Possible uses of nanosatellites for various mission applications

Mr. Gábor Marosy
Budapest University of Technology and Economics
CubeSat Capabilities – Power

http://cubesat.bme.hu/
CubeSat Capabilities – Data rate

http://cubesat.bme.hu/
Remote Sensing Applications

- Gaining information without direct physical contact
- Every segment is fully covered by professional service providers
- Imaging requires sophisticated optical instrument / system

**Importance of remote sensing**
- Homogenous data-collection about extensive areas
- Good spatial and time resolution, fast access to new data
- Relatively small investment, processes can be fully automated

**CubeSat based remote sensing versus large satellites**
- Development time: CS advantage
- Launch costs: CS advantage
- Response & revisit time: CS advantage
- Optical performance: CS is constrained

**CubeSat capabilities**
- $P < 20W$
- $m < a$ few kg
- $V < a$ few $dm^3$

http://cubesat.bme.hu/
Weather Applications

• Some professional payloads could be adopted to CubeSats

<table>
<thead>
<tr>
<th>Instrument / Application area</th>
<th>Mass [kg]</th>
<th>Power [W]</th>
<th>Data rate [bps]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limb-scanning sounder</td>
<td>8</td>
<td>15</td>
<td>3 M</td>
</tr>
<tr>
<td>Special scanning or non-scanning MW radiometer</td>
<td>15</td>
<td>20</td>
<td>?</td>
</tr>
<tr>
<td>MW sounding radiometer with cross-track scanning</td>
<td>14</td>
<td>26</td>
<td>320</td>
</tr>
<tr>
<td>Solar irradiance monitors</td>
<td>6-15</td>
<td>10-15</td>
<td>600-16 k</td>
</tr>
<tr>
<td>GNSS radio-occultation sounders</td>
<td>3-6</td>
<td>10-50</td>
<td>0.5-40 k</td>
</tr>
</tbody>
</table>

• Dedicated CubeSat missions for weather observation (3U & 6U)
  – 3Cat-2, CHARM, MicroMAS, PolarCube, SIMBA
  – Typical payloads: scatterometer, MW radiometer (183 GHz), cavity radiometer

• There are payloads developed especially for use on-board a CubeSat
  – Light Detection And Ranging, Radar Altimeter
  – Typical requirements: 1-6kg, 1-40W, 100k – 6Mbps

http://cubesat.bme.hu/
Typical application areas which might benefit from CubeSat technologies:

- Geoid measurement
- Tectonic plate motion
- Earth rotation measurements
- Oceanography
- Tides

**Geodesy CubeSats**

- DORIS (~1 kg, ~1U, ~10 W)
- GPS (0.1 kg, 96 x 90 x 11 mm, 1.3 W)
- Altimeter (3.1 kg, 95 x 95 x 320 mm, 10 W)
- Satellite-Satellite Tracking (1-1.5U)
- Drag-free (2U, 6.5-9.3 W)
Science and Technology Satellites

- Lower resolution, lower sensitivity (size, mass, power constraints)
- Higher spatial and time resolution and coverage (small sat constellations)
- **Astronomy**
  - Astronomical observations on different wavelength
  - Long term observations, detecting and tracking changes
- **Examination of the Earth’s vicinity**
  - Space weather: magnetic field, gravity field, ionosphere, plasmas, radiation, micro-meteorites, chemical investigation of the upper atmosphere
- **Materials technology research**
  - Material sciences, semiconductors, electronics, single event effects
  - How the space environment effects the lifetime and reliability of different devices, components
- **Biological research**
  - Biological samples in space environment
  - Observing biological processes in microgravity

http://cubesat.bme.hu/
• Typical application areas which might benefit from CubeSat technologies:
  – Telemetry & Telecommand
  – TAG tracking (bird, animal, buoy, ...)
  – AIS (ship tracking)

ISIS Triton 1 satellite with an on-board AIS receiver

http://cubesat.bme.hu/
1U CubeSat

- 1st satellite of Hungary
- Built at the Budapest University of Technology and Economics
- Student initiative, 10 intensively involved, altogether 20 persons
- More than 60,000 work hours
- Fully custom built, redundant main subsystems
- 2,500 electrical and mechanical components
- Up to 250 photos from space
- Up to 5,000,000 received tm packets
- Up to 220 radio amateur tracking Masat-1

http://cubesat.bme.hu/
Qualification tests passed

• Calculated, simulated, and measured every critical function
• First satellite: safety factors, on-board tune and check capabilities to compare tests with flight results
• Testing is very important (1:1 development/test time)
• Flight Model tests:
  – Functional (assembly)
  – Thermo-vacuum
  – Vibration
  – X-ray
  – Sensor calibration
  – Communication field tests

http://cubesat.bme.hu/
Road of Masat-1 to launch pad

- Kourou
- Toulouse
- Noordwijk
- Budapest

http://cubesat.bme.hu/
Cooperation with ESA

THEN:
• Launch campaign
• Documentation
• Acceptance tests
• P-POD integration
• Integration to Vega adapter
• Launch
• Lessons Learned meeting and Operation reports

NOW:
• Development of CubeSat technologies
• Robust Fault Tolerant On-Board Computer with Redundancy
• Telemetry-Telecommand Transceiver with CCSDS compatibility
• 3U CubeSat Structure for high density electrical components

http://cubesat.bme.hu/
Main administrative milestones

Before start
• NMHH, ITU, IARU
• Export license

After start
• OSCAR-72
• 2012-006E-> Masat-1
• UN registration
• HSO – Satellite register
International cooperation with HAMs

http://cubesat.bme.hu/
Photos taken by Masat-1

http://cubesat.bme.hu/
Conclusion and strategic plan

• **Education**
  – Give student hands on experience in the field of space electronics
  – Provide new and amazing space related opportunity for students
  – Continuously updated educational portfolio
  – To train high qualified engineers for the space industry

• **Space industry**
  – Upgrade the results to market-capable devices, services
  – To include and strengthen the SME sector
  – Provide long term engineering support for the industry
  – Participation in international projects

• **Space research**
  – Provide a satellite bus for future scientific missions
  – Provide opportunity for Hungarian research centers

http://cubesat.bme.hu/