# WS8- Towards an Automatic Data Processing Chain for Airborne and Spaceborne Sensors

1300-1700: (Venue: Hunua 3 @Aotea)

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| 13:00-13:10 | Ralf Reulke (Humboldt-Universität zu Berlin) | Welcome and introduction to the workshop |
| 13:10-13:45 | Andreas Eckard (German Aerospace Center) | Real time data information technology based on in Orbit data processing (Invited Talk) |
| | Session 1 | |
| 14:00-14:30 | Winfried Halle (German Aerospace Center) | Infrared-Image Processing for the DLR FireBIRD Mission |
| 14:30-15:00 | Ralf Reulke (Humboldt-Universität zu Berlin) | Temperature Dependence of Dark Signal for Sentinel-4 Detector |
| 15:00-15:30 | Break | |
| | Session 2 | |
| 15:30-16:00 | Hongmou Zhang (German Aerospace Center) | An extended stochastic cloning method for fusing multi-relative measurements |
| 16:00-16:30 | Claas Ziemke (German Aerospace Center) | The PLATO on-board data processing system architecture in comparison to past and future missions |
| 16:30-17:00 | Ralf Reulke (Humboldt-Universität zu Berlin) | Summary, outlook and farewell |

# Real time data information technology based on in Orbit data processing (Invited Talk)

Andreas Eckardt, DLR German Aerospace Center, Institute of Optical Sensor Systems, 12489 Berlin, Germany

Abstract: The Institute of Optical Sensor Systems (OS) of the German Aerospace Center (DLR) has more than three decades experience with high-resolution imaging technology. The technology changes in the development of detectors, as well as the significant change of the manufacturing accuracy in combination with the engineering research define the next generation of spaceborne sensor systems focusing on Earth observation and remote sensing. The paper focuses on new data processing technologies of electro-optic sensors on space platforms, e.g. for real-time classification of images directly in space.

High-resolution sensors in particular generate enormous amounts of data that do not necessarily have to be sent to the ground. Ideally, you can characterize the data beforehand and only send interesting parts to the ground.

The problems in processing such sensor data reside in the most complicated detectors and sensors, which have great radiometric dynamics and require special correction and preprocessing tasks.

On the other hand, these sensors must be permanent checked to keep the spatial, radiometric and spectral resolution. They often require extra effort in terms of ego-localization and orientation.

The lecture gives an overview of the current developments and in orbit applications

**Key words**: AI in Orbit, FPGA data processing, On Pixel analog data processing, Earth observation instrument, In Orbit System Limitations, Data Fusion, Satellite on Chip

**CV – Andreas Eckardt**: Diploma of the Ilmenau University of Technology 1988. Start of work in the Space Research Institute of the GDR Academy of Sciences 1988; works since 1992 at the Institute for Space Sensors and at the Institute for Planetary Research and Space Sensor Technology at DLR.

He received his doctorate in 2002 in the field of digital cameras at the Technical University of Berlin.

He is head of Dept. High-Speed Electronics at the DLR Institute of Optical Sensor Systems. Since 2012 he is a member of the IAA.

Managed a variety of space-based and airborne projects, with the ADS40 and KompSat3 / 3A and Kompsat 7 FPA being the most important. Is author / co-author of about 100 publications and holds about 80 patents.

# Infrared-Image Processing for the DLR FireBIRD Mission

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Abstract. 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 $CO_2$ emissions.
The German Aerospace Center (DLR) is operating the "FireBIRD" con- stellation, which consists of the two satellite missions TET-1 (Technology Test Platform), and BIROS (Bispectral Infrared Optical System) It is dedicated to scientific investigation of the issues involved as well as to early fire detection from space. The satellite and detector approach is based on proven DLR technology achieved during the BIRD (Bispectral Infrad Detection) Mission, which was launched in 2001 and was primarily used for observation of fires and volcanic activity until 2004. The Pay- load of TET-1 and BIROS has spectral channels in visible (VIS), near infrared (NIR), mid wave (MIR) and a thermal infrared (TIR) channel. The paper is focused on the processing for TET- and BIROS- Fire- BIRD image data. In the FireBird standard processing chain level 1b and 2a data-products are generated automatically for all users after the data reception on ground. The so called fire-radiative-power (FRP) is one of the most important climate relevant parameters witch is estimated by using the bi-spectral method. Two characteristics of the FireBIRD sensors are unique: first, the high radiometric dynamic sensitivity for quantitative evaluation of normal temperatures and high temperature events (HTE) in the same scene. Second, the evaluation of the effective fire area in square meters independent of the recorded number of fire cluster sizes, which is given as the number of pixels per cluster. For certain users, such as firefighters, it is necessary to obtain fire data products (location and temperature) quickly and with minimal delay after detection. In such ap- plications, data processing must take place directly on board the satellite without using a complex processing chain. The paper describes also an alternative fire-detection algorithm which uses artificial neural networks (deep learning) and will compare it with the standard Level-2 FireBIRD processing.
**Keywords**: Small Satellite Constellation, Infrared Instruments, High Temperature Events, Bi-Spectral Method, Artificial-Neural-Networks.

# Temperature Dependence of Dark Signal for Sentinel-4 Detector

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Abstract. The Sentinel-4 payload is a multi-spectral camera system which is designed to monitor atmospheric conditions over Europe. The German Aerospace Center (DLR) in Berlin, Germany conducted the verification campaign of the Focal Plane Subsystem (FPS) on behalf of Air- bus Defense and Space GmbH, Ottobrunn, Germany. In this publication, we will present in detail the temperature dependence of dark signal for the CCD 376 (NIR) from e2v. Dark current is strongly temperature- dependent and is based on the thermal excitation of electrons in the conduction band. During the testing the temperature of the detectors was varied between 215K and 290K. Different models were examined, and corresponding deviations determined. Presenting the dark current by means of an Arrhenius plot, it can be shown, that the activation en- ergy is about half of the band gap. As an important result it could be shown that the temperature dependence can be described by two activation energies.

**Keywords**: SENTINAL-4 · dark signal · temperature dependence · ac- tivation energy.

# An extended stochastic cloning method for fusing multi-relative measurements

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Abstract. One of the most important tasks for visual inertial odometry systems is pose estimation. By integrating system poses, motion trajectory of the system can be obtained. Due to errors existing in calculations, the accumulated errors grow unbounded. To decrease the drift, keyframes and loop-closure information can be used as additional references for the system. To use this information, the system should able to handle multi-relative measurements which cross many periods of filter cycles. In Kalman filter-based system the fusion of such information is one of the toughest problems. In this paper, we propose an extended stochastic cloning method to overcome this problem. The proposed method is based on the error state Kalman filter. It also can be used in other Kalman fil- ters. The experimental results show that based on the proposed method trajectory errors and uncertainties of filtered results are decreased significantly. At the same time, the IMUs biases are modeled as a random-walk noise and be updated as well. This way, by using keyframes and loop- closure information, the proposed method is able to improve the accuracy of the sensor models.
**Keywords**: Kalman filter · stochastic cloning · visual odometry · measurement fusion.

# The PLATO on-board data processing system architecture in comparison to past and future missions

Claas Ziemke et. al

Abstract: State-of-the-art optical space instruments are capable of producing data rates that considerably exceed the available down-link capacities. The potential data rates are increasing from mission to mission as the sensor technologies progress. Together these trends require a significant data reduction on-board, most appropriately at the source of the data, the instrument. In this paper we will discuss these trends using the example of the architecture of the data processing system of the PLATO mission. PLATO (PLAnetary Transits and Oscillations of stars) is the third medium (M3) mission in ESA's Cosmic Vision programme. The goal of the PLATO mission is to detect terrestrial exoplanets in the habitable zone of solar-type stars and characterize their bulk properties. In order to achieve this science goal, the PLATO instrument is comprised of 24 identical refracting telescopes each equipped with 4 CCDs, plus 2 additional telescopes which aid the space-craft fine-pointing. The PLATO instrument is developed by an international consortium under the lead of DLR. We show the architecture of data processing systems of past exo-planet missions and compare them to the PLATO instrument, discuss the trade-offs that lead to the current design and propose architectural considerations that could potentially improve the performance of similar instrument designs in the future

Keywords: PLATO, Exo-planet, On-board data processing.