TARANIS mission

T. Farges

with the collaboration of J-L. Pinçon, J-L. Rauch, P-L. Blelly, F. Lebrun, J-A. Sauvaud, and E. Seran

Joint MTG LI & GOES-R GLM workshop – 27-29 May 2015 - Roma
TARANIS (Tool for the Analysis of RAdition from lightNIing and Sprites) is a CNES satellite mission dedicated to the study of impulsive energy transfers between the atmosphere of the Earth and the space environment. Its main objectives are:

- To advance the physical understanding of the links between TLEs, TGFs and environmental conditions (*lightning activity, geomagnetic activity, atmosphere/ionosphere coupling, occurrence of Extensive Atmospheric Showers, etc*).

- To identify the signatures associated with these phenomena (*electron beams, associated electromagnetic or/and electrostatic fields*) and to provide inputs to test generation mechanisms.

- To provide inputs for the modelling of the effects of TLEs, TGFs and bursts of precipitated and accelerated electrons (*lightning induced electron precipitation, runaway electron beams*) on the Earth’s atmosphere.
Main scientific challenge is to measure these phenomenon with all the instruments in high resolution:

- Combined Nadir observations of TLEs and TGFs.
- Energetic electrons measurements
- Wave field measurement over the frequency range [DC - 35 MHz].
TARANIS scientific payload

PI Mission: JL Pinçon (LPC2E)
Scientific co-I: E. Blanc (CEA)

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Description and Parameters</th>
<th>PI</th>
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</thead>
<tbody>
<tr>
<td>MCP</td>
<td>Lightning micro-camera, TLE micro-camera, 4 Photometers (170-260, 337, 762, 600-900 nm)</td>
<td>Th. Farges (CEA)</td>
</tr>
<tr>
<td>XGRE</td>
<td>X and γ detectors: [20keV – 10MeV], e`: [1 MeV – 10 MeV]</td>
<td>P-L. Blelly, IRAP (F) and F. Lebrun, APC (F)</td>
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<tr>
<td>IDEE</td>
<td>Two e` detectors: [70keV – 4MeV]</td>
<td>J-A. Sauvaud, IRAP (F) + Univ. Prague (Cz)</td>
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<tr>
<td>IMM</td>
<td>Triaxial search coil: [5Hz – 1MHz], 0` whisker detector</td>
<td>J-L. Pinçon, LPC2E (F) + Univ. Stanford (USA)</td>
</tr>
<tr>
<td>IME-BF</td>
<td>LF-E antenna: [DC – 1MHz], Ion probe</td>
<td>E. Seran, LATMOS (F) + GSFC (USA)</td>
</tr>
<tr>
<td>IME-HF</td>
<td>HF-E antenna: [100kHz – 35MHz]</td>
<td>J-L. Rauch, LPC2E (F) + Univ. Prague, IAP (Cz)</td>
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</tbody>
</table>

TOWARDS THE EARTH
Event mode: 3 full resolution images per camera and 410 ms waveforms per photometer

Scientific objectives:
• Provide identification, dating and localization of TLEs
• Provide dating and localization of lightning
• Provide spectroscopic (FUV/UV/NIR) information
• Alert generation (if TLE or strong lightning occurrence detected on board)
IME-HF instrument

- 2 antennas along a satellite diagonal, on the opposite side of the solar panels to measure fluctuation of the HF electric field: 100 kHz – 35 MHz
- Alert generation
- Data sampling: 80 MHz
- Event data per half orbit:
  - up to 3 waveform data (full sampling frequency, 41 ms)
  - and narrowband-filtered waveforms (filterbank of 12 frequencies, time resolution of 12 µs, 41 ms)

Scientific objectives:
- Identification of waves and signatures associated to transient luminous phenomena during storms
- Characterization of lightning flashes from their HF electromagnetic signatures, association with TLEs and TGFs
- Detection of precipitated and accelerated particles (including runaway electron beams and very high energy cosmic rays) from their HF electromagnetic or/and electrostatic signatures
- Identification of characteristic frequencies of the medium from cut-off frequencies and polarization (ordinary or extraordinary mode)
**TARANIS measurements for lightning studies**

**Contribution to lightning physics studies**

- **Image:**
  - Lightning localization
  - Filament structure (1 km spatial resolution)
  - (Relative) cloud top height

- **Photometer waveforms:**
  - Physical mechanism: different wavelength

- **HF waveforms:**
  - IC/CG discrimination capability (Davis, JGR, 2012)
  - Identification of lightning phase: preliminary breakdown, stepped leaders, return strokes, ...
  - TIPPs: altitude of discharges determination

- **Comparison of measurements:**
  - Image/photometer: better localization
  - Photometer/HF waveforms: diffusion by clouds

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**LSO data**
Farges et al., 2014

**ISUAL data**
Frey et al., 2005

**FORTE data**
Light et al., 2001
TARANIS operating modes

Survey data:
Continuous monitoring of the background conditions.
2 GB of low resolution data per day!

Event data:
Triggered: when a priority event is detected (TLE, TGF, electron beam, burst of electromagnetic/electrostatic waves), then all instruments record and transmit high resolution data.
2 GB of high resolution data per day!
On-board analyzers will include event buffer memory sized to record high resolution data both before and after the trigger. Time window depends on instrument time resolution.
TARANIS status & launch

Now: platform integration, instrument qualification
Next step: instrument integration on the payload

Platform integration

Scientific payload with 3D models

Launch: late 2017, from Kourou with Soyuz as a piggyback of ESA EarthCare satellite
The TARANIS data server will provide the scientific community with the following services:

1) TARANIS data downloading
2) TARANIS QuickView/QuickLook access
3) TARANIS data online processing

Guest investigators will have access to:
- Calibrated Survey and Event data
- Quickviews (Survey & Event)
- Auxiliary data after TARANIS scientific committee agreement.

TARANIS data will be available via the TARANIS data server

T+24H : TARANIS data server (access via login)
T+18 months : CDPP data server (no login needed)
Comparison of LEO and GEO satellites is not a new problem but:
• Comparing concurrent MCP and LIS/GLM/LI records requires to take into account the instrument characteristics (e.g. wavelengths, time exposure, radiometric sensitivity) and condition of observations (e.g. spatial resolution, viewing angle)
• Cross-validation at the group scale, flash scale and storm scale during MCP viewing period

<table>
<thead>
<tr>
<th></th>
<th>MCP/TARANIS</th>
<th>LI/MTG</th>
<th>GLM/GOES-R</th>
<th>LIS/ISS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timing accuracy</td>
<td>± 1 ms</td>
<td>GPS?</td>
<td>GPS?</td>
<td>GPS?</td>
</tr>
<tr>
<td>Time exposure</td>
<td>97 ms</td>
<td>1 ms</td>
<td>2 ms</td>
<td>2 ms</td>
</tr>
<tr>
<td>Spatial resolution at 10 km altitude</td>
<td>1.08 km at nadir (more in oblique)</td>
<td>4.5 km at nadir</td>
<td>8 km at nadir ~14 km at the edge of FOV</td>
<td>4 km at nadir</td>
</tr>
<tr>
<td>Filter bandwidth (FWHM)</td>
<td>11.3 nm</td>
<td>1.5-2.0 nm</td>
<td>1 nm</td>
<td>1 nm</td>
</tr>
<tr>
<td>Spectral sensitivity in bandwidth</td>
<td>radiometric characterization in progress</td>
<td>?</td>
<td>?</td>
<td>4.7 μJ.m².sr⁻¹ (SNR &gt; 6)</td>
</tr>
<tr>
<td>Viewing direction</td>
<td>nadir</td>
<td>nadir to oblique</td>
<td>nadir to oblique</td>
<td>nadir</td>
</tr>
<tr>
<td>Data</td>
<td>full resolution image (512x512)</td>
<td>neighboring triggered pixels in the same integration period</td>
<td></td>
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</table>
Thank you for your attention

References:
Hébert P et al., paper number 134 of 9th ICSO International Conference proceedings, October 9th-12th 2012, Ajaccio, France