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ART-015: New Observing Strategies Testbed (NOS-T) Design and Development

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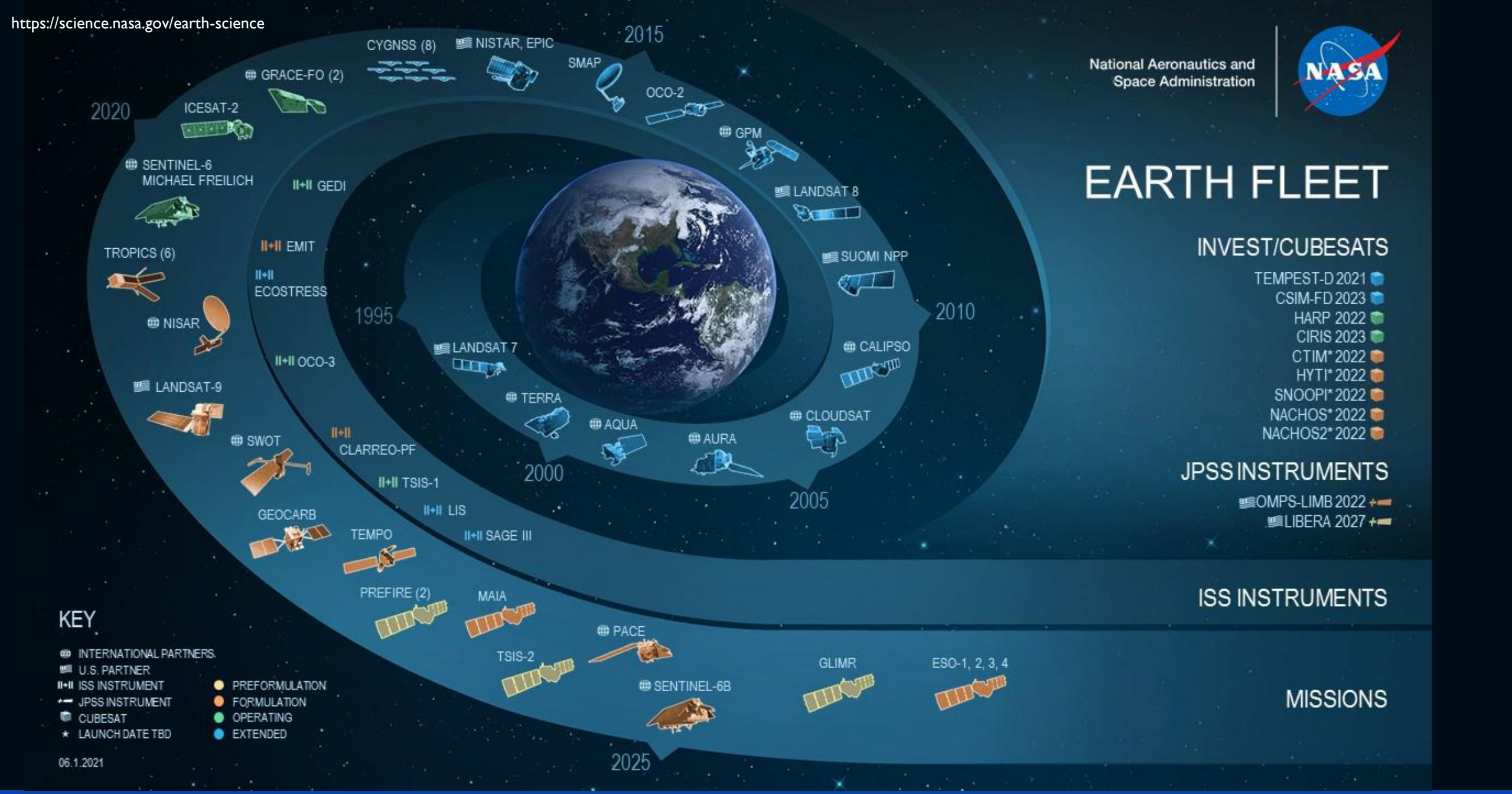
Agenda

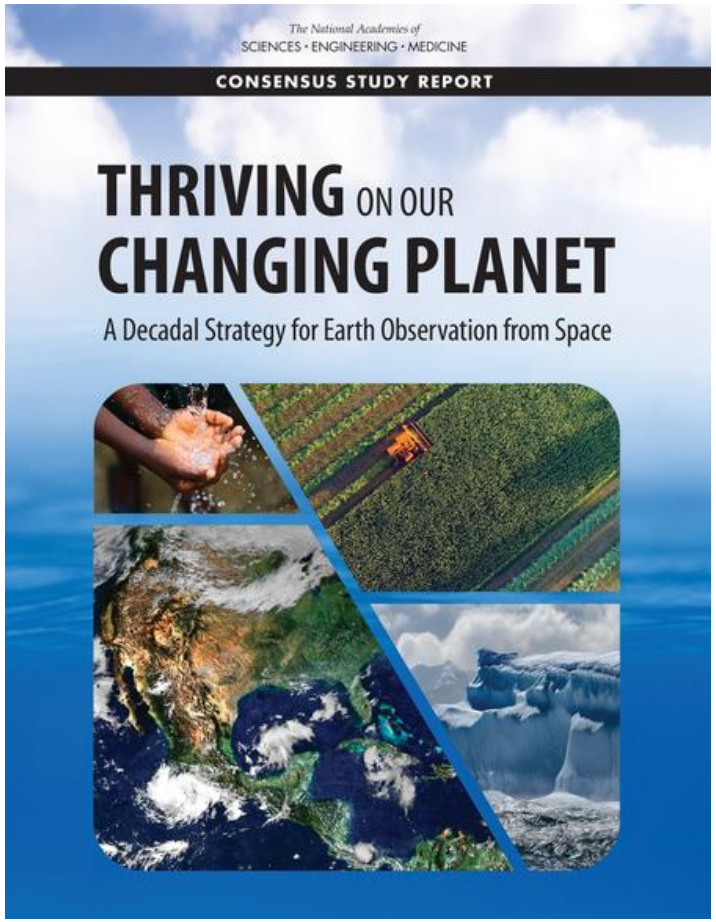
- Context and Background
  - NASA's Earth Science Program
  - New Observing Strategies (NOS)
- NOS Testbed Framework
  - Development Principles
  - Concept of Operations
  - Governance
  - System Architecture
- Example Application Cases:
  - Simulated Mission
  - Real-time Mission
- Technical Architecture
  - Event-driven Architecture
  - Application Interfaces

https://science.nasa.gov/earth-science



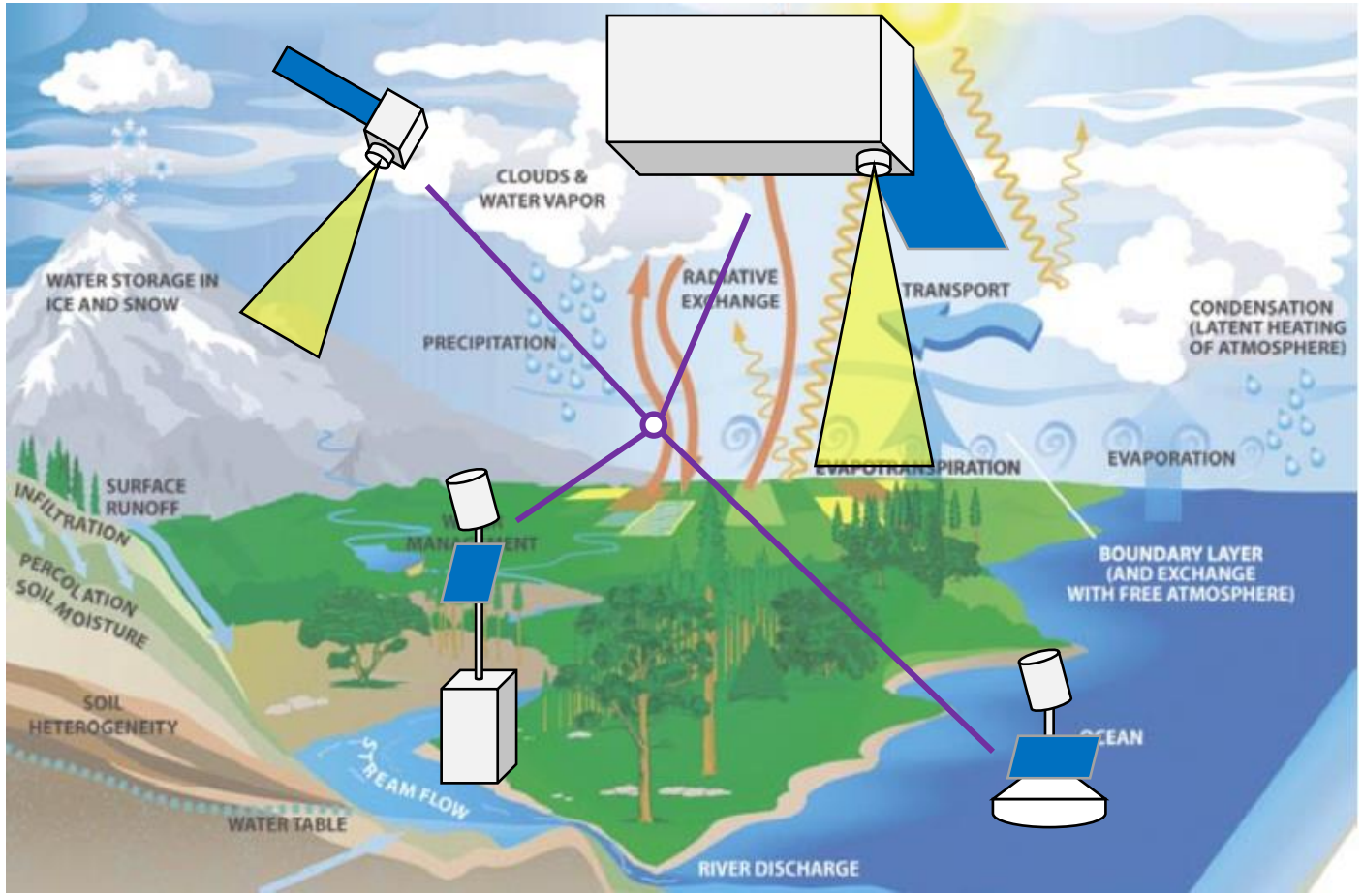
2017 Decadal Survey Strategy Elements

1. Sustained Science and Applications
2. **Innovative Methodologies**
3. Cross-Benefit of Science and Applications
4. **External Resources and Partnerships**
5. Programmatic Agility and Balance
6. **External Trends**
7. Competition
8. Ambitious Science and Applications



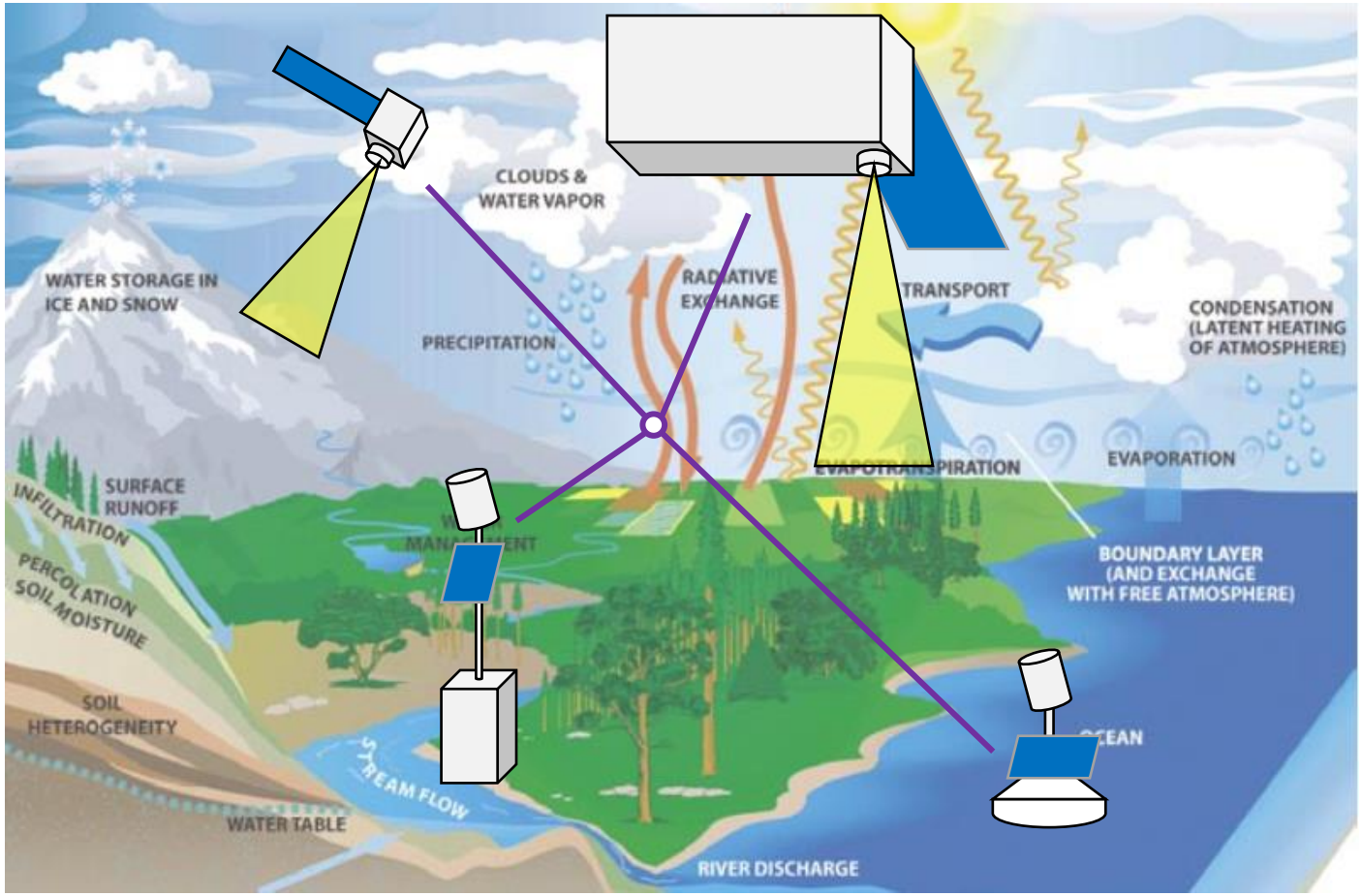
https://doi.org/10.17226/24938

New Observing Strategies (NOS)



- **Optimize** measurement acquisition using diverse observing capabilities
- **Observe** phenomena from different spatial/temporal/spectral vantage points
- **Coordinate** observations based on events, forecasts, or science models
- **Leverage** both NASA and non-NASA assets and data sources

NOS Testbed (NOS-T) Objectives

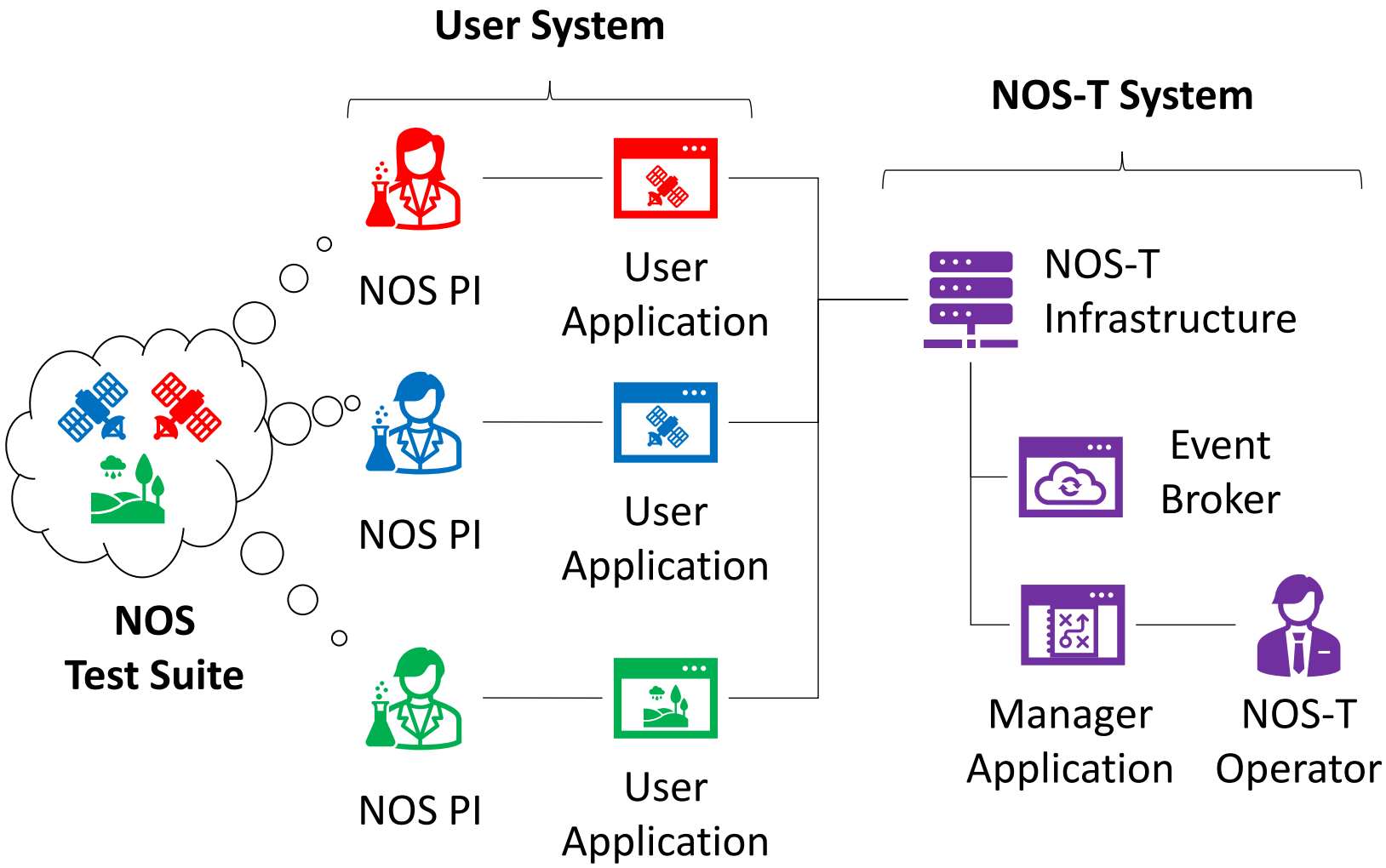


- **Validate** NOS technologies, independently and as a system
- **Demonstrate** novel distributed operational concepts
- **Enable** meaningful comparisons of competing technologies
- **Socialize** new technologies and concepts with the science community by significantly retiring the risk of integration

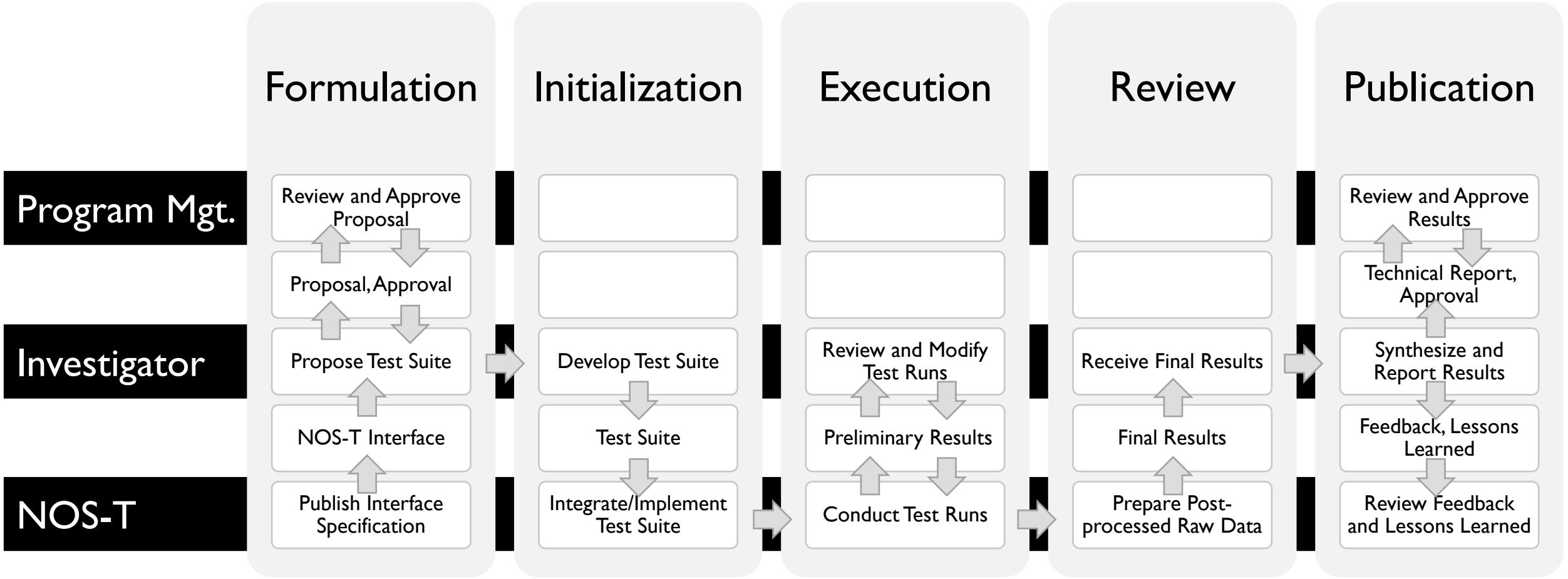
NOS-T Design and Development Objectives

- **Enable disparate organizations to propose and participate in developing NOS software and information tech using the Testbed**
- NOS-T Framework Architecture:
  - Concept of Operations
  - Governance
  - Technical Protocols and Interfaces
- Iteratively develop system prototypes and demonstrate NOS-T operation for a representative Earth science mission with at least three nodes
  - Version 1.0 (18 months ending February 2022)
  - Version 2.0 (18 months ending August 2023)

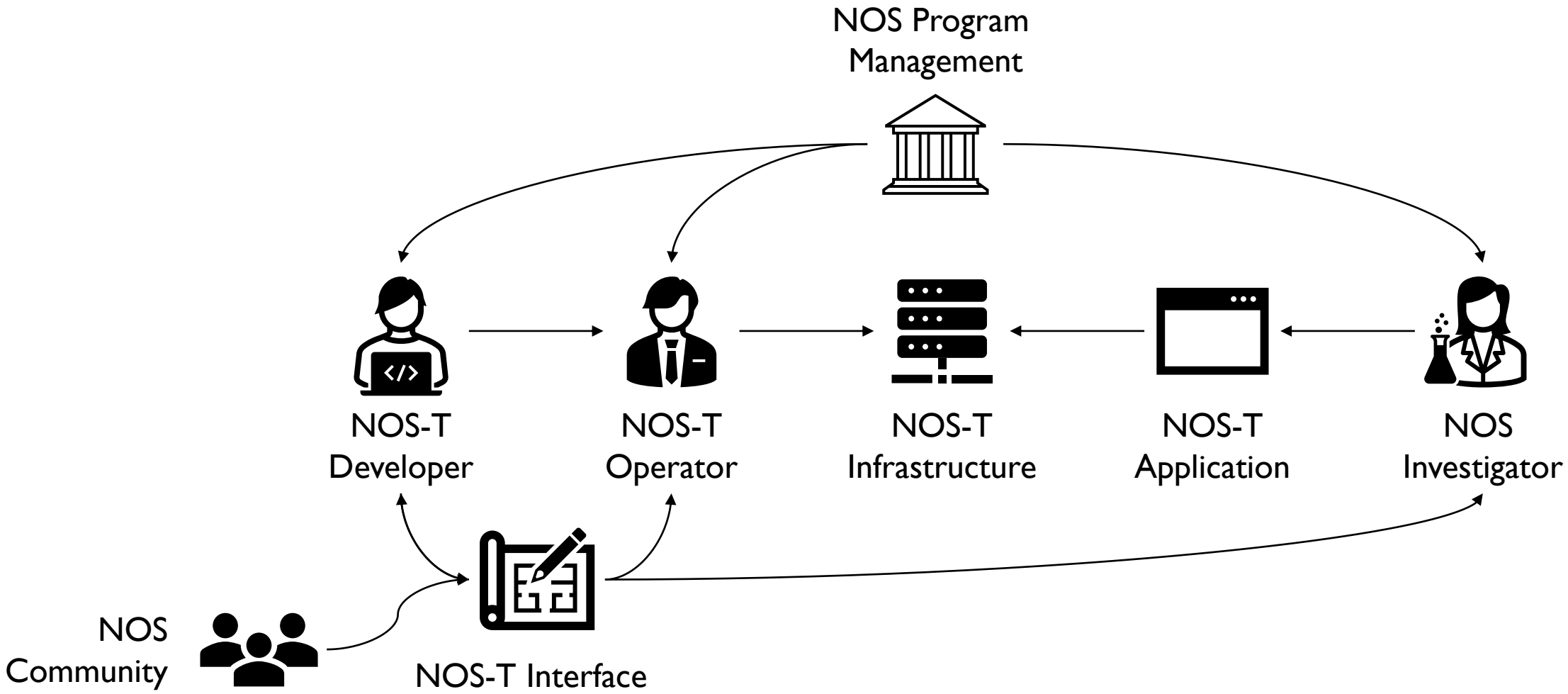
NOS-T Graphical Concept



NOS-T Framework: Concept of Operations



NOS-T Framework: Governance



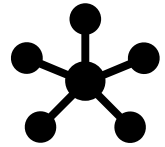
NOS-T Framework: 6 Technical Principles

Geographic distribution: user applications interconnect using standard network interfaces

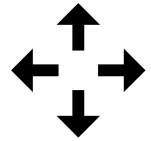
Multi-party participation: user applications exchange limited information via standard messaging protocols

Security: encrypt transport data, provide fine-grain access control rules, monitor hosted infrastructure on authorized information systems

Modularity: loose coupling allows components to be added and updated without modifying the testbed



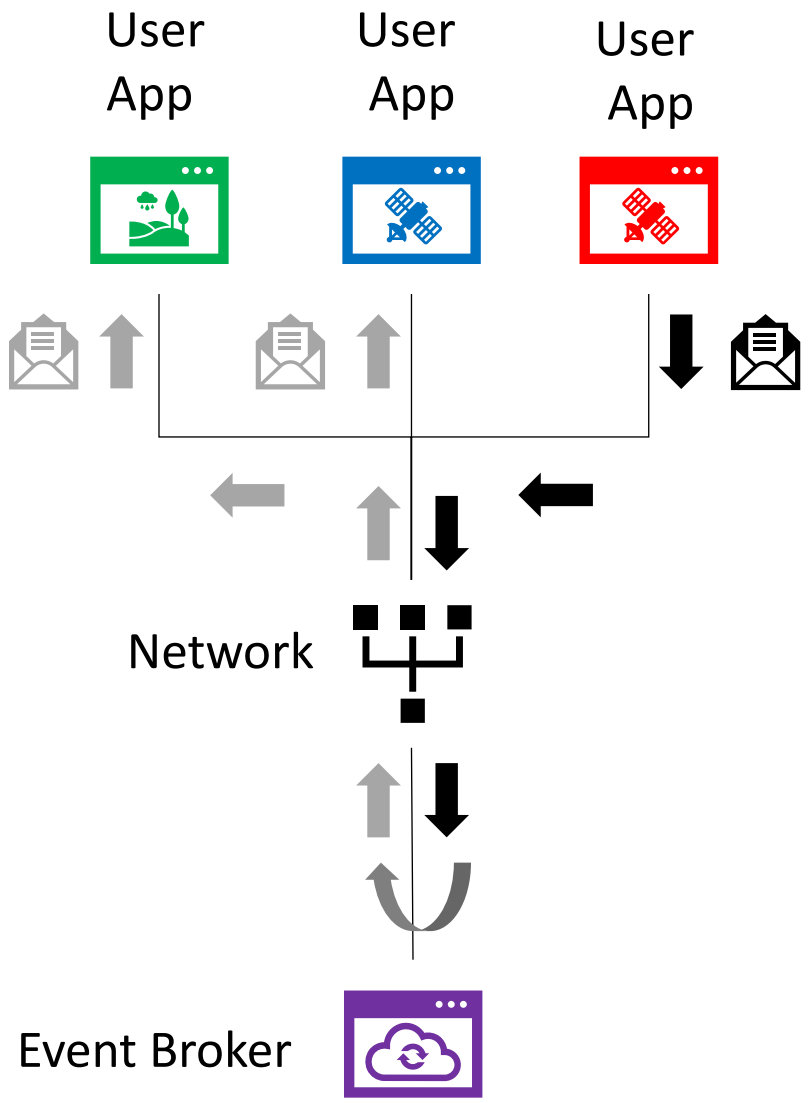
Extensibility: vary the number or capabilities of user applications to explore a wide range of test cases



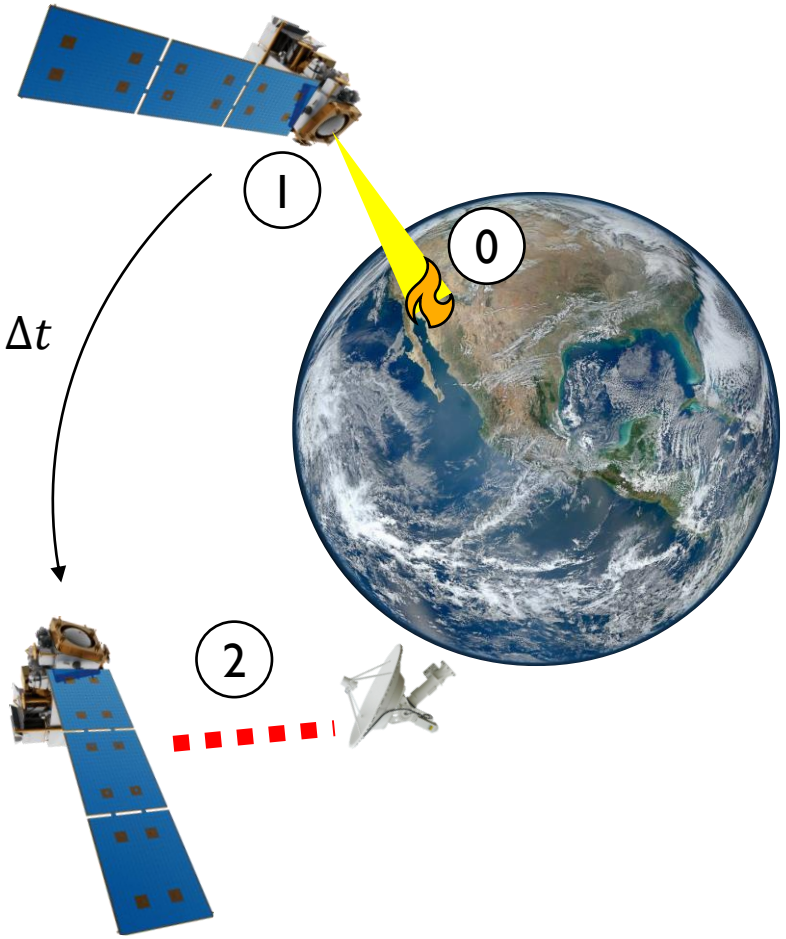
Usability: allow members of the Earth science community to develop test cases and user applications without a substantial learning curve

Event-driven Architecture

- Applications communicate state changes via *events*
  - **Published** to topics
  - Event broker notifies all **subscribers**
- Solace PubSub+ Standard Broker
  - Up to 1000 concurrent connections and 10,000 messages/second
  - MQTT messaging protocol
  - Hosted on the Science Managed Cloud Environment (SMCE), a FISMA Low cloud information system

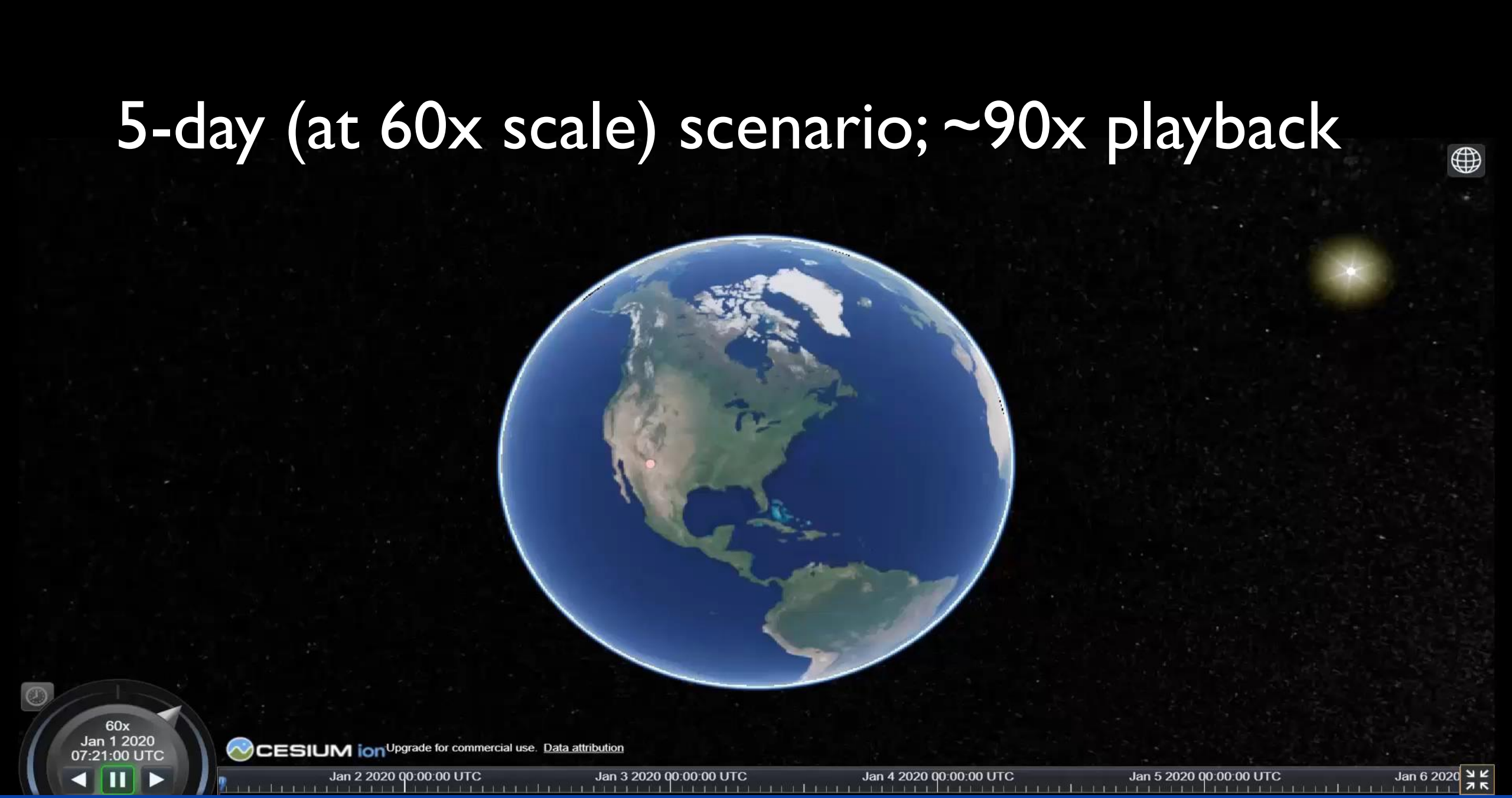


Application Case 1: Simulated Time Execution

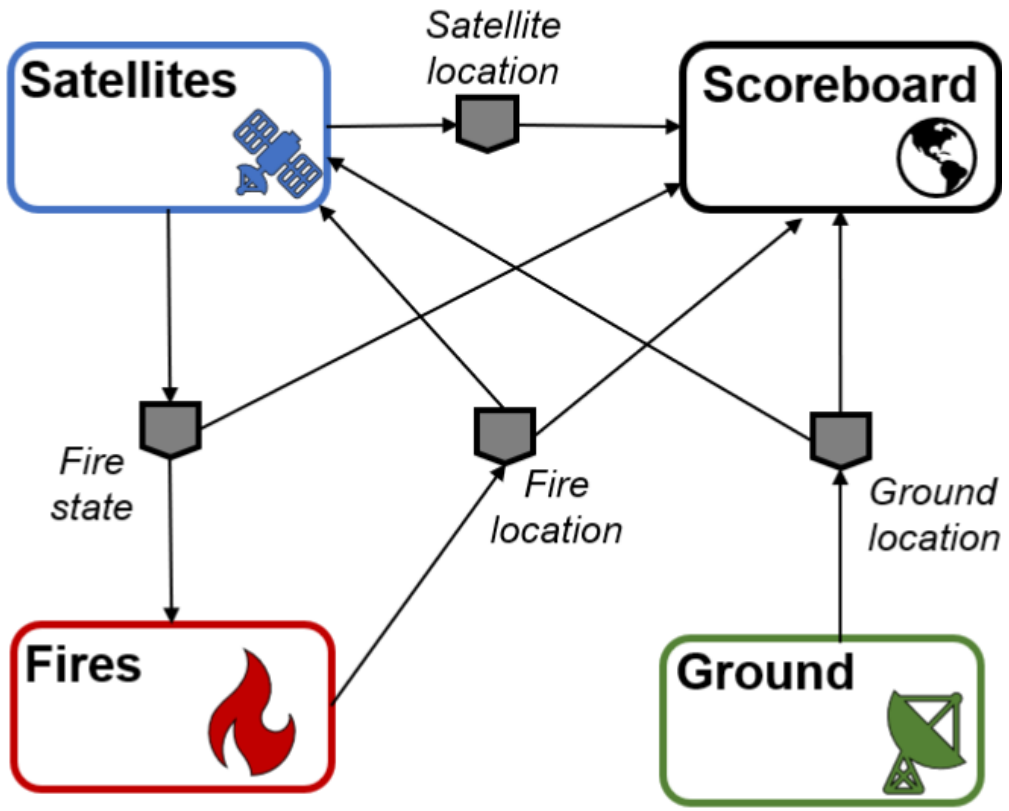


- Fire hazard detection in continental U.S.
  - Initiate fires using 2020 VIIRS data
  - Remote observation by three-satellite constellation
  - Data downlink to ground station
  - Evaluation of key performance measures (observation latency)
- Extensible to design-of-experiment studies to assess observation system variables

5-day (at 60x scale) scenario; ~90x playback

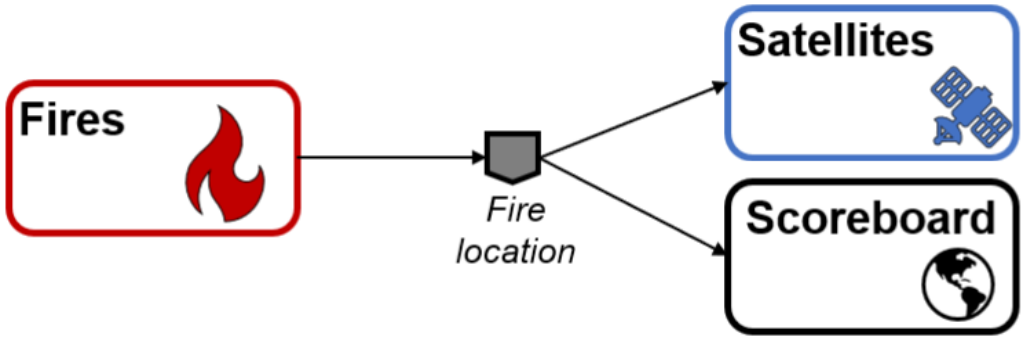


FireSat+ Test Case Architecture

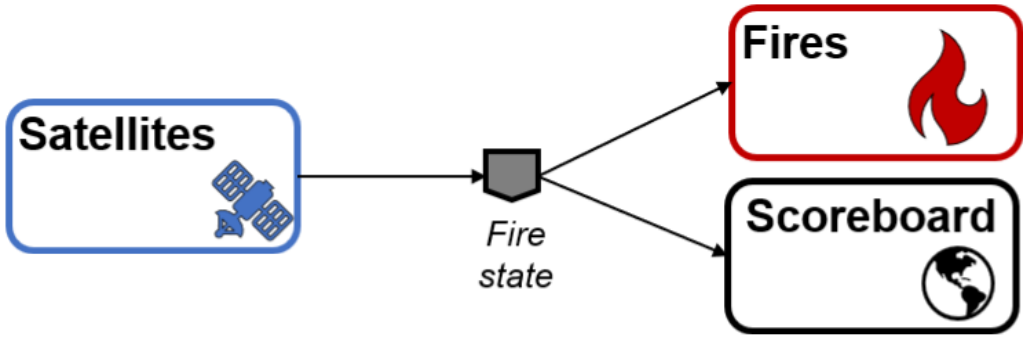


- **Fires:** publishes fire location, records times started/detected/reported
- **Ground:** publishes ground station location
- **Satellites:** models orbit propagation, detects fires, reports fires when link to Ground is possible
- **Scoreboard:** displays graphical representation of mission

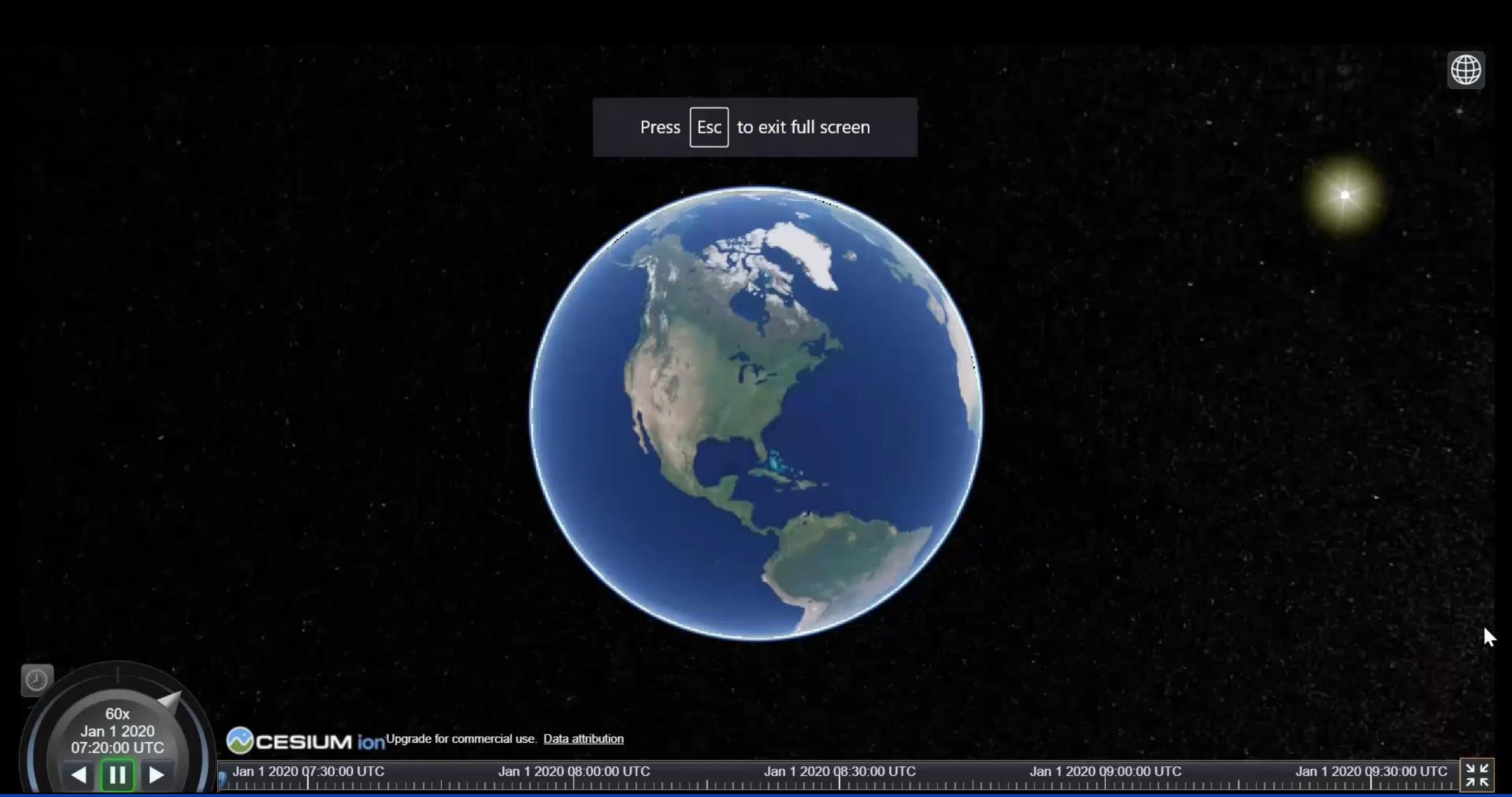
FireSat+ Interface Sample



- Topic:
  - nost-001/fires/location
- Payload:
  - Fire ID, ignition lat/lon, timestamp



- Topic:
  - nost-001/satellite/detected
  - nost-001/satellite/reported
- Payload:
  - Fire ID, satellite ID, timestamp, state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Jan 1 2020 07:30:00 UTC
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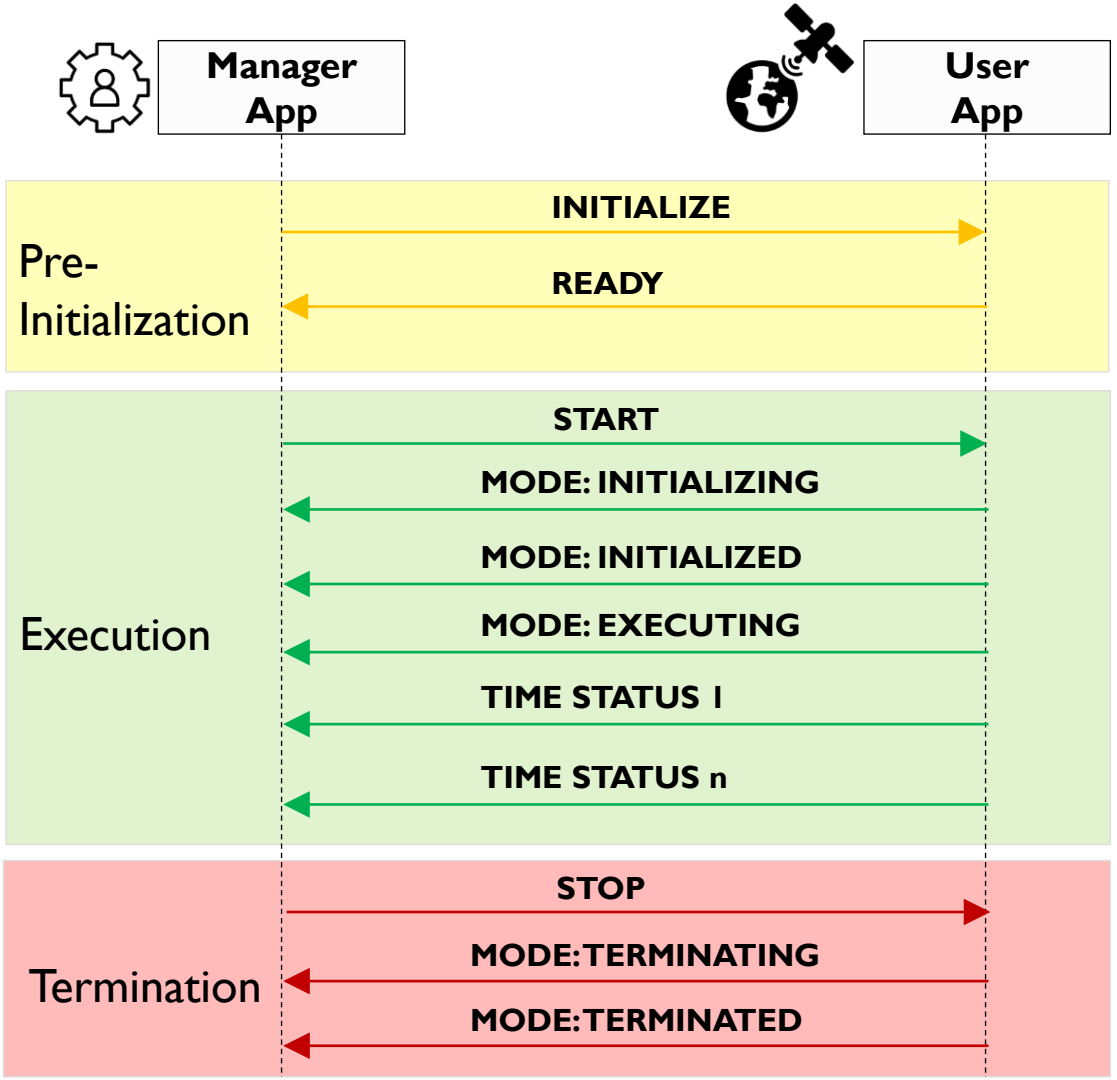
NOS-T Technical Interface

Manager App Messages

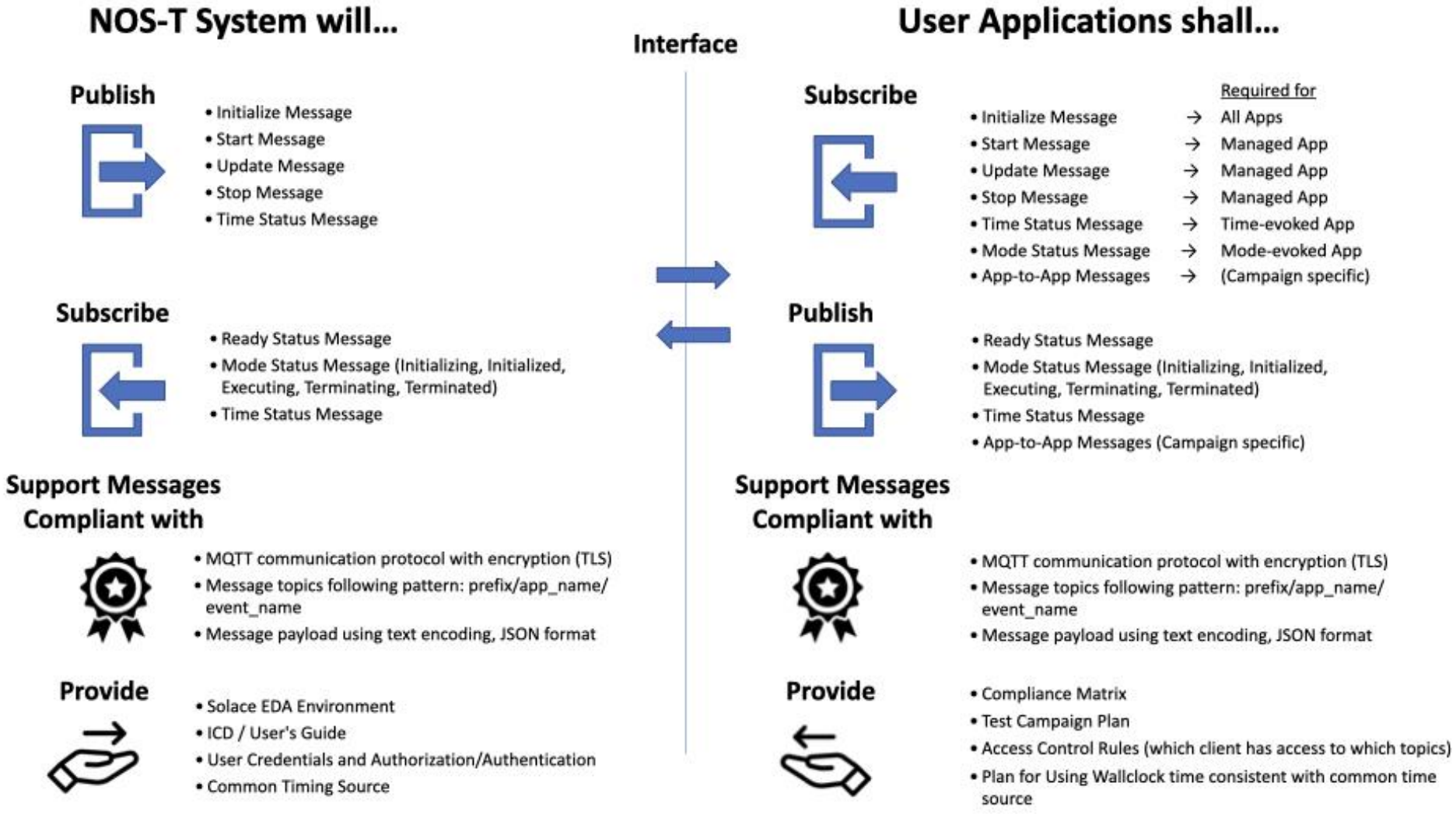
- **Initialize** = Start application
- **Start** = Begin Test Run
- **Stop** = Stop Test Run



User App Messages

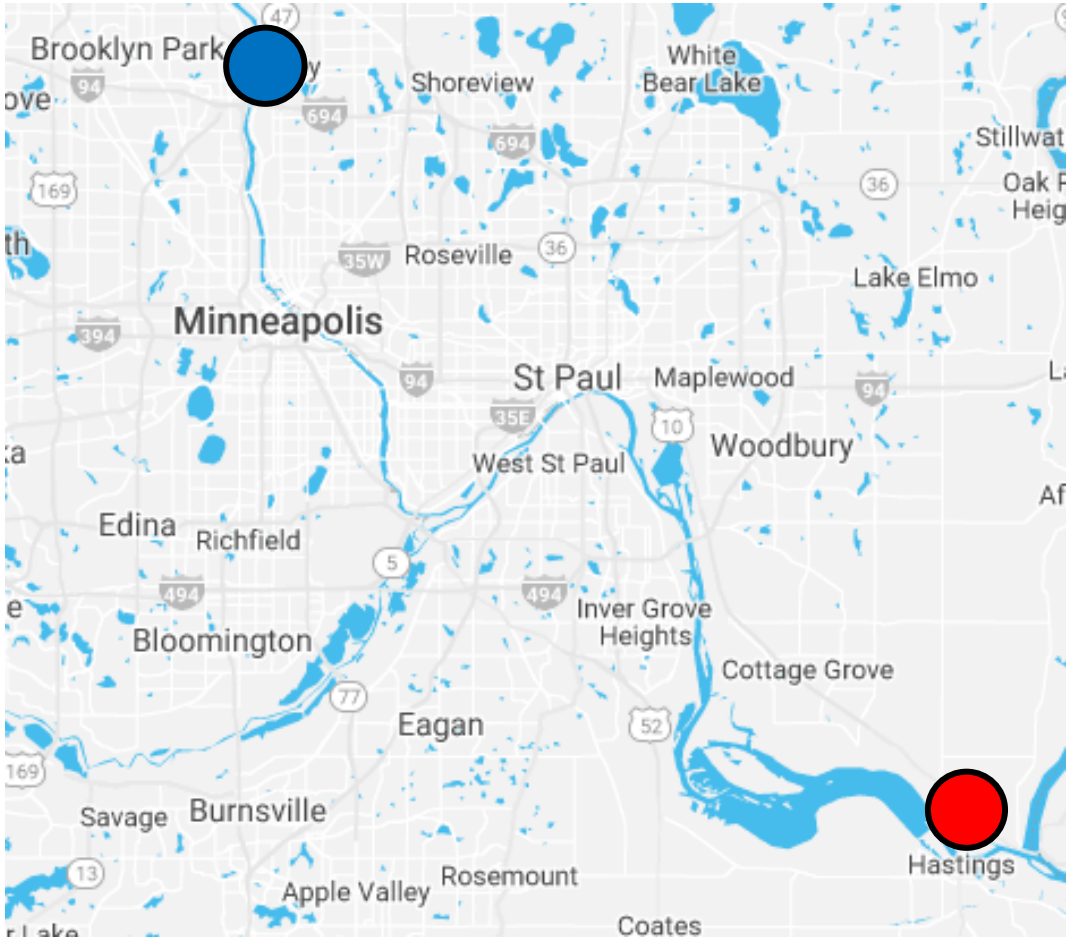
- **Ready** = Ready to Start Test Run
- **Mode: Initializing** = App begins initialization
- **Mode: Initialized** = App is initialized
- **Mode: Executing** = App is Executing
- **Time Status** = Heartbeat
- **Mode: Terminating** = App begins termination
- **Mode: Terminated** = App has terminated run

NOS-T Interface Specification

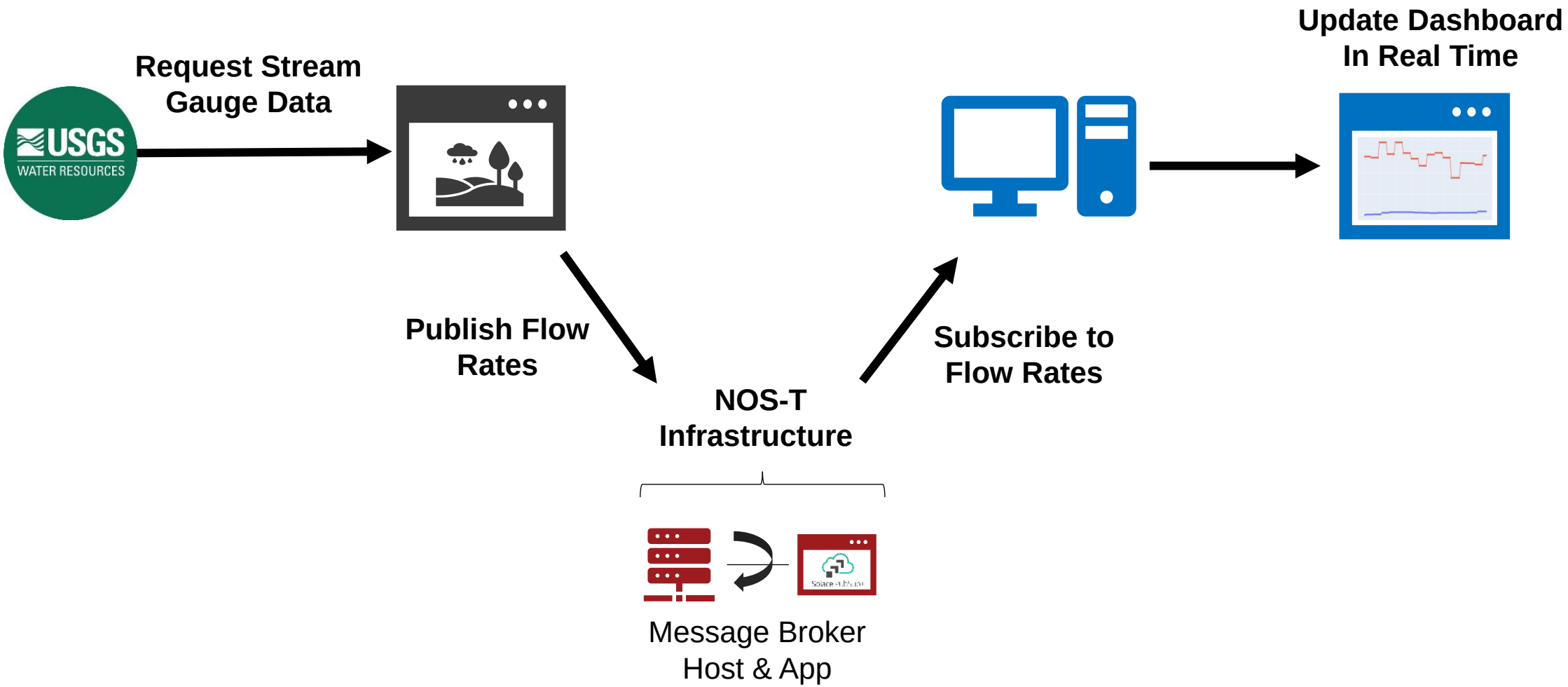


Application Case 2: Real-time Test Case

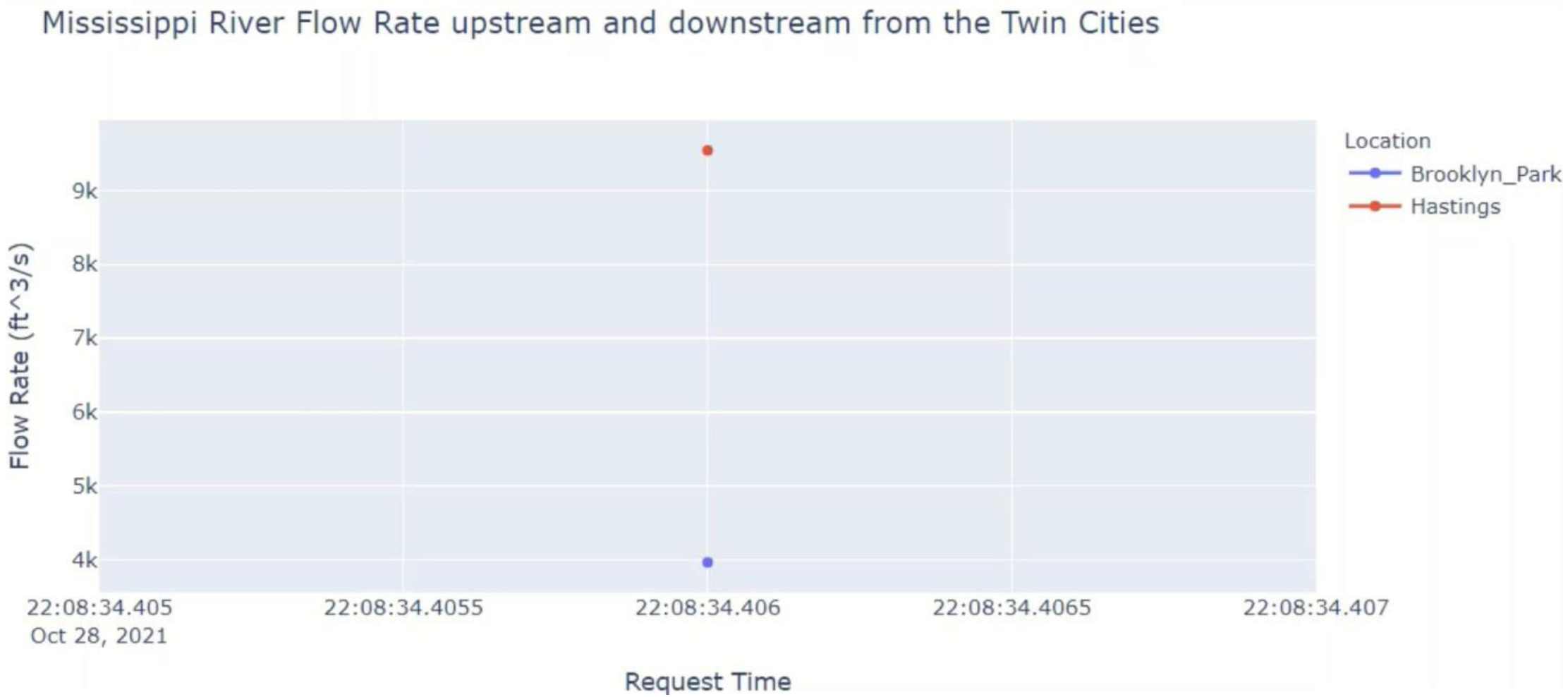
- Real-time stream gauge data retrieved via web requests from the USGS National Water Information System (NWIS)
  - Displays flow rates from two sensors on a dashboard – Mississippi River above and below Minneapolis/St. Paul
  - Demonstrates ability to use real-time data for a test case
- Extensible to trigger spacecraft observations when certain flow rates are met



Real-time Case: Application Architecture



15-hour (real-time) scenario; 2000x playback



Summary

- NOS-T provides an information system to prototype NOS missions
  - **Validate** NOS technologies, independently and as a system
  - **Demonstrate** novel distributed operational concepts
  - **Enable** meaningful comparisons of competing technologies
  - **Socialize** new technologies and concepts with the science community by significantly retiring the risk of integration
- NOS-T framework provides an initial concept of operations, governance model, and technical interface specification
  - Loosely-coupled applications via an event-driven architecture
  - Application cases demonstrate simulated and real-time scenario execution

Acknowledgements

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