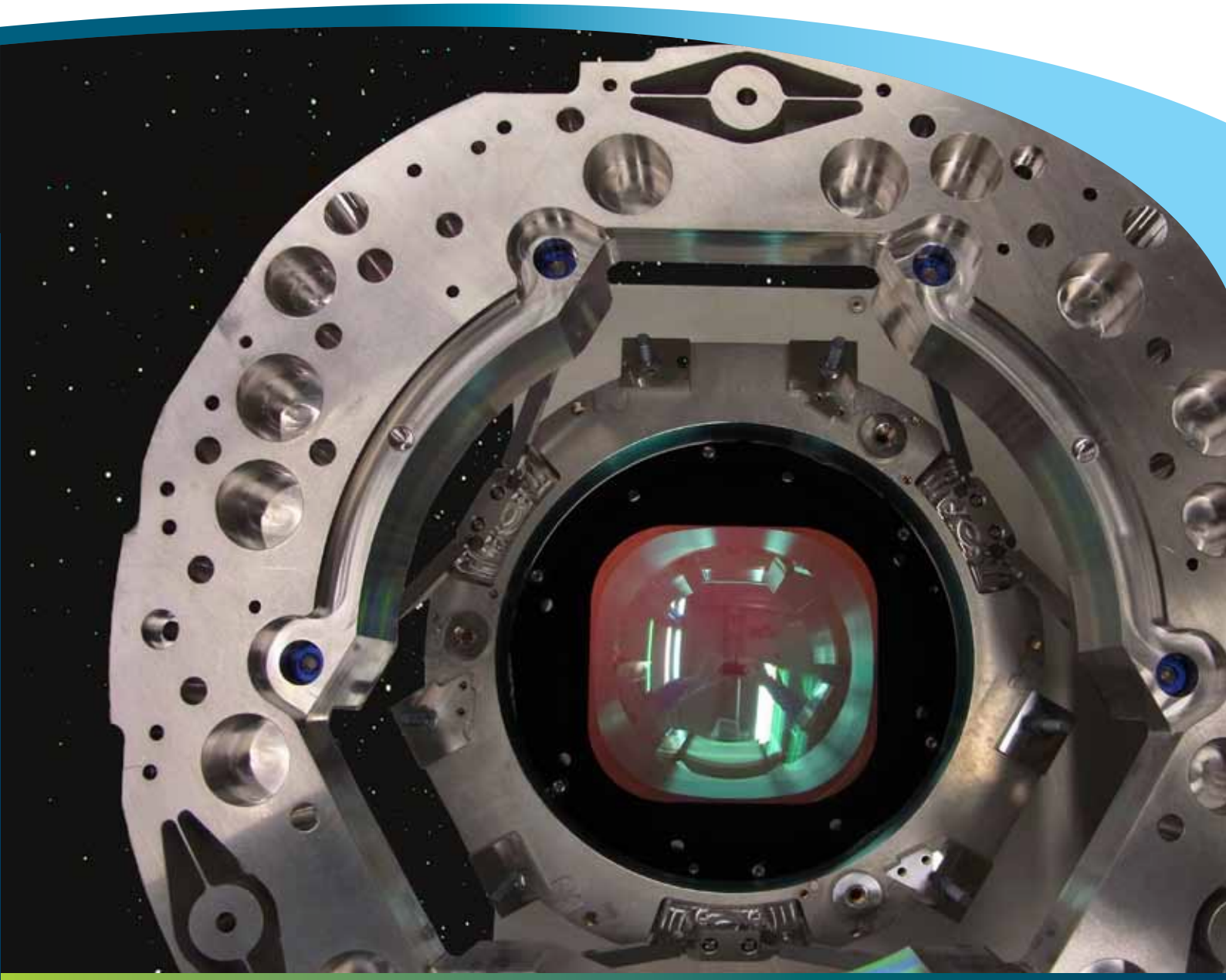
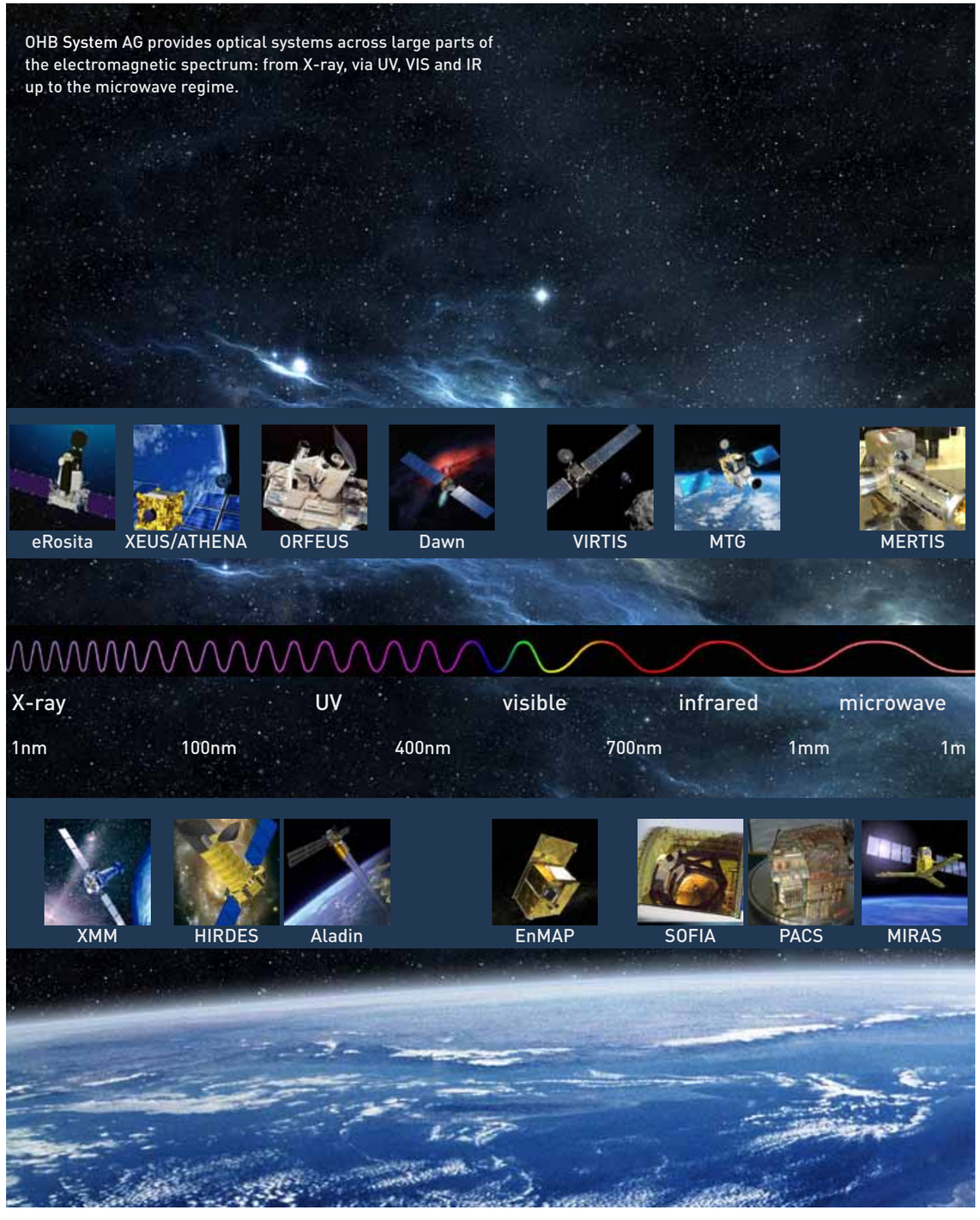
We. Create. Space.



SPACE SYSTEMS

OPTICAL SYSTEMS

OPTICAL SYSTEMS
SPECTRAL BANDWIDTH



OPTICAL SYSTEMS
INTRODUCTION

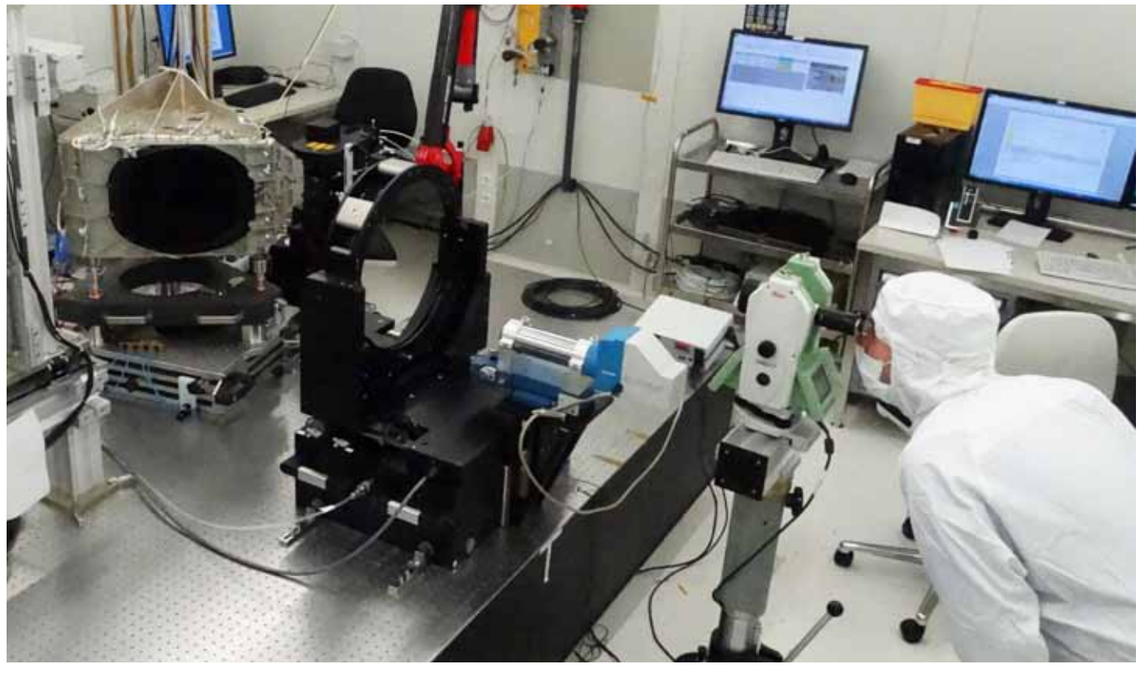
OHB System AG has a tradition of more than 30 years in the design, development and integration of optical systems for space applications. This covers classical optical system architecture and design on assembly, instrument and system level as well as specialty instrument development for various science, astronomy and earth observation missions. The spectral bandwidth of our realized systems covers not only the standard visual (VIS) and near-infrared (NIR) spectrum, but goes far beyond: down to X-ray for space-borne astronomy missions, and up to the far-infrared (FIR) and near-microwave regime for earth observation, planetary or science missions (see chart on the left).

OHB's optical engineering and validation capabilities span classical optical design and performance analyses (optical MTF, PSF, polarization, sensitivity, tolerancing, alignment), straylight analysis and characterization and the assembly, integration and verification of complete optical systems. In our designs, we apply standard optical elements like mirrors, prisms, lenses, gratings and slits, as well as specialty optics immersed gratings (GRISMs, PGPs), ultra-lightweight mirrors, pore optics, replicated optics and optical fibres.

To date we have used our expertise in material selection (various metals, glasses, ceramics, CFRP composites) and optical coatings, to realize more than 40 optical payloads, cameras, subassemblies and OGSEs to meet the demands of our of our international customers.

In most cases, very challenging requirements in terms of spectral resolution, stability, mass, volume and robustness had to be met by our optical systems. To the satisfaction of our customers, their performance was sometimes touching or even surpassing the established technological limits. OHB's optical systems include the opto-mechanical mounting and opto-electronic read-out that provide integrated, ready-to-use instruments and camera systems including opto-mechanical high precision mechanisms. For that purpose, design, development and realization of high-precision/high-stability mounts (bipods, whiffle trees, lightweight frames) as well as high-stability focal plane assemblies based on various types of supplied detectors are part of many of our systems.

System integration and performance verification is carried out under cleanroom conditions (ISO8 and ISO5) and supported by OHB's pool of in-house mounting and validation equipment and optical metrology instruments (like interferometers, wavefront sensors, coordination measurement machines, 6-DOF hexapods, lasers, etc.). In addition, in-house definition and realization of dedicated OGSE allows verification of the functionality and performance of our optical systems in all aspects of the customer requests.



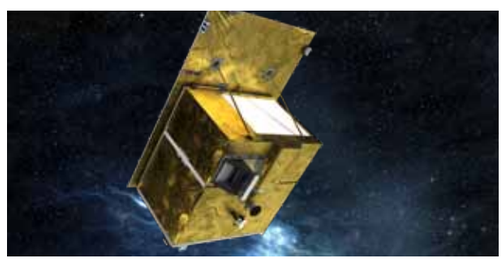
OPTICAL SYSTEMS
INSTRUMENTS & CAMERAS

OHB System AG designs, develops and builds high-complexity optical units at all integration levels: from optical ground support equipment and mock-ups over optical equipment and sub-systems up to entire optical instruments and satellites. The company has more than three decades of optical design and development experience, covering all phases in the product lifecycle: from Phases 0/A (feasibility studies) to Phases D (integration/ validation) and E (space operations).

A vast range of state-of-the-art optical, opto-mechanical and opto-electronic technologies are mastered in-house and continuously extended within national and European programs (GSTP, TRP).

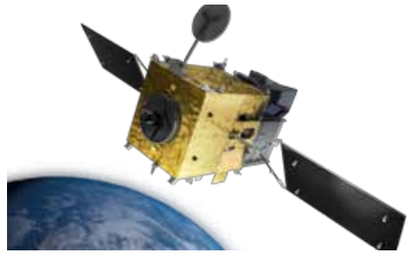
Collaborations with international research organizations, institutes and universities ensure that interesting new scientific and technological developments in the fields of optics, metrology and material science are known to OHB's experts and applied to the design of new instruments with enhanced performance.

Optical Payloads & Cameras



Spectrometer
- UV, VIS, NIR, SWIR and FIR grating, prism and other dispersive spectrometer systems, multiband or hyper spectral
- Offner, Dyson, Schwartzshield, Fery and other designs
- Utilizing ultra-precise optical slits, prisms and gratings of various types (e.g. convex blazed gratings, PGPs, GRISMs)
- Mounting and support structures made from aluminum, CFRP and ceramics, but also metal alloys like Invar, Covar, Inconel and Titanium.

Interferometer
- Fourier transform interferometer systems with double or common path
- Static FTS-type or modulators type, based on double pendulum principle or single linear path
- Corner cube or plane mirror retroreflectors
- Applications in earth observation (scanning EO), planetary missions and manned space flight.



Imager
- Panchromatic, monochromatic or multiband imagers and cameras
- Reflective, refractive or mixed systems
- Applications in high spatial resolution earth observation (LEO & GEO), planetary and asteroid missions.

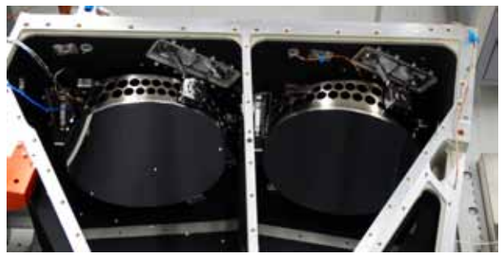
Recent developments: ANITA II on ISS, IRS on MTG, FCI on MTG, MERTIS, FLORIS on FLEX
Flight heritage: PACS on HERSCHEL/PLANCK, ANITA I on ISS, FC Camera on DAWN, TET

OPTICAL SYSTEMS
TELESCOPES

Optical Telescopes

X-ray Telescopes
- Wolter telescope designs
- Mirror modules with up to 58 electroformed Ni mirror shells each
- Silicon pore optics mounted on ceramic petals
- Large effective area
- Lowest HEW.

UV Telescopes
- UV telescope systems with up to 1 meter primary mirrors
- Gregory and Newton designs
- Use of different mirror materials: aluminum and Zerodur
- Robust structural designs using aluminum, titanium, Invar, CFRP.



VIS/NIR Telescopes
- Visible and NIR telescopes with up to 2 meter primary mirrors
- TMA, refractive and Cassegrain designs
- Use of different mirror materials: aluminum, Zerodur, SiC, Pyrex, Astrosital
- Robust structural designs using aluminum, titanium, Invar, CFRP.

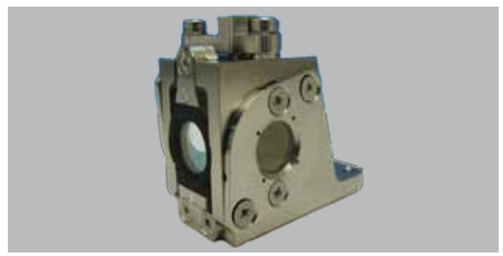
IR Telescopes
- Infrared telescopes with up to 2.7 meter primary mirrors
- Cook-TMA, Cassegrain and Newton designs
- Use of different mirror materials: aluminum, Zerodur, SiC, Herasil
- Robust structural designs using aluminum, titanium, Invar, CFRP.

Recent developments: MTG, EnMAP, Sentinel 4 and 5, eRosita, ATHENA
Flight heritage: ORFEUS, XMM, SOFIA, SUNRISE

OPTICAL SYSTEMS
SUB-SYSTEMS & ASSEMBLIES

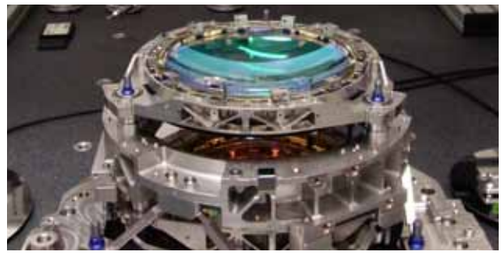
Opto-Mechanical Subassemblies

High-Power UV Laser Transmit / Receivers
- Small form factor optical systems with large number of optical elements
- Use of specialized optical coatings with high laser damage threshold
- Combined transmission/reception paths with ultra-high stability and cleanliness.



Highly Integrated Optics
- Small systems combining several optical functionalities in a small volume
- Polarization splitting, interference filtering and other functions
- Nanostructured optics like optical slits
- Use of miniaturized optical elements.

Optical Camera & Lens Systems
- Framing cameras and microscope systems for visual observation and science applications
- Navigation and observation cameras
- Modular designs with internal and external autofocus mechanisms and filters
- Designed for in-orbit and planetary mission environments.

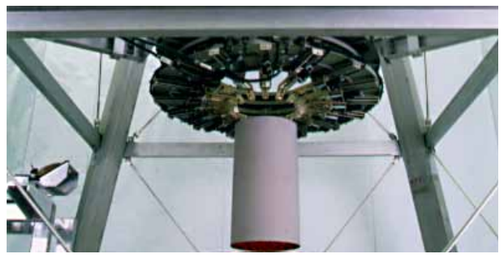


Lens & Mirror Assemblies
- High-performance opto-mechanical assemblies
- Large variety of optical and mechanical materials
- Aspheric and freeform elements
- High optical throughput
- Ultra-high stability within wide operational temperature ranges (ambient to cryogenic).

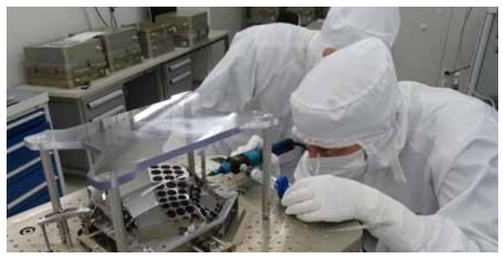
Recent developments: EnMAP, FLEX, EUCLID NI-OA, EXOMARS HRC, ALADIN TRO, MERTIS
Flight heritage: FC camera on DAWN, PACS on HERSCHEL/PLANCK, ANITA I on ISS, SUMER on SOHO

OPTICAL SYSTEMS
OGSE

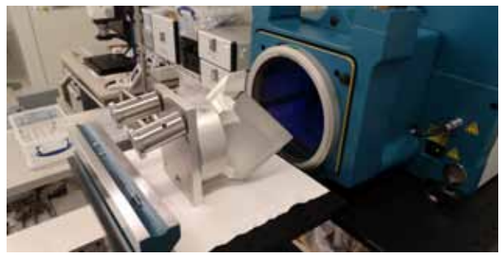
Optical Ground-Support Equipment



Optical Integration & Alignment Systems
- Customized and automated systems for precise optical alignment
- Real-time data evaluation using in-house developed software
- Ultra-high precision and repeatability
- Highest cleanliness (ISO5 compatible or better).



High-Precision Gluing & Monitoring Stations
- Controlled opto-mechanical integration of different types of optical elements (mirrors, prisms, etc.)
- Modular setups, quickly adjustable for different element layouts
- Demonstrated high-precision alignment and integration capabilities with high repeatability
- High precision dosing of adhesives
- Low and ultra-low outgassing materials.



Speciality Surface Form & Waveform Testing
- Modular customized test setups
- Interferometer systems with motorized 6-axis hexapod support
- Custom-designed and in-house developed software for real-time end-to-end data evaluation.

Stress & Strain Testing in Glass
- Stress, strain and defect analyses in different glasses
- Adapted systems capable of analyses on element and on integrated assembly level
- Stress analysis with nanometer resolution.

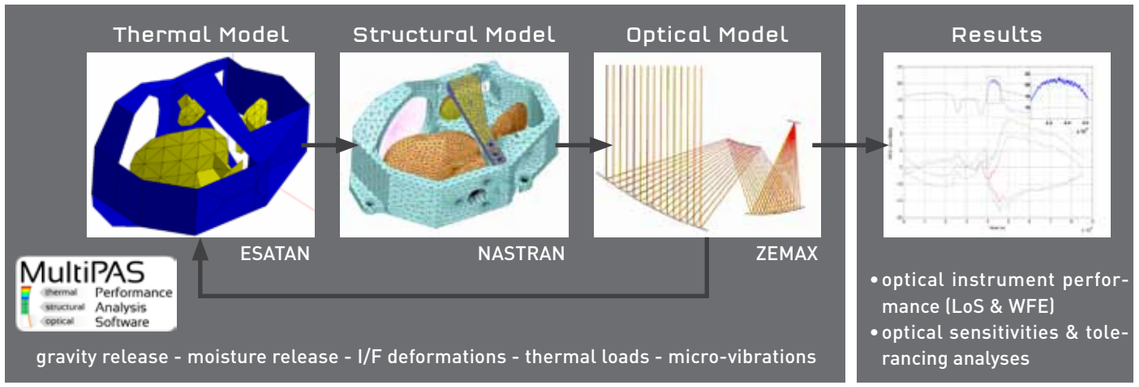
Recent developments: EnMAP, EUCLID NI-OA, EXOMARS HRC, MTG, FLEX
Flight heritage: XMM, ORFEUS, eRosita, ADM AEOLUS, ALADIN, SOFIA, SUNRISE

OPTICAL SYSTEMS
SIMULATION & S/W TOOLS

OHB System AG has developed a dedicated software tool suite to master the numerous challenges in high-precision/high-complexity optical systems design. Beside the classical tools for optical design like Code V and Zemax, OHB uses a number of speciality tools for optical and opto-mechanical simulations: For example, PC Grate is utilized for grating design, GLAD for lasers, physical optics and Gaussian beam propagation and McLeod for design and analysis of optical coatings. In the field of straylight design and analysis, OHB has put special emphasis on developing tailored in-house tools based on ASAP, FRED and COMSOL.

MultiPAS is an outstanding software tool chain for integrated thermo-opto-mechanical performance analysis which has been developed in-house over the last five years and is now routinely applied to the end-to-end performance simulation of all optical instruments designed at OHB. MultiPAS supports a highly efficient development process across multiple disciplines and multiple tools (e.g. ESATAN, NASTRAN, ZEMAX). It allows precise end-to-end analyses of all types of optical instruments without mixture or loss of data.

Using MultiPAS, the impact on optical performance (such as line-of-sight and wavefront error) of effects like gravity release, thermal loads, interface deformations, tolerances and micro-vibration, can easily be simulated and analyzed. This applies also to transient conditions and, if needed, with high temporal and/or spatial resolution. Through the automation of the data linking process, the speed and thus the frequency of thermo-opto-mechanical performance predictions is significantly improved with MultiPAS. This software represents the standard for all instrument performance analyses at OHB. The features of the software are continuously extended to meet the demands of new projects.

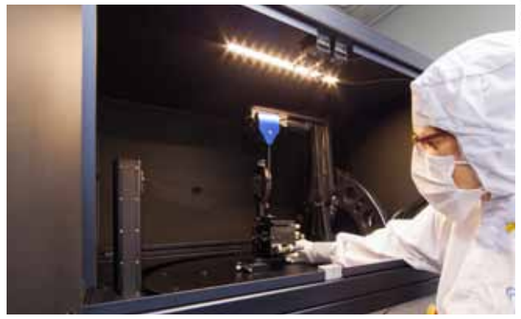


Name	Category	Description	Application	Supplier
Zemax OpticStudio	Optical Design	Optical design and analysis software	Optical Design, Optical Analysis	Zemax
ASAP	Raytracing	System analysis program for imaging and illumination applications	Straylight Analysis	Breault Research
MultiPAS	Thermo-Opto-Elastic Analysis	State-of-the-art coherent and integrated thermo-opto-elastic analyses	Integrated Instrument Performance Analyses	OHB Oberpfaffenhofen
CodeV	Optical Design	Comprehensive optical design software, imaging design software	Optical Design, Optical Analysis	Synopsis (Light Tec)
GLAD	Optical Analysis	Physical optics and laser analysis software	Physical Optics, Beam Propagation	AOR
Essential MacLeod	Optical Design	Thin film design and analysis software	Coating Design & Analysis	Thin Film Center
PC-Grate	Optical Analysis	Analysis of multi-layer diffraction gratings of various groove profiles	Grating Analysis	International Intellectual Group, I.I.G., Inc.

OPTICAL SYSTEMS
LABORATORIES & H/W TOOLS

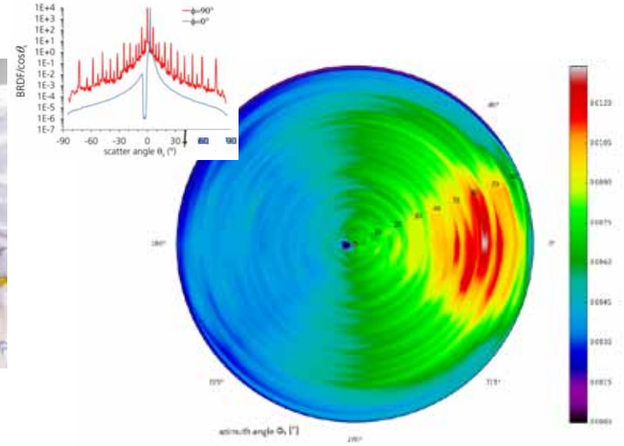
For the verification and validation of optical systems OHB has several optical labs and cleanrooms on site. More than 300 m² of class ISO5 and about 500 m² of class ISO8 cleanrooms are available with a temperature stability down to 0,5°C. One of the ISO5 cleanrooms is equipped with a 4 x 7,5 m² fully vibration-isolated granite optical table. Interferometers, laser trackers, theodolites, autocollimation telescopes and a 3D CMM are available inside the cleanrooms to address all needs during optical assembly, alignment and characterisation.

A 75m² ISO5 class focal plane lab enables OHB to fully characterize and test optical detectors in the wavelength range from VIS to SWIR. A state-of-the art scatterometer is utilized to determine the BRDF of optical and optical black surfaces, complementing OHB's capabilities for in-house straylight prediction and verification.



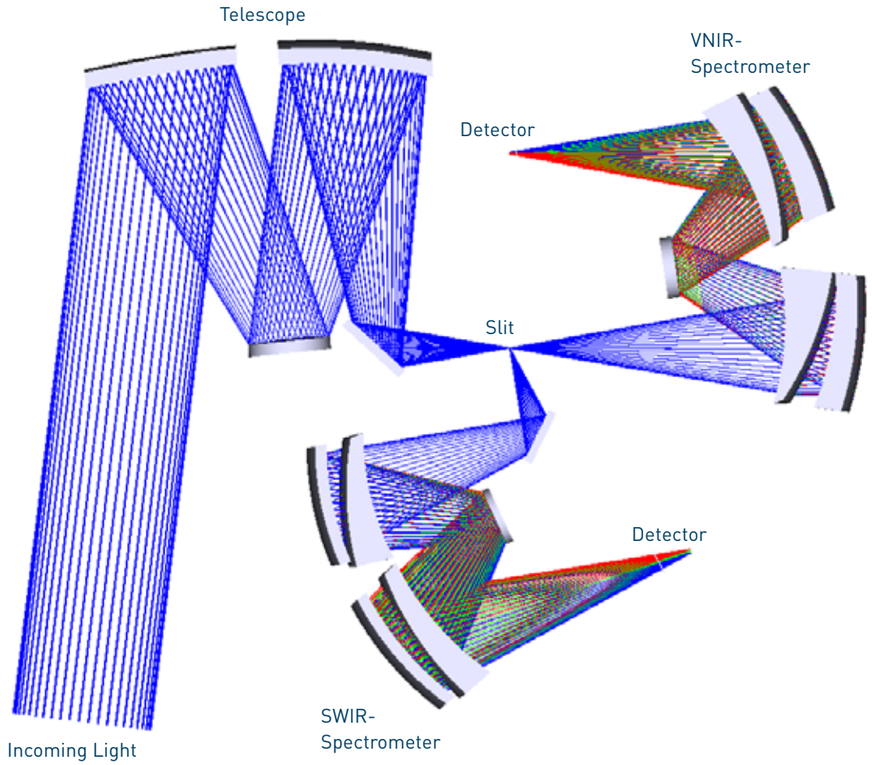
Albatross-TT Scatterometer

Precise characterization of light scattering properties of optical surfaces (BRDF/BSDF).



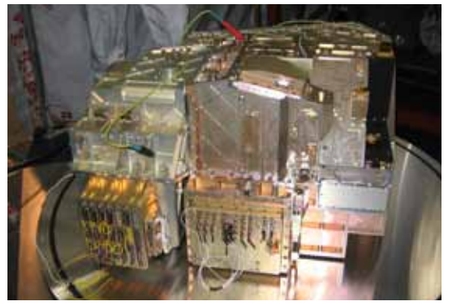
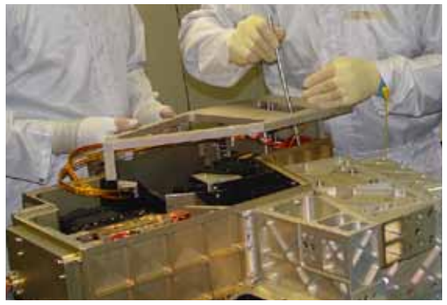
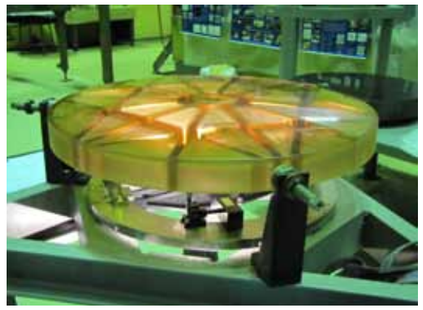
OPTICAL SYSTEMS
KEY COMPETENCIES

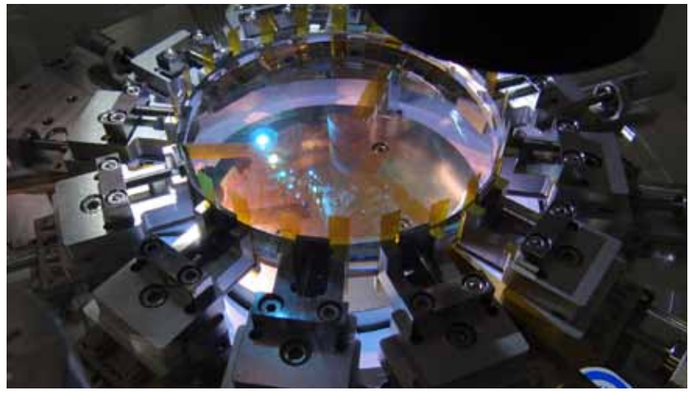
- Optical system architecture and designs (spectral range from X-ray to FIR) on assembly, instrument and system level
- Optical performance analyses (optical MTF, PSF, polarization, sensitivity and tolerancing, alignment) on assembly, instrument and system level
- Straylight analysis and design (incl. baffles, BRDF characterisation and definition) on assembly, instrument and system level
- Development, procurement, integration and characterization of optical components and assemblies
- Optical verification and definition of optical alignment strategies as well as optical characterization on assembly and instrument level
- Standard optics: mirrors, lenses, prisms, optical gratings, optical fibers and optical slits
- Speciality optics: immersed gratings (GRISMs, PGPs), CGHs, CeSiC/SiC mirrors, ultra-lightweight mirrors, X-ray mirrors (pore optics, Wolter optics) and replicated optics
- Design and definition of optical substrate materials and optical coatings
- Design, definition and realization of opto-mechanical mounts with ultra-high precision/stability and low stress; e.g. bipods, whiffle trees and classical lens mountings
- Particular opto-mechanical mounting technologies (high-precision adhesive glueing and dosing)
- Various laser technologies and photonics; e.g. Optical Frequency Combs, QKD and Optical Clocks.

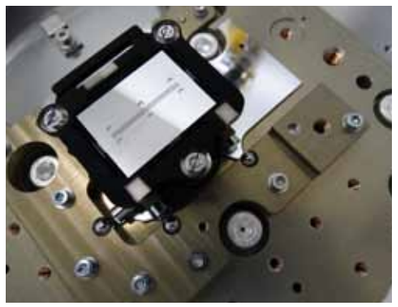
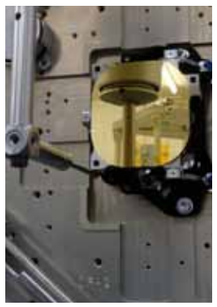
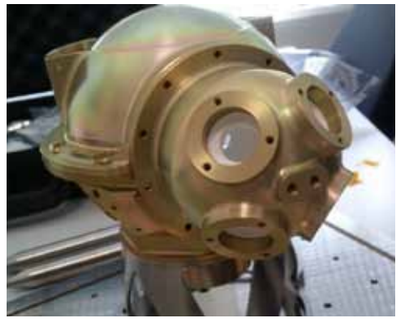


EnMAP Optical Layout

Development on behalf of the German Space Agency DLR with funds of the German Federal Ministry of Economic Affairs and Technology under grant No. 50 EP 0801.





We. Create. Space.

About OHB System AG

OHB System AG is one of the three leading space companies in Europe. It belongs to the listed high-tech group OHB SE, where around 2,800 specialists and system engineers work on key European space programs. With two strong sites in Bremen and Oberpfaffenhofen near Munich and more than 35 years of experience, OHB System AG specializes in high-tech solutions for space. These include small and medium-sized satellites for Earth observation, navigation, telecommunications, science and space exploration as well as systems for human space flight, aerial reconnaissance and process control systems.

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2019/05 Pictures Courtesy: Astronomisches Institut Tübingen; C.C. Meyer; DLR; DSI; ESA; MPE; MPS