The Atmosphere-Space Interactions Monitor (ASIM) for Studies of Thunderstorms and their Effects on the Atmosphere and Ionosphere

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ASIM is a payload for the International Space Station for observations of Terrestrial Gamma-ray Flashes (TGFs), Transient Luminous Events (TLEs) and lightning. The scientific payload is composed of two instrument suites. One is the Modular X- and Gamma-ray Sensor (MXGS) measuring photons with energies from 10 keV – 20 MeV the other is the Miniature Multispectral Imaging Array (MMIA) which carries three photometers two cameras. The instruments are mounted external to the ESA Columbus payload, viewing towards the nadir. ASIM is developed by ESA and is expected to be launched in May 2016. The presentation will give an overview of the ASIM mission and its status. We present the payload instruments and their measurements, the mission scenario and the status of the mission.

1. Historical background

The Atmosphere-Space Interactions Monitor (ASIM) is in ESA's research cornerstone of Fundamental Sciences (Dust and Atmospheres). The ASIM instrument concept was first submitted in 2003 to an ESA call for external payloads on Columbus issued to national delegates. ASIM entered an *Instrument* Pre-Phase A study with the Danish National Space Centre in December 2003. The study was completed in June 2004 with the recommendation to enlarge to a broader European mission, including European partners such as Norway and Spain, in charge of co-developing the upgraded version of the X and Gamma-ray Sensor (MXGS). A *Payload* Pre-Phase A study was performed in October 2004 at ESA/ESTEC, a Payload Phase A study took place in 2005-2006. Phase B was performed during 2007-2009 and Phase C started in August 2010.

2. Research objectives

ASIM is an Earth observation facility to be located on the external payload platform on the Columbus module of the International Space Station for the study of severe thunderstorms and their role in the Earth's atmosphere and climate. The following scientific objectives are to be addressed by ASIM:

Research objectives related to the Atmosphere:

- Provide the most comprehensive global survey of Transient Luminous Emissions (TLEs) and Terrestrial Gamma-ray Flashes (TGFs)
- Study the physics of TLEs and TGFs
- Determine the perturbation of the high-altitude atmosphere by thunderstorms

Research objectives related to Space Science:

- Study effects of thunderstorms on the ionosphere and the radiation belts
- Study meteors in the Earth's environment and quantify their effect on the atmosphere
- Lightning-induced electron precipitation and relativistic electron precipitation
- Aurora borealis

Research objectives related to Earth Observation:

- Effects of mega-cities, dust storms, forest fires and volcanoes on cloud electrification
- Intensification of hurricanes and its relation to eye-wall lightning activity

3. The Payload

The observations use a set of pre-defined wave-lengths in the optical band and in the X- and Gamma bands. The optical band is covered by the Modular Multi-spectral Imaging Array (MMIA) and the X- and Gamma band by the Modular X-ray and Gamma-ray Sensor (MXGS) (Fig. 1). ASIM will be installed as an external payload on the ISS Columbus Module, looking downward at the Earth's atmosphere (nadir direction) (Fig.2). The MMIA must be able to detect the relatively faint emission from TLEs against a strong background of illuminating lightning. Observations in several optical bands are necessary to achieve this. The MXGS has a coded mask that allows identification of the location of the TGF source.

Fig. 1: The ASIM payload

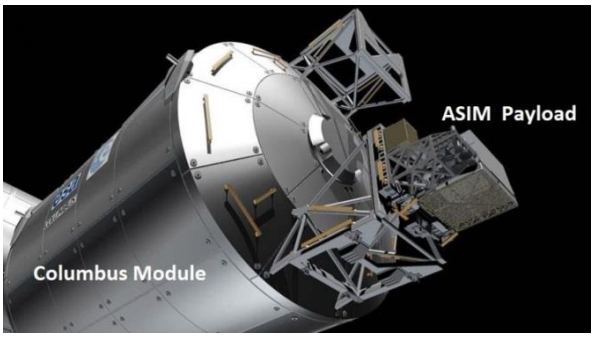

Fig. 2: ASIM on the Columbus module of the ISS.

Observations will be performed either in triggering or in a time tagged mode. In the triggered mode, data are continuously recoded into a circular buffer, and erased again unless the observed photon flux fulfils certain criteria (e.g. intensity, duration). In such cases, all data are saved and transmitted to ground. This cross-triggering of instruments will increase the sensitivity by allowing retaining data even if a module by itself does not trigger. Cross-triggering and identification of TGF location have never been done before and are particularly crucial for understanding the origin and physics of TGFs. The instruments are shows in Fig.3-4, and their specifications in Table 1.

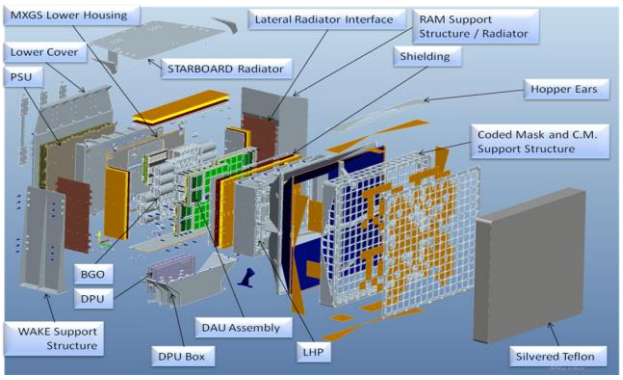

Fig. 3: The MXGS instruments.

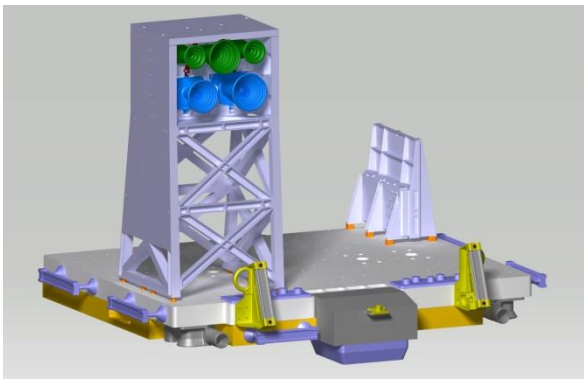

Fig. 4: The MMIA instruments and the MMIA computer.

Table 1: ASIM instrument specifications.

MXGS	**LED**	**HED**
Geometric area	1024 cm^2	900 cm^2
Energy range	15-400 keV	0.2-20 MeV
Energy resolution	<10% /60 keV	<15%/662 keV
Relat. time resolution	≤5 µs	≤5 µs
Angular resolution (source)	Point < 0.7^O Diff < 2^O	NA
MMIA	**Cameras**	**Photometers**
FOV (Nadir)	61.4^O x 61.4^O	61.4^O x 61.4^O
Pixels	1024 x 1024	
Pixel resolution (km)	0.4 - 0.5	
Time resolution (ms)	83	0.01 - 0.1
Spectral bands (nm) (center/width)	NC1:337.0/5 NC2:777.4/5	NP1:337.0/5 NP2:180-230 NP3:777.4/5

4. The consortium

The ASIM consortium is led by Terma A/S, Space Division. Terma is also leading the MMIA consortium and delivers the cameras (heritage from star cameras), with DTU Space as a partner (photometers, power supply, and instrument computer). DTU Space is leading the MXGS consortium and delivers the instrument computer and harness, with University of Bergen (high-and low-voltage sensors), Space Research Center, Poland (power supply), and University of Valencia (mechanical structure and coded mask) as partners. Carlo Gavazzi, Milano, provides the payload computer, interfacing with the ISS.

5. The timeline

Delivery of instrument flight models is expected in February 2015 and the payload acceptance review in September 2015. Shipment to the carrier integrator (Space X) follows in January 2016 with launch in May 2016. The end of the commissioning phase is expected in July 2016 followed by a 2-year science phase.