OHB System AG
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SPACE SYSTEMS

Space Sector Forum – Warsaw, 25th May, 2018

We. Create. Space.

- **OHB SE**
- **OHB System AG**
- **Introduction to selected projects** (annex)

Visionary. European.

- OHB SE is Germany‘s first listed technology and aerospace group
- Approx 2,000 employees stationed around Europe
- Two system branches deliver sophisticated, custom-made technology and systems to international customers
  - Space Systems
    Design and development as well as implementation of space projects
  - Aerospace + Industrial Products
    Product and manufacturing for aerospace and telematics.

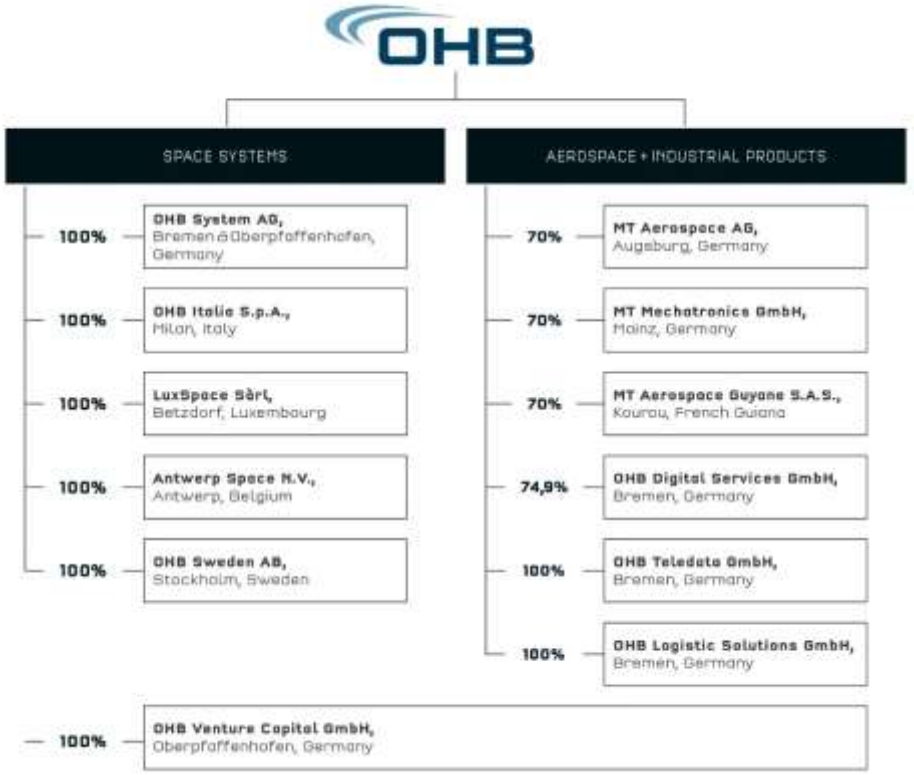
Flexible. Consistent. Independent.

- Family-run company with the character of a medium-sized business
- From modest beginnings to an internationally recognized and consistent player
- Reliable and acknowledged source for high-tech products in Germany and Europe
- Independent entity in the European aerospace sector, contributing to all major space programmes.

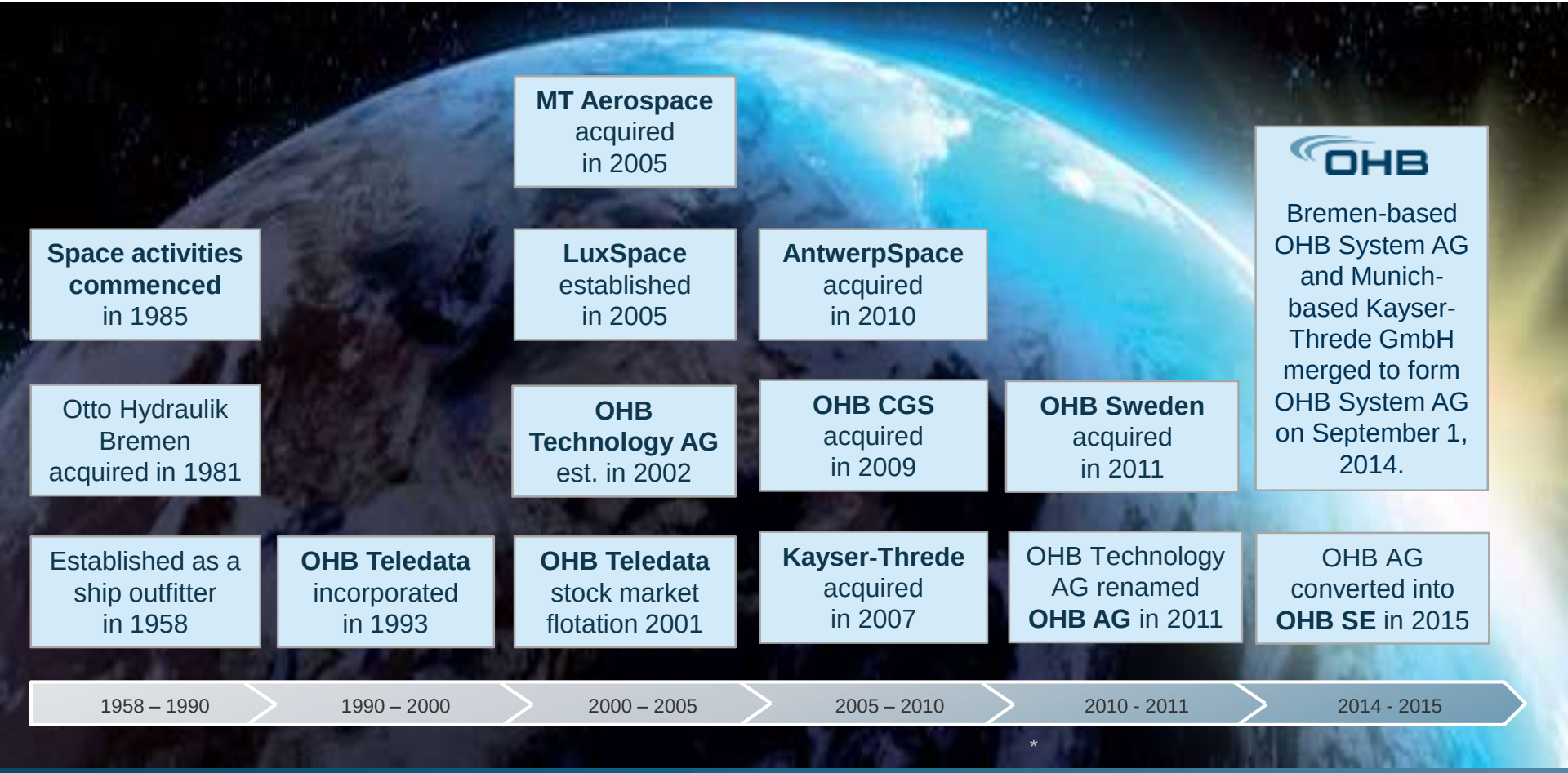
United under one roof

The value chain of the two system branches **Space Systems** and **Aerospace + Industrial Products** of OHB SE includes:

- Satellite design, manufacturing and operation
- Data transmission and processing
- Design, development and manufacturing of scientific payloads
- Structures for aerospace applications.

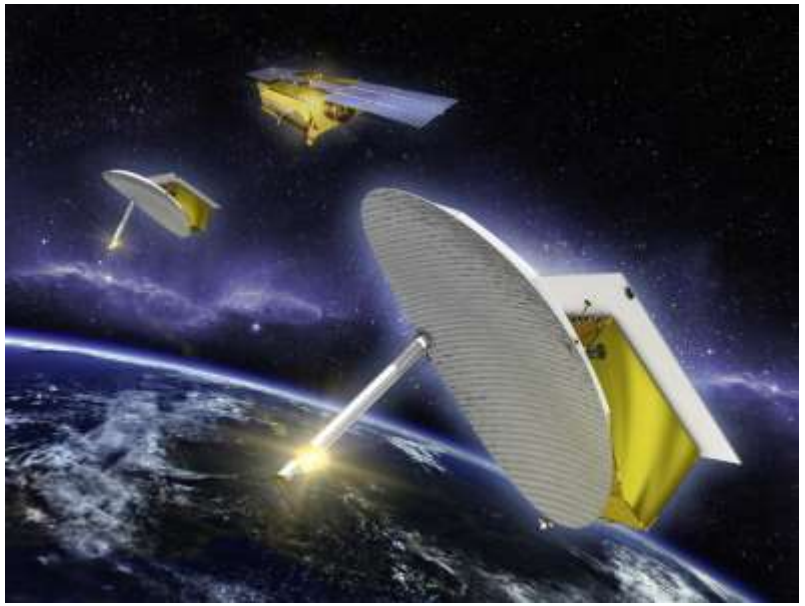


Corporate development milestones



Business activities

- Entire scope of space applications
  Telecommunications, Earth observation, reconnaissance, navigation and security, science and human spaceflight
- Complete range of project management
  from small-scale payloads and missions to large-scale satellite and space infra-structures
- Transfer of technology
  into industrial applications in the field of process control systems for railway power supply.



One company with two strong sites

Bremen site

- Galileo Hall: 1.630 m^2
  of which 1244 m^2 ISO 8 integration area
- SAR-Lupe Hall: 922 m^2
  of which 525 m^2 ISO 8 integration area
- Columbus Hall: 670 m^2 ISO 8
- Electronics-/EQ-Hall: 211 m^2
  of which 35 m^2 ISO 7.

One company with two strong sites

Oberpfaffenhofen site

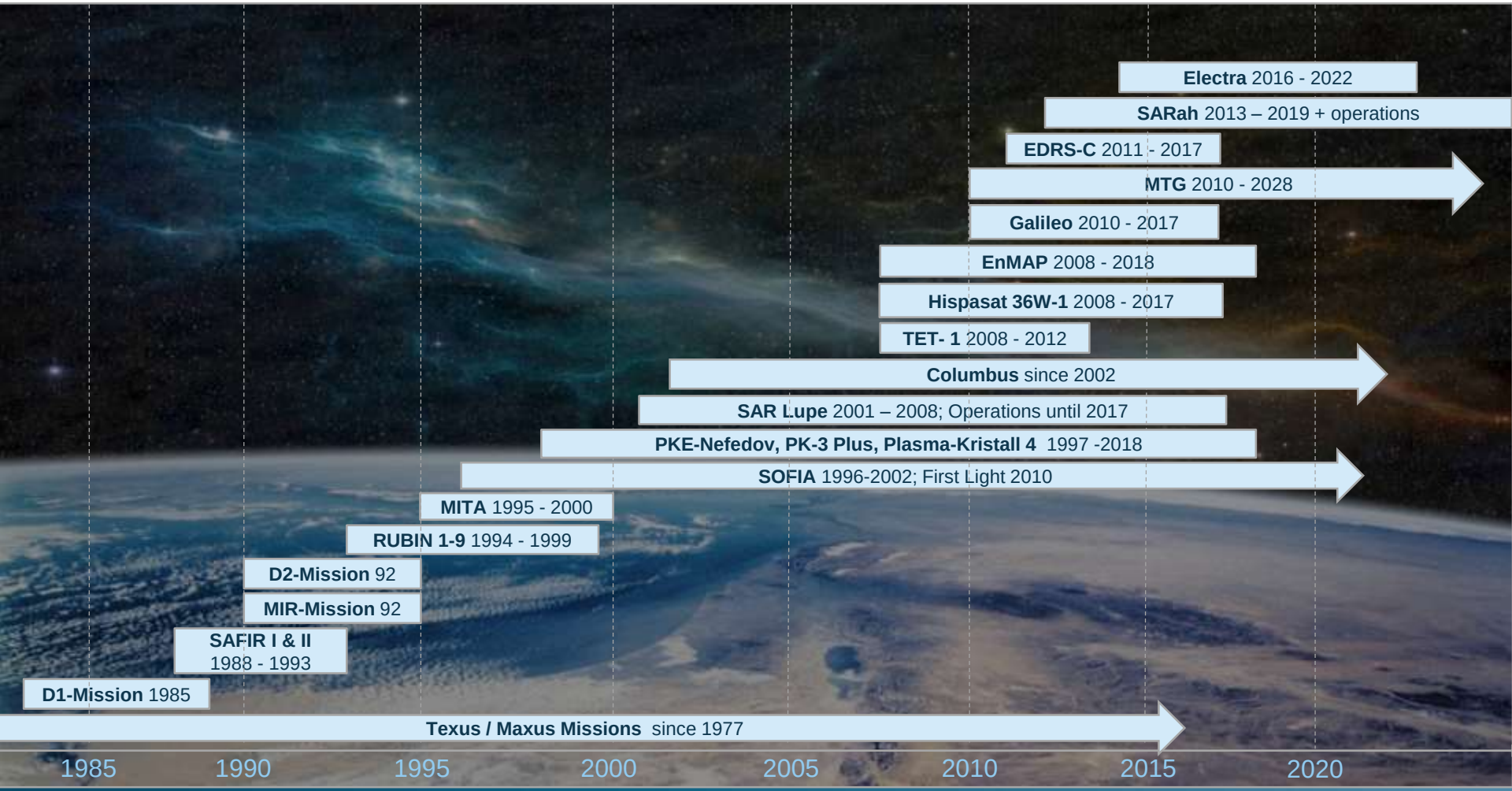
- Integration Hall: 1.420 m²
  - 320 m² ISO8 integration area
  - 300 m² ISO5 integration area
- Electrical product manufacture:

  approx. 200 m² ISO8
- Laboratories:

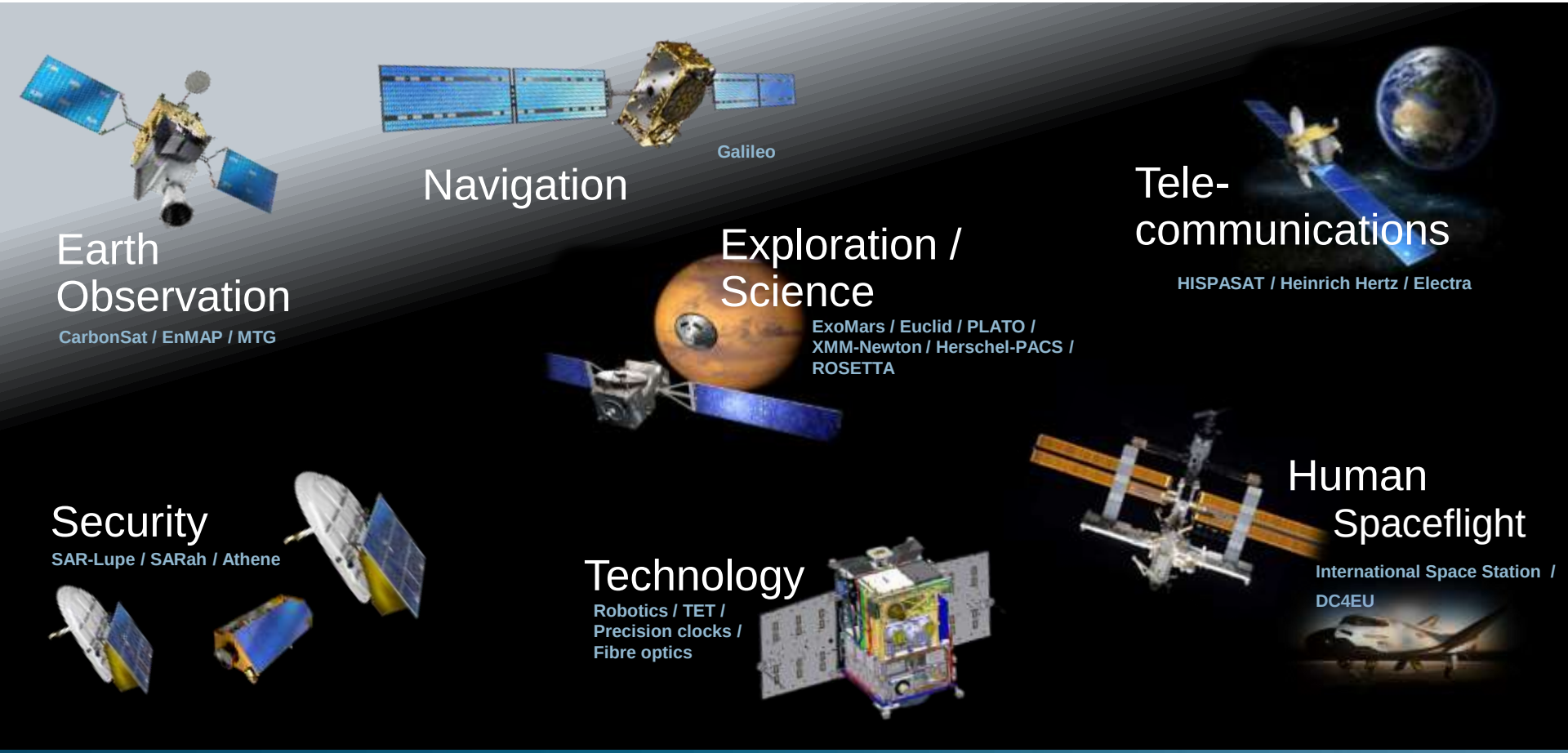
  approx. 730 m².

Pictures taken during comissioning phases of the two ISO 5 clean rooms (middle), the flight hardware storage area and the ISO 8 hall (bottom)

Progression of project portfolio (selection)



Scope of activities



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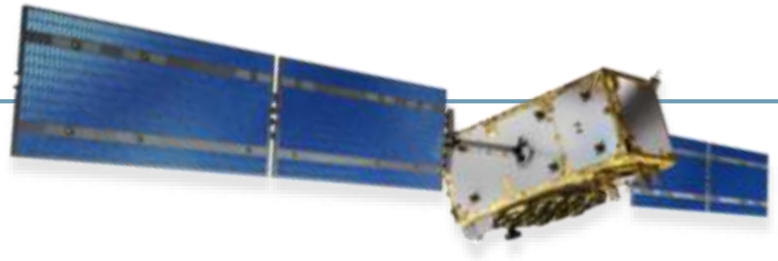
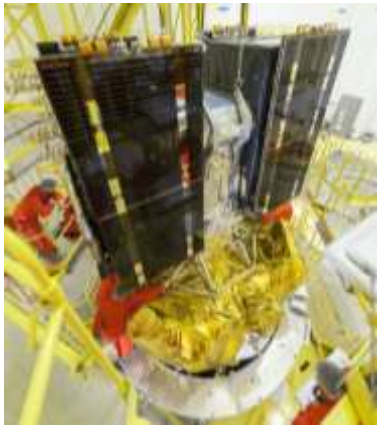
Annex

Brief descriptions of selected projects.

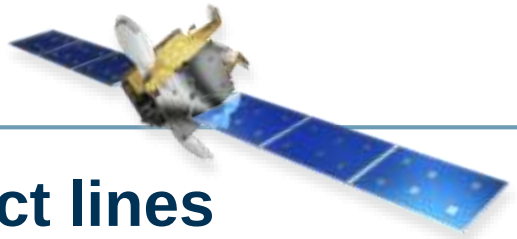


Galileo

- Prime contractor for design and realisation of 22 satellites for the European satellite navigation system Galileo
- Customers: EU Commission and ESA
- The first pair of Galileo FOC satellites was completed in less than 4.5 years and launched 08/2014
- Navigation payload subcontracted to Surrey Satellite Technology Ltd., UK
- Platform based on experience gained from the SAR-Lupe project.



The FOC (full operational capability) phase of the Galileo program is being funded by the European Union. The European Commission and the European Space Agency ESA have signed a delegation agreement under which ESA acts as the design and procurement agent on behalf of the Commission. The views expressed here do not necessarily reflect the official position of the European Union and/or ESA. “Galileo” is a registered trademark owned by the EU and ESA and registered under OHIM application number 002742237.



SmallGEO product lines

Communication, data and video transmission on land, water and in the air

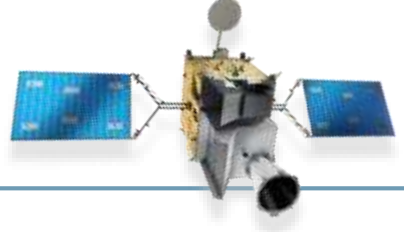
FAST: short delivery periods

- Conventional propulsion system (chemical or hybrid)
- Payload capacity of up to 450 kg, 4.7 kW and 30 active transponders
- From L to Ka band
- Service life of more than 15 years

FLEX: maximum payload

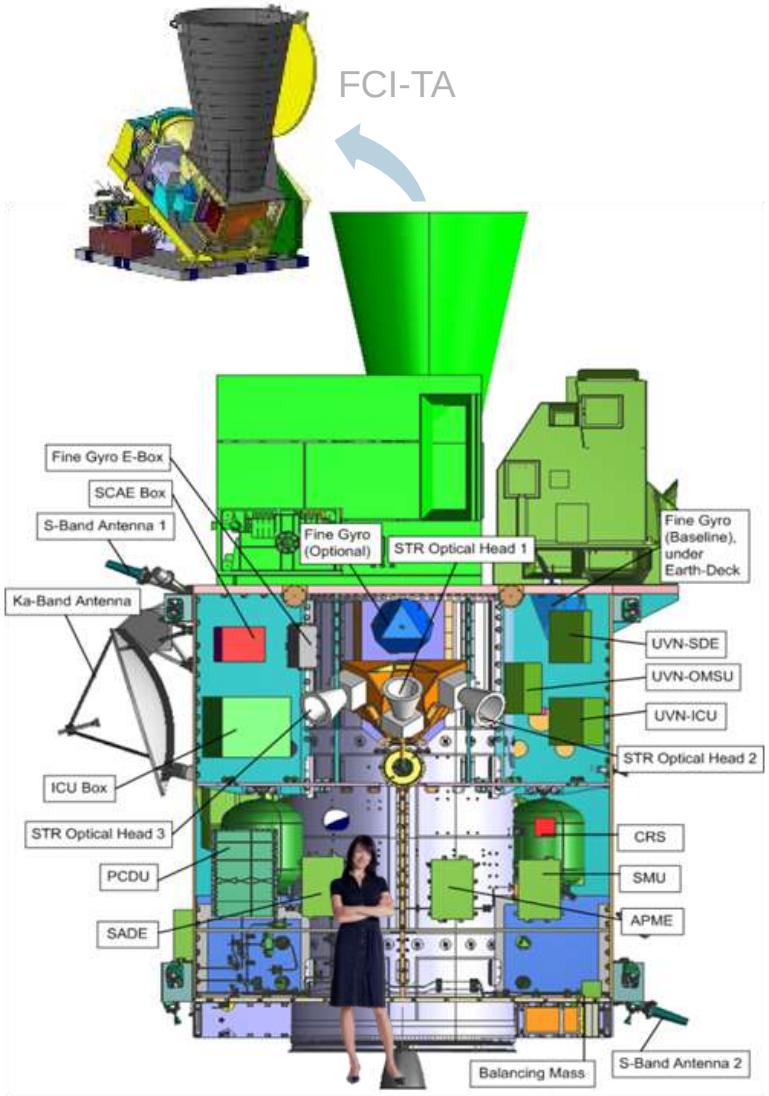
- Fully electric propulsion configuration
- Payload capacity more than 600 kg, 8 kW equivalent to 40 active transponders, service life of up to 20 years
- Dedicated ESA ARTES 33 programme Electra.

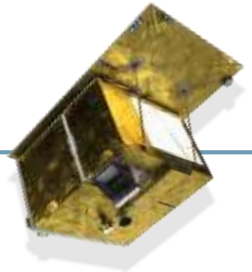
Hispasat 36W-1	EDRS-C	Heinrich Hertz	Electra
Customer: Hispasat S.A./ ESA	Customer: Airbus Defence & Space Services	Customer: German Aerospace Center (DLR)	PPP between ESA, SES S.A. and OHB System AG
Realisation under the ARTES 11 programme	ESA ARTES 7 programme: European data relay satellite system for complementing the Sentinel earth observation satellites under the EU Copernicus programme (formerly GMES)	Economical/technical part of the payload for testing innovative communications and platform technologies in the Ku and Ka band in space and on the ground	Part of the ESA's ARTES 33 programme
Ku and KA band TV transmission applications	Optical satellite links with data rates of up to 1.8 Gbps, downlink in Ka band		SmallGEO satellite with fully electrical propulsion system for transfer manoeuvers and attitude control
Launched January 2017; operational	Additionally: hosted payload for Avanti Communications Group plc	Military payload part for the German federal armed forces	Increased payload capacity compared to the chemical propulsion version, resulting in optimized launch costs



MTG: Meteosat Third Generation

- Customer: EUMETSAT / ESA
- Purpose: to improve weather forecasting by means of new imaging techniques
- Scope: 4 imager satellites and 2 sounder satellites (based on SGEO platform technology)
- First 3-axis-stabilized weather satellite in GEO
- OHB System in Bremen is responsible for the 2 sounder satellites (IRS) and 4 platforms for the imager satellites (FCI)
- OHB System in Munich is the principal contractor for the IRS payload and the largest subcontractor for the FCI-TA (telescope assembly).

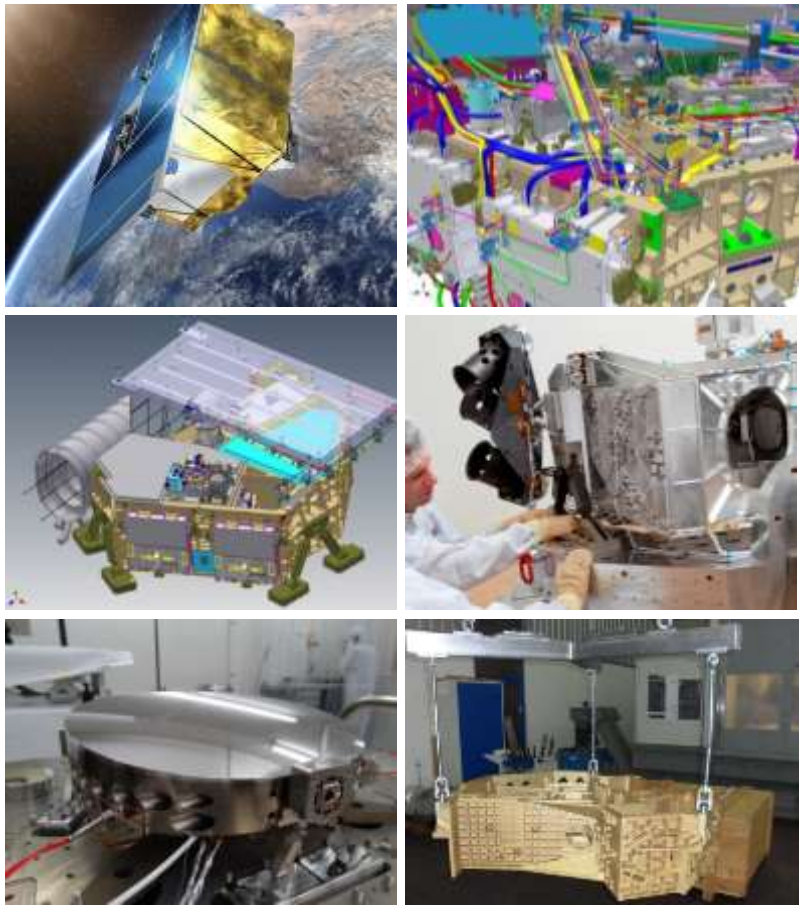




EnMAP

(Environmental Mapping and Analysis Program)

- New type of hyperspectral sensor system for use in environmental observation for a better understanding of the Earth's ecosystem
- First hyperspectral sensor with sufficient signal-to-noise ratio to generate high-quality data for global Earth observation purposes
- More than 200 spectral bands in visible and near infrared range



- Customer: DLR
- Principal contractor: OHB System AG, Oberpfaffenhofen.

SAR-Lupe for the German federal armed forces

- First German satellite-based radar reconnaissance system
- Customer: German Federal Ministry of Defense
- Five radar satellites and a ground system
- High geometric resolution: < 1m
- Short system response time
- Ground station for satellite control and image processing in Gelsdorf (Germany)
- 5 satellites and ground station fully operational since 2007
- Satellites operated by OHB at Gelsdorf since 2007
- 10-year Contract for the operation of the SAR-Lupe satellites ended on November 30, 2017
- Contract for an extension of the operating period signed on November 30, 2017.

SARah - successor to SAR-Lupe

- Contract for the development and manufacturing of the SARah system awarded in July 2013
- Constellation comprises 3 advanced technology radar satellites
- Customer: German Federal Ministry of Defense represented by BAAINBw (Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support)
- OHB System will be supplying two reflector SAR satellites, elements of the ground system and two ground stations
- Sub-contract awarded to Airbus Defence & Space for one phased-array SAR satellite.

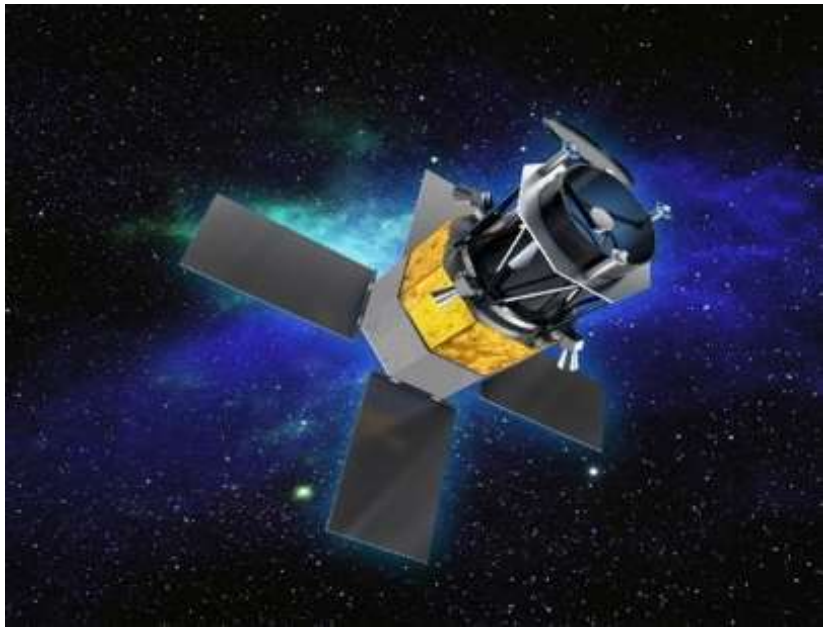
Space segment with two reflector satellites and one phased-array satellite

Ground segment in Gelsdorf

Ground stations

EO-SAT

- OHB is the prime contractor for the development of a satellite system for global electro-optical reconnaissance composed of a space and a ground segment
- Customer is the Federal Republic of Germany
- The contract has a budget of up to EUR 400 million
- The contract was signed on November 27, 2017.



Electro-optical satellite

EO-SAT

- OHB in Bremen is responsible for the overall system and the ground segment
- OHB Bremen is responsible for the manufacturing of the satellite platform and the integration work at the satellite level
- The electro-optical instrument will be developed and integrated at OHB Oberpfaffenhofen
- Environmental testing of the optical instrument and the satellite will be performed at IABG
- With EO-SAT, OHB is implementing a national design approach with a very high share of German content

Integration hall in Bremen

ISO 5 integration hall for optical instruments in Oberpfaffenhofen

ExoMars

ESA programme with 2 missions to Mars

ExoMars-Mission 2016 comprises an orbiter and a lander demonstration module

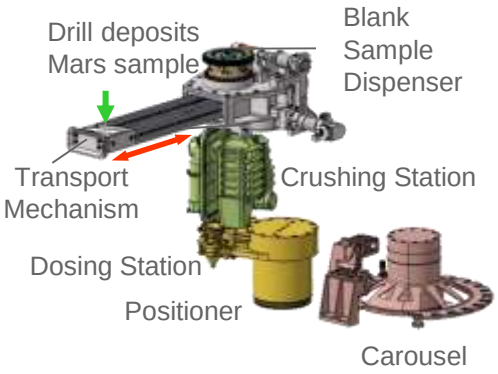
OHB System contribution:

- Core module of the trace gas orbiter (TGO) (thermal- and propulsion system, structure) successfully delivered early 2014

Follow-up mission 2020 with a rover landing on Mars to search for signs of life

OHB System contribution:

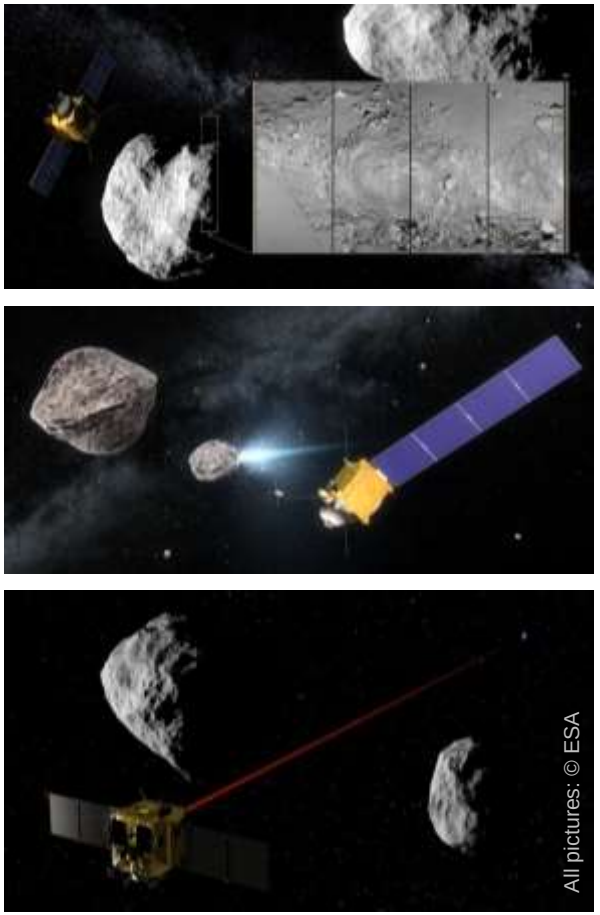
- Carrier
- Sample preparation and distribution system
- Analytical Laboratory Drawer
- High Resolution Camera
- RAMAN/RLS.



Asteroid Impact and Deflection Assessment (AIDA)

- Asteroid mission characterizing the binary asteroid Didymos and demonstrating asteroid deflection
- Collision of NASA's DART spacecraft with the asteroid moon and measurement of the resulting path deflection, along with further impact parameters by ESA's AIM
- Mission start October 2020 determined by the asteroid's flight path, reaching Didymos in July 2022.

Science Objectives	Characterize Didymos (inertia & constitution) and investigate origin of binary asteroid
Asteroid Impact Risk Mitigation	Determine the DART momentum transfer (asteroid deflection)
Technologie-Demonstration	Demonstrate deep-space laser telecommuni-cations as well as ISL (Inter-Satellite Link). Perform lander experiment.



Asteroid Impact Monitoring Mission (AIM)

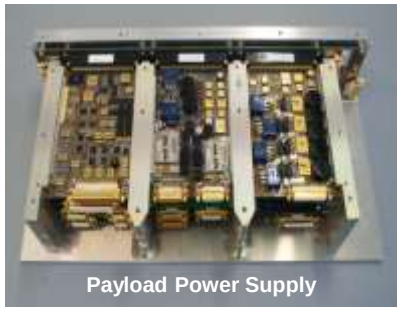
- AIM is ESA's contribution to AIDA, an ESA-NASA cooperation to characterize the binary asteroid Didymos and to demonstrate asteroid deflection
- OHB as industrial prime is responsible for the overall spacecraft design and the whole AIT activities.

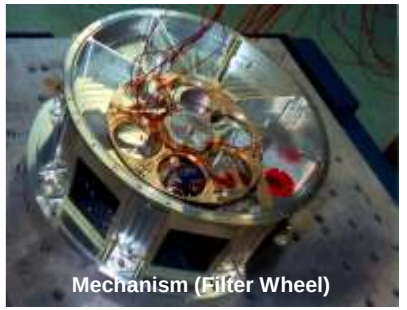
Scientific and technology payloads are provided by independent partners:

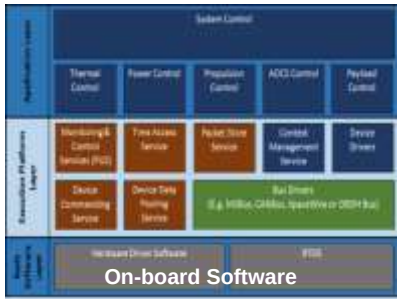
- High- and Low-frequency radars HFR & LFR (France)
- Thermal Infrared instrument TIRI (DLR)
- MASCOT-2 Lander (DLR)
- Laser Terminal OPTEL-D (Switzerland).

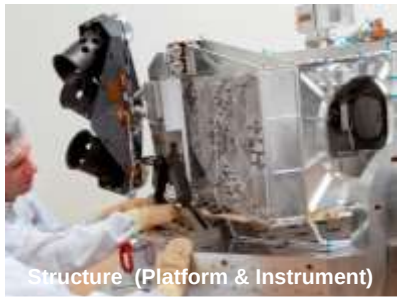
Equipment Design and Development

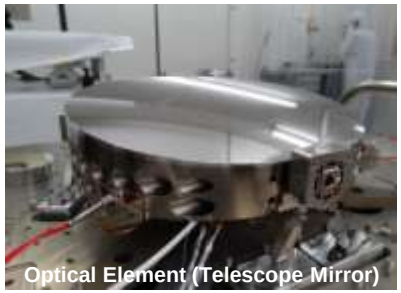
- The OHB engineering and AIT know-how is complemented by in-house equipment and product developments in several areas:
  - Optics
  - Electronics & Avionics
  - Mechanisms
  - Software
  - Simulators
- Space-qualified mechanical and electrical manufacturing and up-to-date integration and test facilities (ISO8 and ISO5) complete the in-house portfolio.
- Until today, successful operations of OHB developed equipment accumulates to more than 600 years in-orbit time.


Payload Power Supply

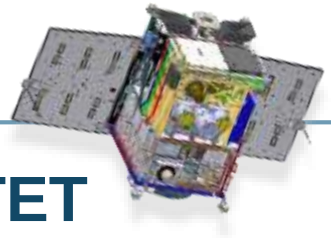

Mechanism (Filter Wheel)


On-board Software


Structure (Platform & Instrument)


Optical Element (Telescope Mirror)


Processing Unit (Controller, Security)



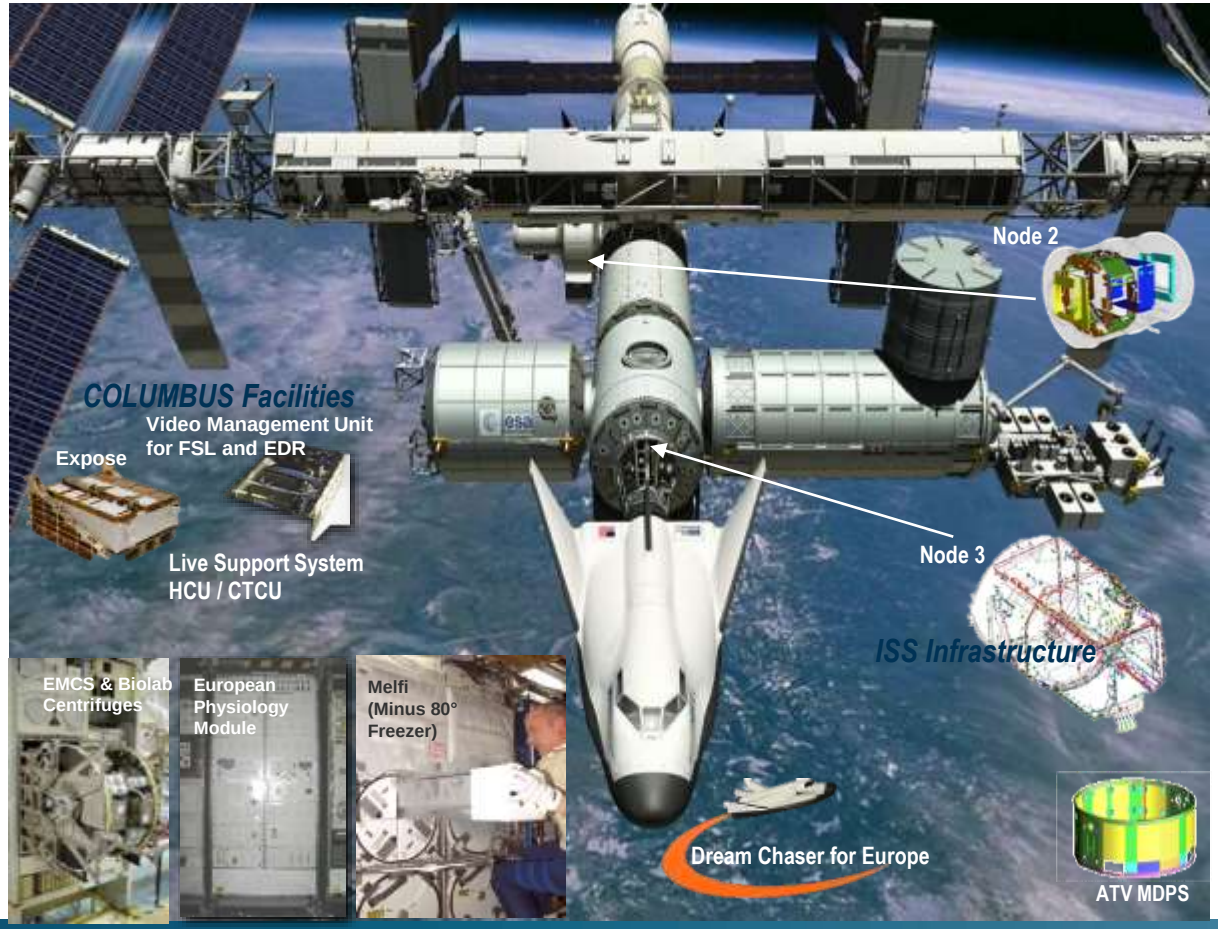
On-Orbit Verification: TET

(Technologie-Erprobungsträger)

- Core element of the national OOV programme
- Verification of products pretested and prequalified on earth prior to their deployment in space
- OHB System, Munich, was principal contractor for TET-1 including the satellite's launch
- Open satellite structure permits convenient accommodation of payloads (TET satellite bus based on BIRD)
- Modular payload supply system
- Low polar orbit (550 km)
- TET-1 launched with 11 payloads in July 2012
- After 1-year demonstration mission, satellite is now used by DLR for global fire detection
- Future missions for the TET platform prepared in several studies.

International Space Station ISS

Payload development & operations



Dream Chaser ®

The versatility of Dream Chaser® offers interesting options for use in European space flight. The joint study **"DC$_4$EU" (Dream Chaser® for European use)** carried out by OHB System, Sierra Nevada Corporation and DLR investigated the following aspects:

- Transportation of astronauts and cargo to ISS
- Re-entry capabilities and re-usability
- Research under weightless conditions (crew or uncrew versions) over extended periods, supplementing or following research on board ISS
- Capture of satellites or space debris and/or orbit correction

As the European partner of the American Sierra Nevada Corp. OHB System AG is set for challenging development tasks and the employment of Dream Chaser® in Europe.

Crew transport flights to ISS

Research under µg conditions at altitudes up to 800 km

Capturing space debris

CONDOR

System for real-time airborne surveillance and reconnaissance

- CONDOR: cost-efficient multi-purpose, medium altitude and medium endurance flight platform
- ARDS data link system: OHB real-time data transmission for 80 Mb/s data rate over 300 km range
- Sensors for surveillance and reconnaissance: Sensor combinations for highly effective results for any given task (HD-Video, EO/IR-Cameras, hyperspectral, laser, SAR)
- Mobile ground control station: system control, in-time-data exploitation, integration in network-centric enabled capability (CSD) and interconnection to command centre via SatCom-On-The-Move (SOTM).