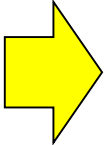


ATD-2 Briefing for Southwest Data Science Community

Aug 21, 2018

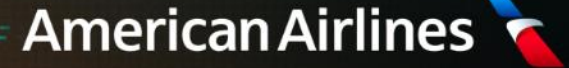
- 
- Background
 - *Al Capps*
 - Data Availability and Analysis Framework
 - *Dr. Andrew Churchill*
 - Taxi Time Prediction Model
 - *Dr. Hanbong Lee*
 - Surface Metering Fundamentals
 - *Isaac Robeson*
 - Benchmarking and Characterizing Operational Days
 - *Dr. Jeremy Coupe*
 - Using Trajectory Options Sets to Reduce Delay
 - *Dr. Eric Chevalley*

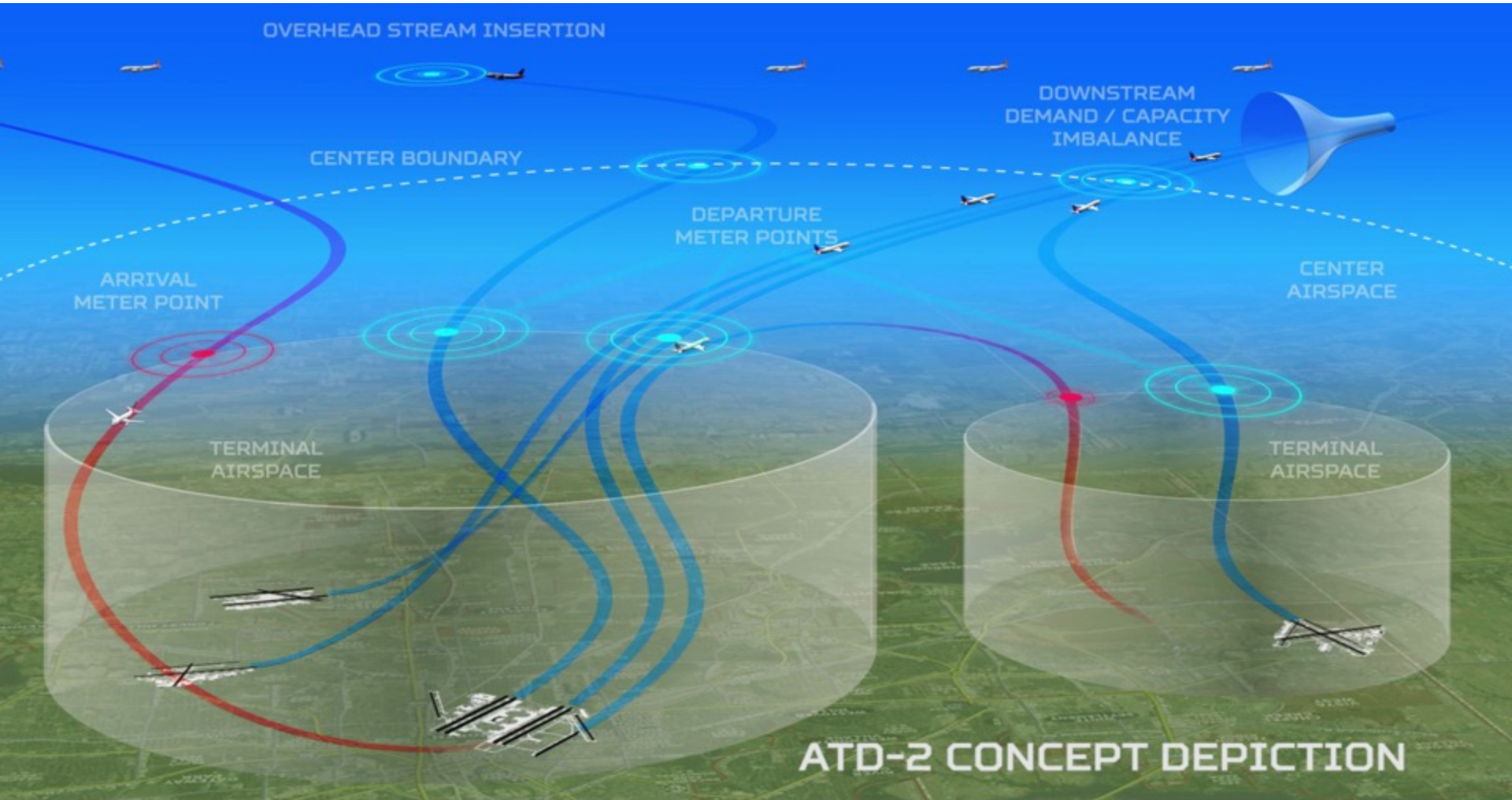


ATD2



DALLAS
FORT WORTH
INTERNATIONAL
AIRPORT





See the ATD-2 Concept Animation Video and Latest Updates here:
<https://www.aviationsystemsdivision.arc.nasa.gov/research/atd2/index.shtml>

- Background
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- **ATD-2 has many sources of input data!**
 - *Challenge 1:* Fusing these sources to collect all related information about each individual “flight”
 - *Challenge 2:* Applying logic to ensure the most accurate or timely source is being prioritized
- **ATD-2 has many kinds of output data!**
 - Primarily built on PostgreSQL, supporting consumers with different needs

Analysts:
flight-level
summaries, deep-
dive ability

Project managers:
aggregated
metrics, example
flights

Developers:
diagnostic logs,
message-by-
message debugs

Ramp controllers:
push regular flight-
level performance
detail

Ramp supervisors:
status dashboards

Airline analysts:
performance and
diagnostic data



ATD-2 takes input from SWIM and other sources...

- TFM Flights – all kinds of flight-related data
- ASDE-X – surface surveillance
- TBFM/TMA/IDAC – terminal-area flight data
- TFM Terminal – EOBTs, etc.
- OIS – TMI around the NAS
- TFM Flow – ground stops, etc.
- Proprietary airline feed – gates, registrations, etc.
- FlightStats – gates
- Ramp controllers & TMCs – clearances, etc.

Each source provides slightly different identifying information, requiring complex logic to fuse these messages to a single flight:

- For example, a flight operates YYY-ZZZ-YYY with same callsign. TFM Flights will give ACID, IGTD, orig/dest, but ASDE-X only gives callsign (and not on every message!). When seen on surveillance, which “flight” is it?

Many data sources provide similar information...

- So how do we know which to use?
- For example, when is a flight going to be ready to pushback? Use the first non-null entry in this list.
 1. Ramp controller entry
 2. EOBT
 3. LTIME/LGTD
 4. FlightStats estimated time
 5. Flight plan time
 6. Scheduled time
 7. Initial time
- Similar rules exist for many other data elements
- These are being regularly updated, as we learn more, get feedback from users, and observe changes in the data feeds themselves.

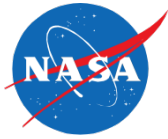


Output data are verbose...

- Full state of flight inserted in db each time some update/action happens on that flight
- Main table includes 222 columns, ~400k rows/hour (~50% are surveillance updates)
 - Departure generates ~5k rows in the hour before takeoff.

However, scale (compute power) is not the issue...

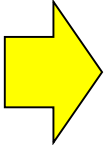
- Many analysts contributing to this research, often working on closely-related questions
- Many possible angles for misinterpretation of data, requiring specific business rules



- We have developed a daily report, with one row per flight (284 columns), cover many categories of data
- Includes numerous business rules / conventions
- Constantly adding new fields to support analyst/user requests, all from primary db to allow backward-compatibility
 - Identifying info
 - Scheduled, proposed, etc. times/routes
 - Actual times/resources
 - Actual, unimpeded, excess taxi times
 - Surface metering
 - EOBT/LTIME info
 - Controller clearances
 - Gate conflicts
 - Bank info
 - Resource predictions at events
 - EDCT info
 - APREQ info
 - Other TMI
 - Various AOBTs
 - Airport configuration

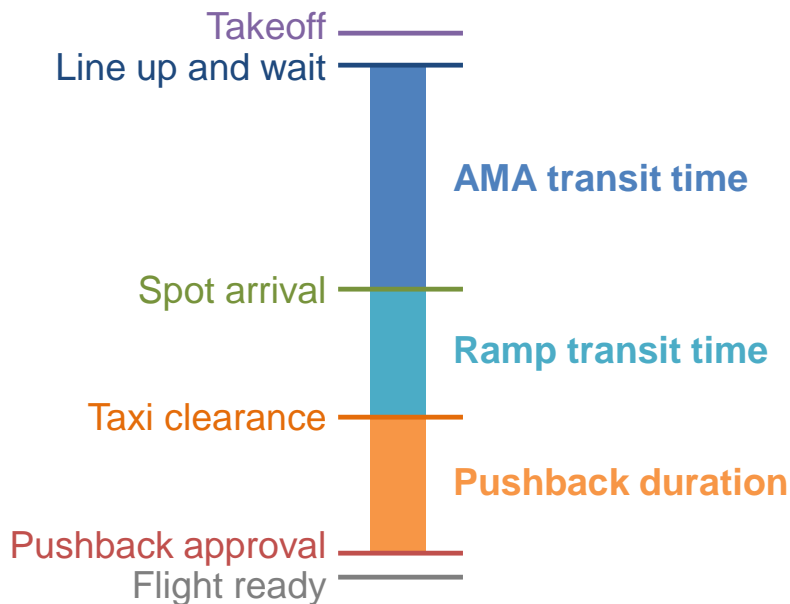


- **AOBTs:** Which systems provided actual out times, and how do these times differ from one another?
- **Resource predictions:** Just before flight pushes back, what spot and runway are expected?
- **Return to gate flights:** What data to report on these flights? Last AOBT & AMAT (this part is easy!). But also need to capture when first were ready.
- **EOBT accuracy:** At m minutes before pushback, what is current airline-provided EOBT? How far from actual is it?
- **APREQs:** How many times did the APREQ time change? Were any of these changes associated with IDAC? Was the first APREQ negotiated while flight still at the gate?
- **Airport configuration:** Was airport in north or south when flight pushed back? What about at takeoff?

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- Objectives of taxi time prediction
 - To estimate the earliest possible takeoff times of departures, which are used for runway scheduling in Tactical Scheduler
 - To predict a possibility of gate conflicts for arrivals
- Taxi time calculation for departures

$$\text{Taxi-out time} = \text{Pushback duration} + \text{Ramp transit time} + \text{AMA transit time}$$



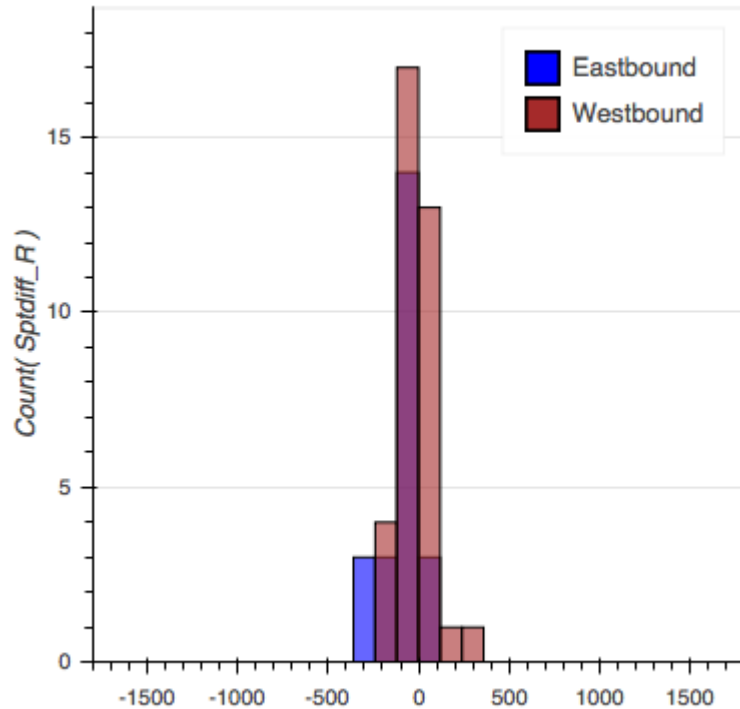


- Compute taxi distances along taxi routes
 - Ramp taxi distances for gate-spot pairs
 - AMA taxi distances for spot-runway pairs
- Calculate taxi speeds in ramp and AMA for individual flights

$$\text{Taxi speed} = \text{Taxi distance} / \text{Actual transit time, for ramp and AMA each}$$
- Provide default taxi speed and pushback duration values in decision trees
 - Ramp and AMA taxi speeds
 - Pushback duration by ramp area (gate group) and aircraft type
- This model is currently used in the field and can update undelayed spot/runway arrival times in real time, based on current positions and remaining taxi distance.

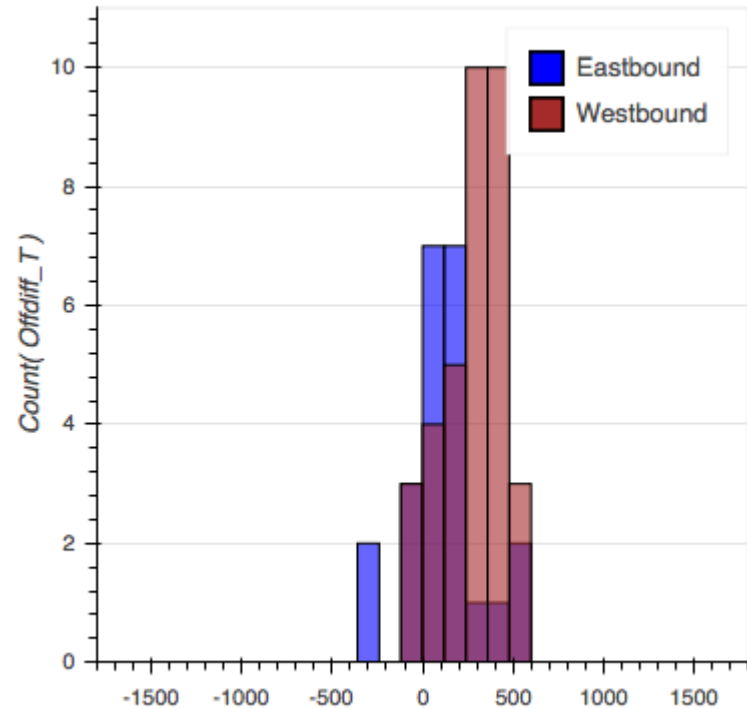
- Taxi time prediction example from trajectory based model
 - Positive gaps between undelayed runway arrival times and actual takeoff times due to runway separations

Taxi Time Difference (Actual – Predicted) (in seconds)



Spot arrival time when start taxiing

Taxi Time Difference (Actual – Predicted) (in seconds)



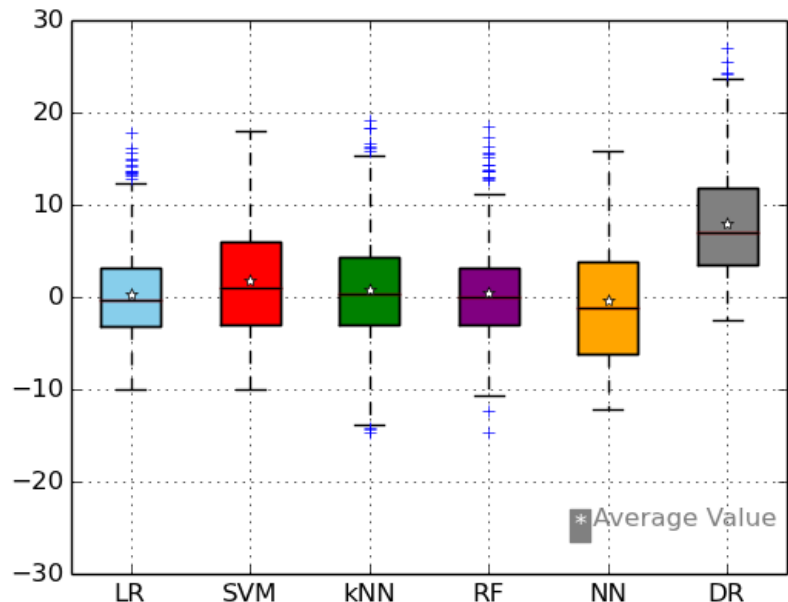
Runway arrival time when passing spot



- Features (variables):
 - Terminal concourse, spot, runway, departure fix, aircraft model
 - Taxi distance, unimpeded taxi time
 - Scheduled OUT time of day
 - Number of departures and arrivals on the surface
- Machine learning techniques tested
 - Linear Regression (LR)
 - Support Vector Machines (SVM)
 - *k*-Nearest Neighbors (*k*NN)
 - Random Forest (RF)
 - Neural Networks (NN)
- Coded in Python using *sklearn* and *PyBrain* libraries
- Trained with actual flight data at CLT

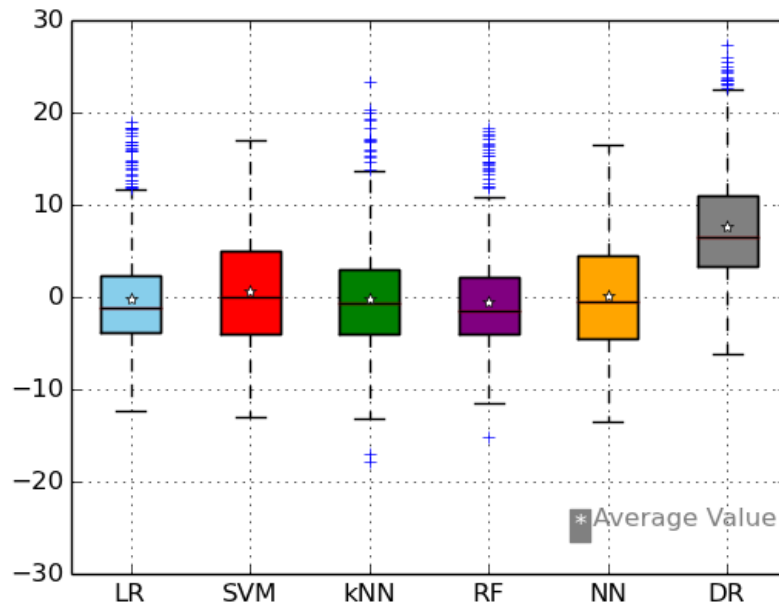
- Machine learning algorithms showed better performance than Dead Reckoning (DR) method based on unimpeded taxi times.
- However, there is still room for improvement.

Taxi Time Difference (Actual – Predicted) (in minutes)



South-flow traffic, good weather

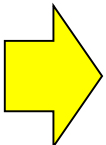
Taxi Time Difference (Actual – Predicted) (in minutes)



South-flow traffic, heavy rain

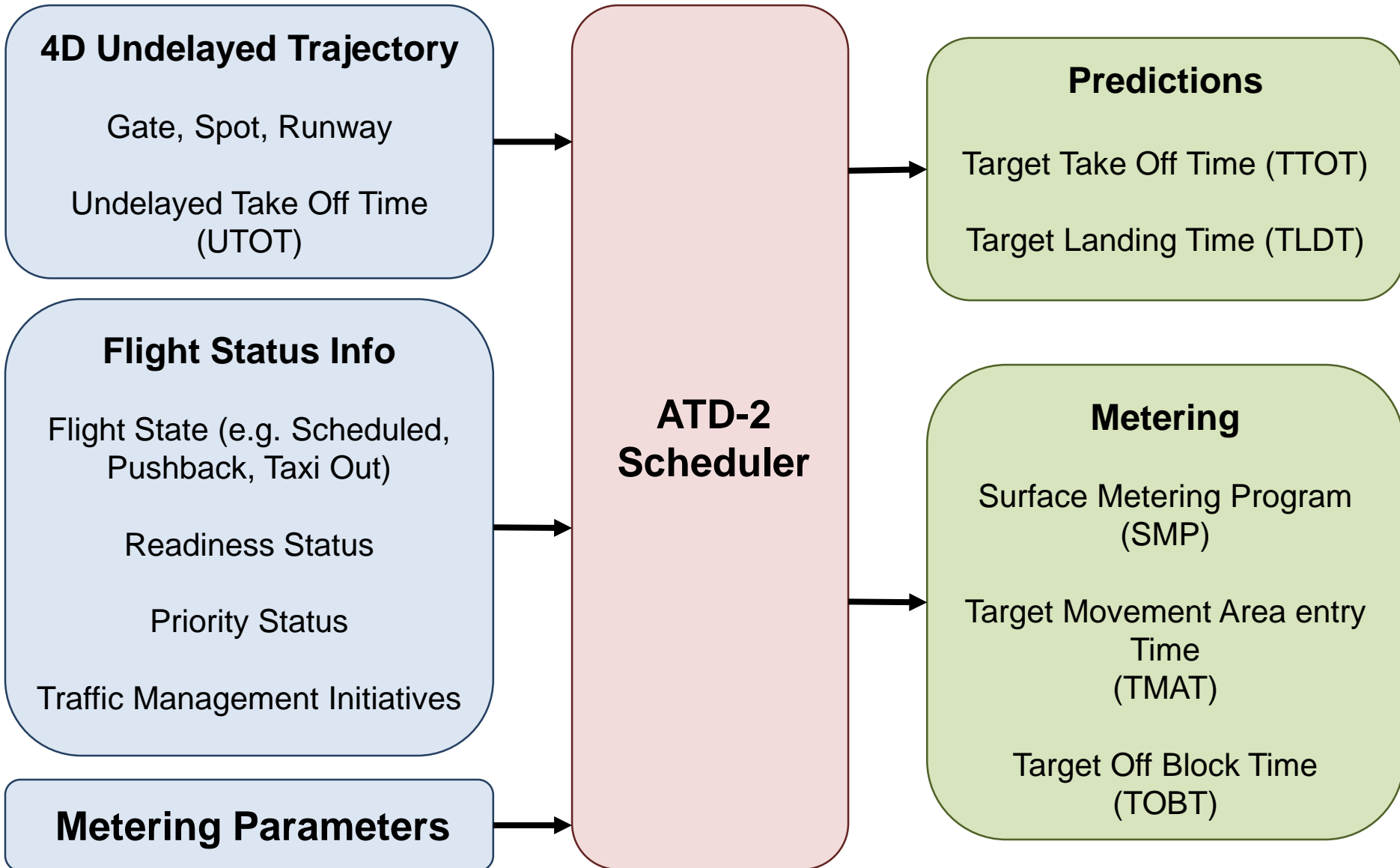


- Decision tree updates for pushback duration and taxi speeds in the ATD-2 model
 - Keep collecting more accurate taxi time data from CLT field
- Further investigation on machine learning algorithms
 - Improve prediction accuracy both in pushback duration and ramp transit time
 - Achieve better maintainability in the long term
 - Apply a common approach to multiple airports, including DFW and DAL

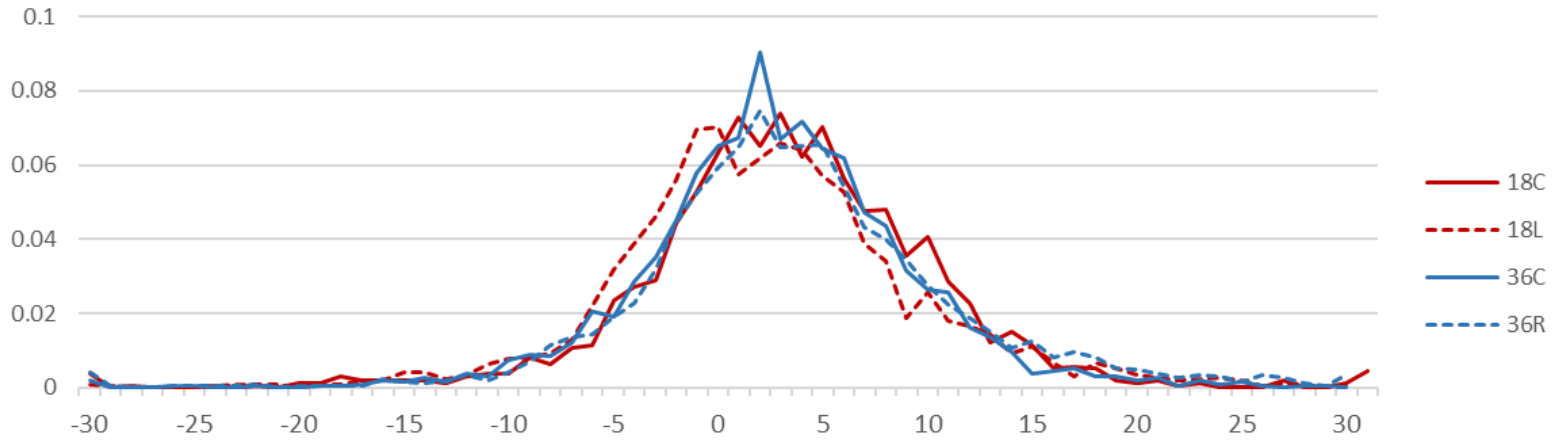
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- Overview of ATD-2 scheduler
- Tactical Surface Metering
- Transition to Strategic Surface Metering
- Future of Surface Metering in the NAS

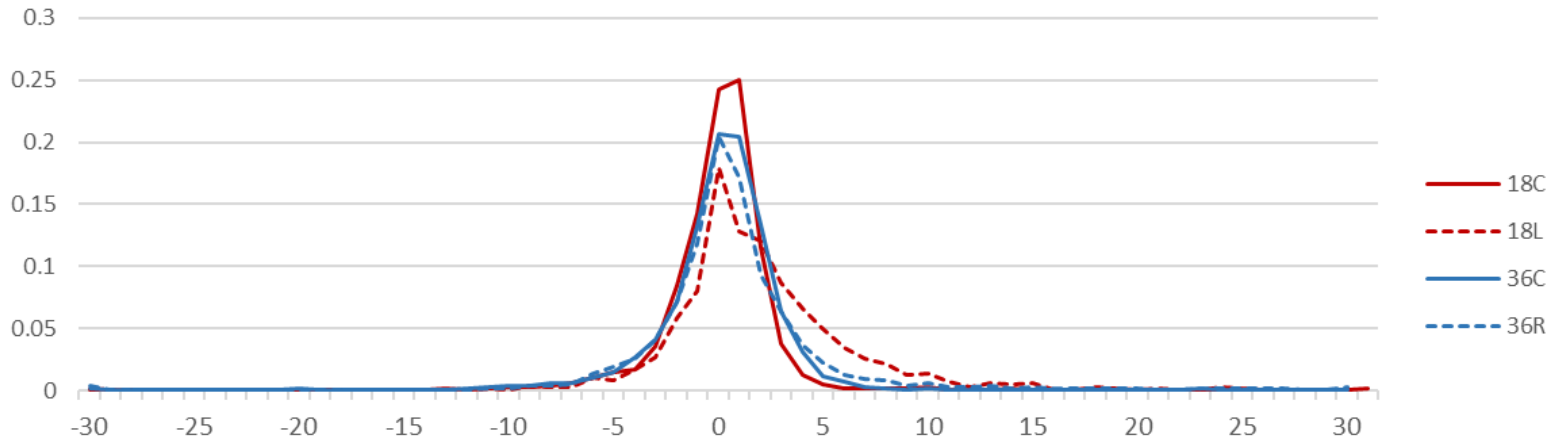


TTOT Accuracy at Gate



TTOT Accuracy in Minutes (TTOT - ATOT)

TTOT Accuracy at Spot



TTOT Accuracy in Minutes (TTOT - ATOT)

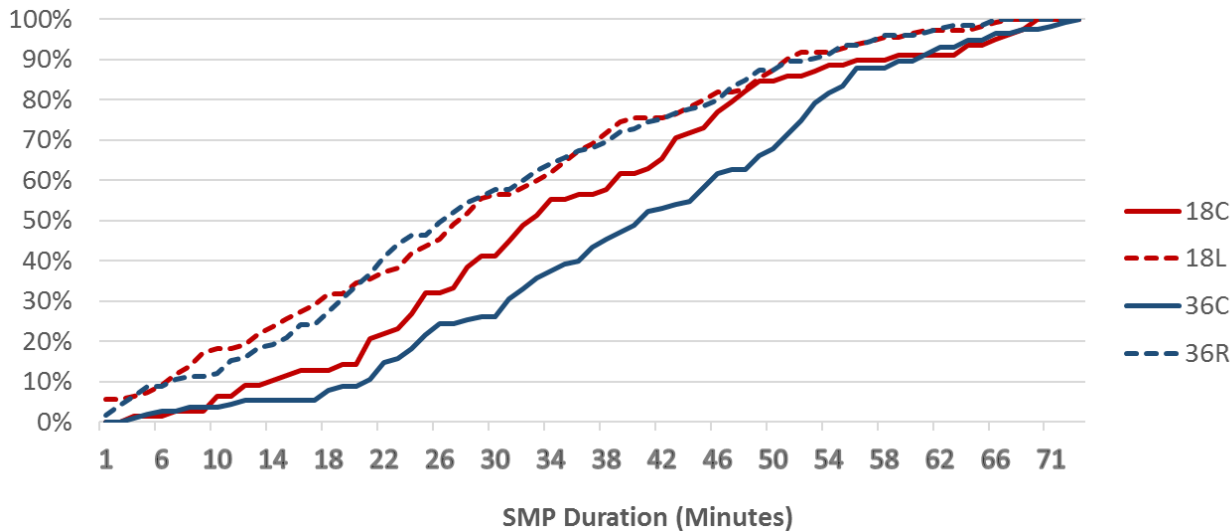
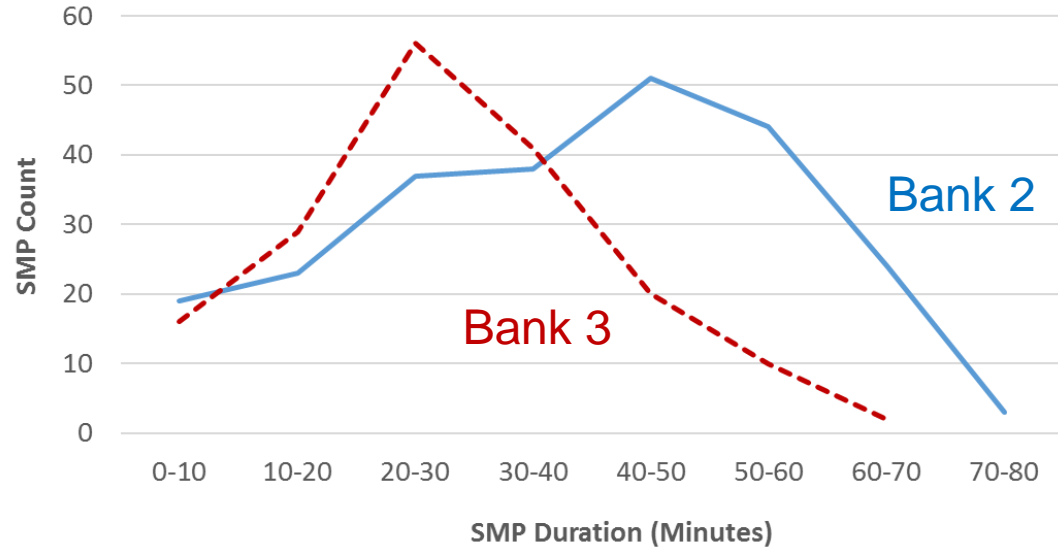
- Capability is enabled during the 2nd and 3rd departure bank at CLT
- Scheduler predicts the amount of excess taxi time (i.e. taxi time beyond unimpeded = $TTOT - UTOT$)
- The schedule will trigger surface metering if it predicts that
 - A departure off the gate will have an excess taxi time $>$ the target excess taxi time
 - And a departure at the gate will have an excess taxi time $>$ the upper threshold
- When metering triggers, the scheduler passes back excess taxi time over the target to the gate
 - $Gate\ Hold = (TTOT - UTOT) - Target\ Excess\ Taxi\ Time$
- Gate hold advisories displayed to ramp controllers

Tactical Metering Statistics from the start of April 2018



Tactical SMP Counts

Runway	Bank 2	Bank 3
18C	39	37
18L	53	45
36C	70	42
36R	62	53
Total	224	167



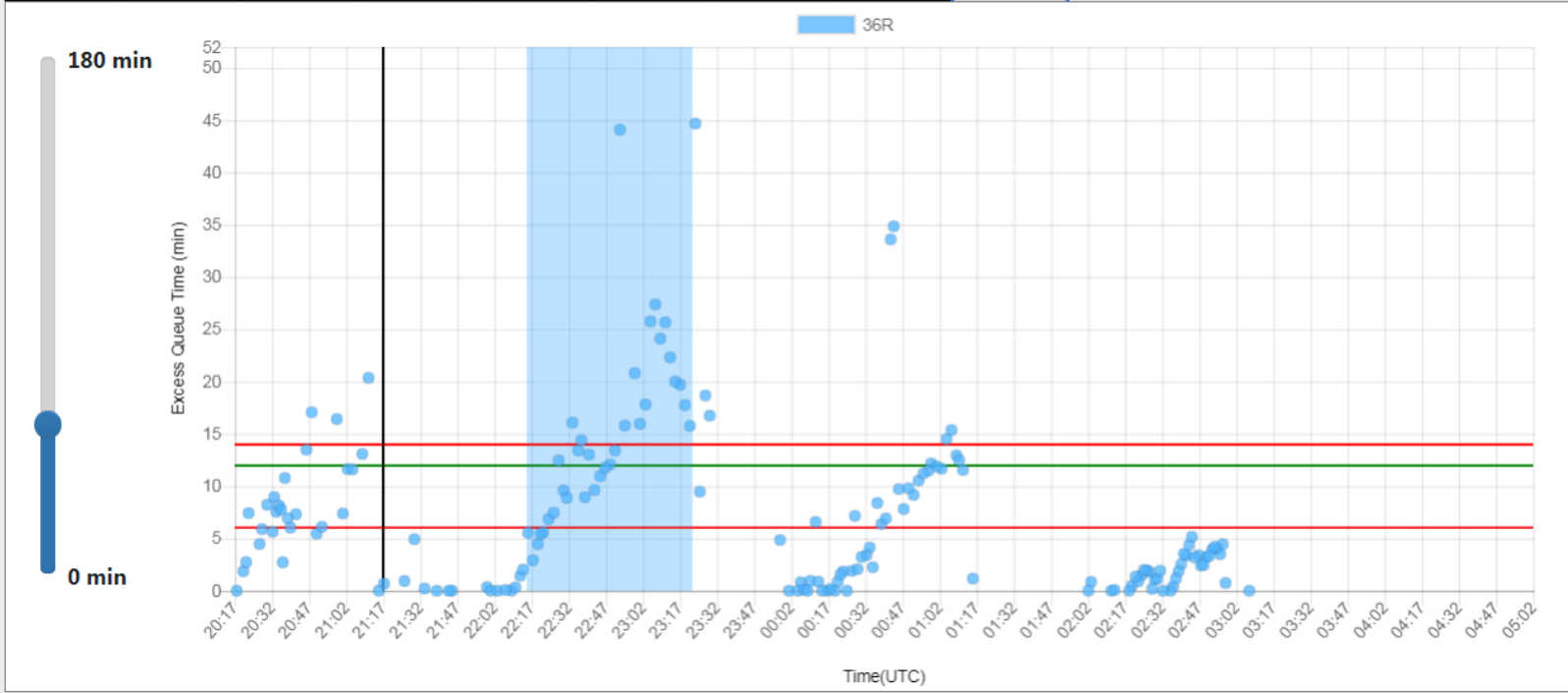


- Predict when metering will be needed in advance
- Scheduler recommends a Surface Metering Program (SMP)
- Allows users at CLT to collaborate on recommended metering
 - Affirm or reject the recommended SMP
- SMP is adjusted at regular intervals based the latest data

Surface Metering Display Configuration: North Scenario: N_Normal Time: 2018-08-15 21:17:18 [Metering Params](#) [Feedback](#)

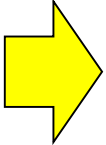
Status ▲	Runway ▾	Start ▾	End ▾	Flt Count ▾	Avg Hold ▾	Max Hold ▾	Action
PROPOSED	36R	15/22:15	15/23:22	24	5.6 min	28.4 min	<input checked="" type="checkbox"/> <input type="checkbox"/>

Airport 5 18L 18C 18R 23 36L 36C **36R**

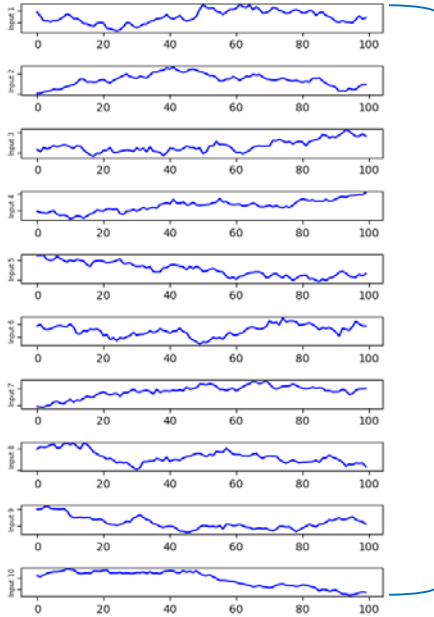




- Terminal Flight Data Manager (TFDM)
 - Electronic Flight Data
 - Traffic Flow Management
 - Collaborative Decision Making for the Surface
 - Surface Metering Programs (SMPs)
 - Systems Consolidation
- TFDM Terminal Publication (TTP) SWIM Service
 - Surface metering information
 - Shared situational awareness
 - Airport configuration
 - Runway assignments
 - TMI data per flight
 - Airport metrics

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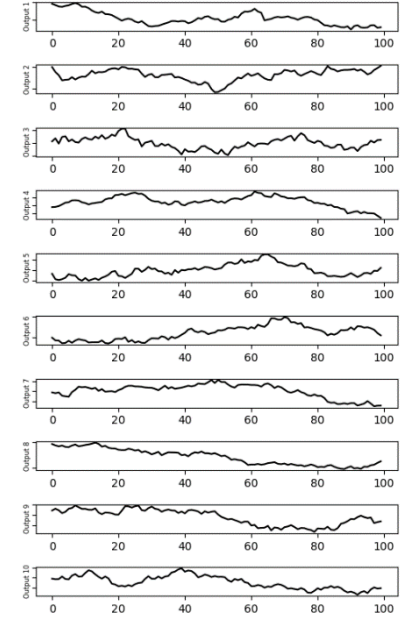
Multiple Inputs



Complex System



Multiple Outputs

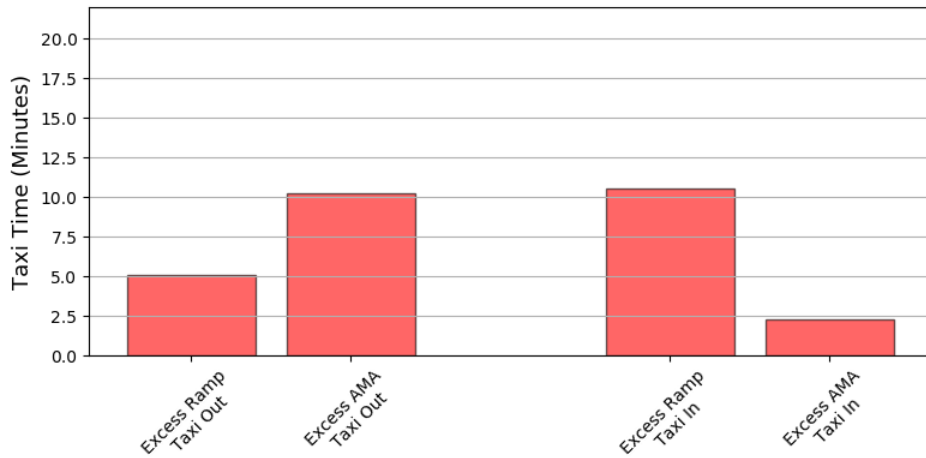




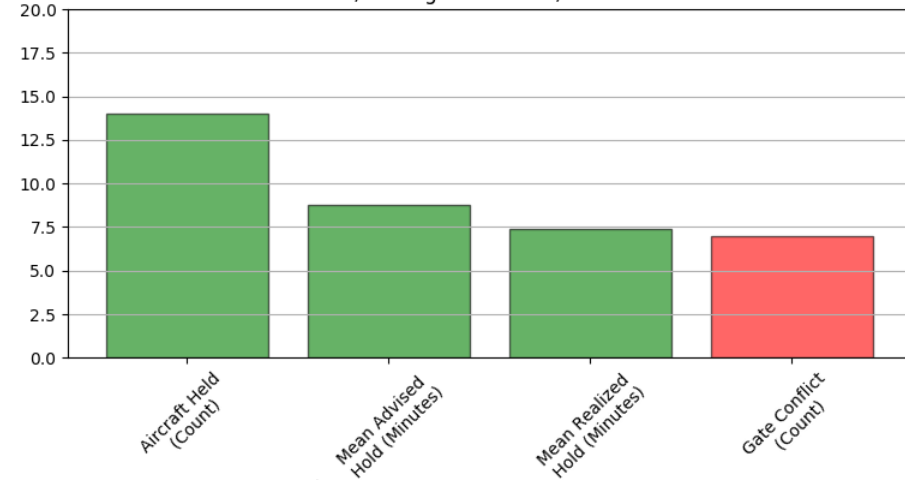
- **Operational views:** Identify important outputs / metrics that are relevant to the users and allow us to quantify the overall health of the surface system
- **System views:** Identify important outputs / metrics that allow us to understand if the system is working as expected, calibrate the parameters, and diagnose problems

2018-1-24 North Flow Bank 2

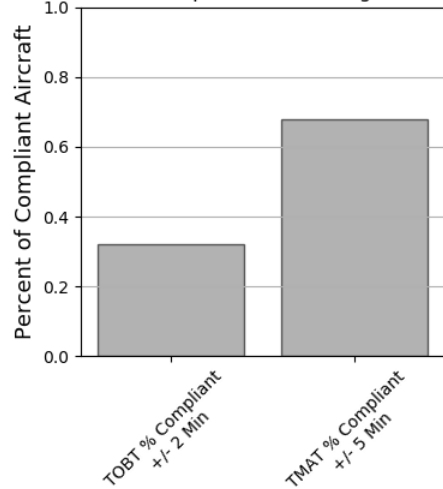
Taxi Time



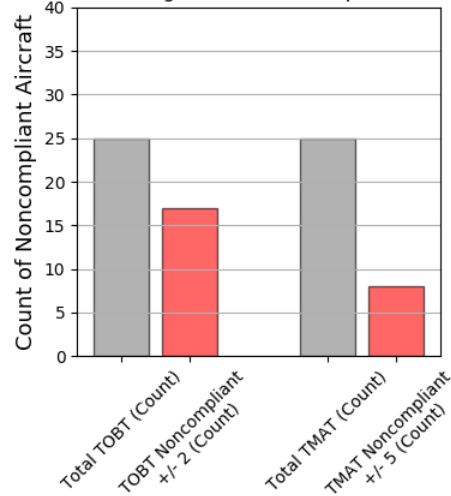
Count of Aircraft Held, Average Gate Hold, and Count of Gate Conflicts



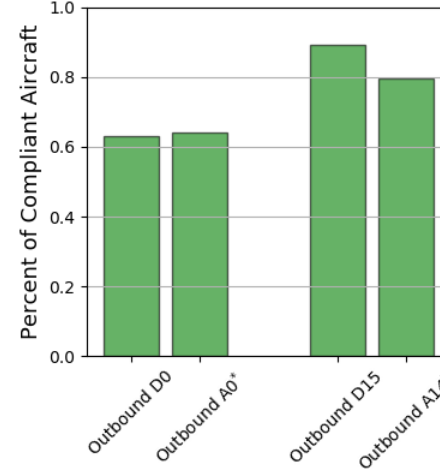
TOBT / TMAT Compliance Percentage



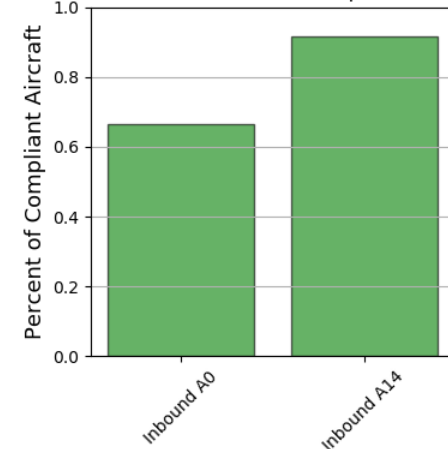
TOBT / TMAT Count Assigned and Noncompliant



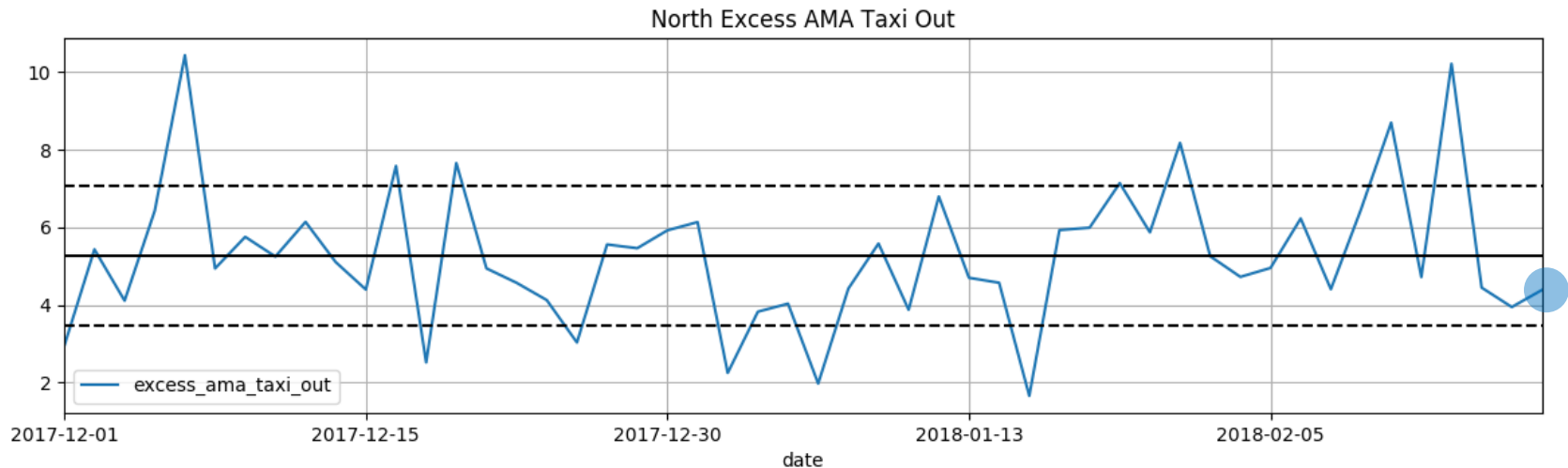
Outbound D0 / A0* and D15 / A14* Compliance



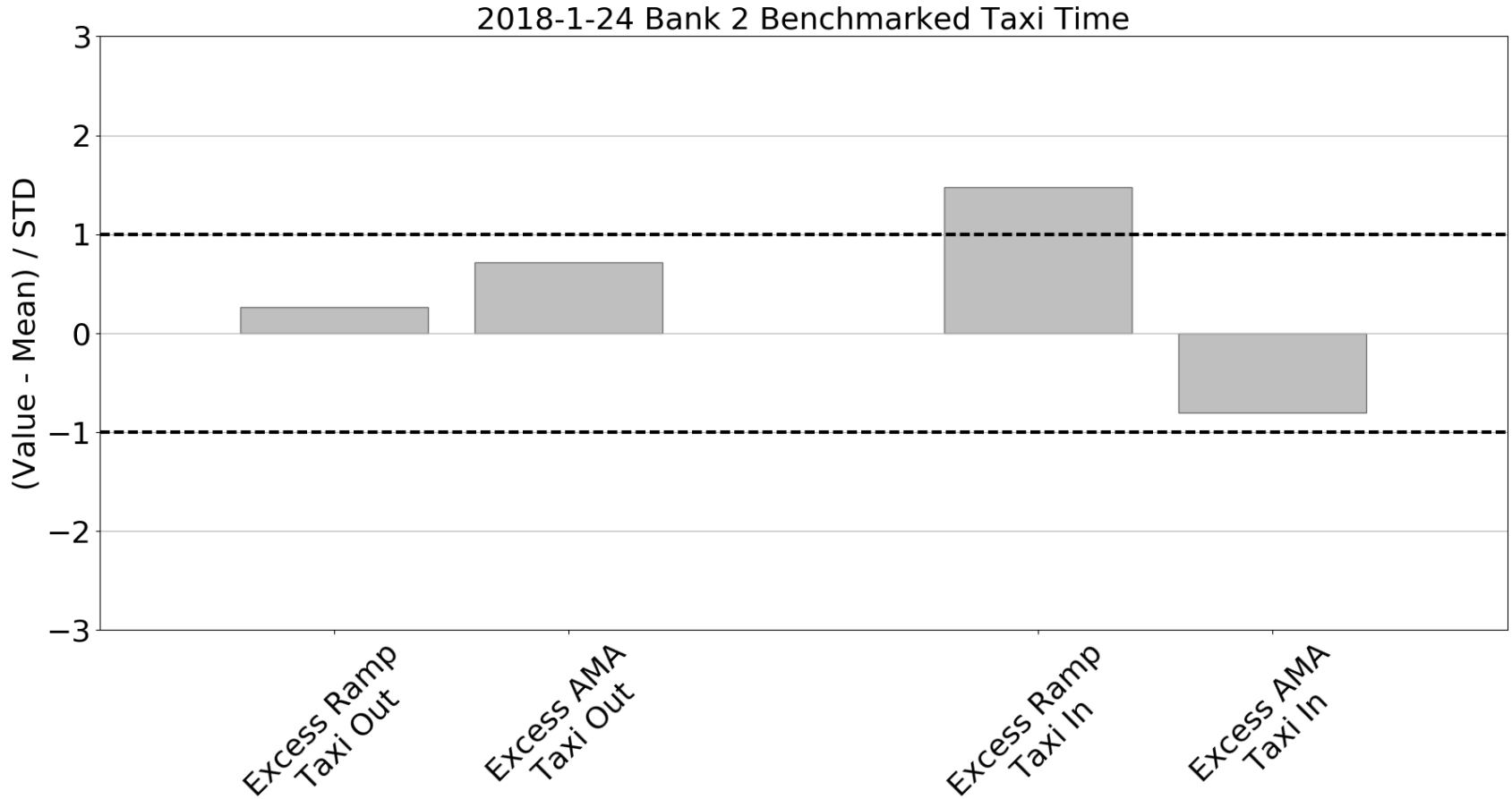
Inbound A0 / A14 Compliance



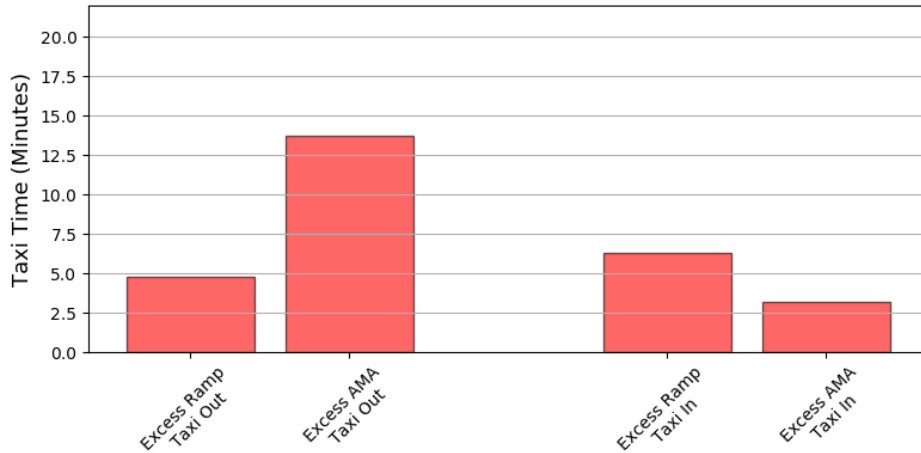
- **Problem:** How to understand the data and metrics in context
- **Solution:** Benchmark single day data against the average and standard deviation of metered days in the same flow



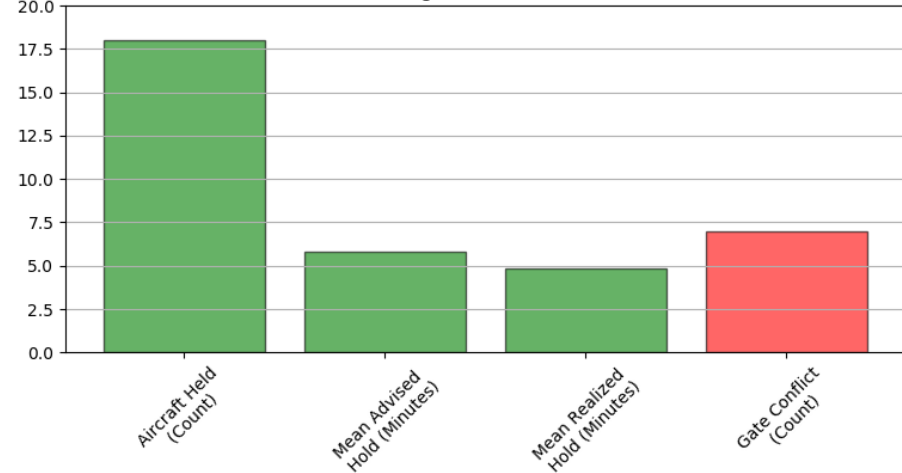
Benchmarked Value = $(\text{value} - \text{average}) / \text{standard deviation}$



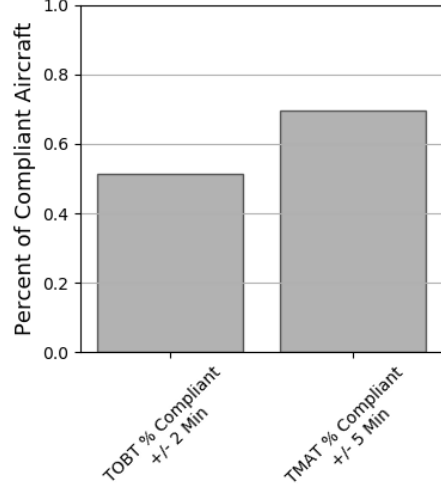
Taxi Time



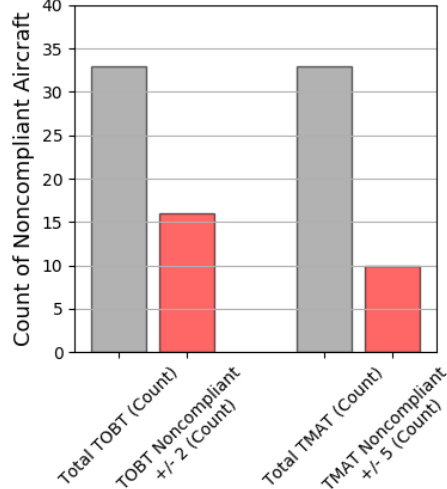
Count of Aircraft Held, Average Gate Hold, and Count of Gate Conflicts



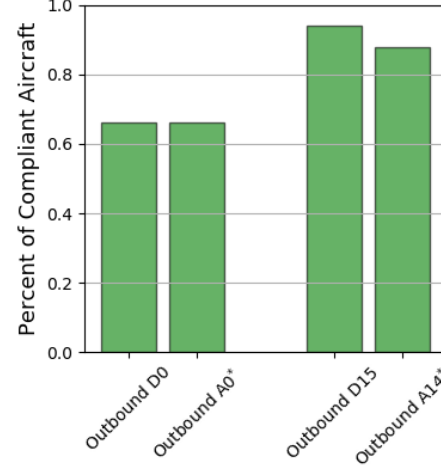
TOBT / TMAI Compliance Percentage



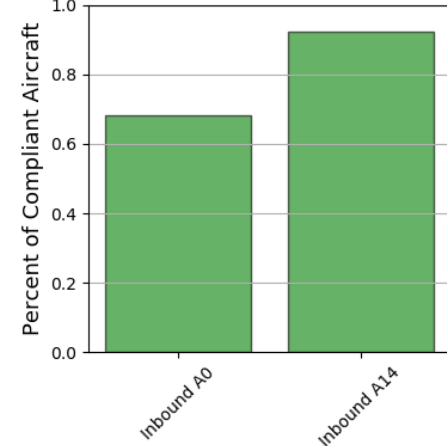
TOBT / TMAI Count Assigned and Noncompliant



Outbound D0 / A0* and D15 / A14* Compliance

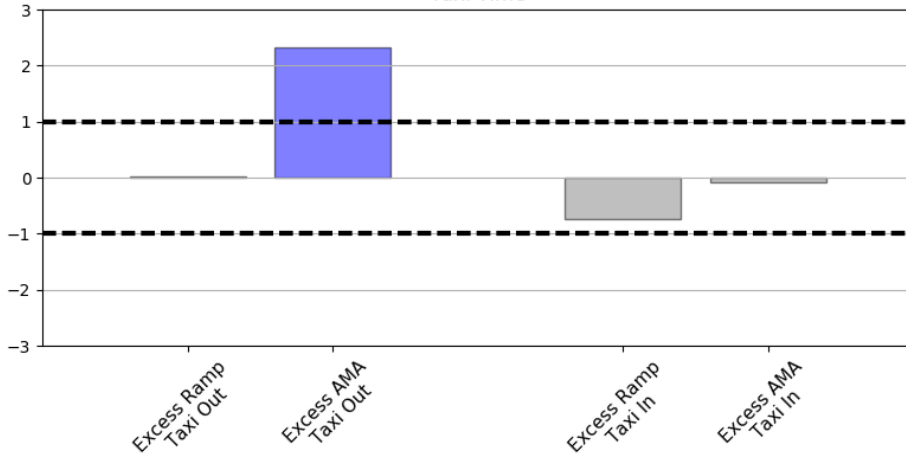


Inbound A0 / A14 Compliance

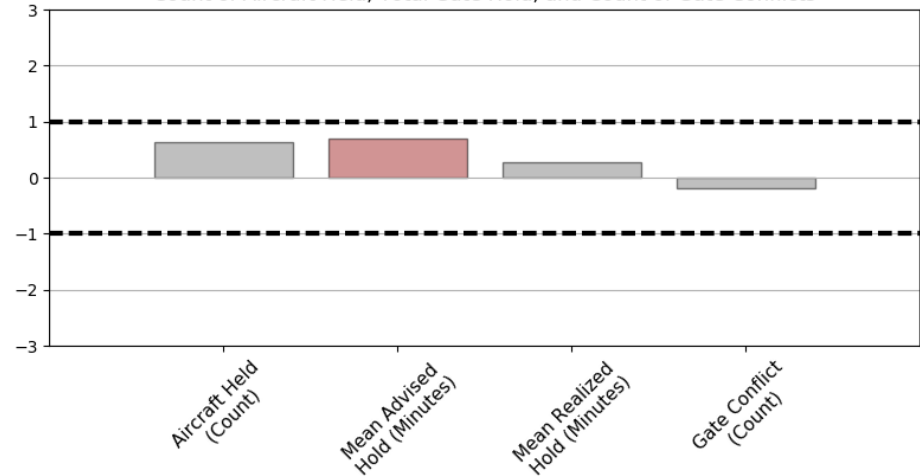


Can the benchmarked data provide additional insights that are not apparent when looking at the summary data?

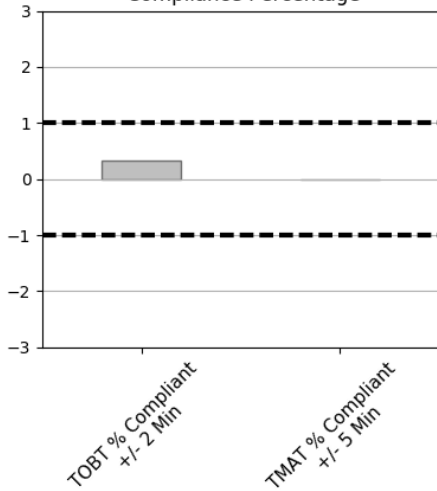
Taxi Time



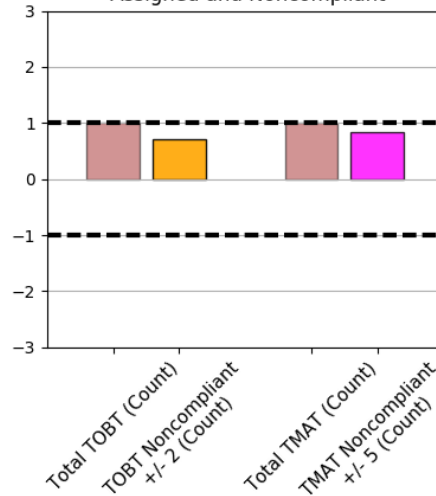
Count of Aircraft Held, Total Gate Hold, and Count of Gate Conflicts



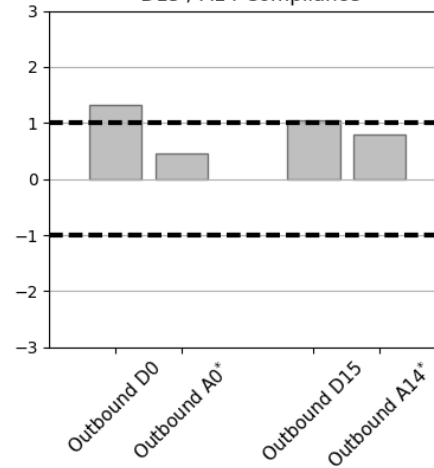
TOBT / TMAAT Compliance Percentage



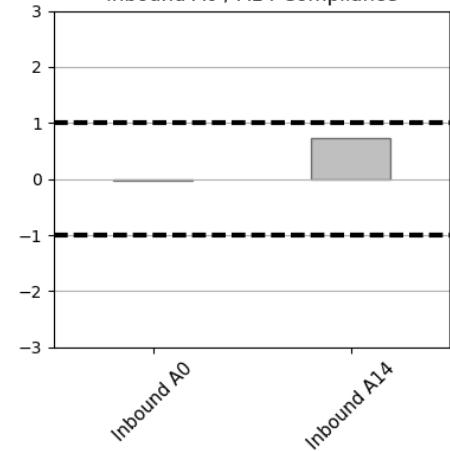
TOBT / TMAAT Count Assigned and Noncompliant



Outbound D0 / A0 and D15 / A14 Compliance



Inbound A0 / A14 Compliance

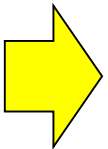


Above average AMA taxi time driven by above average demand capacity imbalance and above average count of aircraft noncompliant to the assigned TOBT and TMAAT

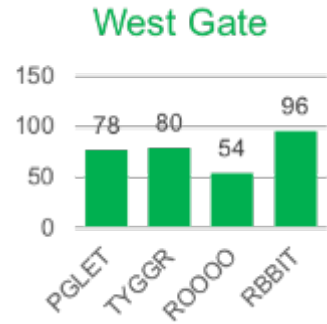


- What is the best benchmark to use?
 - Cluster of “similar” days
 - Data from same month of previous year
 - Metered vs. Non-metered data
- Can the individual benchmarked metrics be rolled up into a single metric that summarizes the overall performance?
- Is the classification of a good / bad day the same for the ramp compared to ATC?

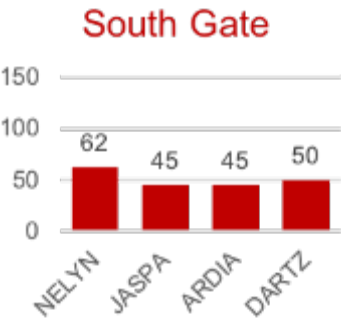
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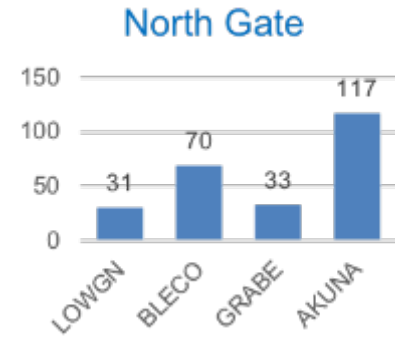
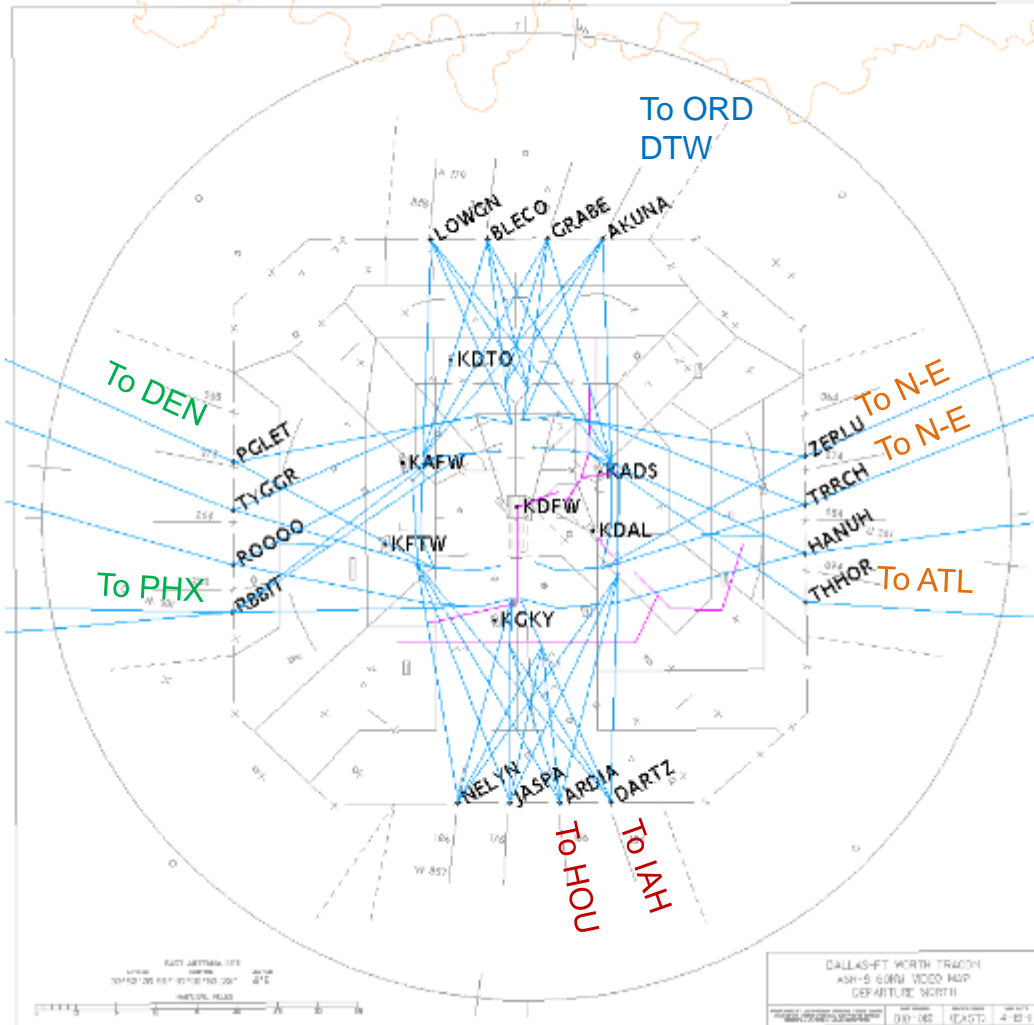
October 2017 departures above 11,000ft



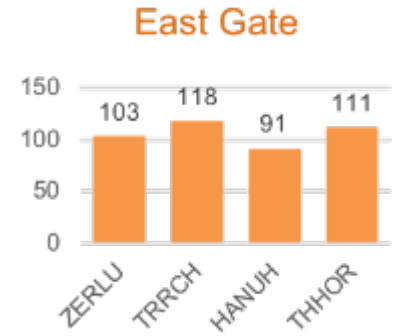
West Gate
306/day



North Gate
252/day



East Gate
435/day



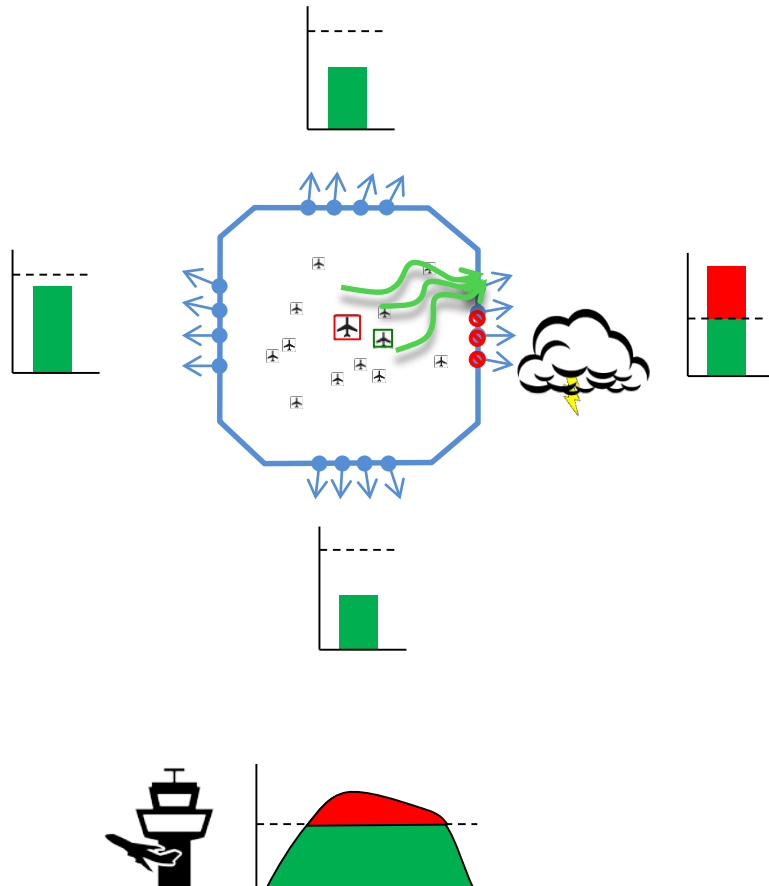
South Gate
201/day

DALLAS-FORT WORTH TRACON
ASH-5 GOWN WOOD MAP
DEPARTURE NORTH
DATE: 09-18-17
TIME: 14:00
SCALE: 4-10-17

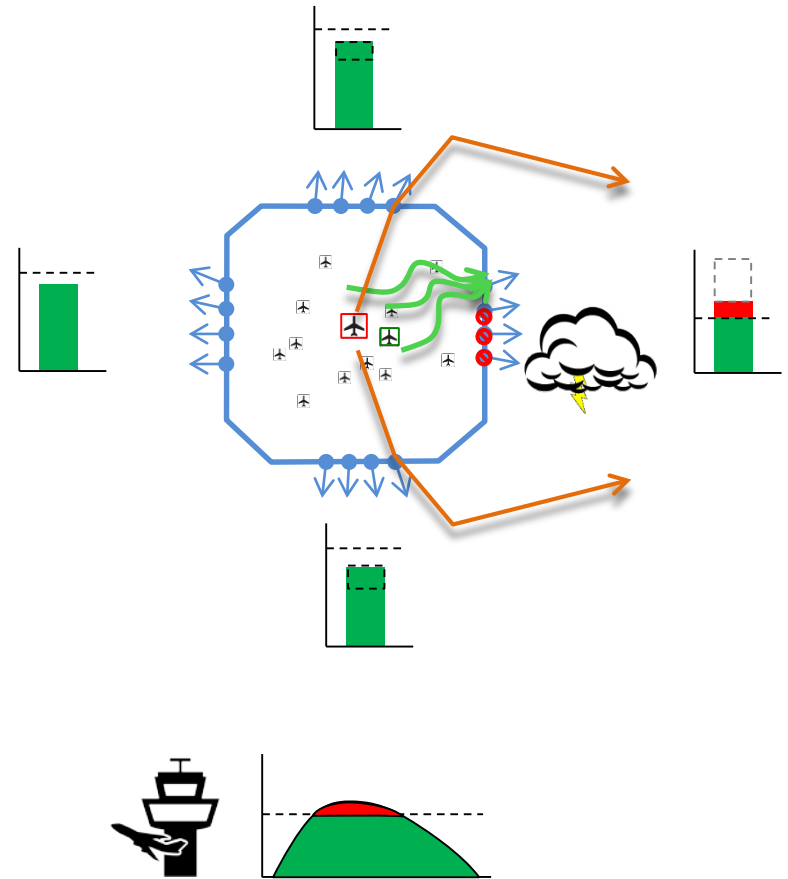
Demand Capacity Imbalances in D10 TRACON Airspace

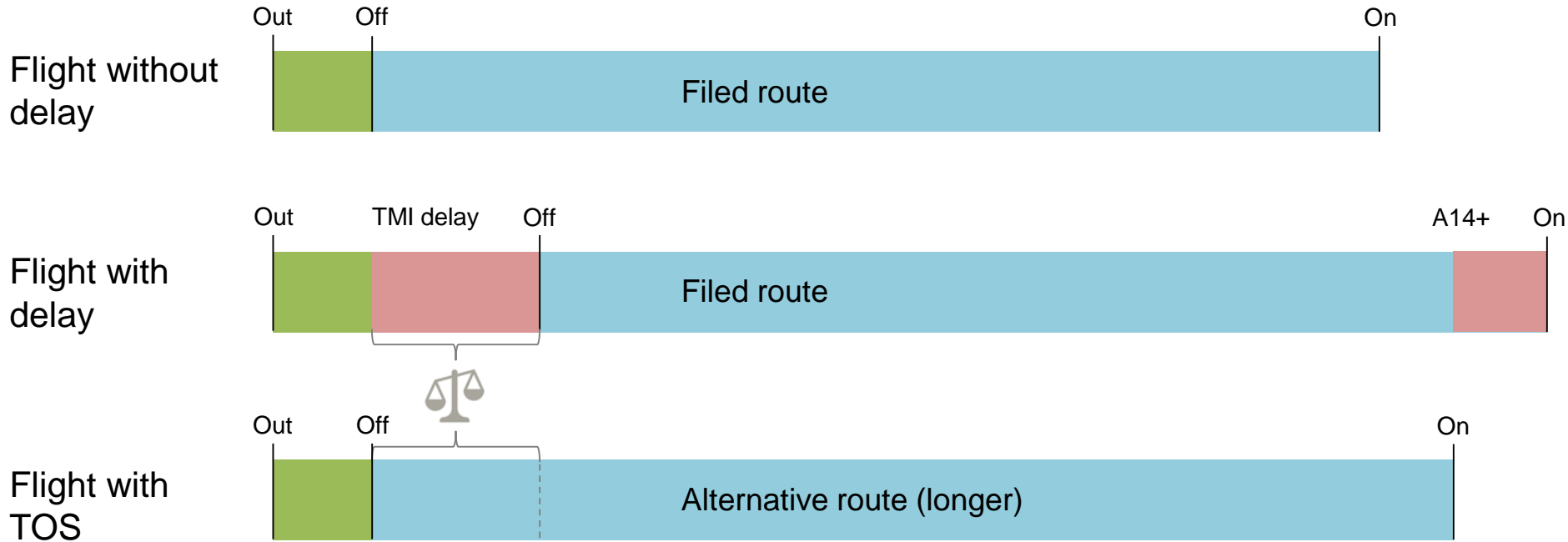
Fix compression caused by weather events near TRACON airspace

Currently



Load Balancing With TOS
(Trajectory Option Set)





Trajectory Option Set Relative Trajectory Cost

Route 1	650nm (filed)	0min
Route 2	680nm	10min
Route 3	720nm	20min
Route 4	750nm	30min
Route 5	780nm	45min

Benefit Case

**Using TOS for SWA at DAL
during an inclement weather day**

**With terminal restrictions
resulting in surface delay**



- July 11th: Day with terminal restrictions and surface delays at DAL and DFW
 - Terminal restriction
 - 1 Flow to the East gate with 10MIT from 16:58 to 20:07
 - Tower restriction
 - Flow rate passed back to DFW and departure stops at DAL
- Collected the departure demand of D10 departures
 - Actual off-block times
 - Estimated take-off times
 - Actual take-off times
 - Actual times at departure fix
 - Estimated surface delays
 - Reported surface delays
- Built a schedule based on the restriction that was applied at the terminal boundary and passed to the towers
- Computed delays due to the restrictions



- Only SWA flights
- All SWA flights with TOS and RTC values
- TOS used when the RTC value matches the surface delay (driven by the terminal restriction)
- First Come First Served allocation
 - First aircraft with RTC value matching delay
 - Repeat until no more aircraft with matching delay
 - Reallocated the TOS flights to the same RWY

ETAs and STAs at the East Gate

Before TOS assignments

DAL Flights in orange
 DFW Flights in yellow
 ADS Flights in green

T +32 BNA SWA2319

+27 RDU 2356

+37 PIE N147SW
 +27 PNS AAL2389

+27 HSV ASQ2911
 +26 MEZ GAJ839

+26 ATL AAL668

+28 PHL UPS2020
 +27 SAV AAL2373
 +26 CLT AAL702

+26 GLH BTQ494
 +48 BNA N710ET

T +47 DCA SWA2392
 +27 BNA AAL1009

+29 PIT N21FE

T +36 MSY SWA2442
 +34 HOT N183CM

+37 PNS ENY3324
 +35 TPA AAL2430
 +35 MCO NKS904

+35 MCO UPS2292

+32 MCO AAL1560
 +31 LEX ENY3777
 +35 ELD FDY2772

+31 GSO ENY3883
 +29 EVV ASQ2949
 +28 TXK ENY3936

+28 BTR ASQ2878
 +27 CLE AAL2487

+28 MIA AAL1908
 +26 ATL DAL1448

+23 INT EJA737

N183CM HOT +34

ENY3324 PNS +37

AAL2430 TPA +35

NKS904 MCO +35

UPS2292 MCO +35

FDY2772 ELD +35

AAL1560 MCO +32

ENY3777 LEX +31

ENY3883 GSO +31

ASQ2949 EVV +29

ENY3936 TXK +28

ASQ2878 BTR +28

AAL2487 CLE +25

AAL1908 MIA +24

N22SM MDT +29

DAL1448 ATL +25

EJA737 INT +23

AAL1018 IND +17

AAL244 FLL +18

AAL1798 PHL +16

ASH5828 BHM +15

NKS296 FLL +14

ASH5927 SDF +12

ENY3629 SHV +10

AAL1476 BOS +10

ENY3674 TYR +13

ETA 1 RTE EAST STA 10MIT



50

N310AZ MCO +42

SWA2282 PIT +36 T

N546MM BTR +42

JTL858 IND +30

N751VL LWB

LWB N751VL

SWA476 MCO +34 T

TYR N680CM

N680CM TYR

AAL2536 MSY +14

AAL654 MEM +15

ENY3317 LIT +19

DAL1375 ATL +22

SWA2319 BNA +32 T

N147SW PIE +37

N710ET BNA +48

SWA2392 DCA +47 T

+14 MSY AAL2536

+15 MEM AAL654

AAL2356 RDU +27

AAL2389 PNS +27

ASQ2911 HSV +27

GAJ839 MEZ +26

AAL668 ATL +26

UPS2020 PHL +28

+22 ATL DAL1375

T +34 MCO SWA476

+42 BTR N546MM

AAL2373 SAV +27

AAL702 CLT +26

BTQ494 GLH +26

AAL1009 BNA +27

N21FE PIT +29

SWA2442 MSY +36 T

ETA 1 RTE EAST STA 10MIT



17:50
 19:50

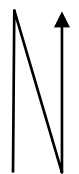


ETAs and STAs at the East Gate

After TOS assignments

DAL Flights in orange
 DFW Flights in yellow
 ADS Flights in green

	50	N183CM HOT +34
+25 RDU 2356		ENY3324 PNS +37
+33 PIE N147SW	45	AAL2430 TPA +35
+25 PNS AAL2389		NKS904 MCO +35
+25 HSV ASQ2911		UPS2292 MCO +35
+24 MEZ GAJ839	40	FDY2772 ELD +35
+24 ATL AAL668		AAL1560 MCO +32
	35	ENY3777 LEX +31
+26 PHL UPS2020		ENY3883 GSO +31
+25 SAV AAL2373		ASQ2949 EVV +29
+24 CLT AAL702		ENY3936 TXK +28
+24 GLH BTQ494	30	ASQ2878 BTR +28
+44 BNA N710ET		AAL2487 CLE +25
+25 BNA AAL1009		AAL1908 MIA +24
	25	N22SM MDT +29
+27 PIT N21FE		DAL1448 ATL +25
	20	EJA737 INT +23
	15	AAL1018 IND +17
+34 HOT N183CM		AAL244 FLL +18
	10	AAL1798 PHL +16
+37 PNS ENY3324		ASH5828 BHM +15
+35 TPA AAL2430		NKS296 FLL +14
+35 MCO NKS904	05	ASH5927 SDF +12
+35 MCO UPS2292		ENY3629 SHV +10
+32 MCO AAL1560		AAL1476 BOS +10
+31 LEX ENY3777	18	ENY3674 TYR +13
+35 ELD FDY2772	00	
+31 GSO ENY3883		
+29 EVV ASQ2949		
+28 TXK ENY3936		
+28 BTR ASQ2878	55	
+27 CLE AAL2487		
+28 MIA AAL1908		
+26 ATL DAL1448		
+23 INT EJA737	50	



	50	LWB N751VL	N751VL LWB
	45	TYR N680CM	N680CM TYR
	40		N310AZ MCO +26
	35		N546MM BTR +29
	30		JTL858 IND +17
	25		AAL2536 MSY +6
	20		AAL654 MEM +8
	15	+6 MSY AAL2536	ENY3317 LIT +12
	10		DAL1375 ATL +15
	05	+ 8 MEM AAL654	N147SW PIE +33
	00		N710ET BNA +44
	55	+17 IND JTL858	AAL2356 RDU +25
	50	+12 LIT ENY3317	AAL2389 PNS +25
		+26 MCO N310AZ	ASQ2911 HSV +25
		+15 ATL DAL1375	GAJ839 MEZ +24
		+29 BTR N546MM	AAL668 ATL +24
			UPS2020 PHL +26
			AAL2373 SAV +25
			AAL702 CLT +24
			BTQ494 GLH +24
			AAL1009 BNA +25
			N21FE PIT +27

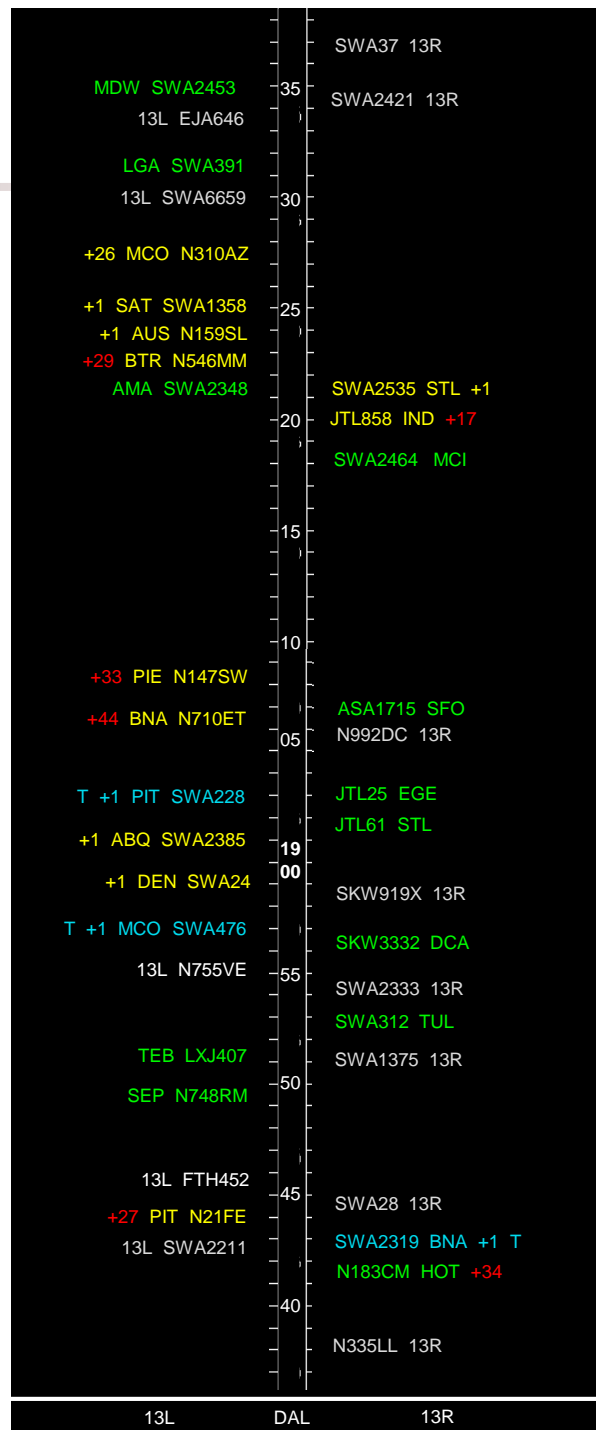
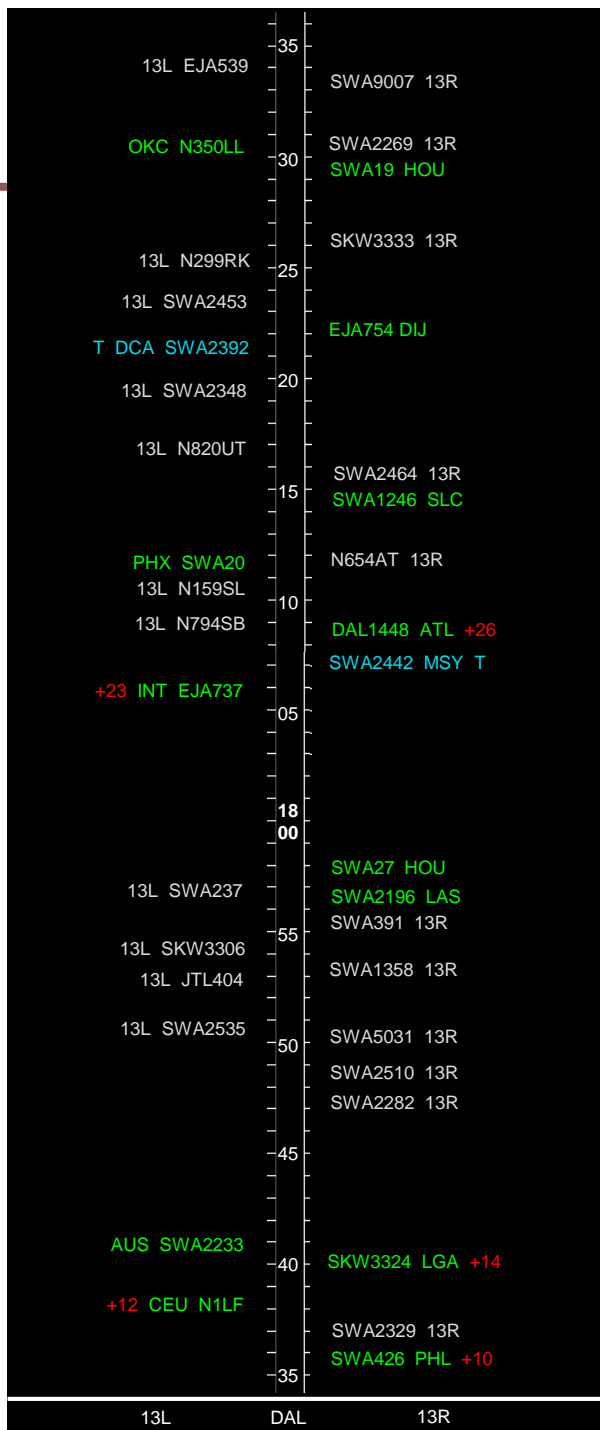
17:50
19:50

RWY Demand at Love Field

After TOS assignments

TOS flights in cyan

Other flights benefitting in yellow



17:35
19:35



DAL SWA Flights	Dest	Est. RTC	Reroute via	Delay was	Delay now	Gain	Sub-totals
SWA2442	MSY	10	South gate	36	0	-36	
SWA2392	DCA	20	North gate	47	0	-47	
SWA2319	BNA	25	South gate	32	0	-32	
SWA476	MCO	20	South gate	34	1	-33	
SWA2282	PIT	25	North gate	36	1	-35	
SWA24	DEN			0	2	+2	
SWA2385	ABQ			0	2	+2	
SWA1358	SAT			0	1	+1	
SWA2535	STL			0	1	+1	177 min
DAL NON-SWA							
N21FE	PIT			29	27	-2	
N710ET	BNA			48	44	-4	
N147SW	PIE			37	33	-4	
N546MM	BTR			42	29	-13	
N3210AZ	MCO			42	26	-16	
JTL858	IND			30	17	-13	
N159SL	AUS			0	1	+1	51 min
DAL flights				413 min	185 min	228 min	
DFW Flights				337 min	289 min	48 min	
D10 Flights				750 min	474 min	276 min	



- Direct benefit
 - Using TOS to reroute departures can lead to a significant delay reduction for TOS flights and subsequent departures for the airline
- Indirect benefit
 - Other airlines (not using TOS) may also benefit from airlines using TOS



- Questions?
- Email Al.Capps@nasa.gov Or William.J.Coupe@nasa.gov
- To learn more visit...
 - <https://www.aviationsystemsdivision.arc.nasa.gov/research/atd2/index.shtml>
- Or attend a webinar, stream a pre-recorded webinar at
 - https://aviationsystemsdivision.arc.nasa.gov/research/atd2/remote_demos.shtml



- Approximately one webinar per month
- Routinely host 60-80 attendees
- Eight sessions recorded and available for replay
- Latest schedule, access info, and recorded sessions online at:

https://aviationsystemsdivision.arc.nasa.gov/research/atd2/remote_demos.shtml

ATD-2 Remote Demos

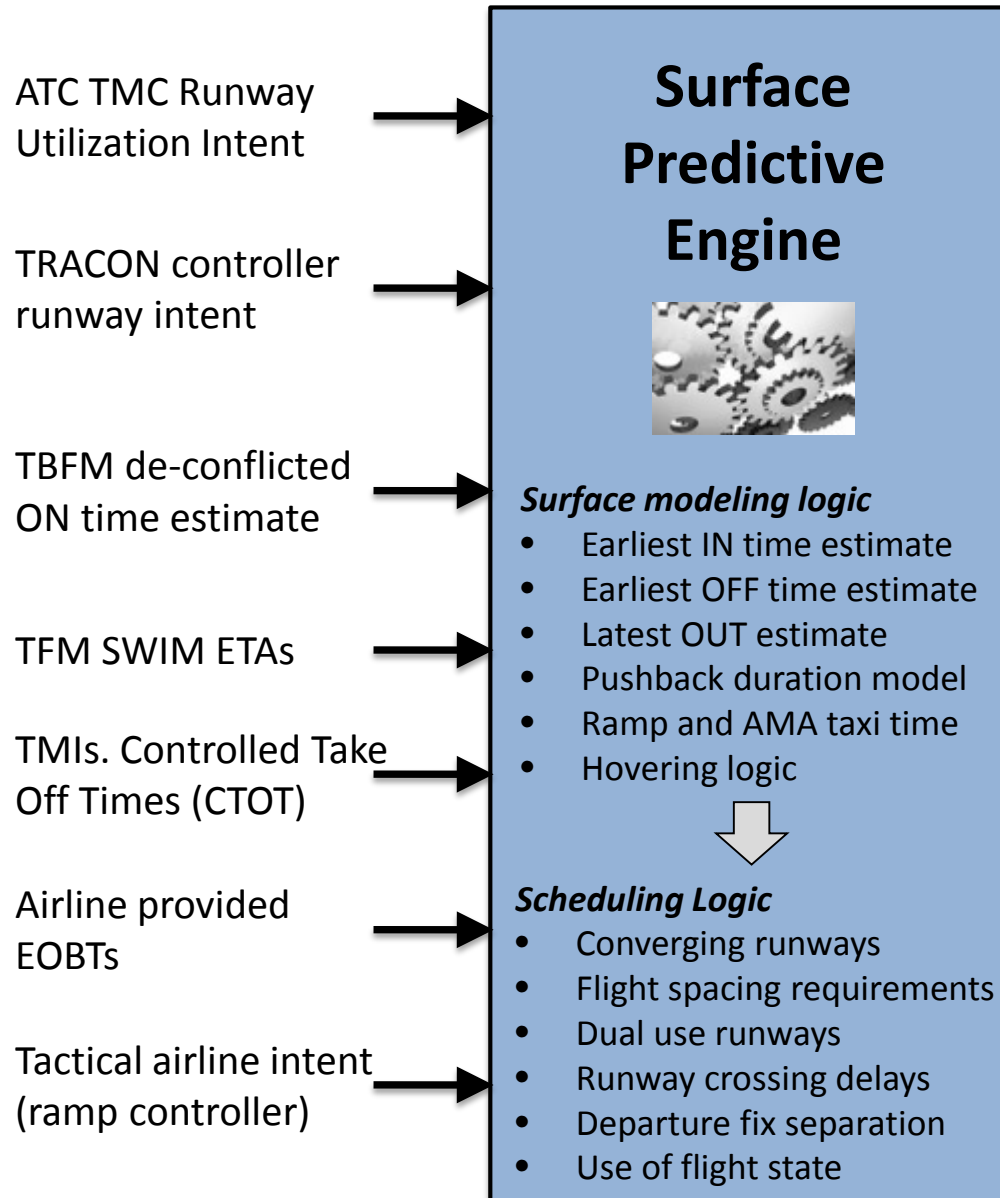
To Join...

1. Go to: <https://ac.arc.nasa.gov/atd2/>
Enter as a guest and type your name. NASA Employees can log-in with their email and password (NDC Credentials).
2. Dial the Telecon Number: **1-844-467-6272**, **Passcode: 592382#**

Demo Objectives

- Keep broad group of ATD-2 stakeholders informed of progress in an inexpensive and unobtrusive manner
- Demonstrate actual system capability and lessons learned (as opposed to documents/plans)
- Take input from stakeholders that can be used to improve the ATD-2 system, processes and/or outreach
- Identify areas where more detailed discussion is desired/warranted







- ATD-2 Surface metering
 - https://aviationsystemsdivision.arc.nasa.gov/research/atd2/remote-demos/ATD2_remote_briefing_20180321_SurfaceMetering.pdf
- Latest ATD-2 IADS Capabilities
 - https://aviationsystemsdivision.arc.nasa.gov/research/atd2/remote-demos/ATD2_remote_briefing_20180314_LatestCapabilities.pdf
- New Surface SWIM feed – TFDM Terminal Publication (TTP)
 - https://aviationsystemsdivision.arc.nasa.gov/research/atd2/remote-demos/ATD2_remote_briefing_20180712_TTP.pdf
- Understand and Process Restrictions in the NAS (Part 1 – Stream)
 - https://ac.arc.nasa.gov/pok8rxacq45g/?OWASP_CSRFTOKEN=205edc6ee12cbf81ae6b17d3d523b0b250eff34d152ff1c368f6d0eb3425452d
- Understand and Process Restrictions in the NAS (Part 2 – Stream)
 - https://ac.arc.nasa.gov/pok8rxacq45g/?OWASP_CSRFTOKEN=205edc6ee12cbf81ae6b17d3d523b0b250eff34d152ff1c368f6d0eb3425452d

Tactical Departure Scheduling – Prior Research



ARTCC



En route tactical departure scheduling



ARTCC

TRACON

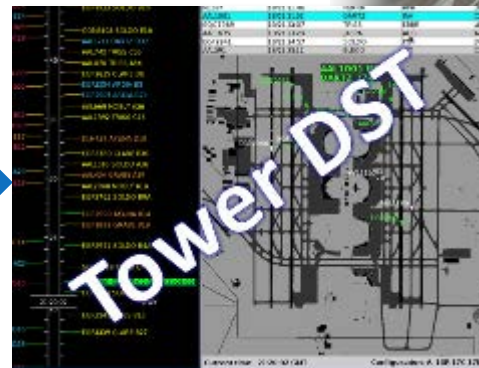
En route system uses information from surface system for more precise tactical departure scheduling.



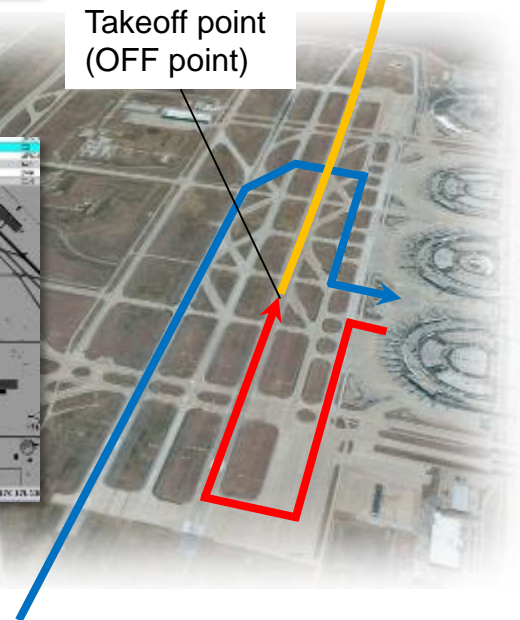
Center DST

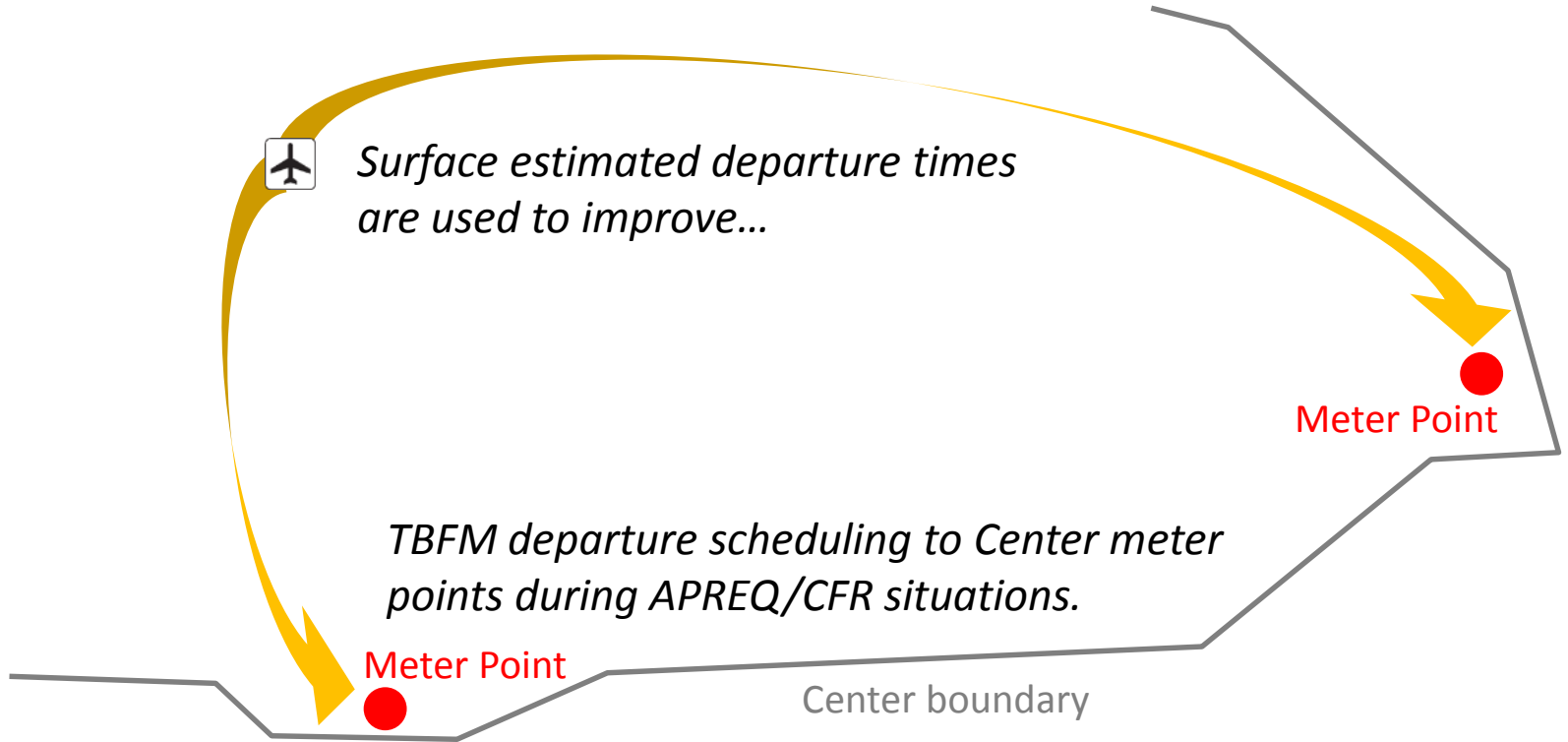
Takeoff point (OFF point)

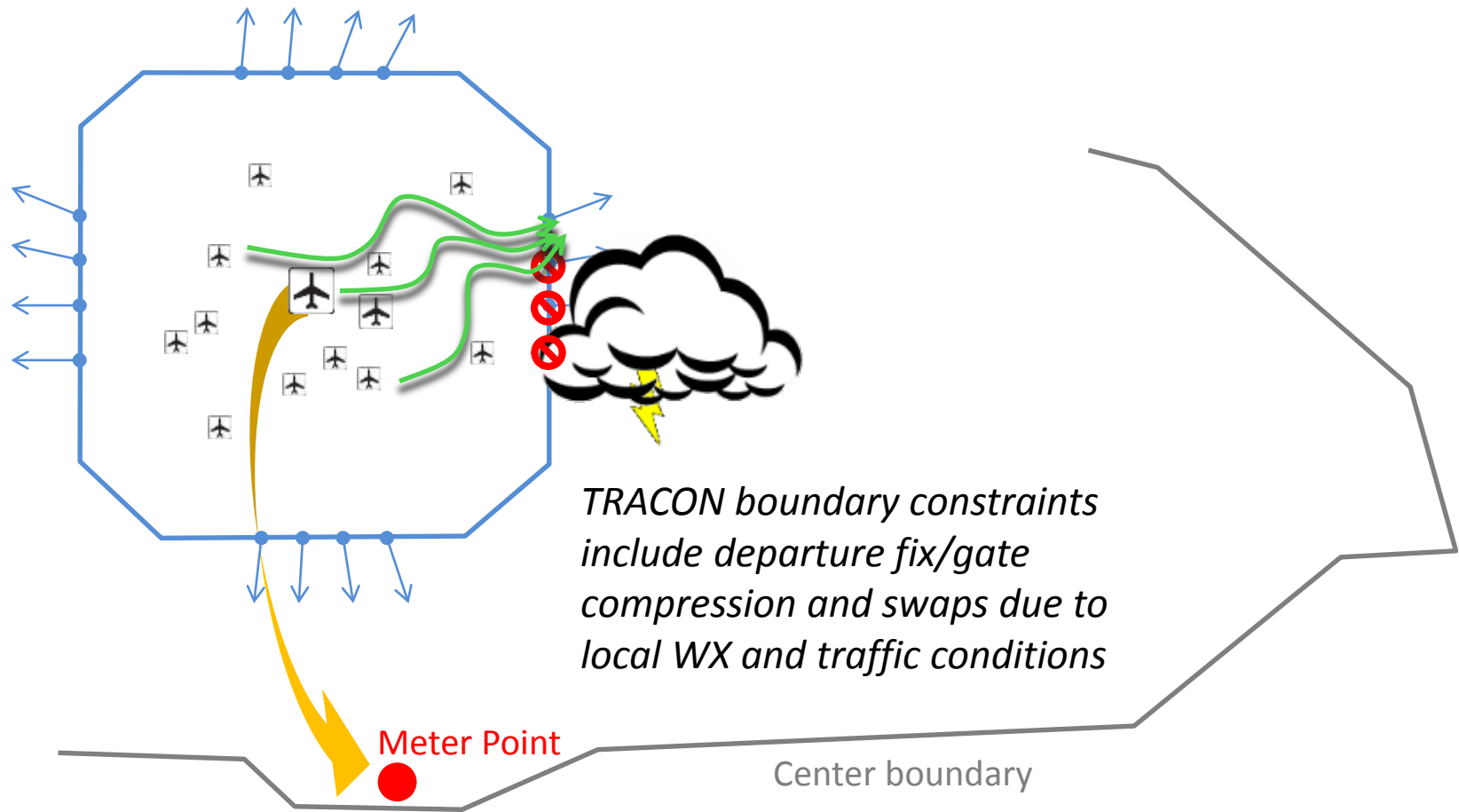
Surface system predicts OFF times and runway assignments for use by the en route scheduling system.



Surface trajectory-based operations

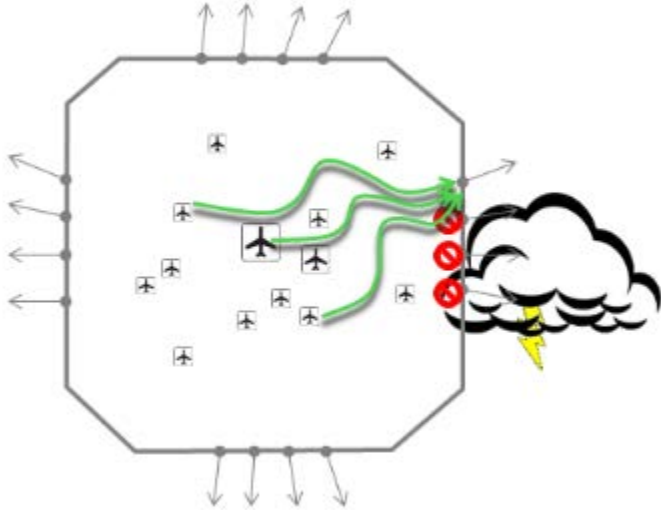




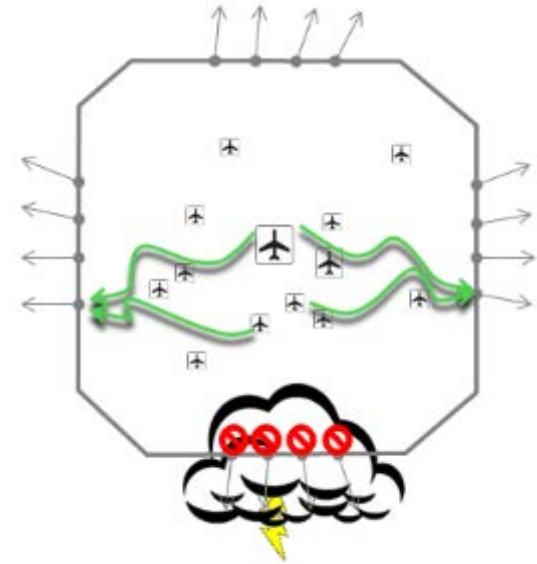


Terminal Departure Coordination

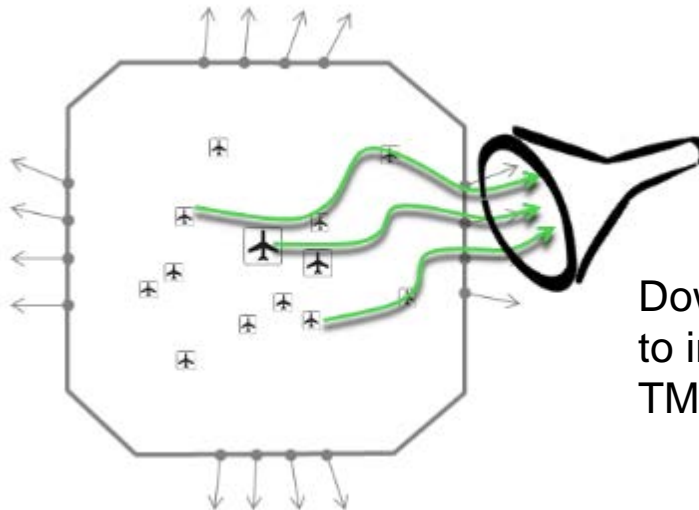
- Enable time-based control of Terminal departures
- Schedules from multiple airports with various automation equipage
- Simultaneously satisfies local, regional, and national traffic constraints



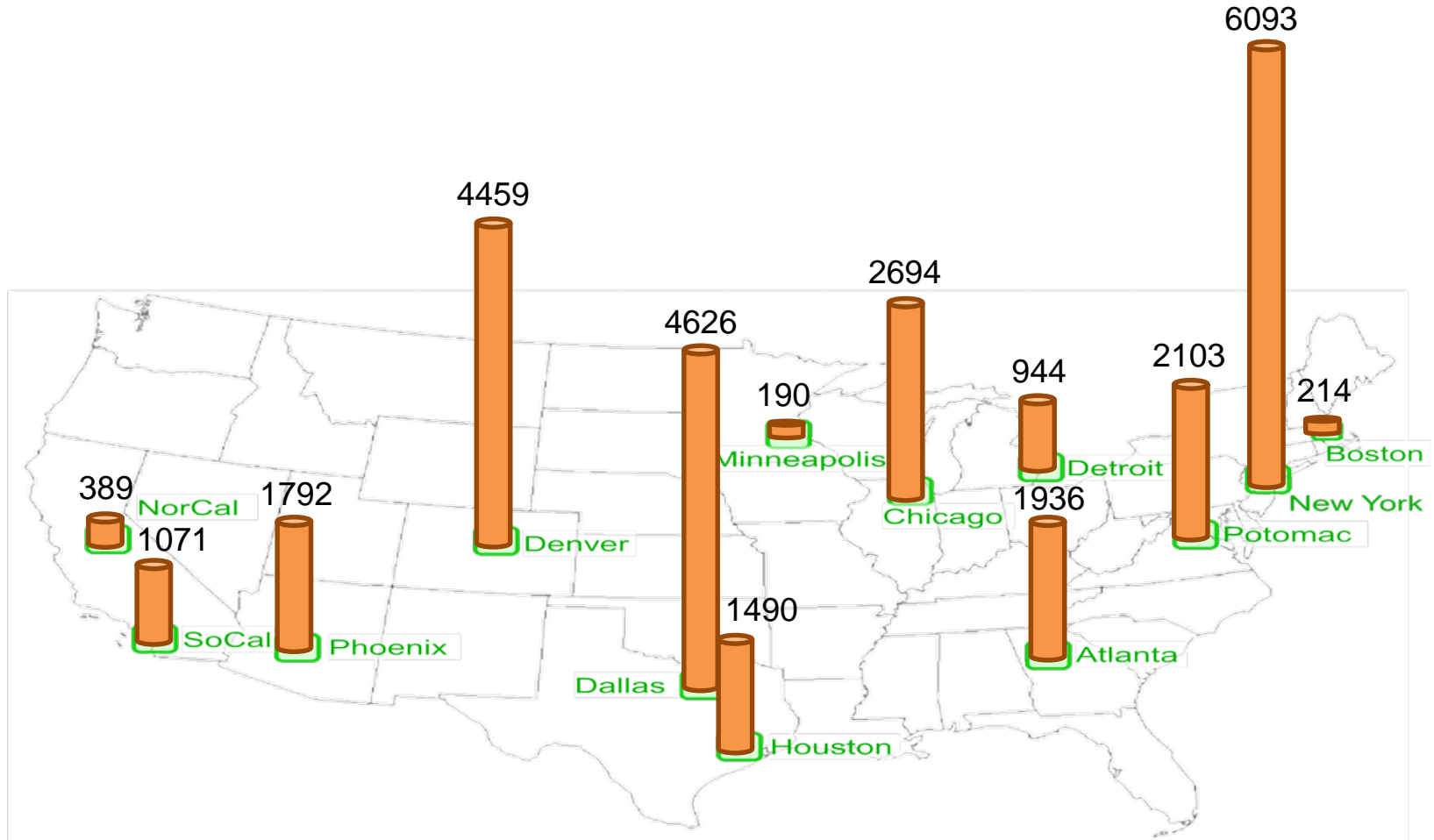
Fix compression caused by weather events in or near TRACON airspace



Complete blockage of departure fixes or gates may lead to fix/gate swaps

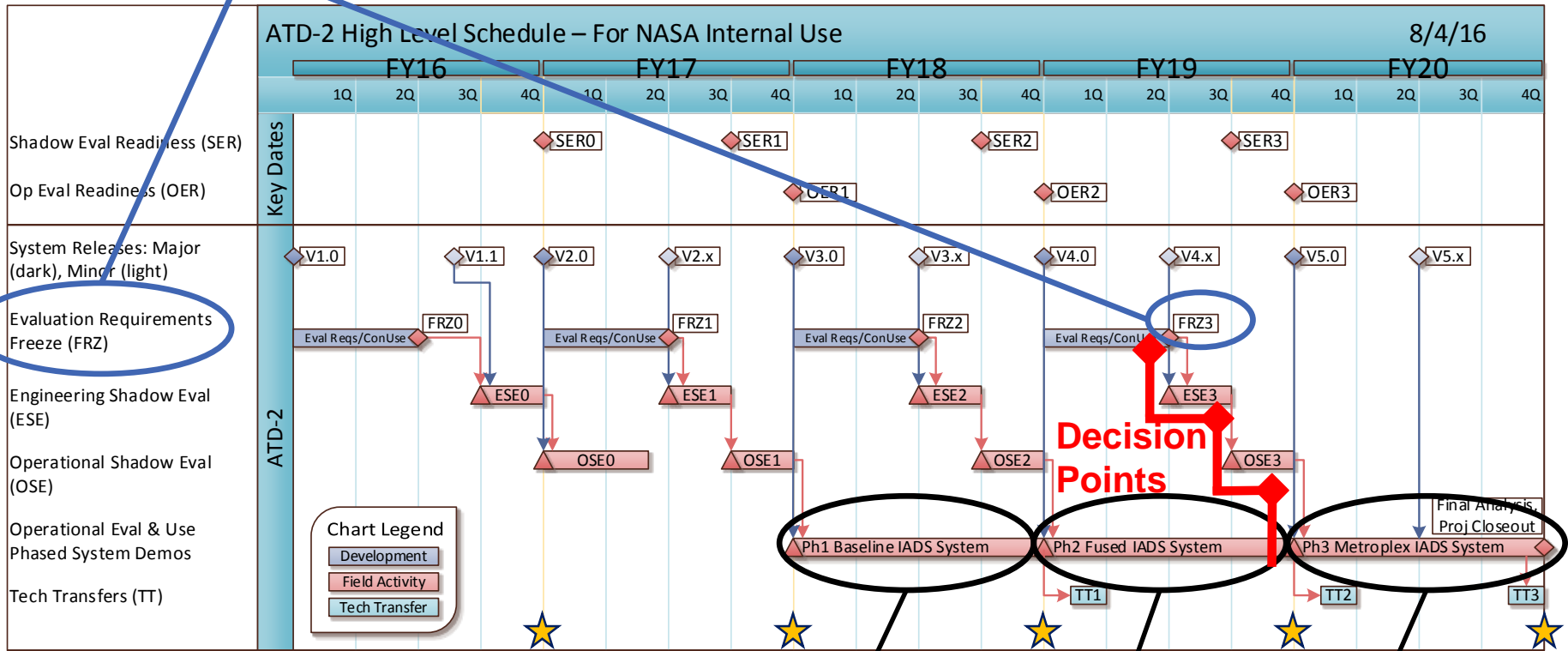


Downstream constraints may lead to implementation of TRACON TMIs



Number of flights involved in a Terminal constraint in July 2013

Evaluation Requirements Freeze (FRZ) assesses current system capability against Field Demo Partner desires and constraints. A joint decision establishes parameters for the upcoming demonstration phase.



★ **Commitments to Demo Partners**

- ✓ Sep 2016 ATD-2 system installation at CLT
- ✓ Sep 2017 ATD-2 demonstration commences
- Sep 2018 interim technology transfer
- Sep 2019 interim technology transfer
- Sep 2020 final technology transfer

Phase 1: Baseline IADS

Phase 2: Fused IADS

Phase 3: Terminal Departure IADS



DFW ATCTs
TMC displays in place

DFW

DFW Ramp Towers
Terminal D & E
Back room displays in place



AAL DFW Control Center
Terminal A, B, C & D
Back room display in place



D10 TRACON TMU
TMC displays in place



DAL ATCT
Network in place



SWA Control Center
Requirements evaluation

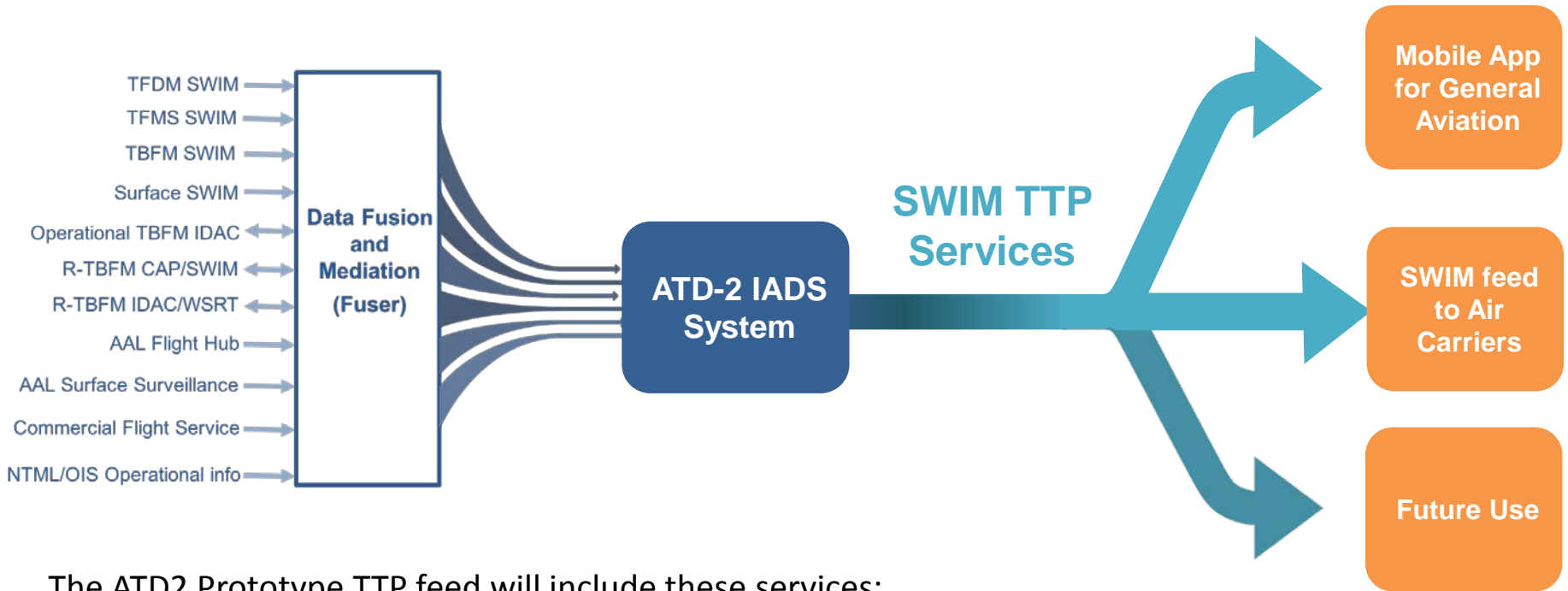


ZFW TMU
TMC displays in place

General Aviation
Discussing with Mobile App partners

NASA and the FAA are collaborating to provide a prototype TFDM Terminal Publication (TTP) feed via SWIM R&D network as part of the ATD-2 Field Demonstration

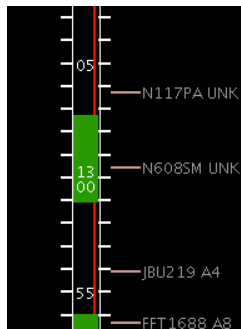
Applications that Leverage the TTP Prototype Feed



The ATD2 Prototype TTP feed will include these services:

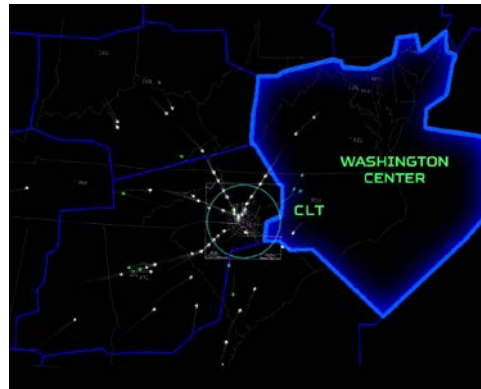
- Flight Data
- Airport Information
- Traffic Management Restrictions
- Flight Delay
- Operational Metrics

Overhead Stream Insertion Collaboration



IDAC-style scheduling between IADS at CLT and TBFM at ZDC

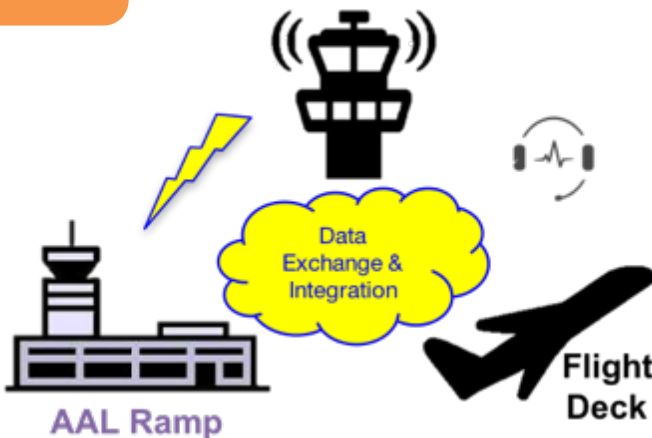
Washington ARTCC (ZDC)



2) TMC electronically negotiates with ZDC for a time based on red/green space

3) ZDC TMC approves or adjusts the time based on center constraints

CLT ATCT & TRACON



4) Ramp utilizes the now visible APREQ time on their strips and pushback advisories

1) Pilot calls into clearance delivery approximately 10 min prior to push back for APREQ times