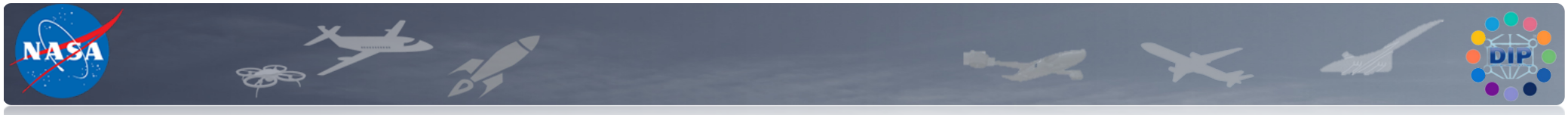
Mirna Johnson, DIP Sub-Project Manager
Gilbert, DIP Deputy SPM
George Szatowski, DIP ASPM

https://nari.arc.nasa.gov/atmx-dip



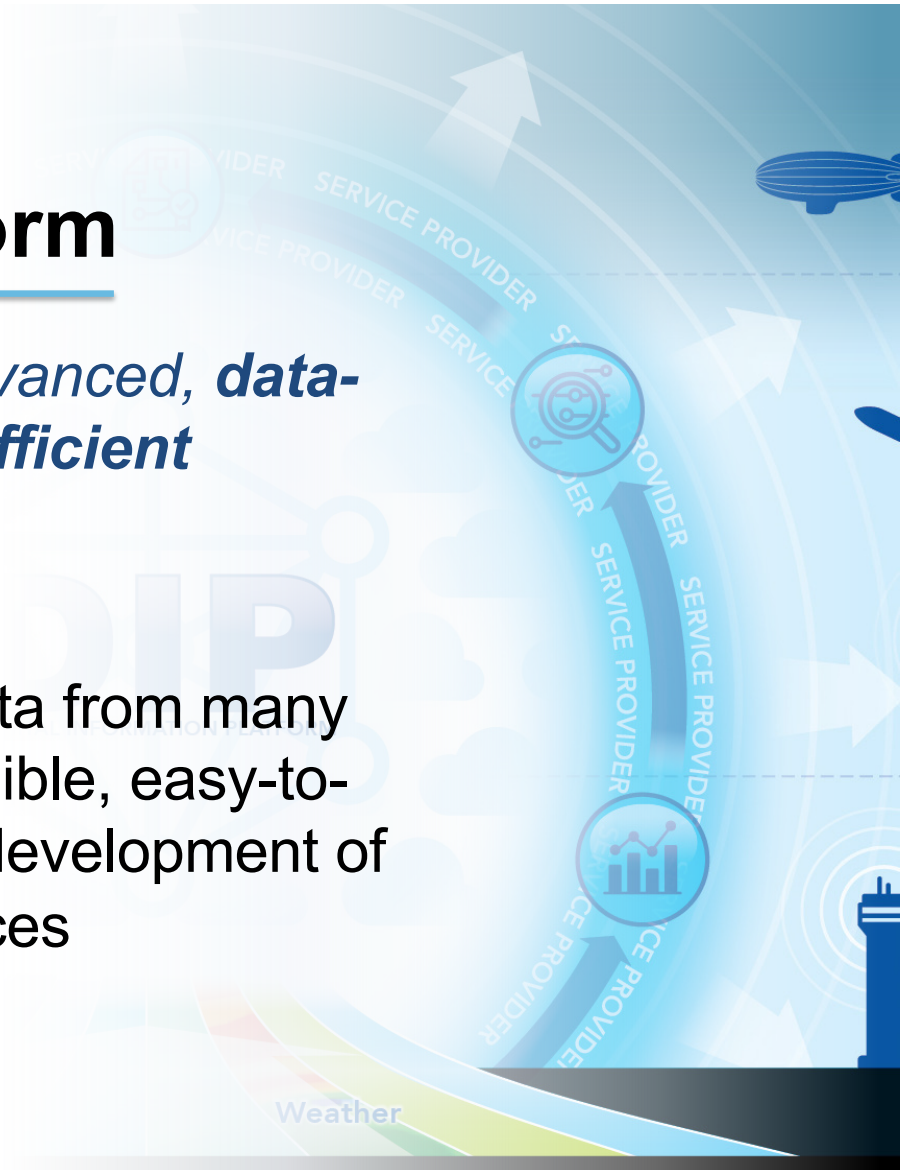
Concept Overview

Mirna Johnson

Digital Information Platform

Accelerate NAS transformation for advanced, ***data-driven, digital services*** *to promote* ***efficient aviation operations***

Cloud-based ecosystem that takes data from many sources and turns it into easily accessible, easy-to-use digital information to expand the development of reusable airspace management services

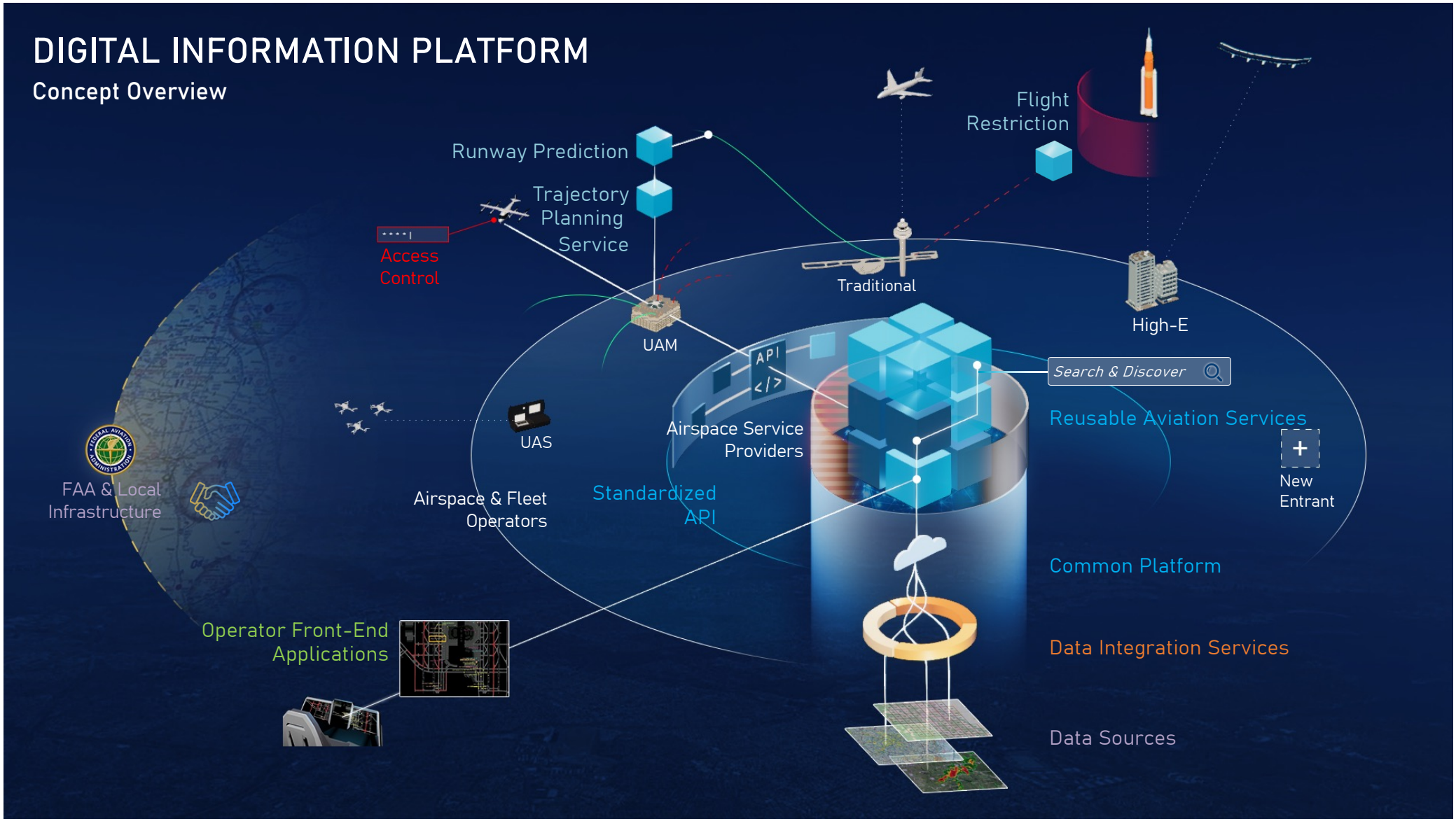


Stakeholder Needs

Increase Access to NAS Information	Easy access to organized airspace data and information **Common, simplified API** to fused information
Improved Data Quality	**Trusted** and **reliable** data sources with safeguards Unified, aggregated, and **validated data** for consumption
High Reuse Solutions	Support **data-driven predictive** models **Scalable** and **adaptable** integration of services
Commercialization Methodology	Architecture that **connects high reuse solutions** for exchange of services and information to create an ecosystem
Services for Efficiency and Sustainability	Advanced services to increase efficiency and predictability Digital Re-route, disruption management, trajectory optimization, etc

Sept – Nov 2019 - collected formulative input from **airline operators, airport operators, NBAA, FAA and vendor groups**.

March 2021 - DIP published a **Request for Information**; Received over 40 responses from flight operators, service providers, data integrators from traditional and emerging operations stakeholders


DIGITAL INFORMATION PLATFORM
Concept Overview
Runway Prediction
Trajectory Planning Service
Access Control
Flight Restriction
Traditional
High-E
UAM
API
Search & Discover
Reusable Aviation Services
UAS
Airspace Service Providers
FAA & Local Infrastructure
Airspace & Fleet Operators
Standardized API
New Entrant
Common Platform
Operator Front-End Applications
Data Integration Services
Data Sources

DIP Ecosystem Features

Data Integration
Faster Service development with fused data for simpler integration

Search & Discover
Ready to-use Services made available

Sustainability
Enable services for sustainable airspace management

DIGITAL DATA AND SERVICES ECOSYSTEM
Larger airspace cohort to provide services with secure access

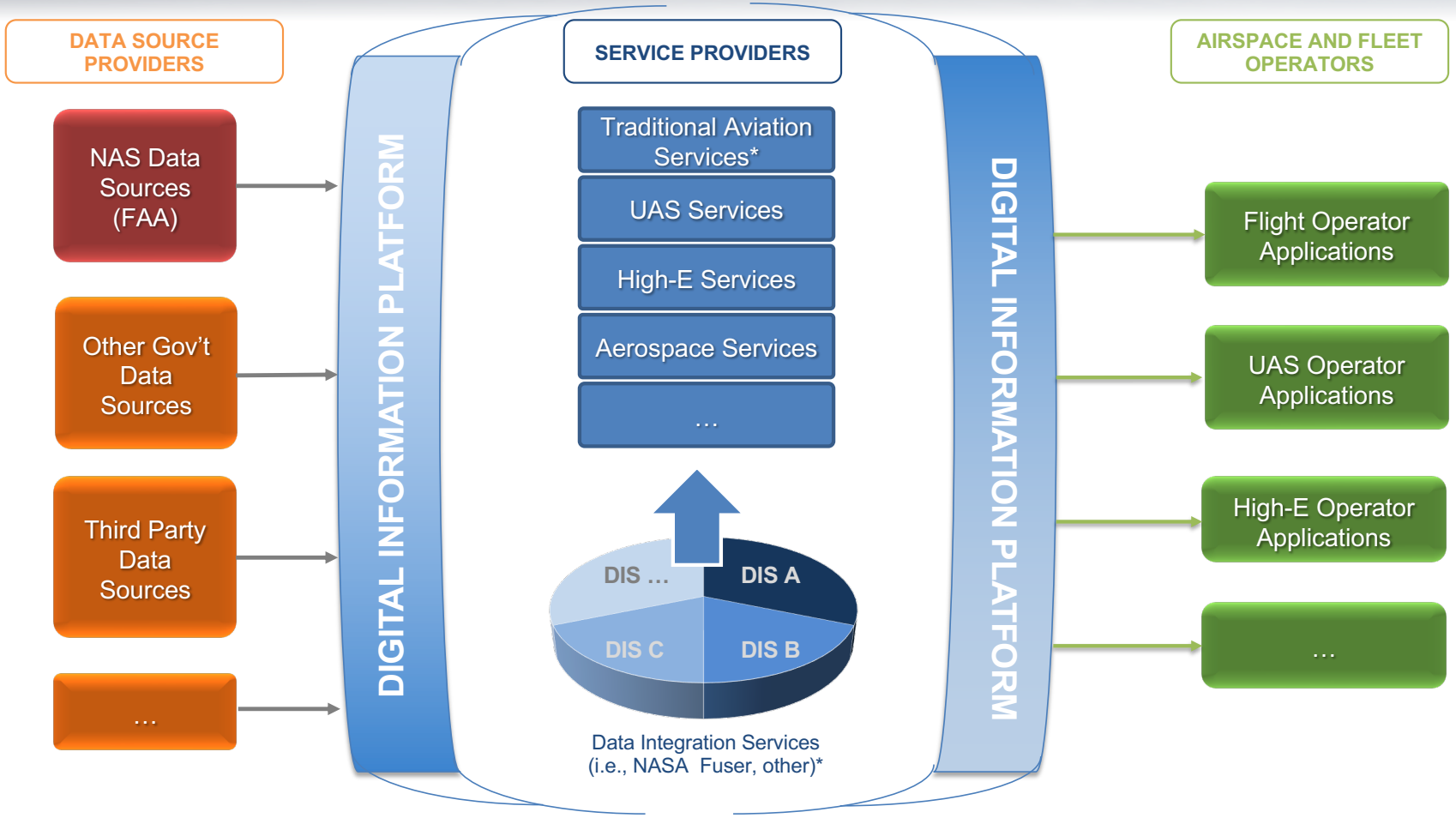
Advanced Technologies
Accelerate Innovation to improve adaptability and extensibility of services

Trusted Information
Reliable quality information with transparency and performance monitoring

Reusable Services
Building blocks for configurability and adaptability

Improve access and usability of NAS digital services for operator decision support tools

DIP Ecosystem



Partnership Strategy

Leverage Existing Partnerships with airlines and airports

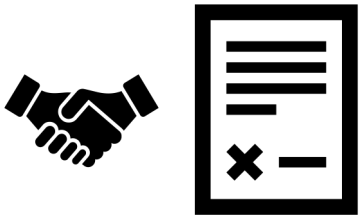
American Airlines

Southwest

DFW

Publish RFI & ACOs to *EXPAND* Industry Engagement

Community to collectively contribute to DIP ecosystem as data and service providers for use by flight operators for evaluation



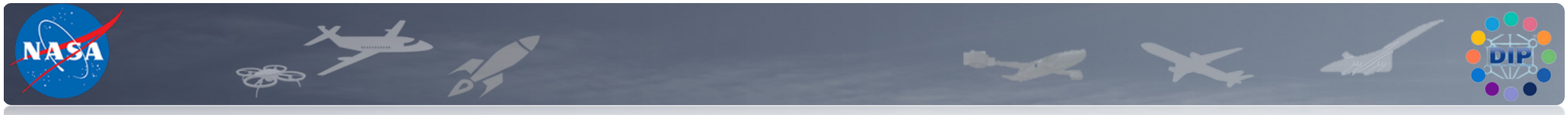
Collaborative Workshops & Demos with Partners

Opportunities for partners to collaborate on standards definition and validate concept. Demonstrate their services and capabilities in DIP ecosystem

University Challenges

Leverage forward-looking research from Universities to propel early AI/ML service concepts and prototypes

NTL NASA Tournament Lab



Technical Approach

Mirna Johnson

DIP Research Areas

NASA Services for Sustainability

Ground and flight deck services focused on improving the sustainability of aviation operations

"SFNP-Ops Demos"

Industry Partner Service Evaluations

Integration and demonstration of Partner services with DIP for validation of the platform

"PS Evals"

University Challenges

NTL NASA Tournament Lab

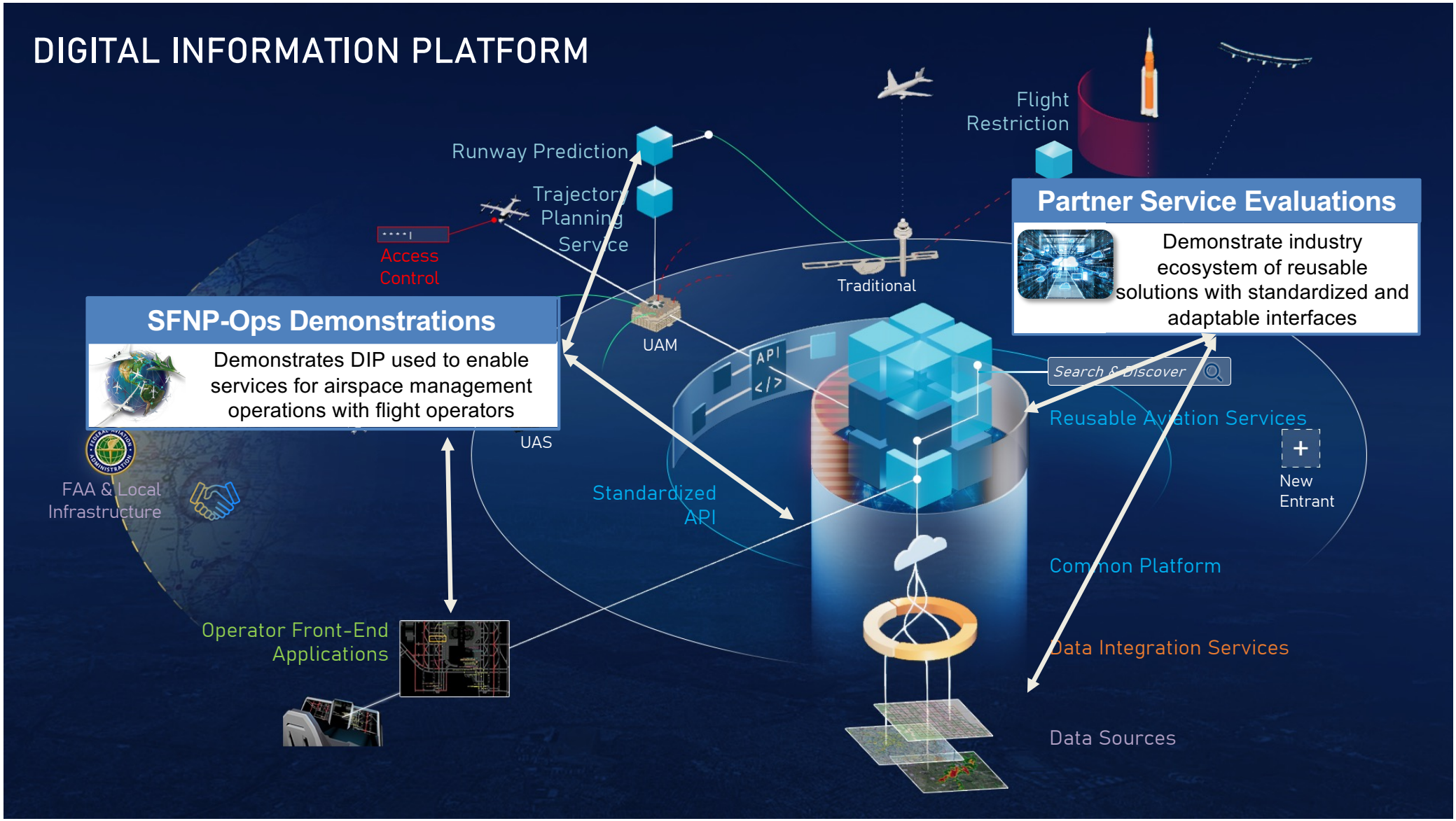
Development of innovative solutions and advanced algorithms for aviation services

Reference Digital Information Platform (DIP)

Development of a platform for advanced, data-driven, digital services for flight operators and service consumers

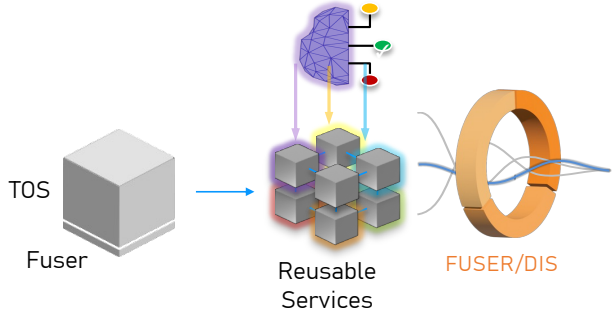
Enables SFNP-Ops Demos, PS Evals and University Challenges

DIGITAL INFORMATION PLATFORM

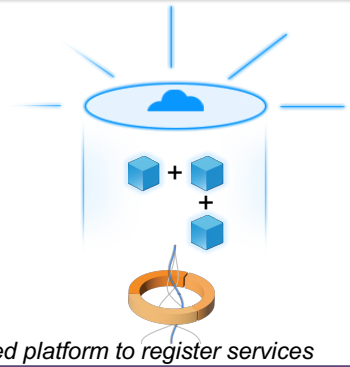


DIP Build Up Progression

TODAY – SFNP-Ops 1a CDDR w/ML @ NorTx



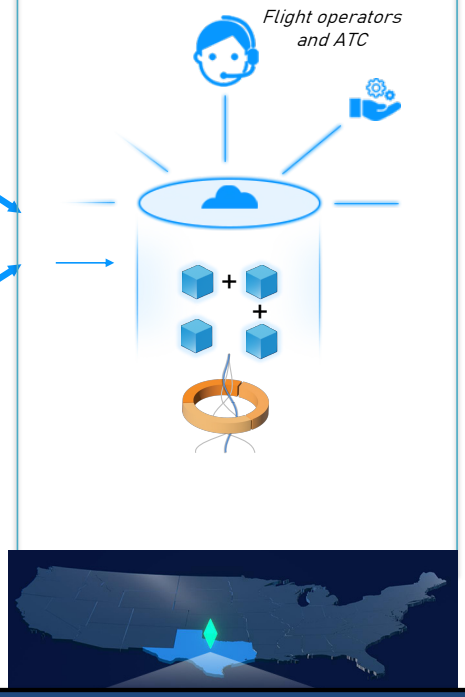
Applied machine learning to digital prediction services
Transformed to service oriented architecture



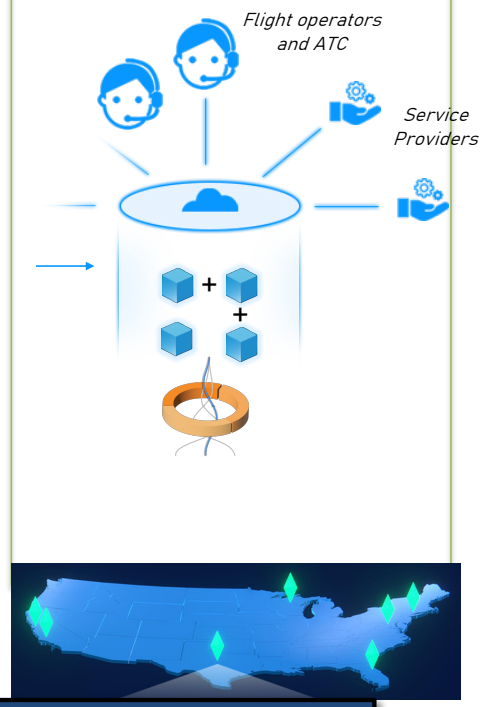
Build up cloud-based platform to register services

TODAY – Platform Build Up

FY23 @North TX – SFNP-Ops1a Integration of CDDR w/Platform

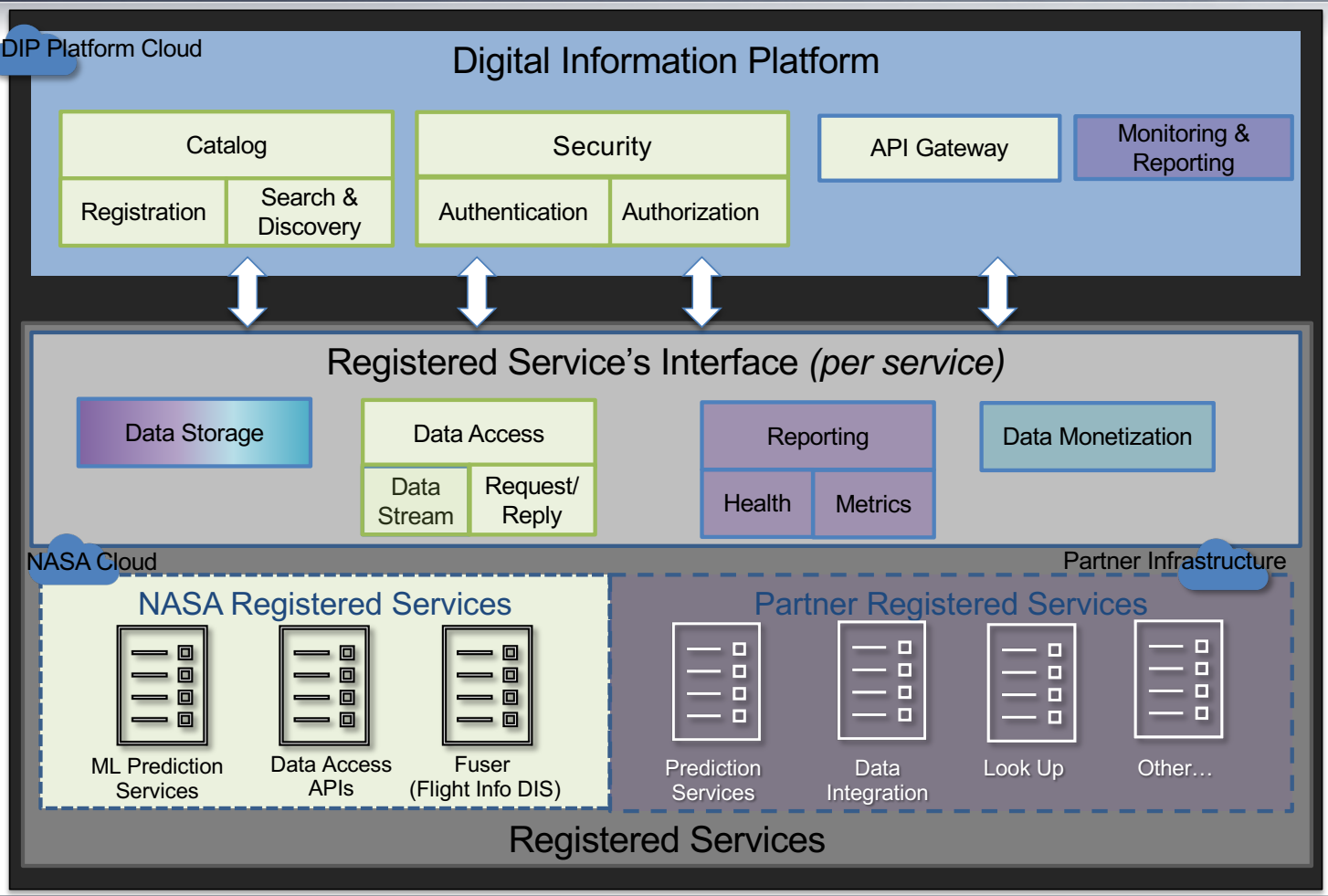


FY24/25 @ TBD– SFNP-Op1b Scale and Adapt to New Airspace



Immediate impact to RW Operations; Agile build up

Platform Capabilities



Features in FY22 Scope

- Secure access
- Service Registration support
- Catalog service
- Access to NASA services

Features for FY23 Scope (SA, PS)

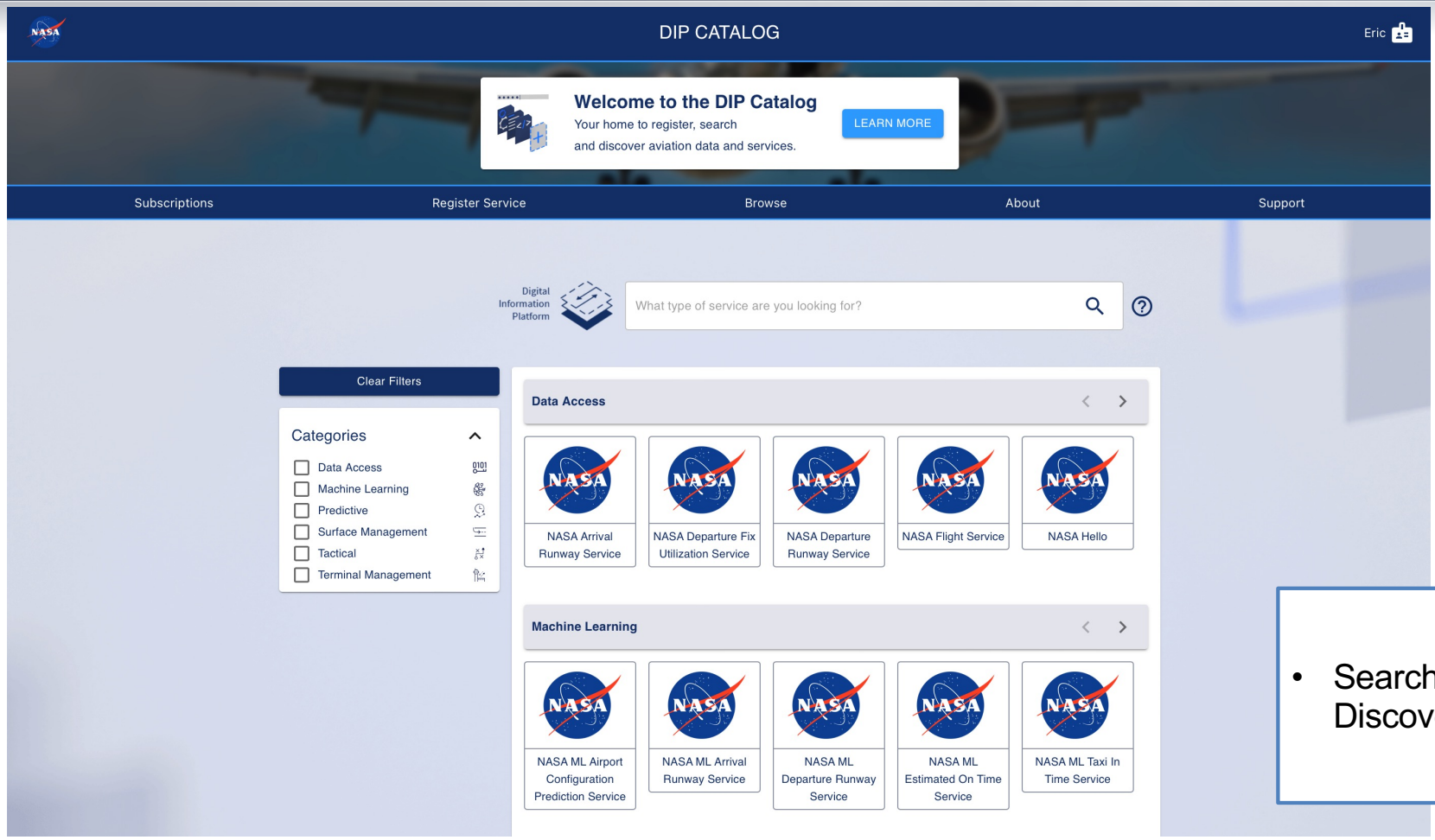
- KPI
- Health monitoring
- Data Storage of NASA Services

Features for FY23 Scope (PS only)

Stretch goals

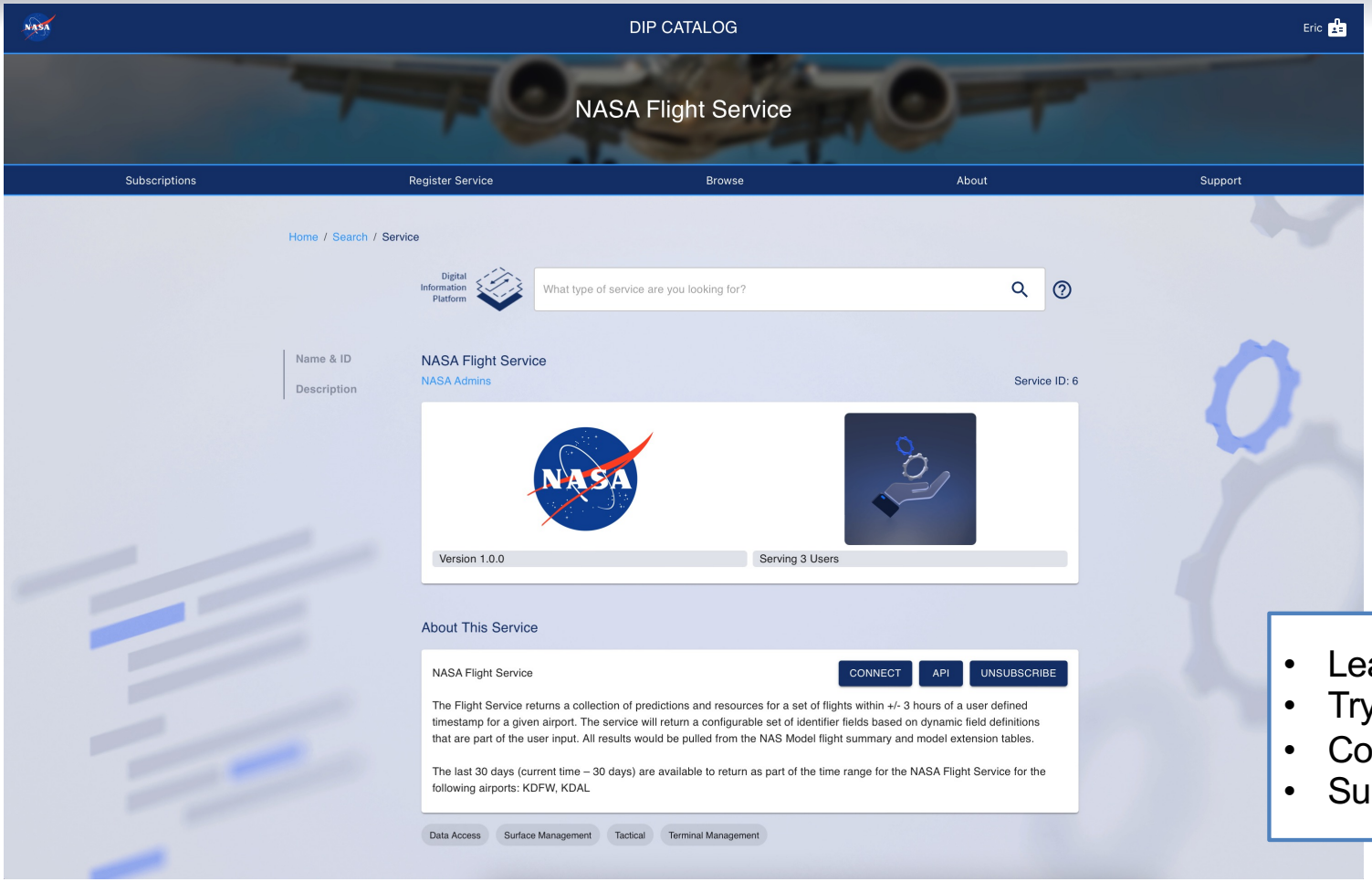
- Data Storage by 3rd party (tied to monetization)
- Monetization mechanism

Registered Services Catalogue Web Page



- Search & Discover

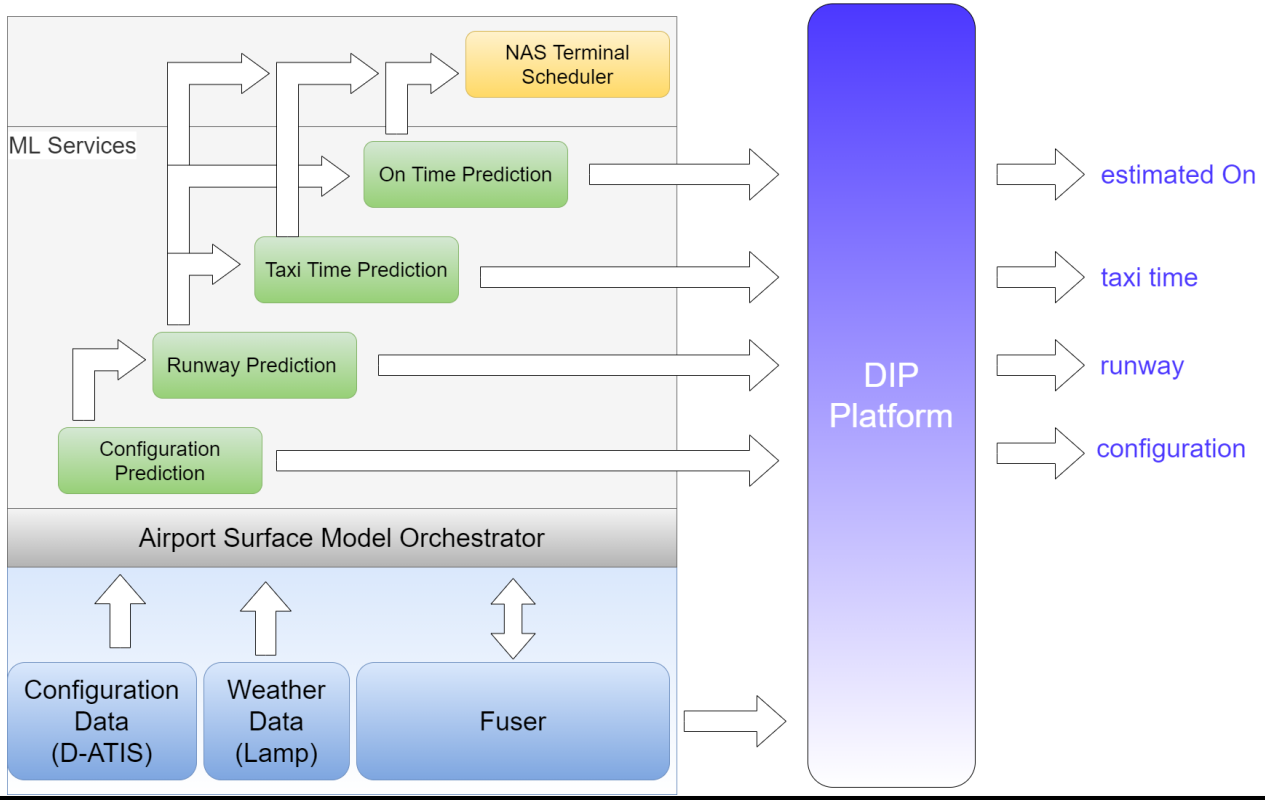
Service Information Web Page



- Learn More
- Try It Out
- Connect
- Subscribe

NASA CDDR Services as Building Blocks

- Outputs from services used as inputs to other services
- Inputs orchestrated by Airport Surface Model Orchestrator
- All orchestrated outputs flow back to Fuser
- All data is streamed to the DIP Platform for consumption



Each Service is independently available on the Platform for consumption

Services Accessed via Platform for PIE-S1

Data Access APIs/Services

- **NASA Arrival Runway Service**
  - *Arrival runway per flight*
  - *Arrival runway per airport*
  - *Arrival runway utilization*
- **NASA Departure Runway Service**
  - *Departure runway per flight*
  - *Departure runway per airport*
  - *Departure runway utilization*
- **NASA Departure Fix Service**
  - *Departure Fix Utilization*
- **NASA Flight Service**
  - *Flight Data Service*
- **NASA On Time Service**
  - *On Time per flight*
  - *On Times per airport*
- **NASA Taxi In Service**
  - *Taxi In Impeded/Unimpeded per flight*
  - *Taxi In Impeded/Unimpeded per airport*
- **NASA Taxi Out Service**
  - *Taxi Out Unimpeded per flight*

ML API/Services

- **NASA ML Airport Configuration Prediction Service**
  - *Airport configuration prediction*
- **NASA ML Arrival Runway Service**
  - *ML arrival runway*
- **NASA ML Departure Runway Service**
  - *ML departure runway*
- **NASA ML Estimated On Time Service**
  - *ML Estimated on time*
- **NASA ML Taxi In Time Service**
  - *AMA/Ramp Impeded Taxi In times*
  - *AMA Ramp Unimpeded Taxi in times*
- **NASA ML Taxi Out Time Service**
  - *AMA*
  - *Full*

Streaming Services

- **Fuser (v1.1)**
  - *Not in FIXM format*
  - *Currently not in the Catalog*

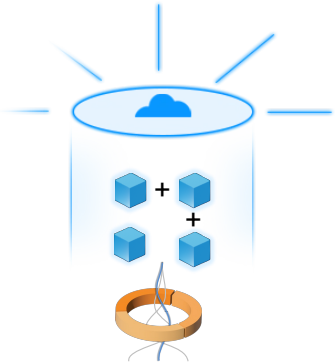
Other Services

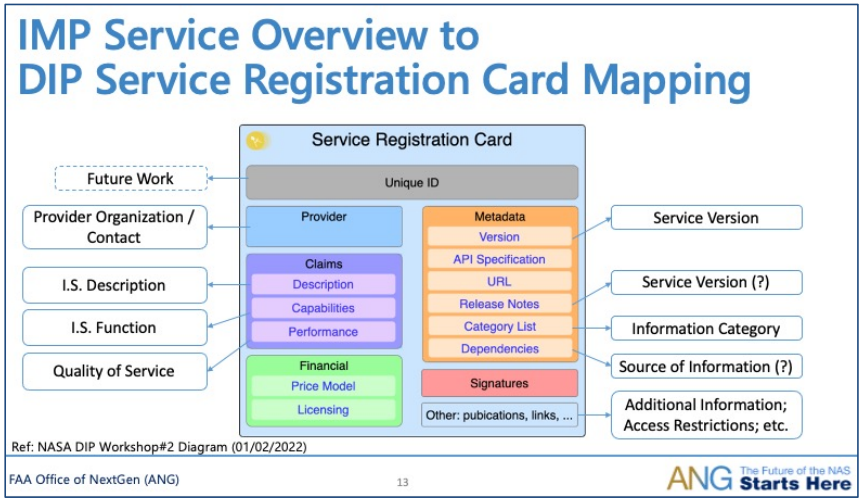
- **TMI Service (v1.1)**

Each Service is independently available on the Platform for consumption

Parallel Progress on Platform Development

- Build cloud-based platform to register and discover services to be deployed in FY23 for SA1a CDDR on the Cloud



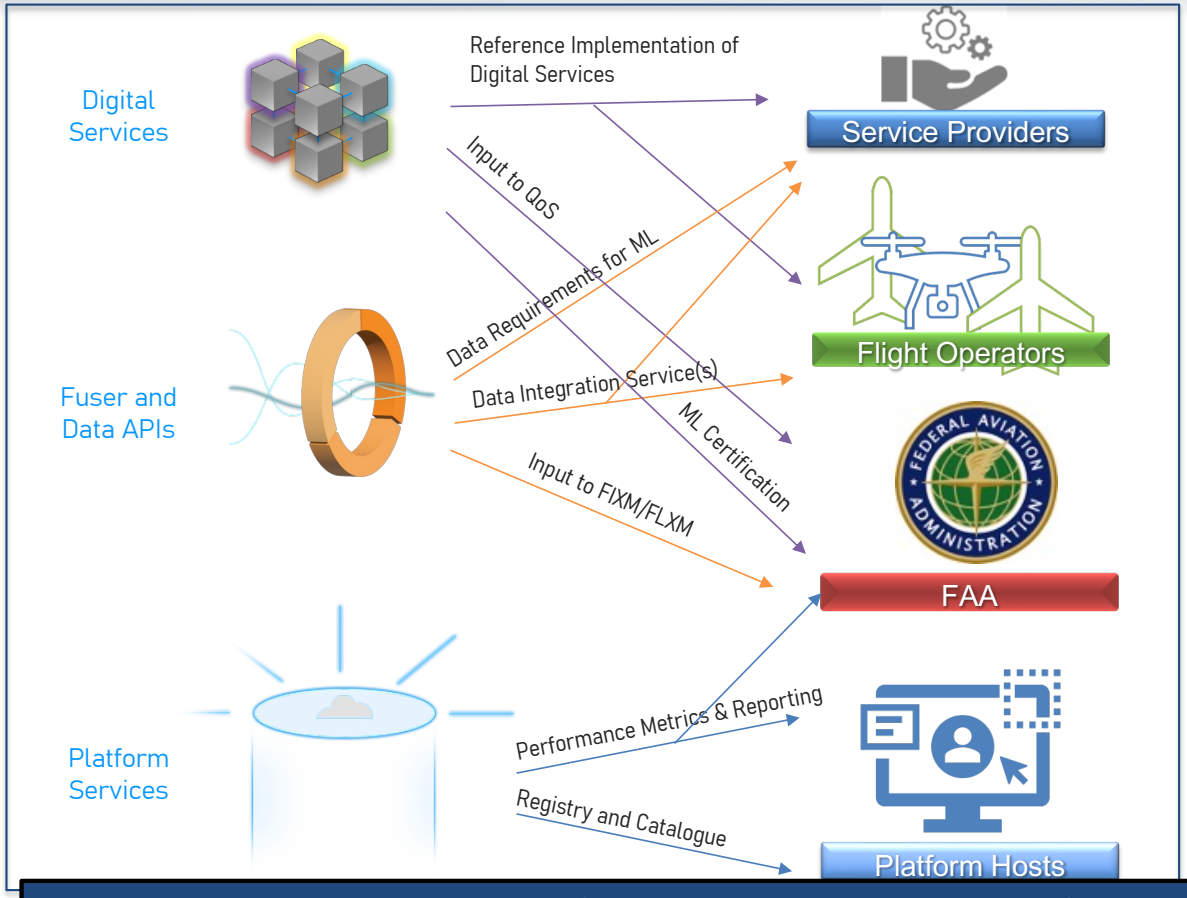


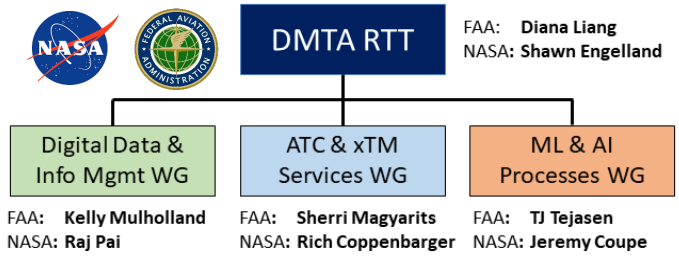
- ✓ Initial Catalogue Registry*
- ✓ Search & Discovery features
- ✓ Registered NASA prediction services
- ✓ Step towards small footprint

***Leveraging Service Info Fields from ICAO IMP discussed at NASA/FAA TIM (Jan 2022)**

Leveraging ICAO and FIXM/FLXM; next TIM on FLXM ~Sept 2022 (TBC)

Tech Transfer Products to Industry and FAA



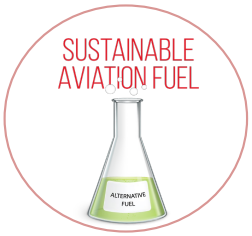


Tech Transfer direct to Partners, via SWIFT forums, and RTTs

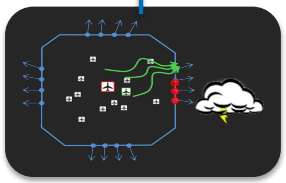
Sustainable Flight National Partnership - Operations (SFNP-Ops) Demonstrations

DIP-Enabled SFNP-Ops Services for Sustainability

Ground Services | Flight Deck Services

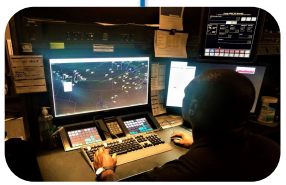


GLOBAL Aviation Industry's Goal:
50% reduction in carbon emissions by 2050 relative to 2005 and possible net zero emissions by 2060 through these three means



Collaborative Digital Departure Reroute (SFNP-Ops-1, FY22-25)

Sustainable Oceanic Airborne Re-Routing (SFNP-Ops-2, FY26)

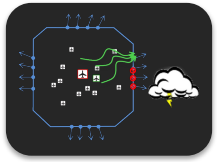


Irregular Ops Recovery/ Disruption Management (SFNP-Ops-3, FY27)

4D Trajectory Optimization (SFNP-Ops-4, FY28)

DIP Supports Sustainability Goals: Deliver reduction in emissions and fuel of aviation operations through digital services technology

Sustainable Operations Demonstrations



TODAY

FY20 | FY21 | FY22 | FY23 | FY24 | FY25 | FY26 | FY27 | FY28 | FY29

Planned

Notional

ATM Services

Flight Deck Services

Industry Services

Digital Information Platform Development

Collaborative Digital Departure Reroute (SA-1a)

Validate service-oriented architecture and ML services

Validate cloud-based deployment

Tech Transfer

Validate Scalability and New Interfaces

Tech Transfer

Transfer to Industry and to FAA through RTP via DMTA RTT

Complex Airspace (SA-1b)

Partner Services Evaluations (PS-E)

Validate Service Discovery and Registration

Validate Standard for Service Connection

Validate Performance Monitoring & Quality

Validate Multiple Platforms

Validate New Data Sources

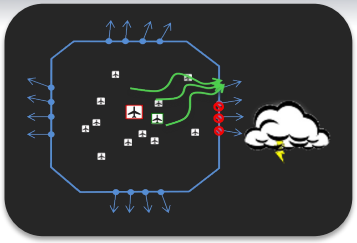
Validate Reusability of Services

Multi-regional Trajectory Based Operations (SA-2)

Tech Transfer

Validate Scalability and New Interfaces to Flight Deck

Sustainable Flight National Partnership Operations- 1 | *CDDR*



SFNP-Ops-1: Collaborative Digital Departure Re-Route (FY22 - 25)

Demonstrate CDDR via Trajectory Option Set (TOS) by rerouting flights and departures starting at NTX towards a high-density operational area

Benefits: *Reduced fuel burn and emissions through reduced surface departure delay. Benefits rerouted flight as well as all departures*

Benefits demonstrated during precursor multi-airport IADS field demonstration

at **D10 North Texas Metroplex** (22 Nov 2020 – 17 Sep 2021)

Fuel Savings

Over **50K** lbs.

Emissions Savings

Over **156K** lbs. **CO^2**

Over **1,100** urban trees

Delay Savings

OFF delay	**IN** delay
11+ hrs	**12+** hrs

DIP can scale these savings across the NAS* validating in SA-1 @ Complex Airspace

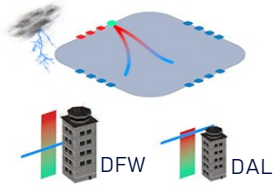
SFNP – Ops - 1 | *CDDR Concept*

1 Preconfigure
TOS Parameters

Alternate Routes

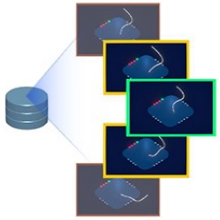
TOS database

2 Monitor
Demand & Capacity



System continuously assesses imbalance

3 Present
Candidate TOS



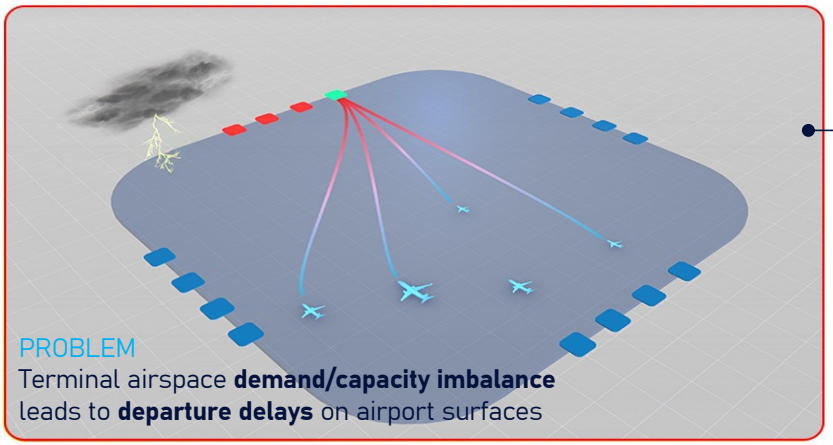
Delay savings > Relative trajectory cost

4 Submit
TOS to ATC

All users notified

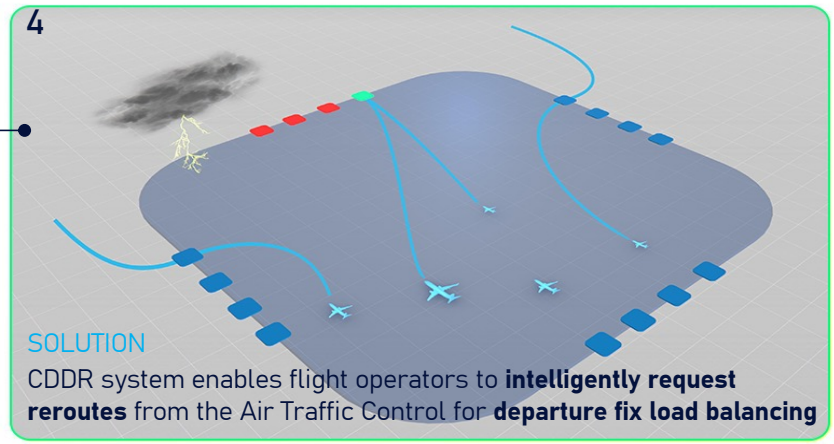
5 Evaluate
Post Operation

Benefits
Refinements
Lessons
Analyses
Reports



PROBLEM
Terminal airspace **demand/capacity imbalance** leads to **departure delays** on airport surfaces

Metroplex airports with departure fixes

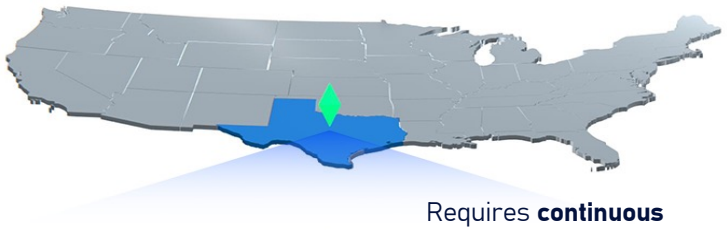


SOLUTION
CDDR system enables flight operators to **intelligently request reroutes** from the Air Traffic Control for **departure fix load balancing**

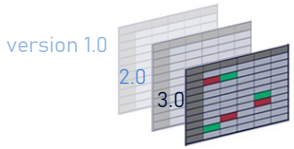
SFNP – Ops - 1 | *CDDR Technology Advancements*

CURRENT

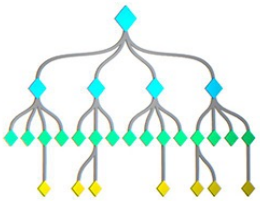
Legacy ATD-2 Surface Model



Requires **continuous** maintenance



Similar to:
Skilled worker



Mental models encoded into **complex decision trees**

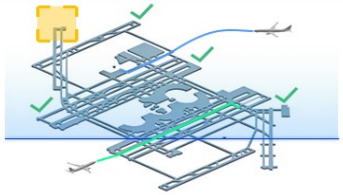
Good at **specific** tasks
Requires detail knowledge

FUTURE

Scalable DIP CDDR Surface Model

Semi-automated maintenance

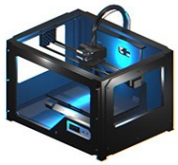
SME data



Surface data

Absorbs information from multiple existing data sources

Similar to:
3D printer



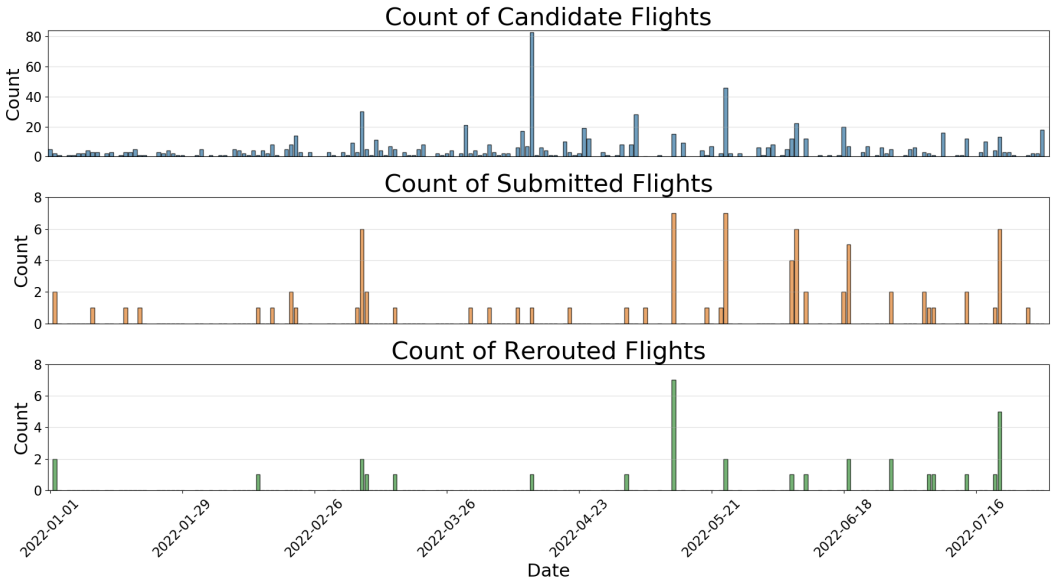
Flexible to new tasks
Learns detailed knowledge

Meeting SA-1a Performance Operational Goals

2022 CDDR Environmental Benefits

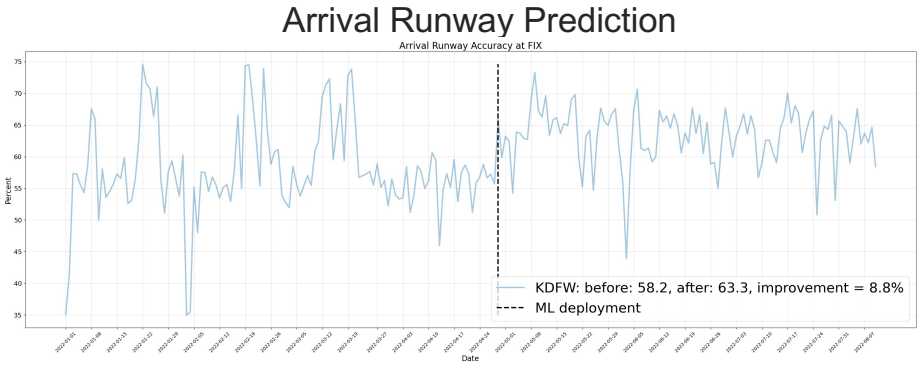
Between **January 1st, 2022 and July 31st**, 2022

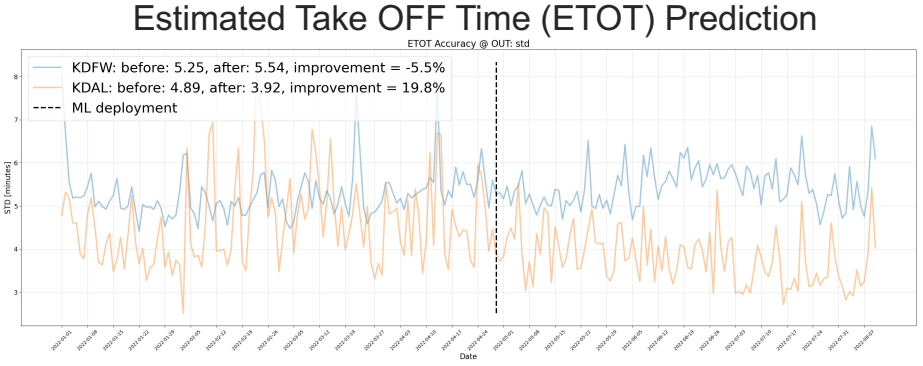
- 22,212 pounds of **fuel** saved
- 68,415 pounds of **CO_2 emission** reduced
- 509 **urban trees** saved
- Average reroute saves 16.9 urban trees **+14% YoY**



DIP Machine Learning vs Legacy ATD-2

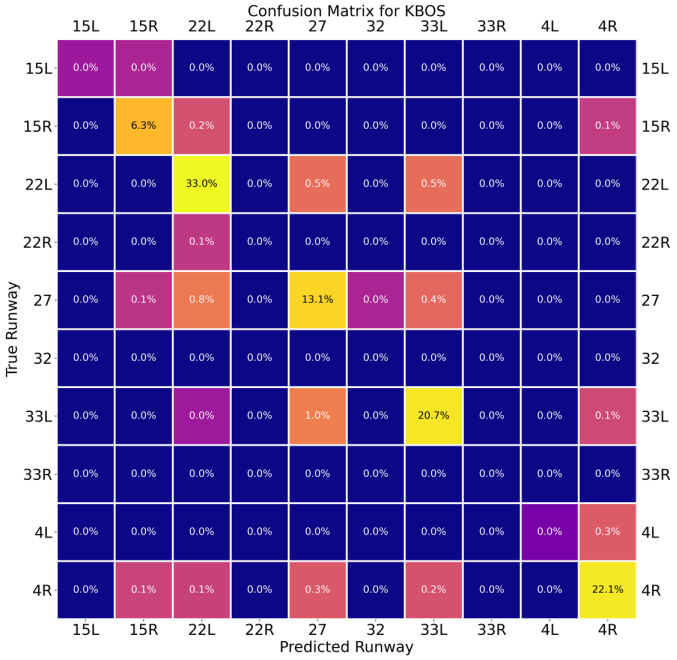
- Arrival Runway Prediction: ML slightly outperforming
- ETOT: ML on par with ATD-2, outperforming TFMS



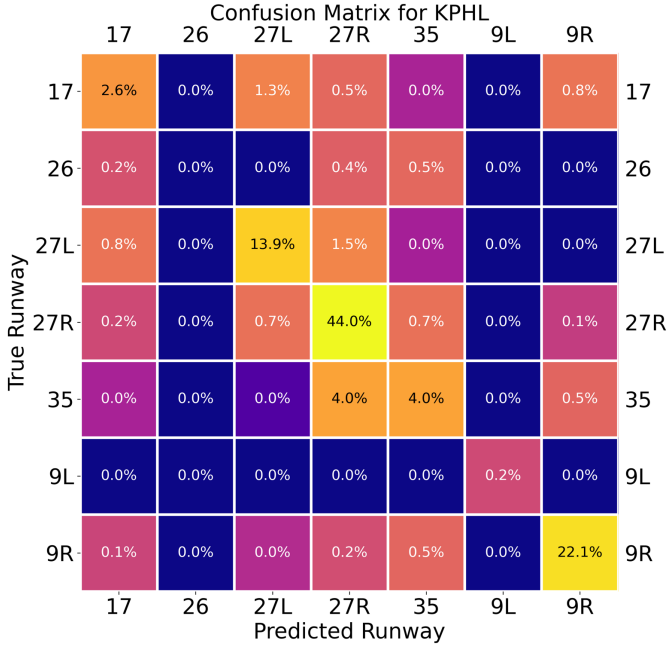


Arrival Runway Prediction at Other Locations

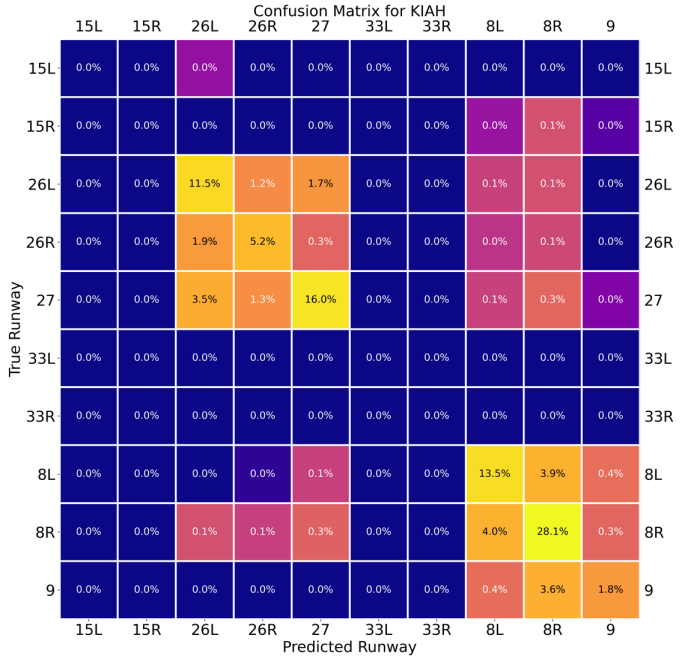
KBOS Arrival Runway
accuracy = 95.1%



KPHL Arrival Runway
accuracy = 87.1%



KIAH Arrival Runway
accuracy = 76.1%



ML pipelines enable new models to be trained by simply changing configuration file

SFNP-Ops – 2 Demo | *SOAR Goals*

Ground Services

Flight Deck Services

SFNP-Ops-2: Sustainable Oceanic Airborne Re-Routing (SOAR) (FY26)

Demonstrate digitally connected flight deck service for efficient trajectories and scheduling in multi-region/oceanic airspace leveraging surveillance and navigation

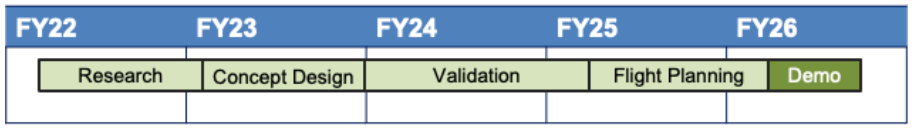
Benefits:

Reduced emissions and fuel-burn on long-haul oceanic flight, contrail reduction

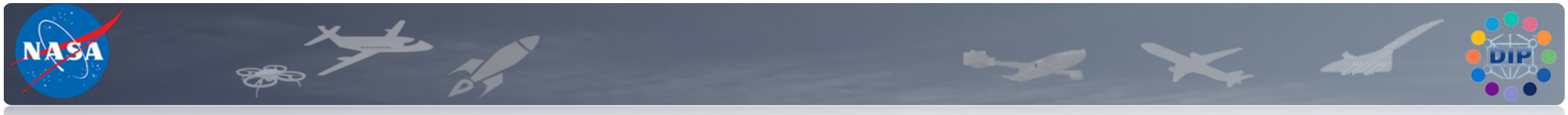
Multi-Regional TBO uses shared trajectory information for flight planning and management

NASA Flight Deck Service | *Status*

- **Schedule**
  - Operational demo planned for FY26
  - Notional SFNP-Ops 2 demo in FY28



- **Partnership Strategy**
  - Continue following FAA's MR TBO concept development and flight demonstration
  - Meet with commercial vendors of flight optimization tools and services
  - Conduct assessment for most viable partnership strategy
- **FY23 look ahead**
  - Conduct benefits assessment of re-route capabilities to increase oceanic airspace efficiency
  - Analyze research gathered from SMEs for initial design based on identified opportunities
  - Develop digital microservices that form the building blocks for



THANK YOU!