Creating an Interface to View Multi-Spacecraft Swarm Telemetry

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Speaker

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Distributed Spacecraft Autonomy (DSA)

https://gameon.nasa.gov/projects/distributed-spacecraft-autonomy-dsa/

Agenda

About DSA

Background

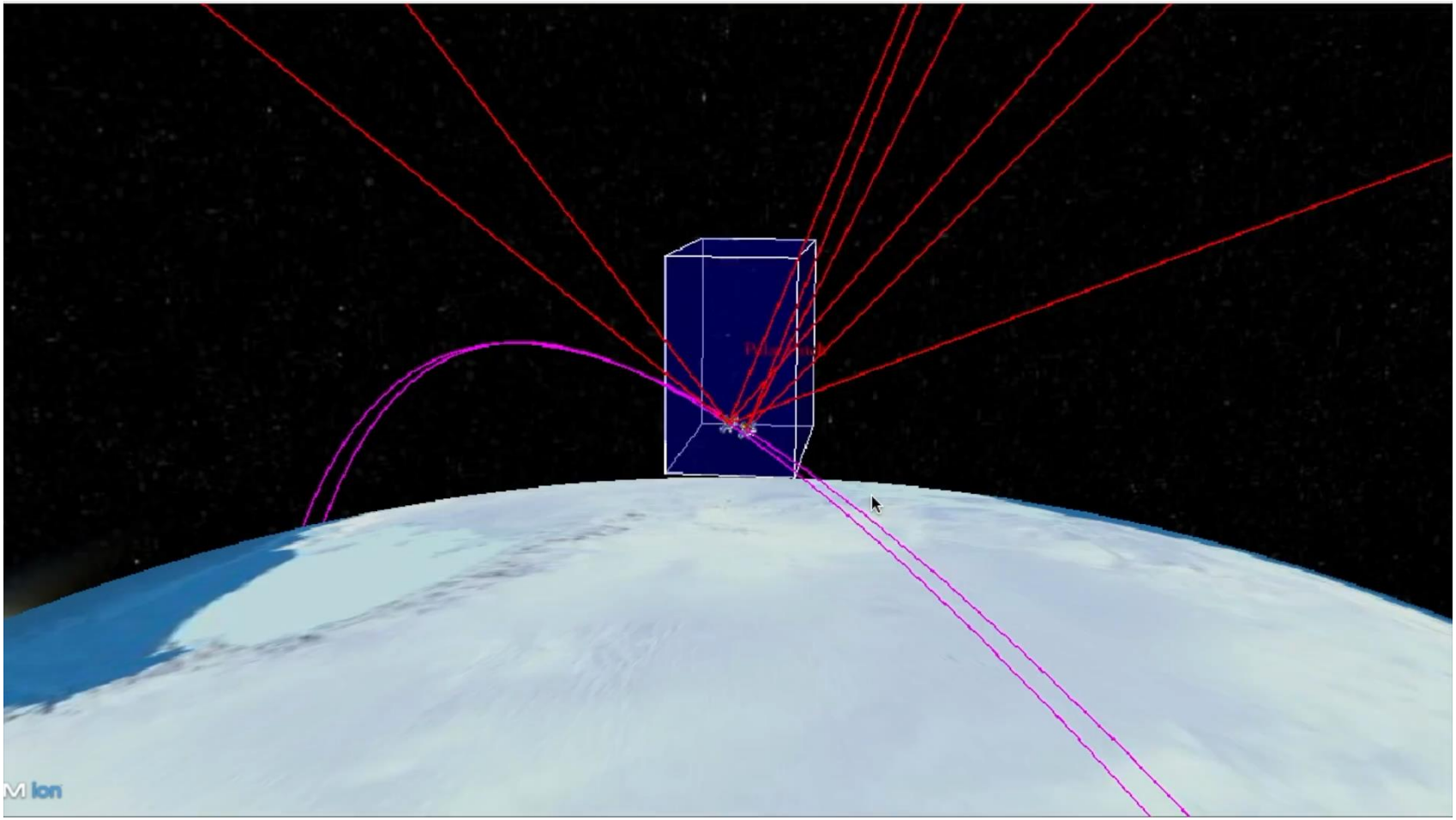
Use Case

Development

Distributed Spacecraft Autonomy (DSA)

- Software payload on Starling which is a 4 CubeSat NASA mission to develop and advance space swarm technologies
- Goal is to advance scalable autonomy capabilities, command/control methodologies
- Includes two segments, a flight launch and a scalability study tested on ground hardware with up to 100 spacecraft

Autonomy Demo



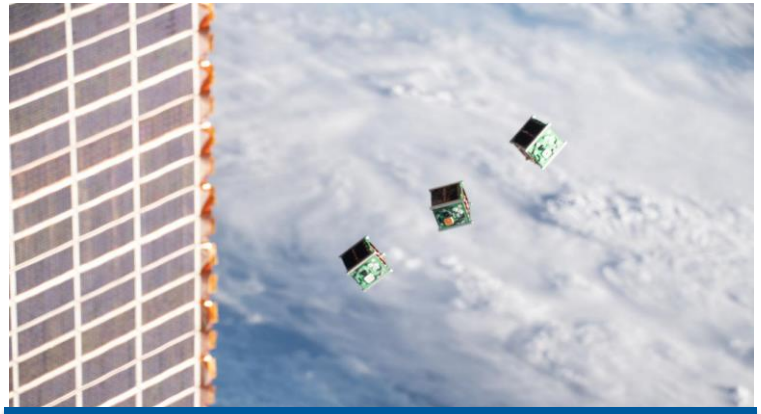
Background

Human-Swarm Interaction (HSI)

- Deals with interface between a human and a swarm of robots within a mission
- Part of the Ground Data Systems sub-team within DSA

Challenges

- Informational complexity
- Reducing information overload
- Large swarm dynamics



Micro-satellite deployment mission- a constellation of three 1U CubeSats developed by Japan, Nepal and Sri Lanka

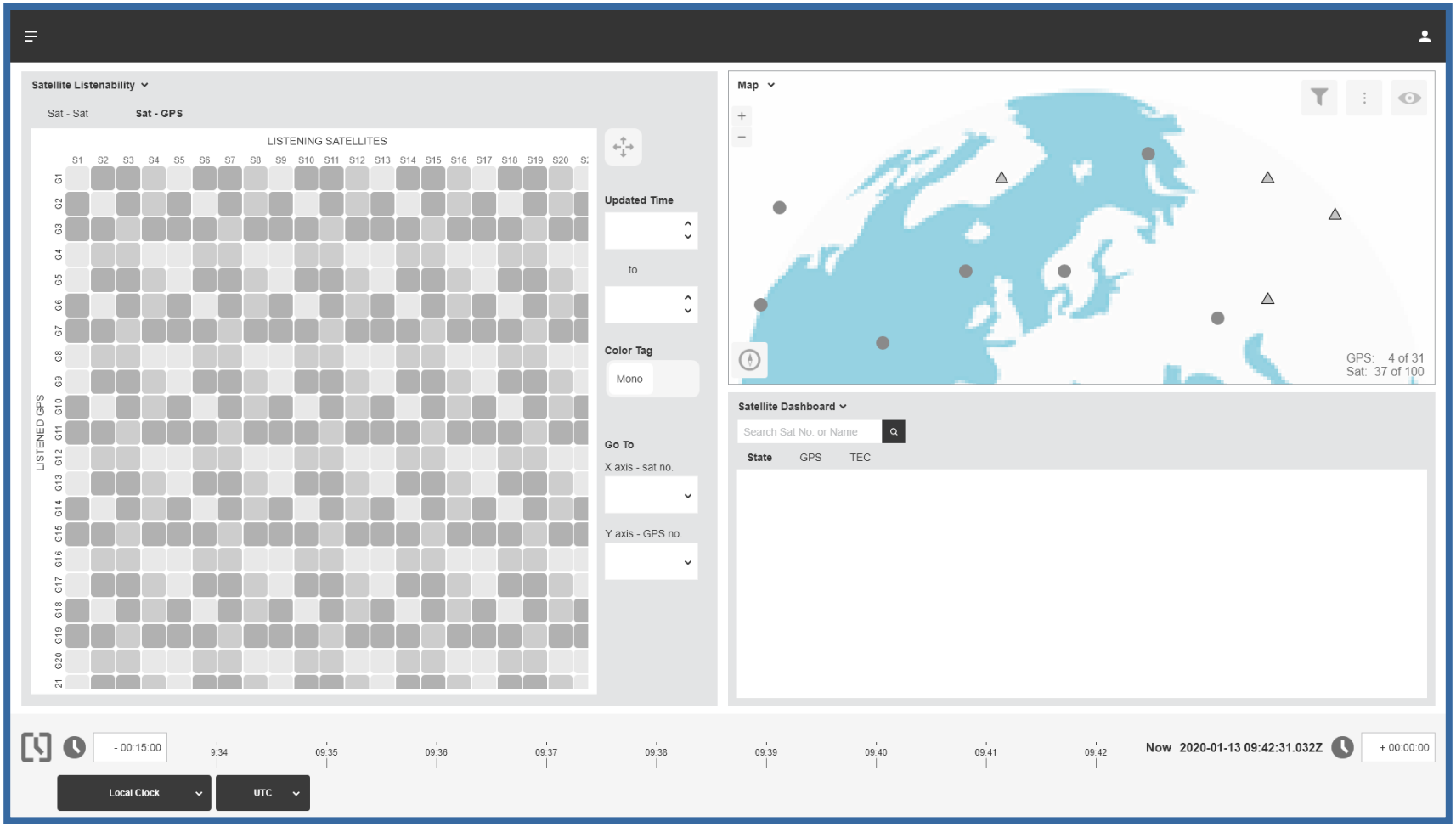
Need to understand the state of the swarm, with the ability to quickly find information of a particular satellite.

Our Approach

- Divide HSI User Interface into several components
  - Satellite Listenability Matrix
  - Timeline
  - Map
  - Dashboard
  - Command Builder
- Determine roles associated with each component

Interface Design

Design created by Yunkyung Kim



Component Roles

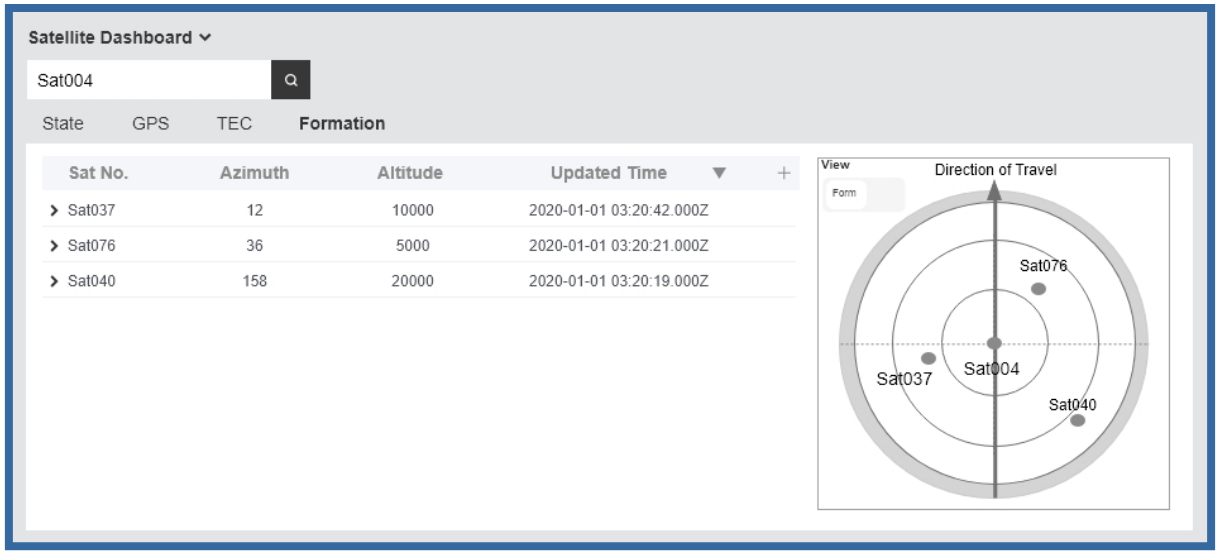
(Supervisor, Teammate, Operator)

Roles

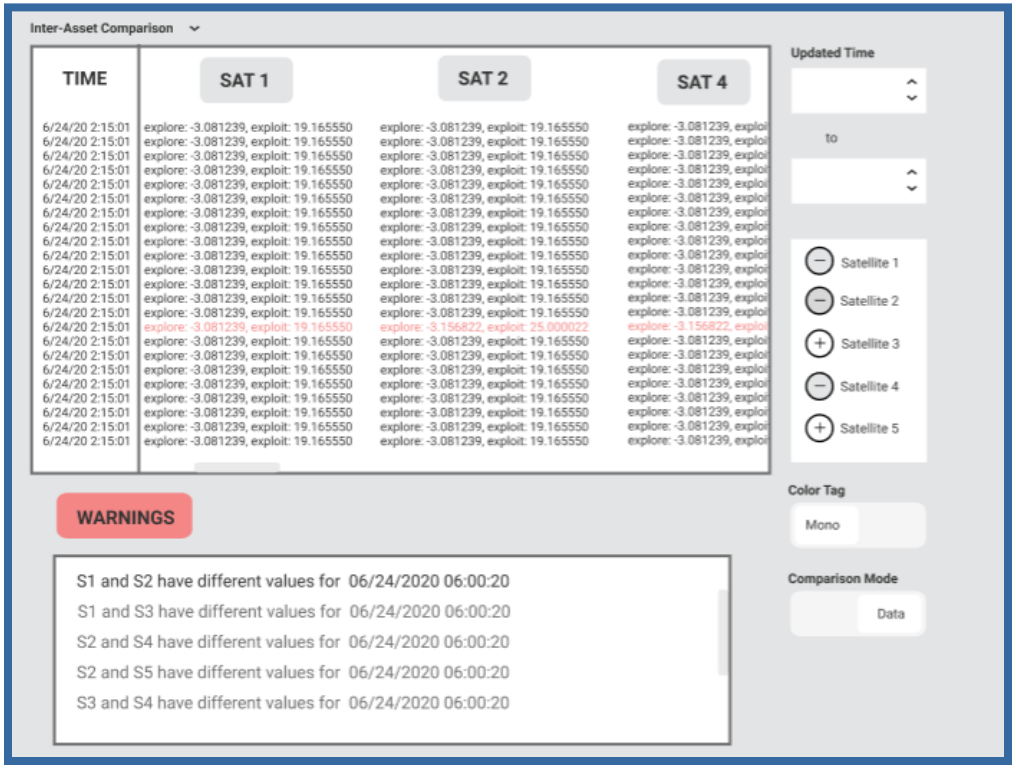
	Supervisor	Teammate	Operator
Interested In	Viewing collective satellite behavior	Details of satellite behavior	Controlling satellite behavior
Mission Goals	Meet overall goals	Accomplish mission goals, but does not change them	Complete low-level tasks related to mission goals
Examples	Project Manager	Tech Lead	Operations Team

Supervisor

Assesses system performance against mission objectives and sets command objectives that change the collective satellite behavior to meet the overall mission goals

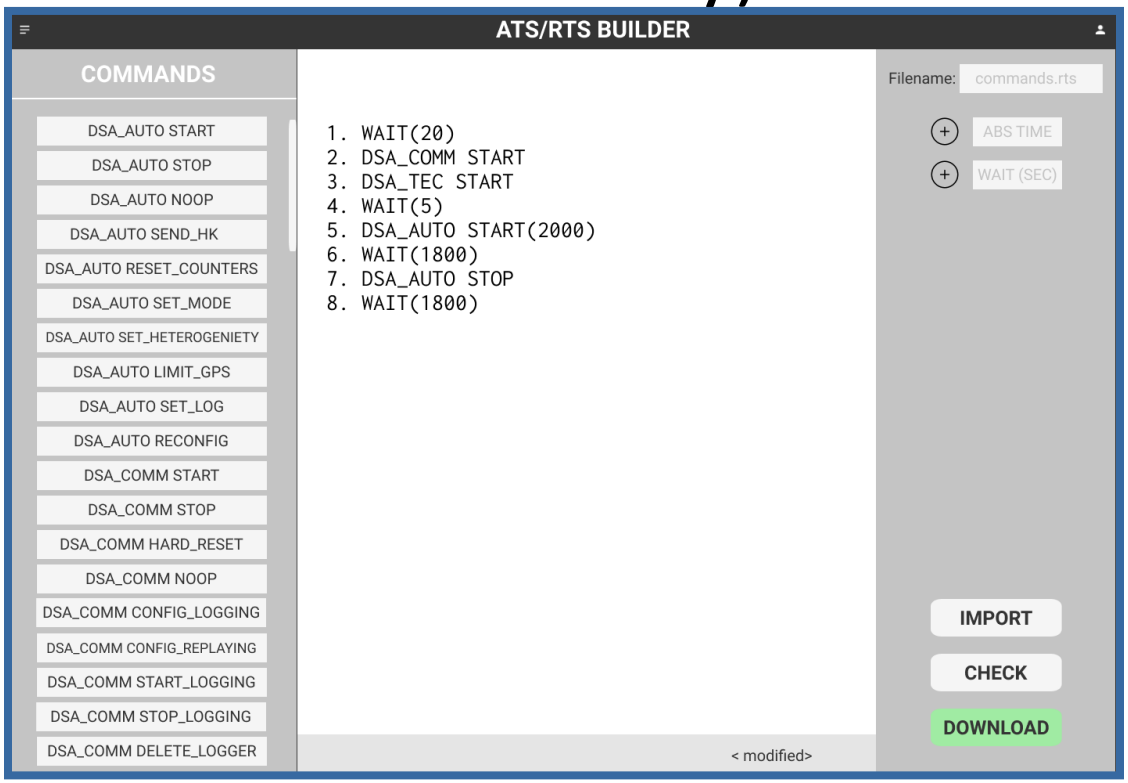


Works with satellites in order to accomplish mission goals without explicitly altering those goals



Operator

Must actively control low-level tasks on the action level (e.g. teleoperation – controlling remotely)



Use Case

How do we…

Interact with the spacecraft as a collective?

Display swarm autonomy?

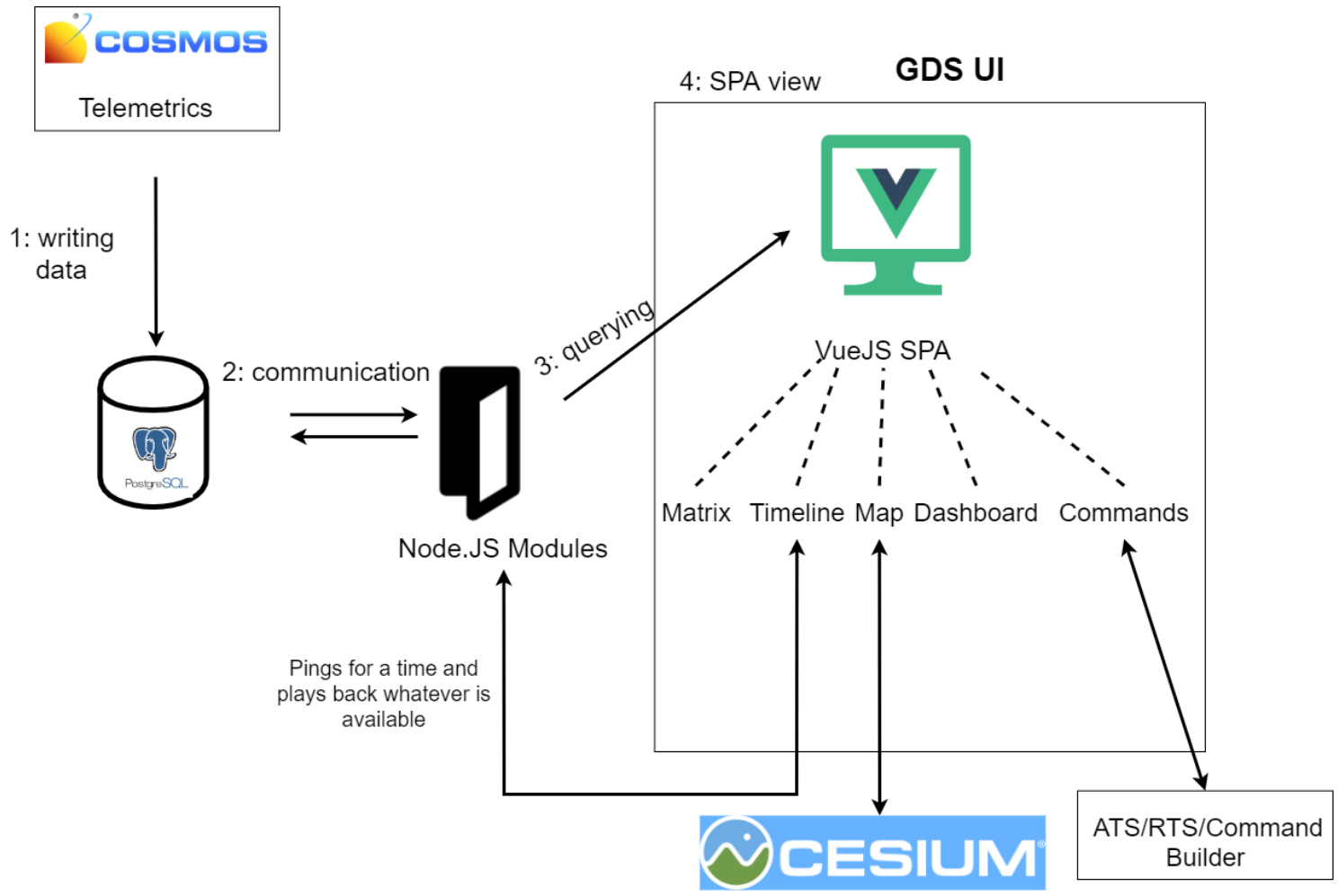
Decrease external dependencies without reinventing the wheel?

Analyzing Stakeholder Requirements

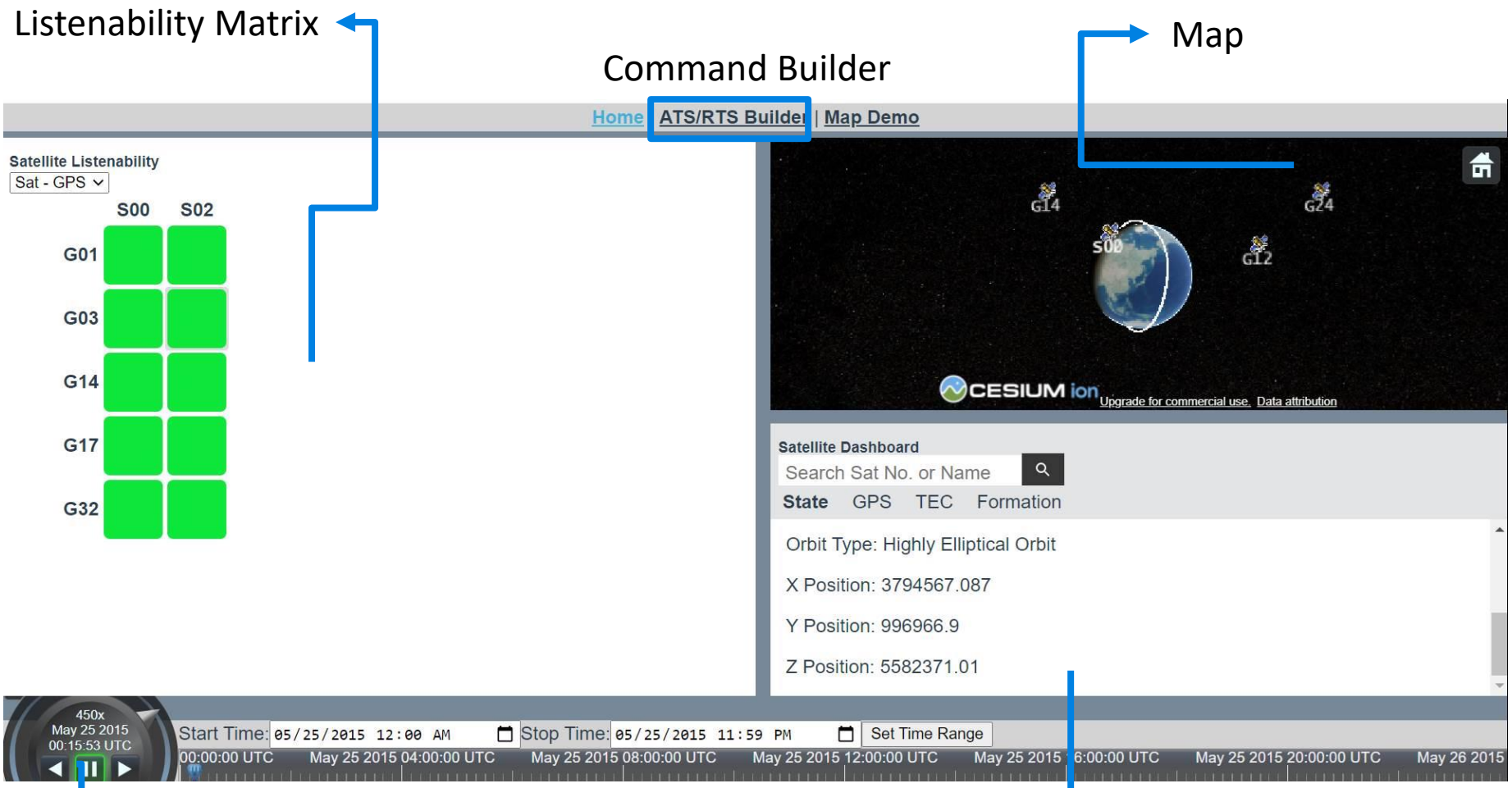
- Stakeholders each hold a different role when assessing interface
- Need to be able to view swarm status as a whole and single satellite data as needed
- Ease of access for different view modes

Development

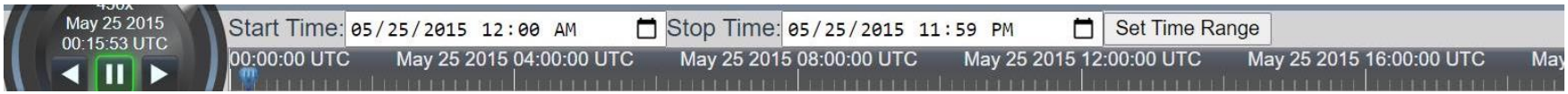
Technology Stack



User Interface (UI)

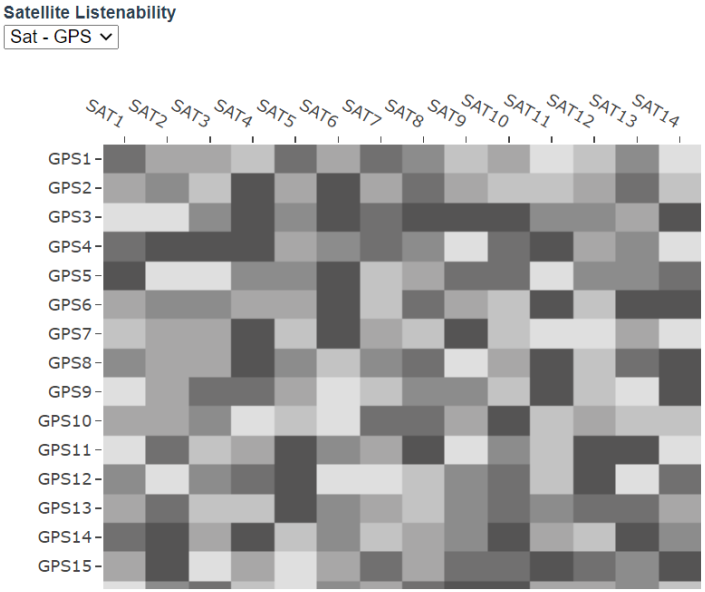


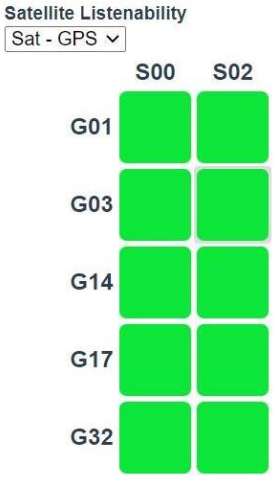
Timeline



- Built using existing Cesium tools
- Controls information outputted in rest of components

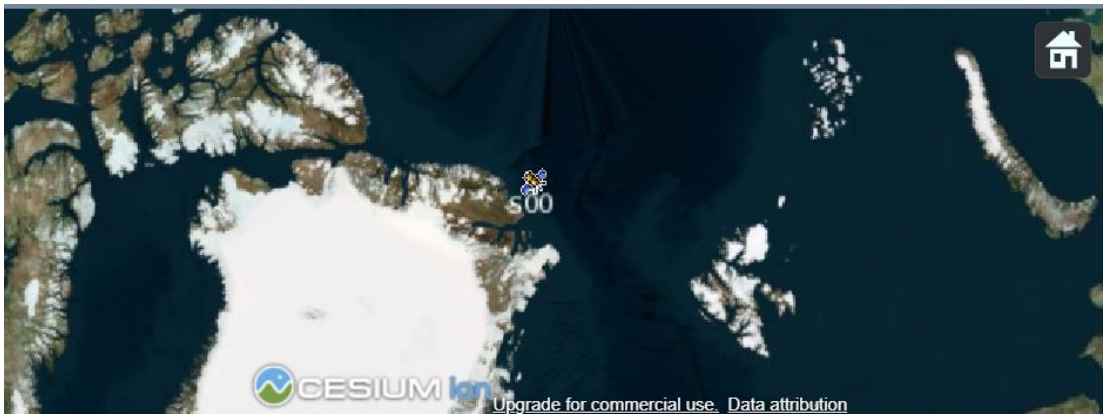
Listenability Matrix



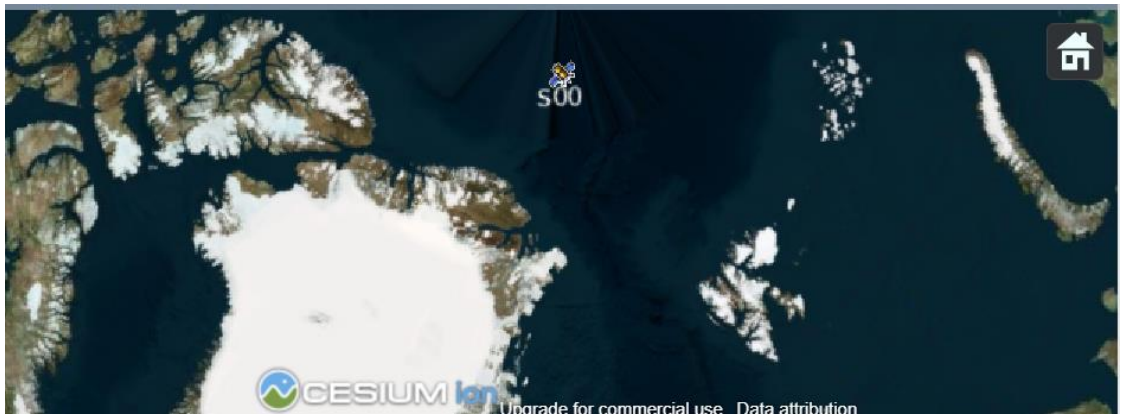


- Shows connectivity between satellites

Map



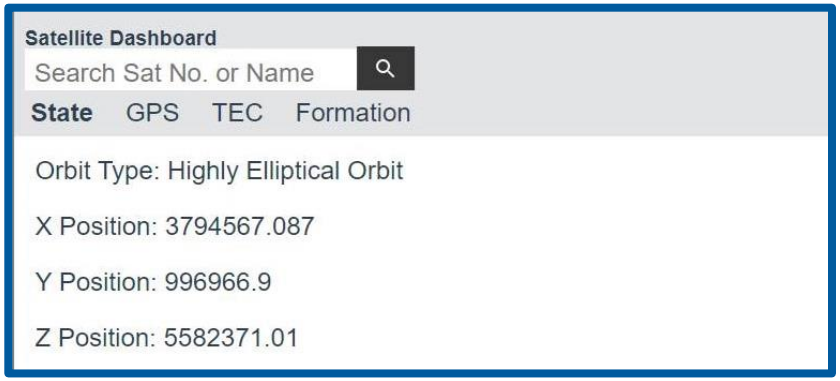
Map



Map

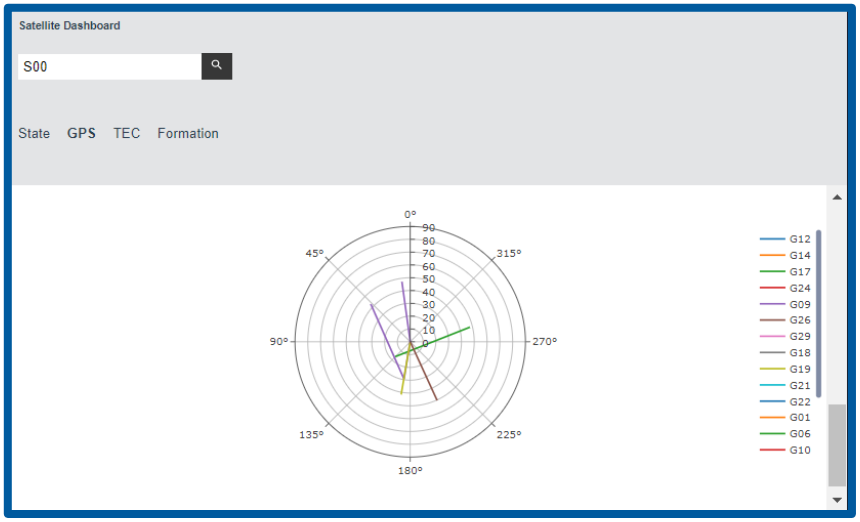
- See overall swarm positioning in reference to the Earth
- Orbit path of the satellite

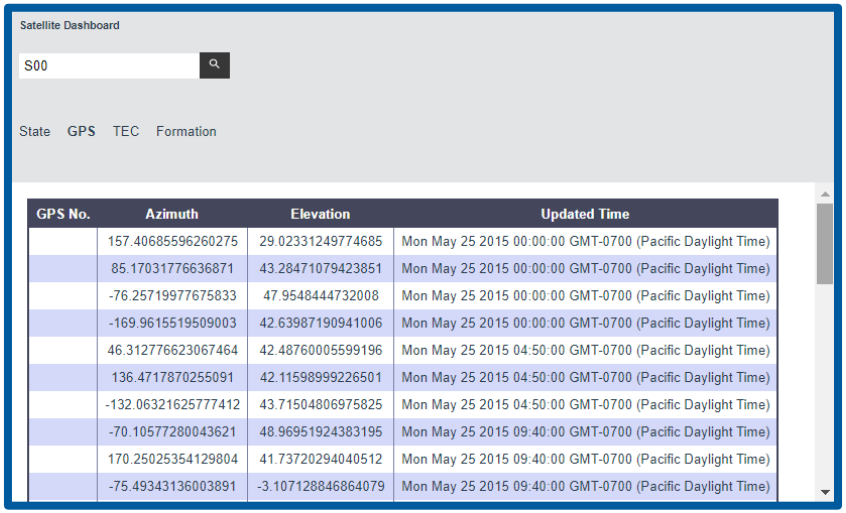
Dashboard



- Multiple tabs for different views
- More detailed data

Dashboard





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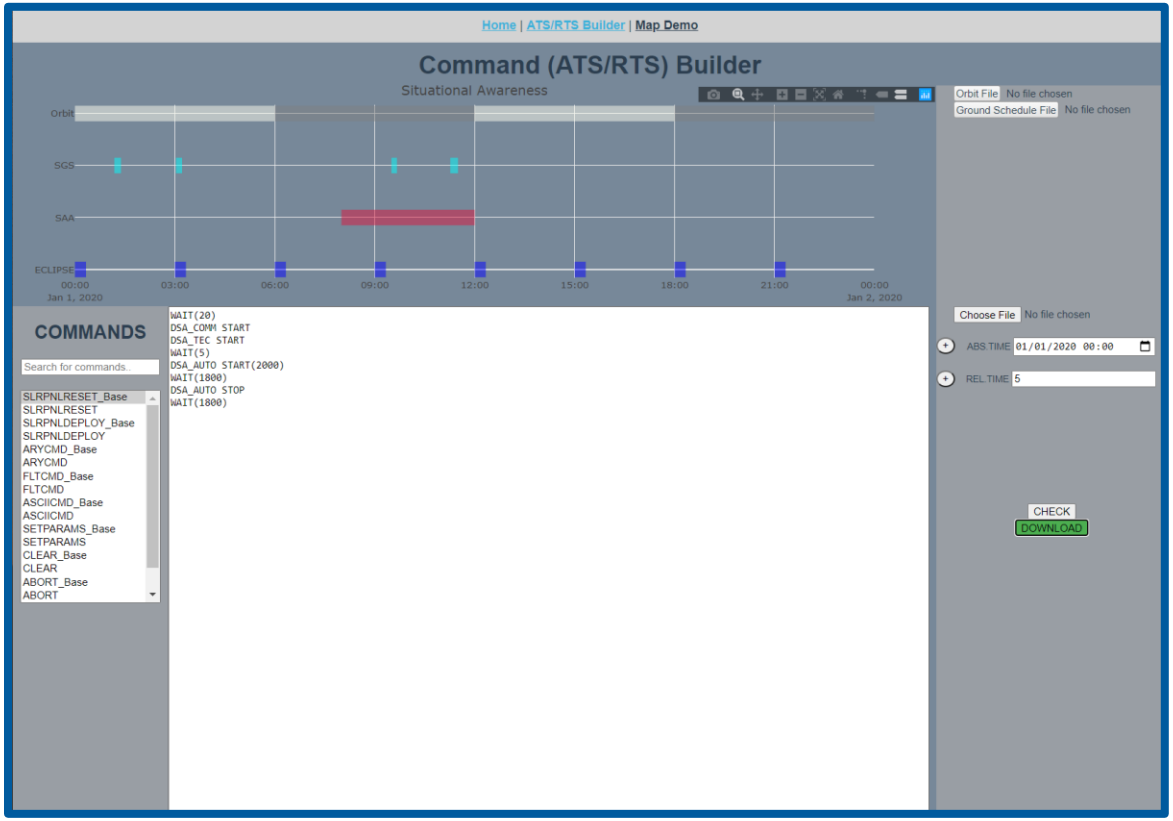
Command Builder

- Build ATS/RTS commands
- Check for flight rules



References

1. A. Kolling, P. Walker, N. Chakraborty, K. Sycara, and M. Lewis. Human interaction with robot swarms: A survey. IEEE Transactions on Human-Machine Systems, 46(1):9–26, Feb 2016.

2. Hussein, A.; Abbass, H. Mixed initiative systems for human-swarm interaction: Opportunities and challenges. In Proceedings of the 2018 2nd Annual Systems Modelling Conference (SMC), Canberra, Australia, 4 October 2018; pp. 1–8. [Google Scholar]

3. NASA Images www.nasa.gov