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GATEWAY TO THE FUTURE

2022 will see NASA, with help from its international partners, take the first major step on humanity's journey back to the Moon, and the start of a mission to establish an outpost alongside Earth's natural satellite

BY DR STUART CLARK

NASA/ALBERTO BERTOLIN

If all goes to plan, sometime in 2022 NASA's Space Launch System rocket (SLS) will blast off from Cape Canaveral, Florida, for its maiden flight. The giant SLS rocket, fully 111.25m tall, is set to launch no earlier than February, but probably not until the summer, and will send an uncrewed capsule on a test mission around the far side of the Moon and back again. Known as Artemis 1, it will truly mark the beginning of humanity's return to the Moon.

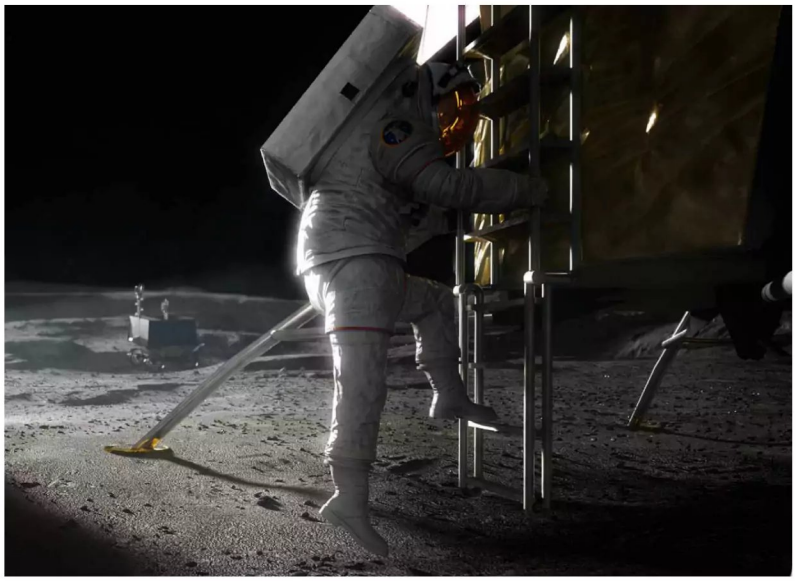
The Artemis 2 mission, currently scheduled for May 2024, will repeat Artemis 1 but this time with a crew of astronauts. In their looping journey around the Moon, they'll go further into space than any previous astronaut. Then comes the big one: Artemis 3, which will carry the next astronauts to land on the Moon.

In between these tent-pole missions will be a sequence of other launches to ensure the astronauts have everything they need to complete their missions when they reach lunar orbit. Absolutely critical to the long-term success of the Artemis programme is the Gateway lunar space station.

Gateway will be a multi-module space station in orbit around the Moon. It will act as a staging post for visits to the lunar surface, provide an orbital platform from which to conduct remote observations of the Moon and provide laboratories to analyse Moon rocks and conduct other scientific studies. It's an international effort between the US, 10 European countries, Canada and Japan.

It may sound like science fiction, but it's very real. And very, very cool...

THE SCIENCE



Gateway will act as a temporary home and workspace for astronauts visiting the Moon, much like the International Space Station does for astronauts visiting low Earth orbit. During the initial exploration of the Moon, astronauts will live on Gateway for up to three months, occasionally travelling down to the lunar surface to conduct science or test devices that will allow them to set up a permanent base on the surface.

Two experiments that have already been commissioned for Gateway are a radiation monitor supplied by the European Space Agency (ESA) and a space weather instrument suite. The radiation monitor will help decide how to keep astronauts safe from unhealthy levels of radiation that can be encountered in space. The space weather instrument suite is related to this because it will measure the intensity of particles released by the Sun during outbursts called coronal mass ejections.

A big focus will be on developing the technique of in-situ resource utilisation. This means using resources found on the Moon to manufacture things that the astronauts will need, for example, water, oxygen, rocket fuel and building materials can all be extracted or manufactured from materials found on or just below the lunar surface.

THE MODULES

Although smaller than the International Space Station (ISS), Gateway is too large to be launched on a single rocket. Instead, it will consist of a number of modules that will be placed around the Moon in a series of launches.

At its heart is the Power and Propulsion Element being developed by Maxar Technologies in the US. This module uses solar panels to generate power. It can also convert that power into propulsion using a 'solar electric propulsion' unit (or ion engine), to move the station into different orbits.

The Habitation and Logistics Outpost (HALO) module is being supplied by Northrop Grumman Innovation Systems. This will be the first module in which astronauts can live. It will include docking ports for the Orion spacecraft carrying the astronauts.

Together these two modules form a workable initial station. Although they were initially planned to be launched separately and then docked in space, NASA will now fix the two modules together and fly them on a single launch, scheduled for November 2024 on a SpaceX Falcon Heavy rocket.

This will be the configuration of the Gateway for the Artemis 3 Moon landing mission, but it will soon be joined by modules supplied by ESA. Europe is a major contributor to Gateway and the Artemis missions. Italy, in particular, is a significant partner with a distinguished heritage in space station design and manufacture. Around half the pressurised modules on the ISS were supplied by Thales Alenia Space in Turin.

"That is a great legacy," says Luigi Pasquali, space activities coordinator of Leonardo, the Italian company that jointly owns Thales Alenia Space. It has allowed the company to win the contracts to provide a number of modules for Gateway.

First will be the European System Providing Refueling, Infrastructure and Telecommunications (ESPRIT). This will consist of two parts, the first will be the station's lunar communications system. As this is essential component from day one, it's being manufactured in advance and will be attached to the HALO module for launch in 2024. The second part of ESPRIT will contain additional fuel tanks, a windowed habitation corridor and docking ports. Currently it's scheduled for launch in 2027.

In addition, Thales will also contribute the International Habitation Module (I-HAB), which will contain a life support system supplied by Japan. Finally, Canada is producing an 8.5m-long robotic arm, similar to the one the country contributed to the ISS and Space Shuttle programmes.

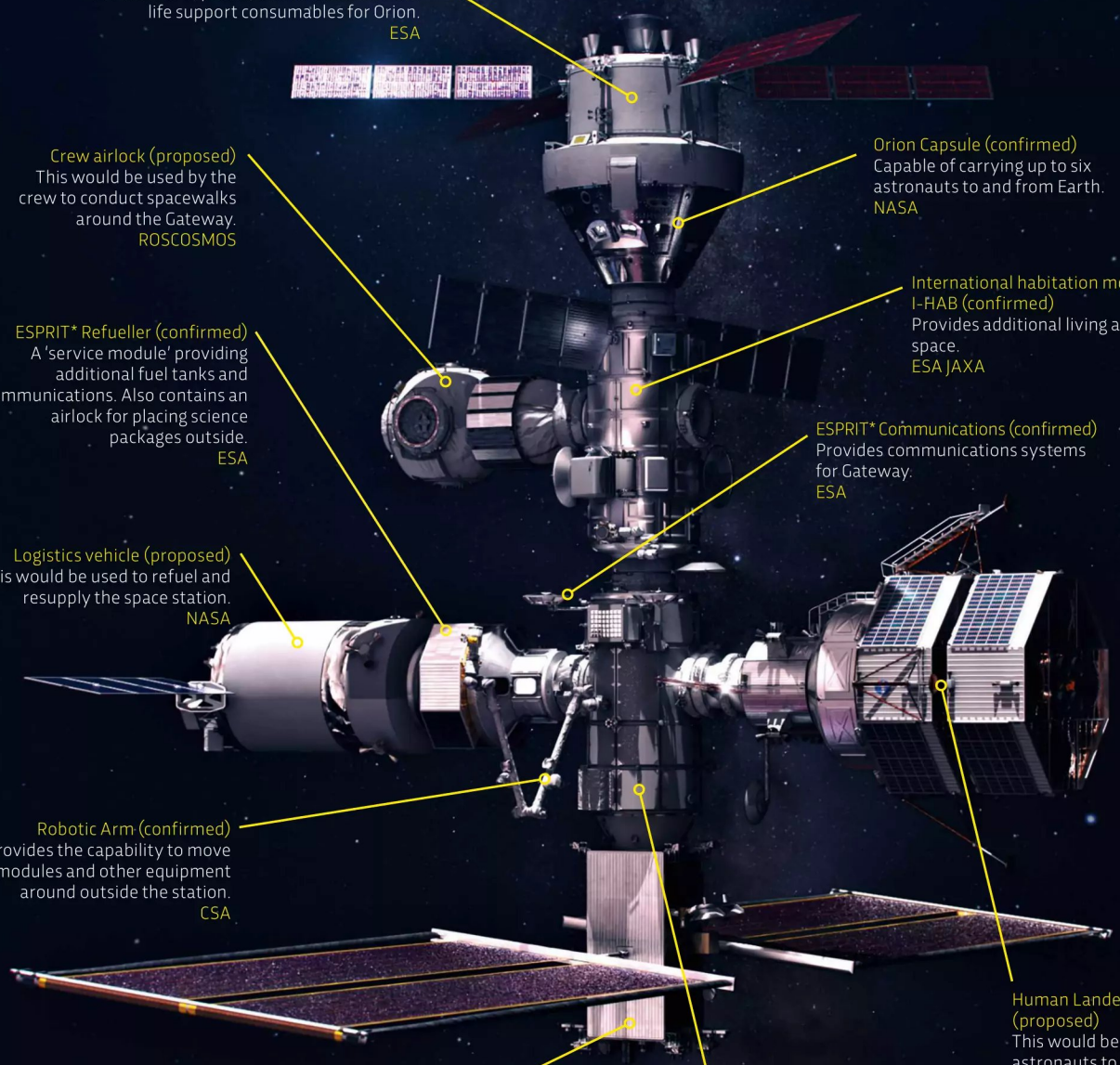
Gateway's HALO module is being supplied by Northrop Grumman

NASA/ALBERTO BERTOLIN X2, THALES ALENIA SPACE

THE GATEWAY

MODULE PROVIDERS
NASA –National Aeronautics and Space Administration
ROSCOSMOS - Roscosmos State Corporation for Space Activities
JAXA – Japanese Aerospace Exploration Agency
ESA – European Space Agency
CSA –Canadian Space Agency

*ESPRIT – European System providing Refuelling, Infrastructure and Telecommunications



European Service Module (confirmed)
Provides fuel, power, communications and life support consumables for Orion.
ESA

Crew airlock (proposed)
This would be used by the crew to conduct spacewalks around the Gateway.
ROSCOSMOS

ESPRIT* Refueller (confirmed)
A 'service module' providing additional fuel tanks and communications. Also contains an airlock for placing science packages outside.
ESA

Logistics vehicle (proposed)
This would be used to refuel and resupply the space station.
NASA

Robotic Arm (confirmed)
Provides the capability to move modules and other equipment around outside the station.
CSA

Power and Propulsion Element PPE (confirmed)
The core of Gateway. Its solar arrays provide power and a propulsion system to alter Gateway's orbit.
NASA

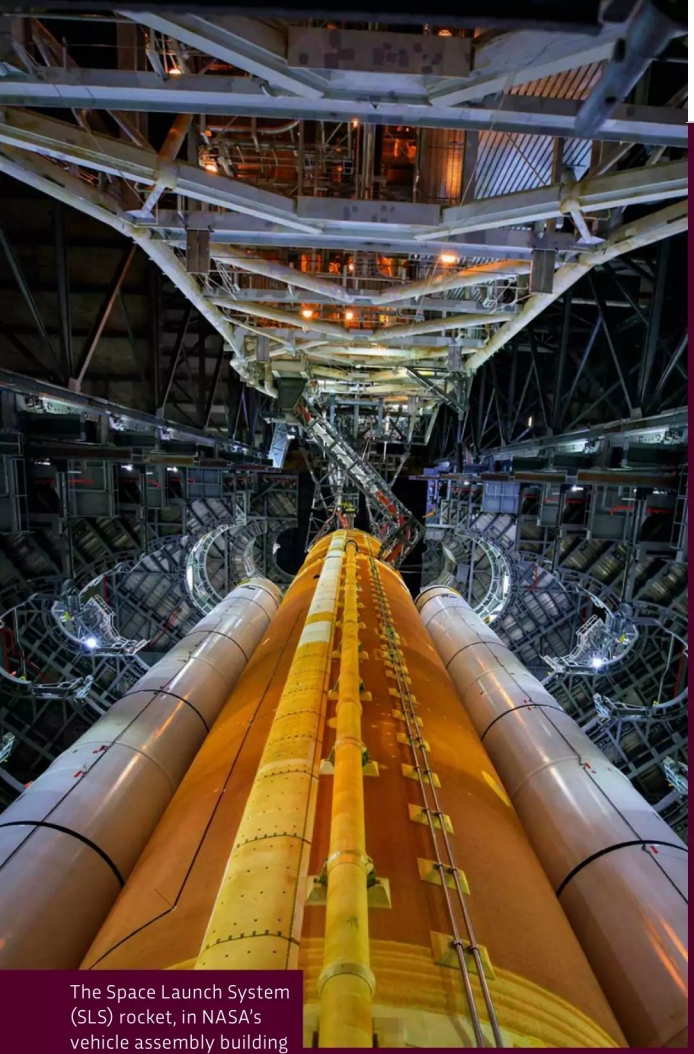
Orion Capsule (confirmed)
Capable of carrying up to six astronauts to and from Earth.
NASA

International habitation module I-HAB (confirmed)
Provides additional living and working space.
ESA JAXA

ESPRIT* Communications (confirmed)
Provides communications systems for Gateway.
ESA

Habitation and Logistics Outpost HALO (confirmed)
Provides living and working space for a crew of up to four for 30 days.
NASA

Human Lander System (proposed)
This would be used to taxi astronauts to and from the lunar surface for missions after Artemis 3. NASA is currently working with five industrial partners on various designs.
NASA



The Space Launch System (SLS) rocket, in NASA's vehicle assembly building

THE SPACESHIPS

Of course, having a space station orbiting the Moon is useless if you have no way of getting astronauts to it. That's where the Orion Multi-Purpose Crew Vehicle comes in. The crew module is being supplied by NASA via Lockheed Martin in the US, and can house up to six astronauts, but the heart of the spacecraft is the European Service Module (ESM) that sits behind the crew capsule. It's being provided by Europe's Airbus company. "ESM provides everything that the astronauts need to live," says Siân Cleaver, who is the Airbus industrial manager for the ESM.

The ESM is based on the Automated Transfer Vehicle (ATV), also manufactured by Airbus. ATV was one of the European Space Agency's contributions to the International Space Station. It carried cargo to and from the facility in low-Earth orbit. To transform it into the ESM and get it to the Moon, however, requires one very obvious difference.

"It's got a massive main engine on the bottom," says Cleaver.

The first ESM is already on top of the Space Launch System rocket, in preparation for the Artemis 1 mission in 2022. The second has been shipped to Florida for mating to the crew capsule. This will be the first Orion to carry astronauts, on the Artemis 2 mission. Cleaver and colleagues are working on ESM 3, the one that will take the astronauts to the Gateway station, before their descent to the lunar surface.

"It's definitely mind-blowing. I feel very lucky. It was always my dream to work in human spaceflight," Cleaver says.

The astronauts of Artemis 3 will shuttle to the lunar surface inside a SpaceX Starship craft. After that, NASA is beginning to develop a smaller lunar lander for more routine missions to and from the surface.

THE SPACESUITS

To walk on the Moon obviously requires a spacesuit – and these are not simple items of clothing. Spacesuits have constantly evolved to give astronauts the protection and the usability they need. For the Artemis Moon landings, those will have to be taken to a whole new level.

If you think of a spacesuit not as a garment, but as a flexible spacecraft that you wear, then you get closer to the complexity involved in making one. On top of that, it should hinder the astronaut's movements as little as possible.

NASA is designing the eXploration Extravehicular Mobility Unit, or xEMU. A big issue for mobility in a spacesuit is the pressure of the air inside. When an astronaut bends a limb, it compresses the material and reduces the volume inside the suit, leading to an increase in air pressure that resists the motion of the astronaut.

Using bearings at the joints rather than compressible fabric helps address this issue. Whereas the Apollo spacesuits worn by Neil Armstrong and Buzz Aldrin on their trip to the Moon in 1969 used bearings only in the arms, the xEMU will use them in the arms, waist, hips, thighs and ankle joints. The suits will also let the astronauts vary the air pressure, allowing them to reduce it in order to kneel down.

NASA engineer Kristine Davis wears the xEMU suit at its 2019 unveiling

All in all, the new innovations should provide far more flexibility for the astronauts and a much more comfortable environment in which to work. It should even allow them to walk more normally than the Apollo astronauts, who developed a kind of loping gait because of the low lunar gravity combined with the inflexibility of the spacesuit.

It's hoped Gateway will enable us to study and use the resources on the lunar surface

NASA/KSC, NASA/ALBERTO BERTOLIN, THALES ALENIA SPACE, ALAMY

THE LOCATION

Gateway will orbit the Moon on a large elliptical path that will take it over both the lunar north and south poles. It will require almost seven days to complete an orbit. At its furthest, it will be 70,000km away from the Moon, before closing to within 3,000km. The orbit offers easier access to land in the lunar polar regions, especially the south pole, which is thought to be rich in ice deposits. It also offers excellent communications possibilities with Earth because it means Gateway spends very little time being eclipsed from Earth's line of sight.

THE FUTURE

The first thing that Gateway will do is make it easier to establish a permanent base on the Moon. "Gateway has a strategic role in really being able to develop a large presence on the lunar surface," says Pasquali.

This is because it will provide a stable, safe base of operation from which to gradually develop the equipment and infrastructure that will bring a lunar base to life.

"I know, it's really cheesy, but whenever I look at the Moon, I always think about the fact that we're going there soon. And then I look at the spacecraft in the clean room the next day and I think, 'Okay, what I'm doing has a real purpose'," says Cleaver.

And unlike the curtailed exploration of the Moon in the 1970s, this time it's being undertaken with a long-term purpose in mind. In November 2021, NASA confirmed that beyond the Artemis 3 lunar landing, the agency is developing a sustainable programme that envisages at least 10 further visits to the Moon's surface.

And beyond that, Mars beckons. This is one reason why the Orion spacecraft is called the Multi-Purpose Crew Vehicle, to indicate that it has uses other than 'just' travel to and from the Moon.

And being well outside of the protection of Earth's magnetic field, the Gateway also allows the effects of deep-space radiation on the health of astronauts to be fully assessed. Knowledge of this is critical for a journey to Mars, where the cruise time in deep space will be at least nine months.

In short, Gateway is essential to all future exploration. Rather than just getting us back to the Moon, history may look back at it as the gateway to the human exploration of the entire Solar System. SF

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