

# Data & Reasoning Fabric

## Minimum Viable Product

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### Abstract

Currently, when data is needed to support airspace operations, the required data sources are typically identified by human experts and custom software systems are developed to access or aggregate the needed data into a single software system. Decision support functions are then built into this software system for the specific airspace application. Each airspace application is addressed the same, resulting in very capable, but isolated, vertical integrations or silos. As we move to more data sources and more airspace applications this approach becomes more and more brittle.

As more data sources are provided by an increasingly diverse range of industries, relying on human experts to remain aware of and make safe decisions from all the relevant and often dynamic data sources will increasingly challenge human capabilities and may heavily constrain air mobility scalability. The early internet evolved from a reliance on a human expert's knowledge of available websites, through human-maintained website lists/books, to self-sustained website catalogs and search engines. Access to airspace data sources needs to similarly evolve to be self-sustaining and scalable. It will also be important to provide data customers (for example, a company that wants to provide air mobility functions) the capability to solicit and vet

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new data sources, as well as to support reliable and consistent exchange and interpretation of data between software systems.

A similar scaling issue is arising with reasoning services. Historically, reasoning algorithms were built into each airspace application. However, reasoning services, ranging from speech recognition services to advanced machine-learning models, are emerging as standalone services. As with data sources, airspace applications need a scalable way to be aware of and integrate this new class of reasoning services. Additional concerns arise related to the current trajectory in that many systemic challenges are not addressed, such as the overall cost of developing many isolated vertical integrations/silos, systematic data quality tracking, and the overall security of the resulting landscape of many airspace application silos.

A Data & Reasoning Fabric (DRF) is envisioned to enable the full potential of advanced air mobility by providing all data and reasoning where they are needed. The DRF (Fig. 1) provides a marketplace based on an open foundational ecosystem of data and reasoning exchange between the many systems that must seamlessly interplay to manage the complex and dense airspace operations required to achieve advanced air mobility goals. DRF activities will identify, test and - as needed - research and develop critical core technologies. In order to deliver reference designs and development environments that catalyze broad private and public sector buy-in and self-sustaining development of DRF and associated standards, DRF activities will collaboratively test these technologies, open standards and architectures, and an integrated framework with end-users.



**Fig. 1 Data & Reasoning Fabirc (DRF) for Advanced Air Mobility**

The objectives of the DRF Project are to:

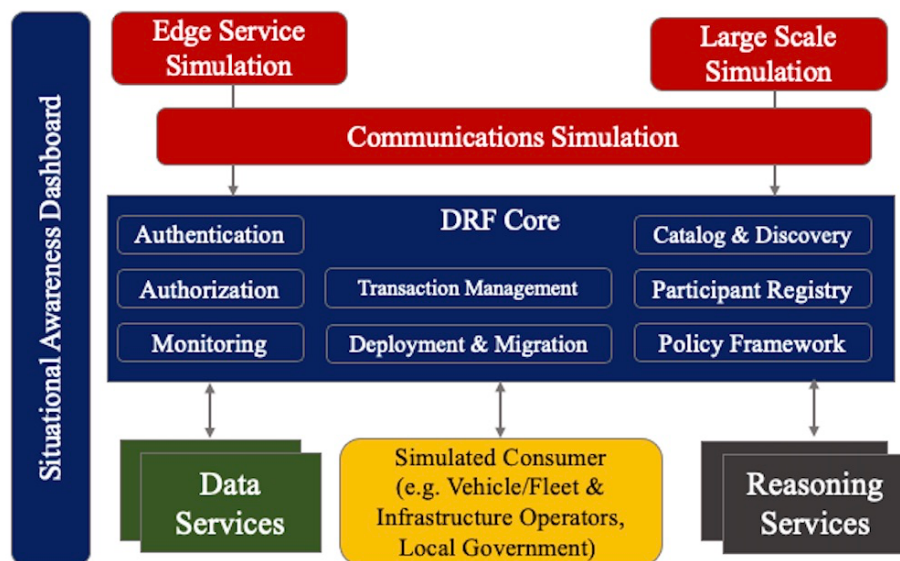
- Deliver a Minimum Viable Product (MVP) implementation of the reference DRF software, data, and reasoning architectures that will be presented in this paper. This MVP, the DRF Accelerator (Fig. 2), includes prototype instantiations of key DRF features, including data and reasoning services, a DRF marketplace software architecture

and other required functions sufficient to engage end-user representatives of key stakeholder communities in representative use-cases.

- Exercise the DRF Accelerator with representatives of key service providers and consumer stakeholder communities in order to demonstrate that the DRF Accelerator provides key data and reasoning functions, enables the future traditional and advanced airspace objectives and informs a business plan for a self-sustaining advanced air mobility data and reasoning marketplace

The DRF Project is developing a DRF Accelerator which will enable the rapid deployment of candidate data and reasoning services to test and evaluate – the DRF core system functionality. The DRF Project is also engage with government and industry early end-users and stakeholders, in order to: (1) assess the technical feasibility of the DRF Accelerator; (2) assess the likelihood of adoption, through shared test and evaluation; and (3) identify what data and services can be shared across the DRF.

The DRF Accelerator Software is a prototype implementation of the DRF Framework. It enables the rapid deployment of candidate data and reasoning services to test and evaluate the DRF core system functionality - enabling the delivery of data and reasoning services to DRF consumers across the cloud-to-edge continuum. The DRF Accelerator showcases the core capabilities and objectively demonstrate the value of DRF across identified use-cases. It enables co-simulation of various DRF components including an initial edge simulation platform (e.g., simulated edge nodes), real and simulated sensors, and simulated vehicles. Further, the DRF Accelerator enables the ability to rapidly plug in and replace services and demonstrate how the three efforts from the data, reasoning, and software teams are complimentary and can converge into a single unified platform. Finally, the DRF Accelerator provides the necessary DRF functionality to engage with representative customers and stakeholders.



**Fig. 2 DRF Accelerator MVP**

### **DRF Core:**

The MVP implementation of the DRF Core provides the essential mechanisms for service discovery, authentication and authorization, transaction management, service monitoring, and the policy framework as shown in the diagram below. In particular, the DRF Core:

- Provides a registry for all participants
- Manages authentication and authorization for participating entities using the participant registry
- Provides a service catalog for service registration and discovery
- Supports immutable and verifiable transaction management for service execution (e.g., billing and contracts)
- Provides a policy management framework
- Monitors services and their quality of service (QoS) and service level agreements (SLA)

### **DRF Data Services:**

The DRF data architecture ensures consistency, availability, usability, safety-relevant quality, and democratization of data for AAM operations. The data produced, traded, and consumed by the diverse AAM ecosystem is going to be complex and the data functionalization model has multiple facets to it. Therefore, the data architecture needs to take into consideration the utilization modes and derived benefits from the perspective of different stakeholders. .

A minimum viable DRF system includes a set of reference data services demonstrating sufficient interoperability for at least two heterogeneous data and reasoning service demands. A successful demonstration of the service life cycle using commercially available data integration and access layer resources will substantially enhance effectiveness and accessibility to the wider user pool.

### **DRF Reasoning Services:**

To establish a DRF that enables UML-6 operations, we need to consider the reasoning needs of highly automated aircraft operations where the human operator might be supervising many aircraft. The notion of 1:N operations is therefore a central driving factor in arriving at the reasoning architecture.

The DRF Project implements reference reasoning services, in order to validate the DRF Core. The DRF Reasoning team has two distinct objectives:

- Reasoning Services - Establish prototype trajectory and situation awareness service examples. Leverage NASA projects to build and research information and health management services.
- Service Migration - Determine requirements and strategies for migrating data and computing between physical, edge, and cloud layers.

### **DRF Simulations:**

The DRF Accelerator simulates some aspects of the DRF Framework. As shown in Fig 2, the simulations will be leveraged to validate the viability of the DRF Accelerator. A large-scale vehicle simulation and visualization capability will be developed. The large-scale vehicle simulation focuses on the demonstration of many (~103) point mass kinematic models executing reasoning services along with at least two full dynamic UAM model-based vehicles.

Visualization includes some point masses to be scheduled for their allotted times to execute trajectory in flight.

An edge simulator simulates edge nodes (e.g., cell towers, building roof tops) and interactions with vehicles and DRF operators. The DRF Accelerator also simulates service deployments and migrations across edge nodes.

A network simulator emulates network communication quality of service characteristics at the Internet protocol (IP) layer such as data throughput rates, packet loss and latency. Modeling at the radio frequency (RF) level is out of scope for the initial efforts as modeling characteristics at the IP layer is sufficient and there are a number of existing software tools to support the modeling, including both open source and commercial solutions. Communications emulation will be leveraged to validate the capabilities of the DRF core, in conjunction with simulations for end-user interactions, edge computing and large-scale vehicle simulations.

### **MVP User Engagement:**

User engagements will include identifying data service providers willing to collaborate with the team to wrap a data service in a DRF data service wrapper for deployment in support of an End-User Use Case. Data Service Providers will be identified subsequent to End-User Use-Cases, to assure that Data Service Providers are providing data relevant to one of the End-User Use-Cases. These engagements will also include reasoning service providers willing to collaborate with the team to wrap a reasoning service in a DRF reasoning service wrapper for deployment in support of an End-User Use Case. Reasoning Service Providers will be identified subsequent to End-User Use-Cases, so as assure that Reasoning Service Providers are providing reasoning relevant to one of the End-User Use Cases. Additionally, these engagements will include, identifying organizations willing to identify and collaborate with NASA on the application of DRF. The End-User Use-Cases may be in a “shadow-mode” where a DRF-based application shadows an actual end-user application, from which the relevant benefits (and disadvantages) of the DRF-based application can be derived. Or, a DRF-based application could be providing decision-support to an actual application, in which case the DRF-based application is an auxiliary data feed to an actual operation. Though not ruled out, it is not required that a DRF-based application is the enabler of an End-Use Use-Case. It is envisioned that the next phase of DRF will nominally support two End-User Use-Cases.

Additionally, as part of ongoing stakeholder engagement efforts, the DRF Project team will identify standards and working group activities that the DRF Project team should monitor. Efforts and products generated by standards and working groups will be used to update and refine DRF requirements and capabilities.

The full paper will describe the specifics of the DRF Accelerator MVP and the planned user-engagement to prototype the DRF Accelerator in greater detail.