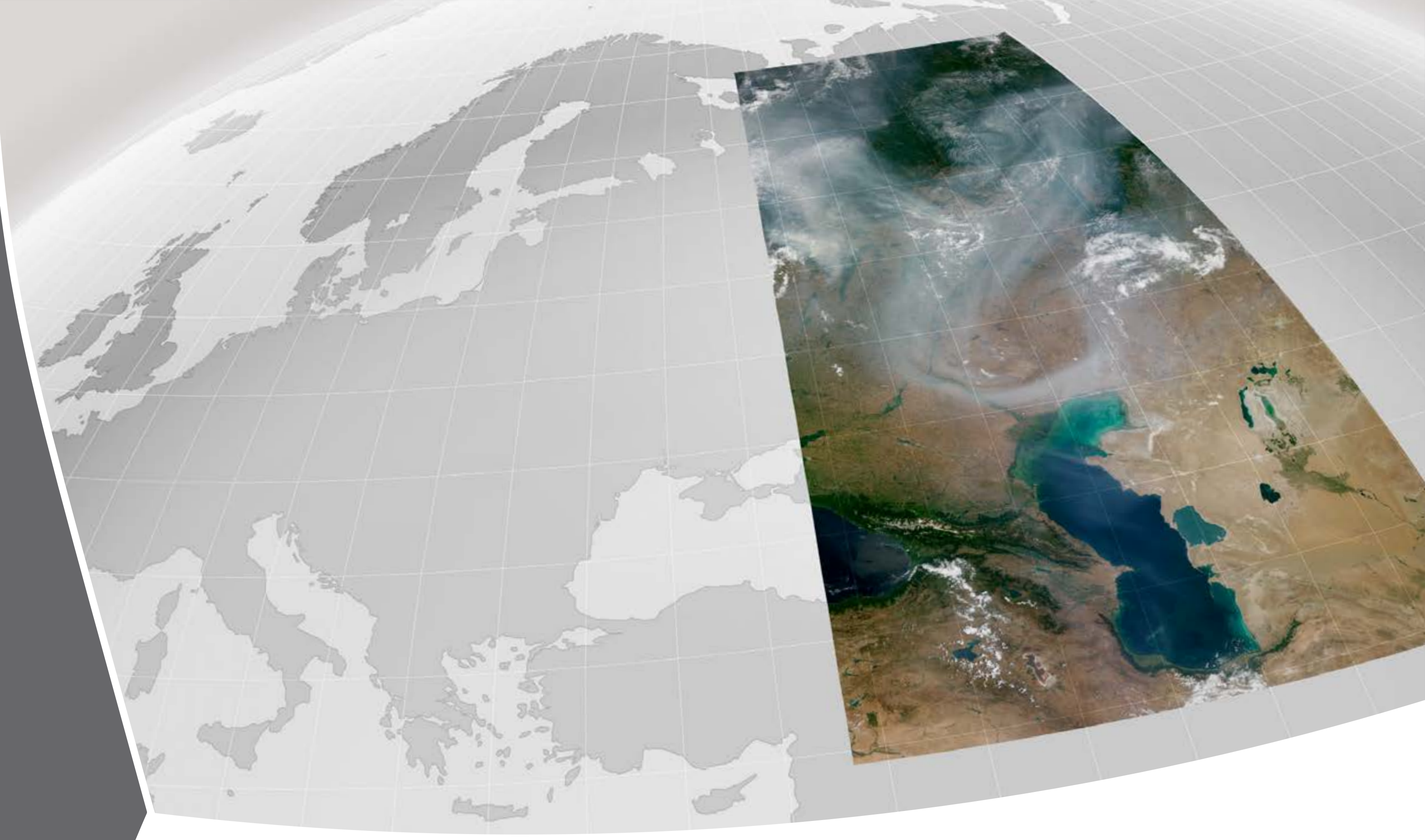


# FireBIRD

A DLR satellite system
for forest fires and
early fire detection

DLR

Fig. 1:
Forest fires on
Borneo

**Contents**

# Introduction

The release of greenhouse gases and aerosols from fires has a large influence on global climate: on average, fires are responsible for up to 30% of anthropogenic CO2 emissions. Currently, however, there are no suitable instruments for more precisely estimating the quantity of emissions and thus their impact on the climate.

In the future, a further increase in the number of fires is expected, a consequence of global warming. This not only increases emissions which affect the climate, but also the specifications for early fire detection. As the severe Russian fires of summer 2010 demonstrated, rapid response is required if fires are to be detected as early as possible and quickly combatted in order to keep their negative consequences for people and the environment as low as possible.

The German Aerospace Center (DLR) is contributing to the FireBIRD constellation, which consists of the two satellite missions TET-1 (Technology Test Platform) and BIROS (Berlin Infrared Optical System) and is dedicated to scientific investigation of the issues involved as well as to early fire detection from space. Commercial extension of this constellation, for example in cooperation with countries which are seriously plagued by fires, will revolutionize near-real-time fire warning worldwide.

**Fig. 2: Forest fires in Greece (MODIS)**

**Fig. 3: Burn scars in Pinheiro Grande, Portugal (IKONOS)**

# Forest Fires and CO2 Emissions

Fires arising from natural causes play an important role in many ecosystems. However, only about 10% of fires have natural causes (such as lightning strikes). Most fires are caused by people.

Deliberate burning of carbon-rich ecosystems is especially problematic. If tropical rain forests or drained swamps are cleared by fire in order to convert the land for agriculture, the carbon bound up in the vegetation and peat is released and accumulates in the atmosphere in the form of carbon dioxide and carbon monoxide. Although the regrowth of vegetation on this land again binds carbon, it does so to a far lower extent than did the original ecosystem.

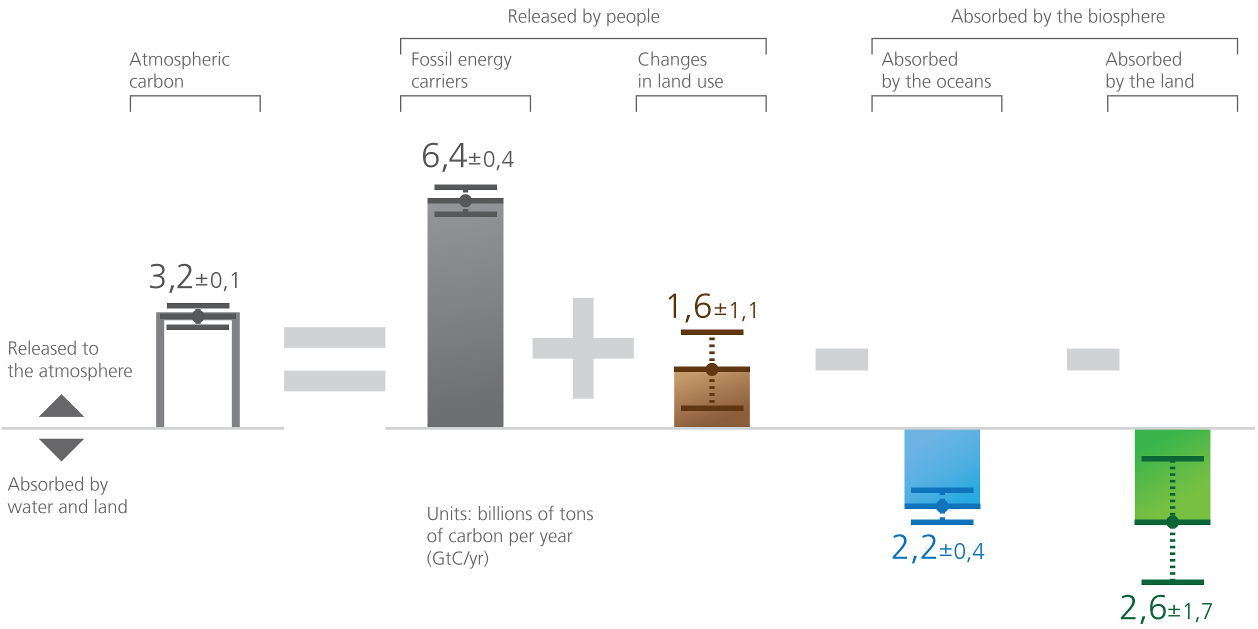
According to the United Nations Food and Agriculture Organization (FAO), 7.3 million hectares of forest are destroyed annually worldwide, in most cases by natural causes and deliberately set fires. It is estimated that 1-2 billion tons of carbon (gigatons, GtC) enter the atmosphere as a result, in addition to some six GtC which are a by-product of the combustion of fossil energy carriers (Fig. 4).

This throws the global carbon balance out of alignment, since the additional CO2 cannot be completely absorbed by the land and ocean surfaces. A net increase of some 3.2 GtC accumulate in the atmosphere annually, and in the form of CO2 contribute, along with other trace gases and aerosols, to a rise in average global temperature due to the greenhouse effect.

Scientists estimate that global CO2 emissions from forest fires alone are responsible for up to 20% of the anthropogenic greenhouse effect. Thus fires have a greater influence on the climate than had been assumed up to now.

The causes are known, the challenge is now above all to estimate the extent of burned areas globally and to precisely measure CO2 emissions.

**Fig. 4: Global carbon balance showing the most important carbon fluxes in gigatons per year. Uncertainties about individual fluxes are indicated by the error bars (Source: IPCC 2007)**



# Early Fire Detection

According to an estimate based on satellite data, 3.5 to 4.5 million km2 of the earth's land surface are damaged by fire annually. This is an area about ten times the size of Germany, whereby different parts of the globe are affected to varying extents by fire (Fig. 5).

The United Nations' International Panel on Climate Change (IPCC) believes that the risk of fires will continue to rise over the next few decades due to anthropogenic climate change and the associated temperature increases. According to calculations based on models, this will not only be a time with longer periods of high fire risk. Those areas which are extremely endangered especially during the summer months will also expand in size. In addition to tropical and subtropical regions, this development will primarily affect the extensive forests in the temperate and boreal zones of Canada and Russia. Uncontrolled fires arising naturally or from human activity in the vicinity of settlements will become an especially serious hazard for the population. The forest fires which raged during July and August 2010 in Russia are only one indication. Thick smoke loaded with pollutants blanketed Moscow and large quantities of grain were destroyed by fire. The fires even threatened nuclear power facilities. In all, over 9,000 km2 were devastated by fire, an area about half the size of the German state of Rhineland-Palatinate.

In the future, only swift and efficient early warning combined with the short-term availability of rapid response teams can help keep such dangers under control.

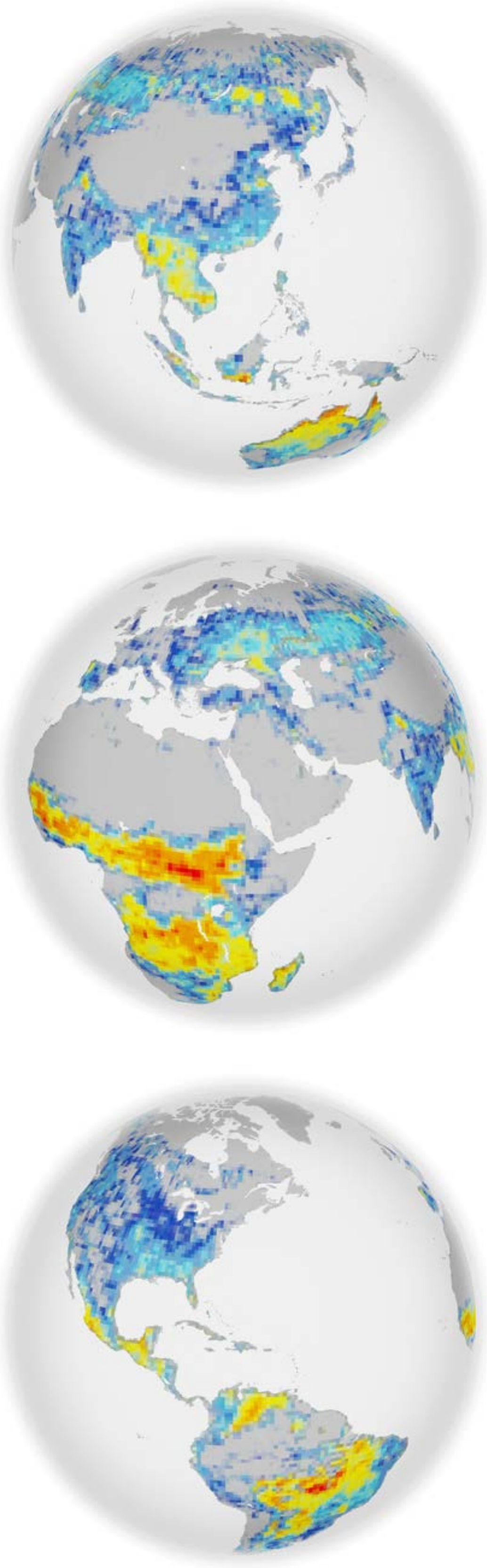
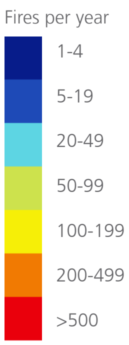


**Fig. 5: Average annual number of fires, derived from satellite data (Source: Giglio et al. 2006)**



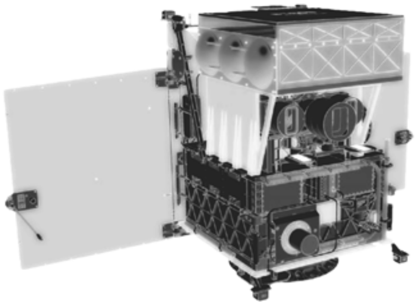
# The FireBIRD Mission

Satellite data have already been used for several years worldwide to detect active fires and to estimate the extent of burn areas globally and the emissions they release. Since the available instruments have a spatial resolution of 1 km x 1 km at best, they can only reliably detect fires which radiate over 10 megawatts (MW) of power, which is the equivalent of a vegetation fire covering about 200 m2. However, about half of all fires are smaller, so they cannot be detected with presently accessible satellite systems. This also means that the emissions arising from these fires cannot be adequately taken into consideration either.

The German FireBIRD mission is designed to significantly reduce the existing uncertainties. Together with systems already in orbit, TET-1 and BIROS will function as "fire magnifiers." With a better spatial resolution of about 200 m x 200 m per pixel, an important monitoring gap can be closed for a large number of small fires (with upward radiation between 1 and 10 MW of power), so that significantly more of them can be detected in the first place and included in the emission balance. In addition, the FireBIRD mission will be used to validate and fine tune emission estimates from data with lower spatial resolution, for example data collected at short time intervals from geostationary satellites.

As to early warning, only a constellation consisting of several satellites in low earth orbit can adequately met the need for fire information of satisfactory spatial and temporal resolution. The FireBIRD constellation will provide on an experi-

**Fig. 6: Forest fires in eastern Russia (MODIS)**



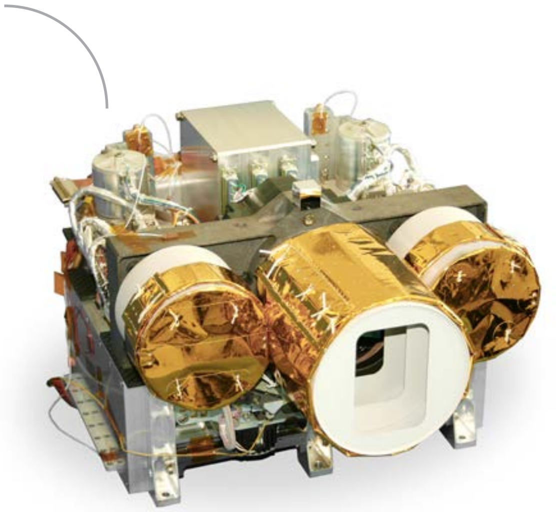


**Fig. 7:**
**The sensor array for TET-1 and BIROS**

mental basis, so to speak as a precursor satellite mission for early fire detection, fire information with good spatial resolution at a maximal time delay of two hours for the coverage area. Toward this end, specific fire parameters will be determined already on board the satellite based on the recorded data. Local response teams can be directly informed via mobile telephones about the location of actively burning or incipient fires.

Both satellites, TET-1 and BIROS, are based on the technological experience gained by DLR during the BIRD mission of 2001 to 2004. BIRD was developed at the Optical Information Systems department of the Institute of Robotics and Mechatronics in Berlin and delivers impressive images of both large and small fires worldwide. The smallest fire detected by BIRD had an area of 4 m².

As in the case of BIRD, the heart of the TET-1 and BIROS payloads is a bispectral infrared sensor (Fig. 7) which records signals in the mid-infrared and thermal spectral ranges (3.4 – 4.2 µm and 8.5 – 9.3 µm). Another camera records the visible and near-infrared ranges in three channels.

**Fig. 8: Overview of the BIROS mission**

| **Mission** | | **Satellite** | | **Sensor** | |
|---|---|---|---|---|---|
| Orbit | 560 Kilometer, sonnensynchron | Dimensions | 83 x 54 x 62 centimeters | infrared sensor (two channels) | mid infrared — 3,4 - 4,2 µm thermal infrared — 8,5 - 9,3 µm |
| Inclination | 97,6° | Total mass | ca. 130 kilograms | | |
| Mission operations | German Remote Sensing Data Center, German Space Operations Center | Payload mass infrared sensor | ca. 14 kilograms | optical sensor (three channels) | visible range - green — 0.5 µm visible range - red — 0.6 µm near infrared range — 0.8 µm |
| Mission planning | < 1,5 years | Power | 200 watt DC | | |
| Mission duration | > 2,5 years | Communications | S-band, UHF | | |

**Fig. 9: Major fire in the San Bernardino Mountains of California (Source: ISS)**

For improved spatial and temporal coverage, the two satellites will circle the earth at an altitude of about 570 km in solar-synchronous orbits with varying local equator crossing times. TET-1 is scheduled for launch in 2011, BIROS in 2013. TET-1 is a technology-testing platform financed by the DLR Space Management division and carries other payloads as well. BIROS is a minisatellite financed primarily by the German Ministry of Education and Research (BMBF).

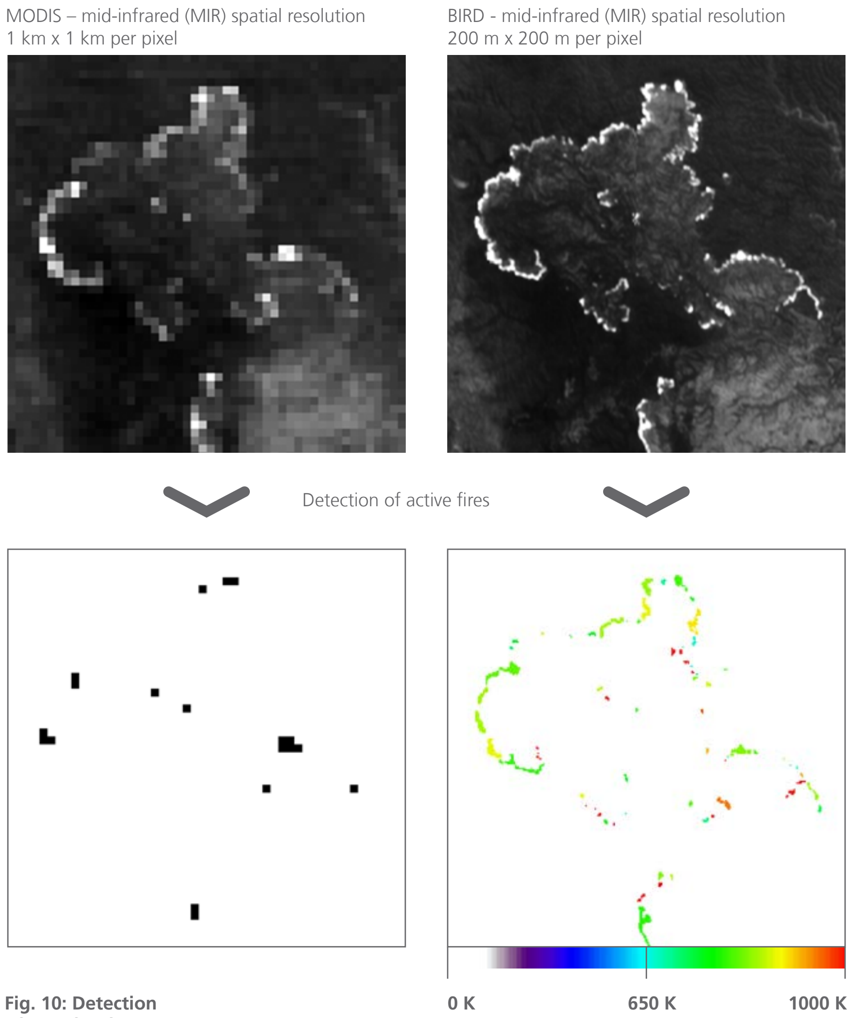



**Fig. 10: Detection of bushfire fire fronts near Sydney, Australia**

# Routine operation of the FireBIRD Mission

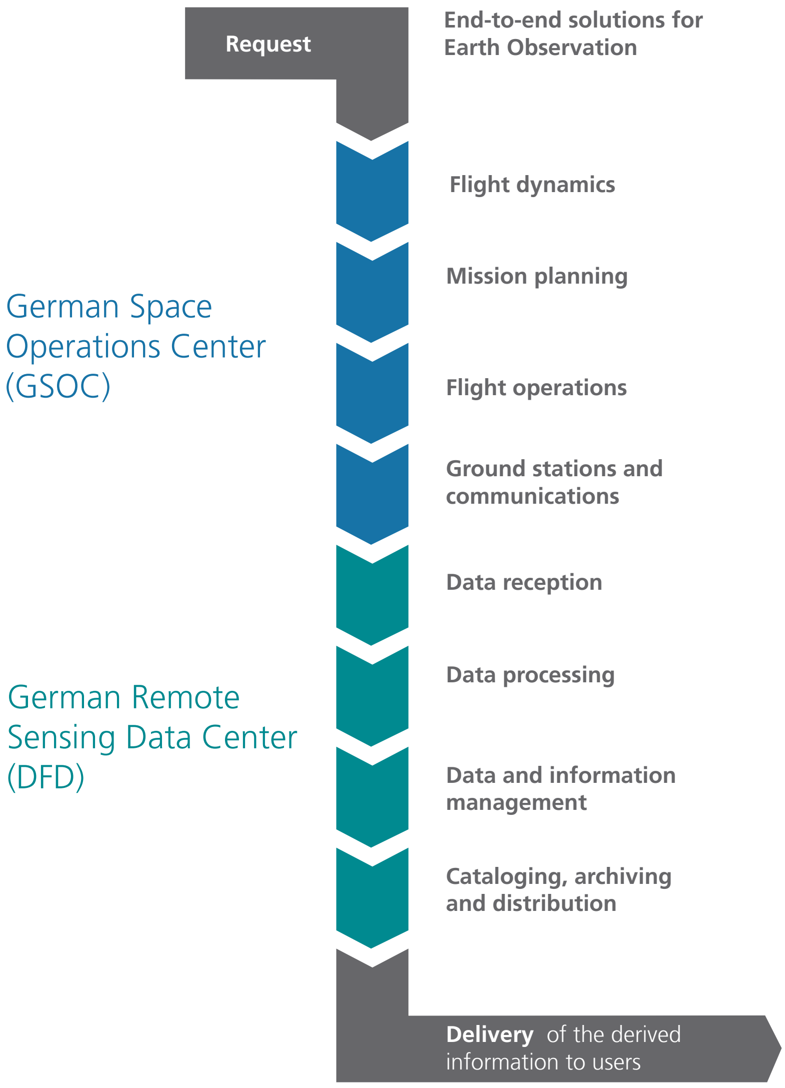



**Fig. 11: Schematic representation of the process chain from data request to delivery**

For all satellite missions, routine data processing is just as important as the development of the instrument itself. The German Aerospace Center DLR has many years of relevant experience and systems expertise, from satellite control to data reception via ground stations distributed worldwide to data processing in near-real-time and archiving.

The ground segment for the FireBIRD mission is handled by two DLR institutes: The German Space Operations Center (GSOC) in Oberpfaffenhofen with its ground station in Weilheim and the German Remote Sensing Data Center (DFD) with a ground station and payload data center in Neustrelitz (Fig. 13).

Planning the operation of the satellite and the infrared sensors is handled by GSOC together with a science team in Berlin. In orbit, the satellites are controlled by GSOC from the Weilheim ground station.

Since the BIROS satellite is based on the TET-1 satellite bus, this mission can be rapidly integrated in the existing system with the additions necessary for formation flight. The DFD ground station in Neustrelitz will receive and process the sensor data.

After reception the data can be automatically processed to provide an assortment of derived products and services in near-real-time. With the help of the Data Information Management System DIMS the data are then cataloged and stored in the National Satellite Data Archive and made available to the science community long-term.

**Fig. 12:**
**Forest fires on**
**Borneo**

# Prospects

**Fig. 13:**
**1. German Space Operations Center (GSOC)**
**2. Reception equipment in Neustrelitz**
**3. The Earth Observation Center is the headquarters of the German Remote Sensing Data Center (DFD)**

With the FireBIRD constellation, Germany will have two satellite missions available which make a significant contribution toward estimating climate-relevant fire emissions: TET-1 from 2011 and BIROS from 2013. The feasibility of this technology for detecting fires and giving fire warnings will also be confirmed. Commercial expansion of the mission to include three to four additional satellites would make possible routine early warnings from space in near-real-time as well. With such a mission it would then be possible to detect fire fronts shortly
after they emerge, to derive their direction and rate of propagation, and to initiate convincing countermeasures. In addition, already the initial FireBIRD constellation will make a significant contribution toward clarifying other scientific issues related to so-called high-temperature events like volcanic and geothermal activity, coal-seam fires, and determining radiant flux.

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Fig.3: European Space Imaging, IKONOS, 2003
Fig.4: Graphic DLR-DFD-WV, nach: IPCC 2007
Fig.5: Rendering DLR-DFD-WV, nach: Giglio et al. 2006
Fig.6: Processing DLR-DFD-WV, NASA, MODIS Aqua 2008/200
Fig.7: DLR BIROS Exposé
Fig.8: Photo DLR
Fig.9: Montage DLR-DFD-WV, NASA/JSC, ISS Digital Camera, ISS007-E-18087, ISS007-E-18088
Fig.10: DLR
Fig.11: Graphic DLR-DFD-WV
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Fig.13: 1. Photo DLR-GSOC, 2. Photo DLR-DFD, 3. Photo DLR-DFD-WV

# DLR at a Glance

DLR is Germany's national aeronautics and space research center. Its extensive research and development activities in the fields of aeronautics, space, energy, transportation and security are integrated in national and international cooperative ventures. In addition to this research, as Germany's space agency the federal government has given DLR the responsibility to plan and implement the German space program. DLR is also the umbrella organization for Germany's largest project management agencies.

Approximately 6,500 people are employed at DLR's 13 locations, which include Köln (headquarters), Berlin, Bonn, Braunschweig, Bremen, Göttingen, Hamburg, Lampoldshausen, Neustrelitz, Oberpfaffenhofen, Stuttgart, Trauen and Weilheim. DLR also operates offices in Brussels, Paris and Washington, D.C.

The DLR mission includes studying the earth and solar system and conducting research on preserving the environment and developing environmentally responsible technologies, increasing mobility, communications and security. The DLR research portfolio extends from basic research to innovative applications and pioneering products. The scientific and technical expertise gained at DLR contributes to strengthening Germany's industrial and technological position. DLR operates major research facilities both for its own projects and as a service for customers and partners. DLR also fosters the upcoming generation of scientists, provides competent advice to the political sector, and is a driving force in the regions where it has branches.

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