# Emerging Aviation Trends in ATD-2 and Vector for Future Innovation

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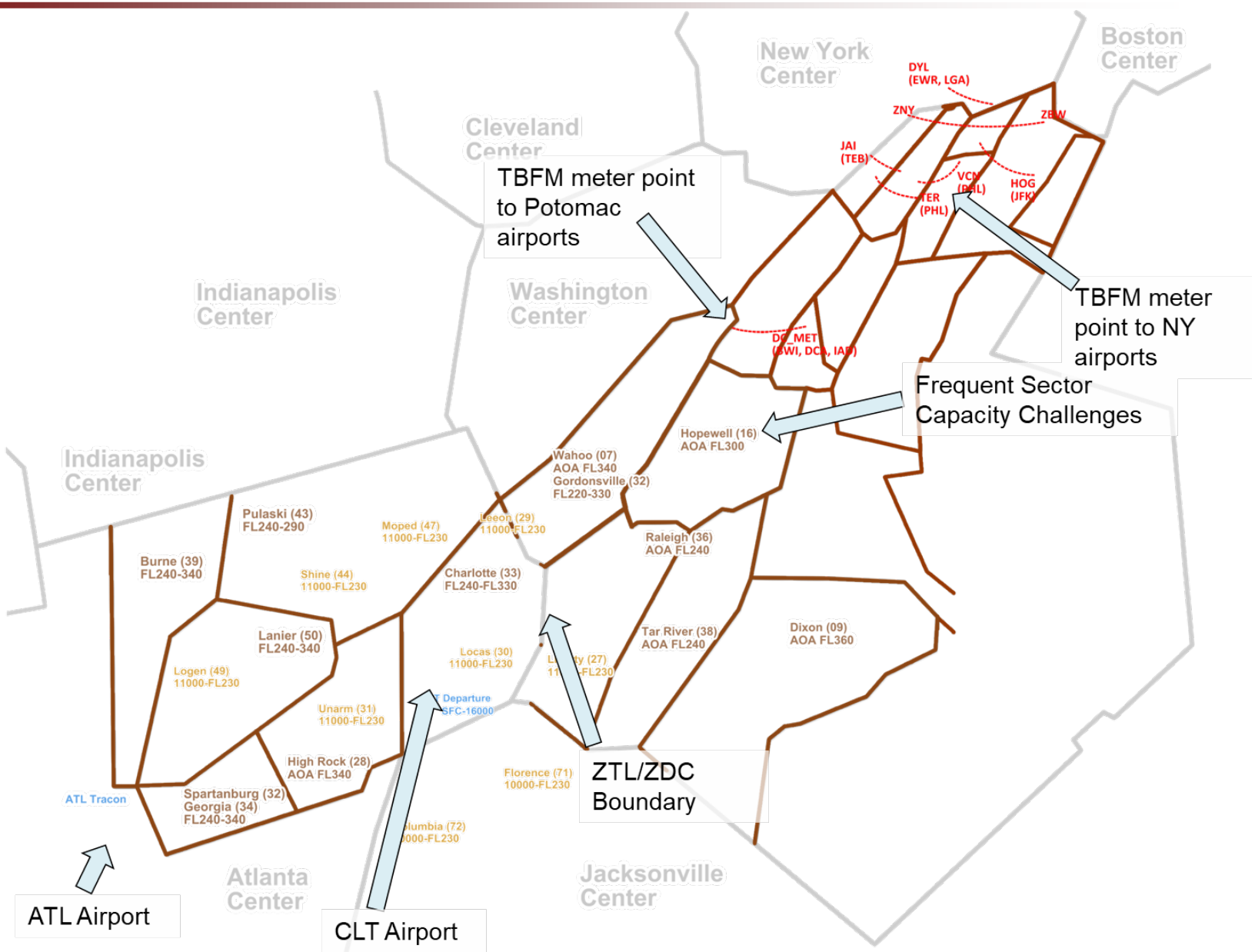
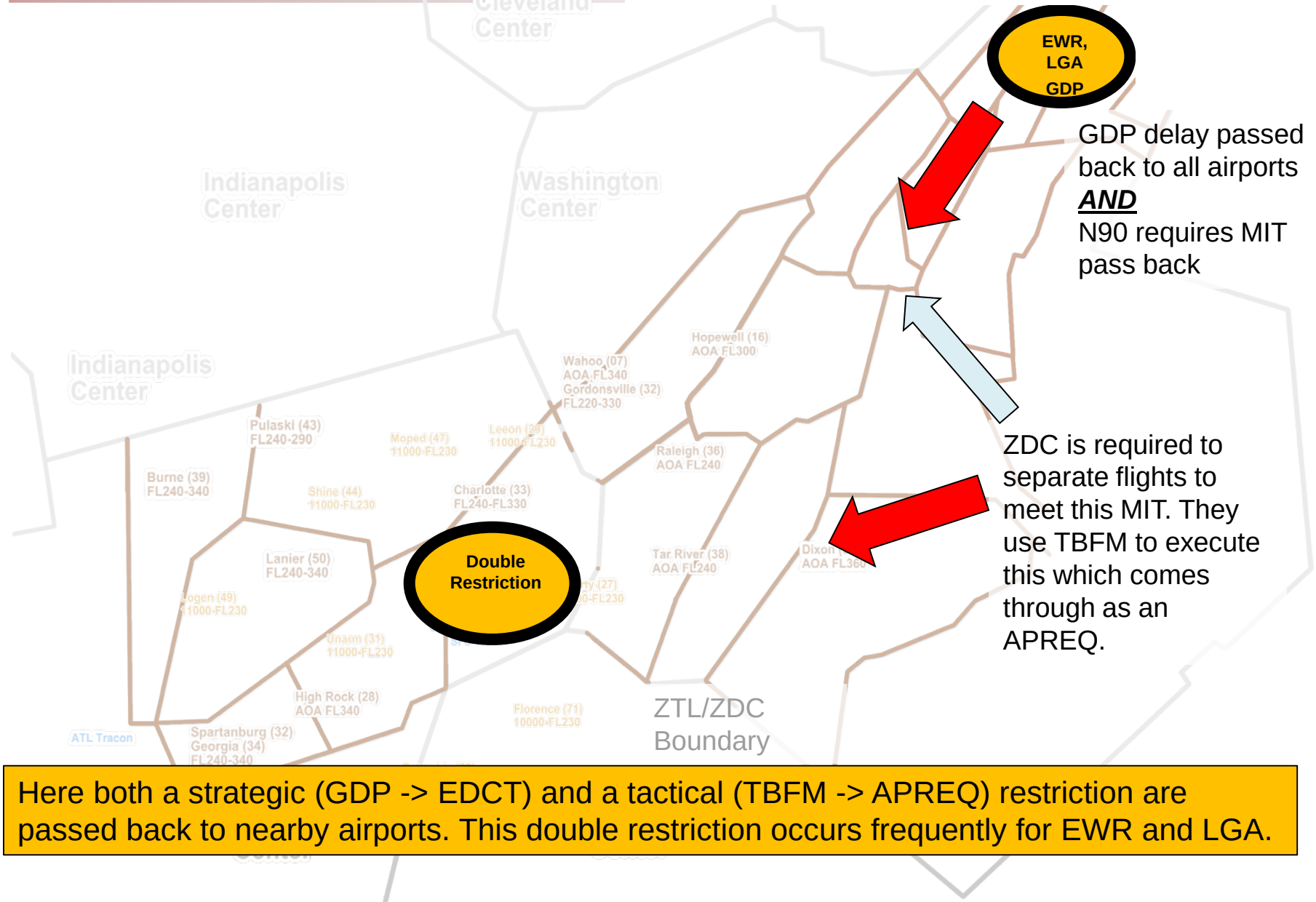
Nov 21, 2019

# Complex and Constrained Overhead Stream into Busy Northeast Corridor (NEC)



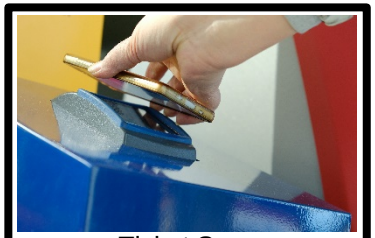
# Example – Double Constraints




Here both a strategic (GDP -> EDCT) and a tactical (TBFM -> APREQ) restriction are passed back to nearby airports. This double restriction occurs frequently for EWR and LGA.

# Increasing Predictability in the Overhead Stream by Leveraging Digital Assets (EOBT)

## Sensors



Ticket Scan


Video detection

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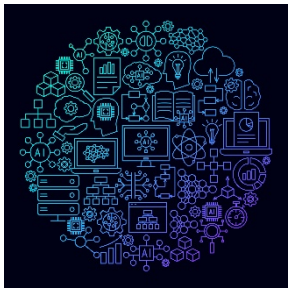
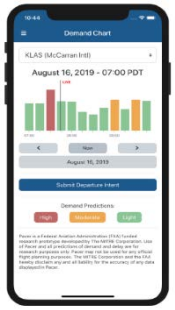
Fueler events

## Operators



For air carriers, algorithms produce EOBTs and send to SWIM




For GA/BA, pilot/ flight operators provides EOBT to system via mobile app/web site

## NASA ATD-2

NASA system consumes EOBTs from SWIM and calculates earliest wheels OFF. Sends to FAA Center TBFM system.

## FAA Systems

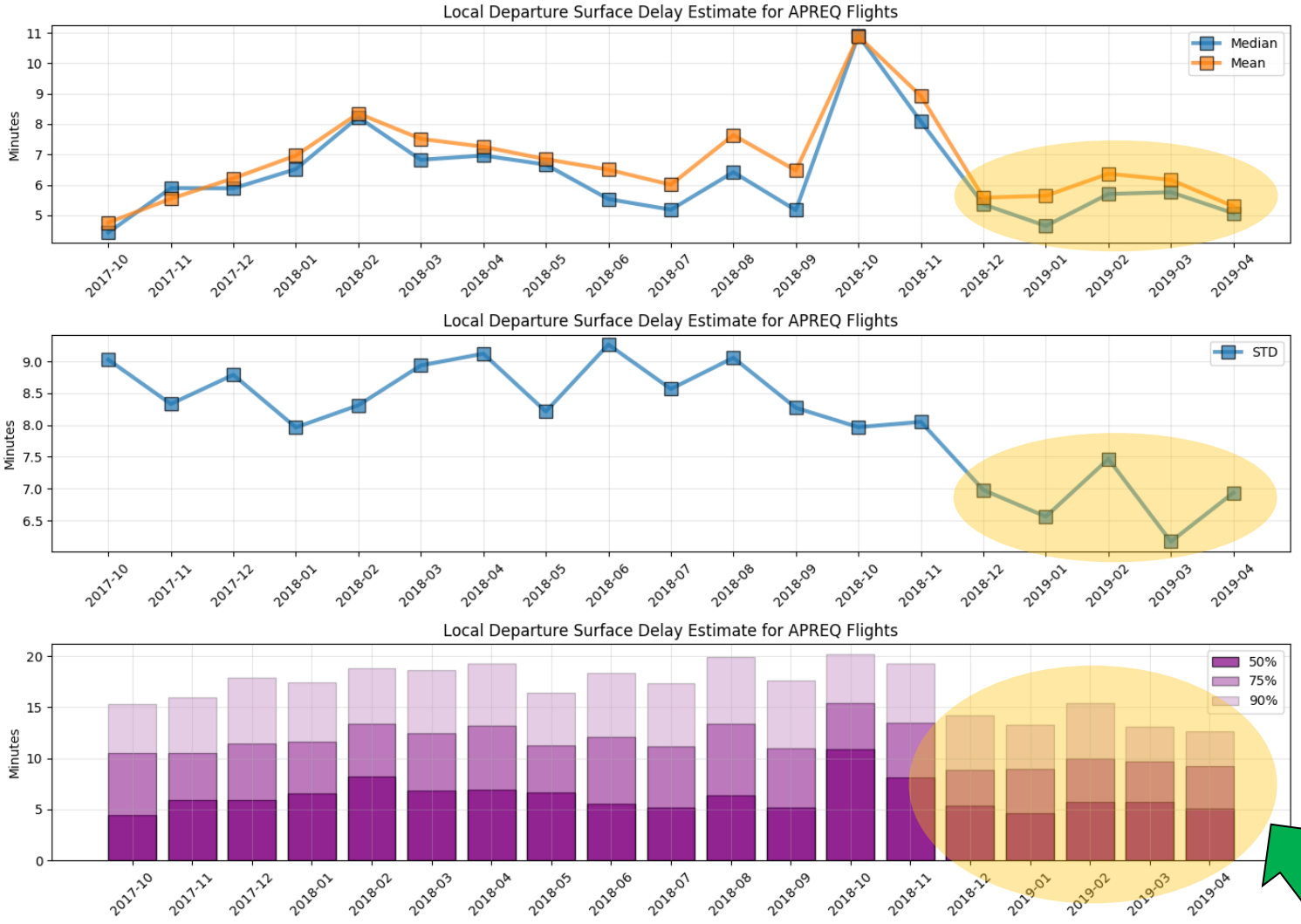

FAA system calculates release time and sends it back to NASA system, which then sends it to SWIM (TTP*) for others to consume.

TTP=TFDM Terminal Publication – currently research-only SWIM topic

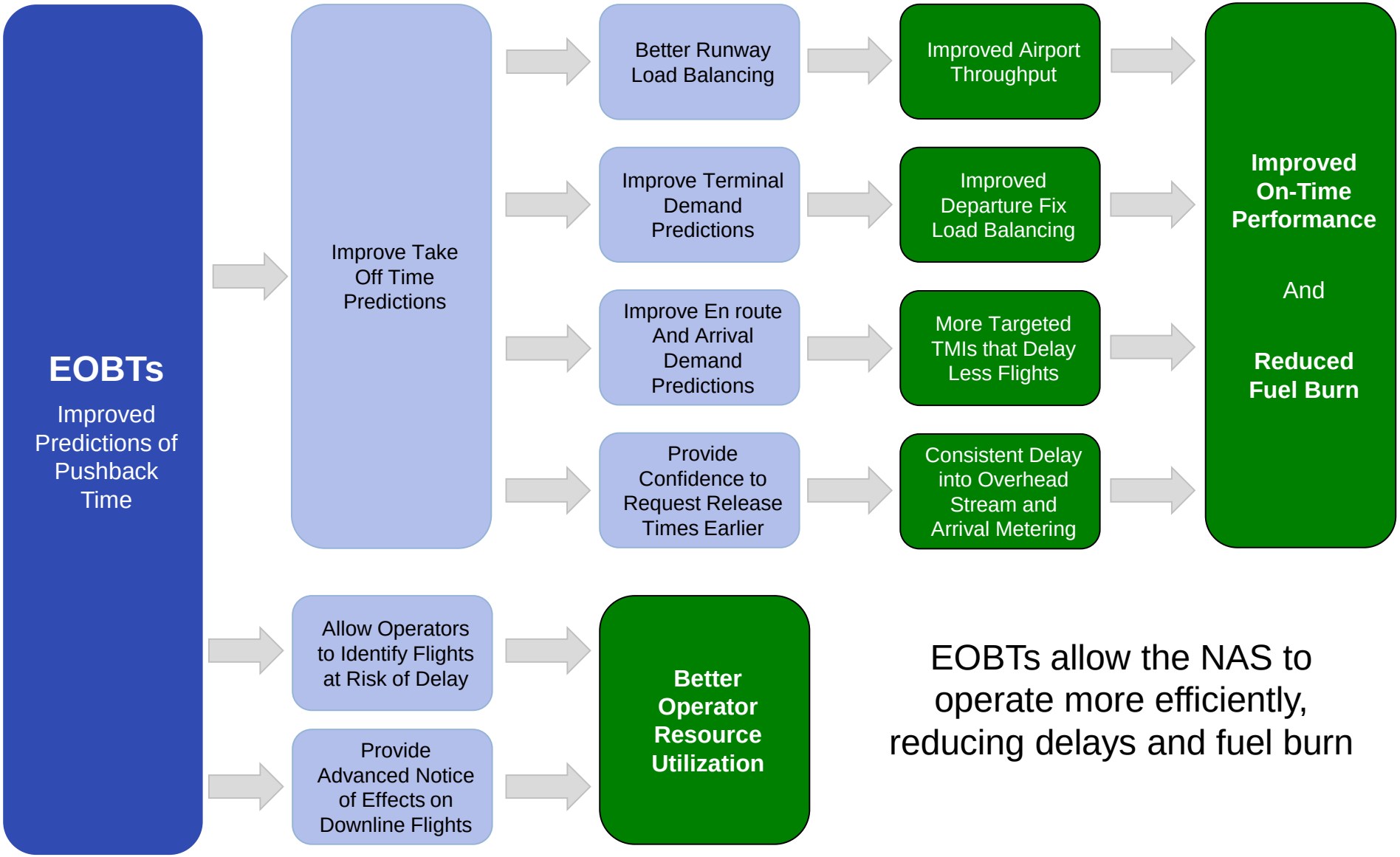
New Use?

# Automatic Scheduling with EOBT Improves Predictability

Did the changes on the previous slide ‘move the needle’ in the NAS? **Yes!**
Substantial Improvements in predictability of overhead stream delay



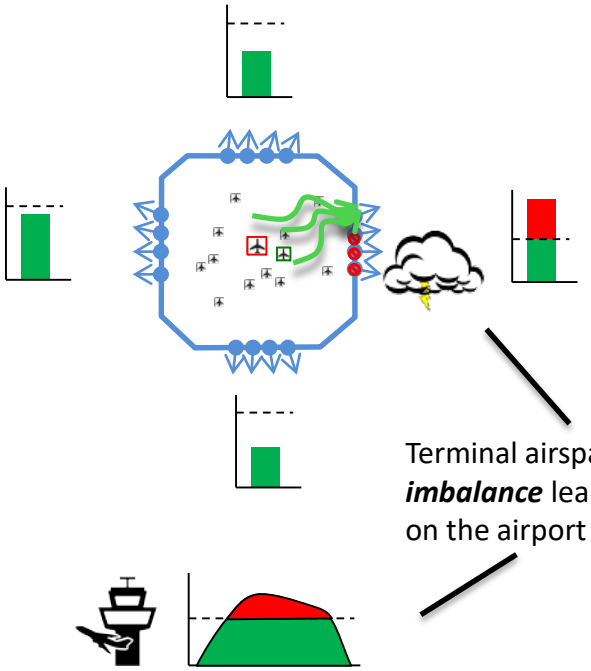
# Other Potential Benefits of EOBT (key new digital asset)




EOBTs allow the NAS to operate more efficiently, reducing delays and fuel burn

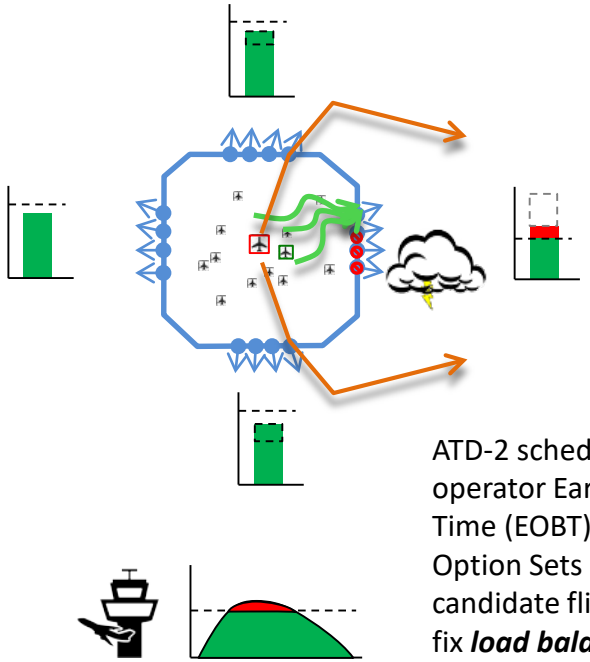
# A Common Multi-Airport Challenge

## The Problem



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

## The Solution



ATD-2 scheduler uses flight operator Earliest Off Block Time (EOBT) and Trajectory Option Sets (TOSs) to identify candidate flights for departure fix ***load balancing***

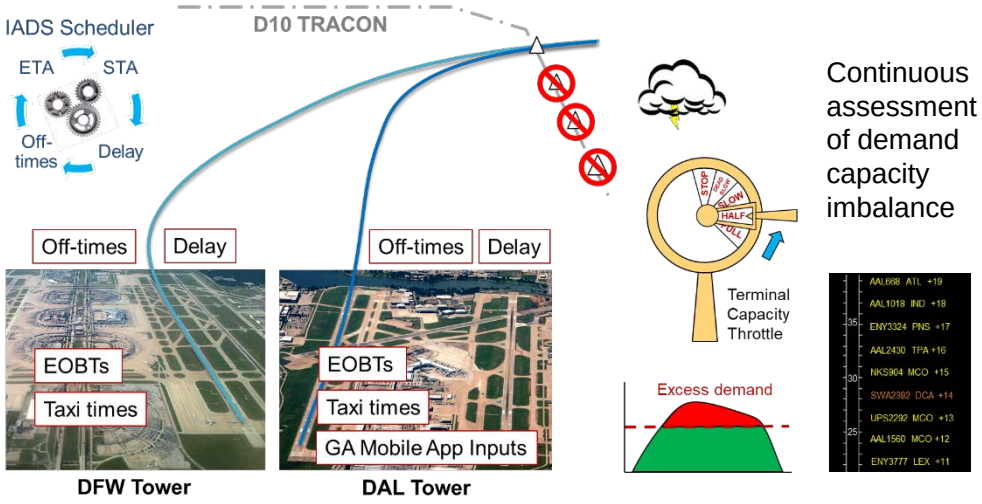
# TOS Alternative Routes – Current Process Flow

## 1 Before Day-Of Ops. Formulate 'Static TOS'

- ATC and operators identify acceptable alternative routes to be notified on
- Routes codified in ATD-2 static adaptation
- NASA and operators agree on Relative Trajectory Cost algorithm

```
<TRAJ_OPTION_LIST>
  <TRAJ_OPTION>
    <TRAJ_INDEX>1</TRAJ_INDEX>
    <REL_TRAJ_COST>0</REL_TRAJ_COST>
    <ROUTE>DCT IPL J18 GBN DCT PXR J18 SJN DCT TCC J6 PNH
    <ALT>F320</ALT>
    <SPEED>N0380</SPEED>
  </TRAJ_OPTION>
</TRAJ_OPTION_LIST>
```

## 2 Terminal Predictive Engine Determines Impact




Continuous assessment of demand capacity imbalance

## 3 'Candidate TOS' are Presented to Operators

- Assess delay savings on alternative routes
- When the RTC thresholds are met, the operator is informed of 'candidate TOS routes"
- Operators can then submit an acceptable TOS

Delay savings > Relative Trajectory Cost ?

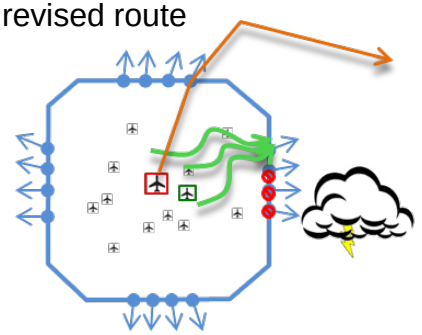
Settings Filter Field Color Alerting **Flight TOS** x

| Callsign | Dest | Route | CDR | Dist | +nm | Terminal Gate | RTC | Delay | Delay Savings | Eligibility State | Coordination State | Scratch pad |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AAL1560 | MCO | KDFW. MRSSH2. ZALEA CREEM CEW J2 CUHAP OTK PIGLT4 KMCO | -- | 880 | -- | EAST | -- | +18 | 0 | N/A | Filed Route | Crew time out 18:10 |
| AAL1560 | MCO | KDFW FORCK2 FORCK ELD MEI OTK PIGLT4 KMCO | DFWMCO0P | 885 | +5 | EAST | +1 | +18 | 0 | Potential | Not Submitted | |
| AAL1560 | MCO | KDFW AKUNA7 MLC RZC ARG MEM J41 SZW OTK PIGLT4 KMCO | DFWMCO1N | 1112 | +232 | NORTH | +15 | +0 | -18 | Candidate | Not Submitted | |
| AAL1560 | MCO | KDFW DARTZ7 TNV IAH LCH J2 SZW OTK PIGLT4 KMCO | DFWMCO1S | 998 | +118 | SOUTH | +30 | +2 | -16 | Potential | Not Submitted | |

Coordination
Op. Submit
Undo

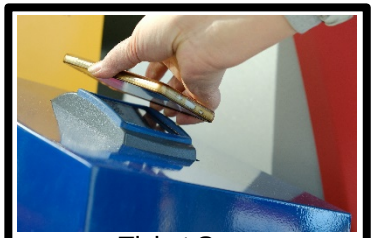
## 4 Operator Submitted TOS's Presented to ATC

- ATC is notified of the Operator approved TOS route
- ATC evaluates the TOS routes for operational feasibility. If approved, all users are notified, the filed route is amended, and pilots are cleared on the revised route



# Maximizing Use of Available Capacity by Leveraging Digital Assets (TOS)

## Sensors



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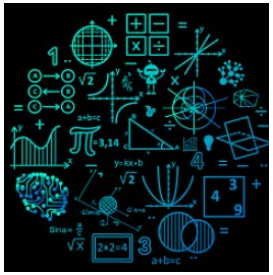

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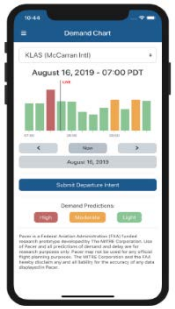
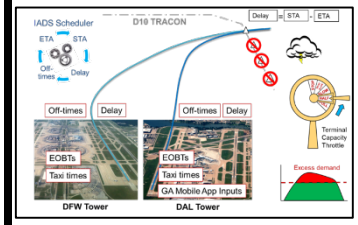



For GA/BA, pilot/ flight operators provides EOBT to system via mobile app/web site

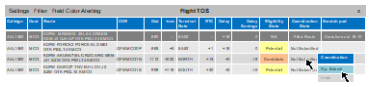
## NASA ATD-2




NASA system consumes EOBTs and ATC restrictions from SWIM and calculates delay impact estimate. Sends 'TOS candidates' to reduce delay to Operator dispatch representatives.

## Operators

Air carrier dispatch uses TOS table to assess 'TOS candidates' and select those that make sense and can fly the alternative route. They 'submit' these as 'operator approved' TOS.



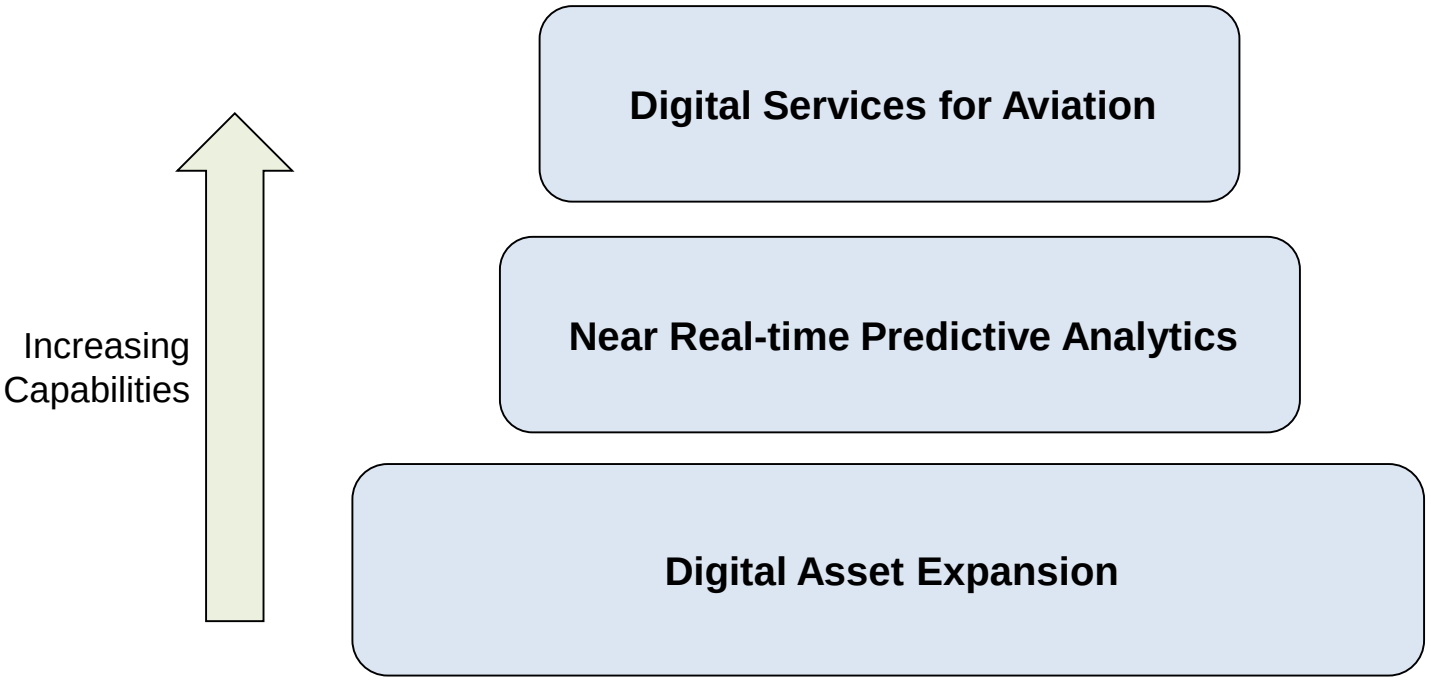
Requires digitization


How do GA/BA, pilot/ flight operators participate?

MITRE/NASA research topic for 2020.

Plan to continue to evolve this in 'Stormy 20' work.

# Noticing a Trend?
# Digital Services for Aviation




On Sept. 5th, NASA began collecting formulative input from the aviation community for potential future work. The input received is heavily data and analytics focused with new cloud based services that address multi-operator challenges.

# Digital Asset Expansion

*Getting key data out of ATC's and Operators brain*

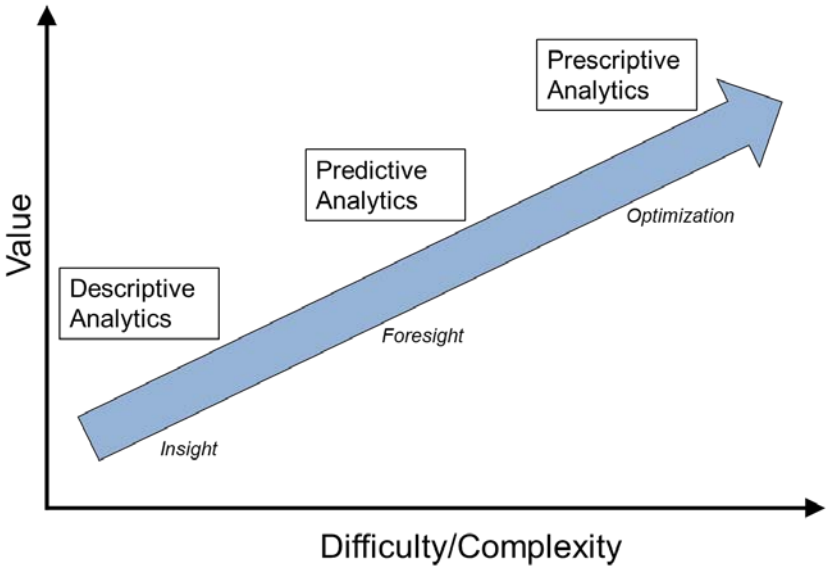
Important information on ATC and Operator constraints and intent is emerging in digital form through the System Wide Information Management (SWIM) system.

Additional effort is required to fully extract and utilize this information and identify additional digital needs for greater benefit to the aviation community.

- Specific examples of high interest digital assets (from community interviews)
  - Provide a "Fuser in the Cloud" capability that integrates key flight information from multiple sources for an accurate and reliable nation-wide stream of data in the cloud
  - Get key information out of TBFM, including parameters and their impact on delay
  - Obtain and process missing ATC restrictions to help reduce uncertainty
  - Create objective measures of data quality that are shared with the community
  - Reduce data access right limitations that prevent broader community innovation
  - Evolve the data dictionary across NAS aviation data sources

Digital assets are the building blocks of future game changing services

# Near Real-time Predictive Analytics



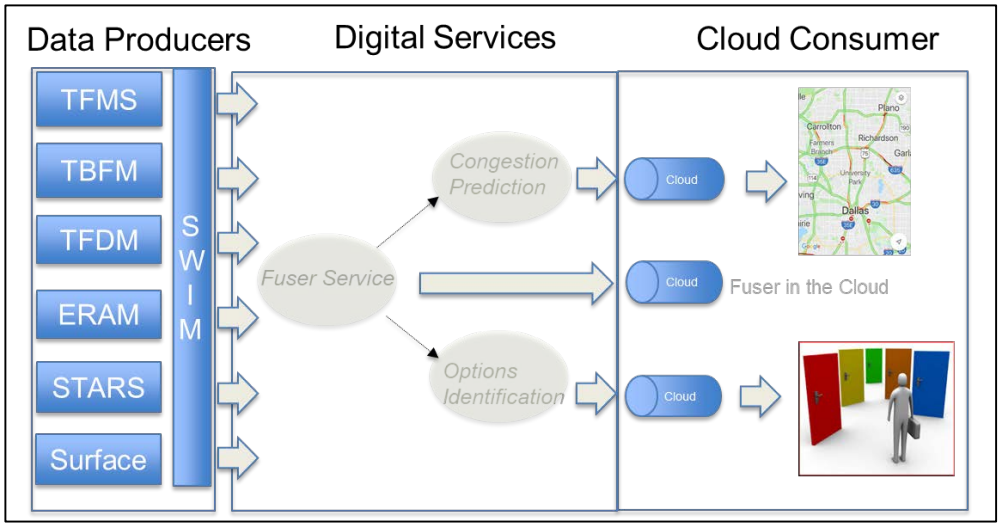

The foundation of valuable analytics (in any industry) begins with descriptive rigor (descriptive analytics).

Predictive analytics seek to give foresight into what is about to happen from analytical models (machine learning, deep learning, traditional algorithms, etc.). Applying this technology in real time can lead to better operational decisions.

- Specific examples of high interest predictive analytics (from community interviews)
  - A processing platform that allows the community to go from model to cloud (M2C) rapidly
  - Uncertainty quantification as a function of time and aviation domain
  - Self-scoring of analytical results to allow truth in reporting
  - Open source libraries that enable more rapid development in aviation machine learning
  - Similar day/operations analysis that allows a more surgical use of data science tools
  - Data science challenges to the community (e.g. Kaggle competitions, etc.)

Predictive analytics provides a sustainable way to create actional foresights

# Digital Services for Aviation




New digital assets and near real-time analytical capabilities become the fuel for new innovative solutions.

Current day operational decisions will evolve to leverage insights and foresights that provide meaningful improvements to efficiency, predictability and reliability.

- Specific examples of high interest in digital services (from community interviews)
  - Use of Trajectory Options Sets for collaborative reroute decisions
  - Space flight disruption mitigation service
  - Operational decision modeling service
  - Disruption management services. Faster recovery to normal operations.
  - Gate to gate congestion prediction service

New services in the cloud enable much faster access to powerful capabilities

# Blockers to Fully Leveraging Digital Assets

## What prevents faster NAS progress in this area?

- NAS silos create a highly complex integration challenge
  - Segmentation by domain (surface, terminal, center) makes holistic analysis difficult
  - Operator and solution provider segmentation leading to many disparate solutions
  - Very few understand the disparate FAA air traffic decision support systems
- Lack of similar day analysis
  - Apples-versus-oranges comparisons of NAS problems. General results that are not actionable.
  - Complex system state variations within the NAS system-of-systems
- Uncertainty
  - Is high in this domain. Analysis and characterization required for decision context.
  - Lack of knowledge of uncertainty can lead to using the wrong tool for the job
- Data access rights
  - Until recently, data was not available even to CDM members
  - Quite a bit of good data is now available, but to CDM members only

# Blockers to Fully Leveraging Digital Assets

## What prevents faster progress in this area?

- NAS silos

The biggest challenges take a community to resolve!

Let's collaborate to move the needle of progress in the NAS!

  - Many complex variations within the system-of-systems of the NAS

- Uncertainty
  - Is very large in this domain. Analysis and characterization needed.
  - Lack of knowledge of uncertainty can lead to using the wrong tool for the job

- Data access rights
  - Until recently, data was not available even to CDM members.
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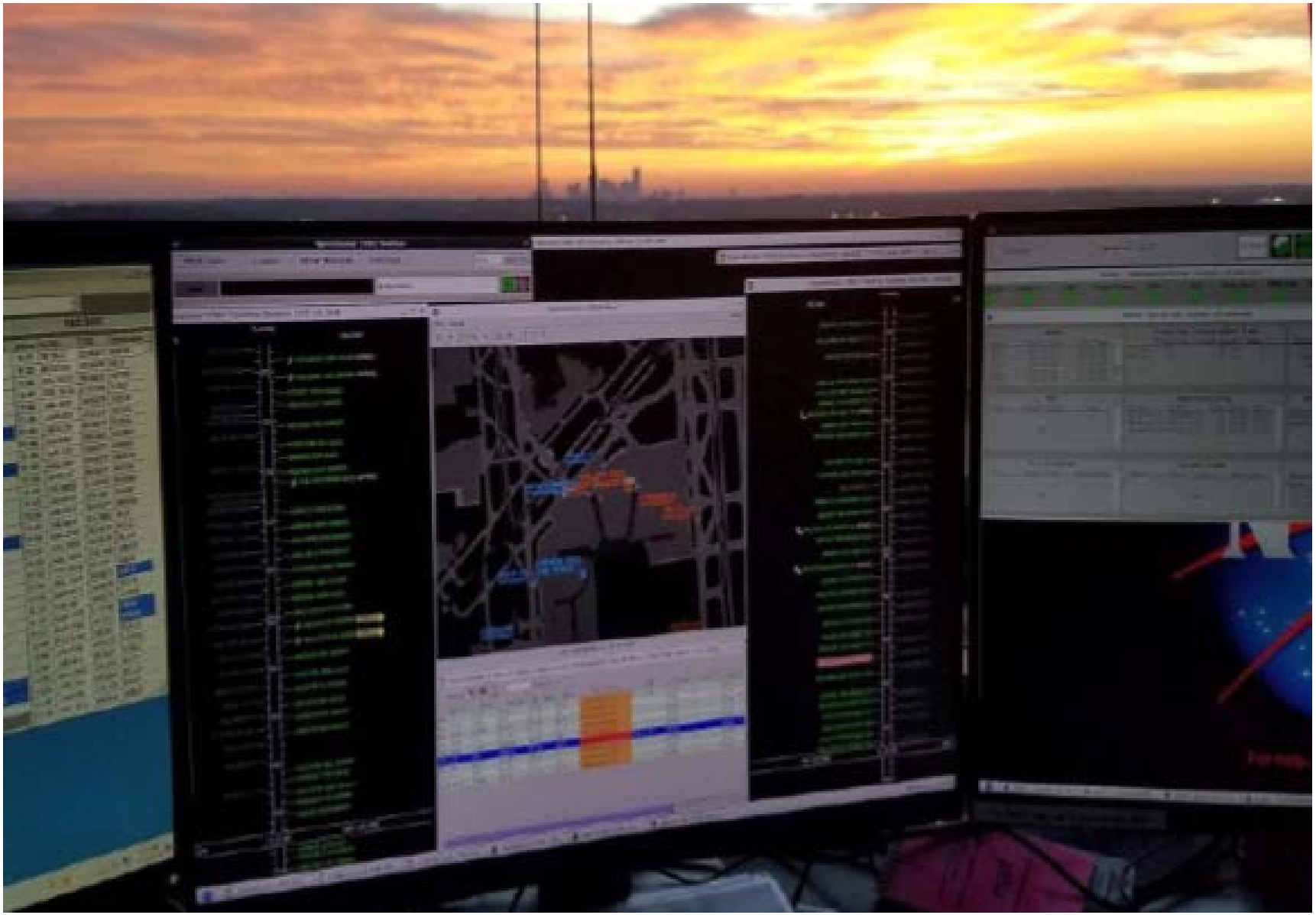
# Questions?



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