The IRIS Project: Student Designed Imaging Satellite for the RASCAL Launch Vehicle

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Background image of San Francisco Bay area courtesy TruEarth, http://www.truearth.com
Introduction

- IRIS is a student-designed micro-satellite mission developed for a Space Systems Design class, spring semester 2004.
- The IRIS mission is a conceptual design, based on technology and capabilities that are either existing or under development.
- Mission inspired by Peersat
- Driving Requirements
  - RASCAL Launch (limits mass and volume)
  - $10 Million cost cap, including launch and operations
- Student Design Approach
  - Simple spacecraft
  - Professionally built, student operated
  - Built to allow follow-on units with upgrades
Mission Overview

IRIS Program: Low Cost Imaging of Earth from Space

Mission Segment: Earth Imaging

Spacecraft Segment

Launch System Segment: RASCAL

Mission Operations Segment

Ground Station Segment

Image Distribution Network
The IRIS mission was designed using USU’s Space Systems Analysis Laboratory, a concurrent design center.
## Potential Markets for Images

<table>
<thead>
<tr>
<th>Market Category</th>
<th>Potential Customer Type and Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science</td>
<td>- Weather: weather patterns, weather images</td>
</tr>
<tr>
<td></td>
<td>- Ice: Ice flows, Iceberg location</td>
</tr>
<tr>
<td>Government (non-military)</td>
<td>- Disaster Response: weather imaging, disaster evaluation</td>
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<tr>
<td></td>
<td>- Forestry Service: forest data, forest fires</td>
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<tr>
<td></td>
<td>- Land Use: population growth, deforestation</td>
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<tr>
<td></td>
<td>- Coastal: shoreline data, shipping routes</td>
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<tr>
<td>Military</td>
<td>- Weather: cloud cover, snow locations, storms</td>
</tr>
<tr>
<td></td>
<td>- Situational Awareness: location of cities or encampments</td>
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<tr>
<td></td>
<td>- Cueing: find targets for other assets to investigate</td>
</tr>
<tr>
<td>Civilian</td>
<td>- Media: image locations of interest</td>
</tr>
<tr>
<td></td>
<td>- Education: geography, student mapping and imaging</td>
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</table>
IRIS Imaging System

- Two Redlake ES11000 cameras
  - 1 at 150 m/pixel maximum resolution
  - 1 at 30 m/pixel maximum resolution
- 4008 by 2672 active pixels (~11 Mega pixels)
- Color (RGBG) CCD array
- Commercial digital camera requiring minimal modifications for creating space qualified version
- Dual camera system allows flexibility in the types of images captured and provides continued operation if one system fails
Field of View

- 400 x 600 km image footprint for 150 m/pixel camera (for regional targets, such as weather)

- 120 x 80 km image footprint for 30 m/pixel camera (for local targets, such as cities, forests, coasts)
Resolution

- Regional 150 m resolution images and local 30 m resolution images provide a good mixture of image types for potential markets.

Images of San Francisco Bay area courtesy TruEarth, http://www.truearth.com
**Imaging Options**

- Store compressed image and download
- Store full image, compress and download only desired images after viewing thumbnails

<table>
<thead>
<tr>
<th>Image Type</th>
<th>Images/day</th>
<th>Compression</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 bit bitmap</td>
<td>69</td>
<td>None</td>
</tr>
<tr>
<td>12 bit greyscale</td>
<td>139</td>
<td>None</td>
</tr>
<tr>
<td>Standard JPEG</td>
<td>559</td>
<td>JPEG, 25% quality loss</td>
</tr>
<tr>
<td>JPEG “thumbnail”</td>
<td>11742</td>
<td>JPEG, 90% quality loss</td>
</tr>
</tbody>
</table>
Pointing Control

• 3-axis stabilization to within 0.5 degrees is provided using momentum wheels, with torque rods for wheel de-saturation
  – Error <1% of smallest side of larger image
  – Error <5% of smallest side of smaller image

• GPS receiver provides positional data required for image targeting
Orbit

- 900 km altitude
- 60° inclination
- 103 min. period
- ~14 orbits /day
- 6-day revisit rate (with slew)
- Covers majority of inhabited areas
Communications Link

- Two ground stations
  - Primary station in Logan, UT
  - Secondary station in Bedford, MA
## Design Summary

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Description</th>
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<tbody>
<tr>
<td>Mass</td>
<td>49 kg</td>
</tr>
<tr>
<td>Structure</td>
<td>Aluminum isogrid</td>
</tr>
</tbody>
</table>
| Imaging   | 2x 11 Megapixel cameras  
30 m & 150 m resolution |
| TT&C      | 10 W S-band transmitter  
1.9 Mbps downlink |
| C&DH      | Hitachi SH7709 CPU |
| ADCS      | 3-axis stabilized |
| G&N       | GPS |
| Thermal   | Active heater control |
| Power     | 39 W orbit average power  
4 GaAs Solar Panels  
62 W-hr Lithium Ion battery |

External view of the IRIS spacecraft
The IRIS mission is designed specifically for launch on the RASCAL launch vehicle.
Conclusions

• The conceptual design was completed meeting all requirements and showing the potential for significant imaging capability at a very low cost

• Cost Breakdown:
  – Satellite Development: $5.1 M
  – Launch and Activation: $2.2 M
  – 3-year Operations: $2.4 M