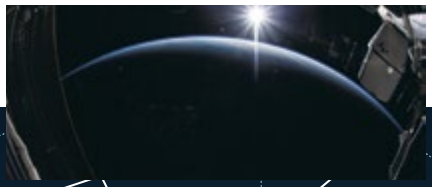
SPACEWALK

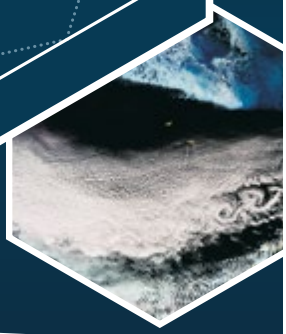
THE CUSTOMER MAGAZINE OF THE OHB GROUP

SpaceDataHighway: OHB's second geostationary satellite complements EDRS laser communication system

Fascination and benefit: Marco Fuchs speaks about the importance of Earth observation from space

Copernicus: Independent infrastructure for the delivery of high-quality data for climate protection and security





DIVERSITY IN TIME AND SPACE:

The whole range of OHB's universe

2018

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Dear reader,

Leaving our planet and viewing it from above is a spectacular and, at the same time, fascinating sight that has become possible with space technology. From above, you can appreciate the sheer vulnerability of this tiny blue speck against the backdrop of the universe. The awareness of this vulnerability and, associated with this, the need to observe the changes on the Earth even more effectively and precisely have been heightened through human space flight.

Satellite technology is indispensable for this purpose. What's more, it makes it possible to gain new insights into the condition of the Earth in the first place by collecting data and facts. In this sense, Earth observation helps us to learn more about the Earth and perhaps find out more effectively and swiftly where it is heading. For this reason, I am also convinced that the environment, including the weather and the climate, will gain enormous importance in the long term. Environmental monitoring from outer space will assume a dimension that we cannot even imagine at this point in time. It will acquire a permanence and complexity that will clearly distinguish it from all other areas. Reconnaissance involves three or four imaging sensors, such as high-resolution electronic optics, radar and infrared. Much more is involved when it comes to monitoring the environment. I think that in the future we will develop and deploy innovative sensors with compatible satellite constellations in order to satisfy the social mandate.

Once again, space technology is at the service of humankind. I am both proud and delighted that OHB can use its expertise in Earth observation technology to contribute to preserving our planet in the long term.

Best regards,
Marco Fuchs

2019

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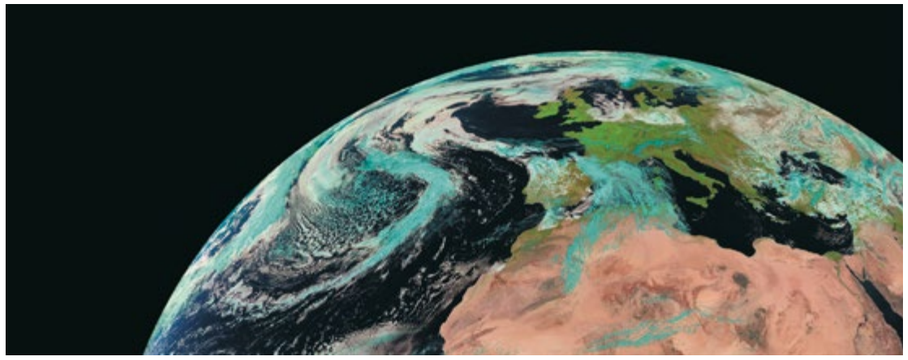


Why Earth observation from space is so essential.

Marco Fuchs has been CEO of OHB SE since 2000 and CEO of OHB System AG since 2011. Born in 1962, he is a lawyer and has been with OHB since 1995. In an interview with the Head of Communications, Günther Hörbst, he spoke about how satellites are helping us to learn more about the Earth.

The return of German astronaut Alexander Gerst from the ISS has once again sparked enthusiasm for space. Where does this fascination come from?
It stems from the fact that with space flight it became possible for humans to leave Earth. That's what's so spectacular about the things that astronauts do. They see the Earth as a whole from above. From space, the vulnerable entirety of our small globe becomes evident. This impression is reflected most vividly in the now iconographic photograph taken by the crew of Apollo 8, who captured the rise of the Earth above the horizon of the Moon in 1968. This picture and Neil Armstrong's first step from the Eagle Lunar Module on the surface of the Moon in July 1969 are the images that epitomise the fascination of space most emotionally. Hardly anyone is left untouched.

After his return, Gerst shot a very emotional video in which he apologised to his unborn grandchildren for the way humanity has been treating the Earth. This emotional appeal was triggered by what is known as the overview effect – the view from space on all of humanity. Is it conceivable that with Earth observation satellite technology this effect could spread to all people, thus arousing greater awareness of our planet's vulnerability?
The emotional element comes from the awareness of Earth's vulnerability. And particularly the realisation that we are all dependent on this one small dot in the vastness of space. In addition, knowledge and a realisation of the things that we actually already know are rendered more tangible through a visual impression. This one single image of the Earth instantaneously shows what is at stake.

Planet Earth from the perspective of an MSG weather satellite.

What is the greatest benefit of Earth observation?
You get the facts straight. Our culture is based on knowledge and on empiricism. You admit that you don't know everything, that observation brings further insight and that this insight may possibly change your behaviour. In this sense, Earth observation helps us to learn more about the Earth and perhaps find out more effectively and swiftly where it is heading. The deeper purpose of space activities in this case is to do this on a larger scale. And great authority can be derived from this. In the end, it always boils down to proving or disproving forecasts or theories. To this end, you have to observe and collect facts. This applies at least to the environment and the climate. In the case of satellite-based reconnaissance, it is perhaps more important to depict reality in a confi-

dent and independent way in order to know what is true. Political and, if necessary, military decisions are then made on this basis.

Which of these areas is most important for OHB?
For a long time, satellite-based reconnaissance was the most important area for OHB. SAR-Lupe was a project that catapulted us into a new league. That was about 18 years ago. If you take a look inside our facilities at the moment, you will see that our activities mainly focus on satellites for weather observation. In the long term, the environment, including the weather and climate, will certainly be the most important area.

And what developments do you see for Earth observation as a whole?
It will advance disparately in a cycle of innovation. Reconnaissance tells us about the status quo. Weather observation provides information about today, tomorrow and the day after tomorrow. However, environmental monitoring will face the question as to how long-term developments are to be assessed and influenced.

Astronaut Alexander Gerst filmed this sunrise from the ISS.

Does this mean that OHB is making a contribution to protecting and preserving the planet in the long term?
Yes it is. The purpose of all space activities is to derive benefits for the Earth. When we monitor the environment, we seek to preserve the Earth.

And the benefits for humanity? Do you think that they will be generally acknowledged in day-to-day life?
As far as weather observation is concerned, there's no doubt that this is the case. That's the most everyday form of information that you can currently get. And many older people still remember that for a long time the weather forecast had more to do with fortune telling than with empiricism. Today it's completely different. Weather forecasts have become reliable. They have become a science that provides precise predictions. In short, the weather is the most important day-to-day question that interests everyone. Everyone, in all cultures, in all situations, is interested in the weather.

That sounds like a permanent business model.
This is what I firmly believe. Weather observation will still be very, very important for a very, very long time to come. Business in satellites in this area will benefit from this because weather observation satellites have become much better in recent decades. The question is always the same: what can we observe, what insights can we gain and what can we deduce from them? From this point of view, space activities have contributed much to weather forecasting; by the same token, however, the weather has also brought a lot to space activities.

The next generation of weather satellites, MTG, is currently being built at our facilities. What major advances have been achieved?
There are imager and sounder satellites. In the case of imager satellites, the aim is to improve imaging capabilities significantly. However, the sounder satellites are where the real progress is being made. Profile measurements in the vertical plane are now possible, enabling the three-dimensional acquisition of atmospheric data. This innovation permits a more accurate long-term forecast and it will also be possible to predict local weather events with greater precision.

In November, at the ESA Council of Ministers conference, a decision will also be taken on the European Earth observation mission Copernicus. OHB is currently involved in the mission with a total of five feasibility studies. How important is Copernicus for OHB?
Very important. So far, we have only been involved in the programme via a limited share of the Sentinel 4 project. There's great future potential for us. From a strategic point of view, it is the largest new field for OHB that we intend to tap.

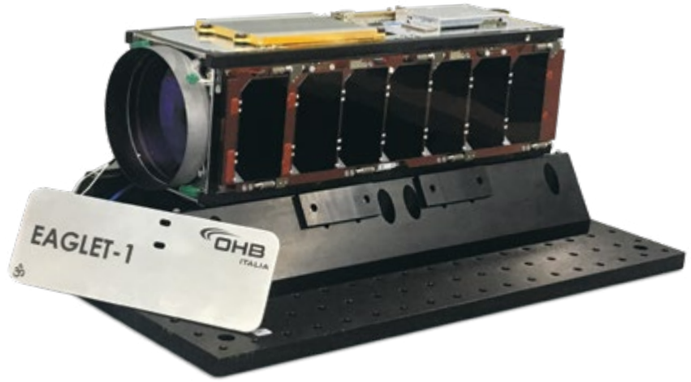
What is the goal for OHB with Copernicus?
We would like to become the system leader for two out of six possible new missions and take on a substantial role in two more, for example payload responsibility.

Another ambitious but very complex project is the EnMAP environmental satellite. There have been many mainly technical problems and delays. In the meantime, however, the project is nearing completion. Are you pleased?
Yes, because it shows that at our company we have the courage to tackle things that have never been done before and that we have the stamina to find solutions to enormous challenges. In this respect, I am very pleased, especially since a similar satellite – PRISMA from our subsidiary OHB Italia – has already been completed.

What was the challenging aspect of EnMAP?
The observation instrument of the satellite is a brand-new development and from this point of view technically enormously challenging. The project was considerably more difficult than we had thought at the beginning. But it has developed enormously over the years. What was originally a simple small satellite has become a very complex medium-sized satellite – both technically and financially.

EnMAP is a hyperspectral satellite. What does that mean?
Hyperspectral means that data is recorded in 20 to 250 spectral channels, ranging from ultraviolet wavelengths to long-wave infrared. Measurements from space were previously not possible with the accuracy that we can now achieve with EnMAP. There are only two projects in the world for which hyperspectral satellites of this complexity are being developed and built – and both of them are being executed at OHB.

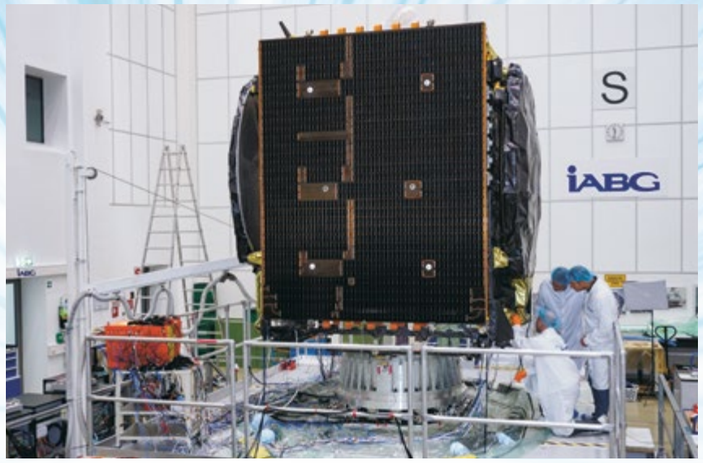
What does this technological lead mean strategically?
This technology delivers high-quality data for environmental monitoring. Hyperspectral technology allows conclusions to be drawn about dynamic environmental influences. It is about being able to make qualitative statements on, for example, the development of soils or vegetation.

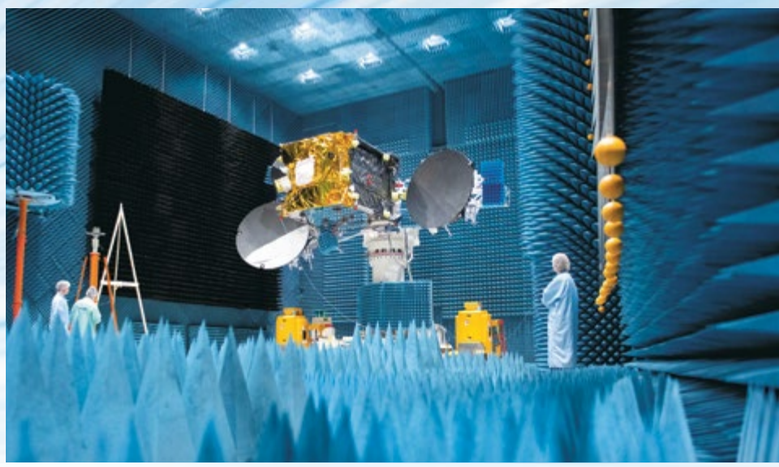


The EAGLET 1 is a satellite of the class under ten kilograms. It was developed and built by OHB Italia.

What projects are the most important for OHB in the area of reconnaissance?
SAR-Lupe has been running very successfully in full operational mode for over eleven years without even the slightest failure. The follow-up system SARah is currently being implemented and has reached an advanced stage of development. We also have two important projects for Germany and Luxembourg in the field of high-resolution electro-optical reconnaissance. We would also like to work with the Italian government on our EAGLET series of small satellites. EAGLET 1 was successfully launched at the end of 2018 and EAGLET 2 is currently being built for the Italian Ministry of Defence.

What potential can you see when you consider the environment and climate?
As far as weather satellites are concerned, we are looking at the imager and sounder satellites that are part of the MTG project. Our third contribution in the weather segment is the microwave imager (MWI), which will be assembled by OHB Italia as a further payload for the future polar-orbiting European weather satellites. With respect to the environmental satellites, I would mention Sentinel 4, our contributions to the FLEX payload, EnMap, PRISMA and the new Copernicus missions. Our main focus is of course on the upcoming Copernicus missions. Being a part of this project on a reasonable scale is the most important thing for us.





Destination: **Space**
Mission: **Relaying Data – Fast & Secure**

OHB's second geostationary satellite to enhance the performance of Europe's SpaceDataHighway

OHB System AG is the principal contractor for the development and manufacture of the EDRS-C satellite, the second node for the European Data Relay System (EDRS), which is also referred to as the SpaceDataHighway. EDRS-C is the second telecommunications satellite by OHB and is based on the company's proven SmallGEO platform.

"We are proud to contribute to the European laser-based data relay system that will establish a new standard in space-based communication," said Marco Fuchs, CEO of OHB SE. "Our first SmallGEO satellite, Hispasat 36W-1, heralded our debut as a satellite provider for the telecommunications market; with EDRS-C we intend to strengthen our position in this segment."

EDRS-SPACEDATAHIGHWAY: THE BASICS

The SpaceDataHighway is the world's first "optical fibre in the sky" based on cutting-edge laser technology. EDRS will be a unique system of satellites permanently fixed over a network of ground stations designed to relay data between low Earth orbiting satellites and the EDRS satellites in geostationary orbit using innovative laser communication technology, and to send the data down to ground stations based in Europe. For the inter-satellite link between low Earth orbiting satellites and the EDRS satellites, laser communication terminals – developed and built by Tesat-Spacecom in Germany – are used for high data rate requirements, while a set of K_a-band RF terminals is used for the high data rate links between the EDRS satellites and the ground stations.

The EDRS-C satellite is based on the modular SmallGEO platform design developed by OHB System AG as part of ESA's Advanced Research in Telecommunications Systems (ARTES) programme. "With the EDRS-C satellite, we realised the first satellite with dedicated optimisation for optical communication. We modified the SmallGEO satellite platform to meet the specific requirements of this mission. Design adjustments were made, for instance, to accommodate the special and demanding requirements of the optical payload. In addition, the modular TM/TC subsystem has been extended in order to operate in the S and K_a band. In addition, secure encryption electronics have been installed," explained Dr Stefan Voegt, EDRS-C project manager at OHB System AG. "Our satellite EDRS-C performed well in the extensive test campaign that stretched over several months and backs our approach to offer customers a modular and versatile satellite platform."

SPECIAL PLACE IN SPACE

"EDRS-C will be shipped to the launch pad in Kourou in French Guyana five to six weeks prior to launch. The satellite is scheduled for a launch on 24th July 2019 on an Ariane 5. The Airbus satellite's operational position is at 31° East, roughly 36,000 kilometres above the equator," said Dr Voegt. "The geostationary position allows data from LEO satellites equipped with dedicated laser terminals to be accessed by the end users in close to real time."

EDRS FOR TIME-CRITICAL AND SENSITIVE INFORMATION

EDRS will provide encrypted data transmission in broadband quality in near- and quasi-real time. Emergency response teams and security services can thus use EDRS to gain much faster access to Earth observation satellite data. User groups include the European Copernicus programme that provides environmental monitoring and climate change services, the European Columbus Module of the International Space Station, government security services, emergency response teams and maritime surveillance as well as weather forecasting authorities. "I am always pleased when our efforts and the expertise of our employees result in a space system useful to a large number of people in Europe and worldwide. EDRS-C is another satellite project fulfilling this criterion," added Marco Fuchs.

TEAM PLAYERS

"We developed and built the satellite under a contract with Airbus Defence and Space. Aboard our satellite is a data relay payload with a laser communications terminal for satellite-to-satellite links supplied by our partner Tesat-Spacecom. The hosted payload HYLAS 3 was provided by Avanti Communications under a contract with ESA as a customer-furnished item to OHB. We, in turn, contracted the test house IABG for the satellite's environmental test campaign," explained Dr Voegt. EDRS is a public-private partnership between the European Space Agency (ESA) and Airbus Defence and Space. EDRS-SpaceDataHighway is supported by the German Space Administration at DLR with funding from the Federal Ministry of Economic Affairs and Energy (BMWi) and the Federal State of Bavaria. Together with its sister company OHB in Bremen, LuxSpace is responsible for the TT&R subsystem which transmits information on the conditions of vital satellite systems to the ground stations. MT Aerospace delivered structure panels.

The satellite was thoroughly checked in the course of the environmental test campaign – e.g., in the space simulation chamber, in the vibration and sound laboratories and in the CATR facility. All to ensure that the SmallGEO satellite will withstand the stresses and strains during launch and the conditions in space.

Would you like to learn more about the SmallGEO platform and our further SmallGEO satellite projects?

FINAL COUNTDOWN
TO THE RED PLANET

Mars has been inspiring human imagination for centuries. Today, in addition to the many myths, there are also a wealth of scientific findings concerning our neighbouring planet. The ongoing ExoMars programme is making a significant contribution to this, and OHB is on board.

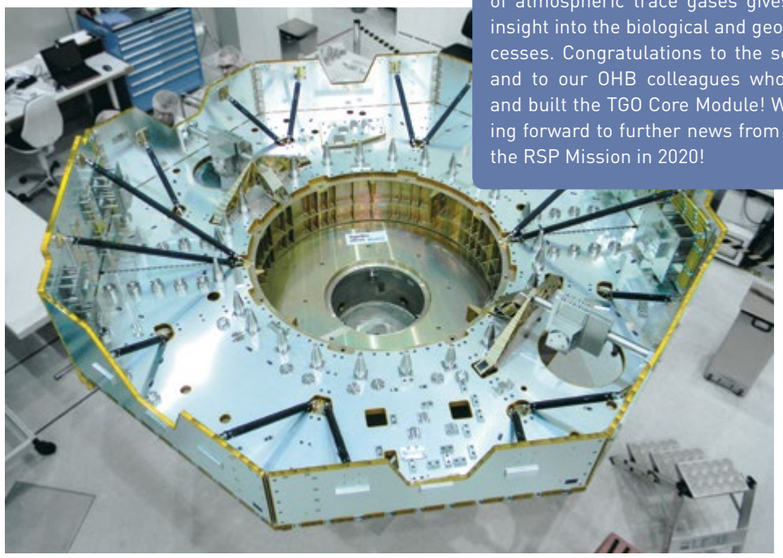
ExoMars, a cooperation between the European Space Agency (ESA) and the Russian space agency Roscosmos, focuses on searching for traces of life on the Red Planet. The first part of the ExoMars mission, a Trace Gas Orbiter (TGO) and an entry and landing module, was launched in 2016. As a subcontractor to Thales Alenia Space, OHB System was responsible for the TGO's core module, the largest German contribution to the mission. Part 2, a carrier with landing module and rover, is planned for 2020. The carrier, which has been built by OHB in Bremen, will carry the Russian landing module from the space company Lavochkin the around 530 million kilometres at that time to our planetary neighbour.

OHB led a core team with partner companies RUAG, Switzerland, its Belgian sister company Antwerp Space and Thales Alenia Space, UK. Together, they supply the structural model, an electronics test stand, the X-band communication system, the flight model as well as spare parts, various items of ground equipment and mathematical simulation models.

In addition to the carrier, OHB is also contributing key elements for the Mars Rover, which was developed by Airbus Defence & Space. The experts at OHB's "Optics & Science" space centre in Oberpfaffenhofen will be contributing their expertise in selecting, preparing, distributing and analysing the soil samples taken at depths of up to two metres. They developed a high-resolution camera, a complex system for sample preparation and distribution housed inside the rover and contributions to the RAMAN/RLS laser instrument, which allows mineralogical investigations to be carried out on site.

The launch with the Russian launcher Proton from Baikonur is planned for July 2020. Agencies, engineers and scientists expect initial results from the mission in April 2021.

"We are delighted with the first results from the Trace Gas Orbiter" (Håkan Svedhem, ESA's TGO project scientist) And so are we at OHB! Orbiting the Red Planet, TGO's analysis of atmospheric trace gases gives scientists insight into the biological and geological processes. Congratulations to the scientists! … and to our OHB colleagues who developed and built the TGO Core Module! We are looking forward to further news from TGO and to the RSP Mission in 2020!

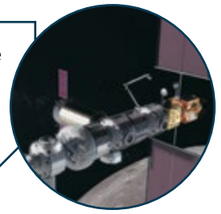


ONE SMALL STEP FOR (A) MAN

The 21st of July 2019 marks the fiftieth anniversary of the first crewed Moon landing. At that time, the exploration of Earth's only natural satellite was driven by the Cold War; it was not about science, but about demonstrating technical superiority. 50 years later, the idea of exploration has come back into focus. At OHB, this idea is a deep-seated tradition.

The OHB subsidiary MT Aerospace develops and manufactures parts of the fuel tanks for NASA's Space Launch System, a future heavy-duty rocket for missions to the Moon, Mars and distant planets.

Through its subsidiary OHB Sweden, OHB has a stake in the Orion Multi-Purpose Crew Vehicle, which will, among other things, take the next NASA astronauts to the Moon. OHB Sweden integrated and tested the propulsion qualification model for the spacecraft. The model was then transported to the USA, where preparations for its maiden flight to the Moon are currently under way.



Like the ISS, the Lunar Orbital Platform-Gateway is to be modular in design. Unlike the ISS, the Lunar Orbital Platform-Gateway will be constructed in lunar orbit. OHB is involved in the development of the European ESPRIT module, which will supply the gateway with fuel and enable telecommunications with the lunar surface.

OHB is cooperating with IAI (Israel Aerospace Industries) and the US space company Blue Origin on lunar landing systems. Together with IAI, a landing system is to be offered for European use. The concept is based on the Israeli lander "Beresheet". In cooperation with Blue Origin, a landing device is to be brought to the Moon as part of the Blue Moon mission. The transport of several tons of freight is also planned.

In preparation for prolonged crewed missions to the Moon and Mars, OHB is working continuously on the topic of sustainability at various locations. These topics include the use of resources available on other planets to generate oxygen or energy as well as the on-site production of structures using 3D printing. In addition, OHB has been working on the development of autonomous ecosystems capable of withstanding the gravitational and radiation conditions of the Moon and Mars since 2010.

Space pioneers at OHB

Why Business Development Manager Andrea Jaime says “I love my job!”

A career in space doesn’t have to stay a dream. OHB is always on the lookout for new pioneers all around the entire world and in all corporate segments. In this interview, Business Development Manager Andrea Jaime described her personal impressions of her dream of a “space job”.

The aerospace engineer Andrea Jaime, in her early 30s, has known ever since she was a little girl that her passion is space, so all her education and professional trajectory has been focused on developing her expertise in the space sector. In addition to her Master’s in aerospace engineering, she is a graduate of the International Space University. She then moved to ESTEC, to work as a young graduate trainee in the human space flight department. Although she started to appreciate the importance of space policy, as an aerospace engineer she missed the technical component in her day-to-day work. In 2015, she found her perfect job at OHB System AG. Working here as a Business Development Manager allows her to demonstrate her expertise in space policy, strategy, programmatic and business development while remaining close to the technical projects and teams.

Apart from this, one of the things Andrea really appreciates at OHB are the opportunities that our company gives each employee. “Each of us can contribute to the current growth of the company. I feel that my voice is heard within the company and my inputs are passed on and followed up.” One example of this is the “OHB NextGen”, a group of young professionals initiated by Andrea Jaime. “This internal initiative brings the OHB young professionals together to share ideas and recommendations with our board members. The aim is to adapt the current processes in our company and design a better future. OHB has still a lot to offer to the space sector in Europe and worldwide, and I am really looking forward not only to seeing this, but also to contributing to it actively. I love my job.”

However, a short break at OHB is also possible as a Business Development Manager: Andrea is then taking care of her two-legged “project”.

Meet Andrea Jaime in this video:

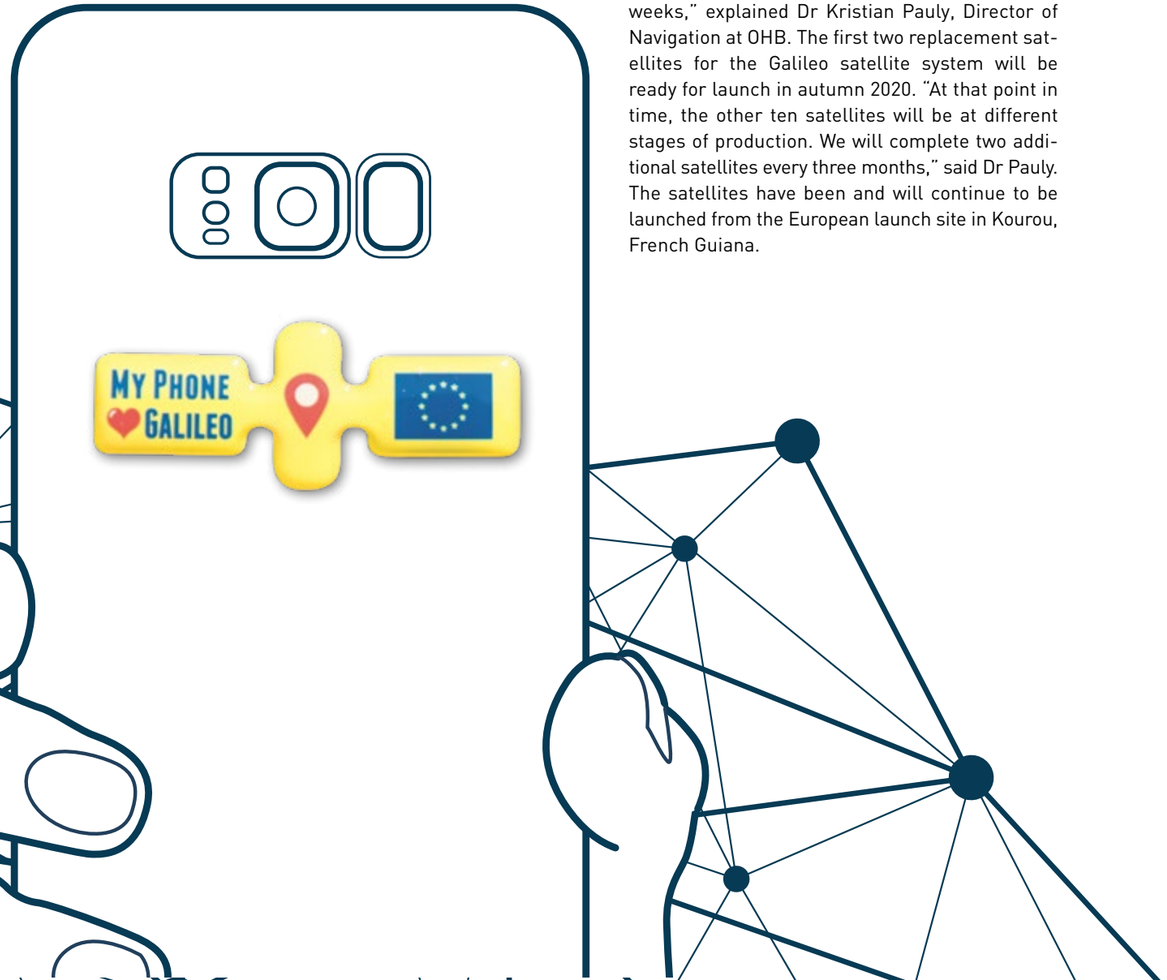
Trailblazing & smart

Europe's navigation system Galileo is in operation. The development of the high-precision service continues. Technical innovations in OHB's design lead to higher positioning accuracy compared with other systems.

They come from OHB and perform their reliable service in space at an altitude of around 23,000 kilometres: we are talking about the Galileo FOC* satellites. 22 of them are currently in extraterrestrial service. They enable citizens in Europe and all over the world to make use of a large variety of helpful navigation applications. Moreover, thanks to Galileo, Europe managed to gain its independence from other global satellite navigation systems like GPS and GLONASS. As of 2020, replacement satellites will be made available to the Galileo constellation** – likewise "made by OHB". ESA's Director of Navigation, Paul Verhoef, praised the performance of our team with these words: "OHB has done a tremendous job in delivering quality satellites in record time. We wish to thank all their teams for their dedication and are looking forward to continuing this partnership."

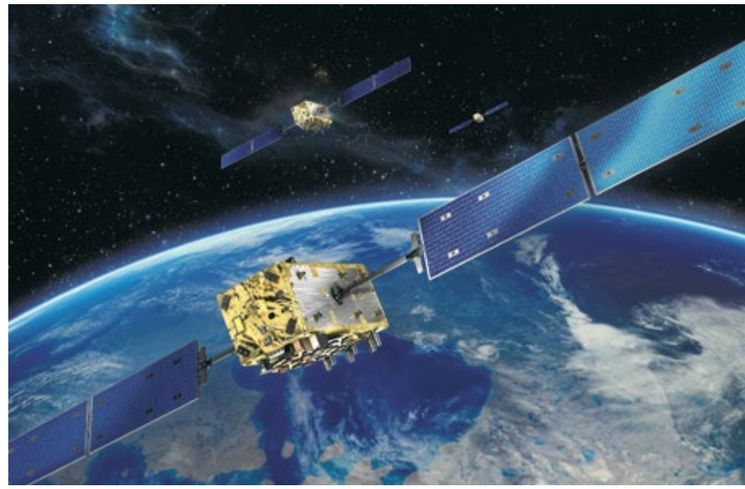
SERIAL PRODUCTION IN FULL SWING

In a total of three bidding rounds, OHB has so far been able to assert itself as the manufacturer of the satellite platforms and system leader and has been commissioned by the European Space Agency (ESA) to develop, build and test a total of 34 Galileo satellites. The team is working at full speed on the final order for twelve satellites: "We took up serial production at our production islands again in December 2018. We now intend to take up production of a further satellite every six weeks," explained Dr Kristian Pauly, Director of Navigation at OHB. The first two replacement satellites for the Galileo satellite system will be ready for launch in autumn 2020. "At that point in time, the other ten satellites will be at different stages of production. We will complete two additional satellites every three months," said Dr Pauly. The satellites have been and will continue to be launched from the European launch site in Kourou, French Guiana.



SERVICES FOR THE POPULATION

Europe's own global navigation system Galileo makes various services available for positioning, navigation and timing. In its final configuration, it will comprise 24 satellites arranged at three levels plus reserve satellites and a worldwide network of tracking (earth) stations. The first services were made available in December 2016. Each satellite newly integrated into the satellite constellation enhances the stability and speed of the system. The development of the high-precision service continues. At present, there are more than 70 types of smartphone able to receive Galileo signals available in Europe, and more than 500 million Galileo devices had been sold by October 2018. The latest smartphones available receive not only GPS and GLONASS, but also the open navigation service on offer to the public at large.



INFO

Our Galileo development team was honoured by the German Society for Aeronautics and Astronautics (DGLR) for outstanding achievement in the conceptualisation and realisation of the system with the Wernher-von-Braun Award.

* The phase until reaching full operational capability (FOC) of the Galileo programme is being funded by the European Union. The European Commission and the European Space Agency (ESA) have signed a transfer agreement providing for the ESA to act on behalf of the Commission as the entity responsible for development and procurement. The views expressed here do not necessarily constitute the positions of the European Union or ESA. Galileo is a registered trademark owned by the EU.

** The present constellation comprises IOV (In-Orbit Validation) satellites and FOC (Full Operational Capability) satellites.

A vulnerable speck of dust in space

How can Earth be protected from asteroid impacts?

The Hera probe is part of a planetary defence mission.

In addition to the Sun and the planets with their moons, there are countless small bodies like asteroids, meteoroids and comets drifting through our solar system. Some of them cross Earth's orbit. These objects, also known as NEOs (near-Earth objects), are observed worldwide by teams of experts. The observation and classification of NEOs serves scientific purposes as well as the protection of Earth. "Every year, we discover around 1,000 new asteroids in our solar system," explained Marc Scheper, Head of Space Transportation, Robotic Missions and Exploration at OHB. "But even if we were to discover a body of a dangerous size on a collision course today, space agencies would not be able to react spontaneously. Their response would require careful planning and prior technological testing in space in order to launch an effective asteroid defence mission."

For this reason, the targeted search for NEOs forms part of ESA's Space Situational Awareness (SSA) programme. The plan is to set up a worldwide network of special "flyeye" telescopes for the automated monitoring of the night sky. Like the complex eyes of the insects to which they owe their name, these telescopes combine several lenses in order to achieve a wider field of vision. The first of these telescopes is currently being built at OHB Italia and is scheduled for installation in Sicily at the end of 2019.

ESA is also participating in a test mission for planetary defence. The AIDA (Asteroid Impact and Deflection Assessment) mission has been developed in collaboration with NASA. As part of AIDA, the smaller body of the near-Earth Didymos twin asteroid is to be pushed to another orbit through the controlled impact of a NASA probe. The European contribution is the Hera probe, which will be tracking the Didymos system closely after impact. OHB is currently working on a detailed mission definition for this probe on behalf of ESA. "It is important to know exactly what effects a collision will have on the orbit of an asteroid," explained Marc Scheper. "Only then can we take effective defensive action."

WHAT DO NORTHERN LIGHTS HAVE TO DO WITH POWER FAILURES?

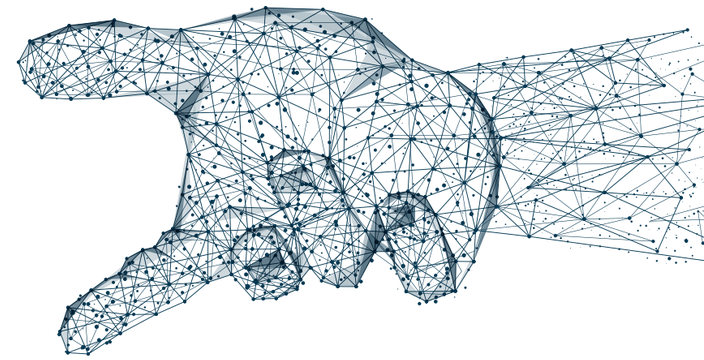
Like the weather on Earth, space weather is also influenced significantly by the Sun. In addition to electromagnetic radiation, which includes visible light, the Sun also emits a constant stream of charged particles, known as solar wind. As solar activity increases, this stream of particles can intensify sharply in a phenomenon known as a solar storm.

Polar lights are formed when the solar wind hits the Earth's atmosphere.

Normally, the solar wind is not perceptible on Earth or only in the polar regions in the form of polar lights, because the terrestrial magnetic field deflects the stream of particles. However, strong solar flares can have severe effects. For example, solar storms can cause large-scale power outages by disturbing the magnetosphere. Satellites are even more exposed to the effects of solar storms than systems on the surface of the Earth, which is comparatively more protected. In addition to damage to solar cells and electronic systems, the heating and expansion of the outermost layers of Earth's atmosphere as a result of the high-energy radiation also poses a threat. Low-flying satellites thus experience increased resistance, which creates a drag on them. They may even fall to the ground if their orbit is not lifted in a steering manoeuvre. The US space station Skylab was also affected and had to be abandoned earlier than planned for this very reason.

Consequently, ESA is also working on a mission to L5, Lagrange point 5. The gravitational conditions at this point allow a space probe to be positioned stably for solar observation. Currently, the warning time before solar storms is only a few hours. However, with the Lagrange probe in position, this period could be extended to four to five days.

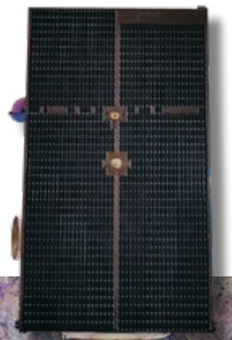
The observatory for the L5 mission is being designed by OHB on behalf of the ESA. Work is currently under way on the specifications for the space probe and the integration process for the instruments. The instruments are a critical point of the mission, as they have to measure and send data to Earth continuously even and especially in times of increased solar activity. Due to the special requirements that the instruments must meet, two further studies have been commissioned by the ESA to explore this matter. OHB is involved as a subcontractor in the development of a special magnetometer.

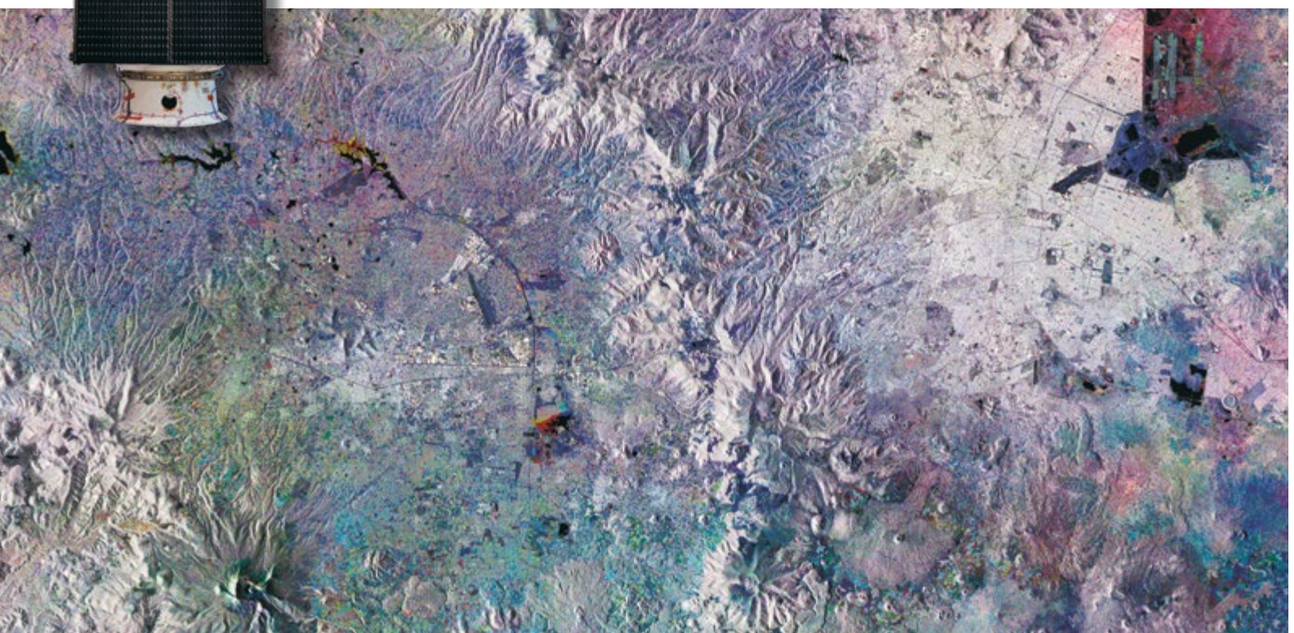


Pioneers in the hyperspectral realm

There are only two projects in the world that can provide complex hyperspectral analyses from space: both are being realised by OHB.

With PRISMA (PRecursore IperSpettrale della Missione Applicativa), the OHB Group has already put its first hyperspectral satellite into space. ASI (Agenzia Spaziale Italiana), the Italian space agency, contracted OHB Italia to build the Earth observation satellite. It observes Earth and collects data for monitoring and predicting environmental changes on our planet. Indeed, climate change and the efficient and sustainable use of Earth's resources are among humankind's core challenges. PRISMA is playing a key role in mastering these challenges and, to that end, is equipped with innovative electro-optical instrumentation which combines a hyperspectral sensor with a medium-resolution panchromatic camera. Its sensors capture the entire spectrum of visible light (approx. 400 nm violet – approx. 700 nm red). The advantage of this combination – in addition to traditional Earth observation; that is, identifying the geographical features of a landscape – is that the satellite can also determine the chemical and physical properties of the objects within the landscape using hyperspectral sensors. This makes it a great asset within the fields of environmental monitoring, resource management, identification and classification of plants, protection against environmental pollution and so on. It also has potential for other applications, such as national security. Roberto Aceti, CEO of OHB Italia said, "The PRISMA mission affirms OHB Italia's expertise as a systems integrator. Thanks to this mission, OHB has acquired skills which are unique in Europe and will allow it to develop further projects in the future and give the average person on the street a better understanding of the benefits of space flight."





The pinnacle of environmental monitoring

Under contract from DLR, the German Aerospace Center, OHB System is currently working on the first German hyperspectral mission EnMAP (Environmental Mapping and Analysis Program). Imaging spectrometers measure the solar radiation reflected by the surface of the Earth in the range from visible light (420 nm – 1,000 nm, VNIR) up to short-wave infrared (900 nm to 2,450 nm, SWIR). In effect, this means imaging Earth in more than 200 different "colours" with a ground resolution of 30 m. As part of the programme, various scientists will study the spectral fingerprints of diverse materials and molecules in order to obtain detailed information about the urban and rural areas, seas and other surfaces it captures.

The images of the highly advanced EnMap sensor will permit a wide array of individual data analyses in different fields, such as the phenomena and impact of climate change, the availability and quality of water, global changes in land use, availability of natural resources, biodiversity and stability of the ecosystem as well as natural disasters and risk assessments.

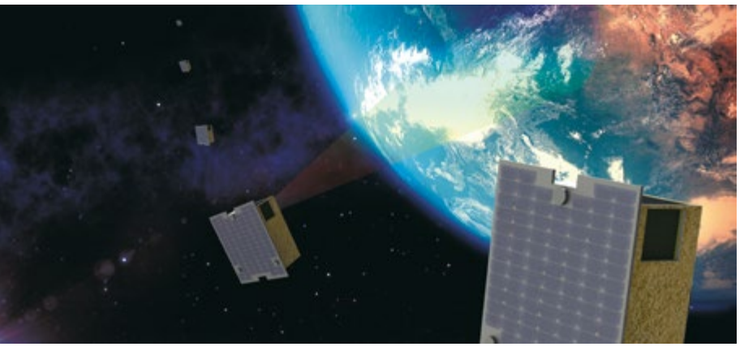
EnMAP will advance satellite hyperspectral Earth observation and produce unique measurements to quantify Earth's most important scientific parameters, with huge potential for a variety of future commercial applications.

"Never before have there been measurements from space with the accuracy of EnMAP. There are only two projects in the world for which hyperspectral satellites of this complexity are being developed and built – and OHB is involved in both projects," said Marco Fuchs, CEO of OHB SE.

EnMAP (Environmental Mapping and Analysis Program) is a German hyperspectral satellite mission for Earth observation by DLR's Space Management. OHB is realising the innovative and sophisticated instrument as well as the satellite platform.

Small but powerful!

LuxSpace develops new microsatellite platform in Triton-X



Triton-X: the modular microsatellites enable affordable regional and global LEO constellations.

With the microsatellite platform Triton-X, LuxSpace is opening up new perspectives in the "New Space" segment for the OHB Group and the global satellite market. Triton-X is designed to enable affordable regional and global LEO (low Earth orbit) constellations. It is being largely funded by the Luxembourg Space Agency (LSA) and the European Space Agency (ESA). The development is being executed in the scope of ESA's ARTES programme for Advanced Research in the field of Telecommunications Systems. "With Triton-X, we are currently developing a new modular platform for small satellites. This modularity enables us to tailor Triton-X to meet the individual needs of our customers. At the same time, the platform can be employed for a variety of missions such as Earth observation missions and telecommunications missions. The platform is suitable for missions in low Earth orbits with one or more instruments. The small satellite segment has always been LuxSpace's strength and we are continuing along this path. Triton-X is the ideal addition to the OHB Group's portfolio. We are now also handling the class of satellites with a mass of up to 150 kg," said Lutz Haumann, Triton-X Project Manager at LuxSpace.

Milestone for EAGLET constellation

OHB Italia sends prototypes of innovative nanosatellites into orbit

With EAGLET, OHB Italia develops a constellation of highly innovative, rapidly deployable and cost-effective satellites that deliver optical and AIS (Automatic Information System) data from a given point above the Earth with a very short revisit time. The aim is to enable a wide range of Earth monitoring and security applications. The prototype of the nanosat for Earth observation and maritime surveillance, the EAGLET 1 satellite, has already been orbiting the Earth since the end of 2018. It was successfully launched from Vandenberg Air Force Base in California on-board a Falcon 9 launcher. EAGLET 1 was placed in a sun-synchronous orbit at an altitude of 575 kilometres carrying two payloads: a high-resolution, optical payload capturing panchromatic images with 5-metre panchromatic resolution using a 300-millimetre focal length telescope with an 85-millimetre aperture and a payload capable of receiving and transmitting AIS signals to Earth. AIS signals are transmitted worldwide by ships and are used to monitor maritime traffic on the seas.

With EAGLET, OHB Italia is supplying a constellation of highly innovative, rapidly deployable and cost-effective satellites providing optical and AIS data.

EAGLET 1 is the in-orbit validation of a nanosat developed in accordance with an industrial approach for reliability and performance. The launch marked an important milestone in the deployment of the EAGLET constellation. The total mass is less than 5 kilograms. The satellite has a precise attitude control system based on Earth, Sun and star tracking and GPS sensors.

Everybody's talking about the weather! And so are we!

OHB to supply MTG, a new, third generation of Meteosat weather satellites

In order to maintain and develop Europe's leading weather forecasting capabilities, the European Meteorological Satellite Organisation (EUMETSAT) is currently commissioning a new third-generation Meteosat weather satellite (Meteosat Third Generation, MTG). The development of the systems is being led by the European Space Agency (ESA), with the total of six satellites to be launched one after the other from 2021 onwards.

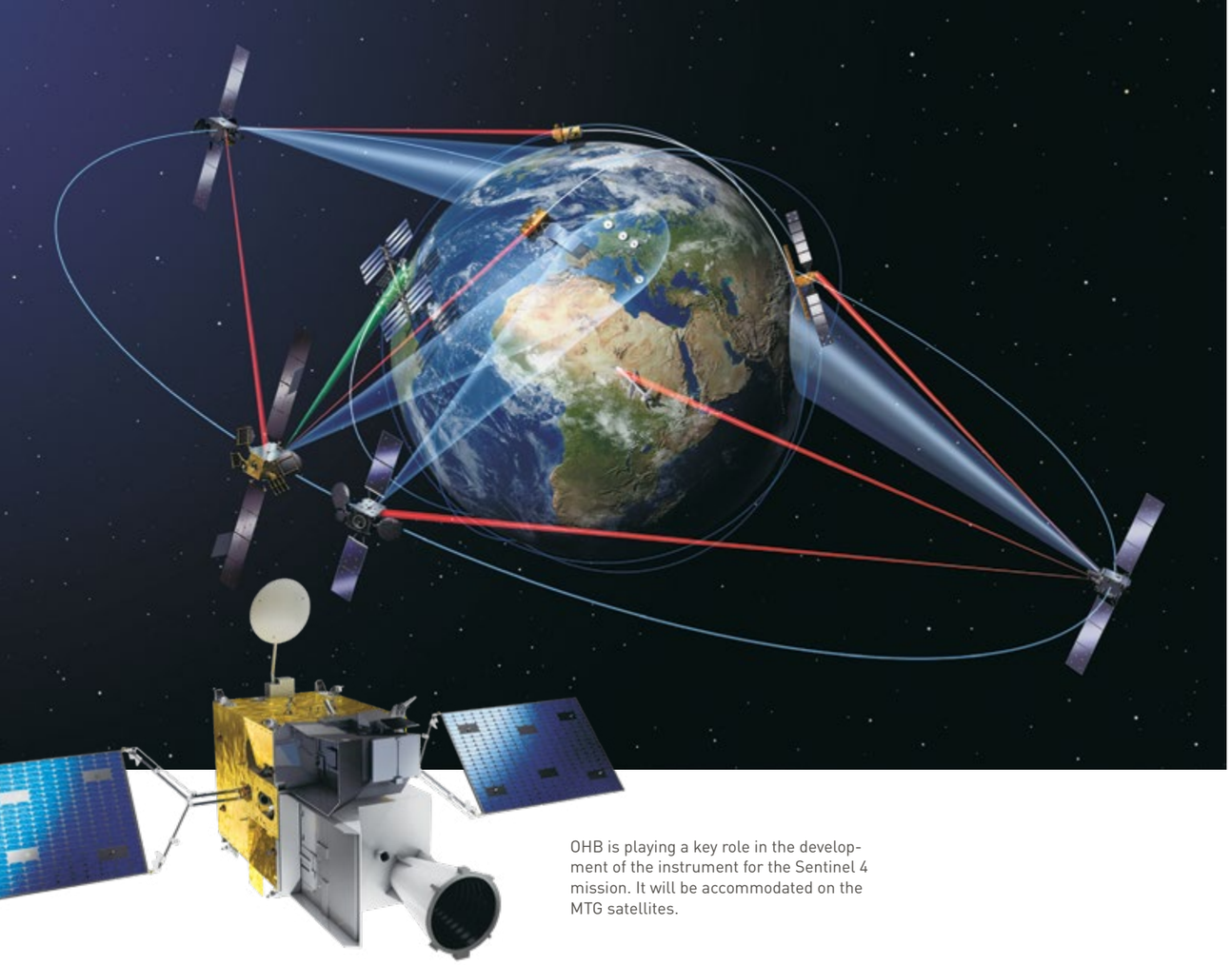
The industrial consortium for the development of the MTG programme is being led by the French company Thales Alenia Space with OHB System AG as its partner. Once the MTG satellites are operational in their geostationary orbit, their new and enhanced capabilities will allow much more accurate weather forecasts. For example, storms with heavy precipitation can be predicted earlier and more accurately, air traffic can be planned more efficiently and cost-effectively and farmers can determine the optimal time for harvesting precisely. In addition, the measurements taken by the MTG satellites will improve our understanding of the Earth's climate system, something from which not only Europe will benefit.

Four of these MTG-I satellites will capture significantly improved images using their main instrument ("imager"). The other two MTG-S satellites carry a new type of high-resolution spectrometer ("sounder"), which will be used to track the three-dimensional movement of water vapour and other gases in the atmosphere.

OHB System is responsible for the development of all six satellite platforms and for the development and manufacture of the sounder satellites.

In addition to its activities at system level, OHB System is working on the instruments for MTG at the "Optics & Science Space Center". The Company is overseeing the entire development of the infrared sounder, the highly sophisticated imaging spectrometer, which is the main instrument fitted to the two sounder satellites.

In order to maintain and further develop Europe's leading weather forecasting capabilities, the European Agency EUMETSAT is currently procuring the third generation of Meteosat weather satellites.



OHB is playing a key role in the development of the instrument for the Sentinel 4 mission. It will be accommodated on the MTG satellites.

Europe's sentinels in space

Copernicus is the EU's second major space programme after Galileo. The aim is to create an independent infrastructure that provides high-quality data to answer environmental and security-related questions.

Sentinel-1A, the first Copernicus satellite, was launched in 2014 and currently the programme comprises three complete Sentinel constellations of two satellites each plus one single satellite. In total, the Sentinel family comprises six different satellite types, which, in combination with other data sources in the air, on the water and on the ground, provide six application-related core services:

LAND MONITORING
SURVEILLANCE OF THE OCEANS
DISASTER AND CRISIS MANAGEMENT
ATMOSPHERIC MONITORING
MONITORING OF CLIMATE CHANGE
SECURITY

ALREADY IN ORBIT: SENTINEL-1 TO SENTINEL-3

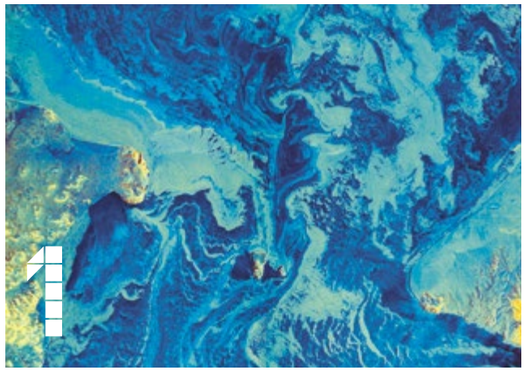
The two **Sentinel-1** satellites carry modern radar instruments (synthetic aperture radar, SAR), which make it possible to take high-quality pictures of the Earth's surface even in dense clouds and at night. The satellites are in the same orbit but offset by 180° and map the entire Earth every six days. The data collected provides information about the distribution of sea ice, changes to landscapes due to human influence and the extent of natural disasters such as floods and earthquakes.

The **Sentinel-2** constellation is equipped with high-resolution multispectral sensors that can record strips of land with a width of 290 kilometres. The two satellites in the constellation are identical in design and also move in the same orbit around the Earth with an offset of 180°. Orbiting close to the equator, they monitor all land masses, large islands and coastal waters every five days; at higher latitudes, the revisiting time is even shorter. The data which the satellites record provide information on the composition of the Earth's surface and vegetation, which are primarily used for agriculture and forestry.

The **Sentinel-3** mission is the most complex project in the Copernicus programme to date, as the two identical satellites carry four different instruments, which, working together, provide a comprehensive view of the Earth:
The sea and land surface temperature radiometer (SLSTR) measures the temperatures of land surfaces and oceans on a daily basis with high accuracy using the emitted infrared radiation. In addition, the instrument includes two channels for thermal infrared radiation, which are used to search actively for fires. The SLSTR has a spatial resolution of 1,000 metres on these channels and 500 metres on the other channels. The width of the strips recorded is 1,420 kilometres.

The ocean and land colour instrument (OLCI) is an imaging spectrometer with 21 discrete spectral channels spanning a wavelength range from 400 to 1,200 nanometers. This section of the electromagnetic spectrum provides relevant information on marine ecosystems, permits the management of agriculture and forestry by tracking the state of soils and vegetation and also maps atmospheric aerosols and clouds. The OLCI has a spatial resolution of 300 metres for all measurements and records strips with a width of 1,270 kilometres.

The two aforementioned instruments are supplemented by a SAR altimeter and a microwave radiometer. In addition to topography measurements over land, the altimeter also records the exact heights of sea levels, sea ice, rivers and lakes. In addition, wave heights and wind speeds over the sea can also be determined. The microwave radiometer determines the atmospheric correction and thus enhances the accuracy of the topographic measurements.



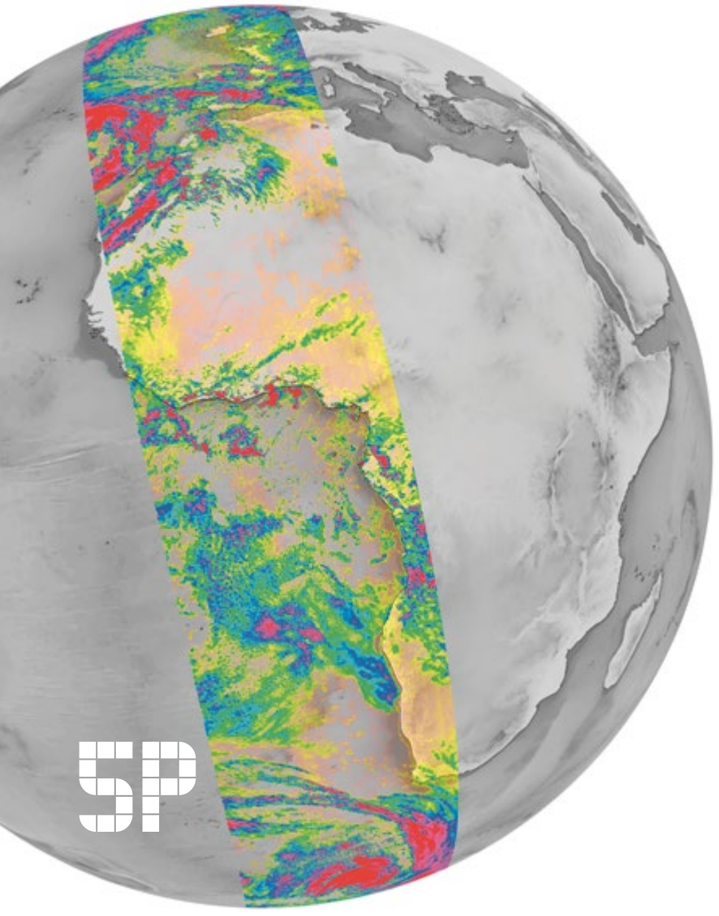
Radar image of the ice-free Bering Strait in March 2019, taken by Sentinel-1

Effects of the dry summer of 2018, recorded by Sentinel-2.

Cloud formations over the Bering Sea, recorded with the OLCI of Sentinel-3.

UNDER DEVELOPMENT: SENTINEL-4 TO SENTINEL-6

The next Copernicus instruments will be launched with the third-generation geostationary sounder satellites of the Meteosat weather satellites (MTG) currently being built at OHB. Like Sentinel-5, Sentinel-4 is designed to monitor the Earth's atmosphere and provide information on air quality, ozone levels and solar radiation. OHB is making a significant contribution to the development of the ultraviolet-visible-near-infrared spectrometer (UVN spectrometer) for the Sentinel-4 mission.



Aerosols in the atmosphere tracked by Sentinel-5P.

The Sentinel-5 instruments will also be installed on European weather organisation EUMETSAT's weather satellites. The second-generation meteorological operational satellites (MetOp-SG) are near-Earth polar orbiting satellites designed to complement the MTG satellites. OHB Italia is developing the microwave imager (MWI), which is the main instrument for these satellites, a microwave radiometer for detecting aerosols in the atmosphere. The MWI is complemented by the Sentinel-5 instrument, a UVN shortwave spectrometer. Pending the launch of Sentinel-5, the gap in data caused by the failure of Envisat in 2012 will be closed at least partially by the single Sentinel-5P satellite (Sentinel-5 precursor) launched in 2017.

Sentinel-6 is a mission for collecting data on the topography of the oceans. The satellites will be carrying high-precision radar altimeters and providing information on changes in sea level as an indicator of climate change. Every 10 days, 95 % of the ice-free oceans are to be mapped for this purpose.

ADDITION TO THE COPERNICUS PROGRAMME: SENTINEL EXPANSION

Encouraged by the great success of the first Sentinel satellites, the EU is already preparing the expansion of the Sentinel family. After analysing the user requirements that are currently not being addressed, six potential missions to complement Copernicus have been identified:

CHIME – Copernicus Hyperspectral Imaging Mission: The satellites of the CHIME mission will carry hyperspectral sensors, perform soil composition analyses in a continuous spectrum from visible light to near infrared and complement the multispectral data collected by Sentinel-2.

CIMR – Copernicus Imaging Microwave Radiometer: The CIMR mission is a response to the special requirements of satellite monitoring in polar regions. The satellites are to be equipped with multi-frequency microwave radiometers, which will detect wide strips of the polar regions by means of conical scanning. Among other things, the data collected will provide information about the temperature and salinity of the sea surface as well as the concentration of sea ice.

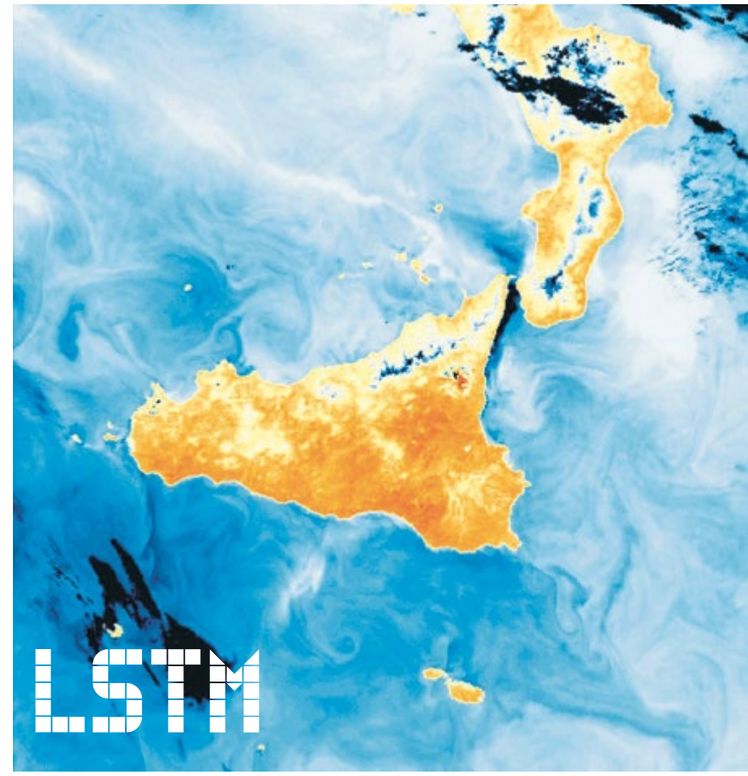
CO_2M – Copernicus Anthropogenic Carbon Dioxide Monitoring: CO_2M is to measure the carbon dioxide produced by humans in the atmosphere and thus make it possible to identify regions which have particularly high emissions. Observance of agreed climate targets can also be verified. The main instruments required for this are a near-infrared and a short-wave infrared spectrometer.

CRISTAL – Copernicus Polar Ice and Snow Topography Altimeter: The CRISTAL mission satellites will determine the thickness of the sea ice and the snow lying on top of it as a basis for planning activities in the polar regions and for monitoring climate change. For this purpose, they are to carry multi-frequency radar altimeters and microwave radiometers.

LSTM – Copernicus Land Surface Temperature Monitoring: LSTM is responsible for the thermal monitoring of land areas. To this end, satellites fitted with sensors for thermal infrared radiation with high spatial and temporal resolution are to be placed in orbit. Measurements of the surface temperature of land masses are important indicators of climate change and facilitate the prediction of droughts and the management of water resources.

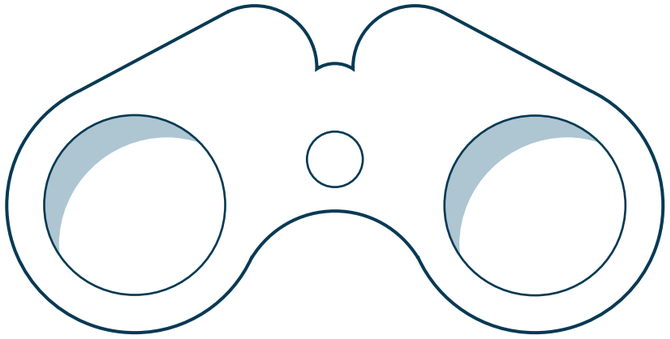
ROSE-L – L-band Synthetic Aperture Radar: The ROSE-L mission will complement the data gained from the Sentinel-1 mission. Wherever the shorter wavelength C-band SAR of Sentinel-1 does not reach the ground due to vegetation, snow or ice, the longer wavelength L-band SAR of ROSE-L will step in to fill the gap. It will be used in agriculture and forestry and for monitoring climate changes through the observation of the polar ice caps, sea ice and seasonal snow cover.

The missions have been undergoing more detailed planning since mid-2018. OHB System AG has been selected as the main contractor for the studies on the CHIME, CO_2M and LSTM missions. OHB Sweden has been awarded the contract for the CRISTAL mission and OHB Italia is the main payload contractor for CIMR.



The mission Copernicus Land Surface Temperature Monitoring serves the purposes of thermal observation of land surfaces.

The Copernicus Imaging Mirowave Radiometer mission is intended, inter alia, to observe the concentration of ice on the sea.



Absolute perspective on all channels

Reconnaissance programmes help to detect developments anywhere in the world at an early stage and to prevent potential crises before they occur. Possible areas of application include disaster management, security applications and humanitarian aid operations. OHB is the Federal Republic of Germany's leading technology partner in the field of satellite-based reconnaissance.

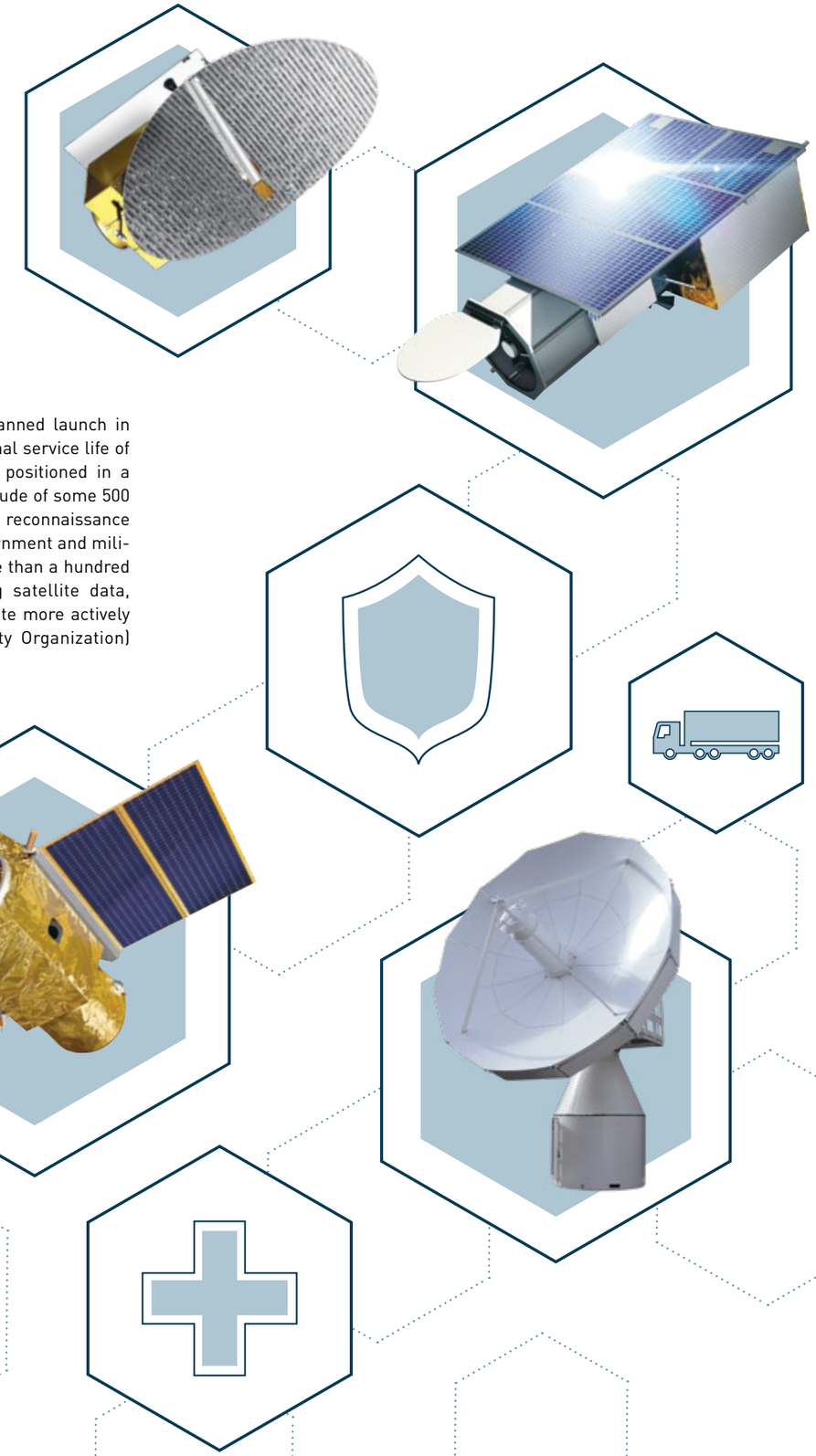
OHB is realising the SARah satellite-based reconnaissance programme on behalf of the German armed forces. The radar reconnaissance system SARah comprises a total of three satellites and two ground stations. Two of the SARah satellites are technically based on a development of the reflector technology used in the German armed forces' SAR-Lupe system, which has also been delivered by OHB System AG and reliably used for radar reconnaissance since 2007. The third SARah satellite is based on a further development of Airbus Defence and Space's phased array radar technology, which has already proven itself in orbit. The general aim is to achieve significant improvements in the performance of the overall radar reconnaissance system.

THROUGH WIND AND RAIN, DAY AND NIGHT: RADAR RECONNAISSANCE

The satellite-based reconnaissance with SARah allows outstandingly clear images in a previously unattainable quality whatever the weather and light conditions on the ground. OHB executes SARah as an integrated system from the preliminary design phase and construction, to the start-up in space, control and beyond to end-of-life disposal. Through the development of the SAR-Lupe and SARah satellites, OHB has built up outstanding expertise in the field of radar systems. In addition, OHB also offers commercial and institutional high-resolution Earth observation systems in the optical, electro-optical and hyperspectral ranges. Possible areas of application include disaster management, security applications and humanitarian aid missions – all applications in which a precise overview is of fundamental importance.

OPTSAT AND NAOS OFFER AN (ELECTRO-)OPTICAL VIEW OF THE EARTH

OHB is the Federal Republic of Germany's leading technology partner in the field of satellite-based reconnaissance. This position is underlined by the order placed at the end of 2017 for a satellite system for worldwide electro-optical reconnaissance (OptSat). In addition, the OHB subsidiary OHB Italia is building the high-resolution optical satellite NAOS (National Advanced Optical System) for the Luxembourg government. NAOS will weigh around 600 kilograms on its planned launch in 2022 and is designed for a nominal service life of at least seven years once it is positioned in a sun-synchronous orbit at an altitude of some 500 kilometres. The high-resolution reconnaissance satellite was developed for government and military purposes and can take more than a hundred pictures per day. By collecting satellite data, Luxembourg intends to participate more actively in NATO's (North Atlantic Treaty Organization) defence efforts.



OHB champions diversity

Diversity is a key topic right across the OHB Group, both in terms of the products we offer and the way in which we treat each other.

OHB has evolved a broad portfolio comprising satellites of all shapes and sizes and for all orbits, spacecraft for exploration missions, systems for human spaceflight, space transport and much more. The teams collaborating on these exciting and dynamic projects are just as diverse as the offering itself: around the world, there are experts from more than 40 nations employed in the OHB Group. In order to demonstrate its commitment to diversity in the workplace, OHB recently signed the Diversity Charter, an employer initiative aimed at promoting diversity within companies. With this step, our companies are underlining their dedication to creating a work environment completely free of prejudices. All our employees should be treated with the same respect and offered the same opportunities, no matter what their sex, gender identity, nationality, ethnic background, religion, ideology, disability, age or sexual orientation. The campaign was initiated by OHB's equal opportunities officer Eileen Ehrhardt. "OHB is diverse and multifaceted. So, on the one hand, it was only logical for us to take this stand. On the other hand, it was overdue and time for us to focus on this strength again. Our diversity drives our creativity day in, day out. As different as we are, we are strong, committed teams working together to achieve shared goals. Every single OHB satellite in space is proof in its own right that diversity works at OHB. They illustrate that anything is possible with diversity. Indeed, it was high time to show with the diversity initiative and the signing of the charter that this is something of which we are very proud."

charta der vielfalt UNTERZEICHNET

OHB's "Diversity Development & Validity Verification" Team took first place in the internal diversity photo competition with its "choreography". Further information on the programme can be found at www.charta-der-vielfalt.de

The OHB group in figures

2,769
employees in total

1,448
at OHB System

€ 1 billion
Total revenues

16%
increase

40
different nations

Academic Share

MT Mechatronics:
63.24 %

New Arrivals

OHB System:
300 new hires
(following almost 6,000 applications and 1,200 interviews)

OHB Sweden:
38 % increase

... and still hiring:

www.ohb.de/en/career

Female workforce

Teleconsult Austria: 37 %
Antwerp Space: 22 %
OHB Sweden: 22 %
OHB Italia: 21.6 %
OHB System: 20 % in total,
13.7 % in technical areas

Average age

MT-companies: 44 years
OHB Sweden: 43 years
LuxSpace: 42 years
OHB System: 41 years
Teleconsult Austria: 35 years

Long-service anniversaries

MT Aerospace: two times 45 years

MT Management Service: three times 45 years

OHB System:
seven times 30 years, seven times 25 years,
seventeen times 20 years

Antwerp Space:
two times 40 years, one time 30 years

OHB Italia: two times 30 years

Figures from 2018