



**STScI** | SPACE TELESCOPE  
SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

# JWST Science & Operations Center

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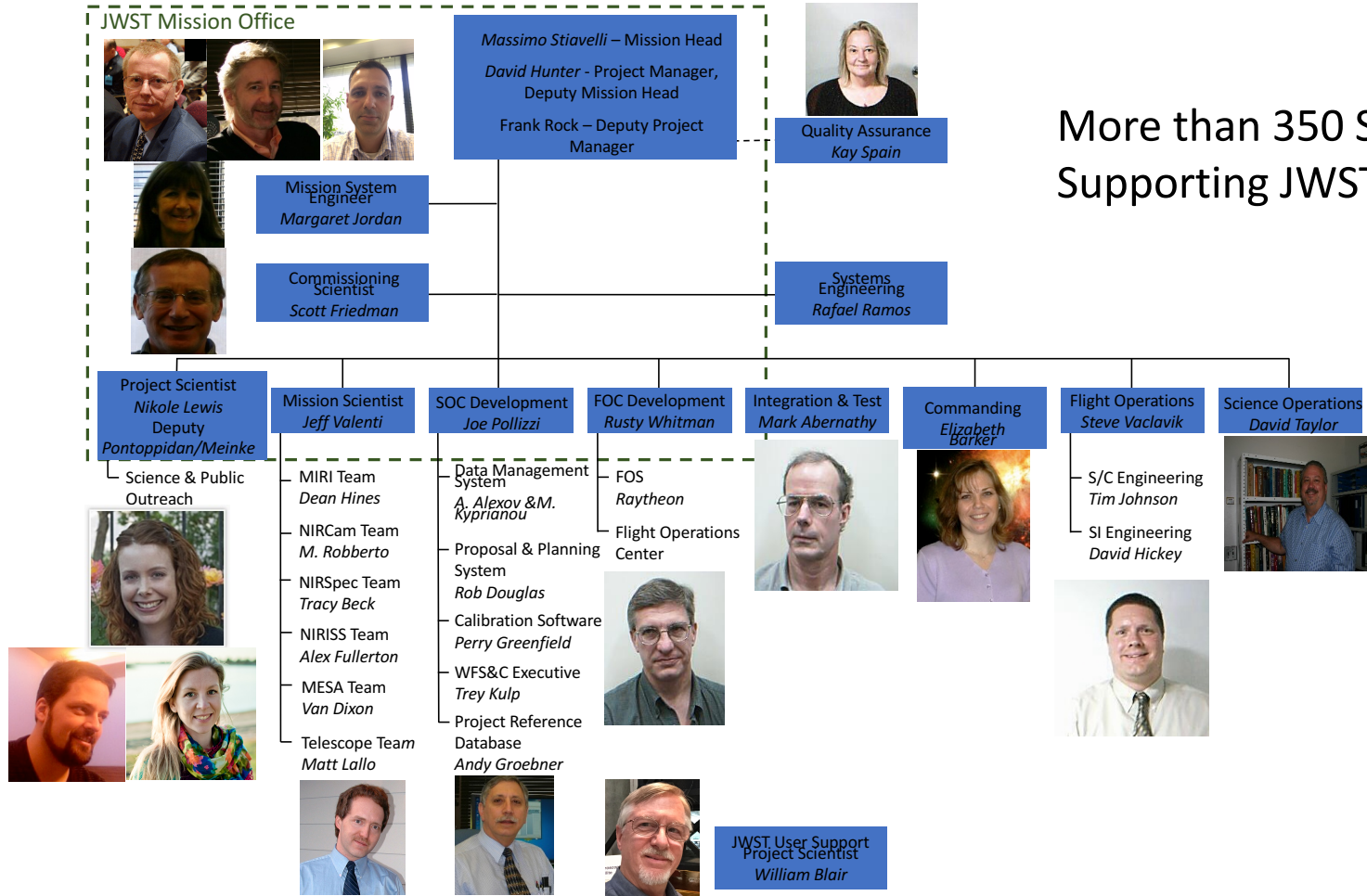
Nikole K. Lewis

September 14<sup>th</sup>, 2017





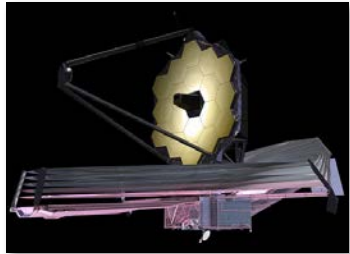
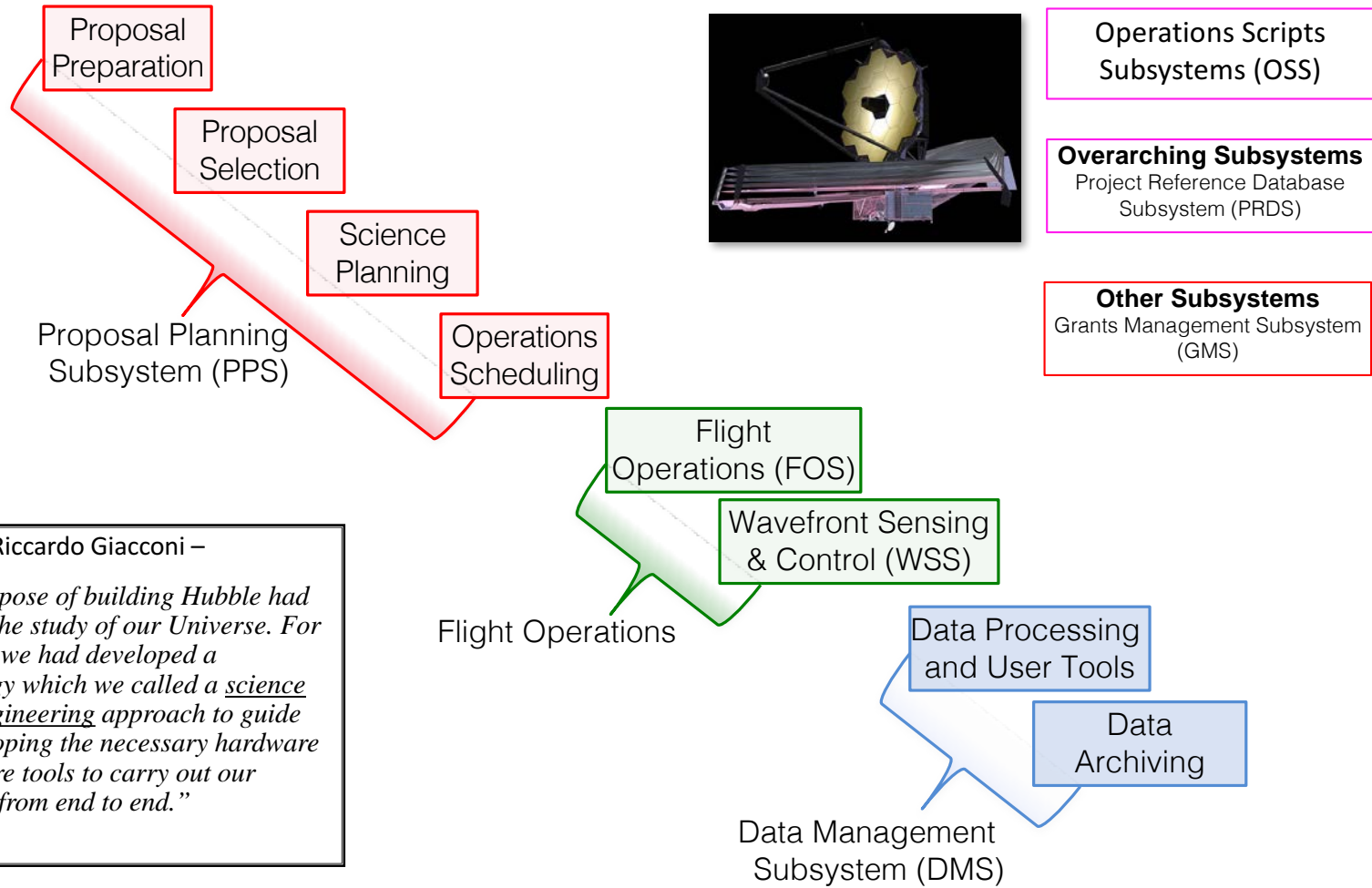
# STScI JWST Mission Organization



More than 350 STScI Staff Supporting JWST



# STScI Systems & Science Systems Engineering

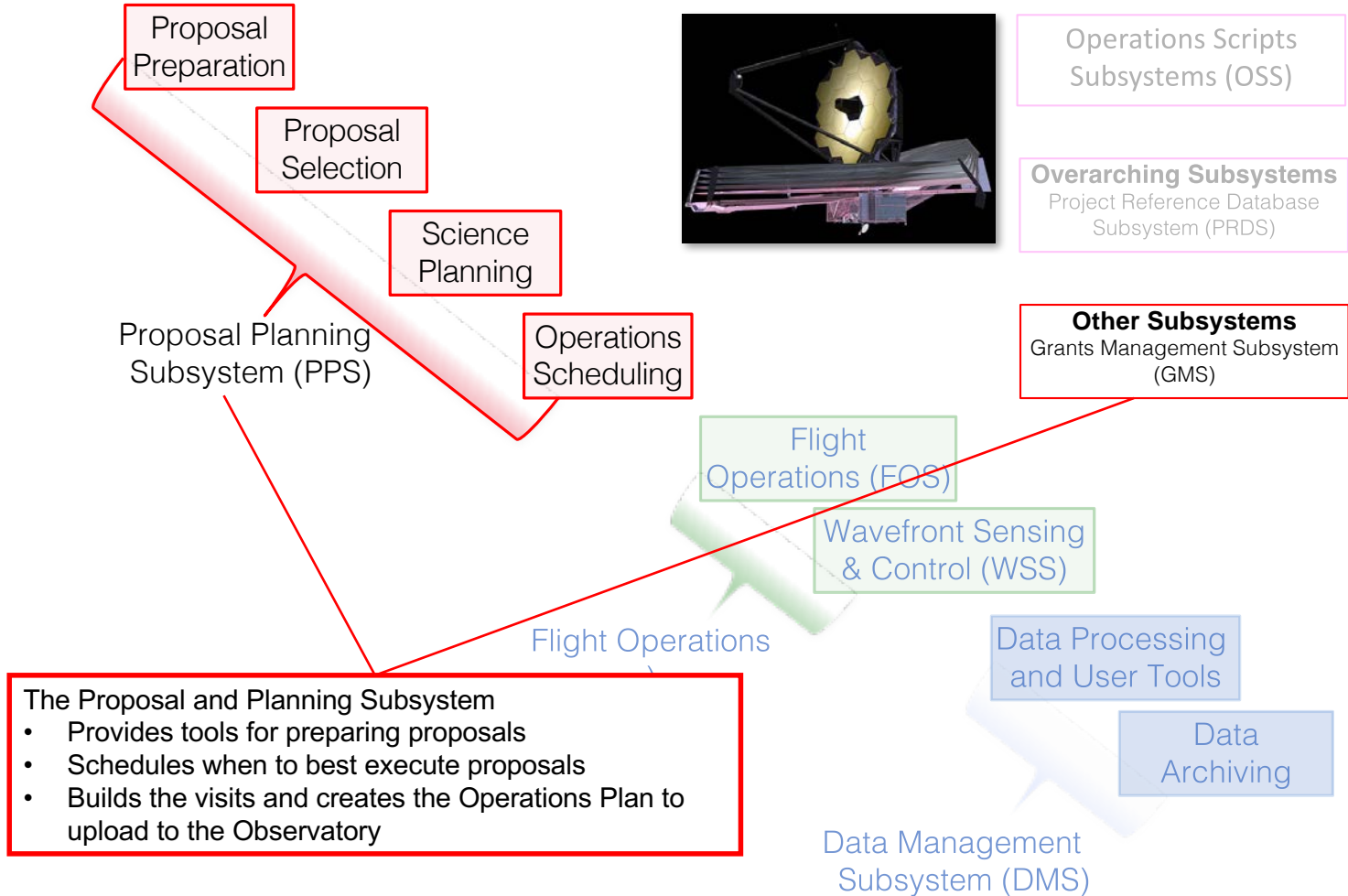


Riccardo Giacconi –

“... the purpose of building Hubble had to do with the study of our Universe. For this reason we had developed a methodology which we called a science systems engineering approach to guide us in developing the necessary hardware and software tools to carry out our operations from end to end.”



# Proposal Planning Subsystem



The Proposal and Planning Subsystem

- Provides tools for preparing proposals
- Schedules when to best execute proposals
- Builds the visits and creates the Operations Plan to upload to the Observatory



# Operations Script Subsystem

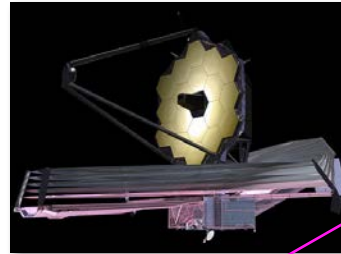
Proposal Preparation

Proposal Selection

Science Planning

Proposal Planning Subsystem (PPS)

Operations Scheduling



Operations Scripts Subsystems (OSS)

Overarching Subsystems  
Project Reference Database Subsystem (PRDS)

Other Subsystems  
Grants Management Subsystem (GMS)

Flight Operations (FOS)

Wavefront Sensing & Control (WSS)

Flight Operations

Data Processing and User Tools

Data Archiving

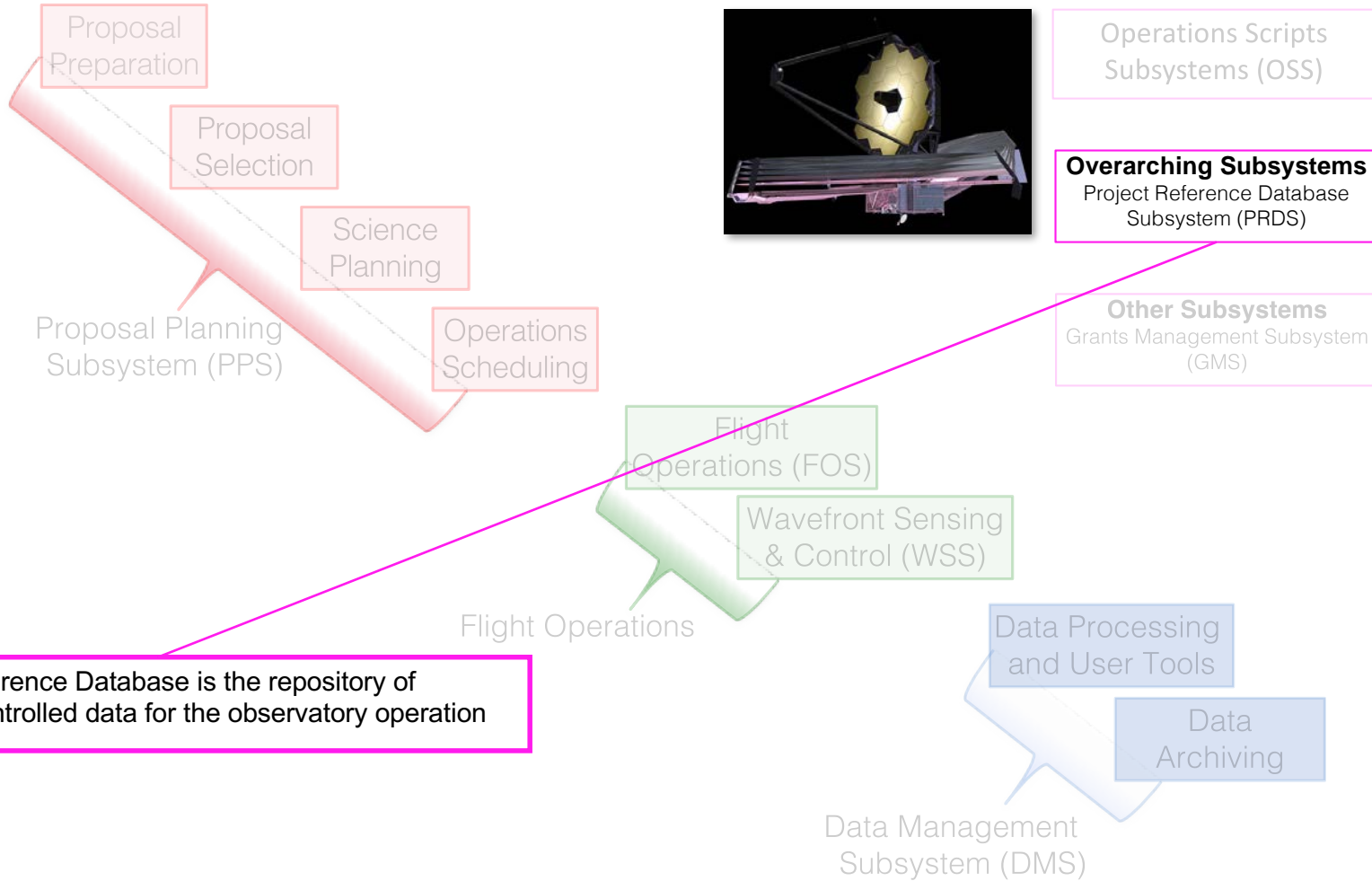
Data Management Subsystem (DMS)

The On-Board Scripts execute the Operation Plan

- Coordinate the low level on-board operations
- Event-driven methodology

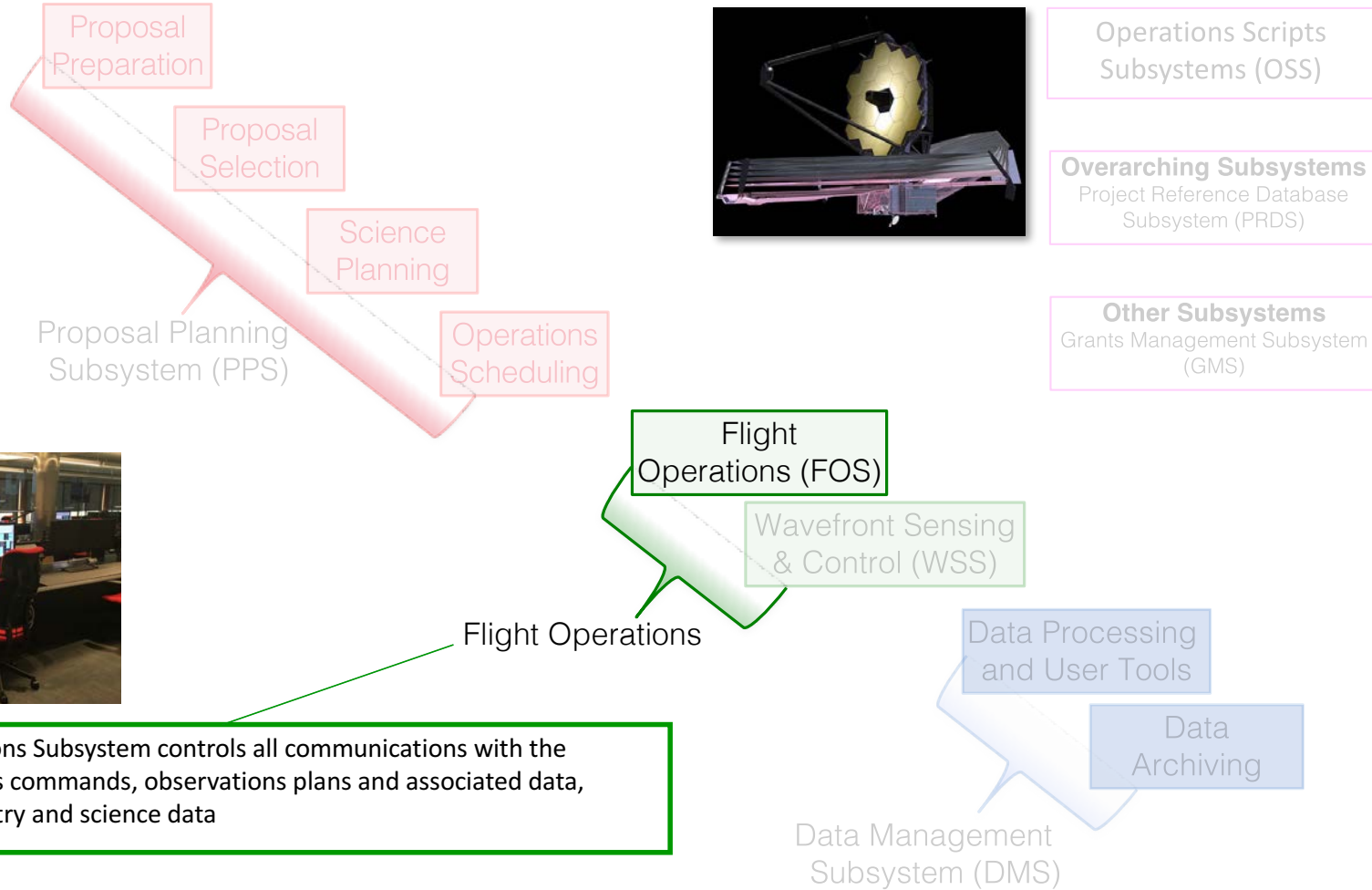


# Project Reference Data Subsystem





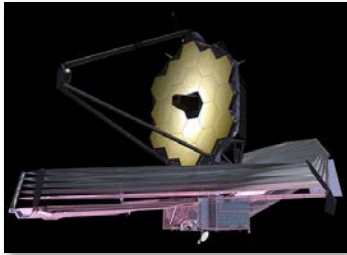
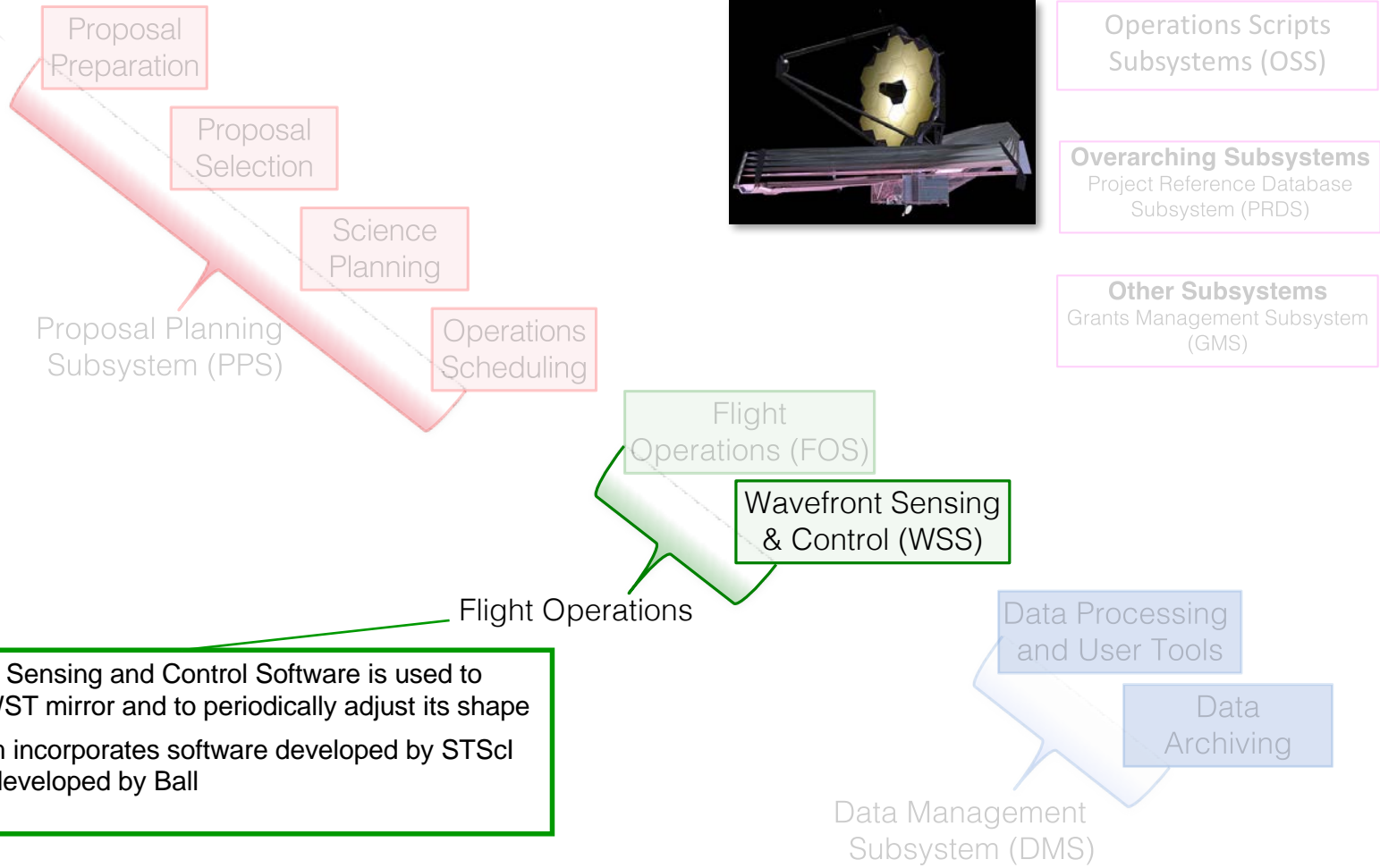
# Flight Operations Subsystem



The Flight Operations Subsystem controls all communications with the spacecraft, uploads commands, observations plans and associated data, downloads telemetry and science data



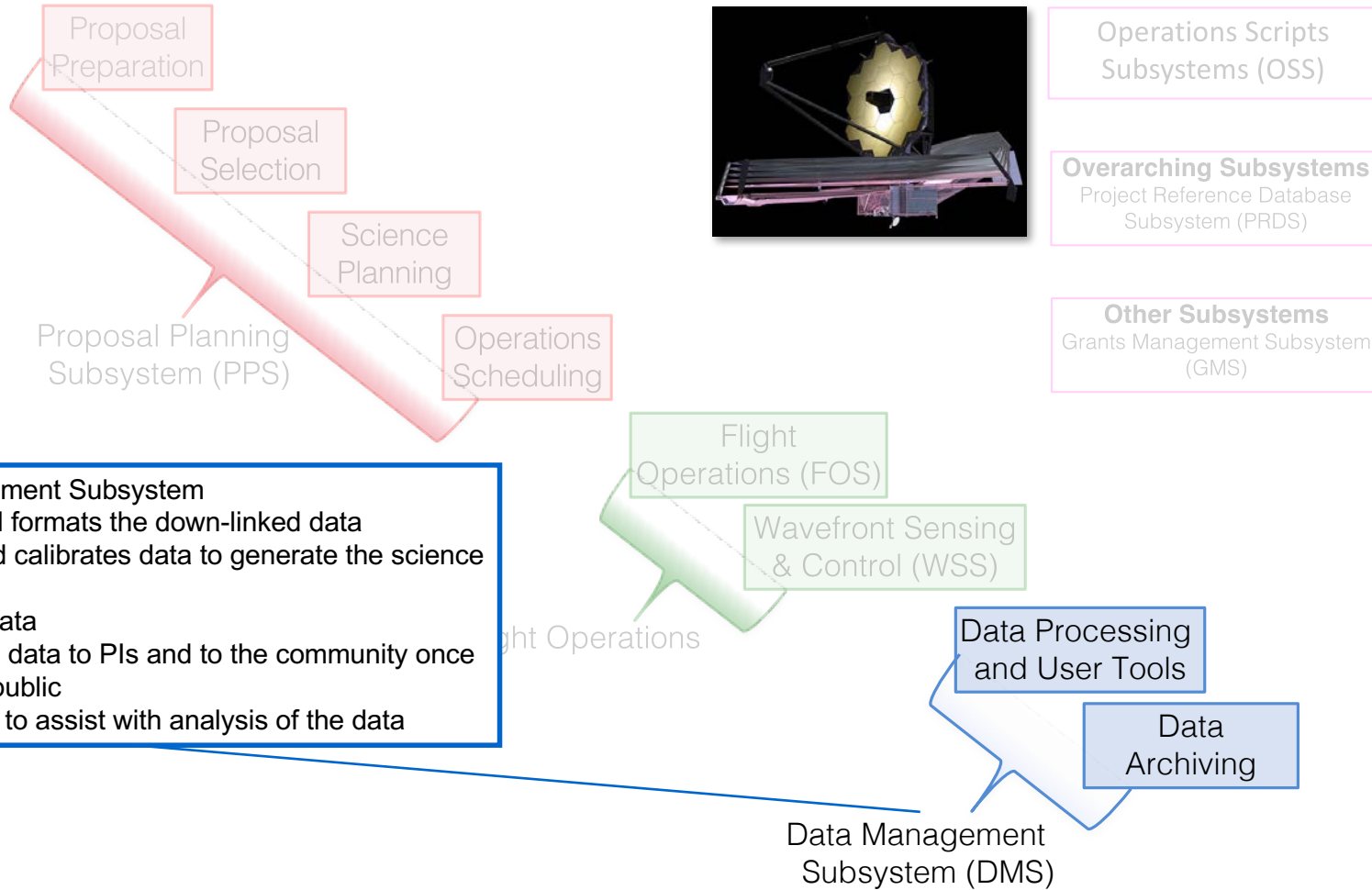
# WaveFront Software Subsystem



The Wavefront Sensing and Control Software is used to monitor the JWST mirror and to periodically adjust its shape  
The subsystem incorporates software developed by STScI with software developed by Ball



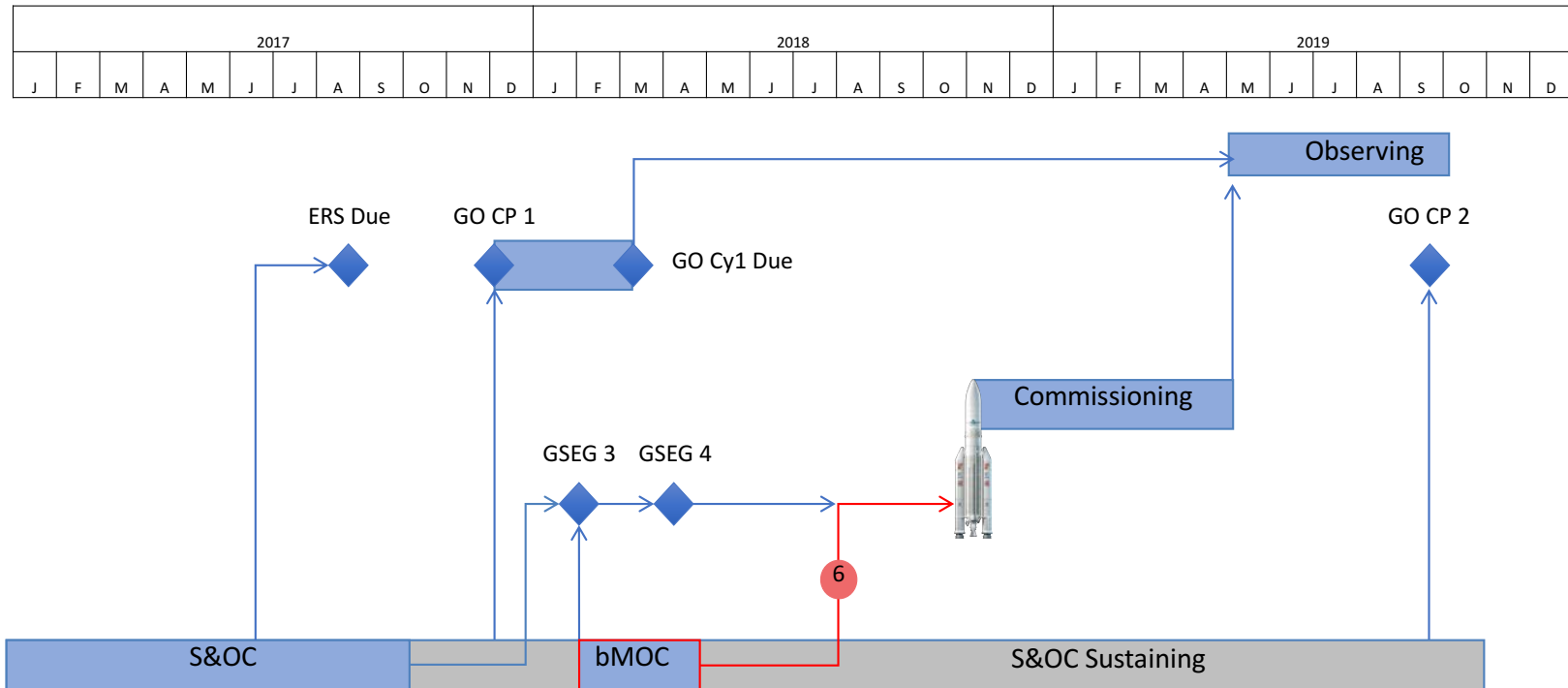
# Data Management Subsystem



- The Data Management Subsystem**
- Organizes and formats the down-linked data
  - Processes and calibrates data to generate the science products
  - Archives the data
  - Distributes the data to PIs and to the community once they become public
  - Provides tools to assist with analysis of the data



# JWST S&OC Simplified schedule



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months of funded critical path schedule reserve



## S&OC Subsystems Overview

S&OC & Subsystem Status						
Subsystem	Build	Development completion date	I&T completion date	Status	% of requirements delivered to date	% of requirements verified to date
Data Management Subsystem (DMS)	7*	December 2016	June 2017	Completed I&T	89%	80%
	7.1	November 2017	February 2018	In Development		
Proposal Planning Subsystem (PPS)	14*	December 2016	June 2017	Completed I&T	97%	91%
	14.1	June 2017	December 2017	Completed Development		
	14.2	October 2017	January 2018	In Development		
Wavefront Sensing & Control (WFS&C) Software Subsystem	6.1*, **	September 2017	February 2018	In Development	97%	97%
Flight Operations Subsystem (FOS)	6.1*	November 2017	December 2017	In Development	83%	80%
Operations Scripts Subsystem (OSS)	6	March 2017	November 2017	In Level 2 Certification Testing	73% Level 2 certified	58% Level 3 certified
	7*	October 2017	March 2018	In Development		
Project Reference Database Subsystem (PRDS)	4.13	April 2017	April 2017	Latest Sustaining Engineering Release	100%	100%
	4.14*	May 2017	May 2017			

\*Supports Launch

\*\* Reflects the addition of 5 new approved Cryo-Cooler Tuning requirements



## S&OC FY17 Milestones

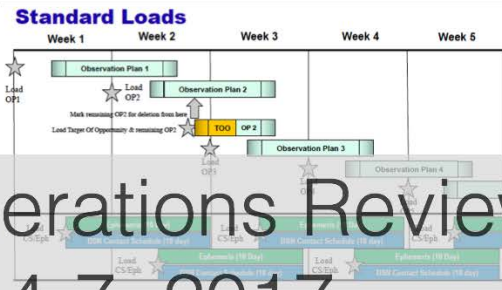
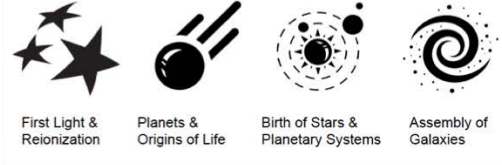
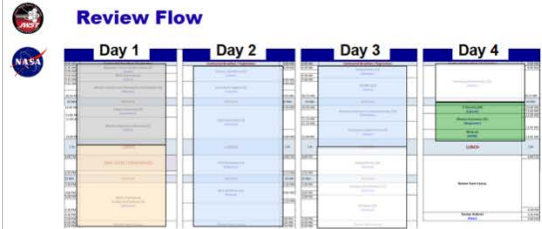
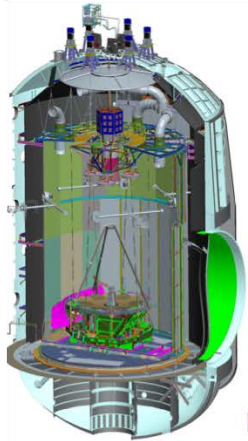
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- Science & Operations Center Release 1 (due November 2016)\*
- PPS build 14 supporting launch (due January 2017)
- WFS&C build 6 supporting launch (due February 2017)\*
- FOS build 6 supporting pre-launch (due March 2017)\*
- GSEG1 testing communications and data handling (due July 2017)
- Mission Operations Review (due May 2017)
- OSS build 6 supporting launch (due June 2017)\*
- Call for Proposal Early Release Science (due June 2017)
- FOT Ops readiness exercise 2 (due July 2017)

\* Completed early



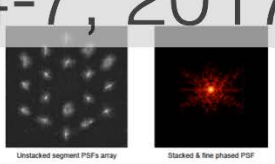
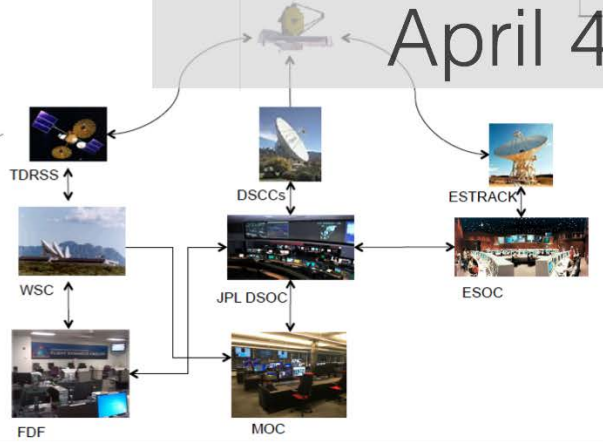
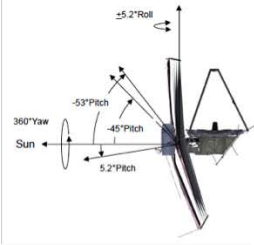
# Mission Operations Review



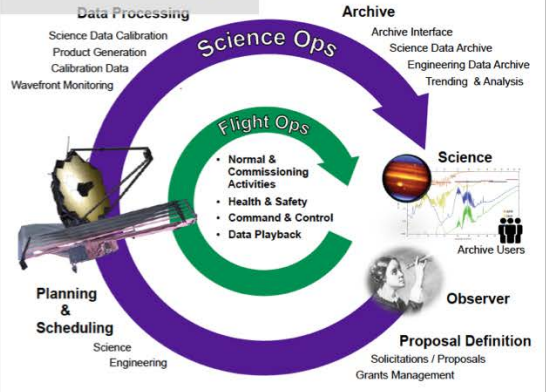
Thermal slew geometry

## Mission Operations Review April 4-7, 2017

### Launch Day Communications with JWST

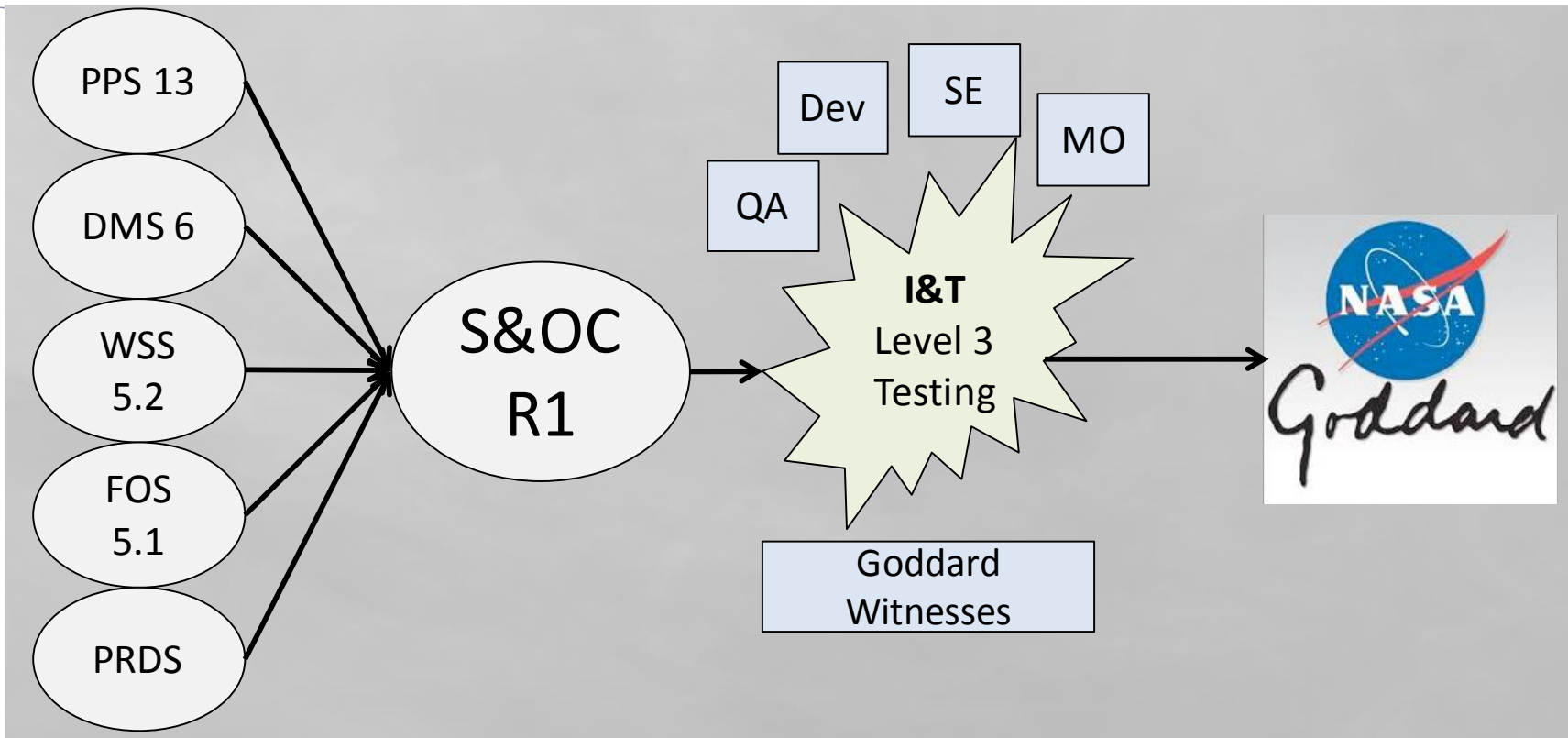


### Science and Flight Mission Operations





## S&OC Release 1



Recent End-to-End Testing with Observatory Test Bed (OTB)  
Simulator Approaching Readiness for JWST Launch



## Subsystem Highlights

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### Flight Operations System

- Build 6 being used for Operational Readiness Tests, GSEG tests, and tests with the Engineering Model Test Bed and the Observatory Test Bed
- Backup Mission Operations Center is in development and has completed factory qualification testing at Raytheon
- Successfully tested Flight Operations Subsystem communication from STScI to JWST spacecraft at Northrop Grumman over ground network and Deep Space Network and space network RF link

### Proposal and Planning System

- APT v25.1 and ETC v1.1 (from PPS 14.1) made available on June 1 to the GTO's and DD ERS proposers for preparing and submitting their proposals
- Focus on completing support for updated timing models, dithered and other associated observations, and performance
- Build 14.2 slated for November 2017 – to close off remaining functionality and to support GO's with their proposal preparation

### WFS&C Software Subsystem

- Build 6 supported OTIS Center of Curvature tests at GSFC
- Support OTIS testing at JSC



## Subsystem Highlights

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### Data Management Subsystem

- Build 6 will be used to process data taken from OTIS/JSC testing
- Build 7.1 (due November 2017) will add additional level 3 data processing and archive distribution support
- Challenge is acquiring flight like data to validate testing DMS

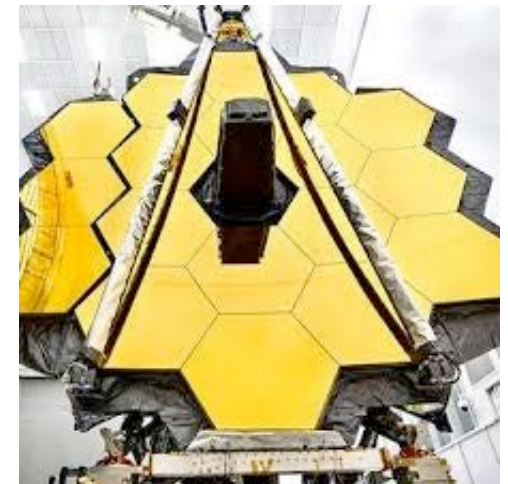
### Operations Script Subsystem

- Build 5 is being used with OTIS/JSC testing
- Build 6 (now in test) supports Target Acquisitions, dithering, and moving targets



# STScI Instrument and Telescope Teams

<p>Short wavelength channel   Long wavelength channel Module A Module B</p> <p>Deep, wide field broadband-imaging</p>	<p>Wavefront Sensing &amp; Control (WFSC)</p> <p>Coronagraphic Imaging</p>	<p>Multi-Object, IR spectroscopy</p>	<p>IFU spectroscopy</p>	
	<p><b>NIRCam</b></p>	<p><b>NIRSpec</b></p>	<p>Long Slit spectroscopy</p>	
<p>Fine Guidance Sensor</p>	<p>Moving Target Support</p>	<p><b>FGS/NIRISS</b></p>	<p><b>MIRI</b></p>	<p>Mid-IR, wide-field Imaging</p>
<p>Slitless Spectroscopy</p>	<p>Near-IR imaging</p>	<p>High Contrast Closure Phase Imaging</p>	<p>Mid-IR Coronagraphic Imaging</p>	<p>IFU spectroscopy</p>





## Telescope/Optics Support

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Optics team is composed of scientists & engineers experienced in design and control of optical systems, I&T of instrument and telescope optics, and in-flight maintenance of telescope optical performance

### Progress:

- Providing optics expertise to development and testing of sub-systems
- Participating in development of hardware simulators for ground tests
- Participated in planning and staffing of ground tests for optics & instruments
- Finalizing plans for commissioning of the primary mirror segments

### Work Remaining:

- Provide optics support to system development & ground tests
- Build additional experience required to support mission in flight



## Telescope/Optics Support Highlights



JSC test chamber



Optics integration

- Most of the STScI Optics staff are participating in the JSC OTIS test as Test Conductors, subject matter experts, quick-look analyst and WSS operators
- Supported “Shadow mode” test in which the JSC data were processed by the WFS&C subsystem and operators in the MOC at STScI
- Generating flight-ready proposals for the OTE commissioning activities
- Assisting astronomy community members to plan coronagraphic observations
- Supported mirror control software tests and mirror environmental tests (End of 2016)



## Science Instrument Support

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Instrument scientists, engineers, and analysts with relevant expertise:

- Instrument development, commissioning, operations, and calibration.
- Astronomical observations, data analysis, and scientific research.

Accomplishments:

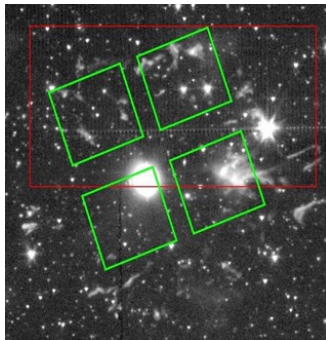
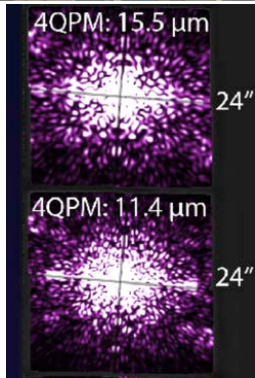
- Supported successful instrument and observatory ground tests.
- Supported development of science and operations center software systems.
- Generated or gathered calibration reference data to support launch.
- Provided documentation, training, and support for user community.

Remaining Tasks (as planned):

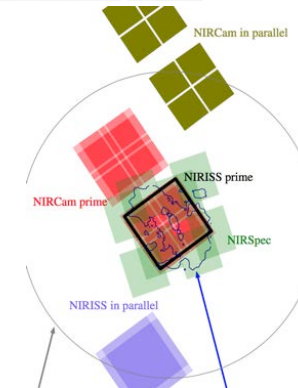
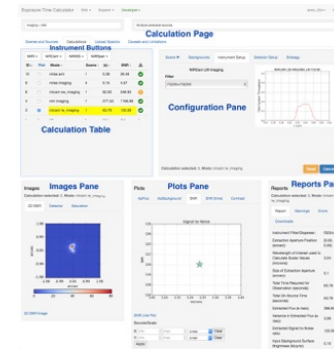
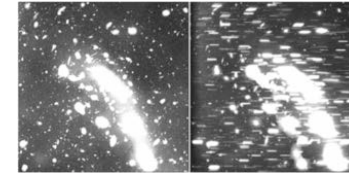
- Validate flight build of science and operations center software systems.
- Finalize commissioning program and in-flight calibration plan.
- Provide user support for Cycle 1 proposal process.
- Perform technical reviews of approved observing programs.
- Complete development of core set of data analysis tools.



# Science Instrument Support Highlights

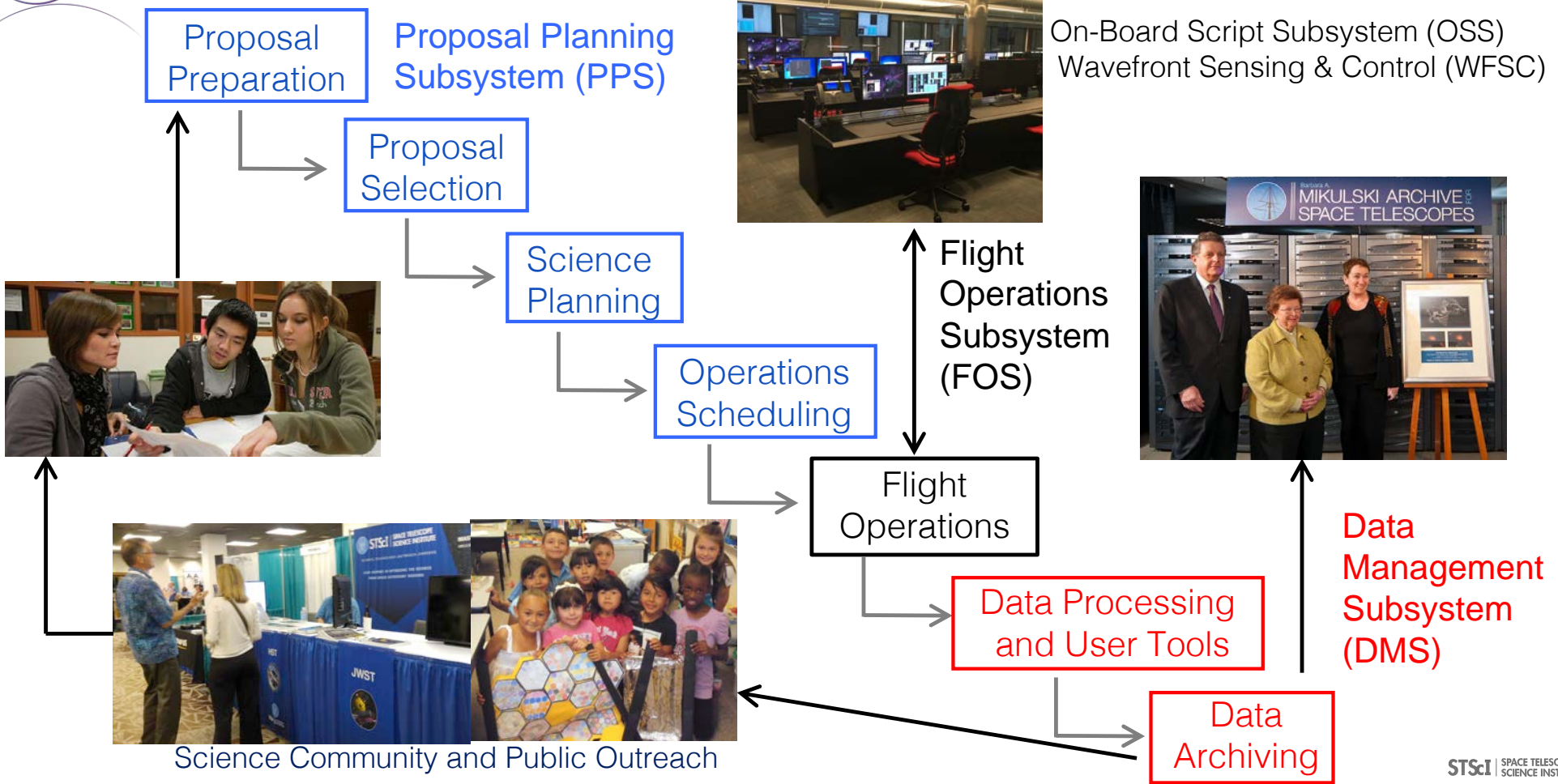


- Specified algorithms for data calibration pipeline.
- Measured detector characteristics and performance in detector lab.
- Developed innovative 3D exposure time calculator.
- Developed observing strategies for high-precision modes, e.g., exoplanet transits and coronagraphy.
- Specified observing templates for parallel observations with multiple instruments.
- Gathered necessary calibration data with other observatories.



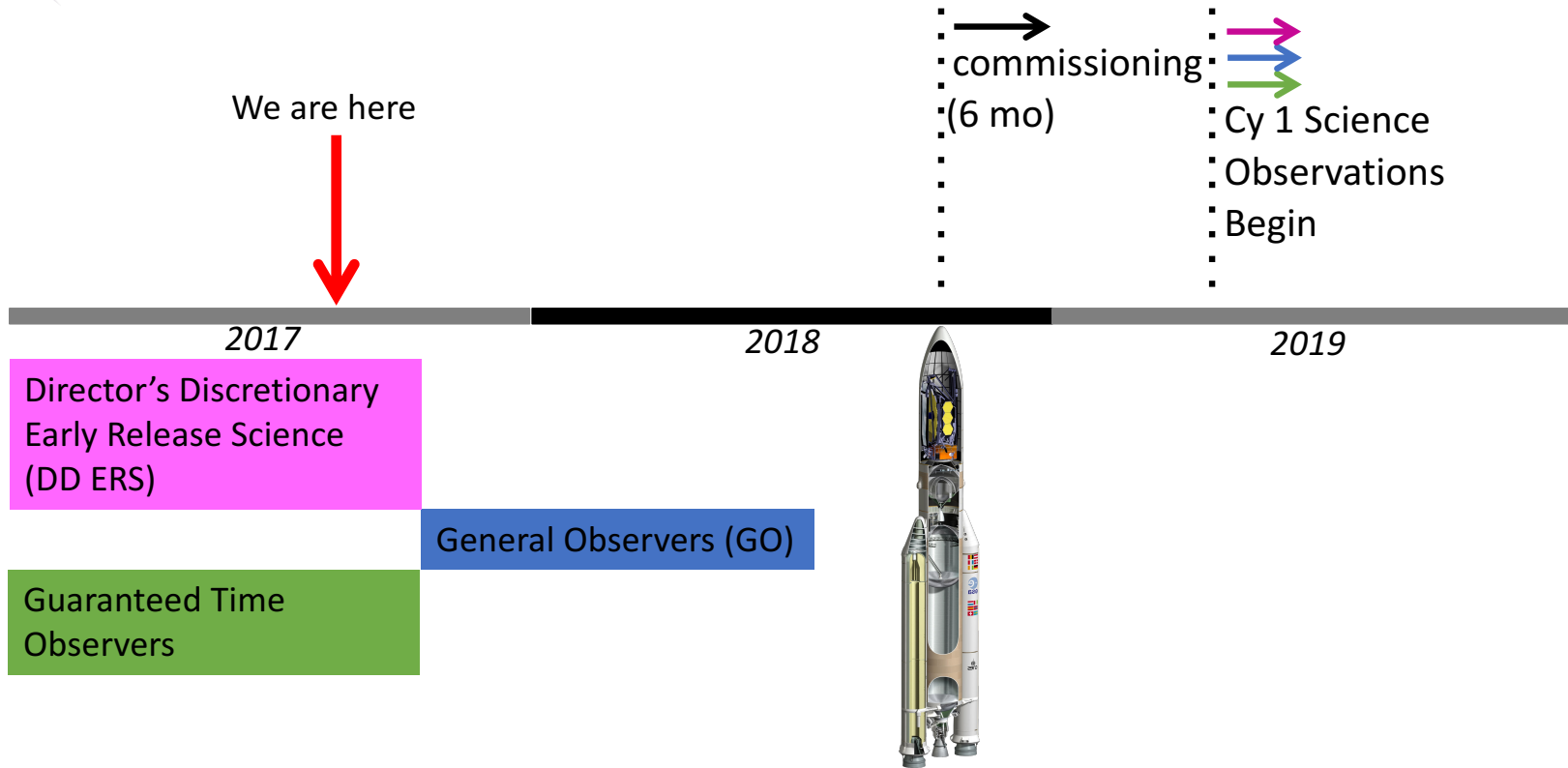


# STScI S&OC Operations Flow



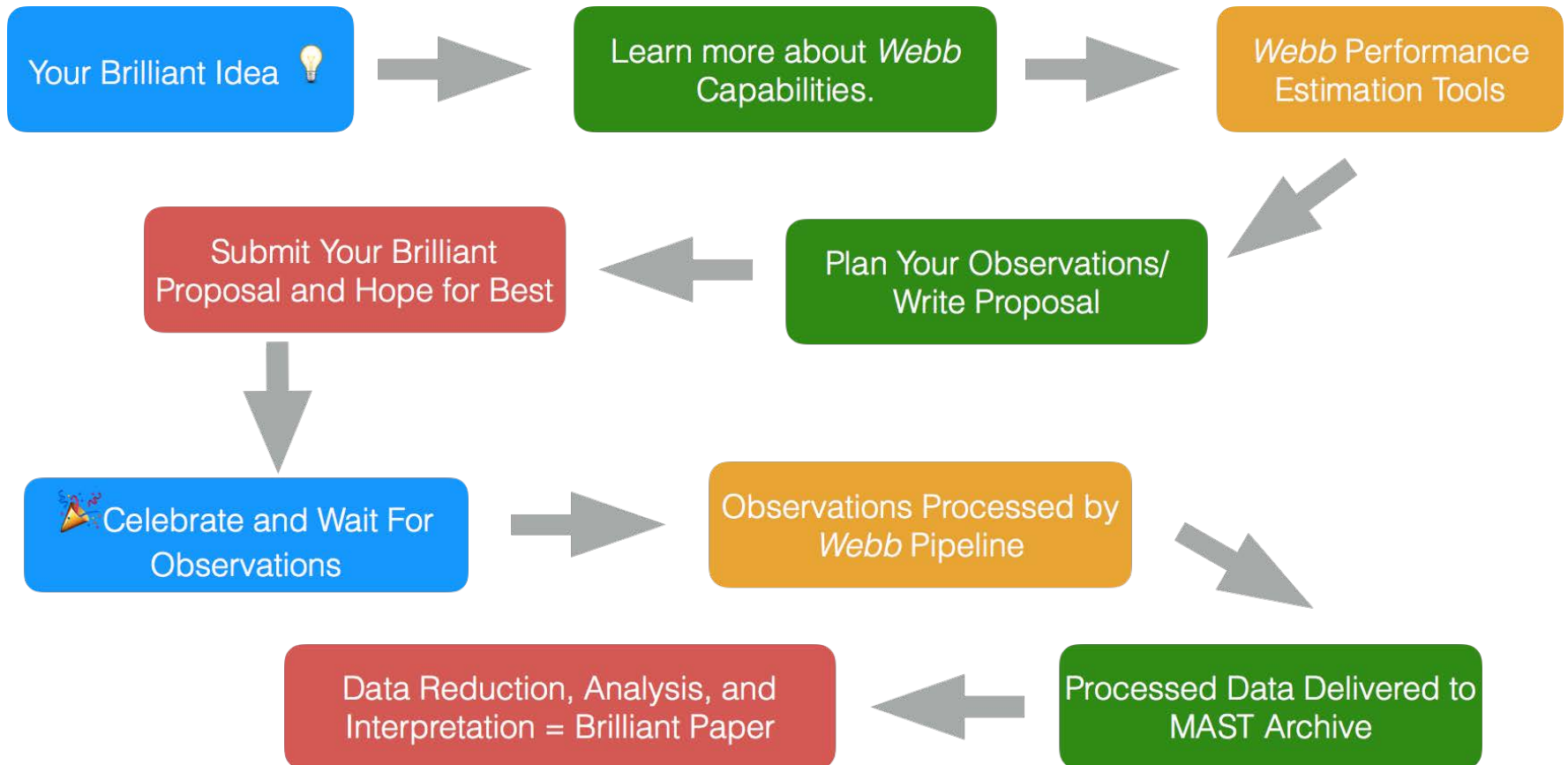


# JWST Science Timeline

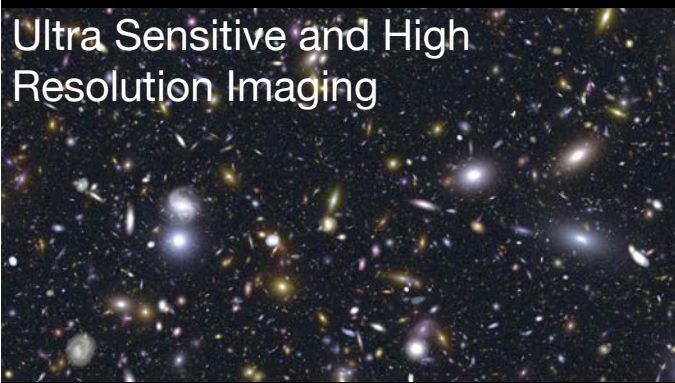




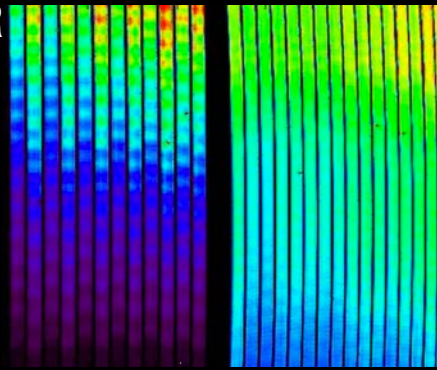
## Life-cycle of your observations with *Webb*



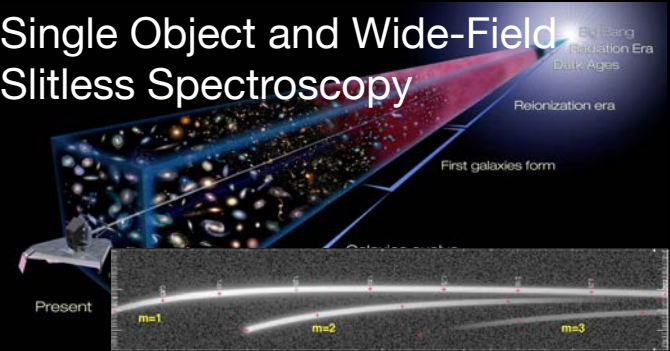
# Ultra Sensitive and High Resolution Imaging



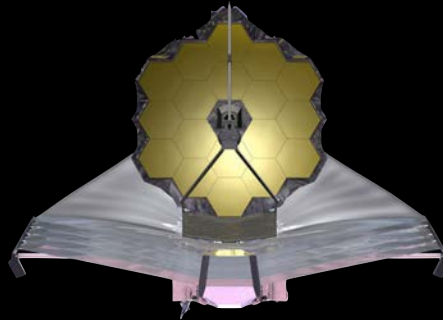
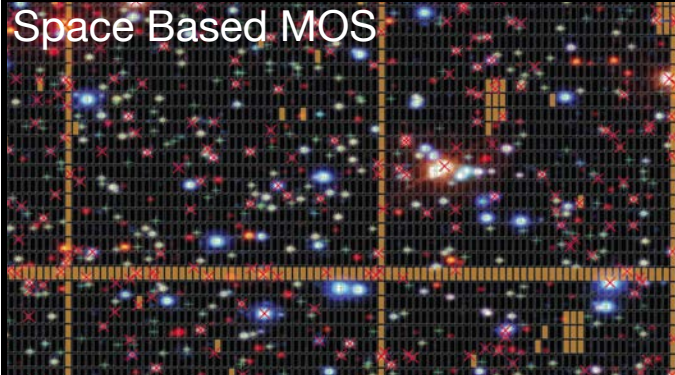
# Mid IR IFUs



# Single Object and Wide-Field Slitless Spectroscopy



# Space Based MOS

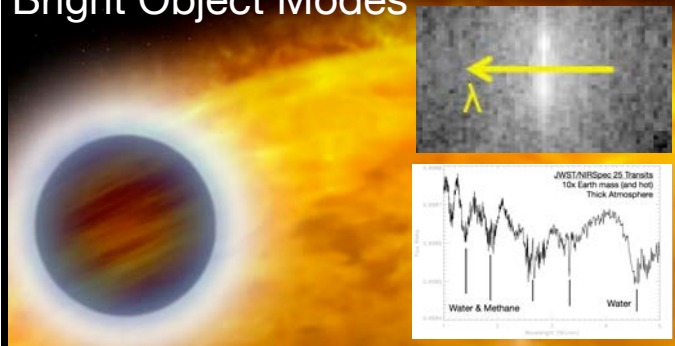


# Science Capabilities

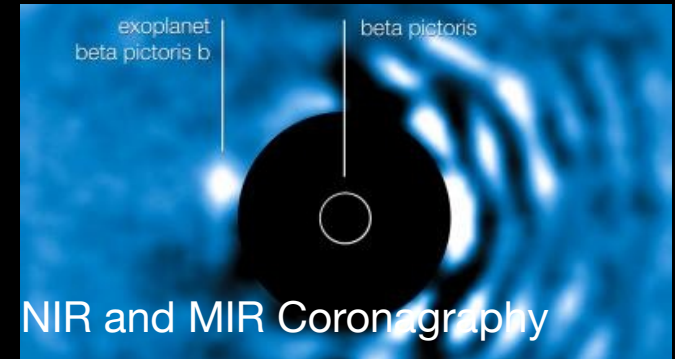
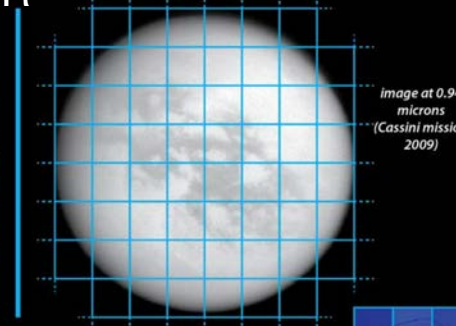
# Moving Target Support



# Bright Object Modes



# Near IR IFUs



# NIR and MIR Coronagraphy



## JWST Documentation (JDox)

### A New Paradigm for JWST User Documentation

New documentation system: “Every page is page one”

- Short articles
- Self-contained, one-level information
- Hyperlinked network rather than monolithic handbook

Think Wikipedia (but it's not a wiki)

Multiple conceptual spaces: Background articles, planning cookbooks, science policy, engineering specs

Incremental releases (as articles are written and reviewed), beginning with instruments, APT, ETC articles

The screenshot shows the 'James Webb Space Telescope User Documentation' website. The header features a navigation menu with 'HOME', 'INSTRUMENTS', 'PLANNING', 'CALL FOR PROPOSALS', and 'DATA', along with a search bar. The main content area is titled 'Mid-Infrared Instrument, MIRI' and includes a 'MIRI summary' section. This section describes the instrument's capabilities, such as imaging and spectroscopy from 4.9 to 28.8 micrometers, and lists observing modes like imaging, low-resolution slitted and slitless spectroscopy, medium-resolution integral field unit (IFU) spectroscopy, and coronagraphy. A sidebar on the right contains a diagram of the MIRI instrument and a list of JWST Observatory and Instrumentation components, including the Fine Guidance Sensor (FGS), JWST Observatory, Mid-Infrared Instrument (MIRI), Near Infrared Camera (NIRCAM), and Near Infrared Imager and Slitless



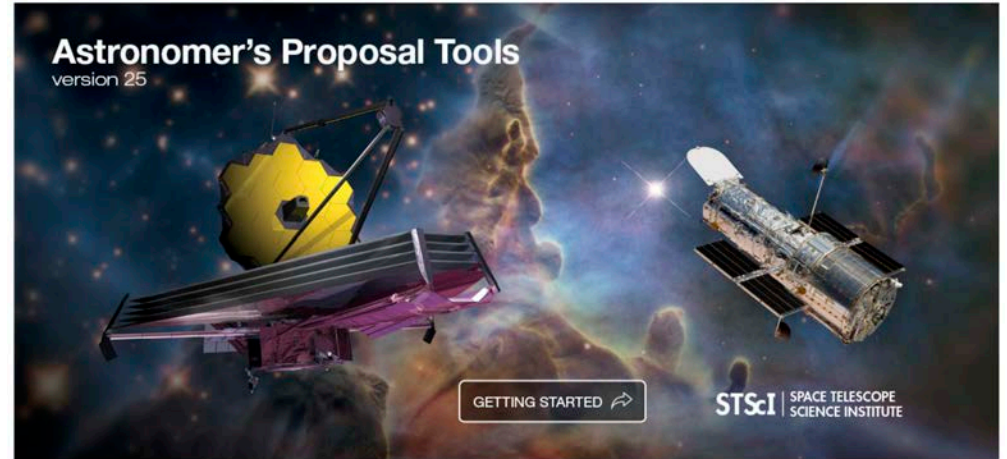
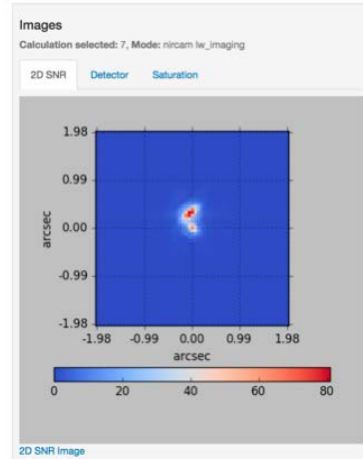
# JWST Proposal Planning Tools

Calculations   Scenes and Sources   Uploaded Spectra

MIRI   NIRCam   NIRISS   NIRSpec

ID	Plot	Mode	Scene	(s)	SNR	⚠
7	<input type="checkbox"/>	nircam lw_imaging	1	63.78	124.40	✓
6	<input type="checkbox"/>	nircam lw_imaging	1	63.78	191.76	✓
5	<input type="checkbox"/>	nirspec fixed_slit	1	458.40	125.73	✓
4	<input type="checkbox"/>	miri imaging	1	277.50	1163.14	✓
3	<input type="checkbox"/>	nircam lw_imaging	1	63.78	120.43	✓
2	<input type="checkbox"/>	nirspec fixed_slit	1	458.40	22.66	✓
1	<input type="checkbox"/>	nirspec fixed_slit	1	458.40	133.39	✓
-	-	-	-	-	-	-

JWST ETC



Welcome to the James Webb Space Telescope Help Desk

Request a MyST Account

Please register to gain full access to the James Webb Space Telescope Help Desk. Without an account you may still search the knowledge base but you will not be able to submit requests or questions.

Search Knowledge Base and JDOX

STScI

NASA's James Webb Space Telescope

Developed in partnership with ESA and CSA. Operated by AURA's Space Telescope Science Institute

JWST SCIENCE   NEWS & EVENTS   INSTRUMENTATION   SCIENCE PLANNING   DOCUMENTATION

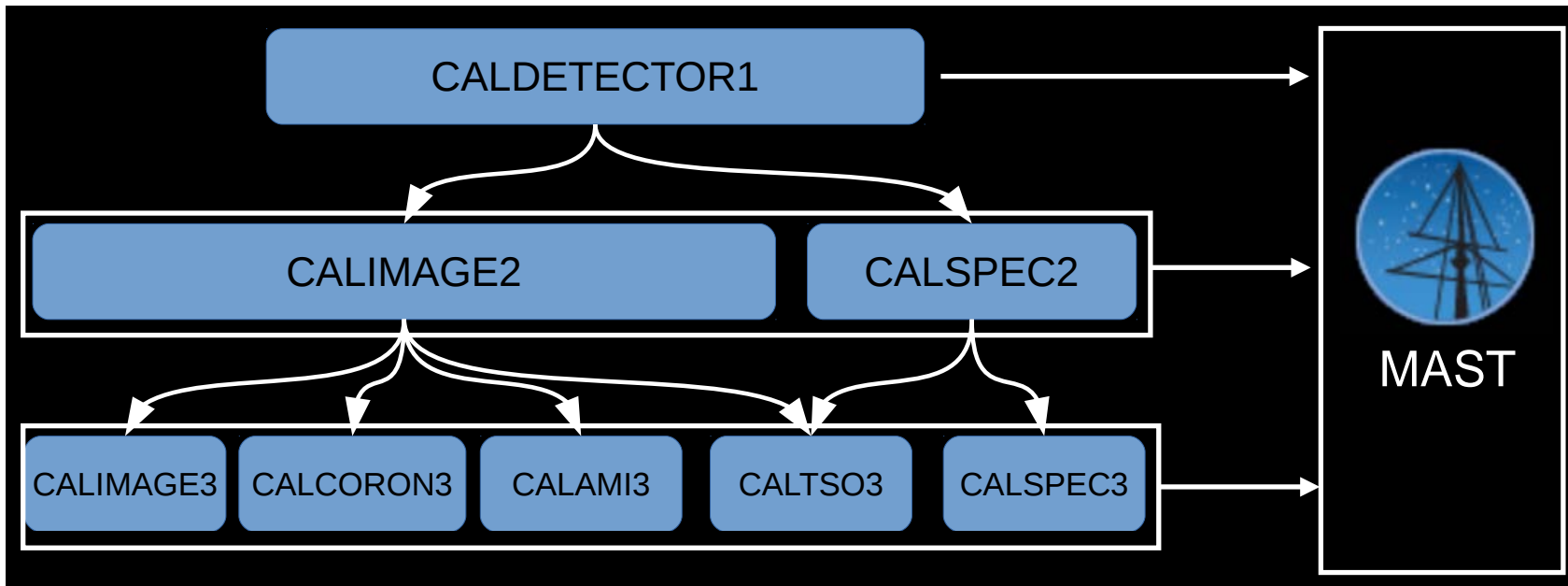
SCIENCE PLANNING > Proposal Planning Toolbox

## Proposal Planning Toolbox

# And Much More!



# The *Webb* Pipeline Architecture



Written in python, based on astropy

Will be freely available (github)

Users can replace specific modules

Users can rerun all or part of pipeline



# The MAST Archive

- Common Archive Observation Model (CAOM)
- JWST-specific views
- Distribution (URL & Curl-scripts)
- Subscription Service
- High Level Science Products (HLSP)
- Digital Object Identifier (DOI): Linking Data to Papers

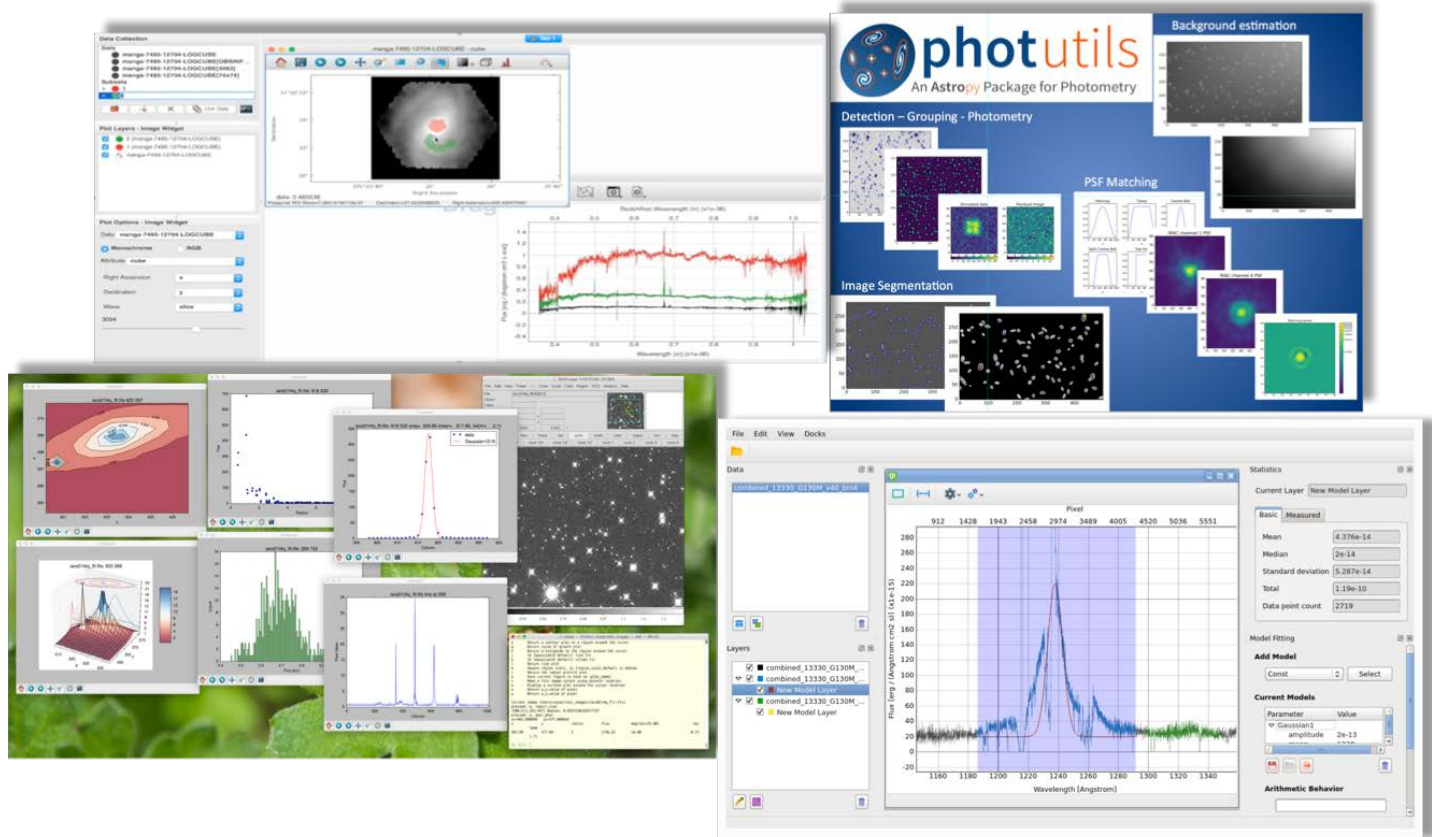
The collage displays several key features of the MAST Archive:

- Multi-mission target search:** A screenshot showing a search interface with filters for mission, instrument, and target type.
- SID product search:** A screenshot showing a search interface for Science Instrument Data (SID) products, including filters for instrument and target.
- Instruments/FITS keyword:** A screenshot showing a table of search results with columns for instrument, target, and FITS file names.
- Image preview:** A screenshot showing a dark-field astronomical image with a bright star and a blue box highlighting a region.
- Spectra preview:** A screenshot showing a spectral plot with a blue line representing the spectrum and a red dashed line for the fit.
- Timeline preview:** A screenshot showing a timeline plot with a blue line representing the data and a red dashed line for the fit.
- Keyword Dictionary:** A screenshot showing a search interface for keywords, including a search bar and a list of keywords.



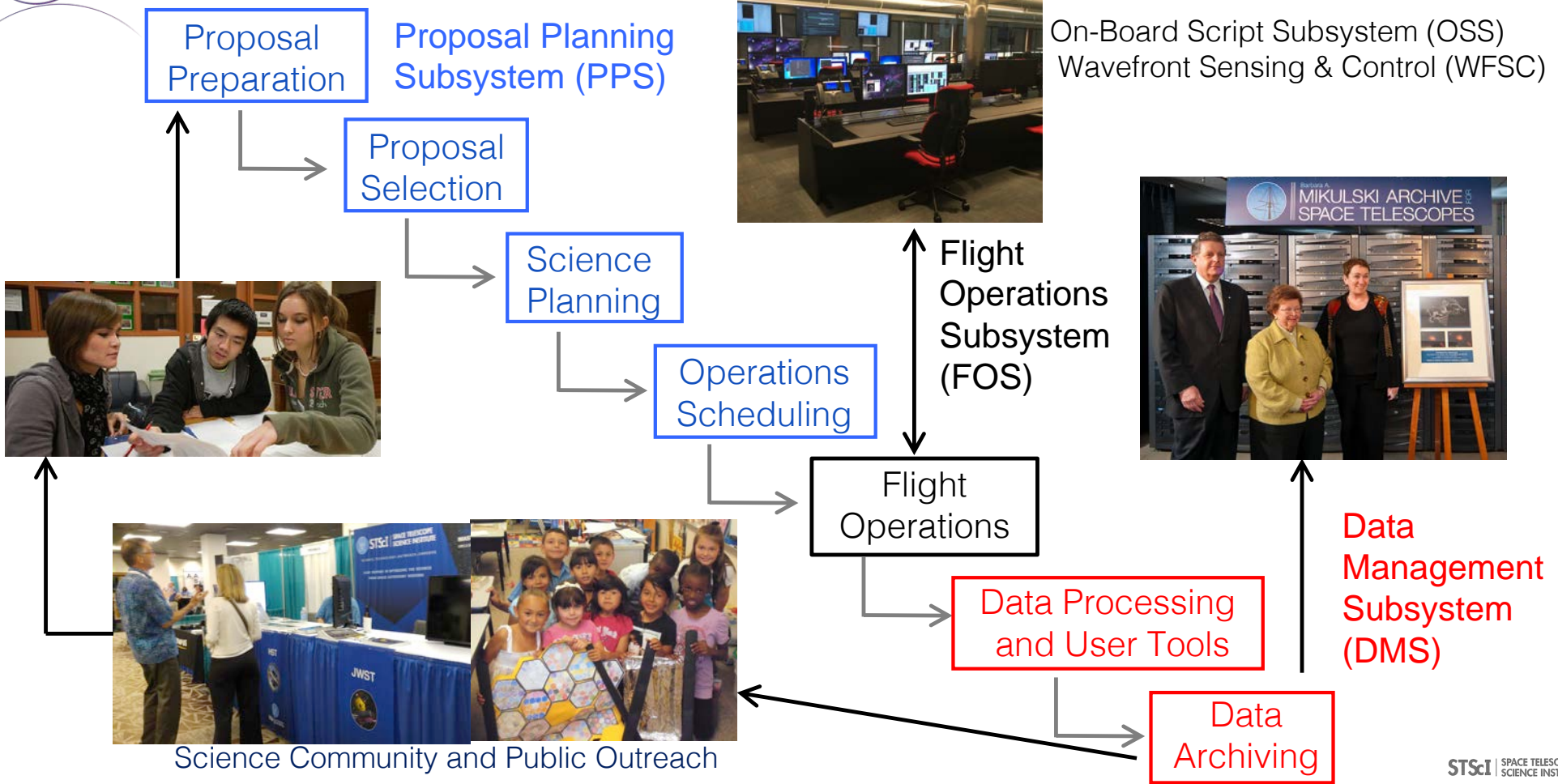
# JWST Data Analysis Tools

- Flexible, Modular tools
- In Python
- Supporting JWST data structures
- Simple installation





# STScI S&OC Operations Flow





## JWST Astronomical Community Outreach

Activities include

- AAS support (winter+summer 2017)
  - JWST town hall, including release of user tools & DD ERS NOI call release
  - Hands-on workshops & ask-an-expert sessions
  - Meeting-in-a-meeting on GTO programs
- Series of data analysis + proposal planning workshops (STScI, Pasadena, Venice, ...)
- For Scientists Website (@JWSTObserver)
- Community lectures



[About STScI](#) | [Archive](#)

# NASA's James Webb Space Telescope

Developed in partnership with ESA and CSA. Operated by AURA's Space Telescope Science Institute

[PUBLIC](#) [EDUCATORS](#)

[JWST SCIENCE](#) ≡

[NEWS & EVENTS](#) ≡

[INSTRUMENTATION](#) ≡

[SCIENCE PLANNING](#) ≡

[DOCUMENTATION](#)





# JWST Public Outreach

Emerging Tech to engage new audiences



Bmore VR exhibition  
-virtually explore JWST at L2



STAR app – JWST model fully deployable!

Large Scale Exhibitions  
and Local Events:



A composite image of a nebula, likely the Helix or Ring Nebula, showing intricate patterns of gas and dust. The colors range from deep blues and purples to bright oranges and yellows, with a central bright region. The text "EXPANDING THE FRONTIERS OF SPACE ASTRONOMY" is overlaid in white, bold, sans-serif font at the bottom center.

**EXPANDING THE FRONTIERS OF SPACE ASTRONOMY**