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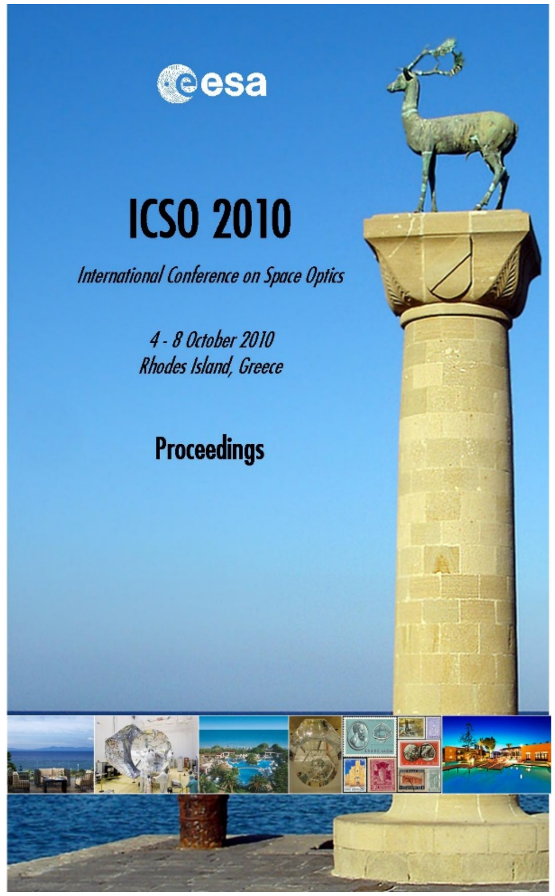


*Edited by Errico Armandillo, Bruno Cugny, and Nikos Karafolas*

# *The Advanced Wide Field Imaging camera(AWFI) for the Amazonia 1 Brazilian satellite*

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# THE ADVANCED WIDE FIELD IMAGING CAMERA (AWFI) FOR THE AMAZONIA 1 BRAZILIAN SATELLITE

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The AWFI camera (Advanced Wide Field Imaging Camera) is part of the payload for the AMAZONIA 1 satellite. This camera and its GSE - Ground Support Equipments, are under development by the Brazilian company Opto Eletrônica S.A. AWFI camera will be used for remote sensing of the Earth and will image a ground swath of 754 km, with a ground resolution of 40m at nadir, in four spectral bands that cover the range of wavelength from 450nm to 890nm. This camera is composed of the optoelectronic block and the signal processing electronics. The opto-electronic block is composed of three identical optical channels and a mechanical frame. This work aims at presenting the optical system developed for the optical channel of this camera and its theoretical performance.

## INTRODUCTION

The AWFI camera (Advanced Wide Field Imaging Camera) belongs to AMAZONIA 1 Brazilian satellite and is being developed in Brazil by the company OPTO ELETRÔNICA S.A. [1]. This company is also responsible for the development of the Multispectral Camera – MUX, and participates in a consortium for the development of the WFI Camera (Wide Field Imaging Camera) that will integrate the CBERS 3 and 4 (China-Brazil Earth Resources Satellite).
The main goal of AMAZONIA 1 mission is to provide remote sensing image data and contributing, together with other satellites, for the DETER (Real Time Deforestation Detection) system continuity in Amazon region deforestation monitoring capability. The DETER system aims to deforestation monitoring and control, especially inside the Brazilian region [2].
This satellite will operate in a Low Earth Orbit (LEO) and has a 5 days revisit time [2]. It is being developed by Brazil and will utilize the Brazilian Multi-Mission Platform (MMP) that is being developed in this country under INPE (National Institute for Space Research) supervision [2,3].
The AWFI camera final image is a composition of the images of three identical optical channels and covers an extension of 754km with a ground resolution of 40m at nadir. AWFI camera images in four distinct spectral bands (from 450nm to 520nm, 520nm to 590nm, 630nm to 690nm and 770nm to 890nm).
The mean temperature of operation of the optics is 17.5ºC and the camera has a thermal control system that maintains the collecting lens and the focal plane in the temperature range from 15ºC to 20ºC.

## THE ADVANCED WIDE FIELD IMAGING CAMERA - AWFI

The AWFI subsystem is composed by three equipments that perform different functions: OEB (Opto-Electronic Block) (Fig. 1,a), SPE1 (Signal Processing Electronics) and SPE2 (Thermal Control and Power Supply) (Fig. 1,b). The functions of each device are described in general terms as:
• **OEB** - consists of three identical optical channels and a mechanical frame. Each optical channel (Fig. 2) is composed of the collecting lens, optical housing and the focal plane assembly, where is located the Detection Unit, the Proximity Electronic and the Calibration Unit;
• **SPE1** - is responsible for radiometric auto-calibration control and processing and formatting of video signals;
• **SPE2** - is responsible for temperature control, power supply, remote control reception and transmission of telemetry.

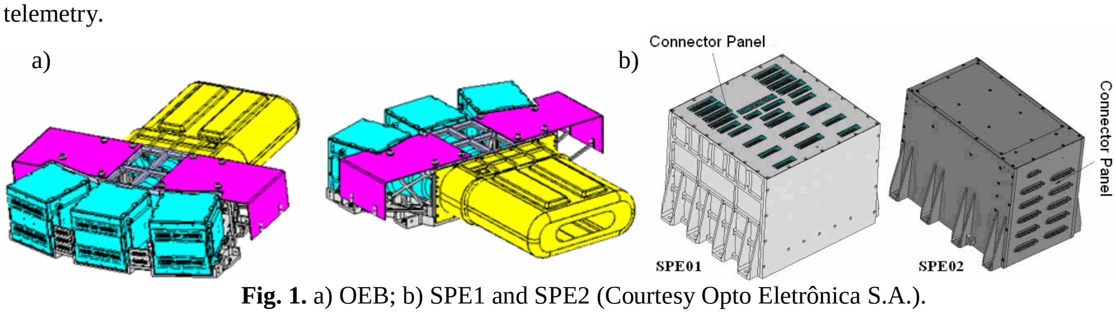


**Fig. 1.** a) OEB; b) SPE1 and SPE2 (Courtesy Opto Eletrônica S.A.).

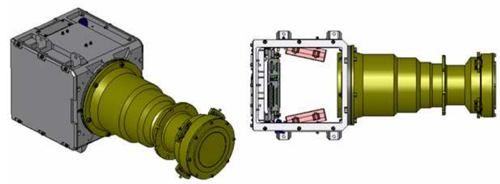

**Fig. 2.** Optical Channel (OC).

OPTICAL DESIGN

*A. Optical Requirements*

Table 1 shows some requirements for the optical system design of the AWFI camera [4]. Besides these optical requirements, the back focal length of the optical system must be able to support an internal calibration system between the latest lens and the focal plane for on orbit calibration.

**Table 1 .** Optical System Requirements [4].

| ***Characteristics*** | ***Requirements*** |
|---|---|
| *Effective Focal Length – EFL* | *251.0 mm* |
| *Relative aperture* | *5.2* |
| *Field of view – FOV* | *±25.5º* |
| *Spectral bands* | *B05: 450 – 520nm;*<br>*B06: 520 – 590nm;*<br>*B07: 630 – 690nm;*<br>*B08: 770 – 890nm;* |
| *Modulation Transfer Function – MTF* | *> 0.60 at 38.5lp/mm* |
| *Distortion* | *< 3.0%* |
| *Polarization Sensitivity* | *< 7.0 %* |
| *Field Illumination* | *Constant within ±3.0%* |
| *Band-to-band registration* | *< 5.2µm* |
| *Mean Temperature of Operation* | *17.5ºC* |
| *Temperature Range* | *15ºC – 20ºC* |

*B. Optical System Characteristics*

Fig. 3 shows the optical system developed for each optical channel. It consists of a refractive optical system with 10 elements. The first element is a window that works as a shield for radiation and thermal protection of the optical channel. Each optical channel has 18º of field of view.

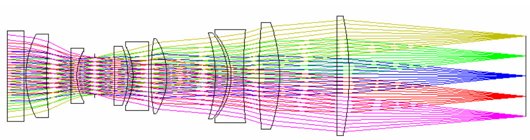

**Fig. 3**. Collecting lens system.

*C. Theoretical Performance*

Fig. 4 shows graphics of grid distortion (<1.2%) and graphics of lateral color. Fig. 5 shows the graphics of the Modulation Transfer Function (MTF) for the four spectral bands at the mean temperature of operation (17.5 ºC). It shows that the MTF for the four bands is > 0.7 at 38.5lp/mm. Fig. 6 shows MTF versus spatial frequency and Through Focus MTF for the wavelength range from 450nm to 890nm in the overall temperature range (15ºC to 20ºC). Polarization sensitivity is < 1.3%.

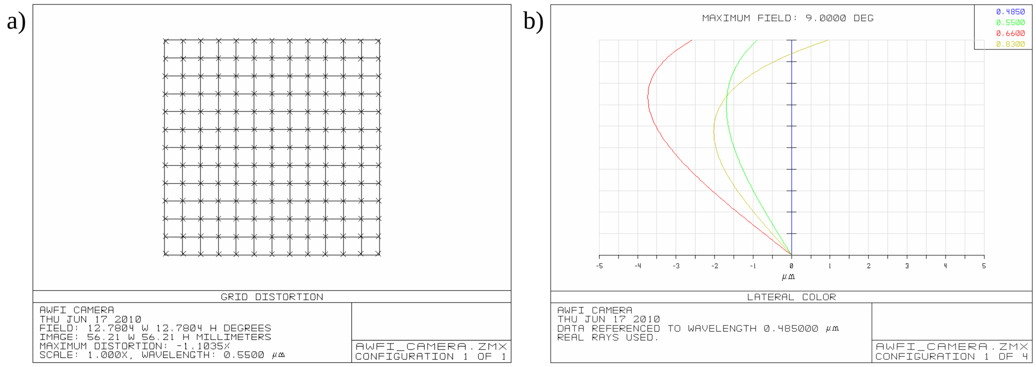


**Fig. 4.** a) Grid Distortion, b) Lateral Color.

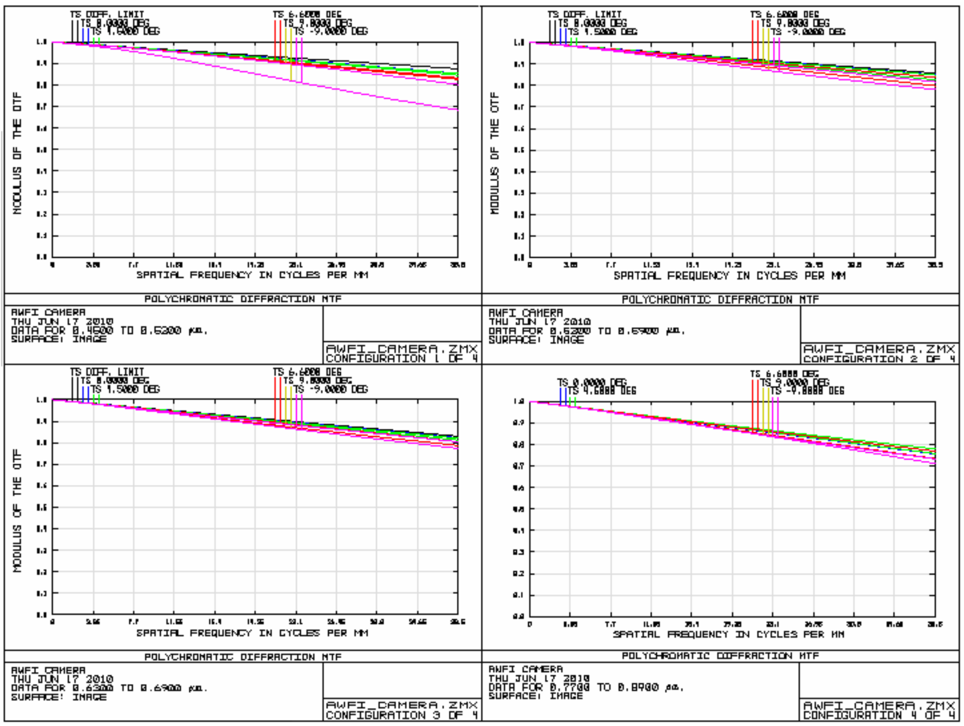


**Fig. 5.** Modulation Transfer Function at 17.5ºC in the four spectral bands.

The sensor used in this camera has four lines, each one with 1 x 6000 pixels of 13x13µm in size. The fours spectral bands are defined by spectral thin films deposited in a windows that covers the photosensitive elements of the CCD.

THE INTERNAL CALIBRATION SYSTEM

The Detection and Calibration Assembly (DCA) is responsible for the on orbit calibration of the CCD (Fig. 7). It is a luminous (LED-emitted light) reference utilized to monitor parametric changes occurred in the system related to the CCD and the analog video channel amplifiers through the life time due to radiation and others orbital environment reasons. It is located between the collecting lens and the focal plane and is composed by LEDs (Light Emitting Diode) that covers the wavelength range in the four spectral bands. It will provide almost uniform irradiance for each CCD line during the flight. It is intended to provide six irradiance levels to fulfill the CCD dynamic range.

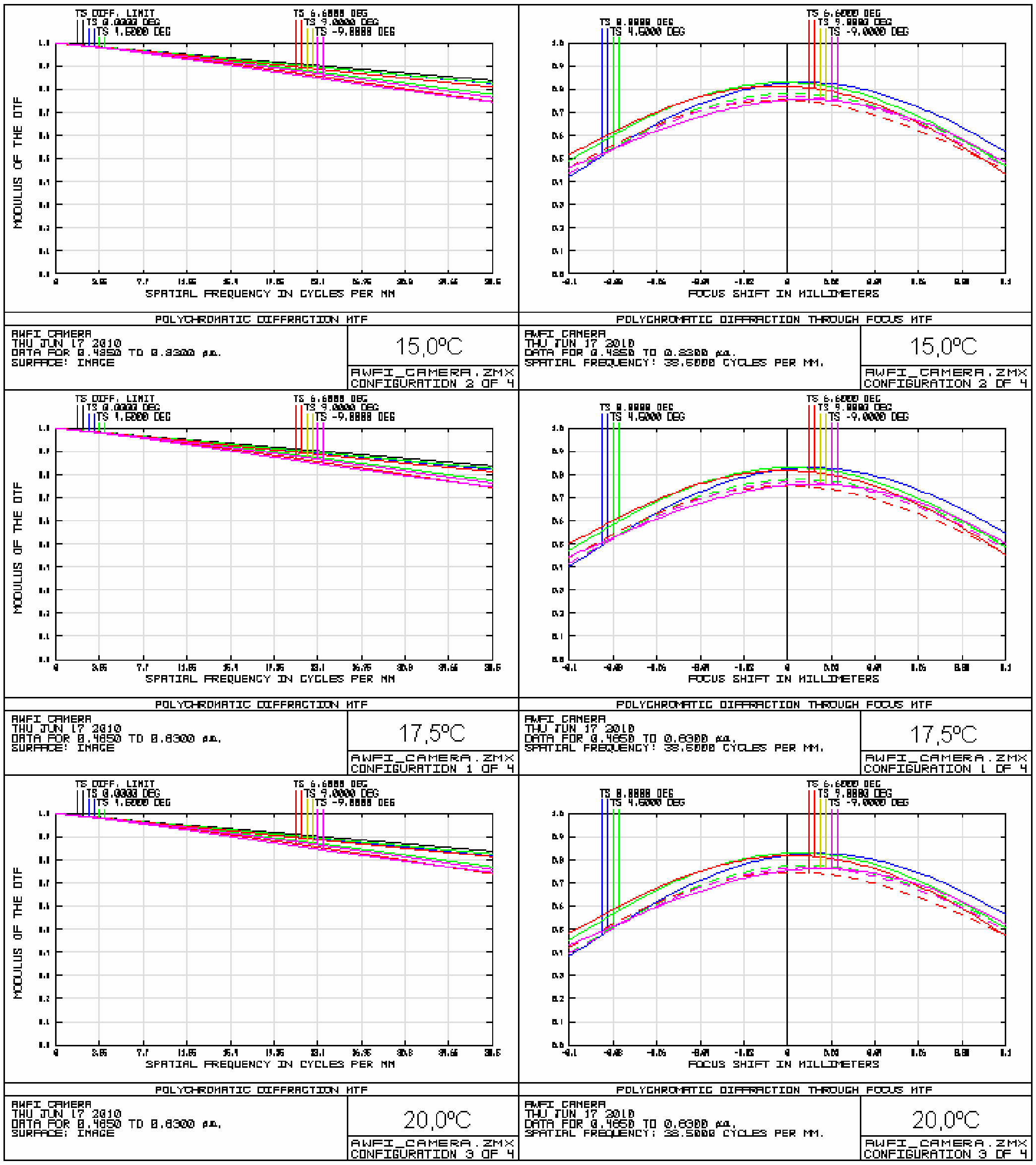


**Fig. 6.** MTF x Spatial Frequency and Through Focus MTF for the overall wavelength range in the temperatures: 17.5ºC, 15.0ºC and 20.0ºC.

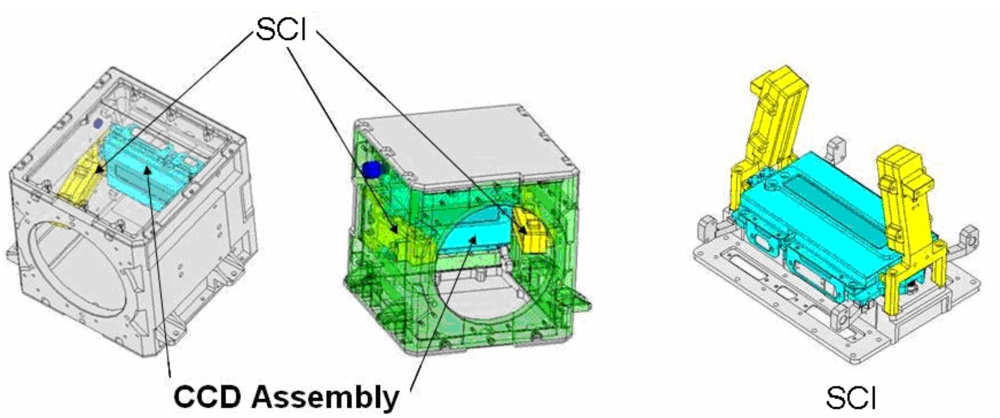


**Fig. 7.** Detection and Calibration Assembly.

## CONCLUSIONS

The development of the AWFI camera, aimed to be used for remote sensing of the Earth on board of AMAZONIA 1 satellite, is nowadays in the preliminary design phase and the Engineering Model is under construction.

During this phase the design is evaluated by a diversity of theoretical analyses, such as performance evaluation, radiation resistance, thermal and structural analyses, etc. For the sake of robustness of the design, the prototype equipment (Engineering Model) shall be evaluated in a series of on ground optical tests, which are predicted to be performed previously and subsequently to the vibration and thermal tests campaign.

## ACKNOWLEDGMENT

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