WEBB – The game changer in astronomy

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CESAR Meeting

24/05/2022

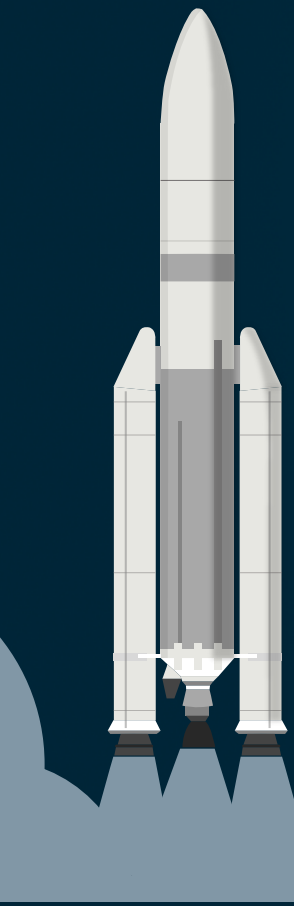
The JAMES WEBB SPACE TELESCOPE

Why James Webb?

- **James Edwin Webb** (October 7, 1906 – March 27, 1992)
  - 2nd NASA Administrator 1961 - 1968
  - Major driving force behind Apollo Program

WEBB IN A NUTSHELL

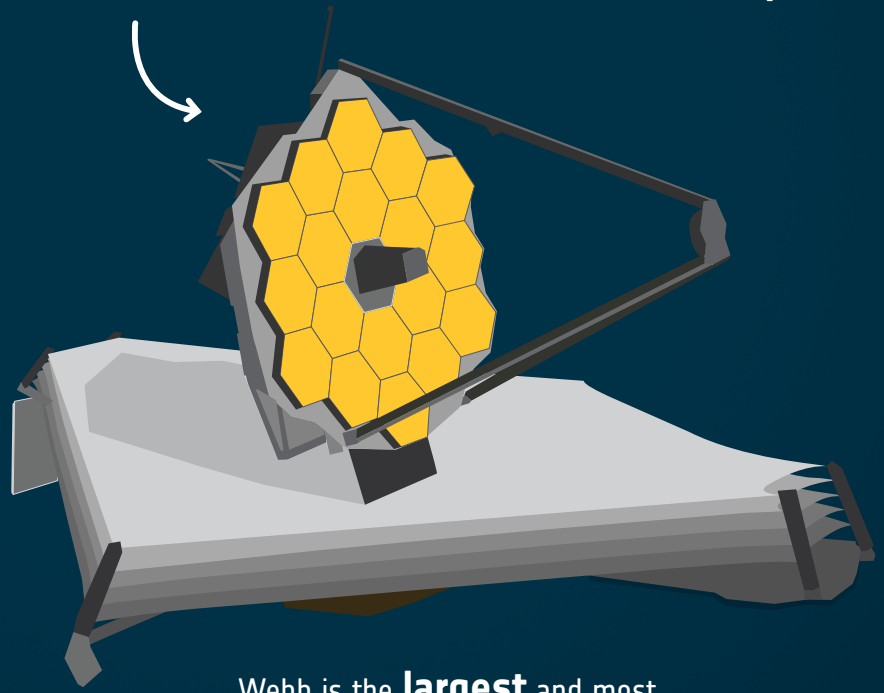
Overview of Webb and ESA's contributions to the mission.



ESA provides a team of **astronomers** and **engineers** to support **science operations**

Webb will reach space on an **Ariane 5** from **Europe's Spaceport** in French Guiana, a launch contributed by ESA

ESA contributed **two** of Webb's four **science instruments**: **NIRSpec** and 50% of **MIRI**



Webb is the **largest** and most **powerful** space telescope ever launched

Webb's partners

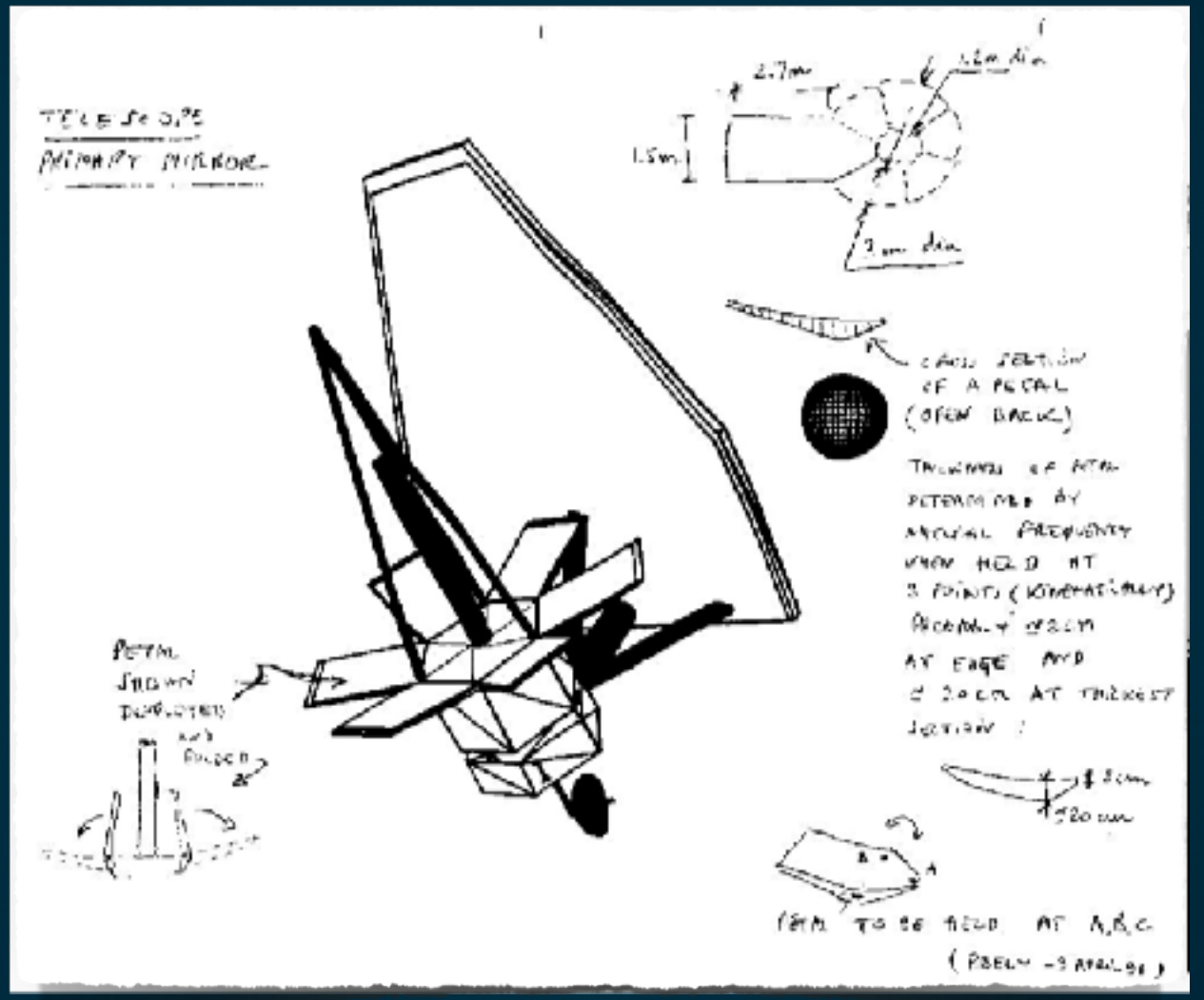
Webb observes **near-infrared** to **mid-infrared** light

Webb studies our own **Solar System** and **exoplanets** around other stars

Webb studies the birth of the **first stars** and **galaxies**

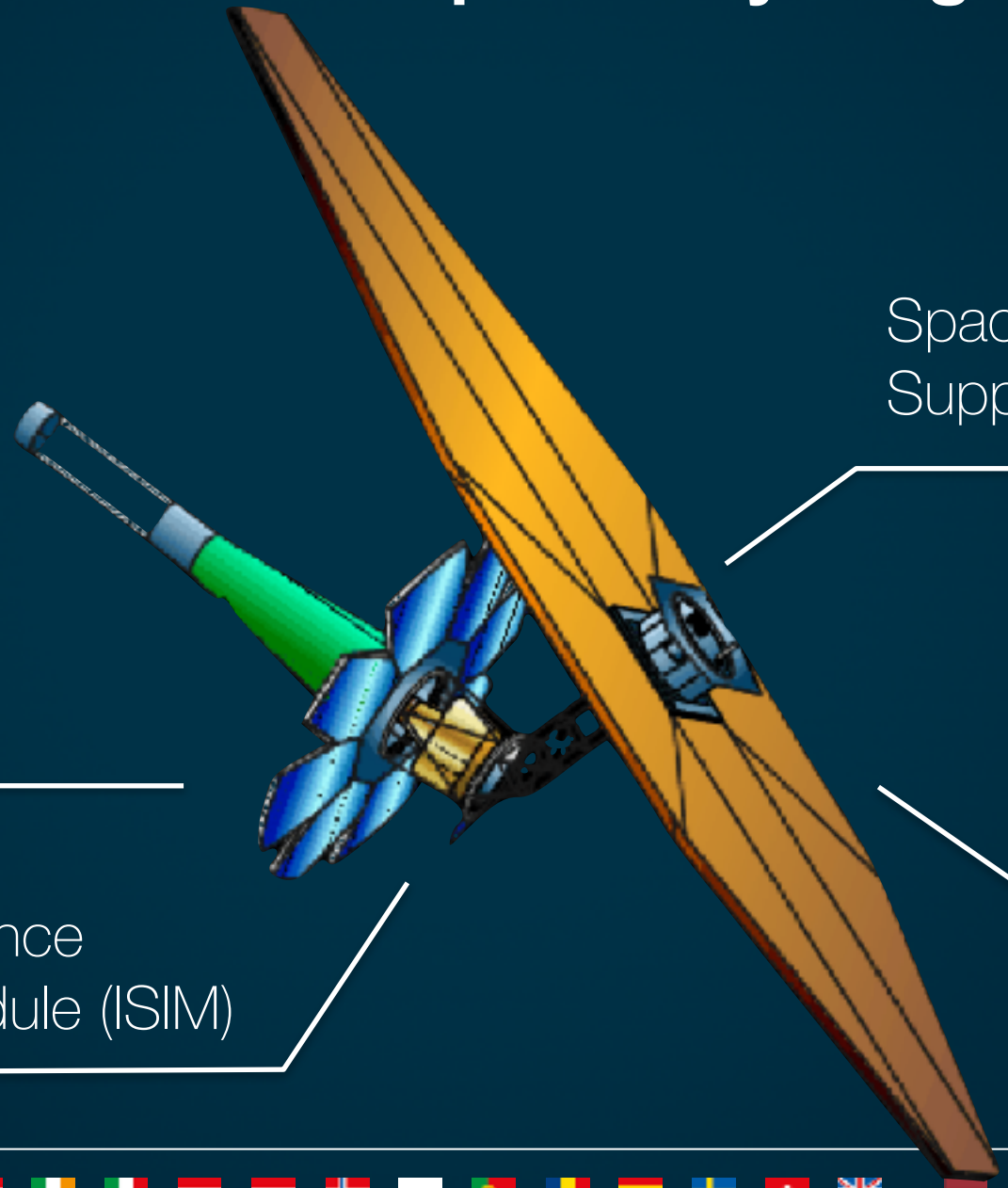
The James Webb Space Telescope - Early Stages

This is how the future begins: scribbles on a napkin



P. Bèly, GSFC, 1996

The James Webb Space Telescope - Early Stages



Secondary Mirror

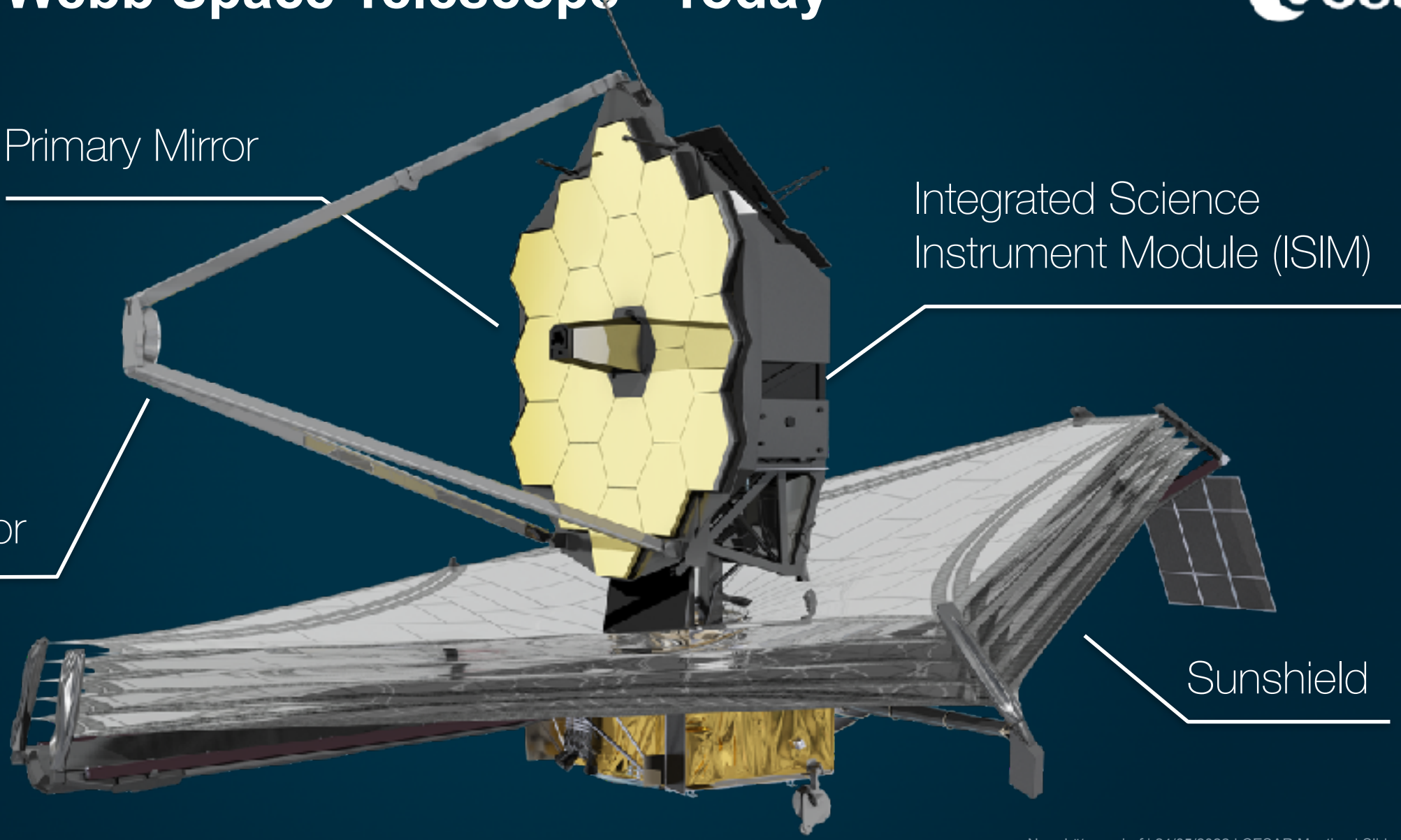
Spacecraft
Support Module

Primary Mirror

Sunshield

Integrated Science
Instrument Module (ISIM)

The James Webb Space Telescope - Today



THE JAMES WEBB SPACE TELESCOPE:
THE NEW FLAGSHIP IN SPACE EXPLORATION

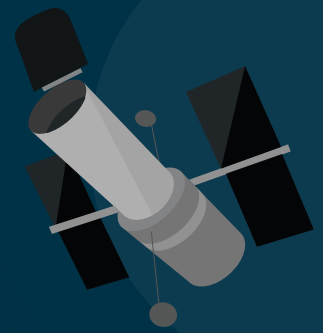
COMPARING WEBB AND HUBBLE

Webb follows the NASA/ESA Hubble Space Telescope in the line of great space observatories. Both space observatories have different capabilities and will operate in parallel, complementing each other.

HUBBLE

570 km

Primary mirror
2.4 m



Young galaxies

12.5 billion years ago

wavelengths

ultraviolet visible parts of near-infrared

Serviceable

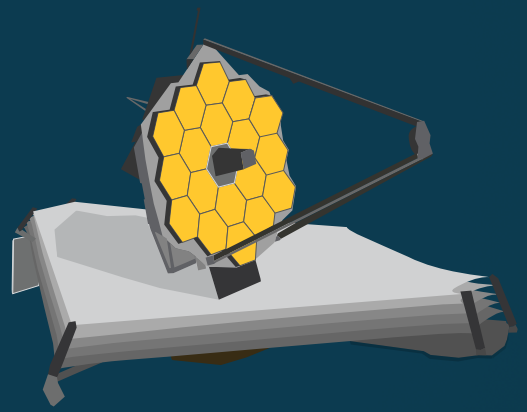
WEBB

1.5 million km

Second Sun-Earth Lagrange point

Primary mirror
6.5 m

18
mirror segments



13.5 billion years ago

Newborn galaxies

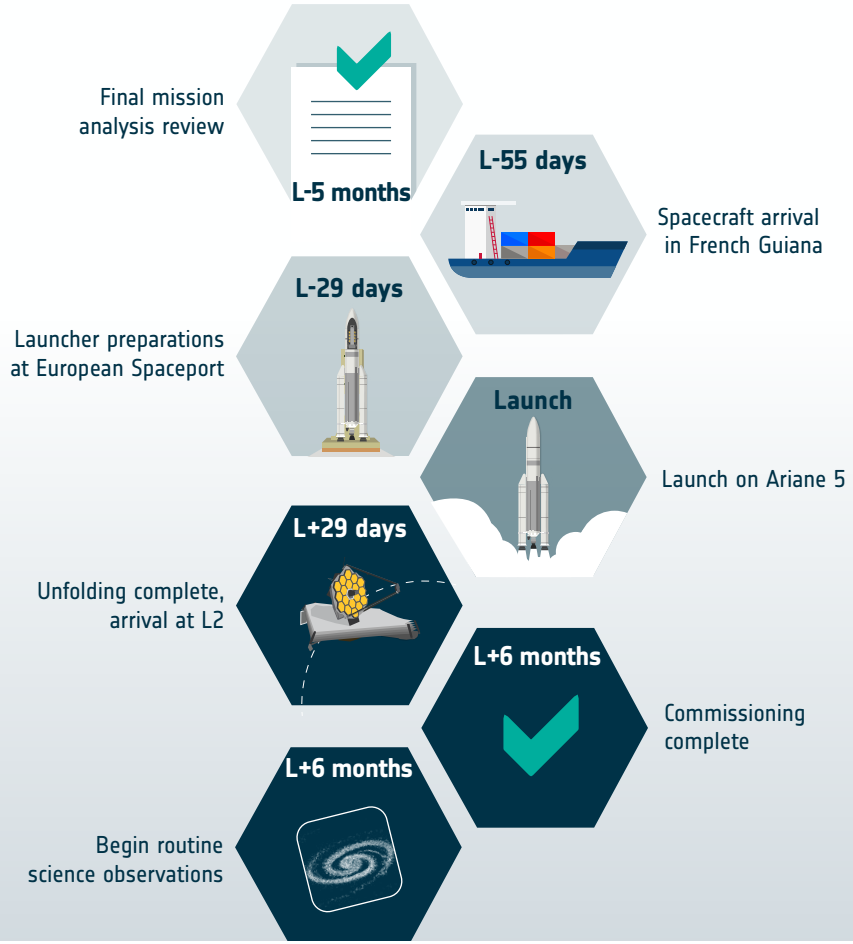
wavelengths

near-infrared mid-infrared

Not serviceable

WEBB MISSION MILESTONES

The following list gives the main Webb mission milestones anticipated in the coming year. Dates are approximate and more information will be provided via ESA's website (esa.int) and social media channels (@ESA_Webb) once details are confirmed.



HOW TO FOLLOW

ESA Web TV: esawebtv.esa.int

Information for general public: esa.int/webb
In-depth information: sci.esa.int/jwst

EuropeanSpaceAgency

@europeanspaceagency

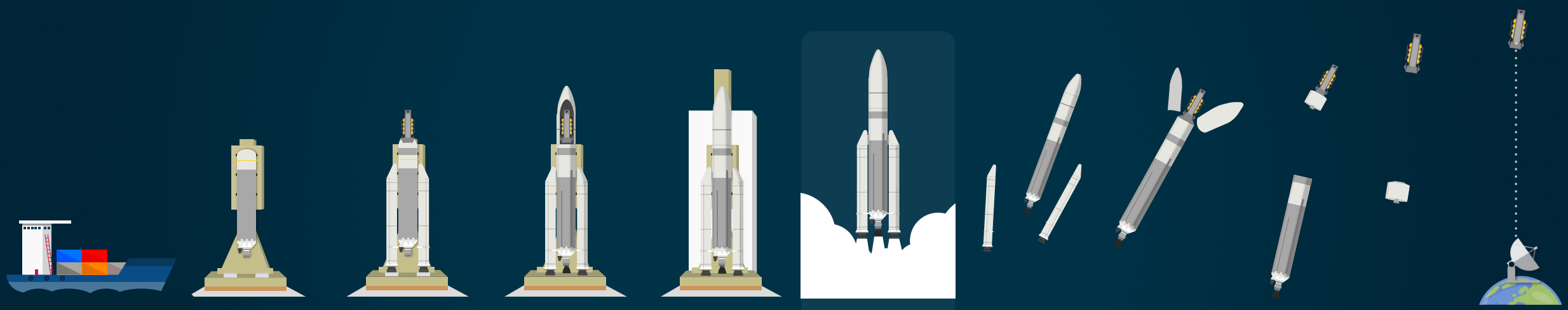
esa

@esa
@ESA_Webb
@esascience
@ariane5

Hashtags: #Webb #UnfoldTheUniverse #WebbSeesFarther #WebbFliesAriane #WorldWideWebb #WebbAtHome

LAUNCH TIMELINE AT EUROPE'S SPACEPORT

ASSEMBLY AND INTEGRATION — **LAUNCH** — **EN ROUTE TO L2**



-55 days
Webb arriving at Pariacabo harbour

-29 days
Main stage positioned on launch table

-7 days
Webb placed on Ariane 5

-6 days
Webb encapsulated in the fairing

-1 day
Ariane 5 rolls out to launch pad

Launch
From Europe's Spaceport in French Guiana

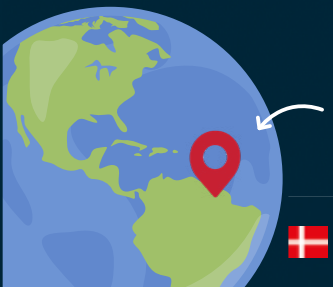
+2 min
Booster separation

+3 min
Fairing separation

+9 min
Main stage separation

+27 min
Spacecraft separation

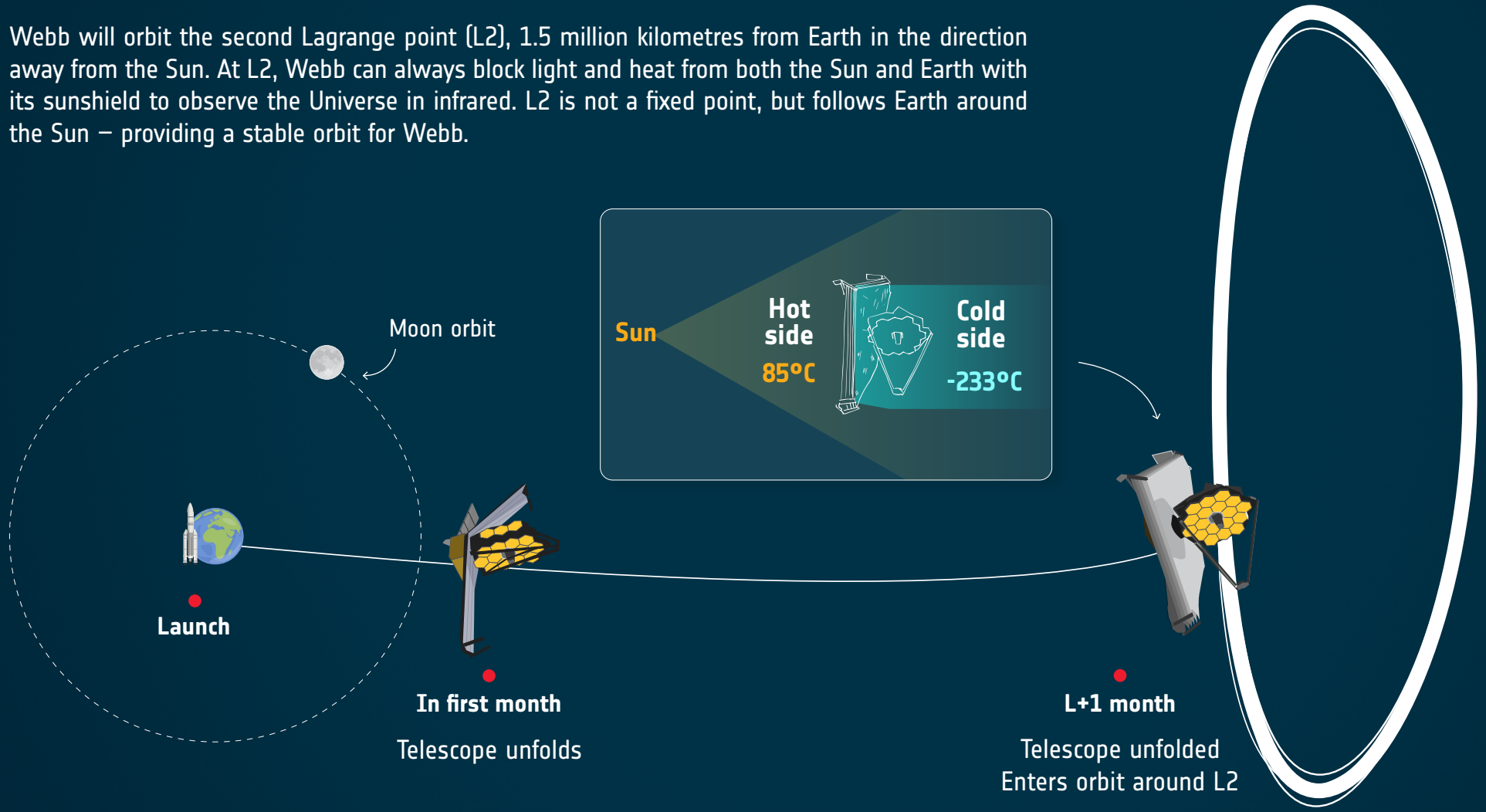
+30 min
ESA tracks Webb in early orbit phase



Europe's Spaceport in French Guiana

WEBB'S JOURNEY TO L2

Webb will orbit the second Lagrange point (L2), 1.5 million kilometres from Earth in the direction away from the Sun. At L2, Webb can always block light and heat from both the Sun and Earth with its sunshield to observe the Universe in infrared. L2 is not a fixed point, but follows Earth around the Sun – providing a stable orbit for Webb.



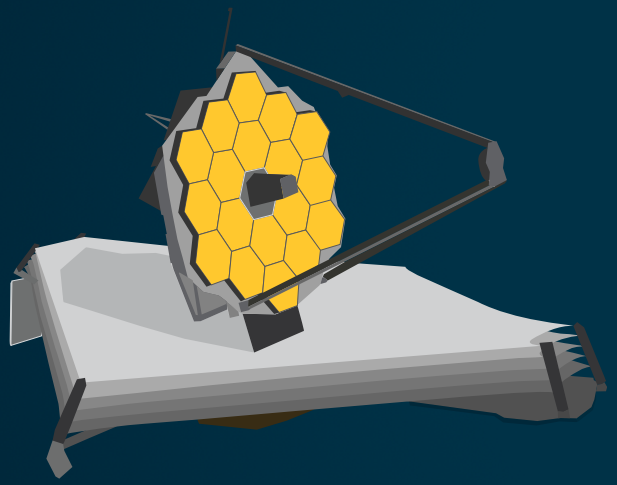
WEBB AND ARIANE 5: A FIT MADE PERFECT

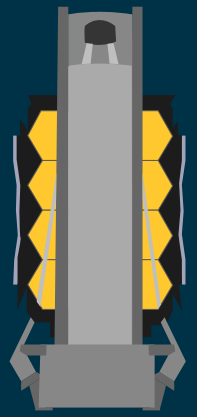
ESA is flying Webb on an Ariane 5 rocket, which has been customised for this extraordinary telescope.

Webb

Height
8 m

5-layered sunshield
21.2 x 14.2 m

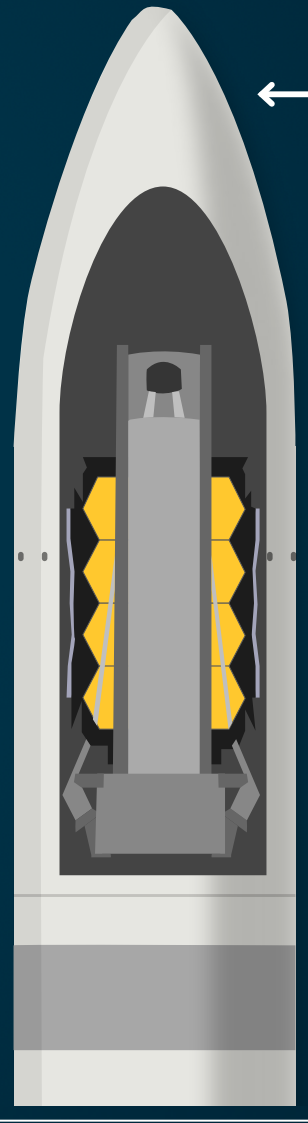




Folded Webb

Height
10.66 m

Width
4.5 m

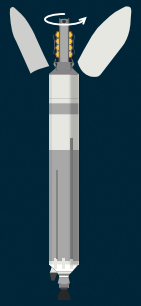


← Fairing

Height
17 m

Diameter
5.4 m

28 venting ports
allow depressurisation during launch sequence



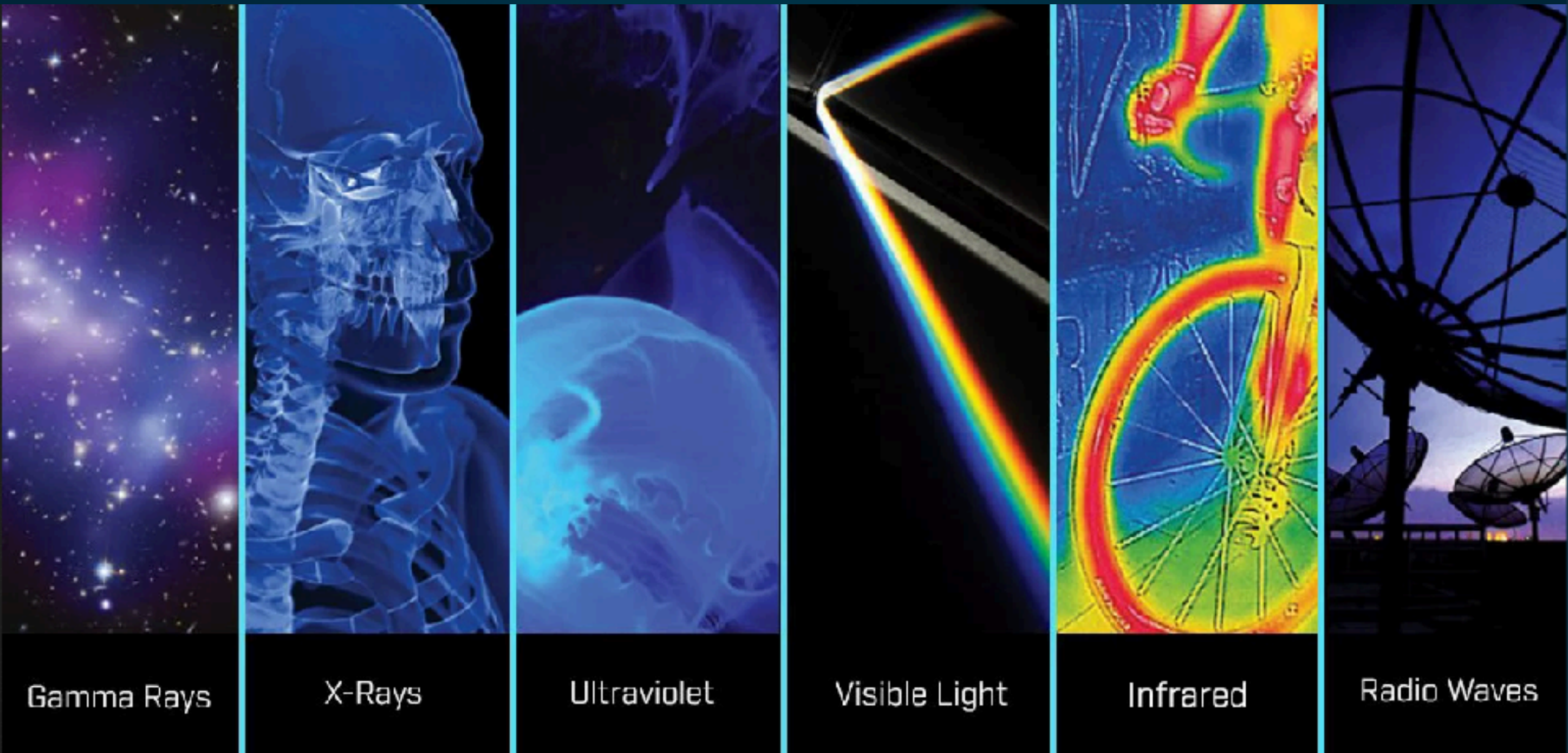
Oscillating
rolling manoeuvre to protect Webb from solar radiation after fairing separation

INFRARED ASTRONOMY

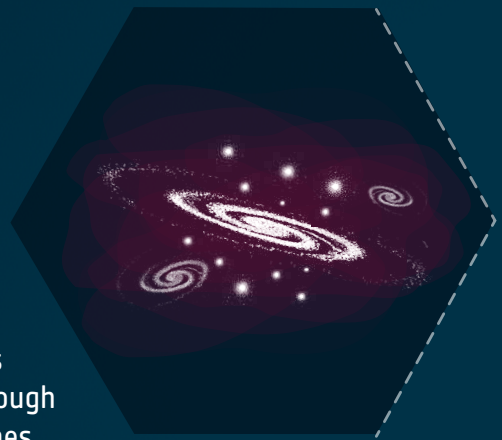
WHAT IS INFRARED?

	Radio	Microwave	Infrared	Visible	Ultraviolet	X-ray	Gamma ray
Penetrates Earth's Atmosphere?	YES	NO	YES	NO			
Wavelength (m)	10^{3}	10^{-2}	10^{-5}	0.5×10^{-6}	10^{-8}	10^{-10}	10^{-12}
Approximate Scale of Wavelength	Buildings	Humans	Butterflies	NeedlePoint	Protozoans	Molecules	Atoms	Atomic Nuclei
Frequency (Hz)	10^{4}	10^{8}	10^{12}	10^{15}	10^{16}	10^{18}	10^{20}	
Temperature of objects at which the radiation is the most intense wavelength emitted	1 K -272 °C	100 K -173 °C	10,000 K 9,727 °C	10,000,000 K -10,000,000 °C			

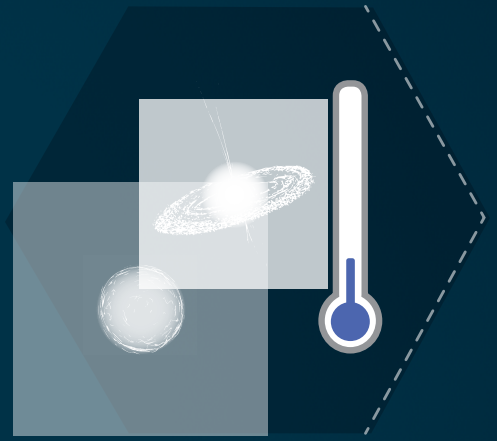
What is infrared?



WHY STUDY THE UNIVERSE IN INFRARED?



Near-infrared light reveals the formation of galaxies, and peers through the dust layers that enshroud new born stars



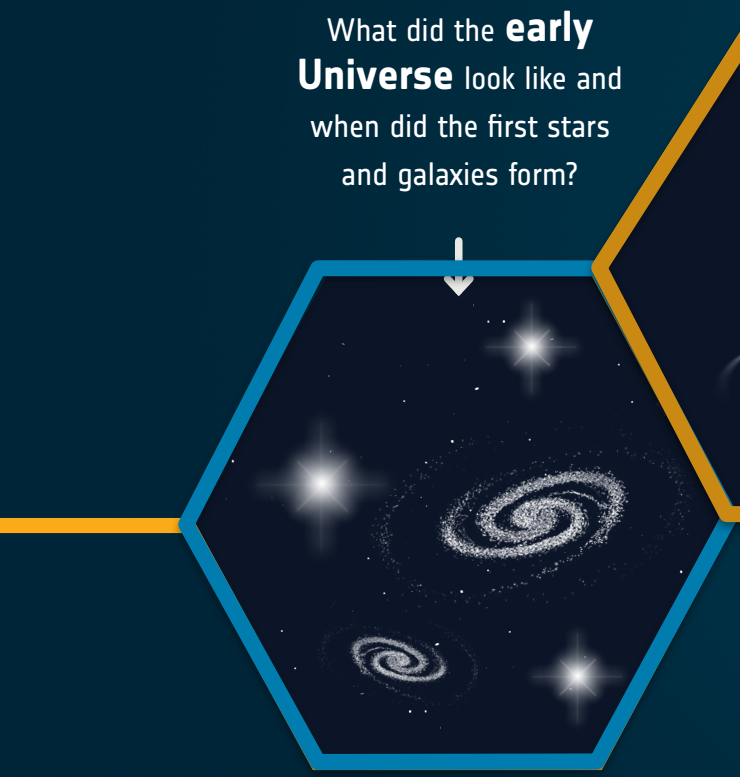
Mid-infrared light peers through the cold dusty regions where stars form, and reveals how massive stars and black holes shape their surroundings

The light of galaxies that are billions of light-years away travels to us through space that is expanding. This stretches the light's wavelength into the infrared allowing Webb to see far back in time

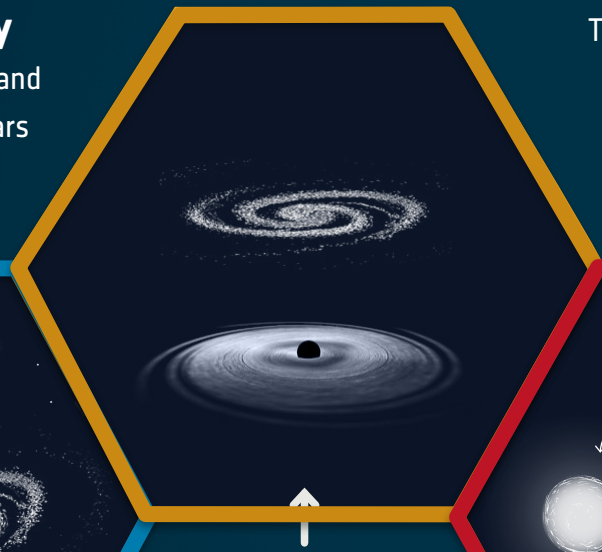
WEBB SCIENCE

Webb is designed to answer outstanding questions about the Universe and to make breakthrough discoveries in all fields of astronomy.

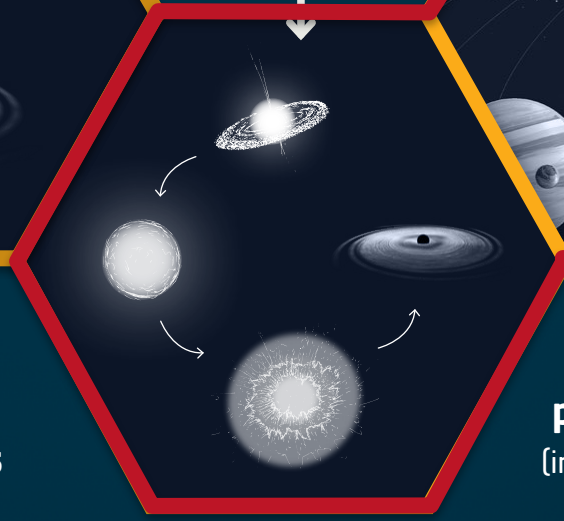
What did the **early Universe** look like and when did the first stars and galaxies form?



Understanding how **galaxies and black holes** form and evolve

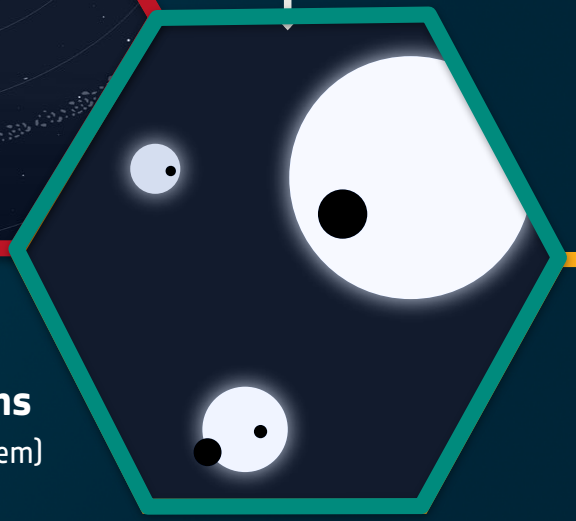


The lifecycle of **stars**: from their birth to their death



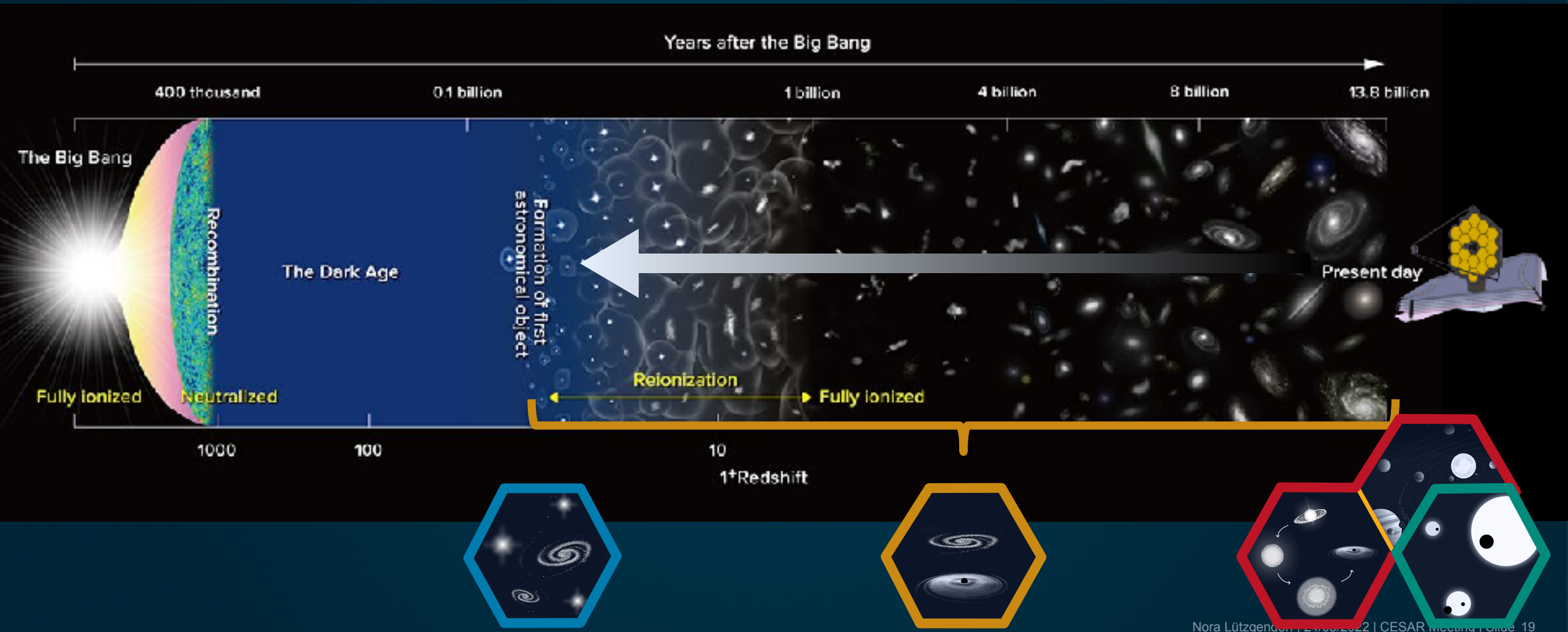
Investigating how **planetary systems** (including our Solar System) form and evolve

Studying **exoplanets, their atmospheres,** and the building blocks of life that they might contain

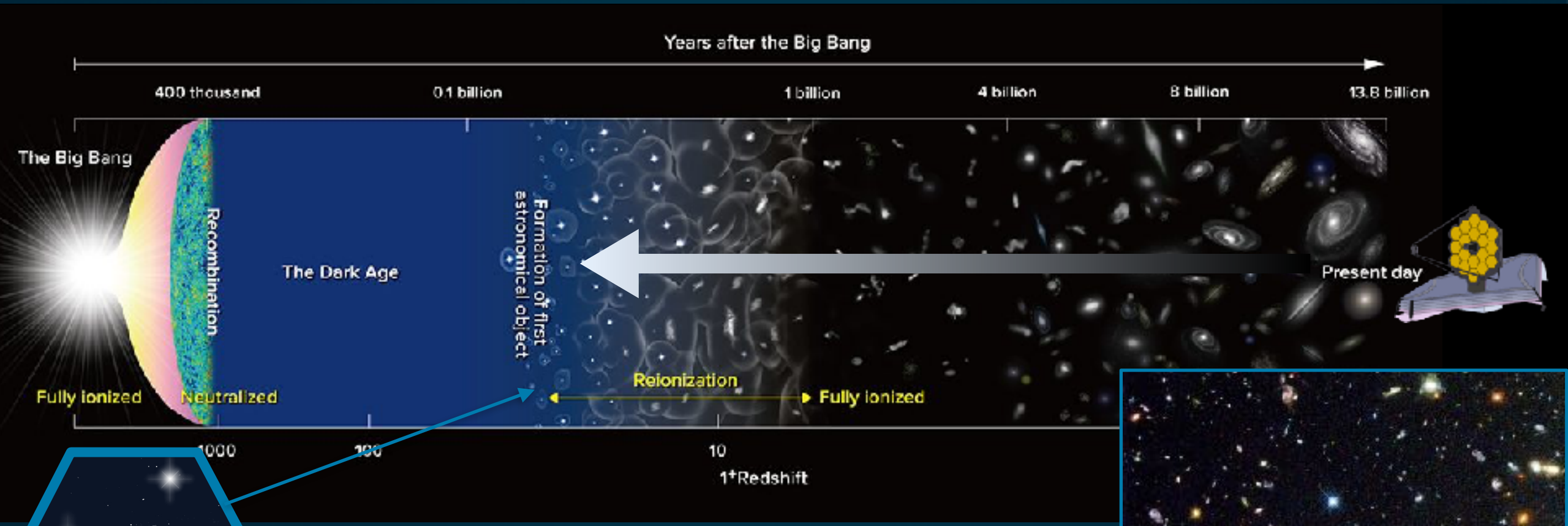


Four major research areas of JWST

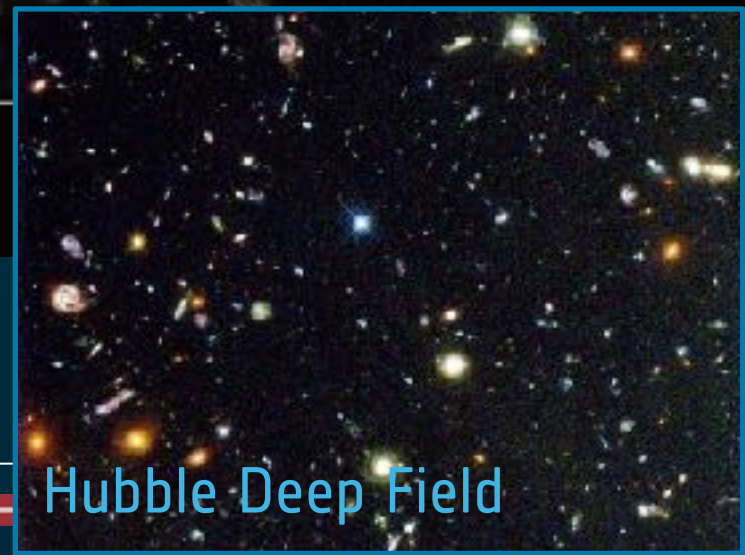
Imaging and spectroscopic exploration probing our universe



First light and reionization



FIRST LIGHT

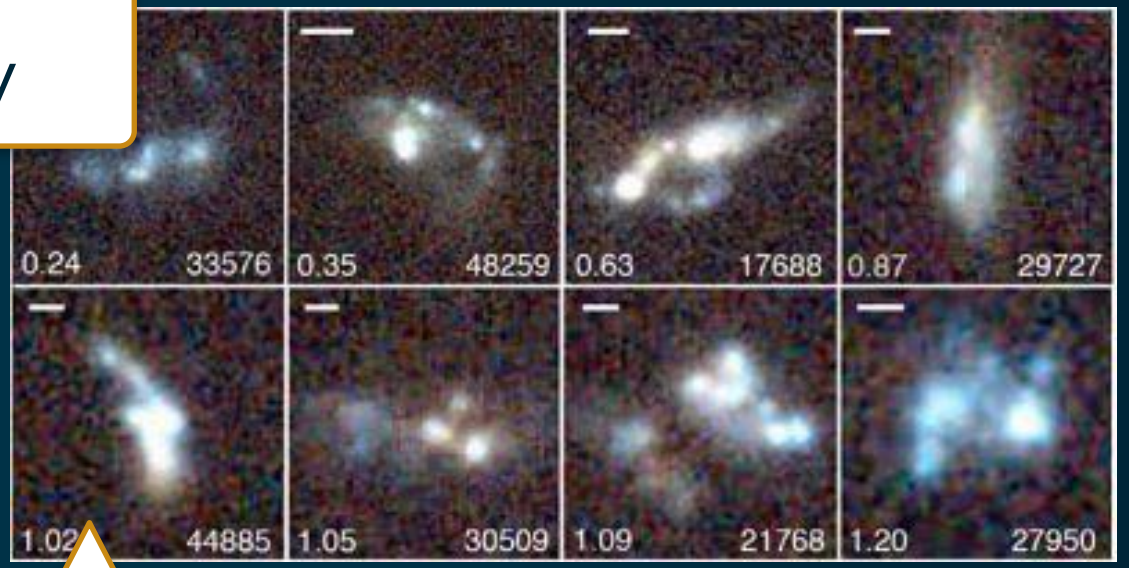


Assembly of Galaxies

Giant Elliptical Galaxy

Giant Spiral Galaxy

Galaxies interact with each other. They even merge.



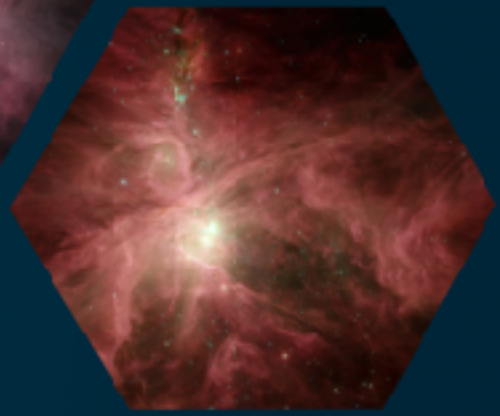
Galaxies looked very different in the past. Very clumpy and irregular.

FORMATION OF STARS AND PLANETS

Mid-infrared light peers through the cold dusty regions where stars form.

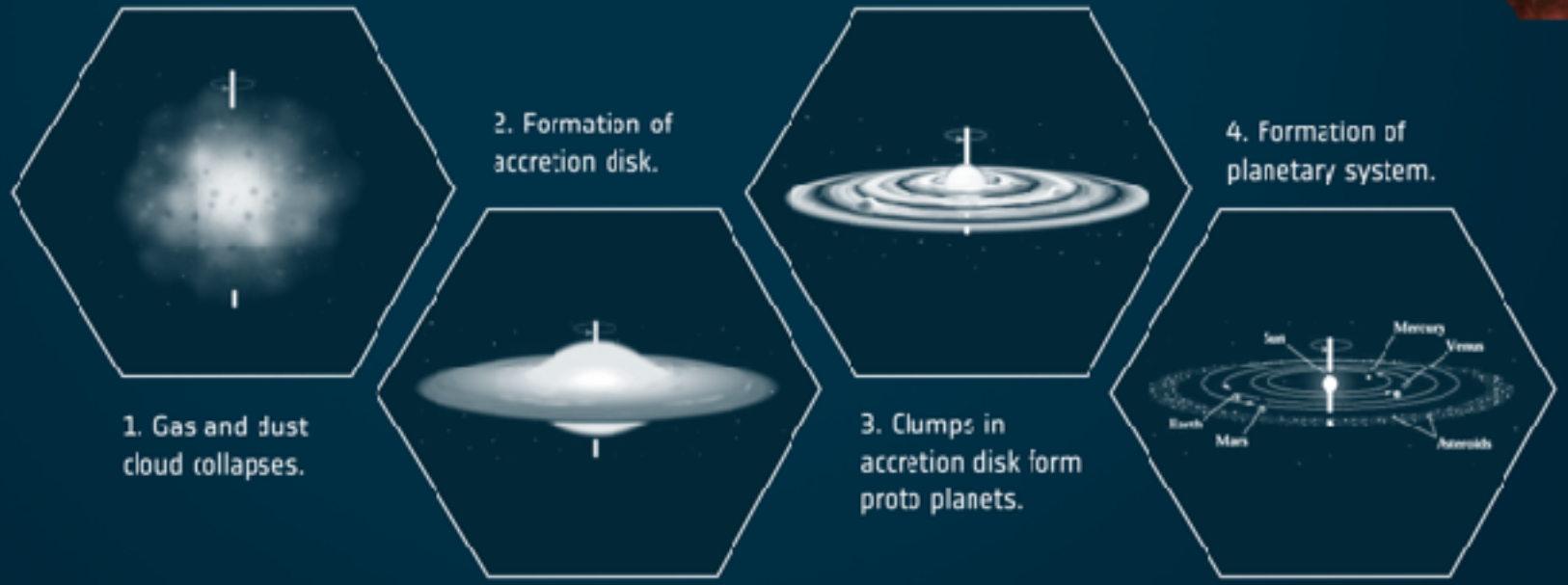
Visible Light

Infrared



Orion Nebula
Star Formation Area

Planet Formation



PLANETS AND THE ORIGING OF LIFE

Starlight
Filters through the planet's sodium-rich atmosphere

Spectrum
Atoms and molecules stamp their unique properties as fingerprints on the spectrum

Planet
in front of a star

Webb's instruments
Light is split into its different wavelengths and focused onto a detector, forming a spectrum

Spectra detectives
Scientists study spectra to analyse what atoms and molecules are present in the source. Spectra also reveal the temperature, density and motion of the objects

PLANETS

JWST'S INSTRUMENTS AND CAPABILITIES

WEBB'S SCIENCE INSTRUMENTS

Mid-InfraRed Instrument (MIRI)

−266°C

Extra refrigerator: **cryocooler**

Observes **cold, distant objects** in mid-infrared

Spectroscopy mapping

Near-Infrared Spectrograph (NIRSpec)

Temperature, mass, chemical composition of objects

Spectroscopy mapping

Can capture spectra of **200 objects** simultaneously

Near-Infrared Camera (NIRCam)

Farthest objects ever in **near-infrared**

Light from **first stars and galaxies**

Critical role in telescope alignment

Near-InfraRed Imager and Slitless Spectrograph (NIRISS)

Temperature, mass, chemical composition of objects

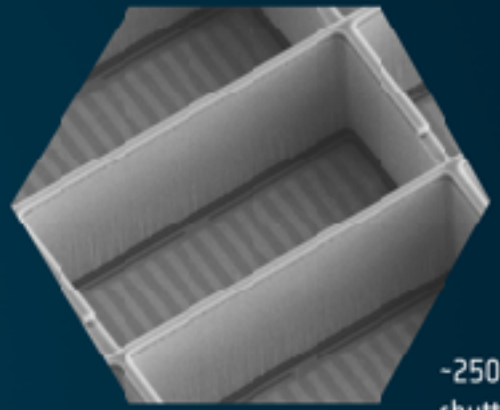
Molecules in exoplanet atmospheres

High precision pointing

THE NEAR-INFRARED SPECTROGRAPH (NIRSPEC)

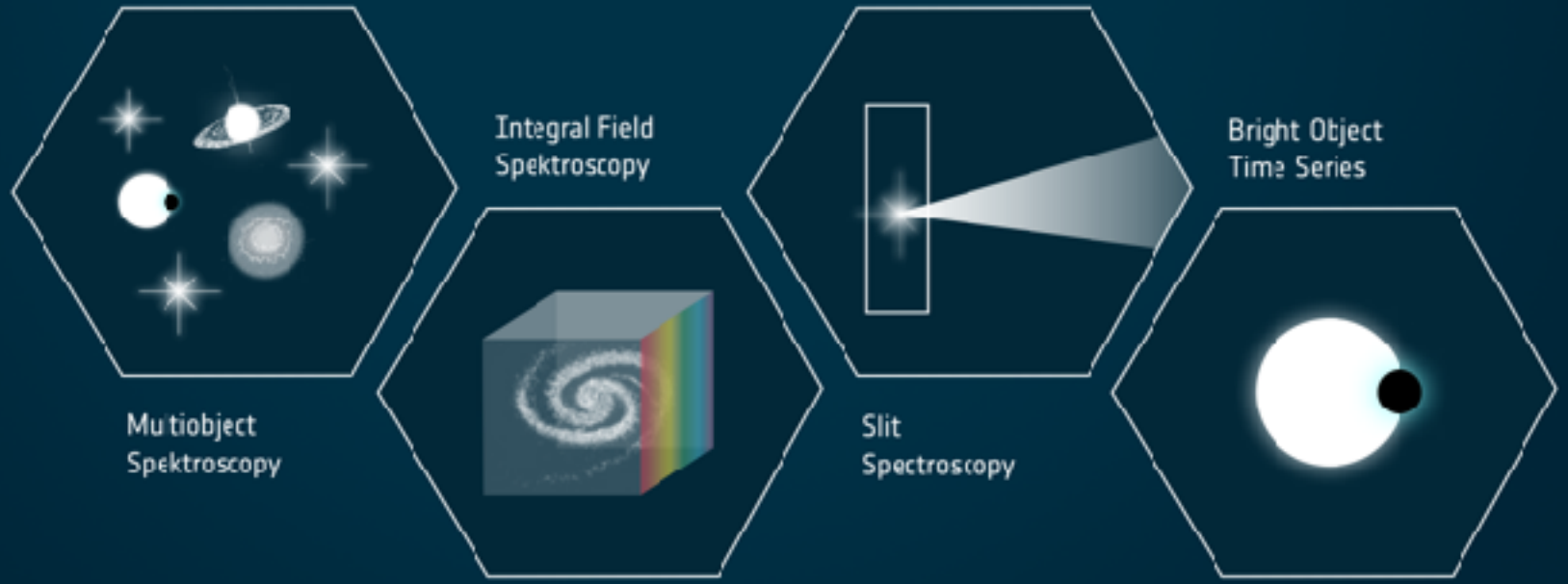
NIRSpec was built for ESA
by a consortium of European industrial
companies led by Airbus Defence & Space,
with contributions from NASA

Micro Shutters



~250 000 micro-shutters that can be opened and closed individually.

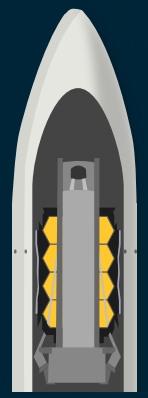
Observation Modes



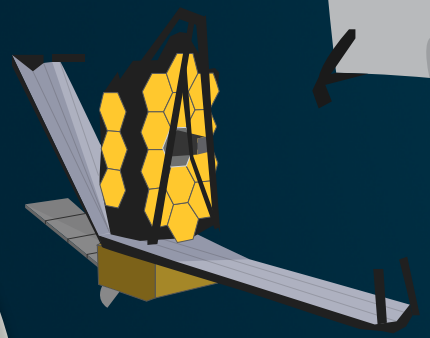
WHAT HAPPENED SINCE LAUNCH?

WEBB UNFOLDING SEQUENCE

Webb is so big that it has to fold origami-style to fit in the Ariane 5 rocket and it will unfold like a 'transformer' in space. This graphic shows a few key steps of the unfolding sequence, which is a complex process that Webb will go through in its month-long journey to L2.



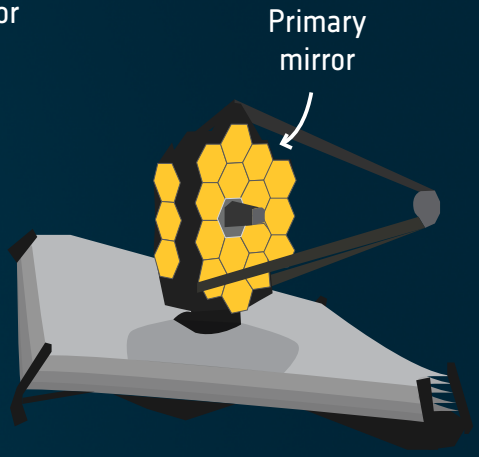
Deployment of the two structures protecting the folded sunshield



Lateral deployment of the sunshield

Tensioning and separation of the five sunshield insulation layers

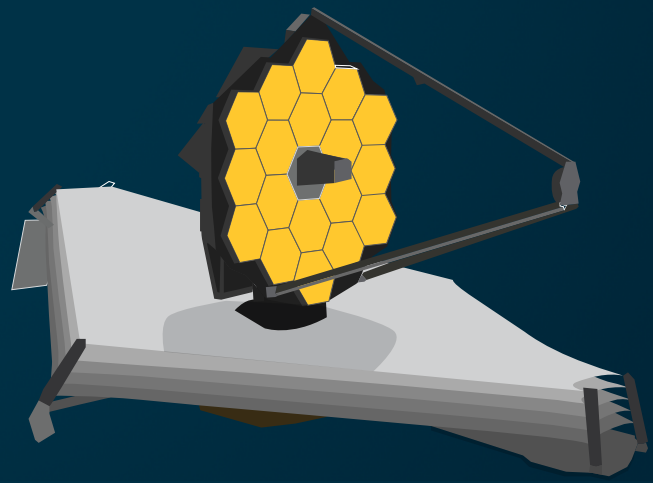
Unfolding of the secondary mirror support structure

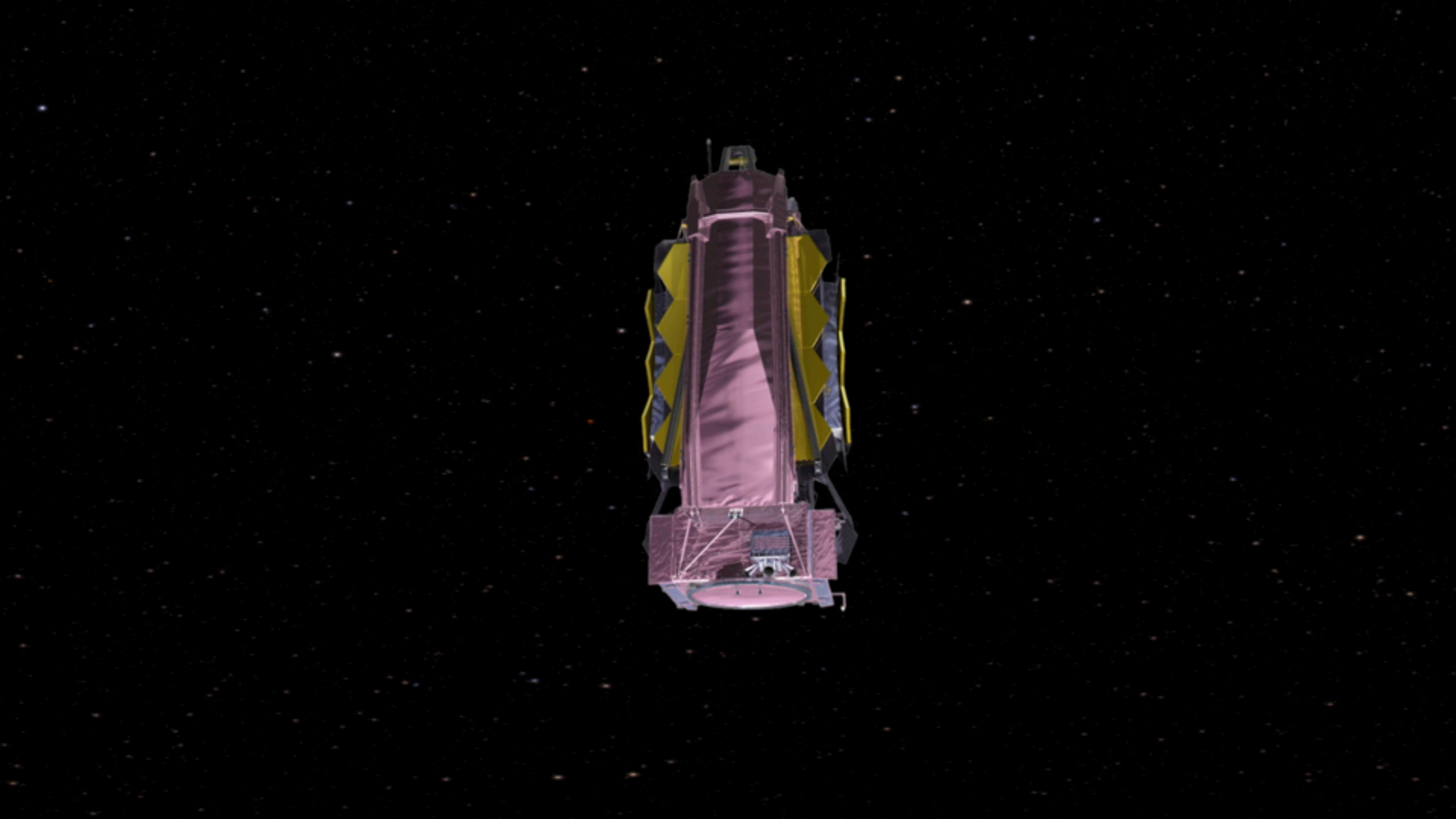


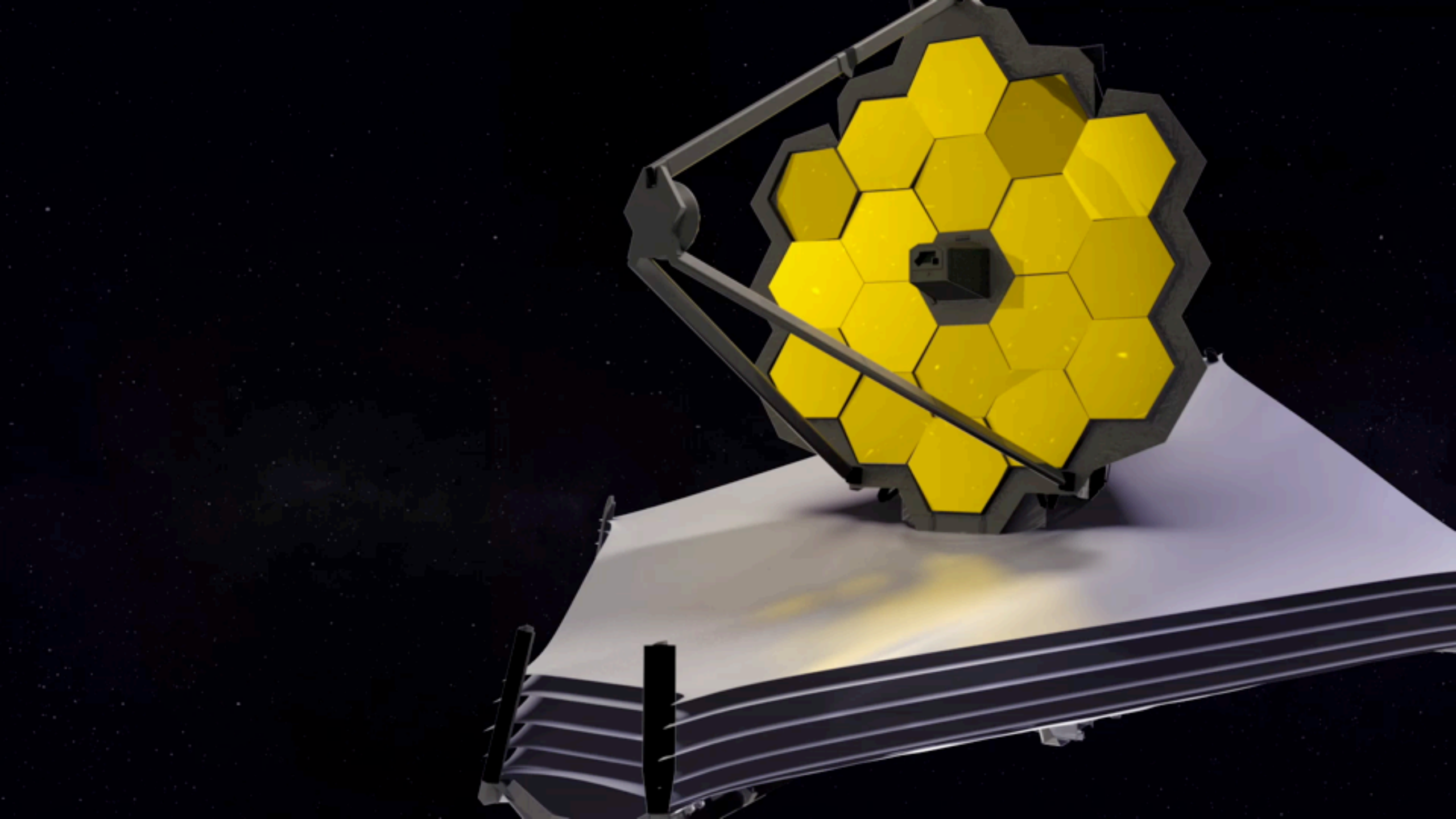
Deployment of the two primary mirror lateral wings

L+1 month

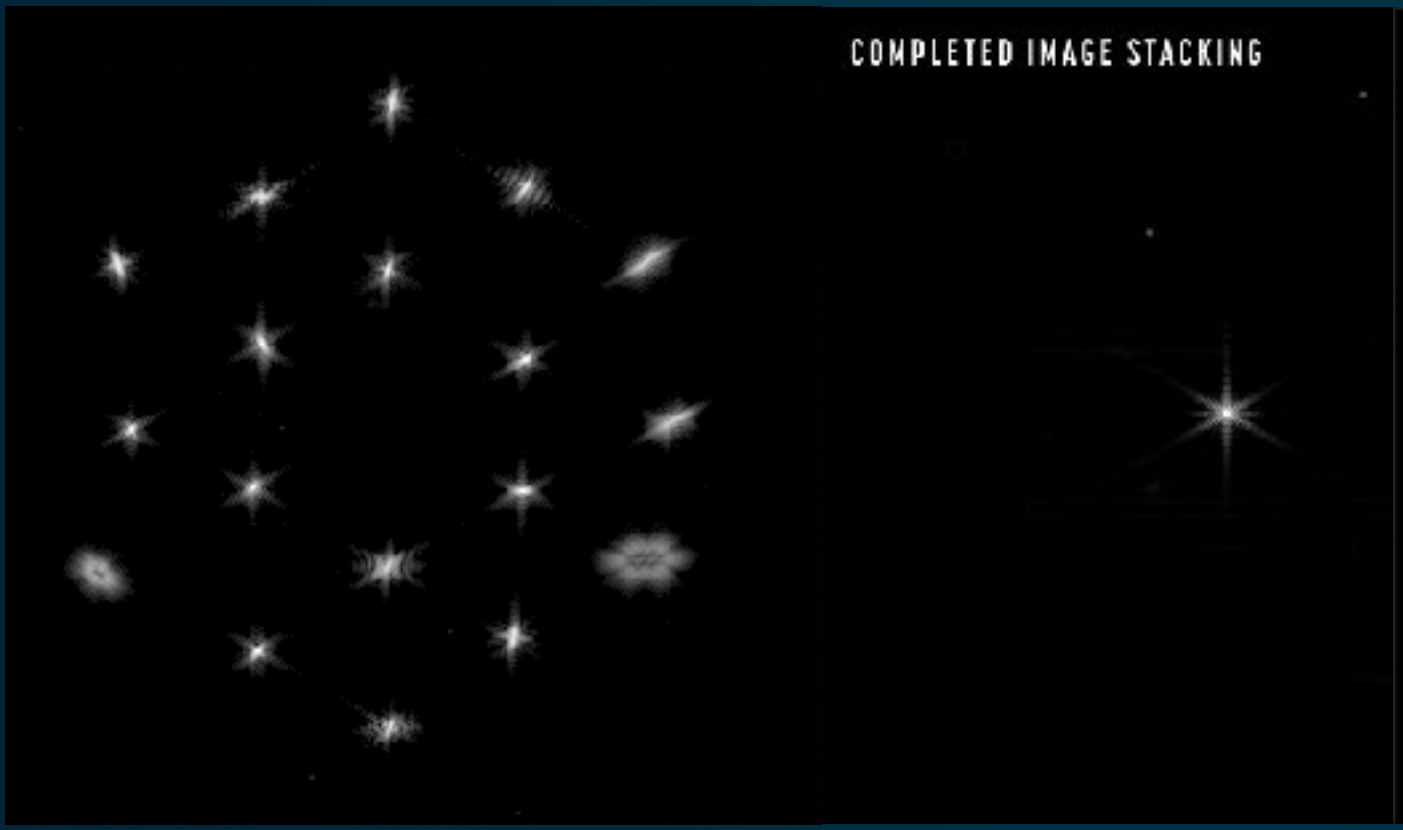
Webb telescope unfolded



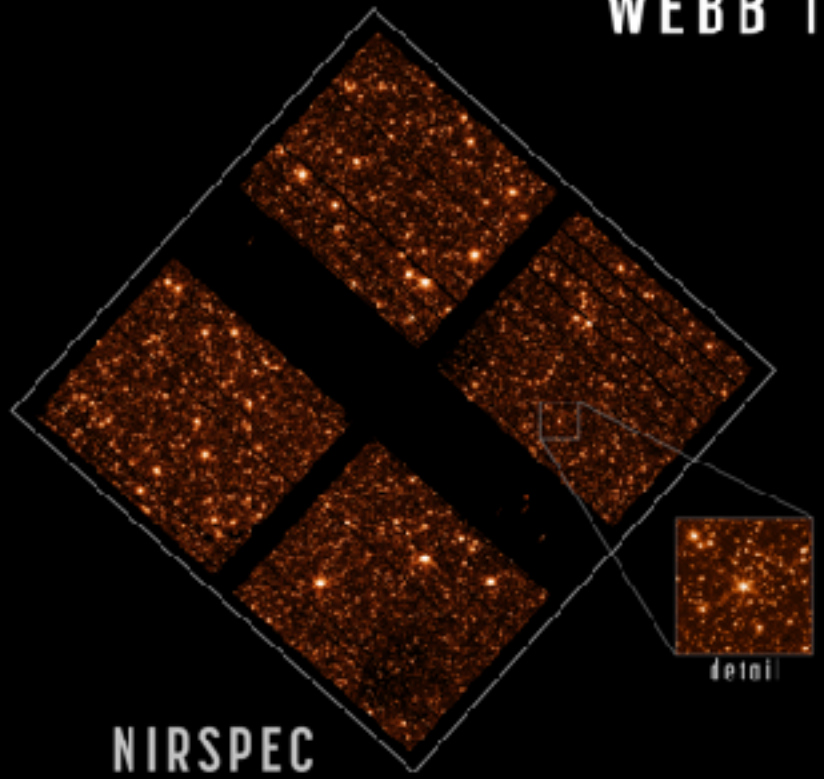




Mirror Alignement

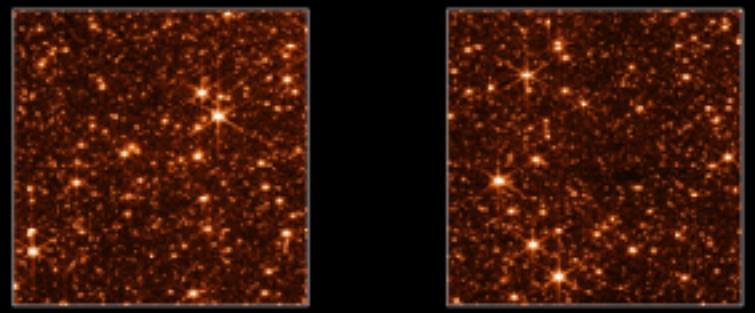


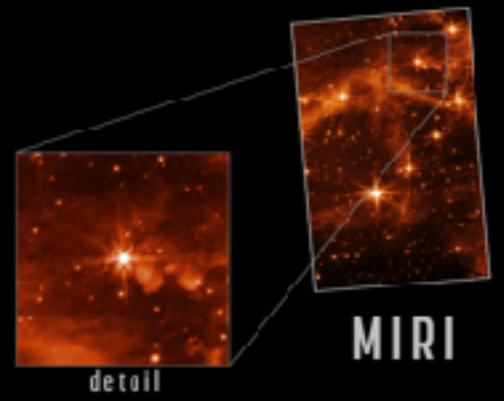
WEBB TELESCOPE IMAGE SHARPNESS CHECK



NIRSPEC

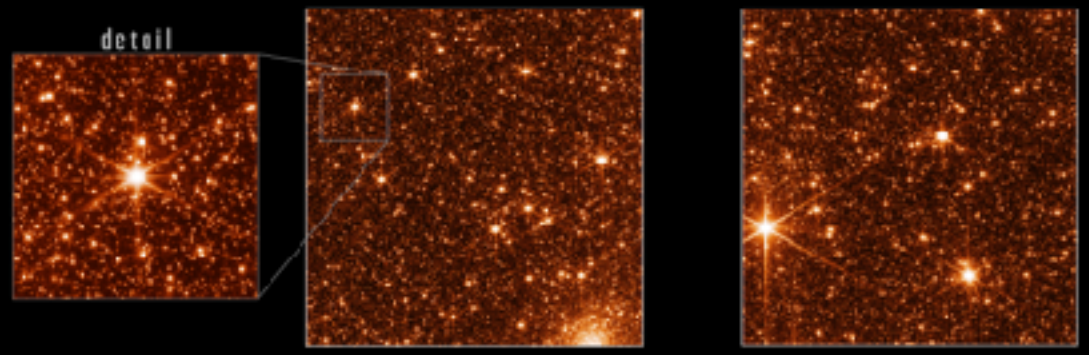
NIRCAM



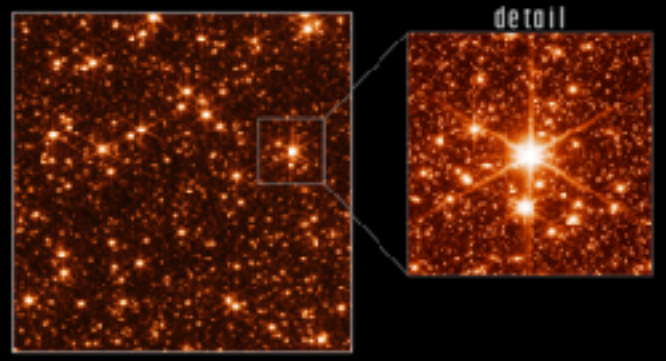


MIRI

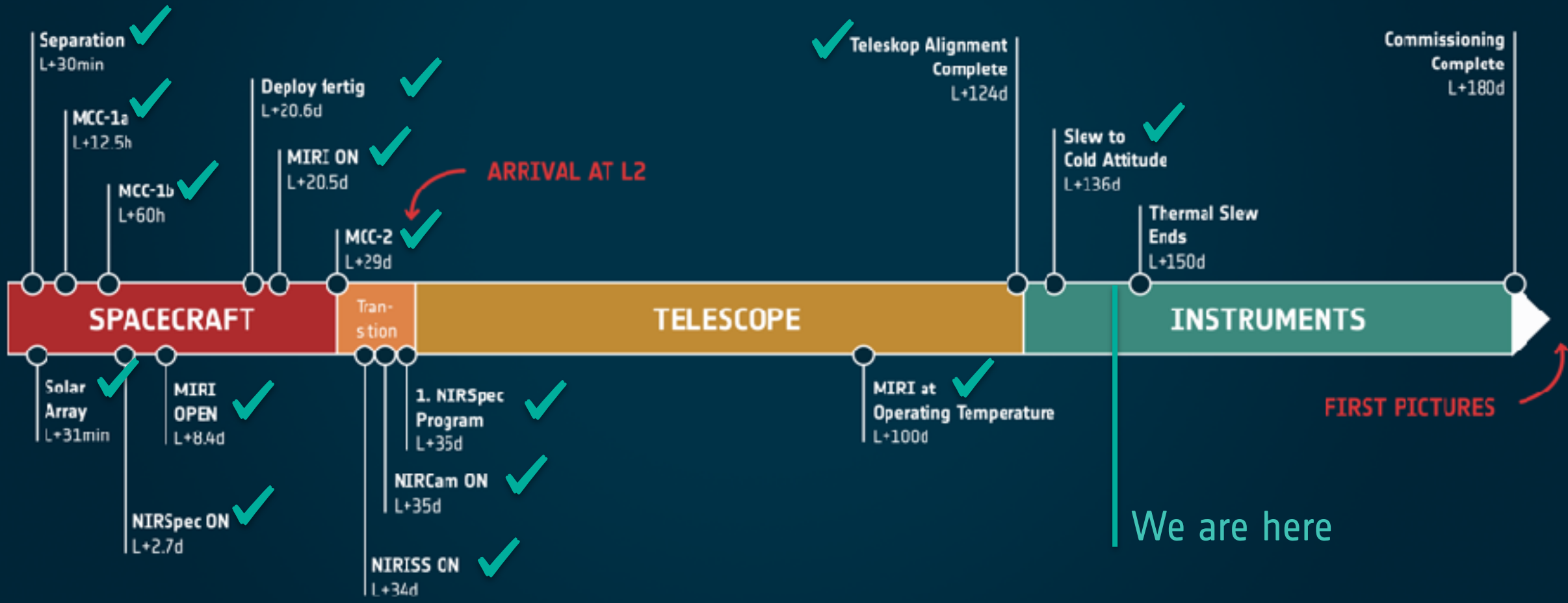
FINE GUIDANCE SENSOR



NIRISS



COMMISSIONING



Where is Webb? NASA/Webb

https://webb.nasa.gov/content/webbLaunch/whereIsWebb.html

JWST LISA Private fos.jwst.nasa.gov/ Pulse Connect Secu... Family - Google Drive Amazon Your Repositories ADS Facebook Twitter GTranslate Instagram The New York Time... LEO Nora Lützgendorf

JAMES WEBB SPACE TELESCOPE
GODDARD SPACE FLIGHT CENTER

WHERE IS WEBB? | About This Page | English <> Metric

https://webb.nasa.gov/content/webbLaunch/whereIsWebb.html
https://blogs.nasa.gov/webb/

Latest News: Blog: Webb's 17 Instrument Modes | Teleconference: Replay from 5/9/22

122F 323K a
56F 286K b
Hot Side

-384F 42K c
-393F 37K d
Cold Side

-449F 06K 1
-390F 39K 2
-395F 36K 3
MIR / NIRCam / NirSpec

-390F 39K 4
-402F 32K 5
FGS-NIRISS / FSM

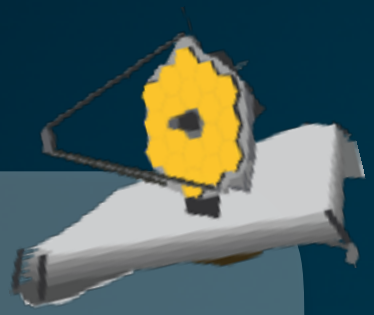
New Weekly
Temperature Plots | Plots Help | About Temps

TOP

For the last 6 months…

… I was home at the MOC (Mission Operation Center)!

Summary



WEBB

- 6.5m mirror, 18 segments
- Sunshield size of tennis court
- 1.5 million km from earth
- Near and Mid-infrared instruments
- Launch: Dec 25 2021

SCIENCE

1. First Light and Reionisation
2. Assembly of Galaxies
3. Birth of Stars and Protoplanetary Systems
4. Planets and Origin of Life

➡ Everything else not imagined yet...

COMMISSIONING

- L+20d: Deployment
- L+30d: Arrival to L2
- L+124d: Mirrors Adjusted
- L+180d: Commissioning end, **first images!**

Critical Phases are already done! We are almost ready.