LaGuardia Airport Systems Operations Study:

Impact of Airport System Operations in the Presence of Airline Aircraft Upguaging

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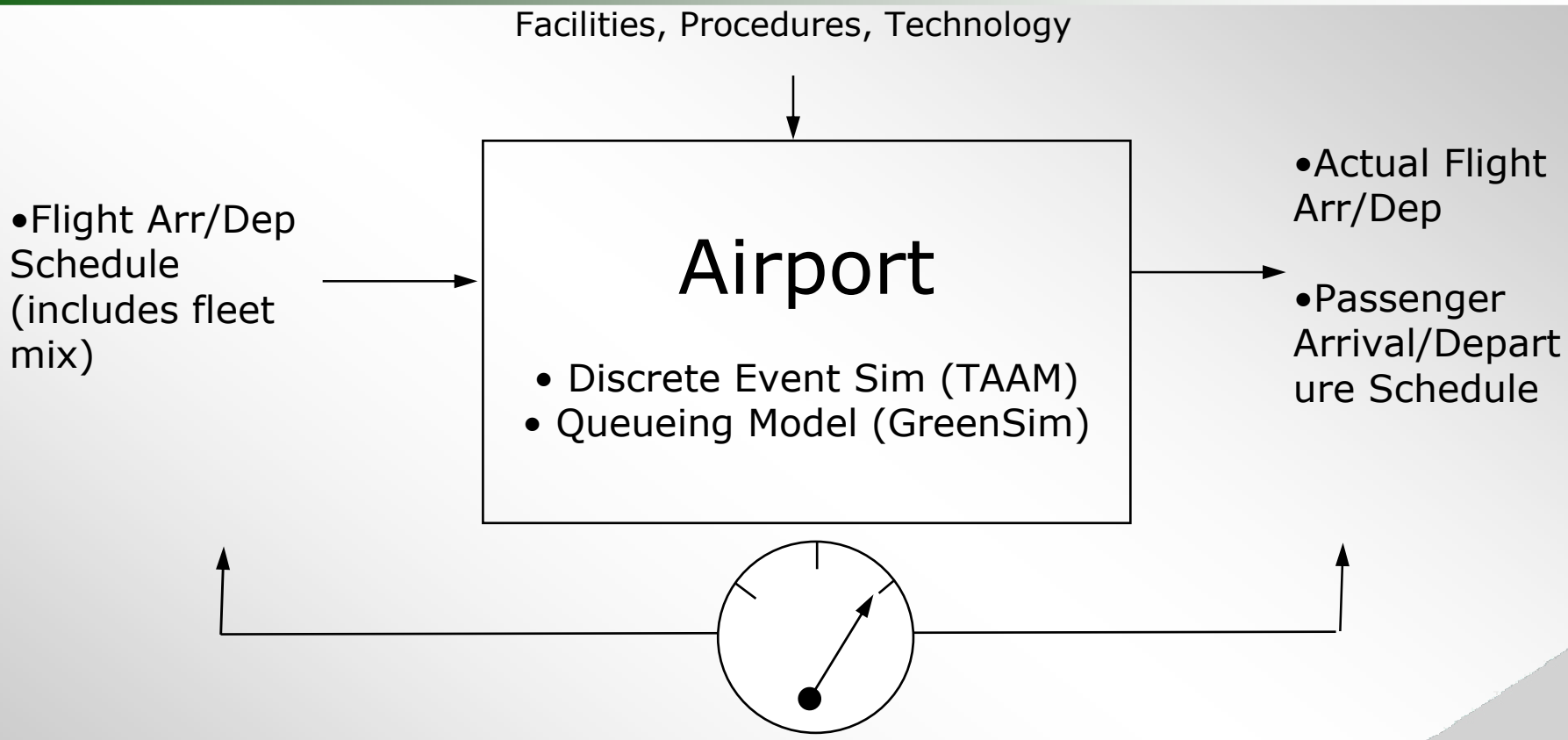
Airport "System" Operations



Performance (and Equity)

- •Seat Capacity, Flight Capacity
- •Delays (Taxi-in, Taxi-out, Departure Queue)
- • Gate Utilization
- • ADOC
- • Fuel, Emissions, Noise

Objective

- Assess the overall impact on "airport system" performance (e.g. available seats, delays, emissions, noise)
  - in the presence of a nominal high demand schedule (e.g. total scheduled flights of 1125 between 0700 and 2159 local time)
  - with a fleet mix containing increased levels of narrow-bodied aircraft and fewer regional jets
- "Airport System" Performance Metrics:
  - Pax throughput, Flight Delays, Fuel-burn, Emissions, Noise

Overall Results

1. Airport pax throughput can improved by upguaging
   - Marginal impact on Flight Delays
     - under assumptions of capacity limits, schedule "bunching" and fleet mix
   - Impact on Emissions and Noise
     - Not proportional to schedule or delay reduction
     - Highly dependent on fleet-mix (engine-type)
2. Future regulations should consider
   - Manage schedule to avoid schedule "peaking"
     - Multiple capacities throughout day (buffer for delays from peak hours)
   - Manage fleet-mix
     - Arrival/Departure separation distance determines capacity
     - Emissions and Noise impact determined by engine-type

Organization

- Study 2.1
  - Delays & Gate Utilization
  - Discrete Event Simulation (TAAM)
- Study 2.2
  - Delays, Fuel, ADOC, Emissions, Noise
  - Queueing Simulation (GreenSim)

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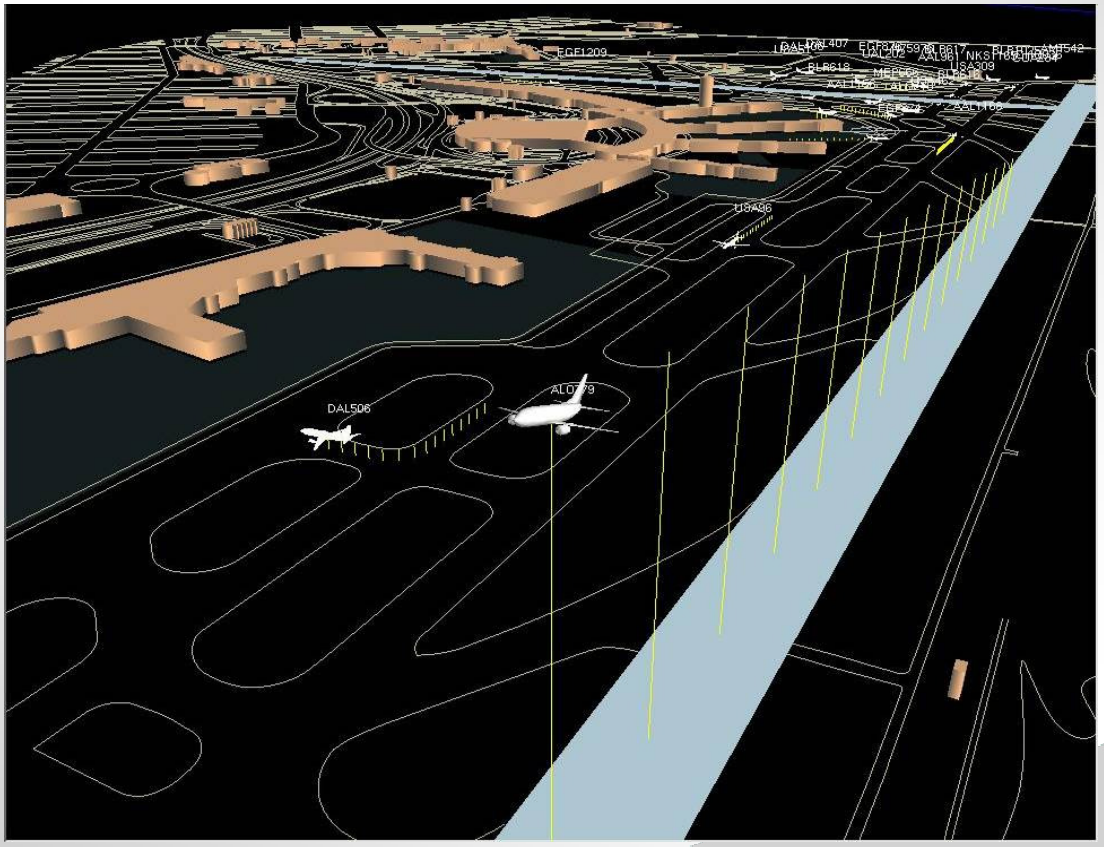
Phase 2.1 (Delays, Gate Utilization)



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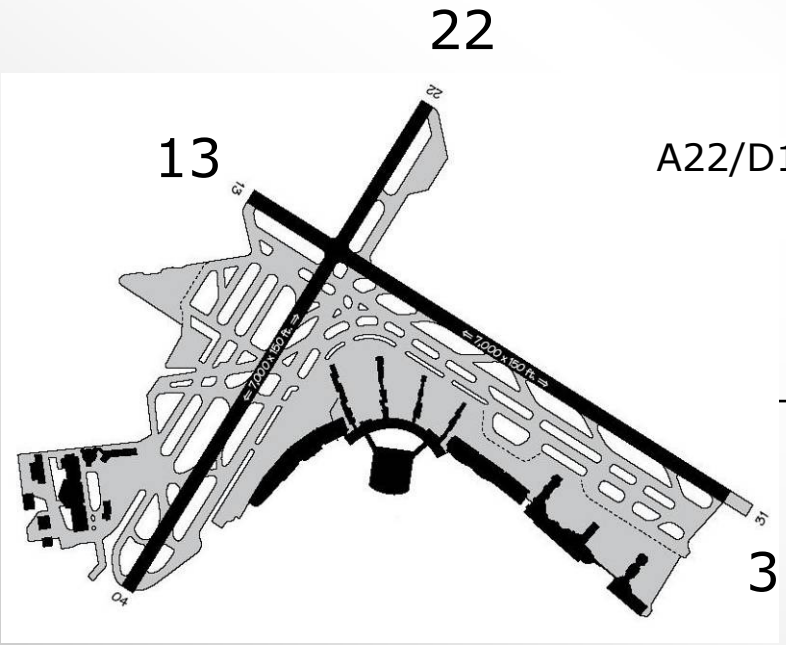
Method

- Analysis was conducted running simulation experiments
- Used Total Airport & Airspace Modeler (TAAM)
- LGA airport model for TAAM provided to GMU/CATSR by the PANYNJ and Leigh-Fisher Associates.
- LGA airport model was enhanced to support this study
- Complete set of data files is available to all parties on request.

Method - Simulation Scenarios



RWY Config	Day	Fleet mix
A22/D13	061404 (ETMS)	Baseline
		12% less RJs
		25% less RJs
	041905 (GRA)	Baseline
		Upgauged
		Upg (757s to A321s)
	081105 (ETMS)	Baseline
		12% less RJs
		25% less RJs
A22/D31	061404 (ETMS)	Baseline
		12% less RJs
		25% less RJs
	041905 (GRA)	Baseline
		Upgauged
		Upg (757s to A321s)
	081105 (ETMS)	Baseline
		12% less RJs
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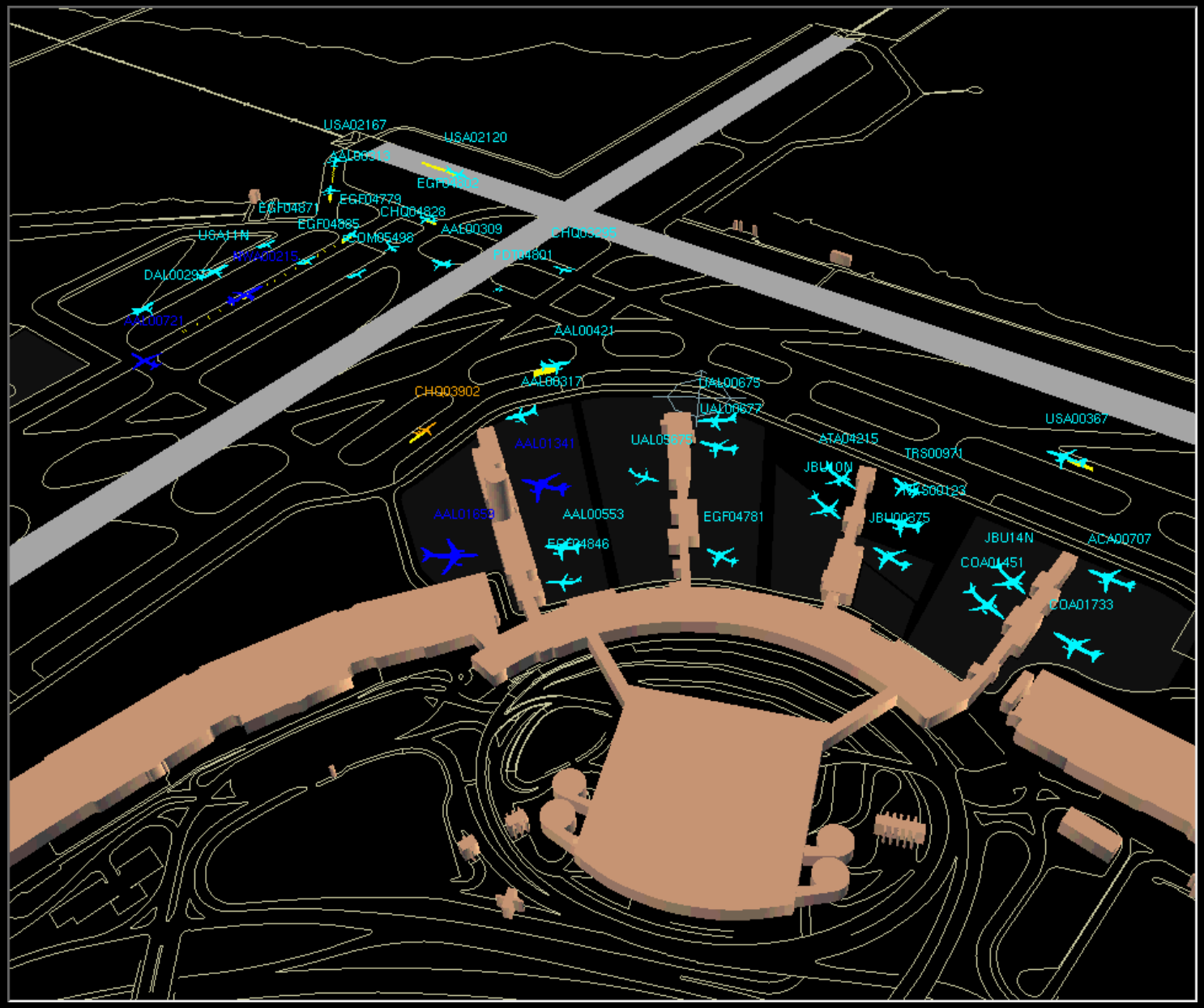
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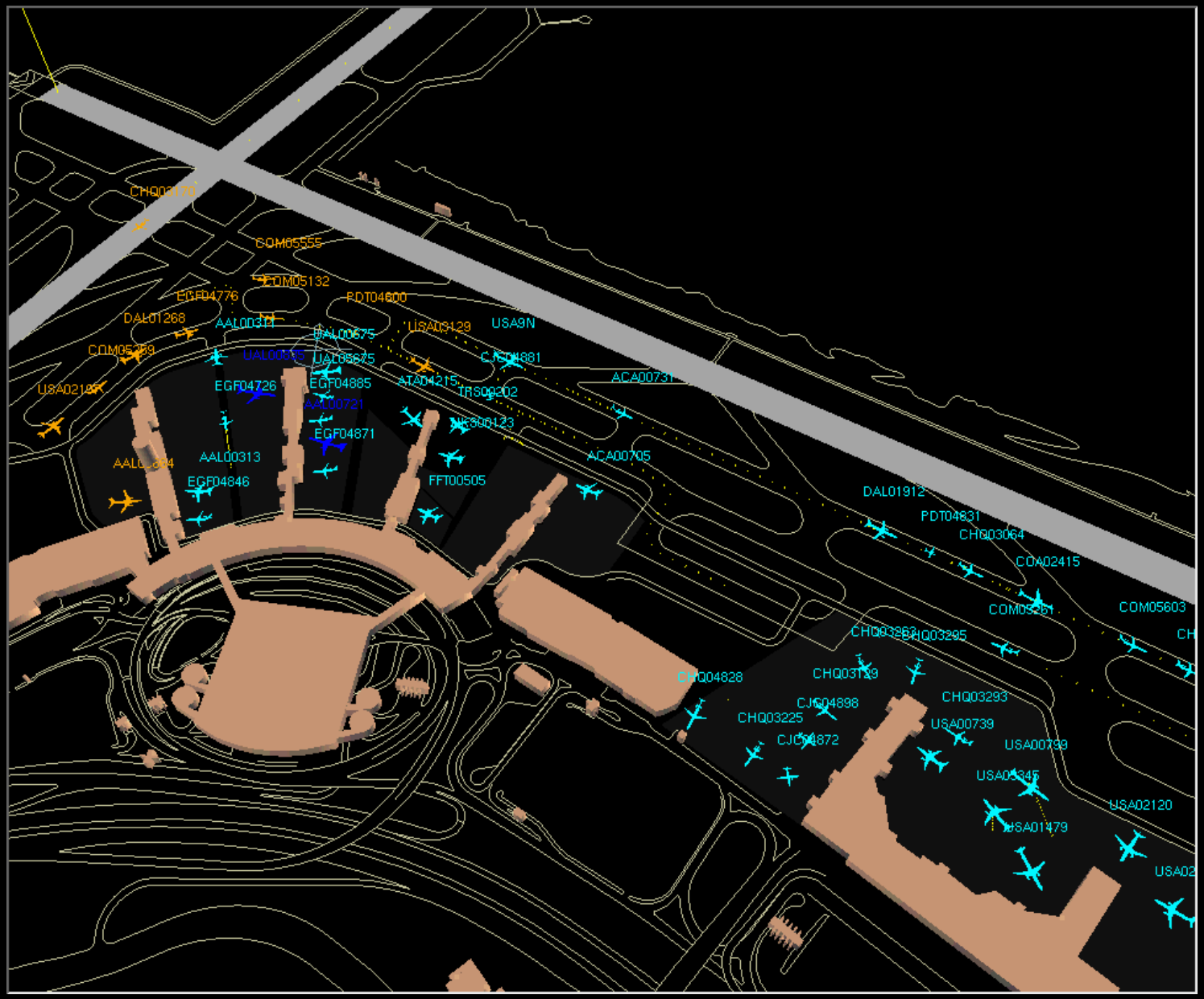
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COM05261
COM05603
CHQ03283
CHQ03295
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CHQ03293
CJC04898
CHQ03225
USA00739
CJC04872
USA00739
USA04345
USA02120
USA01479
USA02

Summary of Results (a)

CATSR

Run	Config	Schedule	Number of Flights in TAAM	Fleet Mix	Total Available Seats per Day	Avg Seats per Flight	Est'd Annual Pax *excluding* GA	Avg Delay per Flight	Avg Delay per Seat	Average Standoff Time per Flight	Est'd Peak-Time Gate Shortage	Carriers Most Affected by Gate Shortages
								Minutes				
1	**A22/D13** (Peak sustained AAR/ADR = 39.5)	ETMS **6/14**/2004 (filled to 75 ops/hr)	1206	Baseline	111279	92	24,795,807	16.0	15.4	0.9	1	None
2			1208	12% RJ to NB	114456	95	25,461,499	17.8	17.6	0.9	1	None
3			1208	25% RJ to NB	118192	98	26,292,597	16.9	16.8	0.7	1	None
4		**GRA** 0419	1178	Baseline	113142	96	25,810,172	11.4	10.5	1.0	1	None
5			1190	Upgauged	135165	114	30,523,169	15.2	14.9	1.5	2	COM, EGF, USA
6			1190	Upg, 757to321	133075	112	30,051,202	13.0	12.9	1.6	2	COM, EGF, USA
7		ETMS **8/11**/2005	1222	Baseline	113851	93	25,036,751	19.0	17.8	2.6	4	USExp, COM
8			1222	12% RJ to NB	117305	96	25,796,314	17.5	16.6	2.7	4	USExp,EGF,COM
9			1222	25% RJ to NB	122567	100	26,953,470	18.6	18.0	2.6	4	USExp,EGF,COM
10	**A22/D31** (Peak sustained AAR/ADR = 38)	ETMS **6/14**/2004 (filled to 75 ops/hr)	1206	Baseline	111279	92	24,795,807	23.5	22.4	1.7	2	COM, EGF
11			1208	12% RJ to NB	114456	95	25,461,499	25.1	23.8	1.5	2	COM, EGF
12			1208	25% RJ to NB	118192	98	26,292,597	27.0	26.1	2.2	3	COM, EGF
13		**GRA** 0419	1178	Baseline	113142	96	25,810,172	16.0	14.2	0.9	1	None
14			1190	Upgauged	135165	114	30,523,169	23.0	21.8	2.5	4	COM, EGF, USA
15			1190	Upg, 757to321	133075	112	30,051,202	21.2	20.0	2.5	3	COM, USA, EGF
16		ETMS **8/11**/2005	1222	Baseline	113851	93	25,036,751	27.8	25.1	3.0	4	USExp,EGF,COM
17			1222	12% RJ to NB	117305	96	25,796,314	27.3	25.0	2.9	4	USExp,EGF,COM
18			1222	25% RJ to NB	122567	100	26,953,470	24.8	22.7	2.4	3	USExp,EGF,COM

Summary of Results (b)

CATSR

Run	Config	Schedule	Number of Flights in TAAM	Fleet Mix	Total Available Seats per Day	Avg Seats per Flight	Est'd Annual Pax *excluding* GA	Avg Delay per Flight	Avg Delay per Seat	Average Standoff Time per Flight	Est'd Peak-Time Gate Shortage	Carriers Most Affected by Gate Shortages
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5			1190	Upgauged	135165	114	30,523,169	15.2	14.9	1.5	2	COM, EGF, USA
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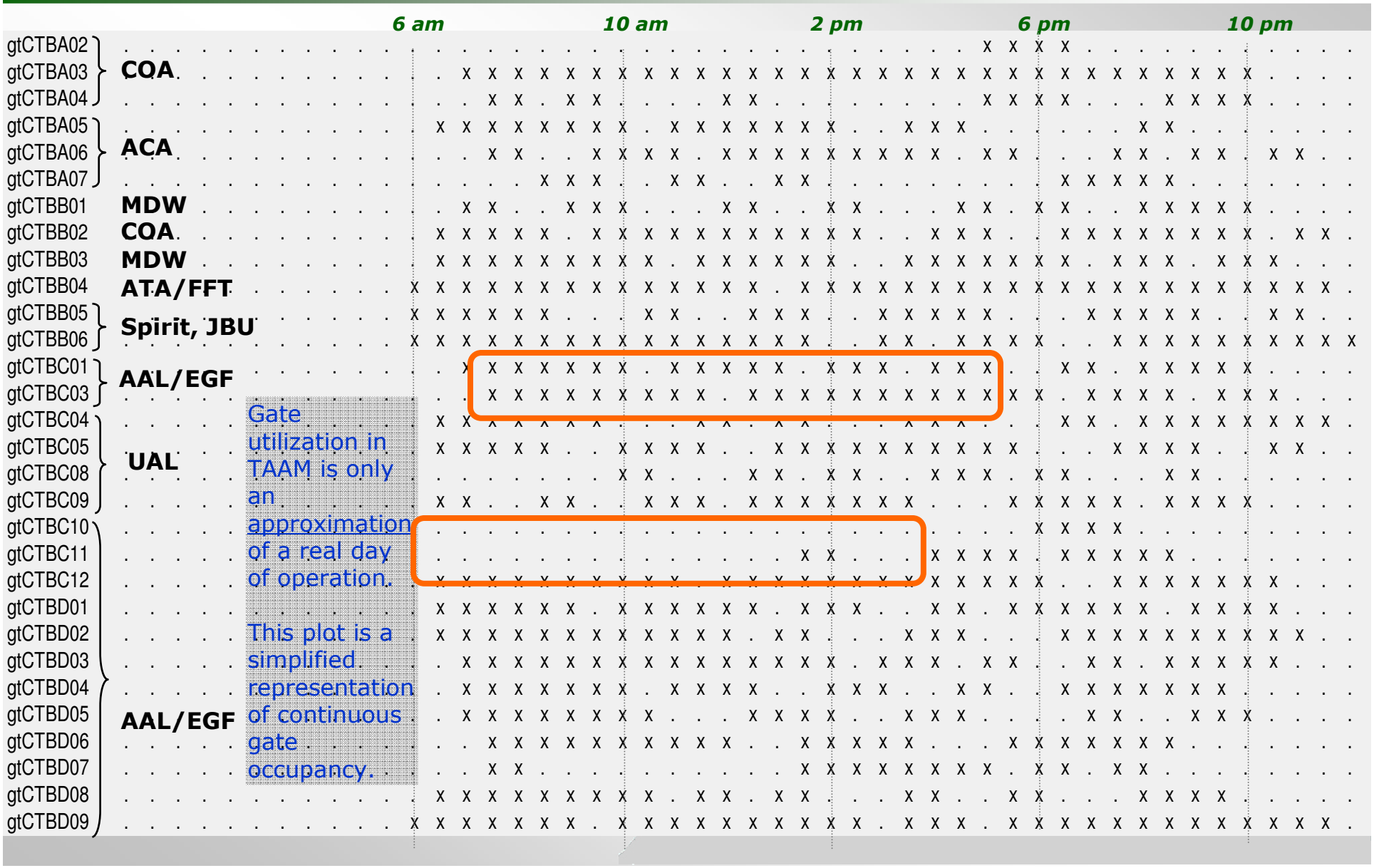
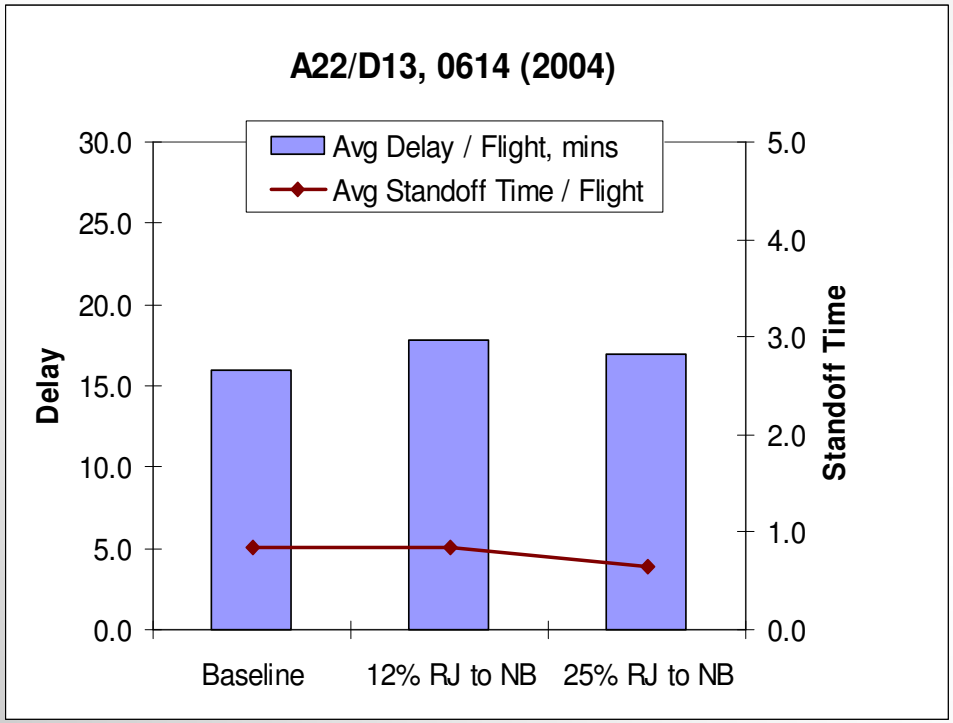
Gate Activity (TAAM Simulation) - excerpt

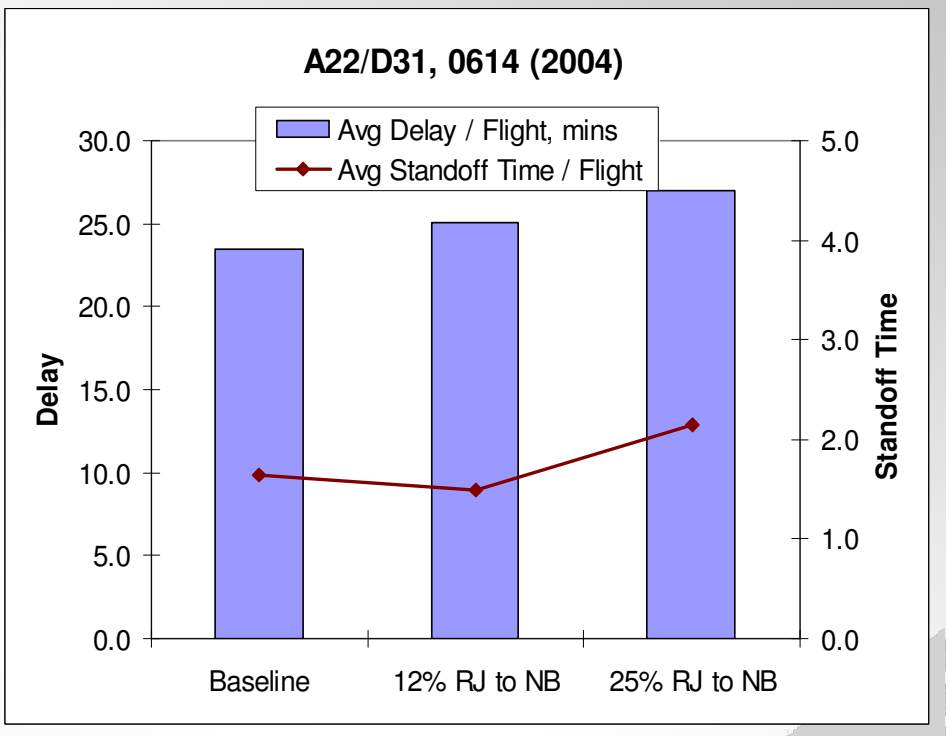
Example: A22/D13, 04/19 (GRA) Upgauged



Average Delay & Standoff Time / Flight

06/14/04 Sample (ETMS)

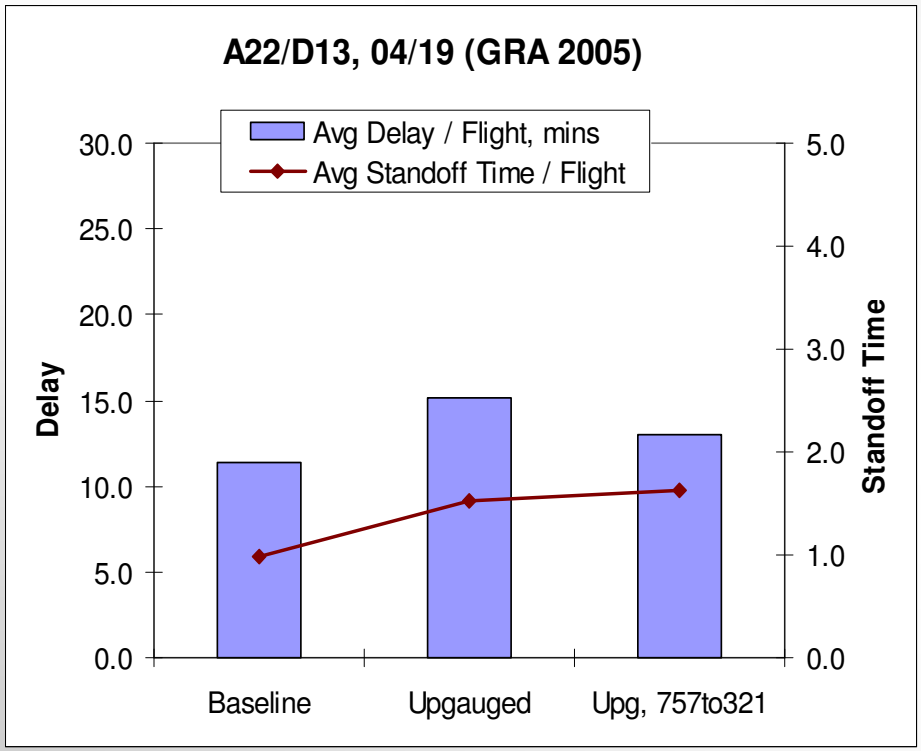


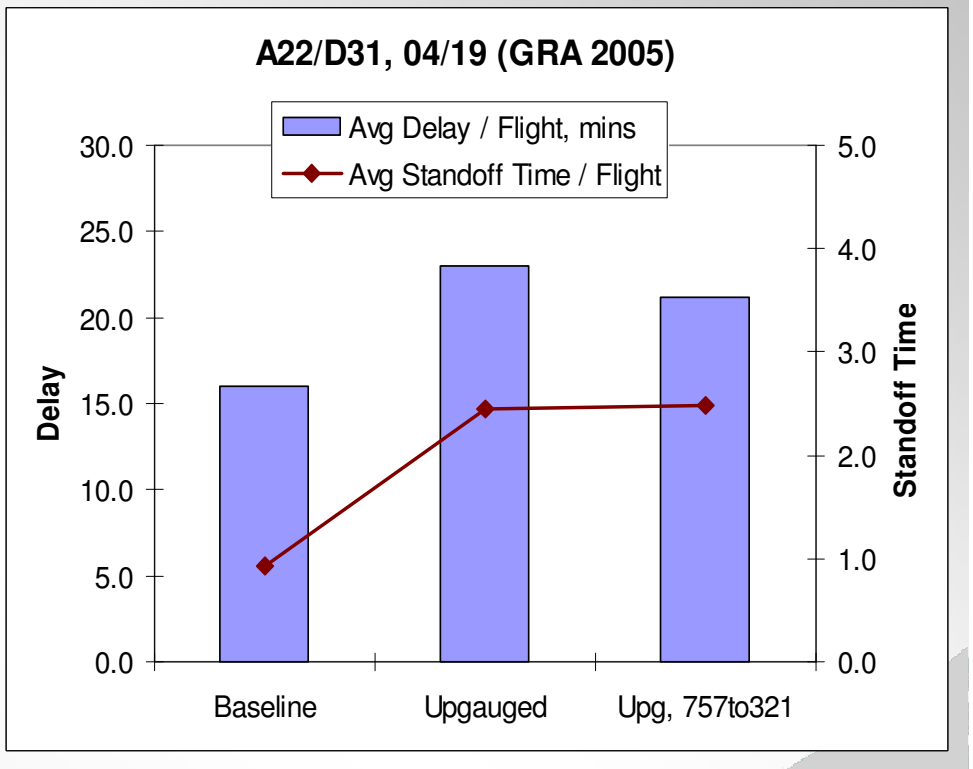


Runway configuration, impacts taxiway, and gate utilization

Average Delay & Standoff Time / Flight

04/19 Sample (GRA)

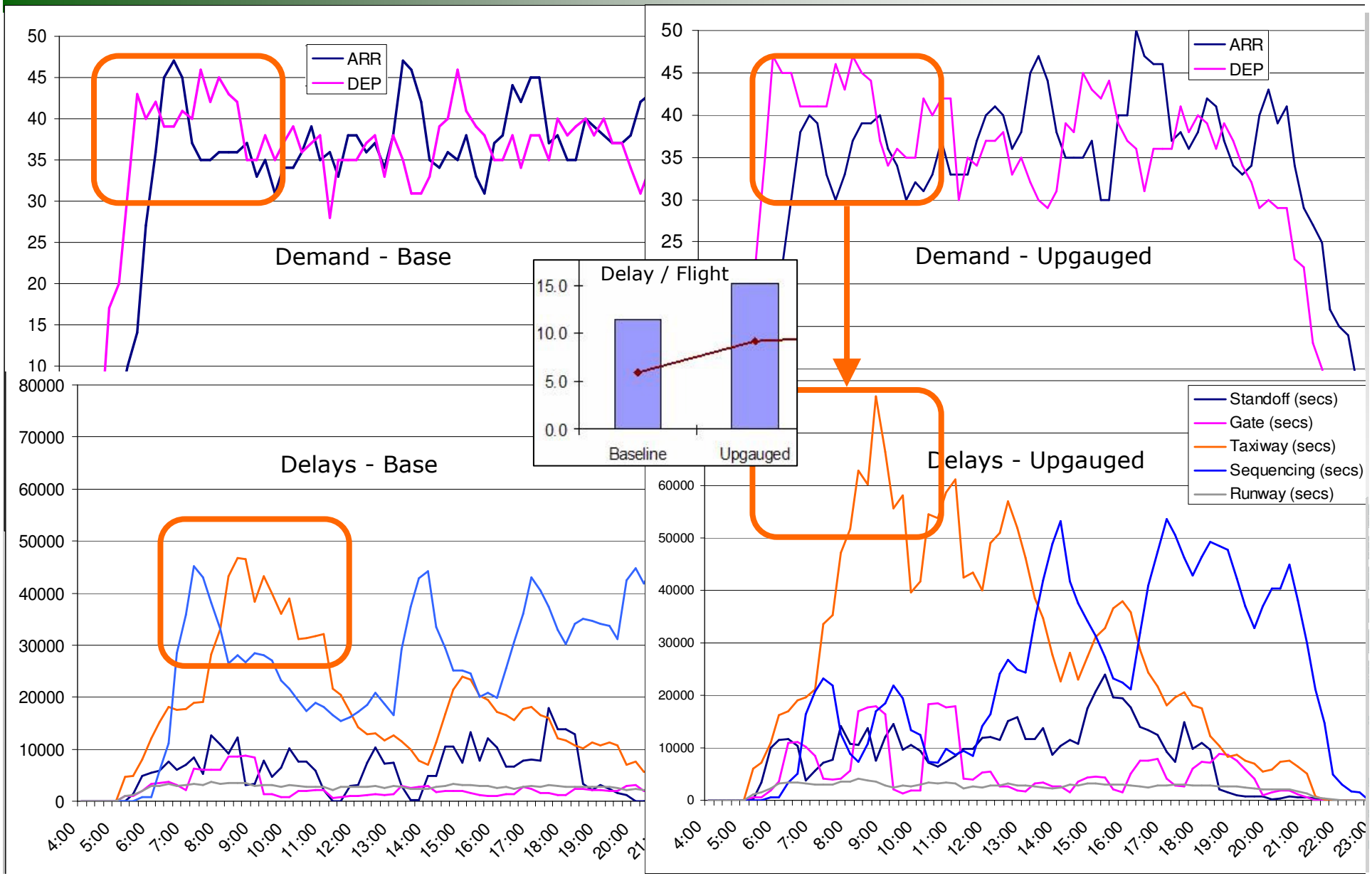




Runway configuration and Fleet-mix, impacts taxiway, and gate utilization

Understanding Differences in Delays

04/19 (GRA) Timetable, Baseline vs. Upgauged

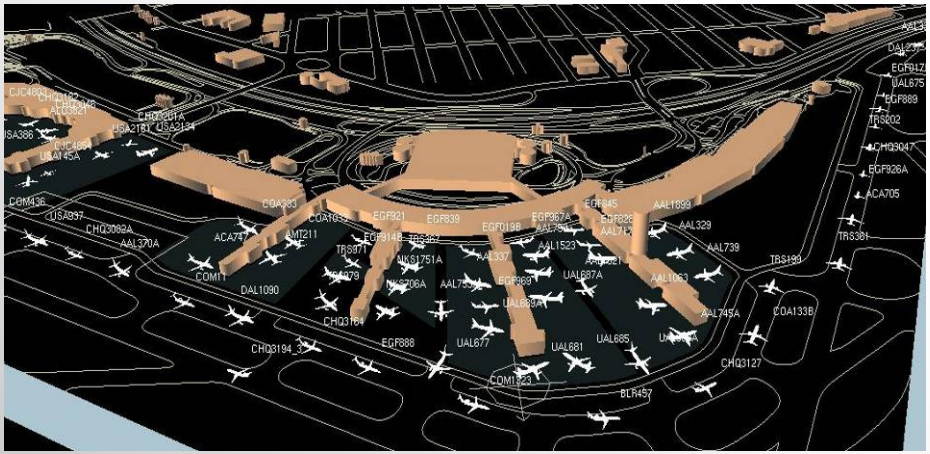


Randomized Simulations

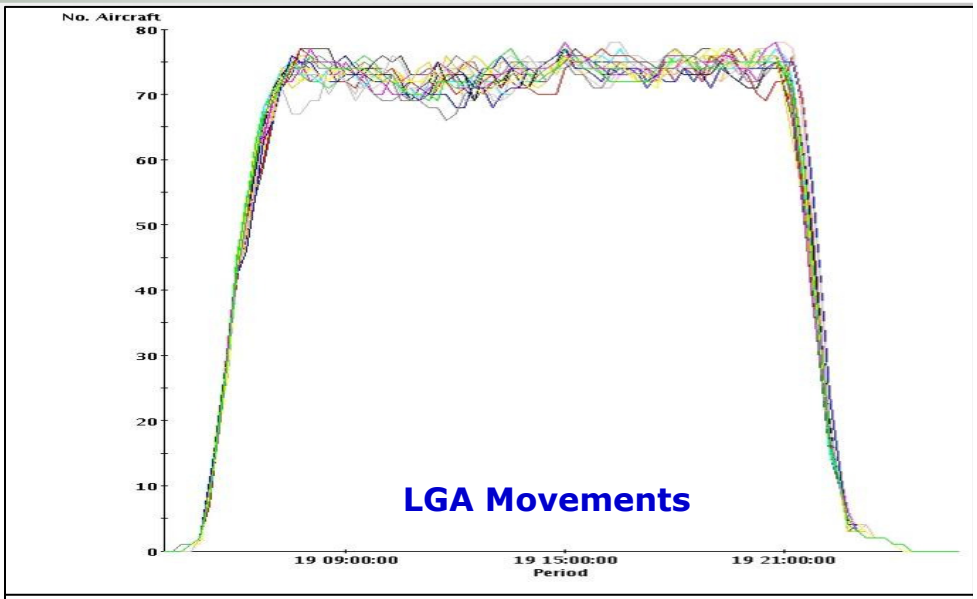
20 Runs per scenario (ATD, acft perf randomized)

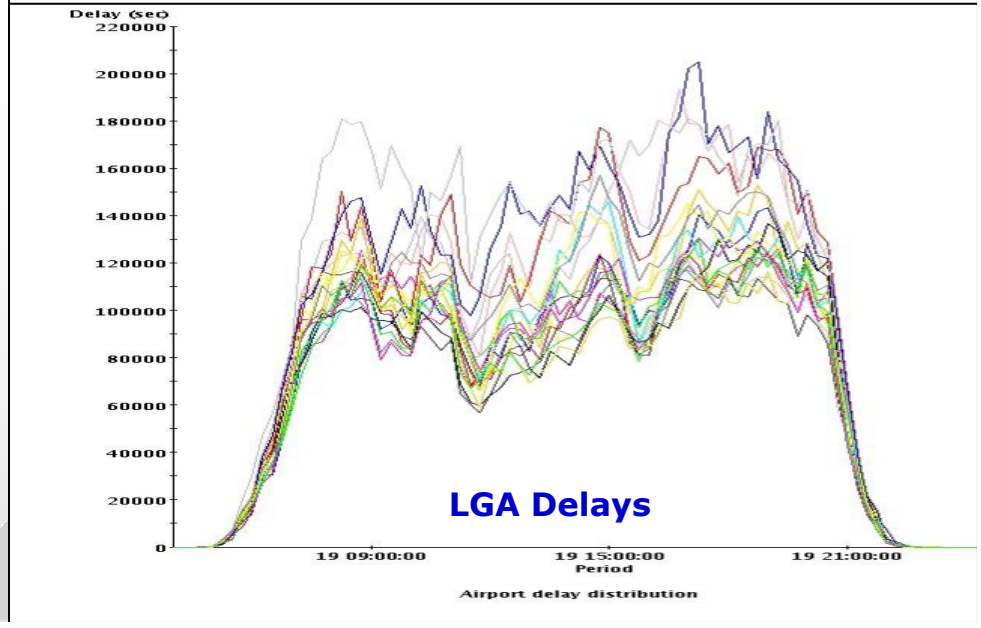
CATSR

At congested airports like LGA, small variations in traffic demand or throughput can lead to large fluctuations in delays

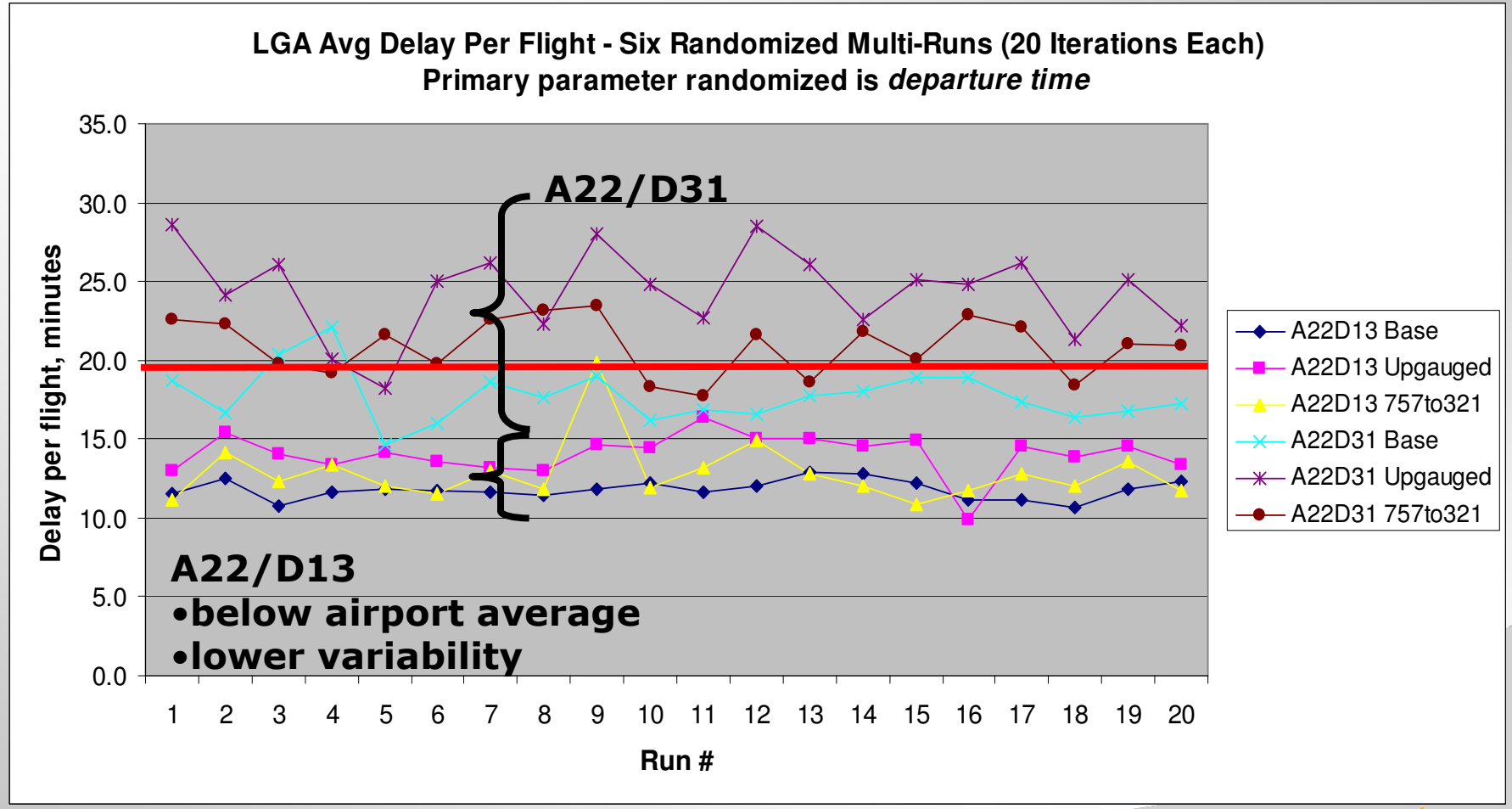


Example for 04/19 schedule, upgauged, A22/D31 runway configuration, is shown →





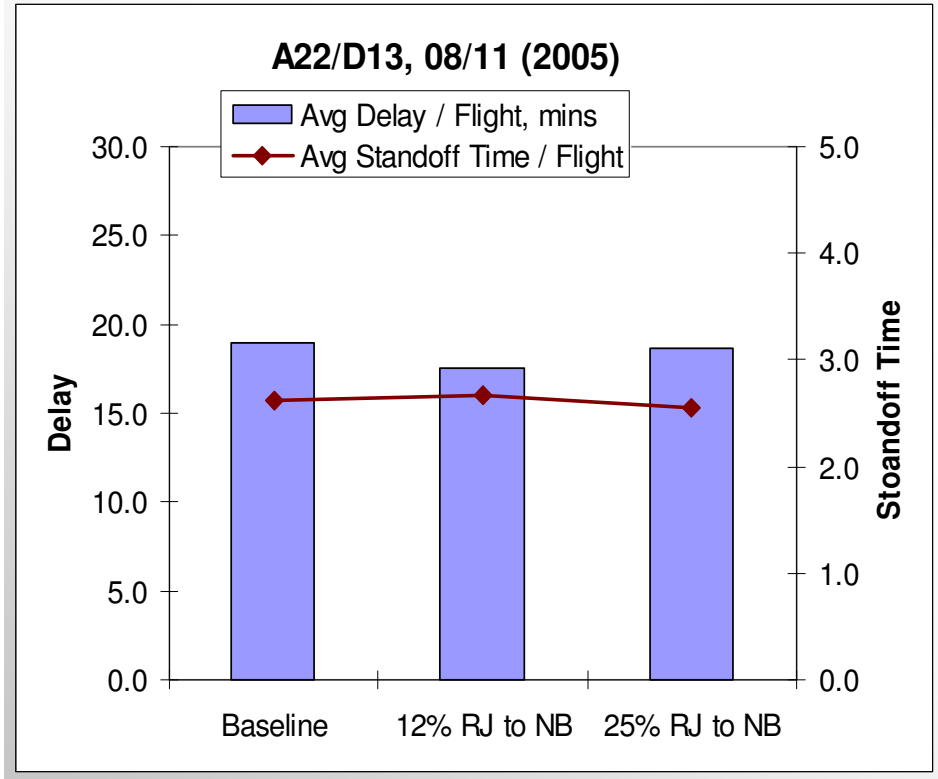
Effect of Randomization on Delays

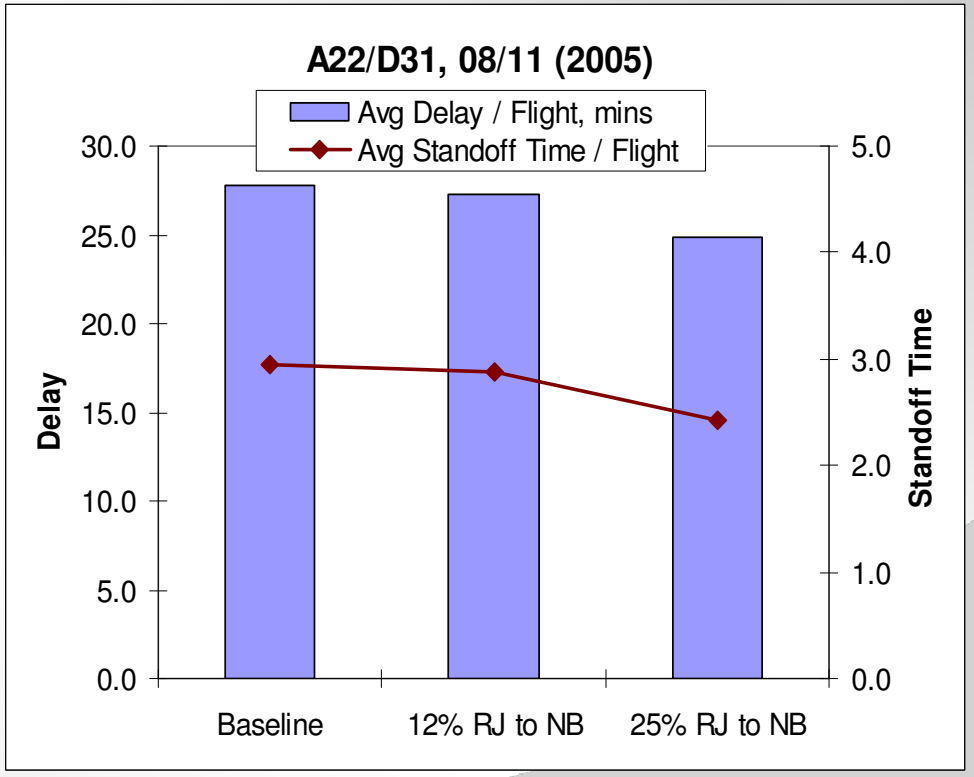


- Average Delay Per Flight for *20 Randomized TAAM Runs for the 6* (04/19, GRA) *Cases*
- Comparison with actual data: average delay/flight at LGA was 19.5 min in Aug 2005

Average Delay & Standoff Time / Flight

08/11/05 Sample (ETMS)





Summary of Results (Delays)

Upgauging could raise LGA's annual Pax throughput by about 3-4M

- Equivalent to increase of about 15-20 seats per aircraft (92-96 to 110-114)

Moderate upgauging does *not* lead to increased delays

- And, gate utilization would improve slightly

More aggressive upgauging *may* lead to some increase in delays

- Could be mitigated in part if 757s were replaced by B737-900, A321
- Could also be mitigated by better scheduling of flights

Summary Results (Gates)

At peak-demand times, LGA can be short of about 3-4 gates

- Gate shortages are highly "local" (carrier and time specific)
- Some un-used gates are always present, even at peak-demand times

Some carriers appear to have occasional overscheduling issues

- Comair, American Eagle, USAirways Express

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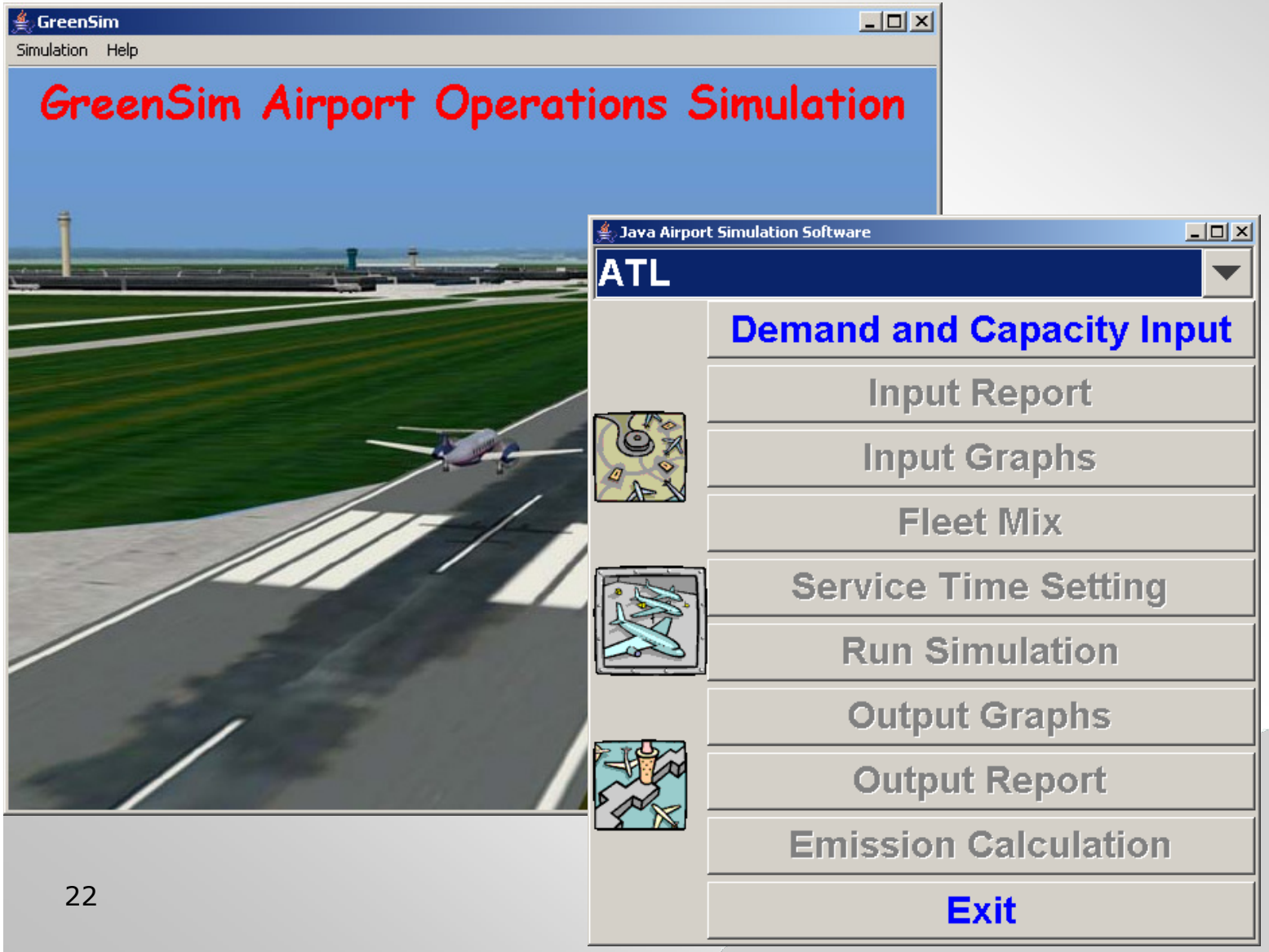
Phase 2.2 (Fuel, Emissions, Noise)

CATSR



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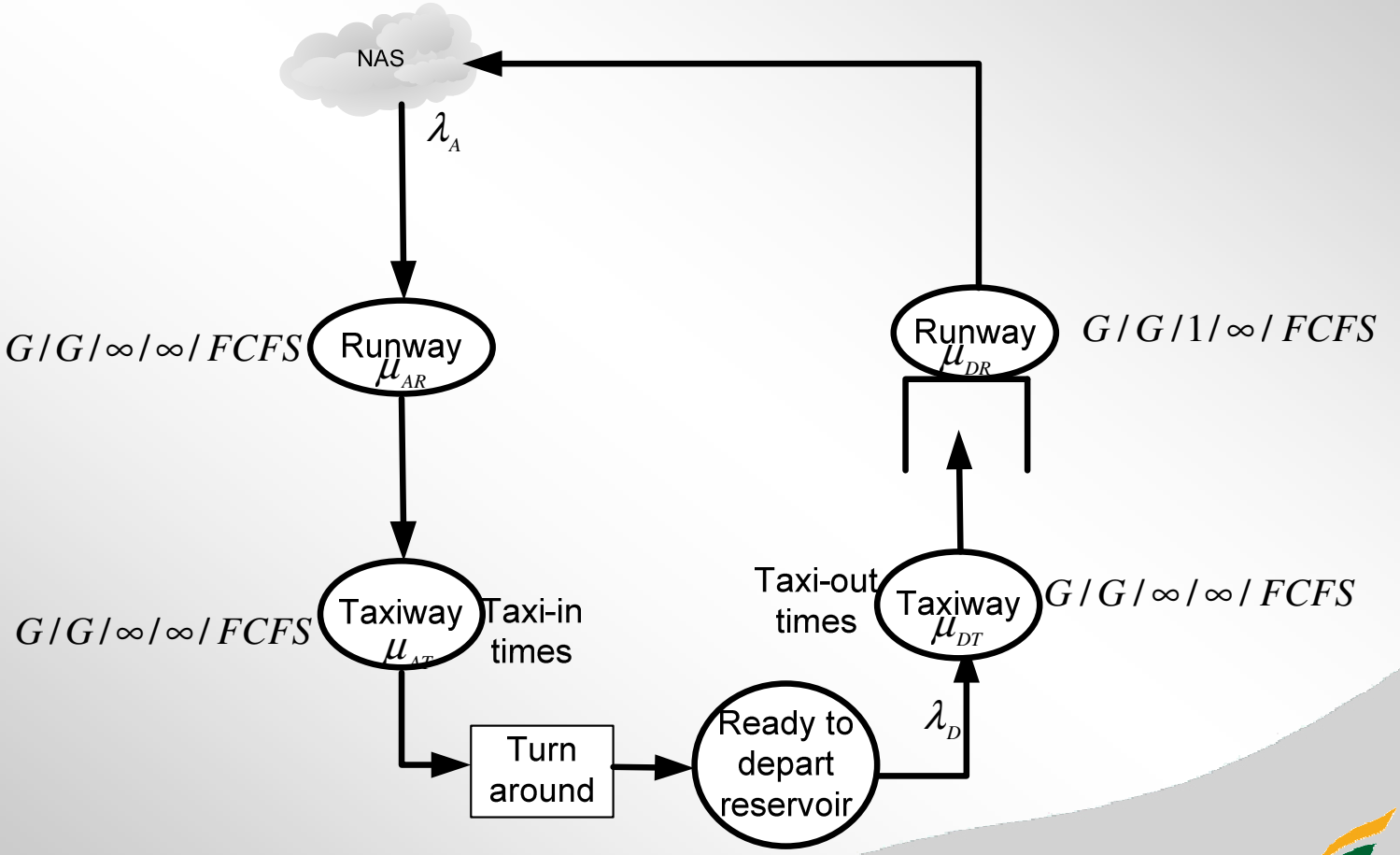
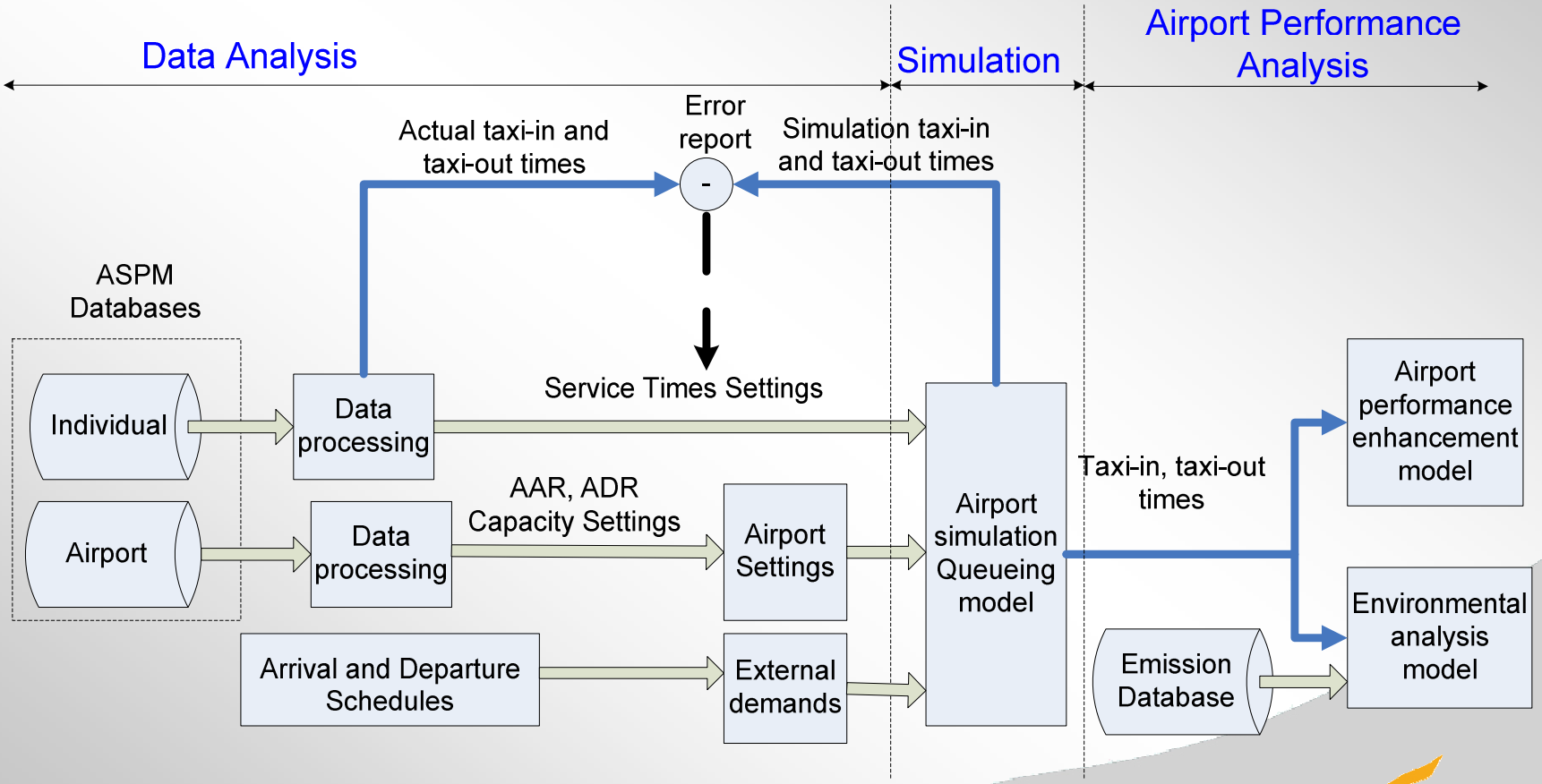
Airport Queueing Model



Functional Block Diagram



Design of Experiment

- 3 Scenarios
  1. ETMS Schedule (4/19/2005 - Baseline)
  2. GRA Schedule (Upguage, no frequency reduction)
  3. Max Efficiency (Upguage with frequency reduction)
- A22/D13
- Used average of 500 replications

Results – Schedule & Capacity

	Baseline	Upguage, No Frequency Reduction (GRA)	% Change	Upguage with Frequency Reduction	% Change
Daily Arrival Demand	**597**	**597**	**0.0%**	**492**	**-17.6%**
Departure Demand/day	597	597	0.0%	492	-17.6%
Hourly Arrival Demand	35	35	0.0%	29	-17.6%
Hourly Departure Demand	35	35	0.0%	29	-17.6%
Total Arrival Seats	**57401**	**68362**	**19.1%**	**58150**	**1.3%**
Total Departure Seats	57401	68459	19.3%	58153	1.3%
Total Seats	114802	136821	19.2%	116303	1.3%
AvgSeats/flight	**96**	**114**	**18.8%**	**118**	**22.9%**

Results - Delays

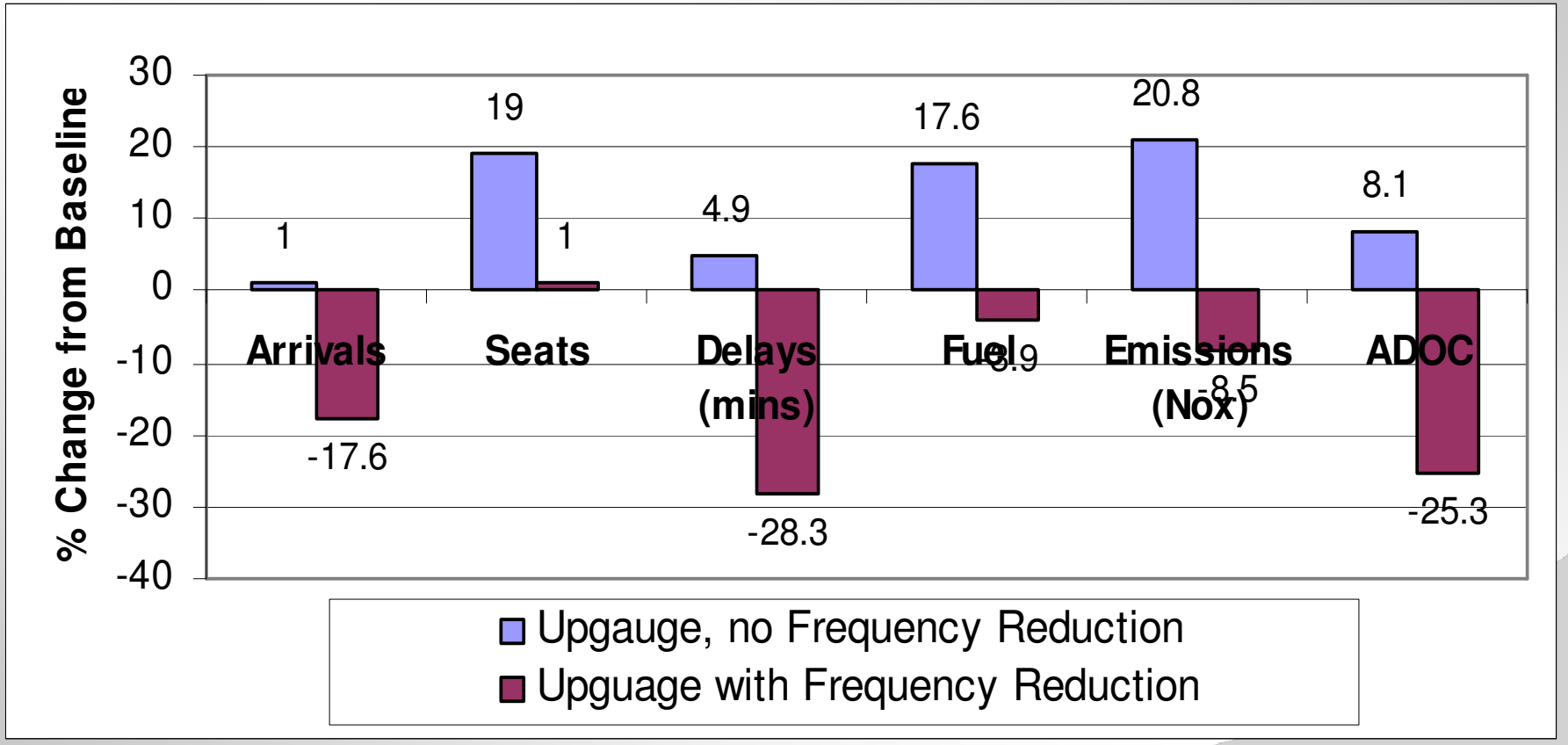
	Baseline	Upguage, No Frequency Reduction (GRA)	% Change	Upguage with Frequency Reduction	% Change
Taxi-in (mean, stdEV)	(6.9, 3.6)	(7.0, 3.6)	--	(6.8, 3.4)	--
Taxi-out (mean, stdEV)	(18.9, 5.8)	(19.4, 6.1)	--	(17.8, 4.9)	--
Total Taxi-in Delays (min)	1430.62	1450.48	1.4%	1109.45	-22.4%
Average Taxi-in Delays (min)	2.40	2.43	1.4%	2.25	-6.2%
Total Taxi-out Delays (min)	4327.11	4586.87	6%	3016.27	-30.3%
Average Taxi-out Delays (min)	7.25	7.68	6%	6.13	-15.4%
Total Delay (min)	**5757.73**	**6037.35**	**4.9%**	**4125.72**	**-28.3%**
Maximum Queue Size	**10.00**	**11.00**	**10%**	**9.00**	**-10.0%**
Mean Queue Size	**2.17**	**2.42**	**11%**	**1.23**	**-43.3%**
Mean Queue Time(min)	**2.49**	**2.77**	**11%**	**1.71**	**-31.3%**

Note: Airport only taxi & gate), not include arrival delays

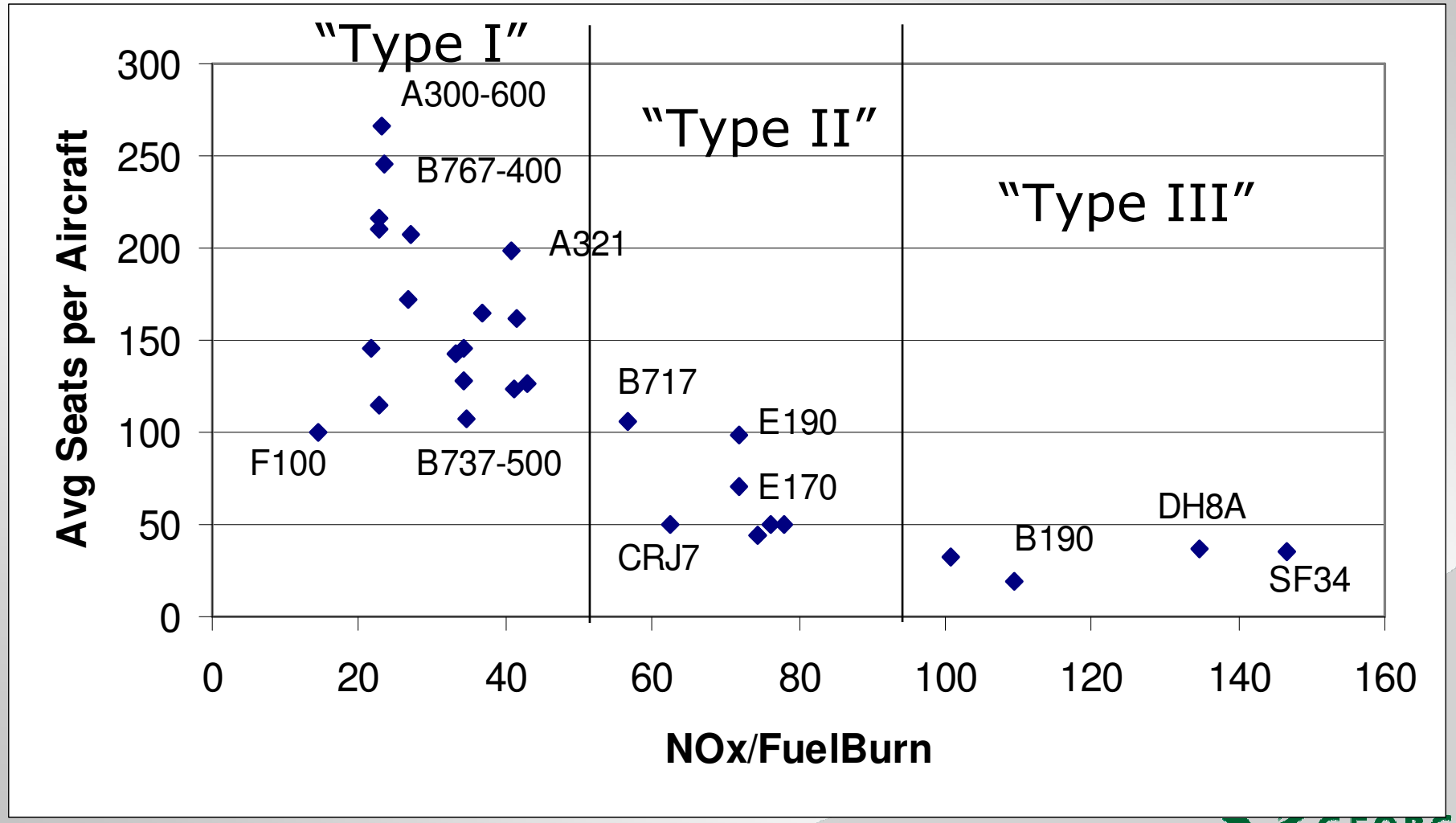
Results – Fuel & Emissions

	Baseline	Upguage, No Frequency Reduction (GRA)	% Chg	Upguage with Frequency Reduction	% Chg
Fuel(ton)	**158.1**	**185.9**	**17.6%**	**152.0**	**-3.9%**
CO(kg)	3733.3	4032.2	8.0%	3700.5	-0.9%
HC(kg)	465.2	433.7	-6.8%	449.5	-3.4%
NOx(kg)	**642.7**	**776.3**	**20.8%**	**588.1**	**-8.5%**
SOx(kg)	158.1	185.9	17.6%	152.0	-3.9%
TotalEm(kg)	4999.3	5428.1	8.6%	4890.1	-2.2%

Results - Summary

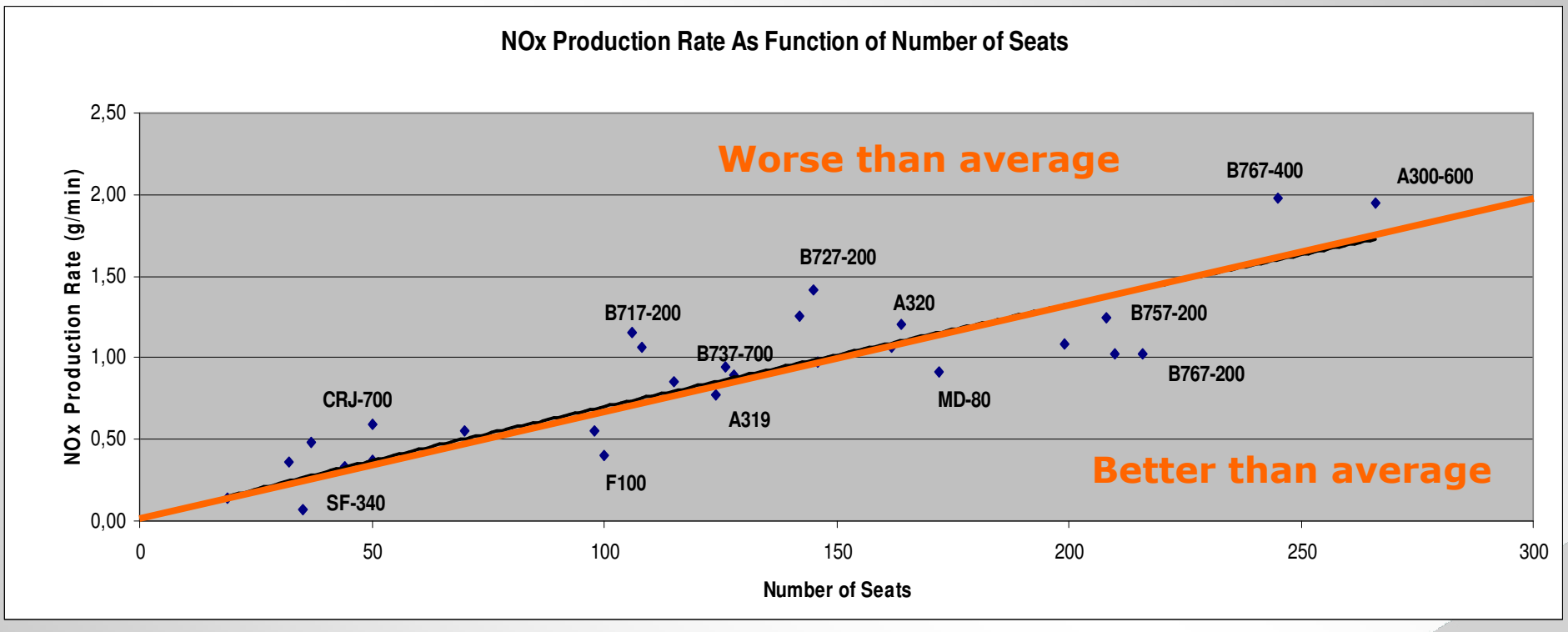


Results – NOx & Fleet Mix



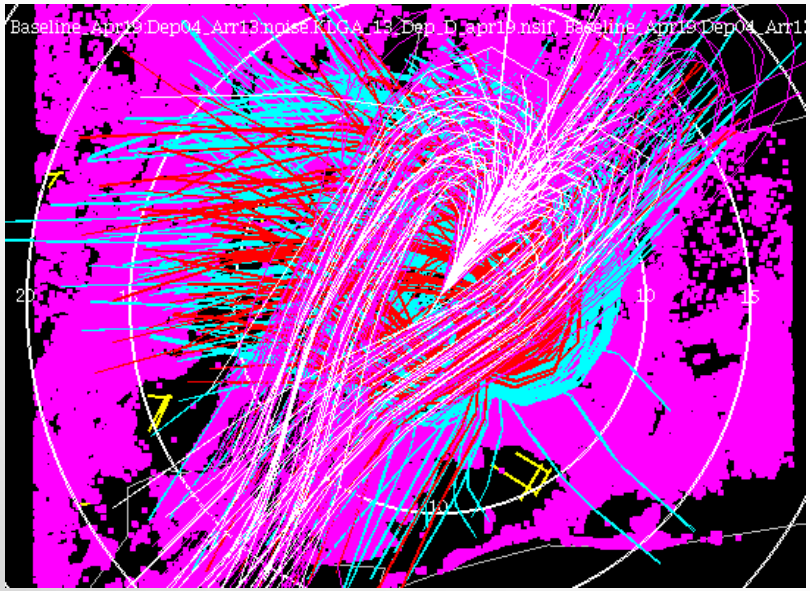
Migrating to "Cat I" has Positive Emissions Implications

Results – Taxi NOx Rate & Fleet Mix



Given choice of delaying one of two aircarft, pick the one with more NOx per passengers.

Noise Effects



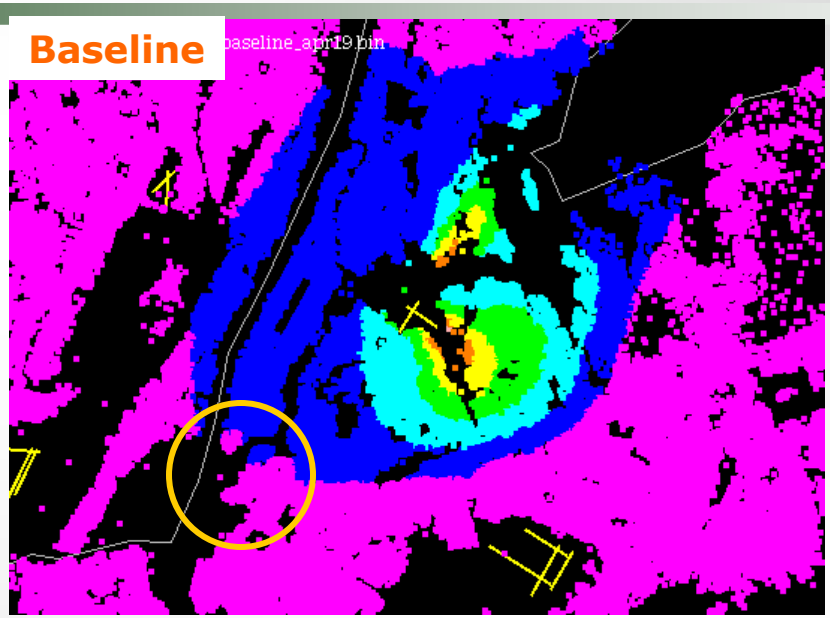
Arrival (22) and Departure (13) Tracks

- **DNL measure of noise**
  - **Dosage to population centers in region**
  - **FAA regional noise model**
  - **Used in NYNJPHL airspace project**
- **Portion of each flight distributed over all annual distribution of trajectories for A22/D13**

DNL Geographic Distributions

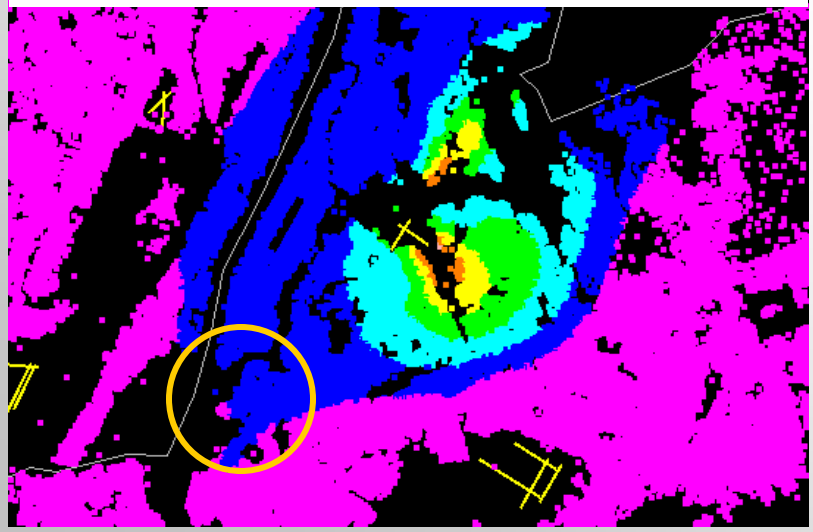
DNL Values at Population Centroids
> 65 db - red
60-65 db - yellow
55-60 db - green
50-55 db - light blue
45–50 db - dark blue
< 45 db - magenta

Baseline

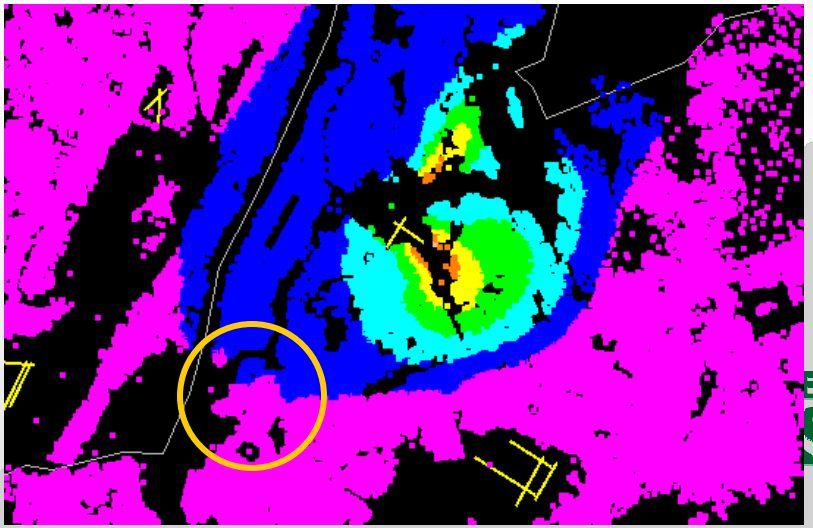


- **DNL geographical distribution around LGA.**
- **The circles highlight *one* area in which there was change**
  - **Larger aircraft low and slow**

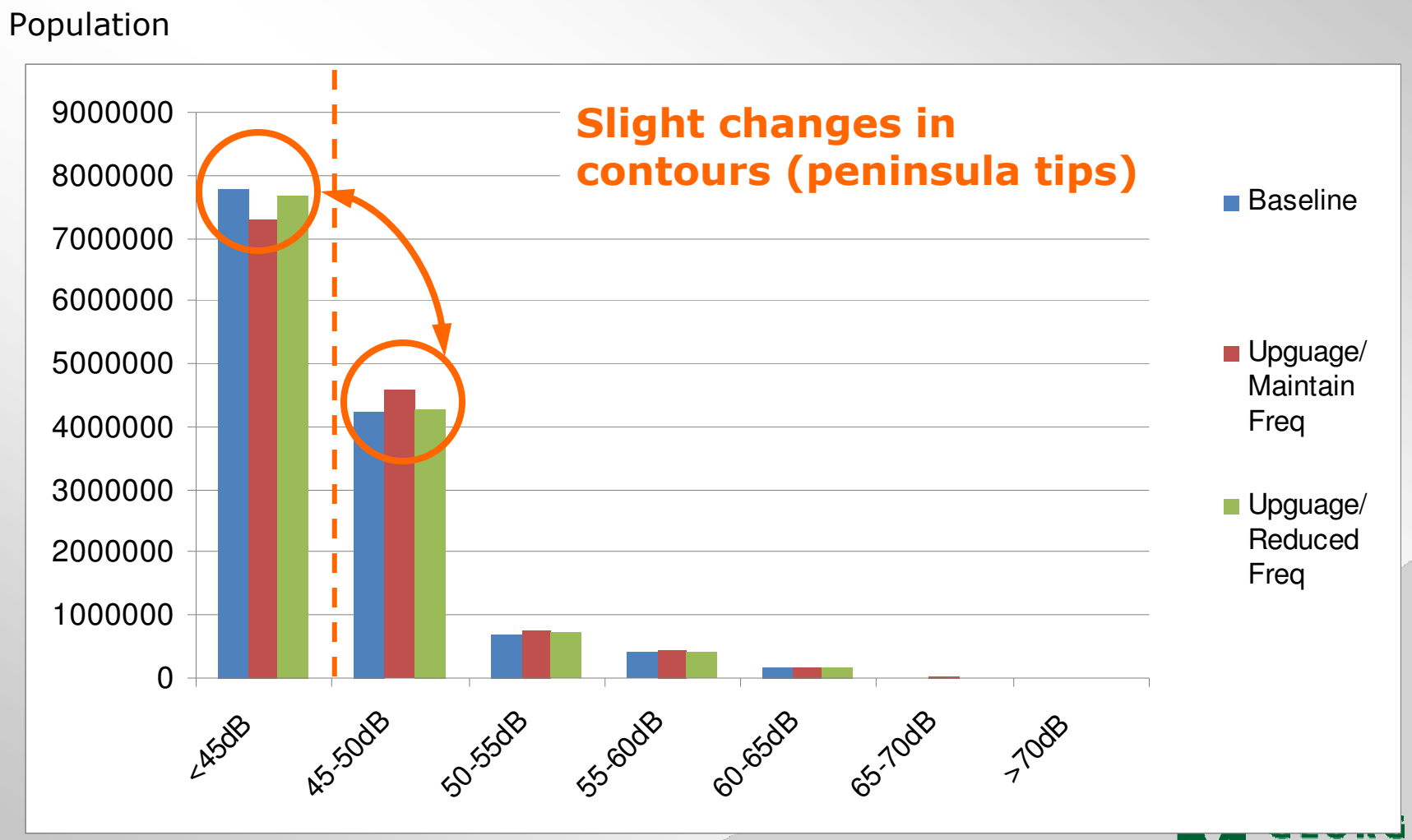
Upguage & Maintain Frequency



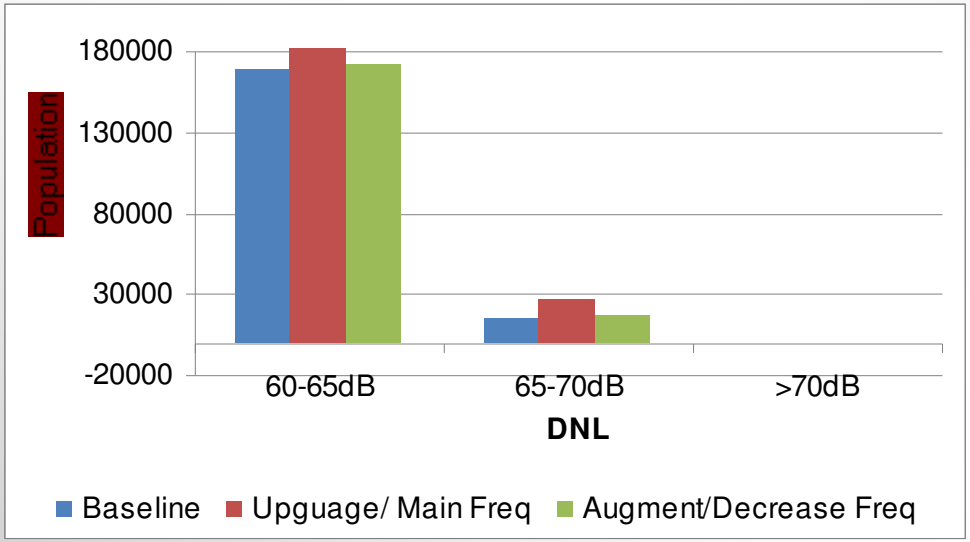
Upguage & Decrease Frequency



Population Exposure at DNL Levels



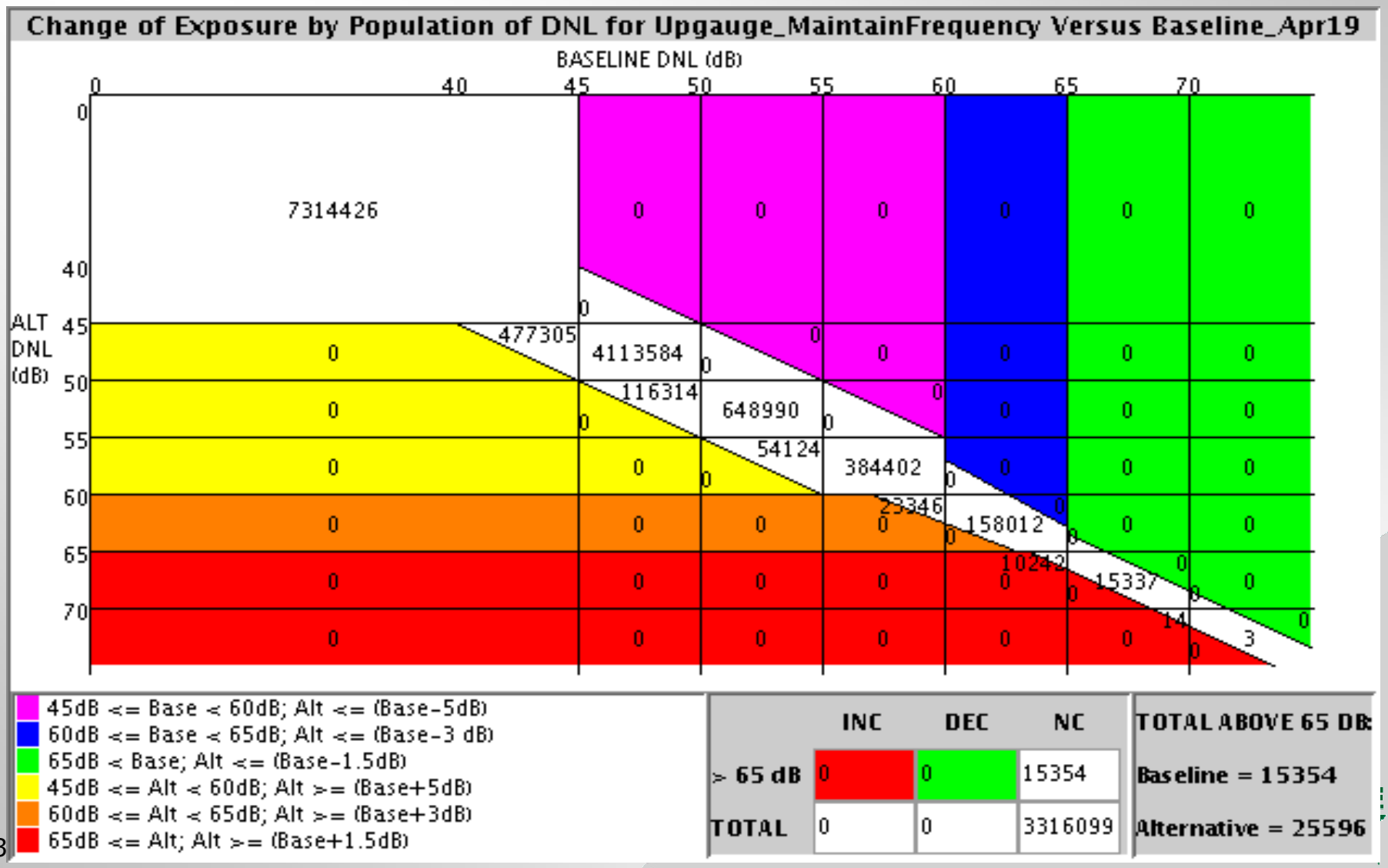
Population Exposed at Different DNL Levels (Cont'd)



Total Population at Levels Above 60 dB DNL

- **Small changes in DNL levels > 60 dB.**
- **Changes do not trigger the standard FAA rules for « significant impact »**
  - **1.5dB above 65dB**
  - **Hence, all colored zones on the Impact Graph contain zero population.**
- **changes for locations recieving more than 65 dB are about 0.5-1.0 dB**

Impact FAA Significance Criteria



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Sensitivity of Noise Impacts

- Noise is sensitive to:
  1. Night events 21:59 to 7:00
     - Baseline & Upguage Reduce Frequency
       - 597 departures with 551 day and 46 night
       - 597 arrivals with 548 day and 49 night
     - Upgauge/No Frequency Reduction:
       - 597 departures with 548 day and 49 night
       - 597 arrivals with 539 day and 58 night
  2. Aircraft/engine fleet composition
     - Age factor

Conclusions

- Upguaging without Frequency change
  - Proportional increase in seat capacity
  - Marginal impact on delays
    - Fleet mix (i.e. separation distance)
    - Schedule “peaking”
  - Proportional increase in fuel-burn & ADOC
    - Derived from fleet mix
  - Proportional increase in Emissions (NOx)
    - Fleet mix (i.e. engine-type)
  - Little impact on noise

- Upguaging with Frequency Reduction
  - Maintain seat capacity
  - Significant reduction in delays
  - Reduced fuel burn and ADOC
    - Derived from delays
  - Marginal reduction in fuel-burn
    - Dependent on fleet-mix
  - Maintains noise contours

Conclusions

- Airport pax throughput improved by upguaging
  - Marginal impact on delays
    - under assumptions of capacity limits, schedule "peaking" and fleet mix
  - Impact on Emissions and Noise not proportional to schedule or delay reduction
    - Highly dependent on fleet-mix (engine-type)
- Future regulations should consider
    - Multiple capacities throughout day (buffer for delays from peak periods)
    - Emissions and Noise by fleet mix