

Flight Deck Implications for the Implementation of an Integrated Arrival, Departure, and Surface (IADS) Traffic Management System



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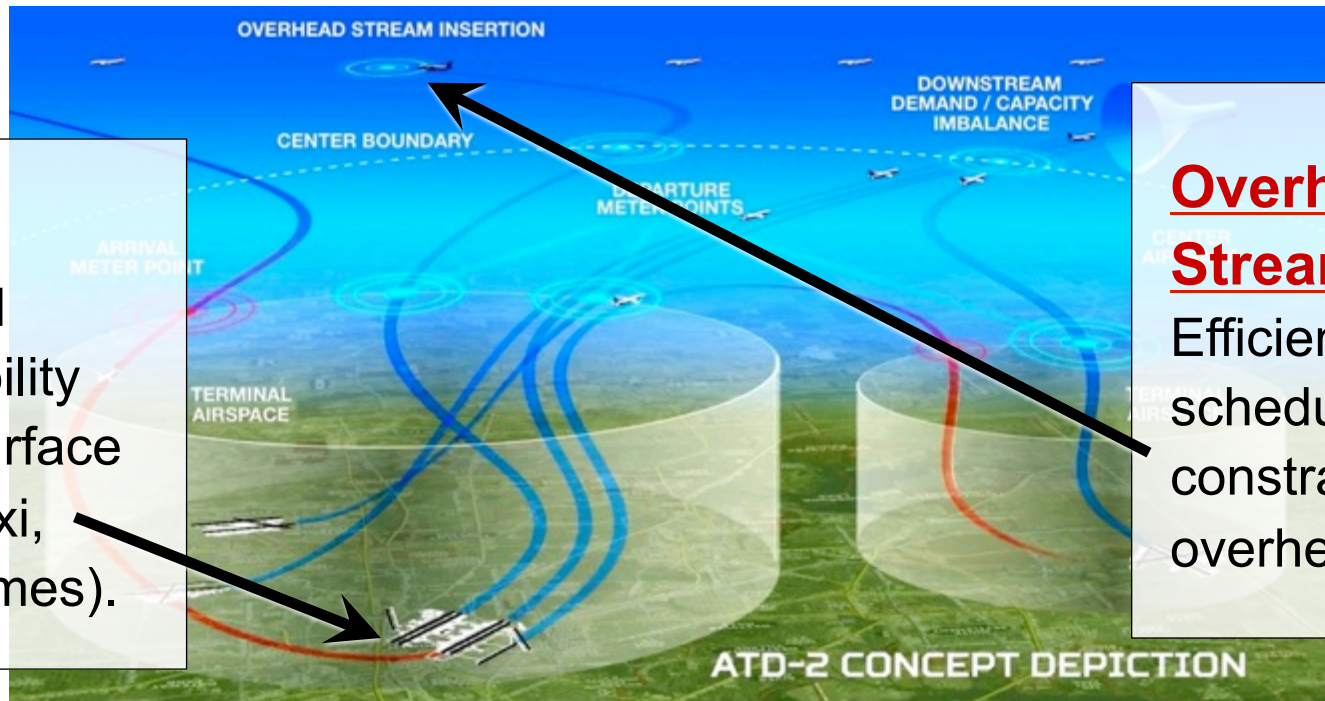
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NASA Ames Research Center



ATD-2 IADS Traffic Management System

- Airspace Technology Demonstration 2 (**ATD-2**)
- Integrated Arrival, Departure, and Surface (**IADS**) traffic management system



Surface

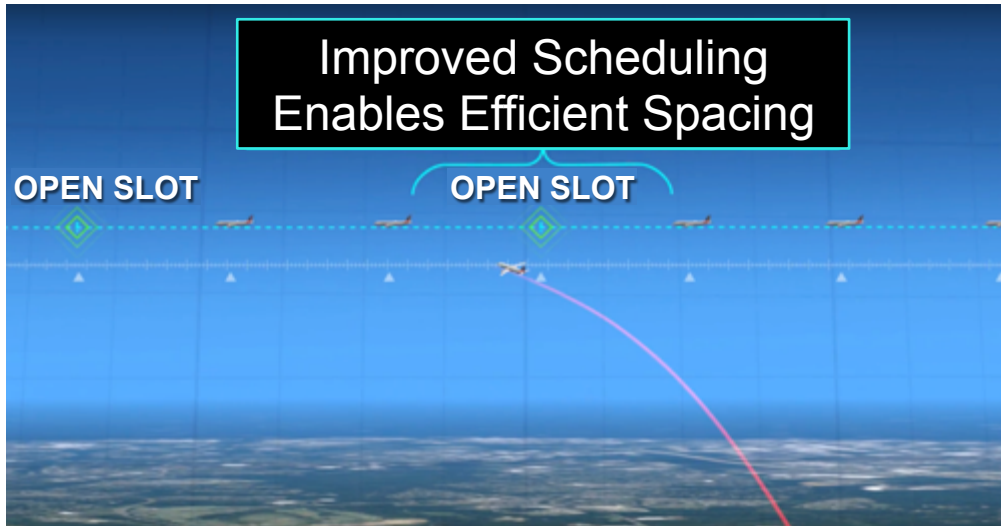
Improved predictability on the surface (push, taxi, takeoff times).

Overhead Stream

Efficient scheduling into constrained overhead flows.

Scheduling tools to efficiently manage traffic from the gate to the overhead stream merge.

- **ATD-2 combines existing and emerging technologies to create the IADS traffic management system**



Departure Scheduler Produces airspace trajectory predictions to enable more precise scheduling into overhead traffic streams.

Information Sharing Increased sharing of data and decision information among users.

Surface Modeler Produces surface trajectory predictions.

Surface Scheduler Generates target times; monitors demand and capacity imbalance estimates.

Surface Metering Throttles demand to the runway.





ATD-2 IADS Displays and Interfaces

- ATD-2 IADS improves predictability through a coordinated schedule between the Ramp, Tower, Terminal, and Center

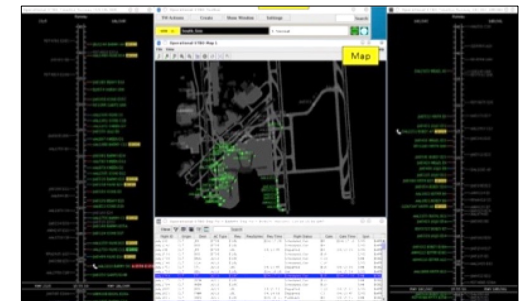
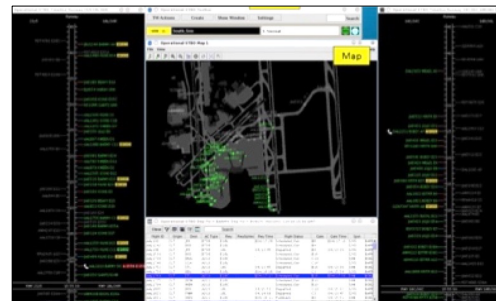
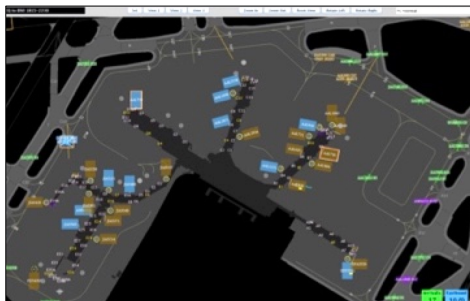
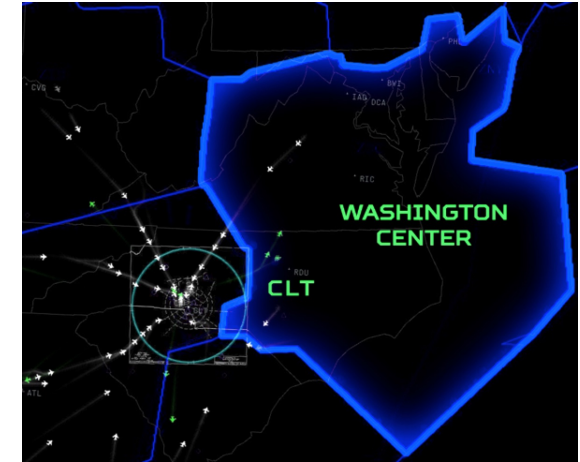
Ramp Tower



ATC Tower



ARTCC (Center)



Display/Interface

Ramp Traffic Console (RTC): Flight info, pushback advisories

Display/Interface

Runway arrival /departure timelines, flight list, map

Display/Interface

Departures into overhead streams



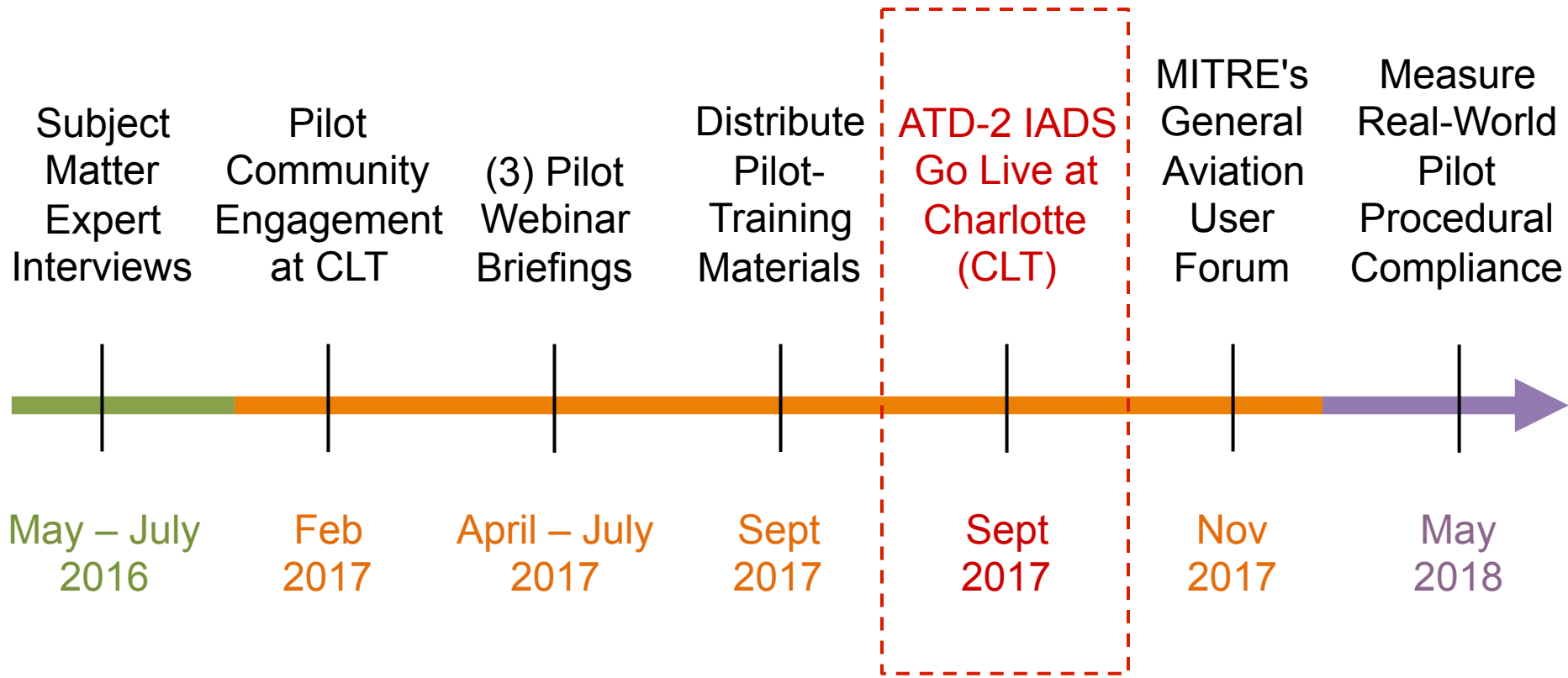
- Airspace Technology Demonstration 2 (**ATD-2**)
- Integrated Arrival, Departure, and Surface (**IADS**) traffic management system

Flight Deck

- Which parts of the ATD-2 IADS system impact the **Flight Deck**?
- What **pilot** training and communication are needed?
- What procedures are required of **pilots** to support the ATD-2 IADS system?



Pilot Engagement and Outreach





Charlotte Douglas International Airport (CLT)





18C

Ramp Tower

ATC Tower

18L

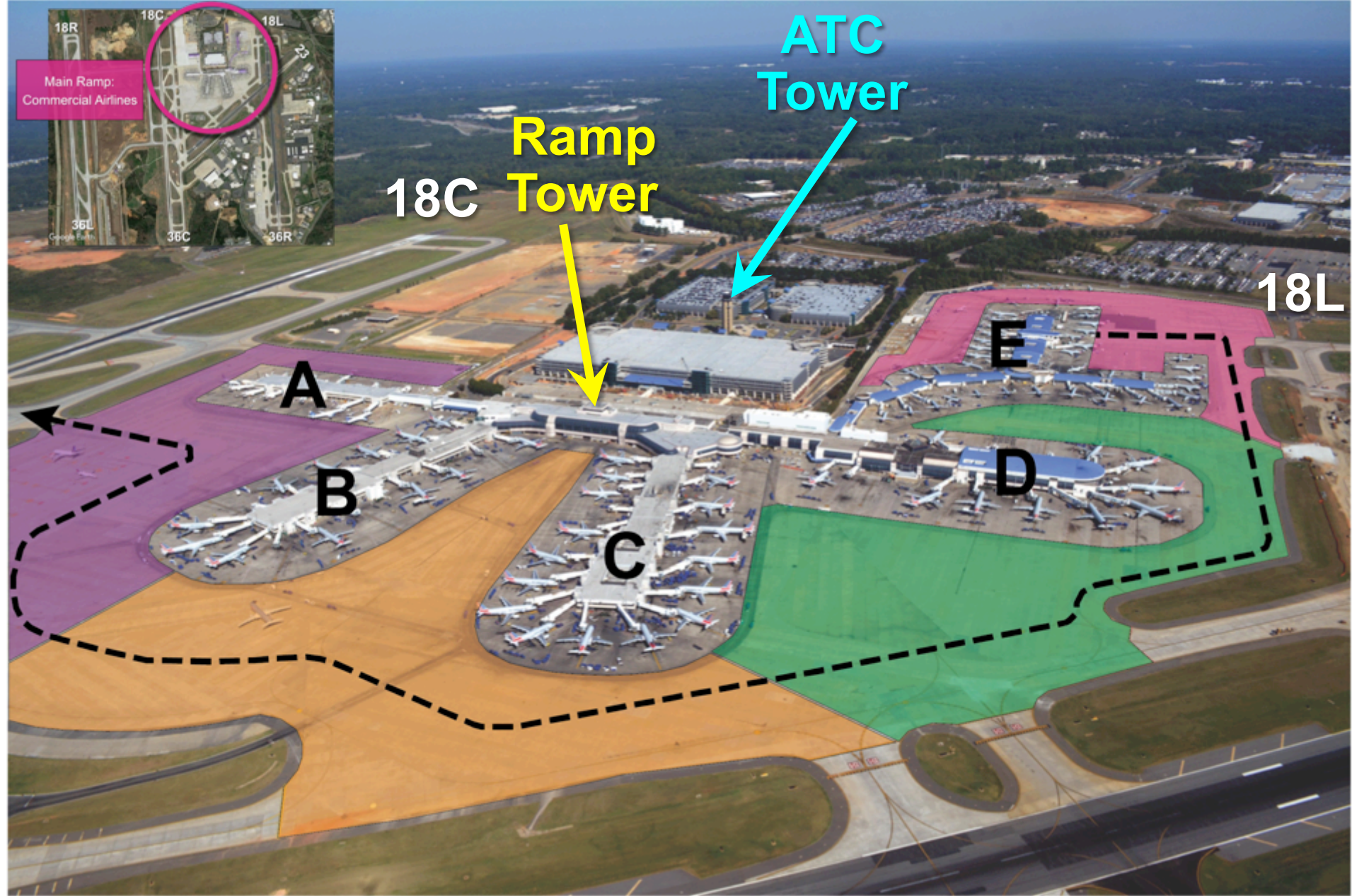
A

B

C

E

D





Charlotte Douglas (CLT) Main Ramp

Airport Movement Area

**Ground Controller
(ATC Tower)**

Taxi Clearance

Runway Assignment

**ATC
Tower**

**Ramp
Tower**

Gate

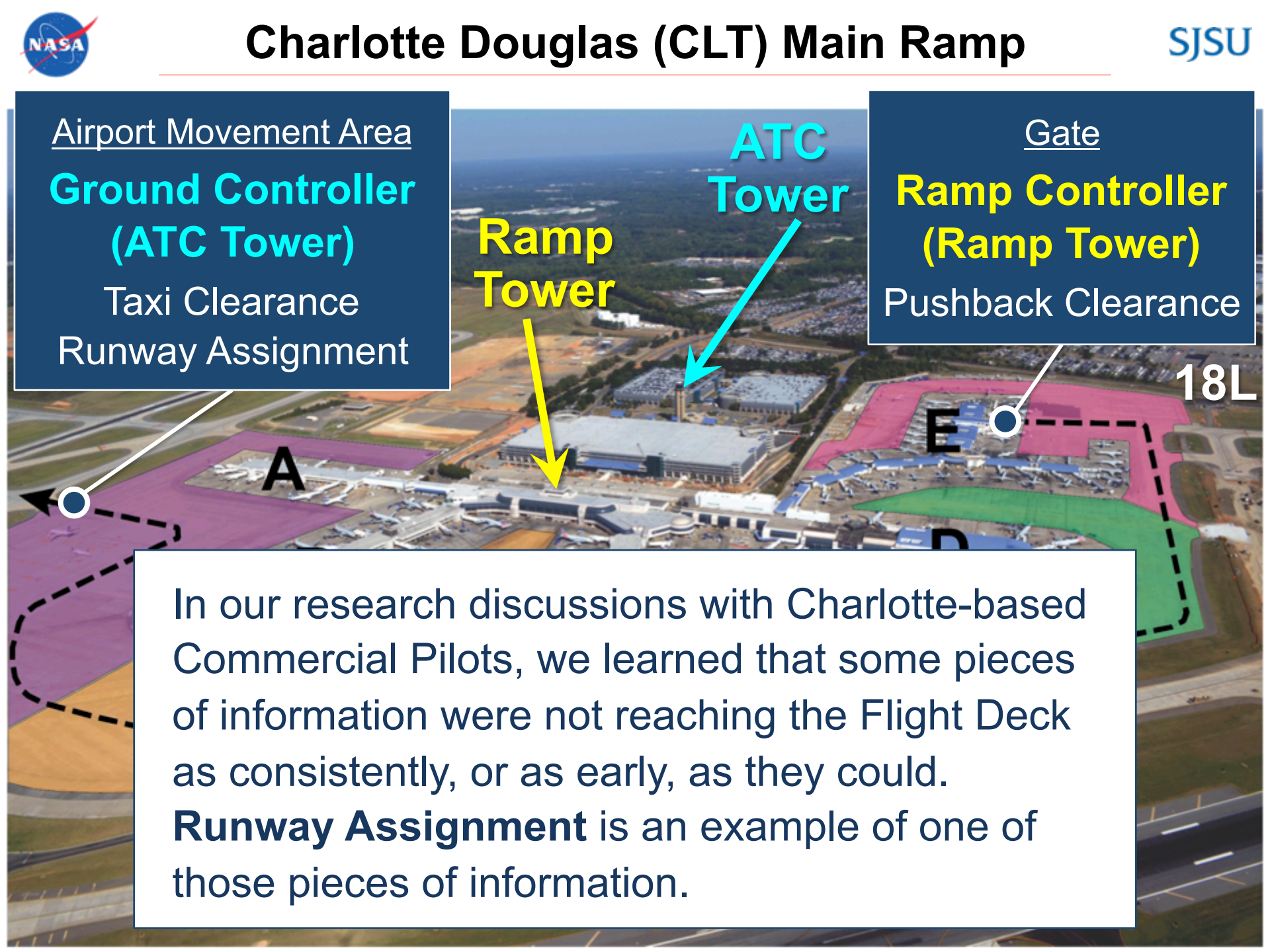
**Ramp Controller
(Ramp Tower)**

Pushback Clearance

18L

In our research discussions with Charlotte-based Commercial Pilots, we learned that some pieces of information were not reaching the Flight Deck as consistently, or as early, as they could.

Runway Assignment is an example of one of those pieces of information.





Charlotte Douglas (CLT) Main Ramp

Airport Movement Area

**Ground Controller
(ATC Tower)**

Taxi Clearance

Runway Assignment

**Ramp
Tower**

**ATC
Tower**

Gate

**Ramp Controller
(Ramp Tower)**

Pushback Clearance

18L

A

E

C

At the AMA Entrance:

Ground Controller issues the Runway Assignment.

At the Gate, prior to Pushback:

Pilots program Flight Deck computers and configure the aircraft for a particular Runway.

If the Runway Assignment issued by the Ground Controller is different than what Pilots planned for, there are implications for Flight Deck workload and traffic flow.



Charlotte Douglas (CLT) Main Ramp

Airport Movement Area

**Ground Controller
(ATC Tower)**

Taxi Clearance
Runway Assignment

**ATC
Tower**

**Ramp
Tower**

Gate

**Ramp Controller
(Ramp Tower)**

Pushback Clearance

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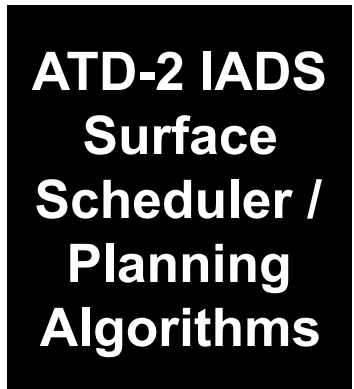
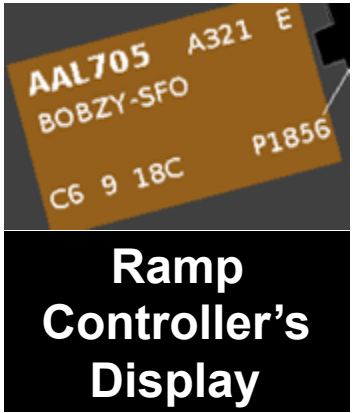
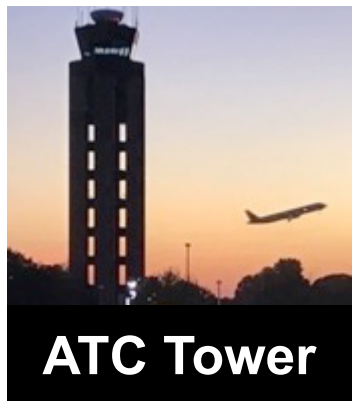
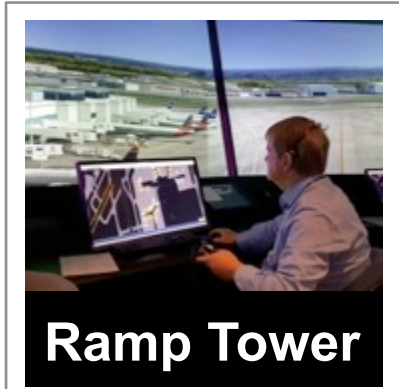
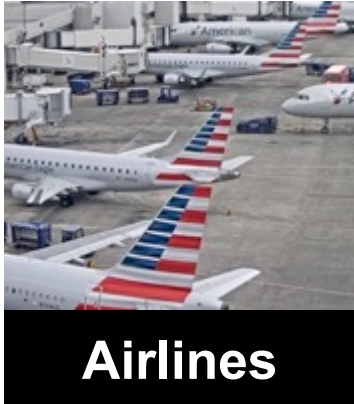
Flight Deck Implications for Changing Runway:

- Request new performance numbers via ACARS
- Reprogram/Verify FMS
- Reconfigure MCP
- Runway-change Checklist (some airlines)
- Eyes-in time
- Pilot Strategies include:
 - Slow taxi speed
 - Stop aircraft












ATD-2 IADS Information Sharing

- Share information among all operators who are responsible for managing traffic to support efficient operations.



ATD-2 IADS Information Sharing with Flight Deck Implications:

-  Runway Assignment
-  TMI: Expect Departure Clearance Time (EDCT)
-  TMI: Wheels-Up Time for Flow Control (APREQ)
-  Departure Fix Closures
-  Ground Stop at Destination Airport
-  Runway for Operational Necessity
-  Anticipated Pushback Delay
-  Surface Metering: Gold Hold Advisories
-  Earliest Off-Block Time (EOBT)





Runway Assignment

<p>Prior to ATD-2 IADS</p>	<ul style="list-style-type: none"> Runway assignment was typically communicated to pilots by Ground Control at the spot or, sometimes, by Ramp Control.
<p>ATD-2 IADS Information Sharing</p>	<ul style="list-style-type: none"> Ramp Control is equipped with runway assignment information. <i>Expected</i> runway (accurate/reliable) is incorporated into the pushback clearance so pilots know their runway earlier.

📶 Pilots call for Pushback





Flight Deck Implications of ATD-2 IADS at CLT SJSU

TRAFFIC MANAGEMENT INITIATIVE (TMI)

Expect Departure Clearance Time (EDCT)

Prior to ATD-2 IADS	<ul style="list-style-type: none"> • Pilots estimated when to pushback to meet EDCT. • Ramp Control and ATC didn't always have the same EDCT.
ATD-2 IADS Information Sharing	<ul style="list-style-type: none"> • Ramp Control tools support pushback coordination to meet the EDCT, without excess taxi time. • Depending on EDCT, scheduler may assign a Gate Hold.





Flight Deck Implications of ATD-2 IADS at CLT SJSU

TRAFFIC MANAGEMENT INITIATIVE (TMI)

APREQ/CFR: “Wheels-Up Time for Flow Control”

Prior to ATD-2 IADS	<ul style="list-style-type: none"> • Pilots were often unaware until contacting Ground Control. • Ramp Control was unaware of Wheels-Up times (APREQs).
ATD-2 IADS Information Sharing	<ul style="list-style-type: none"> • Ramp Control tools support pushback coordination to meet the APREQ (Wheels-Up Time), without excess taxi time. • Depending on APREQ, scheduler may assign a Gate Hold.

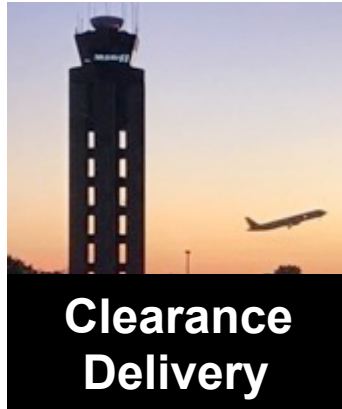
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PRE-DEPARTURE CLR
CTC CD 127.15
JUST B4
PUSHBACK
  
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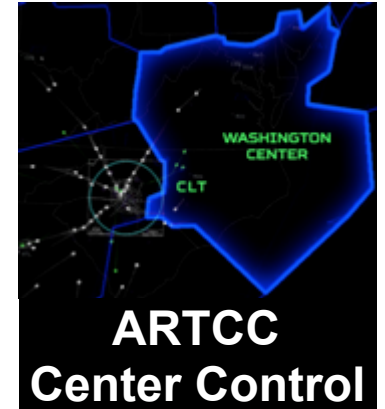


Pilots call Clr. Delivery

Flight Deck before Pushback



***Negotiation of APREQ (overhead slot)**



***Negotiation is not triggered until the Flight Deck contacts Clearance Delivery.**



Flight Deck Implications of ATD-2 IADS at CLT

TRAFFIC MANAGEMENT INITIATIVE (TMI)

APREQ/CFR: "Wheels-Up Time for Flow Control"

<p>Prior to ATD-2 IADS</p>	<ul style="list-style-type: none"> • Pilots were often unaware until contacting Ground Control. • Ramp Control was unaware of Wheels-Up times (APREQs).
<p>ATD-2 IADS Information Sharing</p>	<ul style="list-style-type: none"> • Ramp Control tools support pushback coordination to meet the APREQ (Wheels-Up Time), without excess taxi time. • Depending on APREQ, scheduler may assign a Gate Hold.



📡 Pilots call for Pushback Time Advisory

"You have a Wheels-Up time of 2100, hold for 10 min."

10 min later ...

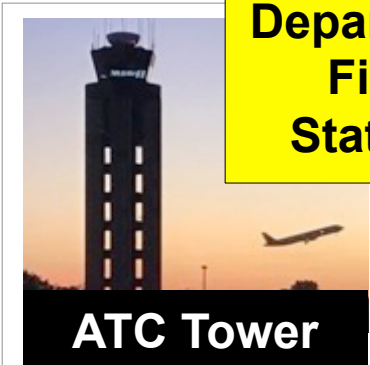
"Pushback approved, expect Runway 18C."



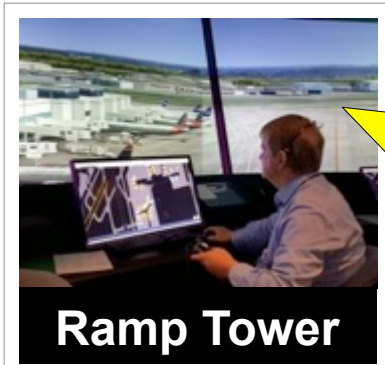
Departure Fix Change/Closure

<p>Prior to ATD-2 IADS</p>	<ul style="list-style-type: none"> Departure Fix closures were typically communicated to pilots by Ground Control at the spot or, sometimes, by Ramp Control.
<p>ATD-2 IADS Information Sharing</p>	<ul style="list-style-type: none"> Ramp Control is equipped with Departure Fix status. Ramp Control communicates to pilots when Departure Fixes are closed or combined.

📶 Pilots call for Pushback



Departure Fix Status



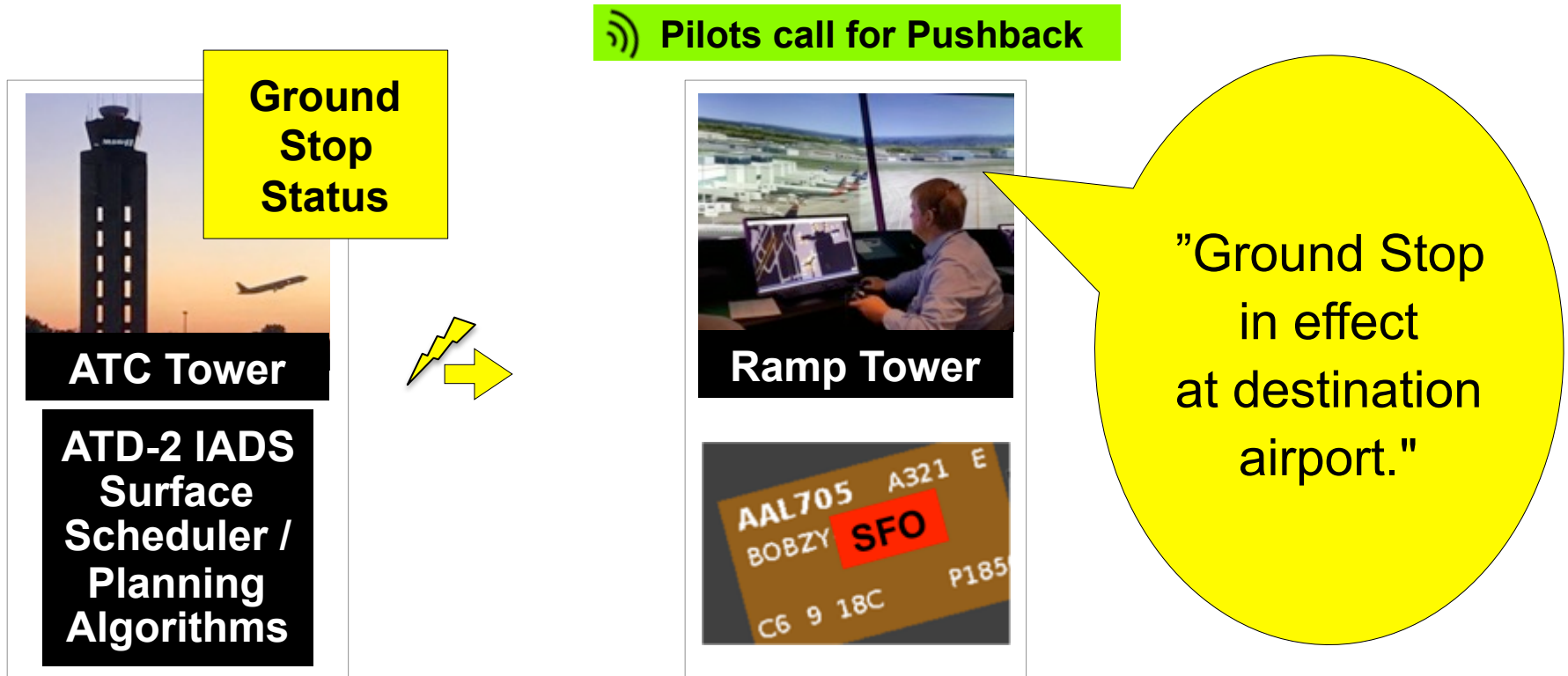
"Contact Clearance Delivery for new route, call when ready for push."

ATD-2 IADS Surface Scheduler / Planning Algorithms



Ground Stop at Destination Airport

Prior to ATD-2 IADS	<ul style="list-style-type: none">Ground Stops were communicated to pilots by Ground Control at the spot or, sometimes, by Ramp Control.
ATD-2 IADS Information Sharing	<ul style="list-style-type: none">Ramp Control is equipped with Ground Stop information.Ramp Control communicates to pilots when the destination airport is closed.



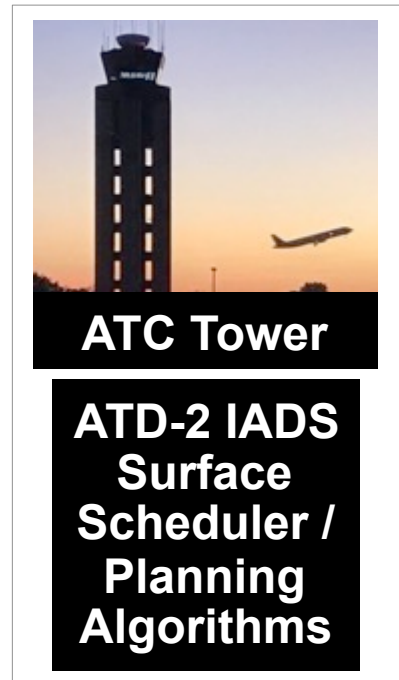
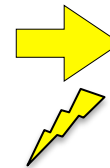
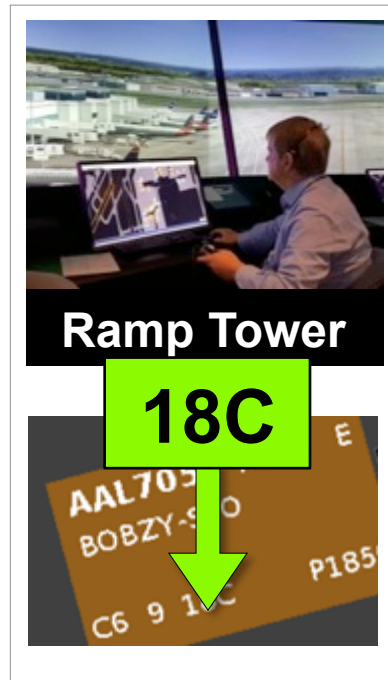
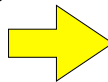
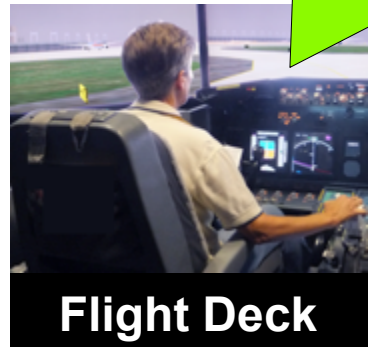


Specify Runway for Operational Necessity

Prior to ATD-2 IADS	<ul style="list-style-type: none">• Pilots specified runway for operational necessity to Ramp Control or Ground Control.
ATD-2 IADS Information Sharing	<ul style="list-style-type: none">• Pilots specify runway for operational necessity to Ramp Controller while at the gate (as soon as known).• Ramp Control electronically communicates need to ATC.

As soon as known:

“Runway 18C for Operational Necessity”

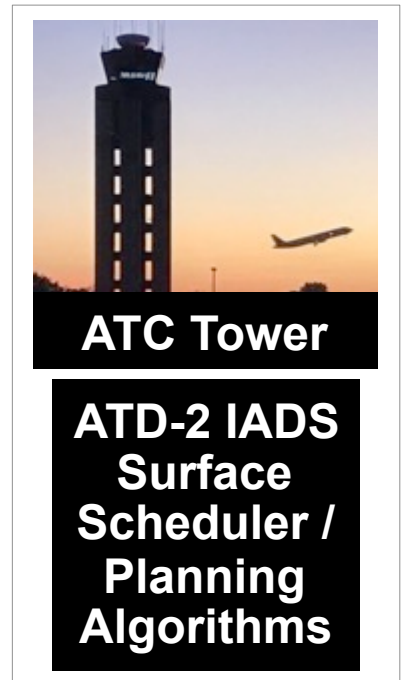
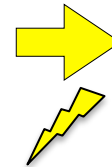
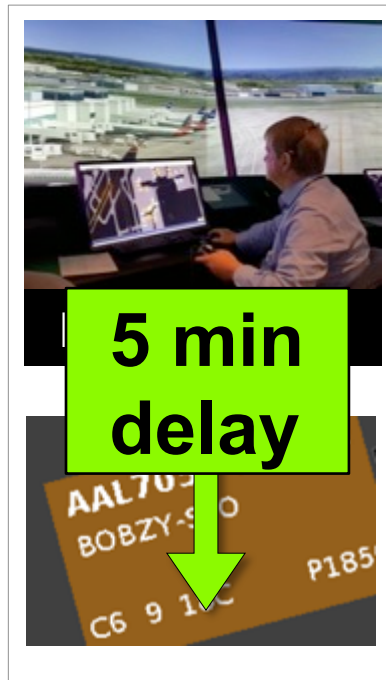
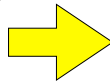




Anticipated Pushback Delay

Prior to ATD-2 IADS	<ul style="list-style-type: none">• Pilots, sometimes, informed Ramp Control of anticipated pushback delays (e.g., maintenance issue).
ATD-2 IADS Information Sharing	<ul style="list-style-type: none">• Pilots inform Ramp Controller of anticipated pushback delay (as soon as known).• Ramp Control electronically communicates delay to ATC.

As soon as known:





Surface Metering: Gate Hold Advisories

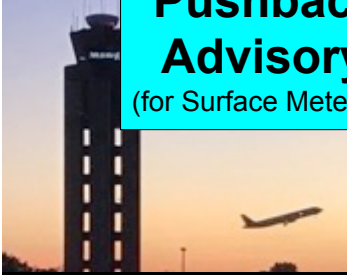


ATD-2 IADS Information Sharing

- Time-based Surface Metering throttles demand to the runway.
- Flights are held at the gate instead of in long departure queues.
- Shifts excess taxi delay from the taxiway to the gate.
- Reduced runway queue, reduced fuel burn and emissions.
- EDCTs and APREQs (Wheels-Up) exempted from Metering.

Pilots call for Pushback

Pushback Advisory
(for Surface Metering)

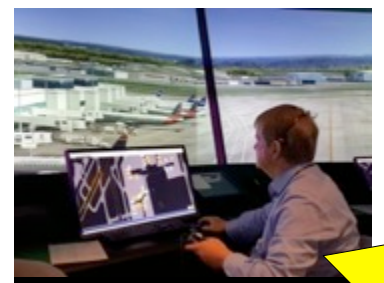


ATC Tower

ATD-2 IADS Surface Scheduler / Planning Algorithms



Ramp Tower



Ramp Tower



5 min later ...



Pilot Communication Distributed Prior to ATD-2 Go Live at Charlotte on September 29th, 2017

- 15 airlines at Charlotte's main ramp (Mainline and Regional)
- 2 pilot organizations (distributed Operational Bulletins)

ATD-2 Integrated Arrival, Departure, and Surface (ADS) Operations

The ATD-2 Integrated Arrival, Departure, and Surface (ADS) traffic management system extends integrated traffic sequencing all the way from the gate to the overhead stream and back again for multi-airport, multi-airport environments. NASA and the FAA are developing the ADS system in close coordination with industry partners.

Expected Benefits: The ATD-2 ADS system will improve the predictability and efficiency of the air traffic system, while reducing fuel usage and emissions. This will be accomplished by sharing data among pilots, controllers, flight operators, and airport operators to produce a fully coordinated schedule.

View the Ampace Technology Demonstration 2 (ATD-2) ADS video at <https://youtu.be/3402-annmation-02>

Overview and Expected Benefits

ATD-2 Integrated Arrival, Departure, and Surface (ADS) Operations - Flight Deck Coordination

ATD-2/ADS Information Flow
The ATD-2 Integrated Arrival, Departure, and Surface (ADS) traffic management system provides schedule and current flight information from flight operations, ATIS and Center to allow Ramp and Air Traffic Controllers to efficiently manage pushback, taxi and runway usage.

Pilot Procedures

Call for Pushback at Holding Position	Surface Metering	Wheels Up Time	Departure/Fs Clearance	Gate Control
<p>What's new?</p> <ol style="list-style-type: none"> Call Ramp when ready to taxi. Do not call Ramp until you are cleared to taxi. Pushback delay is not a concern. Pushback delay is not a concern. Pushback delay is not a concern. Pushback delay is not a concern. <p>What to do?</p> <ol style="list-style-type: none"> Call Ramp when ready to taxi. Do not call Ramp until you are cleared to taxi. Pushback delay is not a concern. Pushback delay is not a concern. Pushback delay is not a concern. Pushback delay is not a concern. 	<p>What's new?</p> <ol style="list-style-type: none"> When in effect, pilots will be able to call for pushback when ready to taxi. This will allow pilots to call for pushback when ready to taxi. When in effect, pilots will be able to call for pushback when ready to taxi. This will allow pilots to call for pushback when ready to taxi. <p>What to do?</p> <ol style="list-style-type: none"> When in effect, pilots will be able to call for pushback when ready to taxi. This will allow pilots to call for pushback when ready to taxi. When in effect, pilots will be able to call for pushback when ready to taxi. This will allow pilots to call for pushback when ready to taxi. 	<p>What's new?</p> <ol style="list-style-type: none"> When in effect, pilots will be able to call for pushback when ready to taxi. This will allow pilots to call for pushback when ready to taxi. When in effect, pilots will be able to call for pushback when ready to taxi. This will allow pilots to call for pushback when ready to taxi. <p>What to do?</p> <ol style="list-style-type: none"> When in effect, pilots will be able to call for pushback when ready to taxi. This will allow pilots to call for pushback when ready to taxi. When in effect, pilots will be able to call for pushback when ready to taxi. This will allow pilots to call for pushback when ready to taxi. 	<p>What's new?</p> <ol style="list-style-type: none"> When in effect, pilots will be able to call for pushback when ready to taxi. This will allow pilots to call for pushback when ready to taxi. When in effect, pilots will be able to call for pushback when ready to taxi. This will allow pilots to call for pushback when ready to taxi. <p>What to do?</p> <ol style="list-style-type: none"> When in effect, pilots will be able to call for pushback when ready to taxi. This will allow pilots to call for pushback when ready to taxi. When in effect, pilots will be able to call for pushback when ready to taxi. This will allow pilots to call for pushback when ready to taxi. 	<p>What's new?</p> <ol style="list-style-type: none"> When in effect, pilots will be able to call for pushback when ready to taxi. This will allow pilots to call for pushback when ready to taxi. When in effect, pilots will be able to call for pushback when ready to taxi. This will allow pilots to call for pushback when ready to taxi. <p>What to do?</p> <ol style="list-style-type: none"> When in effect, pilots will be able to call for pushback when ready to taxi. This will allow pilots to call for pushback when ready to taxi. When in effect, pilots will be able to call for pushback when ready to taxi. This will allow pilots to call for pushback when ready to taxi.

View the Ampace Technology Demonstration 2 (ATD-2) ADS video at <https://youtu.be/3402-annmation-02>

Pilot Procedures

ATD-2 Integrated Arrival, Departure, and Surface (ADS) Operations - Flight Deck Coordination

Typical Pushback Procedures

No Surface Metering

Call Ramp when ready to taxi. Pushback when ready to taxi.

Surface Metering at Gate

Call Ramp when ready to taxi. Pushback when ready to taxi.

Wheels-up Time Procedures

EDCT

Call Ramp when ready to taxi. Pushback when ready to taxi.

Wheels-up Time

Call Ramp when ready to taxi. Pushback when ready to taxi.

View the Ampace Technology Demonstration 2 (ATD-2) ADS video at <https://youtu.be/3402-annmation-02>

Wheels-Up Time Flowcharts

TRAFFIC MANAGEMENT INITIATIVE (TMI)

APREQ/CFR: “Wheels-Up Time for Flow Control”



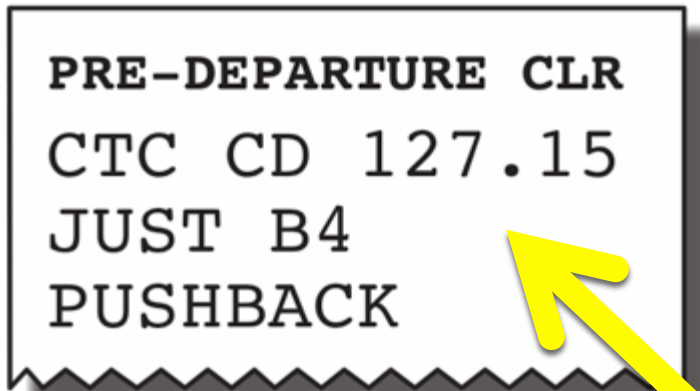
- Of flights subject to a **Wheels-Up Time for Flow Control (APREQ/CFR)**, percent that **had their Wheels-Up Time** when they pushed back.

63%
Average

February 2018

TRAFFIC MANAGEMENT INITIATIVE (TMI)

APREQ/CFR: “Wheels-Up Time for Flow Control”



- Flight is subject to a Wheels-Up Time for Flow Control
- **Action Required:** Contact Clearance Delivery just before pushback

National Aeronautics and Space Administration

ATD-2 Integrated Arrival, Departure, and Surface (IADS) Operations – Initial Benefits and Flight Deck Reminders

IADS at CLT is Working!

Average Monthly Benefits			
30,490 lbs. of Fuel Saved and 47 Tons of CO ₂ Eliminated <i>by small holds at gate</i>	1.7 Minute Reduction <i>in north flow AMA taxi out times</i>	21,412 lbs. of Fuel Saved <i>by scheduling release times at the gate</i>	11.2 Hours of Delay Saved <i>by efficient overhead stream merges</i>

Gate Ramp AMA Runway Overhead Stream Merge

Pilot Procedures Reminder: Wheels-Up Time

In order to see system benefits at CLT, pilots are reminded to contact Clearance Delivery (CD) for their Wheels-Up time PRIOR to calling for pushback. Please check the Pre-Departure Clearance (PDC) for instructions to contact Clearance Delivery (CD).

When a flight is assigned a Wheels-Up time, the PDC will state:

“CTC CD 127.15 JUST B4 PUSHBACK”

Prior to pushback, pilots should contact Clearance Delivery (CD), and then contact Ramp to request pushback time advisory.

Wheels-Up Time Procedures

EDCT	Before Closing Doors:	Ramp:	At specified pushback time:
PDC: Indicates EDCT time. PRE-DEPARTURE CLR EDCT 14:30Z	Contact Ramp to request pushback time advisory.	“Expect to push at <time>. Expect Runway 18C.”	Ramp: “Cleared to push, Expect Runway 18C.”
Wheels-Up Time	Prior to Pushback:	Contact Ramp:	At specified pushback time:
PDC: Indicates contact Clearance Delivery (CD) just before pushback. PRE-DEPARTURE CLR CTC CD 127.15 JUST B4 PUSHBACK	Contact Clearance Delivery (CD) for Wheels-Up time. Clearance Delivery (CD) provides Wheels-Up time.	Contact Ramp to request pushback time advisory. Ramp: “Expect to push at <time>. Expect Runway 18C.”	Ramp: “Cleared to push, Expect Runway 18C.”

View the Airspace Technology Demonstration 2 (ATD-2)/IADS video at: <https://tinyurl.com/atd2-animation-v2>

www.nasa.gov



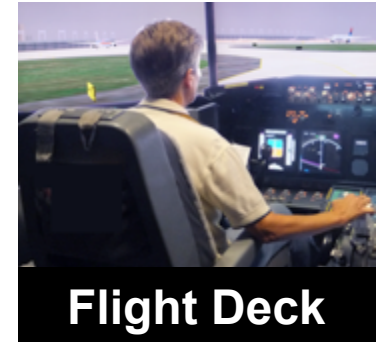
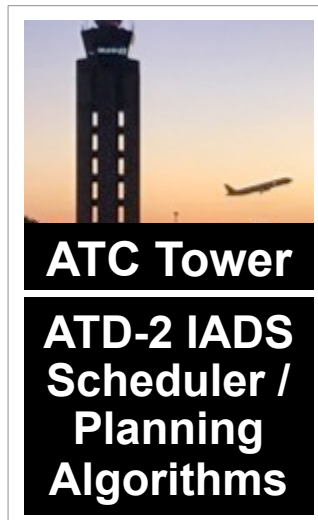
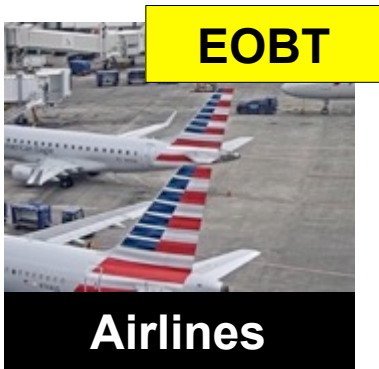
Flight Deck Implications of ATD-2 IADS

Earliest Off-Block Time (EOBT)

ATD-2 IADS

ATD-2 IADS

- Best prediction of earliest expected pushback.
- EOBTs (ready times) are ingested by the Surface Scheduler / planning algorithms.



Earliest Off-Block Time (EOBT):

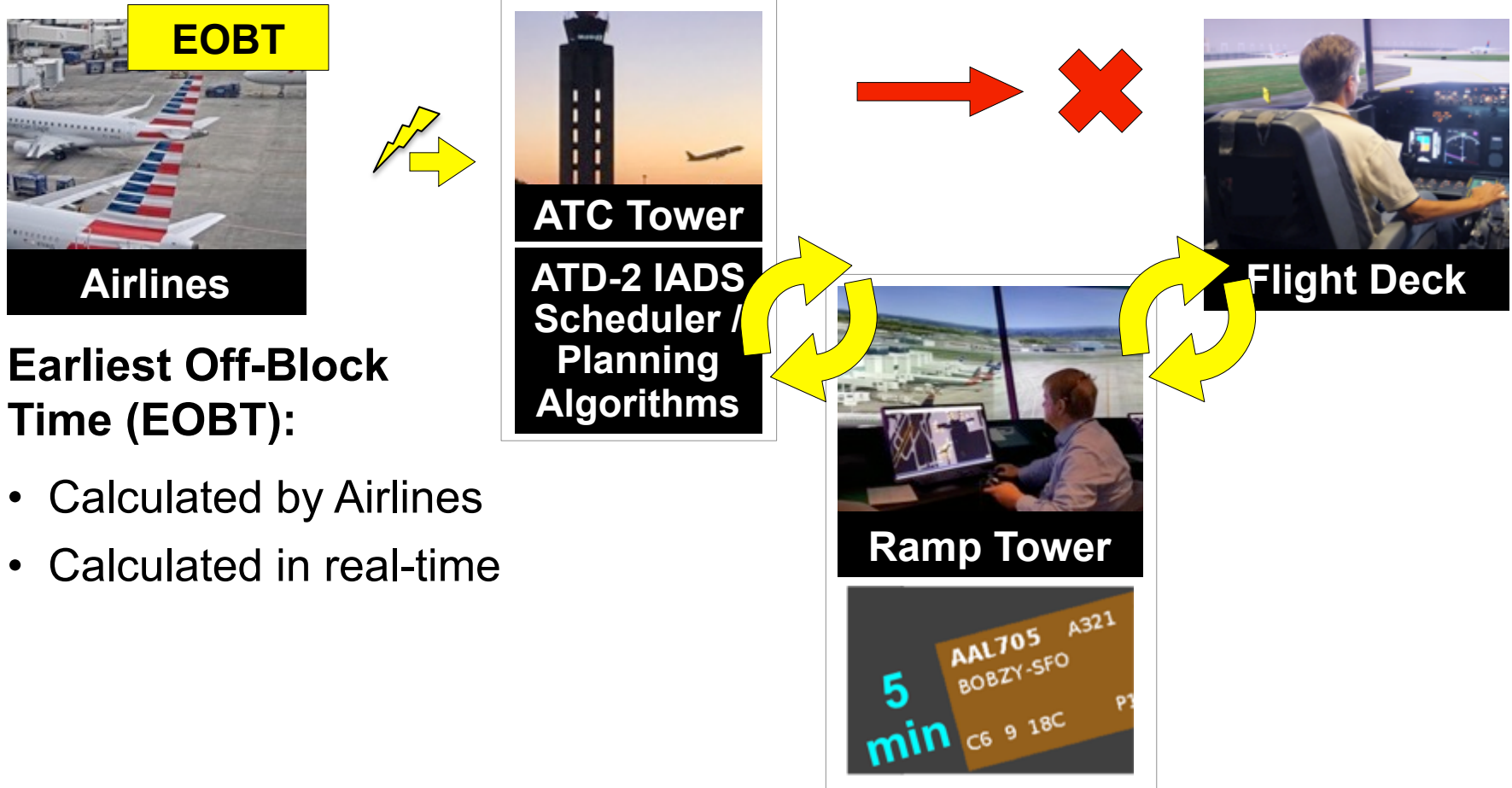
- Calculated by Airlines
- Calculated in real-time

Earliest Off-Block Time (EOBT)

ATD-2 IADS

ATD-2 IADS

- Best prediction of earliest expected pushback.
- EOBTs (ready times) are ingested by the Surface Scheduler / planning algorithms.



Earliest Off-Block Time (EOBT):

- Calculated by Airlines
- Calculated in real-time



Charlotte Douglas International Airport (CLT)



18R

18C

18L

23

Main Ramp:
Commercial Airlines

General Aviation /
Business Jet
Operations

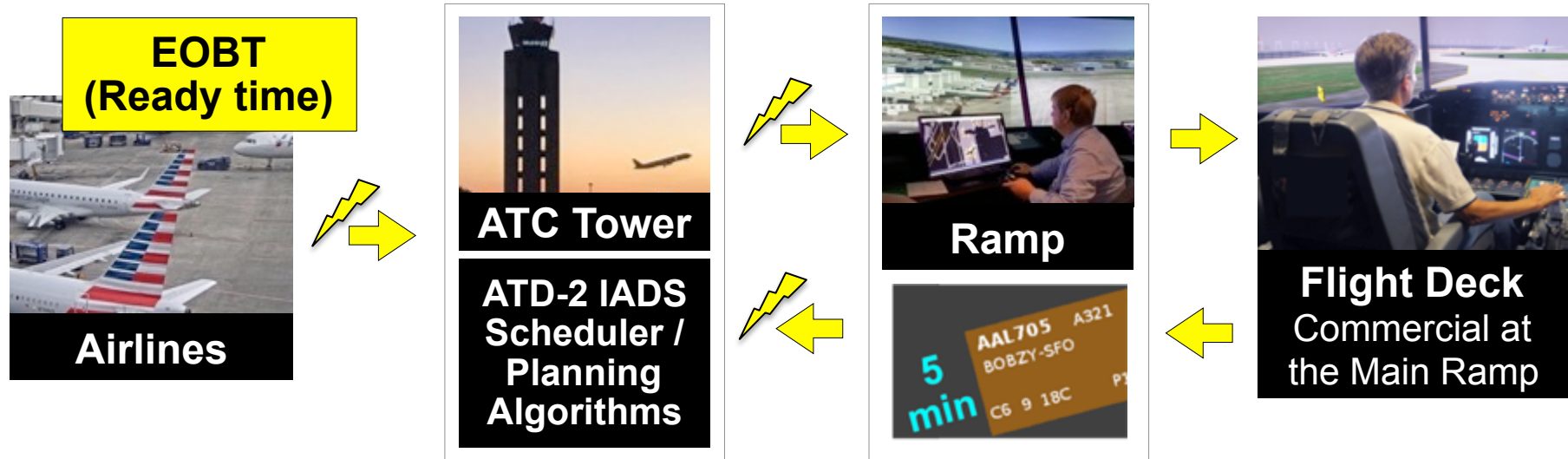
36L

Google Earth

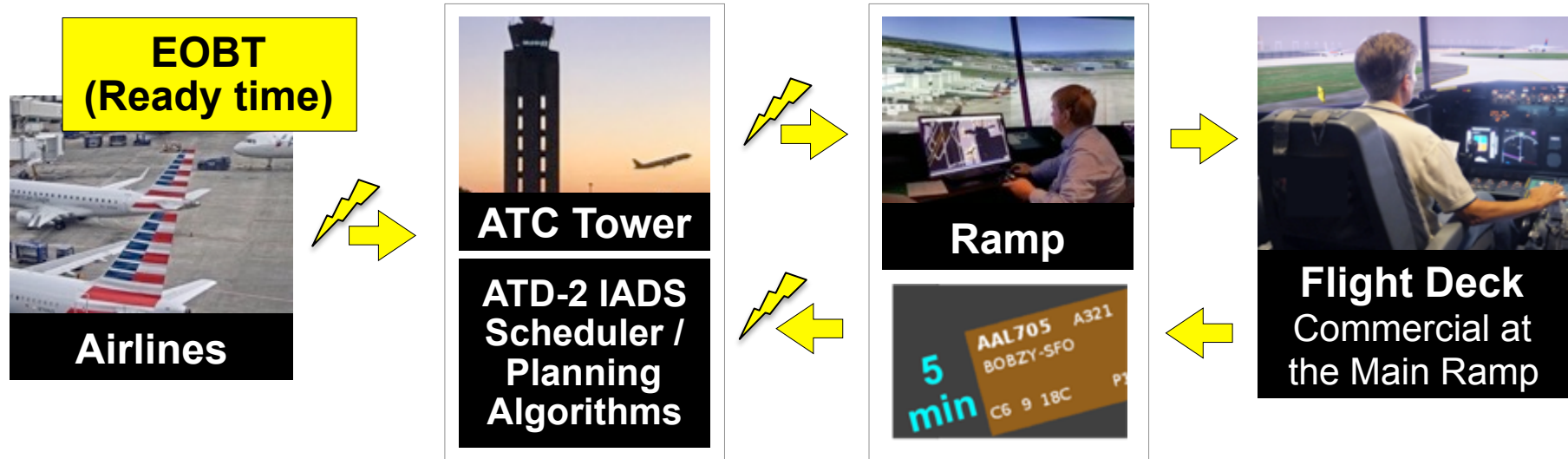
36C

36R

Main Ramp (Commercial Operations) at Charlotte

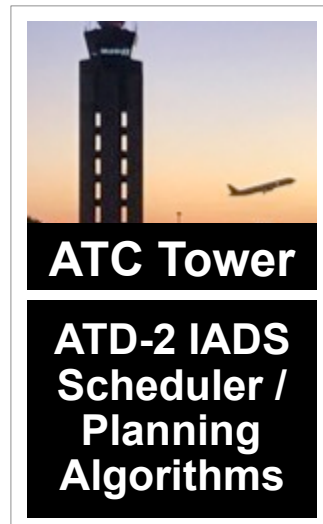


Main Ramp (Commercial Operations) at Charlotte

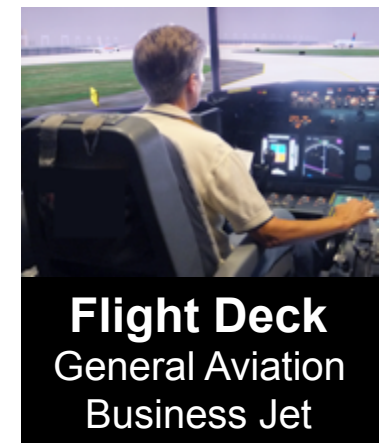


General Aviation / Business Jet Operations at Charlotte

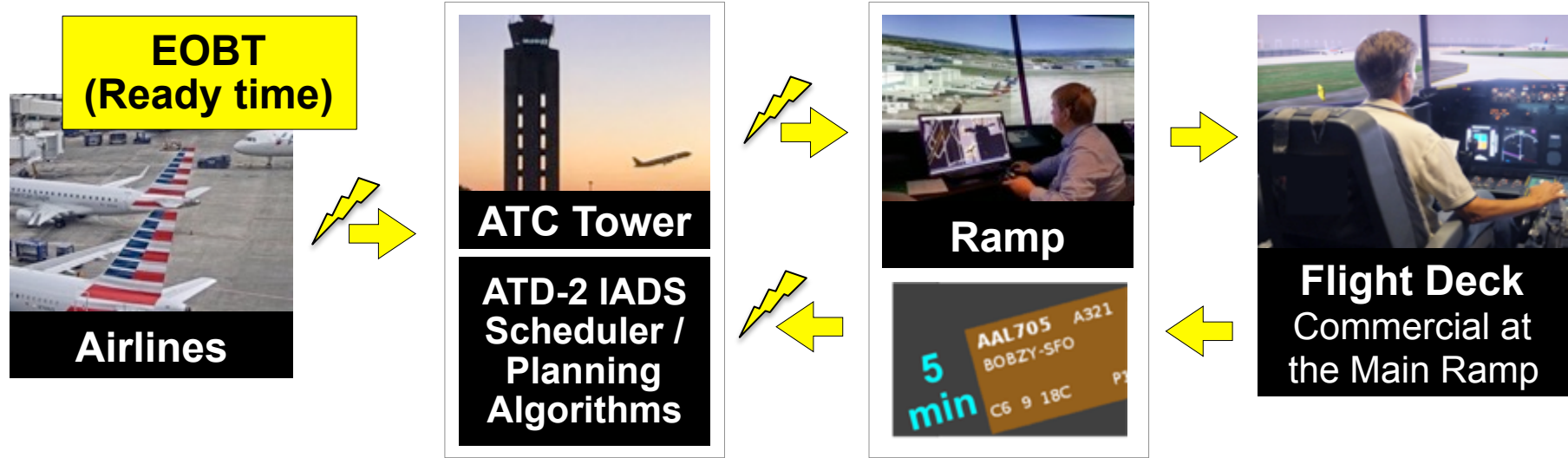
✗ No Airlines to compute and share accurate **EOBT (Ready times)**
**Filed departure time only*



✗ No Ramp Controller to facilitate information exchange with **Pilots**

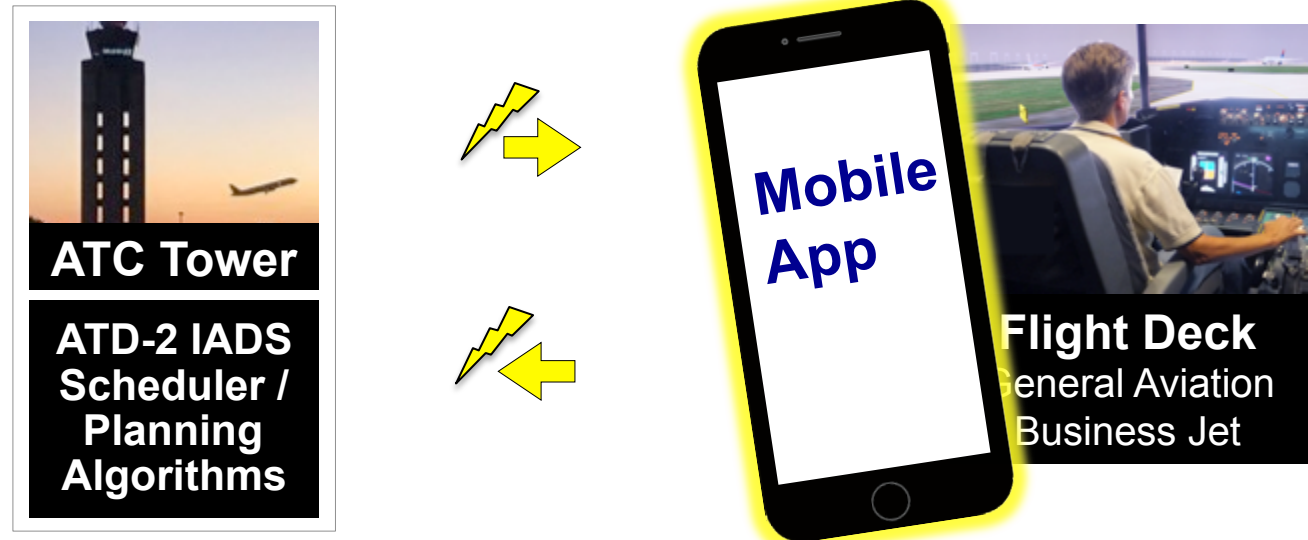


Main Ramp (Commercial Operations) at Charlotte



General Aviation / Business Jet Operations at Charlotte

Mobile Application for GA Pilots to facilitate information sharing





General Aviation (GA) Information Flow

Ready-to-Taxi Time (RTT)

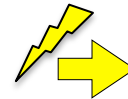


ATD-2 IADS Information Sharing

- Mobile App to enable information flow for GA flights.
- Ready-to-Taxi Time (RTT) similar to EOBT at the Main Ramp.
- **The MITRE Corporation** developing prototype 'Taxi Time' App
 Diffenderfer, P.A., Long, K.M., & Wilkins, S.A. (2018). Concepts for delivering IFR clearances and exchanging pre-departure data using mobile devices. *Proceedings of the 2018 IEEE/AIAA Integrated Communications, Navigation, and Surveillance Conference (ICNS)*.



Flight Deck
General Aviation
Business Jet



ATC Tower

**ATD-2 IADS
Surface
Scheduler /
Planning
Algorithms**

Mobile App: Two-Way Information Flow

ATD-2 IADS Information Sharing

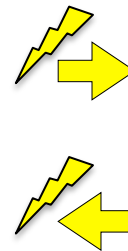
- Two-way information flow to send information back to pilots.
- Expected beta-testing 2018
- **The MITRE Corporation** developing prototype '*Taxi Time*' App
Diffenderfer, P.A., Long, K.M., & Wilkins, S.A. (2018). Concepts for delivering IFR clearances and exchanging pre-departure data using mobile devices. *Proceedings of the 2018 IEEE/AIAA Integrated Communications, Navigation, and Surveillance Conference (ICNS)*.



Flight Deck
General Aviation
Business Jet



- **Runway Assignment**
- **Target Takeoff Time**
- **Wheels-Up Time**
- **Expected Arrival**



ATC Tower

**ATD-2 IADS
Surface
Scheduler /
Planning
Algorithms**

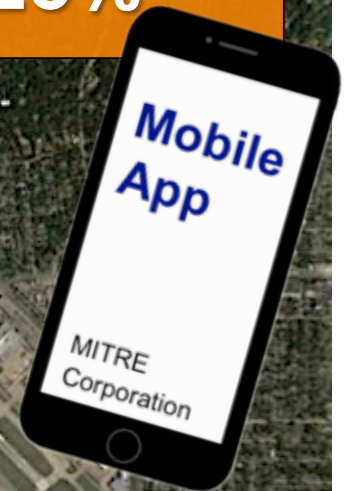
General Aviation / Business Jet Operations

- Larger proportion of GA operations at Dallas Love Field (DAL)
- Greater impact in ATD-2 IADS Scheduler / Planning Algorithms
- Exploring 2019 / 2020 timeframe

Charlotte Douglas (CLT)
6%



Dallas Love Field (DAL)
Close to 25%





- Airspace Technology Demonstration 2 (**ATD-2**)
- Integrated Arrival, Departure, and Surface (**IADS**) traffic management system



Flight Deck Implications for the Implementation of an Integrated Arrival, Departure, and Surface (IADS) Traffic Management System



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