Assessing Global Ground Station Capacity

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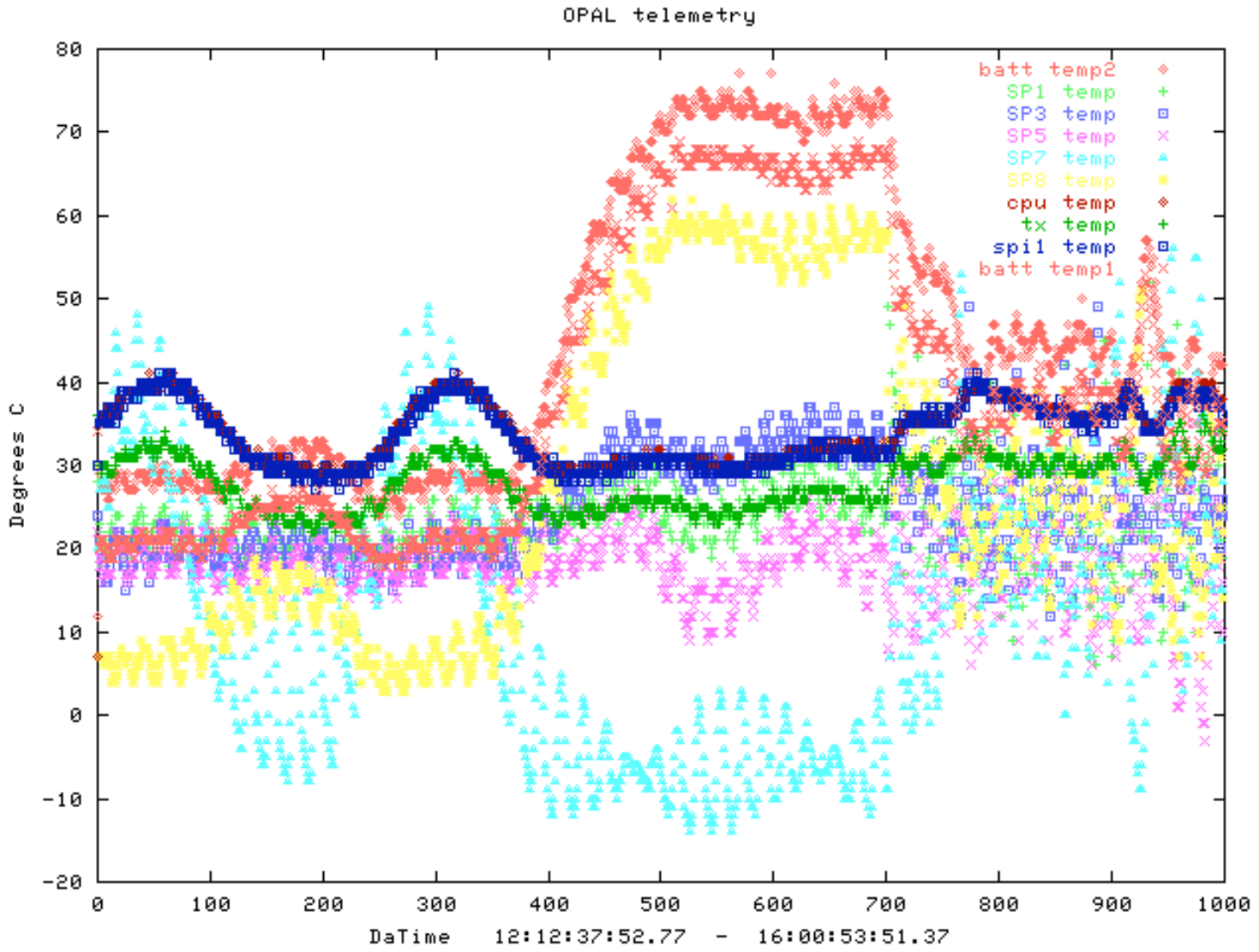
Image courtesy of http://si.smugmug.com/gallery/1674201_UxZmP/1/457184513_4s3Ag

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?

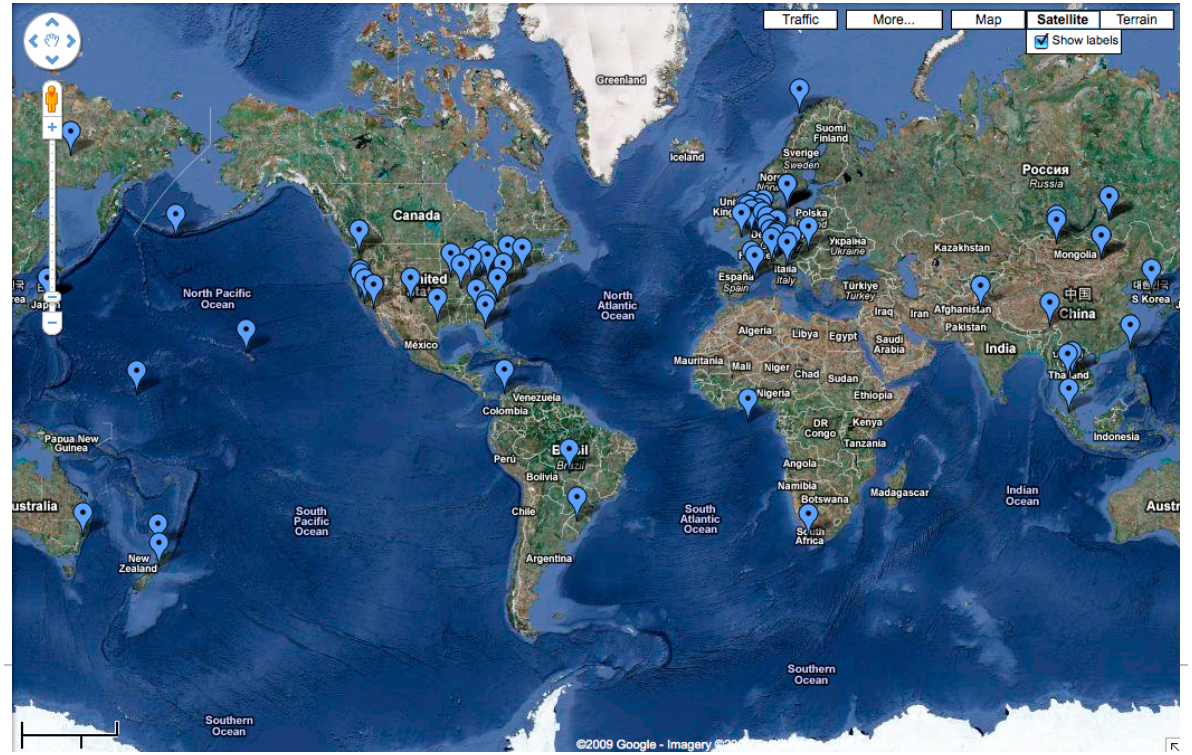
Capacity Modeling

Model	GS Capability	GS Lat/Lon	Orbits	GS Availability	Compatibility	Operations
Maximum	X					
Topological	X	X	X			
Scheduled	X	X	X	X	X	
Actualized	X	X	X	X	X	X

- 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

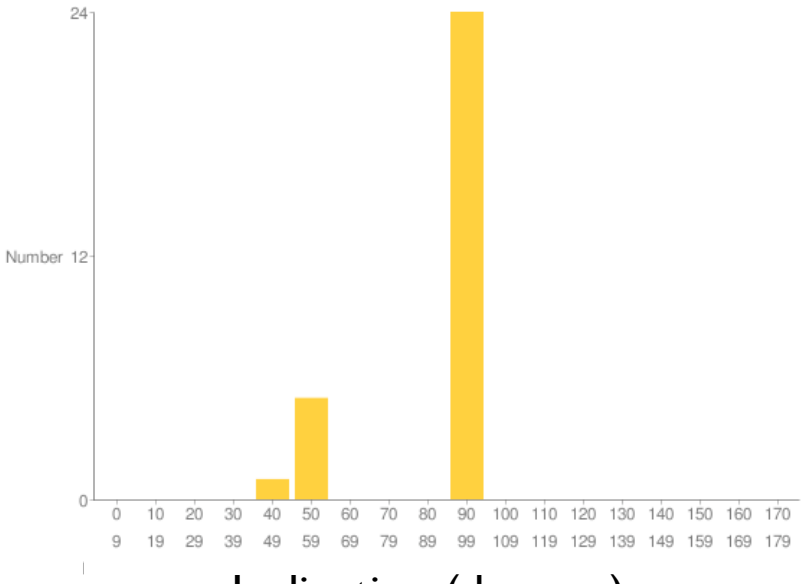
Example 1 - Summary of Ground Station Network

- 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

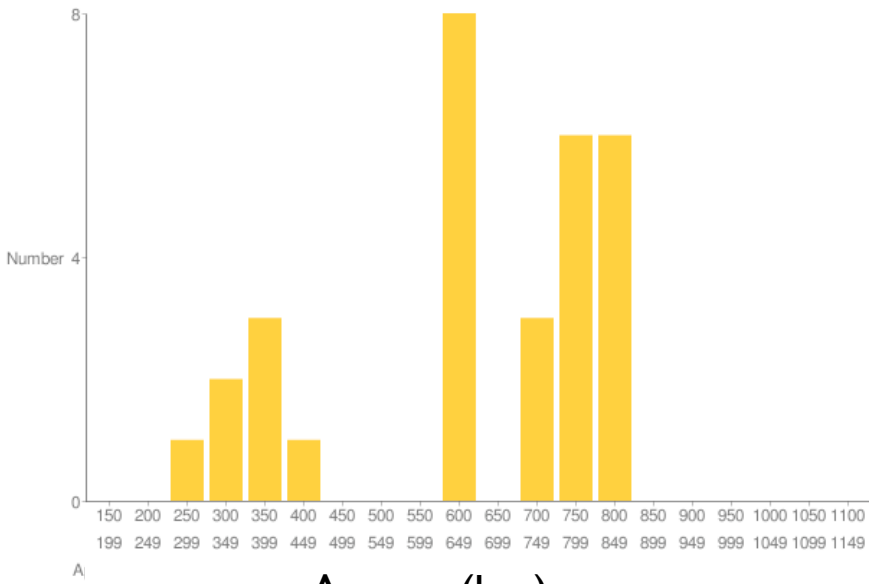


Example 1 – Summary of Satellites

- Cubesats
  - 25 satellites/objects
  - http://celestrak.com/NORAD/elements/cubesat.txt
  - Mostly circular orbits
- ISS Related
  - 4 objects and one toolbag
  - http://celestrak.com/NORAD/elements/stations.txt
  - Circular orbits

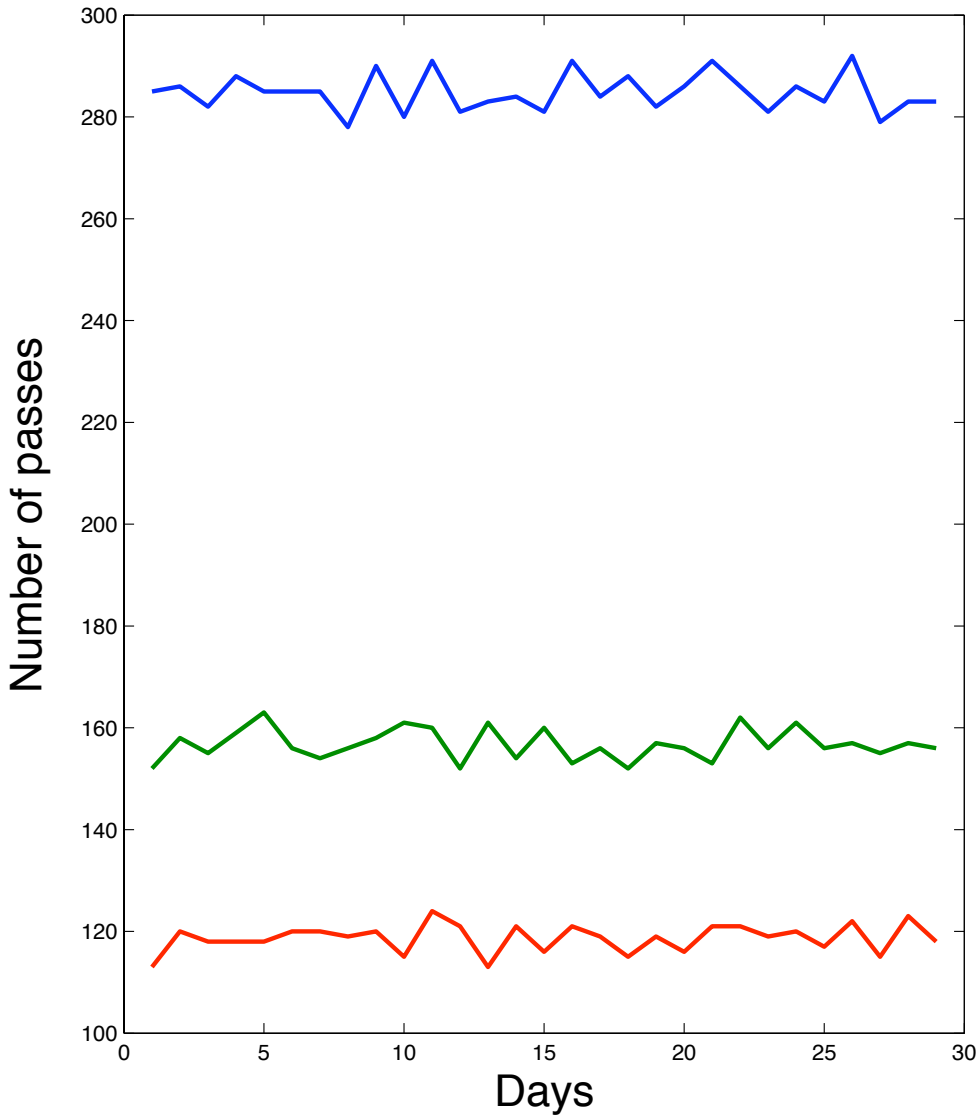


Inclination (degrees)



Apogee(km)

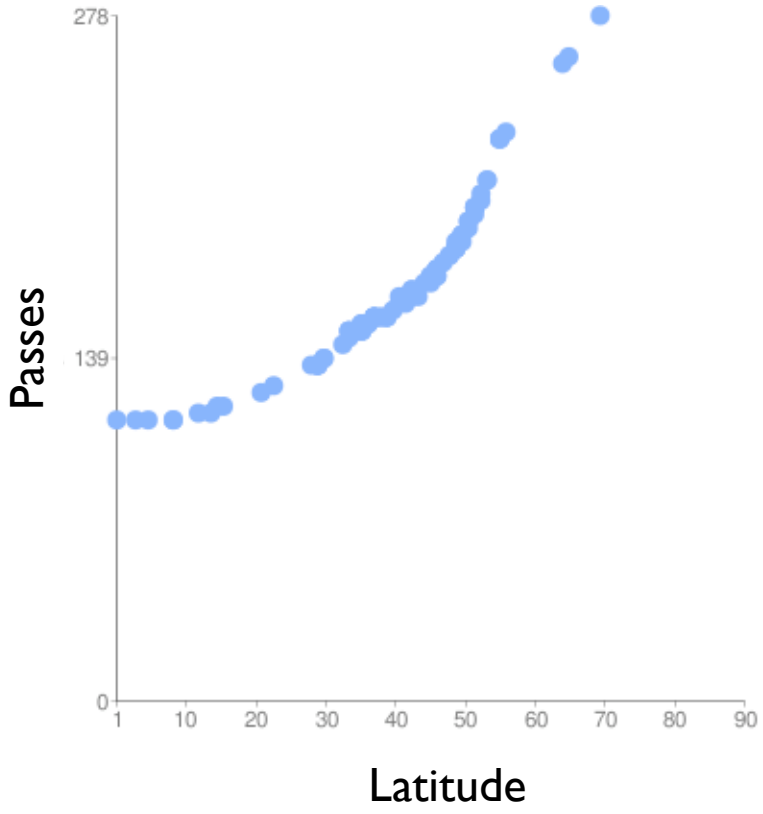
Example 1 – Single Station With All Satellites

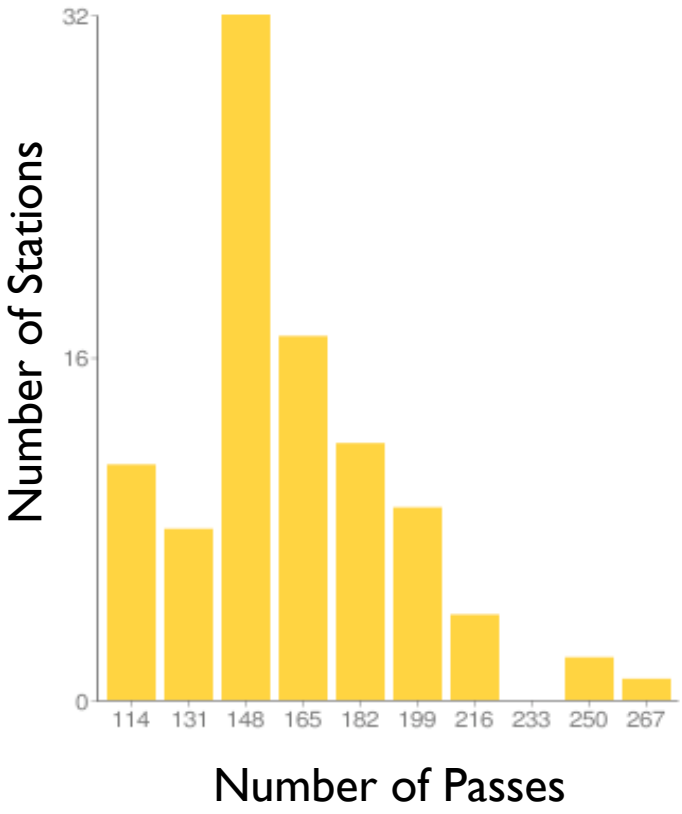


- ANSAT - Norwegian Student Satellite Program
  - Lat.: 69.3, Lon.: 16.1
  - 275 avg. passes per day
  - 1252 minutes avg. time per day
- Cal Poly
  - Lat.: 35.3, Lon.: -121
  - 152 avg. passes per day
  - 832 minutes avg. time per day
- PS8RF
  - Latitude: 5.0486, Longitude: 42.7901
  - 115 avg. passes per day
  - 688 minutes avg. time per day

Passes Per Day at Stations

(30 day simulation)



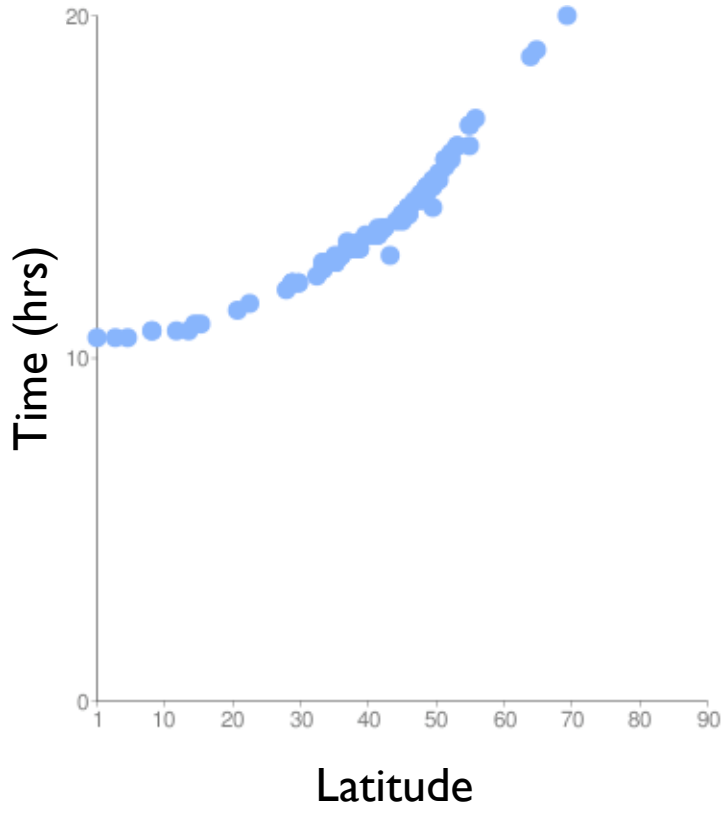


Average number of passes per day per station as a function of station latitude.

Histogram of passes per days at stations.

Topological Capacity – Time Per Day

(30 day simulation – station data)



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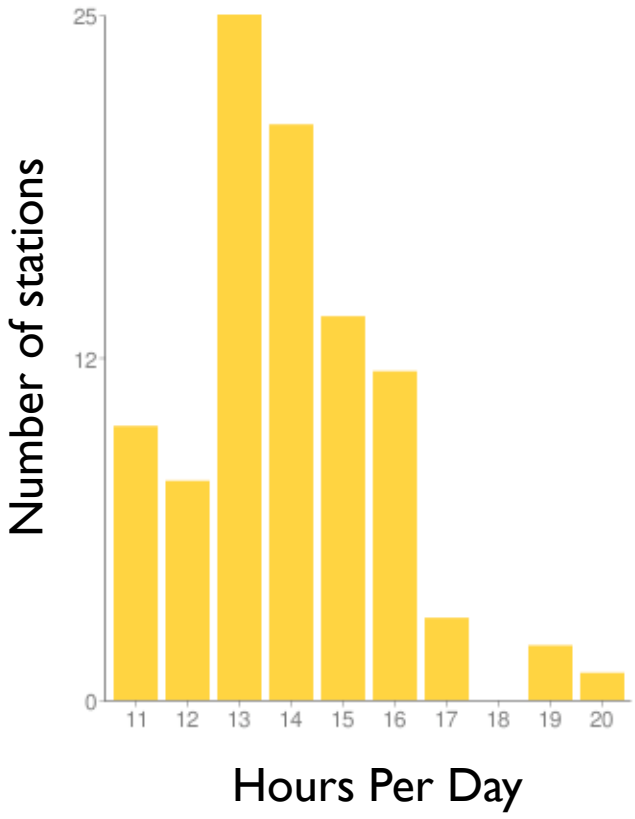
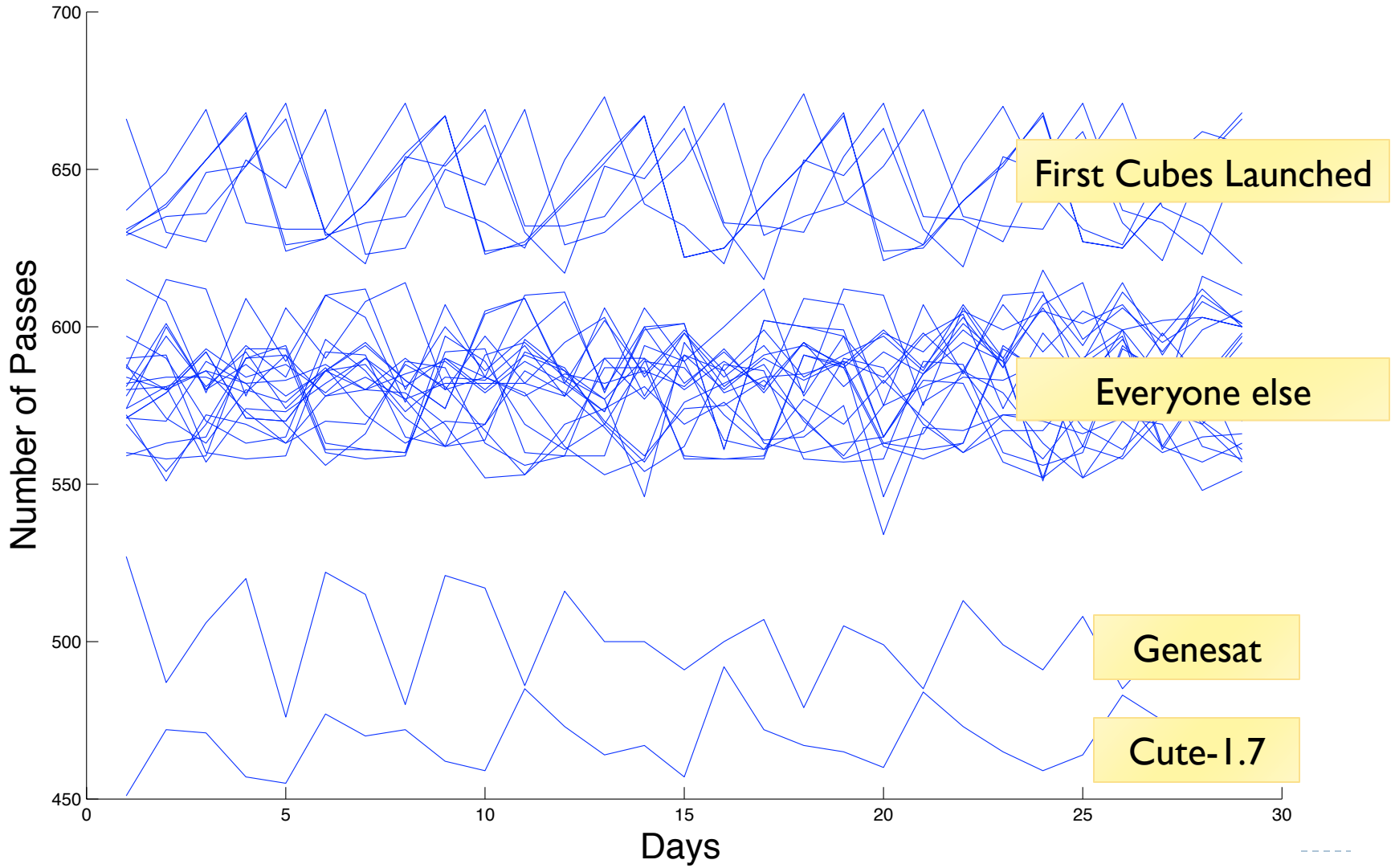


Histogram of time per day at stations.

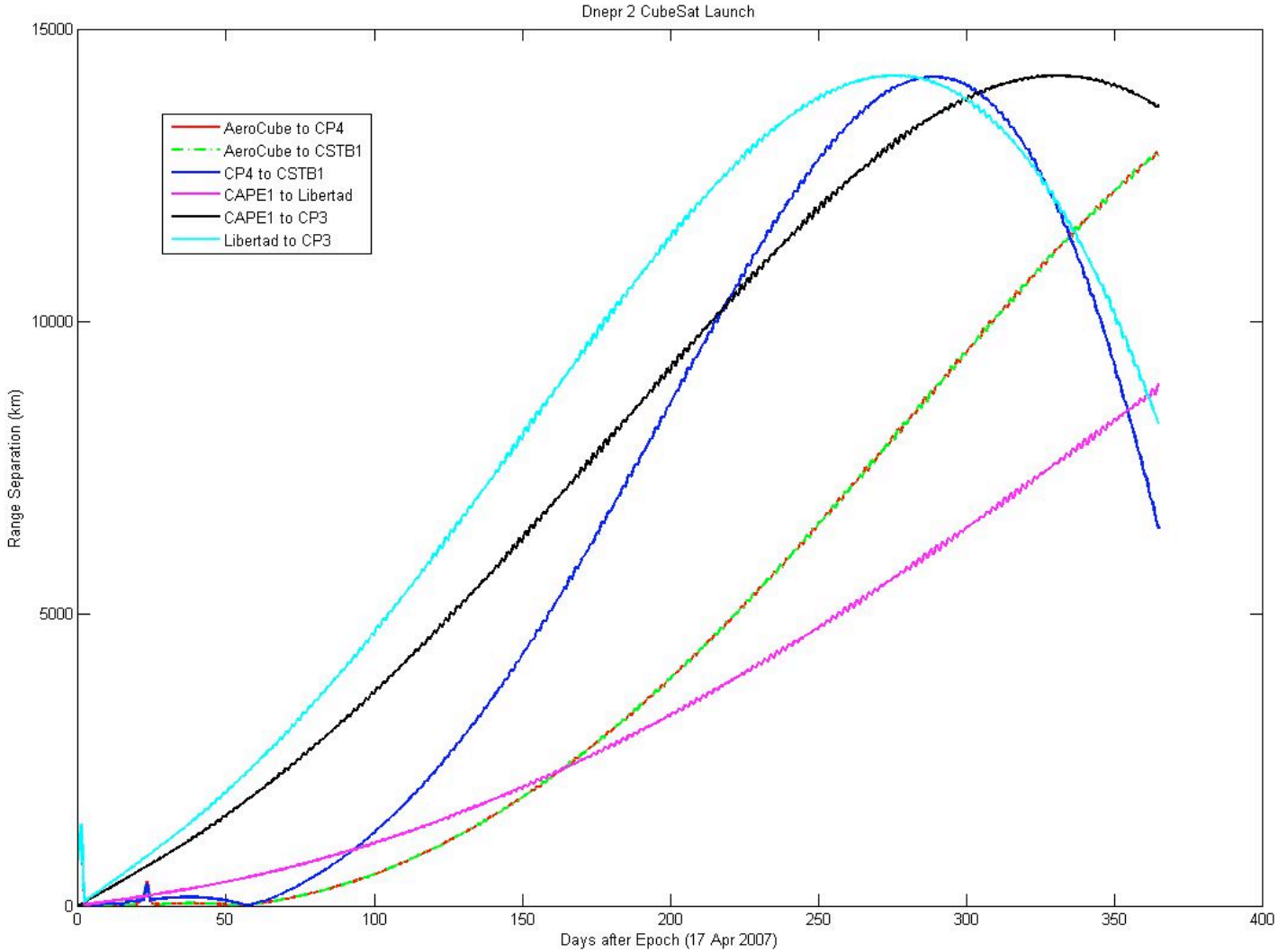
Example 1 –
Passes per day – satellite perspective



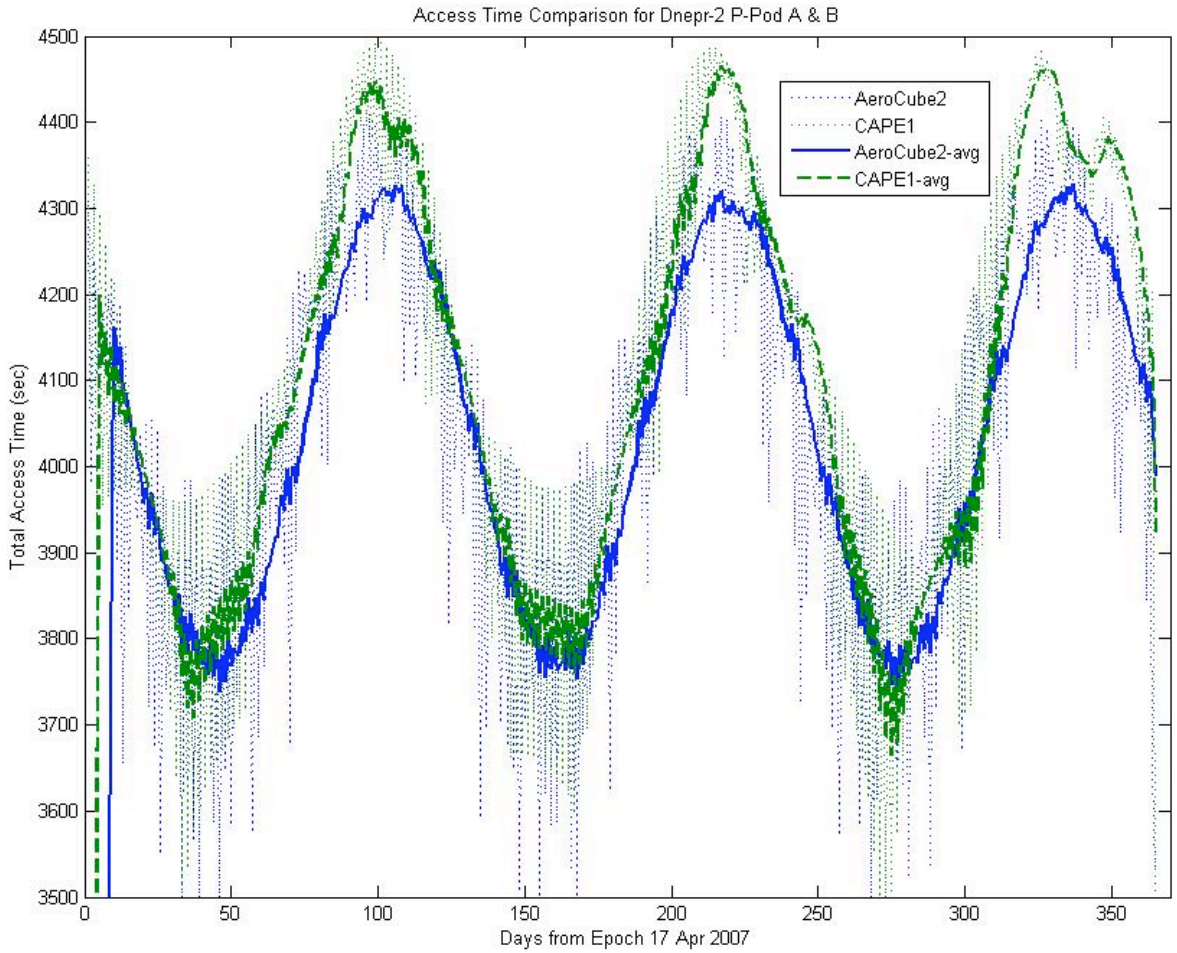
Example 2 – Dnepr 2 Launch

- 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

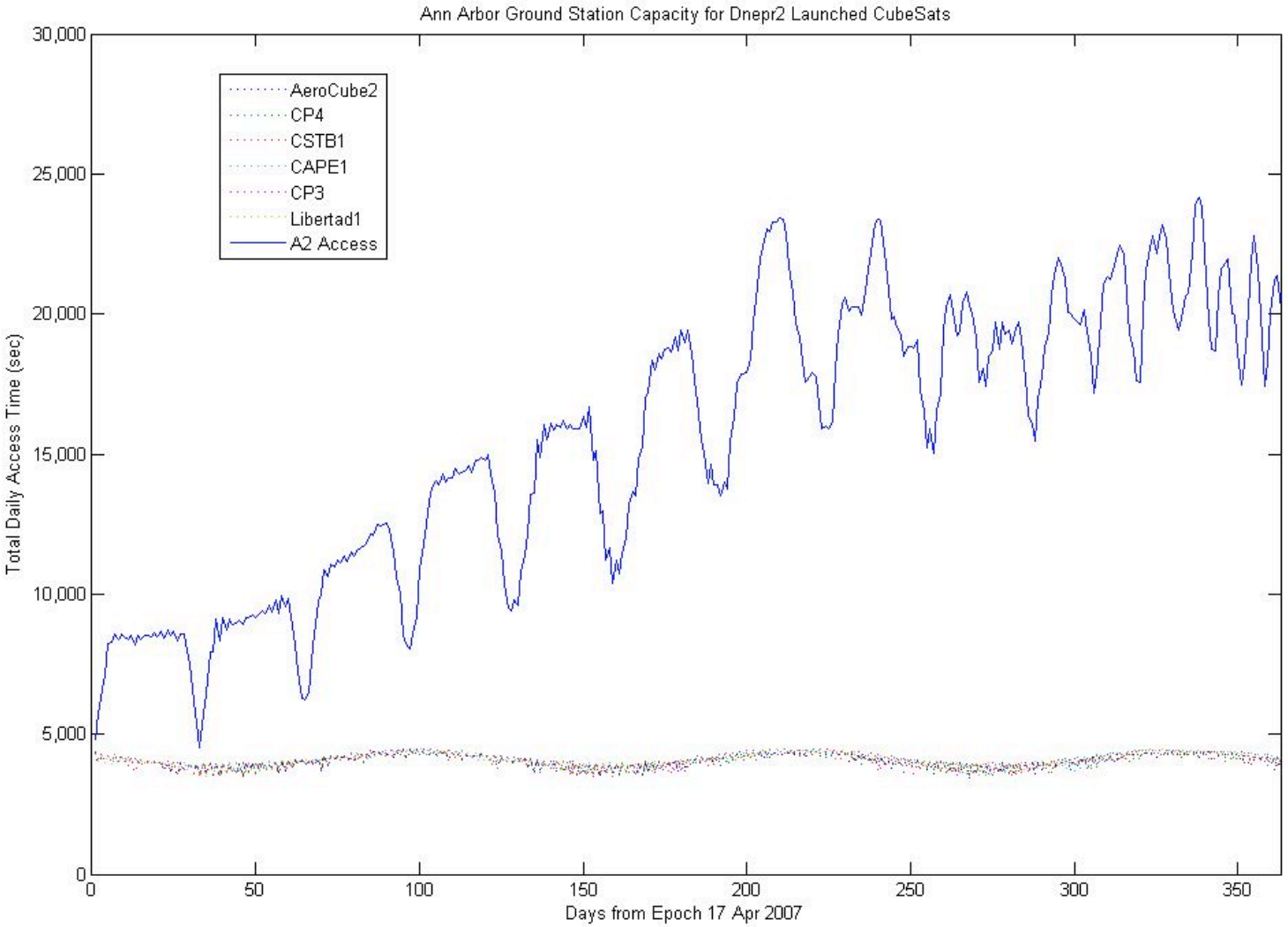
Example 2 – Cubesat Separation – 1 Year



Seasonal Variations



GS Contact Data



Future Work

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