STScI | SPACE TELESCOPE SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

Commissioning of the JWST Science Instruments

Scott Friedman

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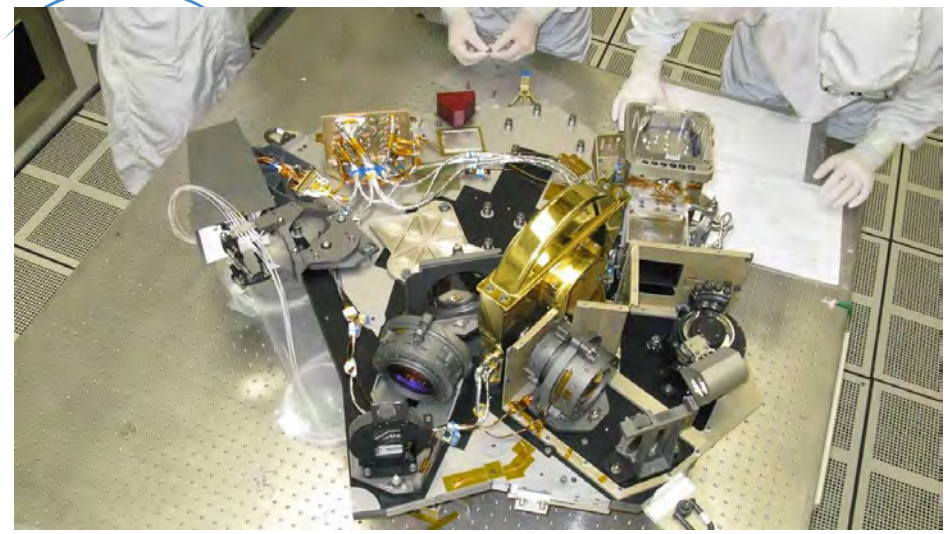
A Note of Thanks

What we show today is the result of hard work and great dedication of thousands of scientists, engineers, technicians, managers, and others over many years from NASA, ESA, CSA, STScI, Northrop Grumman, Ball Aerospace, and many other institutions.

The instrument teams were largely responsible for defining the commissioning activities I will describe shortly as well as the analysis of the data to prepare the observatory for the science that is about to start.

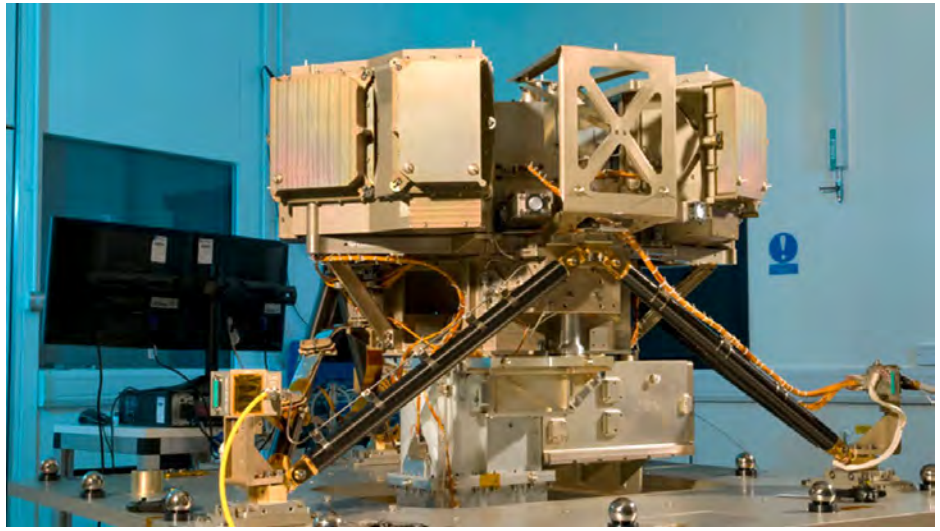
We thank them all.

The Science Instruments on JWST



NIRCam
Univ. of Arizona,
Lockheed Corp.

NIRSpec
ESA,
Airbus Industries



MIRI
European Consortium,
ESA, RAL, JPL,
Univ. of Arizona

NIRISS/FGS
CSA, Honeywell
International

Planning of Science Instrument Commissioning

Commissioning Activity Requests (CARs)

- Instrument commissioning activities are defined by CARs
- Every CAR was preplanned and reviewed multiple times between 2011 and 2020
- There are 132 SI CARs; the vast majority have been executed
  - There are also 17 contingency CARs, only 1 of which needs to be run
- Most CARs are instrument specific but some demonstrate observatory capabilities
  - Moving target tracking
  - Tracking on moons of the giant planets to show the FGS can capture a guide star in the presence of the scattered light from the planet
  - Efficient medium angle slews (~5 arcminutes) that save up to 3 minutes after some dithers and mosaics by eliminating the need for guide star identification each time
  - Two-instrument parallel observations

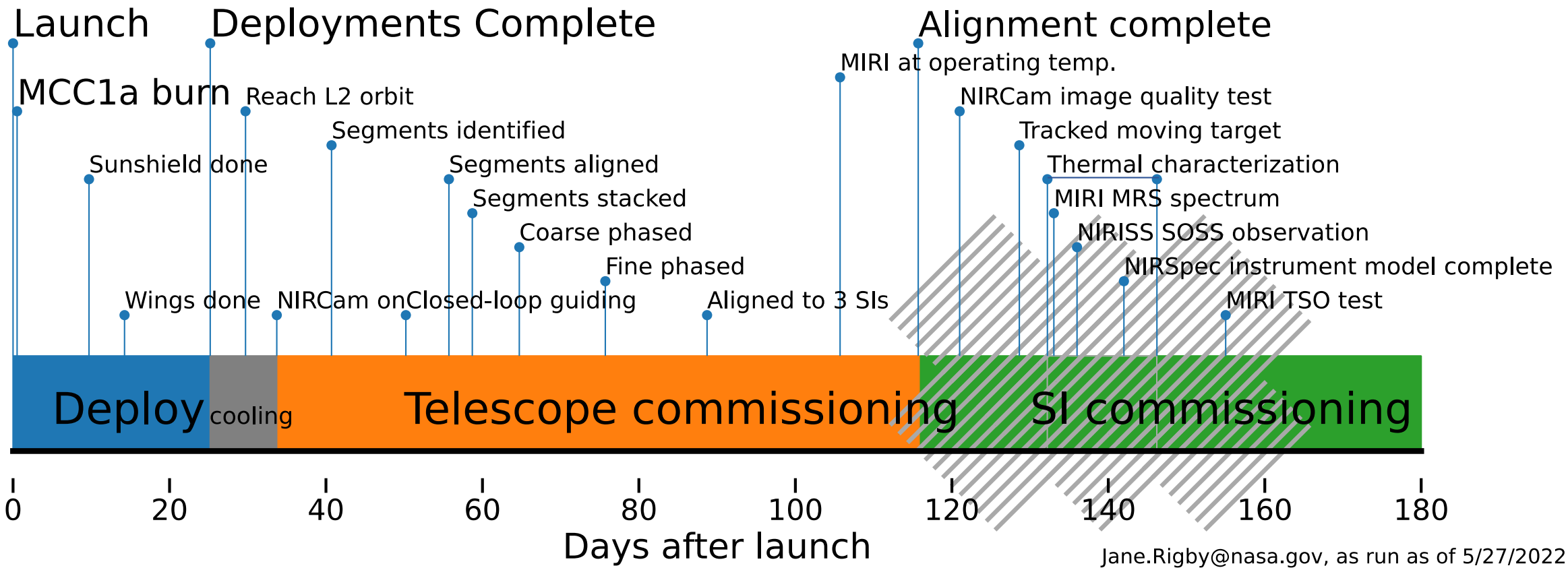
Examples of Science Instrument CARs

All Instruments	
Power-on; detector and mechanism characterization	External flatfields
Detector dark exposures	Photometric zero point sand response
Instrument focus (MIRI has no focus mechanism)	Target acquisition
Astrometric calibration	PSF characterization

NIRCam	NIRSpec
Pre-coarse phasing readiness (supports OTE alignment)	Microshutter performance, geometric characterization
Image quality verification by filter	Microshutter slit loss characterization
Coronagraphic suppression verification	Ghosts, glints, scattered light
Long wavelength grism characterization	Instrument model (mapping sky to shutters to detector)

MIRI	NIRISS/FGS
Sky background with telescope pointing	GR150R/C & GR700XD wavelength calibration
Detector latent characterization	Non-redundant mask performance
LRS & MRS spectral resolution and dispersion	Calibration lamp verification & internal flatfields
Location of centers of Lyot and 4QPM coronagraphs	Stray light contamination

Science Instrument (SI) Commissioning Timeline



Jane.Rigby@nasa.gov, as run as of 5/27/2022

The 17 Science Observing Modes

NIRCam	NIRSpec
Imaging	Multi-object spectroscopy
Wide field slitless spectroscopy (WFSS)	Fixed slit spectroscopy
Coronagraphy	Integral field unit spectroscopy
Grism time series	Bright object time series
Photometric time series	
MIRI	**NIRISS**
Imaging	Single object slitless spectroscopy
Low resolution spectroscopy	Wide field slitless spectroscopy
Medium resolution spectroscopy	Aperture masking interferometry
Coronagraphic imaging	Imaging (parallel only)

For a description of each mode and links to cycle 1 programs using the mode, see https://blogs.nasa.gov/webb/2022/05/12/seventeen-modes-to-discovery-webbs-final-commissioning-activities/

Science Mode Readiness

The 17 observing modes are separately commissioned

- Science readiness criteria were established well before launch to assess when a mode may be considered commissioned and ready for science observations
- Regardless of these criteria we work to maximize the performance of each mode
- A readiness review is held for each mode to review all associated commissioning activities and analyses, and any outstanding issues or anomalies
- Readiness assessment also includes important operational aspects
  - The Astronomer's Proposal Tool (APT) templates work with the planning and scheduling system
  - Dithers and mosaics work correctly
  - Some checks on the pipeline products
- Final approval of mode readiness is made jointly by
  - NASA senior project scientist, John Mather
  - STScI director, Ken Sembach

4 Modes are Science Ready

	NIRCam	NIRSpec
✓	Imaging	Multi-object spectroscopy
	Wide field slitless spectroscopy (WFSS)	Fixed slit spectroscopy
	Coronagraphy	Integral field unit spectroscopy
✓	Grism time series	Bright object time series
✓	Photometric time series	
	MIRI	**NIRISS**
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Science Performance – General Observations (1/2)

- System throughput is equal to or better than preflight expectations
  - At least partially attributable to the cleanliness of the telescope optics
- Image quality is excellent. The telescope is diffraction limited at a shorter wavelength than required (2 microns) and the optical performance of the instruments is very good. Encircled energy closely matches WebbPSF predictions.
- Detector performance is nominal
  - Possibly slightly more cosmic rays than expected
  - A higher incidence than expected of transient events (snowballs) that are larger than cosmic rays
    - But they affect fewer pixels per second than cosmic rays
  - Miscellaneous other detector effects mostly already known from ground test: intrapixel sensitivity variations in some NIR detectors, cruciform light effects in the MIRI detectors at the shortest wavelengths
- Some faint stray light artifacts seen in limited areas NIRCam and NIRISS images
  - Attributable to relatively bright stars in certain susceptibility regions well outside the field of view. Tools are being developed to assist observers in avoiding these extraneous sources.
  - In NIRCam it mostly appears in small areas in 3 of the 8 short wavelength detectors. In NIRISS it covers a very limited and well-defined area which will likely be removable in processing.
- Limiting sensitivity is still being evaluated

Science Performance – General Observations (2/2)

- Open architecture makes JWST subject to stray light from outside the field of view. This extra stray light background is particularly important at 2 – 3 microns. In several low background fields, we have measured this stray light to be at or less than pre-launch expectations.
- Astrometric distortion residuals meet requirements
- Guiding pointing stability generally excellent. We continue to reduce the number of attempts (already usually 1) needed to get into closed loop guiding, thus improving efficiency.
- Target acquisitions are working well
- MIRI cryocooler performing extremely well
  - Induced line-of-sight jitter is almost immeasurably small
- We have demonstrated the capability of tracking moving targets
  - The requirement is up to 30 milli-arcsec/second, sufficient to observe Mars

The Remaining Commissioning Schedule

- There are fewer than 15 commissioning activity requests remaining to execute
- Early Release Observations (EROs) are scheduled along with these CARs
- We expect the CARs and EROs to be completed within several weeks
- The EROs will be released on July 12. This marks the first release of JWST data.
  - All commissioning data will be released within a couple of days of this date
  - At the ERO release, NASA will release a technical document summarizing science performance as known at the end of commissioning (Rigby et al., in prep.)
- Cycle 1 observations will begin at about this time

Summary of JWST Performance

- The instruments have successfully completed most of their CARs
- Some scattered light features have been observed in NIRCam and NIRISS. Most observations will not be affected. The detectors have their own personalities but are generally operating beautifully. These things are expected for new instruments in a new observatory.
- We are learning the characteristics of the observatory and will continue to do so during cycle 1
- 4 observing modes are science ready with more to follow in the coming days
- The instrument teams are completing their analyses in preparation for readiness approval of the remaining observing modes

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JWST is working better than expected by almost every measure.

It will soon be yours to explore the universe!