The FireBird mission – a scientific mission for Earth observation and hot spot detection

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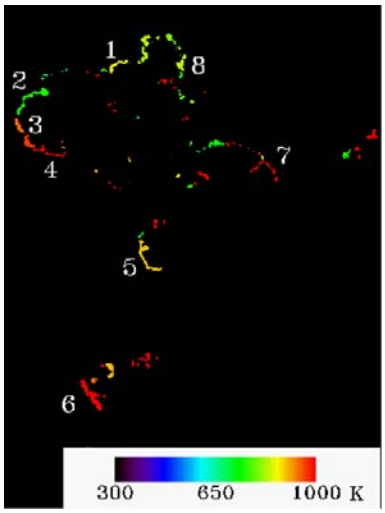
Abstract: More than 10 years ago the first specialized small satellite for hot spot recognition and fire observation was designed, built and operated by several DLR departments. This BIRD (Bi-spectral Infra Red Detection) satellite demonstrated the capability of fire monitoring from space by using a dedicated small satellite and sensor system. On the other hand it has shown that DLR is capable to manage nearly a complete space mission "in house". The comparison of typical BIRD data with the well-known MODIS fire products led to the label "fire zoom" for BIRD data. It is due to the high geometric and radiometric resolution of BIRD fire products. Typically small fires with a diameter of 4m could be detected. The precise estimation of fire parameters was successfully shown without problems like false alarms. The success of BIRD opened the doors for next steps. The scientific DLR Earth observation mission "FireBird" will continue the fire monitoring topic by using two small satellites (TET-1, launched June 2012, BIROS launch planed 2014). The paper shall present this mission. It will finally be focused on possible interfaces for a desired worldwide international scientific cooperation within this running space mission.

1. BIRD HERITAGE FOR FIREBIRD

The satellite BIRD was designed and built by DLR institutes in Berlin [1]. The main mission goal was the verification of a precise Hot Spot Recognition System (HSRS) in space. The ability to derive fire parameters as location and size of burning areas, temperature, energy release, and fire front strength was successfully demonstrated (figure 1). The high radiometric and geometric resolution is still unique. [2][3][4]

Not only the sensor system but even the satellite bus was completely new developed by DLR. The bus design followed a strict "design to cost" philosophy. The mission time was set to one year only. But due to the big success of the mission it was extended till the first devices had problems. For example the low cost gyro system with a mean time before failure (MTBF) of about one year went out of order after nearly 3 years in space. This made finally the fire observation with BIRD impossible. But the DLR Space Administration decided to use the BIRD bus know how for the so called "On Orbit Verification" program (OOV). DLR transferred the technological BIRD knowhow to the local space industry and started the development of the new TET bus (TET is the German abbreviation "Technologie Eprobungs Träger", a platform for technological verifications)[5][6]. The first satellite TET-1 was launched on June 22nd 2012 from Baikonur. TET-1 is equipped with different industrial pay loads for in orbit verification purposes, but also with a BIRD like IR instrumentation. This TET-1 OOV mission is accomplished after one year in space – probably August 2013.

A second outcome of the BIRD mission is a continuation of fire monitoring from space.



Fire cluster No	Eff. fire temp., K	Eff. fire area, Ha	Front length, km	Energy release, MW	Front strength, kW/m
1	815	0.48	4	130	30
2	715	2.3	7.5	310	40
3	893	0.59	3	210	70
4	>670	<0.78	5	79	15
5	852	0.92	10	300	30
6	957	1.0	9	530	60
7	>690	<0.51	4	62	15
8	796	0.39	3	96	30

Figure 1 Typical BIRD data product. The left part shows the geo located projection on Earth with color coded temperatures and right is the table with all typically derived fire parameters of the identified 8 fire clusters. [2][3][4]

Another HSRS system was built by using flight spare parts of the BIRD mission. It became one of the TET-1 payloads. So the TET-1 can continue the work of BIRD. But in order to make a more remarkable step forward it was decided to implement a completely new DLR space mission for the scientific investigation of fires and hot spots. This is the "Fire Bird" mission –in a first step a direct continuation of the BIRD mission but enhanced by two main changes: On board data processing of fire products and the usage of a second satellite in a constellation. This second satellite is called BIROS (Bi Spectral Infrared Detection). It is based on the TET-1 bus and is equipped with a nearly identical IR payload.

2. THE MISSION GOALS

The primary mission goal is fire observation. The success is measured by comparing the data outcome with the BIRD mission. It shall be investigated, how the outcome is improved both in quality and quantity by operating two satellites. By default the fire products shall be produced on board of the FireBird satellites. This will be done by using the proven BIRD on board classification experiment results. [1]
Beside the main goals there are some secondary mission goals. Several DLR institutes contribute with own experiments to the mission on board of the BIROS satellite. These experiments are related to

- autonomous on board mission planning
- bi directional optical communication between satellite and ground stations
- optical navigation and proximity operations (BIROS ⇔ BEESAT 4)
- pico sat launch (BEESAT 4, TU Berlin) from BIROS
- satellite agility

The first priority has always the fire observation. But the experiments have the potential to support the primary mission goal if they succeed.

3. THE MISSION POLICY

The mission is a DLR mission. Therefore all mission segments have to be controlled by DLR. The mission is a scientific mission. It is controlled by a principal investigator (PI) and supported by a science team. It is not the mission goal to sell data products. But aspects of a future commercialization must not be neglected and shall be investigated in parallel. The

mission is mainly an Earth observation mission focused on fire monitoring. Other thinkable scientific applications of the FireBird data for shall not be excluded.
It is in the nature of a scientific mission that a wide national and international cooperation is required. The data policy will support this idea.

4. THE MISSION SCHEDULE

The DLR R&D project “FireBird” was started 2012 und shall end in December 2015. It has mainly 3 phases:

- Phase I: Implementation phase
- Phase II: The TET-1 satellite becomes part of the FireBird
- Phase III: BIROS launch, constellation TET-1 ⇔ BIROS phase

Phase I is already running. Phase II is expected to start in august 2013 and phase III starts with the BIROS launch in the end of 2014. This constellation phase is expected to last one year. The project “FireBird” ends in December 2015, but if the satellites are still working fine it is perhaps not the end of the mission.

5. THE MISSION SEGEMENTS

The ground segment is subdivided into two parts:

- Ground segment “mission control & operations”
- ground segment “data”

The ground segment mission control and operations uses the DLR facilities of the German Space Operations Center (GSOC). This are the control rooms and the own ground station for up – and downlink. It will receive process and archive all satellite bus data from both satellites.
The ground segment data belongs to the DLR “Earth Observation Center” (EOC) und uses the own ground stations and archiving and processing facilities. It will receive process and archive all scientific data from the TET-1 and BIROS IR payloads.

The space segment shall consist of two elements

- TET-1 satellite, SSO, 500 km, LTAN 10:30, (launch June 2012)
- BIROS satellite, desired orbit is SSO, 500 km, LTAN 13:30, launch 2014

Both satellites are equipped with an identical optical payload (HSRS). The BIROS satellite will be equipped with a propulsion system for orbit keeping, collision avoidance and optimizing the constellations with TET-1. The BIROS bus is a copy of the TET-1 bus. BIROS is equipped with a new payload computer. The BEESAT 4 will be launched from BIROS but does not belong to the FireBird mission.
The user segment is organized as an international science team under the lead of the principal investigator (PI). During the mission the PI has to decide the daily imaging schedules of both satellites. The PI is especially the point of contact for the national and international fire community. The principal investigator is responsible for the fulfilling of the primary mission goal.
The coordination of all other remote sensing requests is done by one coordinator at the DLR Earth Observation Center.

The launch segment is responsible for finding the right launch provider, launch vehicle and launch parameter. It will prepare and manage the launch campaign and is controlled by the project leader of the BIROS project.

6. COOPERATION INTERFACES

The outcome of the FireBird mission can be increased remarkable by cooperation. Nearly all mission segments have cooperation interfaces. It is part of the mission policy to look for good cooperation. The cooperation shall be useful for both sides and therefore for the overall scientific output. The fire topic is a worldwide topic while the available data sources are rare. But cooperation has not to be limited on the primary mission goals.
The natural interface is the “science team”. It offers the chance to take part in the selection of targets and discussing the results and this will help the mission in order to assure that the results are relevant and valuable.
The ground segment has other interfaces for cooperation. The number of available DLR ground stations is limited. The downlink is a bottle neck for the mission because the download capacity is the limiting factor for imaging. The BIRD experiences show, that events like big forest fires, active volcanoes or even wars increase dramatically the number of image requests worldwide. The introduction of own ground stations in to the FireBird mission will extend the bottle neck and offers more chances to get more data for the own research purposes and to get it faster. A support with uplink stations can increase the reaction time of the mission on events worldwide.
The space segment has also possible cooperation interfaces. In a best case it is the contribution by own satellites with suitable IR sensing systems. Or it can be a kind of common usage of additional existing satellites by adopting the imaging tasks and exchanging the data. The presentation shall be understood as an invitation for cooperation

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