A Small Satellite Hyperspectral Mission

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Fordate Island, Indonesia
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Salt Lake City 10 June 2005
Mission Overview

CHRIS-PROBA Mission
- **Platform:** PROBA - ESA smallsat technology demo platform
- **Payload:** CHRIS hyper-spectral imager

Mission Objectives
- Technically: to assess viability of EO from a small platform
- Scientifically: perform a range of investigations, particularly land BRDF and aerosol measurements

Special Mission Features
- Highly agile small platform (roll, pitch & yaw)
- Multi-view angle observations of each target
  - (View angles +/- 55°, +/- 36°, 0°)
- Sampling using ground motion compensation (x3)
Mission Overview

Launch: 22 Oct 2001 Indian PSLV
Orbit: SSO @ 10:30am node
Altitude: 570 to 670 km.
Inclination: 97.9 deg.

Mass: 94kgs
Size: 600 x 600 x 800 mm
Avionics: 2x star tracker, GPS receiver, reaction wheels, magneto-torquers, magnetometer,
Stabilization: 3-axis
Multi-angle observations

Nominal view angles: +/- 55°, +/- 36°, 0°
Multi-angle observations

CHRIS

Line-of-sight of imager

End imaging

Begin imaging

Scanning speed = 1/5 of spacecraft ground speed

Image 1

PROBA

Scanning 748 lines

13 km

13 km

Continuous rotation

Image 2

Image 5 Image 4 Image 3 Image 2 Image 1
CHRIS Instrument

Mass: 14kg
Power: 8W
Volume: 790x260x200mm
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image area</td>
<td>13 km square @ perigee</td>
</tr>
<tr>
<td>Spatial sampling interval</td>
<td>17 m @ perigee</td>
</tr>
<tr>
<td>Spectral range (nominal)</td>
<td>400nm to 1050nm</td>
</tr>
<tr>
<td>Spectral resolution</td>
<td>1.25 to 11nm</td>
</tr>
<tr>
<td>Gain stage</td>
<td>4 levels (albedo 0.5, 1, 2, 4 levels)</td>
</tr>
<tr>
<td>Digitisation</td>
<td>12 bits</td>
</tr>
<tr>
<td>Signal-to-noise ratio</td>
<td>200 (@ 0.2 albedo, 17m, 10nm)</td>
</tr>
<tr>
<td>Programmable</td>
<td>spectral &amp; spatial dimensions</td>
</tr>
</tbody>
</table>
## CHRIS Imaging Modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>No. of bands</th>
<th>GSD (m)</th>
<th>Swath Width</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>62</td>
<td>34</td>
<td>Full</td>
<td>Aerosols</td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>17</td>
<td>Full</td>
<td>Water</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>17</td>
<td>Full</td>
<td>Land</td>
</tr>
<tr>
<td>4</td>
<td>18</td>
<td>17</td>
<td>Full</td>
<td>Chlorophyll</td>
</tr>
<tr>
<td>5</td>
<td>37</td>
<td>17</td>
<td>Half</td>
<td>Land</td>
</tr>
</tbody>
</table>

Additional modes: calibration mode (<250 bands)  
public relation modes (3 bands)  
SPOT/IRS look-alike modes
Example Applications

Bromo Volcano, East Java 19 June 2005
Ostend, Belgium
5 August 2003
Retrieval of Chlorophyll and Suspended Particulate Matter

Courtesy of Kevin Ruddick et al, MUMM, Belgium (also University of Leuven, Belgium)
Water quality monitoring - Spain

Chlorophyll-a concentration, Rosarito Reservoir, Spain

27/08/04

26/11/04

Antonio Ruiz Verdú, et al, Centre for Hydrographic Studies, CEDEX. Madrid. Spain
Agricultural – land surface parameters

Barrax, Spain
9 July 2005
SEN2FLEX-2005 Campaign (AirFLEX & Sentinel 2)

PI: Jose Moreno et al, Univ. Valencia, Spain
Cotton Growing Trials

Colly, Australia,
15 Jan 2005
Study of cotton production

Courtesy of Ray Merton, University of New South Wales, Australia
Classification results in Canada

Nadir Only
80.9% (±1.8%)

Five Angles
91.8% (±1.3%)

Andrew Dyk et al, Natural Resources Canada & University of Victoria, Canada
Disaster management - Floods

Since end 2003: Image provider for International Charter

7 Dec. 2003
Arles (France) Floodings
Disaster management - Forest fires

Var, France (3 Sept 03)

San Diego, California, USA (5 Nov 03)
Etna eruption,
Sicily, 20.10.2002
December 2004 - Tsunami

Chris acquisition over:
- Indonesia
- Maldives islands
- Nicobar islands
- Sentinel Islands

N Sentinel Island, 4 May 2005
Three Gorges Dam, Yangtze River, 19 Dec 2003
Mangari, Cook Islands, 17 July 2005
CHRIS Science Sites in 2005

- Science (115 sites): Land use, agriculture, coastal, inland waters & forestry +
- Support to Disaster Management Charter
- Public Relation Images (35+ sites)

- Total 2-3 sets of 5 images per day (≈ 400 images/month) – cloud prediction
Projects for 2005

- Land vegetation and forests
- Estimation of crop types and state
- *Archeological image mining*
- Water run-off and soil erosion
- Carbon flux measurements
- Cloud masking trials
- *Absorption of heavy metal waste in trees*
- Water resources management in Africa
- Biological soil crust assessments in Africa
- *Vineyard phenology in Italy*
- Solid waste classification in landfill sites
- *Detection of meteorite impact craters*
- Inland & coastal water quality assessments
- .....
Conclusions

- Smallsats can provide viable options for hyperspectral imaging & at low cost.

- Mission secured significant & increasing interest from science community

- Programme in its fourth year and hopefully will continue for a further year – PI opportunities?

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  earth.esa.int/missions/thirdpartymission
Thank you