CHALLENGES OF JAMES WEBB SPACE TELESCOPE ON ARIANE 5

EUCASS-2022

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Technical Director Deputy, ArianeGroup

SUMMARY

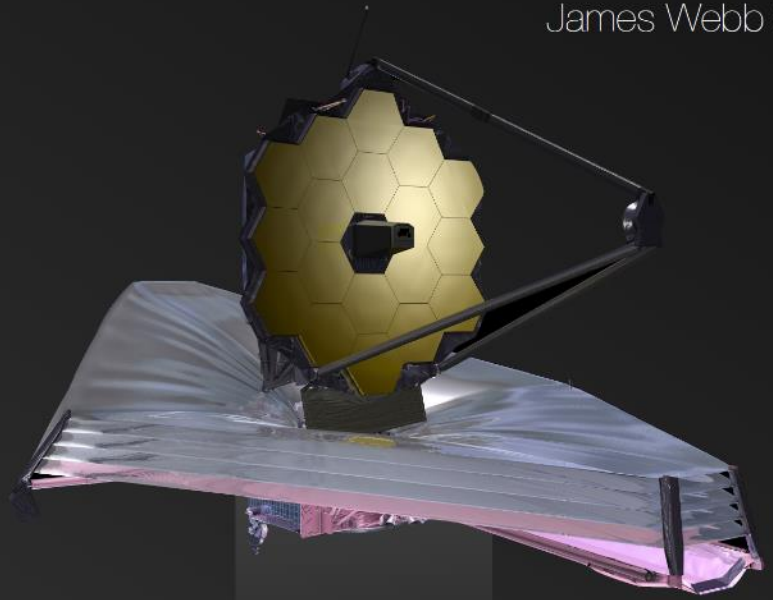
01

JWST PROGRAM

HUBBLE/JWST COMPARISON

James Webb Space Telescope

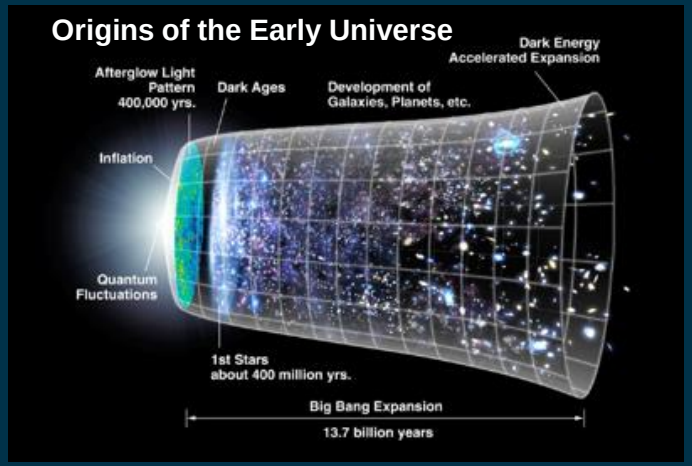
NASA, ESA, CSA



Primary diameter:	2.4 metres
Total mass:	12,437 kg
Wavelength range:	0.15–2.5 µm
Operating temp:	20°C
Orbit:	LEO, ~550 km
Launch date:	1990
Lifetime:	> 31 years
Launch vehicle:	Discovery

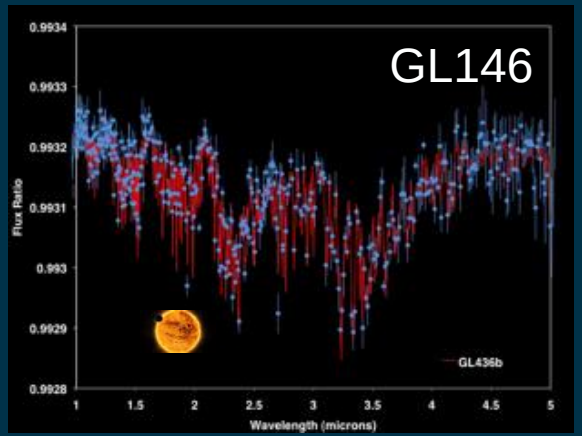
Primary diameter:	6.5 metres
Total mass:	6,200 kg
Wavelength range:	0.6–28.5 µm
Operating temp:	< –223°C
Orbit:	L2, ~1.5 million km
Launch date:	2021
Lifetime:	10 years
Launch vehicle:	Ariane 5 VA256

SCIENCE OBJECTIVES



Evolution of galaxies overtime

Study of the lifetime of stars



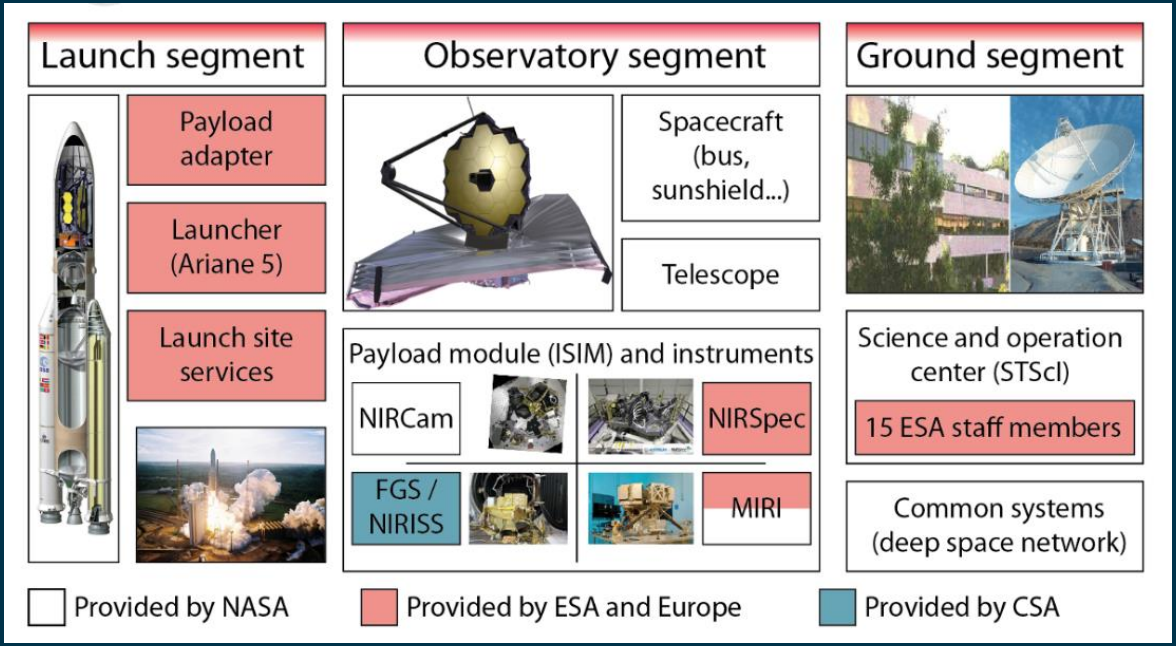
Study of Planetary Systems and exoplanets

WHO WAS JAMES WEBB ?

- James E. Webb (1906-1992) was the second NASA administrator, from 1961, February the 14th to 1968, October the 7th.
- He is mainly known for having managed the Apollo Program, in the sixties
- He also contributed to develop scientific program and interplanetary exploration in NASA
- During his mandate, NASA launched 75 rockets

EUROPEAN CONTRIBUTION

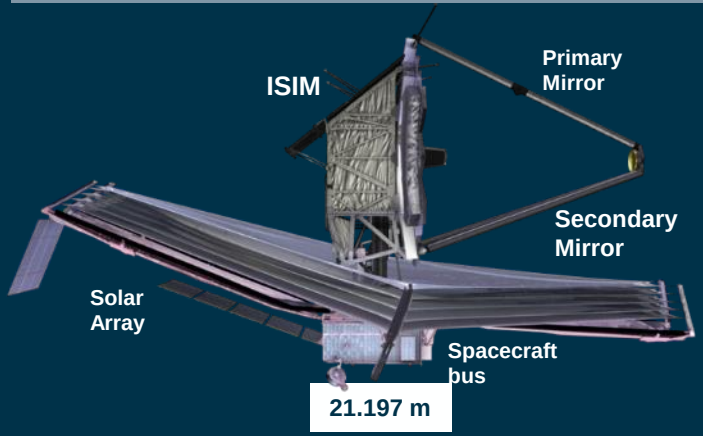
Webb is an unique international cooperation with large European contribution

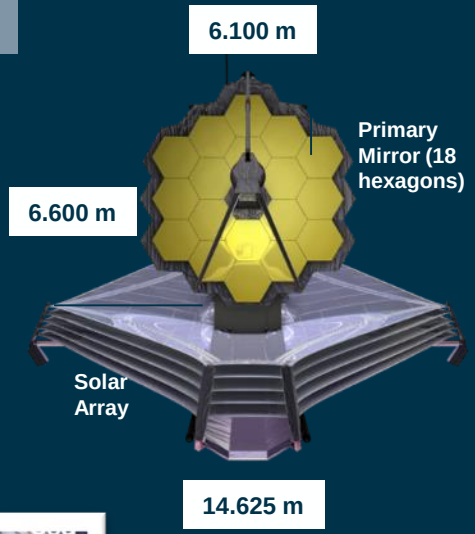


> 10 B$!

In return for this participation, ESA member state scientists will obtain **15% of the observing time** on JWST (on average over the lifetime of the mission)

JWST Observatory Summary



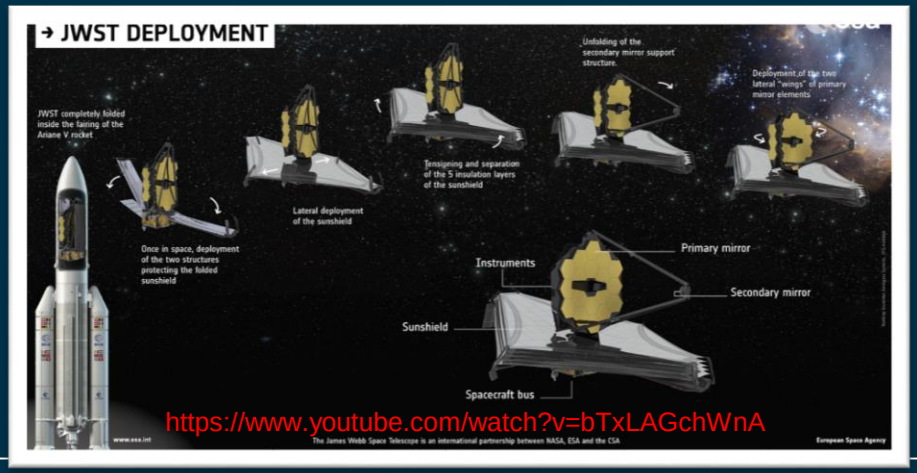


Optical Telescope Element (OTE) diffraction limited at 2 micron wavelength.

- 25 m^2 , 6.35 m average diameter aperture.
- Instantaneous Field of View (FOV) ~ 9' X 18'.
- Deployable Primary Mirror (PM) and Secondary Mirror (SM).
- 18 Segment PM with 6 Degree of Freedom (DOF) adjustability on each.

Deployable sunshield for passive cooling of OTE and ISIM.

- Mass: < 6230 kg .
- Power Generation: 2000 Watts Solar Array.
- Data Capabilities: 471 Gbits on-board storage, 229 Gbits / 12 hours science data.
- Science Data Downlink: 28 Mbps.
- Life: Designed for 10 years of operation.

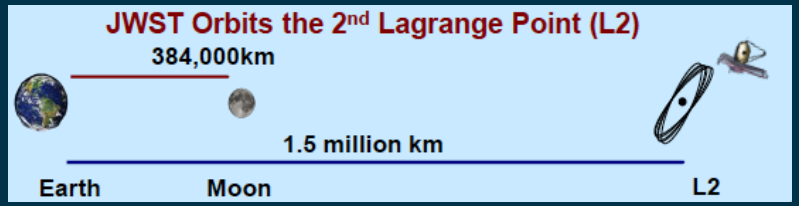


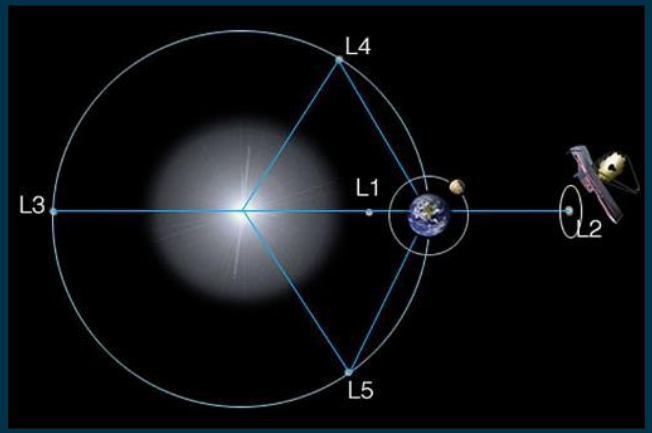
150 deployment mechanisms , "Origami" like!

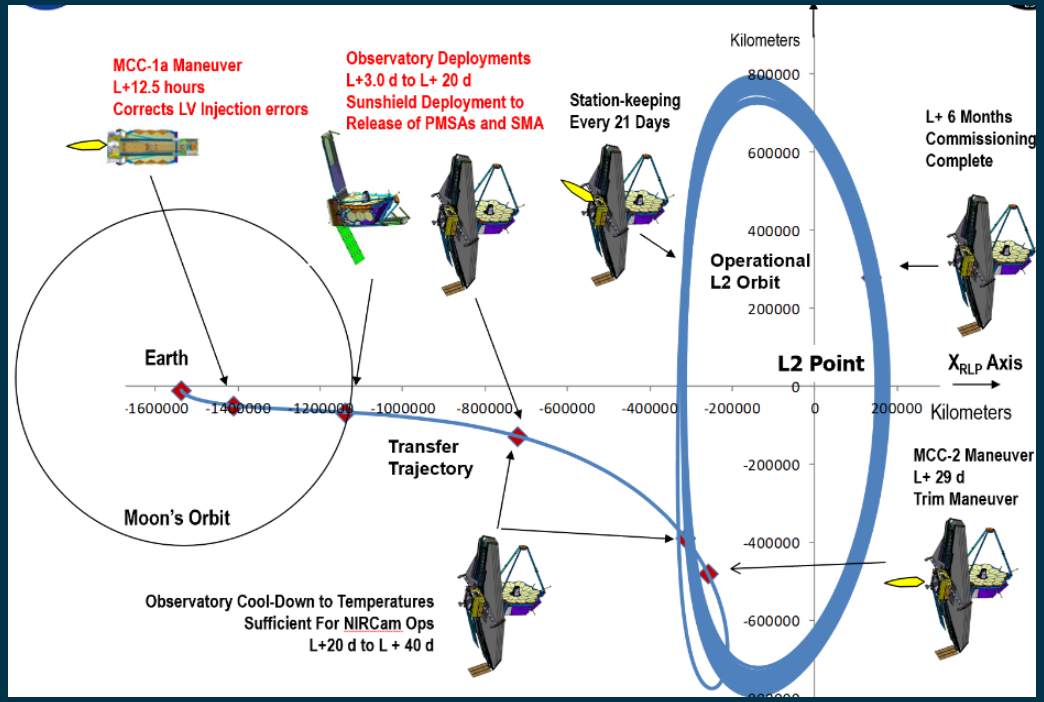
10.661 m

5.40 m

JWST MISSION ORBIT & KEY EVENTS







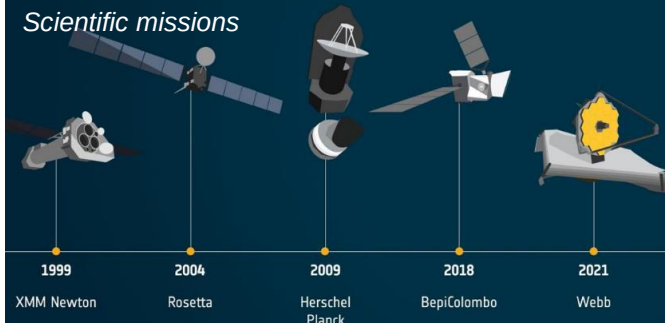
Halo orbit around L2 Lagrange point

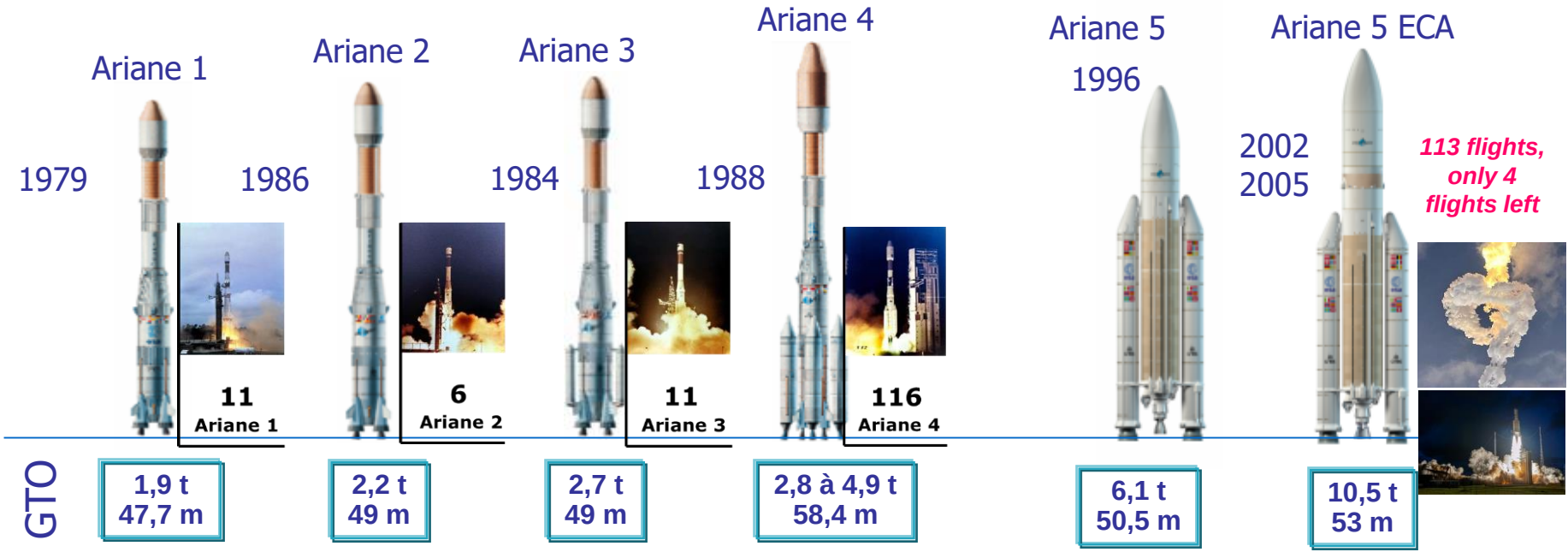
02

ARIANE 5 LAUNCHER CUSTOMIZATION & CHALLENGES

FROM THE BEGINNING TILL NOW

THE ARIANE FAMILY





Payload Mass in orbit
Launcher height

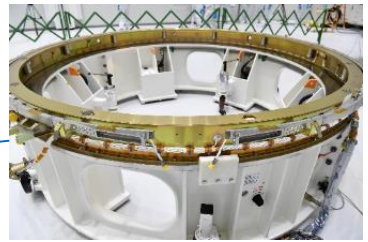
445 satellitessuccessfully injected into orbit

OVERVIEW OF ARIANE 5 LAUNCHER…

- **Heavy launcher with high reliability, single launch configuration, Day launch**

- Orders of magnitude:
  - ✓ Mass: ~**770t at lift-off** / 5.4t at the end
  - ✓ ~50m high at lift-off
  - ✓ ~**1600s up to JWST separation**

Launch Vehicle / Observatory adapter
Optimized position of the separation springs



Out of Autoclave fairing (RUAG)
- Specific venting system
- 2 fairing doors for late access
- 17-m high, 5.4m diameter

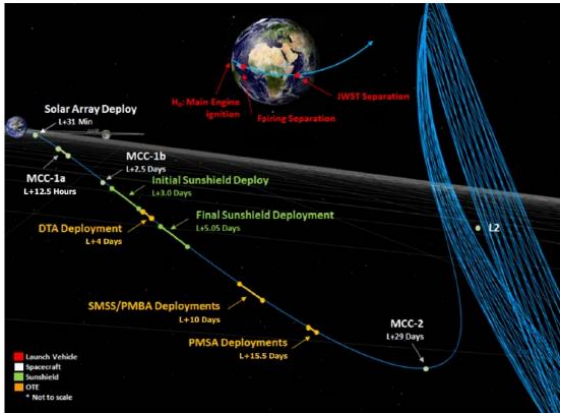
JWST in stowed configuration
- 6.2t, 10.6m high, 4.7 diameter

Upper cryogenic stage (ESC-D)
~2.7t LH2 / ~12.2t LOX loaded

Main cryogenic stage (EPC)
~25t LH2 / ~149t LOX loaded

2 Solid Rocket Boosters
~ 240t of propellant each

WHY IS THE JWST MISSION SPECIFIC?

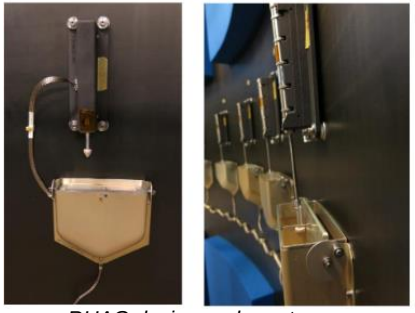


Specific trajectory and flight control requirements

- Injection on a semi-liberation trajectory by Ariane 5
- Illumination requirements (roll control + orientation laws)
- Increased L/V acceleration
- Specific mass/centering/inertia configuration
- **Specific maneuver (End Of Life Manoeuver) performed after JWST separation to ensure escape (space debris mitigation)**

Sensitivity to pressure inside the fairing

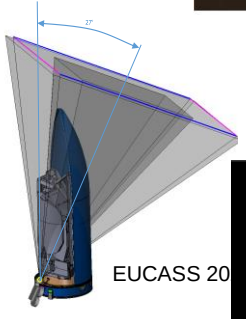
- **Specific venting system** developed for the JWST mission, which has flown on latest A5 ECA missions



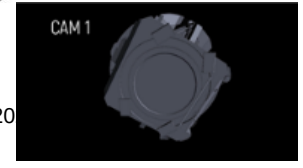
RUAG design and courtesy

Volume - **Particular care on relative displacement of JWST wrt the fairing during integration and flight**

Cleanliness requirements - Adaptations of the L/V maneuvers after JWST separation, taken as specification in EOLM

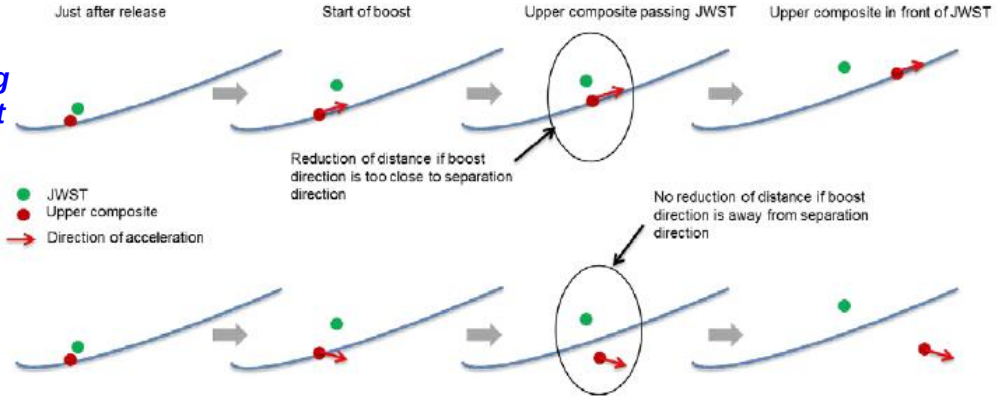


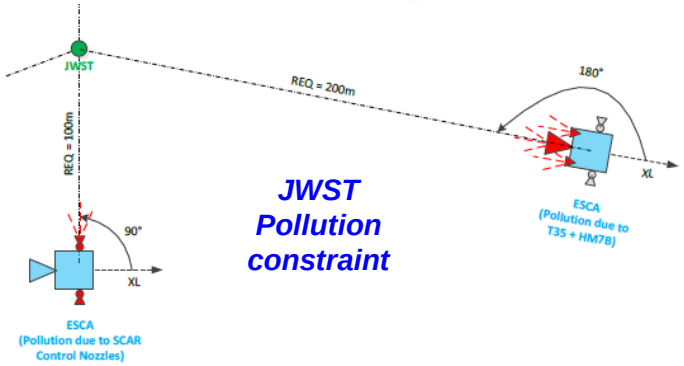
For the pleasure of our eyes - Real-time Video broadcast of JWST separation with use of a video kit implemented on-board



END OF LIFE MANOEUVER: A SMART GNC APPROACH

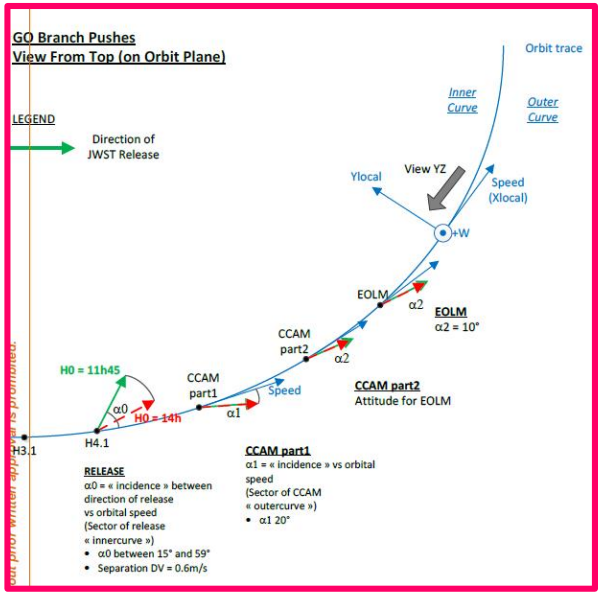
JWST Distancing constraint



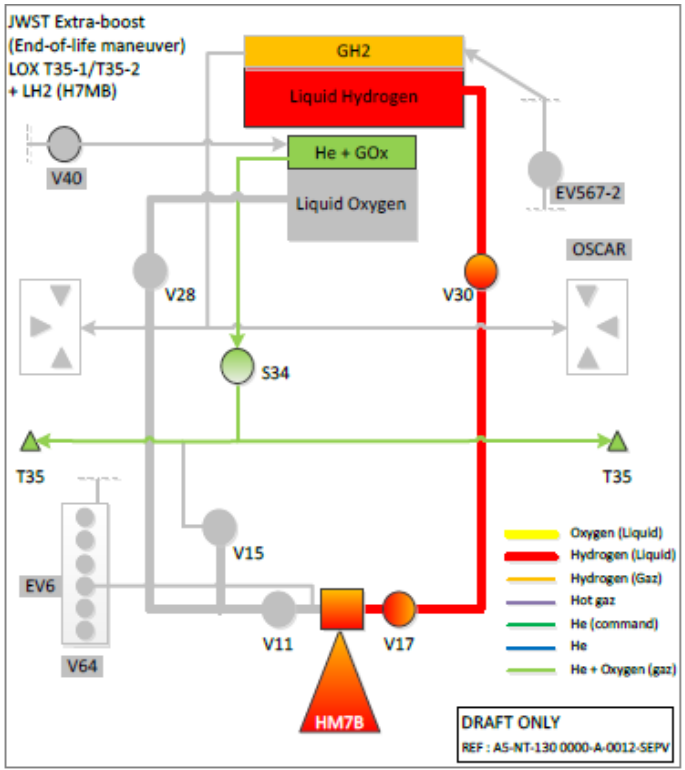


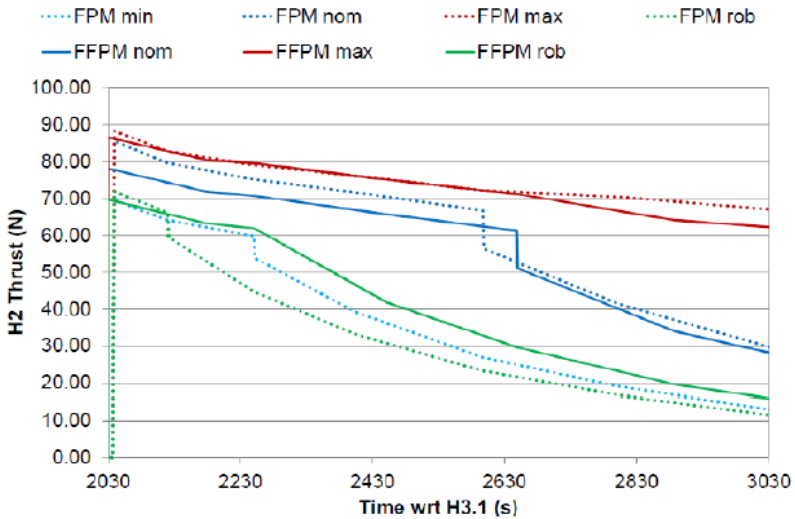
JWST Pollution constraint

Upper stage Liberation constraint (no impact on Earth nor on other planets



END OF LIFE MANOEUVER: SPECIFIC PROPULSION





Qualification of « idle » mode, tested on previous filghts

In final, guarantee of:

- **absence of JWST collision @ 99,999%**
- **absence of ESCA come back to Earth @ 99,9%**

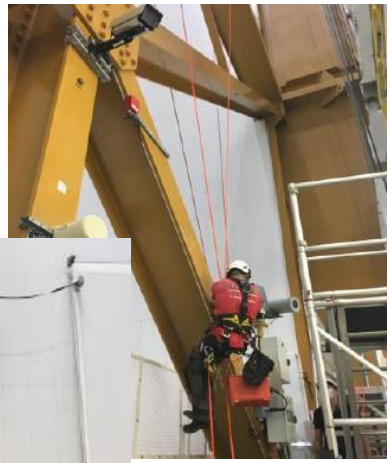
03
LAUNCH MISSION

SPECIFIC ADJUSTMENTS : CLEANLINESS

ESA, NASA, ARIANESPACE and CNES teams ensure an adequate environment for JWST:

specific cleanliness rules, special garments, complete and precise cleaning of the facilities and of all material entering inside the high bay

- In the facilities from the ground to the ceiling … and in every corner



- Inside the fairing, check with blue light to detect dust … and also in existing equipment inside the facilities

SPECIFIC ADJUSTMENTS : CLEANLINESS

2 walls of High Efficiency Particulate Air (HEPA) filters ensure an ISO7 cleanliness class airflow

Dedicated technical equipment's have been developed in Ariane 5's Final Assembly building:

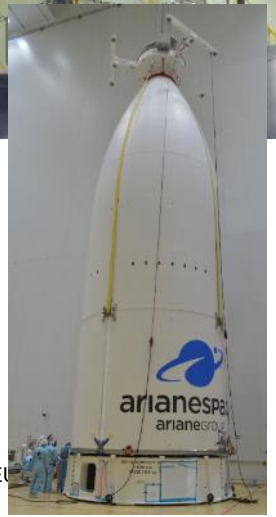
- a protection around the Observatory when integrated on the launcher
- Integration of molecular filters inside the launch table for fairing ventilation

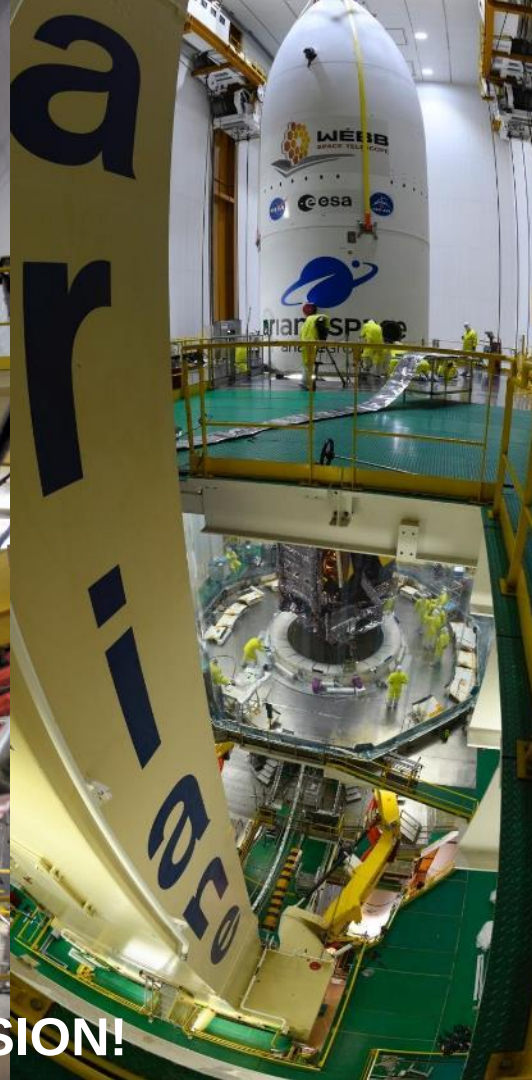
ENCAPSULATION

A system to center and guide the fairing during the encapsulation

Specific rehearsal in previous flight

Millimetric precision with lasers





JWST – A VERY SPECIFIC MISSION!


esa
TITAN


esa
ariane

24th of December, 2021

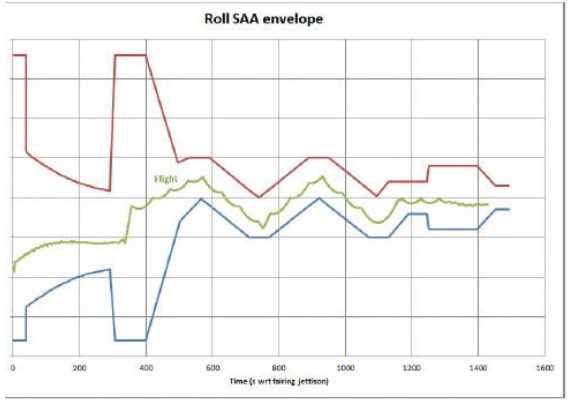
25th of December 2021: Lift-off …

VA256

FLIGHT RESULTS

Smooth flight

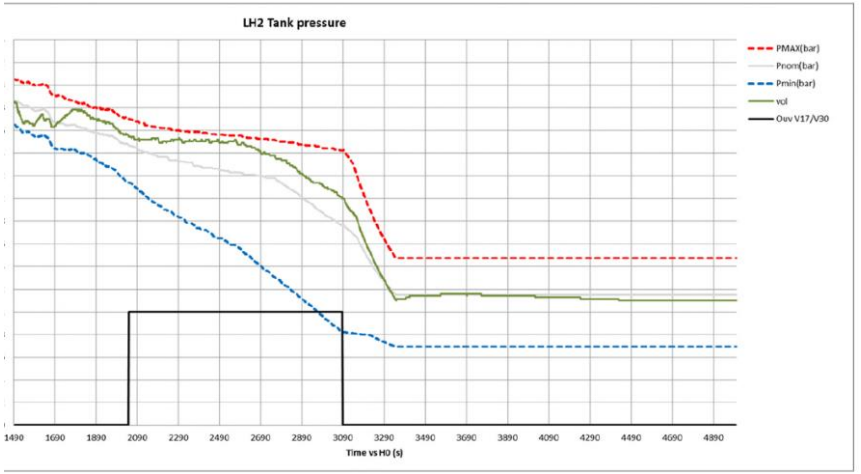
- No perturbation, low dynamic environment **(< 0,5g** in long axis)
- Fully nominal fairing separation, with **24 Pa** of residual pressure
- Perfect SAA requirement fulfilment
- Full success of EOLM manoeuver: + 500 000 km Za



Excellent injection precision

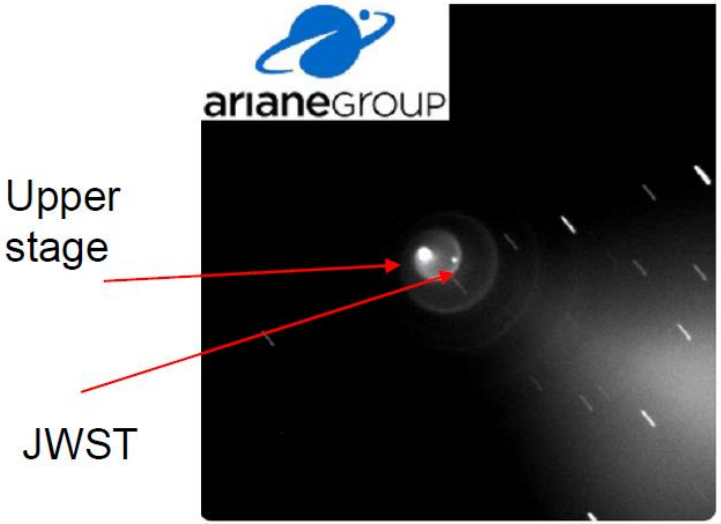
- Position: ≈ **0,4** σ wrt specific DCI allocations on a, e, i
- Misalignment angle < **0,1°** (req 1°)
- Angular rates < **0,02°/s** (req 0,5 °/s)

➔ **Strong increase of JWST life duration**



JWST – EOL AND PASSIVATION

HAVE YOU EVER SEEN THE PASSIVATION PHASE OF A STAGE ?



JWST COMMISSIONNING (1/2)

Spacecraft (radiator; sunshield) and telescope deployment (Jan 22)

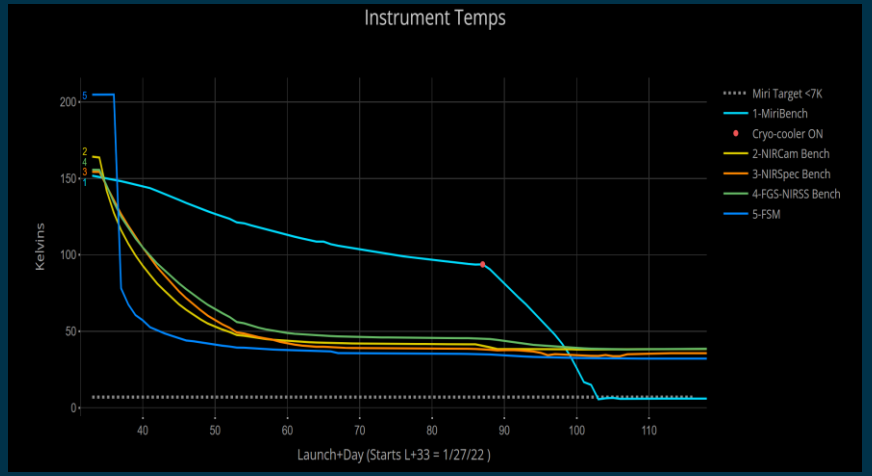
Webb placed on L2 Lagrange orbit (on 21 Jan 22)

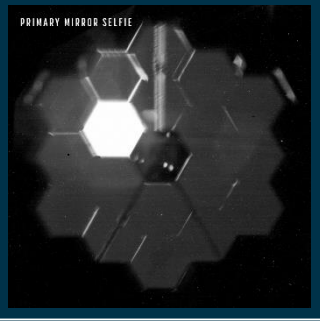
- 2nd station-keeping thruster burn (end March 22 to maintain Webb's position in orbit around the second Lagrange point)

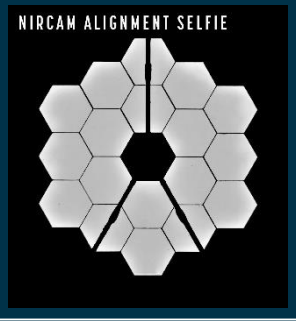
Telescope and instrument cooling

- all equipments and instruments have reached their operational temperature (even the MIRI instrument at 7 K with the help of a cryo-cooler)

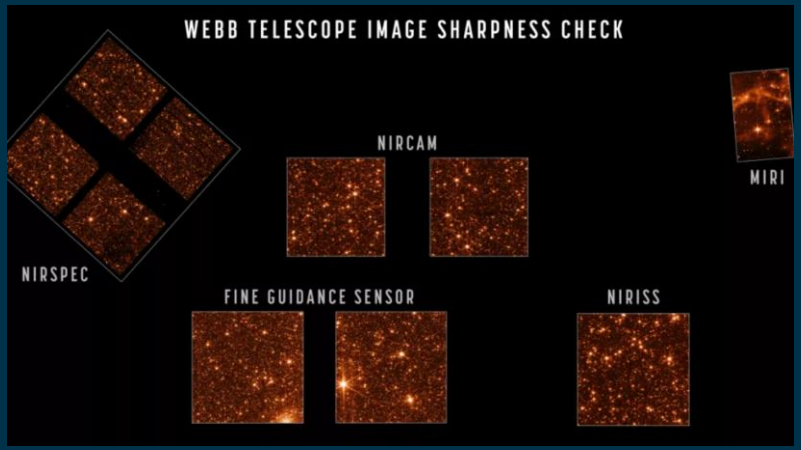
Primary mirror alignment Alignment of telescope to the instruments completed for NIRCam, NIRSpec and FGS







JWST COMMISSIONNING (1/2)



NASA's James Webb Space Telescope can now capture sharp images of celestial objects with multiple instruments, the agency announced April 28, 2022. *(Image credit: NASA/STScI)*

In late May, Webb sustained a dust-sized micrometeroid impact to a primary mirror segment. Not to worry: Webb is still performing at a level that exceeds all mission requirements

Telescope aligned, instruments on calibration process

➔ First images announced on 12th of July ☺

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, MD 20771

January 18, 2022

Reply to Attn of: 665

Stéphane Israël, CEO
ArianeSpace
Boulevard de l'Europe
BP 177 91006 Evry-Courcouronnes CEDEX
France

Dear Stéphane Israël and ArianeSpace:

The James Webb Space Telescope Science Working Group thanks you and your entire team for your magnificent work and perfect launch of the Webb on the Ariane 5, VA256. The Webb is the world's most powerful space telescope ever built, and the entire world placed their faith and trust in you and your team. The trajectory was exactly as desired, maximizing the observing lifetime of this most precious payload.

The extreme JWST requirements placed on the Ariane included tight clearances around the payload, which used every available centimeter of fairing clearance. They also included exceptional cleanliness and contamination control at the launch facility, and tight limits on the residual atmospheric pressure in the fairing. Some parts of the Webb are also very delicate, requiring special attention to vibration and acoustic analysis. The Arianespace team worked very closely with the NASA teams to ensure that all requirements were met.

As we begin the commissioning of the observatory, we look forward to brilliant scientific returns, for a mission lifetime considerably beyond the formal requirement of 10 years of scientific observations. Your success in achieving the perfect trajectory is an enormous contribution to science.

Sincerely,

John C. Mather

John C. Mather
Senior Project Scientist, JWST

Physics Nobel Price!

Thanks for your attention!