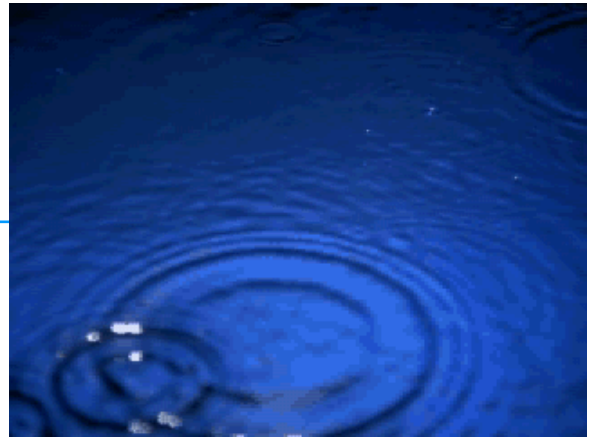
Global Precipitation Measurement

System Requirements Review
Flight Dynamics Analysis



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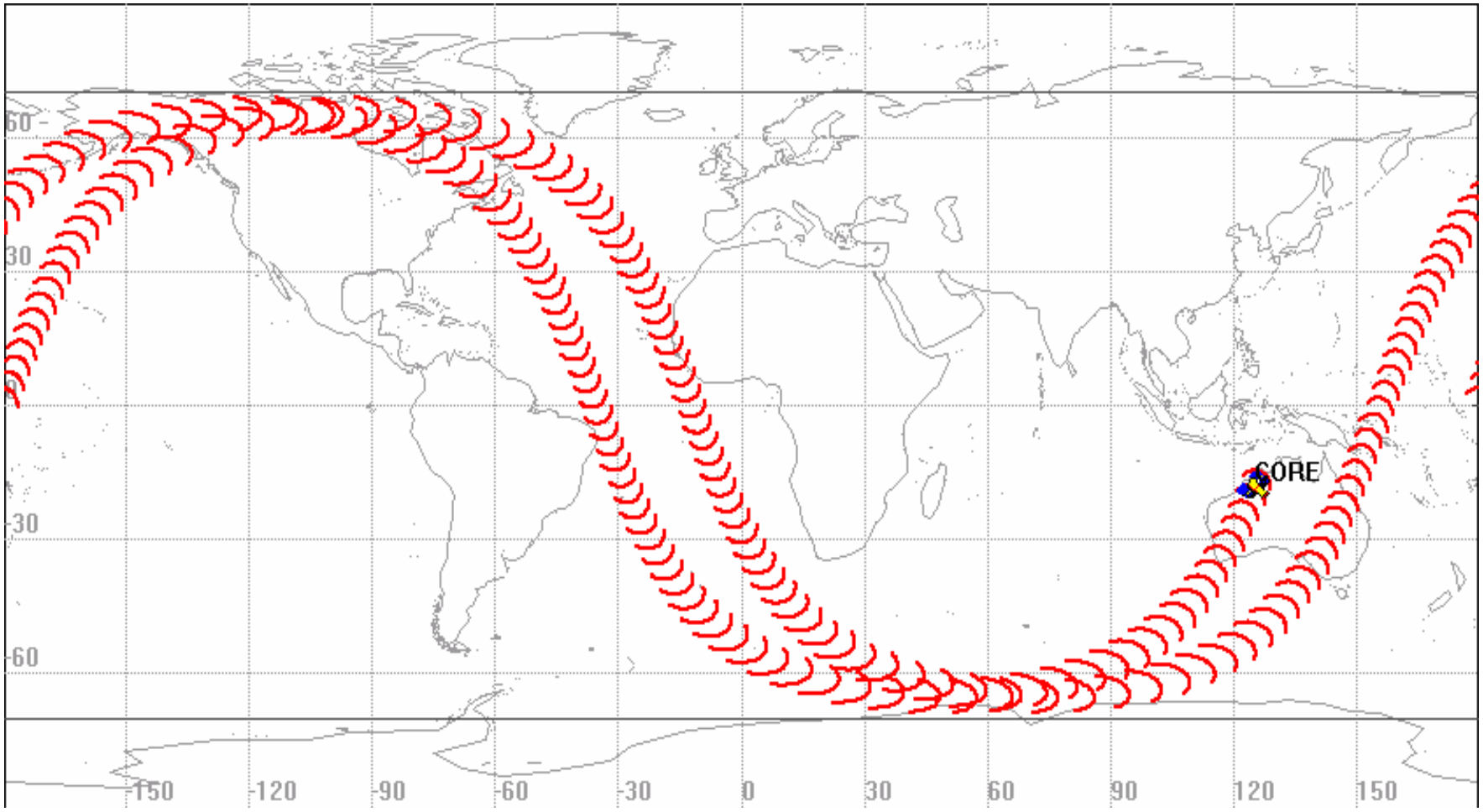
June 4 - 5, 2002

Flight Dynamics Agenda

- *Science Coverage Analysis and Statistics*
- *GPM Orbit, Primary and Constellation*
- *Orbit Maintenance*
- *Autonomous Maneuver Control*
- *Impacted Requirements*
- *ISS Encounters*
- *Future Efforts*

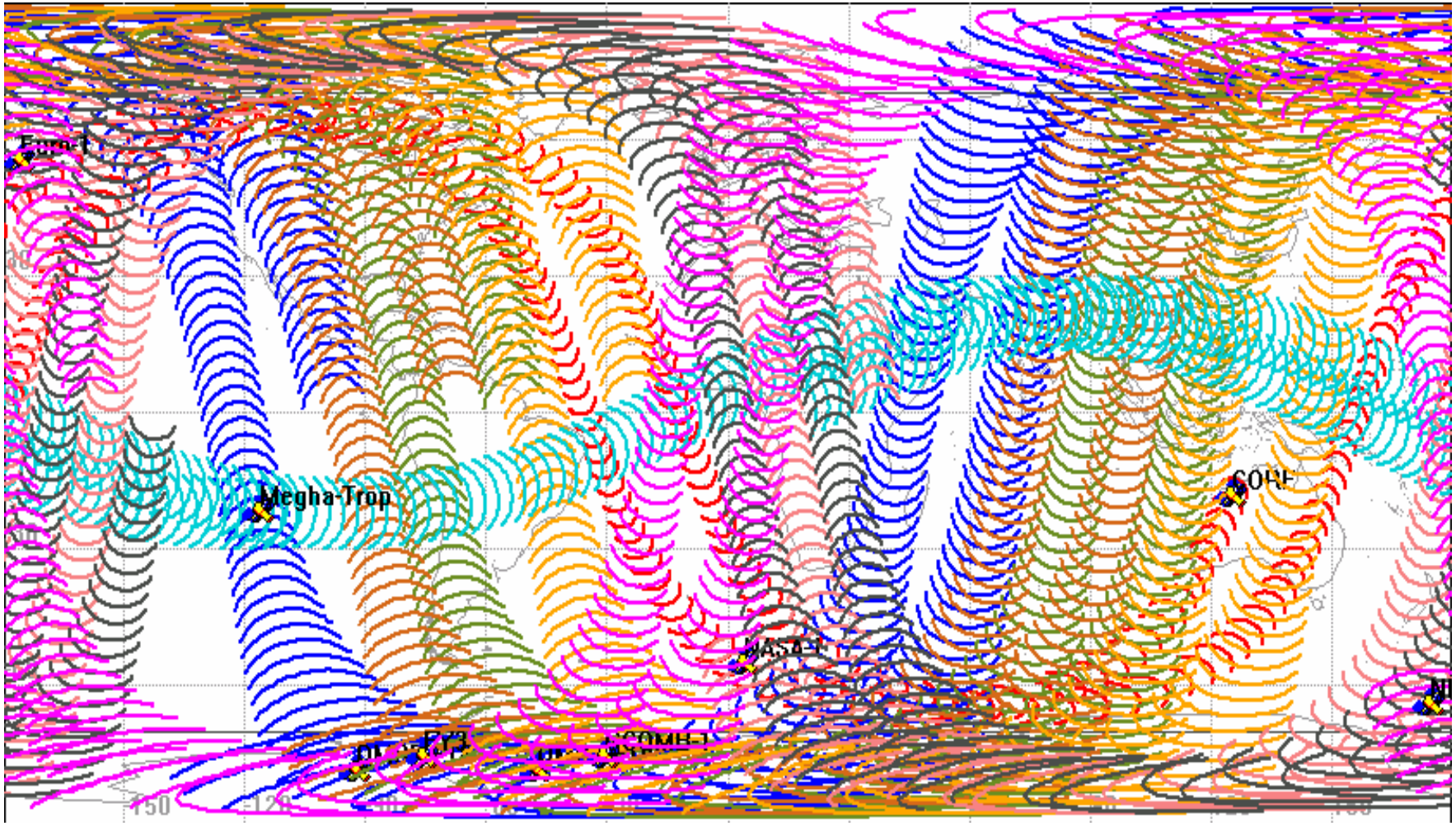
GPM Primary S/C 3-Hr Coverage

Primary

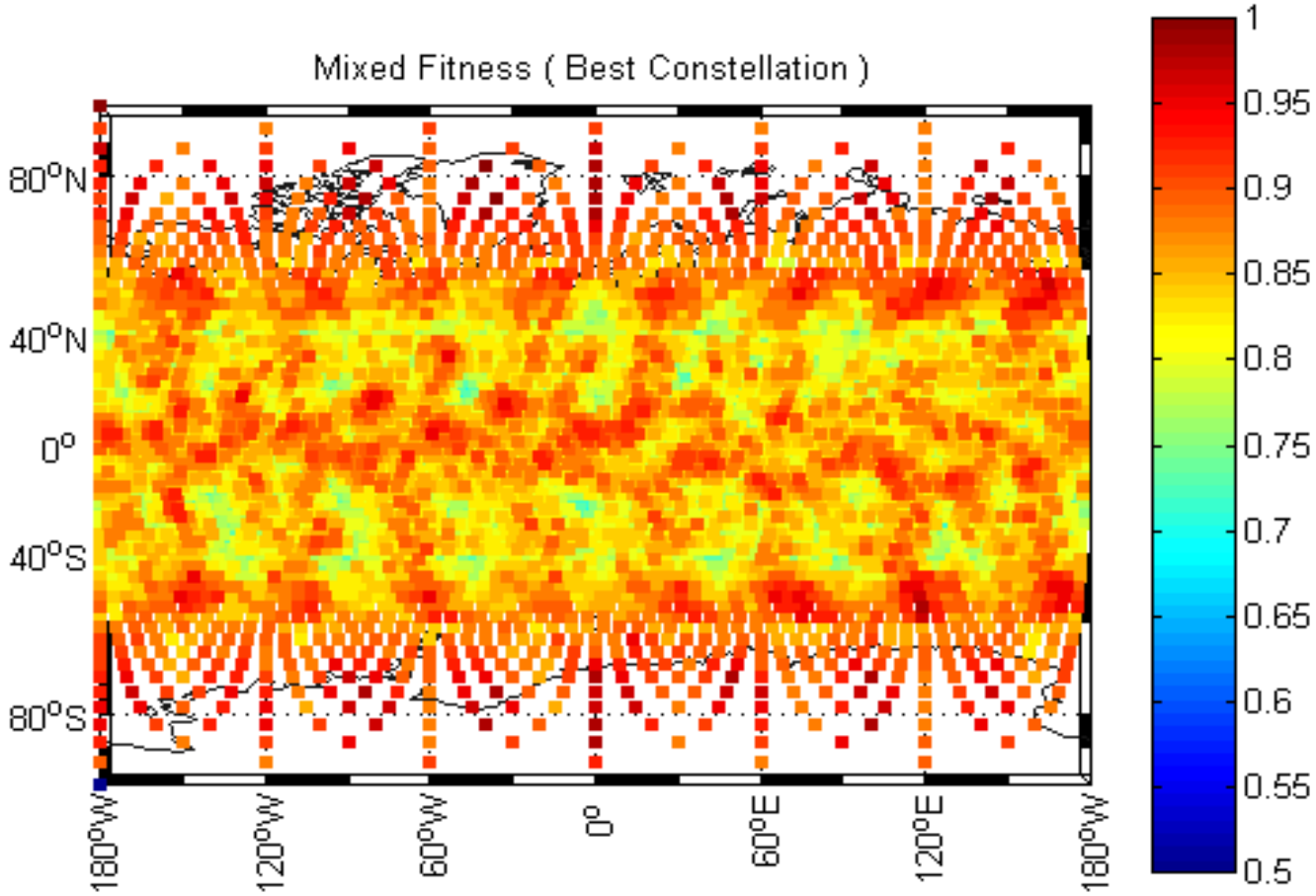


GPM Constellation 3-Hr Coverage

Primary, DMSP-F18, DMSP-F19, GCOM-B1, NASA-1, Euro-1, Megha-Tropiques, NPOES, FY3

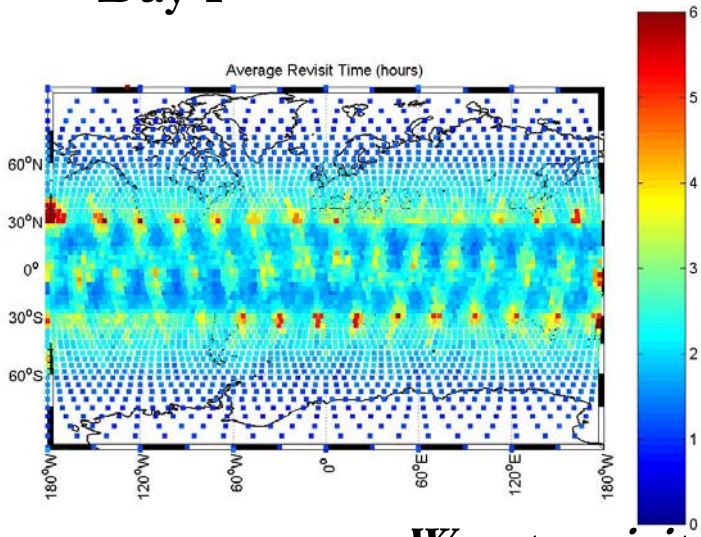


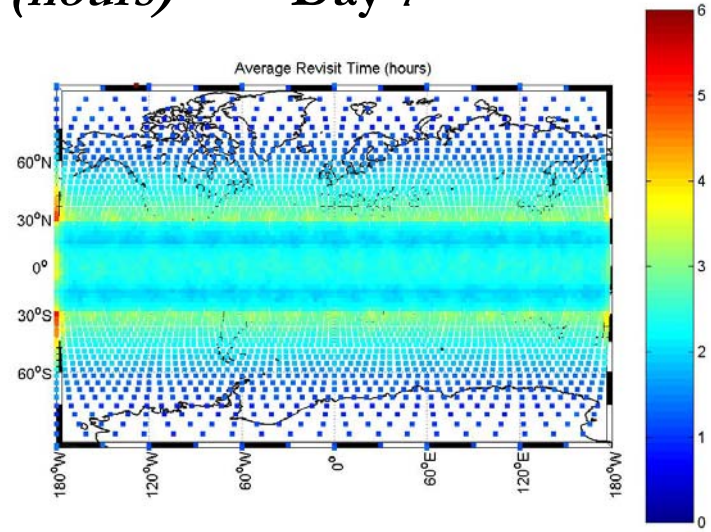
7-Day Average Binning Statistics Plot



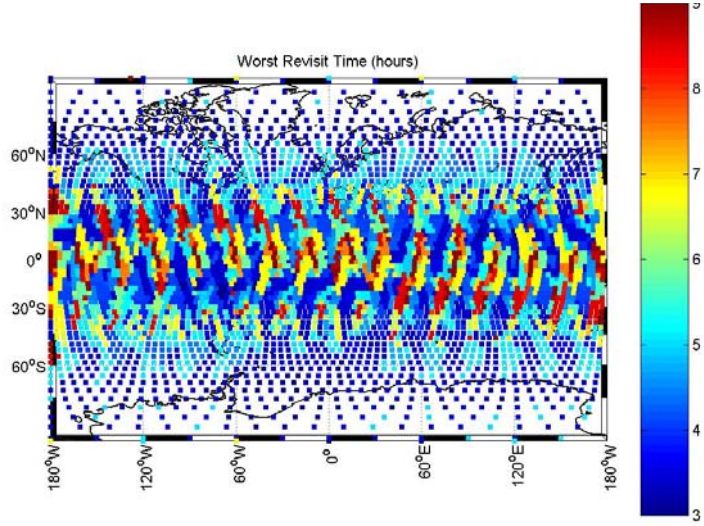
Revisit Time Analysis

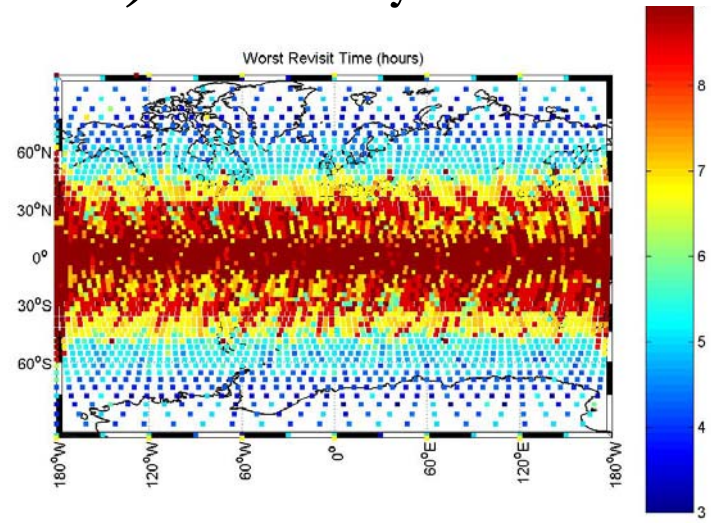
Day 1 ***Average revisit time (hours)*** **Day 7**



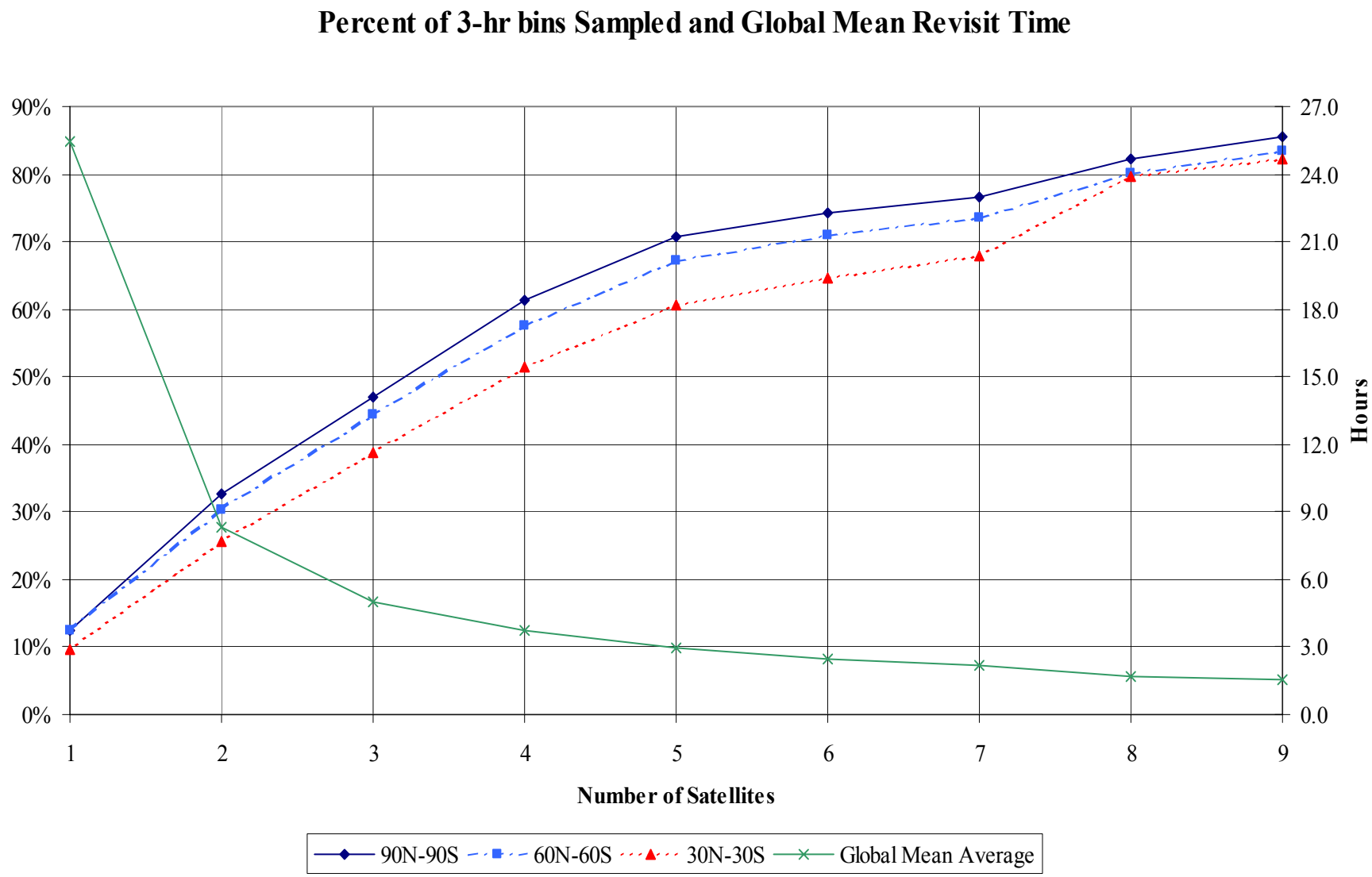


Day 1 ***Worst revisit time (hours)*** **Day 7**

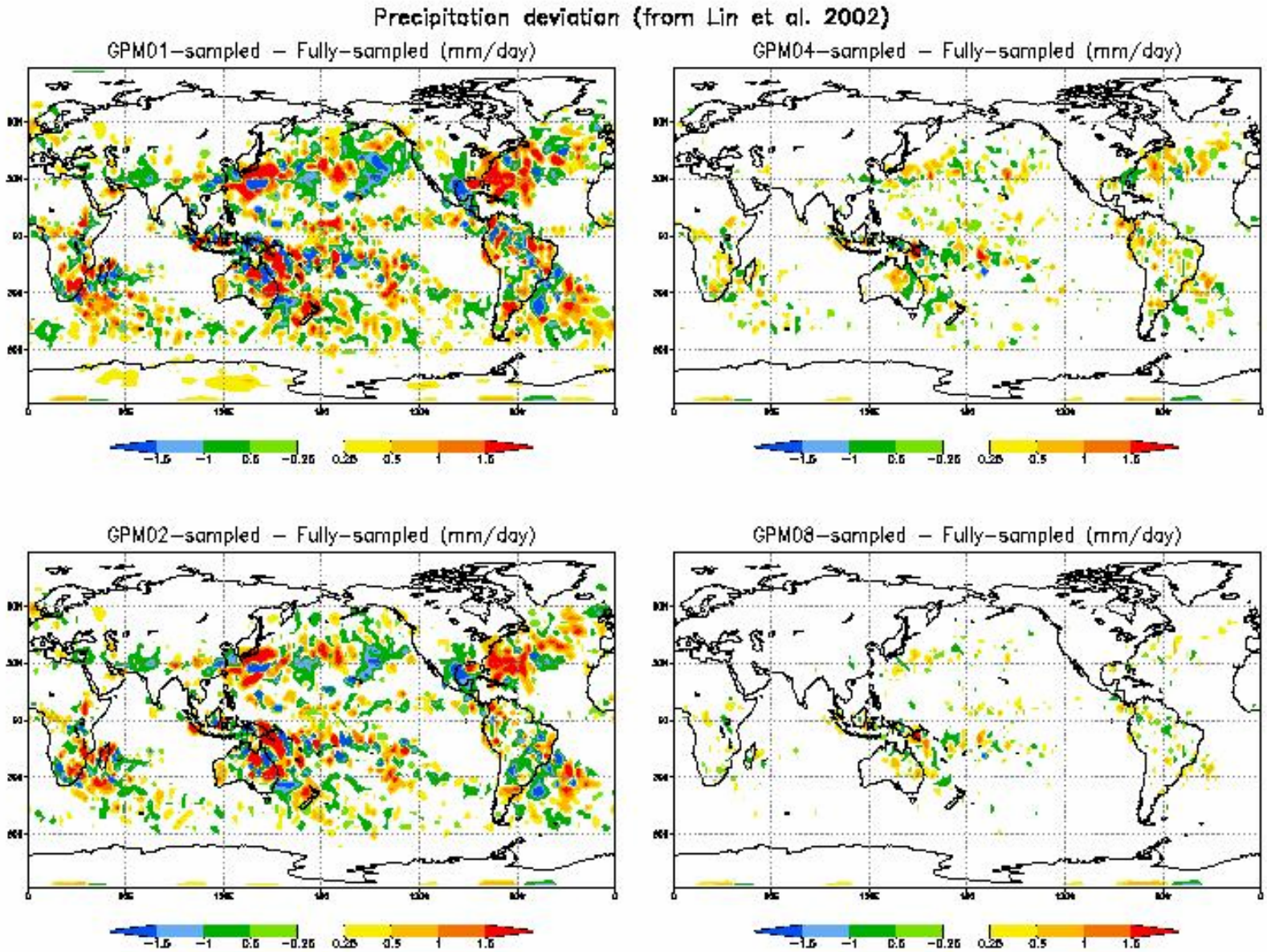




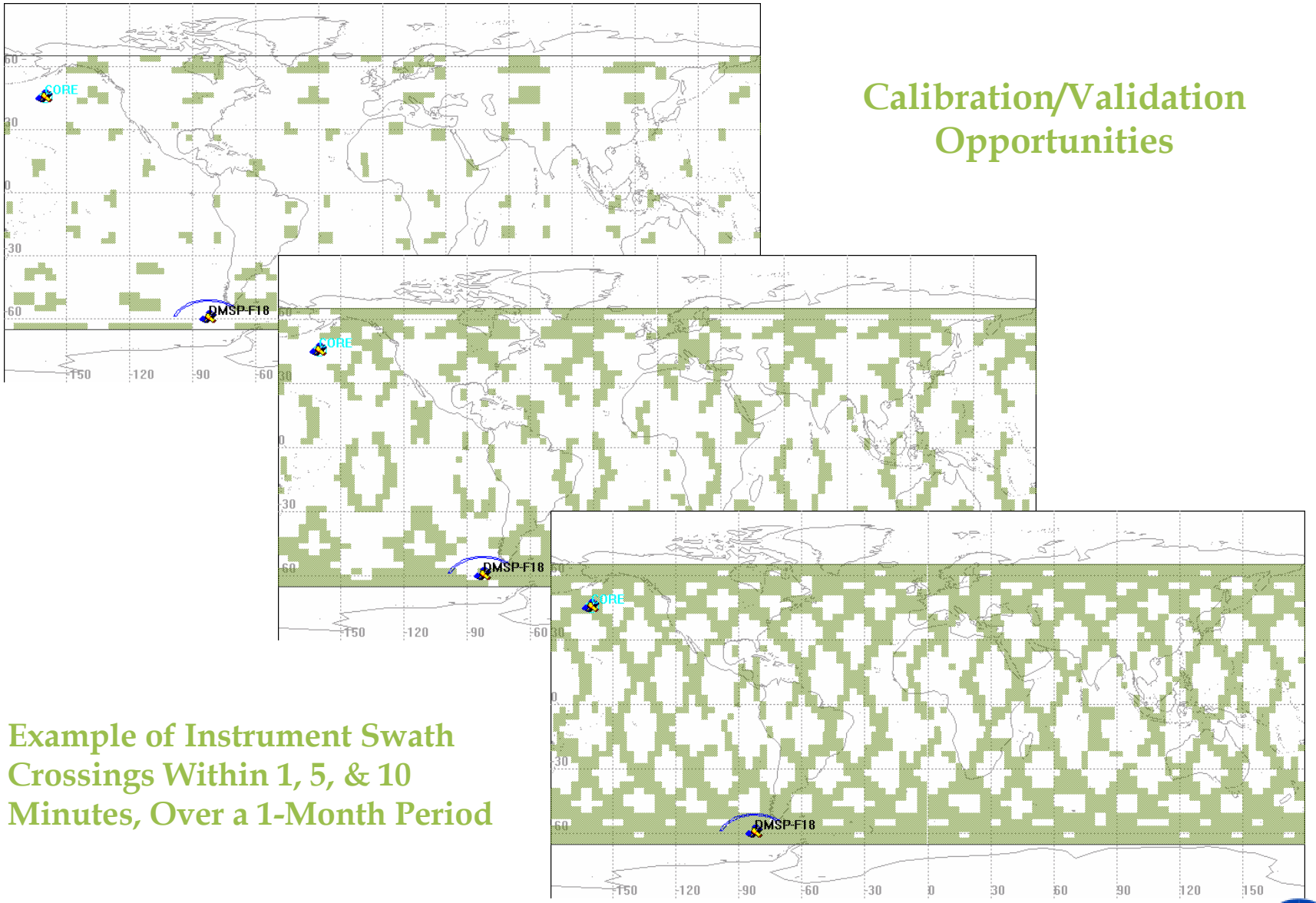
Binning & Revisit Time



Results from Ideal Constellation



Instrument Calibration Analysis

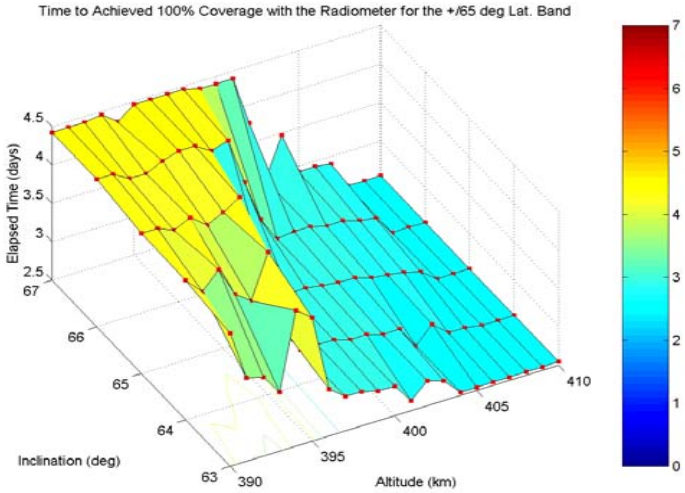


Calibration/Validation Opportunities

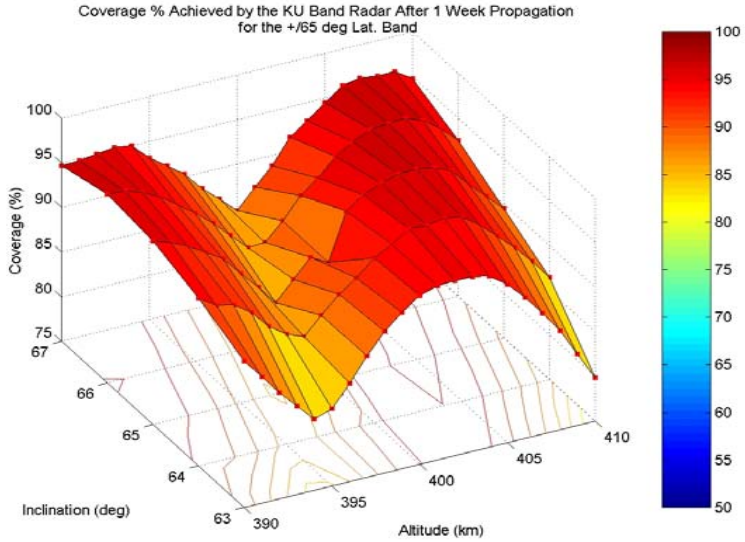
Example of Instrument Swath Crossings Within 1, 5, & 10 Minutes, Over a 1-Month Period

GPM Primary Coverage

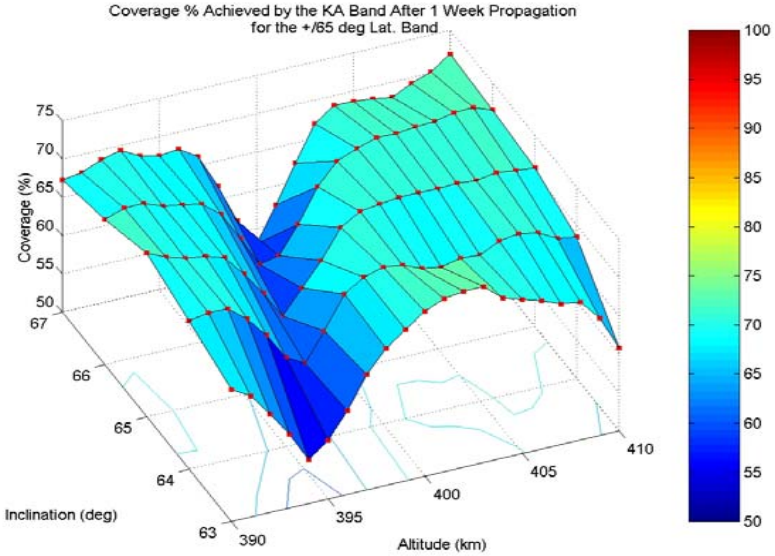
Radiometer



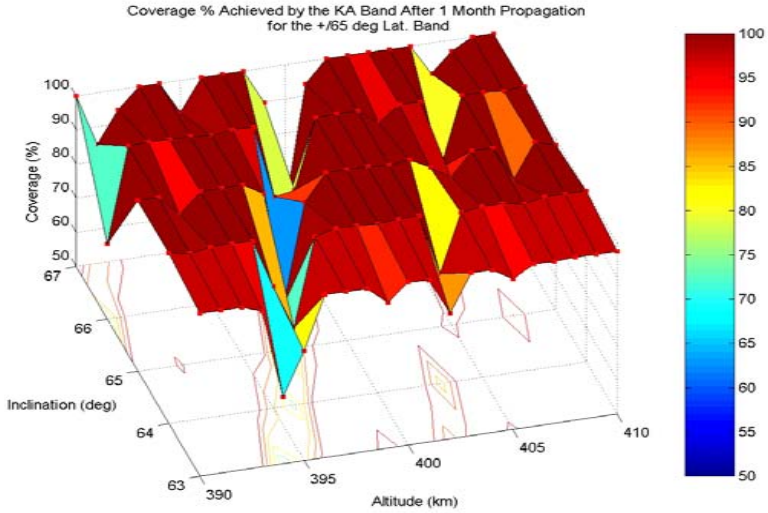
Ku Band Radar



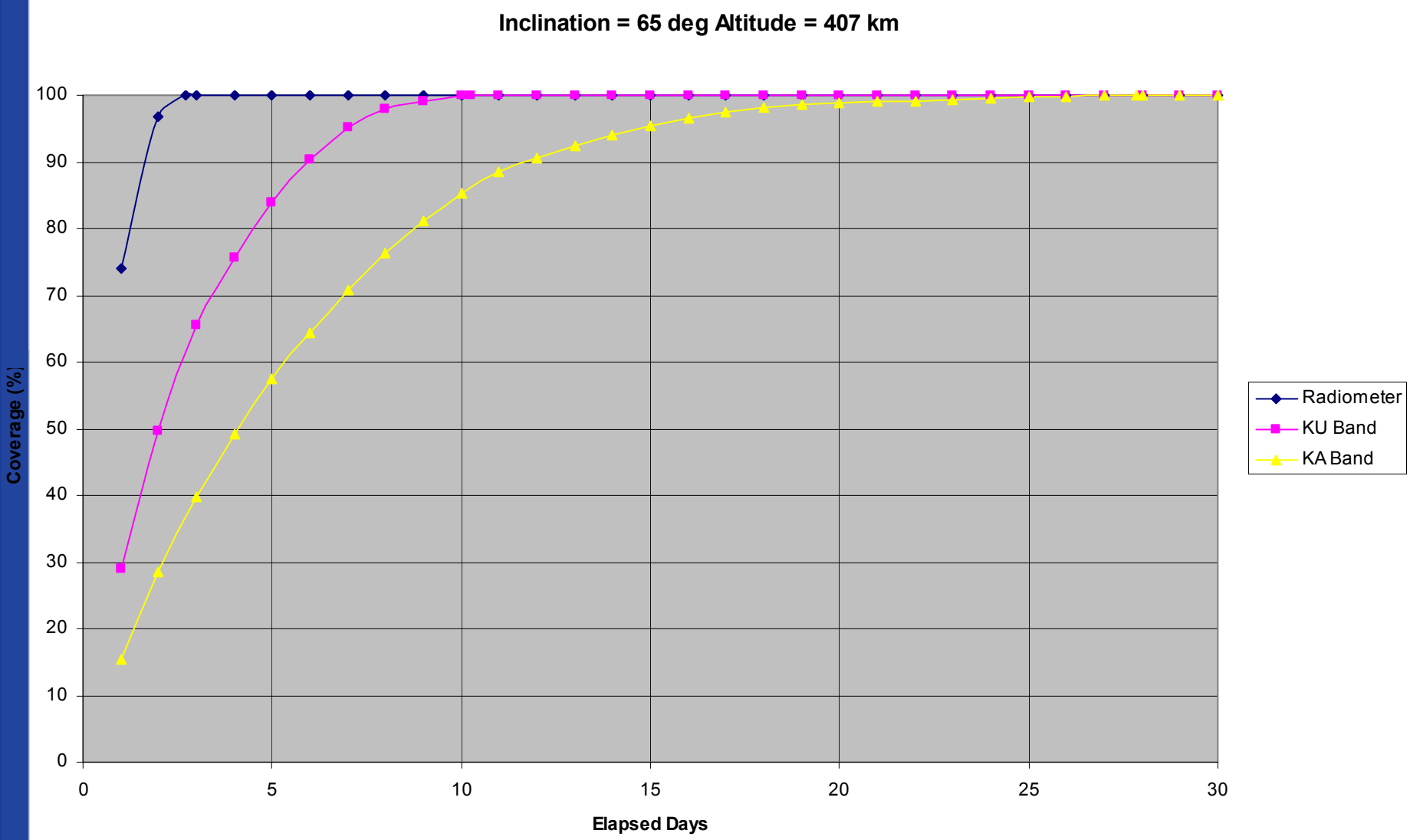
Ka Band Radar



Ka Band Radar



Plot of Primary Coverage



GPM Coverage, Orbit Altitude and Results

	Radiometer	KU Band Radar	KA Band Radar
Reference Altitude (km)	400	400	400
Swath Width (km)	920	245	125
Half Swath Width (°)	4.1	1.1	0.6
Half-Cone Angle (°)	48	17	9

Recommended Orbit Altitude

Inclination(°)	*Optimal Altitude (± control box)*	Radiometer Avg. Days	Ku-Band Avg. %	Ka-Band Avg. %
63	404 (± 1 km)	2.571	94.44	72.85
64	406 (± 1 km)	2.593	95.75	70.43
65	407(± 1 km)	2.649	96.22	71.00
66	408(± 1 km)	2.609	96.30	72.00
67	410(± 1 km)	2.547	96.04	71.92

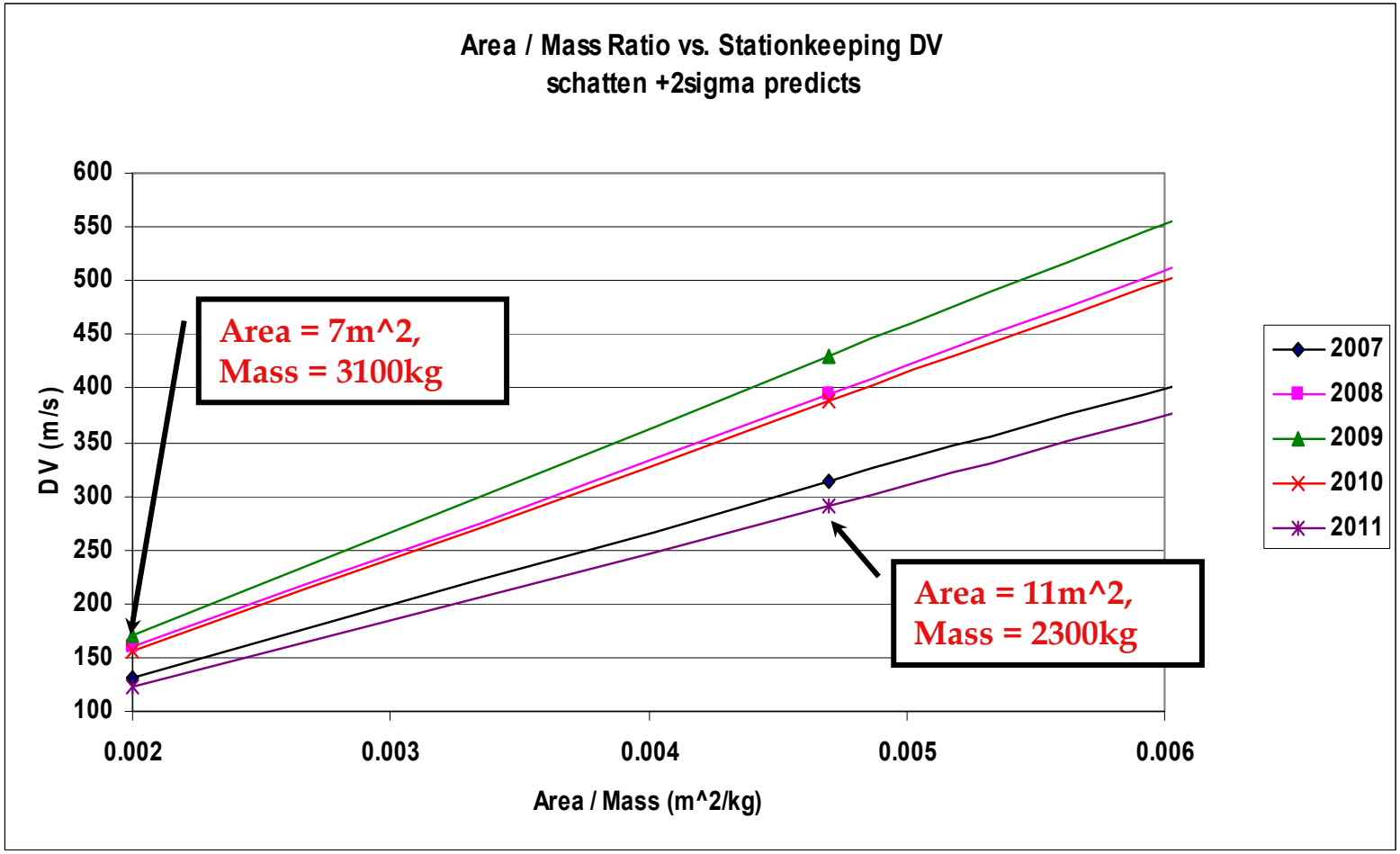
GPM Reference Orbit

Primary Spacecraft

- ***Reference Orbit is a 400km circular orbit***
  - *Frozen Orbit Elements: mean sma=6770.14km, e = 0.0008, i = 65^0, ω = 90^0, Ω=tbd*
  - *Altitude varies as a function of latitude but is repeatable to approximately 1 km*
- ***Launch and mission orbit initialization***
  - *Launch into 650km x 400km orbit*
  - *Transfer to 400 circular which requires approximately 70m/s*
- ***Orbit Maintenance***
  - *Orbit maintained to +/-1 km of mean sma*
  - *Orbit maintenance ΔV varies on ballistic property (orbit average area / mass)*
  - *Maneuver frequency ranges from approximately 1/month to 1/day during peak solar activity*
  - *Maneuver ΔV magnitude of approximately 0.25m/s per maneuver*
  - *Maneuvers currently planned at ascending and descending nodes to maintain frozen orbit*
  - *No fuel allocated for Re-entry*
- ***Constellation Spacecraft***
  - *600km orbit, maintained to +/1 km, a=6978, e = tbd, i = tbd*
  - *Maneuver frequency is approximately once every couple of months*

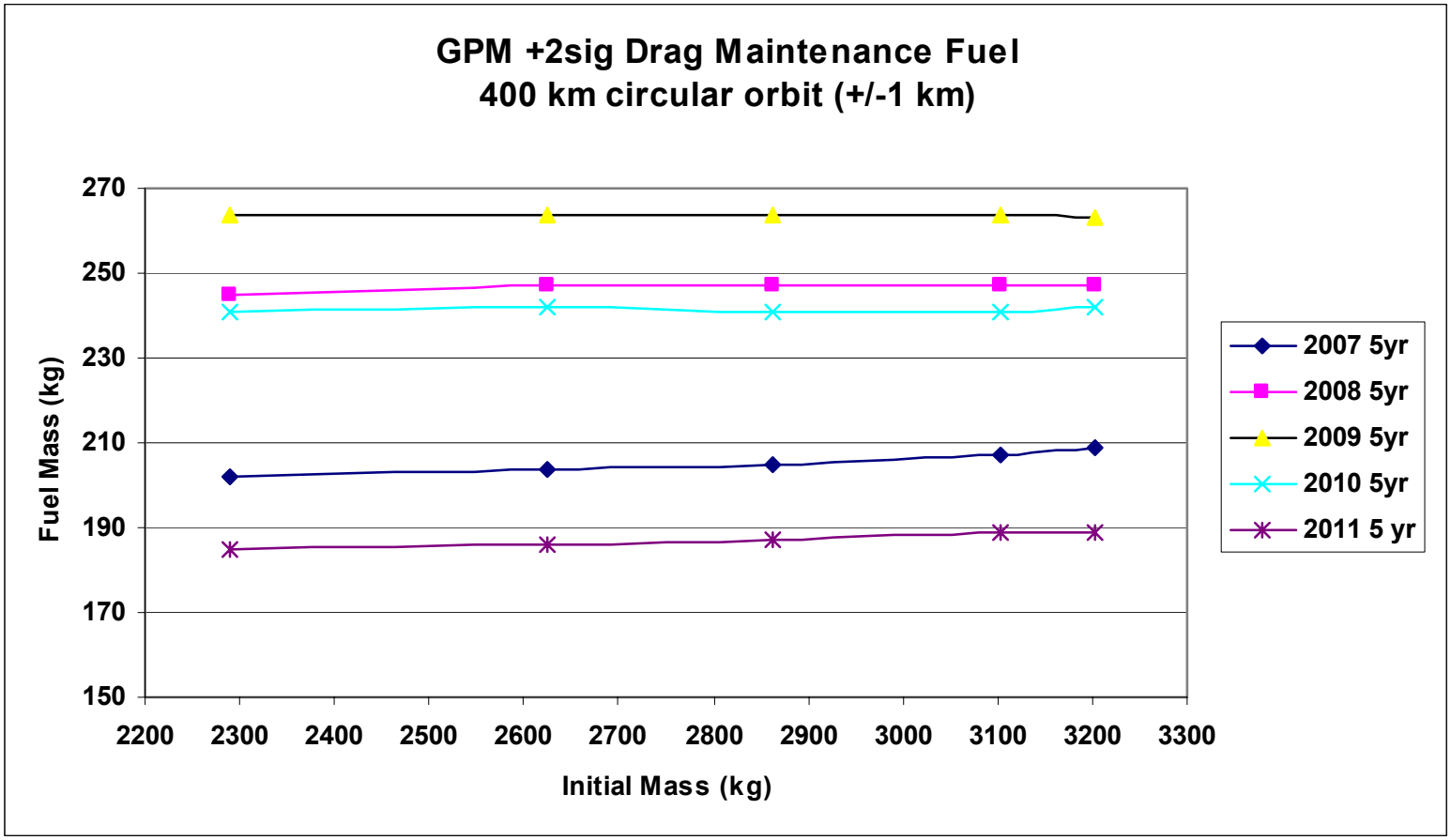
Delta-V Dependency on Area/Mass

- Five year ΔV at reference 400km orbit
- Area to mass ratio has significant impact on ΔV



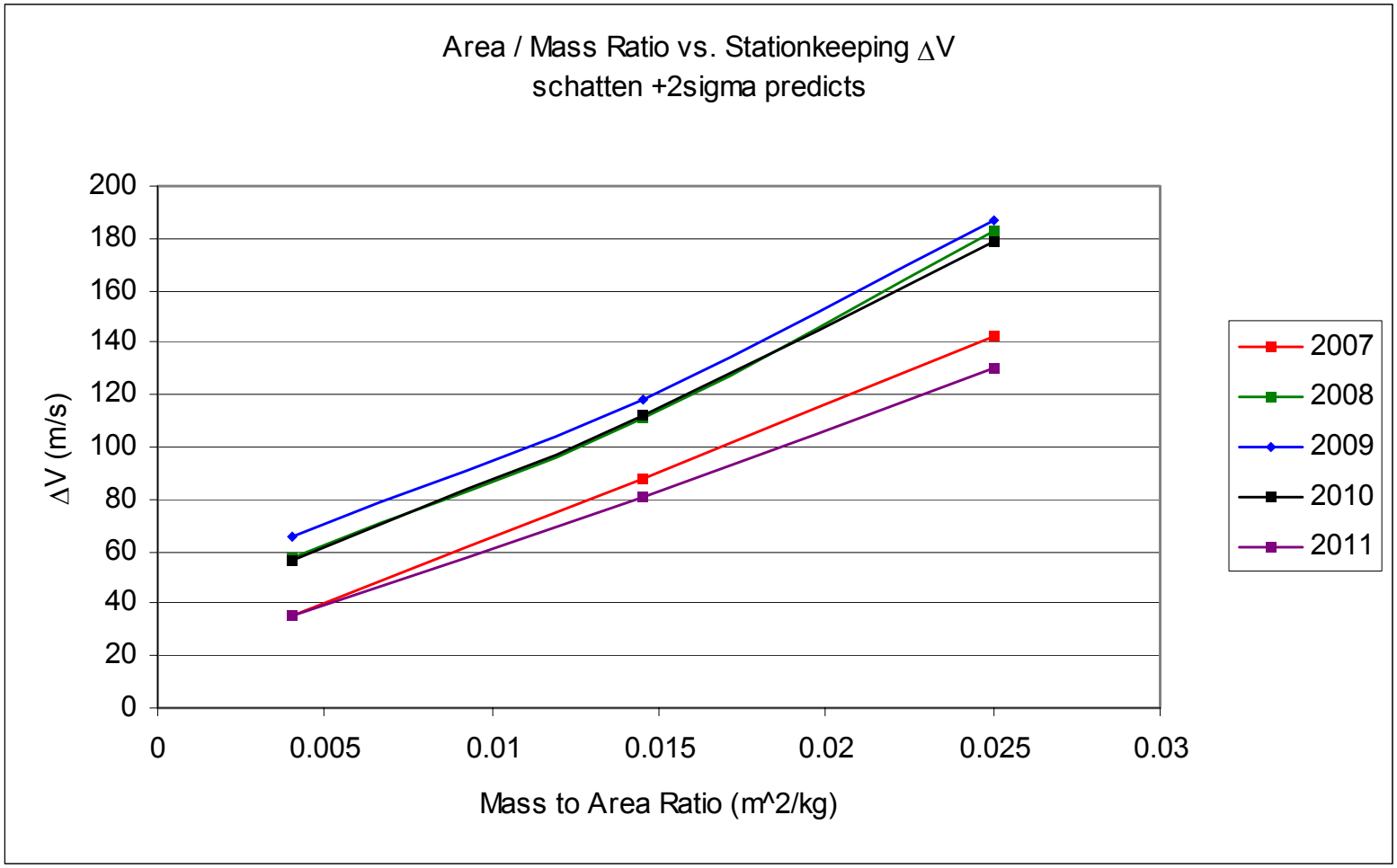
Maintenance Fuel Requirements

- Fuel mass remains relatively constant for a given launch year and cross-sectional area



Delta-V Computations wrt Area/Mass

Constellation ΔV at 600km orbit



Autonomous Maneuver Control

- ***GPM can maintain orbit autonomously by reuse of the New Millennium Program's NMP) Autonomous Onboard Formation Flying System.***
  - Fully Flight tested system used onboard EO-1 for 12 months to perform autonomous formation flying maneuvers
  - Provides autonomous orbit control using GPS Input
  - Provides rapid and quick changes via scripts without software loads
  - Provides reduced operation loads
  - Resides in the onboard computer as an application along with ACS, C&DH
  - Analysis underway to review application to GPM specifications: Code size, memory, maneuver algorithm, interfaces, etc.

- ***Impact is a reduction in operations (manpower)***

Impacted Requirements

3.6 Sampling Frequency

Precipitation sampling measurements of the same geographic footprint shall be repeated every 3 hours, TBD % of the time.

5.3.1 Spacecraft Lifetime

The Primary Spacecraft shall be designed to operate for a minimum of 3 years with consumables sized to reach a 5-year goal.

5.3.8 Nominal Operating Orbit

The primary spacecraft shall be designed to operate in an orbit of 400 km +/- 5 km at an inclination of 65 degrees +/- TBD degrees.

5.3.9 Launch Orbit

The primary spacecraft shall be designed to achieve the nominal operating orbit after launch into an orbit of 400 +/- TBD km x 650 +/- TBD km and 65 +/- TBD degrees inclination.

5.3.10 Launch Vehicle Capability (4-324)

The primary spacecraft shall not exceed the launch vehicle allocated capability of 3200 kg

Impacted Requirements

5.3.13 Autonomous Orbit Maintenance

The primary spacecraft bus shall provide autonomous orbit maintenance.

5.4.1 Spacecraft Lifetime

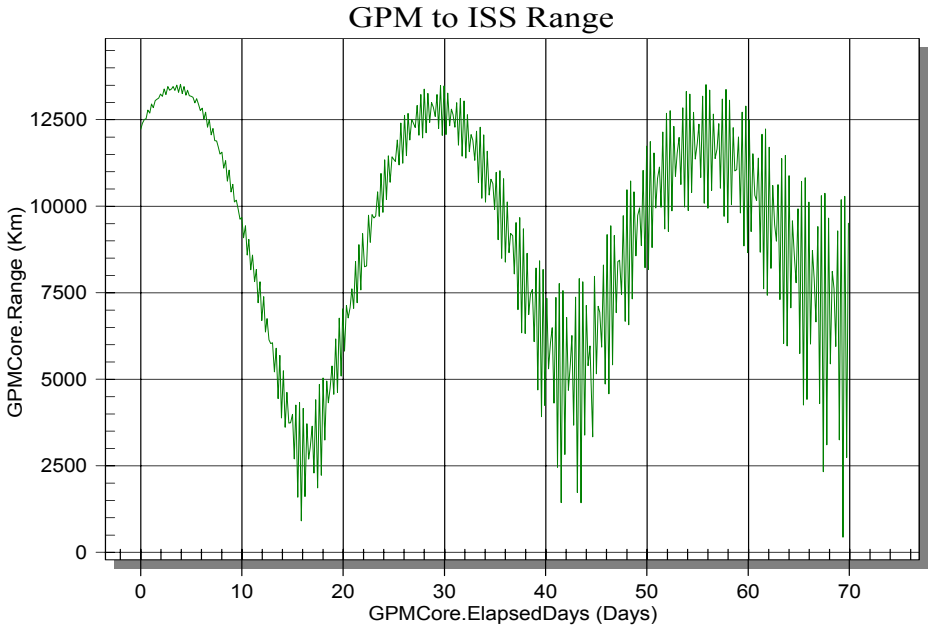
The Constellation Spacecraft shall be designed to operate for a minimum of 3 years with consumables sized to reach a 5-year goal.

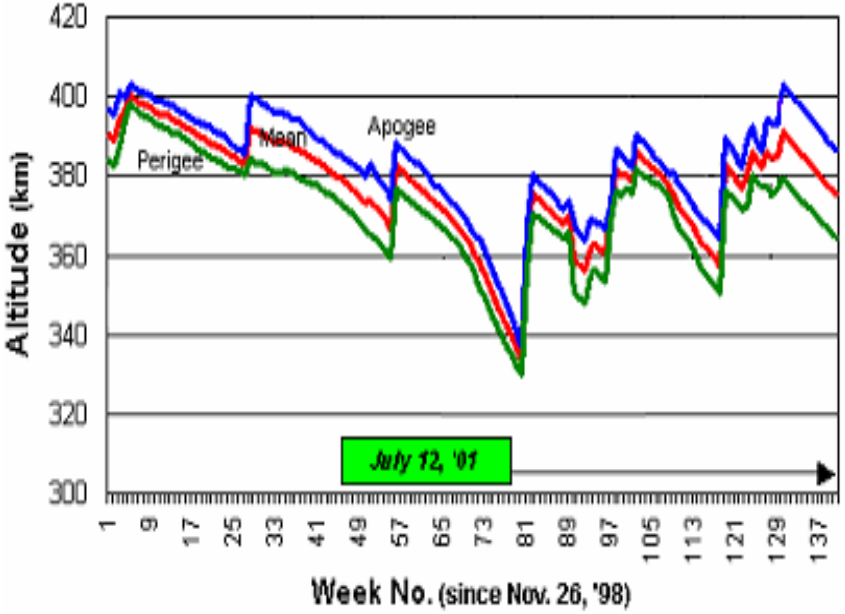
5.4.3 Orbit Definition

The dedicated constellation spacecraft shall operate in a 600 km +/- TBD km, TBD inclination orbit. The orbit shall be selected to satisfy mission coverage requirements.

ISS Collision Avoidance

- ***Preliminary ISS Collision avoidance analysis has been completed.***
- ***General results show***
  - *Possible close encounters of less than 100km once per month without drag profiles and ISS at 400km sma*
  - *Less than six encounters requiring a maneuver in 5 years with drag profiles*
  - *Encounters easily avoided by adjustment to semi-major axis of 250-500 meters*
    - *Adjustments made at 1 week, 1day, and 0.5 days yield ΔVs of approximately 0.2 meters/sec*
    - *Can be performed under routine orbit maintenance plan via simple change to GPM orbit reference to alter orbital period.*





Future Efforts

- Complete Study of orbit altitude for Primary S/C
- Constellation Orbit Parameters
- Products required by science community
- Thruster sizing study
- Measurement calibration & validation opportunities