D-SHIELD: Distributed Spacecraft with Heuristic Intelligence to Enable Logistical Decisions

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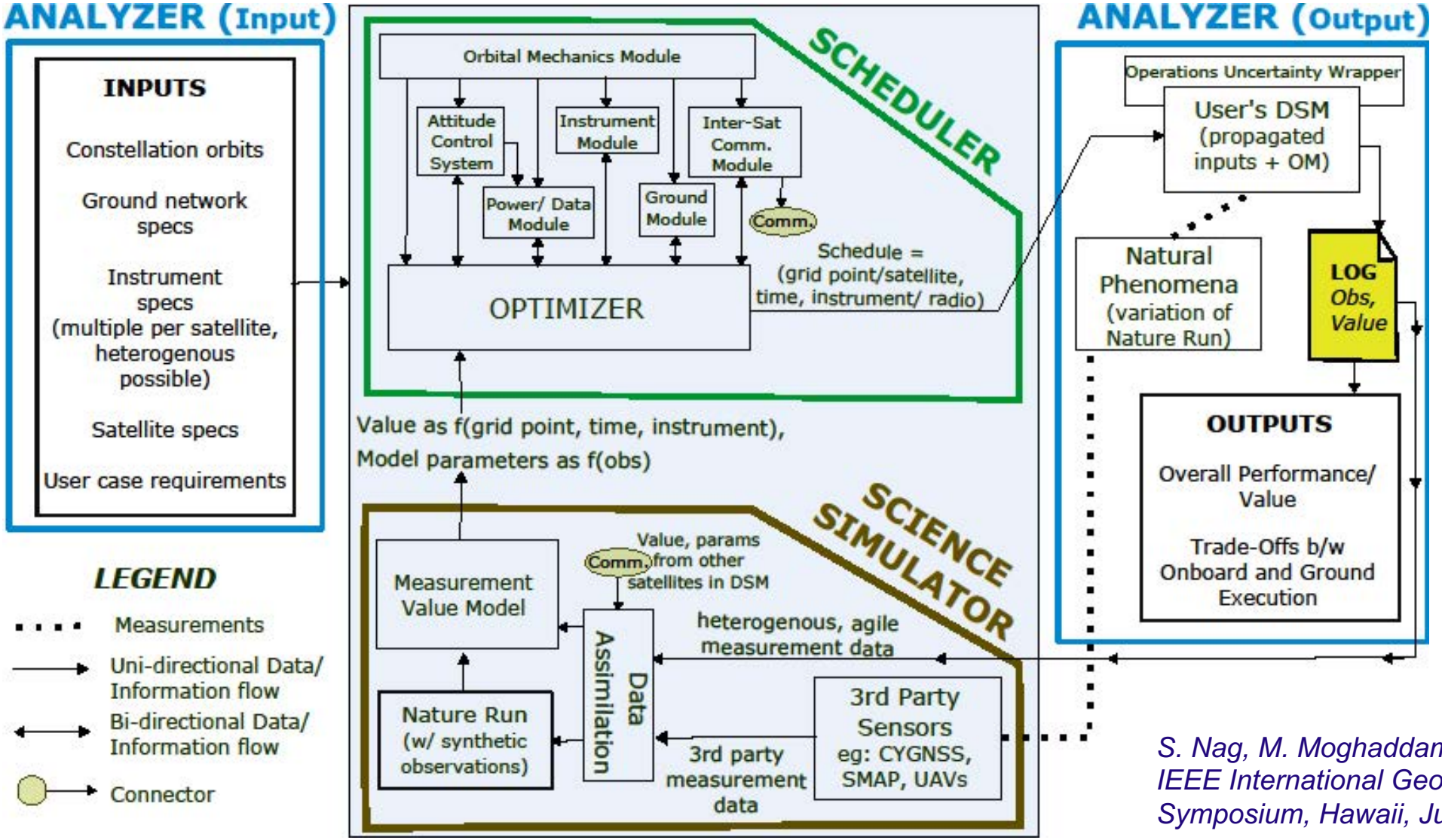
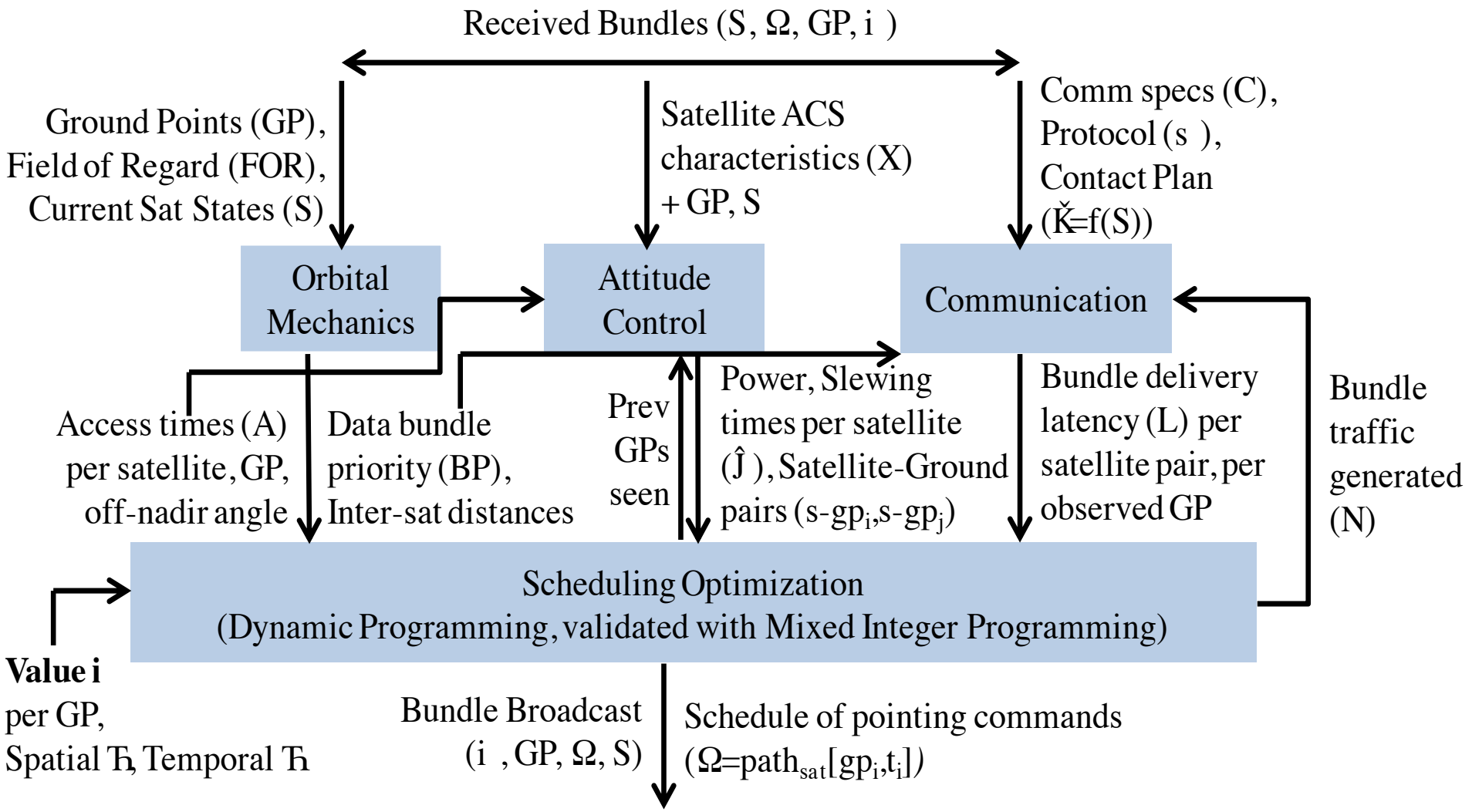
D-SHIELD + Soil Moisture Monitoring for Uncertainty Minimization



Product: Suite of scalable software tools that helps schedule payload operations of a large constellation, with multiple payloads per and across spacecraft, such that the collection of observational data and their downlink, results in maximum science value for a selected use case

S. Nag, M. Moghaddam, D. Selva, J. Frank, "D-SHIELD", IEEE International Geoscience and Remote Sensing Symposium, Hawaii, July 2020

Project Technologies

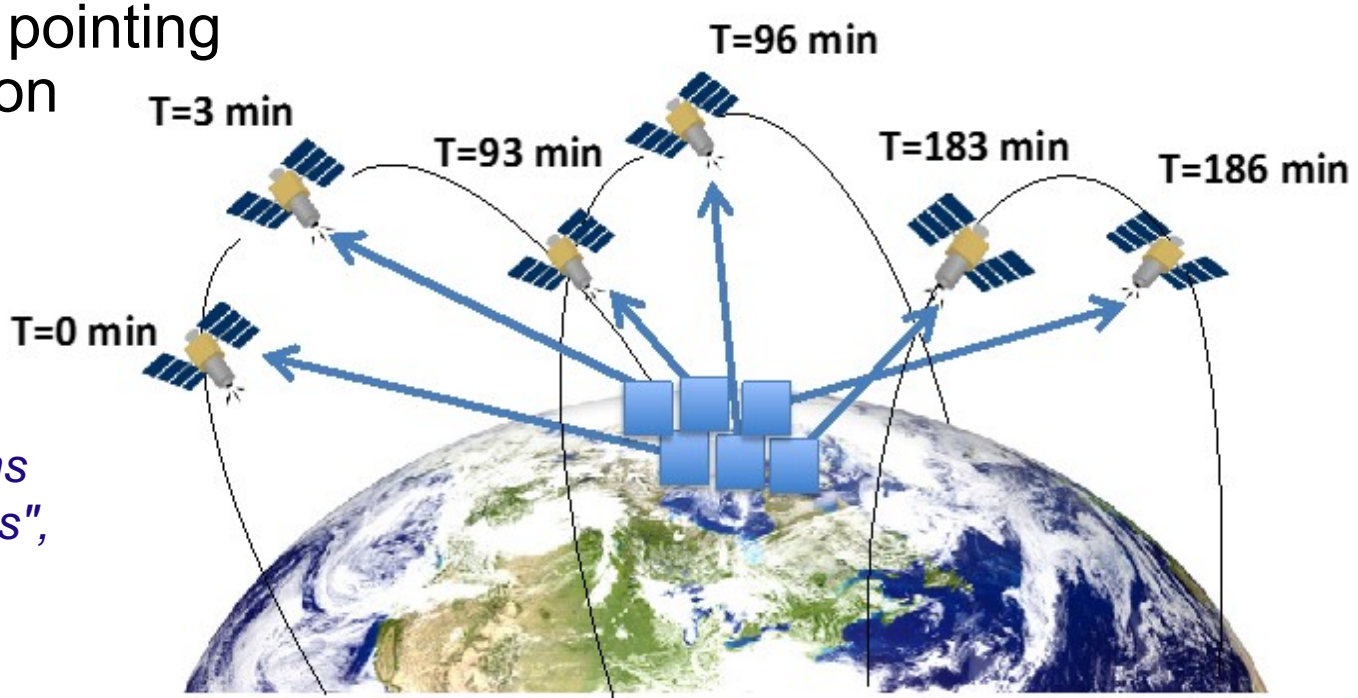


Basic modules

+ Payload module
+ Ground Module
+ Power/Data module
+ New Science Simulator
+ New Scheduler

Agile Spacecraft Constellations Maximizing Coverage and Revisit

- Small Sat constellation + Full-body reorientation agility + Ground scheduling autonomy = More Coverage, for any given number of satellites in any given orbits
- Using Landsat as first case study (710 km, SSO, 15 deg FOV) w/ a 14 day revisit. Daily revisit needs ~15 satellites or 4 satellites with triple the FOV.
- Assuming a 20 kg satellite platform for option of agile pointing
- Scheduling algorithm allows 2 sat constellation over 12 hours to observe 2.5x compared to the fixed pointing approach. 1.5x with a 4-sat constellation
- Extendable to monitoring applications (e.g. coral reefs)

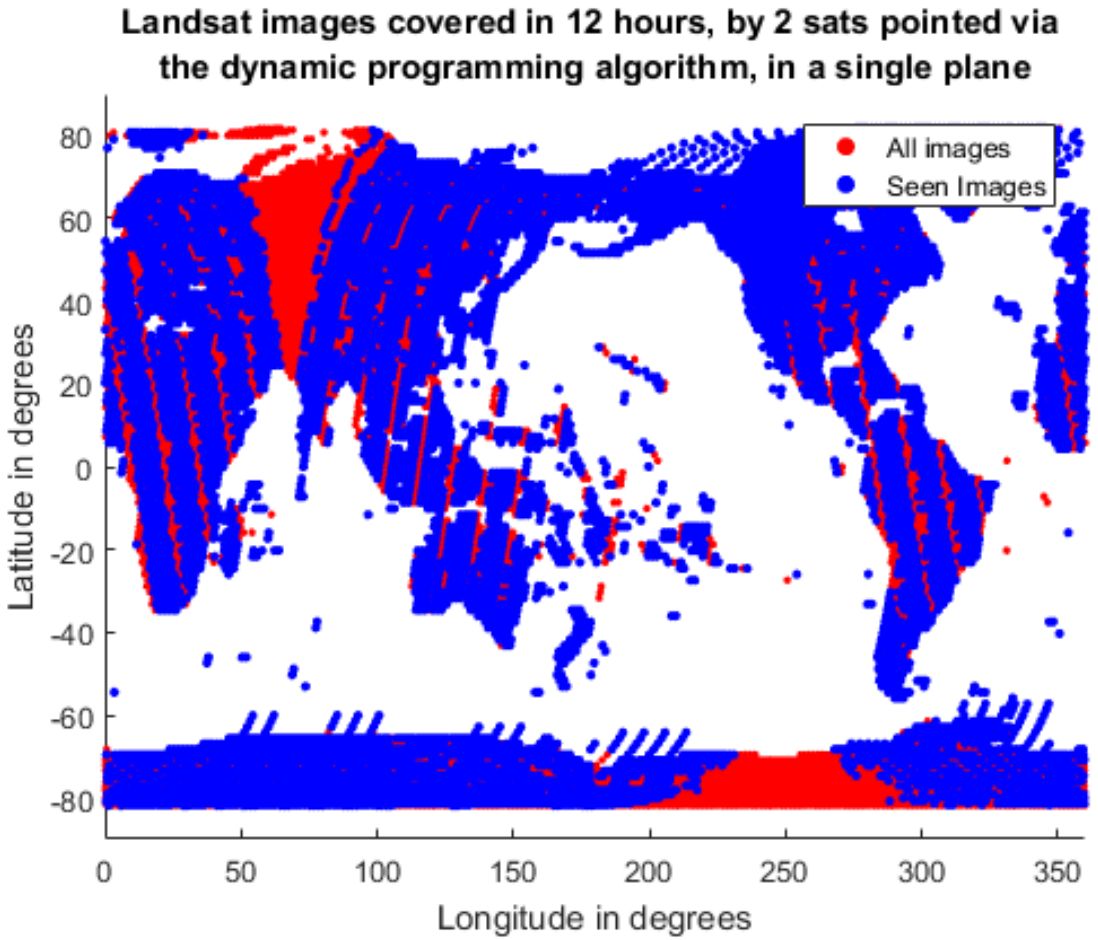


S. Nag, A.S. Li, J.H. Merrick, "Scheduling Algorithms for Rapid Imaging using Agile Cubesat Constellations", COSPAR Advances in Space Research - Astrodynamics 61, Issue 3 (2018), 891-913

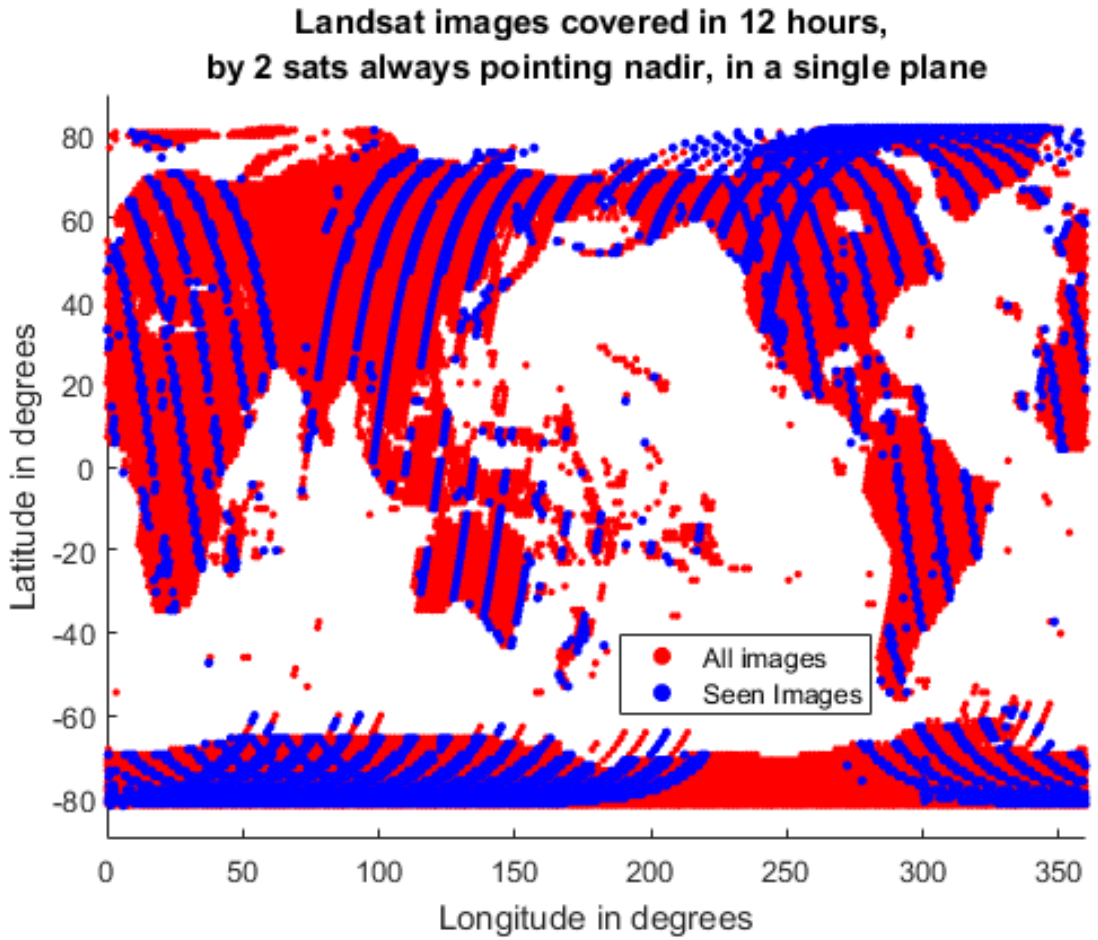
Agile Spacecraft Constellations Maximizing Coverage and Revisit

Over 12 hours of planning horizon using 2 satellites, 180 deg apart in the same plane :

- Using our **proposed DP algorithm**

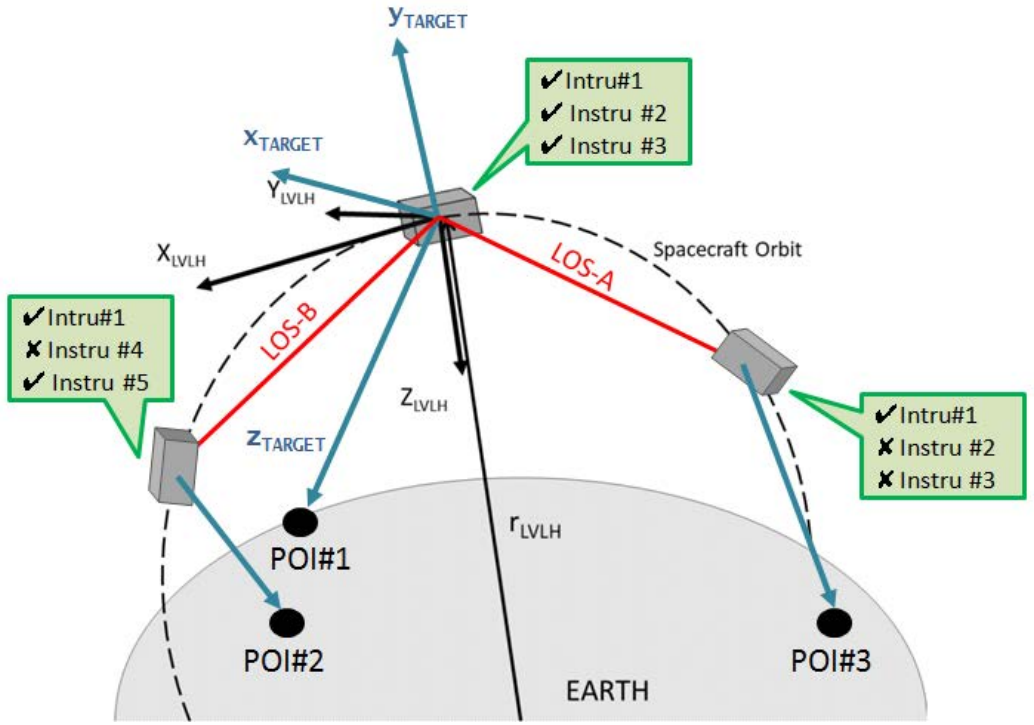


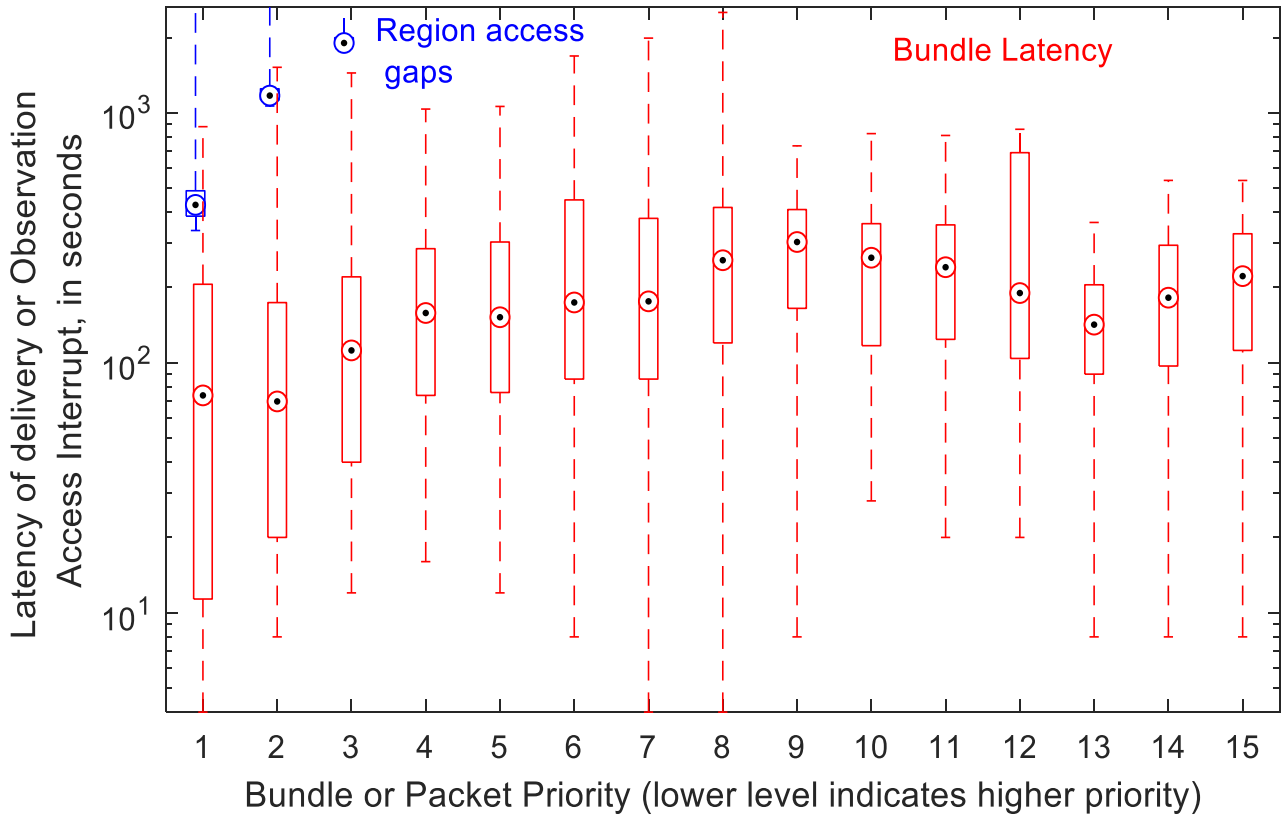
- Using a **fixed Landsat sensor**, as is



Adding onboard autonomy to flight software + inter-sat communication to the constellation can improve science-driven responsiveness?

Agile Spacecraft Constellations with Delay Tolerant Networking for Reactive Monitoring

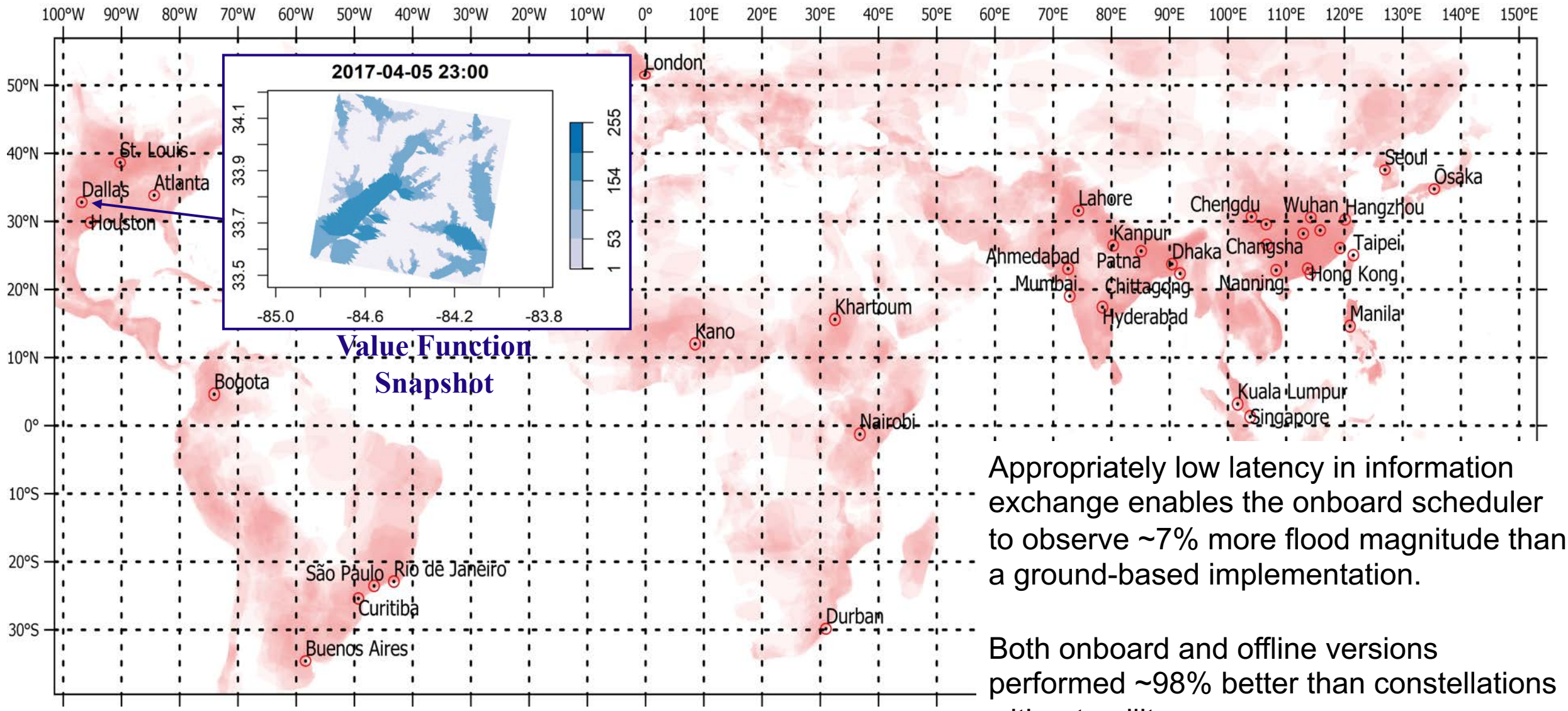




S. Nag, A. S. Li, V. Ravindra, M. Sanchez Net, K.M. Cheung, R. Lammers, B. Bledsoe, "Autonomous Scheduling of Agile Spacecraft Constellations with Delay Tolerant Networking for Reactive Imaging", International Conference on Automated Planning and Scheduling SPARK Workshop, Berkeley CA, July 2019

If longest latency < shortest gap, for pairs with the same priority => each satellite can be considered fully updated with information from all others, i.e. perfect consensus is possible, in spite of distributed decisions made on a disjoint graph.

Initial Tool applied to Episodic Precipitation and Transient Floods



Appropriately low latency in information exchange enables the onboard scheduler to observe ~7% more flood magnitude than a ground-based implementation.

Both onboard and offline versions performed ~98% better than constellations without agility.

Questions?

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Project Relation to NOS Concept

- Brief description of where your project fits into a NOS concept. For example but not limited to:
  - onboard data understanding and analysis;
  - inter-node coordination (including comms, standards, ontologies, commands);
  - Planning, scheduling and decision making;
  - Interaction to science and forecast models;
  - Cybersecurity
- Include graphics or pictures if appropriate.