MicroCameras and Photometers (MCP): the optical instrument on board TARANIS

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The TARANIS microsatellite is dedicated to the study of the impulsive transfers of energy between the Earth atmosphere and the space environment, including transient phenomena such as Transient Luminous Events (TLEs) and Terrestrial Gamma-ray Flashes (TGFs). It observes from above thunderstorm areas. Part of the payload, the "MicroCameras and Photometers" (MCP) instrument is in charge of the remote sensing of TLEs in terms of optical imaging and waveforms. Its objectives are to identify and characterize lightning flashes and TLEs in different optical wavelengths, to determine spectral properties and to provide an alert to all TARANIS instruments for common TLE observations at high resolution. The purpose of this paper is to describe the MCP scientific objectives and the instrumentation.

1. Introduction

TARANIS (Tool for the Analysis of RAdiations from lightNIng and Sprites) is a CNES satellite project dedicated to the study of impulsive transfers of energy between the Earth's atmosphere and the space environment. Objectives more precisely focus on the determination of the mechanisms at the origin of Transient Luminous Events (TLEs), Terrestrial Gamma-ray Flashes (TGFs) and on their effects on the Earth environment [1]. Its scientific payload is composed of six scientific instruments covering a very broadband: from few Hertz to gamma-ray range, through optical range (from UV to NIR).

The MCP originality is to observe at the nadir above the thunderstorms for comparison of light emissions with corresponding X, gamma, radio emissions, instead of at the horizon as previous observations.

TARANIS is presently in construction and foreseen for a launch in the end of 2016. It is expected to be a two-year mission. It will fly in a 98° sun-synchronous orbit at altitudes of about 700 km, for operations around 13:30 LT.

2. MCP scientific objectives

The MCP (Micro-Cameras and Photometers) instrument has been fully described by [2]: its scientific objectives, the nadir measurement methodology, the TLE lightning identification processing, and the instrument. This paper briefly recalls the objectives, describes and updates the instrumentation.

The scientific objectives of the MCP experiment are:

- To identify and characterize the TLEs and the strongest lightning flashes,
- To locate the source regions of TLEs over the world,
- To trigger other TARANIS instruments which may point out associated events.

MCP is composed of two MicroCameras (MCP-MC) and four photometers (MCP-PH). MCP-MC will be used to locate lightning flashes and TLEs and to classify TLEs in their different categories. MCP-PH will be used to detect on board TLEs and strong lightning flashes and to characterize them temporally and spectrally.

3. Instrument description

3.1. MCP-MC

MicroCameras instrument is constituted of the following subparts: an optical module MC-U and an electronic module, MC-A, which is deported 1m away from MC-U.

MC-U contains (Figure 1): two optical heads, each one dedicated to a specific wavelength (762nm for sprite detection and 777nm, for lightning detection with 10nm FWHM), two detection sub-assemblies, based on a cooled CCD 4720 CCD from E2V, a CCD proximity electronic board, used for binarisation of the signals, and a mechanical structure.

The frame transfer CCD produces pictures at a frame rate of 10 per second. The optical heads of the two cameras are nearly identical with a circular field of view of around 46°. The chosen aperture number is 1.6. A telecentric combination is used to avoid a shift of the central filtered wavelength and the spectral filter is placed near the sensor. The resolution is 1.1 km at the center and 1.4 km at the edge of the field of view (due to distortion) at the altitude of the thunderclouds. For TLE identification, a very good mutual covering of camera field of view, the knowledge of the camera misalignment (within few arc seconds), the

synchronization of observation start between both cameras and lossless image compression are necessary.

MC-A includes an electronic board for data compression and data formatting inside a mechanical structure allowing racking with other electronic modules of the payload.

The MC-U volume is 130 mm wide, 180mm long and 190 mm high with a mass of ~2.4kg. The typical MCP-MC power consumption is ~8W.

Figure 1: MCP cameras CAD drawing.

3.2. MCP-PH

As for the MicroCameras, the Photometers instrument is composed of a sensor module PH-U and an electronic module, PH-A. PH-U is composed of four optical and electronic chains (Figure 2):

- PH1: inside the N2 Lyman-Birge-Hopfield (LBH) UV band system from 160 to 260 nm,
- PH2: the most intense line of the N2 second positive band at 337 ± 5 nm for TLEs,
- PH3: the most intense line of the N2 first positive band at 762 ± 5 nm for TLEs,
- and PH4: from 600 to 900 nm. This last spectral band will be dedicated to lightning flash measurements.

Hamamatsu photomultipliers and photodiode have been chosen with respect to the spectral performances. The field of view of PH1, PH2 and PH3 will be the same as the camera one. The mutual covering of photometer and camera field of view must be more than 95%. PH4 will have a much larger field of view (disk of 700 km radius) than other photometers to be similar to the field of view of other TARANIS instruments. The sampling frequency is 20 kHz. The four photometers must be synchronized to be able to perform TLE detection.

The electronic module, PH-A, is in charge to drive the High Voltages of the photomultipliers, to provide the necessary power lines and switching them ON and OFF, to acquire (including digitalizing) signals from the sensor, to process in real time the 4 channel data to rise an “event” alert, and to format and send the data (with compression for the survey mode).

The PH-U volume is 215 mm long, 160 mm large and 202 mm high, with a mass of 2.85 kg. The typical MCP-PH power consumption is ~5.6 W.

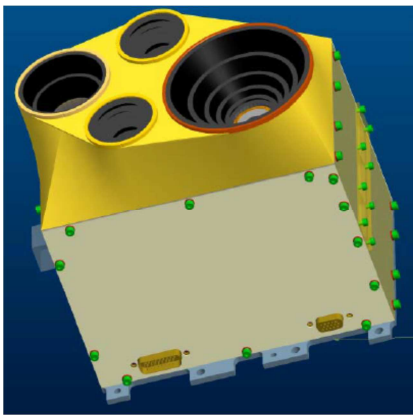

Figure 2: MCP photometers CAD drawing.

4. Current status

MCP instrument is currently in Phase D. Engineering models for Microcameras and Photometers have been manufactured and underwent coupled tests with their analyzers. Manufacturing of flight models is now in progress. Radiometric and geometric characterization of the sensors and environmental tests are planned before delivery. MCP-PH and MC-A delivery are expected in October 2014 while MC-U delivery is planned in January 2015. Payload integration will start in February 2015. Characterization of integrated instruments with the payload is as well planned.

5. References

[1] Lefeuvre F., E. Blanc, J.L. Pinçon, R. Roussel-Dupré, D. Lawrence, J.A. Sauvaud, J.L. Rauch, H. de Feraudy, and D. Lagoutte, TARANIS - A Satellite Project Dedicated to the Physics of TLEs and TGFs, Space Sci. Rev., 137, 301–315, 2008.

[2] Hébert P, Le Mer-Dachard F, Blanc E, Farges T, Jehl A, Binet R, Ravel K, and Sato M, Taranis MCP: a joint instrument for accurate monitoring of Transient Luminous Event in the upper atmosphere, paper number 134 of 9th ICSO International Conference proceedings, October 9th-12th 2012, Ajaccio, France