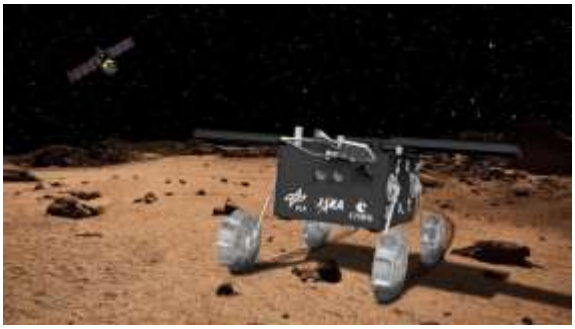
The German-French Rover IDEFIX on its way to the Martian Moon Phobos

"This rover looks like a beer crate on wheels"

IDEFIX prototype packaged (DLR image) [1]



IDEFIX on Phobos fully deployed. DLR [4]

This disrespectful comparison appeared in a local Starnberg newspaper, referring to the new Mars rover presented on Jan. 16, 2024 at the German Aerospace (DLR) robotics research branch in Oberpfaffenhofen, Bavaria. The rover is named *IDEFIX* after the smart dog from the Asterix cartoons, and was designed and built in cooperation with the French space agency CNES as contribution to the Japanese Martian Moons eXploration mission (MMX).

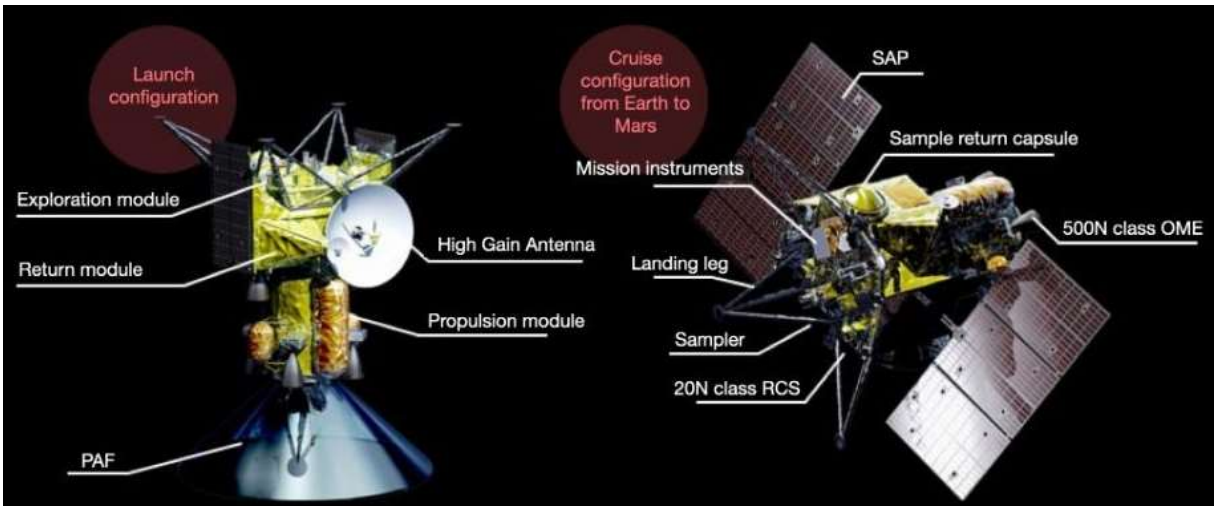
And the 'crate' has it all:

The German-French IDEFIX teams are proud of what they have achieved: "The special thing about this rover for the MMX mission is its extremely compact design. IDEFIX essentially has all the elements of a full-fledged science rover, but with its highly integrated construction it only weighs 25 kg, packaged and folded into a box of approx. 50x50x45 cm. The weight is crucial so that the rover can survive the impact on Phobos unscathed. It is also equipped with cameras, a radiometer, and a Raman spectrometer for in-situ surface exploration. Another special feature of the rover is its ability to erect itself on its 4 wheels and deploy the solar panels automatically regardless on which side it is landing.

IDEFIX is part of the MMX mission, which will explore both moons of Mars under the leadership of the Japanese space agency JAXA. The goal is to decipher the mystery surrounding the creation of the Mars moons Phobos and Deimos. As essential part of the mission, IDEFIX will land on Phobos for the first time on a moon whose gravitational field is less than 1/2000 than that of Earth in order to directly explore its surface. After having received satisfactorily data from the rover the Japanese *Exploration module* will land at the scouted location and take samples from Phobos to bring them back to Earth. After IDEFIX's integration completion in July 2023, extensive qualification testing, including its functionality and resistance to the vibrations during rocket launch as well as the extreme temperature fluctuations on Phobos was successfully performed at DLR.

Integration of the rover into the MMX Exploration module will begin in Japan from February 2024, so January of 2024 is the time to transport the rover to JAXA.
For safety reasons, it will travel to Japan with almost empty batteries, and the first task of the DLR and CNES reception teams will be to recharge the batteries in order to maintain their performance. This is followed by an extensive functional check and the final handover to JAXA.
According to current planning, the start of the MMX mission is scheduled for 2026.
MMX spacecraft approaching Phobos, Propulsion module still attached (artist's conception)[5]

Martian Moons eXploration (MMX) Mission



MMX Spacecraft Configuration [2]
Left: The Propulsion module and the Exploration module will be separated from the Return module according to the mission profile.
Right: Underside of the four legged Exploration module.
The pointer labeled "Mission instruments" indicates the location of the IDEFIX rover. It will be released for a' free fall landing' scouting the surface before the Exploration module makes a 'soft landing' for sample taking with the C-SMP and P-SMP instruments of the Sampler, also mounted on the underside of the Exploration module.

The two moons of Mars, Phobos and Deimos, are the targets of the MMX mission. Due to their small size (Phobos 27 kilometers, Deimos 15 kilometers), both moons are irregularly shaped. Their origin is still an unsolved mystery in planetary research, i.e. whether they have been captured by the gravitational field of Mars or being chipped off Mars by impact. (image montage above) [1]

After approximately a year of flight time, the MMX probe, consisting of the *Propulsion module*, *Exploration module*, *Return module* with *Sample return capsule*, will reach Mars in 2027 and enter its orbit. Then the eight scientific instruments of the Exploration module begin mapping and characterizing the surfaces of Mars and take a close look on Phobos and Deimos.
During the mission, IDEFIX, attached to the Exploration module will be released to land on Phobos in free fall from a height of 40 to 100 meters above the surface. Once landed, it erects itself on its four wheels and deploys its solar panels automatically to be ready for the approximately three-month mission phase. "The biggest challenge for IDEFIX is that it has to carry out many operations – especially righting after landing on Phobos – fully autonomously in order to survive," explains Stéphane Mary, CNES IDEFIX project leader. "It wouldn't survive without further commanding from Earth."
On the surface, IDEFIX specifically searches for and analyzes scientifically interesting areas of Phobos. In doing so, the rover is breaking new technical ground, as a wheeled exploration vehicle has never driven on a celestial body that has less than 1/2000 of the Earth's gravity, i.e. the 'roving' is very, very slow.
The main goal of the MMX mission is to collect Phobos soil samples with the Exploration module and bring them back to Earth safely. [1]

Sampling

The E*xploration module* has four landing legs and a propulsion system, it contains a sample collector, and some other instruments. The *Sampler* and the IDEFIX rover (before it is released) are mounted on the down facing side ('underside') of the Exploration module.
The Sampler is equipped with two sampling instruments: the Coring sampler (C-SMP) to gain regolith at depths deeper than 2 cm from the Phobos surface, and the Pneumatic sampler (P-SMP) for samples from the Phobos surface.

The C-SMP has a robotic arm which will collect regolith from the ground by shooting the C-SMP 'core drill' mechanism into the ground. It is designed to rapidly perform subsurface core sampling to collect over 10 grams of the regolith.
The P-SMP is installed close to the footpad of the landing leg of the Exploration module, and uses an air gun to puff pressurized gas, pushing about 10 grams of soil into the sample container like the OSIRIS-REx TAGSAM did [6]. The P-SMP is NASA's contribution to the MMX mission in return for a share of Phobos samples.
Both C-SMP and P-SMP can collect samples quickly because the entire sampling procedure is scheduled to be performed in only 2.5 hours. [3]

After having collected the samples, a robotic arm will transfer both C-SMP and P-SMP canisters to the *Sample Return* capsule on the Exploration module.
The Exploration module will then lift off from Phobos with its integrated propulsion systems into a Mars orbit and perform several flybys of the smaller moon Deimos before carrying the Sample Return capsule back to be ejected, reenter the atmosphere to land on a designated location on Earth, arriving in 2031. [3]
Needless to say the whole mission represents a tremendous challenge to the orbit-, attitude-, and navigation controllers from Mars orbit insertion to capsule return and landing in Australia.

References

[1] Die Reise zum Marsmond Phobos beginnt (dlr.de)
[2] JAXA MMX: Probe | MMX - Martian Moons eXploration (jaxa.jp)
[3] https://en.wikipedia.org/wiki/Martian_Moons_eXploration
[4] https://www.dlr.de/en/latest/news/2023/02/rover-on-the-home-stretch-to-the-martian-moon-phobos
[5] https://en.wikipedia.org/wiki/Martian_Moons_eXploration
[6] see OSITIS-REx article in the Journal of SpaceOperations & Communicator (issue 2, 2024)