Il Telescopio Fly-Eye come risposta al problema dello Space Debris: la soluzione innovativa tutta Italiana per una tematica di carattere planetario

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Il Telescopio Fly-Eye come risposta al problema dello Space Debris: la soluzione innovativa tutta Italiana per una tematica di carattere planetario

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COMPANY INTRODUCTION

Key data

2013 Audited Results

- Total revenues: 47.7 M€
- EBITDA: 6.0 M€
- EBIT: 2.9 M€

2014 Budget

- Total revenues: 69.7 M€
- EBITDA: 4.1 M€
- EBIT: 1.1 M€

- Available Personnel: 200 (staff and collaborators)
- Clean Room ISO 5: 100 m²
- Clean Room ISO 8: 300 m²
- ISO 9100 certified
- Main locations: Milano, Rivalta Scrivia, Roma
Definition of the Team

CGS has consolidated a complete Italian Consortium, comprising top experts at international level with a recognised experience on SSA themes combining University, SME and National excellences such as:

• the Dipartimento di Matematica of the University of Pisa (DM),
• the high tech SME Space Dynamics Services (SpaceDys),
• the Institute for Applied Physics of the Italian National Research Council (CNR-IFAC)
• the Italian National Institute for Astrophysics (INAF)
• others SMEs
Fly-Eye Study Development Overview

- 2009 - 2010 SARA Study: Scientific demonstration of Fly-Eye capability to effectively complement radar in H LEO
- 2010- 2011 ESA TELAD Study: Telescope and Fly-Eye conceptual design
- 2012 – 2014 FLEP INAF Study: Fly-Eye technology bread-boarding
- 2012 – 2014 CO-II Architectural Design Definition ESA Study with CGS responsible for the NEO Segment architectural Design and for the Optical Subsystem of the SST Segment
- 2014 ESA DC-IV Pilot Data Center- Fly eye Telescope Monitoring and Control SW, in progress
- 2014 ESA NEOSTEL NEO Telescope Detailed Design, in progress
With SARA, CGS demonstrated the capability of optical observation and orbit determination of very high percentages of small objects, with a diameter of some centimeters, in high LEO.

A central area of the LEO around 1000 km of perigee altitude has been identified where the Radar and the Optical network can operate in a high cooperative way.
Performance Aspects

- The Optical Ground Network is already effective starting from High LEO and is mandatory for MEO and GEO, where no realistic radar can have access

- The same Fly-Eye based core Instrument can equally be tailored for NEO

Economic Aspects

- Estimated RADAR deployment costs $>1.5 \text{ B€}$
- Optical Ground Network deployment costs $150-200 \text{ M€}$
- Maintenance Costs are in the same proportion

Other Not Negligible Aspects

- Optical Technologies are green technologies (no huge power delivery in the environment), avoiding all serious safety and security aspects related to huge power radiation released by radar plants
TELAD Study

Since SARA considered the most optical demanding case, with TELAD telescope conceptual design study we defined the suitable instrument

- One meter equivalent Entrance Aperture
- 6.7x6.7° continuous FoV is with 1.5” astrometric resolution (Very Wide FOV, actually non existing)
- 16 4Kx4K CCD cameras (256Mpixels) are applied and managed in parallel (Fast Read/Out)

- The FOV is split in different sub-fields
- The Sub-Fields are corrected by reduced diameter optics
- The primary Mirror is Spherical - easy to manufacture
The optical ground instrument based on the innovative Fly Eye concept is a system solution constituted by the same architecture with a high grade of industrialisation, suitable to catalogue the debris in every orbital zone (High LEO, MEO, GEO) and, in a dedicated version, for NEO.

FLY-EYE TELESCOPE FEATURES

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrance Pupil Area</td>
<td>0.785 m²</td>
</tr>
<tr>
<td>Entrance Pupil Shape</td>
<td>Circular</td>
</tr>
<tr>
<td>Spectral Band</td>
<td>450nm-800nm</td>
</tr>
<tr>
<td>Optical Efficiency</td>
<td>&gt;0.8</td>
</tr>
<tr>
<td>Field Curvature</td>
<td>&lt;10 μm</td>
</tr>
<tr>
<td>Encircled Energy</td>
<td>&gt;80% in &lt;1”</td>
</tr>
<tr>
<td>Field of View</td>
<td>&gt;45 sq. deg.</td>
</tr>
<tr>
<td>Pixel Scale</td>
<td>1.5”x1.5”</td>
</tr>
<tr>
<td>Pixel Number</td>
<td>256 Mpix</td>
</tr>
</tbody>
</table>
ATIP Advanced Tracklet Image Processing

ATIP is an R&D ITI ESA Study aiming to develop an Advanced Image Processing SW for the detection of faint objects trails

SW Architecture Overview

1. **Line Detection Process**
2. **Trail Detection Algorithm**
3. **Trail Measurement**
4. **OUTPUT** (Detected Trails List)

- **Image Preprocessing** (Background subtraction, Identification and removing of high SNR objects)
- **Operator Input Parameters**

- **Graphical User Interface**
- **Command and Error Log Display**
- **Graphical Visualization of Results**
ATIP Advanced Tracklet Image Process Overview

Sample Image, 1.5 $\sigma$ trails

ATIP Key Points:
• Reliable in detecting very faint trails (S/N 1 to 2 range)
• Very good accuracy
• Negligible number of False Detections (~2%)

![Graph showing percentage of trails vs error (pixels)]
CGS has the responsibility for the NEO segment, with the innovative Wide Survey concept.

CGS has the responsibility for the Optical Components of the SST segment.

21 Telescopes for LEO
6 Telescopes for MEO/GEO
5 Telescopes for NEO
From Space the debris is discovered and a couple of correlated observations is passed to Ground for rough preliminary orbit determination.

The rough datum is then used by Ground which refines the orbit by tasking the target debris.
In the EU Horizon 2020 Framework Program context an EU Consortium is under definition trying to merge all pertinent capabilities and assets available from the Member States.

In particular concerning Space Surveillance and Tracking H2020 will allow the participation of Italy in the SST Service Function.

In this view the application of the Fly-Eye core solution will allow Italy to participate with an important role through the implementation of a full National Demonstration System for Space Debris Monitoring.
Hypothesis on a demonstration System for Space Debris Monitoring (SST) – A full Italian Asset

Scope: to demonstrate the Space Debris control capability and the consequent possibility to protect the Space Infrastructures located in Low LEO, High LEO, MEO and GEO orbital belts

Will not constitute a Global Observation Network, but will demonstrate the capability to significantly contribute with a technology ‘made in Italy’
Architecture

• A unique station located in Italy provided with one to three sensors (Full FoV Fly-Eye Telescopes)

• A local Image processing element with storage

• A Data Processing Centre

The system modularity allows also an implementation in two steps

1. Quick Development, Implementation and Deployment of an Operative System in preliminary configuration, already suitable to provide initial data

2. System Upgrade in final version with Data Center for a catalogue build up and maintenance activity
Conclusions

• We offer a full innovative and sustainable solution for EU needs all based on National technologies, playing a primary role at Global level

• It is strongly encouraged by the EU Commission

• Will allow to Italy to enter the EU SST Consortium with a role of primary importance.

• Will represent a booster for Italian Industry, with particular regard for PMIs, and in general for Italy’s System.