Assessing Global Ground Station Capacity

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Image courtesy of http://si.smugmug.com/gallery/1674201_UxZmP/1/457184513_4s3Ag
Motivation – Operations and Failures
Goal

- *Optimized* scheduling for...
  - A *dynamic* satellite population
  - A *dynamic* ground station network

- Dynamic means...
  - Ground stations not under operations team control
  - Federation of stations
  - Satellites from multiple institutions

- *Optimized* could mean...
  - Balanced station utilization
  - Satellite communication needs
  - “Cost” functions

Approach

- Tools to estimate capacity
  - How much uplink and downlink capacity is available now and projected into the future?

- Tools to optimize scheduling
  - Can we schedule in real time to optimize over dynamic nature of the system?
Capacity Modeling

<table>
<thead>
<tr>
<th>Model</th>
<th>GS Capability</th>
<th>GS Lat/Lon</th>
<th>Orbits</th>
<th>GS Availability</th>
<th>Compatibility</th>
<th>Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Topological</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>Scheduled</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Actualized</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

- **Current work**
  - Maximum, Topological

- **Future work**
  - Scheduled, Actualized
  - Requires fielded tools

- **Upcoming examples**
  - **Example 1**
    - Survey of Cubesat communication Stations
    - On orbit Cubesats and ISS
  - **Example 2**
    - Single ground station
    - DNEPR Launch #2, 2007
Example 1 - Summary of Ground Station Network

- Data from 2008 survey of station capability
  - http://gs.engin.umich.edu/gs_survey/
  - Cubesat community stations

- Maximum capacity estimates
  - 10kbps (UHF): 150 GB
  - 200kbps (S-Band): 1273GB
Example 1 – Summary of Satellites

- **Cubesats**
  - 25 satellites/objects
  - Mostly circular orbits

- **ISS Related**
  - 4 objects and one toolbag
  - Circular orbits

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**Inclination (degrees)**

**Apogee (km)**
Example 1 – Single Station With All Satellites

- **ANSAT - Norwegian Student Satellite Program**
  - Lat.: 69.3, Lon.: 16.1
  - 275 avg. passes per day
  - 1252 minutes avg. time per day

- **Cal Poly**
  - Lat.: 35.3, Lon.: -121
  - 152 avg. passes per day
  - 832 minutes avg. time per day

- **PS8RF**
  - Latitude: 5.0486, Longitude: 42.7901
  - 115 avg. passes per day
  - 688 minutes avg. time per day
Passes Per Day at Stations
(30 day simulation)

Average number of passes per day per station as a function of station latitude.

Histogram of passes per days at stations.
Topological Capacity – Time Per Day
(30 day simulation – station data)

- Histogram of time per day at stations.

- Average number of passes per day per station as a function of station latitude.
Example 1 –
Passes per day – satellite perspective

Number of Passes

Days

First Cubes Launched

Everyone else

Genesat

Cute-1.7
Example 2 – Dnepr 2 Launch

- **Launch Time:**
  - 6:46:35 17 April 2007 UTC

- **Three PPods™,**
  - Pod A: CSTB1, Aerocube-2, CP4
  - Pod B: Libertad-1, CAPE1, CP3
  - Pod C: MAST

- **This example**
  - PPod™ A
  - PPod™ B
Example 2 – Cubesat Separation – 1 Year
Seasonal Variations
GS Contact Data

Ann Arbor Ground Station Capacity for Dragon2 Launched CubeSats

Days from Epoch 17 Apr 2007
Future Work

- Develop models for satellite capacity needs.
- Develop optimization algorithms.
- Test on various scenarios and populations.
- More detailed survey.