Airspace Technology Demonstration 2 (ATD-2)

Surface Scheduling and Metering Concept

Joint Workshop for KARI-NASA Research Collaboration
May 23 - 25, 2017

Outline

- **Background/ top-level design**
- Data exchange and integration
- Surface modeling
- Capacity estimation
- Surface scheduling
- Surface metering
- Summary

Phase 1: Baseline IADS Demonstration

- CLT ATCT control positions
- Baseline electronic flight data capability via TFDM EFD

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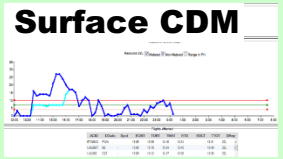
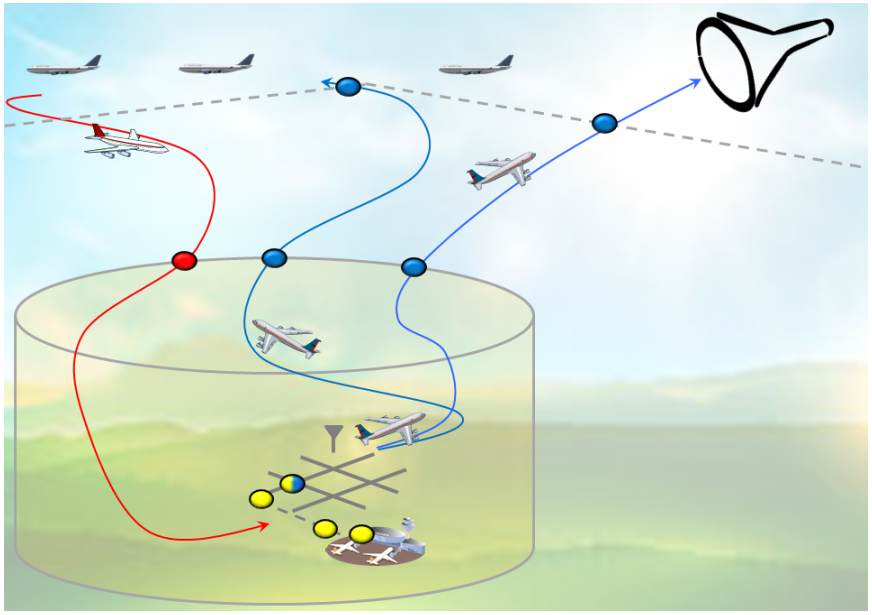
- AAL ramp controller and manager positions
- Tactical pushback advisories via RTC/RMTC display



- All positions as needed
- Predictive mode: strategic metering info for situational awareness and analysis

Surface Components



Phase 1 Demonstration Goals

- Evaluate the Baseline IADS capability
- Enhance American Airlines CLT “departure sequencing” procedure with ATD-2 surface tactical metering
- Demonstrate improved compliance for a significant percentage of tactical TMIs
- Mature strategic Surface CDM capability via operational use, analysis, and feedback
- Reduce ATCT workload by replacing paper strips with EFD

★

- CLT ATCT TMU position
- Tactical departure scheduling capability via STBO display

★

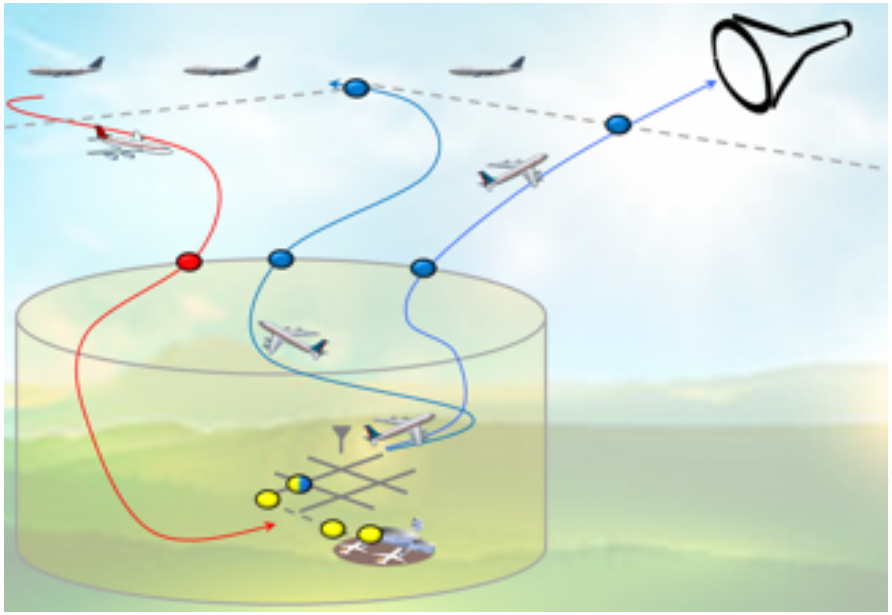
- ZDC TMU
- Tactical departure scheduling via modified TBFM/IDAC

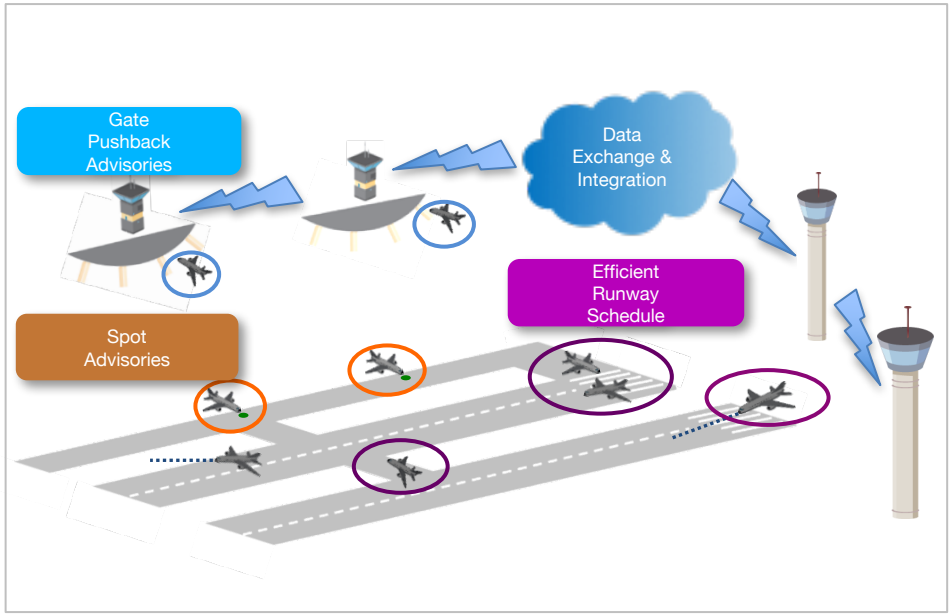
Airspace Components

Interfaces to external systems via SWIM plus ATD-2 SWIM extensions

★ = IADS user interface

Phase 1 Focal Points





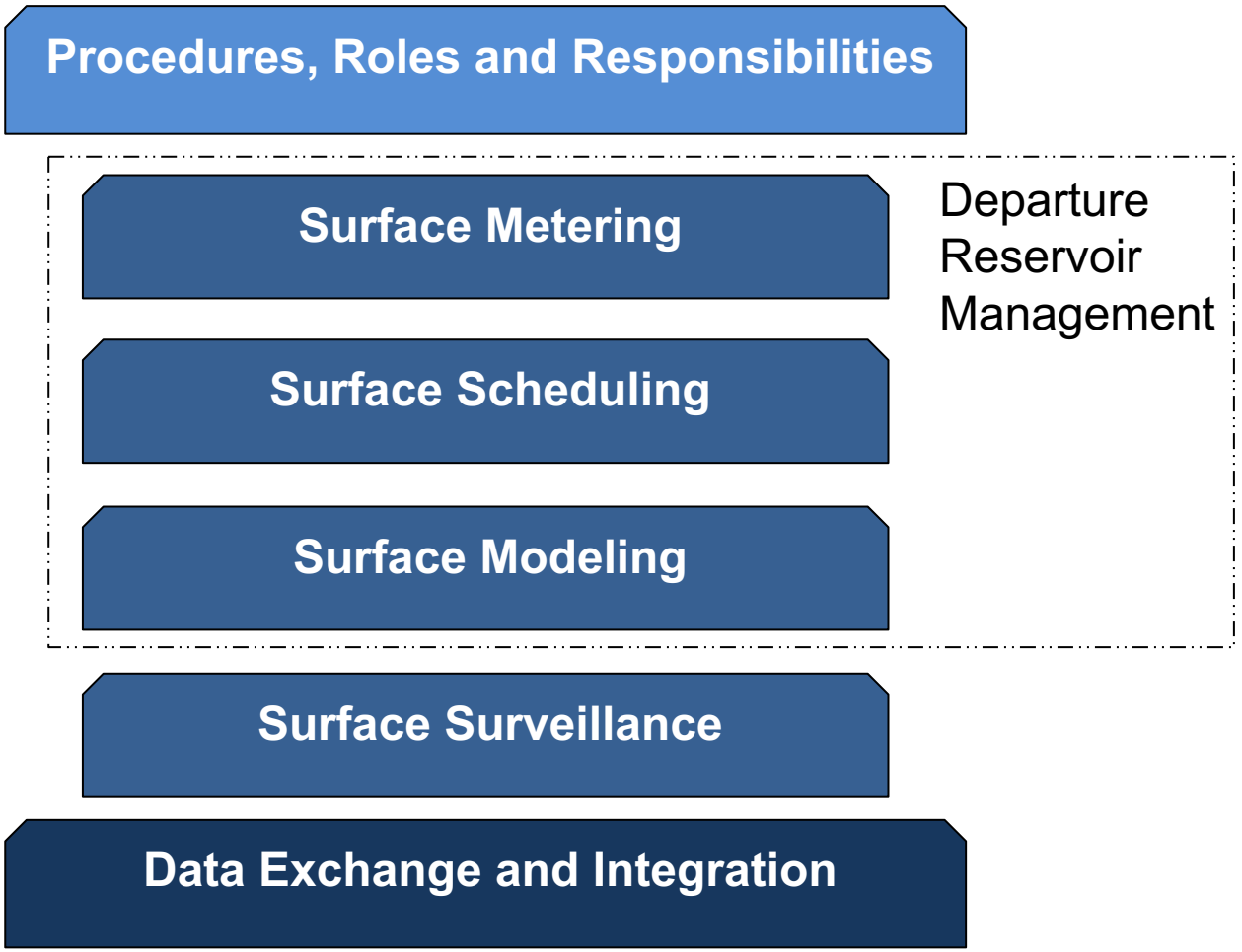
3T Data Exchange & Integration

- Integrated Arrival/Departure/Surface (IADS) footprint
- Onramp to the overhead stream (TFDM with IDAC)
- New data shared between FAA & Industry
- TFDM Electronic Flight Data (EFD) integration
- Real-time dashboard for situational awareness
- Use of controller assigned runway and time on surface

Surface modeling, scheduling & metering

- Trajectory based model of airport operations
- Latest predictions of flight scheduled out/off/on/in
- Scheduling for tactical and strategic timeframes
- Surface Collaborative Decision Making (S-CDM)
- Predictive capacity estimation technology

Working our Way Up the S-CDM Pagoda



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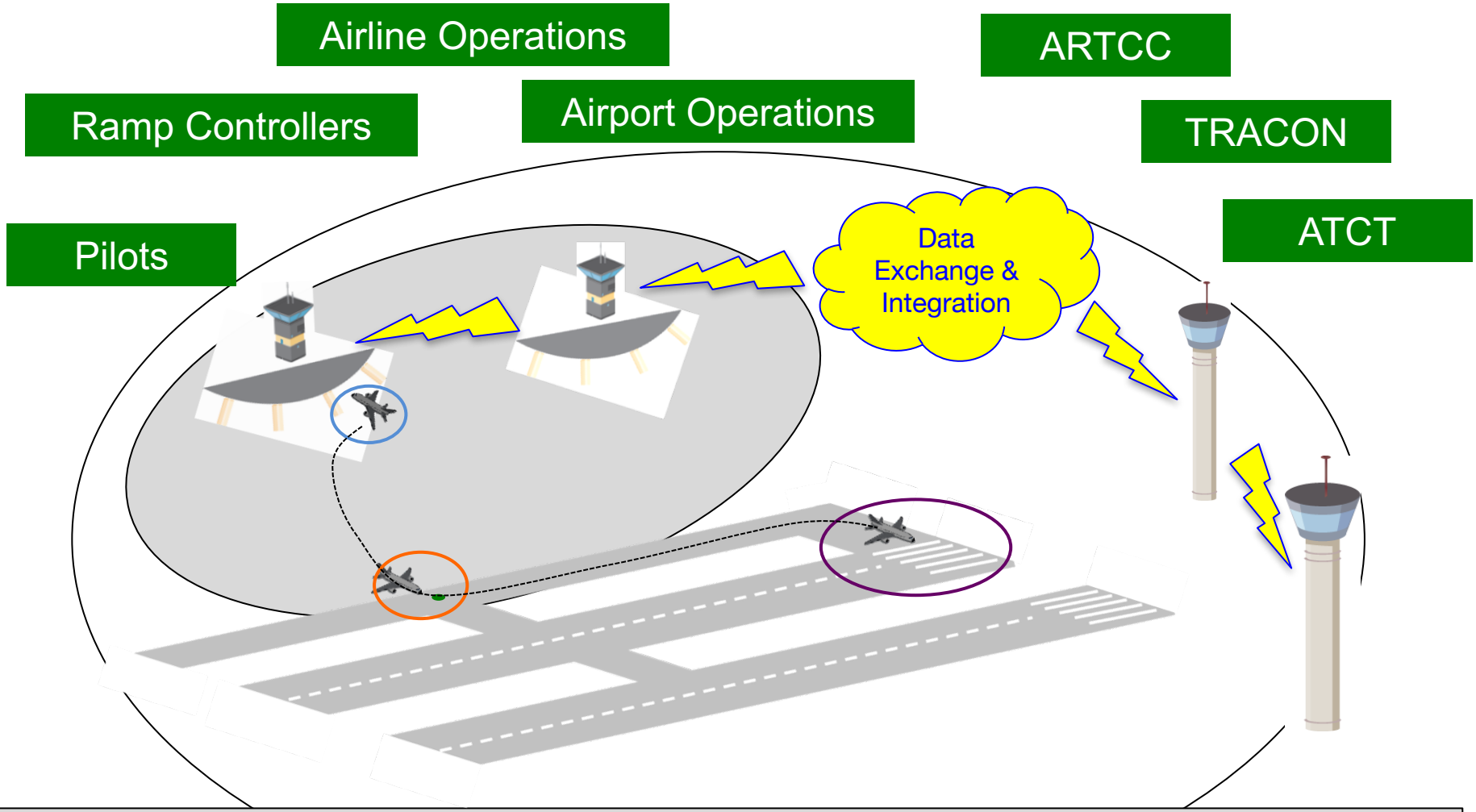
IADS Data Exchange and Integration



Flow Direction	*APREQs/ CFRs*	*MIT restrictions*	*Grounds Stops*	*Dep Fix Closures*	*Gate Conflicts*	*Long on Board*
Runway Utilization	*Runway Assignments*	*EDCTs*	*Runway Closures*	*Flight Cancellations*	*Ramp Closures*	*Data quality updates*

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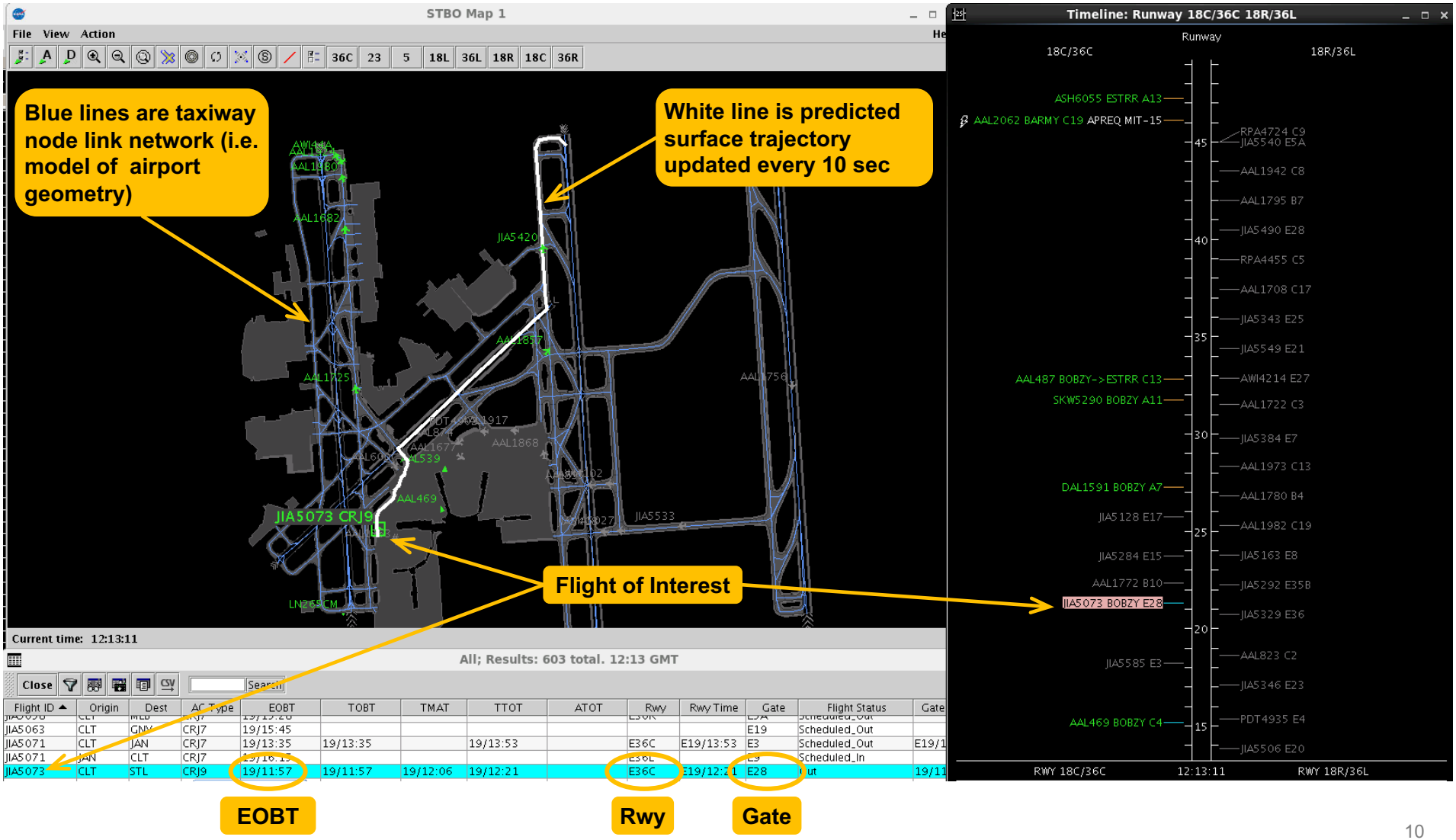
Surface Modeling

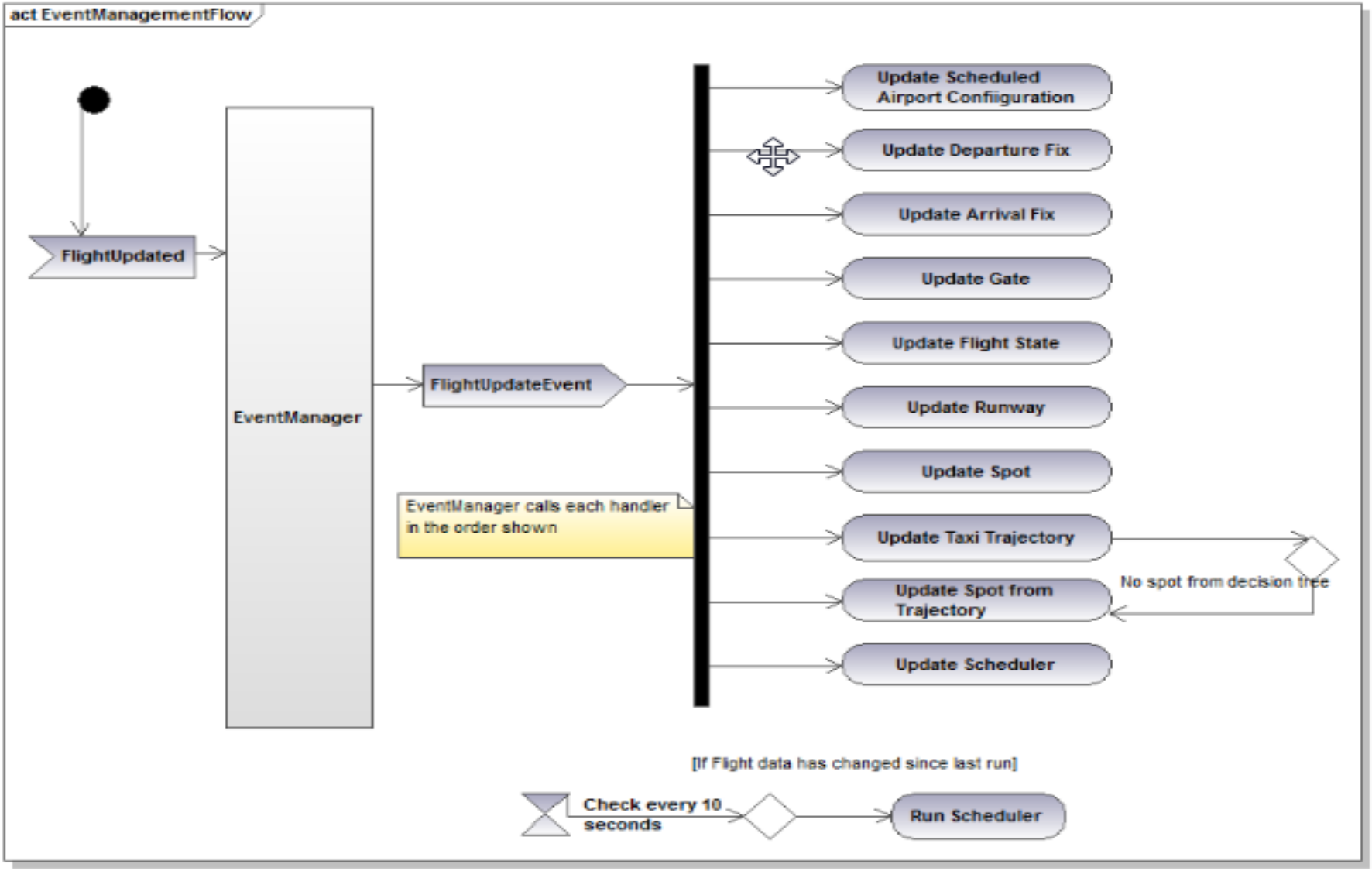
- Performs un-obstructed trajectory predictions based on flight-specific surface routing and gate/runway intent
- Relies on accurate predictions of departure gate and runway assignment
- Relies on accurate gate departure time estimates (based on EOBT or other flight readiness status, e.g., pilot call in)
- Generates arrival predictions by incorporating ON time estimates and landing runway assignment from TBFM
- Surface Modeler output is a combination of truth and predictions
- Provides essential input to surface scheduler

IADS Surface Modeling

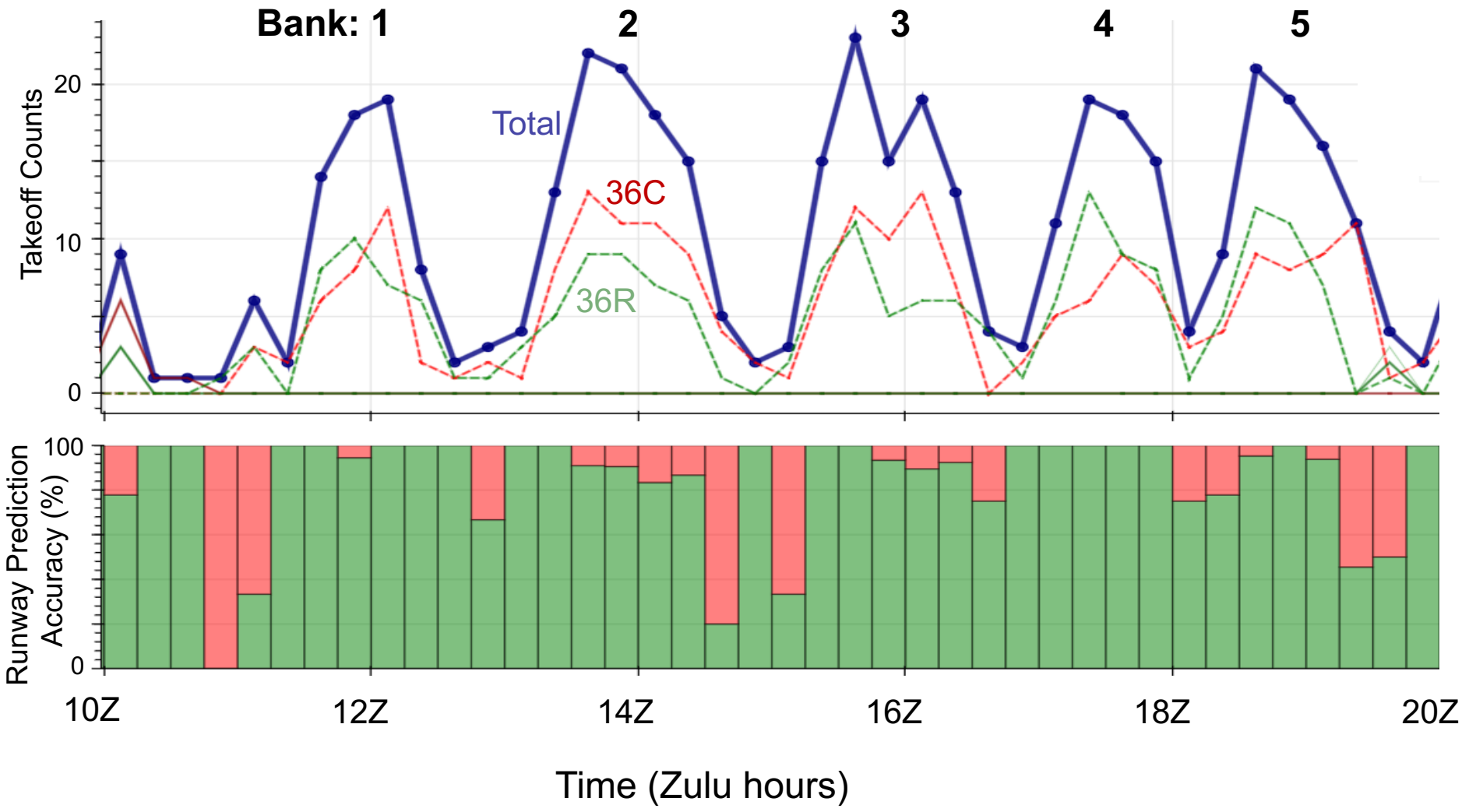
The IADS surface modeler combines airport geometry with flight-specific intent and status information to produce continuously-updated 3D (x,y,t) surface trajectories for each flight.



Surface Modeling: Process Flow



Surface Modeling: Runway Prediction Accuracy
North Flow Example



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Capacity Estimation

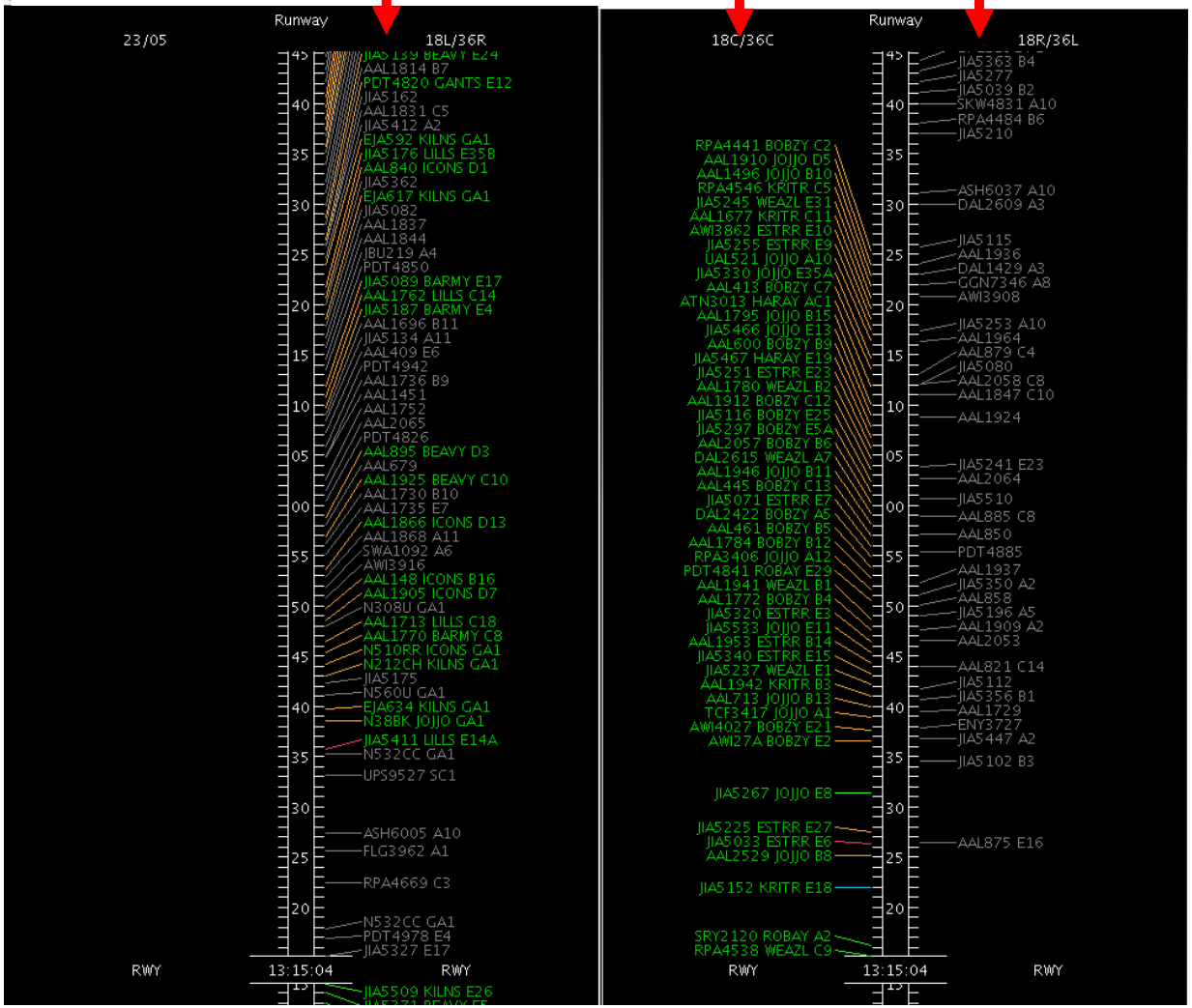
- Runway utilization intent from ATC is used to determine the capacity of a bank
- Information used in capacity estimation
  - Use of converging runway
  - Arrival crossings
  - Mixed/dual use runways
  - Meteorological conditions (IMC, VMC)
  - Flight separation rules (wake vortex, departure fix)
  - Flights subject to FAA restriction (MIT, EDCT, APREQ)
  - Runway and taxiway outages
  - Arrival ON time and runway information from R-TBFM

Capacity Estimation
CLT Runway Utilization Example

East side, mix of arrivals and departures on 18L

West side, departures from 18C

West side, arrivals to 18R



- Insufficient to rely on manual ADR/RDR entry
- Need detailed, frequent capacity estimates that automation can best provide, with limited controller input

Automation Assisted Capacity Prediction

ATC TMC Runway Utilization Intent

TRACON controller runway intent

Highly accurate TBFM de-conflicted ON time estimate

TFM SWIM ETAs

TMIs. Controlled Take Off Times (CTOT)

Air carrier provided EOBTs

Tactical airline intent (ramp controller)

Surface Automation Assisted **Capacity** Predictions

Surface modeling logic
- Earliest IN time estimate
- Earliest OFF time estimate
- Latest OUT estimate
- Pushback duration model
- Ramp and AMA taxi time
- Hovering logic

Scheduling Logic:
- Converging runways
- Flight spacing requirements
- Dual use runways
- Runway crossing delays
- Departure fix separation
- Use of flight state

Capacity predictions are calculated and automatically used in surface metering calculations without required manual user ADR input.

Helps answer the questions:
- How much runway capacity do I have for a specific flight, on a specific runway, at a specific time given the current runway utilization strategy?
- What queue time/length should this flight expect?

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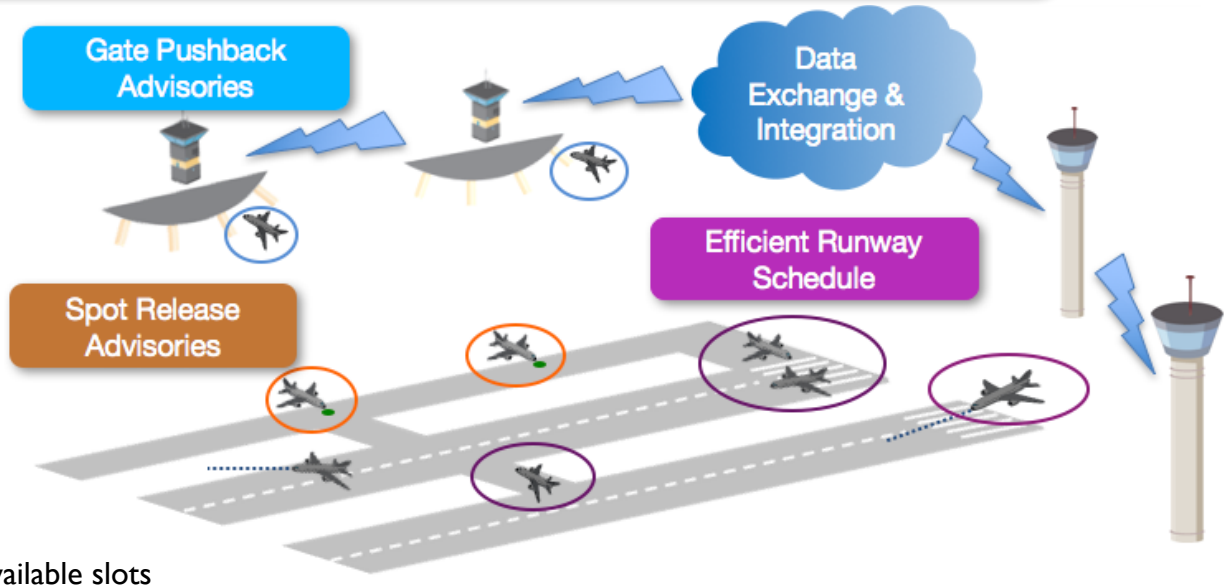
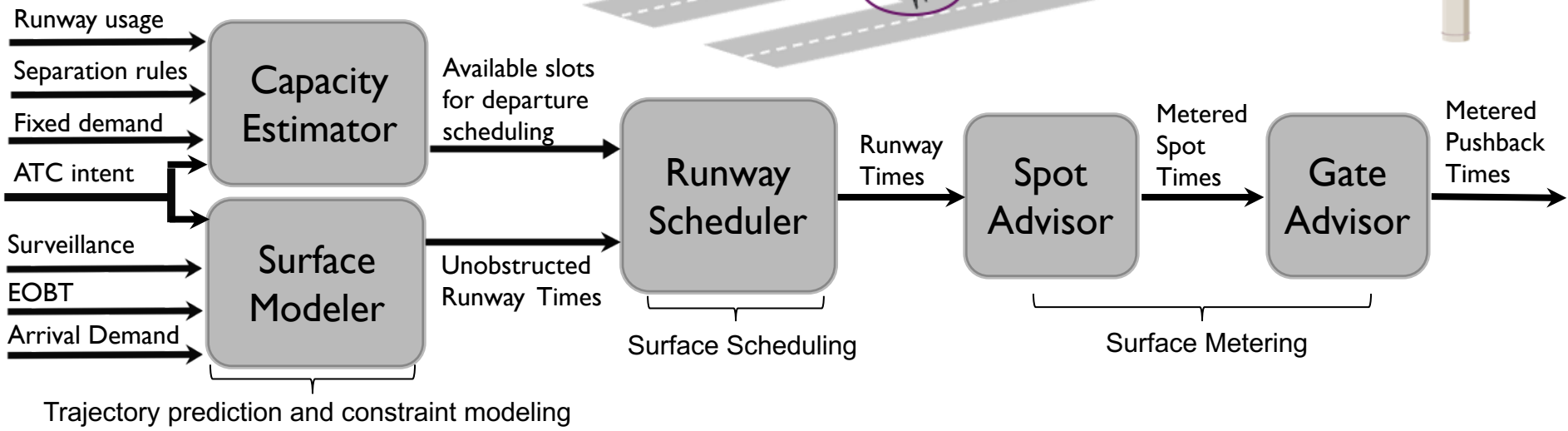
Surface Metering Concept

- Estimates capacity of current and future runway resources
- Builds an efficient runway schedule based on readiness, EOBT and RBS
- Calculates spot advisories that support the metered runway schedule
- Provides push back advisories from gates that support the spot advisories

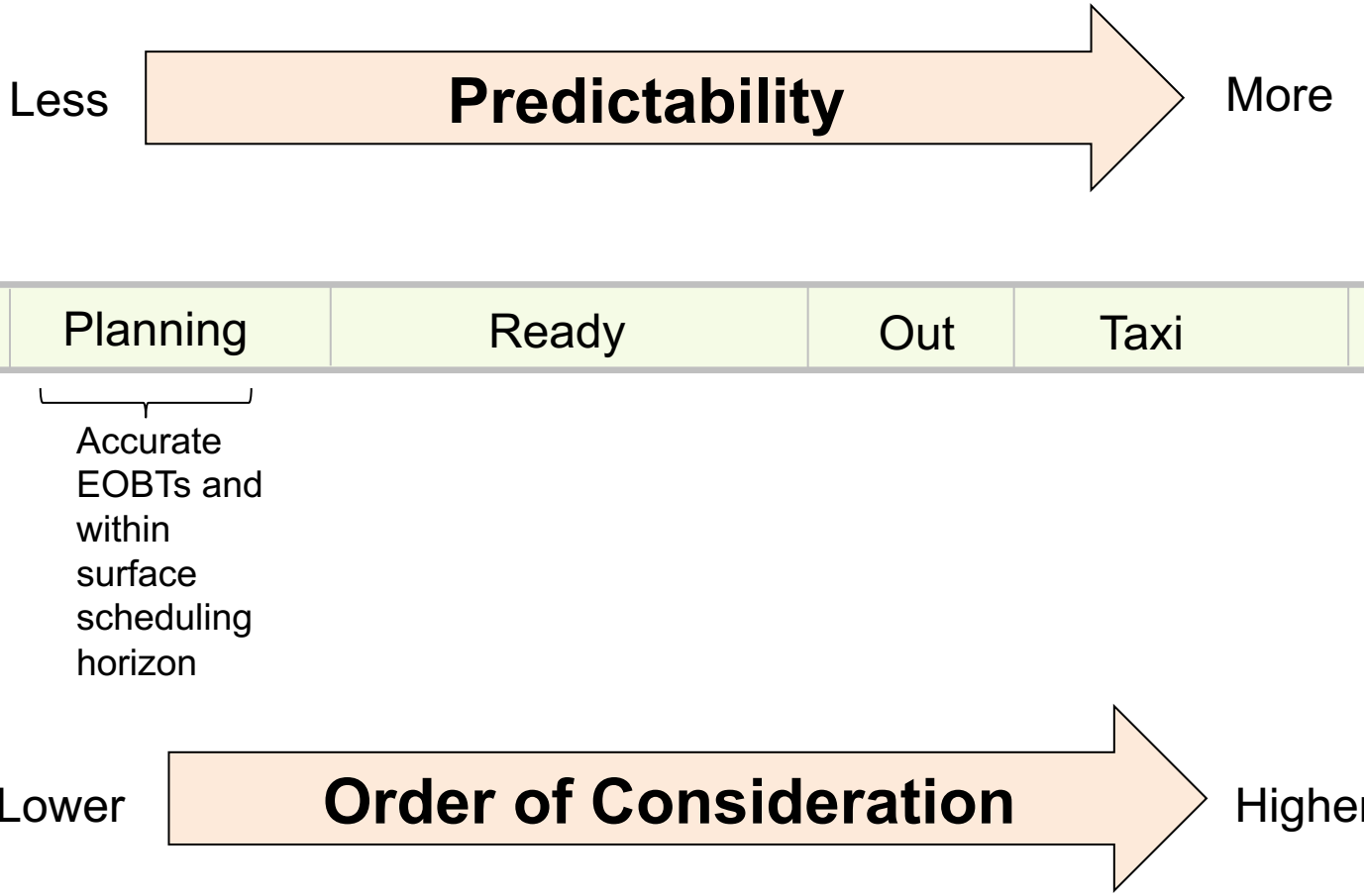




Surface Scheduling: Basics

- Surface scheduling first generates target takeoff times (TTOTs) in keeping with previously-estimated capacity constraints
- Spot (TMAT) and push (TOBT) advisories are back-calculated from TTOT using a delay propagation formula
- Via surface metering, target times *throttle demand* to the runway
- Flights with FAA restrictions (APREQ/EDCT) are not subject to surface scheduling/metering for balancing runway capacity and demand
- Surface scheduling at a tactical level requires that flights be handled differently depending on the expected accuracy of their EOBTs

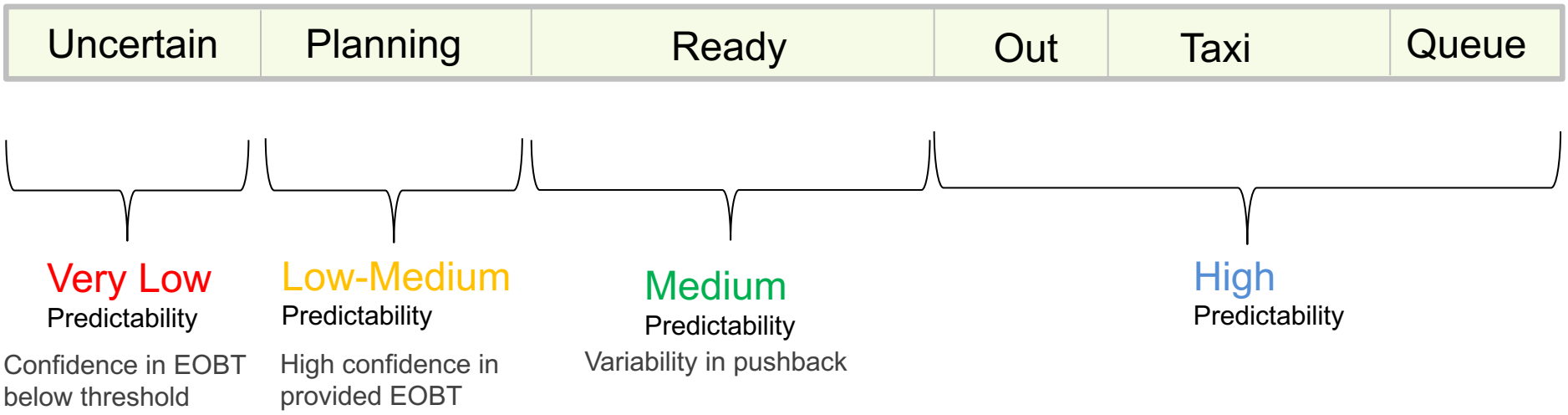
Surface Scheduling: Order of Consideration



Surface Scheduling: How Planning Group Fits In

Planning group challenges:

- Planning is the most challenging category! FSFS used for flights in this group.
- **Without** a planning group to reserve some space, the tactical scheduler could only react to call in order. Thus, flights that call in 10 minutes ahead of scheduled time may take the slot of another flight *dutifully on time* (according to EOBT). This is ripe for gaming especially in a multi-carrier environment
- **With** a planning group to reserve some space for flights that are dutifully on time and/or priority, pre-departure uncertainty may add unnecessary delay



Inclusion/exclusion criteria for planning group membership is ongoing

Surface Scheduling: Handling of Airline Priority Flights

- ATD-2 developed a scheme for prioritizing intra-airline flights without impacting overall surface efficiency
- Prioritization uses a binary indicator, informed using pre-assigned priority rules for sequencing flights off the runway
- Prioritization algorithm was developed and tested in close partnership with American Airlines
- Sequencing based on priority can be handled automatically without relying on user inputs (manual swapping)
- Automated priority handling is more feasible in a tactical timeframe where a simple and rapid process is required

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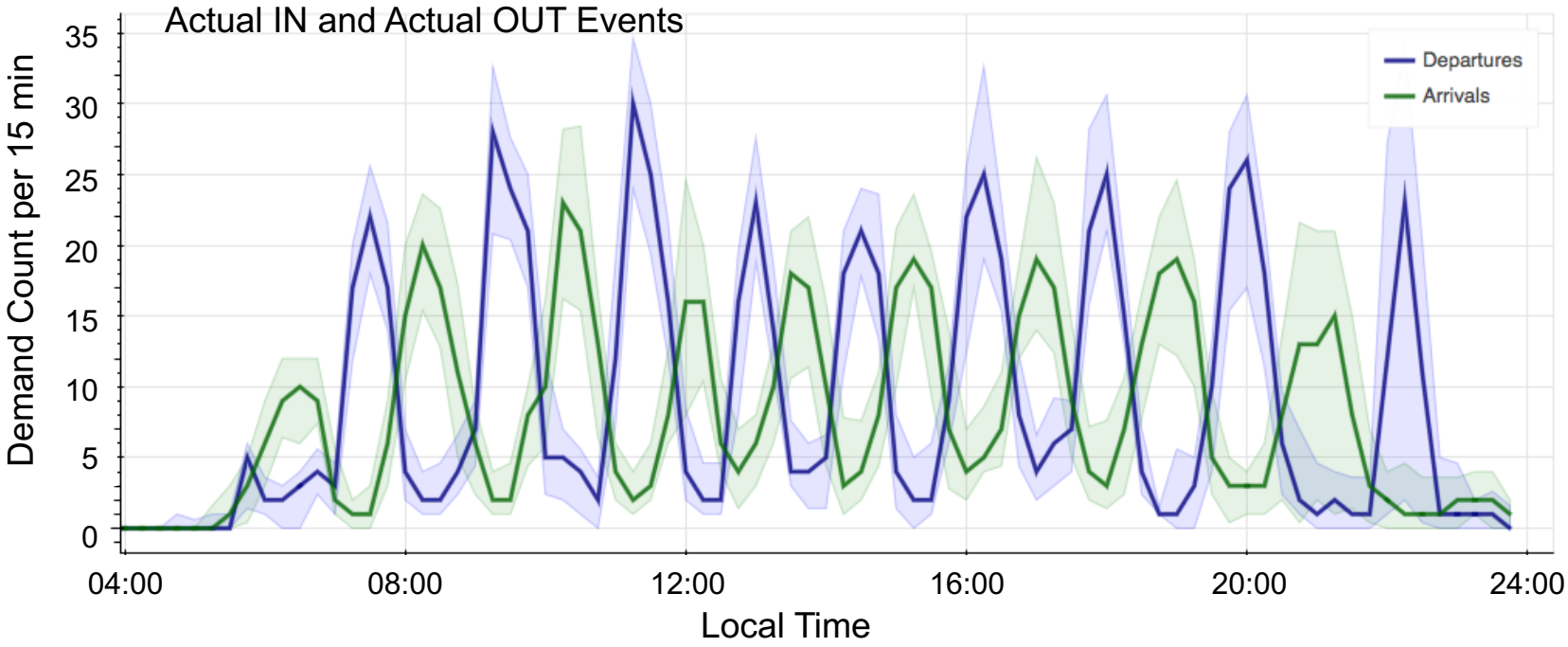
Surface Metering: Basics

- Surface metering is implemented to balance demand and capacity
- When surface metering is on, target times from surface scheduler are converted to advisories for throttling demand
- Through the scheduling process, flights with CTOTs will not get added metering delay (avoids potential for ‘double delay’)
- Carriers can designate certain flights as exempt from metering holds
- Demand throttle in Phase 1 at CLT is through advisories sent to ramp controllers for pushback instructions to the flight deck
  - Push now
  - Hold for an advised period of time (in minutes)
- Principles of surface metering can be more generally applied to other airports in the NAS to throttle demand via spot-release times (TMATs)

Surface Metering:
Demand Profile at CLT – Gate OUT / IN Events



- CLT has highly dynamic departure and arrival demand
- Other airports in NAS have similarly dynamic demand profiles
- Need for metering at such airports can be intermittent and must be informed by both departure and *arrival* demand predictions

Surface Metering: Delay Propagation Control by Ramp

- ATD-2 has implemented a single “knob” that allows ramp manager to control how delay is apportioned between surface and gate
- Knob controls maximum metering delay for absorption on taxiways before remaining delay is propagated to the gate
- There are currently three settings for our implementation for CLT
  - ***Nominal***: Nominal amount of delay tolerance in the Airport Movement Area (AMA) relative to an unimpeded taxi-out trajectory
  - ***Less AMA delay, more gate hold***: Reserves less delay in the AMA for absorption through queueing, resulting in longer gate hold times
  - ***More AMA delay, less gate hold***: Reserves more delay in the AMA for absorption through queueing, resulting in shorter gate hold times
- Single ‘knob’ for controlling metering behavior simplifies usage and could help ensure a common implementation of TFDM across the NAS

Surface Metering Process Flow Diagram

1 Generate Demand and Capacity Predictions

ATC TMC Runway Utilization Intent →
TRACON controller runway intent →
Highly accuracy TBFM de-conflicted ON time estimate →
TFM SWIM ETAs →
TMIs. Controlled Take Off Times (CTOT) →
Carrier provided EOBTs →
Tactical airline intent (ramp controller) →

IADS Automation Assisted Capacity Predictions

Surface modeling logic
- Earliest IN time estimate
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- Ramp and AMA taxi time
- Hovering logic

Scheduling Logic:
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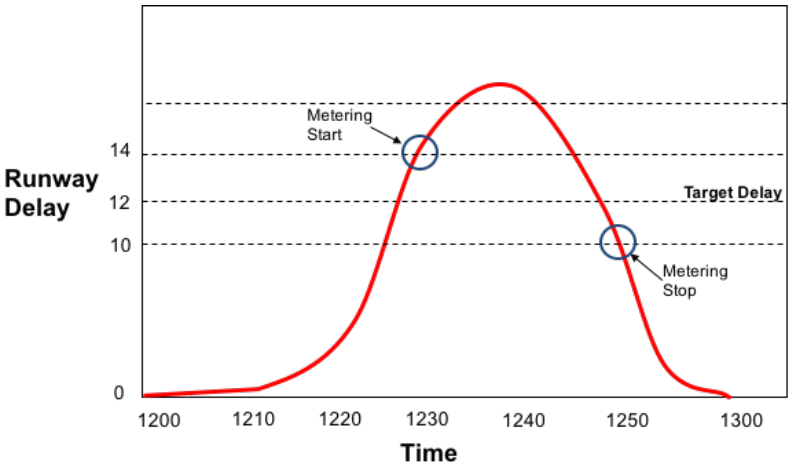
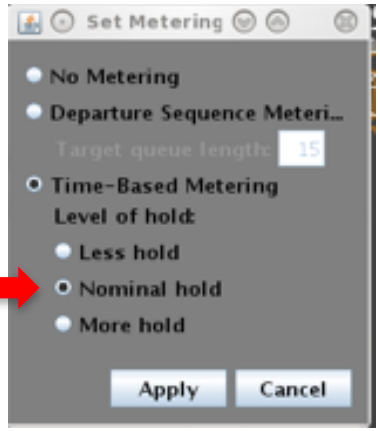
- Departure fix separation
- Use of flight state

2 Monitor Surface Demand Capacity Imbalances



If Surface Metering, Go to Step 3

3 Enable Metering. Set Hold Level

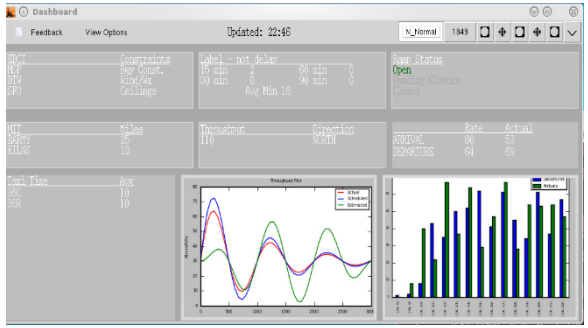


4 Honor TOBT and TMAT advisories

TOBT Advisory →

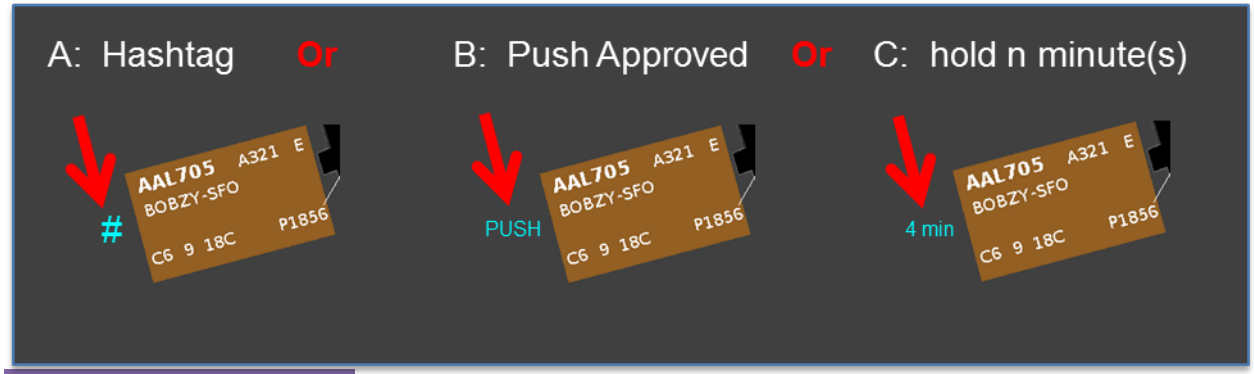
TMAT Advisory →

5 Evaluate Metering Effectiveness



ATD-2 Phase 1 Surface Metering

- Surface metering tool available for the CLT Ramp.
  - Provides advisories for gate hold to meet TOBT and TMAT times.
- Gate Hold recommendations and TMATs are **always shown for TMI flights with controlled take off times** irrespective of metering mode
- The system places flights in groups based on the quality of their EOBTs
  - Uncertain Group, Planning Group and Ready Group
  - Ready group flights have higher certainty due to pilot call in
  - Planning group ensures flights that are dutifully on time have slot
- Display to ramp controller
  - For the Uncertain Group, a hashtag will be displayed in place of the advisory
  - The controller can click on the hashtag to get an advisory B or C.
  - When pilot calls for pushback, advisory (in cyan) will recommend: A, B or C



Ramp display

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Advantages of the ATD-2 Metering Approach

- Strong focus on optimal use of airport resources
- Flexibility enables stakeholders to vary the amount of delay they would like transferred to gate
- Addresses practical aspects of executing surface metering in a turbulent real world environment
- Algorithms designed for both short term demand/capacity imbalances (banks) or sustained metering situations
- Leverage automation to enable surface metering capability without requiring additional positions
- Represents first step in Tactical/Strategic fusion
- Provides longer look-ahead calculations to enable analysis of strategic surface metering potential usage

For more information

ATD-2 Concept Animation:

https://www.aviationsystemsdivision.arc.nasa.gov/research/tactical/atd2.shtml

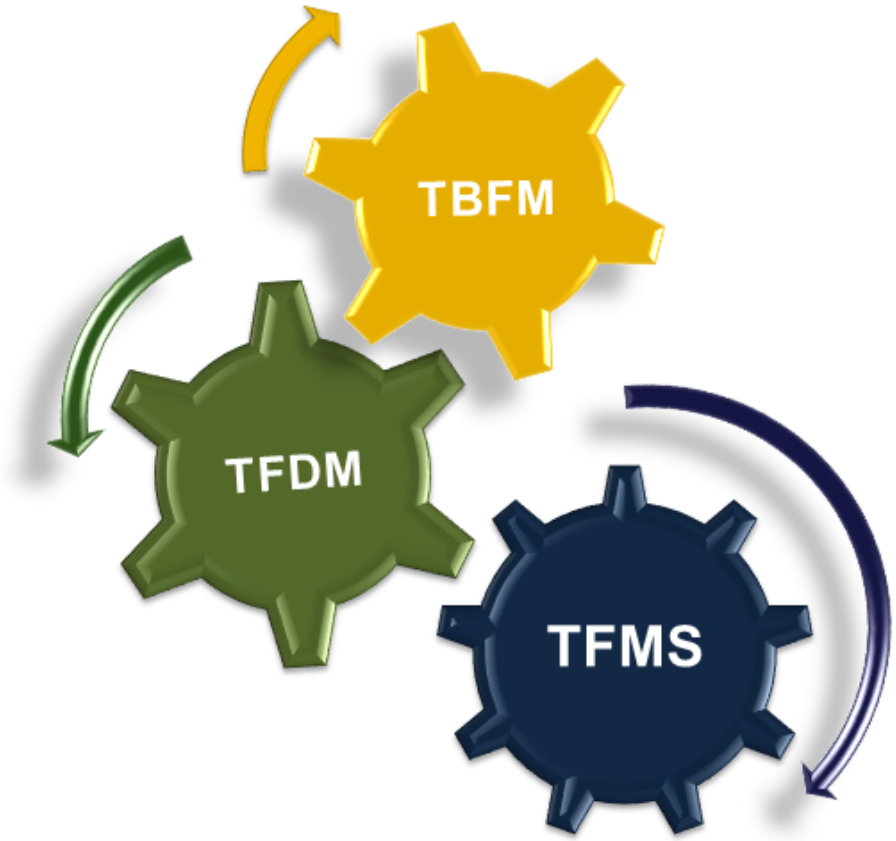
ATD-2 Phase 1 Materials:

https://aviationsystems.arc.nasa.gov/publications/atd2/frz1/

Backup

Contributing Technologies: FAA Decision Support Systems

DSS components: 3Ts are the engines of DSS



Traffic Flow Management System (TFMS)

Decision support system for planning and mitigating demand-capacity imbalances in the NAS.

Time-Based Flow Management (TBFM)

Decision support system for metering based on time to optimize the flow of aircraft.

Terminal Flight Data Management (TFDM)

A new decision support system for airport surface management and ATC tower functions.

ATD-2 is Technology Integration

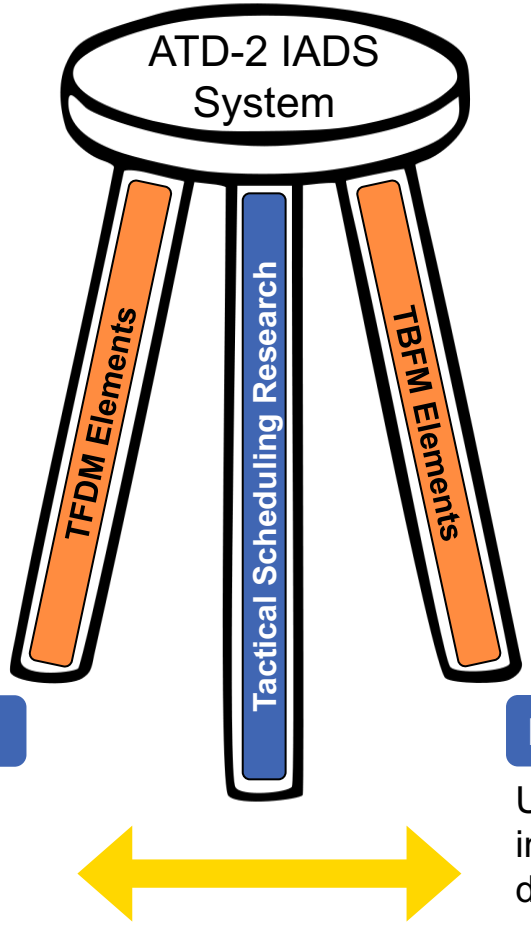
ATD-2 combines existing and emerging FAA technologies with technologies developed through NASA research to create an Integrated Arrival/Departure/Surface (IADS) traffic management system for the metroplex.

TFDM Terminal Flight Data Manager

Emerging tower tool with electronic flight data and Surface CDM capabilities

TBFM Time Based Flow Management

Existing en route tool for time based scheduling of arrivals and departure into constrained flows



SARDA Spot and Runway Departure Advisor

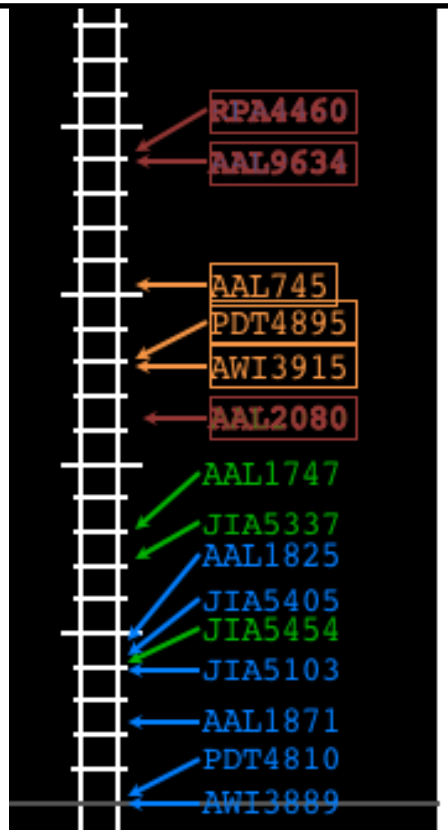
Tactical surface modeling and scheduling plus user interfaces for ramp area traffic management

PDRC Precision Departure Release Capability

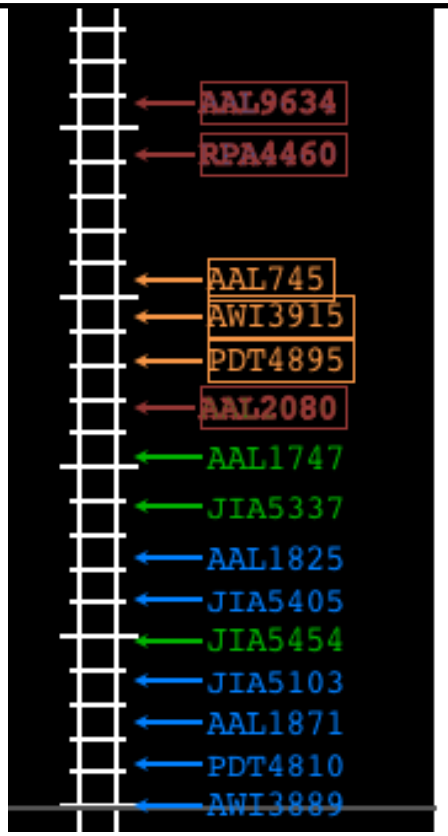
Uses trajectory-based surface information to improve en route tactical departure scheduling

Surface Scheduling: Order of Consideration

Unimpeded Times to Runway



TTOT



The surface scheduler has an ‘order of consideration’ for the aircraft groups

Surface Metering: Delay Propagation

- Prevent too much or too little gate hold from being assigned
- Prevent runway over-saturation or starvation
- Approach:
  - Absorb delay in AMA and Ramp area by adding buffers in computing pushback time (TOBT)

TOBT = max (EOBT, TTOT - X*taxi_time - Y - Z)

X: *Taxi time buffer* (e.g., X = 1.1)
Y: *Delivery buffer* (e.g., Y = 5 min)
Z: *MIT buffer* (A dynamic delay buffer applied to MIT flights to make sure that the flights do not receive any extra delay at gate due to MIT restriction. The Z value shall be the same amount of extra delay accrued for the aircraft in runway schedule due to MIT restriction. Z=0 for non-MIT flights.)

- Implement tunable parameters to maintain pressure on runway queue depending on demand/capacity