEPA process and documentation is completed, thereby adding delay, costs, and potentially jeopardizing the Project. The Project is responsible for compliance with NEPA/EO12114.

3.10.7 Timing NEPA Compliance with Project Planning

CEQ regulations state that agencies ". . . shall integrate the NEPA process with other planning at the earliest possible time to ensure that planning and decisions reflect environmental values, to avoid delays later in the process, and to head off potential conflicts. . . ." (40 CFR §1501.2).

As required in NPR 8580.1 and NPR 7120.5, the NEPA/EO12114 process is to be completed by PDR/KDP C. This is before the project reaches a point where NASA's ability to implement reasonable alternatives is precluded (i.e., before hard decisions are made regarding project implementation). During this stage, the project manager will have the greatest latitude in making adjustments in the project planning to mitigate or avoid important environmental sensitivities. Figure 3-9 displays the proposed schedule for the JWST NEPA/EO12114 compliance process. Note: Completion of the EO12114 process may be delayed past PDR/KDP-II to allow for concurrence from the foreign country.

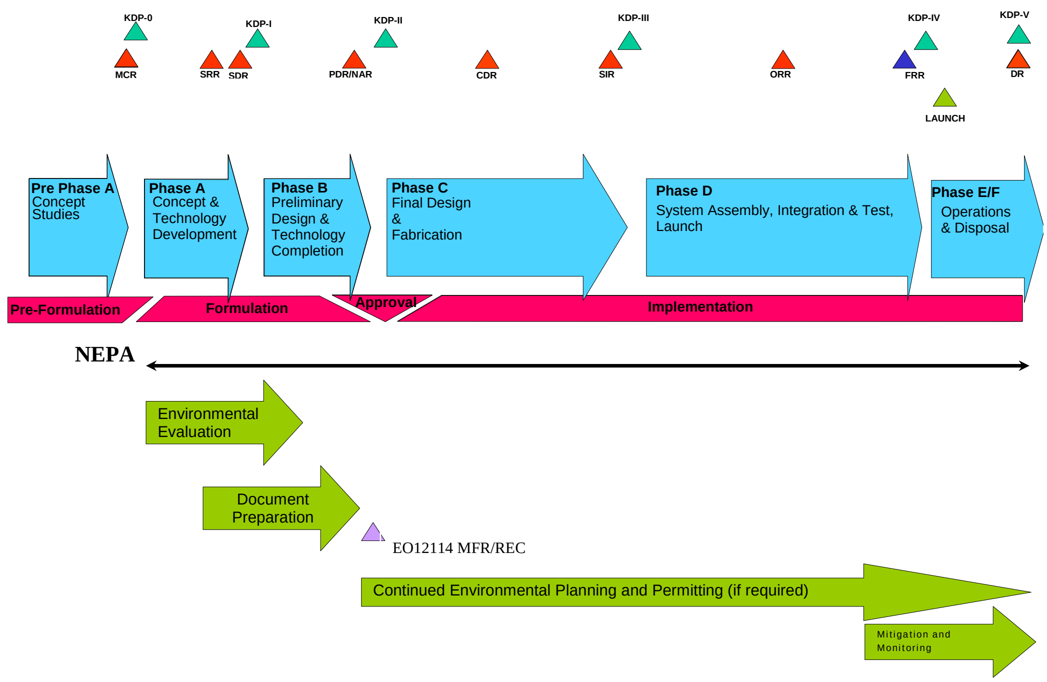


Figure 3-9 NEPA/EO12114 Compliance Schedule for JWST

3.10.8 Permits

It is not anticipated that the project will require any new or amended permits, waivers, documents, approvals or concurrences for compliance with applicable Federal, State, Tribal government and local environmental regulations. Any required permits for the mission should fall under existing permits and documentation at the development and launch sites.

If at any time conditions change and permits may be required the Project will contact the Environmental Management Office.

The JWST mission will carry a small radioactive source, Thorium Fluoride (ThF_4), for use in the Mid-Infrared Instrument (MIRI) instrument being developed by the Jet Propulsion Laboratory (JPL) as a surface coating for an optical element in the instrument. The launch of this radioactive source will require the approval of the NASA Nuclear Flight Safety Assurance Manager (NFSAM). The project must contact the Radiation Safety Officer at GSFC (6-0280) to initiate the launch approval process. The RSO must also be contacted prior to arrival of the source at GSFC.

Approximately 720 kg of beryllium is being used for the Optical Telescope Element (OTE) mirror elements and the Near-Infrared Camera (NIRCam) Optics Assembly bench structure. Manufacturing/rework of beryllium parts will take place at contractor facilities and not at GSFC. The project shall ensure that the manufacturing/rework of beryllium is being performed in compliance with applicable safety and environmental controls and regulations.

3.10.9 Pollution Prevention

The Pollution Prevention Act of 1990 established national policy that pollution should be:

- Prevented or reduced at the source
- Pollution that cannot be prevented should be recycled
- Pollution that cannot be prevented or recycled should be treated
- Disposal or other release into the environment should be employed only as a last resort

With support from the EMO, the Project will employ pollution prevention techniques to minimize the use of hazardous materials, the generation of wastes, and emissions of pollutants to the environment. Such techniques include:

- Reducing the use of toxic and hazardous chemicals
- Reusing and recycling materials
- Purchasing environmentally preferable and recycled products through affirmative procurement programs

3.11 LOGISTICS PLAN

3.11.1 Hardware, Software, and Ground Support Equipment

The responsibility for the necessary packaging and delivery of any deliverable is with the shipping party. This responsibility includes the necessary cost for shipment.

Movement of flight hardware and any equipment once delivered to NASA, until such time as the operation is complete, shall be the responsibility of NASA.

Movement of flight hardware and any equipment once delivered to the ESA or CSA, until such time as the operation is complete, shall be the responsibility of ESA/CSA.

Each party will retain ownership of elements and equipment it furnishes to the other party. Any equipment not launched into space will be returned to the furnishing Party at such time as mutually agreed. Each party will transport its equipment to the designated delivery points. If the equipment is to be returned to the furnishing party, the receiving party will arrange the transport.

GSFC will prepare appropriate shipping documentation to properly transfer accountability of the ESA/CSA hardware to U.S. industry facilities as necessary.

3.11.2 Assistance and Maintenance

The exchange of services and provisions for logistics are related to all hardware, software, and GSE deliverables. Such service and assistance encompass:

Assistance for joint tests and integration of delivered hardware

Assistance for joint tests and integration of FSW

Training for use of deliverables (component models, SW, GSE)

Repair and maintenance of models, software, and GSE

In general, the deliverer will provide adequate training and assistance to installation and use of any delivered hardware, software, or GSE as delineated in the applicable Joint Project Implementation Plan (JPIP).

Furthermore, in case of malfunction or problem, adequate assistance will be provided by co-locating experienced personnel and/or replacement of items, as necessary. The test plans will detail adequate period of training and locations of tests.

3.11.3 Transportation

The Observatory Prime Contractor, NGST, is contractually responsible for preparing the Observatory and GSE Transportation Plan (JWST-LPAN-002030). The document defines the preparations, operations support, and scheduling required to safely transport the JWST Observatory and associated GSE from the I&T Facility to and from Government Test Facilities, to the launch site, and for return of the GSE following launch. Included are both ground and air transportation as required.

The content includes:

- List of preparations and descriptions with process flow for all activities necessary prior to shipment
- Roles and responsibilities of the members of the transportation team
- Details of GSE transportation to and from Government Test Facilities, and to launch site, including list of items to be transported, schedules, applicable procedures, inventory control provisions, documentation required, and modes of transportation
- Details of Observatory transportation to and from Government Test Facilities, and to launch site, including schedule, support equipment to be transported, applicable procedures, contamination controls, hazardous materials provisions, safety provisions, facilities required, and modes of transportation
- Details of GSE transportation return from launch site, including schedules, applicable procedures, documentation required, and modes of transportation

3.12 SCIENCE AND DATA MANAGEMENT PLAN

Under contract with NASA/GSFC, the AURA/STScI will operate the JWST Science and Operations Center. Under this contract, AURA/STScI will prepare a “stand alone” JWST Science Data Management Plan (JWST-PLAN-006956) prior to the JWST Mission CDR. The Plan will be put in force no later than the Program/Project Mission Operations Review. The Plan will be prepared in accordance with the following guidelines:

- NPD 2200.1, Management of NASA Scientific and Technical Information and
- NPR 2200.2B, Requirements for Documentation, Approval, and Dissemination of NASA Scientific and Technical Information, as applicable to program science data.

A Preliminary JWST Science Data Management Plan is included in the Space Telescope Science Institute James Webb Space Telescope Mission Science and Operations Center JWST Technical Management Plan (JWST-PLAN-002920). The pertinent section is extracted/reprinted below:

6.0 DATA MANAGEMENT PLAN

The STScI JWST Data Management Plan is designed to achieve the widest possible distribution of JWST data consistent with the policies that have been established by NASA. The elements of that plan are as follows:

6.1 STScI JWST Data Management

JWST science and engineering data will be recorded on solid-state recorders on-board and periodically downlinked from JWST through the ground station network to the STScI. Both engineering and science data will be processed then stored in the Multimission Archive at Space Telescope (MAST). The S&OC will also archive flight software ground master images and ancillary data received from the spacecraft (e.g., status logs) in a special facility in the Flight Operations System (FOS). The Flight Operations Team (FOT) is responsible for receiving all data before delivery to MAST for processing, archiving, and user distribution. The transmission quality is expected to be such that very few packets require repair. However, an FOT operator will perform limited repairs on or flag damaged data. Quality statistics, information, and other ancillary management information will be automatically generated, archived, and made available to users. This information is used to support data accounting requirements, anomaly reporting and investigation, and to assist archival researchers. The Operations Division has responsibility for all aspects of operations and management of MAST. The data processed by OPUS is archived on mass storage devices (e.g., high density disks) and on a suitable backup medium (magneto optical disks). These backup data are maintained in secure storage facilities at a site other than the STScI main facility, e.g., the JHU Bloomberg Building.

The Operations Division is charged with assuring observers' proprietary rights and in fulfilling user requests for archival data. Most data will be transferred via the Internet. However, the Operations Division can generate hard-copy digital data products, in accord with instructions furnished by the GO and ship these to the destination specified by the GO. The Operations Division also provides hot-line user support. Data stored in the archive will sometimes need to be reprocessed to correct for errors in original processing or to update the archived version with additional necessary information. The required reprocessing effort is also the responsibility of the Operations Division.

6.2 Data Rights, Access and Distribution

Policy guidelines on data rights, access and distribution will be developed in consultation with STScI and STIC, approved by the NASA Associate Administrator (OSSA), and transmitted to the Institute through the Contracting Officer; the following policies reflect the practice for HST and the preliminary JWST policies.

6.2.1 STScI Policy and Implementation

The Principal Investigator (PI) of each JWST proposal will have exclusive access to the scientific data during a nominal 12 month proprietary period with the exception that selected STScI staff members will have access authorized as required to discharge operational responsibilities. The Co-Investigators on a program do not have any explicit rights to the data; however, administrative procedures will be provided to allow the PI to authorize access to the data by other individuals. This proprietary rights policy applies to data obtained by Guaranteed Time Observers, by General Observers, and to observations made during the Director's Discretionary Time that are assigned to individual scientists. At the end of the proprietary period, the data will become available to any interested party.

Under certain circumstances, the automatic proprietary period described above can be modified by the STScI Director. For example, longer extensions to the proprietary period may be granted if supported by strong scientific requirements (e.g., long-term programs which require a complete data set before any reasonable scientific use can be made of any part of the data set). Conversely, compelling scientific reasons or special programs such as the Hubble Deep Field or Legacy programs may argue for shorter periods.

6.2.2 JWST Data Classes

The STScI will enforce a proprietary period for certain types of JWST data during which access to the data will be restricted. The different classes of data and their respective proprietary period, if any, are discussed below:

- At the end of the commissioning period, all the commissioning and calibration data become available to any scientific investigator. Any GTO data obtained during this period is governed by the normal 12-month proprietary period, which applies to all GTO, and GO observations.
- All GTO observations are covered by the nominal 12-month proprietary period unless specifically waived by the PI.
- All GO observations are covered by the nominal 12-month proprietary period unless specifically waived by the PI or modified as a condition of approval by the Director (like SIRTF Legacy Programs).
- Scientific Instrument calibration data (using either internal or external sources), which are collected at the direction of the STScI to ensure proper working conditions of the SIs are available to any scientific investigator as soon as the data are placed in the STScI data archive. However, SI calibration data that are collected and charged to a specific observing program at the request of an observer are considered part of the science data associated with that program and will be covered by the same proprietary rights policy as other GO and GTO data.
- Engineering data files that are not directly associated with particular SI observations may be made available to principal investigators. Generally, the STScI will limit access to JWST engineering data to STScI operations staff and supporting contractors.
- Access to the Project Reference Data system, status logs, and flight software master images will be restricted to STScI operations staff and supporting contractors.
- The Director will determine the data rights associated with Director's Discretionary observations on a case-by-case basis.

6.3 Disposal of Data

Data will be maintained for the duration of the mission. Plans for the maintenance JWST data following the completion of JWST flight operations and of the JWST data thereafter will be defined in subsequent versions of this plan.

6.4 Computing Resources

Computing resources, both hardware and software, are used to support many STScI activities. The Center for Processes and Technology (CPT) is responsible for all science and general staff support computing resources, the JWST ground system and operations software development computing resources, and the Administration Division computers, peripherals, and support personnel.

6.5 Software Availability Policies

There are two categories of software under STScI custody: mission-specific operations (JWST, HST, NVO, etc) software and scientific software. The former may have no application outside the specific missions and its distribution to other parties is not generally authorized. However, some general utilities (e.g., standard database and network access routines), generic advance planning software (e.g., Spike), and pipeline processing systems (e.g. OPUS) have been requested by other astronomical and related groups, and STScI has distributed these. The scientific software needs a wide distribution among observatory users in order to maximize the scientific return from the mission, and consequently STScI has established, with NASA concurrence, policies encouraging such distribution with prior review and authorization by the ESS Division Head and the Head of Business Resources Center. Release of any software to third parties may require a Licensing Agreement depending on the specific items included.

3.13 INFORMATION AND CONFIGURATION MANAGEMENT PLAN

3.13.1 Configuration Management

All changes impacting the JWST Project objectives are reviewed and controlled in accordance with the JWST Configuration Management Procedure (JWST-PROC-000654), prepared in accordance with GPR 1410.2, Configuration Management.

All technical performance, cost, or schedule trade-offs not impacting the JWST PCA are under the control of the JWST Project Manager and will be handled in accordance with the JWST CM Procedure.

The JWST organization utilizes five CCB levels as illustrated in Figure 3-4. Each CCB level is defined below:

- o Level 1 – NASA Headquarters
- o Level 2 – JWST Project (GSFC)
- o Level 3A – Observatory (GSFC)
- o Level 3B – ISIM (GSFC)
- o Level 3C – G&OC (GSFC)
- o Level 4 – Contractor, agency, and GSFC internal organizations providing products/services to Level 3
- o Level 5 – Subcontractor, agency, and GSFC internal organizations providing product/services to Level 4

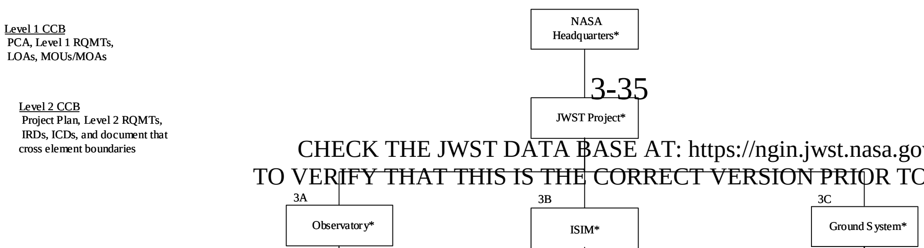


Figure 3-10 JWST Project Configuration Control Board Hierarchy

The JWST Project manages CCB Levels 2 through 3C while CCB Levels 1, 4, and 5 have the authority to disposition changes for which they are responsible.

Each CCB has been delegated authority for particular documents, milestones, CIs, or monetary limits within the scope of that level. The CCB will assign a disposition to change requests within the authority of that CCB level. The CCB will review and comment on change requests initiated at higher levels.

The highest level CCB that has authority in a particular area designates the final disposition of a change request.

Changes affecting higher-level requirements will be submitted, with recommendations, to the next higher-level CCB for disposition.

3.13.2 Information Management

JWST data management involves, but is not limited to, the following:

- Identifying, collecting, logging, scheduling, processing, tracking, both project- and contractor prepared documents
- Acquiring and distributing documents to project personnel and other reviewers using an on-line database
- Establishing and maintaining a schedule of all contractor deliverables and tracking the status
- Apprising management of the status of active data items and schedules, and reporting any data scheduling problems
- Coordinating the delivery of contractor deliverables
- Maintaining an electronic library of contractor deliverables, presentation packages, videotapes, photographs, graphics, software, reference material, and project-related documentation

- Maintaining the on-line library database

The JWST Program/Project information management is controlled in accordance with the JWST Project Data Management Procedure (JWST-PROC-000655.

The JWST Observatory Prime Contractor documentation deliverables to the JWST Project Library are delineated in the JWST Project Deliverable Item List and Schedule for the JWST Observatory Contract NAS5-02200 (JWST-LIST-000637).

The Science and Operations Center documentation deliverables to the JWST Project Library are delineated in the JWST Project Science and Operations Deliverable Items List and Schedule (JWST-LIST-000723).

The JWST/ISIM documentation deliverables to the JWST Project Library are delineated in the indicated/applicable DILS.

NIRCAM	JWST- LIST-002571	James Webb Space Telescope Project Integrated Science Instrument Module Near-Infrared Camera Government-Furnished Property List for Contract NAS5-02105
NIRSpec	JWST-LIST-000823	James Webb Space Telescope Integrated Science Instrument Module Near-Infrared Spectrograph Deliverable Items List and Schedule
MIRI	JWST-LIST-000824	James Webb Space Telescope Integrated Science Instrument Module Mid-Infrared Instrument Deliverable Items List and Schedule
FGS	JWST- LIST-000825	James Webb Space Telescope Integrated Science Instrument Module Fine Guidance Sensor Deliverable Items List and Schedule
ISIM	JWST-LIST-002627	JWST Project ISIM Goddard-Provided Components Deliverable Items List and Schedule

3.13.3 Knowledge Capture

Knowledge capturing, storing, and sharing best practices and lesson's learned from team activities will be fostered throughout the entire project.

The "lessons learned" process involves in researching and analyzing data sources and information from other programs/projects, conducting interviews, examining databases, including the NASA Lessons Learned Information System (LLIS), NASA Center and Project databases, Department of Defense, and US Department of Energy data products, as well as web-based 'self-evaluation' checklists. These checklists include team surveys that will be conducted periodically with the aim of developing superior, high-performance project teams. The survey measures ten team characteristics shown to be strongly correlated with project performance and helps define metrics for Project team development and performance. The data resulting from this process will be used to identify opportunities for improvement and initiate explicit actions to improve programmatics and the JWST team as a whole. As an example, using lessons learned from the HST Program, many of the cost and schedule risks encountered on that program will be mitigated by systems engineering innovations.

The Senior JWST Project Management will participate in formal sessions of knowledge capture after each important event.

Knowledge capture repositories exist in the NGIN project management website. Process related lessons learned are reported to the chief systems engineer. Each functional organization is required to submit their 'Top Ten' lessons learned on a monthly basis and a separate forum reviews and submits to the knowledge management portion of the NGIN database. Access authority will be assigned to those with program or ITAR sensitivity and a pipeline will be established for sharing the others with the GSFC community.

The JWST pan for knowledge capture is documented in the JWST Knowledge Management Plan (JWST-PLAN-006451).

3.14 SECURITY PLAN

3.14.1 Security Requirements

Personnel Security - All JWST Program/Project personnel positions will be evaluated and the appropriate risk designations will be determined. Once risk designations are determined, appropriate background investigations (NACI, Secret, Top Secret) will be initiated within the appropriate time frames as required in NPR 1600.1 Security Program Procedural Requirements -Chapter 3: NASA Personnel Security Program: Position Risk Designation Process, Background Investigations, and Employment Suitability Determinations for NASA Employees

Physical Security - All JWST Program/Project employees (Civil Servant and Contractors) shall comply with all badging requirements for access. The Program/Project shall assure that access to all secure areas will be controlled by the use of keys or an electronic access reader and access will only be granted to those with a legitimate need to access the area as required in NPR 1600.1 Security Program Procedural Requirements -- Chapter 7: Physical Security Program

Should any unauthorized personnel be detected within or having been within the Program/Project facilities the cognizant security officials shall be contacted by telecom. Additional reporting, investigation, and corrective actions as required shall be coordinated with the security officials.

Industrial Security - NASA supervisors at all levels shall ensure that all personnel entrusted with classified information or material are fully knowledgeable of and comply with the provisions set forth in NPR 1600.1 and established National level policies governing accessing, protecting, accounting for, and safeguarding classified information and material, and that management of classified information be included in individual performance plans as a critical element.

Counterintelligence/Counterterrorism Security JWST program/project managers are responsible for fulfilling all requirements associated with the protection of NASA personnel and assets. Accordingly, the program/project manager will consult with the Counterintelligence Office to determine the presence of any Critical Program Information elements, Technology Transfer Control, and to assure that any traveler who experiences any unusual contacts with foreign nationals provides appropriate reporting.

3.14.2 Information Technology Security Plan

The JWST project IT system is listed as a subsystem under the Flight Projects Directorate plan SC-001-M-GSF-4120, "Flight Projects Moderate Science System." This plan includes 39 subsystems (of which JWST is one) funded through the Science Mission Directorate. The Information Systems Categorization of this plan (and the JWST IT system) is Moderate. This system received full Authorization To Operate (ATO) in September 2007.

The JWST IT systems are well-protected by firewall; Group-level access on NGIN protects ITAR data from unauthorized release to foreign partners; systems are regularly backed up.

The JWST project also has formed the JWST Inter-organizational IT Working Group, comprised of representatives from interested JWST partners (both US and international) to guide overall JWST IT system development, with particular emphasis on managing IT security requirements while enabling required interoperability.

3.14.3 Emergency Response Plan

JWST Program/Project will coordinate with/work thru the GSFC Security Division (Code 240) to implement the applicable requirements delineated in the Emergency Preparedness Program Plan for Greenbelt (GPR 8710.2A).

Additionally, the JWST Program/Project has prepared a Program/Project Contingency Plan (JWST-PLAN-007411).

3.15 EXPORT CONTROL PLAN

The JWST Program/Project has generated an International Collaboration Annex / Technology Transfer Control Plan (TTCP) (JWST-PROC-001009); prepared in accordance with NPR 2190.1, Procedures and Guidelines for the NASA Export Control Program, paragraph 3.5, Technology Transfer Control Plans

The TTCP provides an overview of the various international collaboration considerations that will be experienced through the development phases of the Program/Project. The document is intended to serve as an aid and a guide to the JWST Project personnel, as well as other NASA officials and contractors involved with the JWST Project.

The document addresses the following four fundamental questions:

1. What technologies, software, or hardware will JWST be working with that are subject to export control?
2. What foreign nationals (and what foreign partners) are JWST working with?
3. What technologies, software, or hardware does JWST need to provide to those foreign partners, according to the agreement(s) governing these activities? Which ones do JWST need to protect?
4. How will JWST provide those export controlled technologies, software, or hardware to those foreign nationals with whom JWST is collaborating? How will JWST protect export-controlled technologies, software, or hardware from unauthorized transfer?

3.16 EDUCATION AND PUBLIC OUTREACH PLAN

The GSFC Office of Public Affairs (PAO) has generated a Public Engagement Plan (JWST-PLAN-009246). This plan will be reviewed and updated on a regular basis to remain consistent with changes in the JWST Program Plan, as well as to take advantage of new opportunities and alliances that engage the public. The JWST PAO lead is responsible for updating this document.

The goal of the Public Engagement Plan is to engage, inform and inspire the public about JWST and to make JWST a household word.

To achieve this goal, the following objectives have been established and will be implemented:

- Objective 1- Reach out to and inform Congress, National Academies, NASA management, National Science Foundation and other influential people in aerospace and astrophysics about JWST
- Objective 2- Spread the news about JWST throughout the astronomical community and the broader scientific community
- Objective 3- Increase the general public's awareness and appreciation for JWST technology and science capabilities
- Objective 4- Establish a JWST Education and Public Outreach program to educate a wide variety of audiences in various settings – in formal education (K-12) and information education (science centers, planetariums, etc)

4.0 WAIVERS LOG

NONE

5.0 CHANGE LOG

Following baseline issue of this plan, all changes will be made using the JWST CCB process. The changes will be documented in Configuration Change Requests (CCR), which will be processed through and maintained on file in the JWST Configuration Management Office (CMO). Page iii of this document will be annotated to indicate the applicable CCR for each change.

APPENDIX A: ACRONYMS AND ABBREVIATIONS

AA	Associate Administrator
ACS	Attitude Control System
AMSD	Advanced Mirror Systems Demonstrator
AO	Announcement of Opportunity
ARC	Ames Research Center
ASO	Astronomical Search for Origins
ASWG	Ad Hoc Science Working Group
AURA	Association of Universities for Research in Astronomy
BPA	Board on Physics and Astronomy
CAA	Committee on Astronomy and Astrophysics
CCB	Configuration Control Board
CCR	Configuration Change Request
CDR	Critical Design Review
CM	Configuration Management
CMO	Configuration Management Office or Officer
COTR	Contracting Officer's Technical Representative
CSA	Canadian Space Agency
DRM	Design Reference Mission
DSN	Deep Space Network
EC	European Consortium
ELV	Expendable Launch Vehicle
EGSE	Electrical Ground Support Equipment
ESA	European Space Agency
ETU	Engineering Test Unit
FY	Fiscal Year
FGS	Fine Guidance Sensor
FMEA	Failure Modes and Effects Analyses
FOV	Field of View
FPA	Focal Plane of Assembly
FPD	Flight Projects Directorate
FPE	Focal Plane Electronics
FRR	Flight Readiness Review
FSW	Flight Software
GCS	Ground Communications Subnet
GFE	Government-Furnished Equipment
GFRP	Graphite Fiber Reinforced Plastic
GO	General Observer
GPMC	Governing Program Management Council

GPR	Goddard Procedural Requirement
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
GSTS	Ground Station System
HQ	Headquarters
HST	Hubble Space Telescope
I&T	Integration and Test
ICD	Interface Control Document
ICE	Instrument Control Electronics
ICDH	ISIM Command and Data Handling
ICR	Interface Control Requirement
IIRP	Integrated Independent Review Plan
IPAO	Independent Program Assessment Office
IPDR	Instrument Preliminary Design Review
IR	Infrared
IRT	Independent Review Team
ISIM	Integrated Science Instrument Module
ISWG	Interim Science Working Group
ITAR	International Traffic in Arms Regulations
IV&V	Independent Verification and Validation
JPIP	Joint Project Implementation Plan
JPL	Jet Propulsion Laboratory
JWST	Next Generation Space Telescope
L2	2^{nd} Lagrange Point
LC	Launch Complex
LLIS	Lessons Learned Information System
MAR	Mission Assurance Requirements
MAST	Multi-mission Archive at Space Telescope
MDR	Mission Definition Review
MEMS	Micro-Electro-Mechanical Systems
MIRI	Mid-Infrared Instrument
MO&DA	Mission Operations and Data Analysis
MOR	Mission Operations Review
MOU	Memorandum of Understanding
MPR	Monthly Program Review
MSFC	Marshall Space Flight Center
MSR	Monthly Status Review
NAR	Non-Advocate Review
NASA	National Aeronautics and Space Administration
NCR	Nonconformance Review

NEPA	National Environmental Policy Act
NGST	Northrop Grumman Space Technology
NIRCam	Near-Infrared Camera
NIRSpec	Near-Infrared Spectrograph
NPD	NASA Policy Directive
NPR	NASA Procedural Requirement
OBA	Optical Bench Assembly
ORR	Operations Readiness Review
OS	Origins Subcommittee
OSS	Office of Space Science
OTE	Optical Telescope Element
PCA	Program Commitment Agreement
PDR	Preliminary Design Review
PI	Principal Investigator
PIT	Product Integrity Team
PLF	Payload Fairing
PMC	Program Management Council
POP	Project Operating Plan
PRA	Probabilistic Risk Assessment
PSF	Point Spread Function
PSR	Pre Ship Review
QA	Quality Assurance
QE	Quality Engineer
RF	Radio Frequency
RMT	Risk Management Tool
RPM	Revolutions Per Minute
SAM	Safety Assurance Manager
SCB	Schedule Control Board
SDR	Systems Definition Review
SEMP	Systems Engineering Management Plan
SI	Science Instrument
SIP	Subsystem Implementation Plan
SMD	Science Mission Directorate
SMOC	Science/Mission Operations Center
S&OC	Science and Operations Center
SQMS	Software Quality Management System
SRB	Solid Rocket Boosters
SRR	System Requirements Review
SscAC	Space Science Advisory Committee
SSM	Spacecraft Support Module
SSR	Solid State Recorder

ST-ECF	
STScI	Space Telescope Science Institute
SWG	Science Working Group
TAC	Time Allocation Committee
TCS	Thermal Control System
TMG	Thermal Model Generator
TRL	Technology Readiness Level
TRR	Test Readiness Review
TSS	Thermal Synthesizer System
WBS	Work Breakdown Structure
WFSC	Wavefront Sensing and Control
WISP	Workforce Integrated Strategic Plan

APPENDIX B: DEFINITIONS