Wildfire Mapping Using FireBIRD Data

Global Wildfire Information System (GWIS) – GOFC GOLD Fire IT

20-23rd November 2017, Cumberland Lodge

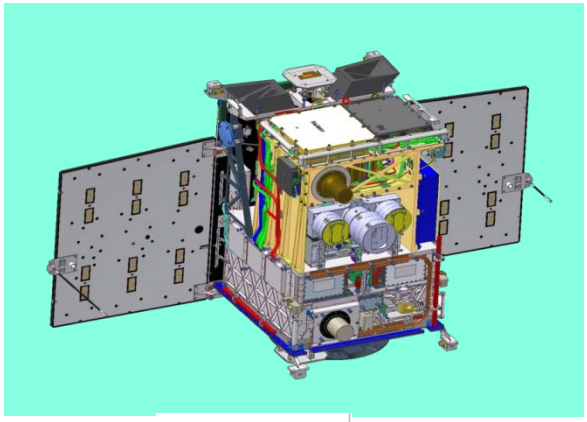
Christian Fischer on behalf of the FireBIRD-Team

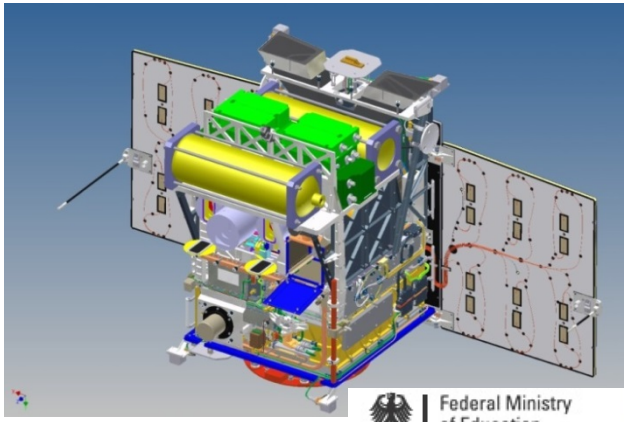
German Aerospace Center (DLR)
Institute of Optical Sensor Systems (IOS)
c.fischer@dlr.de

Contents

- Mission Organisation & Status
- Sensor Systems
- Detection of High Temperature Events (HTE)
  - Concept
  - Hot Spot Detection
  - Spatial Sampling & Radiometric Dynamic
- Sensor Validation
- Forest Fire Examples
- Conclusion & Outlook

Heritage from BIRD to FireBIRD





Astro- und Feinwerktechn Adlershof GmbH

KAYSER-THREDE

-> OOV - program

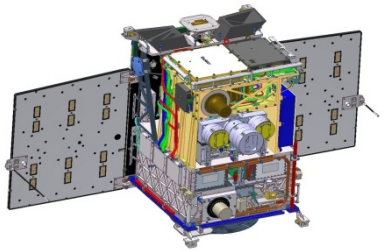
Federal Ministry of Education and Research

BIRD (2001-2007 [2014]) TET-1 (2012 - ?) BIROS (2016 - ?)

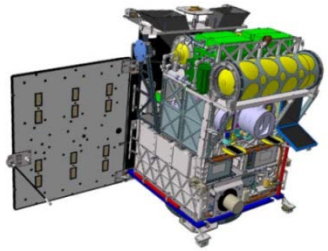
FireBird is an Infrared Mission mainly dedicated to the investigation of High Temperature Events (HTE), but also to other thermal processes.

DLR

Mission Schedule



TET-1



BiROS

Implementation phase | **Operational phase I** | **Operational phase II**

Mission Start	TET-1 launch as part of the OOV mission	TET-1 becomes part of the **FireBIRD** mission	BIROS launch constellation with TET-1	follow-up mission **…?**
July 2011	**July 2012**	**2013**	**June 2016**	**May 2020**

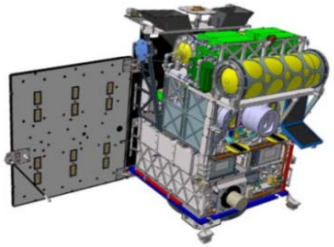
Orbit

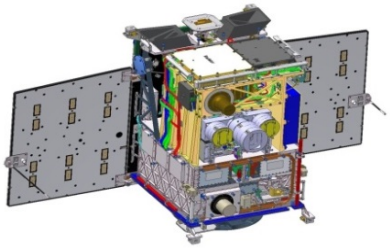
- Orbit
  - ~ 500 km
  - Sun synchronous
  - Period: about 1h30

- Crossing times
  - 11:30 asc. UTC (TET-1)
  - 13:30 asc. UTC (BIROS)
  - De-pointing abilities: +/-30^{o} across track

- Repetition rate with +/- 30^{o} across track acquisitions
  - < 5 days (TET-1)
  - **< 3 days (TET-1 + BIROS)**

Ground Segment





LEOP, CP, Off-Nominal

External receiving stations

LEOP , CP, Routine, …

Weilheim

Ground Segment (DFD)

Routine

Neustrelitz

Polar Station

Receiving Station Neustrelitz DFD-BN

German RS Data Center FD-BI

DLR

Launch Service Provider

start segment

Flight Dynamics

Network of Receiving Ground Stations

Flight Operations

Mission Planning

German Space Operations Center GSOC

DLR

Ground segment, Mission & Operations

Main payloads IR Camera Systems (TET + BIROS)

OOV experiments (BIROS):

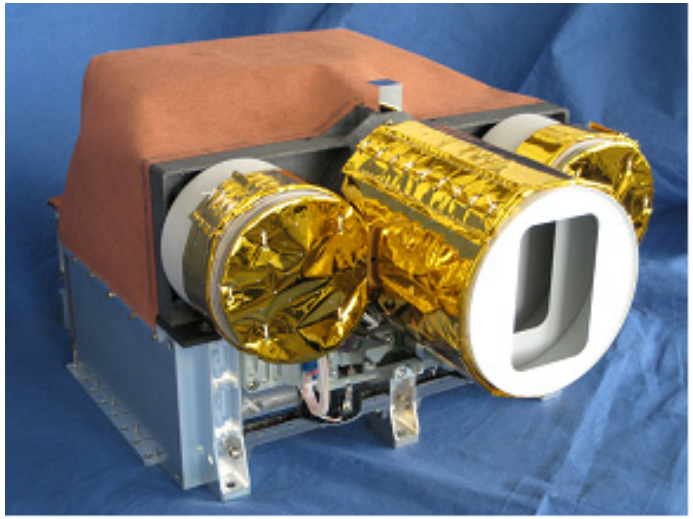
- HTW
- OSIRIS (inkl. TOL)
- AVANTI
- VAMOS+ (VAMOS + VIMOS)
- PICOSAT (incl. N-Link)
- OrbCom-Modem
- RGB camera system

Payload

DLR

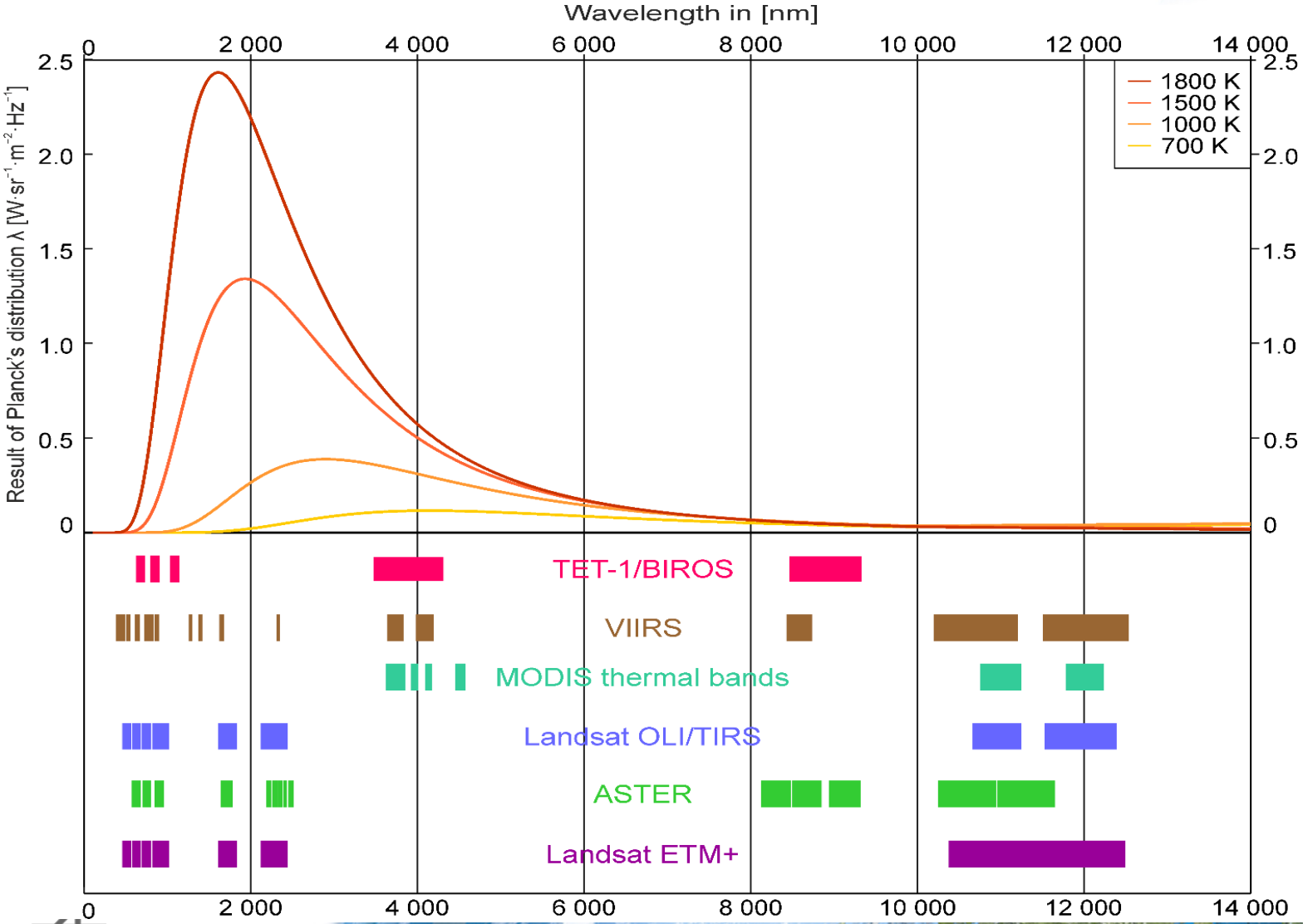
Sensor Systems

- Imaging sensors systems
  - Two infrared cameras
    - Nadir looking
    - Staggered CCD arrays
  - One 3-band VNIR camera
    - +6º, nadir, -6º (along track) looking
  - Spectral band definition



Band	Wavelength
Green	460 - 560 nm
Red	565 - 725 nm
Near Infrared (NIR)	790 - 930 nm
Midwave Infrared (MWIR)	3400 - 4200 nm
Long we Infrared (LWIR)	8500 - 9300 nm

Sensor System Layout



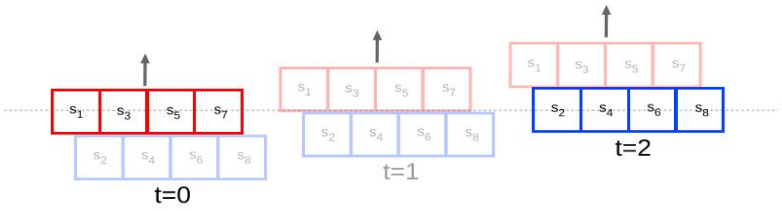
Acquisition Modes

	Spatial resolution (m)					GSD (m)		Size (km)
Acquisition Mode	**Green**	**Red**	**NIR**	**MWIR**	**LWIR**	**MWIR**	**LWIR**	**Swath**
Fire 4x4	160	160	160	360	360	180	180	211 / 178
Fire Night				360	360	180	180	211 / 178
VIS 1 - Green	40			360	360	180	180	211 / 178
VIS 1 - Red		40		360	360	180	180	211 / 178
VIS 1 - NIR			40	360	360	180	180	211 / 178
VIS 3	40	40	40	360	360	180	180	105 / 178

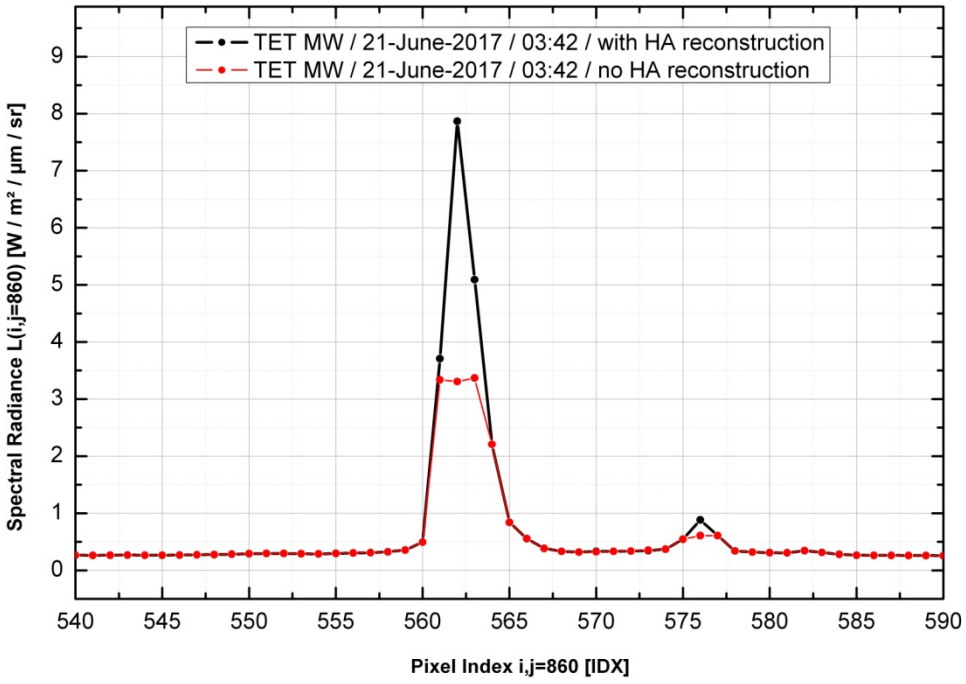
Dynamic Range: 14-bit (except for TET-1, VIS-3, VNIR: 8 bit)

Improved Spatial Sampling & Radiometric Dynamic

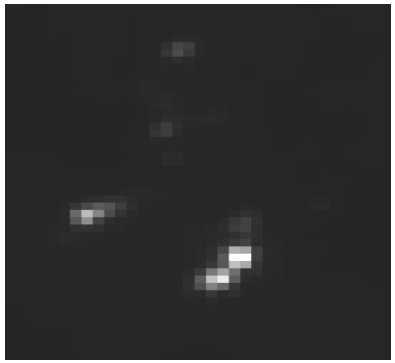
- Staggered pixel arrangement enabling **spatial double - sampling** across- and along-track
- Pixel pitch is ca. 30 µm => sampling distance is around 15 µm



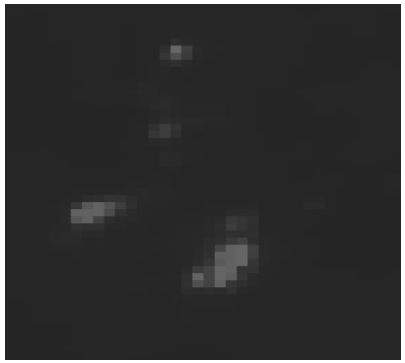
- **Radiometric double sampling** by measuring a scene twice - e.g. with integration times of 4000 µs and 500 µs („HA-mode“)
- Both measurement taken rapidly within a 1/3 of dwell time
- Synthesis of double-sampled radiometric image data during radiometric processing
- **Increased radiometric dynamic range** and a broader class of HTE becomes quantifiable, i.e. without saturation



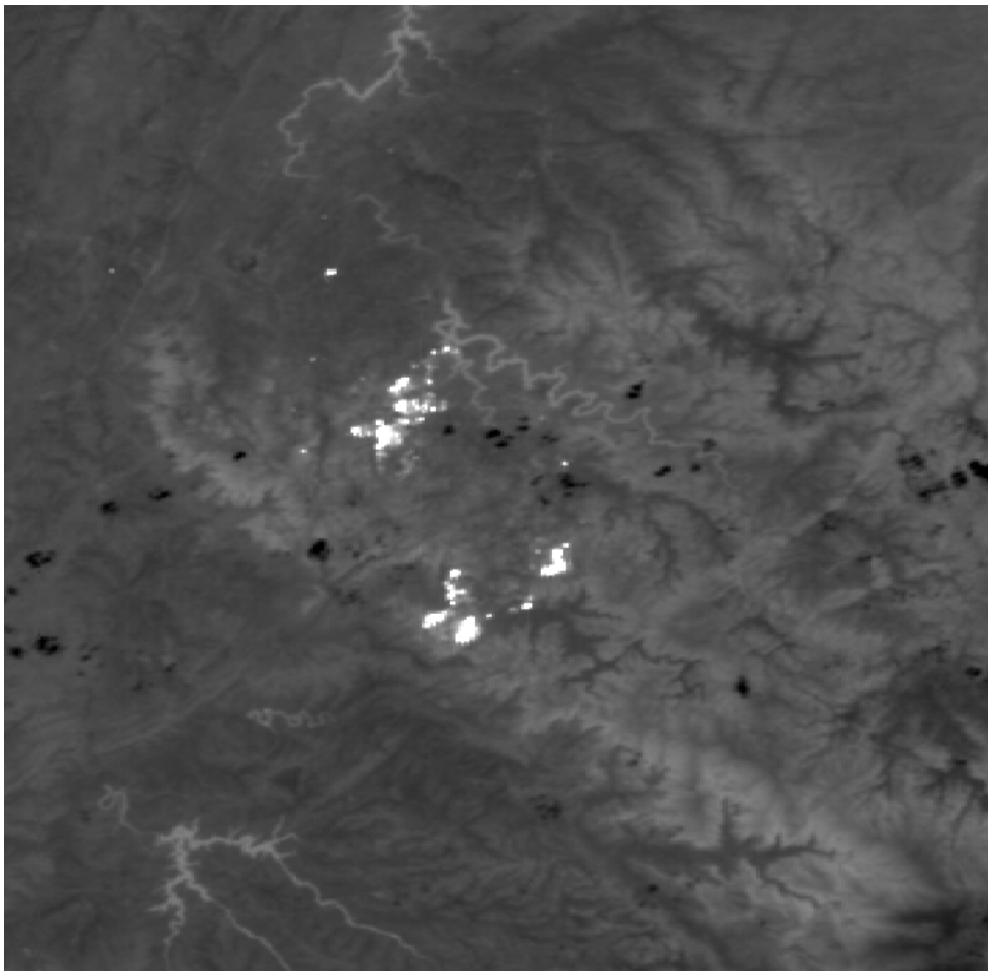
Improved Spatial Sampling & Radiometric Dynamic



With
HA-Processing



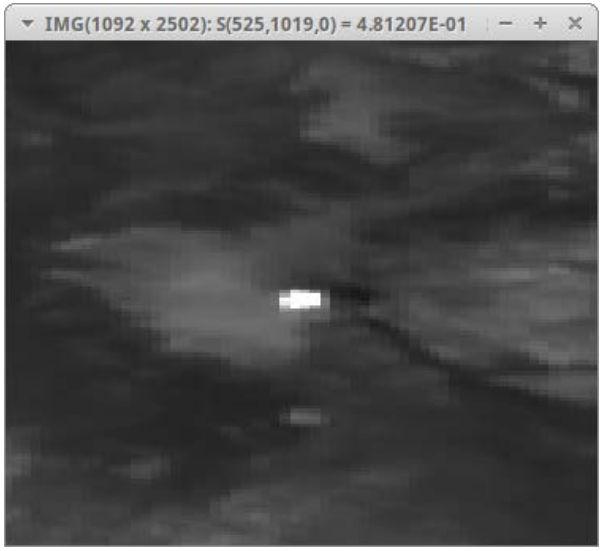
Without
HA-Processing



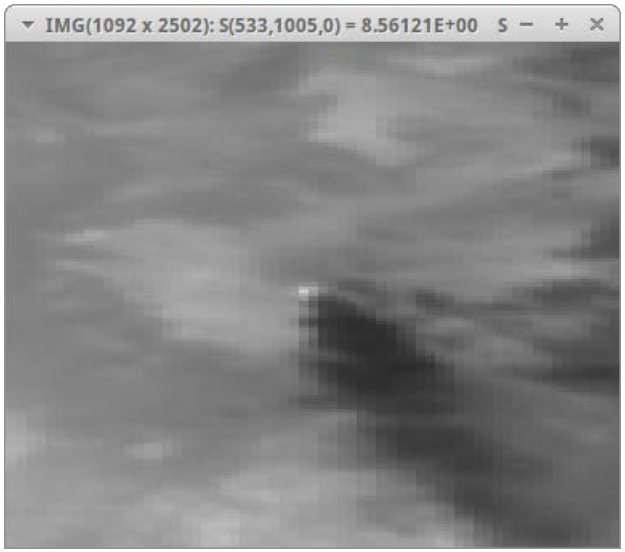
- Example: Portugal Forest Fire, 21 June 2017
- TET LWIR / MWIR image with improved Hot-Area processing and increased radiometric dynamic range

Estimation of Radiance Image Quality – SNR

TET / 16-August-2013 / DT56 / Mexico/ Volcano Popocatépetl



MWIR



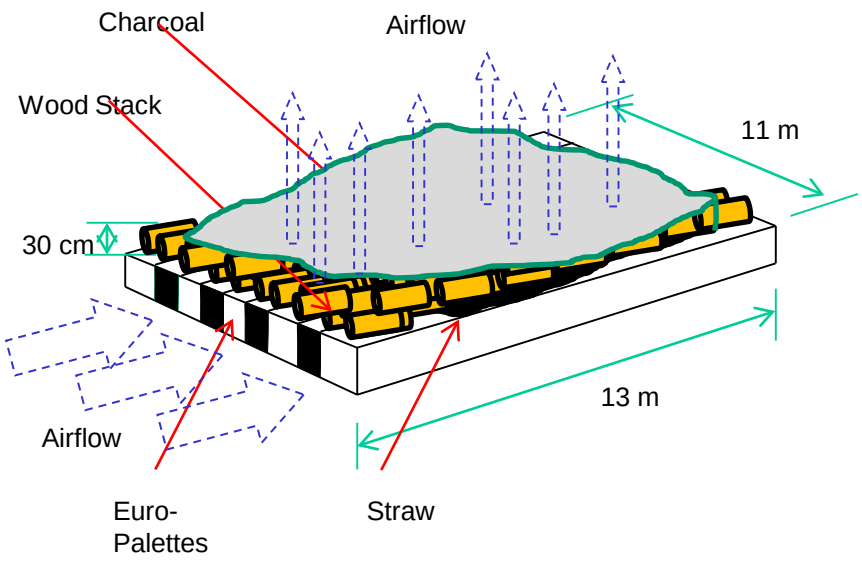
LWIR

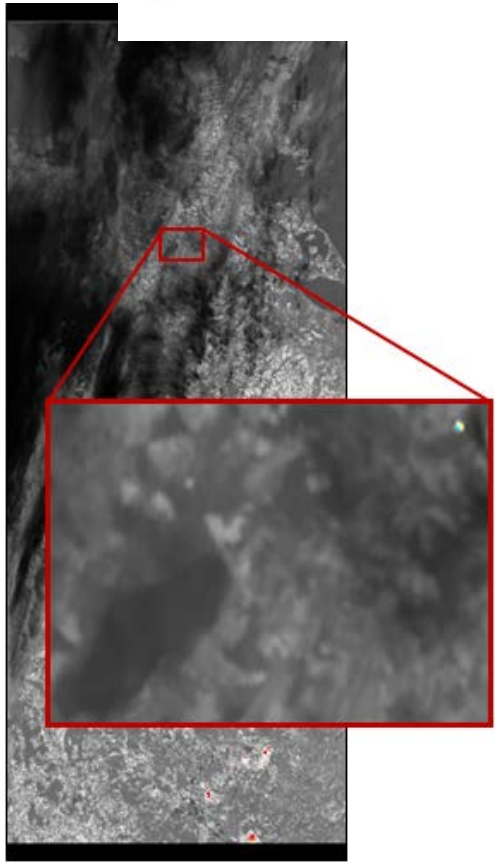
SNR measure: related to an image crop around a the volcanic hotspot and a maximum radiance difference DL=(L_max-L_min)

SNR ca. 310 (without hot spot)
SNR ca. 370 (with hot spot)

SNR ca. 380 (without hot spot)
SNR ca. 2900 (with hot spot)

Validation - Fire Experiment

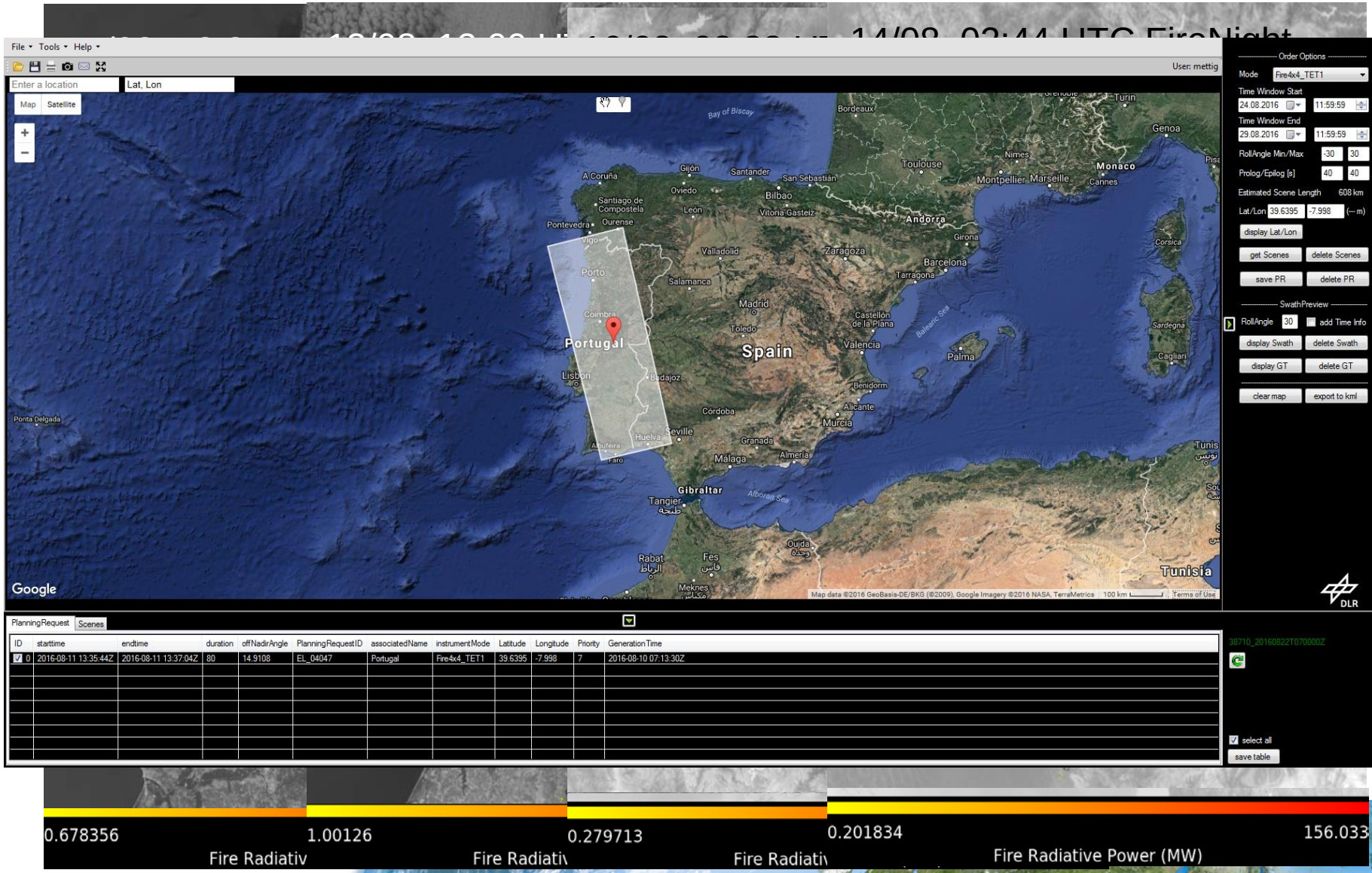




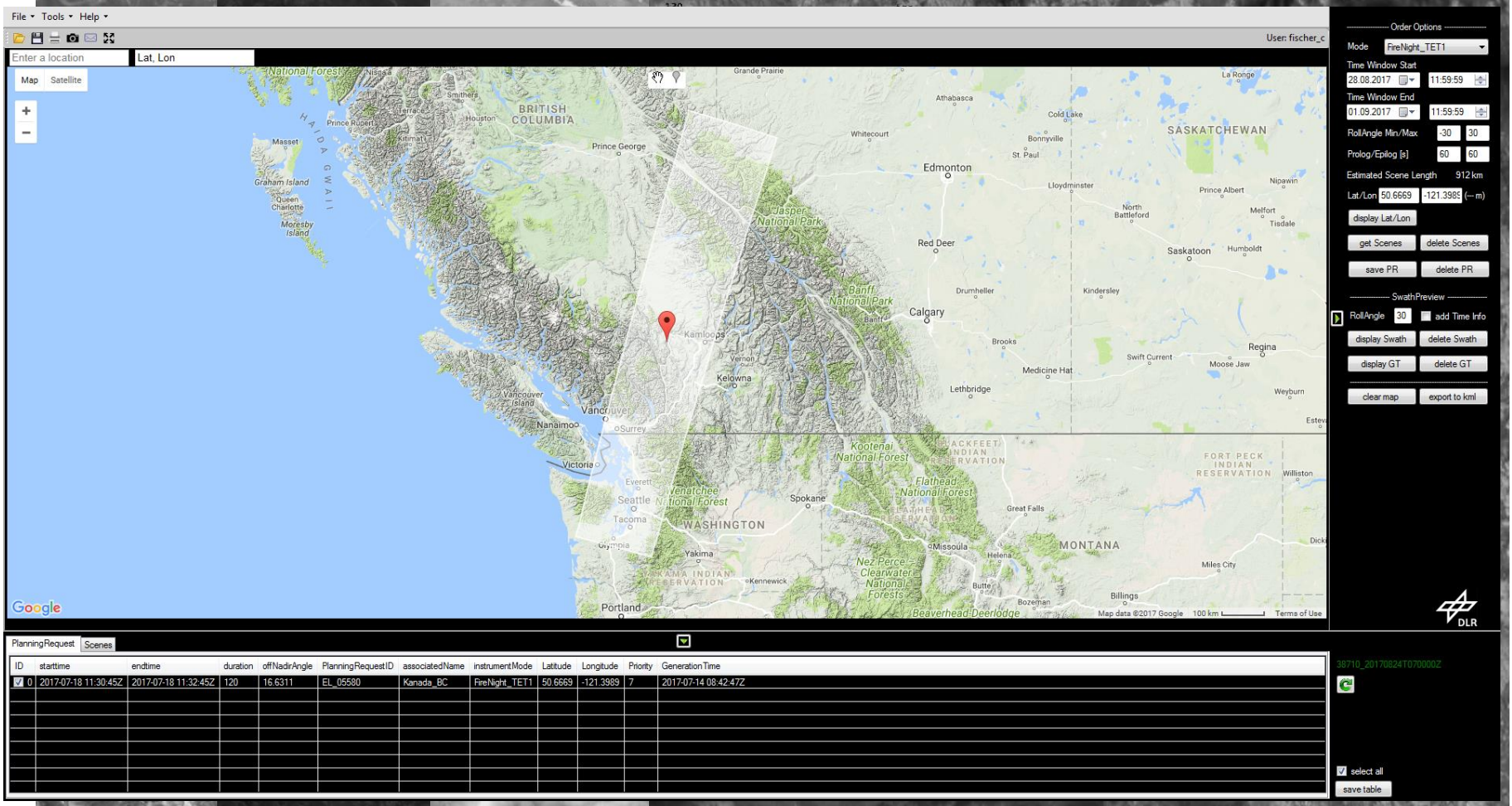
Reference fire experiment in Demmin on 17 August 2013

.

Fire Detection – Portugal 2016



Fire Detection – British Columbia, 2017



Conclusion & Outlook

FireBird Mission is:

- A key topic in the DLR R&D Program
- The first TIR small satellite constellation in orbit
- Sensitive HTE detector & accurate fire parameter analyzer
- Extends DLRs R&D activities of small satellite missions, including
  - Sensor systems, satellite bus design and technical experiments
  - Flight operations
  - Application development for different temperature ranges
  - Input for future mission requirements, national & international

- Next steps include
  - On-going validation activities
  - Detailed cross-validation tasks with other sensor systems, including VIIRS and SLSTR data
  - Establishment of a scientific data pool for further application developments

Thank you !

Contacts @ DLR-IOS

Christian Fischer	c.fischer@dlr.de
Eckehard Lorenz	eckehard.lorenz@dlr.de
Winfried Halle	winfried.halle@dlr.de