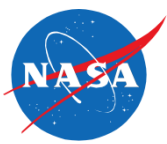


AAM NC ATI Tech Talk Series

Aerograph Architecture



Divya Bhadoria, Tim Bagnall, Jerry Wilwerding, Amanda Unger
ATI Data Services | May 2022



About NASA's AAM NC Tech Talks

- Purpose of these talks is to engage with the community on types of technologies NASA is designing and developing in support of Advanced Air Mobility
 - Additional Tech Talks are planned
 - <https://www.nasa.gov/aamnationalcampaign/techtalks>
- Ground rules:
 - Answers to questions you have may be in upcoming slides
 - It's okay to ask an important question on a slide, but if it can wait then please do so
 - Mute your mic unless you need to talk
 - We'll keep an issues parking lot to keep the Tech Talk on point and on time
 - Remember the Tech Talk is being recorded for NASA and its Partners
- **Recording.** NASA is recording these Tech Talks and will post online, once approved for external release

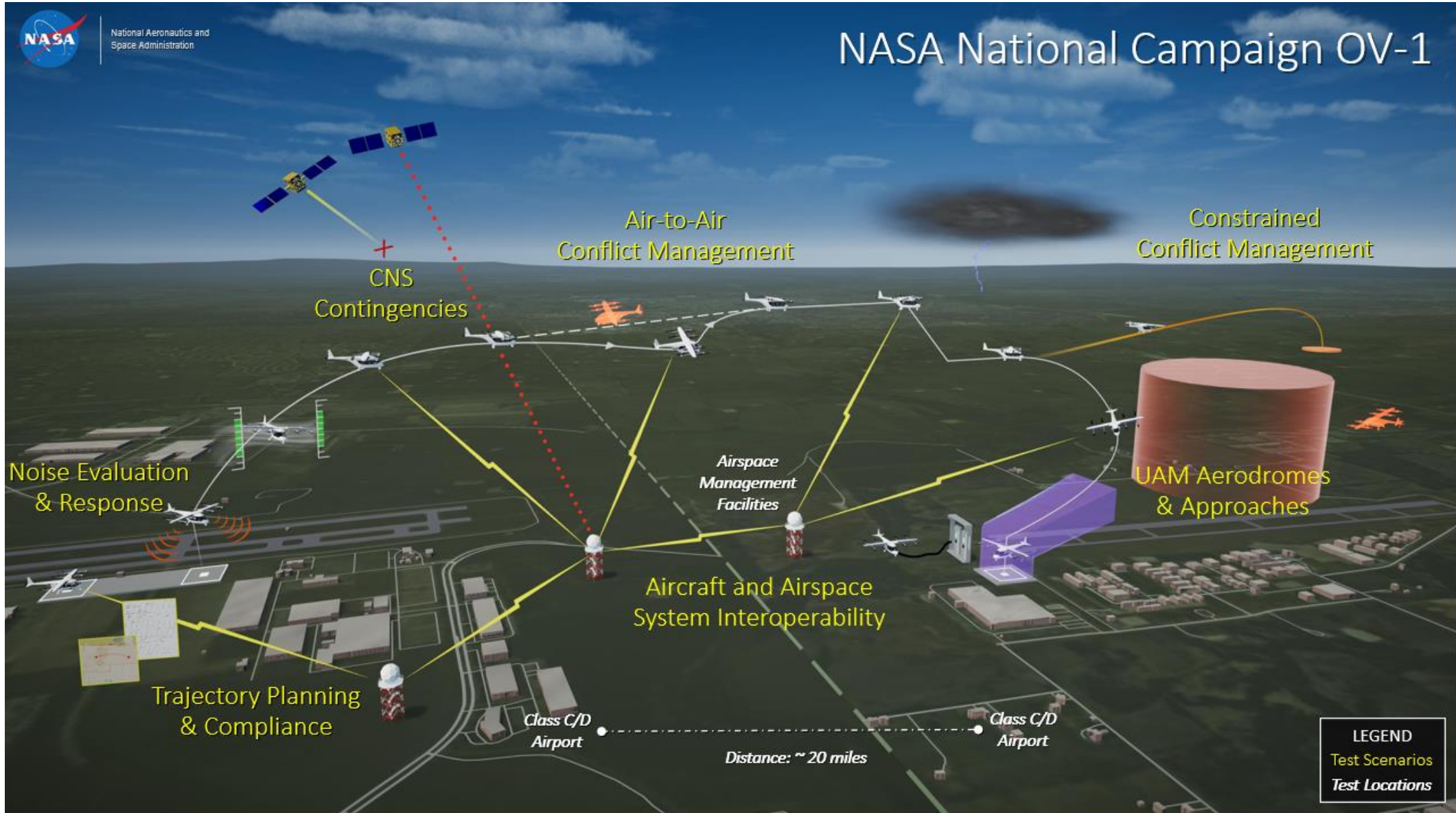


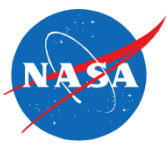
Agenda

- Overview
- Architecture
- Next Steps
- Summary



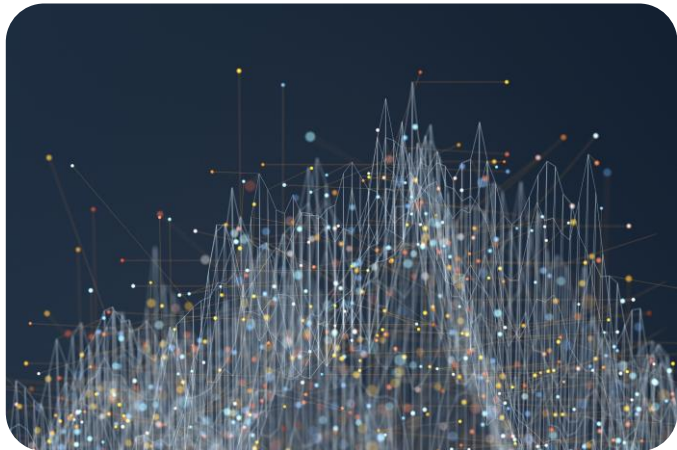
Aerograph National Campaign Operational View





Aerograph Overview

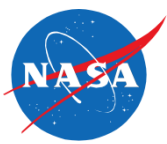
- Aerograph is NASA's data management system for Advanced Air Mobility.
- Its mission is to support AAM research by providing a reliable and secure system that collects, stores, protects, and shares AAM data.
- Its vision is to provide a system that AAM research scientists, aerospace engineers, data scientists, and analysts trust for obtaining NC data and performing key analyses.



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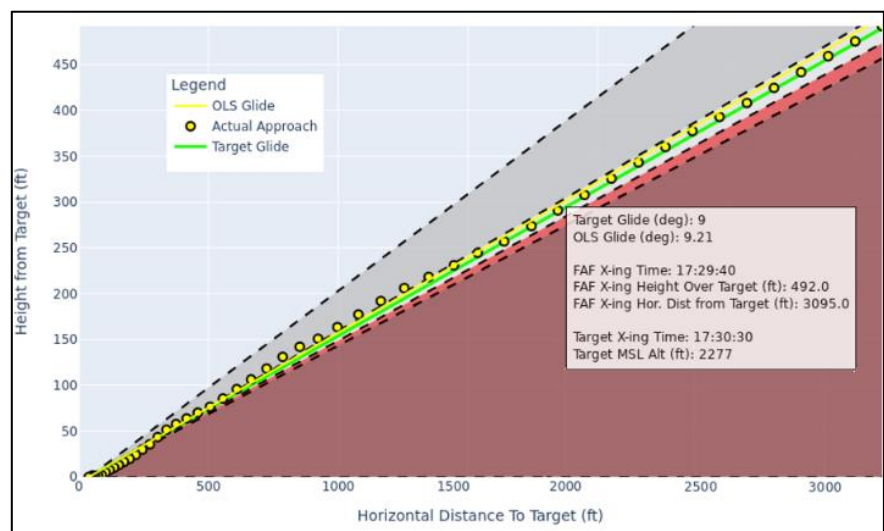


“You cannot have information without data.” — Daniel Keys Moran

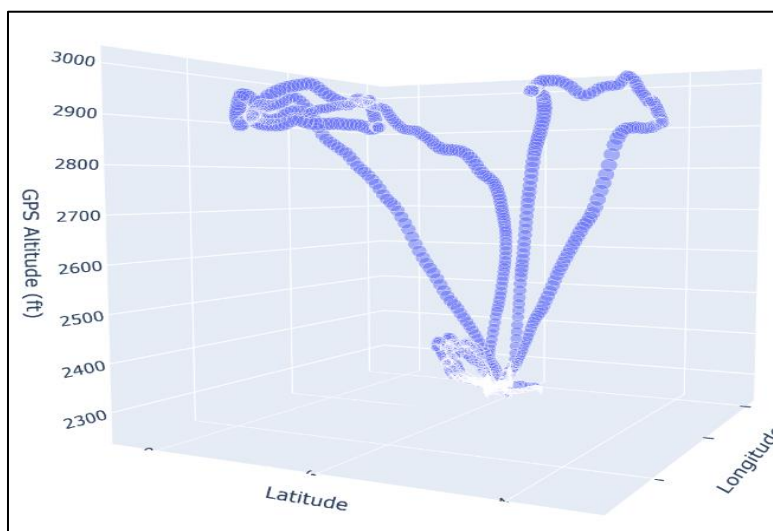


Aerograph Data

- The types of data Aerograph manages involves data related to flight test events, including:
 - Aircraft Performance and Characterization (e.g., position reports)
 - Airspace (e.g., operation intent, waypoints, and constraints)
 - Environment (e.g., surface and wind weather)
 - Infrastructure (e.g., surveillance coverage)
 - Derivative Analytical Artifacts (e.g., glide path performance chart, 3D position chart, Integrated Data Product)



Glide Path Performance Chart



3D Track Position

UTC	LAT	LONG	ALT	WIND	GUST
2021-04-11 16:28:38.01	38.03	78.05	2590.32	3.7	12.3
2021-04-11 16:28:38.02	38.03	78.02	2590.30	4.7	14.1
2021-04-11 16:28:38.03	38.04	78.01	2588.39	4.4	11.6
2021-04-11 16:28:38.04	38.03	78.01	2592.39	3.4	13.7
2021-04-11 16:28:38.05	38.03	78.01	2594.03	3.7	17.0
2021-04-11 16:28:38.06	38.04	78.02	2595.08	3.0	14.5
2021-04-11 16:28:38.07	38.04	78.03	2594.90	3.4	11.5
2021-04-11 16:28:38.08	38.04	78.05	2593.32	3.0	13.5
2021-04-11 16:28:38.09	38.04	78.03	2595.86	2.8	13.9
2021-04-11 16:28:38.10	38.04	78.03	2596.64	2.7	14.0
2021-04-11 16:28:38.11	38.04	78.03	2597.43	2.5	14.1

Integrated Data Product*

* Planned for a future Tech Talk Topic

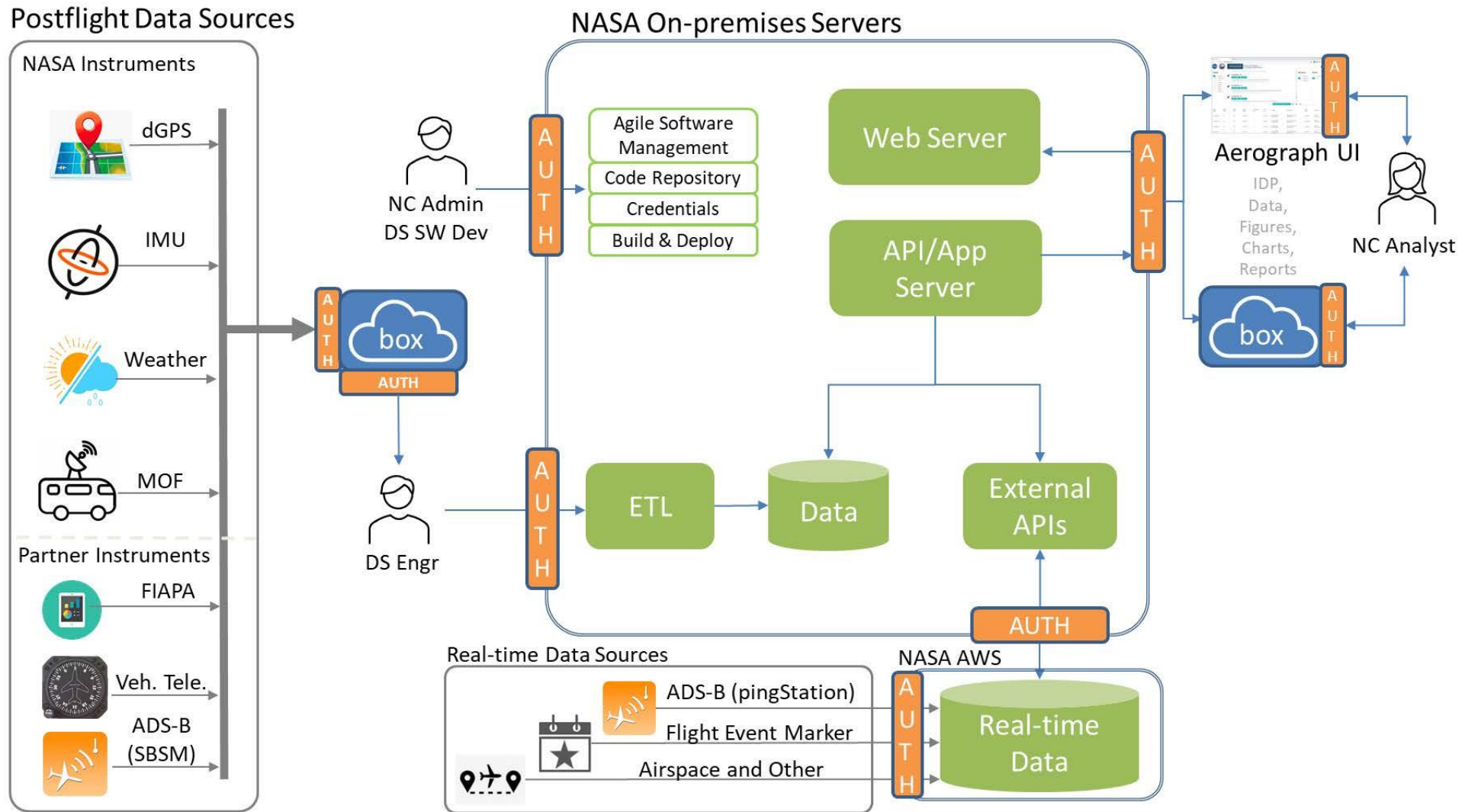


Aerograph Capabilities

Capability	Description
Pipeline	<p>Through real-time RESTful endpoints, the pipeline ingests many types of aircraft, airspace, and environment data</p> <p>* The NASA AAM NC Data Pipeline plays a significant role in ingest. Watch a Tech Talk on the Pipeline here: https://www.nasa.gov/aamnationalcampaign/techtalks</p>
Post-Flight Ingest/ETL	<p>Aerograph <i>Extracts, Transforms, and Loads</i> data into choice databases (e.g., graph, timeseries, relational)</p>
Automated Analytics	<p>Aerograph invokes algorithms to automate the production of analytical artifacts (e.g., glide path charts, altitude profiles, track overlays, etc.)</p>
Access and Retrieval	<p>Aerograph provides two mechanisms for accessing and retrieving data: 1) Box, and 2) a Native User Interface</p> <ul style="list-style-type: none">• Box is a NASA-approved, FIPS 140-2 certified, commercial cloud-based file storage system• The Aerograph UI provides an intuitive and well-organized interface tailored to the AAM analyst• REST services exist allowing direct access to data and analytical products
Security	<p>Aerograph follows standard security best-practices, including:</p> <ul style="list-style-type: none">• Two-factor Authentication (2FA)• Security Assertion Markup Language (SAML) 2.0• Personal Identity Verification (PIV)• OAuth 2.0• Transport Layer Security (TLS) 1.2 AES 256-bit file encryption



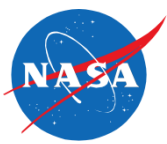
Aerograph Overview – System Architecture





Aerograph Architecture – Free and Open Source Software (FOSS)

- Why leverage FOSS Components?
 - Proven reliability
 - Faster development time
 - Responsible use of taxpayer dollars



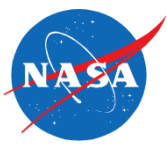
Aerograph Architecture – Data Stores

- Data Stores
 - Timescale
 - FOSS application that extends PostgreSQL
 - Optimized for time series data
 - Relational data store
 - <https://www.timescale.com/>
 - MongoDB
 - Document based database
 - Unstructured data store
 - <https://www.mongodb.com/>
 - Dgraph
 - Graphing database that allows complex relationships to be captured
 - Leverages GraphQL or DQL
 - <https://dgraph.io/>
 - Parquet
 - Not a traditional data store, but an efficient file format
 - Column-oriented data file for efficient storage and retrievals
 - <https://parquet.apache.org/>



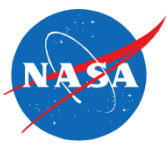
Aerograph Architecture – Inter-process Communication

- Apache ActiveMQ
 - MessageBroker that supports clients in many languages and platforms
 - Allows messages to be sent to a single consumer (Queues) or multiple consumers (Topics)
 - <https://activemq.apache.org/>
- Apache Camel
 - Integration framework that allows various systems consuming or producing data to work seamlessly together
 - Supports Enterprise Integration Patterns with extensive out of the box capabilities
 - Supported by many languages and platforms
 - <https://camel.apache.org/>
- Apache HTTPD
 - Acts as an entry point / gateway to server-side components
 - Routes requests to the correct application
 - <https://httpd.apache.org/>



Aerograph Architecture – Security

- KeyCloak
 - Provides Authentication
 - Integration with NASA Launch Pad to support PIV based access
 - Supports username and password access
 - Provides Authorization
 - Users are mapped to roles and groups to control access to data at a granular level
 - All data requests are validated against these configurations to control access
 - Supports OpenID Connect, Oauth 2.0 and SAML
 - <https://www.keycloak.org/>



Aerograph Architecture – Exposing Content to Users

- Aerograph User Interface
 - A browser application that provides analysts and users access to flight test data and analytics
 - Leverages the security components for authentication and authorization to protect data
 - **Topic of a future TechTalk**
- Web Services via REST interfaces
 - All data retrieval is supported through a set of REST API
 - Most responses are JSON
 - Allows integration with clients in many languages and platforms
- Box
 - NASA Box provides secure access to sensitive data
 - Extensive NASA user vetting process
 - CUI training
 - NAMS approval
 - Folder and file level permissions granted through groups / roles
 - <https://nasagov.app.box.com/>

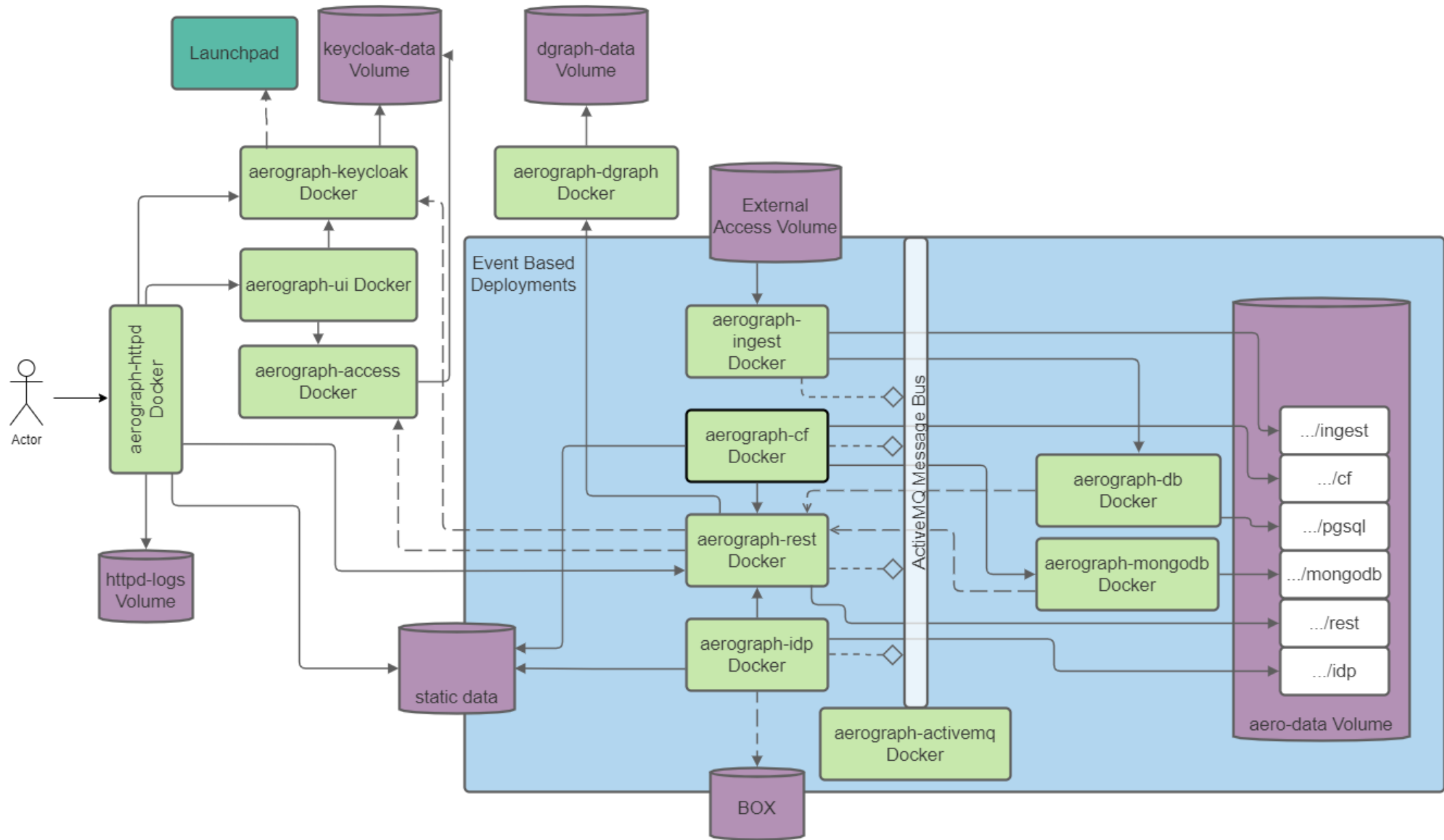


Aerograph Architecture – Deployment

- Docker
 - Container based approach for deploying applications
 - Base Images provide a consistent starting point for deployments
 - Custom software applied over the base image
 - Tailoring for deployed environments
 - Container management, network management, scaling, etc. through configurations
 - <https://www.docker.com/>

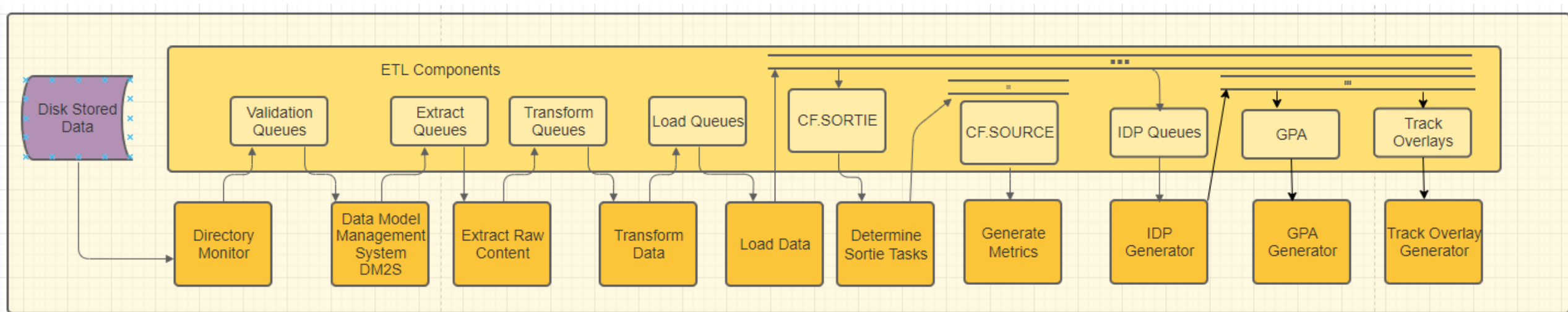


Aerograph Architecture – Putting the Pieces Together



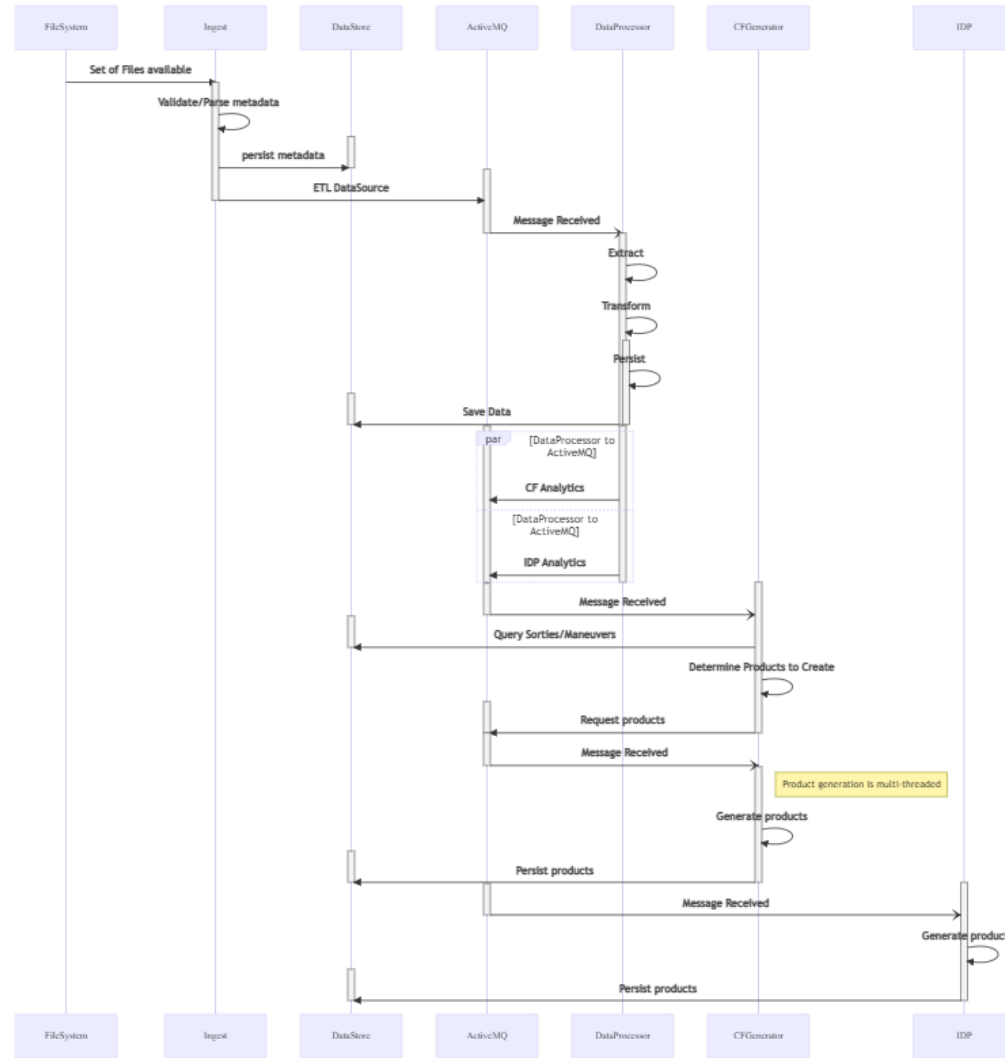


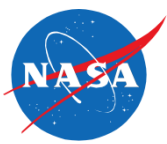
Aerograph Architecture – Nominal Message Flow Diagram





Aerograph Architecture – Nominal Process Orchestration





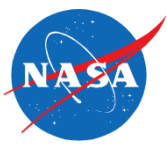
Aerograph Architecture – Nominal Process Orchestration

- Messaging drives the data workflow through the system
- Camel uploads products through its File Monitoring components
- Files are routed through the ingest / ETL components by writing messages to queues
- Design patterns allow for new data sources to be injected into the ingest framework
- Queue listeners for specific data formats process messages with content persisted in a data store
 - Queue listeners allow for vertical scaling by configuring additional instances / threads
- After ETL, messages are sent simultaneously to multiple queues to start the generation of analytical products
- Generation of analytical products may send additional message to other queues to further multi-thread generation or create additional products
- All analytical products are stored
 - Metadata is stored in MongoDB
 - Actual product is stored on disk and retrievable via its metadata

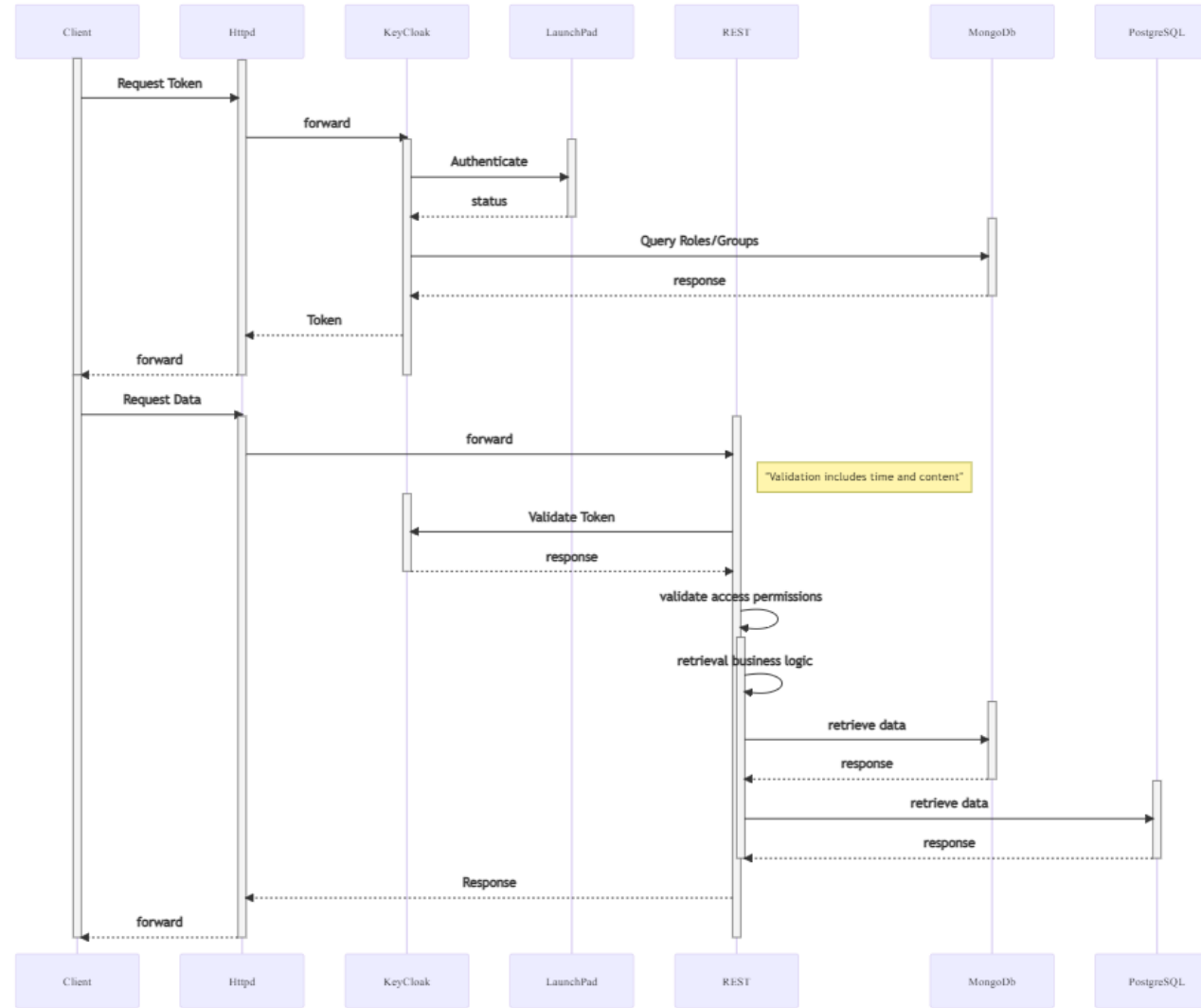


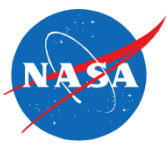
Aerograph Architecture – REST Retrievals

- REST retrievals for data leverage POST and GET requests depending upon the complexity of the parameters
- POST requests have parameters passed within a json object that conforms to a well-known schema
- GET requests follow KVP patterns
- Most responses are in JSON format
- What can be retrieved via REST?
 - Metadata
 - Actual data
 - Analytics



Aerograph Architecture – REST Retrievals





Aerograph User Interface*

The screenshot displays the Aerograph web application interface. At the top, there is a navigation bar with the NASA logo, the Aerograph title, and the subtitle 'AAM National Campaign Data Management System'. On the right side of the navigation bar are icons for home, database, charts, share, and user profile.

On the left side, there is a filter panel with the following settings:

- Event: NC1-DT1-FOFT
- ACID: A124DF
- Date: 2021-11-10
- Flight: 1
- Maneuver: entire_sortie

Below the filters are several toggle switches for data visualization options:

- sodar_heatmap_speed:
- sodar_heatmap_direction:
- sodar_windrose:
- sodar_windrose_by_height:
- sodar_time_series:

The main content area contains three charts:

- sodar_heatmap_speed**: A heatmap titled 'Wind Speeds (ws), Sodar Station, 2021-11-10'. The y-axis represents height in meters (20 to 250), and the x-axis represents time in UTC (14:52:00 to 16:14:00). A color scale on the right indicates wind speed in m/s, ranging from 0 to 12.
- sodar_heatmap_direction**: A heatmap titled 'Wind Direction (wd), 2021-11-10'. The axes are the same as the speed heatmap. A color scale on the right indicates wind direction in degrees, ranging from 0 to 300.
- sodar_windrose**: A wind rose chart titled 'Wind Speed & Direction, 2021-11-10'. It shows wind direction distribution with segments for N-W, N, and N-E. The N segment is labeled with 12.2% (total measurements: 1967) and the N-E segment is labeled with 9.76%.

* Planned for a future Tech Talk Topic

- Shares concept for previewing and downloading flight test event charts and tables
- A role-based access control (RBAC) system qualifies user access to data
- Other capabilities not shown include:
 - Raw data preview and download
 - IDP preview and download
 - ATI flight test report download



Aerograph Next Steps

- Support Additional Data Sources as needed
- Incorporate Additional Analytics
- Scale the application to handle greater volumes of products and users
- Continue to evolve with the dynamic research needs of the AAM program
- Future Aerograph Tech Talks
 - Aerograph User Interface
 - Integrated Data Product



Aerograph Summary

- This tech talk covered technical details of NASA's Aerograph Architecture
- Aerograph is NASA's AAM data management system, providing a reliable and secure system that collects, stores, protects, and shares AAM data
- A regimented data governance and security policy presides over its design and implementation, helping to protect proprietary data and information
- Upcoming NC Tech Talks:
 - Check Link: <https://www.nasa.gov/aamnationalecampaign/techtalks>
- Direct Questions to Divya Bhadoria, Airspace Testing & Integration (ATI) Lead divya.bhadoria@nasa.gov and John Sprague, Data Services Lead, john.sprague@nasa.gov



Aerograph Wrap up

- Questions?



Abbreviations

AAM NC	Advance Air Mobility National Campaign
ADS-B	Automatic Dependent Surveillance - Broadcast
ATI	Airspace Testing & Integration
CNS	Communications, Navigation, and Surveillance
dGPS	Differential Global Positioning System
DQL	Dgraph Query Language
ETL	Extract, Transfer, Load
FIAPA	Flight Inspection Airborne Processor Application
FOSS	Free and Open Source Software
FOFT	Follow On Flight Test
IDP	Integrated Data Product
IMU	Inertial Measurement Unit
MOF	Mobile Operations Facility
NAMS	NASA Account Management System
OLS	Optical Landing System
SBSM	Surveillance and Broadcast Services Monitor
UAM	Urban Air Mobility