ATD-2
Integrated Arrival/Departure/Surface

NASA

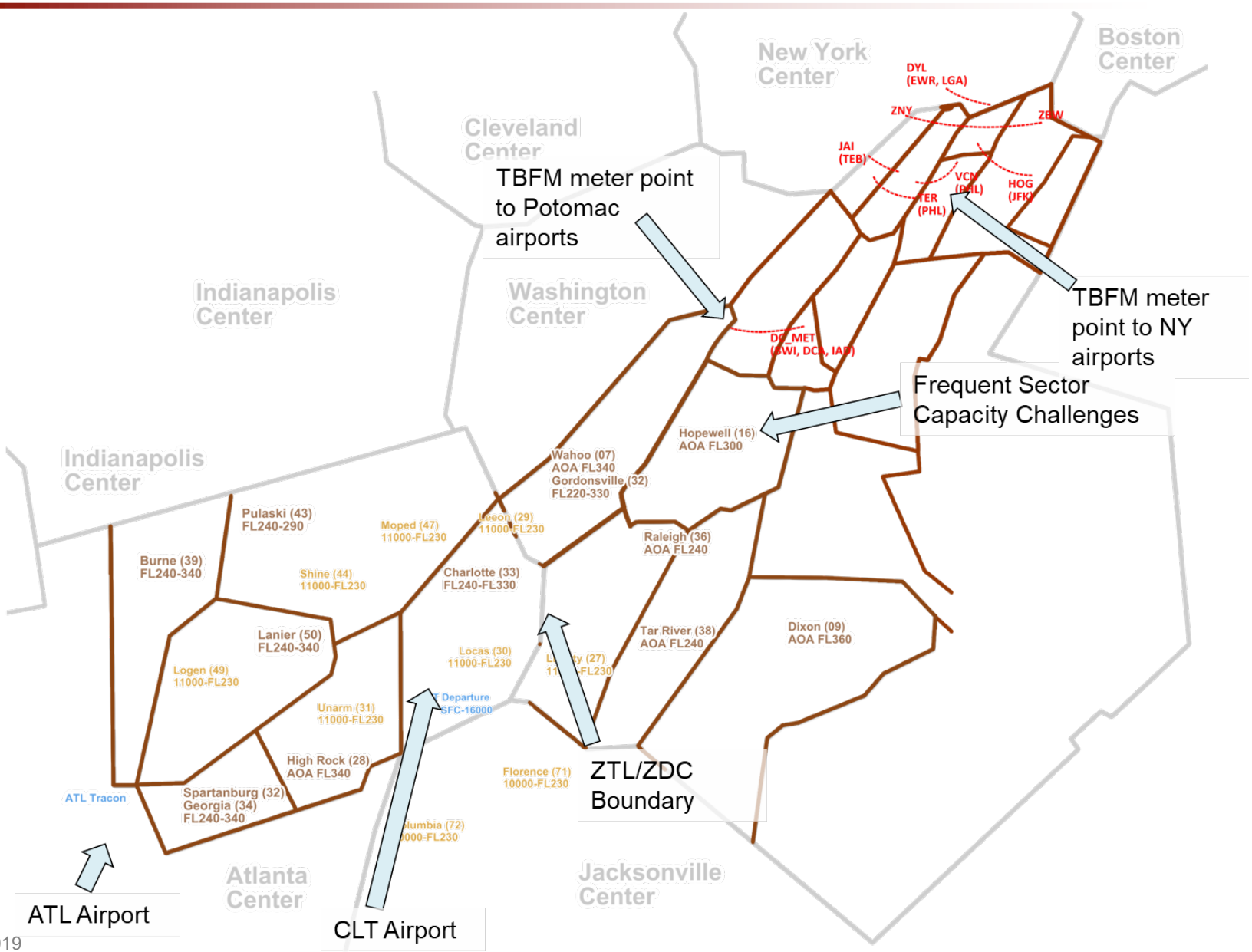
Surface Meets TOS Update & Potential Future Work

Oct 23, 2019

Potential Agenda Items

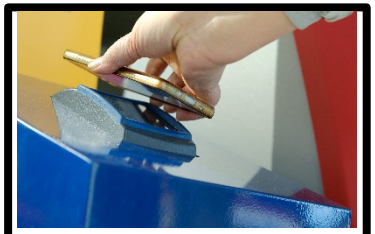
- EOBT and TOS Progress
- Uses of TOS outside of CTOP
- What accuracy is needed to assess RTC?
- ‘Stormy 20’ Potential Items

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



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

Sensors



Ticket Scan

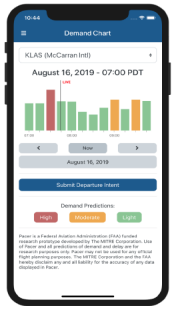
Video detection

Customer bag scan

Fueler events

Operators

For air carriers, algorithms produce EOBTs and send to SWIM

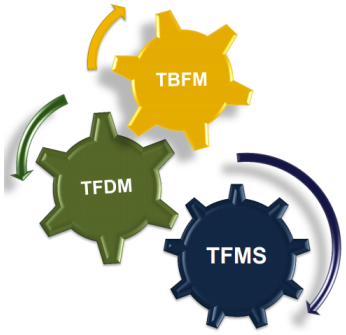


For GA/BA, pilot/ flight operators provides EOBT to system via mobile app/web site

NASA ATD-2

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

FAA Systems



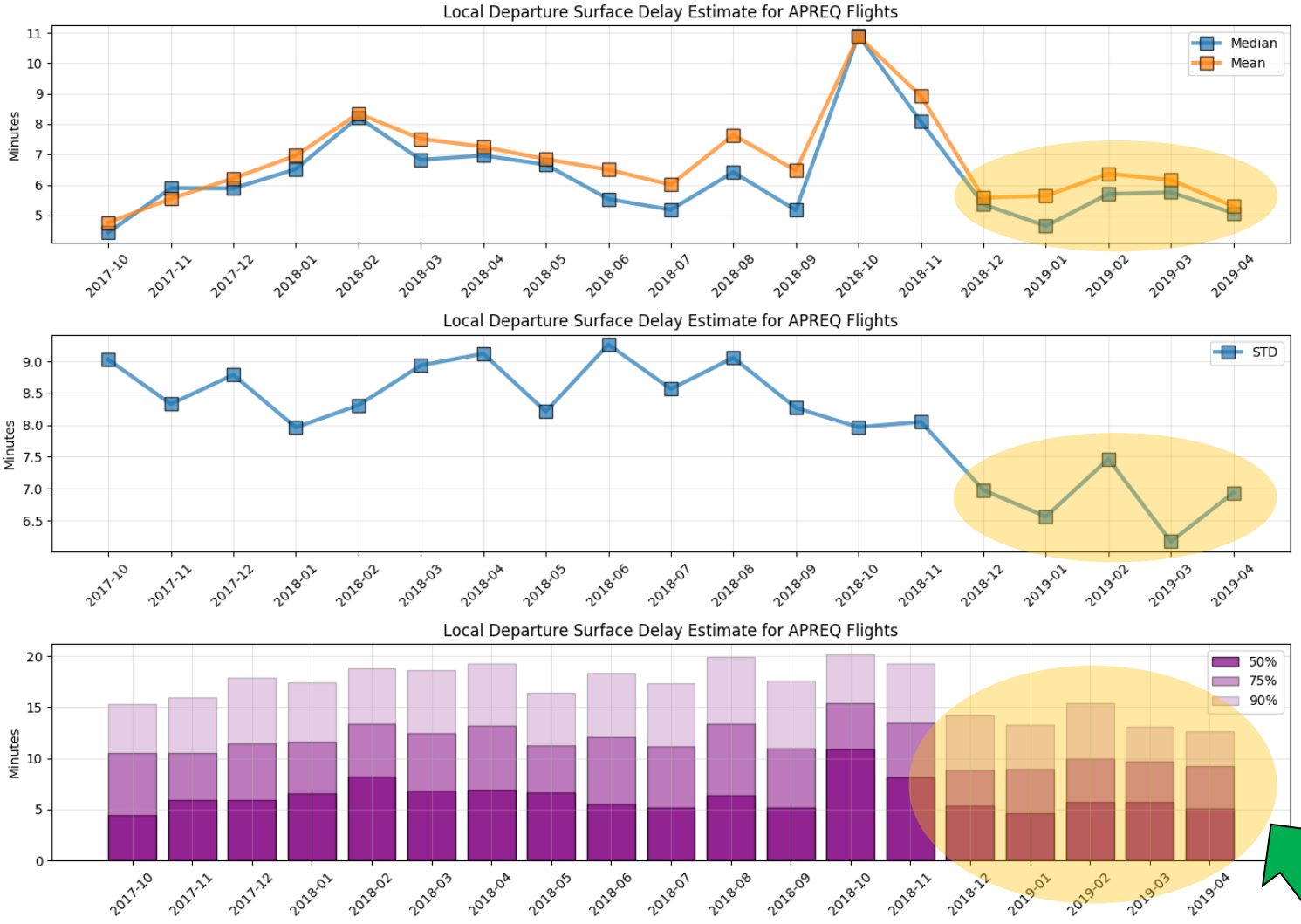
FAA system calculates release time and sends it back to NASA system, which then sends it to SWIM (TTP*) for others to consume.

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

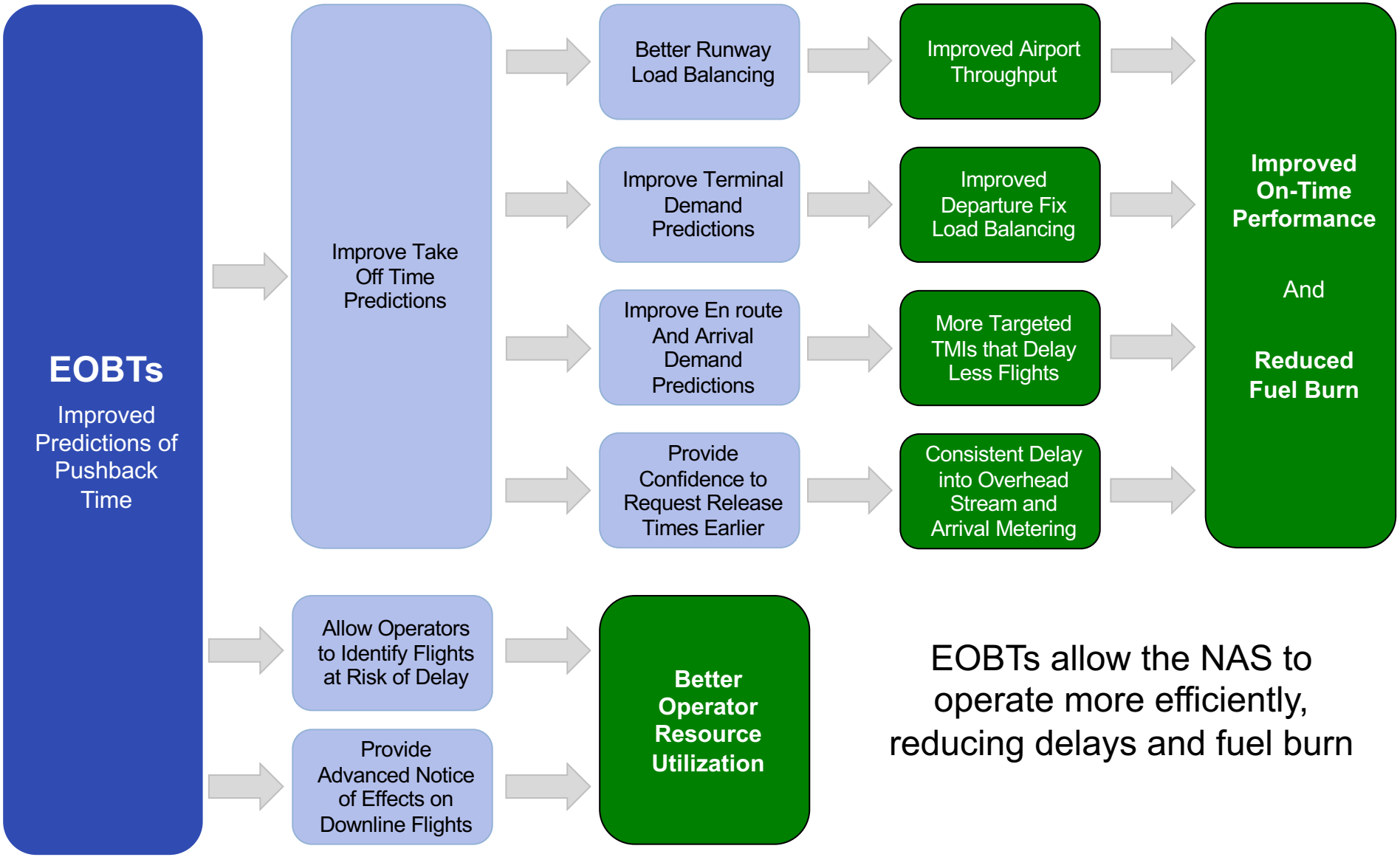
New Use?

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



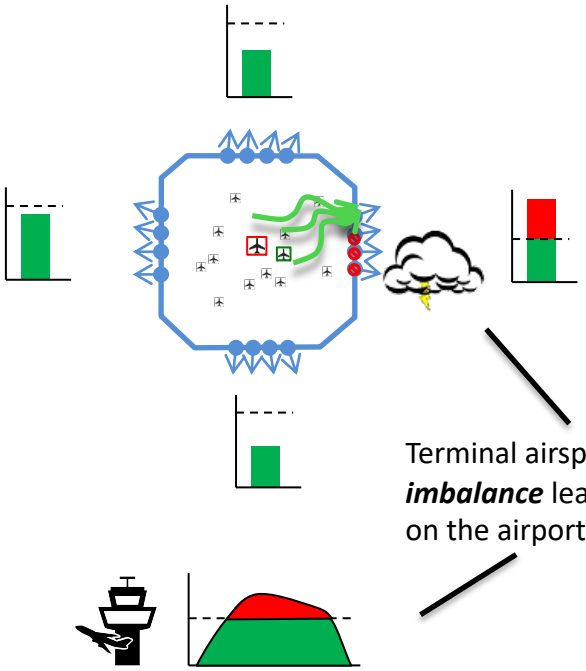
Other Potential Benefits of EOBT (key new digital asset)



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

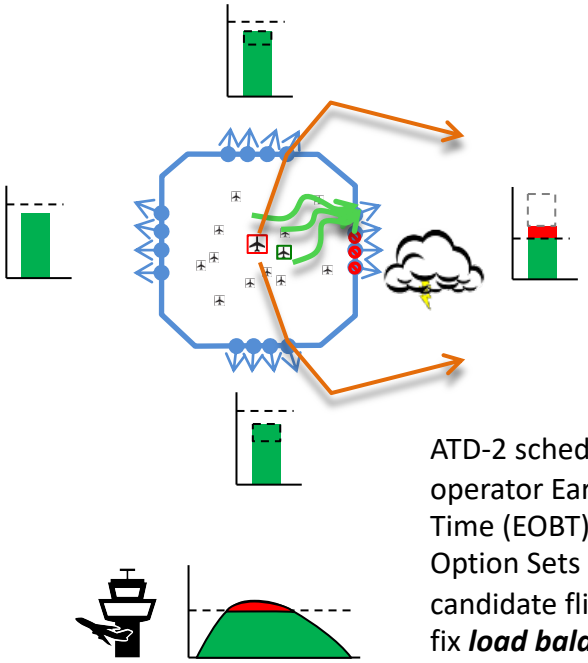
Addressing the Multi-Airport Challenge

The Problem



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

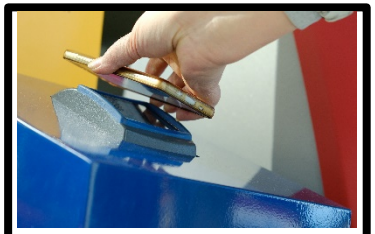
The Solution



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***

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

Sensors



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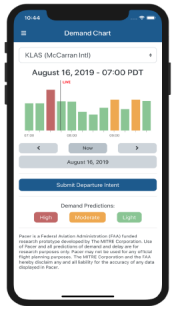

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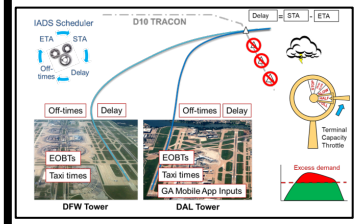
NASA ATD-2



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.

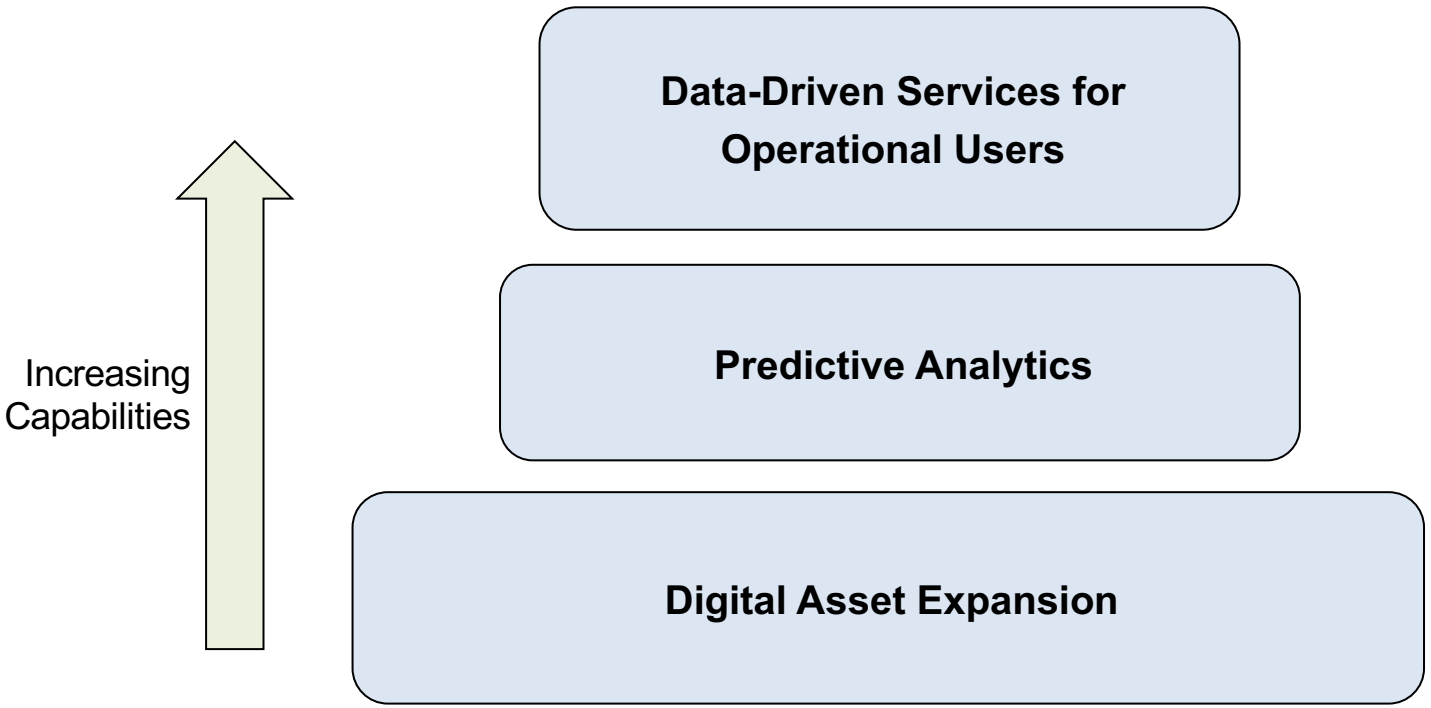
How do GA/BA, pilot/ flight operators participate?

MITRE/NASA research topic for 2020.

Requires digitization

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

NASA Aero Wants Your Input on Future Work!



On Sept. 5th, NASA began collecting formulative input from the aviation community for potential future work. Thus far, a considerable proportion of the input is data and analytics focused with new cloud based services that address complex areas.

NASA Aero Wants Your Input on Future Work!

Data-Driven Services for Operational Users

Does FET/SCT have input on potential future NASA investments/work?

Digital Asset Expansion

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Potential Agenda Items

- Surface Meets TOS
- Uses of TOS outside of CTOP
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Surface Meets TOS

- In the main CDM forum, 2018, some CDM members asked NASA to extend its current logic at CLT to focus on where “Surface meets TOS” in Phase 3
  - NASA Phase 3 plans were adjusted to allow for this (and we are glad we did!)
  - Initial indications from FY19 are promising

- Lesson: Surface Viewer changes are not going to be enough
  - Surface viewer is a read only tool that will not be easy to use for Surface TMCs
  - Primarily targeted at Center areas, not the tool that a Surface TMCs use
  - Surface TMCs are evaluating and executing the majority of the reroutes!

- TFDM program office recently mentioned they expected capability like that being demonstrated in Phase 3 to (possibly) be added to a future TFDM work package
  - FAA ANG folks are beginning the WP process, should TOS on surface make the list?
  - Does the FET/SCT want to be involved in this?
  - What additional information is needed to help craft initial TFDM WP requirements?

TOS Outside of CTOP

- What uses of TOS does FET/SCT see outside of CTOP?
  - MITRE paper – "User Preferences and Trajectory Options Sets (TOS) to Achieve Traffic Flow Management Benefits", Sept 2017
  - TOS for Targeted Departure Escape and Congestion Relief roughly analogous to NASA ATD-2 Phase 3 work

- If Industry continues to build toward submitting TOS with intent outside of CTOP, what changes are required to allow FAA systems to take advantage of this?
  - Has this been discussed?

- What is the biggest area of need to grow TOS usage?
  - More multi-operator evaluations?
  - Tools for FO to lower barrier of identifying and submitting TOS?

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Accuracy for Good RTC Calculations

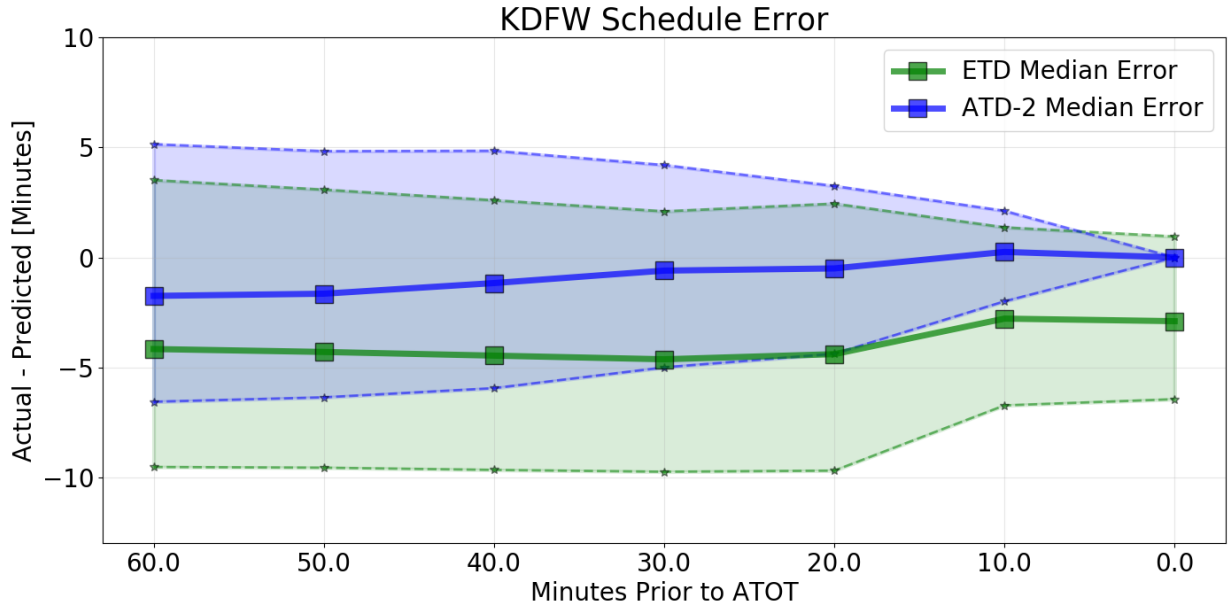
- When it comes to assessing relative trajectory costs, accuracy of the OFF time calculations and corresponding delay estimate is key

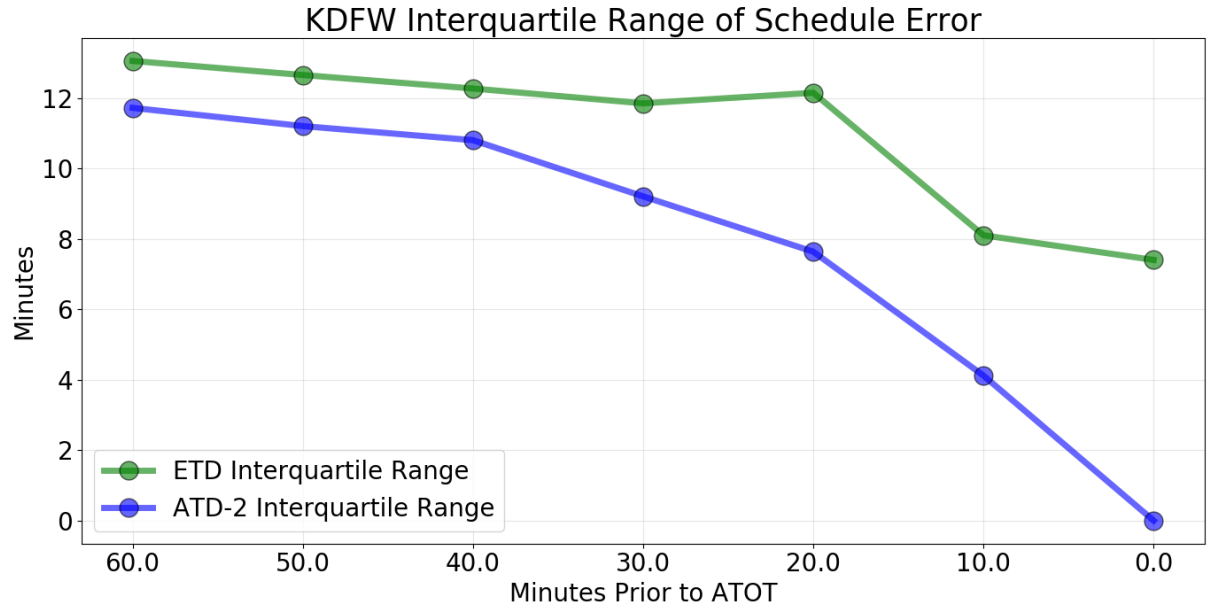
- TFMS
  - Measurement of TFMS accuracy today, with and without good EOBTs from all Operators (and GA/BA)
  - TFDM + TFMS well positioned to provide higher quality estimates

- Wind miles
  - Estimates of transit time with and without winds can greatly vary
  - Is a NAS-wide provision of this in the works? Needed?

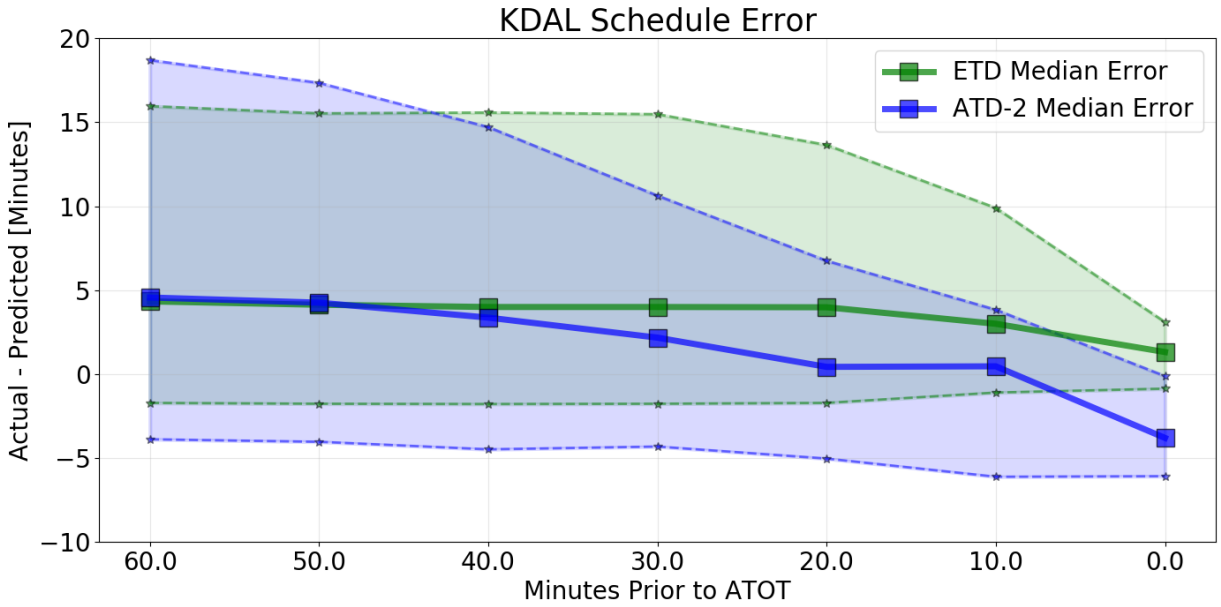
- Which uses of TOS require higher or lower accuracy?
  - Which scenarios might low accuracy be “lost in the noise”?

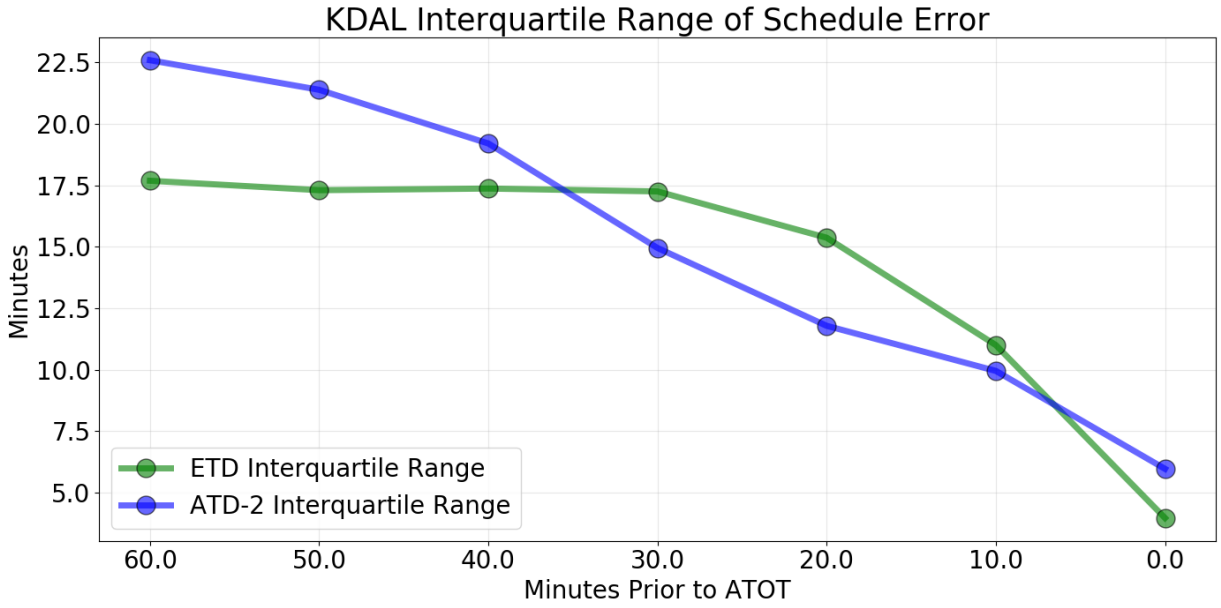
Actual VS Predicted Off Time – KDFW





Actual VS Predicted Off Time – KDAL





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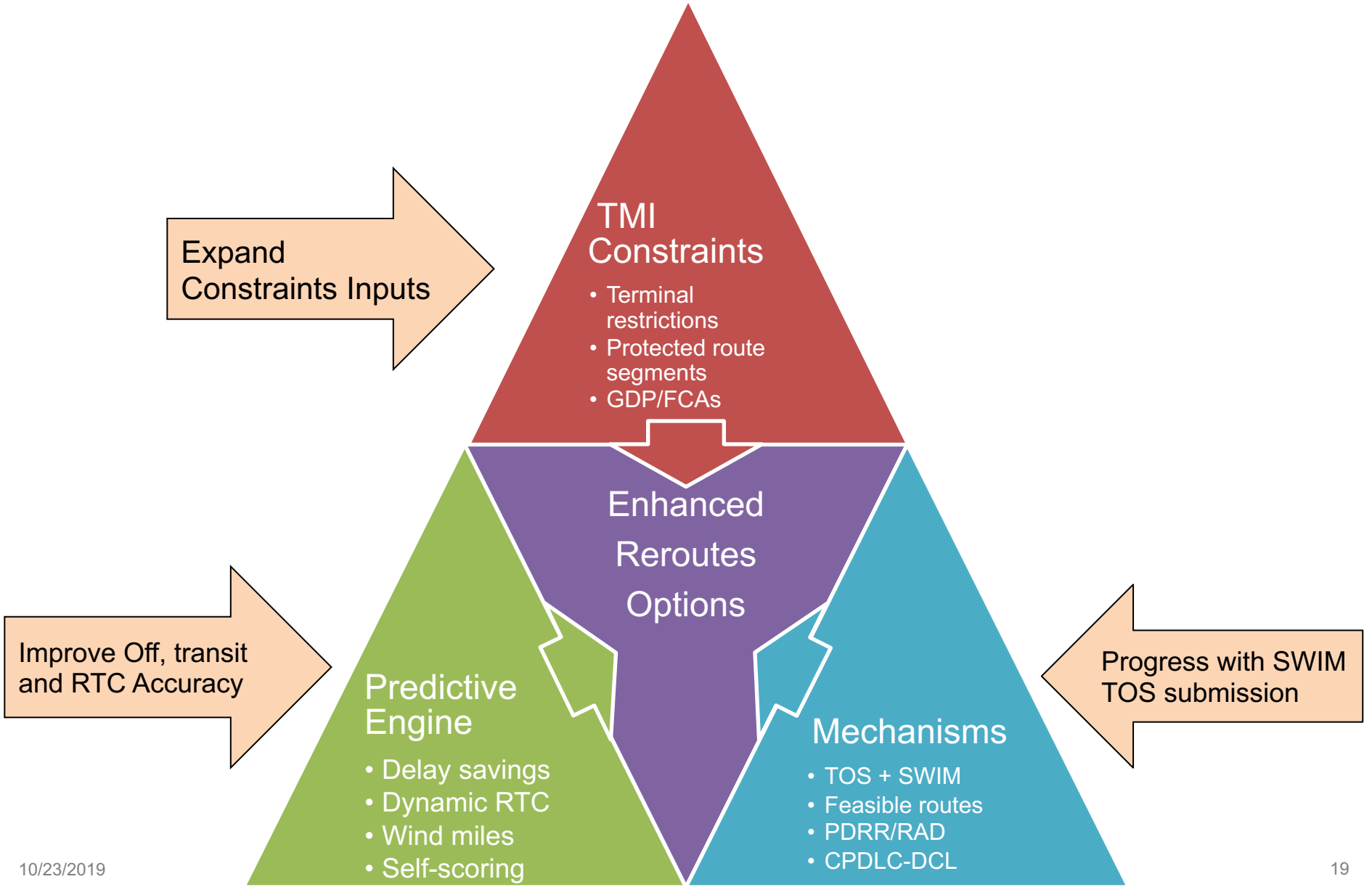
Proposed Strategy for TOS Evolution



Potential Development for ATD-2 and Beyond

Potential Developments For Stormy 20

- For Consideration For Stormy 20 (pending on feasibility and feedback)
  1. Provide real-time metrics on uncertainty and benefit pool
     - Self-scoring of uncertainty, or other key metrics
     - Aggregated delay
  2. Dynamic RTC
     - Dependent of what the FO want and how usable we can make it
  3. Targeted parsing NAS wide restrictions
     - Automatically update TOS RAM based on *targeted* data in DCC's Advisories
  4. New CDR procedures to help off load demand, as needed
     - Dependent on ZFW's initiative
     - May require adding altitude restriction
  5. Progress towards submitting TOS to TFM SWIM (CDRs)
     - Flesh out use case and requirements for TFM's subscribing systems (PDRR/ABRR)
     - Figure out messages

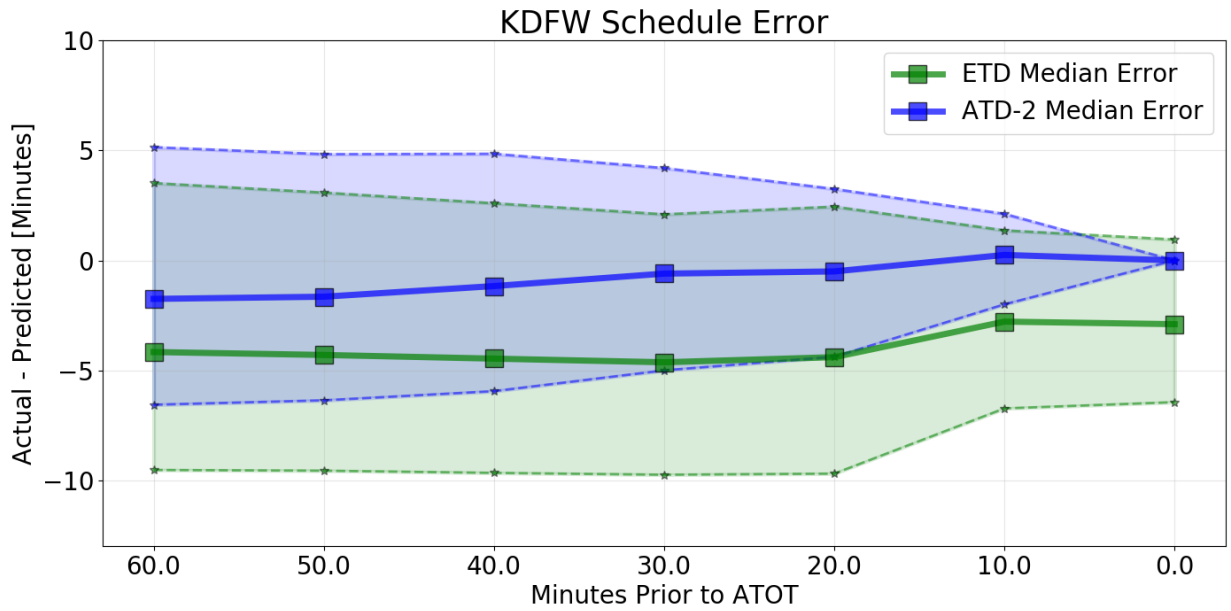
Long-Term Potentials

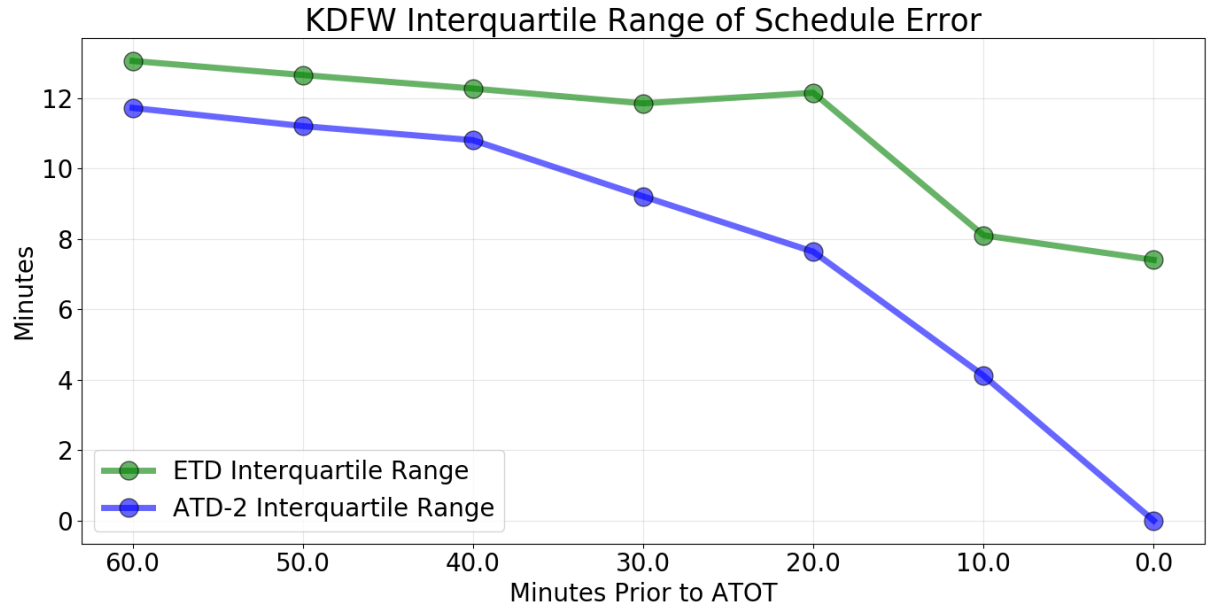
- Likely Beyond ATD-2
  - Inclusion of wind miles to route and RTC computations
  - Include Radar Surveillance Data In Love Field Surface Predictions
  - Transition to web-based and cloud-based system
  - Rerouting EDCT flights under GDPs or FCAs
  - Submit dynamic TOS to SWIM (could support modified routes)
  - Flight plan amendments with PDRR/ABRR with RAD
  - Route modifications to comply with DCC's reroute restrictions

Real-time Metrics

- Motivation
  - Provide data to Flight Operators and ATC to help them to
    - Determine a threshold of cost/benefit decision point
    - Assess tactical and strategic benefits
- Current Limitations
  - Error in predictions are not communicated
  - Off-Times and delay savings predictions are dependent on fluctuations in the input data and scheduling process
  - System identifies delay savings for one flight at the time
- Goals
  - Provide “self-scoring” real-time metric on predicted times and/or delay uncertainties
  - Provide real-time metrics of predictable benefits
    - Identify benefit pool metrics (delay savings for multiple flights)
    - Identify deterministic mechanism to indicate real-time benefits
- Potential Synergies
  - Dynamic RTC
  - Ingestion of surface surveillance data at DAL and progress with our scheduler
  - Post-ATD2 predictive analytics framework
- Potential Challenge
  - Enough time to develop robust metrics

Actual VS Predicted Off Time – KDFW





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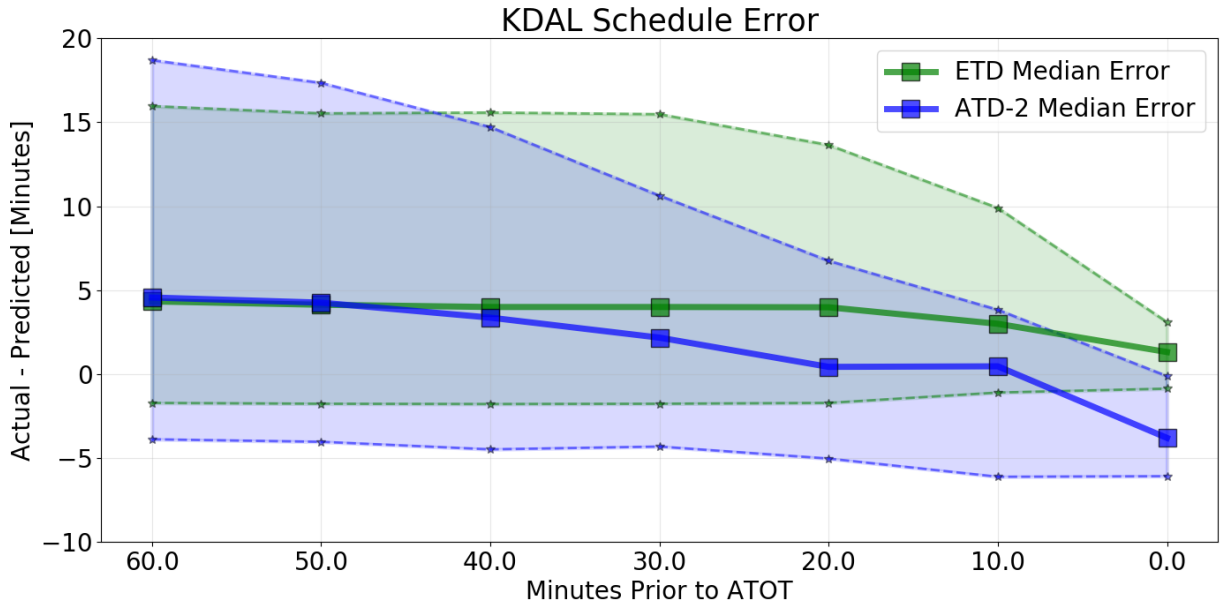
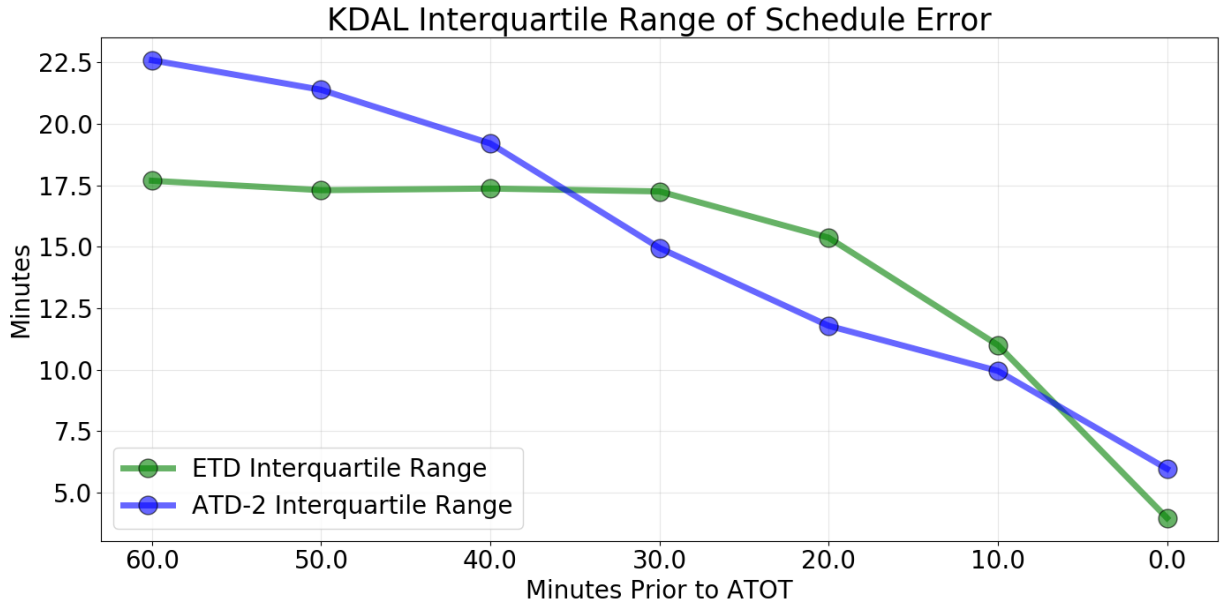




Dynamic RTC

- Motivation
  - RTC is a key data element that is used to determine when a flight needs to be considered for a reroute
  - What data elements should be considered to prioritize rerouting of flights?
- Current Limitations
  - RTC are currently static, which prevents FO from modifying its value
- Goal
  - Provide FO with a menu to adjust RTC computation, as needed
    - Determine current and new parameters
      - Cost Factor
      - Minimum RTC value
      - Other?
        - » Are there other data elements that would need to be included to determine when a candidate route threshold is met?
- Potential Synergies
  - Route distance and time computation (wind miles)
  - Benefits Pool
- Potential Challenge
  - Potential sensitivities with data elements

Example of All Flights RTC Parameters Menu

Note: initial mock-up based on current data element. Needs refinement and vetting with users.

MP User – RTC Parameters

Relative Trajectory Cost

Default Cost Factor	2.0	air/surface ratio
Minimum Value	5	minutes

Destination airports			Correction
List 1	ORD, MDW	Select	-0.5
List 2	SAN, MSY	Select	+0.5

Aircraft types			Correction
List 1	CRJ9, DH8C	Select	-0.5
List 2	B772, B781	Select	+0.5

Time of the day (UTC)				Correction
Period 1	1101	-	1700	-0.5
Period 2	1701	-	2300	+0.5
Period 3	2301	-	0200	0.0
Period 4	0201	-	1100	+1.0
Period 5		-		

BOGUS Examples:

B781 to SAN at 1800 = 3.5

Default	2.0
Dest	0.5 (SAN)
AC type	0.5 (781)
Time	0.5 (2)
Total	3.5

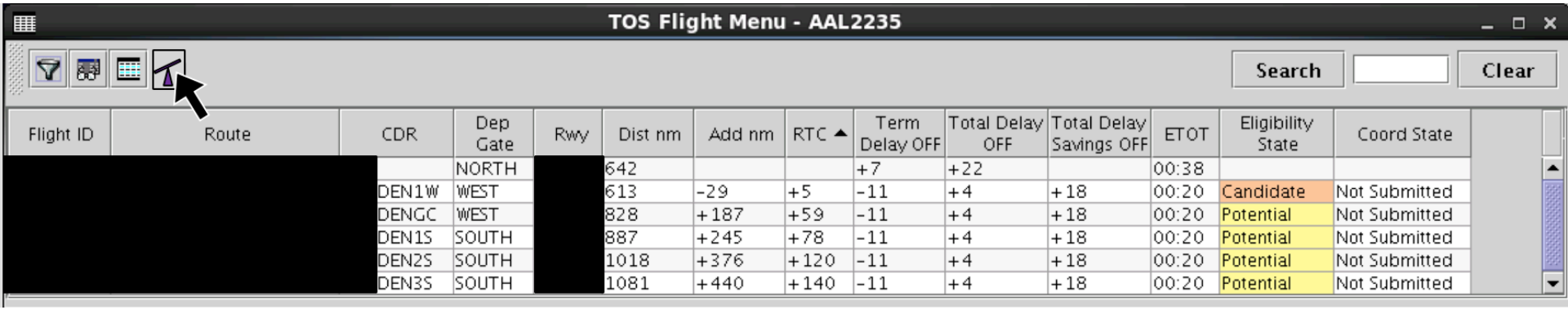
DH8C to LGA at 1200 = 1.0

Default	2.0
Dest	0.0
AC type	-0.5
Time	-0.5
Total	1.0

Note:

- Rule-based parameters
- New FO parameters and new rules could be added as needed

Example of Flight Specific RTC



Flight ID	Route	CDR	Dep Gate	Rwy	Dist nm	Add nm	RTC ▲	Term Delay OFF	Total Delay OFF	Total Delay Savings OFF	ETOT	Eligibility State	Coord State
[redacted]	[redacted]		NORTH	[redacted]	642			+7	+22		00:38		
		DEN1W	WEST		613	-29	+5	-11	+4	+18	00:20	Candidate	Not Submitted
		DENGC	WEST		828	+187	+59	-11	+4	+18	00:20	Potential	Not Submitted
		DEN1S	SOUTH		887	+245	+78	-11	+4	+18	00:20	Potential	Not Submitted
		DEN2S	SOUTH		1018	+376	+120	-11	+4	+18	00:20	Potential	Not Submitted
		DEN3S	SOUTH		1081	+440	+140	-11	+4	+18	00:20	Potential	Not Submitted

MP User – RTC Parameters – XXX1234

Destination	DEN
Aircraft type	B738

Parameters

Cost Factor	**2.0**	air/surface cost ratio
Minimum Value	**5**	minutes

Route	Term Gate	RTC	Delay Savings
DEPDEN1W	North	5	18
DEPDENGC	South	59	18
DEPDEN1S	South	78	18
DEPDEN2S	South	120	18
DEPDEN3S	South	140	18

Note: initial mock-up based on current data element.
Needs refinement and vetting with users.

Parsing of NAS Wide Restrictions

- Motivation
  - Account for NAS wide restrictions impacting filed routes and route options to support demand predictions, scheduling and users' strategic and tactical decisions
- Current Limitations
  - Downstream restrictions, such as DCC's reroute advisories prevent certain TOS CDR routes from being viable candidates to submit
- Goals
  - Automate the inclusions and exclusions of flights and routes in the TOS RAM (global filters)
  - Parse targeted DCC reroute advisories data, initially (ie. VUZ, MGM plays)
- Potential Synergies
  - Potential new CDRs
    - Conditional of operational feasibility and FO's ability to support new routes
- Potential Challenge
  - The identification of the exclusion of CDR may be limited by the complexity of parsing advisories

New CDRs to Support Routes Options from the North and South Gate

- Motivation
  - Provide flexibility to reroute flights when accounting for both local (terminal restrictions) and distal (NAS wide) restrictions
- Current Limitation
  - Existing CDRs join Playbook routes from nominal terminal departure gates, only
- Goal
  - Add CDRs to provide opportunities to off load demand during restrictions
    - ZFW discussed exploring opportunities:
      - For CDRs to join Plays from the North and South
      - To create more efficient procedures
        - » Use of altitude restriction to reduce MIT restrictions in SWAP events
    - Review potential routes and procedures with the FO
- Potential Synergies
  - Parsing of NAS Wide Restrictions
- Potential Challenge
  - Use of new routes may be limited to particular weather events
  - Conditional to FO's ability to fly the route

Use Case – Capping Westbound Departures To Avoid Large MIT

- Scenario
  - Cold front from the Northwest is approaching the North Texas Region. Severe weather builds along the front inside ZFW airspace.
  - As a result, the entire West Gate get closed and departures are swapped South
  - In addition departures from the Houston are bounded to the North and Northwest are routed further West
  - In addition W-E trans continental flights are also routed further South in ZHU airspace
  - The airspace in ZHU is saturated

- Impact on DFW/DAL departures
  - Most commonly, 20, 30, or 40 MIT for all jets and turbojets through the South gate.
  - With tactical coordination, some departures to AUS, SAT, will be capped to stay in lower sectors

- Potential opportunities
  - Apply more expansive capping for departures to the West, such as short haul flights to MAF, ELP, ABI, AMA, LBB and ABQ or even beyond.

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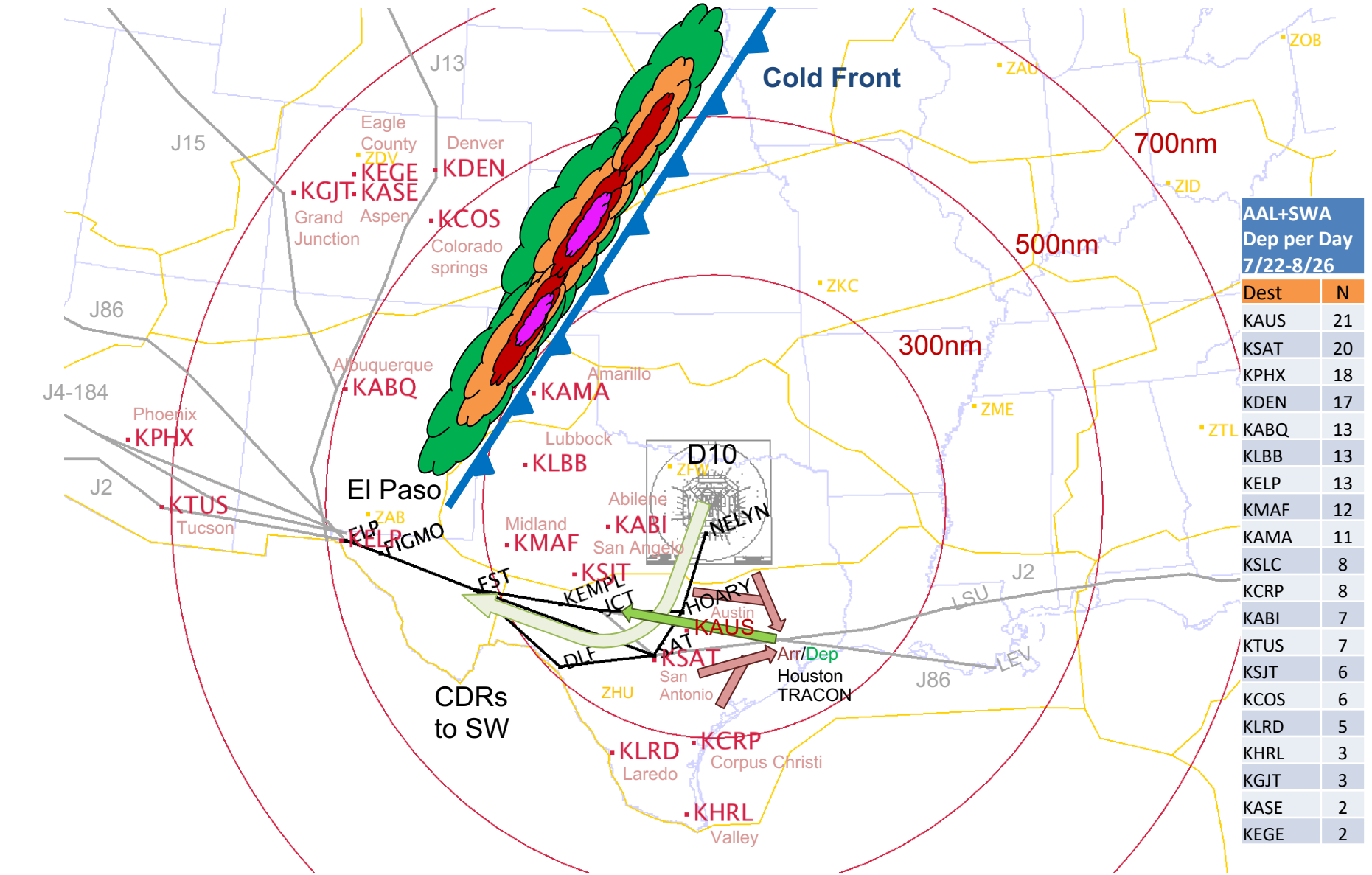

AAL+SWA Dep per Day 7/22-8/26

Dest	N
KAUS	21
KSAT	20
KPHX	18
KDEN	17
KABQ	13
KLBB	13
KELP	13
KMAF	12
KAMA	11
KSLC	8
KCRP	8
KABI	7
KTUS	7
KSJT	6
KCOS	6
KLRD	5
KHRL	3
KGJT	3
KASE	2
KEGE	2

Submission of Dynamic TOS Through SWIM

- Motivation
  - Initial evaluation of TOS as a key digital asset for future capabilities
  - Determine use cases to support both ATC flow management and Flight Operators business decisions
- Current Limitations
  - FO's TOS routes are not available in ATC systems
  - ATD system relies on static CDR routes
  - Initial test indicates that current TOS messages in TFM Data may be incomplete (RTC missing in messages)
- Goals
  - Make progress towards an initial TOS submission to SWIM via ATD system
  - Sample test with target flights, if able
  - Draw Lessons Learned for future use cases
    - How will TOS data looks like in SWIM to support future capabilities and uses?
- Potential Synergies
  - Dynamic RTC (short term)
  - Evolution of 3T integrations and DSTs for both ATC and FO (long term)
- Potential Challenges
  - Dependencies with SWIM partners
  - PDRR/RAD availability to test TOS updates and flight plan amendments

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Require more maturity to accomplish due to additional dependencies and heavy data processing

Wind Miles - Enhancement to Route and Dynamic RTC Computations – Long-Term Potential

- Motivation
  - Provide more accurate transit time to support predictions and awareness in decisions by ATC and FO
- Current Limitations
  - ATD-2 system compute routes (filed and alternative) mile distances based on point-to-point 2-D trajectory
  - Airlines compute transit time that includes “Wind miles” correction based on direction and velocity of winds
- Goals
  - Account for winds in the computation of route distances and RTC values
  - Possible approaches:
    - Ingest wind data from supporting system
    - Ingest FO’s data via Java Message Service
    - User entries of sectorized winds on the client
- Potential Synergies
  - Dynamic RTC (short term)
  - Evolution of 3T integrations and DSTs for both ATC and FO (long term)
- Potential Challenge
  - Ability for FO to support wind miles computation for all route options

Include Radar Surveillance Data In Love Field Surface Predictions – Long-Term Potential

- Motivation
  - Improve Off-time predictions, and leverage benefits of EOBTs
- Current Limitations
  - Transit times from parking Gate to the runway are relying on historical data
- Potential Synergies
  - Accuracy of OFF times
  - Real-time metrics
- Potential Challenge
  - Potential dependencies with 3rd party data

Transition to Web-Based and Cloud-Based System – Long-Term Potential

- Motivation
  - Readying the system to wider TOS use cases under ATM-X
- Current Limitations
  - System and data not readily available to additional users and third party players
- Potential Synergies Beyond-ATD2
  - Third-party use and input (DCC, FO)
  - ATM-X and follow-up work
  - …
- Potential Challenge
  - LOE to transition the entire system to Web-based

Rerouting EDCT flights
Long-Term Potential

- Motivation
  - Account for NAS wide restrictions in the rerouting of flights and use TOS as lever to off load demand beyond the terminal restrictions

- Current Limitations
  - EDCT flights who are subject to AFP/FCA or GDP are excluded in the TOS reroutes to comply with the Controlled Take Off Time
  - Not accounting for EDCT flights who could be exempted if rerouted outside of FCAs
  - 22% of EDCTs were driven by FCAs during 7/22-8/26
  - Today's limitations with updating EDCTs:
    - EDCT is updated in TFMS when FO submits new CETE, under a GDP
    - EDCT is not updated when ATC amends flight route, under a GDP
    - Unclear if flight would be exempted if flight route is amended to fly outside an FCA in today's operation

- Potential Long-Term Goals (GDPs only)
  - DCC exempts EDCT flights on a case-by-case basis
  - Flights that are exempted can depart on alternative routes
    - No s/w development, only procedural agreement with DCC, ZFW and ATCTs
- Potential Long-Term Challenge (GDPs only)
  - Exemption coordination between ATC facilities (ZFW, DCC, ATCT) may be time consuming
  - Update of TFM Control times every 5min is long

- Potential Longer-Term Goals (GDP+AFPs)
  - ATD system parses AFP data to automatically detect when flights and which TOS/CDR are impacted
  - ATD system computes new EDCT based on mileage and wind routes for GDP flights
  - FO submits new CETE for reroute
  - ATD system picks up EDCT update in FTM data (new time or exemption)
  - ATCT complies to the updated EDCT as normal
- Potential Longer-Term Challenge (GDP+AFPs)
  - Rescheduling of EDCT without FO's help
  - Mismatch between ATD-2 system and TFM system
  - Compliance reporting when flight take off outside of EDCT window

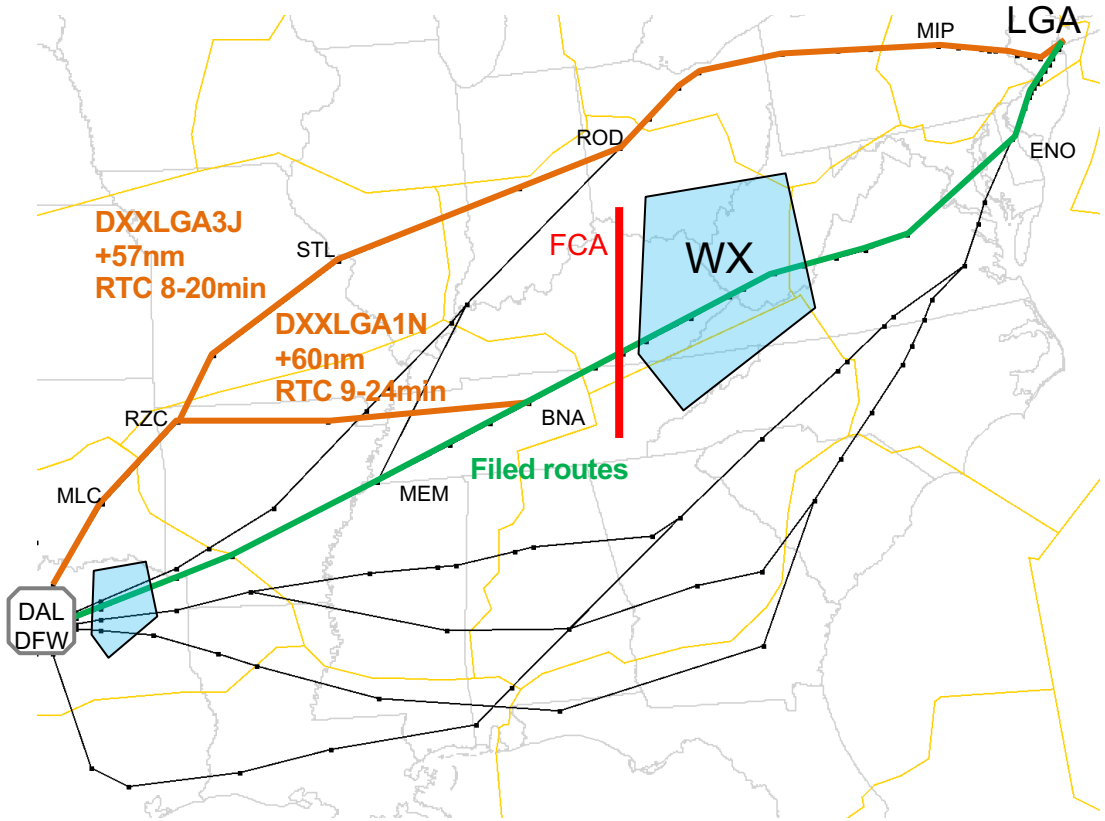
Example Use Case to Exempt EDCT Flights
Long-Term Potential

- Flights to the NE are subjected to both GDP and terminal restrictions and thus are subject to surface delay
- ATD-2 scheduler assumes the flight would takeoff within EDCT +5/-5 window
- ATD-2 scheduler detects an earlier departure time on alternative routes that bypass terminal restrictions
- Flight is exempted by DCC and released unconstrainted

- Benefits
  - On the FO side: rerouted flight has reduced surface delay, avoided terminal restriction
  - On the ATC side: rerouted flight has also contributed to better use of capacity

- Notes
  - Flight is still contributing the demand capacity imbalance at destination
  - Limited and early examples of leveraging TOS on flights under multiple schedule constraints in future NAS Wide TOS work

Use Case of Rerouting EDCT Flight Under AFP



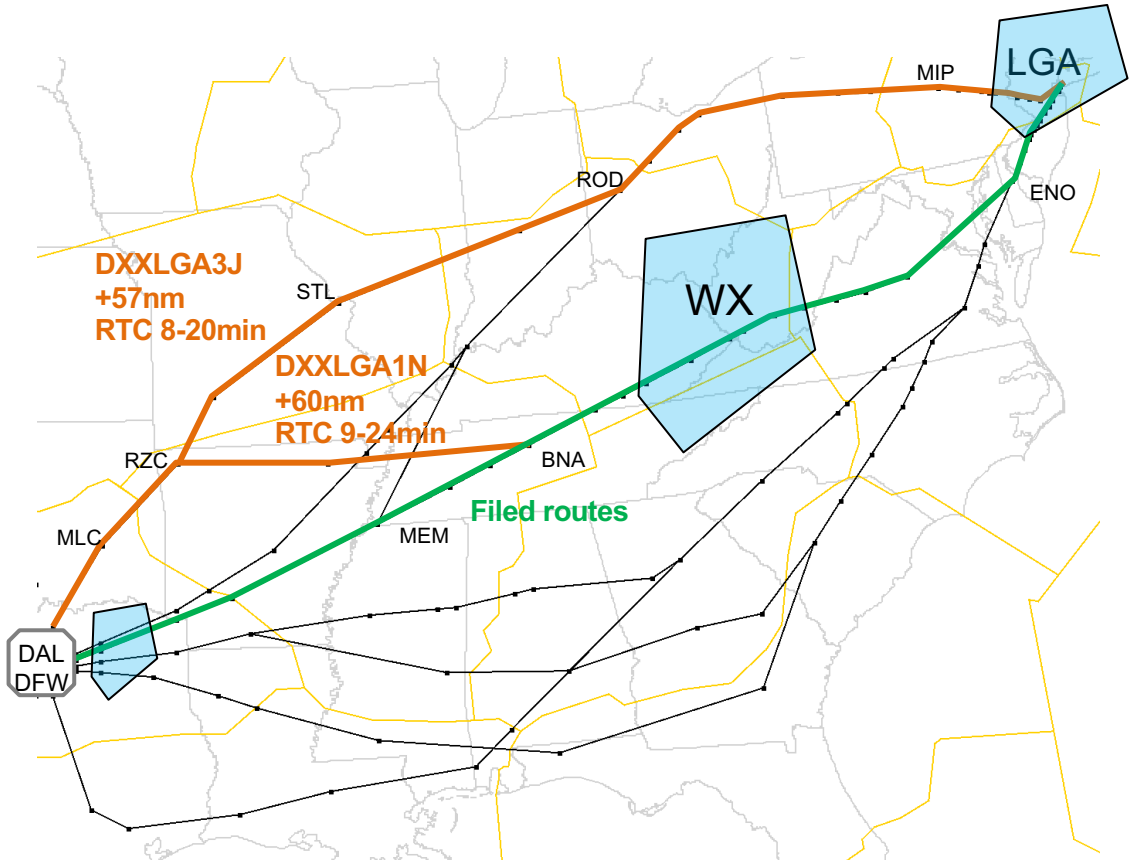
AFP/FCA case
The alternative route no longer crosses the arc and therefore the flight becomes exempt

Routes	Filed Route	Alt Route	Time Diff
UTOT	11:45	11:45	0min
EDCT	12:30	12:00	-30min
Flight time	03:30	03:45	+15min
STA (FCA)	16:00	15:45	-15min
Overall savings		00:15	-15min

Ideal capability would:

- Detect routes outside of FCAs
- Accounts for Wind miles in flight transit time
- Reschedule EDCT based on new flight route

Use Case of Rerouting EDCT Flight Under GDP



GDP case
Any alternative route remains subject to EDCT compliance (non-exempt)

Routes	Filed Route	Alt Route	Time Diff
UTOT	11:45	11:45	0min
EDCT	12:30	12:15	-15min
Flight time	03:30	03:45	+15min
STA (dest)	16:00	16:00	0min
Overall savings		00:00	0min

Ideal capability would:

- Accounts for Wind miles in flight transit time
- Reschedule EDCT based on new flight route

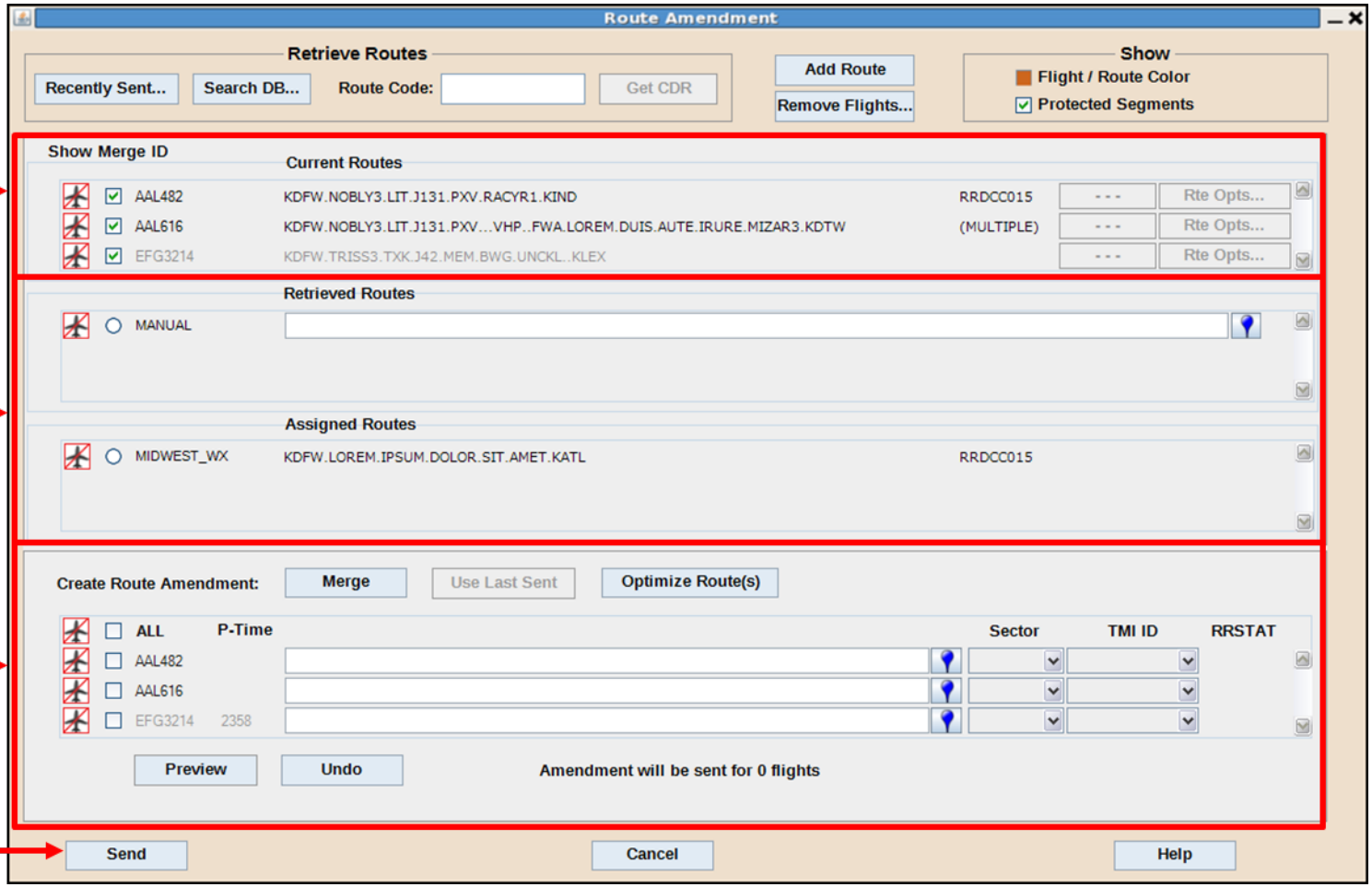
Submission of Dynamic TOS Through SWIM
Long-Term Potential

- Motivation
  - Leverage lessons learned from initial development towards submitting TOS to SWIM
- Current Limitations
  - ATD system relies on static CDR routes
  - Initial test indicates that current TOS messages in TFM Data may be incomplete (RTC missing in messages)
- Potential Long-Term Goal
  - Submission of dynamic ad-hoc TOS routes (beyond CDR)
- Potential Long-Term Synergies
  - Dynamic RTC
  - Approve TOS reroute with PDRR/RAD
  - Modification of TOS routes based on dynamic NAS wide restrictions
- Potential Long-Term Challenges
  - Compatibility of PDRR/RAD
  - Risk of route rejection when submitting modified routes

Use of RAD to Amend Routes
Long-Term Potential

- Motivation
  - Provide ability for ATC to use FO's TOS in TFM system
- Current Limitations
  - ATC personnel relies on existing tool, such as the FDIO, to amend flights plans
  - ATC personnel is limited to approve static TOS routes (CDR)
  - Deployment of new version of PDRR/RAD on the Departure Viewer
    - at ZFW may be outside of ATD-2 demonstration
    - At DFW may not be feasible
  - Potential issues identified with TOS in PDRR/RAD:
    - Routes are ranked order based on the RTC (lowest RTC may not viable route, unless TOS list only the requested routes)
    - Do not time out (may be an issue with updating TOS routes)
    - PDRR/RAD does not alert ATC user when TOS has been submitted (requires phone call)
- Potential Long-Term Goal
  - Use beta version of PDRR/RAD in the Departure Viewer at ZFW
  - Approval of submitted TOS via SWIM via PDRR/RAD at the Towers
- Potential Long-Term Synergies
  - Submission of TOS via SWIM
  - Modification of TOS routes
- Potential Long-Term Roadblocks
  - Limited ability to amend flight plans with RAD at ATCT facilities (Center tool)

Overview of RAD



Select the flights to be rerouted

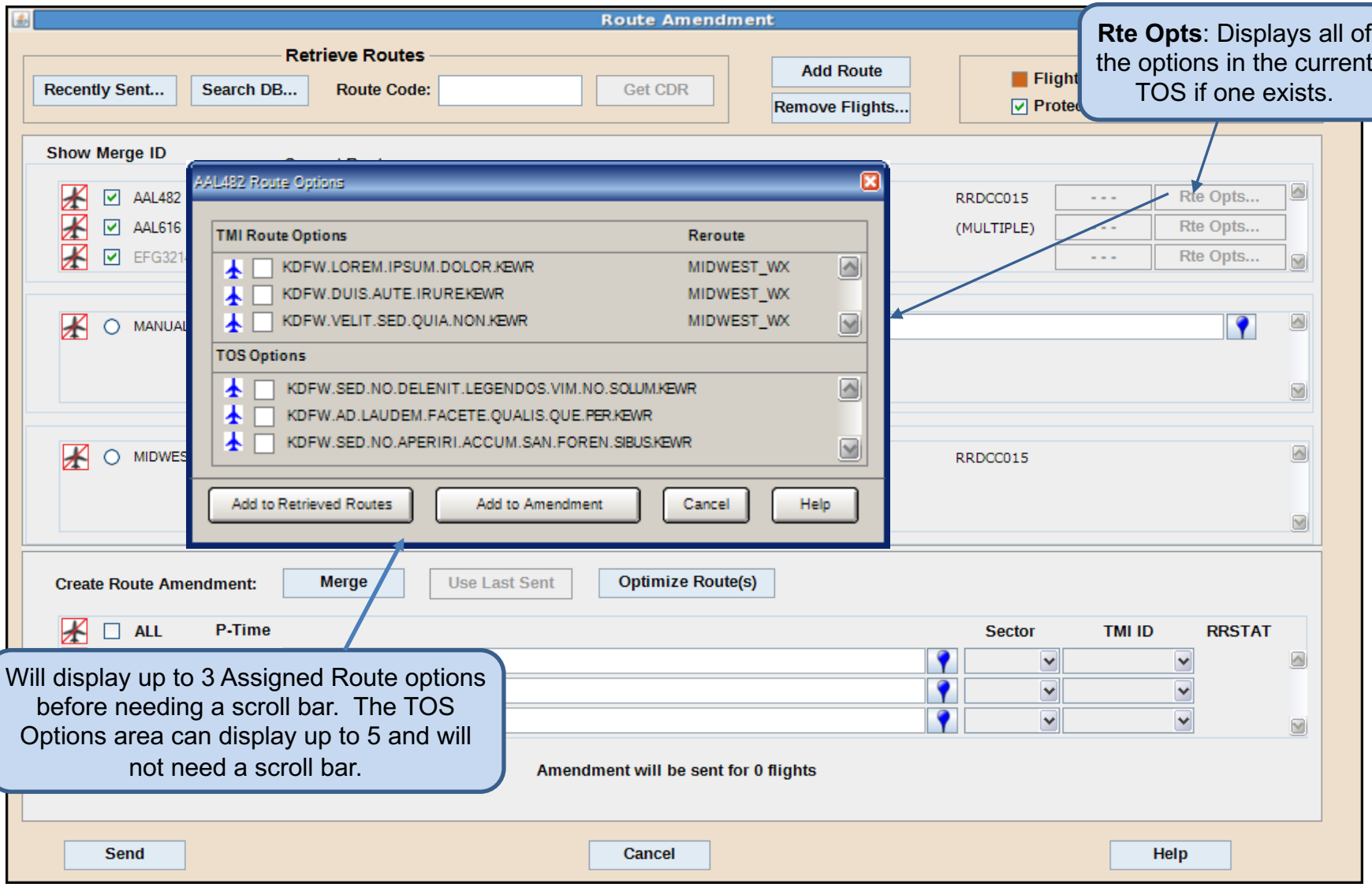
Construct the New Route

Merge the Current and New Route

Send to ERAM

TOS Options Visible in RAD

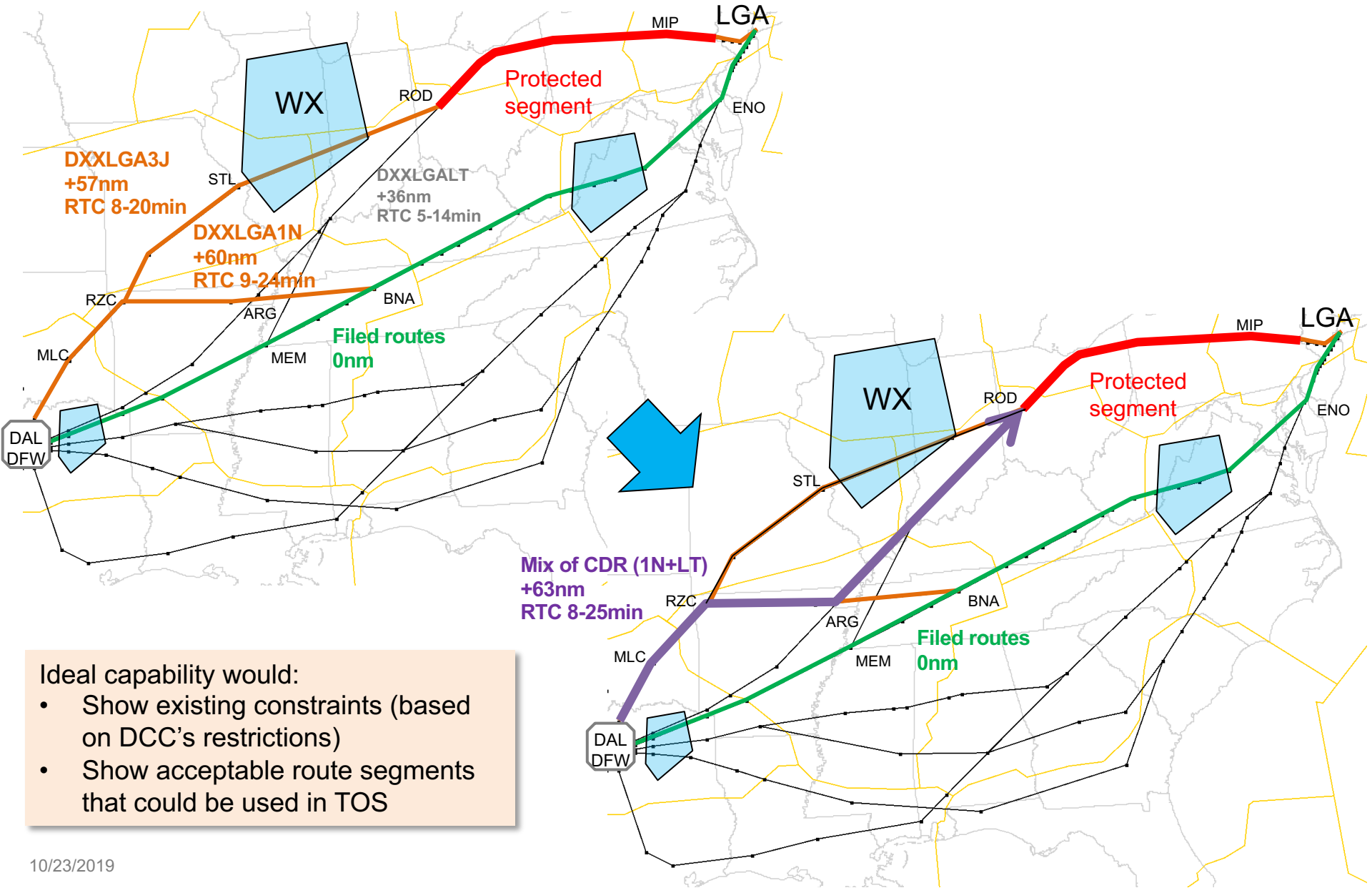
Note: the RAD would be available from the Departure Viewer



TOS Route Modifications
Long-Term Potential

- Motivation
  - Provide ability to modify route options as needed to maximize opportunities to off load demand and minimize delays
- Current Limitations
  - CDR in the TOS may conflict with NAS wide reroute restrictions
- Potential Long-Term Goal
  - Leverage existing parsing of NAS wide TMIs, such as Playbook advisories
  - Provide route modification options based on TBD criteria, such as partial CDR route segments, to comply with reroute restrictions, as needed
- Potential Long-Term Synergies
  - Wind data
  - Dynamic RTC
  - Parsing of NAS wide restrictions
  - Submission of TOS via SWIM
  - Use of PDRR/RAD and CPDLC-DCL
- Potential Long-Term Challenges
  - If PDRR/RAD is not available, modified route would have to be typed manually (unlike CDR)
  - Non-standard routes may get rejected by ERAM when submitted via PDRR (unlike CDR)

Use Cases with Route Modification
Long-Term Potential



Ideal capability would:

- Show existing constraints (based on DCC's restrictions)
- Show acceptable route segments that could be used in TOS

Potential Development for ATD-2 and Beyond

Potential Developments For Stormy 20

- For Consideration For Stormy 20 (pending on feasibility and feedback)
  1. Provide real-time metrics on uncertainty and benefit pool
     - Self-scoring of uncertainty, or other key metrics
     - Aggregated delay
  2. Dynamic RTC
     - Dependent of what the FO want and how usable we can make it
  3. Targeted parsing NAS wide restrictions
     - Automatically update TOS RAM based on *targeted* data in DCC's Advisories
  4. New CDR procedures to help off load demand, as needed
     - Dependent on ZFW's initiative
     - May require adding altitude restriction
  5. Progress towards submitting TOS to TFM SWIM (CDRs)
     - Flesh out use case and requirements for TFM's subscribing systems (PDRR/ABRR)
     - Figure out messages

Long-Term Potentials

- Likely Beyond ATD-2
  - Inclusion of wind miles to route and RTC computations
  - Include Radar Surveillance Data In Love Field Surface Predictions
  - Transition to web-based and cloud-based system
  - Rerouting EDCT flights under GDPs or FCAs
  - Submit dynamic TOS to SWIM (could support modified routes)
  - Flight plan amendments with PDRR/ABRR with RAD
  - Route modifications to comply with DCC's reroute restrictions

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