# Integrated Demand Management

## Stakeholder Engagement: Demonstrating Benefits of Submitting Multiple Trajectory Options

**ARMD/AOSP Technical Seminar**
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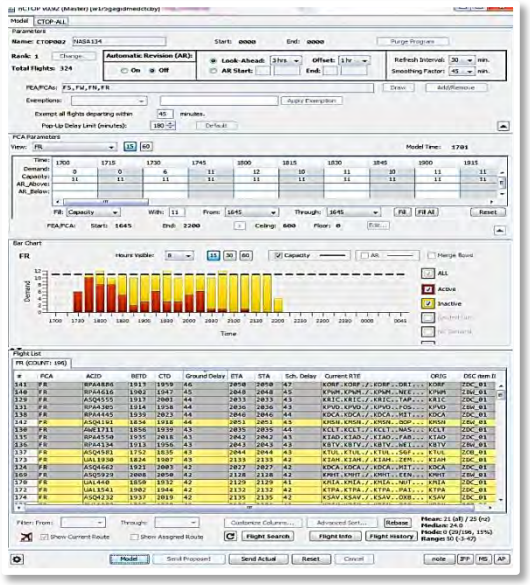
# Integrated Demand Management and Stakeholder Engagement

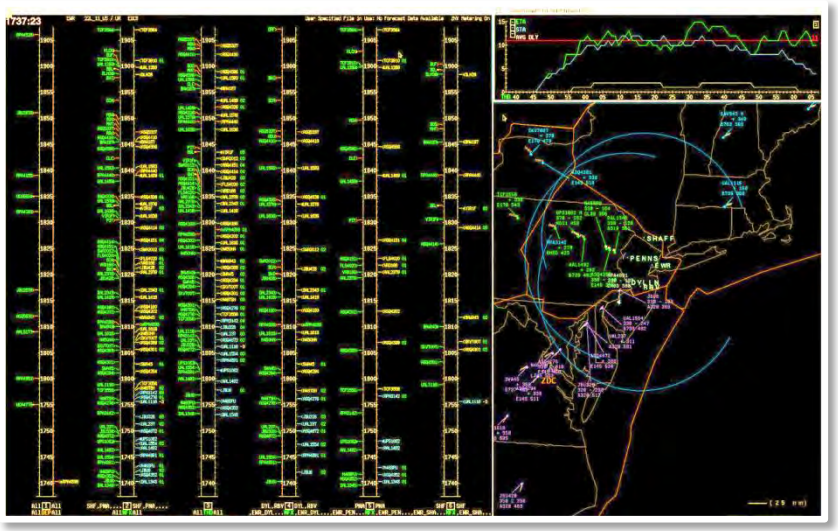
**Integrated Demand Management (IDM)** addresses traffic demand/capacity imbalances through coordinated use of two of the FAA's NextGen Decision Support Systems:

- **Traffic Flow Management System (TFMS)** and its new **Collaborative Trajectory Options Program (CTOP)** capability, and
- **Time-Based Flow Management (TBFM)**

## TFMS/CTOP



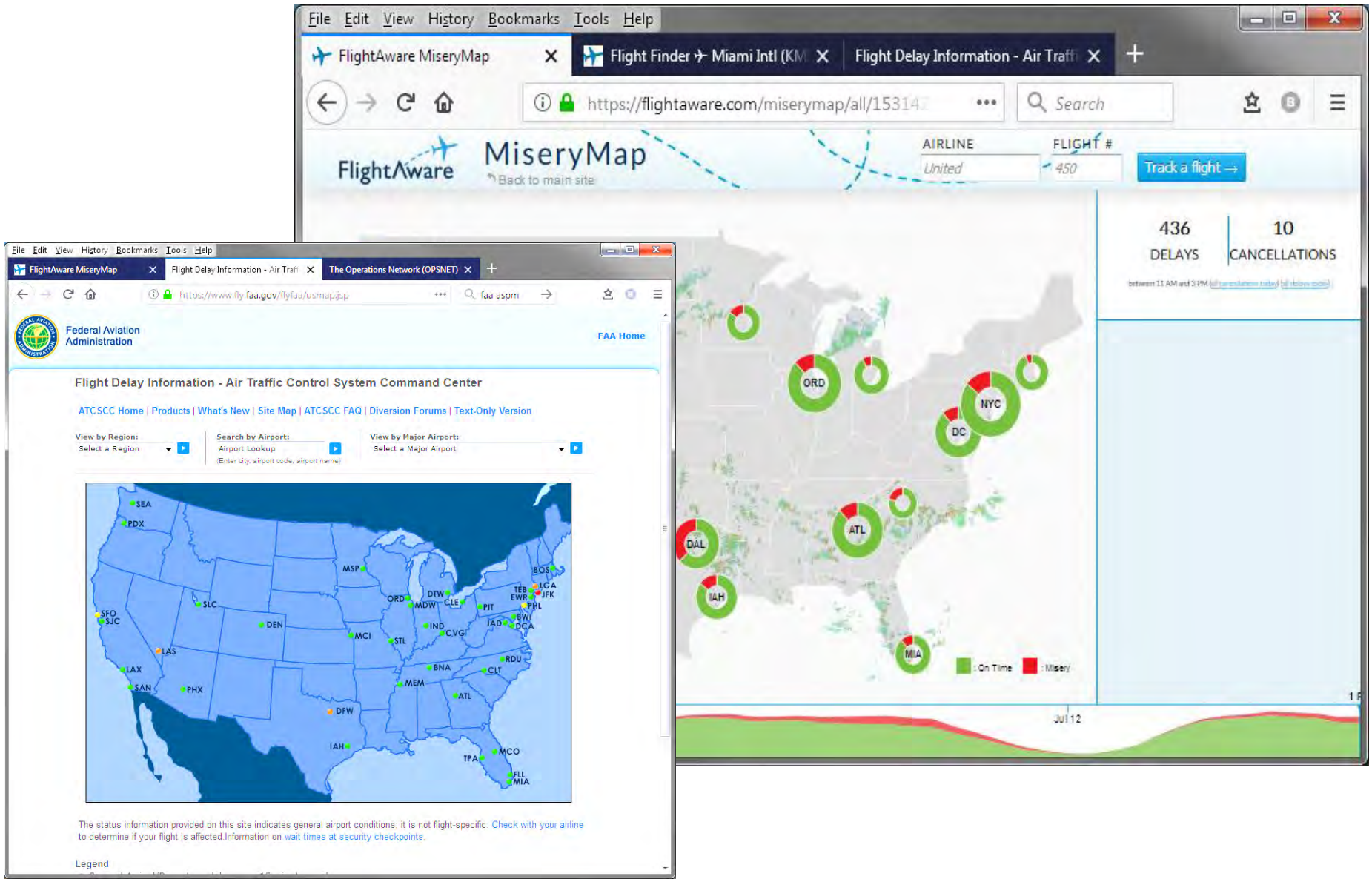
## TBFM



An IDM workshop with the **Collaborative Decision Making (CDM) Flow Evaluation Team working group** demonstrated the value of stakeholder engagement, both for concept development and stakeholder buy-in.

# BACKGROUND

# Motivation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The status information provided on this site indicates general airport conditions; it is not flight-specific. Check with your airline to determine if your flight is affected.Information on wait times at security checkpoints.
Legend

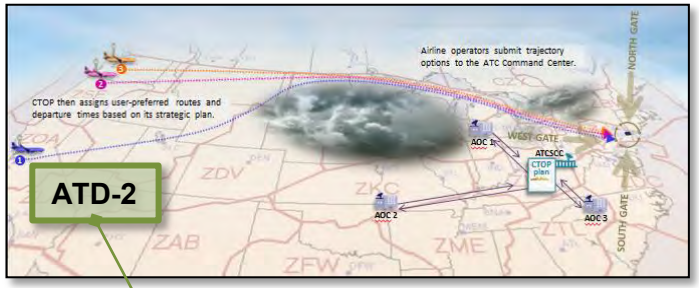
# Integrated Demand Management (IDM)

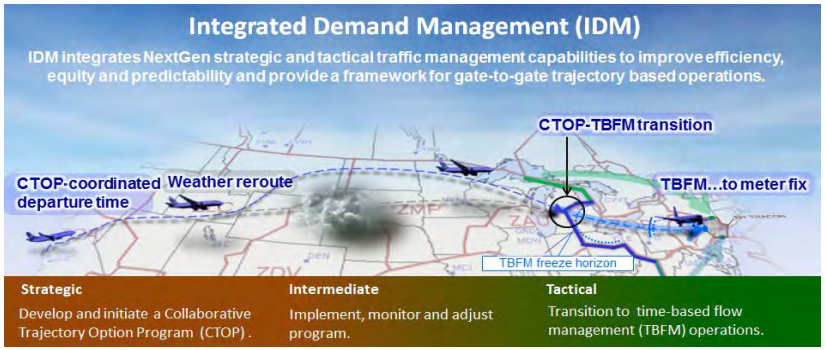
- Objectives
  - Coordinate demand across TFMS and TBFM:
    - TFMS/CTOP “strategically” manages demand into TBFM
    - TBFM “tactically” manages delivery to capacity-limited airport
  - Near- to mid-term concept
  - Engage stakeholders early and throughout the process
- User Benefits
  - Predictability, stability and flexibility of flight schedules and trajectories

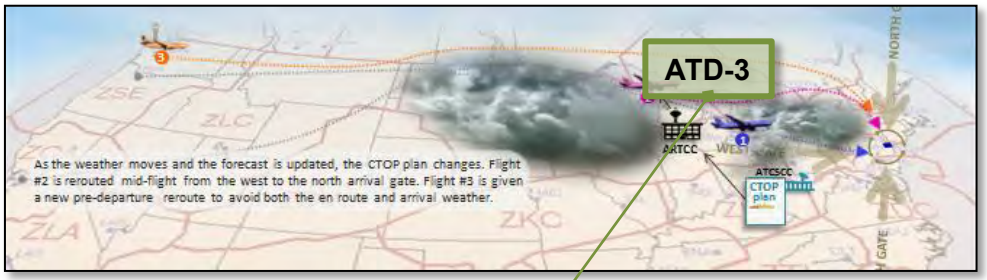
***TFMS**: Traffic Flow Management System* ***TBFM:** Time-Based Flow Management*
***CTOP**: Collaborative Trajectory Options Program*

# IDM Overview

## Strategic – Initial Traffic Management Initiatives

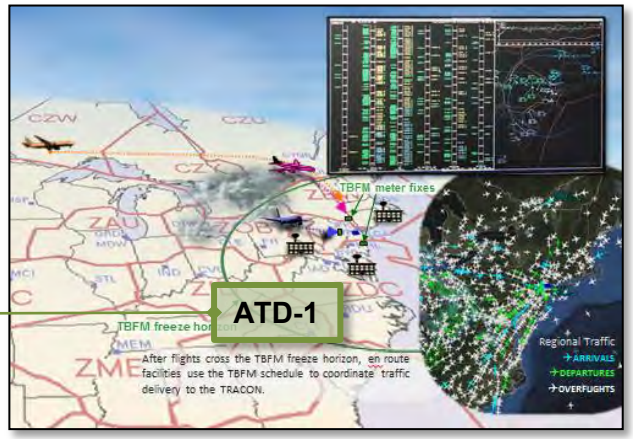


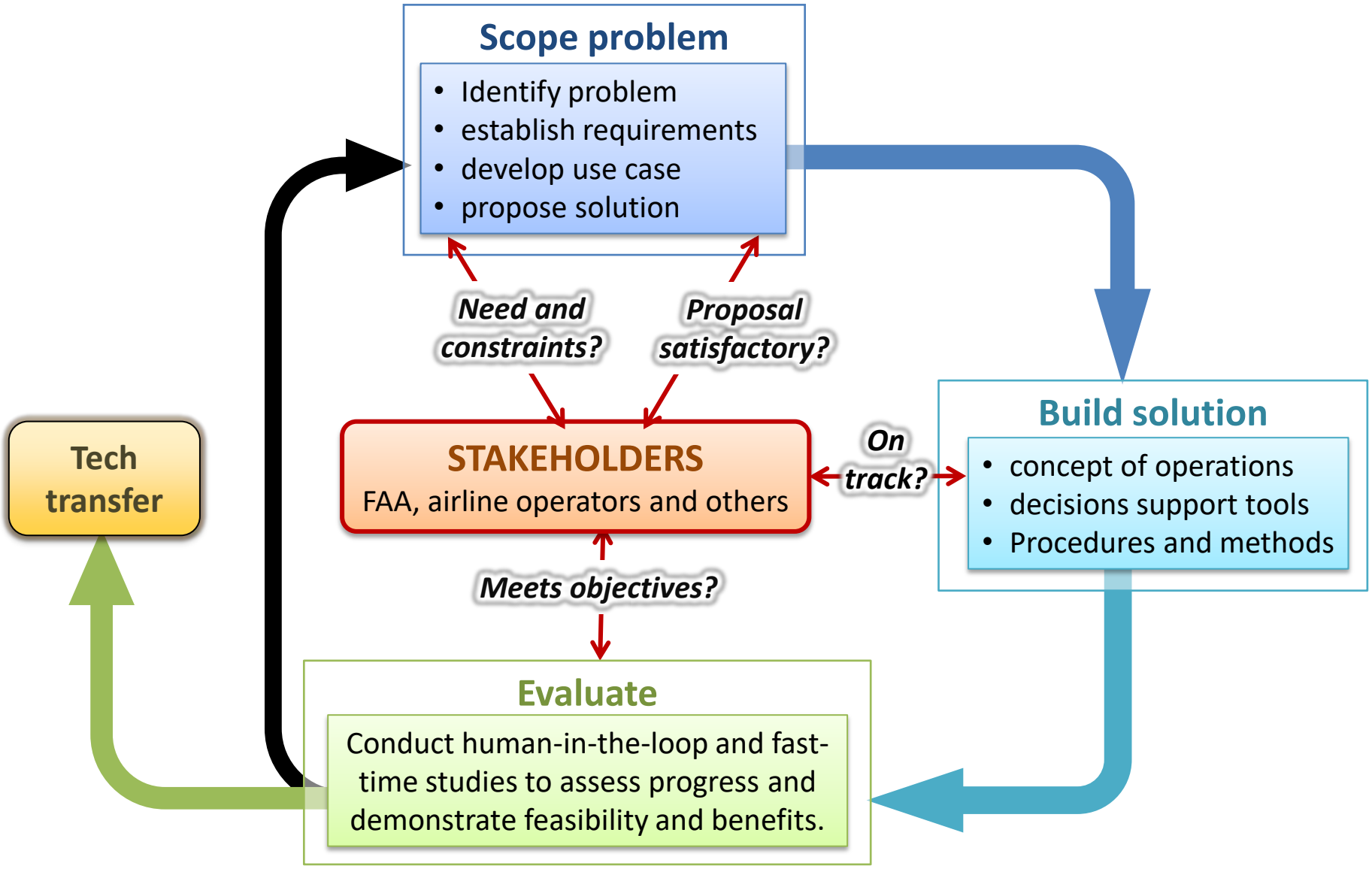

## Intermediate – Airborne and Pre-departure Adjustments

## Tactical – TBFM Scheduling to the Airport



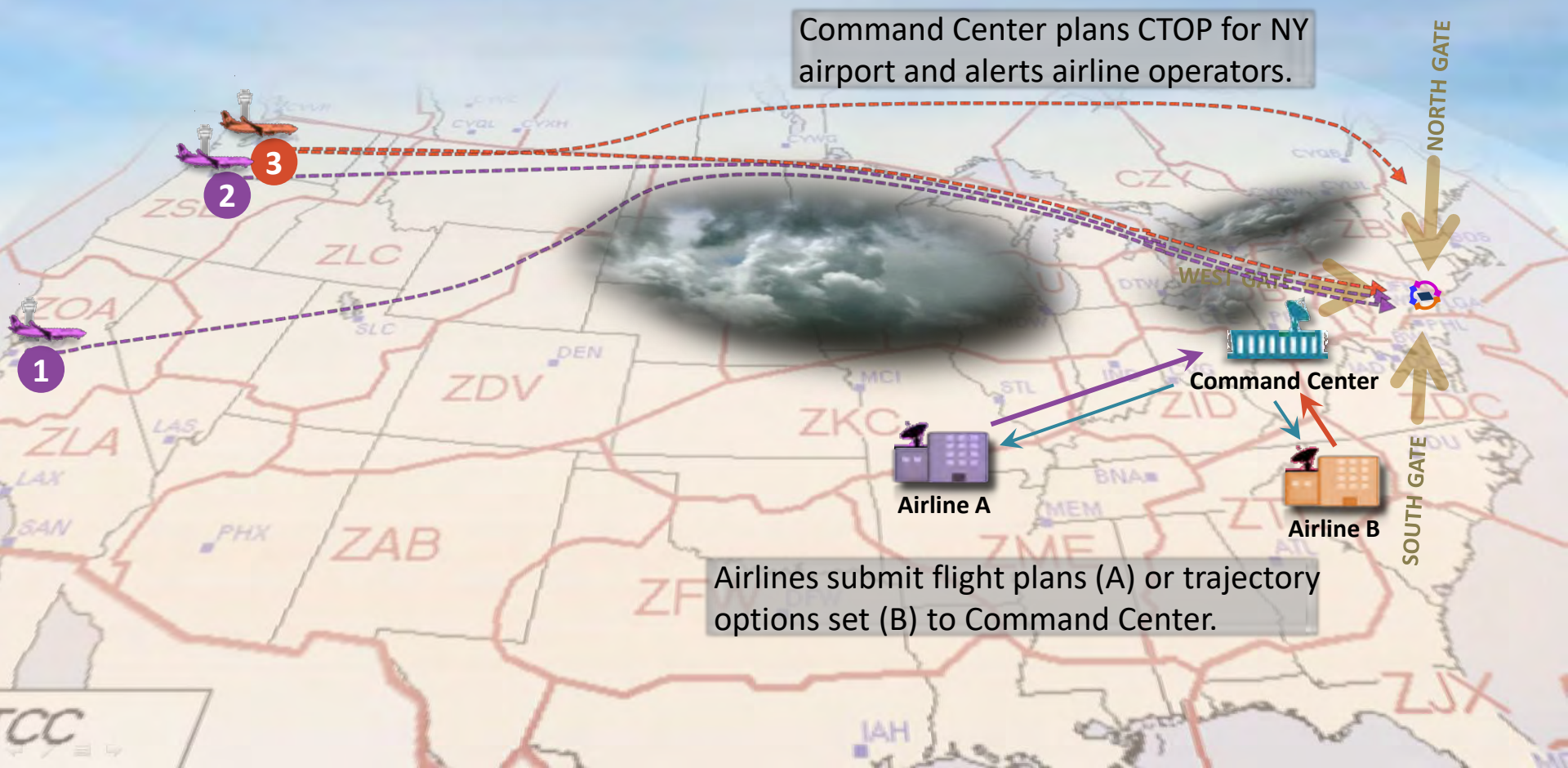

**IDM in conjunction with ATDs can form an initial gate-to-gate TBO framework**

# "Stakeholder-Centric" Development



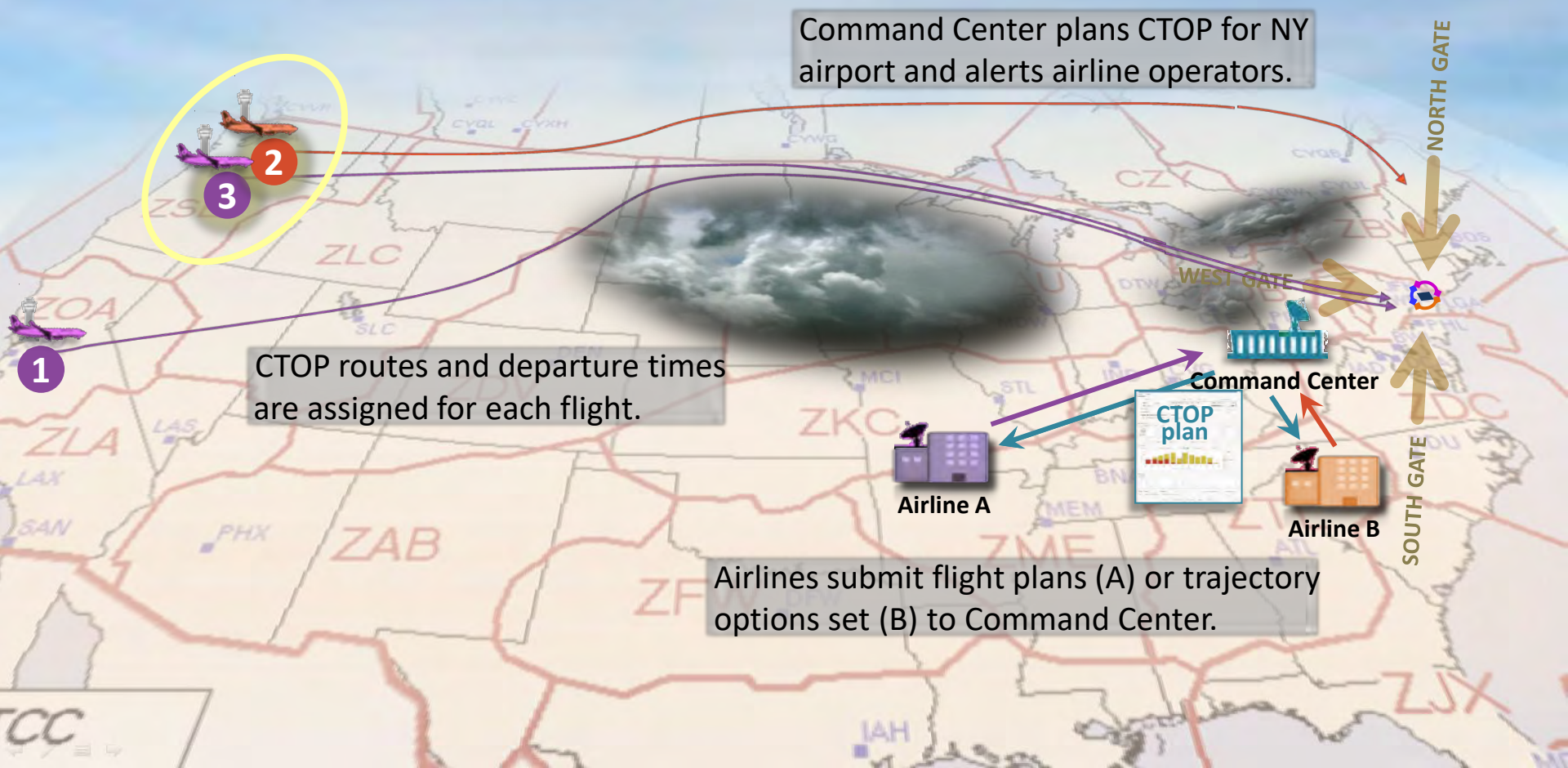
# IDM Operations (1)

## Strategic: Collaborative Trajectory Options Program (CTOP)



# IDM Operations (1)

## Strategic: Collaborative Trajectory Options Program (CTOP)



# IDM Operations (2)

## Tactical: Time-Based Flow Management (TBFM)

After flights cross the TBFM freeze horizon, en route facilities use the TBFM schedule to coordinate traffic delivery to the TRACON.

TBFM meter fixes

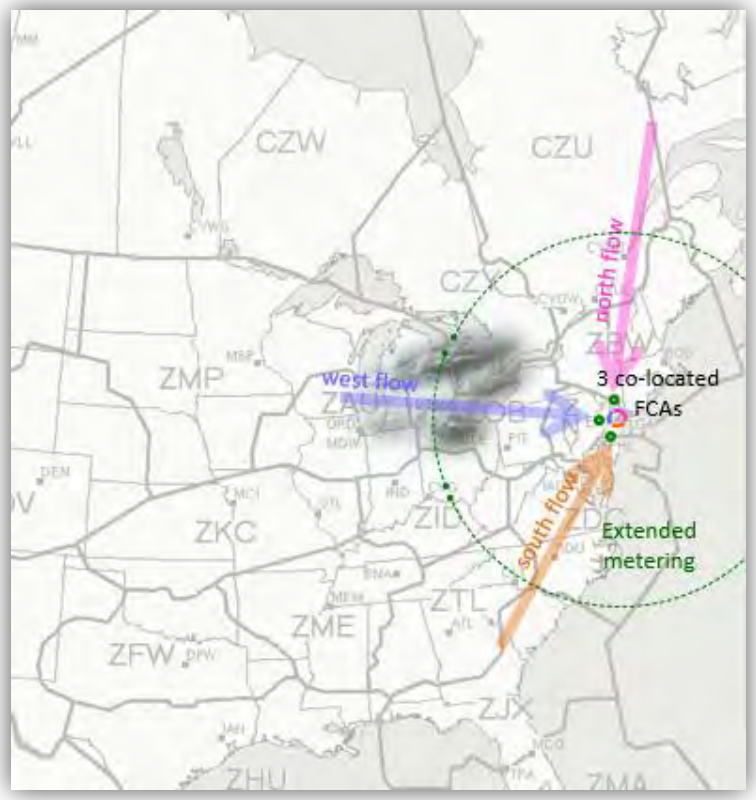
Air Traffic Control Centers

TBFM freeze horizon

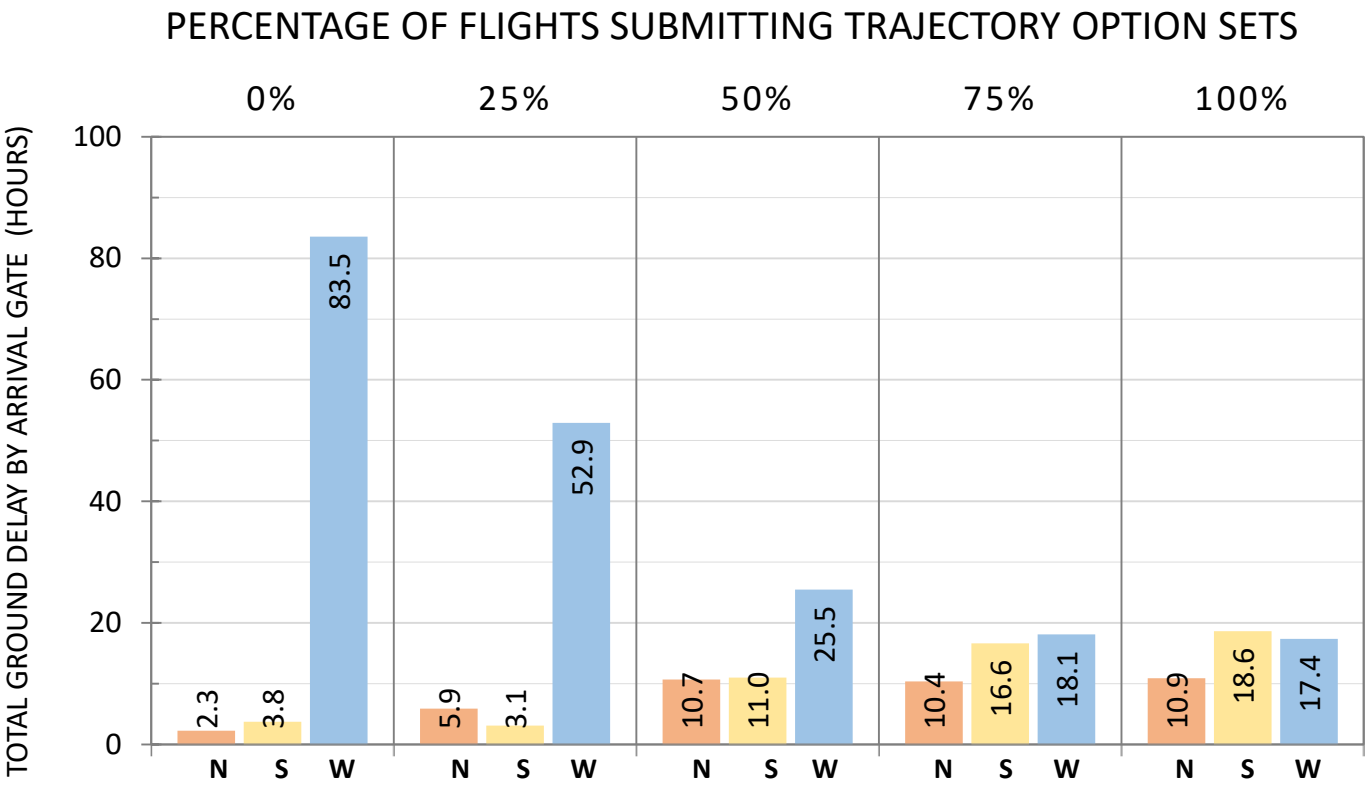
# IDM PART-TASK EXPERIMENT, AUGUST 2017: BENEFITS OF SUBMITTING MULTIPLE TRAJECTORY OPTIONS

# August 2017 Experiment: Overview

- **Research Question**
  - *What happens at different Trajectory Option Set (TOS) submission levels?*
- **Problem**:
  - Newark Liberty International Airport (EWR) arrival demand exceeds target capacity
  - En route weather limits west flow capacity
- **Conditions**:
  - TOS submission levels: 0%, 25%, 50%, 75%, 100%
- **Metrics**: Arrival throughput, ground delay
- **Scenario Characteristics:**
  - Target arrival rate is 44 flights/hour
  - Arrival demand ~55 flights/hour for 4 hours.
  - Heaviest flows from the West and South.
  - West gate is limited to 12 flights/hour
  - North and South flows share remaining 32 slots



# August 2017 Experiment: Results*




*Off-loading traffic from the west flow can substantially reduce ground delay for arrivals on that gate <u>and</u> meet airport capacity if 50% or more flights submit trajectory option sets.*

* Hyo-Sang Yoo, C. Brasil, N. Buckley, G. Hodell, S. Kalush, P. U. Lee, N. M. Smith (2018). "Impact of Different Trajectory Option Set Participation Levels within an Air Traffic Management Collaborative Trajectory Option Program." In *18th AIAA Aviation Technology, Integration, and Operations Conference*.

# MARCH 2018 WORKSHOP WITH CDM WORKING GROUP

# March 2018 Workshop: What We Did

- Human-in-the-loop simulation conducted with CDM Flow Evaluation Team
- FAA members and airline representatives from United, Delta, American, Southwest and FedEx were asked to role-play in LaGuardia Airport (LGA) simulation similar to August 2017 experiment
- Series of runs were completed with different airlines submitting trajectory option sets, including:
  - *All* airlines submit trajectory options sets
  - *No* airlines submit trajectory options sets
  - *Subset* of airlines – United, Delta, American, Southwest and/or JetBlue – submit trajectory options sets
- After each run, output showing airline-specific impact was provided to participants
- Operators described implications for their company operations

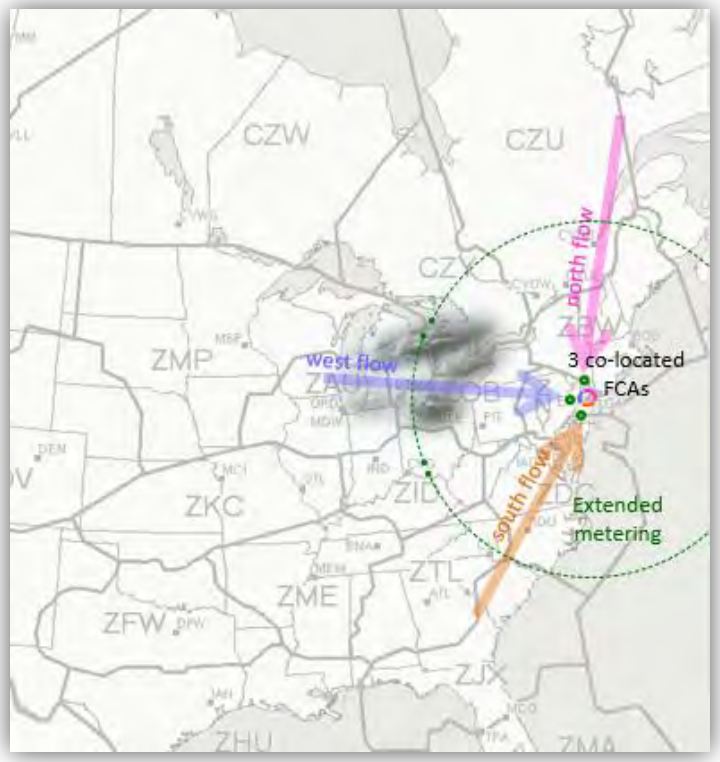
# March 2018 LGA Simulation Demo: Overview (1)

- **Objectives**
  - Explore IDM's concept of using CTOP to precondition traffic for TBFM when users have different TOS submission capabilities
  - Obtain stakeholder feedback on benefits for *all* users, feasibility and suggestions
- **Research Questions**
  - *What happens when different airlines submit Trajectory Option Set (TOS)?*
  - *Who benefits more: TOS submitting airlines? Or non-submitting airlines?*
- **Problem**:
  - LaGuardia Airport (LGA) arrival demand exceeds target capacity
  - En route weather limits west flow capacity
- **Conditions**:
  - Participants decide who will be "TOS-capable"
- **Metrics**:
  - Ground delay, reroute count, added flight time

# March 2018 LGA Simulation Demo: Overview (2)

- **Scenario Characteristics:**
  - Target arrival rate is 36 flights/hour
  - Arrival demand 40-43 flights/hour for 4 hours.
  - Heaviest demand from South, then West.
  - West gate is limited to 4 flights/hour
  - North and South flows share remaining slots

- **Approximate traffic distribution by airline:**
  - Delta: 78 flights (53%)
  - American: 34 flights (25%)
  - JetBlue: 3 flights (3%)
  - Southwest: 10 flights (7%)
  - United: 4 flights (5%)
  - Others: 11 flights (9%)



# RESULTS

# Results: No-TOS vs. All TOS comparison

**Run 1** No Flights Submit Trajectory Options Sets

**Run 2: NO Airlines are TOS Capable** (Preliminary Run, 3/14/2018)

Average Arrival Rate: 33 Delay Averages by Assig... Other DAL SWA JBU AAL

Average Ground Delay (total): 118.5 hou

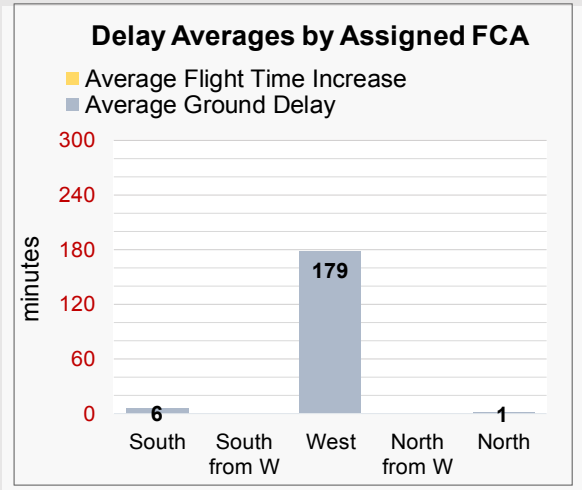
**ALL AIRLINES**

| | | | |
|---|---|---|---|
| Total flight count: | **185** | | |
| Eligible flights only: | **142** | | |
| Total Ground Delay: | **7110** min | **118.5** hours | |
| TOS-rerouted flights: | **0** | | |
| Flight Time increase: | **0** min | **0.0** hours | |
| Ground Delay reduction: | **0** min | **0.0** hours | |

**Ground Delay Distribution**

on-time
20-60 min
1-2 hours
2+ hours

25, 18%
6, 4%
3, 2%
108, 76%




**Run 1: ALL airlines are TOS Capable** (Preliminary Run, 3/14/2018)

Average Arrival Rate: 36 Delay Averages by Assig... Other DAL SWA JBU AAL

Average Ground Delay (total): 44.6 hou

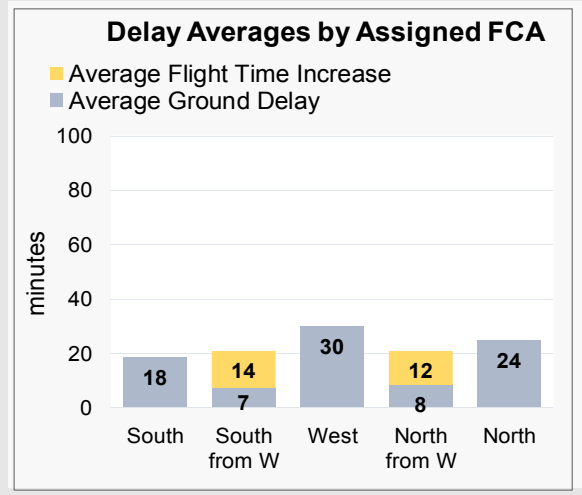
**ALL AIRLINES**

| | | | |
|---|---|---|---|
| Total flight count: | **185** | | |
| Eligible flights only: | **142** | | |
| Total Ground Delay: | **2674** min | **44.6** hours | |
| TOS-rerouted flights: | **23** | | |
| Flight Time increase: | **298** min | **5.0** hours | |
| Ground Delay reduction: | **717** min | **11.9** hours | |

**Ground Delay Distribution**

on-time
20-60 min
1-2 hours
2+ hours

0, 0%
1, 1%
62, 44%
79, 55%



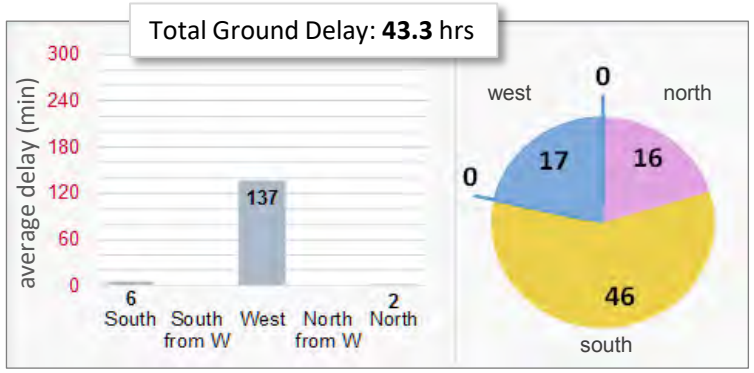
# Results: Delta and American, three different conditions

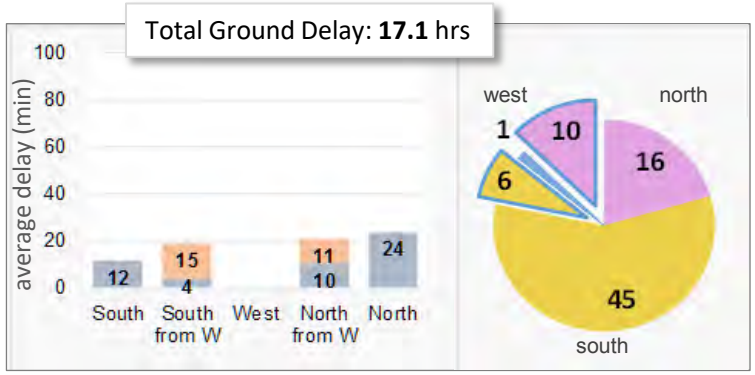
**Run 1.** No airlines submit Trajectory Options Sets

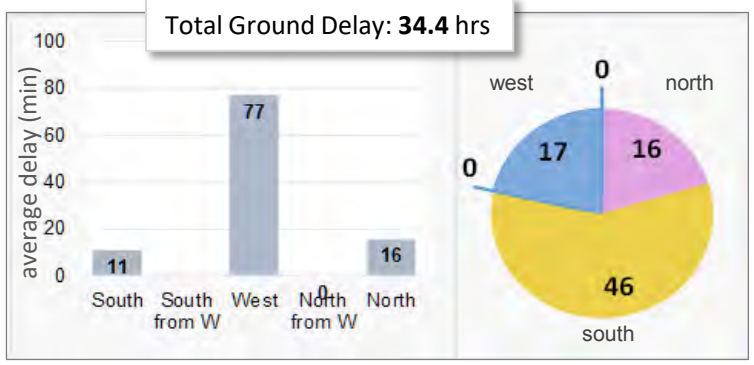
**Run 3:** Only Delta submits Trajectory Options Sets

**Run 4:** Everyone *but* Delta submits Trajectory Options Sets

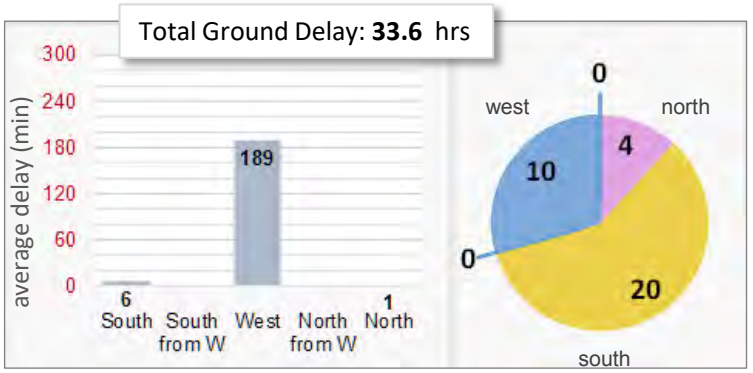
## DELTA AIRLINES

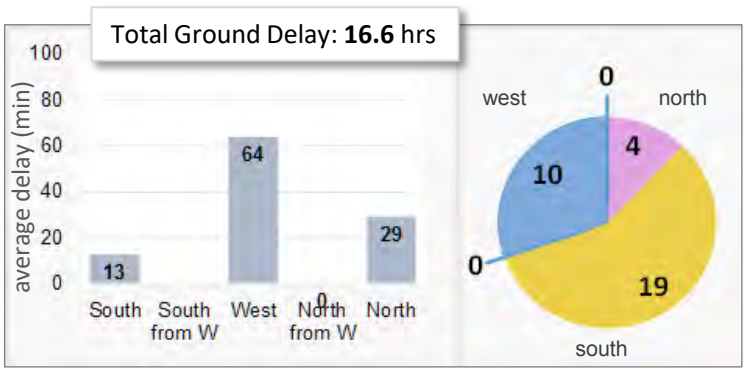


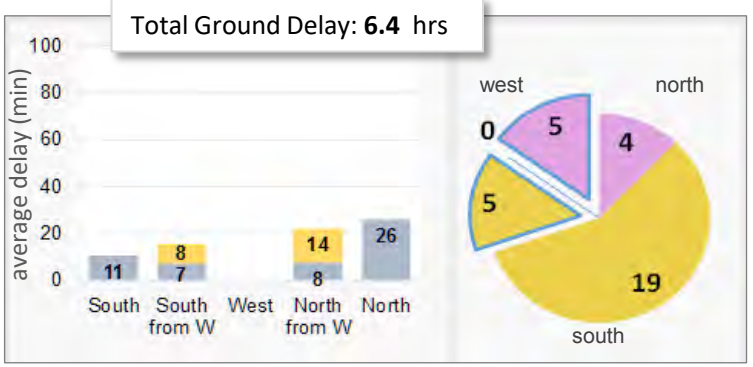




## AMERICAN AIRLINES



# Summary

- Coordination of two Decision Support Systems to manage demand across multiple constraints
- "Stakeholder-centric" approach
  - Ongoing relationships with FAA Operational Concepts, Validation and Requirements Office (AJV-7); CDM Flow Evaluation Team; and TFMS Deployment Team
  - Valuable input on concept feasibility, potential benefits, operational concerns, metrics, implementation barriers, etc.
- Workshops in March 2018
  - Both the system and airline benefits, especially for TOS "early adopters"
  - Addressed key concerns for stakeholders on the cost and benefits of early adoption - *has been a key implementation barrier*
- IDM concept and procedures are maturing and on track to be completed by the end of its project cycle (FY20/FY21)

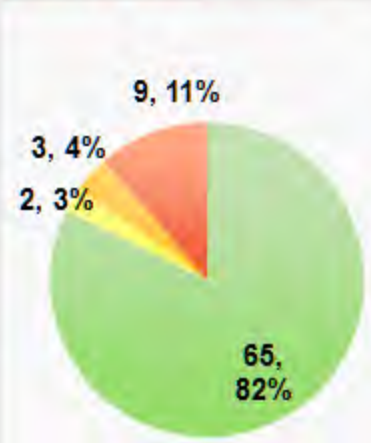
# BACK-UP SLIDES

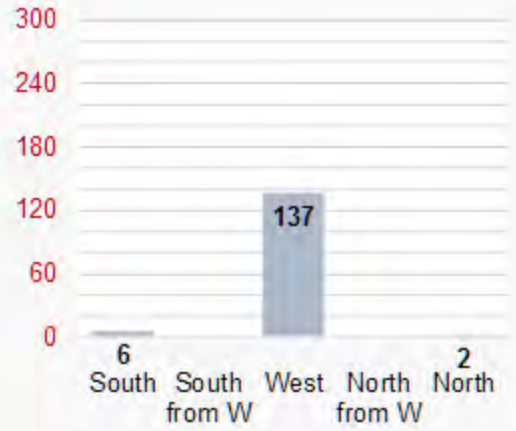
# Results: Delta and American, no flights submit TOSs

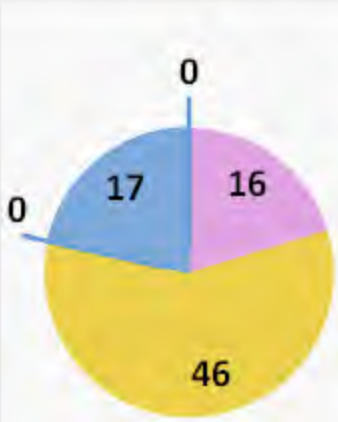
## Results by Airline: No TOS Options submitted

### DELTA

| | |
|---|---|
| Total flight count: | 99 |
| Eligible flights only: | 79 |
| Total Ground Delay: | 2629 min |
| TOS-rerouted flights | 0 |
| Flight Time Increase | 0 min |
| Ground Delay Savings | 0 min |

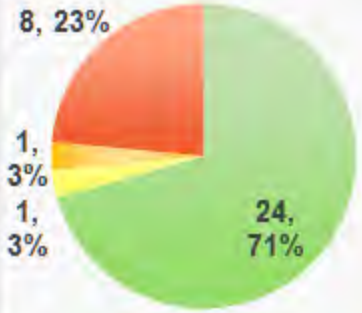


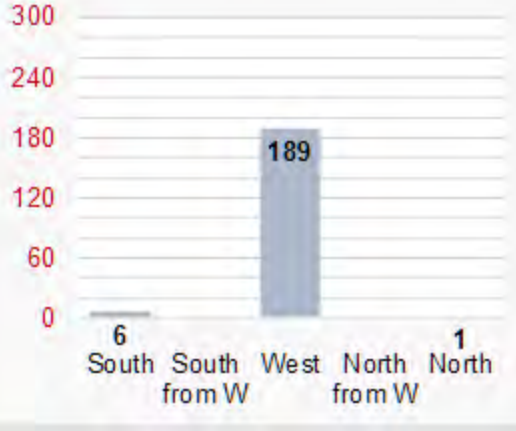



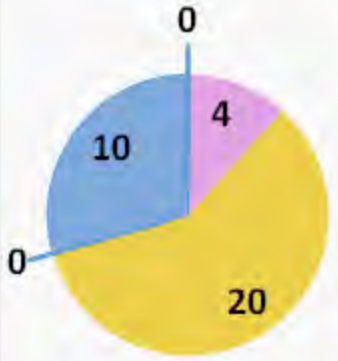




### AMERICAN

| | |
|---|---|
| Total flight count: | 45 |
| Eligible flights only: | 34 |
| Total Ground Delay: | 2017 min |
| TOS-rerouted flights | 0 |
| Flight Time Increase | 0 min |
| Ground Delay Savings | 0 min |



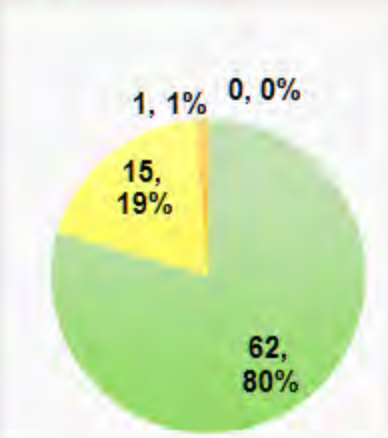



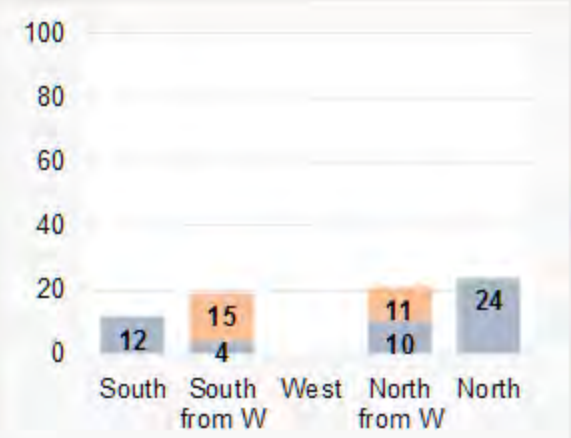
# Results: Delta and American, Delta submits TOSs

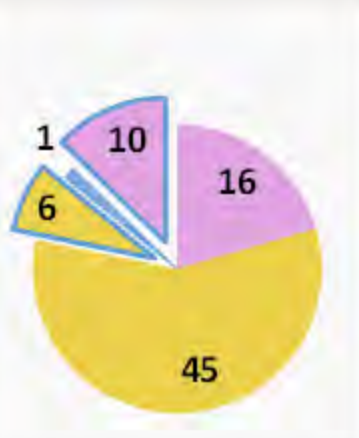
## Results by Airline: TOS Options submitted

**DELTA**

| | |
|---|---|
| Total flight count: | 99 |
| Eligible flights only: | 78 |
| Total Ground Delay: | 1026 min |
| TOS-rerouted flights: | 16 |
| Flight Time increase: | 196 min |
| Ground Delay Savings: | 819 min |



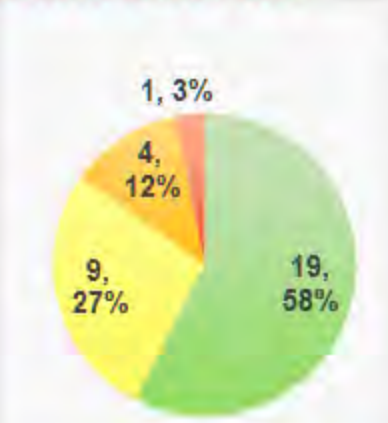



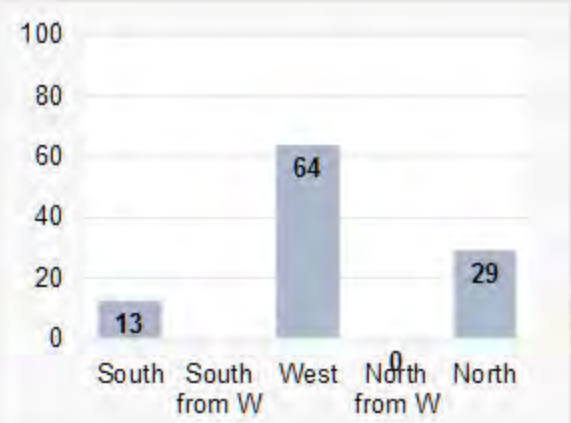



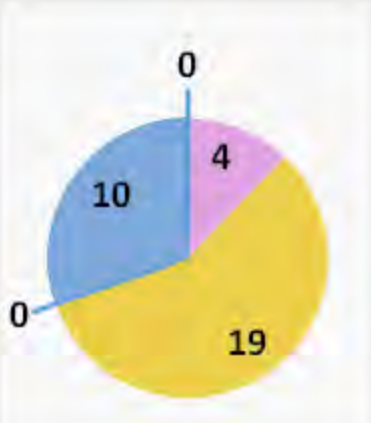

## Results by Airline: No TOS Options submitted

**AMERICAN**

| | |
|---|---|
| Total flight count: | 45 |
| Eligible flights only: | 33 |
| Total Ground Delay: | 993 min |
| TOS-rerouted flights: | 0 |



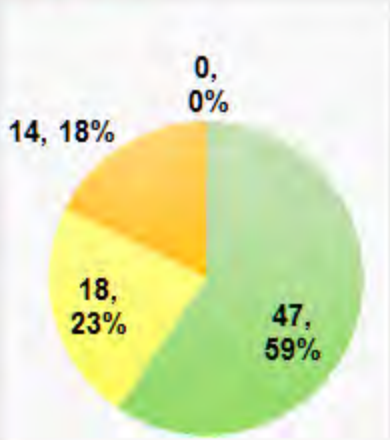



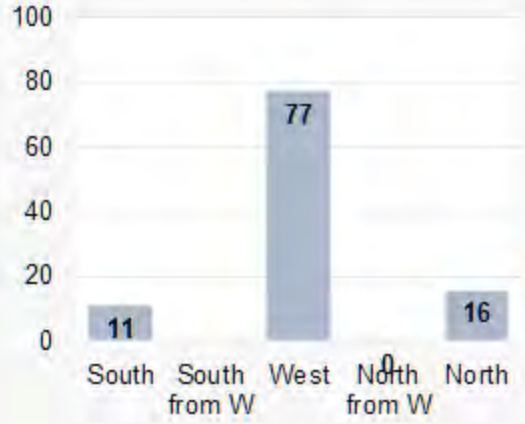
# Results: Delta and American, all airlines *except* Delta submit TOSs

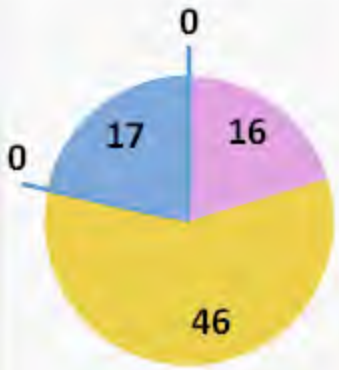
## Results by Airline: NOT TOS-Capable

### DELTA

| | |
|---|---|
| Total flight count: | 99 |
| Eligible flights only: | 79 |
| Total Ground Delay: | 2064 min |
| TOS-rerouted flights: | 0 |
| Flight Time increase: | 0 min |
| Ground Delay Savings: | 0 min |



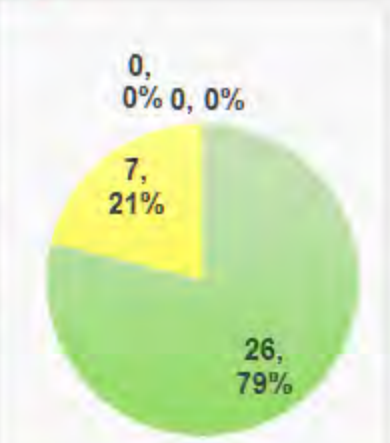



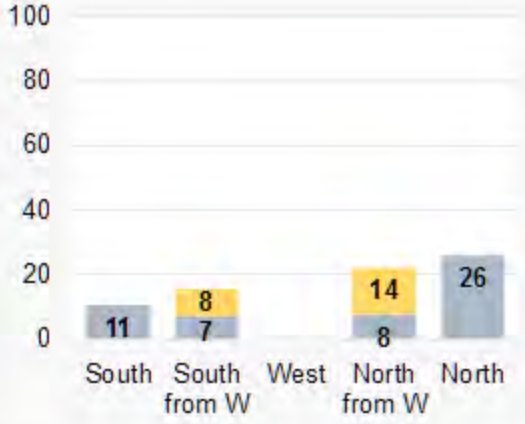



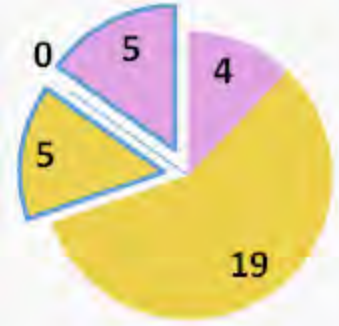

## Results by Airline: TOS-Capable

### AMERICAN

| | |
|---|---|
| Total flight count: | 45 |
| Eligible flights only: | 33 |
| Total Ground Delay: | 385 min |
| TOS-rerouted flights: | 10 |
| Flight Time increase: | 113 min |
| Ground Delay Savings: | 876 min |



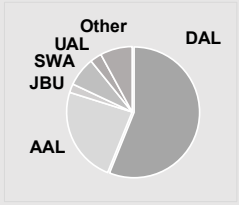



# Results: No-TOS vs. All TOS comparison, all flights

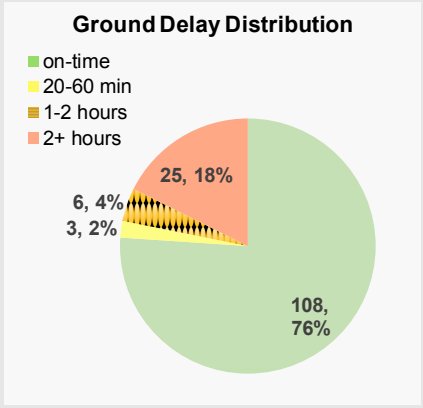
**Run 2: NO Airlines are TOS Capable** (Preliminary Run, 3/14/2018)

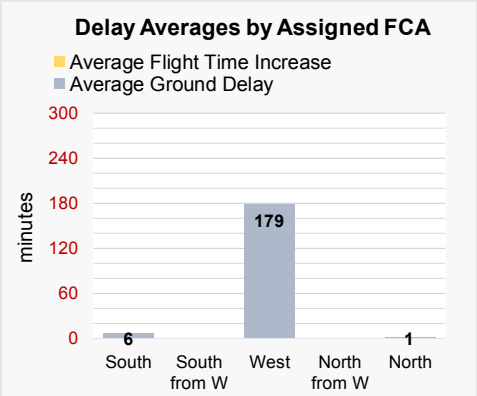
Average Arrival Rate: **33**

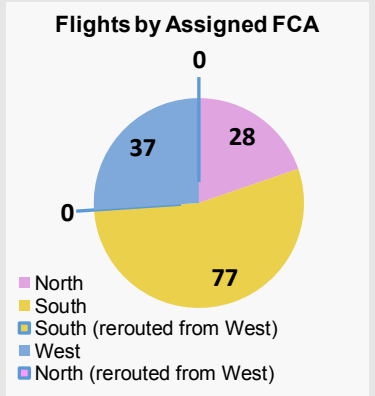



**ALL AIRLINES**

| | | |
|---|---|---|
| Total flight count: | **185** | |
| Eligible flights only: | **142** | |
| Total Ground Delay: | **7110** min | **118.5** hours |
| TOS-rerouted flights: | **0** | |
| Flight Time increase: | **0** min | **0.0** hours |
| Ground Delay reduction: | **0** min | **0.0** hours |

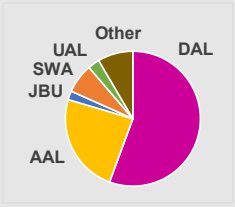


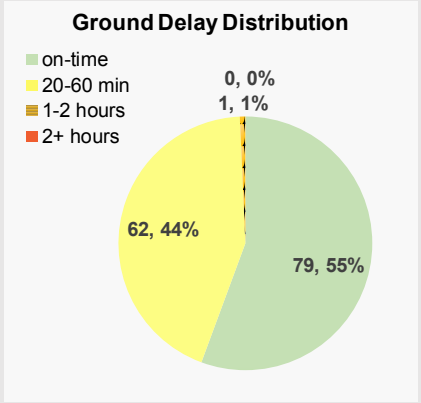

**Run 1: ALL airlines are TOS Capable** (Preliminary Run, 3/14/2018)

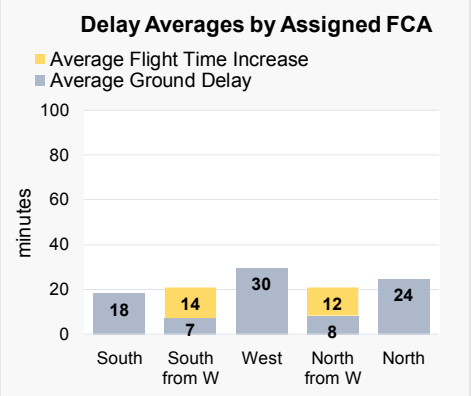
Average Arrival Rate: **36**

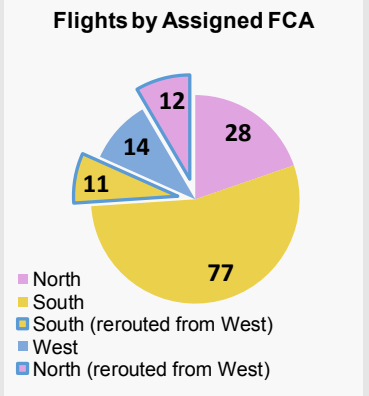



**ALL AIRLINES**

| | | |
|---|---|---|
| Total flight count: | **185** | |
| Eligible flights only: | **142** | |
| Total Ground Delay: | **2674** min | **44.6** hours |
| TOS-rerouted flights: | **23** | |
| Flight Time increase: | **298** min | **5.0** hours |
| Ground Delay reduction: | **717** min | **11.9** hours |



# Results: No-TOS vs. All TOS comparison

## Run 1. No Flights Submit Trajectory Options Sets

Throughput: **33** flights/hour

Ground Delay (total): **118.5** hours

TOS-reroutes: flights

Added flight time (total): hours

14/2018)

**Run 2: NO Airlines are TOS Capable** (Preliminary Run, 3/14/2018)

Ground Delay Distribution

me
0 min
ours
ours

25, 18%

4%
2%

108,
76%

Delay Averag

Average Flight Time increase

Average Ground

300
240
180
120
60
0

minutes

6

South

South
from W

Average Arrival Rate: **33**

ALL AIRLINES

| | | |
|---|---|---|
| Total flight count: | **185** | |
| Eligible flights only: | **142** | |
| Total Ground Delay: | **7110** min | **118.5** hours |
| TOS-rerouted flights: | **0** | |
| Flight Time increase: | **0** min | **0.0** hours |
| Ground Delay reduction: | **0** min | **0.0** hours |

Other
UAL
DAL
SWA
JBU
AAL

Ground Delay Distribution

on-time
20-60 min
1-2 hours
2+ hours

25, 18%
6, 4%
3, 2%
108,
76%

300
240
180
120
60
0

minutes

## Run 2. All Flights Submit Trajectory Options Sets

Throughput: **36** flights/hour

Ground Delay (total): **44.6** hours

TOS-reroutes: **23** flights

Added flight time (total): **5.0** hours

3/14/2018)

**Run 1: ALL airlines are TOS Capable** (Preliminary Run, 3/14/2018)

Ground Delay Distribution

ime
60 min
hours
hours

0, 0%
1, 1%

62, 44%

79, 55%

Delay Averag

Average Flight Time increase

Average Ground De

100
80
60
40
20
0

minutes

18

14
7

South

South
from W

Average Arrival Rate: **36**

ALL AIRLINES

| | | |
|---|---|---|
| Total flight count: | **185** | |
| Eligible flights only: | **142** | |
| Total Ground Delay: | **2674** min | **44.6** hours |
| TOS-rerouted flights: | **23** | |
| Flight Time increase: | **298** min | **5.0** hours |
| Ground Delay reduction: | **717** min | **11.9** hours |

Other
UAL
DAL
SWA
JBU
AAL

Ground Delay Distribution

on-time
20-60 min
1-2 hours
2+ hours

0, 0%
1, 1%
62, 44%
79, 55%

Ave
Ave
100
80
60
40
20
0

minutes

# Results: No-TOS vs. All TOS comparison

## Run 1. No Flights Submit Trajectory Options Sets

**2: NO Airlines are TOS Capable** (Preliminary Run, 3/14/2018)

Throughput: **33** flights/hour

Ground Delay (total): **118.5** hours

TOS-reroutes: flights

Added flight time (total): hours

age Arrival Rate: **33**

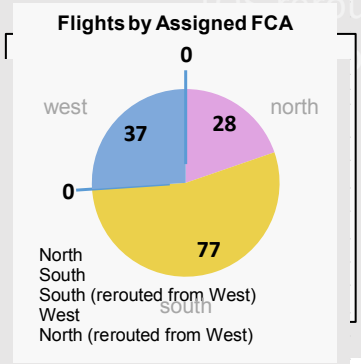
IRLINES

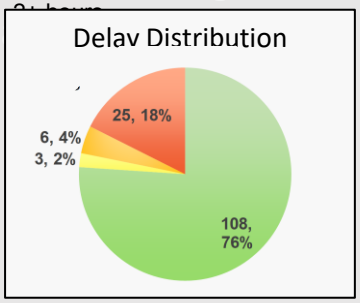
e Flight Time Increase
e Ground Delay

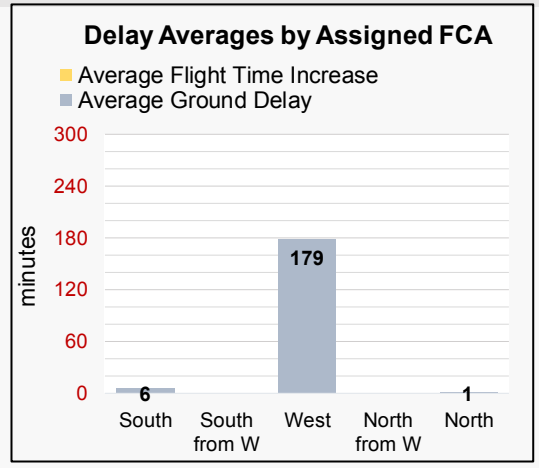
179

South from W | West | North from W | North

1




Flights by Assi

0

37

0

North
South
South (rerouted from
West
North (rerouted from

## Run 2. All Flights Submit Trajectory Options Sets

**1: ALL airlines are TOS Capable** (Preliminary Run, 3/14/2018)

Throughput: **36** flights/hour

Ground Delay (total): **44.6** hours

TOS-reroutes: **23** flights

Added flight time (total): **5.0** hours

age Arrival Rate: **36**

IRLINES

Total flight count: **185**

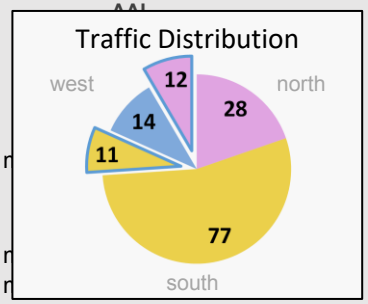
gible flights only: **142**

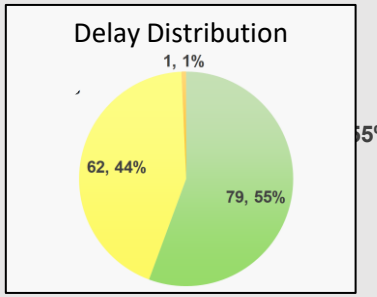
Total Ground Delay: **2674** r

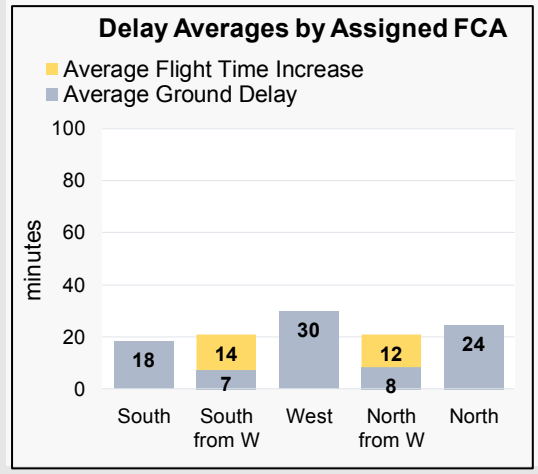
-rerouted flights: **23**

Flight Time increase: **298** r

nd Delay reduction: **717** r




Flights by Ass

12

14

11

North
South
South (rerouted fro
West
North (rerouted fro

# Results: Participant Feedback

LGA problem really struck home for working group

Advantages of concept and CTOP itself were immediately apparent

...



29

# TOS List Sample

Original FCA

Main carrier regional flights will be denoted with an R in the call sign. UAL = UAR

| Callsign | FCA | TOS Option | Flight Plan |
|---|---|---|---|
| UAL556 | WEST | 1 | KDEN./.ZIRKL..MCK..LNK.J60.DJB..YNG..ETG.MIP4.KLGA |
| UAL556 | SOUTH | 2 | KDEN./.PER..RZC..ARG.J46.BNA.J42.BKW.J42.GVE.KORRY4.KLGA |
| UAL556 | NORTH | 3 | KDEN./.BRYCC..TAYOT..DAYYY..RUBKI..SIKBO..TULEG..RKA.HAARP3.KLGA |
| UAR4314 | WEST | 1 | KCLE./.FAILS..JFN..ETG.MIP4.KLGA |
| UAR4314 | NORTH | 2 | KCLE./.FAILS..ERI..JHW..MEMMS..WILET..RKA.HAARP3.KLGA |
| UAR5706 | WEST | 1 | KORD./.MOBLE..ADIME..GERBS.J146.ETG.MIP4.KLGA |
| UAR5706 | NORTH | 2 | KORD./.HANKK..EXTOL..RKA.HAARP3.KLGA |
| UAR5706 | SOUTH | 3 | KORD./.EARND..ELANR..EMMLY..ERECO..IIU.J526.BKW.J42.GVE.KORRY4.KLGA |
| UAR6256 | SOUTH | 1 | KIAD./.AGARD.KORRY4.KLGA |