RTCA

THE GOLD STANDARD FOR AVIATION SINCE 1935

Approved by the NextGen Advisory Committee June 2016

Joint Analysis Team: Performance Assessment of Wake ReCat

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

June 2016

Joint Analysis Team: Performance Assessment of Wake ReCat

Contents

Introduction/Background 3
Methodology 4
Summary of Findings 4
Summary of Data Analysis Results 5
Appendix A: Members of the Joint Analysis Team 6
Appendix B: NAC Performance Metrics 7
Appendix C: Detailed Methodology and Analysis of Wake ReCat 8

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. Additionally, the industry, through RTCA, selected PASSUR Aerospace to provide a database and associated analytical capability to track performance of these six metrics.

The JAT's scope involves evaluation of the following capabilities at the following locations:

- Wake ReCat Implementations at Charlotte Douglass International Airport (CLT) and two Chicago area airports – O'Hare International Airport (ORD) and Chicago Midway International Airport (MDW)
- Performance Based Navigation (PBN) Metroplex Implementation in North Texas
- PBN Established on RNP (EoR) in Denver International Airport (DEN)

This report includes findings on Wake ReCat implementations. Findings on the two PBN-related implementations are planned for October 2016.

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. This team initially agreed by consensus on a methodology to evaluate the impacts of ReCat. A subset of team members then utilized their own company data to assess ReCat using this methodology. Comparisons were conducted between the raw data from the FAA, American Airlines, United Airlines and eventually PASSUR. After validating the consistency of these data sources, team members utilized the agreed-upon methodology to analyze the impacts and benefits of ReCat. Again, comparisons were done between the FAA, airline and PASSUR to ensure consistency of results. Finally, the JAT utilized these analysis results to document agreed upon findings that follow in this report.

The working dynamic between the FAA and industry team members was 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 built trust and confidence amongst members throughout the process.

Summary of Findings

- Fleet mix and overall demand levels are critical drivers of ReCat impact. Busy airports with a higher presence of Heavy/C, B757/D and Small/F aircraft are expected to see the greatest impacts.
- Operational data demonstrates that ReCat achieves changes in separation when expected.
- Before and after analysis of airborne/taxi times and throughput are inconclusive due to exogenous factors, such as changes in demand, weather, airport construction, etc.
- Airborne or taxi out savings can be expected when ReCat impacted flights operate to an individual runway that is experiencing pressure. As long as pressure remains, savings accrue for all subsequent aircraft.
- Throughput improvement can be expected when ReCat-impacted flights operate in peak demand. Modeled throughput based on actual separation changes indicates improvement. Throughput improvements are empirically observed at ORD for IMC peak periods when ReCat pairs exist, but these are not sustained enough to justify an increase in called rate.
- The PASSUR data has been compared to FAA and industry data, and can be used as a trusted data source to evaluate the impact of Wake ReCat implementations.
- JAT's ReCat methodology may be leveraged to prioritize future implementations of ReCat.

Summary of Data Analysis Results

The JAT conducted ReCat analysis for three airport sites: CLT, ORD and MDW. Results are summarized in the table below. A full set of analysis details may be found in Appendix C.

Implications of Wake ReCat		*Airports*		
		CLT	**ORD**	MDW
Percent of eligible pairs[1] of flights at the airport potentially impacted by ReCat (% with decreased separation / % with increased separation)	**Arrivals**	2.6% / 0.0%	4.4% / 0.0%	1.1% / 0.0%
	Departures	3.3% / 1.1%	4.7% / 0.6%	1.1% / 7.6%
Modeled Potential Change in Throughput During Peak Periods due to ReCat (Operations per hour)	**Arrivals**	0.5	1.8	0.1
	Departures	0.6	1.5	-0.4
Estimated total savings in Airborne and Taxi Out Time due to ReCat[2]	**Airborne**	$180K	$590K	-$2K
	Taxi Out	$57K	$360K	-$32K
	Total	***$237K***	***$950K***	***-$34K***

[1] Eligible pairs of flights are sequential flights on the same runway that are the same type of operation (both arrival or both departure), are within 5 minutes of each other and operate during the study's reporting hours (0600-2200 Local for ORD, 0700-2100 Local for MDW and 0700-2300 Local for CLT). For ORD, approximately 92% of flights are captured in eligible pairs, 47% of flights at MDW are captured in eligible pairs, and 76% of flights at CLT are captured in eligible pairs.

[2] Due to the significant year-over-year change in O'Hare during the JAT's study time period (new runway, United and American banking schedules, etc.), year-over-year taxi analysis was deemed to be meaningless. Instead, the JAT used queueing models to estimate impacts on taxi time.

Appendix A: Members of the Joint Analysis Team

Mike Cirillo	Airlines for America
John Heimlich	Airlines for America
Chris Oswald	Airports Council International (ACI North America)
Balaji Nagarajan	American Airlines, Inc.
Ilhan Ince (Chair)	American Airlines, Inc.
Stephen Smothers	Cessna Aircraft Company
Eugene Maina	Dallas/Fort Worth International Airport
Steve Tobey	Dallas/Fort Worth International Airport
Barrett Nichols	Delta Air Lines, Inc.
Patrick Burns	Delta Air Lines, Inc.
Almira Ramadani	Federal Aviation Administration
Brian Kravitz	Federal Aviation Administration
Dan Murphy	Federal Aviation Administration
Dave Knorr (Chair)	Federal Aviation Administration
LaVada Strickland	Federal Aviation Administration
Leslie Higgins	Federal Aviation Administration
Pamela Gomez	Federal Aviation Administration
Paul Eckert	Federal Aviation Administration
Bradley Ammer	FedEx Express
Kyle Smith	FedEx Express
Joe Bertapelle	JetBlue Airways
Ken Elliott	Jetcraft Avionics LLC
Lee Brown	Landrum-Brown
Mark McKelligan	National Air Traffic Controllers Association
Chris Maccarone	PASSUR Aerospace
David Brukman	PASSUR Aerospace
Andy Cebula	RTCA, Inc.
Margaret Jenny	RTCA, Inc.
Trin Mitra	RTCA, Inc.
Bill Sperandio	Southwest Airlines
Debby Pool	The MITRE Corporation
Jeff Shepley	The MITRE Corporation
Pete Kuzminski	The MITRE Corporation
Alex Burnett	United Airlines, Inc.
Glenn Morse	United Airlines, Inc.
Marc Brodbeck	United Airlines, Inc.
Kevin Swiatek	United Parcel Service

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: Detailed Methodology and Analysis of Wake ReCat

RTCA

THE GOLD STANDARD FOR AVIATION SINCE 1935

Joint Analysis Team Report to the NextGen Advisory Committee

June 17, 2016

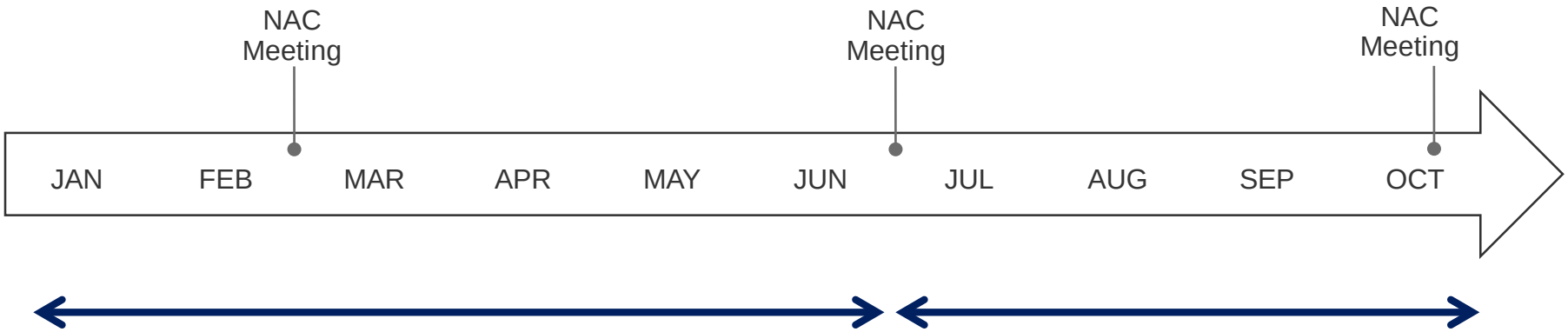
Ilhan Ince, American Airlines
Dave Knorr, FAA
Co-Chairs of the Joint Analysis Team

Joint Analysis Team

- Goal: develop common statement of facts on NAS performance attributable to NextGen
- Analytical experts from industry and FAA

Mike Cirillo	Airlines for America
John Heimlich	Airlines for America
Chris Oswald	ACI North America
Balaji Nagarajan	American Airlines, Inc.
Ilhan Ince (Chair)	American Airlines, Inc.
Stephen Smothers	Cessna Aircraft Company
Eugene Maina	DFW International Airport
Steve Tobey	DFW International Airport
Barrett Nichols	Delta Air Lines, Inc.
Patrick Burns	Delta Air Lines, Inc.
Almira Ramadani	Federal Aviation Administration
Brian Kravitz	Federal Aviation Administration
Dan Murphy	Federal Aviation Administration
Dave Knorr (Chair)	Federal Aviation Administration
LaVada Strickland	Federal Aviation Administration
Leslie Higgins	Federal Aviation Administration
Pamela Gomez	Federal Aviation Administration
Paul Eckert	Federal Aviation Administration
Bradley Ammer	FedEx Express
Kyle Smith	FedEx Express
Joe Bertapelle	JetBlue Airways
Ken Elliott	Jetcraft Avionics LLC
Lee Brown	Landrum-Brown
Mark McKelligan	NATCA
Chris Maccarone	PASSUR Aerospace
David Brukman	PASSUR Aerospace
Andy Cebula	RTCA, Inc.
Margaret Jenny	RTCA, Inc.
Trin Mitra	RTCA, Inc.
Bill Sperandio	Southwest Airlines
Debby Pool	The MITRE Corporation
Jeff Shepley	The MITRE Corporation
Pete Kuzminski	The MITRE Corporation
Alex Burnett	United Airlines, Inc.
Glenn Morse	United Airlines, Inc.
Marc Brodbeck	United Airlines, Inc.
Kevin Swiatek	United Parcel Service

JAT Schedule and Status



Wake ReCat Assessment

- CLT
- ORD/MDW

FOCUS FOR TODAY

PBN Assessment

- North Texas Metroplex
- Denver Established on RNP (EoR)

JAT Accomplishments

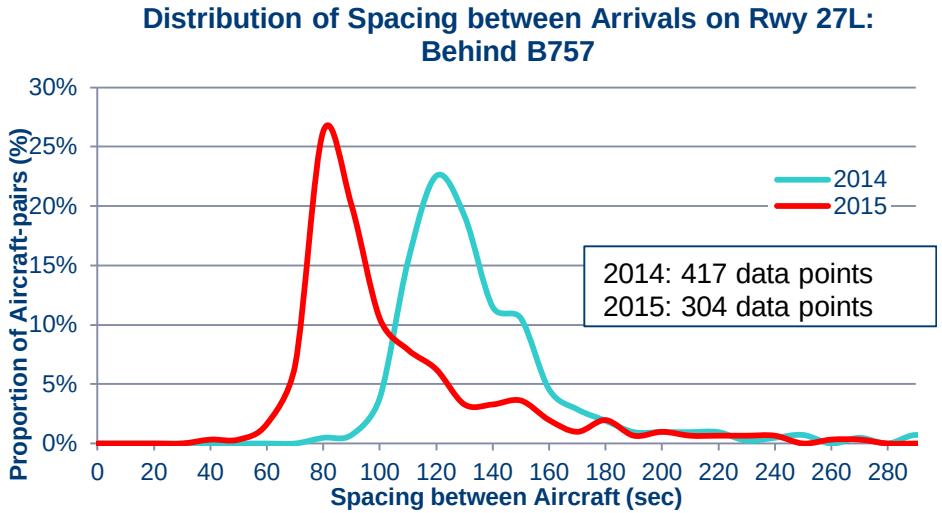
- Agreed on a methodology to determine RECAT impacts and benefits
- Validated consistency of data sources between FAA, AA, UA, and PASSUR
- Agreed on findings/statement of facts
- Built trust and confidence

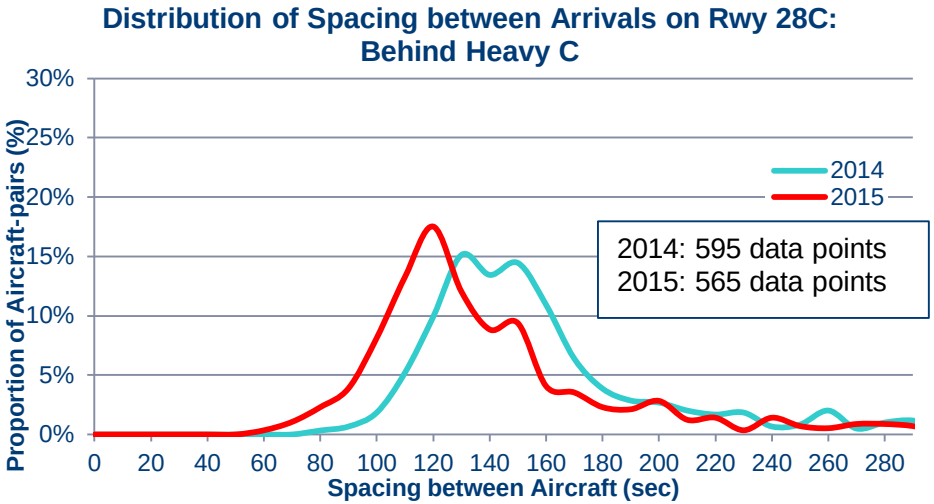
JAT Findings (1 of 4)

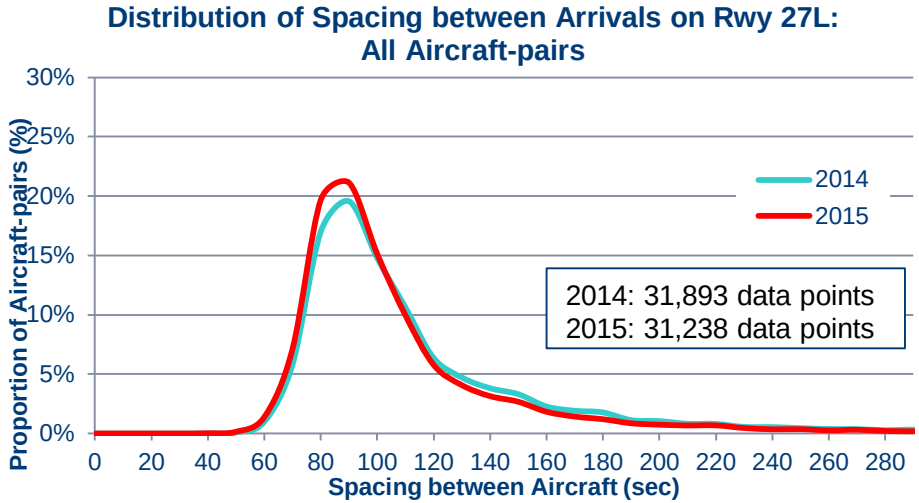
- Fleet mix and demand levels are critical drivers of ReCat impact
- Operational data demonstrates ReCat achieves changes in separation as expected
- Before and after empirical analysis of terminal area and taxi times, as well as throughput, inconclusive due to exogenous factors
  - e.g. changes in demand, weather, airport construction, etc.

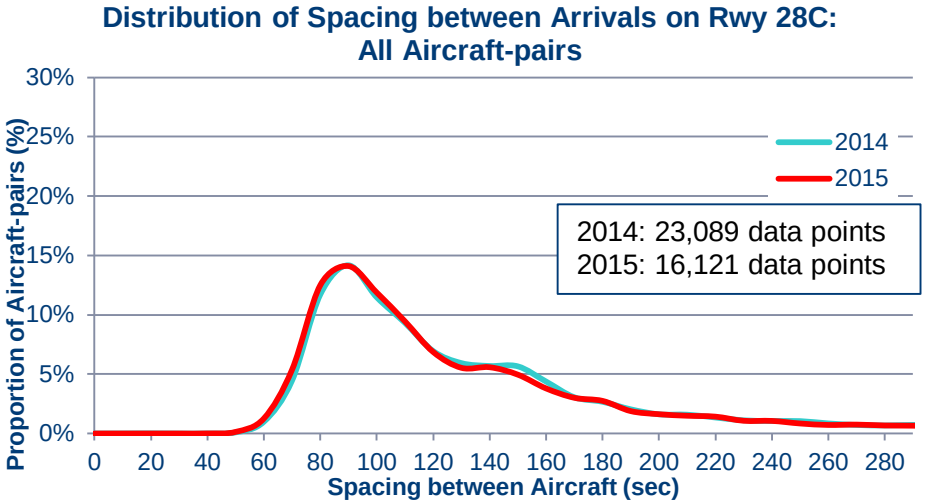
Examples of Changes in Aircraft Spacing at ORD

Arrivals on the Same Runway









Data Source: ASDE-X

JAT Findings (2 of 4)

- **<u>Airborne and taxi out savings</u>** expected for ReCat-impacted flights on runways experiencing pressure
  - Includes propagation of changes in separation onto subsequent aircraft when pressure/queueing is present

Implications of Wake ReCat		*Airports*		
		CLT	**ORD**	MDW
Estimated total annual savings in Airborne and Taxi Out Time due to ReCat[2]	**Airborne**	$180K	$590K	-$2K
	Taxi Out	$57K	$360K	-$32K
	Total	***$237K***	***$950K***	***-$34K***

JAT Findings (3 of 4)

- **<u>Throughput improvement</u>** expected when ReCat-impacted flights operate in peak airport demand
  - Modeled throughput based on actual separation changes suggests improvement in throughput
  - Throughput improvements empirically observed at ORD for IMC peaks when ReCat pairs exist, but not sustained enough to justify increase in called rate

Implications of Wake ReCat		*Airports*		
		CLT	**ORD**	MDW
Modeled Potential Change in Throughput During Peak Periods due to ReCat (Operations per hour)	**Arrivals**	0.5	1.8	0.1
	Departures	0.6	1.5	-0.4

JAT Findings (4 of 4)

- PASSUR data has been compared to FAA and industry data and may be used for ReCat analysis
- JAT's ReCat methodology may be leveraged to prioritize future implementations of ReCat

ANALYSIS DETAILS

Summary of Analysis Results

Implications of Wake ReCat		Airports		
		CLT	ORD	MDW
Percent of eligible pairs[1] of flights at the airport potentially impacted by ReCat (% with decreased separation / % with increased separation)	**Arrivals**	2.6% / 0.0%	4.4% / 0.0%	1.1% / 0.0%
	Departures	3.3% / 1.1%	4.7% / 0.6%	1.1% / 7.6%
Modeled Potential Change in Throughput During Peak Periods due to ReCat (Operations per hour)	**Arrivals**	0.5	1.8	0.1
	Departures	0.6	1.5	-0.4
Estimated total annual savings in Airborne and Taxi Out Time due to ReCat[2]	**Airborne**	$180K	$590K	-$2K
	Taxi Out	$57K	$360K	-$32K
	Total	***$237K***	***$950K***	***-$34K***

[1] Eligible pairs of flights are sequential flights on the same runway that are the same type of operation (both arrival or both departure), are within 5 minutes of each other and operate during the study's reporting hours (0600-2200 Local for ORD, 0700-2100 Local for MDW and 0700-2300 Local for CLT). For ORD, approximately 92% of flights are captured in eligible pairs, 47% of flights at MDW are captured in eligible pairs, and 76% of flights at CLT are captured in eligible pairs.

[2] Due to the significant year-over-year change in O'Hare during the JAT's study time period (new runway, United and American banking schedules, etc.), year-over-year taxi analysis was deemed to be meaningless. Instead, the JAT used queueing models to estimate impacts on taxi time.

Change in Separation Requirements (nm)

Traditional Classes	Trailing Aircraft				
	Super	Heavy	B757	Large	Small
Super	MRS	6.0	7.0	7.0	8.0
Heavy	MRS	4.0	5.0	5.0	6.0
B757	MRS	4.0	4.0	4.0	5.0
Large	MRS	MRS	MRS	MRS	4.0/MRS
Small	MRS	MRS	MRS	MRS	MRS

RECAT Categories	Trailing Aircraft					
	A	B	C	D	E	F
A	MRS	5.0	6.0	7.0	7.0	8.0
B	MRS	3.0	4.0	5.0	5.0	7.0
C	MRS	MRS	MRS	3.5	3.5	6.0
D	MRS	MRS	MRS	MRS	MRS	4.0A
E	MRS	MRS	MRS	MRS	MRS	MRS
F	MRS	MRS	MRS	MRS	MRS	MRS

Trailing Aircraft

Leading Aircraft

Traditional		Super	Heavy		B757	Large		Small	Aircraft Types
	RECAT	A	B	C	D	D	E	F	
Super	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	A380's, AN225
Heavy	B	0.0	-1.0	0.0	0.0	0.0	0.0	0* Arr 1 Dep	B747's, B777's, A340's, A330's
	C	0.0	-1.5	-1.5	-1.5	-1.5	-1.5	0.0	A300, A310, B707, B767, DC8, DC10, MD11
B757	D	0.0	-1.5	-1.5	-1.5	-1.5	-1.0	-1.0	B757's
Large	D	0.0	0.0	0.0	0.0	0.0	0.0	0* Arr 1 Dep	A319, A320, A321, B727's, B737's
	E	0.0	0.0	0.0	0.0	0.0	0.0	-1.0	CRJ's, DH8's, E135, E145, E170
Small	F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	C550, C560, C570, E120

Red indicates an increase in separations
Green indicates a decrease in separations
***Based on observations at CLT, ORD, and MDW**

RECAT Affected Aircraft Pairs at ORD

Jul 1-Sep 25, 2015: Reporting Hours (6am-9:59pm local time)

3,922 Affected Arrival Pairs
(4.4% of all arrival pairs)

Trailing Aircraft

Leading Aircraft	Traditional	Heavy		B757	Large		Small
	RECAT	B	C	D	D	E	F
Heavy	B	742 (0.8%)	153 (0.2%)	21 (0.0%)	1,198 (1.3%)	1,827 (2.0%)	53 (0.1%)
	C	165 (0.2%)	53 (0.1%)	11 (0.0%)	365 (0.4%)	733 (0.8%)	18 (0.0%)
B757	D	37 (0.0%)	14 (0.0%)	11 (0.0%)	355 (0.4%)	546 (0.6%)	23 (0.0%)
Large	D	1,169 (1.3%)	401 (0.4%)	351 (0.4%)	10,901 (12.2%)	17,318 (19.4%)	543 (0.6%)
	E	1,826 (2.0%)	692 (0.8%)	572 (0.6%)	17,355 (19.4%)	29,564 (33.0%)	867 (1.0%)
Small	F	55 (0.1%)	25 (0.0%)	23 (0.0%)	543 (0.6%)	887 (1.0%)	40 (0.0%)

4,753 Affected Departure Pairs
(5.3% of all departure pairs)

Trailing Aircraft

Leading Aircraft	Traditional	Heavy		B757	Large		Small
	RECAT	B	C	D	D	E	F
Heavy	B	917 (1.0%)	170 (0.2%)	49 (0.1%)	1,337 (1.5%)	1,532 (1.7%)	26 (0.0%)
	C	194 (0.2%)	52 (0.1%)	32 (0.0%)	453 (0.5%)	604 (0.7%)	11 (0.0%)
B757	D	85 (0.1%)	20 (0.0%)	16 (0.0%)	345 (0.4%)	564 (0.6%)	13 (0.0%)
Large	D	1,154 (1.3%)	423 (0.5%)	373 (0.4%)	12,523 (13.9%)	17,936 (19.9%)	485 (0.5%)
	E	1,595 (1.8%)	696 (0.8%)	551 (0.6%)	17,442 (19.4%)	28,032 (31.1%)	947 (1.1%)
Small	F	84 (0.1%)	18 (0.0%)	30 (0.0%)	521 (0.6%)	790 (0.9%)	69 (0.1%)

Separation Requirements	Arrival Pairs	Departure Pairs
Decreased	4.4%	4.7%
Unchanged	95.6%	94.7%
Increased	0.0%	0.6%

Data Source: ASDE-X

Red indicates an increase in separations
Green indicates a decrease in separations

Comparison of Underlying Data

ORD Wake RECAT Analysis

Aircraft Pairs - Jul 1, 2015 to Sep 25, 2015

All Reporting hours (0600 – 2159)

Comparison of Aircraft-pair Counts	Reporting Hours					
	Arrivals			Departures		
	UA	AA	FAA	UA	AA	FAA
Total Number of Pairs	91,098	91,261	89,457	90,893	91,200	90,089
Decreased Separations (% of pairs)	4.1%	4.4%	4.4%	4.2%	4.3%	4.7%
Increased Separations (% of pairs)	0.0%	0.0%	0.0%	0.3%	0.4%	0.6%

RECAT Impact Comparison

RECAT Impact		No. of Days in Study Period	% AC in Peak Periods	% Time Peak Periods Occur	No. Aircraft Pairs during Reporting Hours	No. Aircraft Pairs in Peak Periods	Avg. Flight Count during Reporting Hours	Avg. Flight Count in Peak Periods
ORD	Arrivals	87	16.4%	11.8%	89,457	14,231	1,117.3	182.9
	Departures		23.4%	16.3%	90,089	21,905	1,125.2	262.8
MDW	Arrivals	87	33.5%	21.3%	13,402	5,557	296.9	99.4
	Departures		32.4%	20.2%	10,621	4,582	293.7	95.2
CLT	Arrivals	153	7.8%	4.3%	77,739	6,409	679.7	52.8
	Departures		36.6%	20.6%	83,559	33,961	704.4	257.8

RECAT Impact		No. Aircraft Pairs Impacted by RECAT during Reporting Hours		No. Aircraft Pairs Impacted by RECAT in Peak Periods		% Aircraft Pairs Impacted by RECAT in Peak Periods	
		Positive	Negative	Positive	Negative	Positive	Negative
ORD	Arrivals	3,922	0	611	0	4.3%	0.0%
	Departures	4,242	511	817	93	3.7%	0.4%
MDW	Arrivals	149	0	67	0	1.2%	0.0%
	Departures	116	806	52	333	1.1%	7.3%
CLT	Arrivals	2,058	0	125	0	2.0%	0.0%
	Departures	2,790	905	876	196	2.6%	0.6%

Data Source: ASDE-X and ASPM

Queuing Benefits Summary

Average Change in Spacing: 30 sec

Summary of Savings		CLT	ORD	MDW
Individual Flight Savings	Range (secs/flt)	-48 to 67	-60 to 180	-60 to 53
	Avg. (secs/flt)	0.58	2.69	-0.30 sec
	Affected Flts. (%)	4%	11%	3%
	Avg. per Affected Flight (secs/flt)	15 sec/aff. Flt	24 sec/aff. Flt	-10 secs/aff. flt
Daily Savings	Range (mins/day)	0.25 to 42.53	44.22 to 214.18	-16.45 to 4.18
	Avg. (mins/day)	23.42	100.53	-2.99
Annual Savings ($): Terminal		$180,380	$590,325	- $42,136
Annual Savings ($): Airport Surface		$56,878	$359,618	- $31,856
Total Annual Savings ($)		**$237,257**	**$949,942**	**- $33,992**
ADOC: Airborne		$29.56/min	$28.86/min	$39.22/min
ADOC: Ground		$23.24/min	$22.15/min	$30.71/min

Modeled Throughput Improvement: Peak Periods

CLT: Apr-Aug, 2015 / C90: Jul 1-Sep 25, 2015

Change Potential		Aircraft Spacing (%)	Throughput (ops/hr)	Throughput Change (%)	Avg. Daily Ops Count	Separation Requirements		
						# Pairs Decreased	# Pairs Unchanged	# Pairs Increased
CLT	Arrival	-0.82%	0.50	0.83%	52.8	125	6,284	0
	Departure	-0.92%	0.63	0.94%	257.8	876	32,889	196
ORD	Arrival	-1.99%	1.76	2.07%	182.9	611	13,620	0
	Departure	-1.56%	1.54	1.61%	262.8	817	20,995	93
MDW	Arrival	-0.47%	0.10	0.47%	99.4	67	5,490	0
	Departure	2.33%	-0.42	-2.22%	95.2	52	4,197	333
C90	Arrival	-	-	-	-	3.4%	96.6%	0.0%
	Departure	-	-	-	-	3.3%	95.1%	1.6%

Data Sources: ASDE-X and ASPM

RECAT Affected Aircraft Pairs and Modeled Throughput at ORD

Jul 1 - Sep 25, 2015: Peak Periods

611 Affected Arrival Pairs
(0.7% of all arrivals pairs)

Trailing Aircraft

Leading Aircraft		Traditional	Heavy		B757	Large		Small
		RECAT	B	C	D	D	E	F
Heavy		B	78 (0.5%)	18 (0.1%)	4 (0.0%)	171 (1.2%)	274 (1.9%)	4 (0.0%)
		C	19 (0.1%)	11 (0.1%)	1 (0.0%)	53 (0.4%)	128 (0.9%)	4 (0.0%)
B757		D	7 (0.0%)	0 (0.0%)	2 (0.0%)	66 (0.5%)	113 (0.8%)	2 (0.0%)
Large		D	185 (1.3%)	51 (0.4%)	64 (0.4%)	1,698 (11.9%)	2,802 (19.7%)	88 (0.6%)
		E	270 (1.9%)	127 (0.9%)	106 (0.7%)	2,787 (19.6%)	4,738 (33.3%)	131 (0.9%)
Small		F	5 (0.0%)	6 (0.0%)	6 (0.0%)	72 (0.5%)	138 (1.0%)	2 (0.0%)

910 Affected Departure Pairs
(1.0% of all departure pairs)

Trailing Aircraft

Leading Aircraft		Traditional	Heavy		B757	Large		Small
		RECAT	B	C	D	D	E	F
Heavy		B	77 (0.4%)	18 (0.1%)	9 (0.0%)	186 (0.8%)	221 (1.0%)	4 (0.0%)
		C	23 (0.1%)	9 (0.0%)	9 (0.0%)	89 (0.4%)	110 (0.5%)	0 (0.0%)
B757		D	10 (0.0%)	7 (0.0%)	3 (0.0%)	85 (0.4%)	147 (0.7%)	3 (0.0%)
Large		D	148 (0.7%)	76 (0.3%)	85 (0.4%)	3,113 (14.2%)	4,524 (20.7%)	89 (0.4%)
		E	262 (1.2%)	135 (0.6%)	143 (0.7%)	4,516 (20.6%)	7,221 (33.0%)	245 (1.1%)
Small		F	15 (0.1%)	4 (0.0%)	5 (0.0%)	109 (0.5%)	193 (0.9%)	12 (0.1%)

Separation Requirements	Arrival Pairs	Departure Pairs
Decreased	4.3%	3.7%
Unchanged	95.7%	95.8%
Increased	0.0%	0.4%

Change Potential	Arrivals	Departures
Aircraft Spacing (%)	-1.99%	-1.56%
Throughput (ops/hr)	+1.76	+1.54
Throughput Change (%)	+2.07%	+1.61%

Data Sources: ASDE-X and ASPM

Red indicates an increase in separations

Green indicates a decrease in separations

RECAT Affected Aircraft Pairs and Modeled Throughput at MDW

Jul 1-Sep 25, 2015: Peak Periods

67 Affected Arrival Pairs
(0.5% of all arrival pairs)

Trailing Aircraft

Leading Aircraft		Traditional	Heavy		B757	Large		Small
		RECAT	B	C	D	D	E	F
Heavy	B		0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
	C		0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
B757	D		0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (0.1%)	1 (0.0%)	2 (0.0%)
Large	D		0 (0.0%)	0 (0.0%)	5 (0.1%)	3,447 (62.0%)	258 (4.6%)	489 (8.8%)
	E		0 (0.0%)	0 (0.0%)	0 (0.0%)	290 (5.2%)	22 (0.4%)	61 (1.1%)
Small	F		0 (0.0%)	0 (0.0%)	0 (0.0%)	651 (11.7%)	70 (1.3%)	258 (4.6%)

385 Affected Departure Pairs
(3.6% of all departure pairs)

Trailing Aircraft

Leading Aircraft		Traditional	Heavy		B757	Large		Small
		RECAT	B	C	D	D	E	F
Heavy	B		0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
	C		0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
B757	D		0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (0.0%)	0 (0.0%)	0 (0.0%)
Large	D		0 (0.0%)	0 (0.0%)	1 (0.0%)	3,096 (67.6%)	151 (3.3%)	333 (7.3%)
	E		0 (0.0%)	0 (0.0%)	0 (0.0%)	174 (3.8%)	12 (0.3%)	50 (1.1%)
Small	F		0 (0.0%)	0 (0.0%)	0 (0.0%)	387 (8.4%)	46 (1.0%)	330 (7.2%)

Separation Requirements	Arrival Pairs	Departure Pairs
Decreased	1.2%	1.1%
Unchanged	98.8%	91.6%
Increased	0.0%	7.3%

Change Potential	Arrivals	Departures
Aircraft Spacing (%)	+0.47%	+2.33%
Throughput (ops/hr)	+0.10	-0.42
Throughput Change (%)	+0.47%	-2.22%

Data Sources: ASDE-X and ASPM

Red indicates an increase in separations

Green indicates a decrease in separations

RECAT Affected Aircraft Pairs and Modeled Throughput at CLT

Apr-Aug 2015, Peak Periods

125 Affected Arrival Pairs
(0.2% of all arrival pairs)

Trailing Aircraft

Leading Aircraft		Traditional	Heavy		B757	Large		Small
		RECAT	B	C	D	D	E	F
Heavy	B		3 (0.0%)	0 (0.0%)	0 (0.0%)	4 (0.1%)	7 (0.1%)	0 (0.0%)
	C		0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
B757	D		0 (0.0%)	0 (0.0%)	1 (0.0%)	15 (0.2%)	14 (0.2%)	1 (0.0%)
Large	D		10 (0.2%)	0 (0.0%)	11 (0.2%)	1,173 (18.3%)	1,470 (22.9%)	42 (0.7%)
	E		4 (0.1%)	0 (0.0%)	19 (0.3%)	1,399 (21.8%)	1,995 (31.1%)	91 (1.4%)
Small	F		1 (0.0%)	0 (0.0%)	1 (0.0%)	53 (0.8%)	79 (1.2%)	16 (0.2%)

1,072 Affected Departure Pairs
(1.3% of all departure pairs)

Trailing Aircraft

Leading Aircraft		Traditional	Heavy		B757	Large		Small
		RECAT	B	C	D	D	E	F
Heavy	B		1 (0.0%)	0 (0.0%)	2 (0.0%)	92 (0.3%)	119 (0.4%)	0 (0.0%)
	C		0 (0.0%)	1 (0.0%)	7 (0.0%)	72 (0.2%)	53 (0.2%)	0 (0.0%)
B757	D		2 (0.0%)	2 (0.0%)	1 (0.0%)	114 (0.3%)	134 (0.4%)	1 (0.0%)
Large	D		106 (0.3%)	74 (0.2%)	121 (0.4%)	6,381 (18.8%)	7,655 (22.5%)	196 (0.6%)
	E		122 (0.4%)	56 (0.2%)	112 (0.3%)	7,511 (22.1%)	9,789 (28.8%)	488 (1.4%)
Small	F		11 (0.0%)	2 (0.0%)	8 (0.0%)	376 (1.1%)	309 (0.9%)	43 (0.1%)

Separation Requirements	Arrival Pairs	Departure Pairs
Decreased	2.0%	2.6%
Unchanged	98.0%	96.8%
Increased	0.0%	0.6%

Change Potential	Arrivals	Departures
Aircraft Spacing (%)	-0.82%	-0.92%
Throughput (ops/hr)	+0.50	+0.63
Throughput Change (%)	+0.83%	+0.94%

Data Sources: ASDE-X and ASPM

Red indicates an increase in separations

Green indicates a decrease in separations

CLT Wake RECAT Analysis

PASSUR comparison – Qualifying aircraft pairs

- **Table below shows the qualifying lead-trail aircraft pairs identified using AA and PASSUR data**
- **No significant differences were found in the aircraft-pair identification showing a good match between the two datasets**
- **April – August 2015, Reporting hours (0700 – 2259)**

Comparison of Aircraft-pair Counts	All Operating Hours				Peak Hours				Peak Hours IMC			
	Arrivals		Departures		Arrivals		Departures		Arrivals		Departures	
	AA	PASSUR	AA	PASSUR	AA	PASSUR	AA	PASSUR	AA	PASSUR	AA	PASSUR
Total Number of Pairs	79,256	79,904	83,294	82,841	6,489	6,544	34,046	33,811	1,394	1,426	4,989	4,929
Decreased Separations (% of pairs)	2.65%	2.65%	2.98%	3.2%	1.97%	2.06%	2.33%	2.53%	1.94%	1.89%	2.49%	2.68%
Increased Separations (% of pairs)	0.0%	0.0%	0.99%	1.11%	0.0%	0.0%	0.5%	0.62%	0.0%	0.0%	0.64%	0.73%

CLT Wake RECAT Analysis

PASSUR Comparison – Throughput and Taxi Time Metrics

QrtHr ARR and DEP throughput and taxi-times show a strong match between the two datasets

AA

Peak Periods	Arrivals		Departures	
Throughput	2014	2015	2014	2015
25th %le	18	18	19	18
50th %le	20	20	20	20
75th %le	22	21	22	21
Average	19.86	19.25	20.17	19.66
Std.dev	3.49	3.11	2.61	2.65

PASSUR

Peak Periods	Arrivals		Departures	
Throughput	2014	2015	2014	2015
25th %le	18	18	18	18
50th %le	20	20	20	20
75th %le	22	21	22	21
Average	20.03	19.26	20.18	19.49
Std.dev	3.44	3.19	2.75	2.86

Difference (AA – PASSUR)

Peak Periods	Arrivals		Departures	
Throughput	2014	2015	2014	2015
25th %le	0	0	1	0
50th %le	0	0	0	0
75th %le	0	0	0	0
Average	-0.2	0.0	0.0	0.2
Std.dev	0.1	-0.1	-0.1	-0.2

AA

All Periods	Taxi Out		Taxi In	
Taxi (min)	2014	2015	2014	2015
25th %le	13	14	6	7
50th %le	17	18	9	10
75th %le	22	24	13	14
Average	18.7	20.3	10.7	11.7
Std.dev	8.7	9.7	6.7	7.7

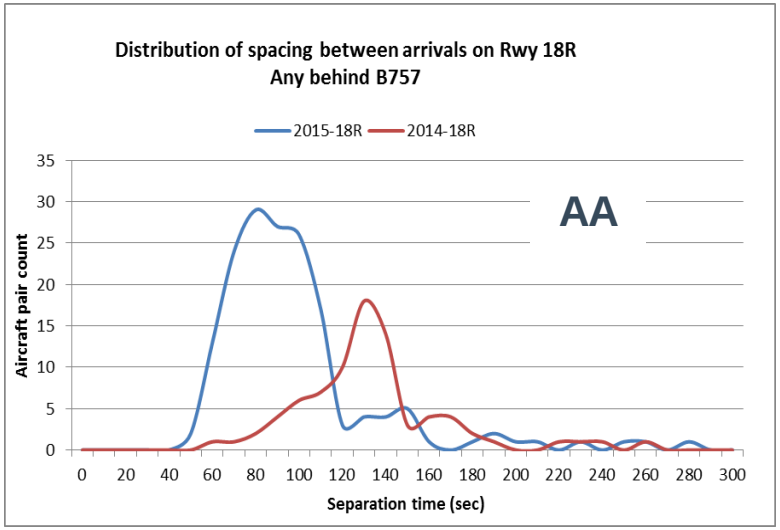
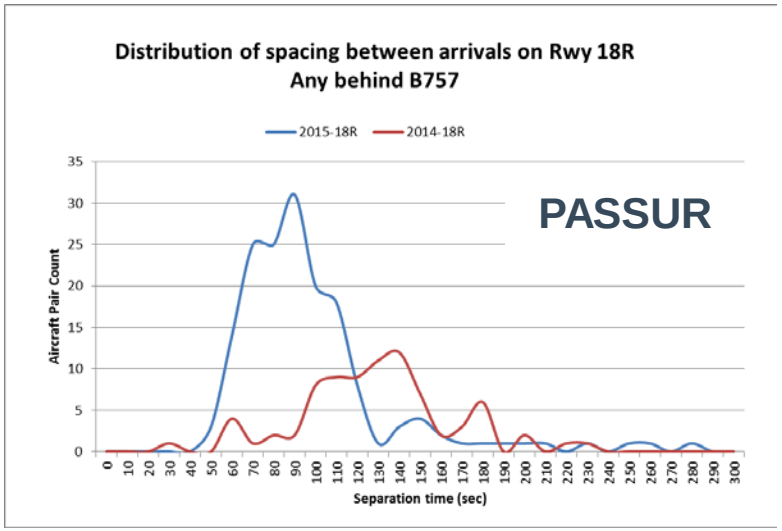
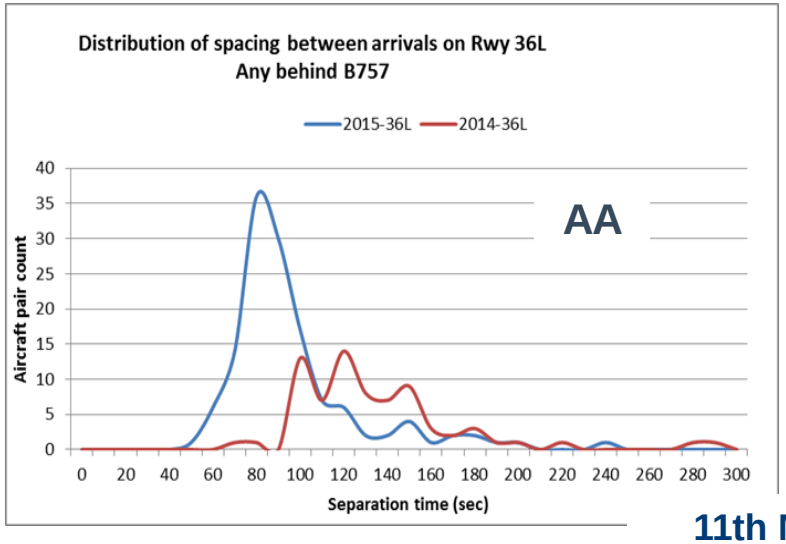
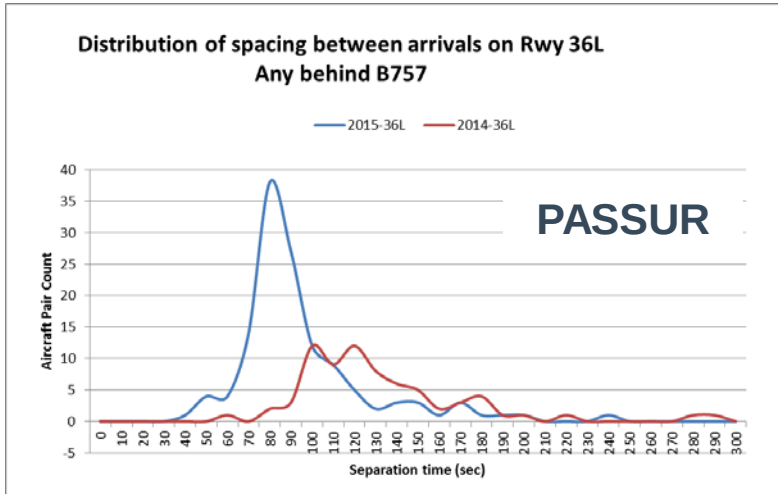
PASSUR

All Periods	Taxi Out		Taxi In	
Taxi (min)	2014	2015	2014	2015
25th %le	13	14	6	7
50th %le	17	19	9	10
75th %le	23	25	13	15
Average	19.52	20.68	10.50	11.77
Std.dev	10.80	9.76	11.18	9.18

Difference (AA – PASSUR)

All Periods	Taxi Out		Taxi In	
Taxi (min)	2014	2015	2014	2015
25th %le	0	0	0	0
50th %le	0	-1	0	0
75th %le	-1	-1	0	-1
Average	-0.5	-0.38	0.2	-0.07
Std.dev	-2.1	-0.06	-4.48	-1.48

CLT Wake RECAT Analysis

PASSUR comparison – Separation time distribution

- **Arrivals behind 757**