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A microsatellite platform for hot spot dedection

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Abstract

The main payload of the BIRD micro-satellite is the newly developed hot spot recognition system. Its a dual-channel instrument for middle and thermal infrared imagery based on cooled MCT line detectors. The miniaturisation by integrated detector/cooler assemblies provides a highly efficient design.

Since the launch in October 2001 from SHAR/India the BIRD payload, claiming 30% of the BIRD mass of 92 kg, is fully operational. Among others forest fires (Australia), volcanoes (Etna, Chile) and burning coal mines (China) have been detected and their parameters like size, temperature and energy release could be determined. As the status of the payload system is satisfactorily it has a potential to be applied in new missions with the help of modern detector technology.

1. Introduction

There are several operational systems used for global observations of active fires (e.g. NOAA, EOS, ENVISAT), nevertheless the technology to be operated comprises remarkable potential of further developments, for instance, aspects of resolution and saturation of the sensors.

Based on the core activity to design a new generation of imaging infrared detectors the interest to investigate their operational behaviour in space led to a complete micro-satellite development, which is oriented on a set of ambitious objectives:

1. Development, qualification and demonstration of small satellite technologies in space.
2. Test of a new generation of infrared array sensors adapted to Earth remote sensing objectives by means of small satellites.
3. Detection and scientific investigation of hot spots (forest fires, volcanic activities, burning oil wells or coal seams).

2. Scientific instruments of BIRD

The temperature of vegetation fires varies from 500 up to 1200 K depending on the type of combustion. Their spectral density distribution occurs in the mid-wave infrared (MIR) wavelength region at 3–5 μm.

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Table 1
BIRD multi-sensor system parameters (altitude 572 km)

	WAOSS-B	MIR	TIR
Wavelength	600–670 nm 840–900 nm	3.4–4.2 μm	8.5–9.3 μm
Focal length	21.65 mm	46.39 mm	46.39 mm
Field of View	50°	19°	19°
F-number	2.8	2.0	2.0
Detector	3 CCD-line arrays	MCT-line array	MCT-line array
Detector cooling	Passive, 20 °C	Stirling, 105 K	Stirling, 80 K
Pixel size	$7 \times 7\,\mu m^2$	$30 \times 30\,\mu m^2$	$30 \times 30\,\mu m^2$
Number of pixels	2884	2 × 512 staggered	2 × 512 staggered
Quantization	11 bit	14 bit	14 bit
Ground pixel size[a]	185 m	370 m	370 m
Swath width[a]	533 km	190 km	190 km

WAOSS-B—Wide angle optoelectronic stereo scanner, modified for BIRD,
MIR—Medium infrared sensor,
TIR—Thermal infrared sensor.
[a]Orbit height = 572 km.

Hence it is the main target for a space-born fire sensor. Reflection effects (e.g. sun glint) as sources of data misinterpretation have to be distinguished by combination of MIR and VIS (visible) channels.

Furthermore, temperature information has to be derived from thermal infrared (TIR) imaging data by bi-spectral data processing techniques. The so arising multi-channel system is able to detect hot spots of sub-pixel size.

2.1. Payload architecture and parameters

The payload is designed to fulfil the scientific requirements under the conditions of a micro-satellite. It consists of the following main parts (Table 1):

- Bi-spectral infrared HSRS (HSRS including MIR and TIR-Sensor),
- Wide-angle opto-electronic stereo scanner (WAOSS-B, VNIR-Sensor) for vegetation analysis and fire classification,
- Payload data handling system (PDH) with a mass memory,
- A neural network classificator for an on-board classification experiment.

2.2. HSRS—the main BIRD payload

The main payload of the BIRD micro-satellite is the newly developed hot spot recognition system (HSRS). Its a dual-channel instrument for middle and thermal infrared imagery based on cooled MCT-line detectors.

These linear arrays consisting of 2 × 512 pixels in staggered configuration are based on loophole diode technology with detector electronics on a hybridised detector assembly. Their operating temperatures are 80 K for the TIR and 105 K for the MIR channel, respectively.

Based on experiences with a airborne laboratory model using a split Stirling cooler design the detector assembly was optimised regarding stray-light suppression and power needs to meet the radiometric requirements and to cope with the limited resources of the micro-satellite concept. A detector assembly for military applications (see Fig. 1) was modified into a space-qualified solution. The main aspects of the sensor design are:

- integrated miniaturised Stirling cycle cooling device,
- adapted cold shield design inside the Dewar covered by the IR-window,