Remote Sensing Technology Institute

Institut für Methodik der Fernerkundung

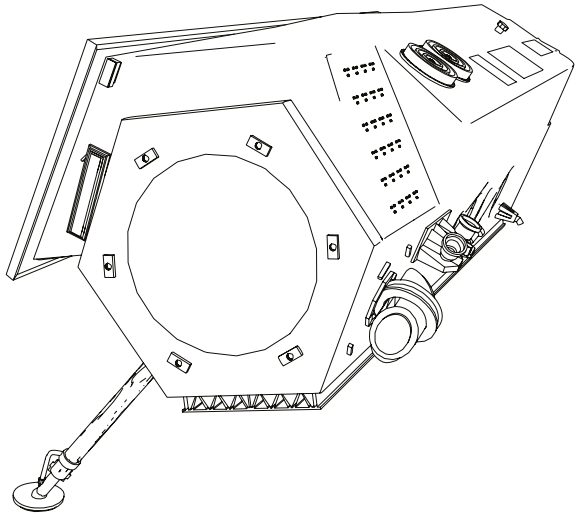
Status Report 2007 – 2013

DLR

Important Earth Observation Missions

As a leading Earth observation facility, EOC participates in and contributes to a large number of national and international Earth observation missions. Our portfolio of past, current and future mission involvement illustrates the reputation EOC has gained in these areas.

Depending on the EO mission our involvement can range from providing only data acquisition services up to hosting an entire payload data ground segment including the full chain of tasks from receiving data downlinked from a spacecraft to processing to product dissemination and archiving. The required ground segment systems and subsystems are continuously developed and maintained at EOC. Our commitments now extend to 2020 and beyond. This will ensure continuous data availability, a must for developing state-of-the-art Earth observation applications and for our contributions to global climate change exploration.



National and DLR Missions

TerraSAR-X

TerraSAR-X is a German radar satellite mission providing high resolution Synthetic Aperture Radar (SAR) image data to scientific and commercial users since 2007.

The satellite's main instrument is an advanced high-resolution X-band imaging SAR which is based on active phased array technology. This technology allows electronic beam steering and thus the operation of many different SAR imaging modes characterized by their individual resolution, polarization and image size. Especially the maximum resolution of 0.5 m in spotlight mode surpasses the performance of previously available systems by an order of magnitude.

The mission is implemented in a public private partnership model between DLR and the German space industry. EADS Astrium manufactured the TerraSAR-X spacecraft, with its subcompany Infoterra GmbH dealing with the commercial product service aspects. Several DLR facilities developed and operate the entire TerraSAR-X ground segment. For EOC this comprised prior to launch the development of:

- the payload data receiving stations and data links
- a multimode SAR processor (TMSP)

- the complete SAR data payload ground segment
- a service segment for scientific users.

During the in-orbit mission phase, we are now responsible for all major elements, such as:

- product ordering
- high rate satellite data reception
- SAR processing
- product archiving and dissemination.

Furthermore, we coordinate the scientific use of the SAR data. More than 800 science data proposals with applications in geology, georisks, hydrology, glaciology and other fields are being handled. The ever increasing use of TerraSAR-X data is reflected at international conferences and in publications in remote sensing journals.

The success accomplished so far has provided EOC with the opportunity to contribute to future missions such as the Spanish PAZ, which is based on Astrium's TerraSAR-X platform and our SAR processor, and TerraSAR-X HD, a commercial follow-on mission with even higher resolution and performance.

TanDEM-X

TanDEM-X is an innovative radar mission consisting of two cooperating satellites with the purpose of producing a global Digital Elevation Model (DEM) with 12 m horizontal resolution.

To calculate 3D elevation maps from 2D radar images, the TerraSAR-X satellite was complemented by a second satellite in 2010. Both are now flying in close formation only some hundred meters apart. They are jointly operated to form a bistatic interferometer, i.e., one satellite transmits and both satellites synchronously receive the echoes.

TanDEM-X at IABG in Ottobrunn ready for dispatch to the launch site in Baikonur

The close formation flight and the smooth cooperation of the radar systems posed numerous technical challenges which were all successfully met with the help of newly developed algorithms and techniques.

The TanDEM-X mission is financed and operated in a public private partnership like the TerraSAR-X model. Concerning data products, EADS Infoterra is again responsible for commercial DEM distribution while DLR handles the scientific data usage.

Our major contributions to the TanDEM-X mission are the development and, since launch, the operation of the complete SAR data payload ground segment, including:

- payload data receiving stations and data transfer links
- a bistatic InSAR DEM processor (ITP)
- a calibration and global mosaicking processor.

By 2013, two gapless coverages of the major land surfaces will have been acquired and processed in a first step, with calibrated and mosaicked products to follow. The final global TanDEM-X DEM will be a milestone in remote sensing with benefits for all disciplines of the geosciences and for commercial geo-applications.

MERLIN

The Franco-German collaborative MERLIN mission is intended to measure atmospheric methane concentrations with unprecedented accuracy. It will carry an active SWIR instrument which exploits a differential-absorption lidar technique as a novel sensor approach.

The workload shared by the mission participants is such that France provides an extension of the Myriade platform together with its operations while Germany develops the lidar instrument and takes care of all aspects of the payload.

MERLIN has successfully passed the mission definition (pre-phase A) and preliminary readiness (phase A) reviews. Phase B started in April 2013. It is planned to launch the satellite in 2016 for a mission duration of at least three years.

Our development responsibilities for MERLIN include:

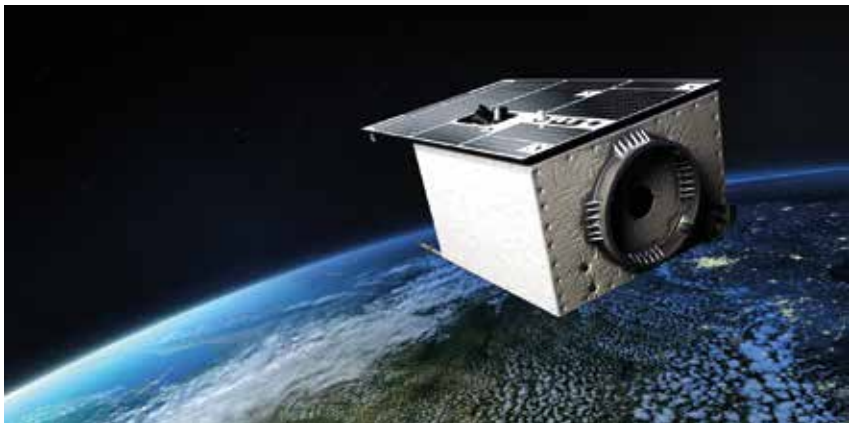
- operational data processors for level 0-1a and level 1a-1b
- long-term instrument performance monitoring
- short-term instrument health and safety monitoring
- payload command and control facilities
- host interface structures for data processing, data archiving and a data user interface via WDC-RSAT.

EnMAP

The Environmental Mapping and Analysis Program (EnMAP) establishes the first national hyperspectral remote sensing satellite mission. It is based on the long German heritage and expertise in imaging spectroscopy.

EnMAP is a scientific pathfinder mission, driven by the need to quantify the status and processes of Earth's environments in the context of growing anthropogenic impacts.

The 228 channels of EnMAP's imaging spectrometers cover the reflectance spectrum from the VNIR to the SWIR range with geometric resolution of 30 m. Operational geometric and atmospheric correction is applied to ensure products of excellent quality. With its 30° pointing capability and capacity of 30 km × 5000 km per day in a sun-synchronous



The German hyperspectral Satellite EnMAP forseen to be launched in 2017

orbit, EnMAP will permit frequent and global acquisitions. Currently, only airborne sensors such as EOC's HySpex are capable of delivering products reflecting similar performance.

The EnMAP mission, managed by the DLR Space Agency, assigned to EOC responsibility for the complete mission ground segment, which is realized in a collaborative effort with DLR's GSOC. Our role comprises:

- project management of the complete ground segment for all mission phases
- instrument pre-flight simulations and in-flight calibration
- X-band data reception
- processor development and operation with data quality control
- long-term data archiving
- web-based acquisition and product request handling using EOC's multimission infrastructures.

EnMAP has an anticipated launch date in late 2017.

Tandem-L

Tandem-L is a DLR scientific SAR mission proposal to monitor dynamic processes in the bio-, litho-, cryo- and hydro-sphere. The variables to be assessed–among them seven essential climate variables– include biomass, tectonic and volcanic activity, soil moisture, ice extent and ice dynamics. The mission employs two fully polarimetric L-band SAR systems flying in formation and operating in either bistatic Pol-InSAR (for forest profiling) or repeat-pass InSAR (for deformation measurements) modes. An innovative digital beam-forming concept provides a mapping capacity two orders of magnitude better than TanDEM-X: mapping of Earth's entire land mass is achieved twice in eight days.

Fully polarimetric L-band SAR system: Tandem-L

A pre-phase-A study together with JPL was conducted during the last few years. Most of the technological concepts and the performance estimates have been finished. The Helmholtz Alliance 'Remote Sensing and Earth System Dynamics' has been charged with supporting algorithm development and federating the scientific user community for Tandem-L.

EOC will be in charge of:

- developing and operating a payload ground segment handling unprecedented data rates and volumes
- developing algorithms for geotectonic, cryospheric and oceanographic parameter retrieval.

These operational duties will be complemented by participation in science team activities.

FireBIRD

The FireBIRD mission consists of two satellites, TET-1 and BIROS. Its primary objective is the spaceborne detection and characterization of high-temperature events such as wildfires and volcanoes.

The first platform, TET-1, was launched in July 2012. Its purpose is to provide national industry and the science community the possibility to verify and demonstrate new technologies under space conditions. The second satellite, BIROS, has an anticipated launch date in 2013.

The principal imaging payload on both satellites is a bi-spectral IR sensor with channels in the mid-IR and thermal IR range, supplemented by a three-band VNIR camera.

EOC is responsible for satellite data reception. In addition, the standard processors are integrated into DIMS for the operational processing of the FireBIRD products.

RapidEye

The commercial RapidEye system consists of five identically designed satellites. The entire configuration was launched in August 2008 and became operational in 2009. The optical imaging payload covers the VNIR wavelength range and captures about five million km^2 per day with a maximum spatial resolution of 6.5 m.

EOC is a scientific coordinator in partnership with the RapidEye company and provides the German user community with RapidEye data on the basis of peer-reviewed proposals. In this context EOC has established and is hosting the corresponding data pool.

Additionally, we provide advice to the DLR Space Agency on integrating RapidEye services into the European Copernicus initiative in order to assure the safeguarding of national interests.

CHAMP

CHAMP, a German satellite mission addressing Earth science needs concerning the geosphere and the atmosphere, was operational from 2000 to 2010. Its prime mission goal was high precision gravity field and magnetic measurements. In addition, radio occultation technology and GPS measurements delivered information about the state of the atmosphere and space weather.

The mission was managed by GFZ Potsdam and operated by DLR's GSOC. We contributed the CHAMP raw data center, including data reception, pre-processing, near-real-time dissemination to the project partners and long term archiving.

GRACE

Since 2002 the twin satellite mission GRACE continues the CHAMP mission goals to generate a global high-resolution model of Earth's gravity field with unprecedented accuracy. Its secondary mission is to provide globally distributed status profiles of the ionosphere and atmosphere using limb sounding.

GRACE is a joint effort between DLR and NASA/JPL, with GSOC handling spacecraft operations and GFZ functioning as one of the science centers. As for CHAMP, EOC hosts the raw data center for data processing, archiving and dissemination to the mission control center and to the scientific centers.

ESA and EUMETSAT Missions

ERS-1 and ERS-2

ERS-1 was Europe's first Earth observation mission, operated between 1991 and 2000. The platform carried a payload suite of active and passive sensors, including an imaging SAR and a wind scatterometer.

In 1995, ESA launched ERS-2, the successor to ERS-1. It was decommissioned after 16 successful years of in-orbit service. In a short-track development, ERS-2 was equipped with GOME to carry out atmospheric measurements, particularly ozone and chemical composition, for the first time from a European spaceborne platform. The rest of the payload was identical to ERS-1.

On behalf of ESA, both for ERS-1 and ERS-2, we hosted the German Processing and Archiving Facility D-PAF. For the SAR instrument the tasks assigned to the D-PAF included:

- acquisition and archival of level 0 data, particularly from our acquisition stations located on the Antarctic peninsula and in Chetumal, Mexico
- on-request processing and dissemination of products to users.

For GOME, we developed the required algorithms for trace gas retrieval and implemented the resulting processor in D-PAF. D-PAF's role for GOME included:

- acquisition, reception, and archival of the entire level 0 data repository

Multitemporal ERS 1/2 radar image, City of Madrid, 2004

- systematic near-real-time and offline processing and dissemination services for level 1 radiances and level 2 total column products
- repeated reprocessing campaigns using continuously improved versions of the GOME processors.

The work successfully accomplished in the framework of D-PAF formed the basis for our manifold involvement in other ESA and EUMETSAT Earth observation missions.

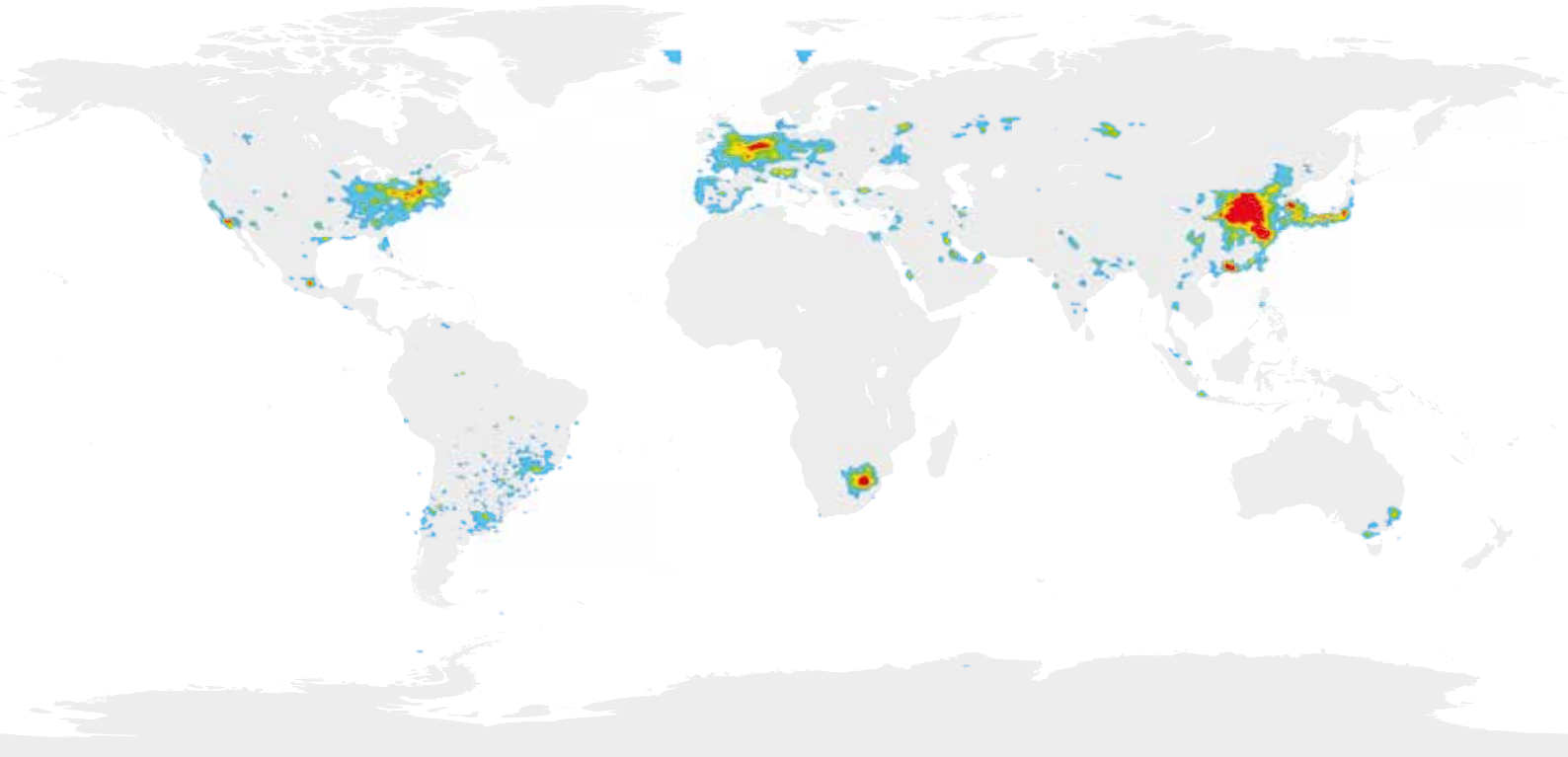
ENVISAT

ENVISAT was ESA's Earth observation flagship mission in the first decade of the 21st century. Launched on March 1, 2002 the mission operated until April 8, 2012. It carried a payload of ten instruments suitable for studying the entire Earth system from polar orbit. Seven instruments of the payload complement had the status of an ESA-developed instrument. SCIAMACHY, AATSR and DORIS were Announcement of Opportunity instruments. They were provided by national agencies, with tasks in instrument operation and data processing shared by ESA and the instrument providers.

EOC was tasked by ESA and DLR to be one of the major facilities in the ENVISAT ground segments for the atmospheric science instruments SCIAMACHY, MIPAS and GOMOS, together with the radar sensor ASAR and the imaging spectrometer MERIS.

For SCIAMACHY, jointly provided by Germany and the Netherlands, both flight operations and data processing functions

Global NO_2 concentration in 2007 measured by SCIAMACHY on ENVISAT



were hosted by EOC. In cooperation with IUP-IFE, University of Bremen, we were responsible for instrument operations comprising mission planning, instrument configuration control and performance monitoring. In the data processing domain, algorithm development for instrument calibration (level 0-1) and atmospheric parameter retrieval (level 1-2) was pursued as part of a Europe-wide quality working group. The algorithms finally selected formed the basis of the operational data processors that had been implemented in the framework of the German D-PAC, a de-centralized ESA facility in the ENVISAT payload data segment. EOC operated the D-PAC on behalf of ESA not only throughout the now completed in-orbit phase, but also continues its operation in the current post-mission phase for the purpose of product generation, archiving and dissemination.

For the other payload instruments, D-PAC's role comprised:

- MIPAS: externally developed processors were implemented for the generation and subsequent storage and dissemination of operational level 1 and level 2 data products
- GOMOS: hosting all level 1 and 2 products for the complete mission
- ASAR: all production steps, as well as archiving and disseminating products derived from data when the instrument operated in high rate mode, were assigned to D-PAC. This was complemented by systematic dissemination of wave-mode data
- MERIS: archiving all level 0 data which had been acquired at EOC's Neustrelitz station together with the corresponding level 1 and 2 processing under national auspices.

MetOp

The series of three MetOp satellites defines EUMETSAT's polar Earth observation system. With MetOp-A launched in October 2006 and MetOp-B launched in September 2012 two components are presently operational. Lifting MetOp-C into orbit is currently envisaged for 2018. One of the prime goals of MetOp is to provide unique operational data products for Copernicus until at least 2020.

The MetOp payload includes the GOME-2 instrument, an advanced version of GOME which was successfully flown on ESA's ERS-2 mission from 1995 to 2011. With MetOp, remote sensing of atmospheric composition was successfully transferred to the domain of operational meteorology.

The Satellite Application Facility on Ozone and Atmospheric Chemistry Monitoring (O3M-SAF) is responsible for providing the operational atmospheric products based on MetOp data. EOC plays a prominent role in the O3M-SAF that is hosted by the Finnish Meteorological Institute but implemented as a decentralized facility in cooperation with a Europe-wide network of research organizations.

At EOC the O3M-SAF project builds on the experience gained over almost two decades in algorithm development and systematic operational processing of data from atmospheric sensors. The share of responsibilities at EOC includes:

- development of retrieval algorithms and operational processors for MetOp/GOME-2 total column products
- operational data processing and data dissemination in the distributed O3M-SAF payload data ground segment.

Copernicus Sentinel Missions

The space segment of Copernicus extends the capabilities of the former and existing European Earth observation missions. In addition to the national platforms for high resolutions optical and radar observations and to the pure science (Earth Explorer) and operational meteorological (EUMETSAT) missions, the Sentinels provide a basic range of measurements with global coverage for operational needs in Europe. Five Sentinel series satellites have been identified. Their full operational scenario calls for having two spacecraft of one kind in orbit at any time.

The core ground segment of the Sentinel missions is managed by ESA and to some extent by EUMETSAT. Processing of the raw data occurs at Sentinel-specific PACs, where products are generated, archived and sent to users.

All Sentinel data will be free of charge and access to all product information will be unrestricted for public, private and science use. In addition, ESA member states can directly access the Sentinel satellites with their own national stations and offer their own services.

Sentinel-1

The first Sentinel-1a satellite, to be launched early in 2014, will ensure the continuity of the C-band SAR data from the ERS-1/2 and ENVISAT missions, with the second Sentinel 1-b following in 2015. The SAR on Sentinel-1, operating in four modes, has higher capabilities than its predecessor instrument on ENVISAT.

Both Sentinel-1 satellites will provide coverage of Europe, Canada and most global areas in 1-3 days. For some areas and in sight of a local ground station, products can be delivered within one hour.

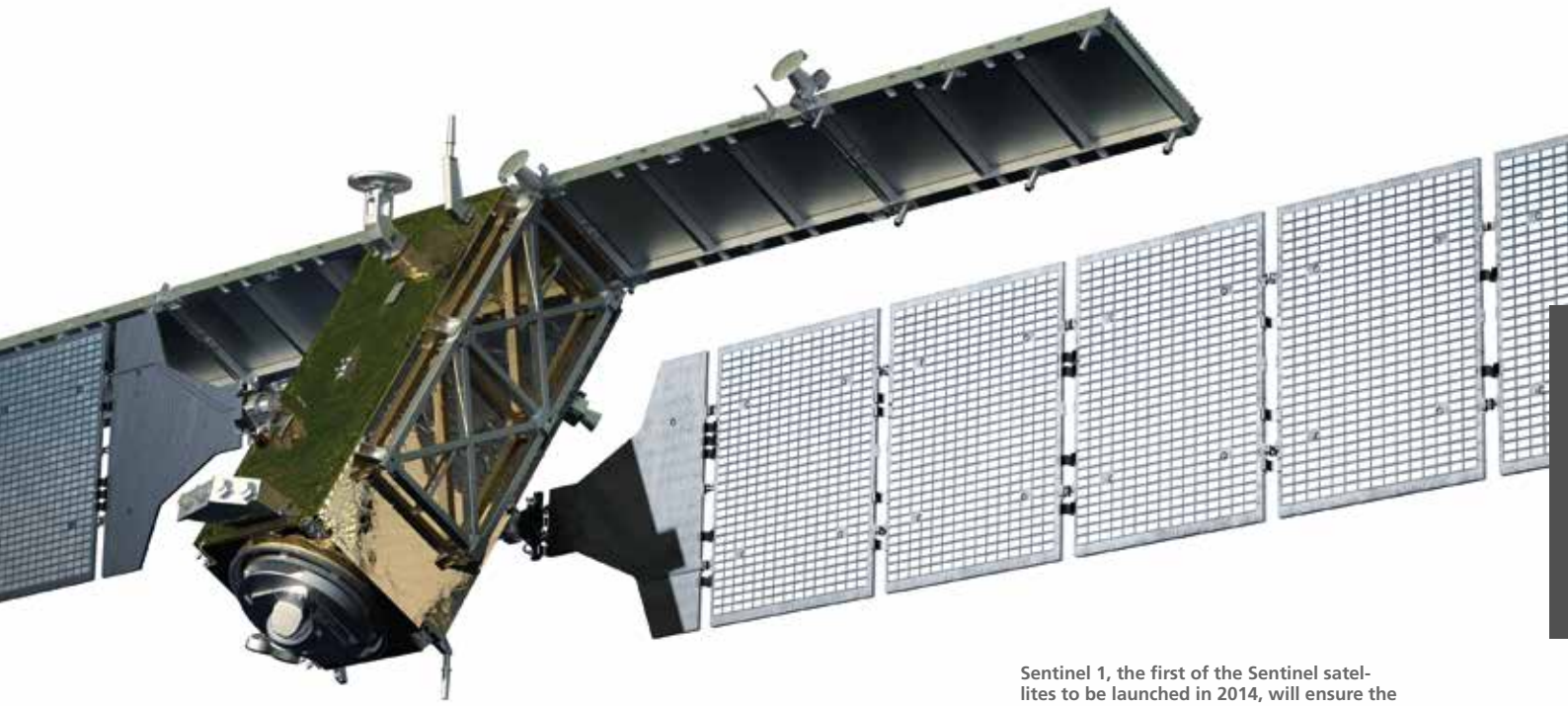
EOC was selected to host a PAC for Sentinel-1. The data will also be received at the EOC data acquisition stations and via the European Data Relay Satellite System, primarily for use in a national maritime security project.

Sentinel-2

The pair of Sentinel-2 satellites (Sentinel-2a being launched in 2014 with Sentinel-2b following about one year later) will routinely deliver high resolution optical information on all land masses of Earth. It complements other systems such as the Landsat series. The two satellites will have a revisit time of 2-3 days at mid-latitudes, which increases to 5 days at the equator.

Sentinel-2 will carry an optical payload for the VNIR-SWIR range with 13 spectral bands providing a maximum spatial resolution 10 m. The Sentinel-2 products will be used for land cover mapping, agriculture, vegetation and ecologic change monitoring.

EOC plans to acquire, process and use Sentinel-2 data as part of the national collaborative Copernicus ground segment and initiatives such as the Bavarian Copernicus Center.



Sentinel 1, the first of the Sentinel satellites to be launched in 2014, will ensure the continuity of the C-band SAR data from the ERS-1/2 and ENVISAT missions

Sentinel-3

The goal of the Sentinel-3 mission is derivation of sea and land surface parameters with high accuracy and reliability in support of ocean forecasting systems and for environmental and climate monitoring. Its products will contain information about the state of the sea and the land surface.

Owing to the wide range of objectives, the extensive Sentinel-3 payload includes a multitude of sensors of ENVISAT or Cryosat heritage. Of particular importance is the Ocean and Land Colour Instrument (OLCI), which is based on ENVISAT's MERIS. It will permit the retrieval of parameters related to sea surface temperature, water quality, water pollution and marine ecosystems.

EOC has been selected to set up and operate the PAC responsible for Sentinel-3 OLCI data. In addition, Sentinel-3 data is also planned to be received and used in the national collaborative ground segment.

Sentinel-4 and Sentinel-5

Both Sentinels focus on the state of Earth's atmosphere and its chemical composition. Their payloads will be implemented on operational EUMETSAT missions.

Sentinel-4, on board MTG-1, carries a UV-VNIR spectrometer into geostationary orbit for frequently monitoring the northern hemisphere over Europe. It will be launched in 2019, with the second spacecraft following in 2026.

Sentinel-5 will operate on the MetOp Second Generation platform. The payload complement includes a UV-VNIR-SWIR spectrometer. Sentinel-5 is targeted for launch in 2020.

Currently, in the early phases of instrument design, EOC is involved in developing algorithms for the instrument calibration of both sensors and for specification of level 0-1 processing.

Sentinel-5 Precursor

The Sentinel-5 Precursor (S5p) spacecraft, also part of Copernicus, will deliver a key set of atmospheric composition, cloud and aerosol data products for air quality and climate applications. The UV-VNIR-SWIR imaging spectrometer TROPOMI together with the operational level 1 and level 2 processors will achieve a significant improvement in the precision as well as temporal and spatial resolution of derived atmospheric constituents. S5p is planned for launch in 2015.

ESA has overall responsibility for the development of S5p. The TROPOMI sensor is jointly developed by The Netherlands and ESA. In the ground segment domain we have been assigned major tasks in the key areas of the payload data ground segment and algorithm and processor development.

For the payload data ground segment, the whole chain of on-ground payload data handling, including data reception, processing, archiving, and near-real-time and offline delivery to end users, will be developed and hosted by EOC. In the algorithms and processors domain we develop, in cooperation with partner institutes, the tools for the retrieval of key atmospheric trace gases and cloud products.

Thus S5p continues our strong heritage relating to atmospheric missions that started with GOME, SCIAMACHY and GOME-2. The work on S5p will, in addition, prepare for EOC involvement in the Sentinel-4 and Sentinel-5 missions.

ADM-Aeolus

The primary aim of the ESA Earth Explorer mission ADM-Aeolus is to provide global data on vertical wind profiles to improve numerical weather forecast and climate modeling. The launch of the mission is planned for 2015.

The ADM-Aeolus atmospheric instrument ALADIN is based on a direct detection Doppler lidar operating in continuous mode in the UV. It is a novel design and provides an enormous challenge not only for its development but also for operating the sensor during the in-orbit phase. The instrument measures the backscattered Doppler shifted signal emitted by the laser for retrieving profiles of the line-of-sight velocity in the troposphere and parts of the stratosphere.

Our responsibilities include:

- development of new instrument models and their implementation in the ADM-Aeolus end-to-end simulator
- elaboration of the codes for the operational level 0-1b and level 1b-2a processors
- maintenance of the ADM-Aeolus mission long-term archive.

All EOC tasks in support of the ADM mission are carried out in close collaboration with DLR's Institute of Atmospheric Physics.

ESA's Earth Explorer mission ADM-Aeolus will provide global data on vertical wind profiles from 2015 on

CarbonSat

CarbonSat is a proposed mission in the framework of the ESA Earth Explorer program with the goal to measure global concentrations of carbon dioxide and methane.

These are the two most important greenhouse gases with partially anthropogenic origin. The CarbonSat mission is intended to lead to a better understanding of the cycles of both gases in the context of climate change and global warming, including the identification of their sources and sinks. Crucial for successfully accomplishing these objectives is measuring the atmospheric concentrations of carbon dioxide and methane with very high spatial resolution and unprecedented accuracy.

In the present phase, CarbonSat competes with another mission proposal for the role of Earth Explorer 8. The mission is currently in phase A/B1 with feasibility studies of the different subsystems being performed on the way to constituting a fully qualified Earth observation mission.

ESA has tasked EOC with the definition of level 0-1 processing and with studies on the spectral calibration of the instrument.

International Missions

NOAA, Terra and Aqua

These missions are relevant because of the on-board AVHRR and MODIS sensors. The AVHRR sensor constitutes one of the most frequently used data sources in Earth observation. It is part of the payload complement of several NOAA missions dating back to 1978 and is now also installed on EUMETSAT's MetOp satellites. MODIS flies on NASA's Terra (since 1999) and Aqua (since 2002) platforms. Both instruments provide medium resolution optical imagery data from the VNIR and thermal IR ranges.

EOC began to receive such data in the early 1980s and continued direct reception until 2011. Meanwhile, AVHRR data from MetOp is also being received. Similarly, MODIS data are received at the EOC facilities in Oberpfaffenhofen and Neustrelitz.

The entire data archive of AVHRR and MODIS data at EOC covers more than 30 years. Parameters like temperatures of water and land surfaces or vegetation indices are derived on a regular basis. Furthermore, an automated value adding processing chain harvests this data repository.

The resulting products are made available for various applications including near-real-time services for fire detection.

Landsat-8, the Landsat Data Continuity Mission, has begun its normal operations on May 30th, 2013

Landsat

Landsat is the longest running spaceborne Earth imagery program, a cooperative effort between NASA, NOAA and USGS together with a private data vendor. Started in 1972 it has meanwhile seen the successful launch of eight satellites.

The Landsat program supports a wide range of user communities worldwide. The applications addressed by analyzing the data acquired from the VIS-NIR-SWIR

WorldView-2 with its 1100 mm aperture allows for the differentiation of details in the sub-meter range

and thermal IR bands cover areas such as global change research, agriculture, forestry, geology, resource management, mapping, water quality and oceanography.

In the past, Landsat-5 and Landsat-7 were the platforms providing the data. Currently, the Landsat Data Continuity Mission, now known as Landsat-8, has begun its operational in-orbit lifetime with enhanced imagery capabilities.

EOC's international ground station network supported local data reception for Landsat-5 and Landsat-7. In addition, our Neustrelitz ground station is a European acquisition node in the ESA third party mission network for acquiring Landsat data. In preparation for receiving data for Landsat-8, joint tests with two other European ground stations in that network, Kiruna and Matera, have been successfully carried out.

Ikonos-2 and WorldView-2

The Ikonos-2 spacecraft, launched in 1999, provided for the first time civilian access on a commercial basis to optical very high resolution satellite data of 1 m panchromatic and 4 m multispectral resolution. Even higher resolution is now available: 0.5 m panchromatic and 2 m multispectral with WorldView-2, which was sent into orbit in 2009. Both satellites can acquire imagery on either side of the ground track. They permit local regional tasking, which can be performed and optimized up to about one hour before the satellite passes occur.

DLR established a partnership with European Space Imaging EUSI, Munich, to exploit the data from both satellites. While EUSI handles all commercial aspects, DLR contributes its EOC ground segment facilities and engineering know-how. In exchange, the acquired data can be used for research purposes and in the framework of the Center for Satellite Based Crisis Information.

EOC operates and maintains, at least partially, the Earth terminal for both satellites. These functions include:

- direct tasking
- payload commanding
- payload data reception, processing and archiving.

In order not to be hampered by clouds, we developed and implemented a concept for efficient cloud-free tasking that uses up-to-date weather information in the planning process. Until 2009 this was implemented at the German regional operations center for the Ikonos satellite. In 2010 it was replaced by the direct access facility for WorldView-2, featuring nearly identical functionality.

ALOS

The Japanese Advanced Land Observing Satellite was operated between 2006 and 2011. It carried the L-band radar PALSAR and two optical remote sensing instruments. One was PRISM, providing a geometric resolution of 2.5 m for digital elevation model production. The other was the four-band radiometer AVNIR-2 with a geometric resolution of 10 m for disaster monitoring and precise land coverage observation.

On behalf of ESA, we assumed tasks for processing ALOS data, including the establishment of:

- operational processors for high-precision orthorectification of optical data starting from level 1 products
- prototype processors for systematic, radiometric, geometric corrections, quality improvements for PRISM, and atmospheric correction for AVNIR-2 starting from level 0 products

- provision of a quality-controlled service for orthorectification of ALOS optical data covering major European urban areas.

ALOS contributed to ESA's third party mission program.

Radarsat

Radarsat-1, nonoperational since early 2013, and Radarsat-2 are SAR spacecraft owned and operated by the Canadian Space Agency and Radarsat International. Since 1995 they have delivered C-band SAR coverage for a wide range of applications such as the monitoring and mapping of ice, marine and land surfaces, and resource management in Canada and globally. In 2018 Radarsat-2 will be supplemented by the Radarsat Constellation Mission (RCM), consisting of three satellites.

Radarsat data can also be directly received and used by other nations. In order to contribute to maritime security applications over European waters, we are receiving Radarsat-2 data in Inuvik. Additionally, preparations are ongoing for acquiring data from Radarsat-2 and RCM at Neustrelitz.

IRS-P6 and IRS-P5

Both satellites are part of India's Earth observation remote sensing program. IRS-P6, also known as Resourcesat-1, was launched in 2003. It provides multispectral and panchromatic imagery of Earth's surface with medium to high spatial resolution using three sensors. In 2005, IRS-P5, termed Cartosat, was launched. Its payload comprises two panchromatic cameras especially designed for in-flight stereo viewing to support applications like cartography and terrain modeling.

Since the mid-1990s, collaboration between DLR and ISRO, the Indian Space Research Organization, ensures access to data from the IRS program. It permits acquisition of raw data from IRS spacecraft at EOC and the harvesting of an IRS science data pool by DLR staff. Data reception occurs in support of the remote sensing company Euromap on the basis of a mutual cooperation agreement. It addresses the exchange of data products and software, such as the EOC-developed processor for the generation of digital elevation models from Cartosat data, which has been licensed for usage by Euromap.

ACE

ACE, NASA's Advanced Composition Explorer, a mission for studying solar-terrestrial interactions by measuring the properties of the solar wind upstream from Earth, was launched in 1997. Placed at the Earth-Sun libration point L1 at a distance of 1.5 x 10^6 km from Earth, ACE carries out in-situ-measurements of particles originating in the solar corona.

Cooperation between NOAA and DLR focuses on the development of real time solar wind detection capability using instruments on ACE. These data can be used to provide accurate alerts of impending geomagnetic storms with a lead time of one hour. The ground-based portion of the infrastructure consists of a worldwide network of antennas, each of which acquires the continuously transmitted solar wind data during local daytime hours when the satellite is in view.

The EOC facility at Neustrelitz is the European acquisition node. It sends the acquired data to the Space Weather Prediction Center in Boulder, Colorado. In joint projects with DLR's Institute of Communication and Navigation and national and international partners, the data are used for scientific purposes and for such applications as those relating to the Space Weather Prediction Center.

The sun releases a stream of charged particles, the solar wind, potentially damaging for Earth observation and communication satellites as well as for technical infrastructure on Earth

Earth Observation missions and EOC involvement
Blue marked tasks indicate where EOC is active either based on mission provider's and/or national assignments. Light blue cells illustrate our intentions for missions well into the future.

Mission	Operator/Partner	EOC Task						Task Period	Mission Objective
National and DLR Missions									
TerraSAR-X	DLR/Infoterra	MD	ACQ	A&P	PRC	ARC	DIS	2007 →	X-SAR
TanDEM-X	DLR/Infoterra	MD	ACQ	A&P	PRC	ARC	DIS	2010 →	X-SAR IF, Global DEM
MERLIN	DLR/CNES	MD		A&P	PRC	ARC	DIS	2016 →	ATM
EnMAP	DLR	MD	ACQ	A&P	PRC	ARC	DIS	2017 →	HYPER
Tandem-L	DLR	MD	ACQ	A&P	PRC	ARC	DIS	beyond 2019	L-SAR IF
FireBIRD	DLR		ACQ		PRC	ARC	DIS	2012 →	IR Fire
RapidEye	RapidEye AG/DLR					ARC	DIS	2008 →	MULT
GRACE	DLR/GFZ,JPL		ACQ		PRC	ARC	DIS	2002 →	GRAV
CHAMP	DLR/GFZ,JPL		ACQ		PRC	ARC	DIS	2000-2010	GRAV
ESA, EUMETSAT Missions									
ERS-1	ESA/DLR		ACQ		PRC	ARC	DIS	1991-2000	C-SAR, OPT, ALT
ERS-2	ESA/DLR		ACQ	A&P	PRC	ARC	DIS	1995-2011	C-SAR, OPT, ALT, ATM
ENVISAT	ESA/DLR	MD	ACQ	A&P	PRC	ARC	DIS	2002-2012	C-SAR, OPT, ALT, ATM
MetOp	EUMETSAT/DLR			A&P	PRC	ARC	DIS	2006	OPT, ALT, ATM
Sentinel-1	ESA/DLR		ACQ		PRC	ARC	DIS	2013 →	C-SAR
Sentinel-2	ESA/DLR		ACQ	A&P	PRC	ARC	DIS	2014 →	OPT
Sentinel-3	ESA/DLR		ACQ		PRC	ARC	DIS	2014 →	OPT, ALT
Sentinel-4	EUMETSAT/DLR		ACQ	A&P	PRC	ARC	DIS	2019 →	ATM
Sentinel-5	EUMETSAT/DLR		ACQ	A&P	PRC	ARC	DIS	2020 →	ATM
Sentinel-5 Pre.	ESA/DLR		ACQ	A&P	PRC	ARC	DIS	2015 →	ATM
ADM-Aeolos	ESA/DLR			A&P		ARC	DIS	2015 →	ATM (wind)
CarbonSat	ESA/DLR		ACQ	A&P	PRC	ARC	DIS	beyond 2020	ATM

Mission	Operator/Partner	EOC Task						Task Period	Mission Objective
International Missions									
NOAA-7 –19	NOAA/DLR		ACQ	A&P	PRC	ARC	DIS	1981 ➔	OPT, ATM
Terra	NASA/DLR		ACQ	A&P	PRC	ARC	DIS	1999 ➔	OPT, ATM
Aqua	NASA/DLR		ACQ	A&P	PRC	ARC	DIS	2002 ➔	OPT, ATM
Landsat-5, -7, -8	NASA,USGS/ESA,DLR		ACQ				DIS	1984 ➔	MULT
IKONOS	GeoEye/EUSI		ACQ		PRC	ARC		1999 ➔	OPT
WorldView-2	DigitalGlobe,EUSI/DLR		ACQ		PRC			2009 ➔	OPT
ALOS	JAXA/DLR			A&P	PRC			2006-2011	L-SAR, OPT
Radarsat	MDA,CSA/DLR		ACQ		PRC	ARC	DIS	1995 ➔	C-SAR IF
IRS-P6 Resourcesat	ISRO/Euromap,DLR		ACQ					2003 ➔	MULT
IRS-P5 Cartosat	ISRO/Euromap,DLR		ACQ	A&P				2005 ➔	OPT ST
ACE	NASA/DLR		ACQ		PRC		DIS	1997 ➔	Solar wind, Space Weather

MD: Mission Design, ACQ: Acquisition, A&P: Algorithm & Processor Development, PRC: Processing, ARC: Archiving, DIS: Dissemination

ALT: Altimetry
ATM: Atmospheric sounding
GRAV: Gravity mapping
HYPER: Hyperspectral imaging
IR Fire: Infrared fire detection
MULT: Multispectral imaging
OPT ST: Optical stereo mapping
OPT: Optical imaging

C-SAR, L-SAR, X-SAR: C-, L-, X-Band SAR imaging
X-SAR IF: Global DEM via X-band SAR interferometry
C-SAR IF, L-SAR IF: L-band SAR interferometric global imaging