The James Webb Space Telescope Mission

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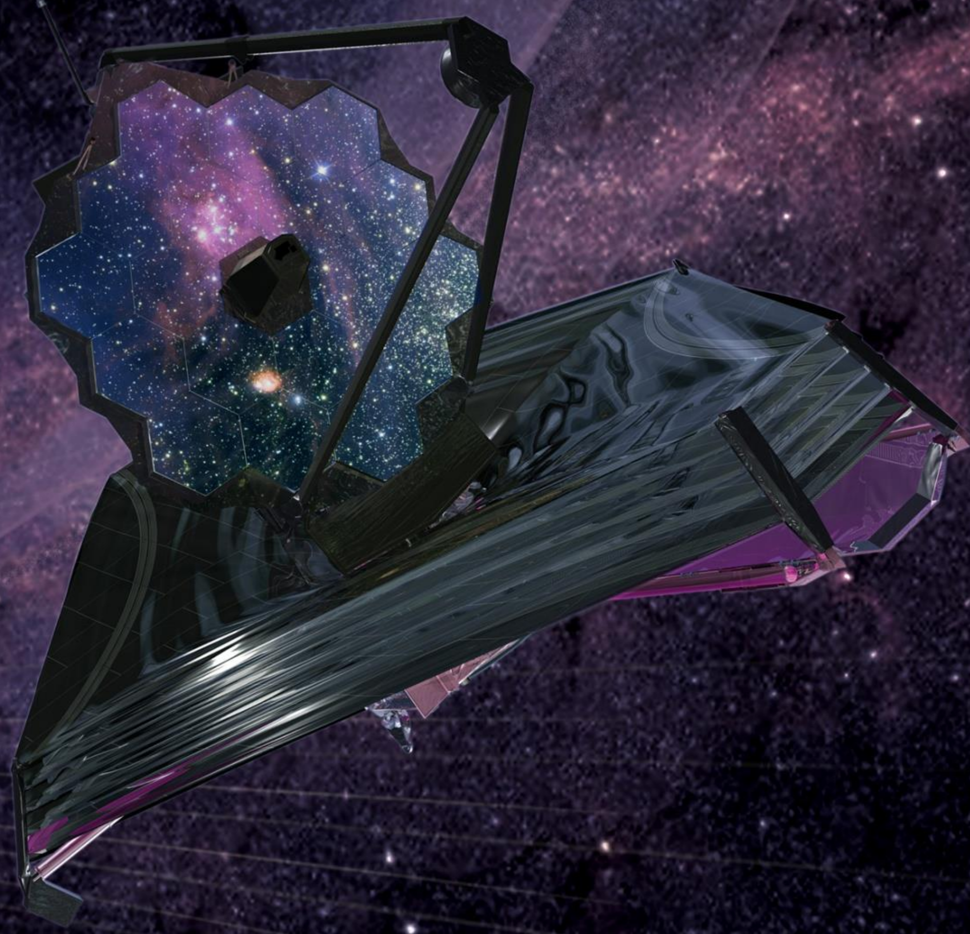
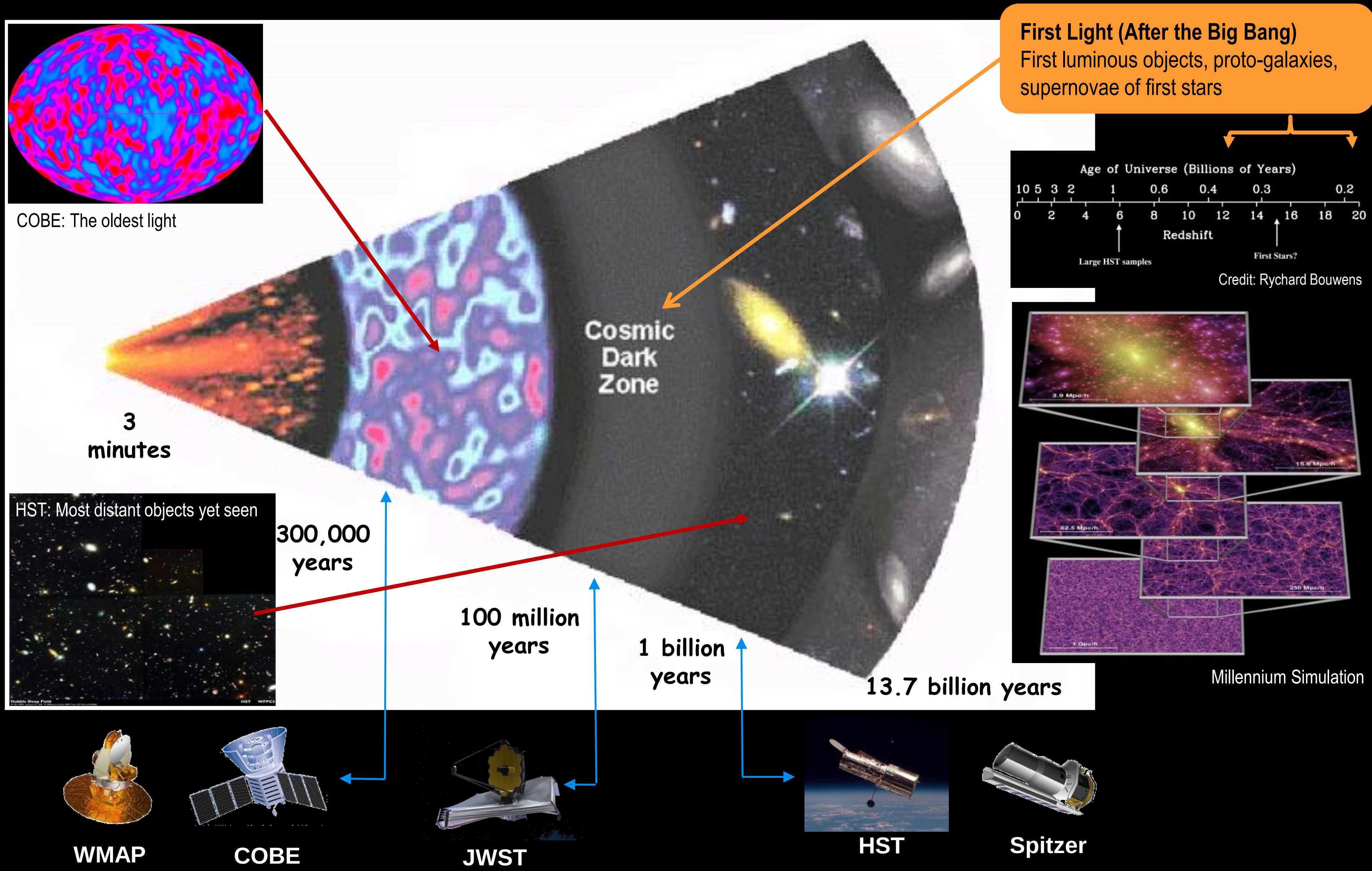
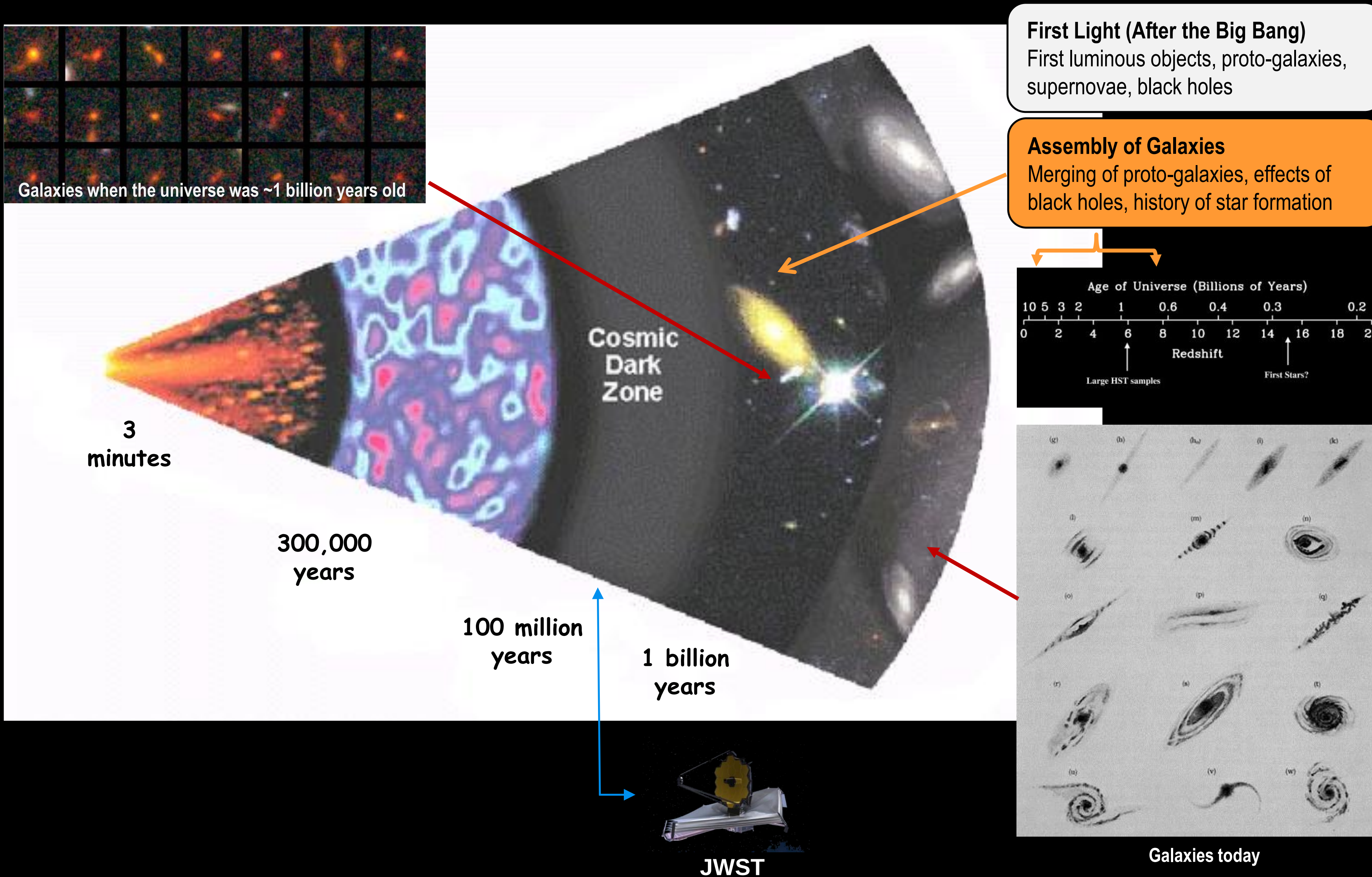
@NASAWebbTelescp
#JWST



JWST is designed to look back in time to see the first galaxies

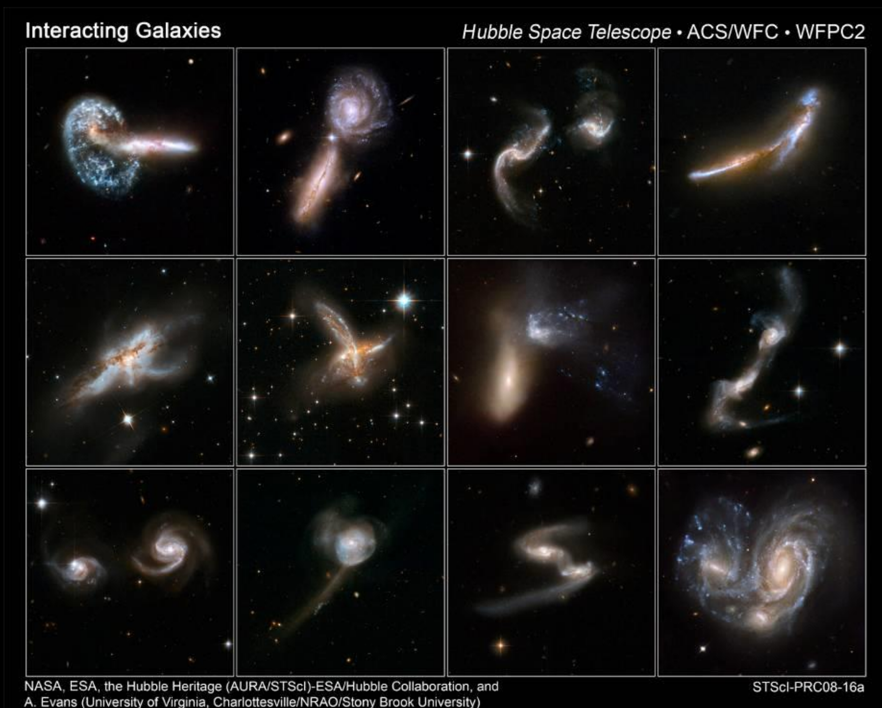


JWST will image the infrared universe with unprecedented clarity



JWST will see how the structure and composition of galaxies evolve across cosmic time

Click Video



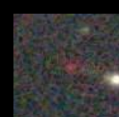

5.8 Gyr


3.3 Gyr


2.2 Gyr

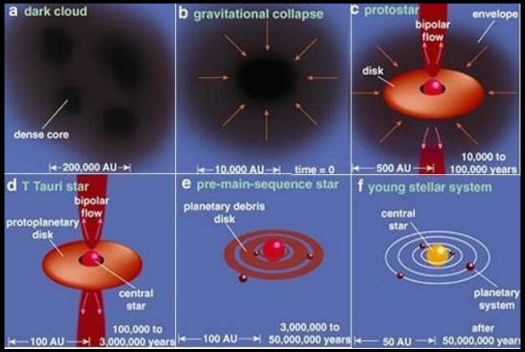

2.2 Gyr

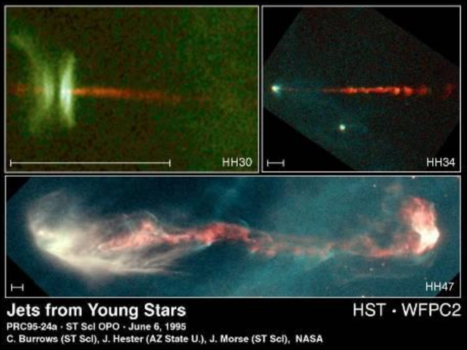

1.8 Gyr


1.0 Gyr
(z~6)

JWST will see into the birthplaces of stars to reveal how they form

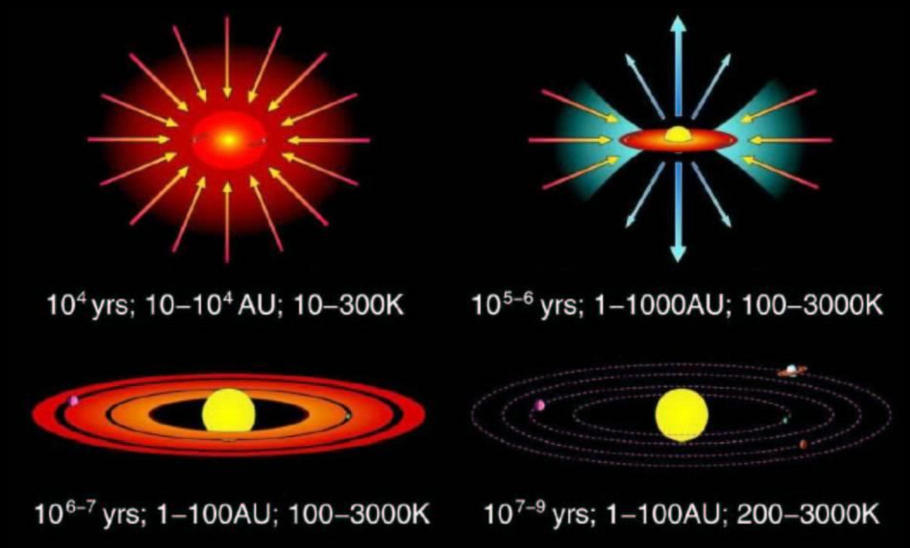
Birth of Stars and Planetary Systems
How stars form and chemical elements are produced





Protostar

Circumstellar disk

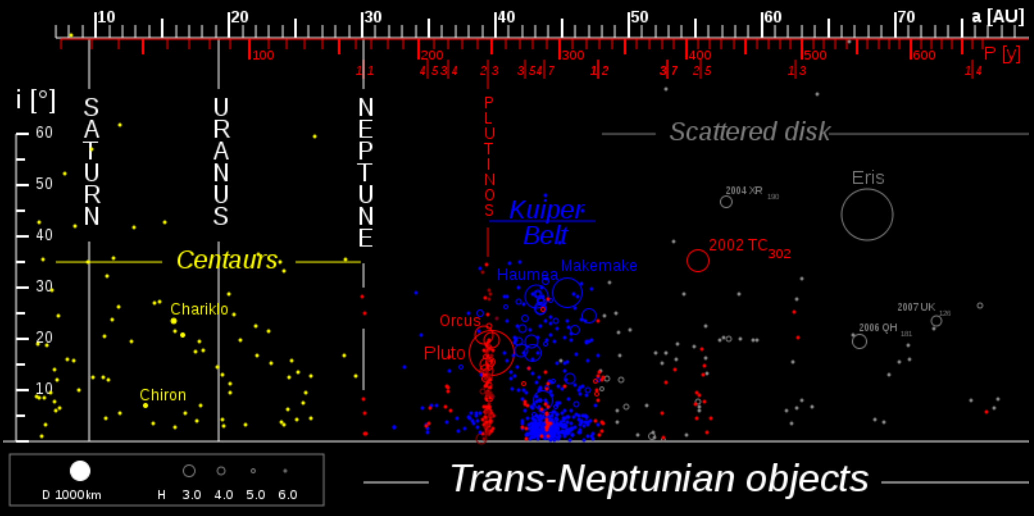


Planetesimals

Mature planetary system

The Eagle Nebula as seen in the near-infrared

JWST will observe how planetary systems form and evolve

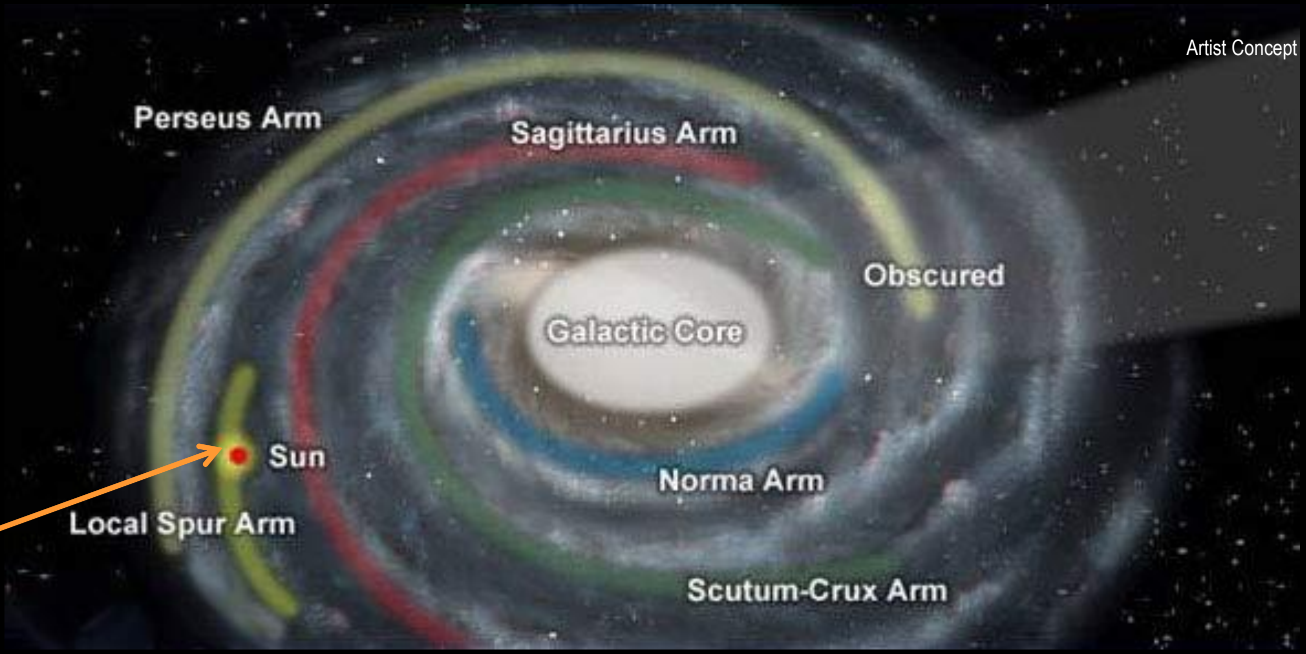


First Light (After the Big Bang)
First luminous objects, proto-galaxies, supernovae, black holes

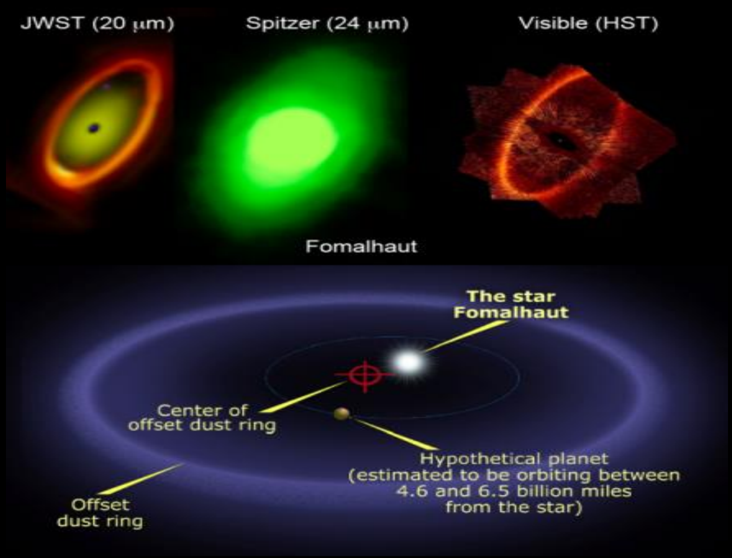
Assembly of Galaxies
Merging of proto-galaxies, effects of black holes, history of star formation

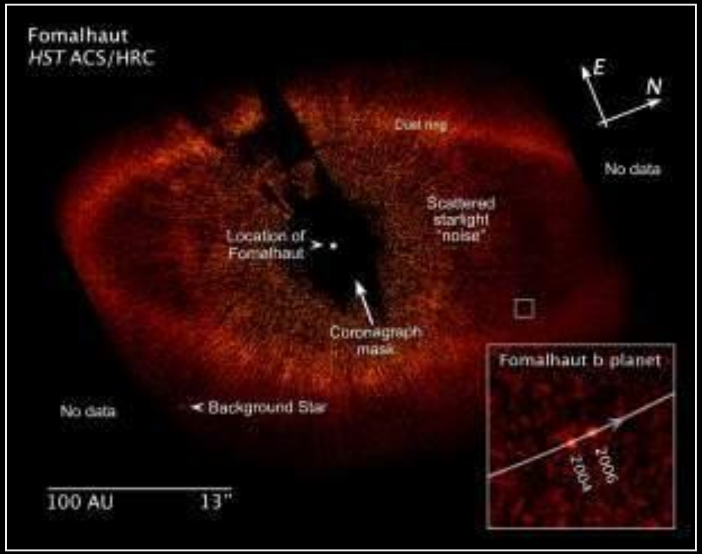
Birth of Stars and Planetary Systems
How stars form and chemical elements are produced

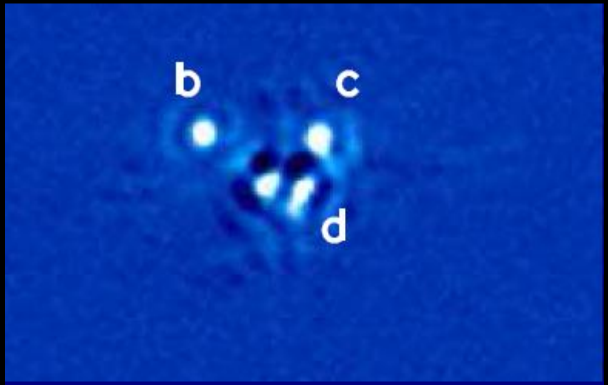
Planetary Systems & Origins of Life
Formation of planets



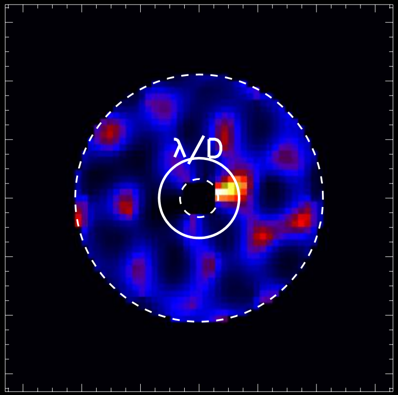
JWST will image exoplanets (planets orbiting stars other than the Sun)







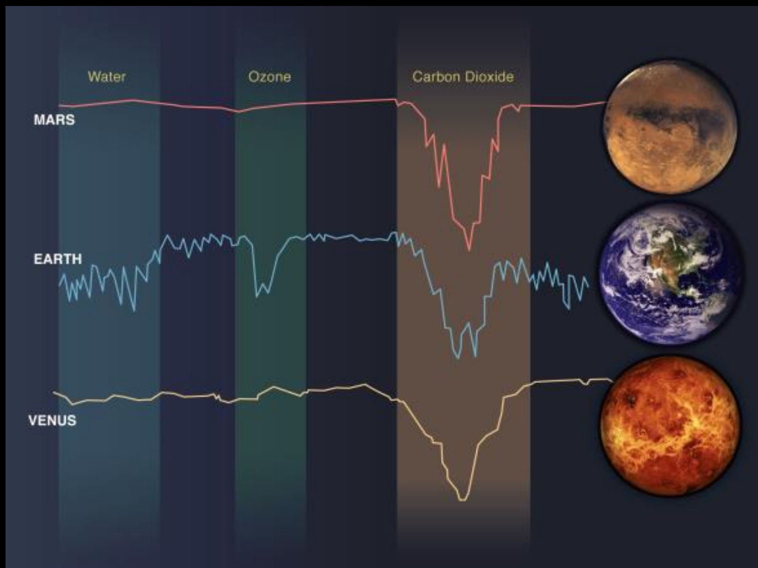
JWST simulated mid-infrared image of planets orbiting star HR 8799.

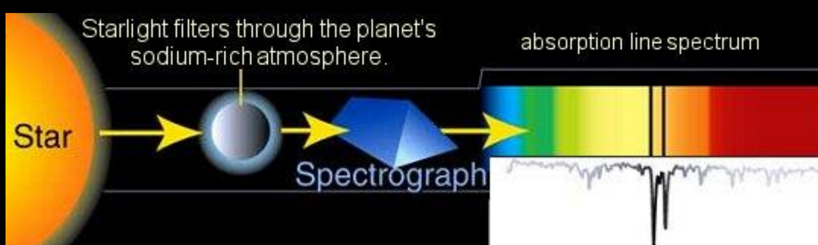


JWST simulated near-infrared image of a 1-2 M_{Jup} planet at ~1 AU of a M0V star 10 pc from the Sun.

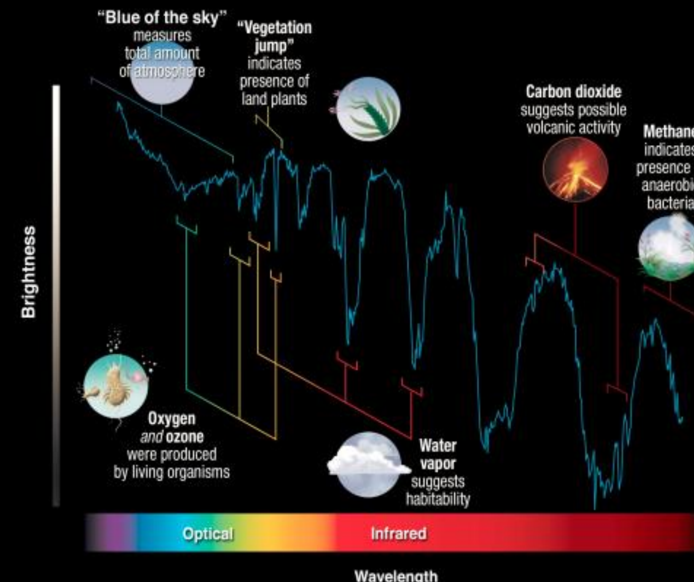
JWST will revolutionize understanding of exoplanet atmospheres

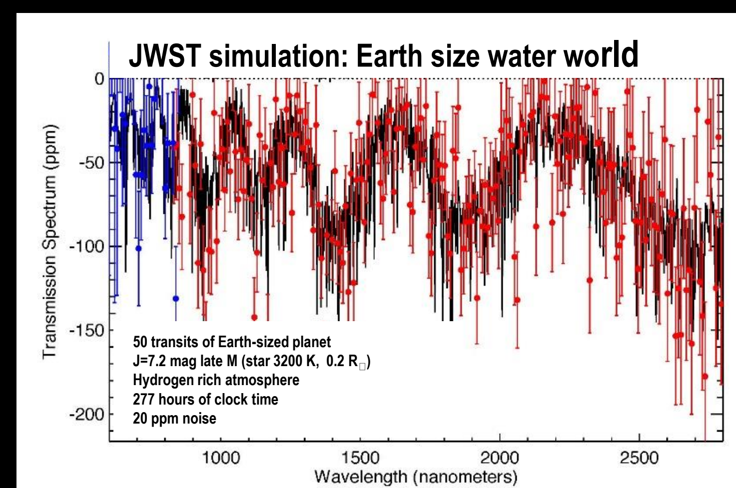
Composition is revealed by spectroscopy





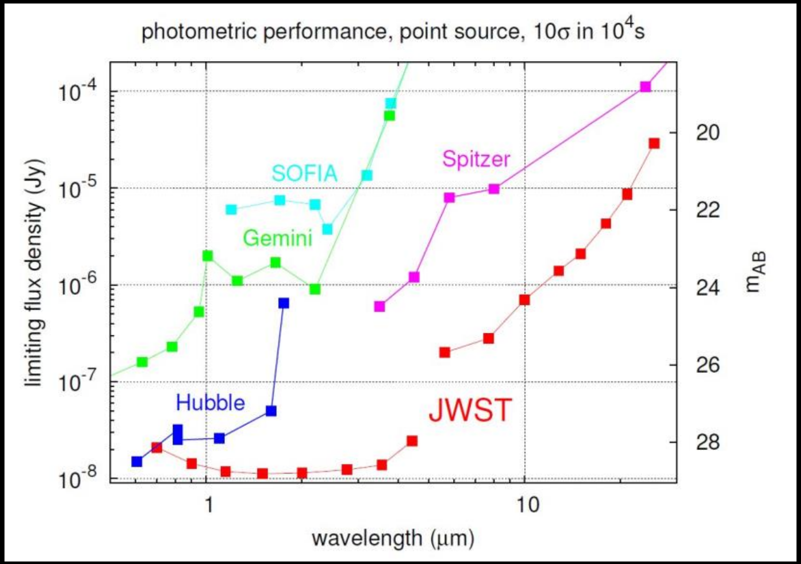
So is the presence of life!

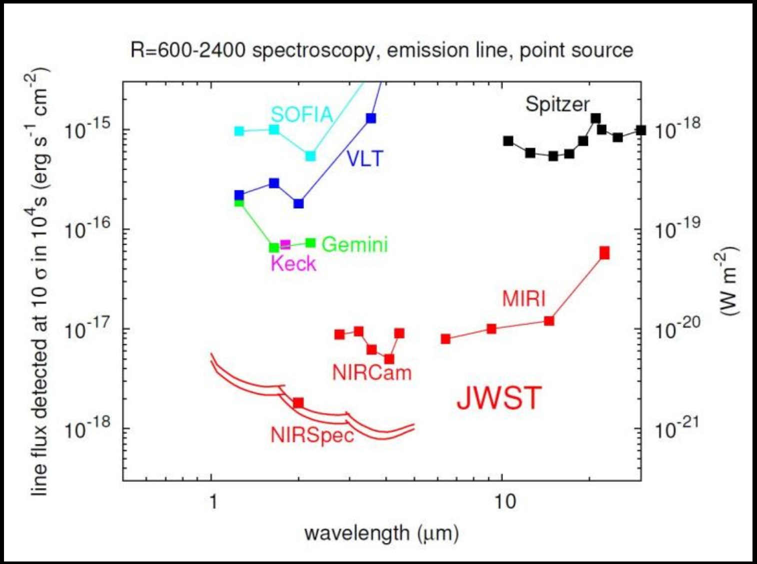




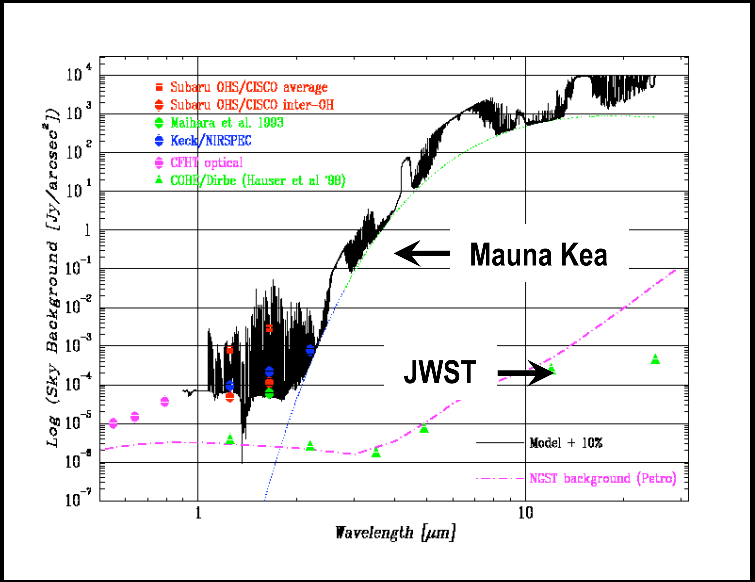
There are tens of billions of habitable worlds in our galaxy. JWST can detect liquid water on an exoplanet that is a few times the size of the Earth.

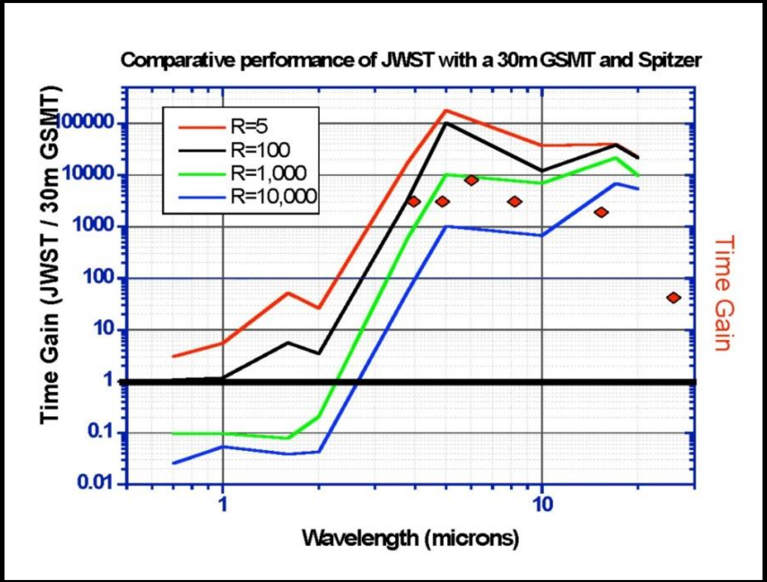
JWST will achieve unprecedented infrared sensitivity





However, 30 m ground-based facilities can exceed JWST performance for R > 1000 spectroscopy at wavelengths < 1.7 microns

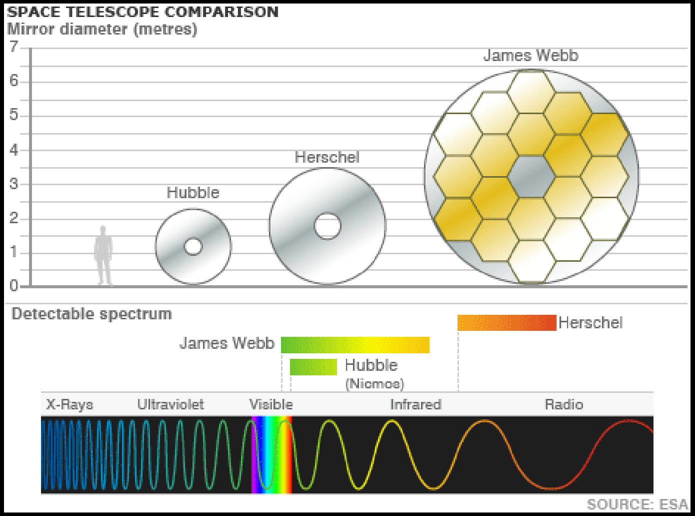


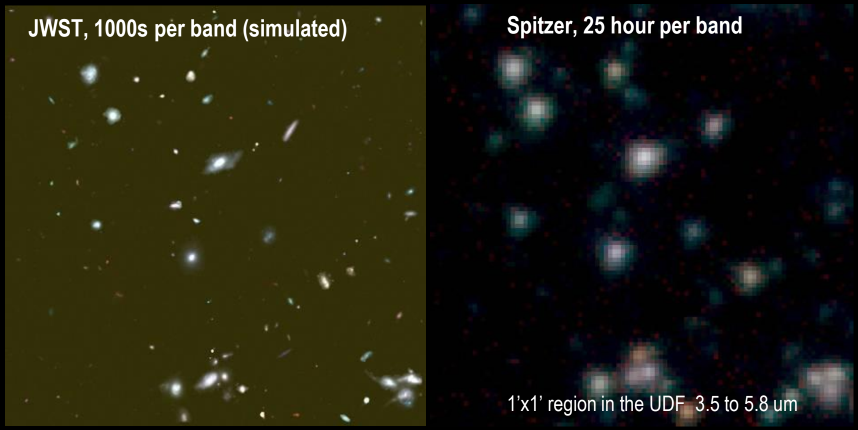


JWST requires the largest cryogenic telescope ever constructed

To achieve its science objectives, the JWST mission requires:

- 7X the light gathering capability of the Hubble Space Telescope
- Observing capability spanning the optical to mid-infrared spectrum
- Hubble-like angular resolution in the near-infrared





JWST will provide the first high definition view of the infrared universe

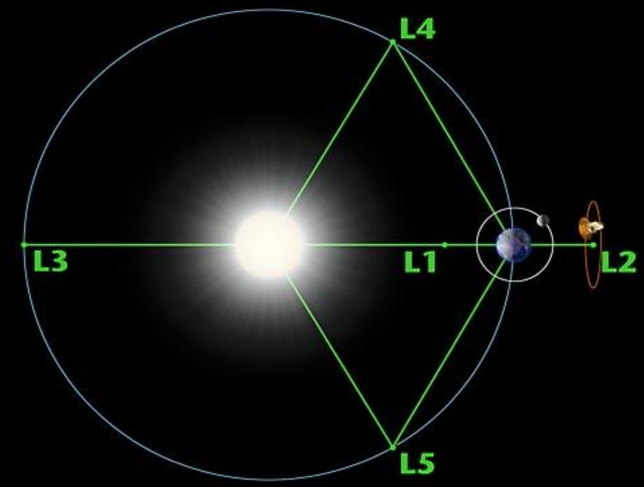
To meet these requirements, the JWST team had to solve two key problems:

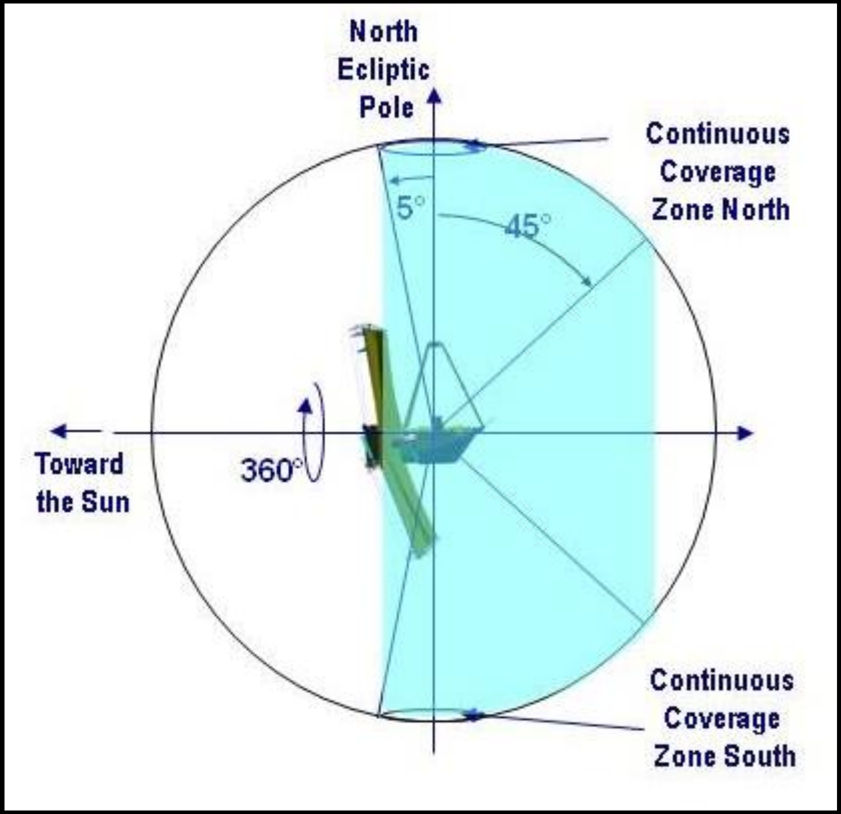
- Provide a primary mirror that is larger in diameter than available rocket fairings
- Achieve a high stability cryogenic 40K (-233 C, -388 F) operating temperature

The JWST will be placed in orbit about the Sun-Earth L2 point approximately 1.5 million km from Earth

An L2 point orbit was selected for JWST to enable passive cryogenic cooling

- Station keeping thrusters are required to maintain this orbit
- Propellant sized for 11 years (delta-v ~ 93 m/s)
- ~100 day direct transfer trajectory





The JWST can observe the whole sky while remaining continuously in the shadow of its sunshield

- Field of Regard is an annulus covering 35% of the sky
- The whole sky is covered each year with small continuous viewing zones at the Ecliptic poles

The JWST program is a multi-agency partnership

James Webb Space Telescope System

Launch Segment


Ariane Launcher

- Launch Vehicle
- Payload Adapter
- Launch Site Services

Observatory Segment


JWST Observatory

- Optical Telescope Element (OTE)
- Integrated Science Instrument Module (ISIM)
  - NIRCam
  - MIRI
  - NIRSpec
  - FGS
- Spacecraft Element (SE)
  - Spacecraft Bus
  - Sunshield

Ground Segment


Deep Space Network


Space Telescope Science Institute

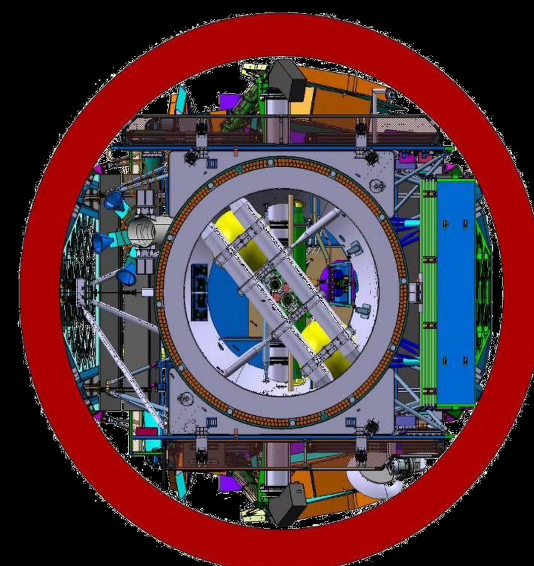
- Science and Operations Center (SOC)
- Common Systems

Provided by NASA (green)
Provided by ESA (blue)
Provided by CSA (yellow)

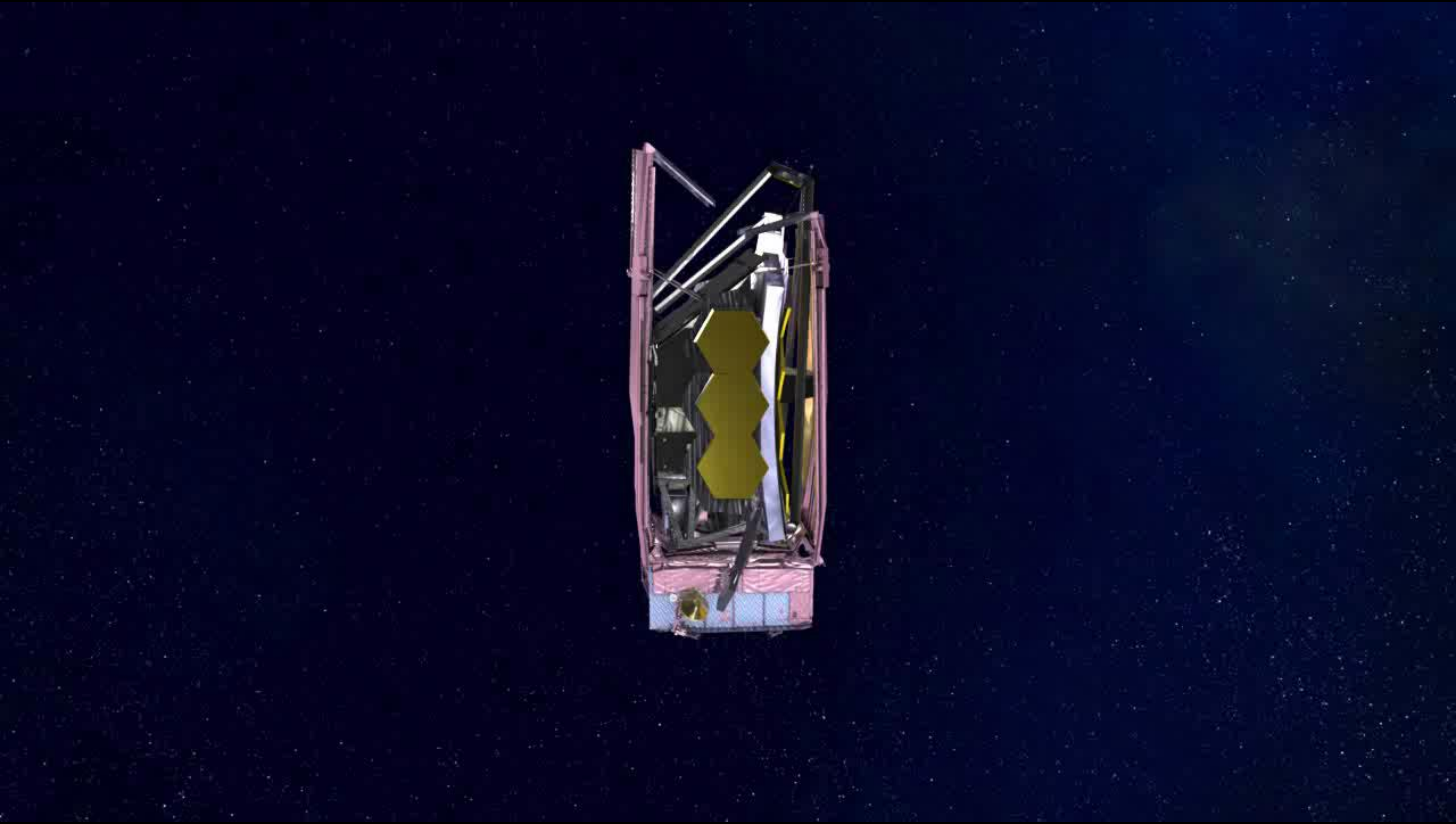
The telescope requires a segmented deployable mirror

Ariane 5 ECA

- JWST is designed to integrate with an Ariane V launch vehicle and 5 m diameter fairing
- Launch from Kourou Launch Center (French Guiana) with direct transfer to L2 point.
- Payload launched at ambient temperature with on orbit cooling to 50 K via passive thermal radiators
- JWST payload: 6530 kg



Deployment Sequence Overview

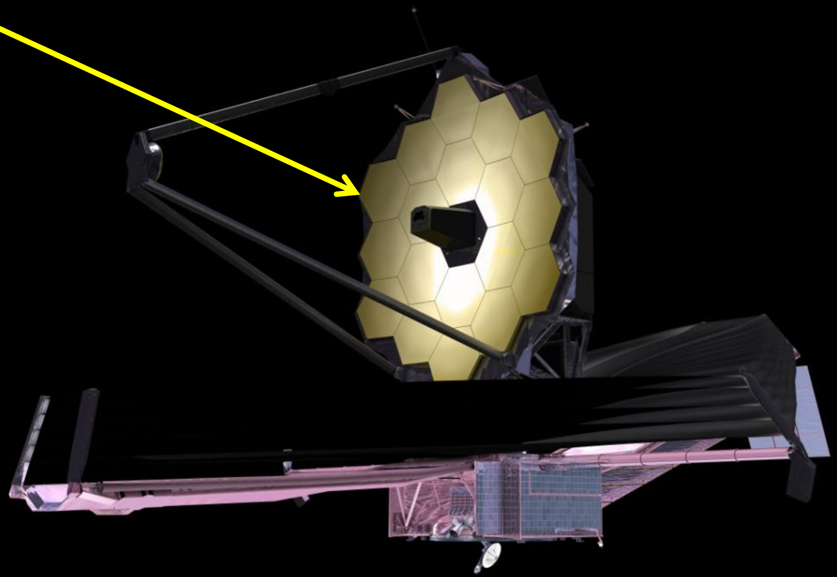


The JWST space vehicle consists of three elements

Optical Telescope Element (OTE)
Collects star light from distant objects

Integrated Science Instrument Module (ISIM)
Extracts physics information from star light

Spacecraft
Attitude control, telecom, power & other systems



The telescope mirrors are fabricated from Beryllium

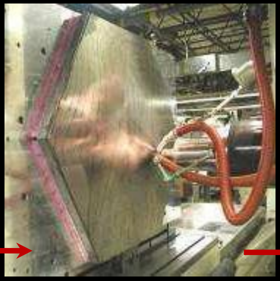
Key physical properties of Beryllium:

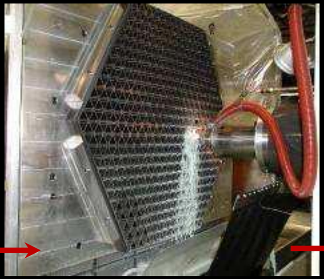
- low coefficient of thermal expansion at 50 K
- high thermal conductivity
- high stiffness to mass ratio

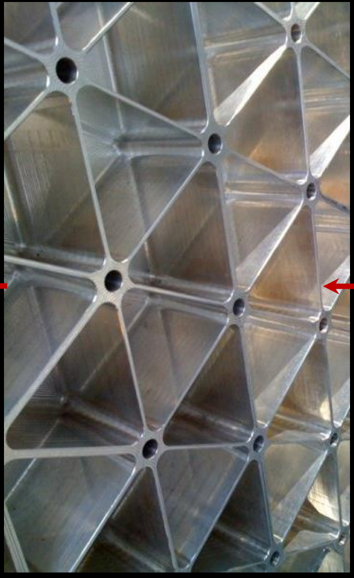
- Type O-30 spherical powder
  - uniform CTE, high packing density, low oxide content

Primary mirror mass properties

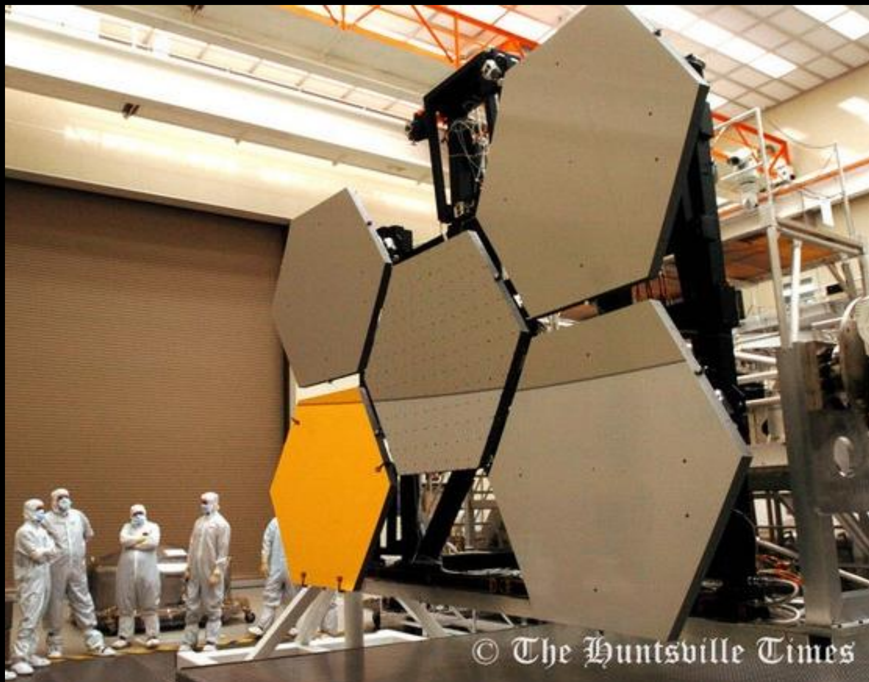
- substrate: 21.8 kg
- segment assembly: 39.4 kg
- OTE area density: ~28 kg m^{-2}
  - HST (ULE) ~ 180 kg m^{-2} (~ 6X heavier)
  - Keck (Zerodur) ~ 2000 kg m^{-2} (~71X heavier)

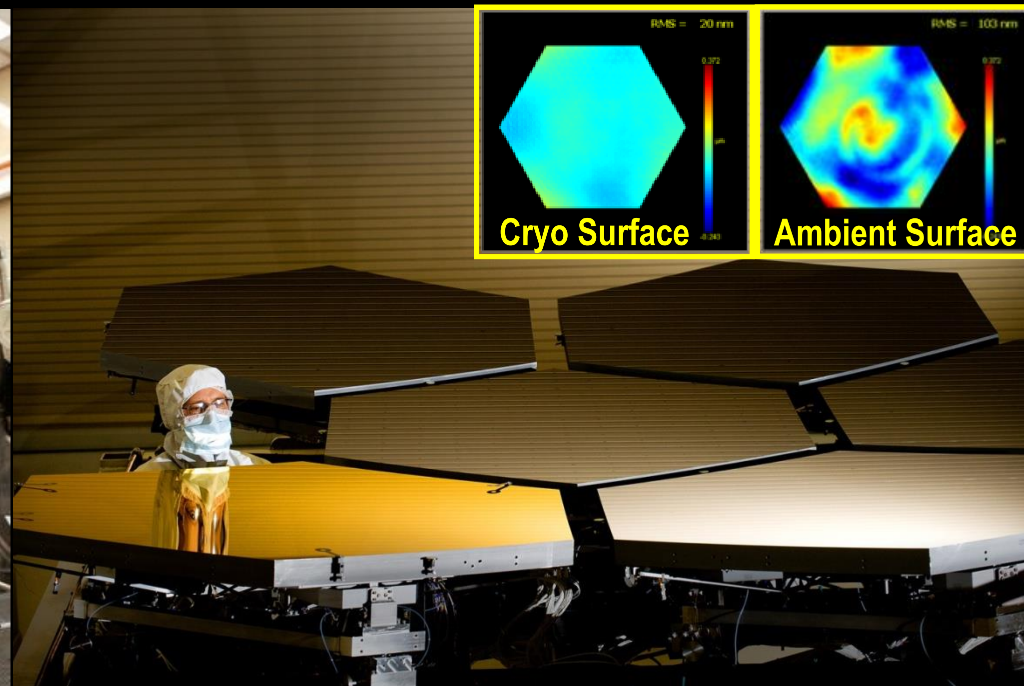


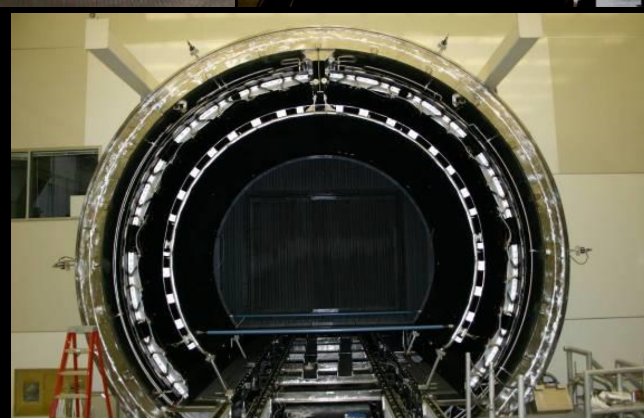


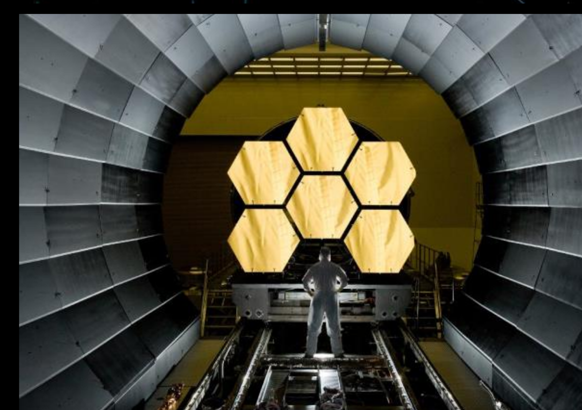


A specially instrumented space simulation chamber at Marshall Space Flight Center was used to optically test the primary mirror segments at 50 K (-225 C, -370 F)

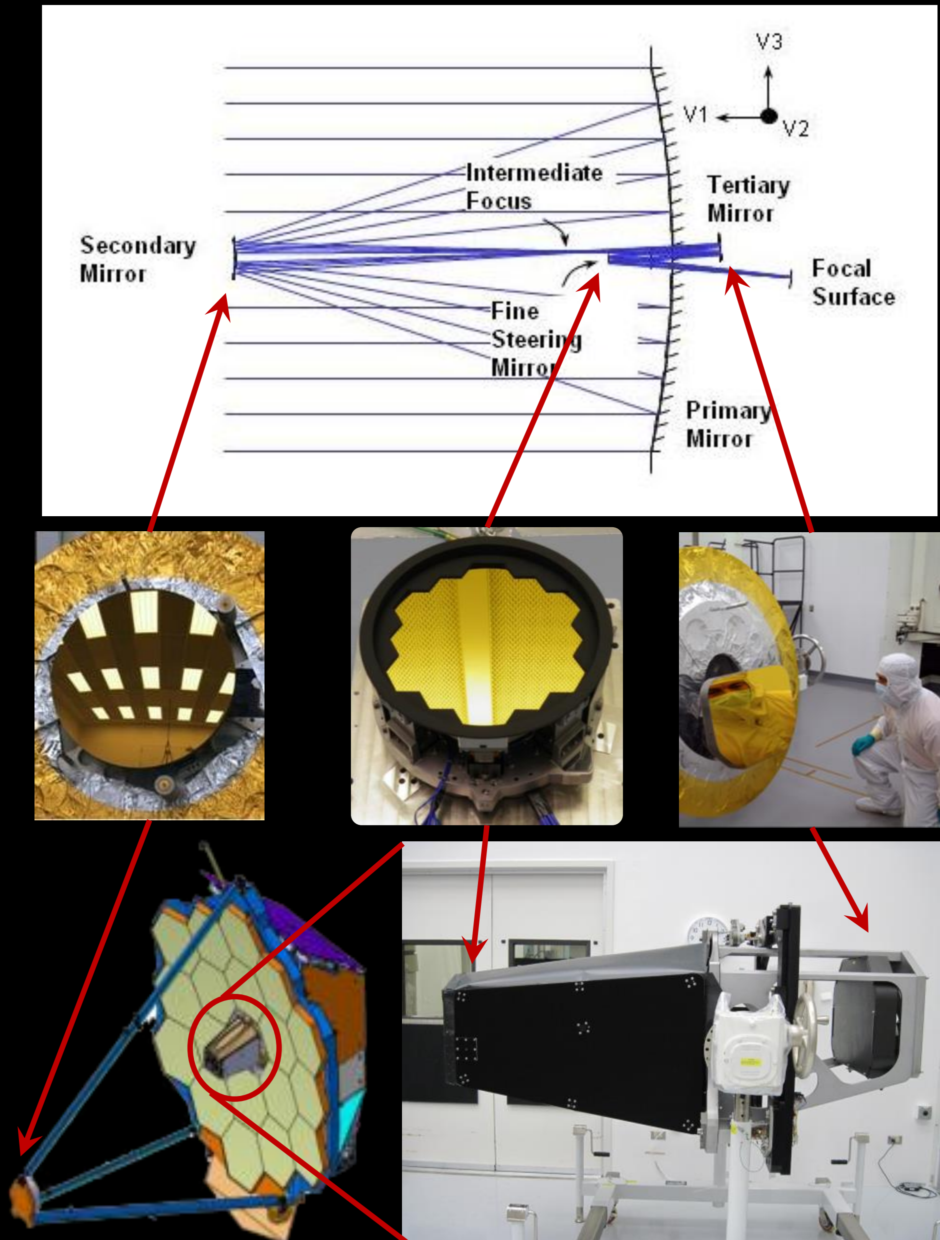






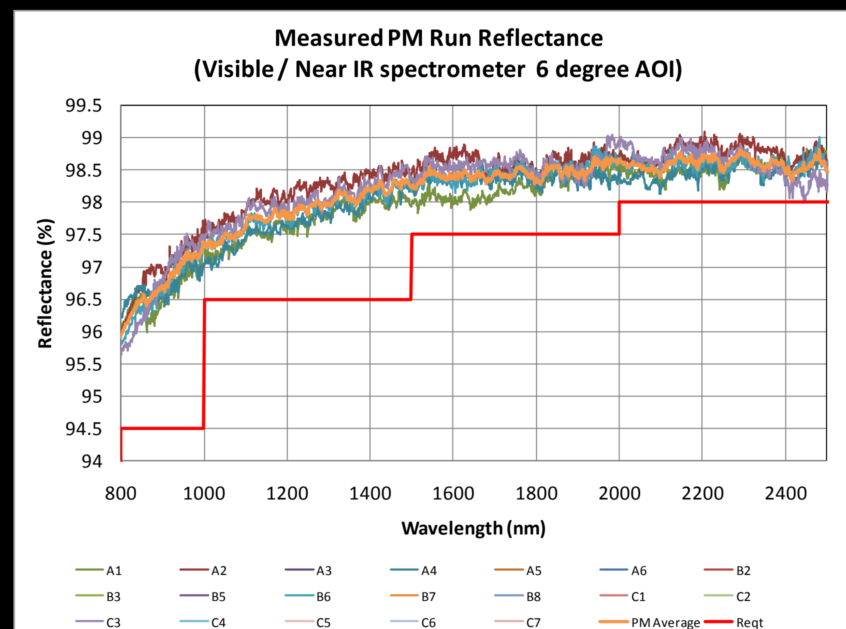


All telescope optics are in-spec in every respect



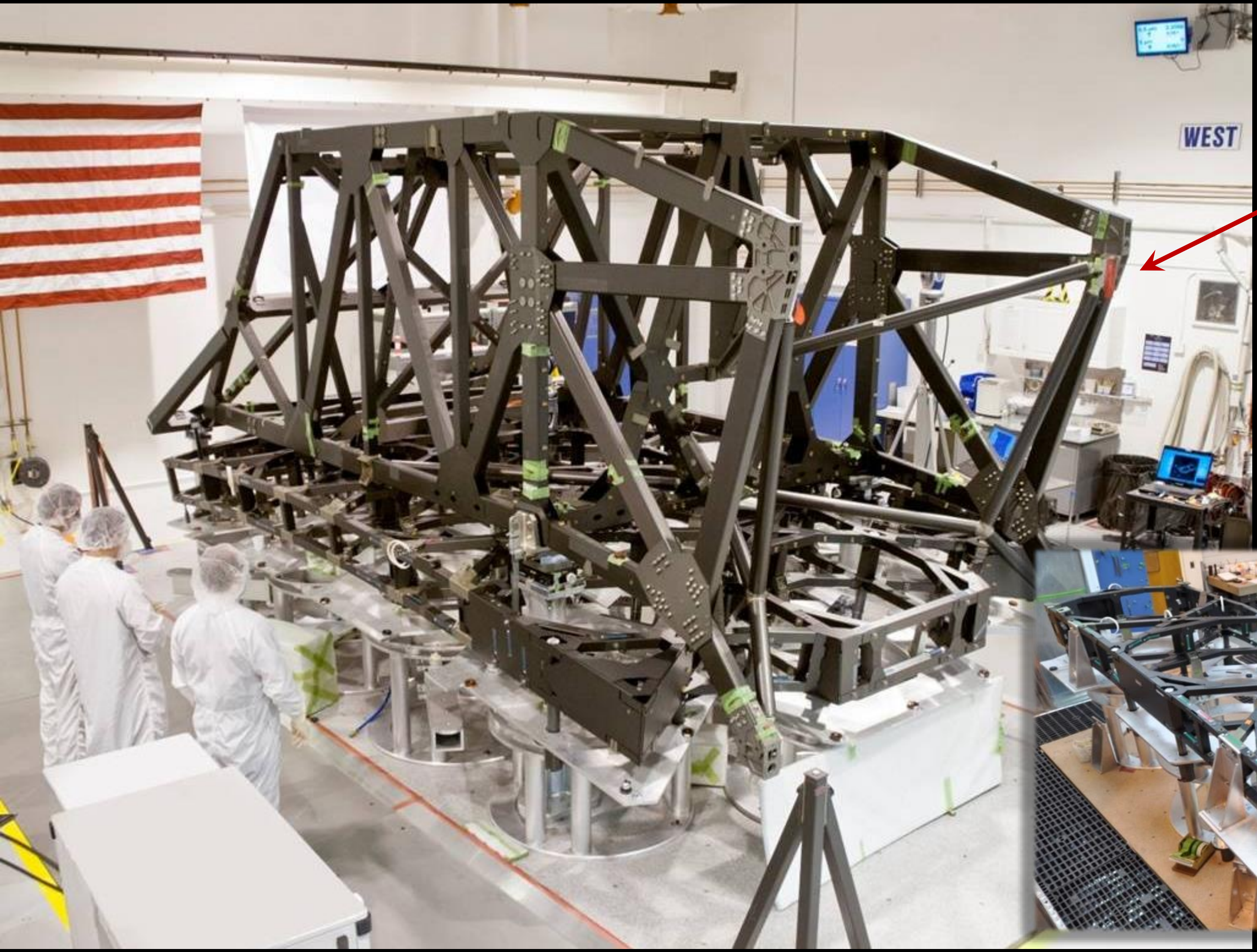
All of the mirrors are seen through testing to be smooth and reflective enough to enable the mission science objectives

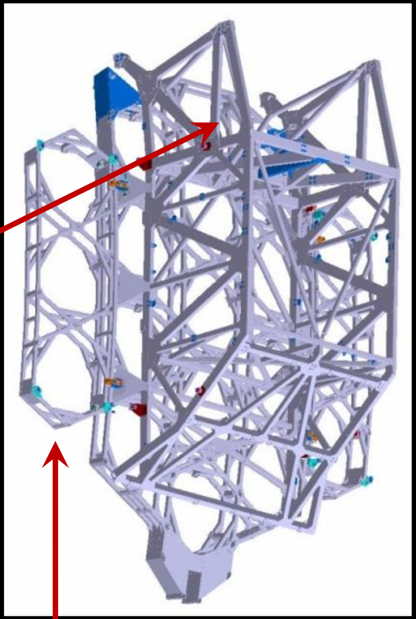
Mirror	Total (RMS SFE)	Requirement (RMS SFE)
18 primary Segments (Composite Figure)	25.0	25.8
Secondary	19.8	23.5
Tertiary	20.5	23.2
FSM	14.7	18.7



Buildup of telescope flight structure is complete

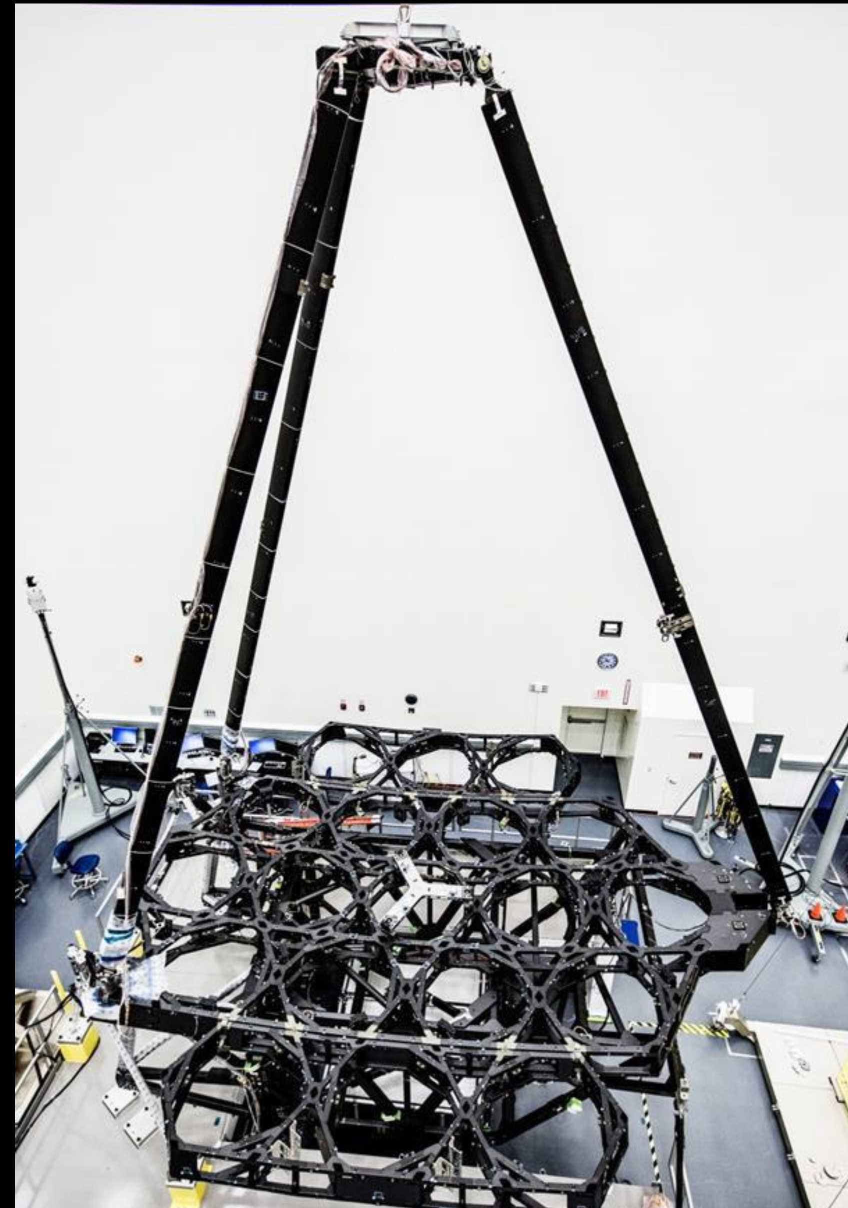
The structure consists of ~3,200 bonded composite piece parts





Pathfinder and flight telescope structures in handling test

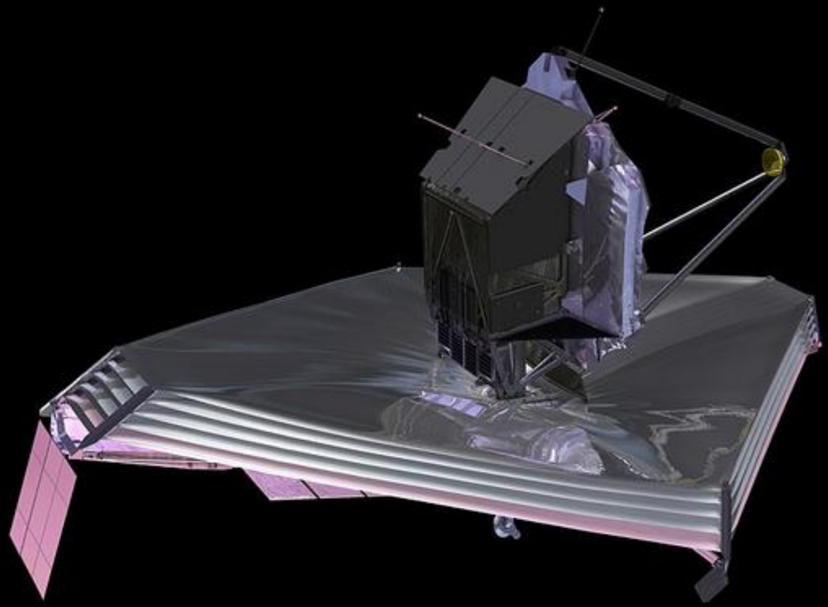
Pathfinder secondary mirror structure deployment test

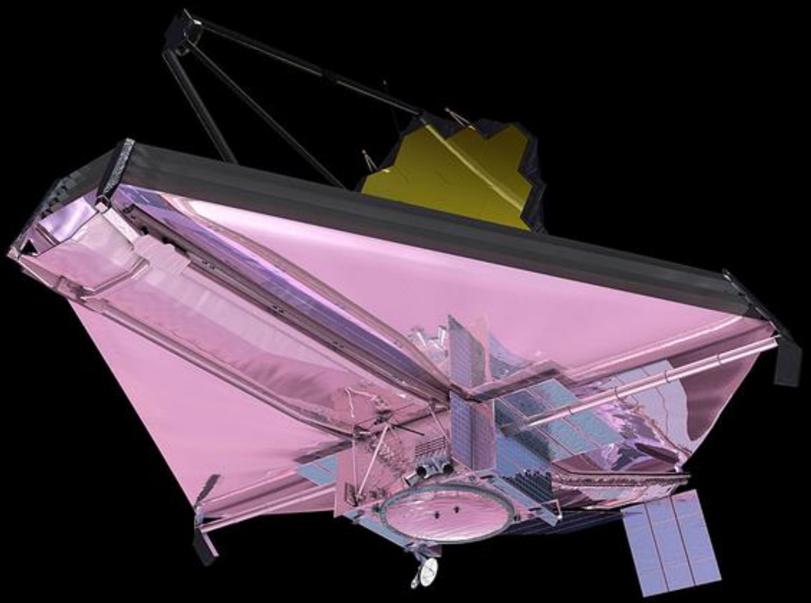


Flight backplane structure

OTE pathfinder structure manual deployment test: June 2014

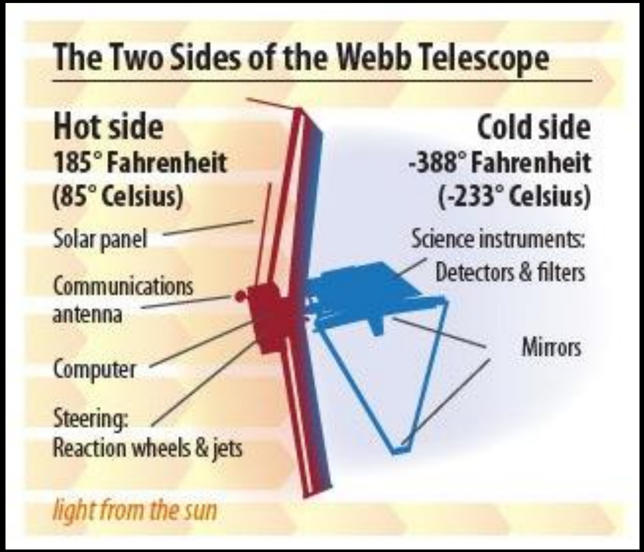
The JWST's 5 layer sunshield has an SPF of ~10^6





Sunshield Facts

- Measures 73 x 40 feet and has 5 layers
- Made of heat-resistant Kapton coated with silicon on sun side and aluminum on other surfaces
- Sun side reaches 358 K (85^o C), dark side stays at 40 K (-233^o C)
- Each of 5 layers consist of 50 pieces to form shape
- Seaming involves 7,000 inches of thermal welds
- Seam-to-seam accuracy ~ 0.05 inch with shape of (tennis court size) layers accurate to a few tenths of an inch



Sunshield Manual Deployment Test: June 2014

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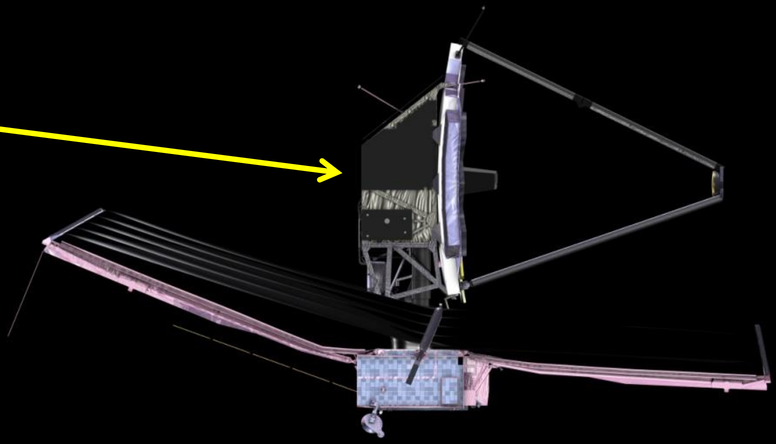
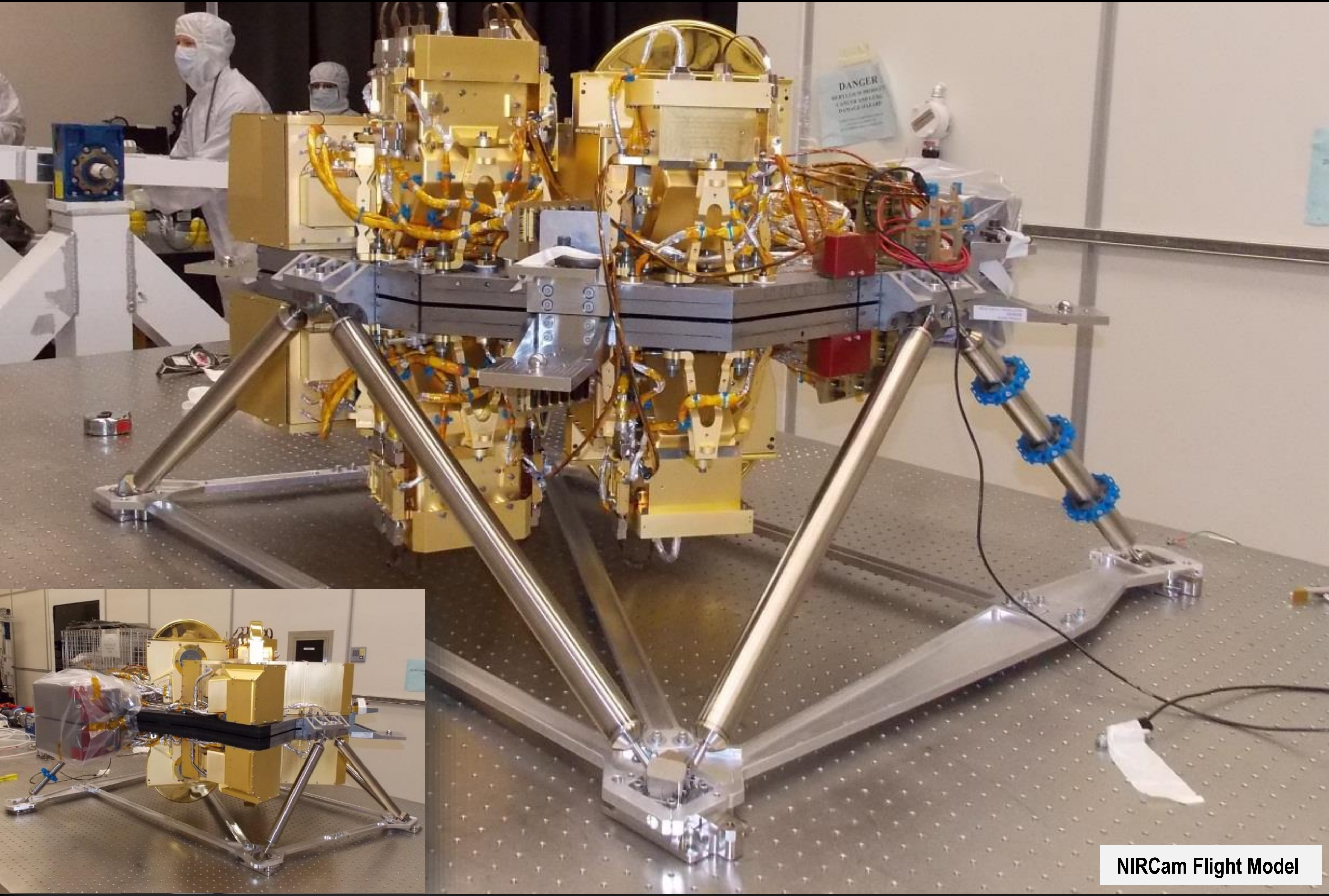
Optical Telescope Element (OTE)
Collects star light from distant objects

Integrated Science Instrument Module (ISIM)
Extracts physics information from star light

Spacecraft
Attitude control, telecom, power & other systems



The NIRCam will image the earliest epoch of galaxy formation



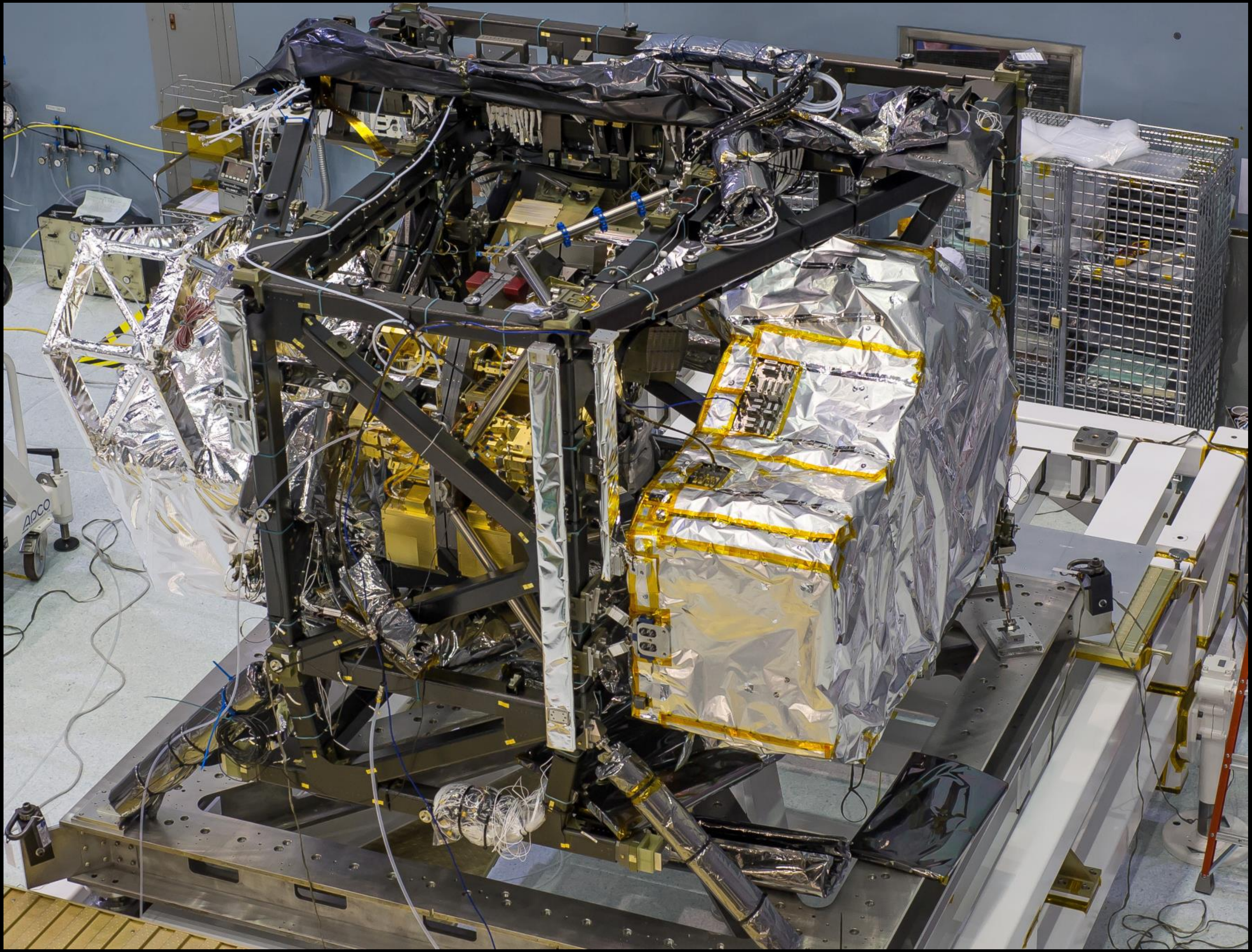
NIRCam Flight Model

NIRSpec can obtain spectra of 100 compact galaxies simultaneously

MIRI will provide humanity's first high definition view of the mid-infrared universe

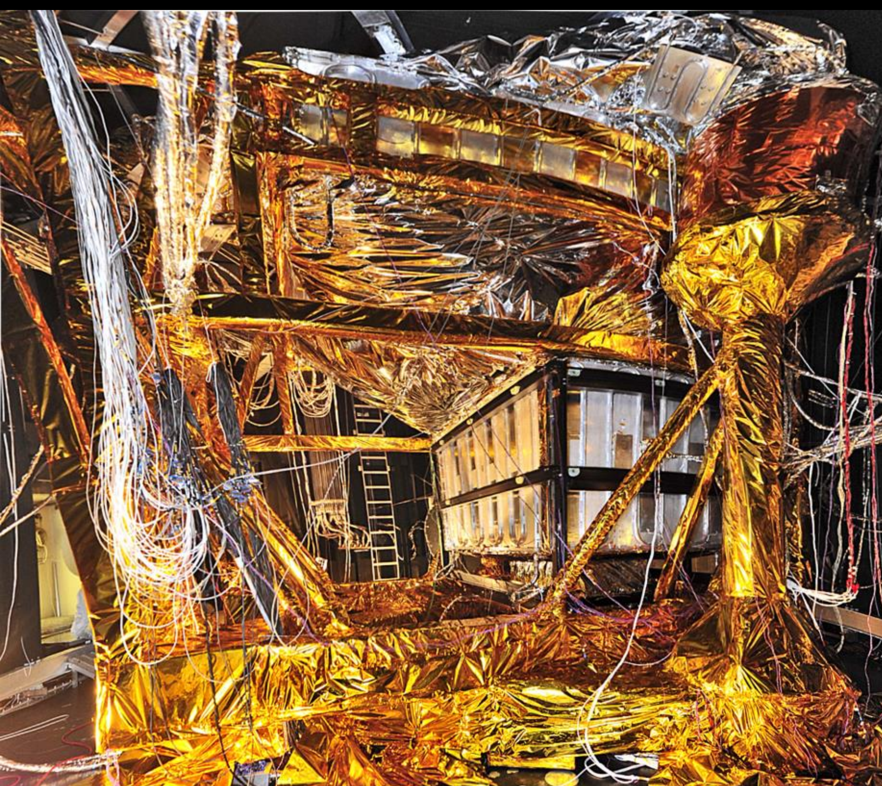
FGS can sense pointing to 1 millionth degree precision
NIRISS can image exoplanets that are too close to their star for coronagraphs

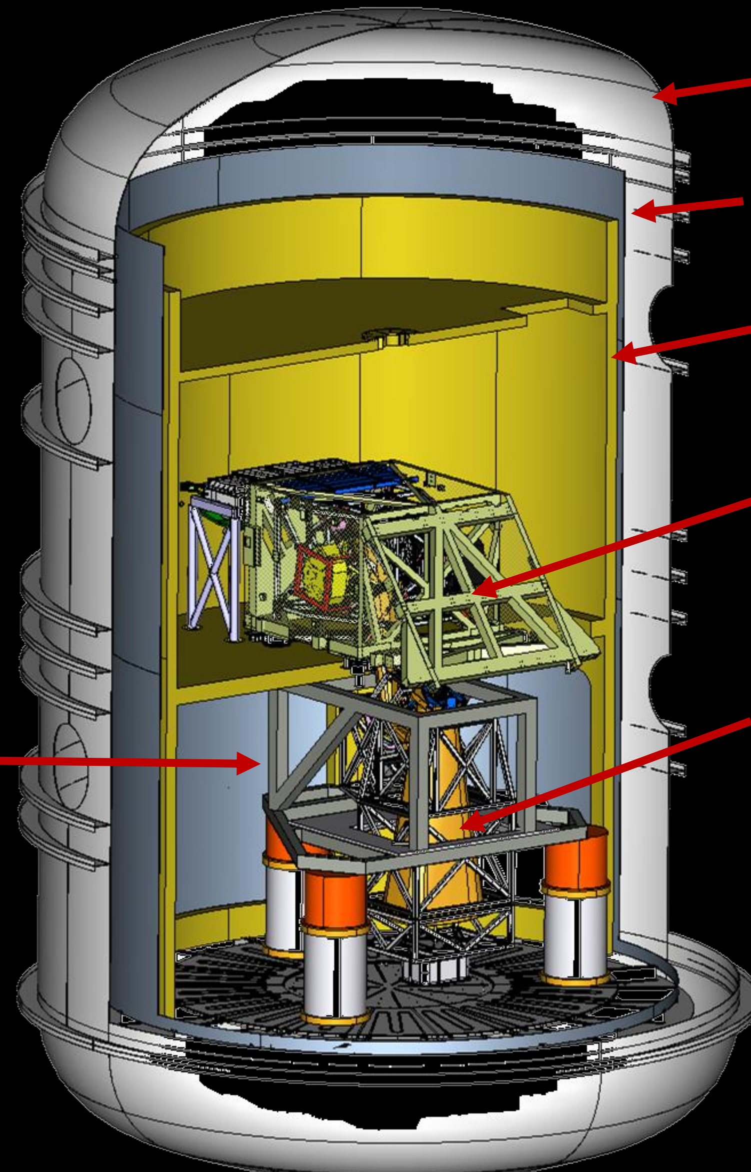
The JWST science instrument payload began construction during 2006 and is now in the final stage of testing ahead of integration with the telescope

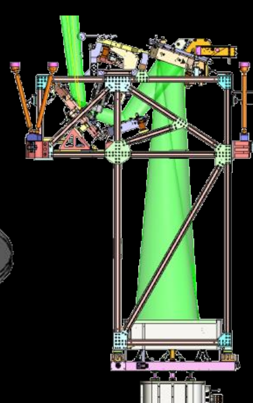


ISIM is tested in the Goddard Space Environment Simulator (SES) chamber using a cryogenic telescope simulator (OSIM)

The 3rd of 3 SES test cycles of the ISIM Will begin during October 2015







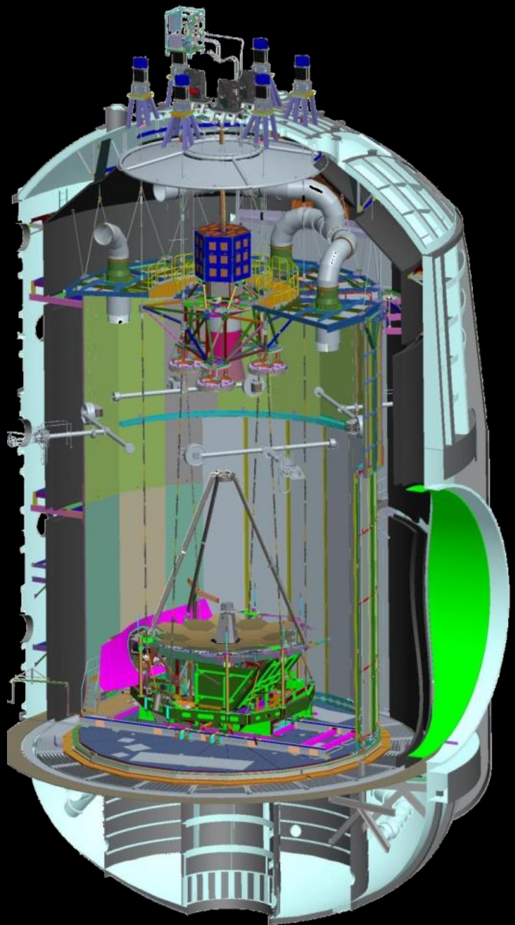
The telescope and instrument module will be integrated to each other at GSFC and will then be sent to Johnson Space Flight Center during 2016

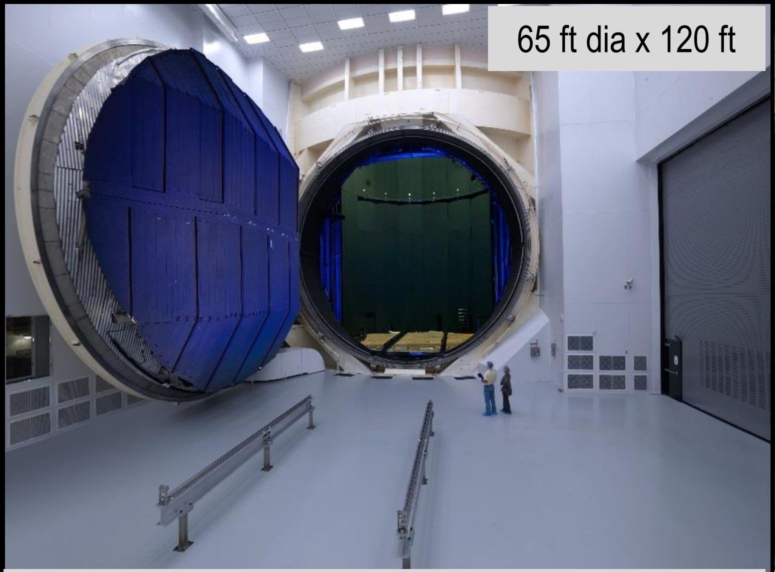
STTARS being loaded into a C5 aircraft

Space Telescope Transporter for Air Road and Sea (STTARS)

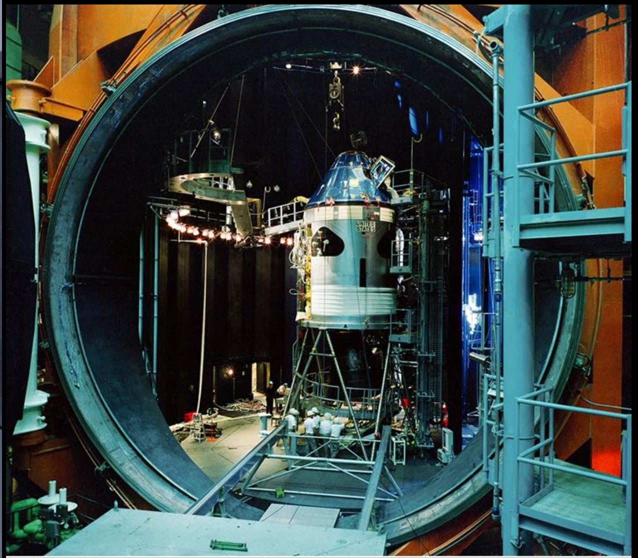
Then …. the OTE + ISIM will be tested in the largest space simulation chamber in the world

Apollo era facility extensively refurbished for JWST
Largest deep cryogenic space simulation chamber in the world
Performance certification completed during Aug 2012
13 K and 10^{-8} Torr reached during test





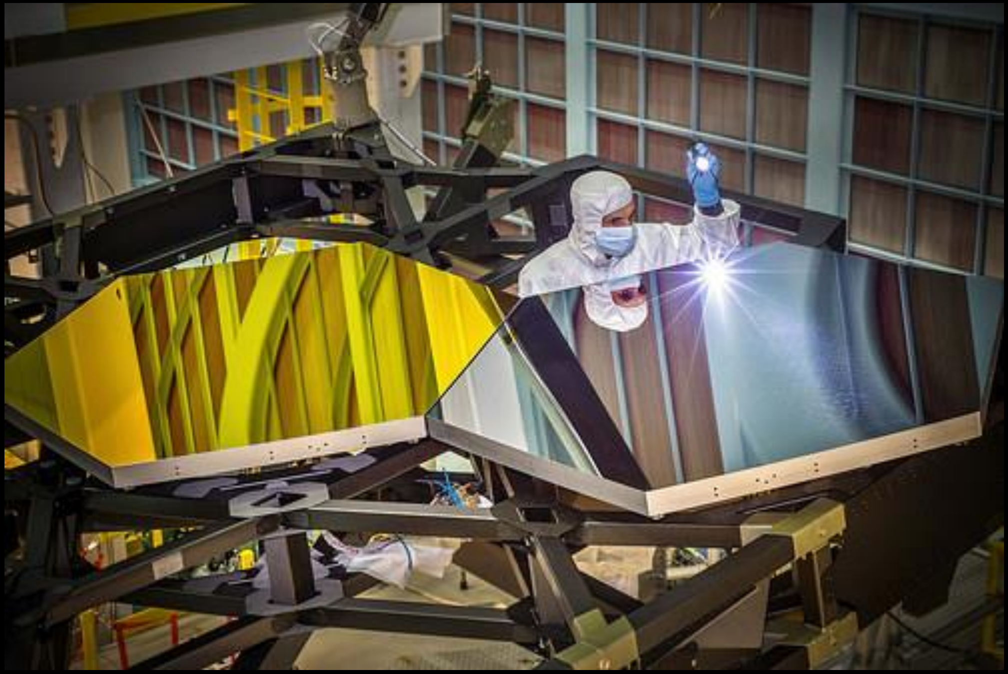
JSC Chamber A today

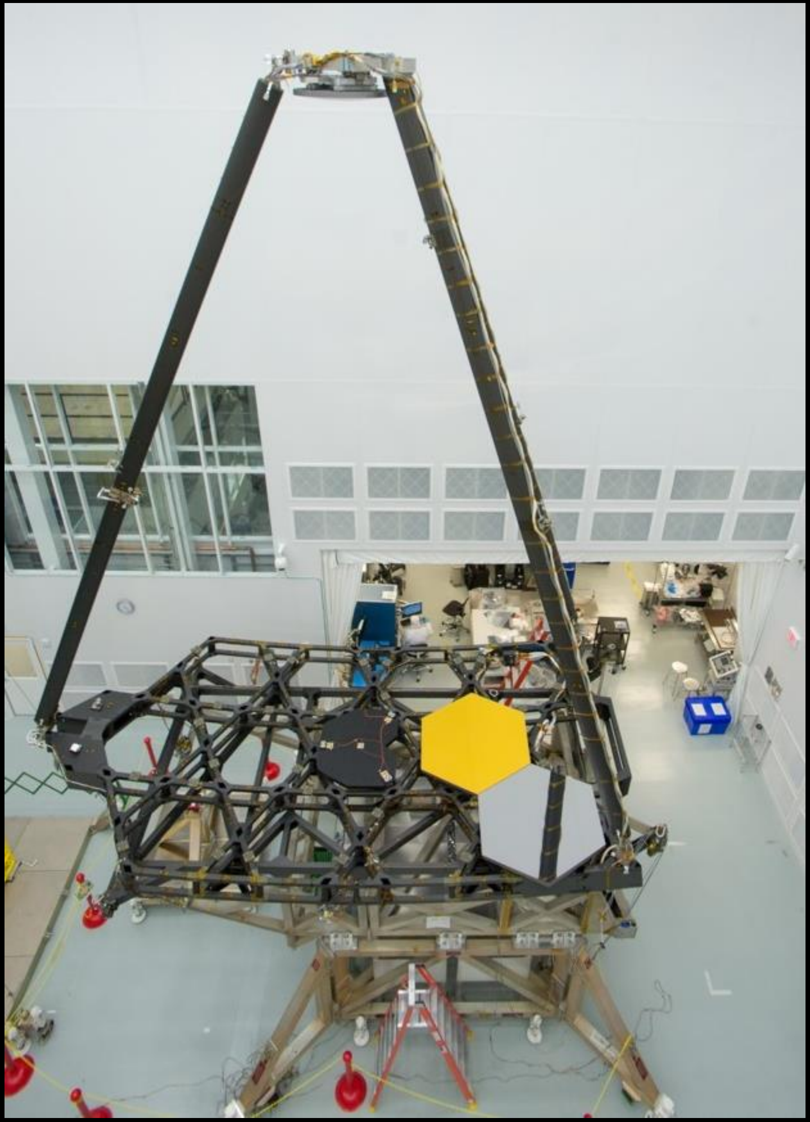


JSC Chamber A during Apollo

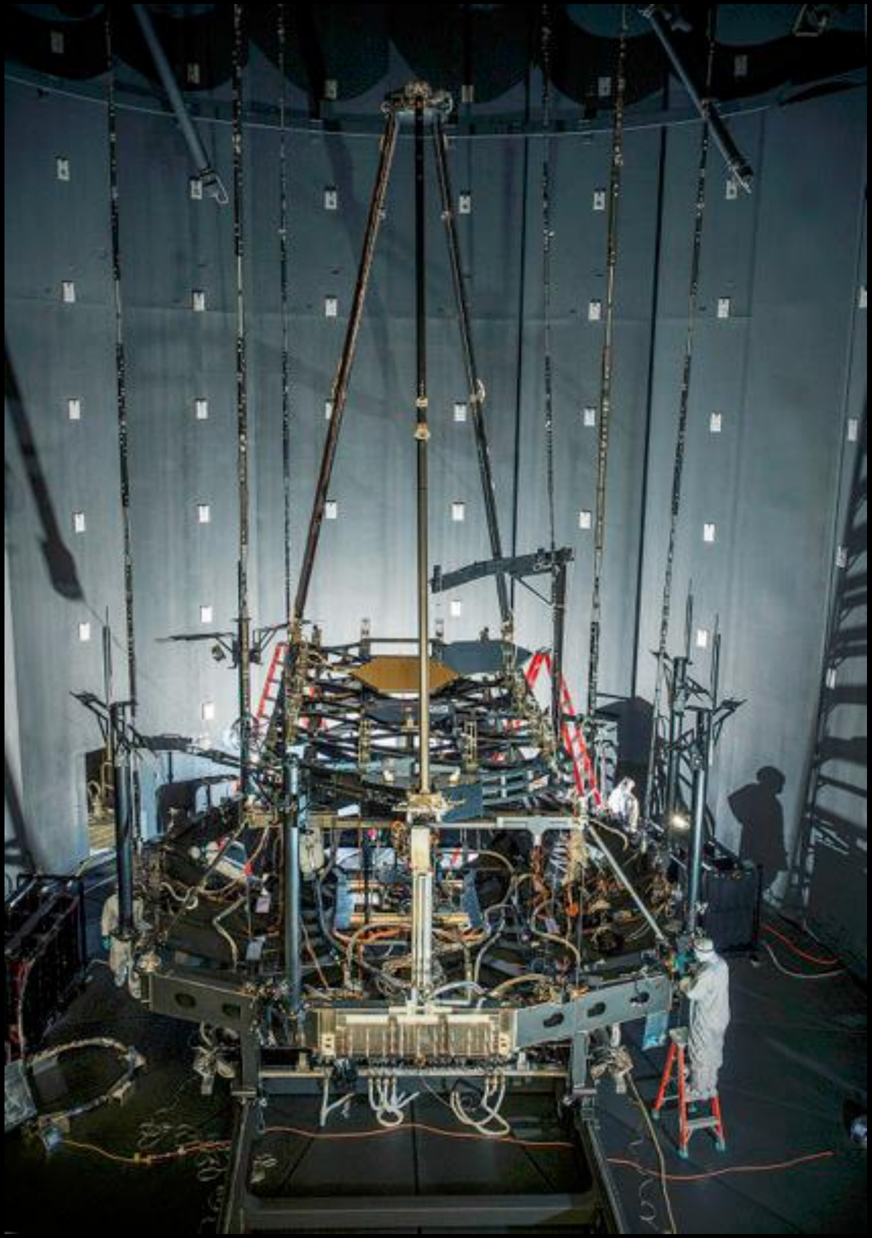
The Pathfinder telescope structure began cryogenic testing at Johnson Space Flight Center during May 2015

- The Pathfinder is flight-like in every respect expect:
  - Does not include the deployable "wings" of the backplane
  - Is populated with two flight spare mirror segments

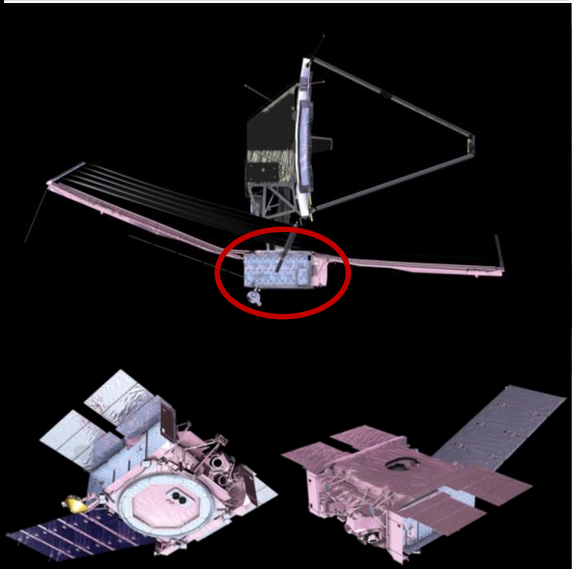




Space simulation testing of the pathfinder telescope structure began during May 2015



The telescope and instrument module will then be sent to Northrop Grumman Aerospace Systems for integration with the spacecraft bus and sunshield during 2017



Space Telescope Transporter for Air Road and Sea (STTARS)

Then … The JWST will be transported by ship through the Panama Canal to French Guiana for launch during 2018

6900 Nautical Miles
Approximately 20 days

Roll on roll off transport ship built in the Netherlands by Merwede Shipyards
Length 116m
Displacement about 4200 metric tons
Garage deck length 95m (plenty of room for STTARS)
Speed: 15 knots

Space Telescope Transporter for Air Road and Sea (STTARS)

The End (of this presentation)

But

with JWST, we will see the beginning of *everything*

The first galaxies
The origins of galactic structure
The birth of stars
The creation of planets
and more
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