



Global Coverage from ad-hoc constellations in rideshare orbits

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Introduction



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- Why a constellation?
 - improved temporal coverage compared to the temporal coverage from a single satellite
 - Low per-unit cost
 - Potential for ease of batch manufacturing
 - useful for Earth science, reconnaissance, and weather applications.
- Why and ad-hoc constellation?
 - Cost and launch frequency of secondary launches
 - Particularly well suited if revisit and coverage are favored over measurement quality

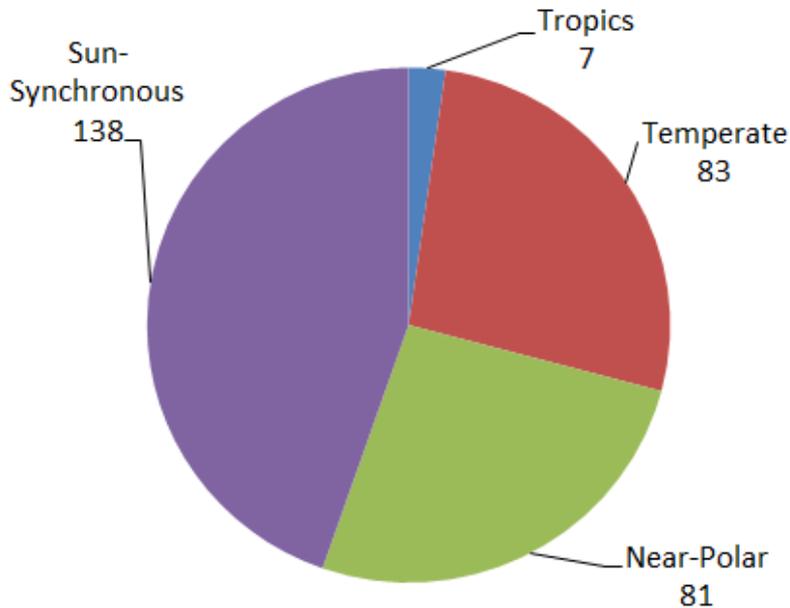
We compare the ground coverage from satellites in ad-hoc orbits and satellites in Walker orbits.



Dataset



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- Satellites
 - Launch mass <350 kg
 - Launched from 2001 to present
- 309 satellites were identified
- Orbits with apogee or perigee greater than 1600km were not included
- The data set is broadly considered as covering the Tropics, Temperate, Polar, and Global regions

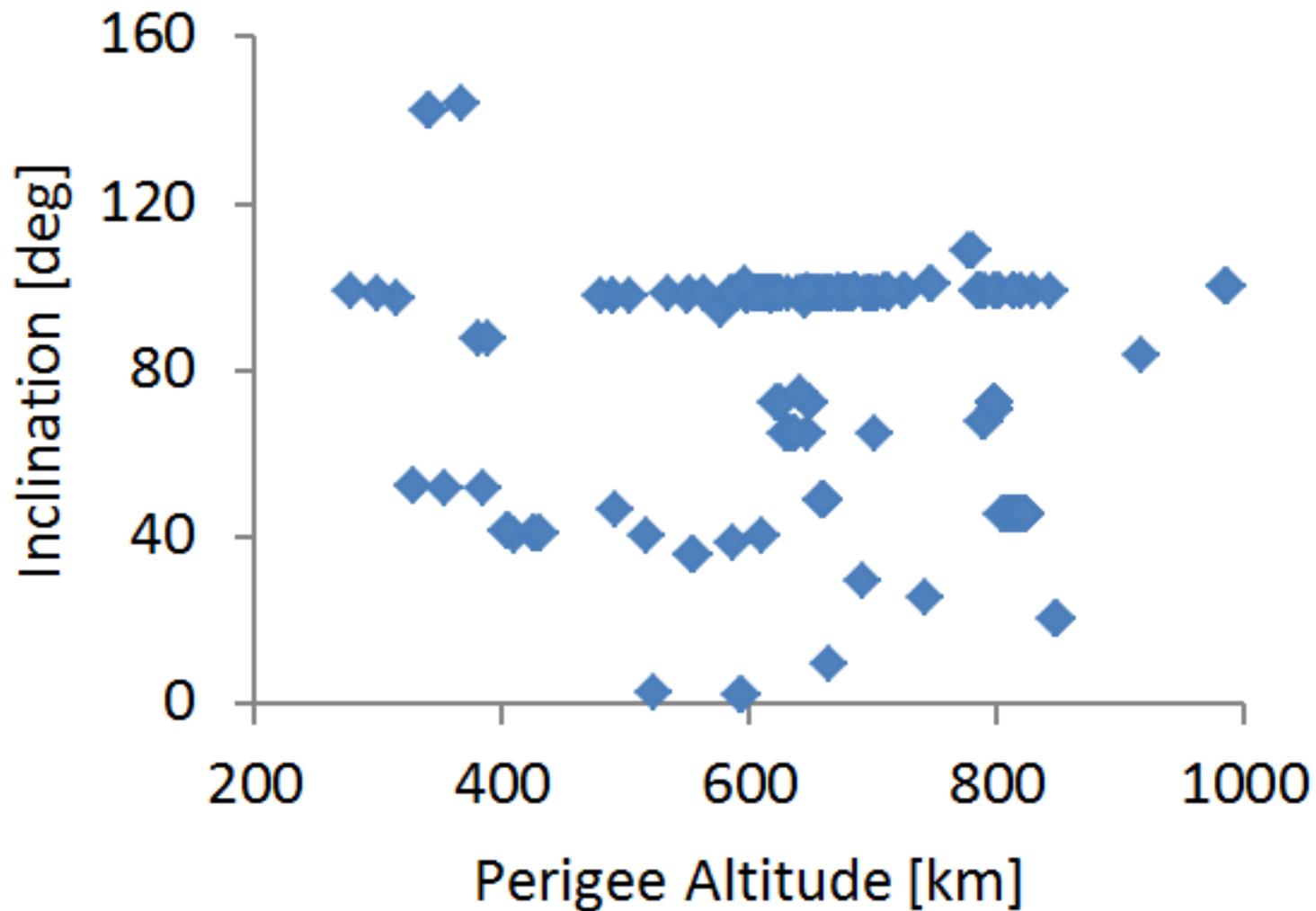
Region	Latitude Range [°]
Poles	> 66.5 and < -66.5
Temperate	-66.5 to -23.5 and 23.5 to 66.5
Tropics	-23.5 to 23.5
Global	-90 to 90



Quick look



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Objectives



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1. If we had randomly launched satellites in our a multi element constellation, what would our coverage look like?
1. How would the ground track of our ad-hoc coverage compare to the performance of a planned Walker constellation?



Methodology



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- Monte Carlo analysis for 2 – 12 element constellations
- 4 fields of view corresponding to swaths of 20, 90, 300 and 500km from altitude of 650km
- All assumed to be nadir pointing
- MODIS like swaths (1500km) are not included due to class of instrument
- Figures of Merit:
 - Mean revisit time (mean gap between coverage)
 - Time to 75% coverage

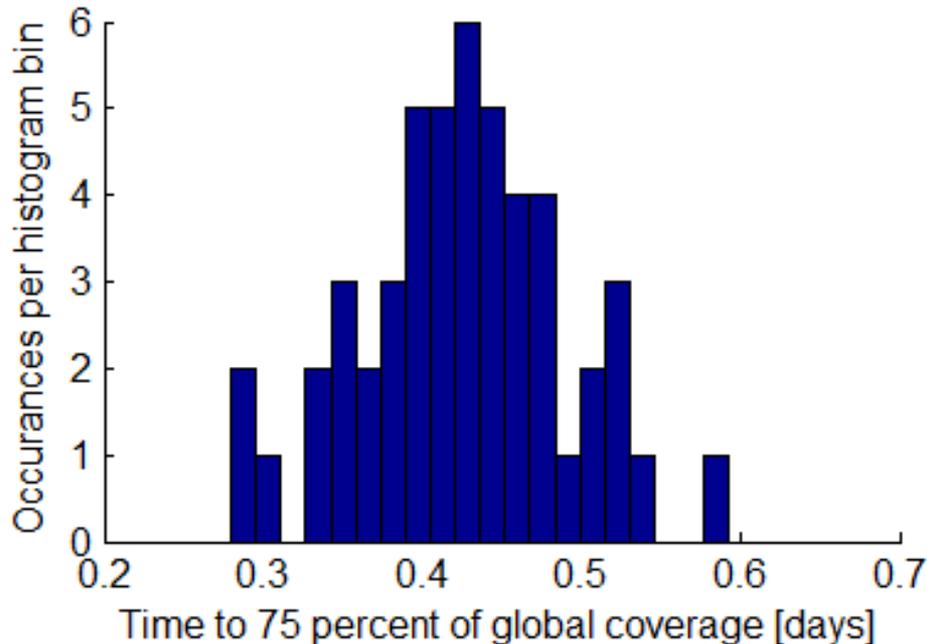
Parameter	Value(s)
“N” – The # of satellites in a constellation	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
FOV (degrees)	1.8, 7.9, 25.9, 41.8
RAAN	Randomly generated
Perigee, Apogee, Inclination	Taken from the “N” randomly selected members of the database of “ad-hoc” missions of opportunity
Mean Anomaly	Arbitrarily set to 0
Argument of Perigee	Arbitrarily set to 0



Monte Carlo Example



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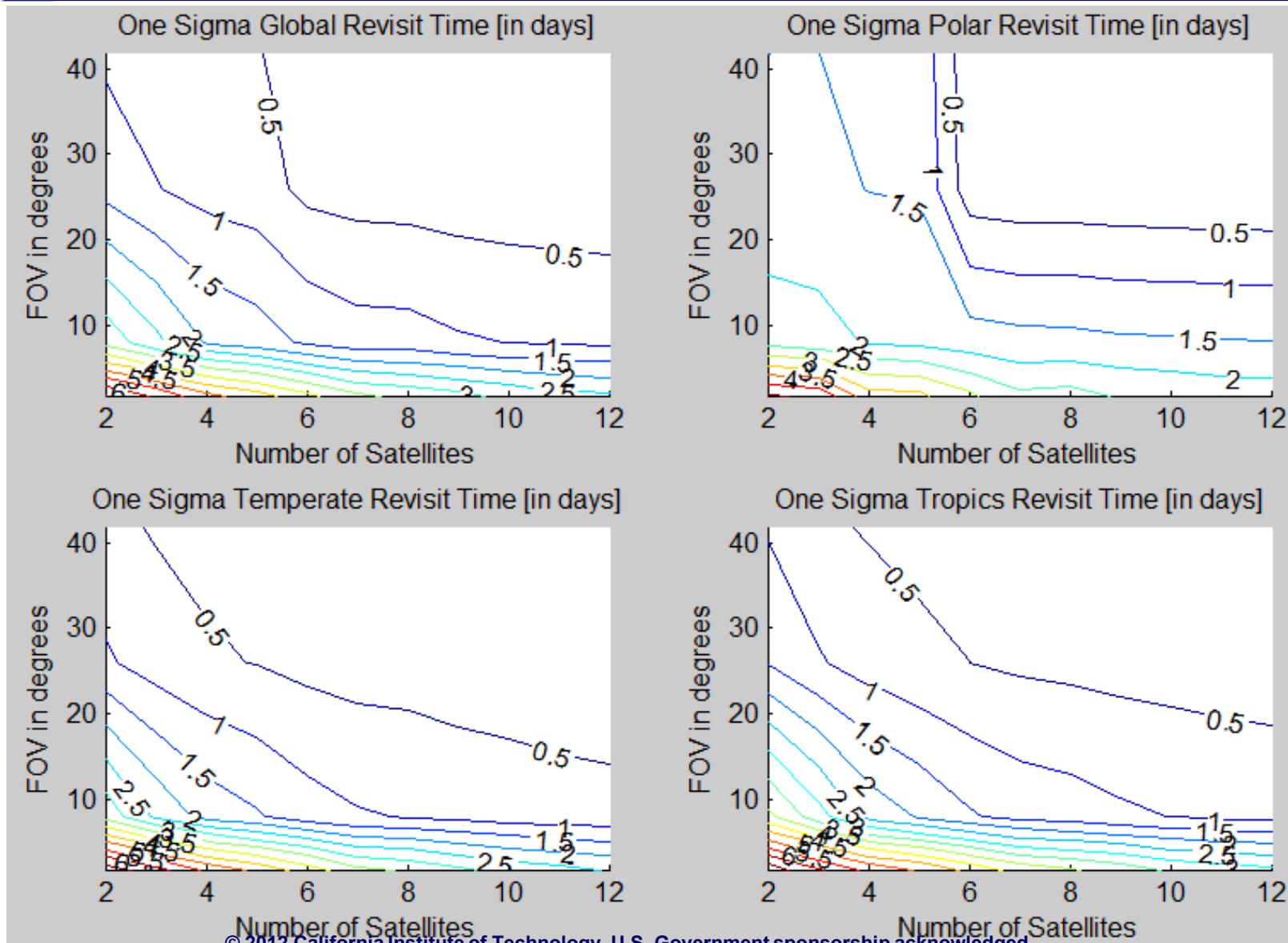
- Example showing
 - 8 satellites constellation
 - 75% coverage
 - 25.9 degree FOV (300km swath from 650km)
- 50 Monte Carlo runs



1 σ time for 75% ground revisit for ad-hoc constellation



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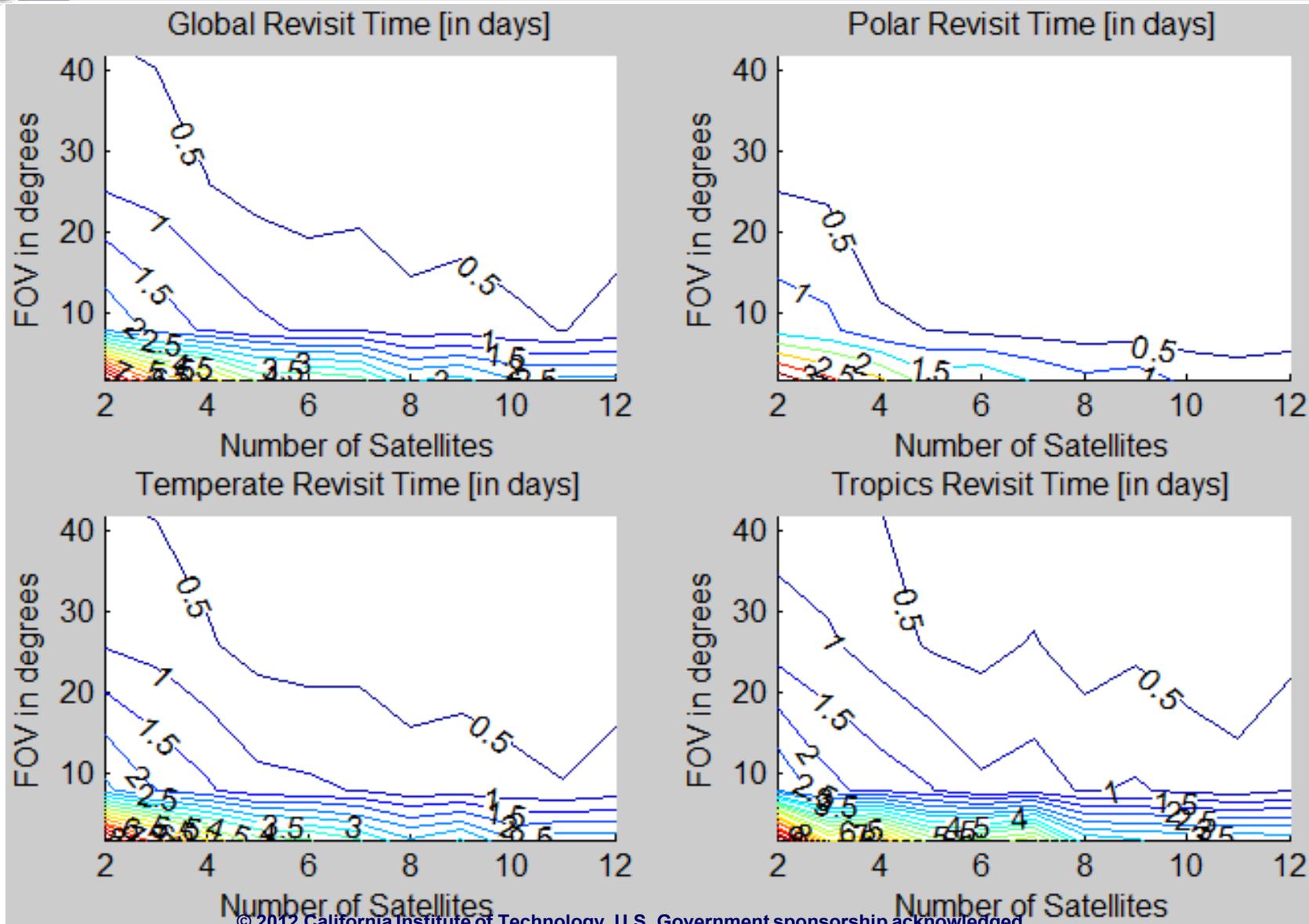




Mean time between ground revisit in number of days for satellites in Walker constellation



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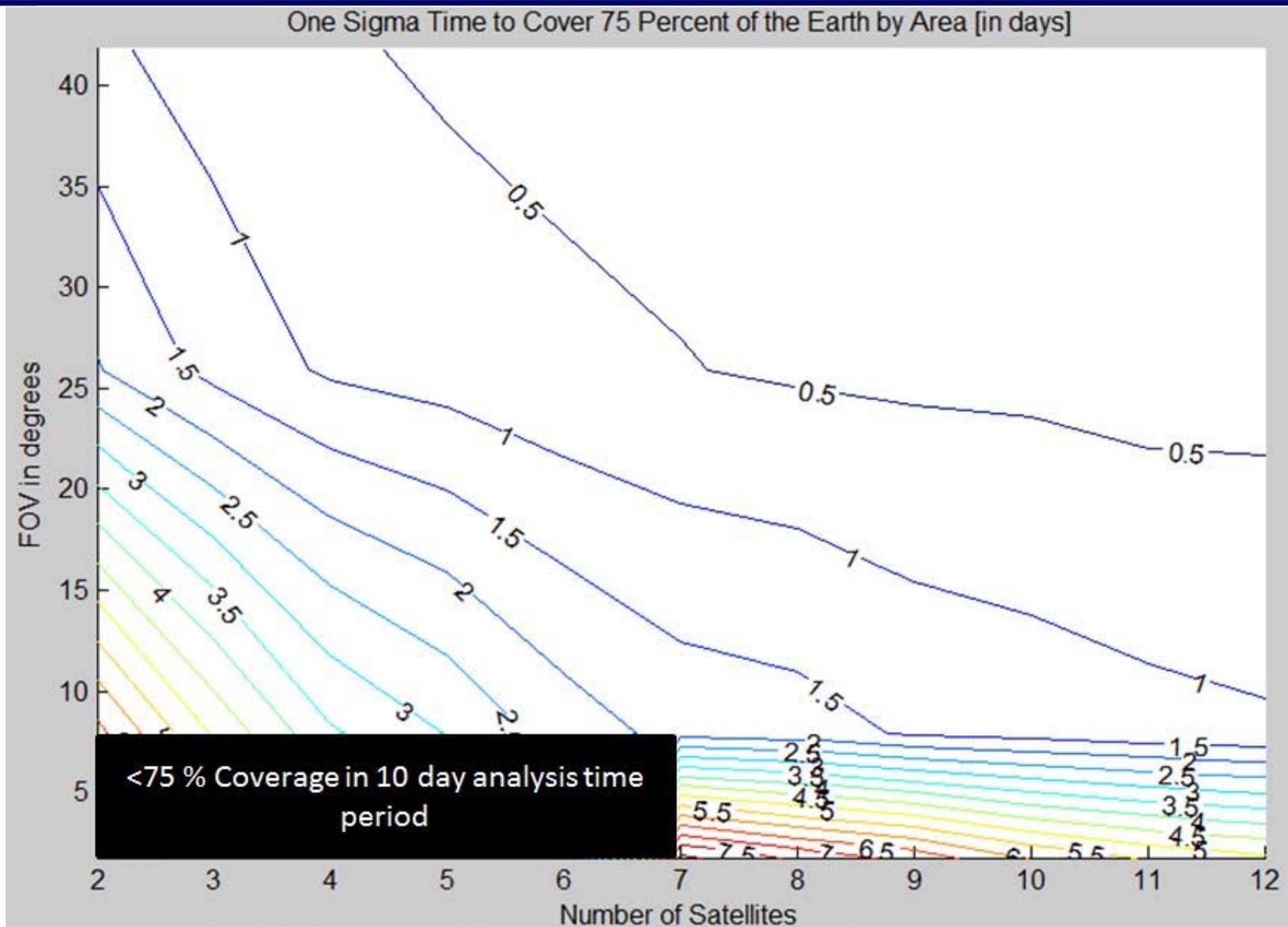




1 σ time for 75% ground coverage in ad-hoc constellation



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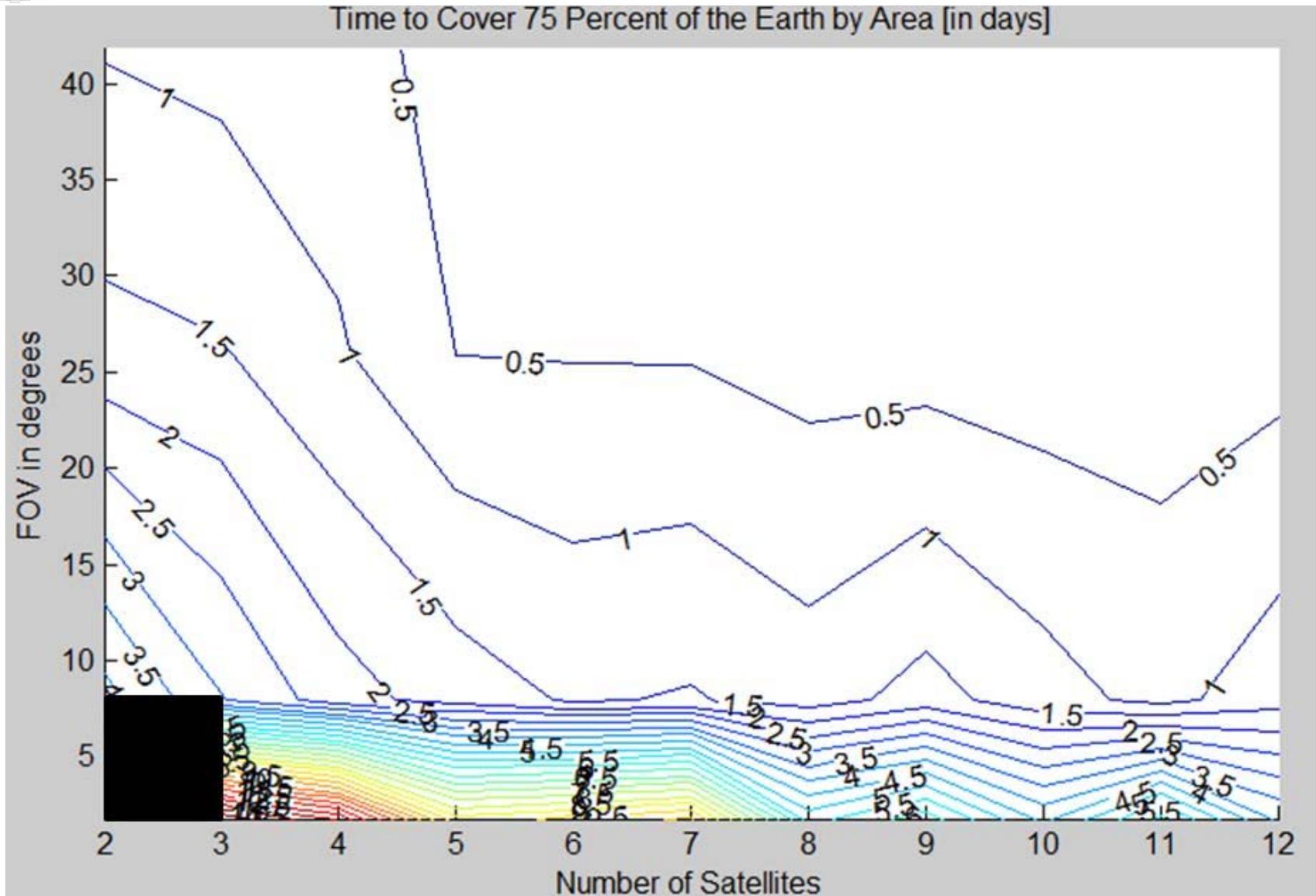




Time of ground coverage for 75% of ground coverage with Walker constellation



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Conclusions



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- Ad-hoc constellations can provide similar coverage to the more common constellation designs, especially for smaller number of nodes in the constellation
- Ad-hoc constellations best for tropic and temperate region revisits
- Walker constellations had faster revisit for Polar and Global regions
- Implications to constellation design:
 - Augmentation of lower cost/smaller missions in an ad-hoc fashion for lower latitude observations
 - under sampling can be remedied using
 - Ad-hoc satellites can solve under-sampling by providing diurnal samples.