THE GOLD STANDARD FOR AVIATION SINCE 1935

Approved by the NextGen Advisory Committee October 2017

Joint Analysis Team: Performance Assessment of Boston/Gary Optimal Profile Descents and DataComm

Report of the NextGen Advisory Committee in Response to Tasking from the Federal Aviation Administration

October 2017

Joint Analysis Team: Performance Assessments of BOS/GYY OPDs & Datacomm

Contents

Introduction/Background

The NextGen Advisory Committee (NAC) has been instrumental in helping the Federal Aviation Administration (FAA) move forward with NextGen implementation. In 2014, the Committee approved a recommendation for a set of integrated plans on four focus areas of NextGen capabilities (DataComm, Multiple Runway Operations, PBN, and Surface).

These plans were developed by a joint FAA-Industry team, the NextGen Integration Working Group (NIWG), operating under the NAC. The goal of the NIWG is to identify implementation priorities that deliver measurable benefits by certain dates, and, thereby, increase the community's confidence in NextGen.

In June 2015, the NAC considered and approved six high level performance metrics intended to measure performance impacts attributable to the deployment of the four key NIWG capabilities outlined in the "NextGen Priorities Joint Implementation Plan" of October 2014. The set of metrics are intended for the FAA and industry to collaboratively monitor performance to understand the impact of implementations. The six metrics (detailed in Appendix B) are:

1. Actual Block Time
2. Actual Distance Flown
3. Estimated Fuel Burn

} Measured by city pairs

4. Throughput – Facility Reported Capacity Rates
5. Taxi-Out Time
6. Gate Departure Delay

} Measured at airports

Subsequently, the NAC formed the Joint Analysis Team (JAT) which includes operational and analytical experts from the FAA and industry. The JAT was formed to reach a common statement of fact regarding performance impacts and benefits that can be attributed to implementation of NextGen capabilities. To accomplish this goal, the JAT has analyzed data, metrics, methods and tools typically used by each of the parties in this type of assessment. This has included analyses of other measures deemed appropriate beyond the six metrics noted above.

The JAT has previously evaluated the following capabilities at the following locations:

- Wake ReCat Implementations at Charlotte Douglass International Airport (CLT), O'Hare International Airport (ORD), Chicago Midway International Airport (MDW), Indianapolis International Airport (IND) and Philadelphia International Airport (PHL)
- Performance Based Navigation (PBN) Metroplex Implementation in North Texas
- PBN Established on RNP (EoR) in Denver International Airport (DEN)

This report includes findings on Optimal Profile Descent (OPD) implementations in Boston Logan International Airport (BOS) and Gary/Chicago International Airport (GYY) as well as impacts of implementation of Data Communications.

Methodology

The JAT is comprised of data and analysis experts from the FAA as well as the aviation industry, and the team conducted a series of meetings to discuss and review ongoing analysis. For the OPD analyses, this team utilized a methodology previously agreed upon by the JAT to evaluate the change in time, distance and fuel in a terminal environment.

For the DataComm analysis, the JAT worked with the FAA's DataComm Program Office and their primary contractor, Harris Corporation, to develop the logic of an analysis methodology. The Harris Corporation was instrumental in providing operational data that the JAT processed and analyzed according to the agreed upon methodology.

The working dynamic between the FAA and industry team members remains a positive and professional one in which capable analysts from different perspectives challenged one another's perspectives. The final product of this body is the result of strong collaboration and sharing of data and ideas between the FAA and industry. The JAT continues to build trust and confidence amongst members throughout this process.

Summary of Findings

Boston OPDs

- For flights that reach cruise altitude outside 200 NM from Boston
  - Vertical profiles have improved through increased proportion of continuous descent operations, and shorter time and distance in level flight
  - Approximately 30 kg fuel savings per flight are attributable to OPDs
  - Observed minimal change in flight time, and between 0.2 and 0.6 nm increase in flight distance
- For flights that do reach cruise altitude inside 200 NM (includes flights from New York area to Boston)
  - Vertical profiles have improved through shorter time and distance in level flight
  - Approximately 20-25 kg fuel savings per flight are attributable to OPDs
  - Observed minimal change in flight time, and between 0.7 and 1.1 nm decrease in flight distance

Gary OPDs

- Safety benefits resulting from reduced interaction of high performance jets with VFR traffic, and from reduced interaction between Midway and Garry-Indiana traffic flows
- The JAT was unable to quantify benefits because of the small data sample; however, operator reported savings in fuel burn

DataComm

- Use of DataComm for delivering route revision clearances results in reduced workload for pilots and controllers
- Analysis demonstrates that flights using DataComm for route revision clearance exhibit shorter taxi-out times compared to those that use voice
  - Because of differences in demand profiles and airport geometry, feasibility of resequencing departures varies across airports, and causes variation in magnitude of benefit by airport
  - On average, taxi-out time savings are between 0.2 and 8.5 minutes for DataComm equipped aircraft with route revisions during May and June 2017 at BWI, EWR, DFW, MDW and PHX.
- Individual airlines prefer to evaluate DataComm benefits on a network (including all airports that provide DataComm service) or fleet level (i.e., narrow vs. wide body aircraft).
  - Network analysis by one large operator resulted in approximately 2.8 minutes of savings in average taxi out time for flights that used DataComm for route revision clearance compared to those that used voice.

Appendix A: Organizations Participating in the Joint Analysis Team

Airlines for America

Airports Council International (ACI North America)

American Airlines, Inc.

Cessna Aircraft Company

City of Houston, Texas

Dallas/Fort Worth International Airport

Delta Air Lines, Inc.

Federal Aviation Administration (FAA)

FedEx Express

Harris Corporation

ITI Aviation

JetBlue Airways

Jetcraft Avionics LLC

Landrum-Brown

National Air Traffic Controllers Association (NATCA)

PASSUR Aerospace

QED Consulting, LLC

RTCA, Inc.

Southwest Airlines

The MITRE Corporation

United Airlines, Inc.

United Parcel Service (UPS)

Appendix B: NAC Performance Metrics

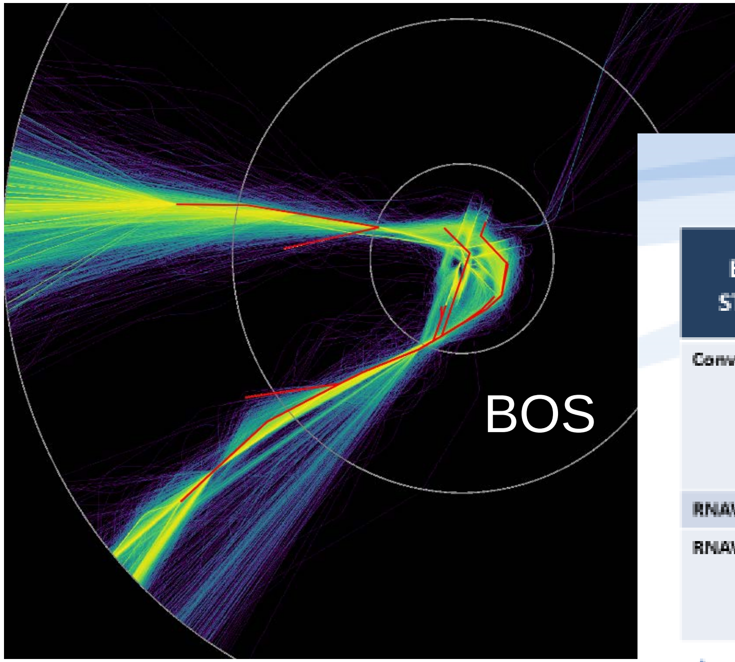
		Metric	Reported Values	Comments[1]
Measured on applicable existing *104* city-pairs:	1.	Actual block time	Mean and std dev or 60% percentile	• Actual time from Gate-Out time to Gate-In time for a specified period of time by city pair • GA: I FR flight time from ramp taxi to ramp park
	2.	Actual distance flown	Mean and std dev or 60% percentile	• Actual track distance between key city pairs for a specified period of time • GA: IFR flight distance from take-off to TOC & from TOD to touch down
	3.	Estimated Fuel burn	Mean and std dev	• Actual fuel burn for a specified period of time
Measured at applicable airports	4.	Throughput - facility reported capacity rates *	Mean and peak capacity rates	• Facility Airport Arrival Rates (AAR) & Arrival Departure Rate (ADR) Airlines (recommend: http://www.fly.faa.gov/ois/ however, the working group is open to alternate measurements that meet the requirements) • GA: measured as access events - Radar vector and not SID as OUT event and Ground based nav and not GPS / WAAS-LPV as IN event
	5.	Taxi-out Time *	Mean and std dev or 60% percentile	• Actual time from Gate-Out to Wheels-Off time by airport (minutes/flight) • GA: IFR flight taxi time from ramp taxi to take off
	6.	Gate Departure Delay	Delays/100 act depts. And total delay minutes	• Difference in actual Gate-Out time and scheduled Gate-Out time, Not measured for GA

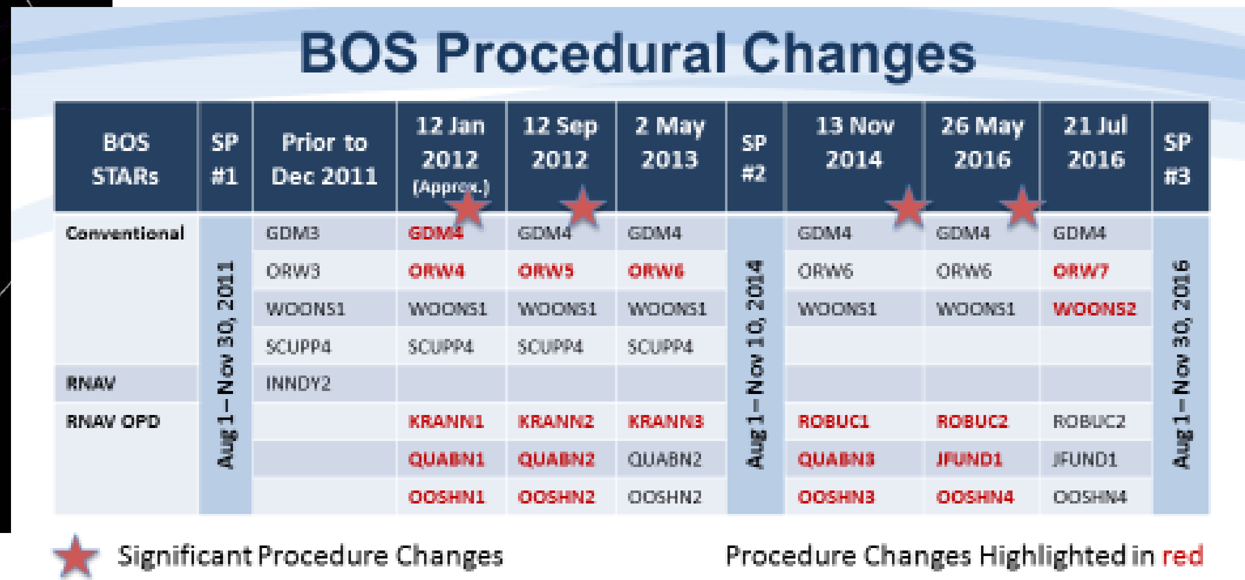
*** - Identified by FAA**
1 GA data may not currently be collected

2

Appendix C: Further Detail on Methodology and Analysis

RNAV STARs with OPDs at BOS



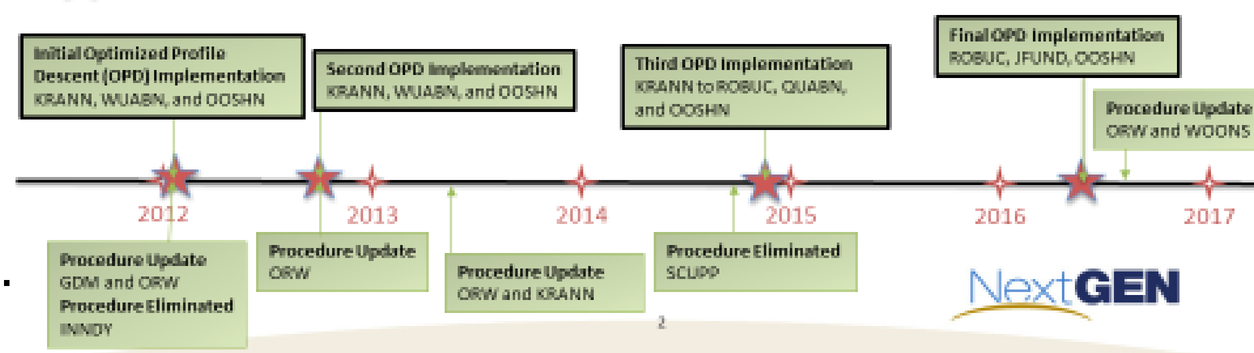


BOS Procedural Changes

BOS STARs	SP #1	Prior to Dec 2011	12 Jan 2012 (Approx.) ★	12 Sep 2012 ★	2 May 2013	SP #2	13 Nov 2014 ★	26 May 2016 ★	21 Jul 2016	SP #3
Conventional	Aug 1 – Nov 30, 2011	GDM3	GDM4	GDM4	GDM4	Aug 1 – Nov 10, 2014	GDM4	GDM4	GDM4	Aug 1 – Nov 30, 2016
		ORW3	ORW4	ORW5	ORW6		ORW6	ORW6	ORW7	
		WOONS1	WOONS1	WOONS1	WOONS1		WOONS1	WOONS1	WOONS2	
		SCUPP4	SCUPP4	SCUPP4	SCUPP4					
RNAV		INNDY2								
RNAV OPD			KRANN1	KRANN2	KRANN3		ROBUC1	ROBUC2	ROBUC2	
			QUABN1	QUABN2	QUABN2		QUABN3	JFUND1	JFUND1	
			OOSHN1	OOSHN2	OOSHN2		OOSHN3	OOSHN4	OOSHN4	

★ Significant Procedure Changes

Procedure Changes Highlighted in red



Between 2012 and 2016, there were five iterations of OPD implementations and amendments at BOS.

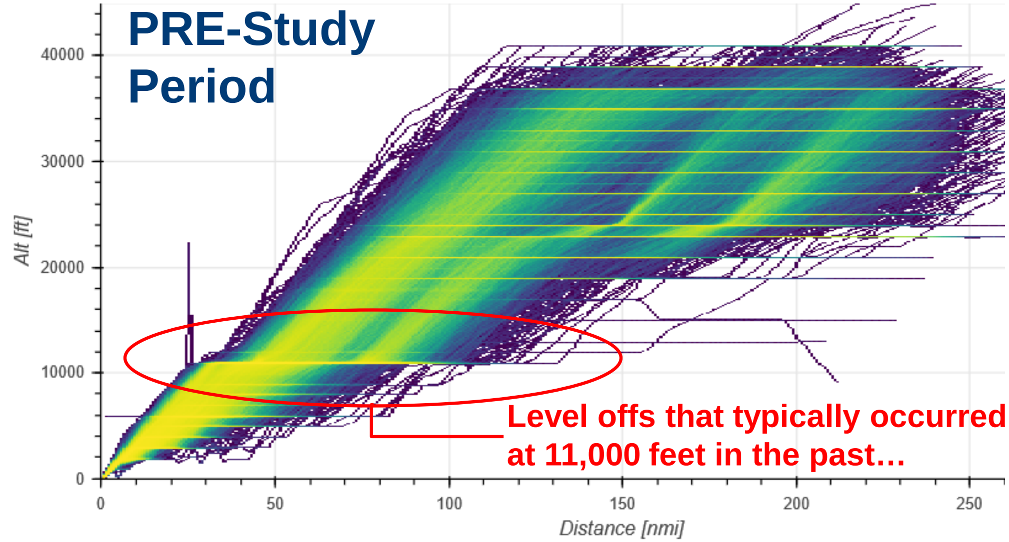
Study Approach

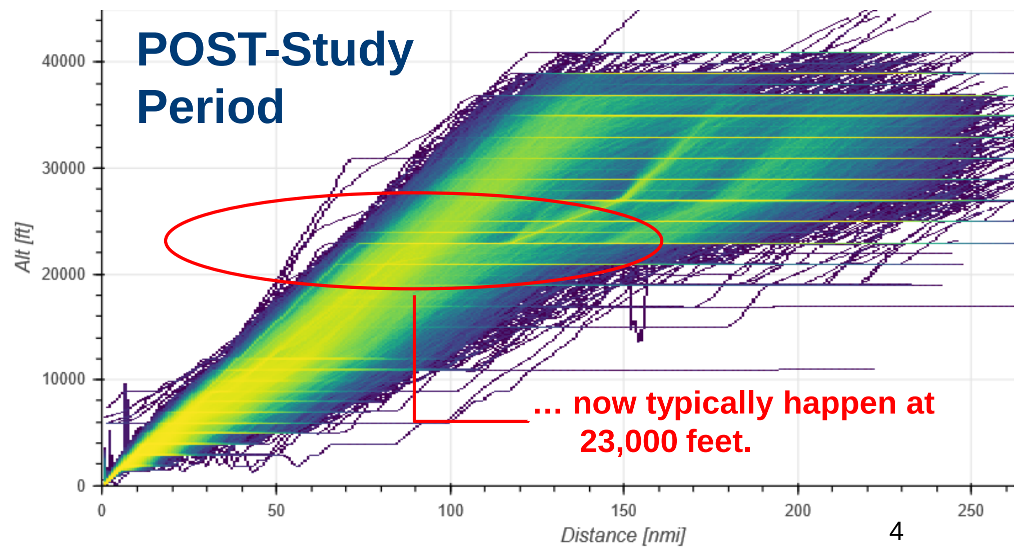
- Compare trajectories from before OPD implementation to trajectories after the latest amendments were enacted <u>while holding everything else constant</u>
- Unfortunately, neither the NAS, the weather, nor the operators hold things constant
  - Runway improvements/closures
  - Discontinued use of CRO
  - Weather/Wind
  - Fleet Mix and TAS
  - Demand and new city pairs

Vertical Efficiency with BOS OPDs has Improved

BOS ARR: LONG Flights*	Pre to Post	
	100nm	40nm
Change in Proportion of CDOs	1.6%	9.8%
Change in Time in Level Flight (min)	-1.6	-1.5
Change in Distance in Level Flight (nm)	-8.6	-9.4
Change in Altitude at Ring (ft)	755	1,767

* Flights reaching their cruise altitude outside 200nm from BOS





BOS OPD: Change in Performance Outcomes of Long Flights

BOS ARR: LONG Flights	Pre to Post (per flight)			
	200nm Observed	200nm OPD Driven*	100nm Observed	100nm OPD Driven
Change in MITRE Fuel Burn (kg)	3.9	-27.9 to -30.9	-27.6	-24.8 to -27.9
Change in Flight Time (min)	0.6	Minimal	0.4	Minimal
Change in Flight Distance (nm)	1.0	0.2 to 0.6	0.6	0.2 to -0.2
Change in Average Wind Speed (kts)	11.0	N/A	6.6	N/A
Change in Average True Air Speed (kts)	4.2	N/A	1.1	N/A

* Adjustments made to isolate OPD impacts

Non-OPD Event (at 200 nm)	Fuel Impact (kg)
Entry Point Altitude Change (-511 ft)	6.7
Change in Winds (11 kts)	22.2
CRO Implementation (0.4 to 0.8 nm)	3.0 to 6.0
Higher True Airspeed (4.2 kts)	Not included in the adjustments due to many influencing factors

BOS OPD: Change in Performance Outcomes of Short* Flights

(from JFK, EWR or LGA)

Changes in Vertical Efficiency

BOS ARR: Short Flights	Pre to Post (per flight)	
	100nm	40nm
Proportion of CDOs	0.0%	21.6%
Time in Level Flight (min)	-0.7	-1.2
Distance in Level Flight (nm)	-3.4	-7.4
Altitude at Ring (ft)	451	1,925

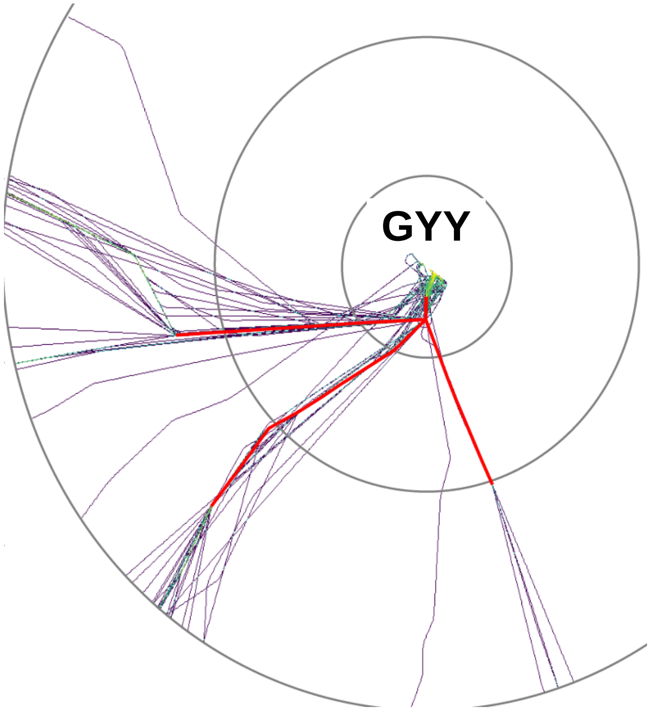
Changes in Other Perf. Outcomes

BOS ARR: Short Flights	Pre to Post (per flight)	
	100nm Observed	100nm OPD Driven**
MITRE Fuel Burn (kg)	-6.7	-21.9 to -24.5
Flight Time (min)	0.5	Minimal
Flight Distance (nm)	-0.3	-0.7 to -1.1
Average Wind Speed (kts)	8.3	N/A
Average True Airspeed (kts)	-0.7	N/A

* Flights reaching their cruise altitude within 200nm from BOS
** Adjustments made to isolate OPD impacts

Since short flights are typically still ascending 200nm out of BOS, OPD impacts on these flights were investigated within 100 NM of the airport

OPDs at GYY



- GYY is GA airport that utilizes same STAR as MDW arrivals
- Before GYY OPD (LUCIT 1), GYY arrivals:
  - Broken off STAR, vectored ~40 miles as low as 3000 feet
  - Traversed airspace with high VFR traffic that drove TCAS RAs
- Operated at low altitudes out of ORD's Mode C veil – some VFR aircraft only identified visually
  - Had safety challenges that drove ASAP reports
- Users are pleased with the new OPDs from the west and de-confliction of MDW traffic, which provide significant safety benefit and improved efficiency
- Data sample was too small for the JAT to quantify change
  - Small signal supporting fuel burn savings

GYY OPDs: Weighted Perf. Outcomes

200nm to Airport	Pre	Post	Weighted Change
MITRE Fuel Burn (kg)	398.6	348.7	-10.9
Flight Time (min)	38.6	[illegible]	[illegible]
Flown Distance (nm)	218.8	[illegible]	[illegible]
Avg Wind Speed (kts) at 200nm Ring*	[illegible]	[illegible]	[illegible]
Avg True Air Speed at 200nm Ring (kts)	[illegible]	[illegible]	[illegible]
Altitude at Ring (ft)	[illegible]	[illegible]	224

100nm to Airp[illegible]	[illegible]	[illegible]st	Weighted Change
MITRE Fuel Burn (k[illegible]	[illegible]	187.5	-3.5
Flight Time ([illegible]	[illegible]	23.6	0.5
Flown Dis[illegible]	113.7	112.9	0.7
Avg Wind Spe[illegible]	-10.5	-12.7	-3.2
Avg True Air Spee[illegible]	310.4	302.6	-9.2
Altitude at Ring (ft)	22,055	22,682	721

Sample too small to estimate savings

** Negative value indicates tailwind*

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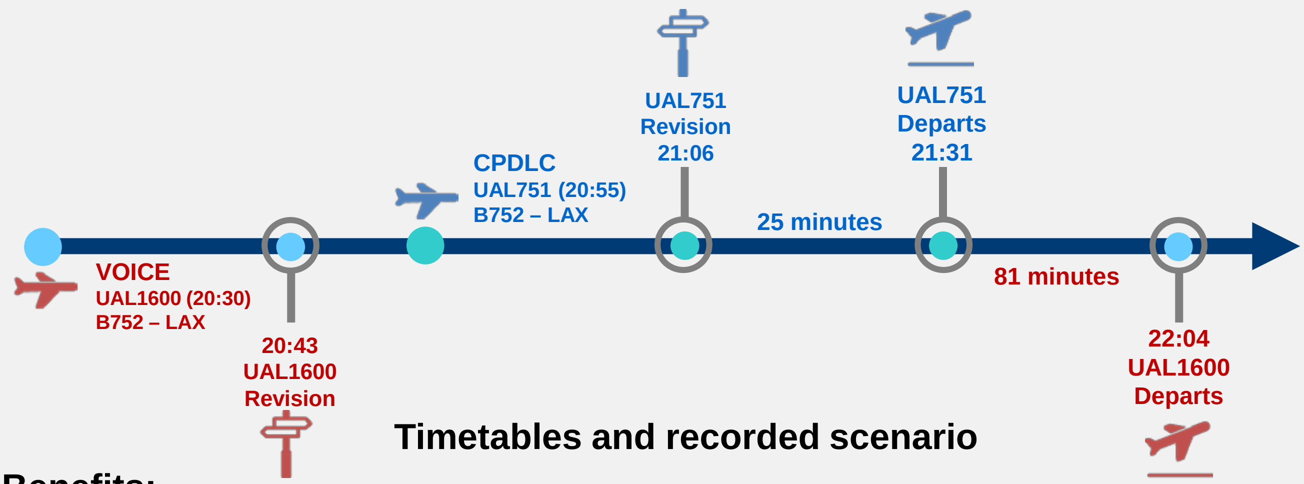
JAT Analysis Of Benefits from DataComm Pre-departure Route Revision Clearance

Background

- JAT recognizes that DataComm is clearly reducing workload related constraints on airline departures
- DataComm's primary benefit mechanism is in *reducing negative impacts* of ground delay programs and ground stops, airport reconfigurations, convective weather, and airspace congestion
- Past reporting from the PMO and several airlines have already confirmed that using DataComm to communicate pre-departure route revision clearances during adverse weather events is beneficial and reduces delay
- *JAT's objective was to develop a methodology to capture benefits in a consistent manner across applicable conditions and flights*
    - Harris Corp. provided merged FANS, FDPS, and ASPM records to the JAT
        - The FAA team received May-Jun 2017 data for BWI, DFW, EWR, MDW and PHX
        - Airlines received their individual network data for Apr-Jul 2017

DataComm Benefits:
Off-nominal Event at EWR on April 20, 2017



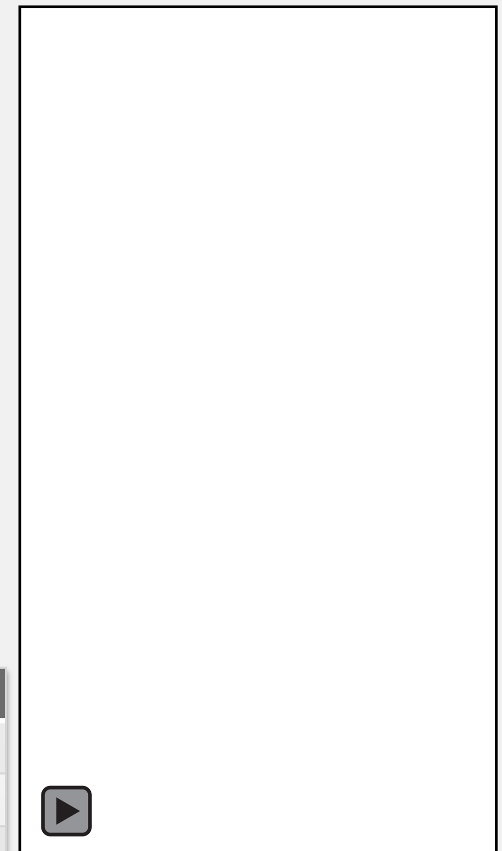
Timetables and recorded scenario

Benefits:

- CPDLC flight pushes after voice flight, able to depart first
- 56 minute time savings for CPDLC flight compared to voice flight

Time	Event
20:55	UAL751 (CPDLC) Clearance
21:06	UAL751 (CPDLC) Revision
21:31	UAL751 (CPDLC) Departure

Time	Event
20:30	UAL1600 (Voice) Clearance
20:43	UAL1600 (Voice) Revision
22:04	UAL1600 (Voice) Departure



Source: Harris Corp.

JAT Recommended Methodology

- Compare ASPM gate delays and actual taxi-out times of DataComm flights with route revision clearance to those of non-DataComm flights with route revision clearance during same time period and location
- Applicable flights
  - All OOOI reporting flights with route revision clearances at airports with data availability
    - Preferred analysis would include all DataComm airports i.e. NAS or airline network based
  - Individual carriers may need to focus on specific aircraft or operation types to support their analyses and decision-making (such as narrow and wide body aircraft, or exclude regionals)
- Applicable savings
  - Taxi Out Time Savings for flights that received RR DCL within 30mins before leaving gate and take-off
    - Out event - 30 minutes <= RR DCL Time < Off event
  - Gate Delay Savings for flights that received RR DCL within 30mins before leaving gate and pushback
    - Out event - 30 minutes <= RR DCL Time < Out event
- Applicable conditions
  - All conditions with route revisions: while DataComm use may be more beneficial during special off-nominal events, it is very hard to identify such events consistently across all locations

High-level Savings Summary*

All Carriers, all AC types and all periods											
		Taxi Out Time (mins)					Gate Delay (mins)				
Apt.	Comm Equipment	Num Flts	Total	Avg.	Avg. Saving	Total Savings	Num Flts	Total	Avg.	Avg. Saving	Total Savings
KBWI	Non-Data Comm	397	10,055	25.3			88	2,386	27.1		
KBWI	Data Comm	240	6,034	25.1	0.2	45	51	1,284	25.2	1.9	99
KDFW	Non-Data Comm	1,033	33,049	32.0			102	2,942	28.8		
KDFW	Data Comm	361	8,489	23.5	8.5	3,061	44	922	21.0	7.9	347
KEWR	Non-Data Comm	1,241	50,471	40.7			86	3,102	36.1		
KEWR	Data Comm	270	10,237	37.9	2.8	744	18	411	22.8	13.2	238
KMDW	Non-Data Comm	151	3,503	23.2			30	898	29.9		
KMDW	Data Comm	172	3,956	23.0	0.2	34	39	653	16.7	13.2	514
KPHX	Non-Data Comm	275	4,886	17.8			57	1,803	31.6		
KPHX	Data Comm	85	1,159	13.6	4.1	351	20	458	22.9	8.7	175
"Network" Savings					**3.8**	**4,234**				**8.0**	**1,373**

* Additional Considerations:

- Min group size of 30 DataComm and non-DataComm flights
- Min period of three months by each of the airports with DataComm capability
- Investigate and remove outliers in performance outcomes caused by data errors, but not outliers in performance outcomes that are driven by adverse conditions

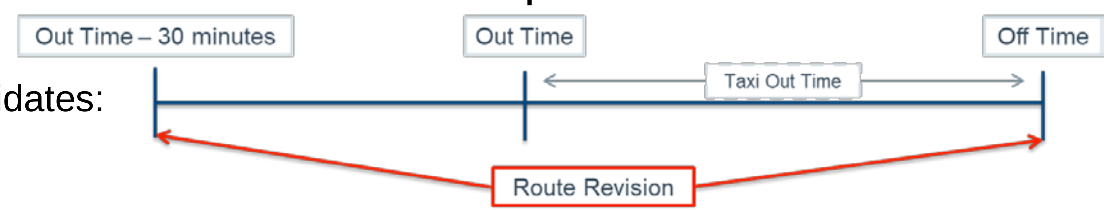
High-level Savings Summary* without Regional Aircraft

All Carriers, Narrow and Wide Body AC types, and all periods											
		Taxi Out Time (mins)					Gate Delay (mins)				
Apt.	Comm Equipment	Num Flts	Total	Avg.	Avg. Saving	Total Savings	Num Flts	Total	Avg.	Avg. Saving	Total Savings
KBWI	Non-Data Comm	362	9,116	25.2			81	2,251	27.8		
KBWI	Data Comm	240	6,034	25.1	0.0	10	51	1,284	25.2	2.6	133
KDFW	Non-Data Comm	661	20,602	31.2			67	1,919	28.6		
KDFW	Data Comm	361	8,489	23.5	7.7	2,763	44	922	21.0	7.7	338
KEWR	Non-Data Comm	690	28,420	41.2			40	1,356	33.9		
KEWR	Data Comm	270	10,237	37.9	3.3	884	18	411	22.8	11.1	199
KMDW	Non-Data Comm	110	2,561	23.3			26	696	26.8		
KMDW	Data Comm	172	3,956	23.0	0.3	48	39	653	16.7	10.0	391
KPHX	Non-Data Comm	232	4,035	17.4			47	1,568	33.4		
KPHX	Data Comm	85	1,159	13.6	3.8	319	20	458	22.9	10.5	209
"Network" Savings					**3.6**	**4,024**				**7.4**	**1,271**

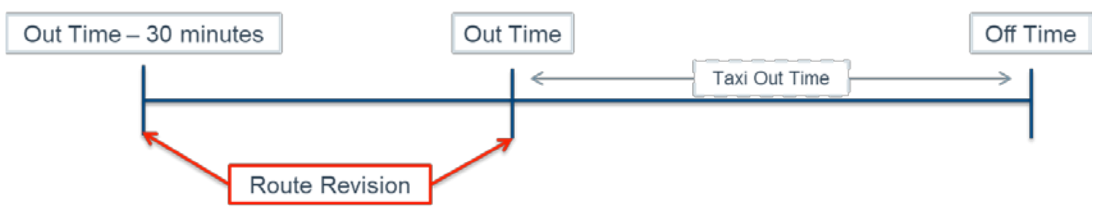
* Additional Considerations:
- Min group size of 30 DataComm and non-DataComm flights
- Min period of three months by each of the airports with DataComm capability
- Investigate and remove outliers in performance outcomes caused by data errors, but not outliers in performance outcomes that are driven by adverse conditions

American Airlines DataComm Review

- Used JAT methodology to analyze four months of AA network (CPDLC airports which AA operates) data: April – July, 2017
- Taxi out and gate delay of DataComm and non- DataComm flights which received route revision clearances compared
  - Taxi out time savings candidates:



  - Gate savings candidates:



- Program is popular with pilots: *almost 100% use when available*
- DataComm flights realized taxi out time and departure delay benefit

Benefit Type	Number of DataComm Flights	Avg. Savings per Flight (mins)	Overall Savings (hours)
Departure Delay Savings	1,435	4:58	118.8
Taxi Out Time Savings	2,544	2:48	118.7

DataComm Summary

- JAT finds a positive DataComm benefit signal across sample sites using a consistent methodology and data
  - Benefits measurable at both the Macro and Airline level
- Anecdotal feedback and logic supports DataComm's increased value during off nominal events
  - More analysis and possibly data collection is needed to quantify specific events
- Airlines/JAT request that Harris/FAA provide a merged data-set across all carriers and airports
  - Airlines prefer a network based analysis and desire special breakouts for their equipage business cases