BBC

WHAT COMES NEXT FOR THE WEBB TELESCOPE

After deployment success, what will its first images show?

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Waking up WEBB

The James Webb Space Telescope's launch and deployment was a storming success, but why haven't we seen the first pictures yet? **Govert Schilling** has the answer

The most powerful space telescope launched into space, JWST is a worthy successor to Hubble

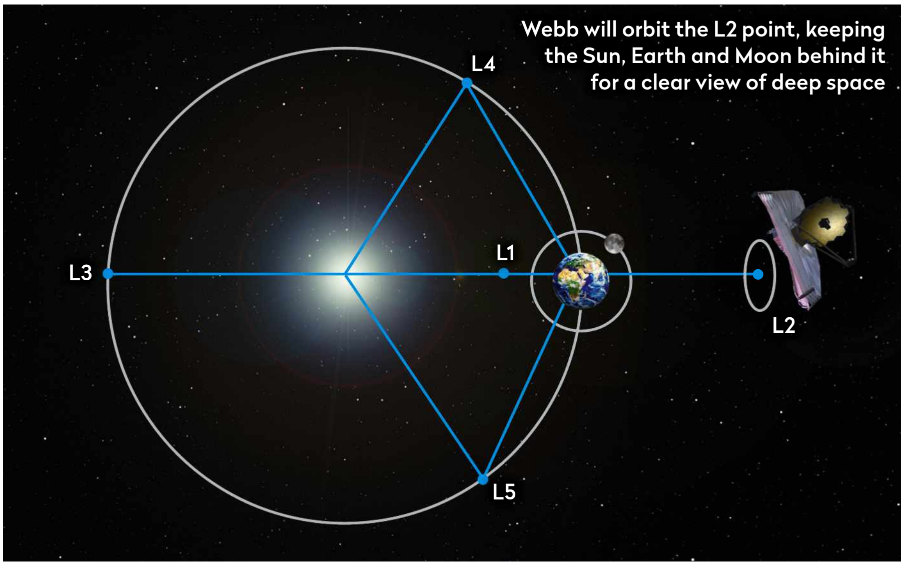
ILLUSTRATION

Captured by cameras on the upper stage of its Ariane 5 rocket, JWST sets off on its 1.5 million km voyage to L2 after separating on 25 December 2021

After 25 years and over 10 billion US dollars, on Christmas Day 2021, the James Webb Space Telescope (JWST) was finally launched into space by a European Ariane 5 rocket. With its 6.5-metre primary mirror and its tennis-court-sized sunshield, Webb had to be folded up to fit in the rocket's fairing, only to be deployed step by step in the first two weeks of its mission (see box, 'Unfolding the telescope', on p36). However, the successor to the Hubble Space Telescope won't take its first images of the Universe before late June or early July 2022, which begs the question – why?

It seems like an excessively long wait, especially since JWST arrived in its final orbit on 24 January. A total of three mid-course correction manoeuvres successfully placed the huge space telescope in a slow looping orbit around the second Lagrange point (L2), a stable gravitational point some 1.5 million kilometres behind Earth as seen from the Sun. "But a lot more needs to be done before we can start science operations," says Mark McCaughrean, the Senior Advisor for Science and Exploration at ESA (the European Space Agency), NASA's main partner in the programme.

For one, the telescope and its sensitive instruments, which left the French Guiana ▸



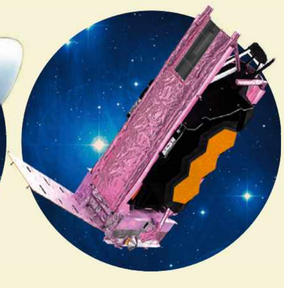
Webb will orbit the L2 point, keeping the Sun, Earth and Moon behind it for a clear view of deep space

DETLEV VAN RAVENSWAAY/SCIENCE PHOTO LIBRARY, ARIANESPACE/ESA/NASA/CSA/CNES

Unfolding a space telescope

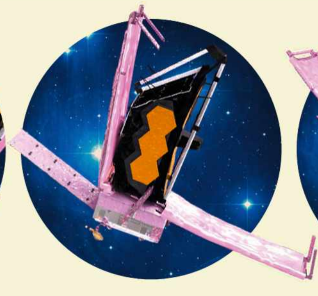
It took more than 50 individual steps and two weeks to set JWST up

25 December, 12:20 UT
JWST launches from the Guiana Space Centre on an Ariane 5 rocket; after 27 minutes, it separates from the launcher's upper stage to travel to L2 alone.



25 December, 12:48 UT
Deployment of JWST's 6m, five-panel solar array, which delivers about 1Kw of power. The telescope can now switch from battery power to its own power.

26 December
Deployment of the high-gain communications antenna, which allows communication with Earth through NASA's Deep Space Network.

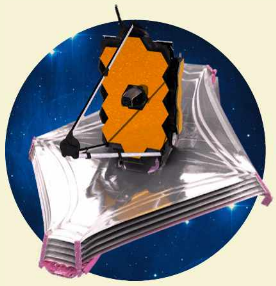


28 December
The Forward Unitized Pallet Structure (UPS), which supports and contains the five folded layers forming the front half of the sunshield, is lowered into place.

29 December
The Deployable Tower Assembly (DTA) is raised by 1.2m for better thermal isolation and to give room for the sunshield to unfold in front and behind.

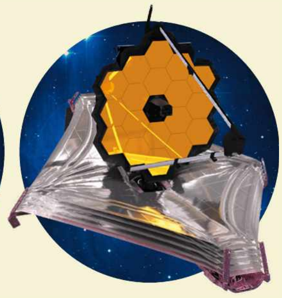
30–31 December
Sunshield mid-booms are extended on either side, pulling the folded sunshield layers with them, to form the first part of its distinctive 21m x 14m kite shape.

3–4 January
The five Kapton layers of Webb's sunshield are tensioned. While the Sun-facing side endures temperatures up to 90°C, the shielded side will be as cold as –230°C.



5 January
JWST's 74cm convex secondary mirror is deployed. The foldable structure supporting it has been dubbed "the world's most sophisticated tripod".

6 January
Deployment of the 1.2m x 2.4m Aft Deployable Instrument Radiator (ADIR), which radiates heat from the space telescope's science instruments into space.



7–8 January
Deployment of the two side panels forming JWST's 6.5m primary mirror. Its 18 hexagonal segments are made of lightweight beryllium coated with pure gold.

▸ launch platform at tropical temperatures, have to cool down to 230°C below zero. Thanks to its giant multi-layer sunshield, JWST had already reached –200 °C by early January, but the passive cooling slows down over time. It's a delicate process, says McCaughrean. For instance, the optics can never be the coldest parts of the telescope, lest molecules being released as gases from the graphite-composite support structure freeze down on the mirrors, degrading its performance.

When the NIRCam instrument (Near Infrared Camera) got cold enough for its sensitive mercury-cadmium-telluride detectors to pick up infrared light, the process of aligning the telescope's 18 mirror segments could finally commence. Each hexagonal segment is fitted with seven actuators and can be slightly tilted, shifted, rotated and deformed to ensure that they operate together as one perfect parabolic surface. And since the alignment procedure is done with starlight, it marks JWST's 'first light'. But it will take months of incremental precision adjustments before the 18 individual stellar images from each mirror are all brought together into one single focus.

Instrument testing

Around late April, engineers will also start commissioning JWST's four large science instruments: NIRCam (Near InfraRed Camera), NIRSpec (Near InfraRed Spectrometer), MIRI (Mid InfraRed Instrument (see box, opposite), and the Canadian FGS/NIRISS (Fine Guidance Sensor/Near InfraRed Imager and Slitless Spectrograph). Equipped with beam splitters, filters and micro-shutters, all have different observing modes, and these have to be fully tested and calibrated before they are handed over to the astronomy community. "Of course, every instrument has been tested and checked on Earth," says McCaughrean, "But we need to prove that they also perform flawlessly in space."

So what about that supposedly awe-inspiring first picture taken by the new space telescope? Well, that's not expected until some six months after launch, which would be late June or early July. And according to McCaughrean, "What it will show is a closely guarded secret. Most likely some kind of star-forming region."

NASA'S GODDARD SPACE FLIGHT CENTER X 10, JUAN RUIZ PARAMO/ISTOCK/GETTY IMAGES, NASA/CHRIS GUNN X 2

"Astronomers can't wait to train their new, expensive toy on their favourite objects"

ILLUSTRATION

With more fuel left over after its precision Ariane 5 rocket launch, JWST can stay in orbit at L2 for much longer than anticipated

Then again, he imagines that NASA may eventually decide to release an earlier test or alignment image at some time. "The longer it takes, the more people will start to believe something must be broken. There may even be political pressure on NASA to put something out at an earlier stage – they'd better prepare for this."

Anyway, the first round of science observations won't start before summer. Astronomers can't wait to train their new, expensive toy on their favourite objects, be that a remote galaxy at the dawn of time, a planet-spawning circumstellar disc, an exoplanet's atmosphere, or a denizen of our own outer Solar System.

Field of regard

Webb has less pointing flexibility than Hubble: since the telescope must face away from the Sun to keep its instruments consistently cool, its 'field of regard' will cover 40 per cent of the sky on any given day, and it will take around six months to access the whole of the sky.

The good news is that JWST's mid-course corrections used up less fuel than expected, which means there's more left to keep the space telescope in its L2 orbit. As a result, its operational lifetime may be extended beyond the projected operational period of 10 years. In any case, the exciting results Webb is bound to deliver will make up for the half-year wait we're experiencing right now.

Govert Schilling is an astronomy journalist and broadcaster, and author of *Ripples in Spacetime*

Europe's place on Webb

Led by the UK, European partners built one of JWST's main instruments

MIRI (Mid Infrared Instrument) is the major European contribution to Webb, apart from the Ariane launch. A camera and spectrometer combined, it was designed and built by a 10-country European consortium led by the UK, in collaboration with NASA.

MIRI's high spectral resolution enables it to identify a huge range of molecules in star-forming regions, protoplanetary discs and exoplanet atmospheres. The instrument's principal investigator is Professor Gillian Wright of the UK Astronomy Technology Centre, Edinburgh.

"MIRI's capabilities cannot be achieved by ground-based telescopes," she says. "The Earth's atmosphere is too efficient at blocking mid-infrared wavelengths. Uncooled telescopes on Earth also emit their own mid-infrared light; for them to do MIRI's work would be like looking for a match with a telescope that's on fire. Webb is cold and far beyond Earth's atmosphere, making MIRI hundreds of times more sensitive than any other instrument like it."

To be this sensitive, MIRI has to be cooled to 6.7°C above absolute zero, or –266.5°C. Since JWST's sunshield will only provide temperatures as low as –230°C, the instrument also has a cryo-cooler, which acts like a refrigerator. A set of four coronagraphs enables the study of extrasolar planets without being 'blinded' by the radiation of the planets' host stars.

MIRI (left) being integrated into JWST's science payload module at NASA's Goddard Space Flight Center in 2013

MIRI was Webb's first instrument to be completed and was integrated with the JWST in the US in 2013, after a final round of tests at the Rutherford Appleton Laboratory in Oxfordshire.