

Digital Information Platform (DIP) Overview, CDDR Capability, Platform Technology and Services

DIP
DIGITAL INFORMATION PLATFORM

NASA-United Airlines Technical Interchange
November 2, 2022

SWIM

Weather



DIP 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 aviation services



Stakeholder Needs



Increase Access to NAS Information

Improved Data Quality

High Reuse Solutions

Commercialization Methodology

Services for Efficiency and Sustainability

Easy access to organized airspace data and information
Common, simplified API to fused information

Trusted and **reliable** data sources with safeguards
Unified, aggregated, and **validated data** for consumption

Support **data-driven predictive** models
Scalable and **adaptable** integration of services

Architecture that **connects high reuse solutions** for exchange of services and information to create an ecosystem

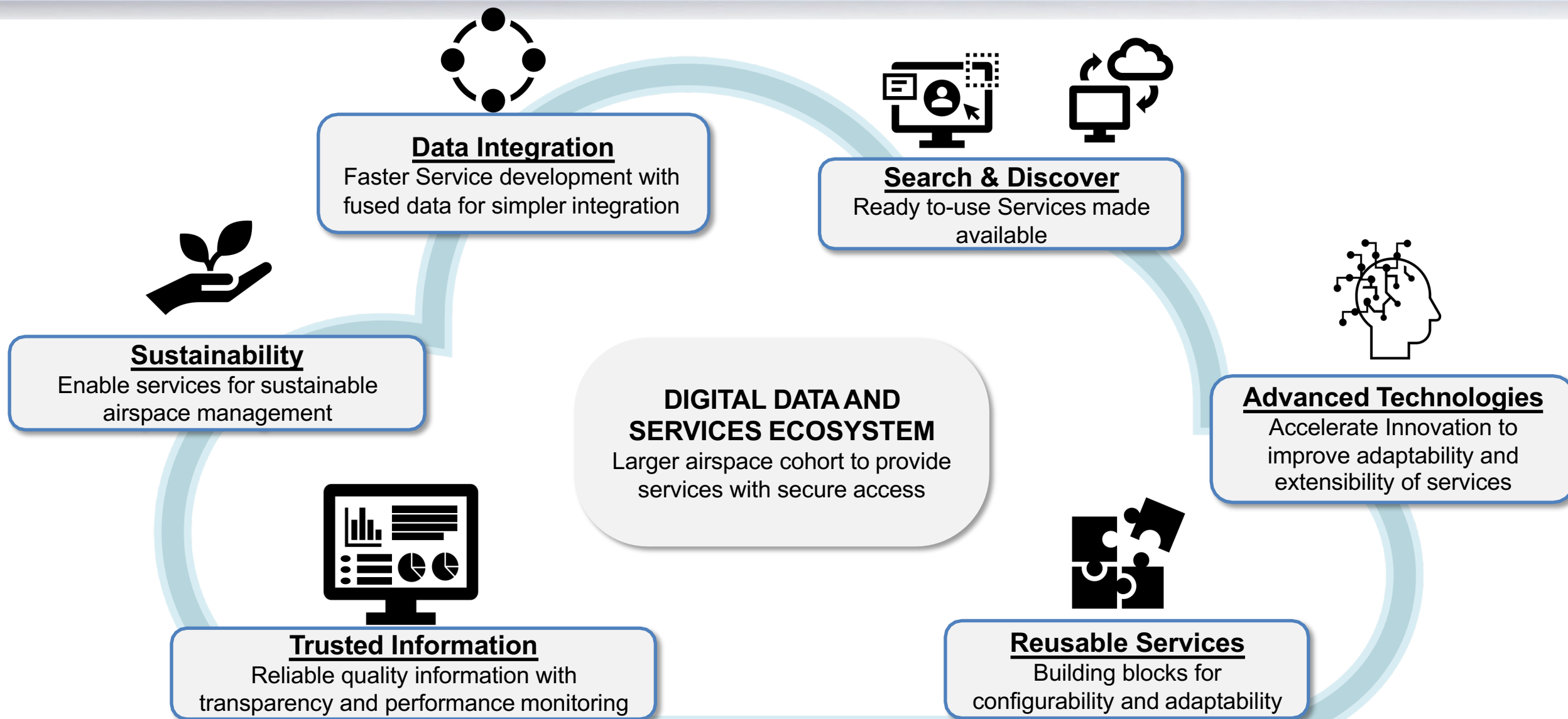
Advanced services to increase efficiency and predictability
Digital Re-route, disruption management, trajectory optimization, etc

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



DIP Ecosystem Features

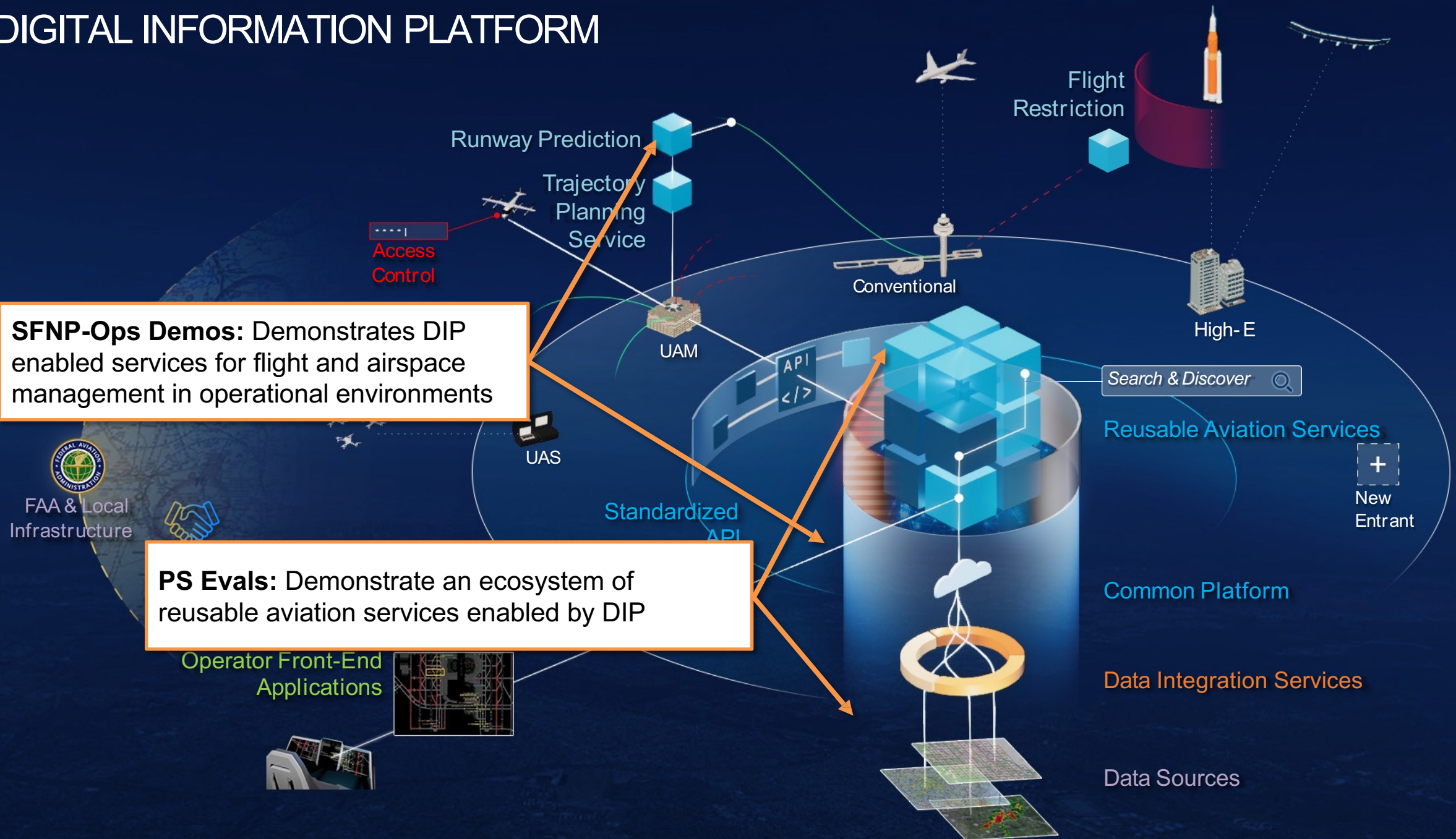


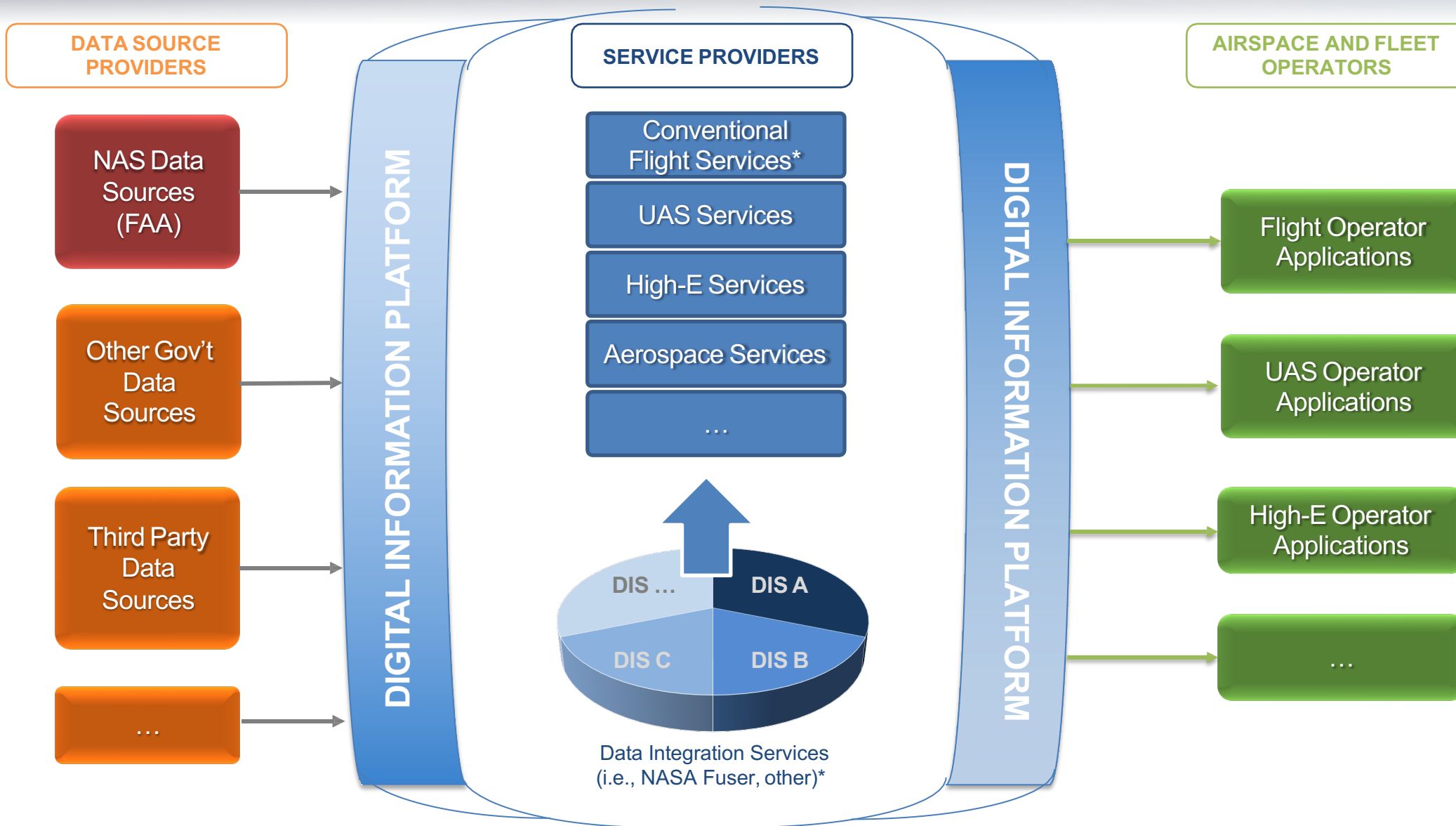
Improve access and usability of NAS digital services for operator decision support tools

DIGITAL INFORMATION PLATFORM

SFNP-Ops Demos: Demonstrates DIP enabled services for flight and airspace management in operational environments

PS Evals: Demonstrate an ecosystem of reusable aviation services enabled by DIP





NASA Led DIP-Enabled Services for Sustainability



“SFNP-Ops Demos”

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

Industry Led Partner Service Evaluations



“PS Evals”

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

University Challenges



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



Opportunities for Demos



SFNP-Ops Demos

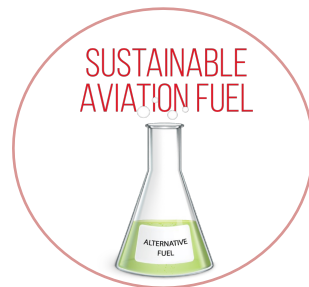
- Reach **Flight Operator** and **Consumer** stakeholders
- In a **High TRL** environment
- To demonstrate **airspace management** use cases
- With a **data-to-platform-to service-to-application** (E2E) system
- Achieve sustainability benefits using DIP

PS Evaluations

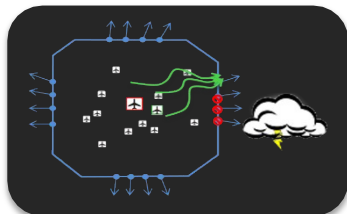
- Reach **service provider** and **platform host** stakeholders
- In a **Medium TRL** environment
- To demonstrate **service management** use cases
- With a **data-to-platform-to-services** system
- Achieve ecosystem of data and services



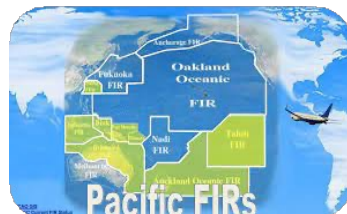
DIP-Enabled Demos for Sustainability



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)**



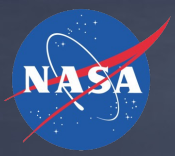
**Irregular Ops Recovery/
Disruption Management
(SFNP-Ops-3, FY27)**



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

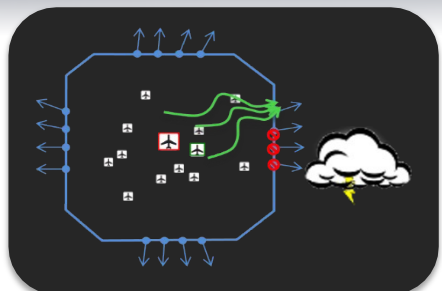
SFNP-Ops = Sustainable Flight National Partnerships - Operations

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



Collaborative Digital Departure Re-Routing (CDDR) for SFNP-Ops-1

Jeremy Coupe

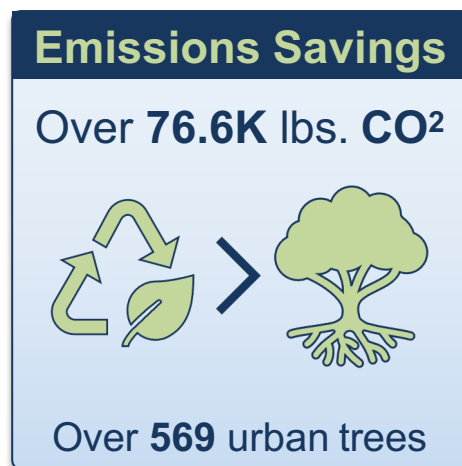


SFNP-Ops-1: Collaborative Digital Departure Re-Route (FY22 - 25)

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

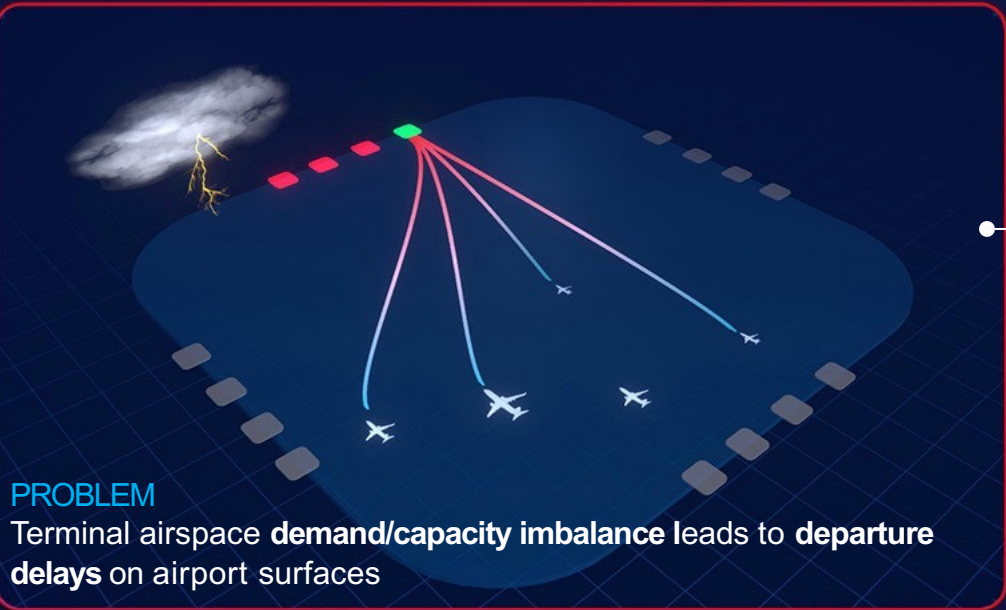
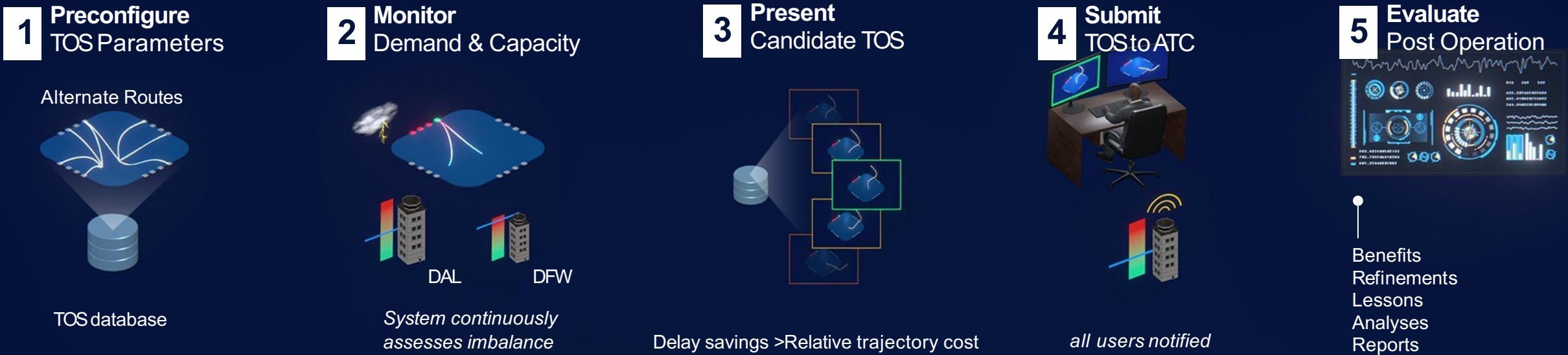
SFNP-Ops 1 system-wide aggregated savings (individually re-routed + other flights)
at **D10 North Texas Metroplex** (01 Jan 2022 – 16 Sep 2022)



1038 CANDIDATE flights ➡ 102 Airline Re-Route Requests ➡ 41 ATC-approved re-routes

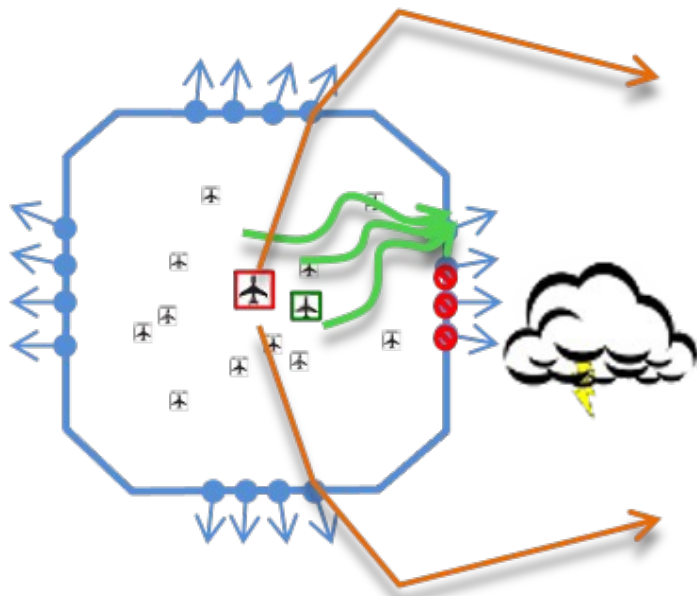
DIP can scale these savings across the NAS; additional validation in FY24 in more complex airspace

Collaborative Digital Departure Re-Routing



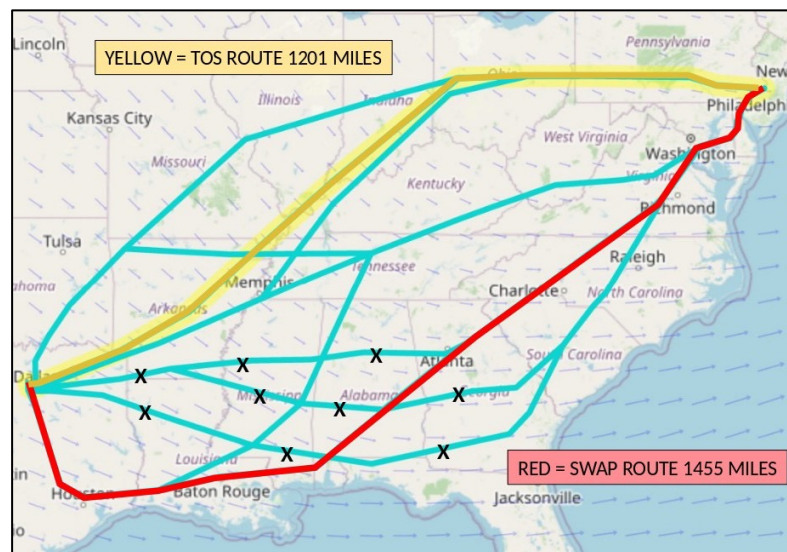
Metroplex airports with departure fixes





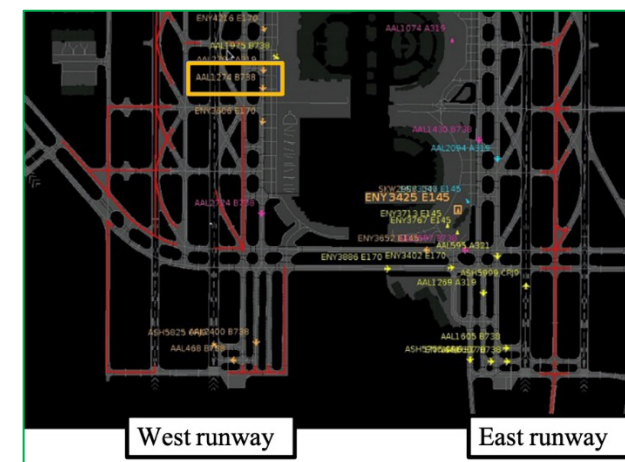
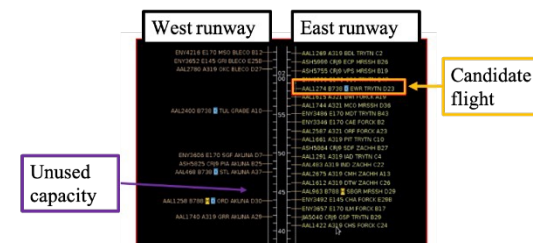
Traffic Management Initiative (TMI)

- Filed route is most direct route but subject to TMI
- Filed route remains through the original departure gate
- TOS route through adjacent departure gate and requires additional flight time
- TOS reroute reduces surface delay in exchange for increased flight time



Recovery from SWAP

- Filed route is amended by ATC through an adjacent departure gate during a SWAP event
- SWAP event ends and TOS routes through the original Filed departure gate much shorter than SWAP route
- TOS reroute reduces surface delay and also has shorter flight time compared to SWAP route



Non-TMI Tactical Reroutes

- Often occurs when the parking gate is physically closer to the TOS runway than the Filed route runway
- Provides tactical opportunities to load balance runway demand to take advantage of unused capacity



CDDR User Interface in North TX (SFNP-Ops-1a)



Flight Operator - AAL Toolbar

TM Actions Create Show Window Taxi List Settings Search Clear

NEW 4... DAL STOP 2030-2200

Flight Operator - AAL Timeline Runway Arrival Departure

Arrival Runway Departure

20
15
10
05
00
55
50
45
40
35
30

Arrival
RBBIT ELP UPS2796
TYGGR STS ENY3514
PGLET SEA AAL2009
TYGGR LAX AAL2318
2 BLECO OKC AAL1707
2 TYGGR SAF SKW3293
3 BLECO LGA AAL652
2 LOWGN BZN AAL2522
1 BLECO ICT AAL1865
BLECO OMA AAL2466
LOWGN PANC AAL521
BLECO EWR AAL2448
2 TYGGR LAX AAL969
5 NELYN SPJC AAL909
8 NELYN HRL SKW3252
9 R0000 COU SKW3170
14 TYGGR LAS NKS380
13 R0000 MSUP AVA441
12 R0000 LBB AAL3324
8 TYGGR SFE AAL2554
7 TYGGR SFO AAL1175
7 PGLET SLC AAL1456
PGLET SLC DAL1389
6 RBBIT SAN AAL2516
5 PGLET PDX AAL2433
4 BLECO JFK AAL2292
3 BLECO MCI AAL1269
2 BLECO BIL ENY3559
2 JASPA SAT AAL1959
1 NELYN MMUN AAL2650
1 BLECO DSM ENY3770
RBBIT SNA AAL2100
2 LOWGN DEN AAL2652
2 NELYN LRD SKW3171
2 NELYN MFE ENY4193
1 BLECO LGA AAL2716
RBBIT PHX AAL372

Runway
SKW4971 JAN THOR->TRCH 15M
ENY3923 BTR THOR->TRCH 15M
NKS202 BWI TRCH 15M
ENY3629 LFT THOR->TRCH 15M
AAL641 CMH AKUNA
AAL1829 TUL GRABE
AAL1484 CLE ZERLU->TRCH 15M
DCM8979 SHV THOR->TRCH 15
AAL2079 MEM HANUH->TRCH 15M
UAL1186 ORD AKUNA 3
AAL371 MSY THOR->TRCH 15M 5
UAL1890 IAH DARTZ 5
TAI441 MSUP DARTZ 11
SKW253H COU AKUNA 6
AAL2401 TPA THOR->TRCH 15M 5
AAL472 DCA TRCH 15M 4
DAL32 ATL TRCH 15M 4
AAL3413 CLL ARDIA 9
ENY3636 TYR THOR->TRCH 15M 4
SKW3284 MOB THOR->TRCH 15M 4
AAL646 MIA THOR->TRCH 15M 4
JZA978 CYYZ AKUNA 4
ENY4237 XNA AKUNA 3
ASH5871 GPT THOR->TRCH 15M 2
AAL2011 TJSJ HANUH->TRCH 15M 2
AAL2334 PHL ZERLU->TRCH 15M 2
AAL2202 ORD AKUNA 3
SKW3167 EVV ZERLU->TRCH 15M 4
ASH5842 SDF ZERLU->TRCH 15M 4
ENY4008 TXK TRCH 15M 3
AAL1761 PIT AKUNA 2
ENY3752 SFE AKUNA 2

Departure
DAL925
DAL2155
AAL576
AAL2433
AAL791
ENY3413
NEL JAS RDAAR
JEN
CQY
ZER OTG
15M 1168
AAL575
HAN OTG
HH OTG
ENY3681
ENY3814
ENY3886
ENY3912
AAL2299
SKW3035
FIN20
BTQ669
FDY426
AAL2716
ENY4103
SKW3144
ENY3752

Flight Operator - AAL Map 3 : DFW

Flight Operator - AAL Map 1 : DFW

DIP CDDR Interface — Mozilla Firefox

DIP CDDR Interface

Updated: 22:20:44

Filter: ((Eligibility State = Candidate) AND (Coord State = Not Submitted) AND (Airline != ENY) AND (EOBT < Minutes 30)) OR (Has Scratch Pad is True)

Scratch Pad	Flight ID	Rwy	Dest	Route of Flight	Dep Gate	EOBT	ETOT	Top ETOT	Top CDR	Top RTC	Top Off Del Sav	Top Prob Del Sav > RTC	Top Agg AAL Fleet Del Sav	Flight Status	TMI Info	Eligibility State	Coord State	IN Delay	Top IN Del Sav
	SKW3167	17R	EVV	KDFW.ZACHH.BSKAT..	EAST	22:10	22:45	22:28	DFWEVV1N		-16	67.0%	-65.7	Pushback	15M FixCld	Candidate	Not Submitted	+36	-10
	ASH5871	17R	GPT	KDFW.MRSSH2.ZALEA..	EAST	22:20	23:02	22:36	DFWGP11S		-26	72.3%	-69.4	Scheduled	15M FixCld	Candidate	Not Submitted	+52	-15
	AAL646	17R	MIA	KDFW.MRSSH2.ZALEA..	EAST	21:58	23:06	22:36	DFWMA1S		-29	96.4%	-69.4	Scheduled	15M FixCld	Candidate	Not Submitted	+43	-30

Route Options Menu - AAL646

Route	CDR	Dep Gate	Rwy	Dist nm	Add nm	RTC	ETOT	OFF Del Sav	Agg Carrier Del Sav	Eligibility State	Coord State
KDFW.MRSSH2.ZALEA..SWB.MCB.J50.CEW.J..		EAST	17R	1063			23:06				
KDFW.DARTZ8.TNV.IAH.J86.LEV.Y290.GAW..	DFWMA1S	SOUTH	17R	1056	-7		22:36		-29	-49.9	Candidate
KDFW.AKUNA9.MLC.RZC.ARG.MERON.DER..	DFWMA1N	NORTH	17R	1320	+257		22:36		-29	-49.9	Potential

Front End User Experience is Unimpacted; Targeting first piece to Tech Transfer

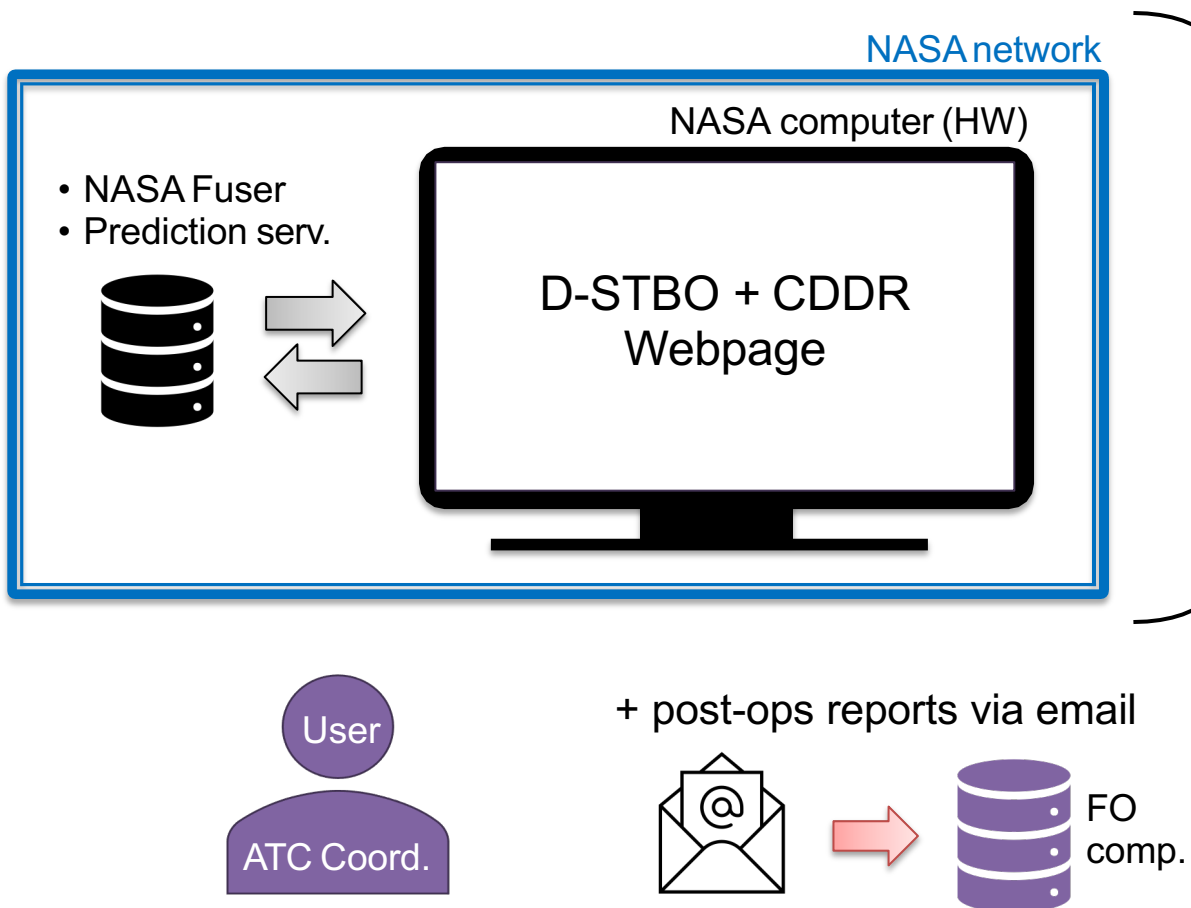
RBBIT PHX AAL372

ENY3912 SHV THOR->TRCH 15M

RWY Arrival 22:20:45 RWY Departure

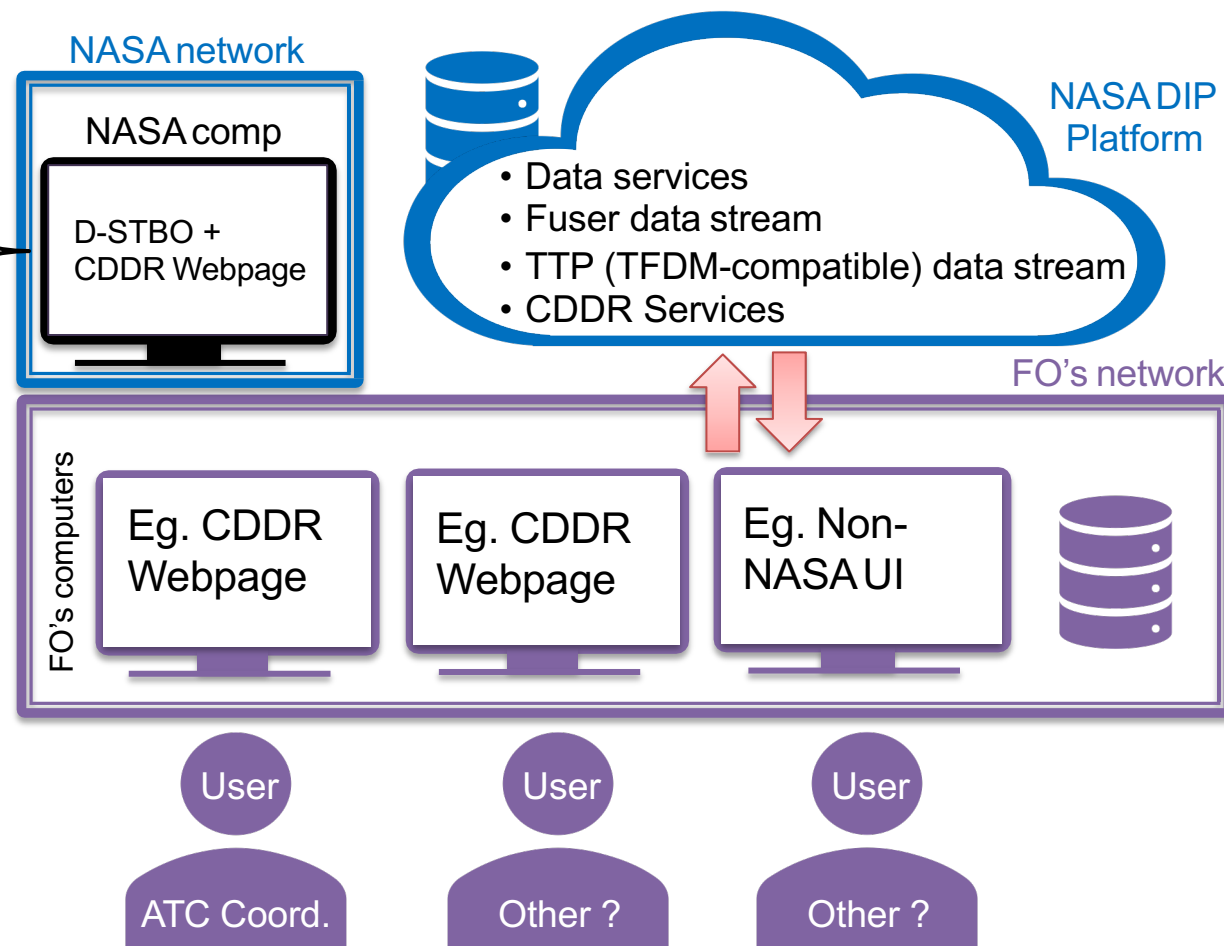
SKW4971 17R JAN KDFW.MRSSH2.MRSSH.. EAST 22:47 23:54 23:03 DFWJAN1S +46 66.4% -56.6 Scheduled 15M FixCld Candidate Not Submitted +43 -26

In FY22



Access to data, services and interface *is limited to* a NASA computer behind a firewall

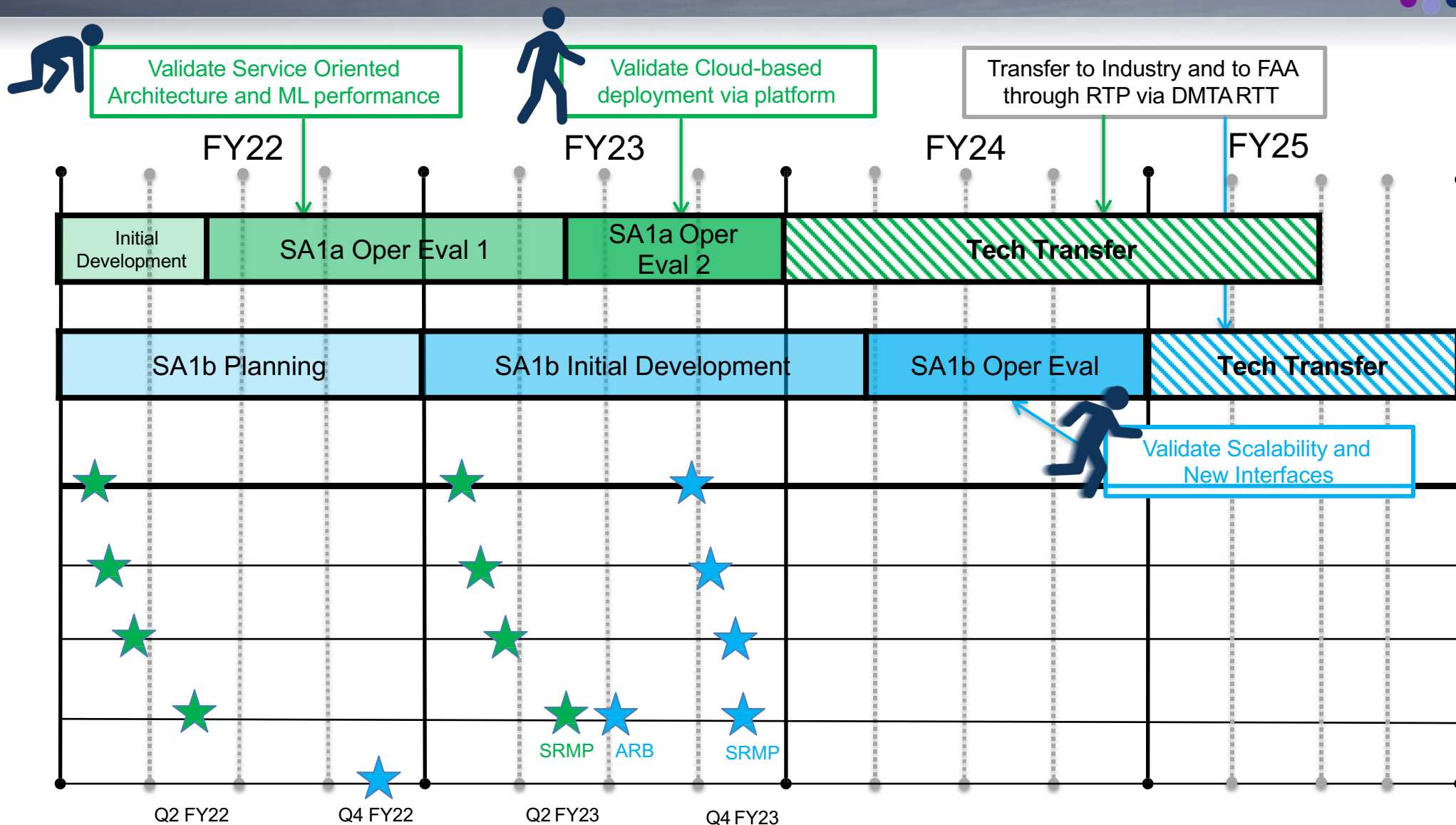
Starting in FY23 and beyond



Access to data, services and interface *is available* from the cloud

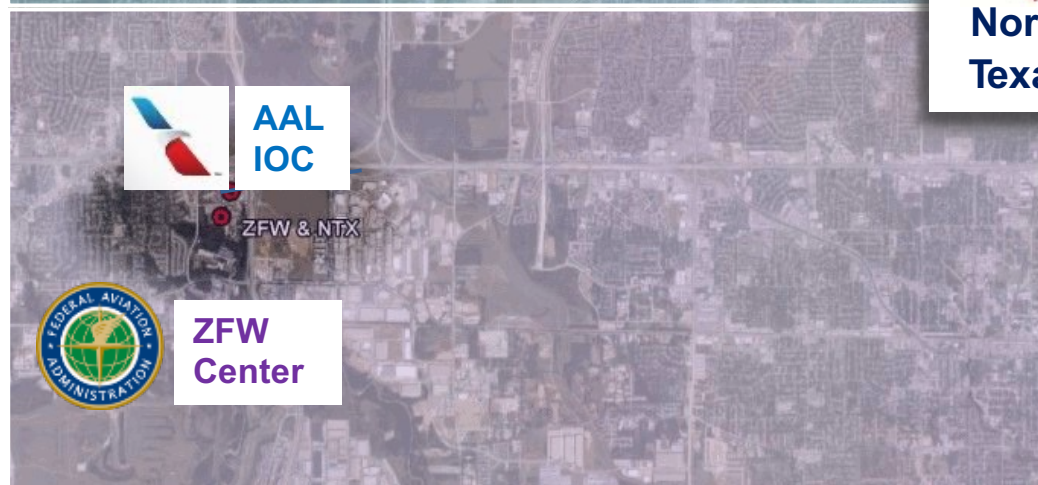
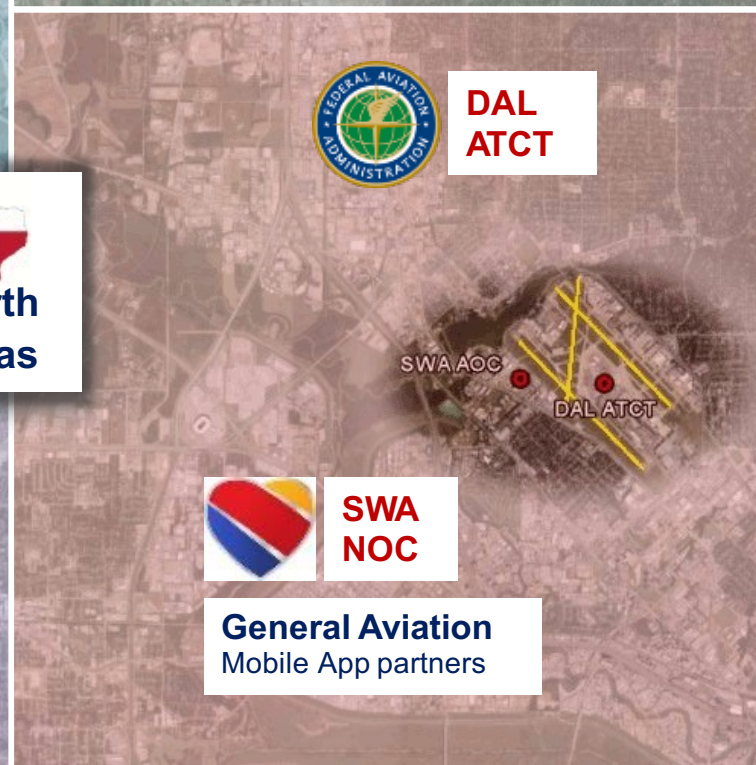
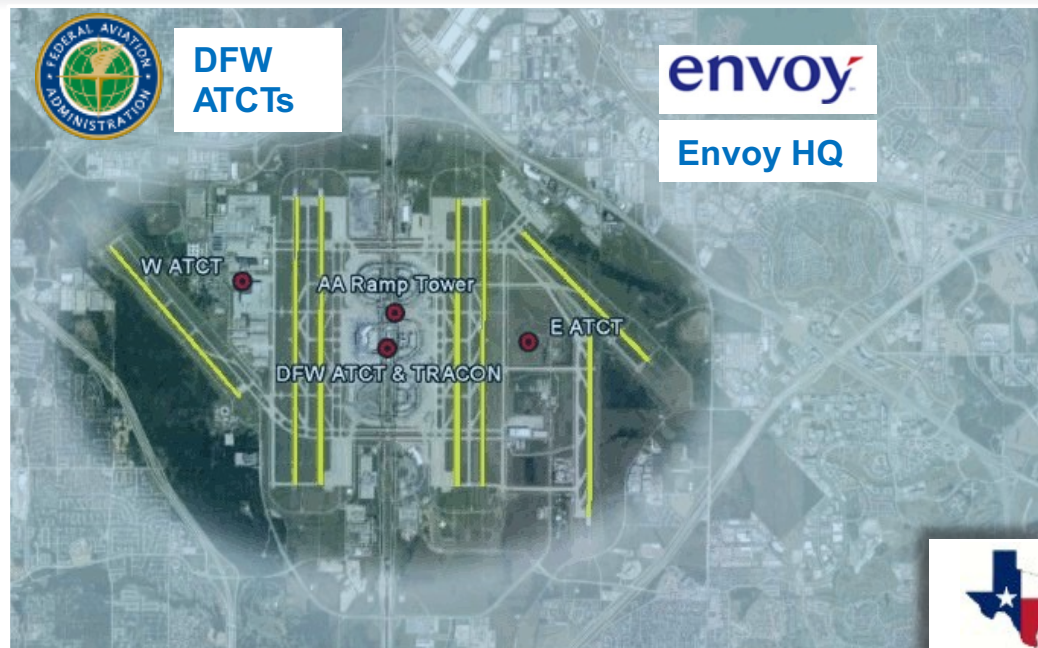


SNFP-Ops-1 Progress and Milestones



SNFP-Ops-1a North Texas Milestones in Green

SNFP-Ops-1b Complex Airspace Milestones in Blue

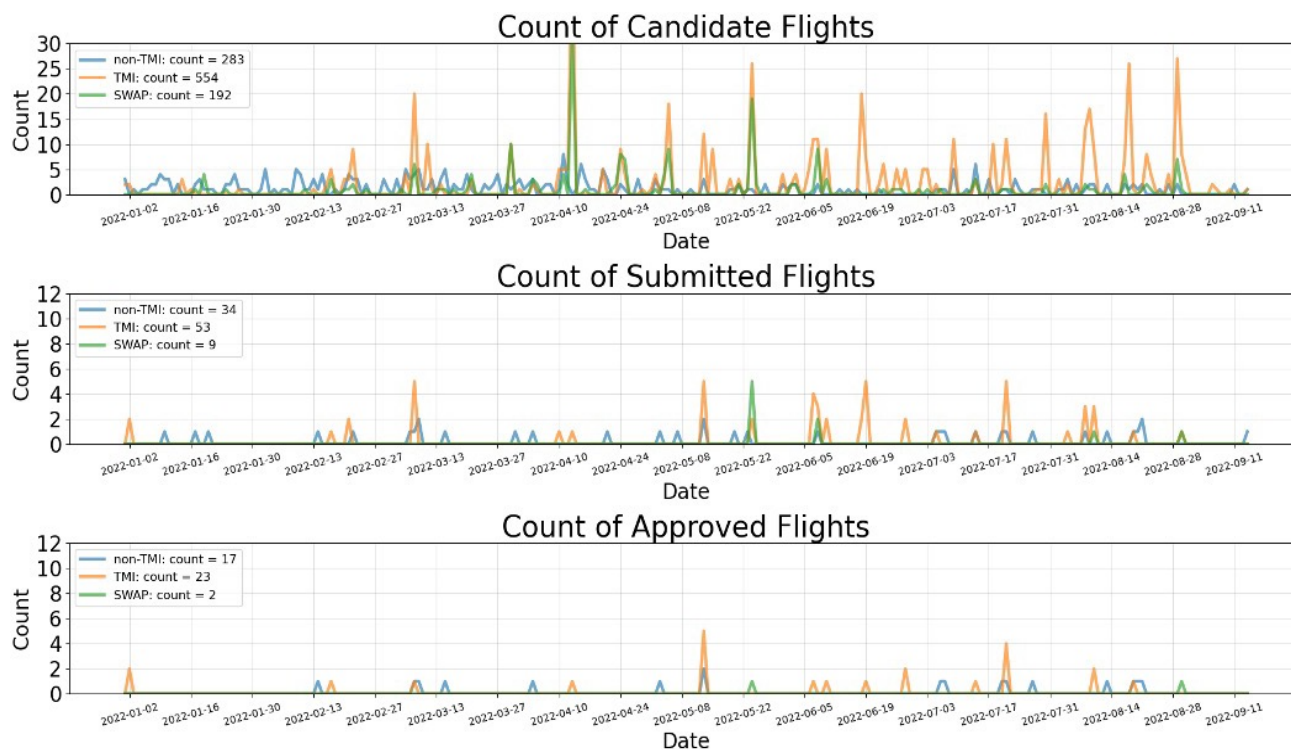


- 1a Field Demo partners leverage the existing relationships from ATD-2 Phase 3 Field Evaluation
- 1a plans to use the existing NTX NASA network installed at FAA and Flight Operator facilities
- 1a Field Demo partners already familiar with the CDDR concept, technologies, and workflow
- Provides an experienced field demo partner cadre to evaluate the 1a digital services that could be deployed to other locations

2022 CDDR Environmental Benefits

Between **January 1st, 2022** and **Sep 16th, 2022**

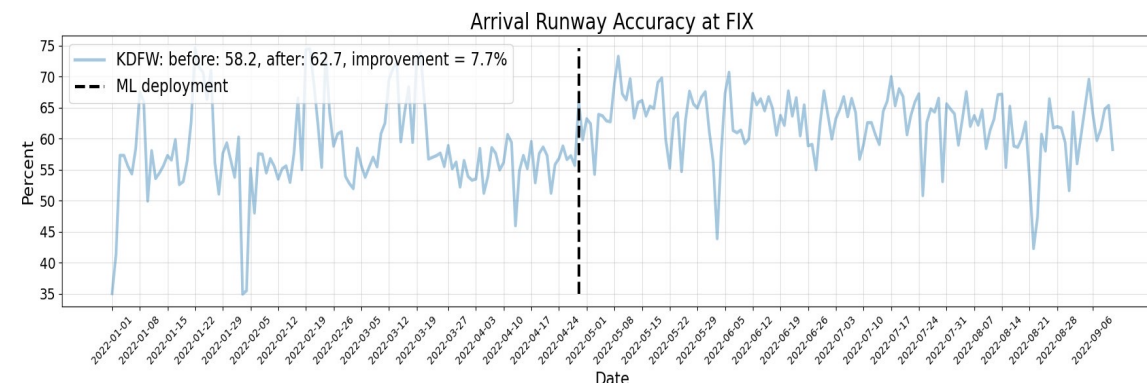
- 24.8K pounds of **fuel** saved
- 76.6K pounds of **CO₂ emission** reduced
- 569 **urban trees** saved
- Average reroute saves 15.4 urban trees **+3.5% YoY**



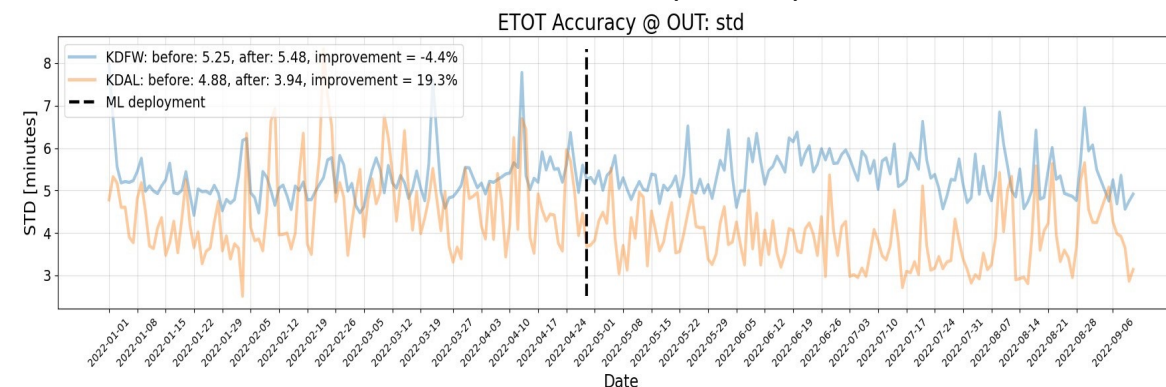
DIP Machine Learning vs Legacy ATD-2

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

Arrival Runway Prediction

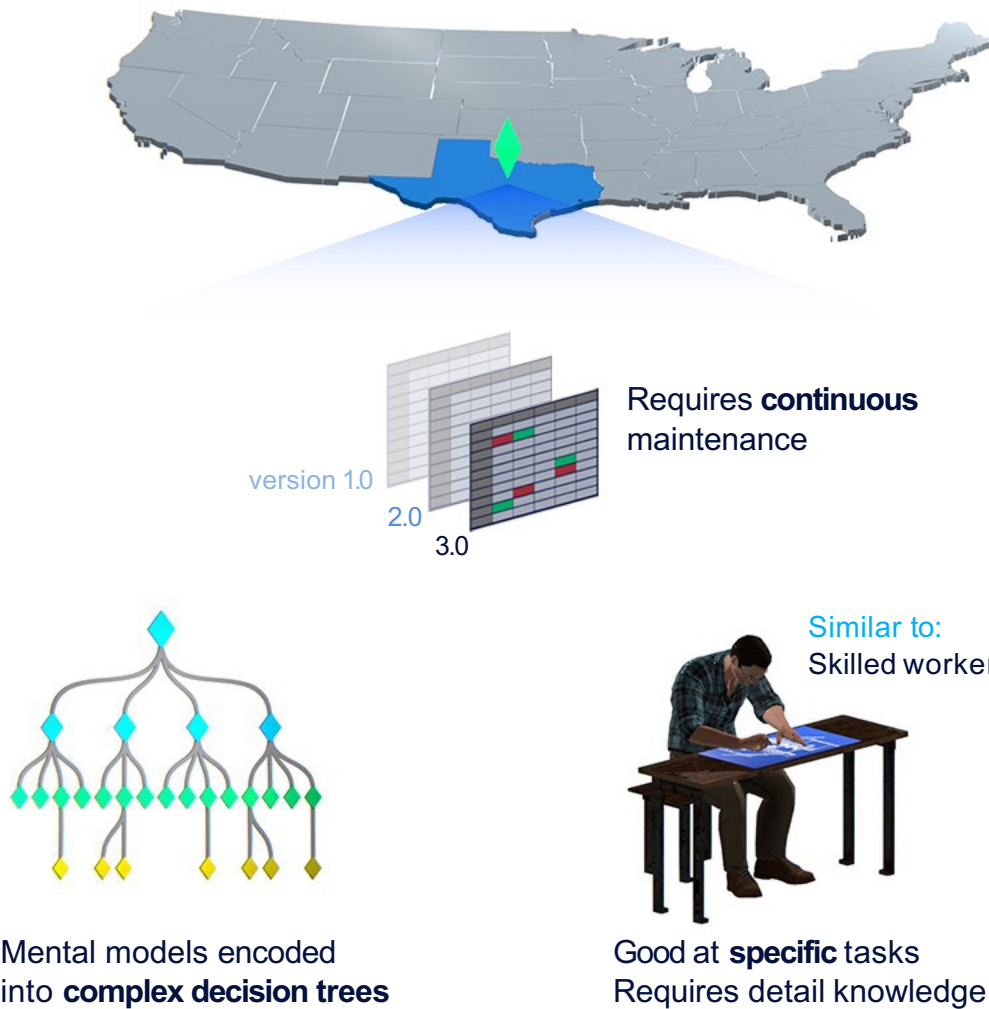


Estimated Take OFF Time (ETOT) Prediction



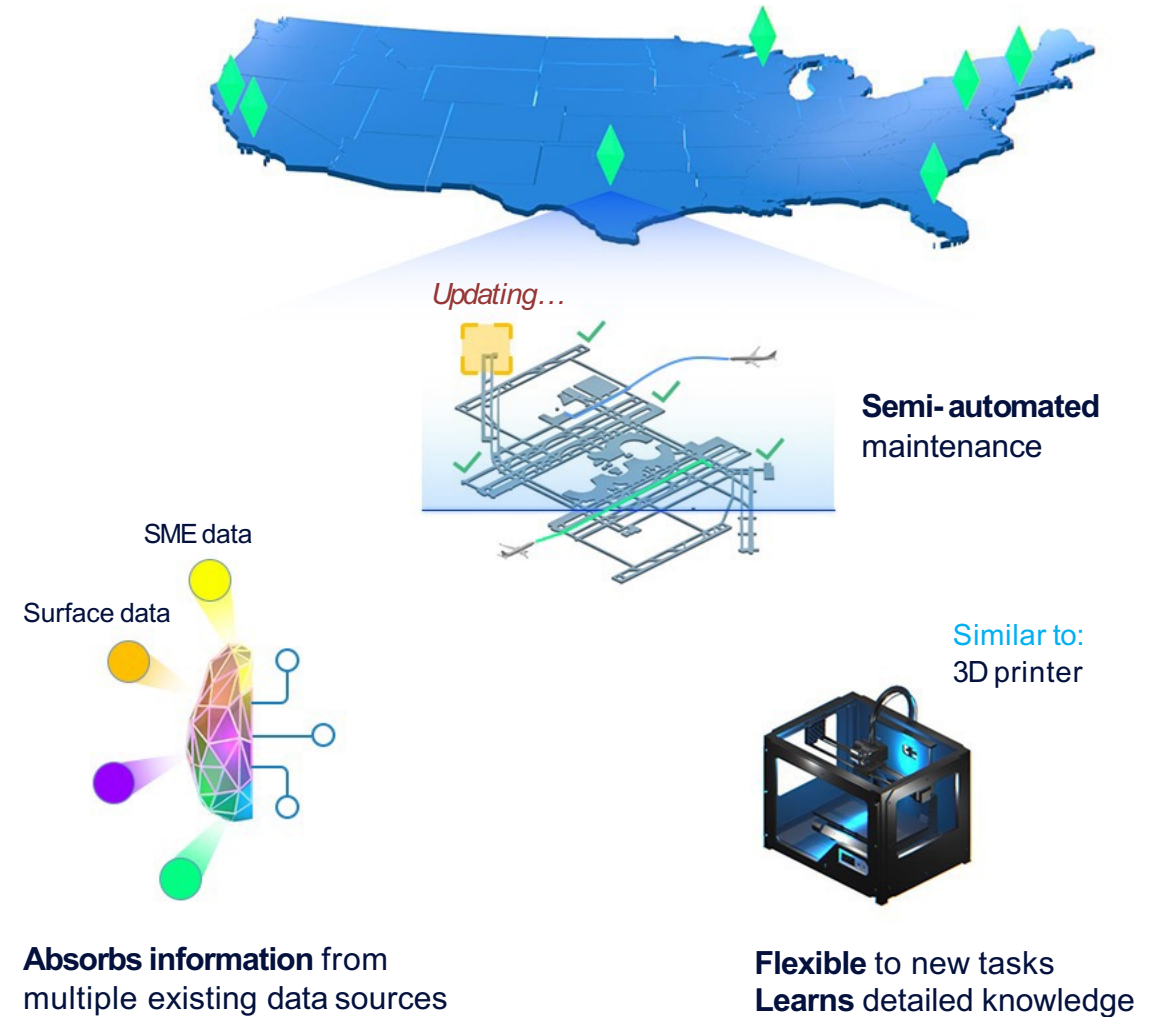
Legacy

ATD-2 Airport Surface Model



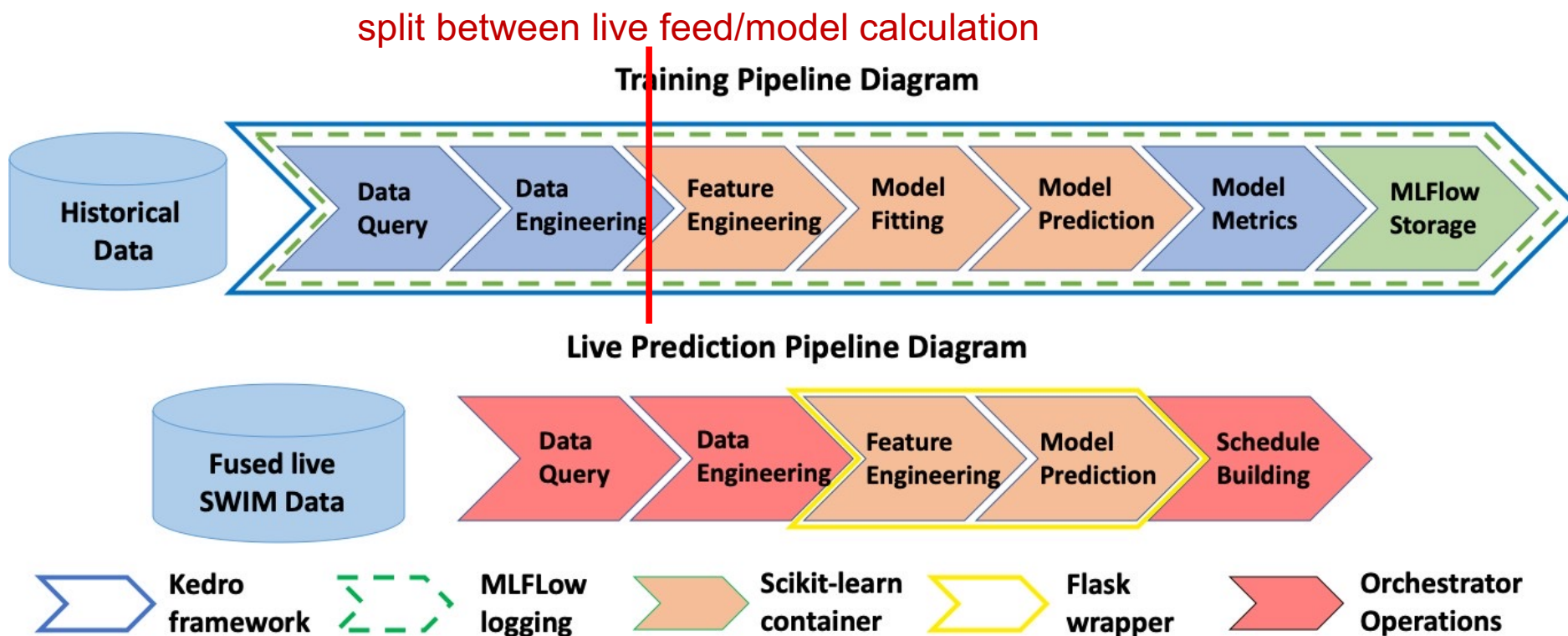
Current

Scalable DIP Machine Learning Airport Surface Model



We developed our training pipelines in Python around mainly three Python libraries :

- Kedro : pipeline structures defined by DAGs, help to abstract inputs and to define a common design for the team
- Scikit-learn: used for the Pipeline class that allows to store some feature engineering into the model
- MLflow : keeps track of the models, their artifacts, performances, tags the latest models



ML service code available on GitHub : <https://github.com/nasa/ML-airport-configuration>

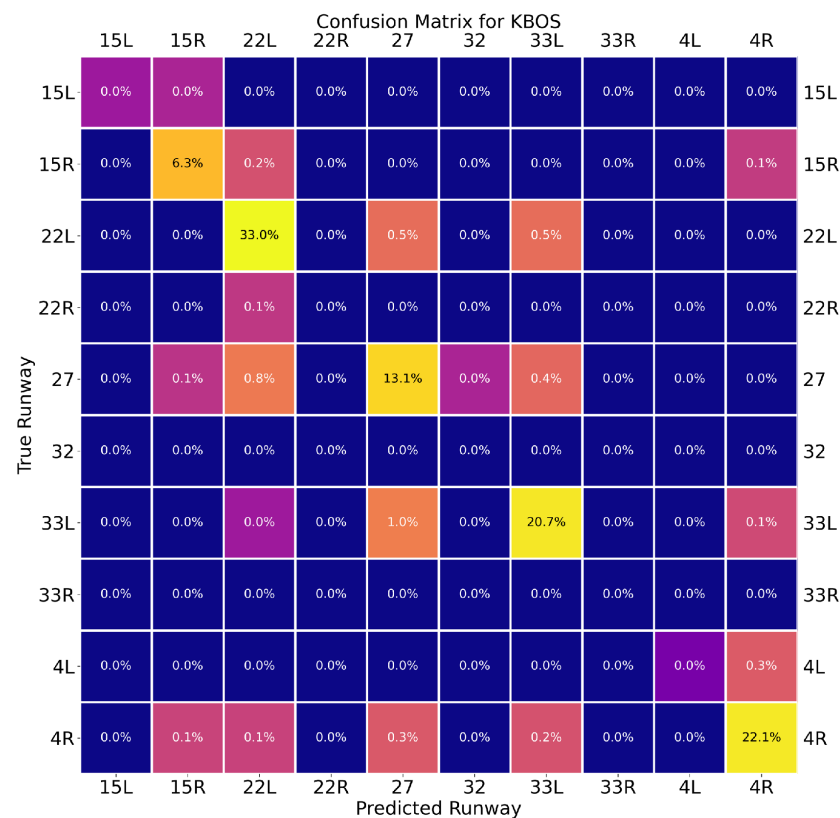


Arrival Runway Prediction at Other Locations



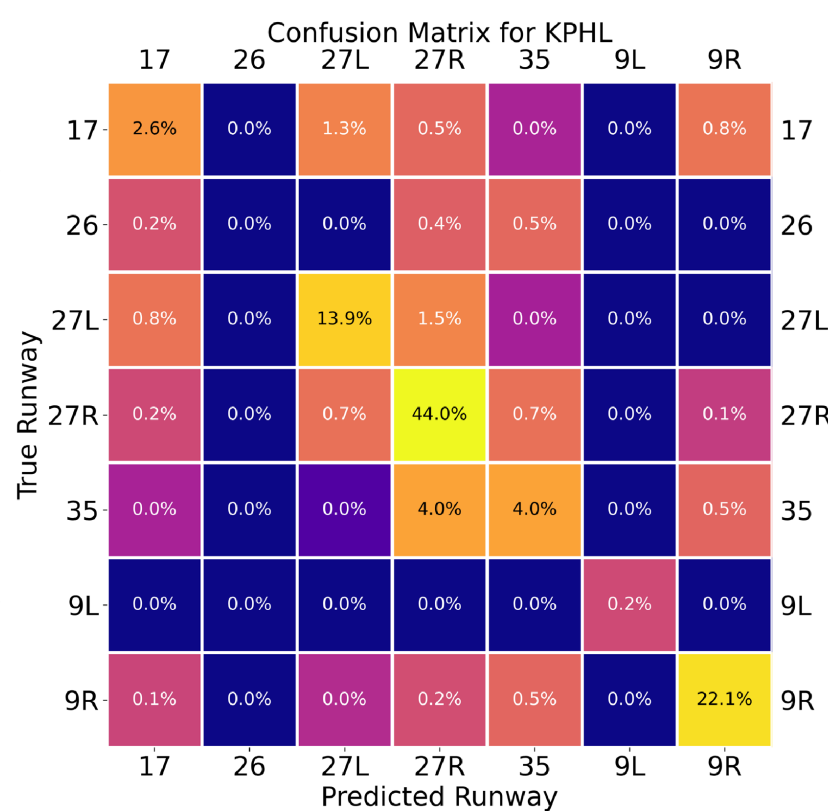
KBOS Arrival Runway

accuracy = 95.1%



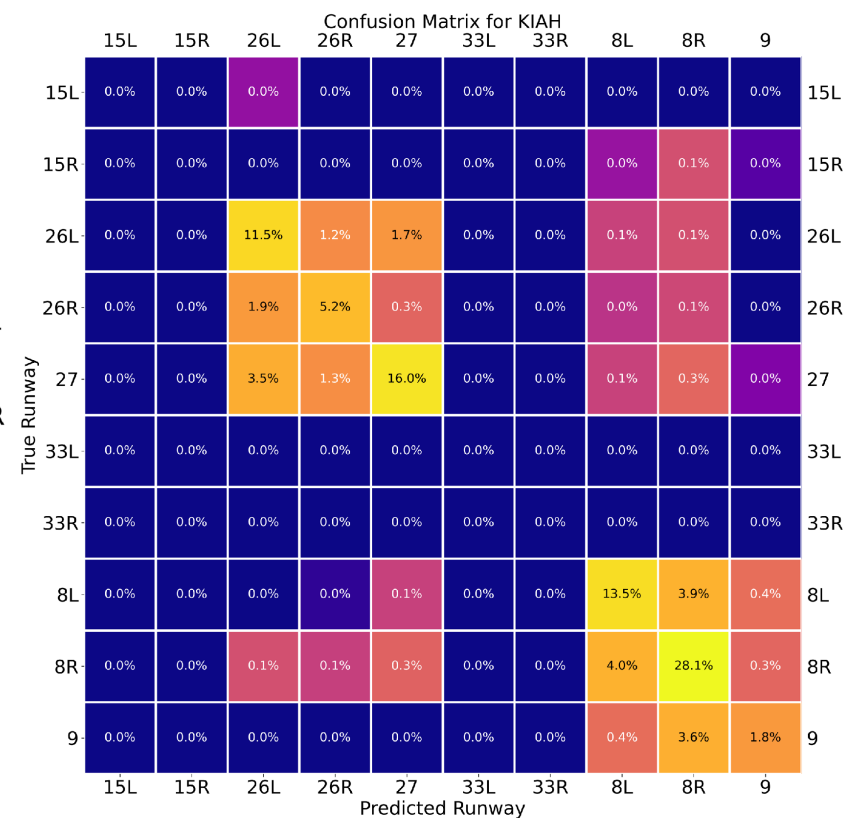
KPHL Arrival Runway

accuracy = 87.1%



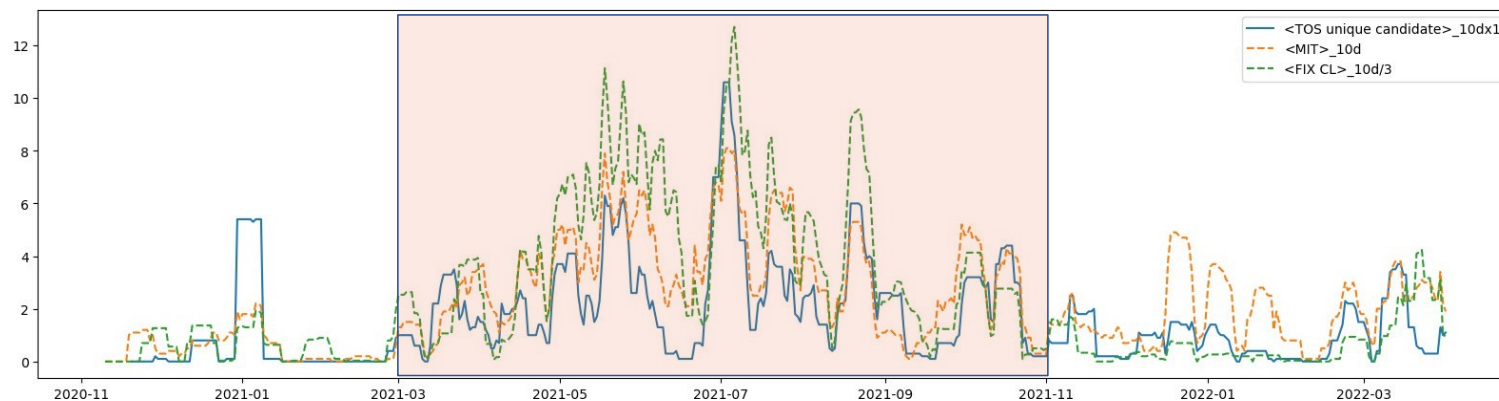
KIAH Arrival Runway

accuracy = 76.1%



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

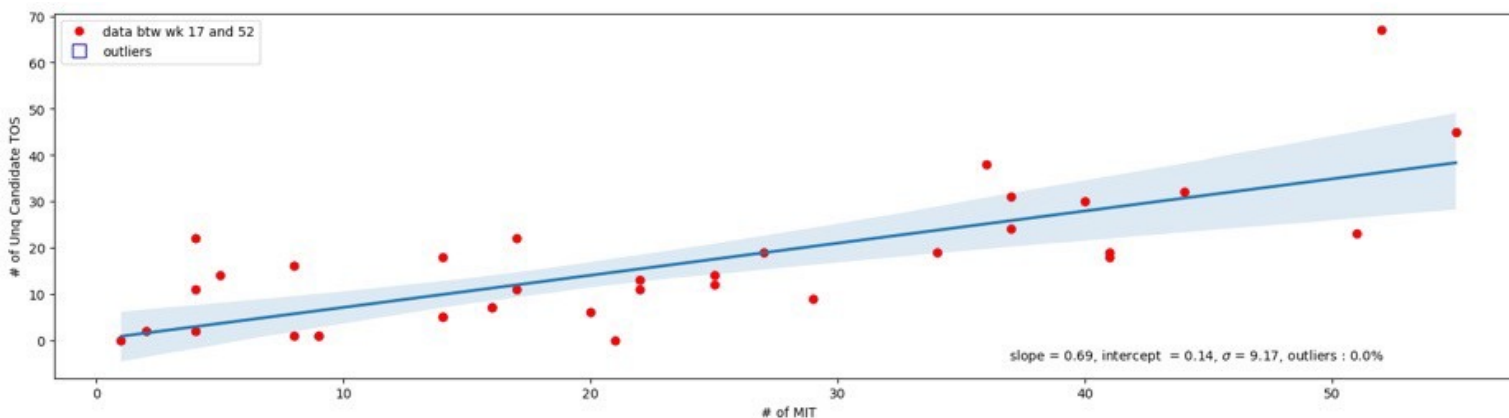
North Texas: Model Candidates as a Function of TMI



Model Applied to Other Airspaces



TRACON	Model with # of MIT (min)	Model with # of MIT (hour)
D10	675+-299	11.3+-5.0
N90	997+-443	16.6+-7.4
PCT	380+166	6.3+-2.8



Benefits vary Depending on Operations & TMIs; EX: N90 ~1.5x; PCT ~.5x of North Tx



Platform Technology & Partner Services

Pallavi Hegde

Eric Chevalley

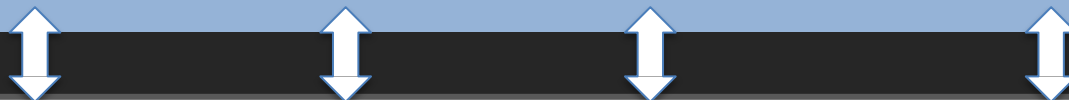


Current Platform Development



DIP Platform Cloud

Digital Information Platform



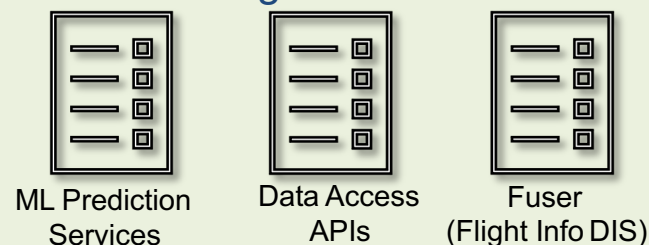
Registered Service's Interface (*per service*)



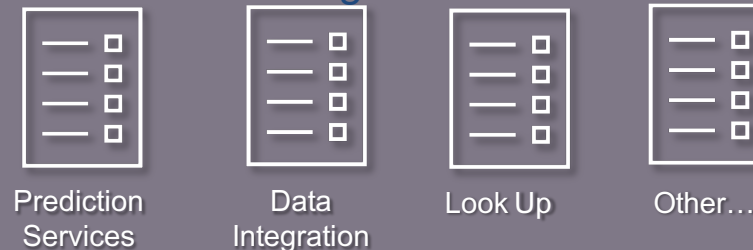
NASA Cloud

Partner Infrastructure

NASA Registered Services



Partner Registered Services



Registered Services

Current Features

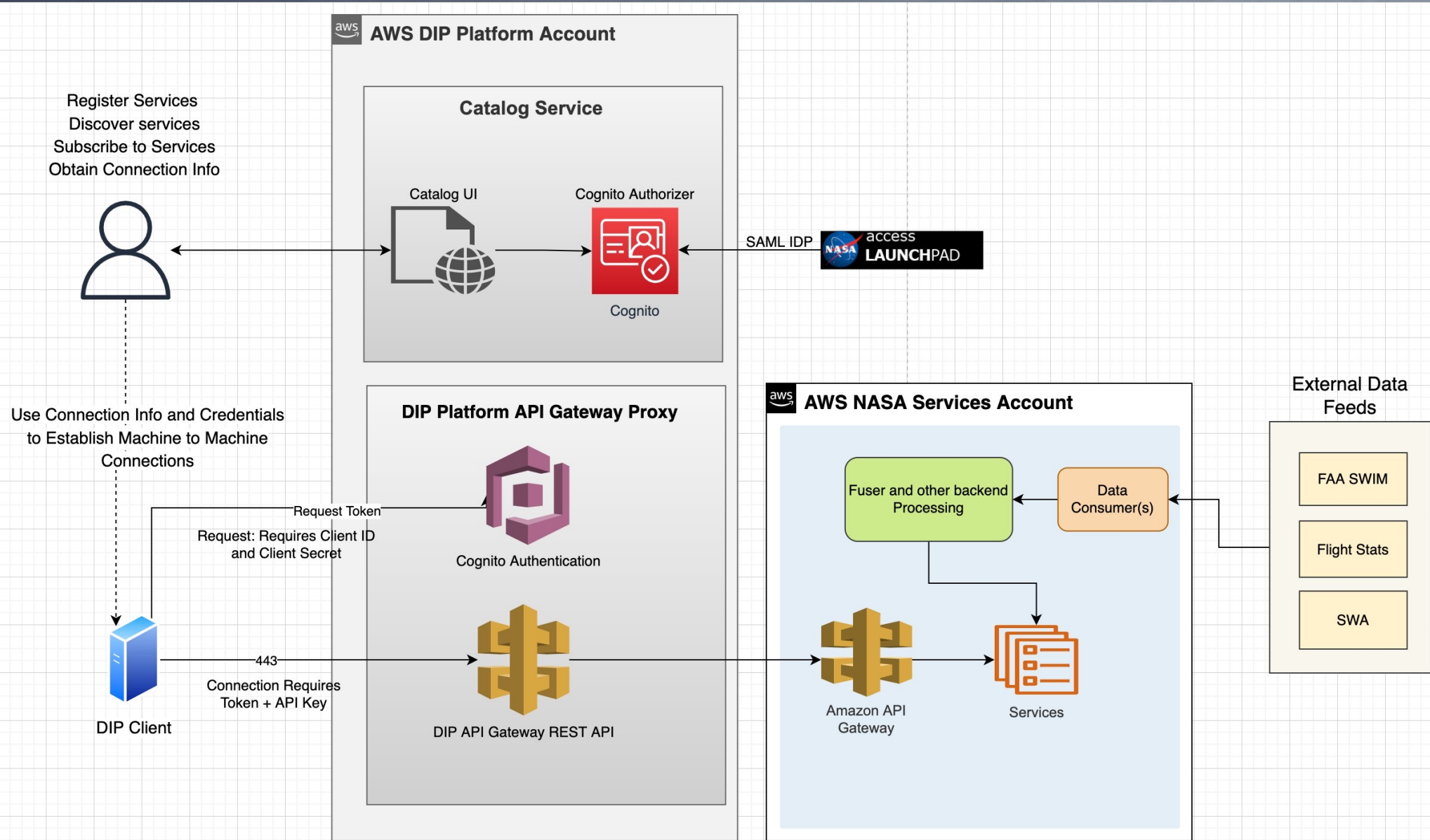
- Secure access
- Service Registration support
- Catalog service
- Access to NASA services

Features for FY23

- Key Performance Indicator
- Health monitoring
- Data Storage of NASA Services

Stretch Goal Features for FY23

- Peer-to-peer Communication with Payment gateway





Platform Features



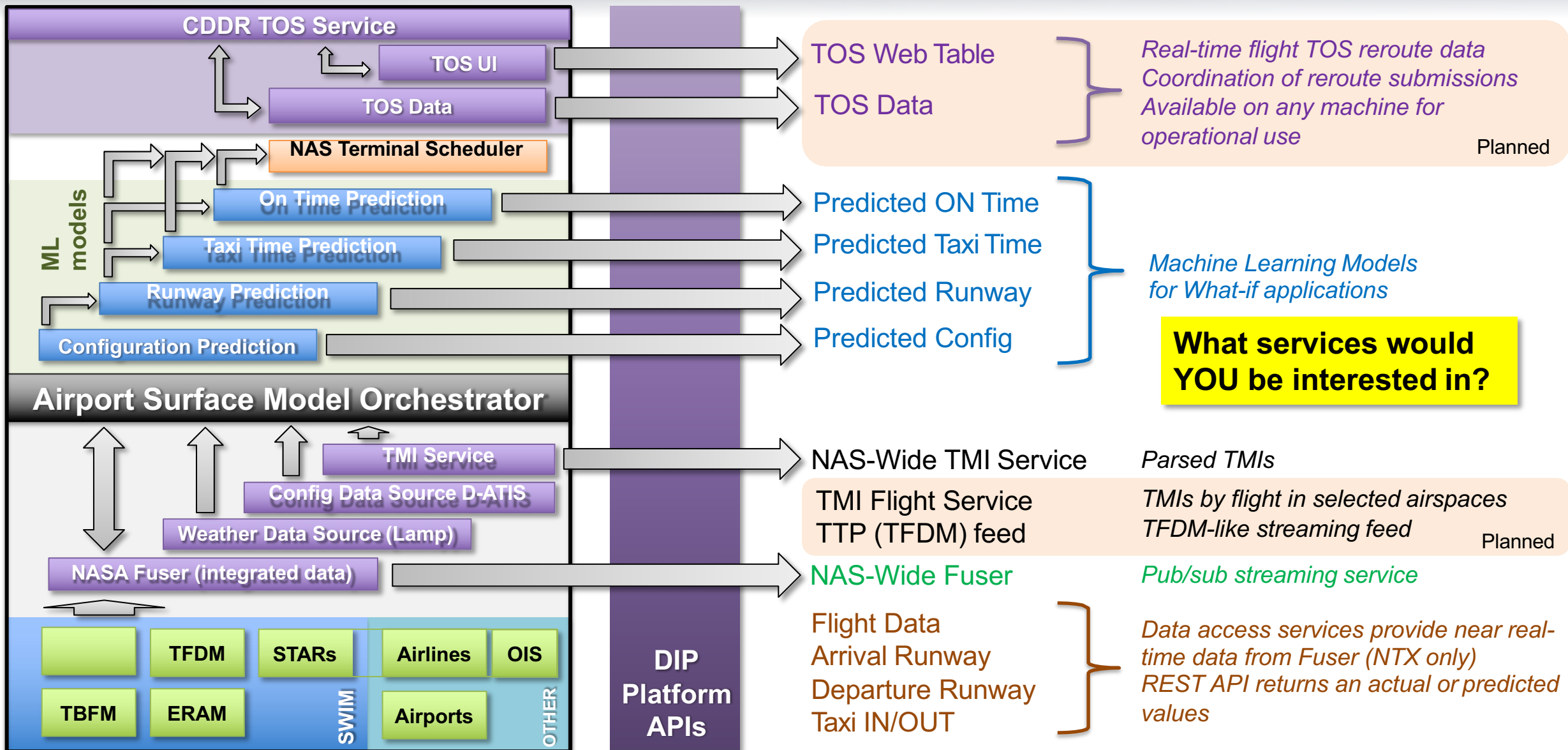
Features	Description	Scope
DIP Catalog	The DIP Catalog is a repository of information about services provided and available to the aviation community. The catalog allows users to register, browse, search, try, subscribe, and connect to services.	FY2022
Reporting and Monitoring	The platform facilitates Reporting and Monitoring Dashboard to visualize metrics at various levels	FY2023
Data Storage and Data Archival Service	Platform provides historical data archival and Data Archival service to access stored data	FY2023
Streaming Data API Solutions	Abstract implementation for Streaming and pub-sub solution using Distributed Application Runtime (DAPR)	FY2023
Data Governance - Identity	The DIP Identity Management Service (DIMS) provides the necessary APIs for entities to query, manage and verify identities within the DIP ecosystem	FY2023
P2P Communication & Payment Delegation	DIP enables P2P interaction between the DIP Platform and Partner infrastructure, facilitating the subscribers with URLs provided by service owners to pay for services using a payment gateway	FY2023-24
Distributed Architecture	The long-term vision for the platform is to move towards a distributed architecture approach where the network traffic is distributed using P2P-enabled interactions	FY2024



Current NASA Services via the Platform



NASA's Building Blocks





Identified High-Value Services From RFI Responses



- | | |
|---|--|
| • NAS-wide Fuser Service | NASA's ATD-2 service expanded to the NAS |
| • NAS-wide TMI Service | NASA's TMI service expanded to the NAS |
| • TOS related Services | NASA's CDDR service expanded to new airspaces |
| • Landing runway prediction service | NASA's EON prediction service |
| • IROP Disruption Management | Potential multi-partners solution |
| • NAS-wide Wind Miles Prediction | Potential service |
| • Weather Data Integration Service | Potential service |
| • NAS simulation and Playback | Potential solution |
| • Earliest Off Block Time (EOBT) generation | Potential service for traditional aviation |
| • Surface congestion prediction (Bank overlap) | Potential prediction service |
| • Surveillance Data Integration Service | Potential service for traditional and new entrants |
| • Noise Prediction for New Entrants | Potential service for new entrants |
| • ... | |

- à Services and Solutions as identified by the Community who responded to the DIP Request For Information (RFI)
- à Via next ACO, DIP will seek Service Providers who can support the development of innovative solutions
- à DIP will continue to contribute to identified needs, however,
- à DIP ecosystem will enable the development of collaborative solutions across Partners

Goals

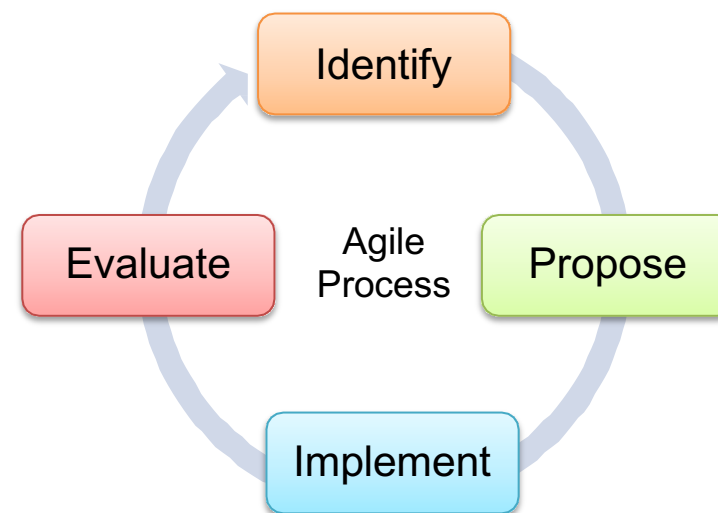
- Establish a cohort of partners of Service Consumers and Service Providers
- Complete PS-1 and conduct PS-2 evaluations
- Support partners to develop their use cases and facilitate high-value solutions that leverage DIP services

Approach

- Onboarding process and familiarization with Platform
- Individual Meetings (identify needs and use cases, provide support, get feedback on proposal and use)
- Group Meetings (provide updates, discuss topics, get feedback, eco-system events)
- Data Collection (usability + actual platform and services use)

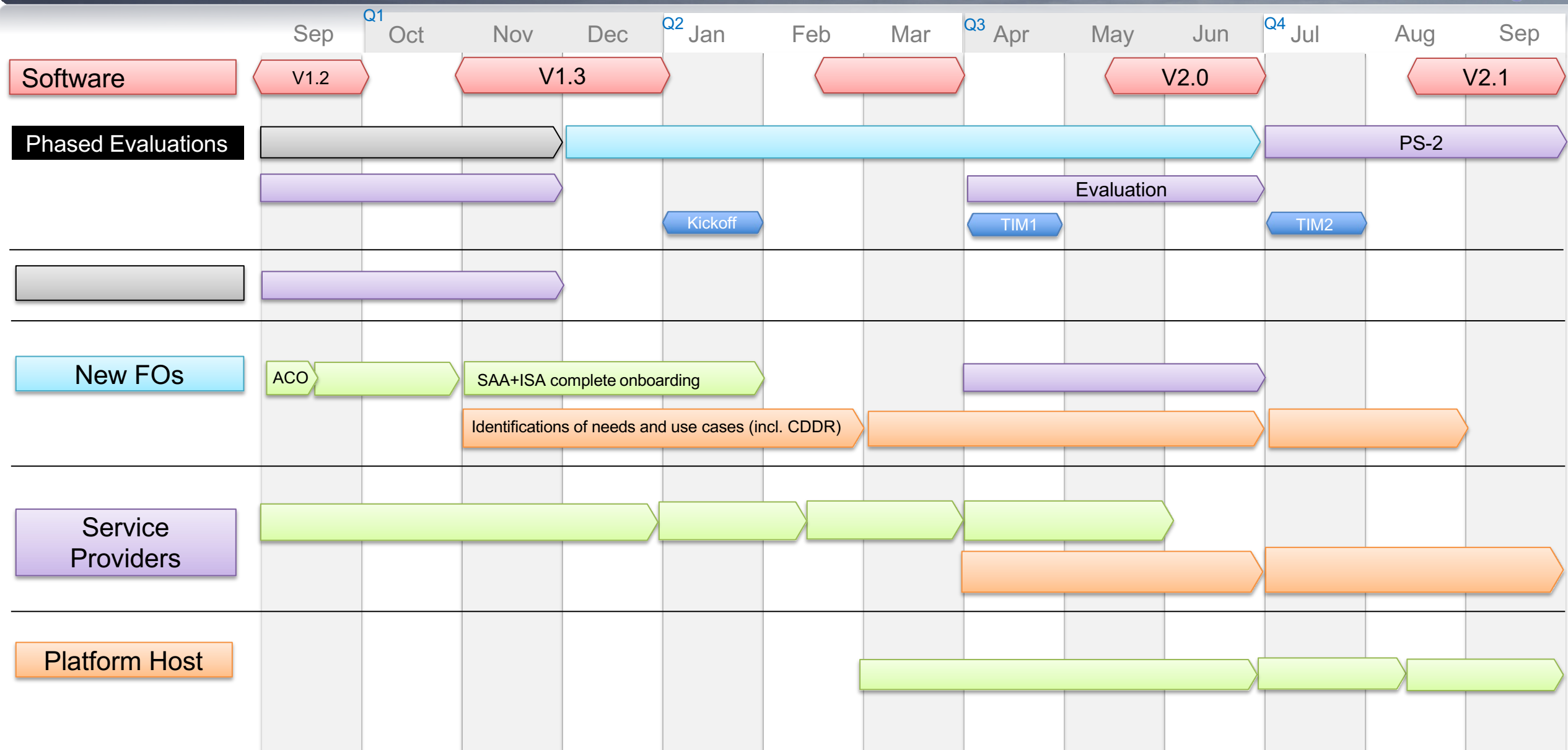
Outcome

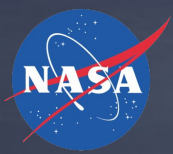
- Recommendations of Platform and Service development
- Lessons Learned and Benefits Analyses





Timeline With Partners





DIP Catalog



DIP CATALOG

bogusairlineuser1

Welcome to the DIP Catalog
Your home to register, search and discover aviation data and services. [LEARN MORE](#)

SubscriptionsRegister ServiceBrowseAboutSupport

What type of service are you looking for?

Clear Filters

Categories

☐ Capacity, Demand, and Flow
☐ Data Access
☐ Environmental
☐ Flight Information
☐ Machine Learning
☐ Meteorological
☐ Other
☐ Predictive
☐ Surface Management
☐ Surveillance
☐ Tactical
☐ Terminal Management

Service Types

☐ REST
☐ STREAMING

Capacity, Demand, and Flow

NASA Arrival Runway Service

NASA Departure Fix Utilization Service

NASA Departure Runway Service

NASA Flight Service

NASA Fuser CDM Stream

Data Access

NASA Arrival Runway Service

NASA Departure Fix Utilization Service

NASA Departure Runway Service

NASA Flight Service

NASA Fuser CDM Stream

Environmental

Search & Discover



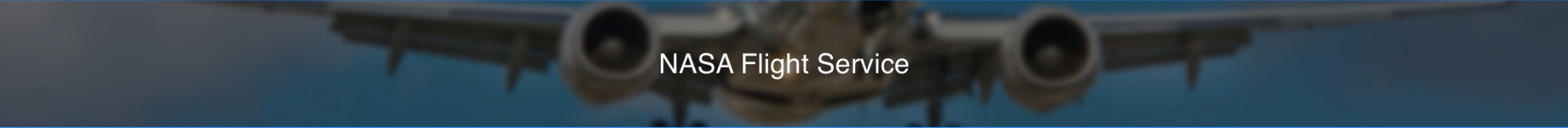
Service Information Web Page





DIP CATALOG

Eric 



NASA Flight Service

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What type of service are you looking for?



Name & ID

Description

NASA Flight Service

[NASA Admins](#)

Service ID: 6



Version 1.0.0

Serving 3 Users

About This Service

NASA Flight Service

[CONNECT](#)[API](#)[UNSUBSCRIBE](#)

The Flight Service returns a collection of predictions and resources for a set of flights within +/- 3 hours of a user defined timestamp for a given airport. The service will return a configurable set of identifier fields based on dynamic field definitions that are part of the user input. All results would be pulled from the NAS Model flight summary and model extension tables.

The last 30 days (current time – 30 days) are available to return as part of the time range for the NASA Flight Service for the following airports: KDFW, KDAL

[Data Access](#)[Surface Management](#)[Tactical](#)[Terminal Management](#)

- Learn More
- Try It Out
- Connect
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Questions?

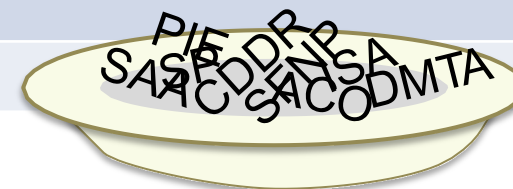
- Please email to ARC-DIP-EXT@mail.nasa.gov for questions or comments
- Visit <https://nari.arc.nasa.gov/atmx-dip> for more information regarding DIP sub-project and future events

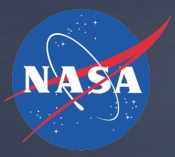


Acronyms (Selected)



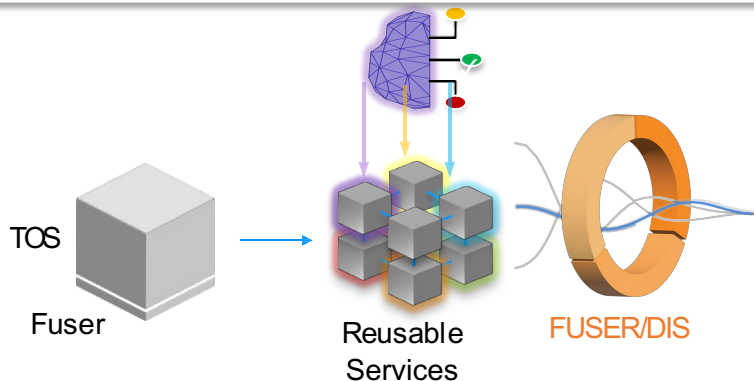
Acronyms	Full Names
ACO	Announcement for Collaborative Opportunity
CDDR	Collaborative Digital Departure Rerouting
D-ATIS	Digital Automatic Terminal Information Service
DMTA-RTT	Digital Mesh Technology and Application-Research Transition Team
ISA	Interconnection Security Agreement
LAMP	Localized Aviation MOS Program
NTX	North Texas
PIE	Platform Integration and Evaluation
PS	Partner Services
RFI	Request for Information
SA	Sustainable Aviation
SAA	Space Act Agreement
SFNP	Sustainable Flight National Partnership
STBO	Surface Trajectory Based Operation



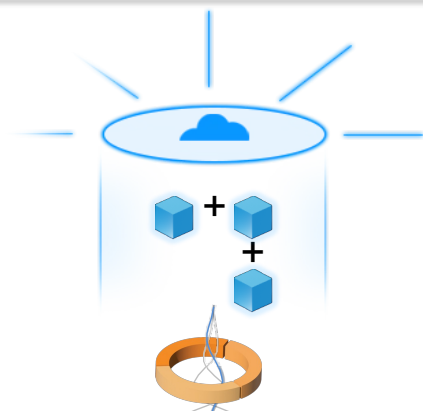


Back up Slides

TODAY – SFNP-Ops 1a CDDR w/ML @ NorTx



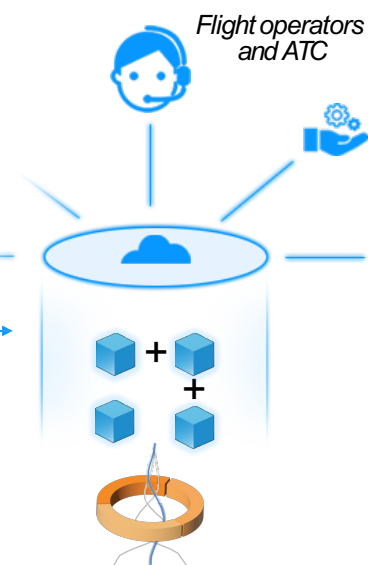
*Applied machine learning to digital prediction services
Transformed to service oriented architecture*



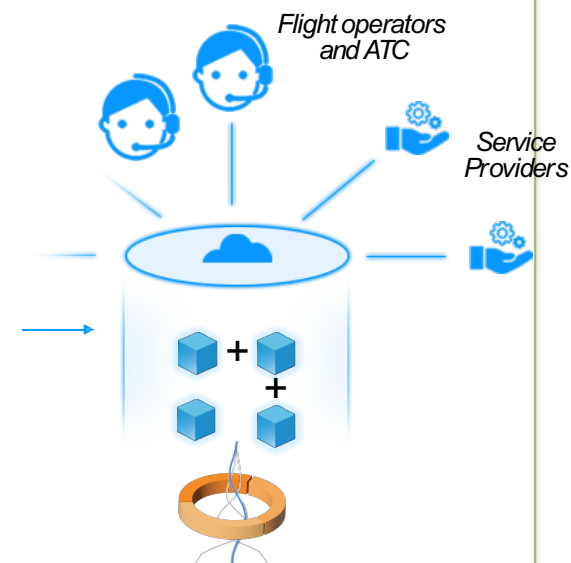
Build up cloud-based platform to register services

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



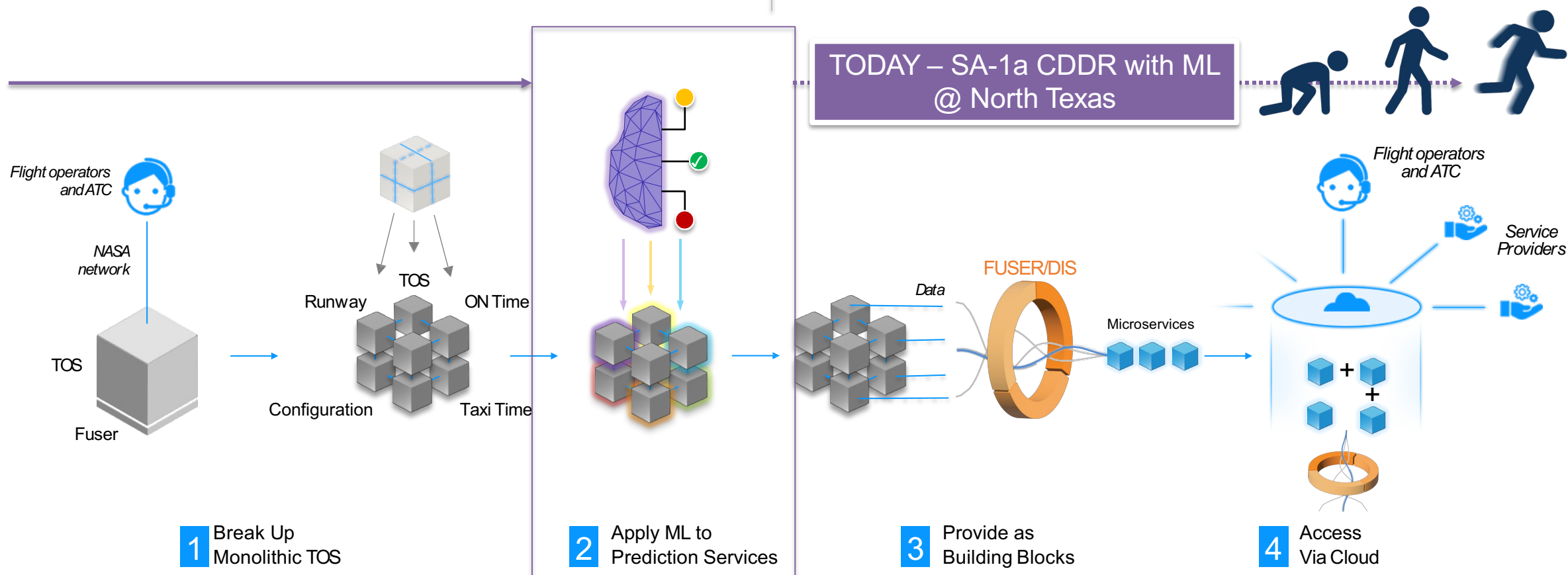
Immediate impact to RW Operations; Agile build up

BEFORE: ATD-2

Monolithic service for single application, using adaptation-based algorithms to generate trajectory predictions as input to terminal scheduler; requiring site-to-site deployment

FUTURE: DIP

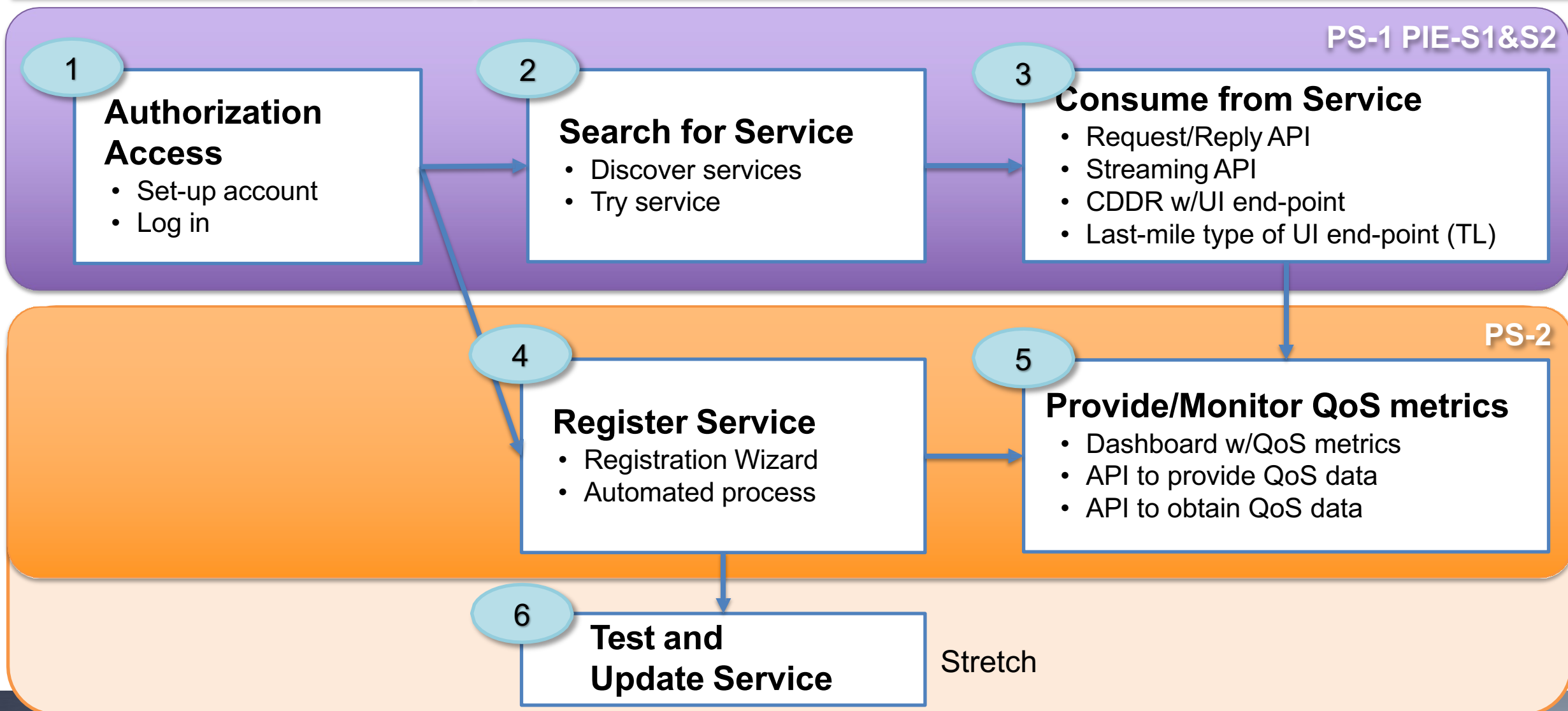
Transformed into service-oriented architecture of highly reusable digital services accessible on the platform to support many advanced applications; upgraded to machine learning-based algorithms for predictions to enable NAS-wide scalability



Advancing Technology to scale and adapt for reusability in the NAS

Onboarding

Evaluation and Validation



• Data Storage

- RDS Database
 - Loaded continuously
 - Data will roll off after 1 month
- S3 Buckets
 - Nightly process to export from Postgres, convert to parquet, load to S3
 - Data will roll off after 3 months
- Sherlock
 - Process to copy from S3 buckets and store in Sherlock

Ways to Access NASA services and Data

- **Query data access API:** prediction services write results to data archive which can be queried for near real-time or historical results
- **Query model API:** machine learning models can be queried in what-if mode where user provides required input and model returns the prediction
- **Consume real-time Fuser data:** prediction services write results to the real-time Fuser data feed which can be consumed as pub/sub service
- **CDDR cloud-based TOS table:** prediction services write results to the backend system which show real-time data in cloud-based User Interface

