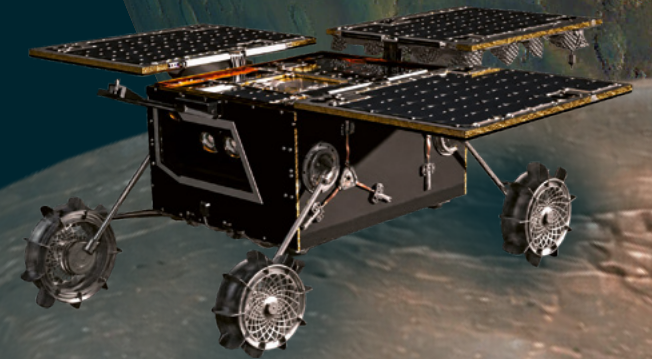


Idefix®

The MMX rover, landing for the very first time on Mars' 'scary' moon



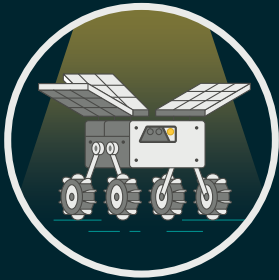
Interactive launchkit



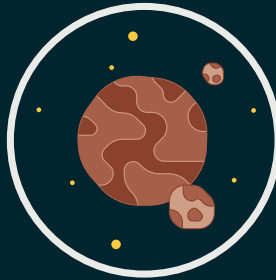
Contents



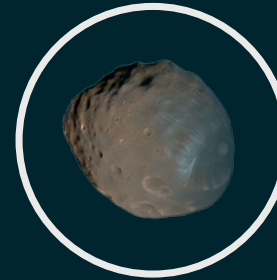
Click on an icon to go to the corresponding page of the kit



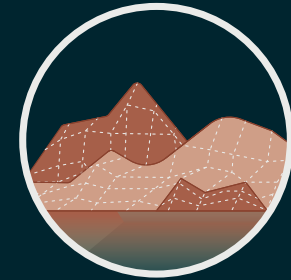
Spotlight on Idefix®



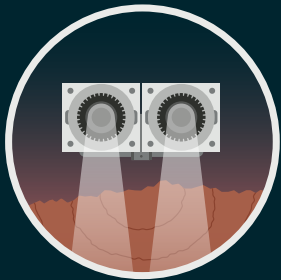
Mission milestones



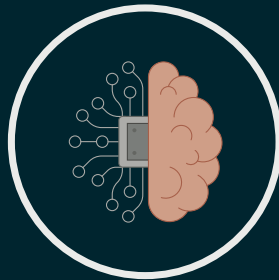
A 'terrifying' destination



Science goals



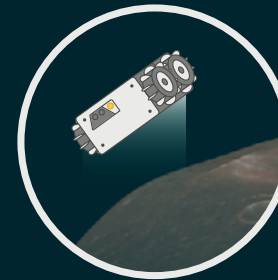
Instruments



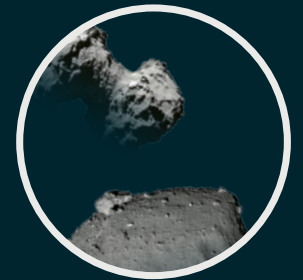
Engineering



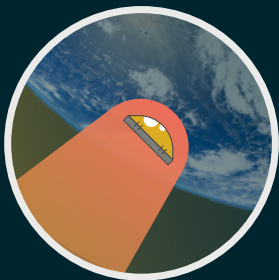
Journey



Landing



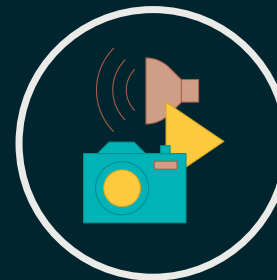
Low-gravity operations



MMX sample return



FAQ



Multimedia



Contact

Spotlight on Idefix[®]

The German-French Idefix[®] rover will be the first human-made object to land on Phobos – scouting the small moon's surface to help the MMX main spacecraft safely land, collect a sample to bring home and help us understand the formation and evolution of the Martian system.

International collaboration

DLR

Structure and mobility:

- lightweight body
- connection/separation system to MMX main spacecraft
- locomotion and uprighting system

Science payload:

- RAX and miniRAD

Lander Control Center (Cologne):

- rover operations on Phobos
(in collaboration with CNES)

CNES

Navigation and vision:

- stereo navigation cameras
- wheel cameras

Central service module:

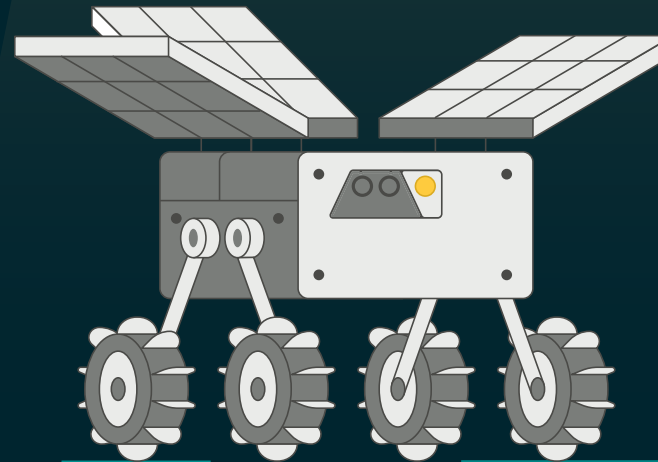
- on-board computer
- power
- communications

Lander Control Center (Toulouse):

- rover operations on Phobos
(in collaboration with DLR)

JAXA

- mission lead
- MMX main spacecraft
- launch on a H3 rocket
- data relay



- 4 instruments
- 23 kg mass
- 15 gram weight on Phobos – a grape!
- 100 days of science
- 41 cm x 37 cm x 23 cm



Idefix[®] has three main jobs:



- Characterise the site for the main spacecraft's landing and sampling



- Investigate surface properties of Phobos



- Test low-gravity operations

Idefix[®]'s firsts:



- First rover to explore the surface of a Martian moon

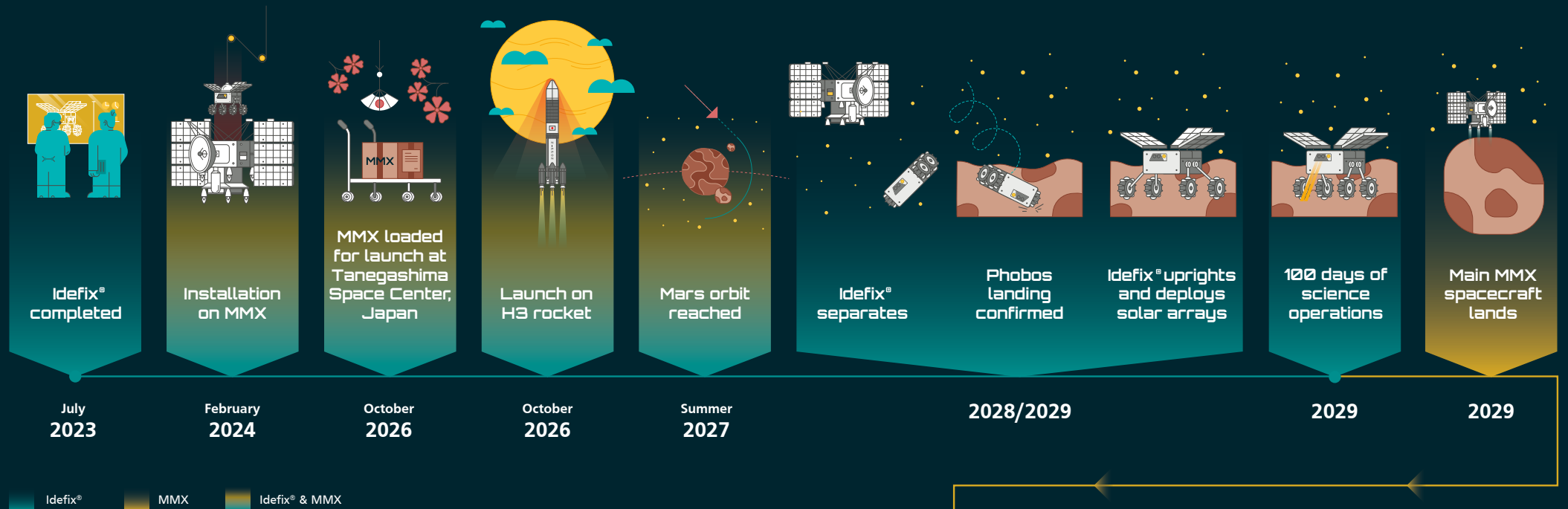


- First wheeled locomotion in milligravity



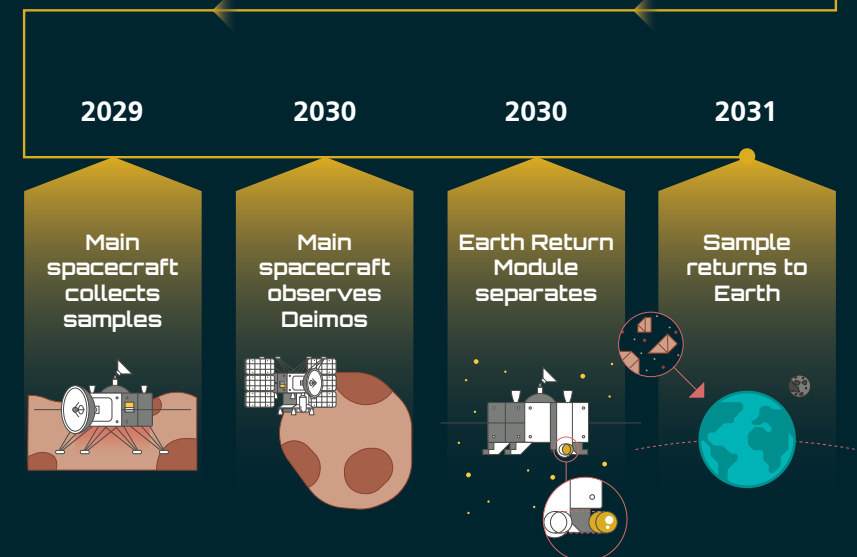
- Part of the first sample-return mission from the Mars system

Idefix[®] mission milestones



As part of the Martian Moons eXploration mission, Idefix[®] will be the **first rover to land on a Martian moon, Phobos**, paving the way for the MMX sample return mission to follow. Here are the main mission milestones along the way.

Dates are approximate and more information will be provided once confirmed via the **JAXA**, **DLR** and **CNES** websites and social media, and on the official Idefix[®] Instagram account **@idefix_rover_mmx**.



A 'terrifying' destination

Phobos: the moon named after the Greek god of fear

MARS



PHOBOS

Doomed

Spiralling towards Mars, Phobos will eventually either crash into it or be pulled into fragments in orbit – giving Mars a ring

Teeny

Averaging ~22 km wide, with almost no gravity, it's a valuable test under low gravity

Close and fast

Orbiting just 6000 km up, approximately three times a Martian day

Dark

One of the Solar System's darkest bodies, it reflects less than 7 % of sunlight

Origins unknown

May be a captured asteroid, debris from a Martian impact or leftover material from Mars' formation

A Martian time capsule

Phobos holds dust blasted from Mars, plus atoms from its lost atmosphere

Mass: 1.06×10^{16} kg (two billionths of Earth's mass)

Gravity: 0.0057 m/s^2 (roughly 1/1700th of Earth's gravity)

Escape velocity: 11.4 m/s (roughly the sprint speed of an elephant)

Surface area: 1640 km² (not even twice the area of Berlin)

Temperature: -170 °C to +70 °C (colder than Antarctica to about as hot as the Sahara)

Grooved

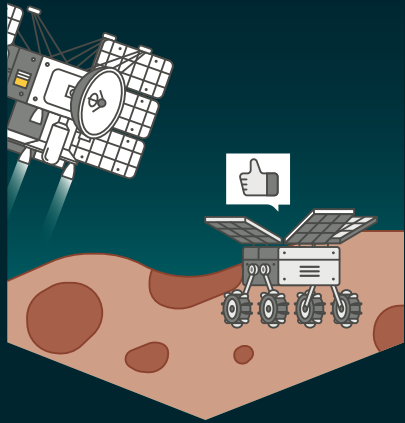
Covered in giant fractures, possibly from Mars' tidal pull or rolling boulders

DEIMOS



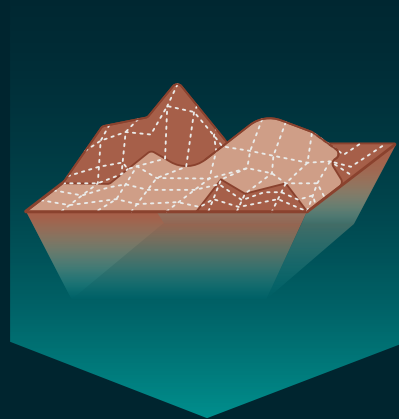
100 days of science

Idefix® will be the first human-made object to land on a Martian moon, Phobos. During 100 days of science, it will:



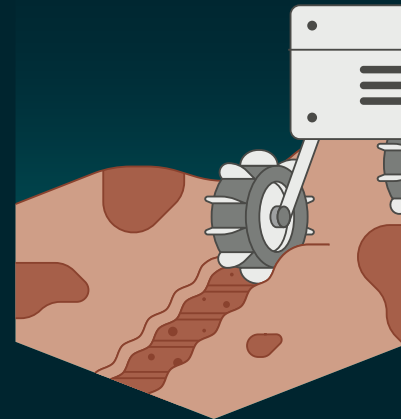
Scout for MMX

Idefix® goes first, reducing the risk for the main MMX spacecraft



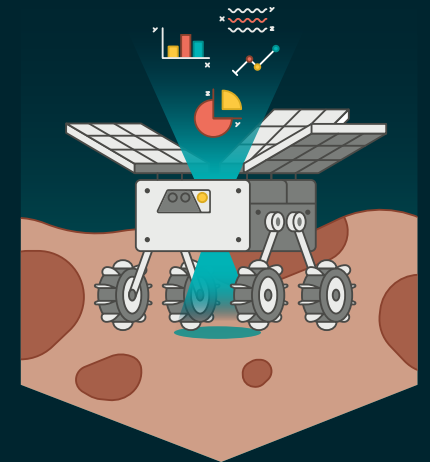
Map Phobos' surface

down to the millimetre, the first ground-level view of the terrain



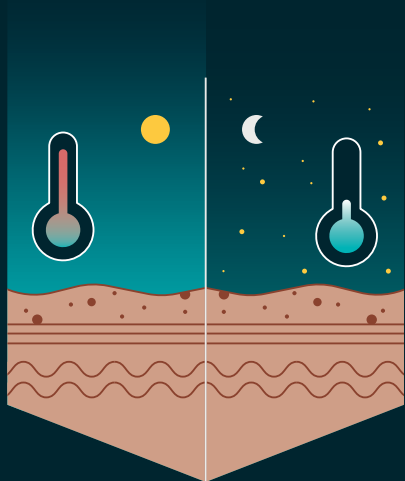
Test the ground

how it grips and sinks, informing MMX's landing and future low-gravity exploration



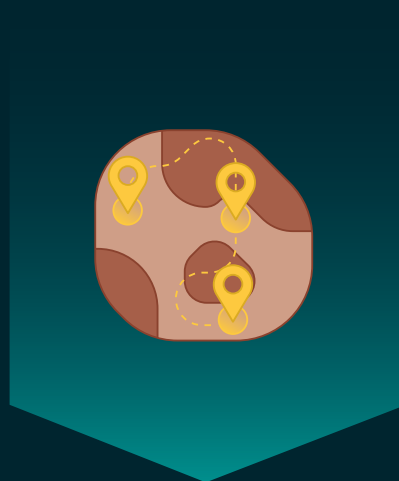
Identify minerals

with the first readings ever taken on Phobos – a clue to its origins



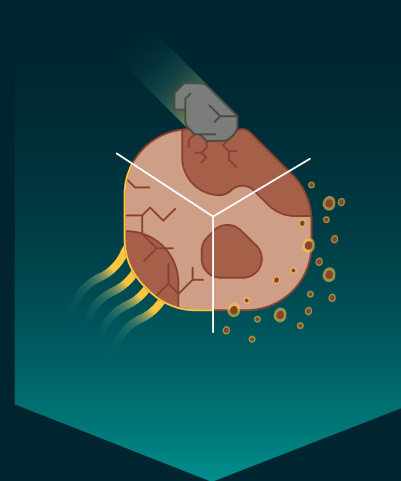
Track the temperature

through a full day-night cycle, revealing whether the ground is fine dust or coarse rock



Check for variation

does one patch on Phobos speak for the whole moon?



Track weathering

how space reshapes a surface with no atmosphere



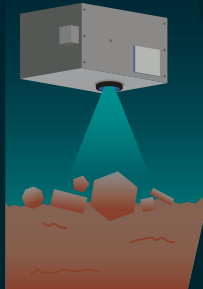
Give context

helping interpret the samples MMX brings home, and what they reveal about Phobos, Mars and planet formation

Idefix[®] instruments

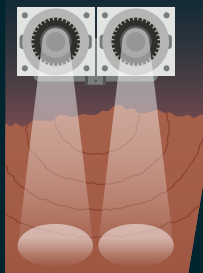


Idefix[®] carries four instruments to study Phobos up close. DLR contributes the two science instruments – RAX and miniRAD – while CNES provides the NavCams and WheelCams used for navigation and surface analysis.



RAX the Raman spectrometer

A spectrometer that **identifies the minerals in the ground** beneath Idefix[®], revealing what Phobos is made of



NavCams the navigation cameras

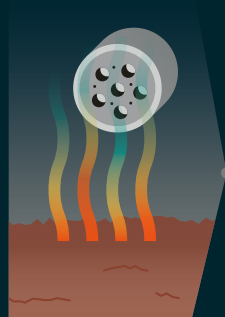
Two cameras side by side atop Idefix[®]'s front panel, tilted downwards

These stereo cameras build a **3D map of the terrain ahead**, guiding Idefix's movement across Phobos



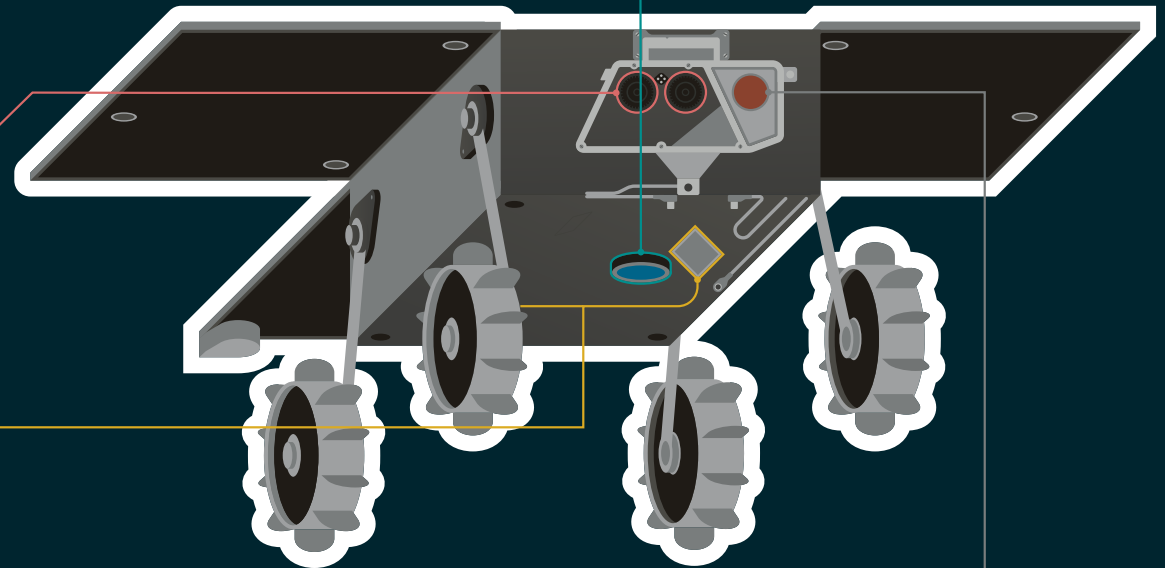
WheelCams

Two cameras placed on Idefix[®]'s 'belly' watch its wheels grip and move over the ground, revealing Phobos' **surface properties** and rover mobility in low-gravity



miniRAD the infrared radiometer

A radiometer that measures Phobos' **surface temperature and thermal properties**, helping to characterise the surface



Engineering Idefix[®]

Landing, standing, exploring in milligravity



The **Mechanical-Electrical-Communication and Separation System** connects Idefix[®] and MMX, then pushes the rover away with controlled speed and direction.

Non-steerable wheels spin at **different speeds**, using 'skid steering' to turn Idefix[®] or an 'inching' crawl for soft or steep ground.

Incredibly low gears provide huge force at a snail's pace of 1 mm/s – any faster risks tipping or bouncing out of control.

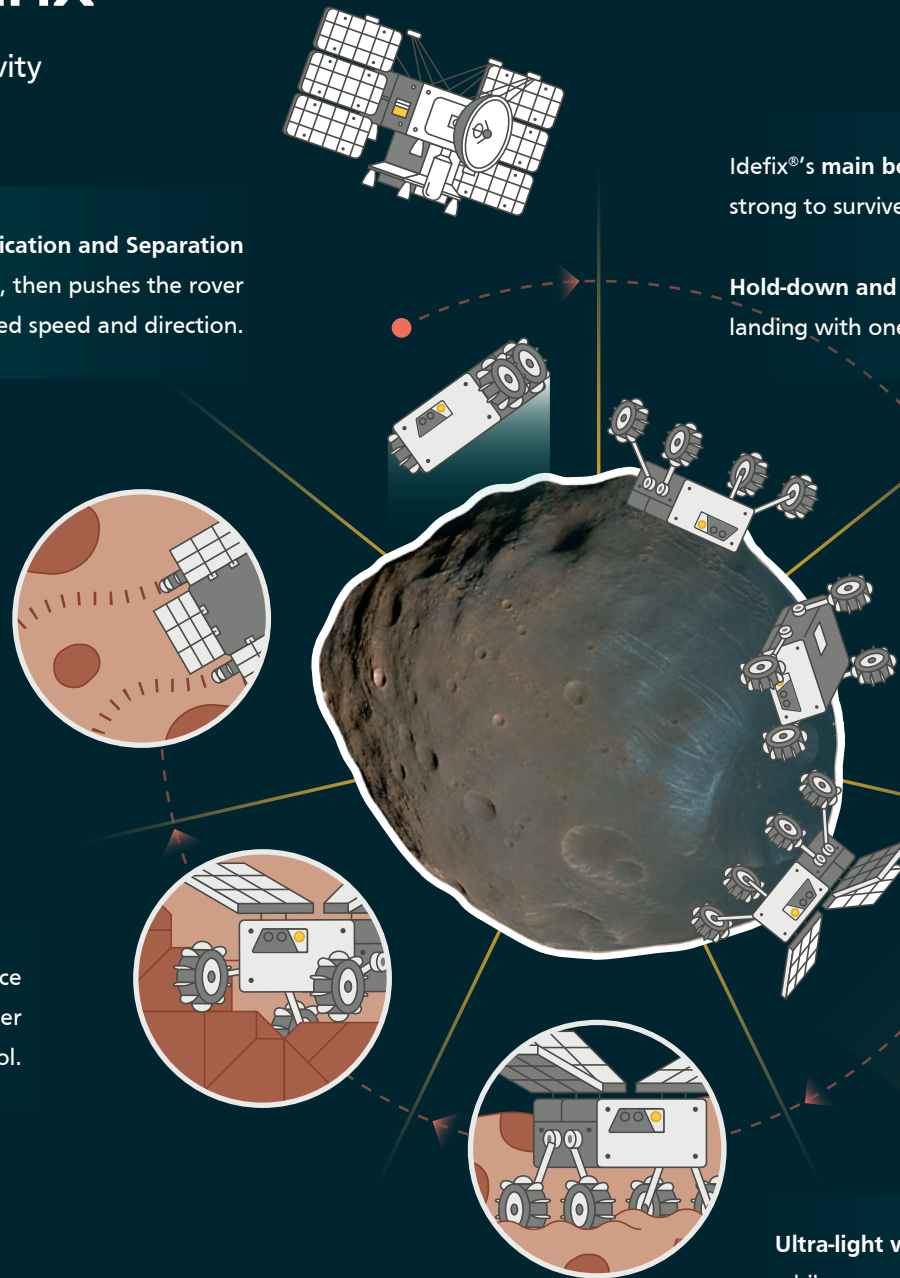
Idefix[®]'s **main body** is made of carbon-fibre panels – strong to survive landing

Hold-down and release mechanisms release legs upon landing with one pulse

In whatever position it comes to rest, Idefix[®] **autonomously rights itself**.

The **locomotion system** of four shoulders, legs and wheels drives Idefix[®] and tilts it toward the Sun.

Ultra-light wheels are strong enough for hard rocks, while curved blades prevent sinking into soft sand.



Engineering Idefix[®]

Testing, thinking, surviving – a long way from Earth



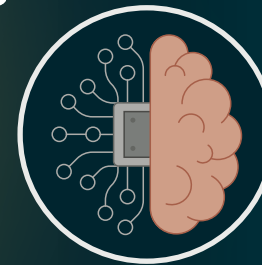
Idefix[®] works with a mix of **autonomy and human guidance**. Operators at DLR (Germany) and CNES (France) send **directions and tasks**, while the rover **keeps itself safe** and powered up. After years of testing and simulations, Idefix[®], from software to wheels, is **ready for the unknown**.

Idefix[®]'s 'brain' has three main software systems:



Plant-like

Like a sunflower, Idefix[®] automatically tilts to **point its solar panels at the Sun**.



Animal-like

A fast onboard chip handles reflexes so Idefix[®] can act on its instincts, autonomously avoiding rocks and other hazards – like the autonomic nervous system, reacting before the brain has time to think.



Human

For longer term mission goals, controllers on Earth send commands to Idefix[®]'s main computer.



Testing

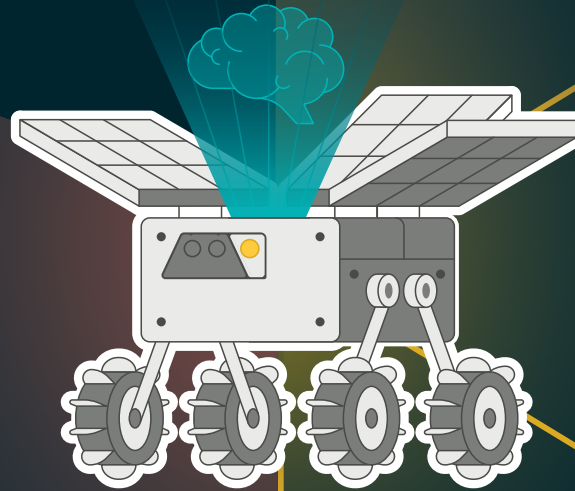
Three prototypes, three years of development, over a kilometre driven in the lab.



Simulation

Detailed computer simulations have tested everything from landing to driving, shaping Idefix[®]'s design.

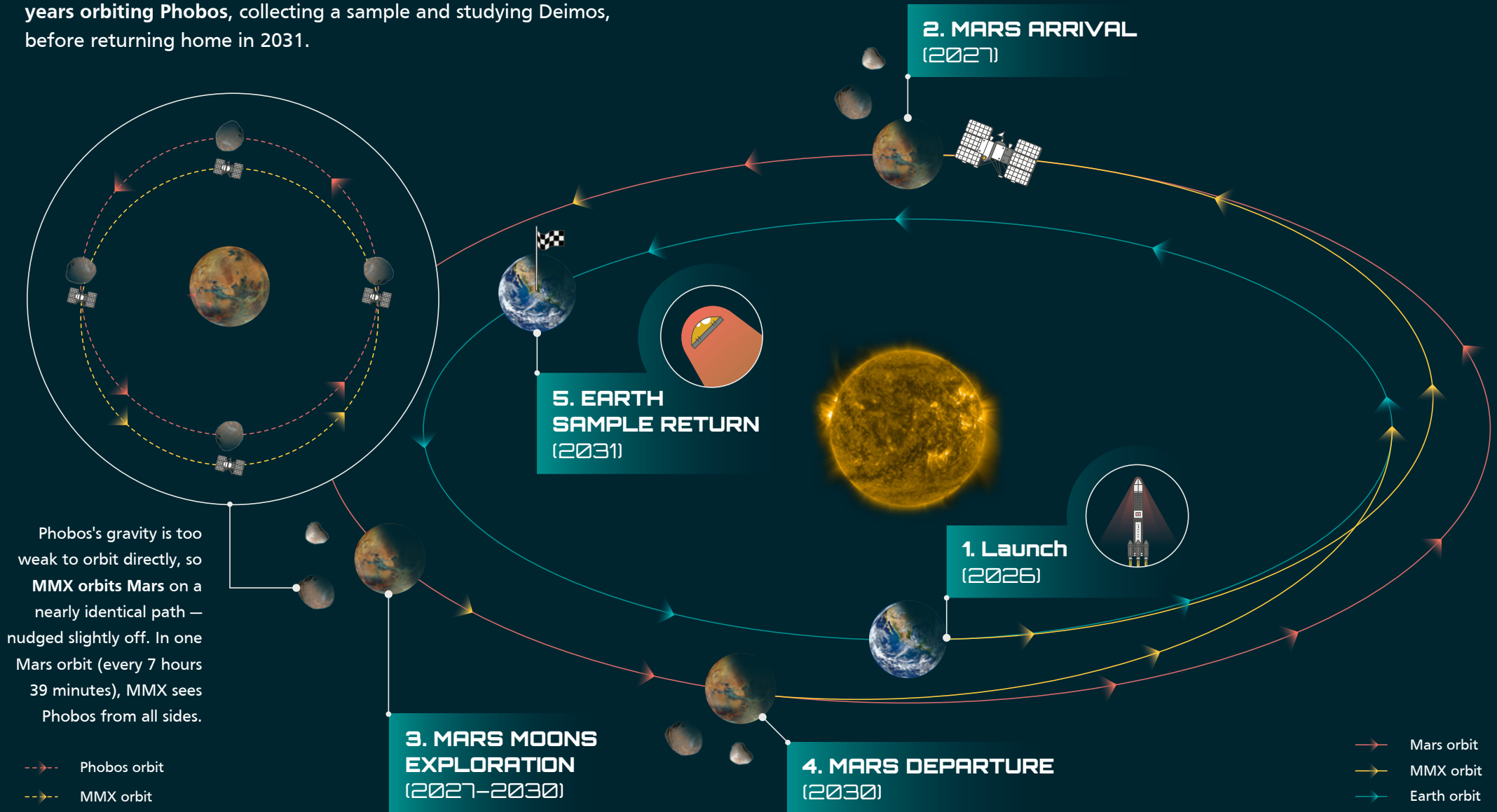
Refined and readied:



Orbiting the Red Planet and its charcoal moon



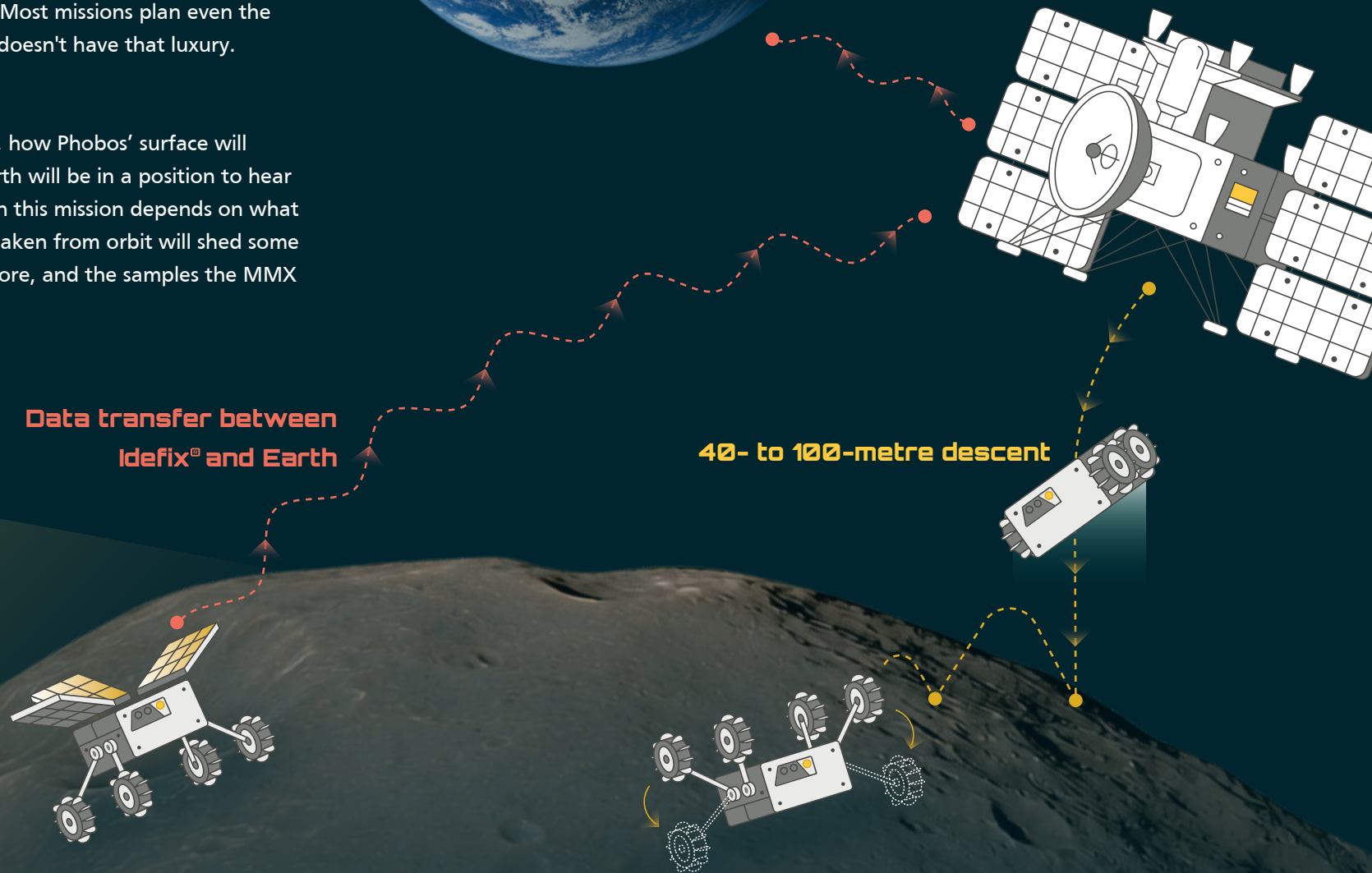
MMX takes less than a year to reach Mars, where it spends three years orbiting Phobos, collecting a sample and studying Deimos, before returning home in 2031.



Approach, descent and landing

"Seven minutes of terror" is how long it took for NASA's Curiosity rover to enter Mars' atmosphere, descend and land – a 14-minute signal delay meant no help was possible from home. Idefix® faces the same isolation, and for its scientists, an even longer wait. Most missions plan even the smallest details years in advance – Idefix® doesn't have that luxury. Phobos is unknown.

We don't know where Idefix® should land, how Phobos' surface will behave beneath it, or when MMX and Earth will be in a position to hear from the rover once it has arrived. Much in this mission depends on what we learn the closer we get. Observations taken from orbit will shed some light, Idefix®'s own landing a great deal more, and the samples the MMX mission returns home, a treasure trove.



Lessons from low gravity

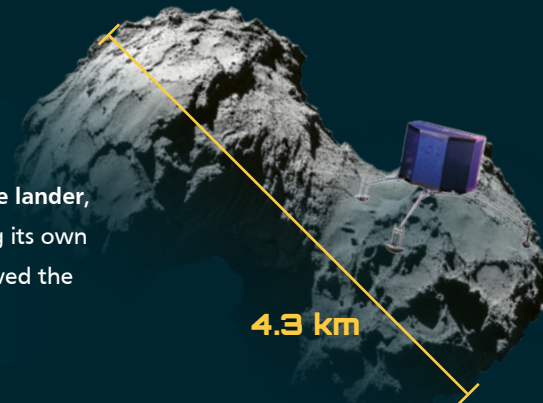
Experience from exploring small Solar System bodies



Landing on a low-gravity body means no atmosphere to slow you, barely any gravity to hold you down, unpredictable ground, extreme day-night cycles, and no time to wait for help from Earth. Fortunately, DLR and CNES have decades of experience visiting some of the Solar System's smallest bodies.

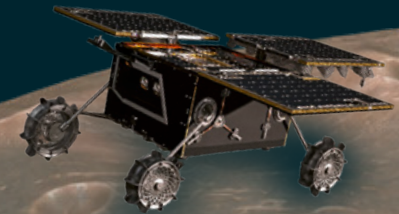
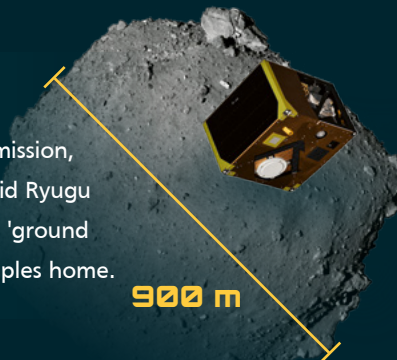
Philae (2014)

DLR led the international team behind the Philae lander, part of ESA's Rosetta mission, with CNES running its own science centre in Toulouse. Together, they achieved the first-ever landing on a comet.



MASCOT (2018)

Built by DLR and CNES for JAXA's Hayabusa2 mission, MASCOT hopped across the surface of asteroid Ryugu with a swing arm, providing scientists with the 'ground truth' for the main mission which brought samples home.



DLR and CNES are feeding all this experience into Idefix® – and making sure that Europe plays a major role in the next stage of Mars exploration. The first landing on a moon of Mars and the first locomotion there will deliver important insights about Phobos. They will also prepare JAXA's world-first sample return from the Mars system.

22 km

Idefix[®] sets the stage for the main spacecraft

The main MMX spacecraft, emboldened by Idefix[®]'s experience and data, will land on **Phobos** and take samples from the doomed Moon. It will then leave, observe **Deimos** and bring its material home. Brave Idefix will be left on **Phobos**, with a front row and lifetime seat in orbit around the Red Planet.

1. MMX main spacecraft safely lands, using Idefix[®]'s first-of-its-kind data from the surface of Phobos.

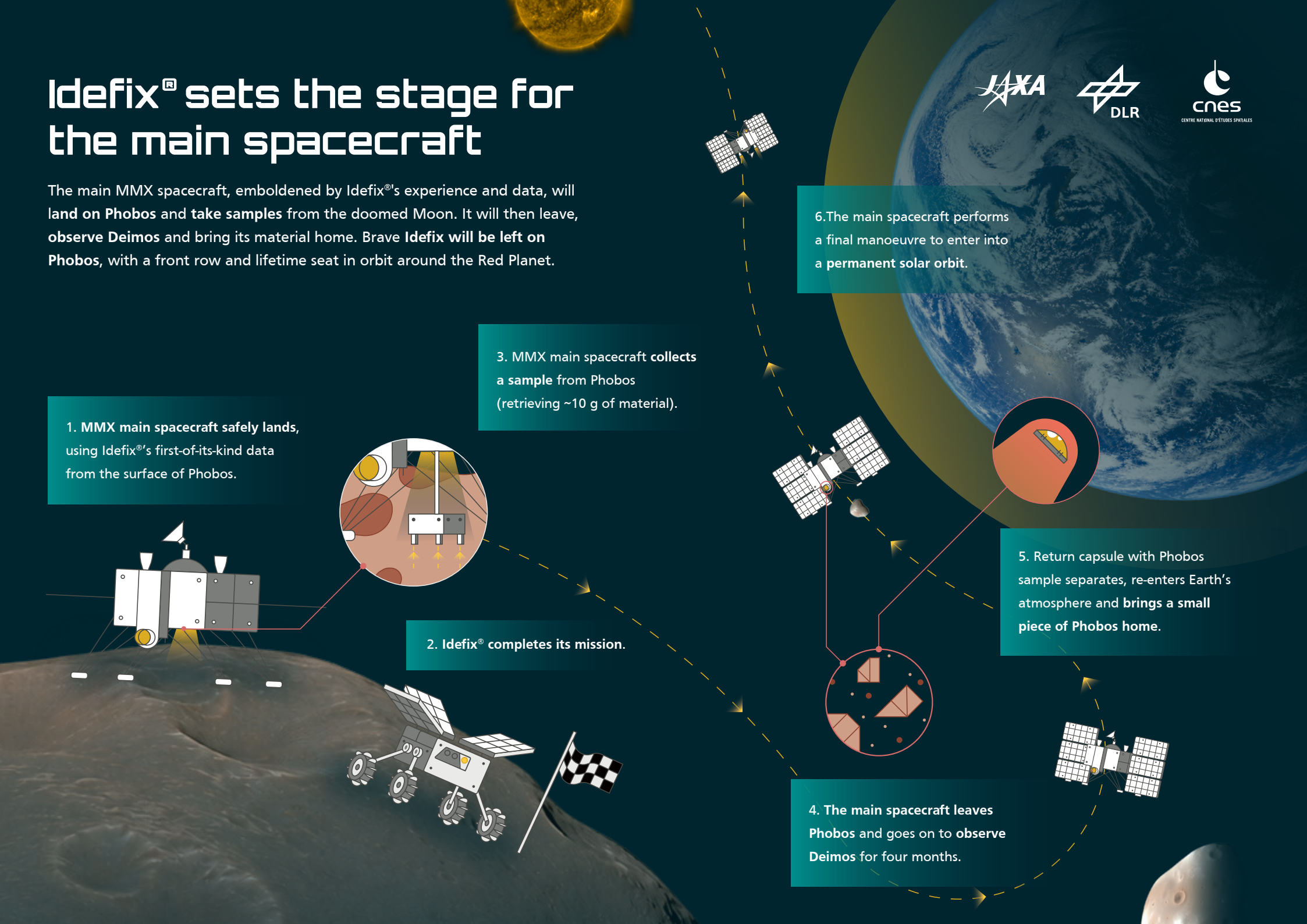
3. MMX main spacecraft collects a sample from Phobos (retrieving ~10 g of material).

2. Idefix[®] completes its mission.

6. The main spacecraft performs a final manoeuvre to enter into a permanent solar orbit.

5. Return capsule with Phobos sample separates, re-enters Earth's atmosphere and brings a small piece of Phobos home.

4. The main spacecraft leaves Phobos and goes on to observe Deimos for four months.



FAQ



WHY IS MMX GOING TO PHOBOS, AND WHY DOES IT NEED IDEFIX®?

The MMX mission aims to solve one of the Solar System's open questions: Where did Phobos and Deimos, the moons of Mars, come from? MMX will study Phobos up close and bring a sample home. This will be the first sample return from the Mars system. The goal is to find out whether the moons are captured asteroids, debris from an ancient impact on Mars or bodies that formed alongside Mars. No-one has landed on Phobos before, so its surface is largely unknown. That's where the Idefix® rover comes in – to scout the ground first, check what it's made of and how it behaves, and where would be safe for the main spacecraft to land and collect its samples.

HOW DO YOU LAND ON – AND DRIVE ACROSS – A MOON WITH ALMOST NO GRAVITY?

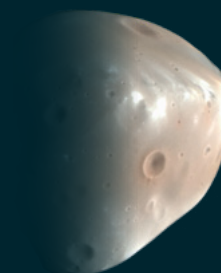
Phobos' gravity is approximately 1700 times weaker than Earth's – this means landing is possible without a 'crash', without thrusters and landing gear. Idefix® is simply dropped from the MMX main spacecraft, 40 to 100 metres above the surface, and falls freely for about a minute before bouncing to a stop. Once down, it rights itself and drives at just one millimetre per second – any faster risks tipping or bouncing out of control. The exact landing site isn't fixed yet: it will be chosen in orbit, using close-up images from the MMX main spacecraft, which will orbit Phobos. Scientists would prefer a spot with gentle slopes, few boulders and strong sunlight.

HAS ANYONE TRIED TO LAND ON PHOBOS BEFORE?

Yes, twice – and neither succeeded. The Soviet Union's Phobos 2 mission reached Mars orbit in 1989, but lost contact before it could release its own landers. Russia's Phobos-Grunt, designed to land and return a sample, never left Earth orbit after a launch failure in 2011. If Idefix® succeeds, it will be the first human-made object ever to land on Phobos.

COULD PHOBOS CONTAIN LIFE, AND DOES THE MMX MISSION NEED TO AVOID CONTAMINATION OF PHOBOS, OR EARTH?

No, on both counts. Phobos isn't considered a place life could have started, so missions there only need minimal precautions against carrying Earth microbes onto its surface. Bringing samples home, MMX has approval for "unrestricted Earth return" – which means no special containment is needed. The one twist: some of the sample may include tiny fragments of Mars itself, blasted onto Phobos by ancient impacts. However, the journey between the two – a violent Mars impact, then years of radiation and extreme heat and cold on Phobos – is thought to sterilise anything along the way.



FAQ



WHO CONTROLS IDEFIX®, AND HOW LONG DO SIGNALS TAKE TO TRAVEL BETWEEN EARTH AND PHOBOS?

Idefix® is jointly operated by DLR in Cologne and CNES in Toulouse. These control centres plan where Idefix® drives and what it measures, and send it its commands. There is no direct link between Idefix® and Earth – every signal passes through the MMX main spacecraft, which acts as a relay. Because Phobos orbits so close to Mars, the delay is much the same as between Earth and Mars: 3 to 22 minutes each way, depending on their positions and whether the spacecraft is in sight of both. That is why Idefix® has to think for itself: landing, uprighting and orienting its solar panels towards the Sun all happen entirely autonomously, without waiting for instructions.

WHAT WILL IDEFIX®'S PICTURES LOOK LIKE?

Idefix®'s cameras are built for navigation and precise 3D mapping. They will take black and white photos, close up of Phobos' surface. The RAX and miniRAD instruments will analyse the ground's minerals and temperature. Together, Idefix®'s instruments will reveal what Phobos is made of and how it's held together – crucial for the main spacecraft's own landing, and a first step toward answering how Phobos and Deimos formed.

WILL IDEFIX® COME HOME?

No. Idefix® will complete 100 days of science, helping the main spacecraft to land safely, collect a sample and depart for Earth. Idefix® will remain on Phobos, and communication will no longer be possible once the main spacecraft has left – Idefix®'s only link to Earth. Phobos itself is doomed: it is slowly spiralling into Mars, and in tens of millions of years it will likely be torn apart.

WHY IS A MISSION LED BY JAPAN WORKING WITH A ROVER BUILT IN GERMANY AND FRANCE?

DLR and CNES have decades of experience in developing landers for low gravity environments. In 2014, the DLR-led Philae lander touched down on 67P/Churyumov–Gerasimenko as part of ESA's Rosetta mission – the first ever landing on a comet, with CNES as a contributing partner. Moreover, JAXA's sample-return mission Hayabusa2 carried MASCOT, a small lander built jointly by DLR and CNES. Idefix® builds directly on these missions and others. With MMX, experts from JAXA, DLR and CNES work together on the safe operation of the entire mission and its successful sample return.

Multimedia



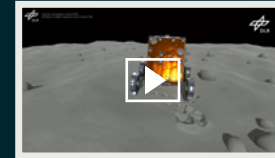
The journey to the
Martian moon Phobos



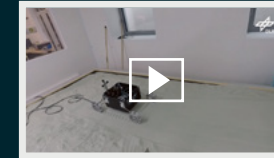
Testing, assembly and
preparation of Idefix®



Teamwork for Idefix®



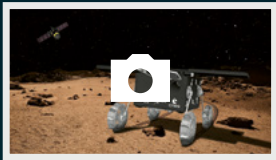
The MMX rover
starts its mission



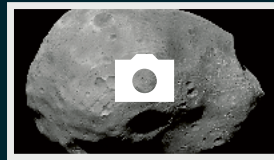
Model of the MMX rover
on the test bench



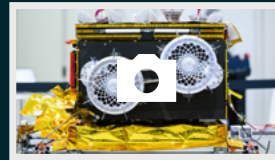
Simulation: Optimising the
wheels of the MMX rover



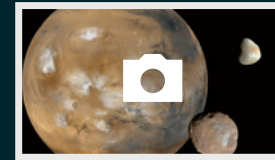
Artist's impression of
Idefix® on Phobos



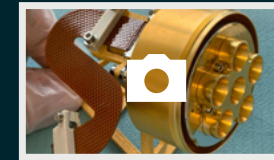
Mars' moon Phobos



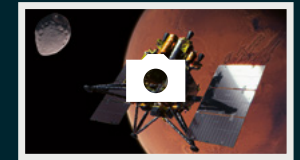
Idefix® side view



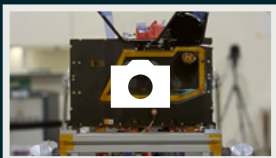
Mars with Phobos and
Deimos



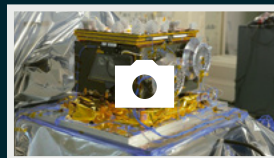
miniRAD radiometer for
Idefix® mission



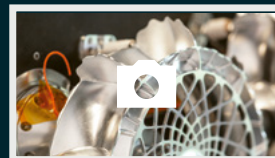
Artist's impression: MMX
spacecraft in Mars orbit



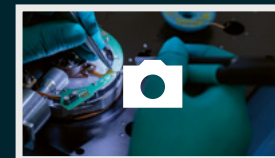
View of the rover's
navigation cameras and
spectrometer



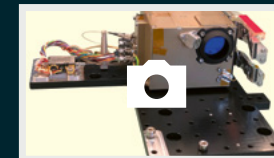
Idefix® during shaker
test in Toulouse



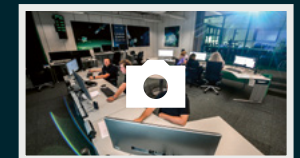
Idefix® wheels



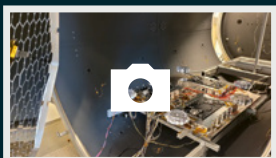
Idefix® shoulder module



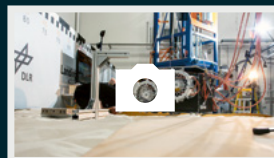
Idefix®'s RAX Raman
spectrometer



The German control
centre for Idefix® rover



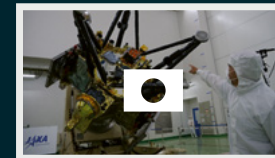
MMX rover during
vacuum tests



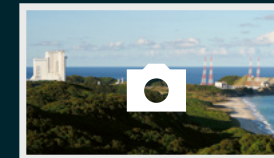
Preparation for Idefix
drop tests



Idefix® ready to be
delivered



Idefix® aboard MMX,
alongside landing and
return modules



Tanegashima spaceport,
Japan



Idefix® logo

More information on the Idefix® project page of the DLR website

Contact us



German Aerospace Center (DLR)

Falk Dambowsky
Head of Media Relations
falk.dambowsky@dlr.de

Centre National D'Études Spatiales (CNES)

Raphael Sart
Head of External Relations and Media
raphael.sart@cnes.fr

Japan Aerospace Exploration Agency (JAXA)

Elizabeth Tasker
Communication
elizabeth.tasker@jaxa.jp

Follow Idefix to Phobos ...

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📷 and via DLR @dlr.en

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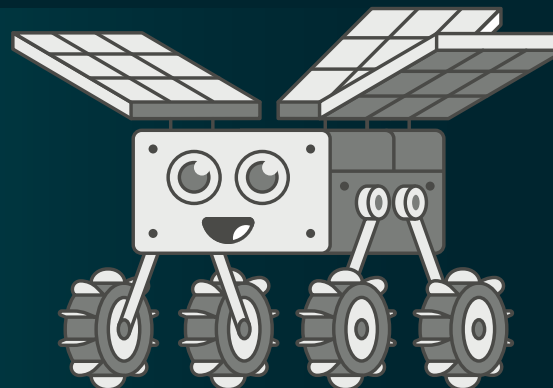
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Hey! I am sharing
my journey up close
on my Instagram!

... and on the DLR website