Operational Inefficiencies due to Airport Interaction in the New York Airspace

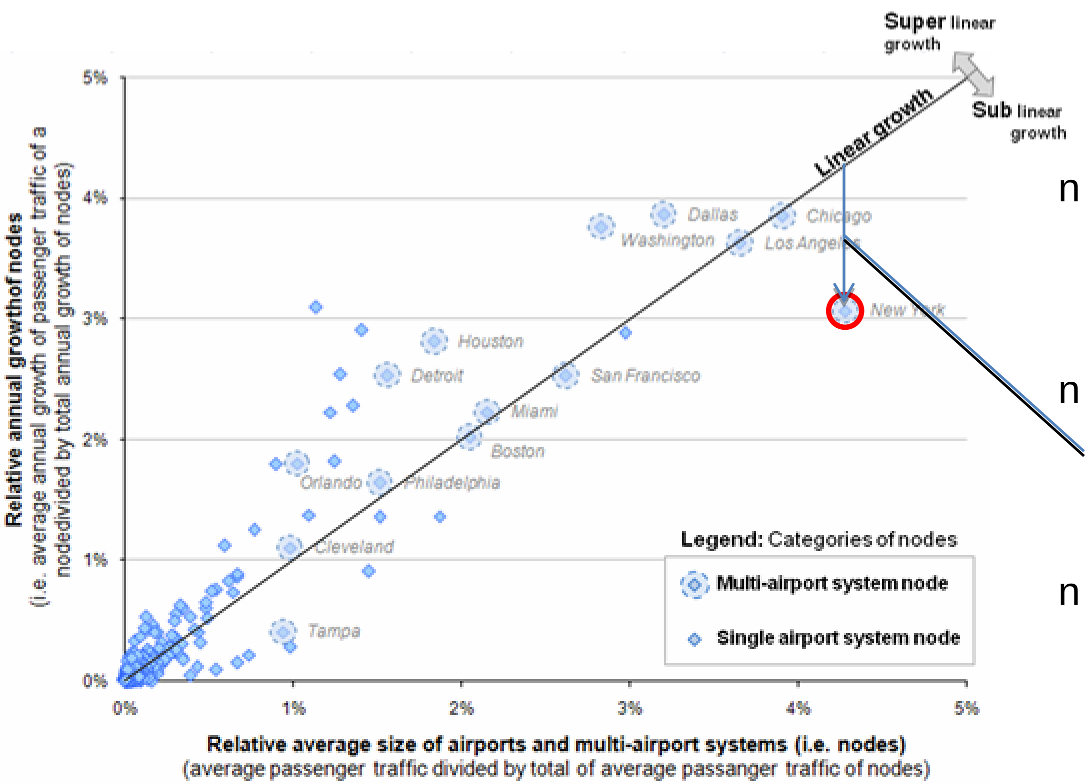
A. Donaldson

P. Bonnefoy

R. J. Hansman

Motivation

(Why New York is Important)



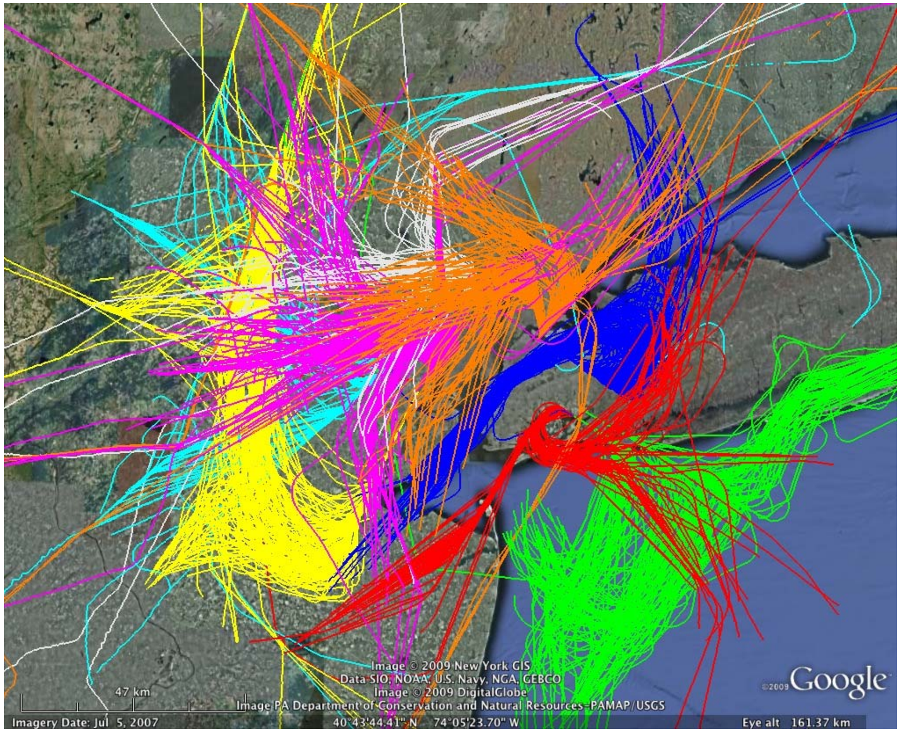
- Growth in traffic at nodes in the airspace network would be equal to their share of the traffic for balanced growth
- This rule holds true for almost all the major hubs (where a hub may be a multi-airport system)
- New York is an exception, growth is significantly lower than its share of the traffic
- This suggests that the New York airspace is reaching its capacity and is a bottleneck to growth of the entire network

Figure: Courtesy of Dr P. Bonnefoy

Motivation

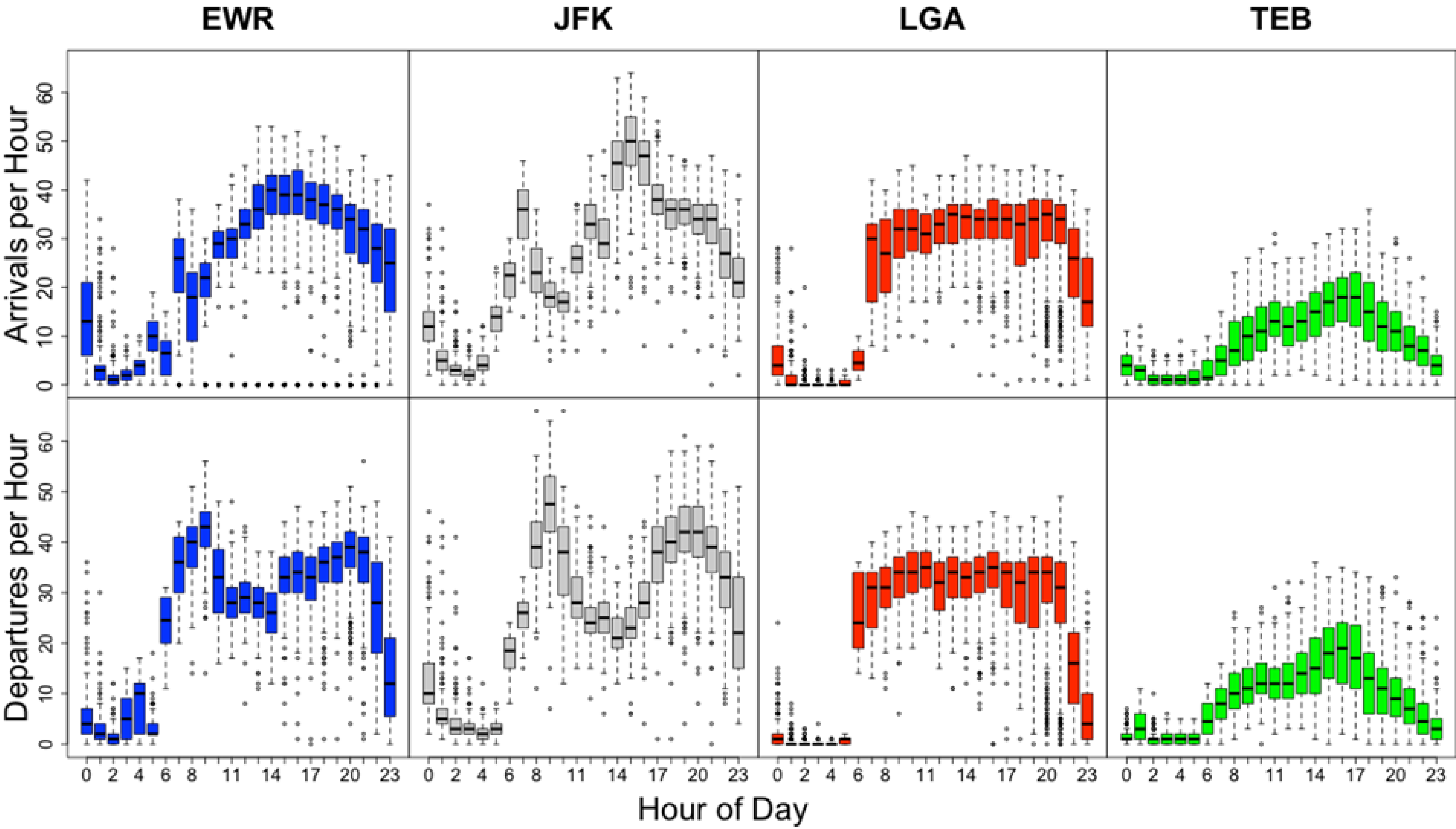
(Why New York is Hard)

- **The New York airspace is the most complex in the national airspace system (NAS)**
- **New York operates many high density routes in close proximity**
- **The configuration of routes into and out of each airport depends heavily on the configuration of surrounding airports**
- **Currently tactical choices about sharing airspace efficiency are made by NY TRACON**
- **<u>New York is likely the hardest and most important point in the NAS for NextGen to find extra capacity</u>**



Quantification of the current limiting factors can then be used to highlight the procedures that would benefit the most from changes under NextGen

Background: NY Traffic Trends



Initial Analysis

- **Conventional airport capacity analysis measures the arrival and departure rates into individual airport**
- **Initial work by Prof. Hansman and Dr. Bonnefoy instead measured the capacity of the entire system of New York airports and compared this to the individual airport capacity measurements**
- **Hypothesis:**
  - The maximum capacity of the NY system will be lower than the sum of maximum capacities of the individual airports
  - This capacity gap is due to the interaction between operations from different airports

Slide created by Dr P. Bonnefoy

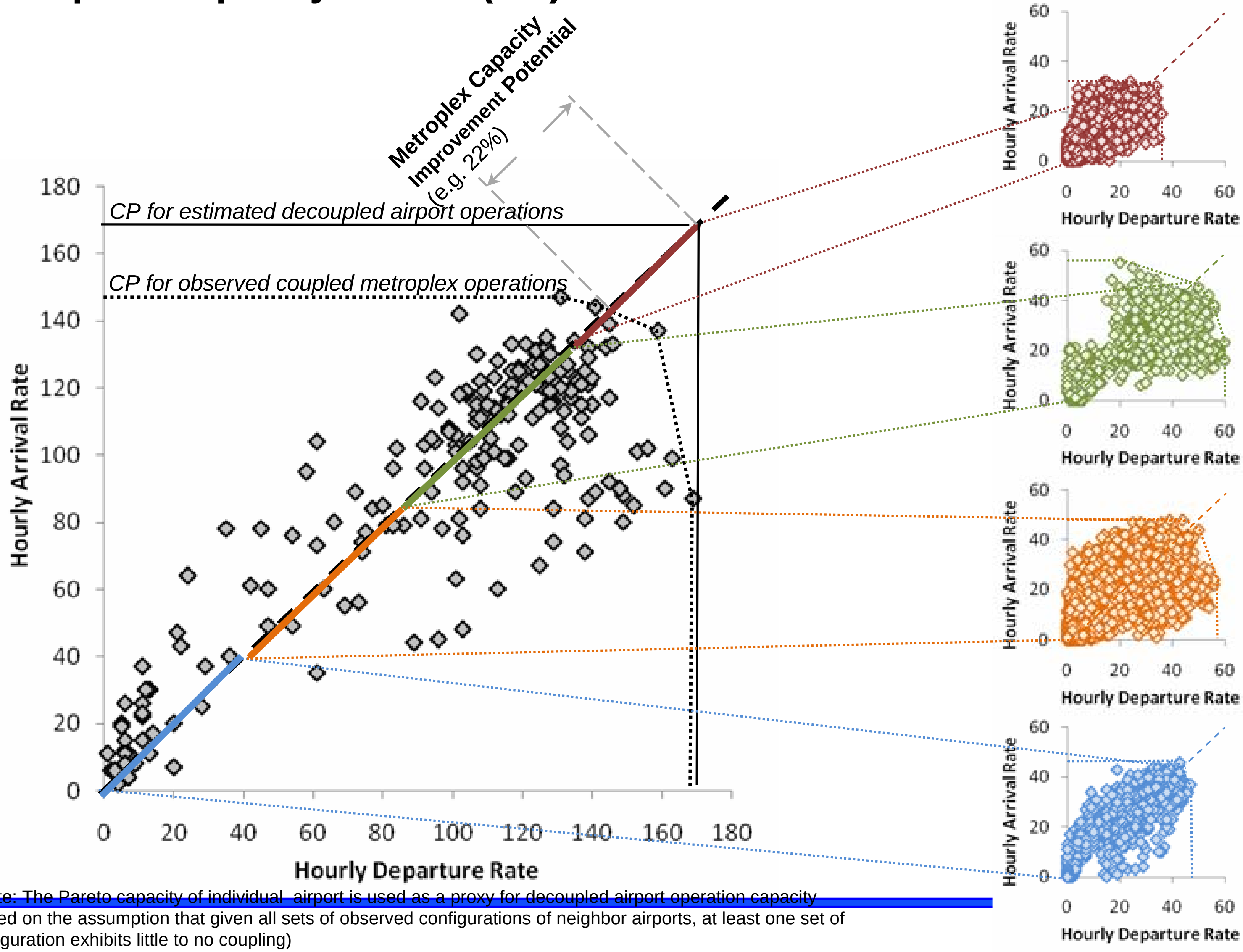
Estimation of the Metroplex Capacity Improvement Potential

(i.e. Difference between the Capacity from Coupled Metroplex Operations and the Sum of Capacity from Decoupled* Airport Operations)

Illustration with configuration: LGA 22 | 31 -- EWR 22L | 22R -- JFK 22L | 22R, 31L -- TEB 19 | 24

Metroplex Capacity Profile (CP)

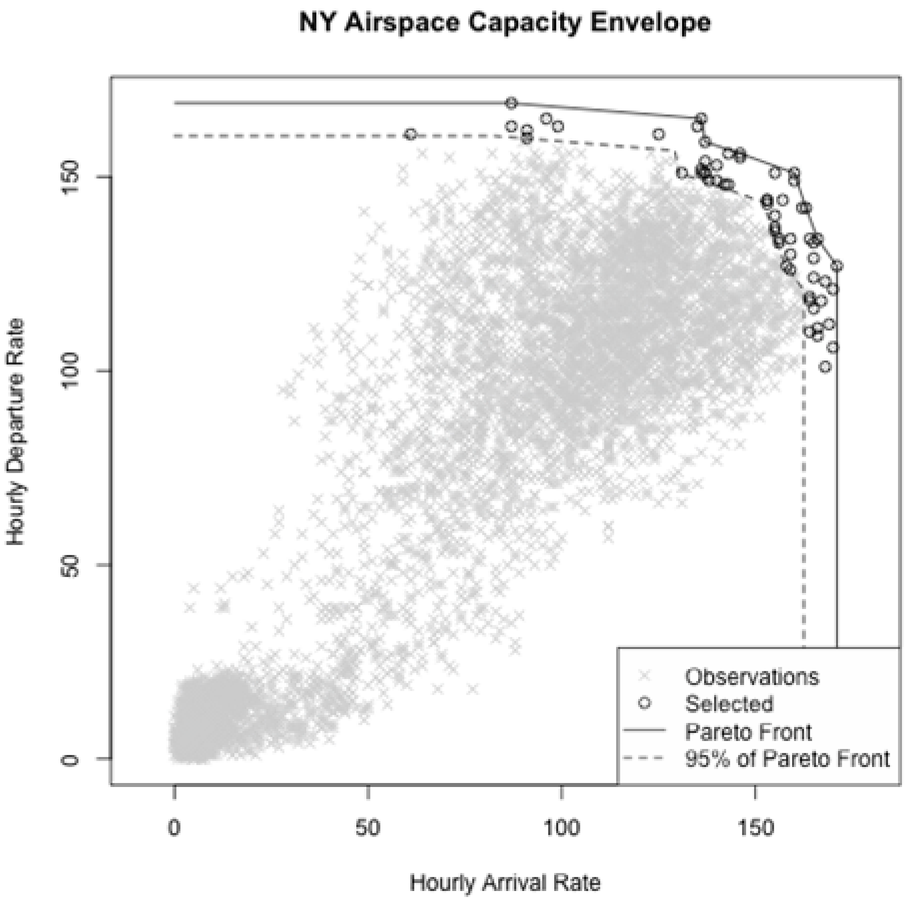
CPs for Individual Airports



* Note: The Pareto capacity of individual airport is used as a proxy for decoupled airport operation capacity (based on the assumption that given all sets of observed configurations of neighbor airports, at least one set of configuration exhibits little to no coupling)

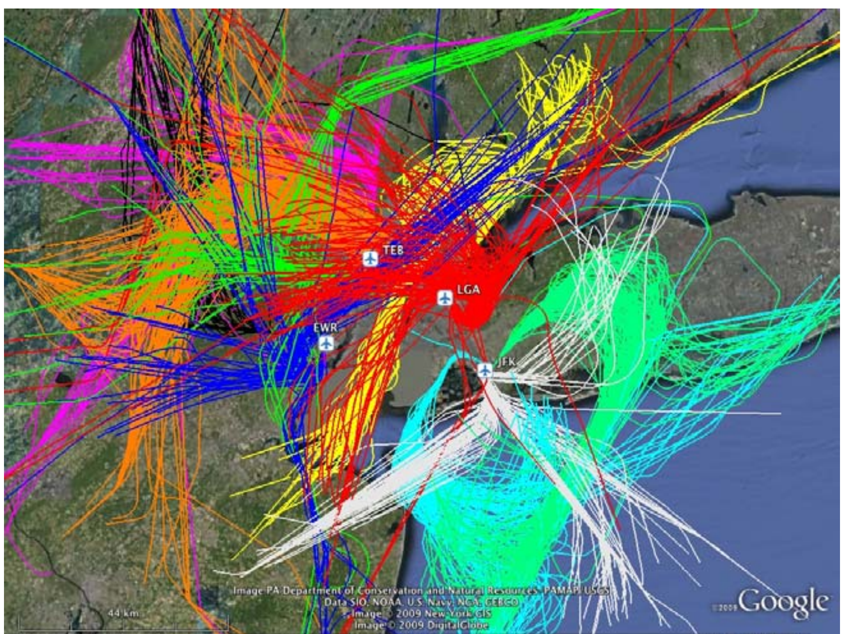
General Analysis

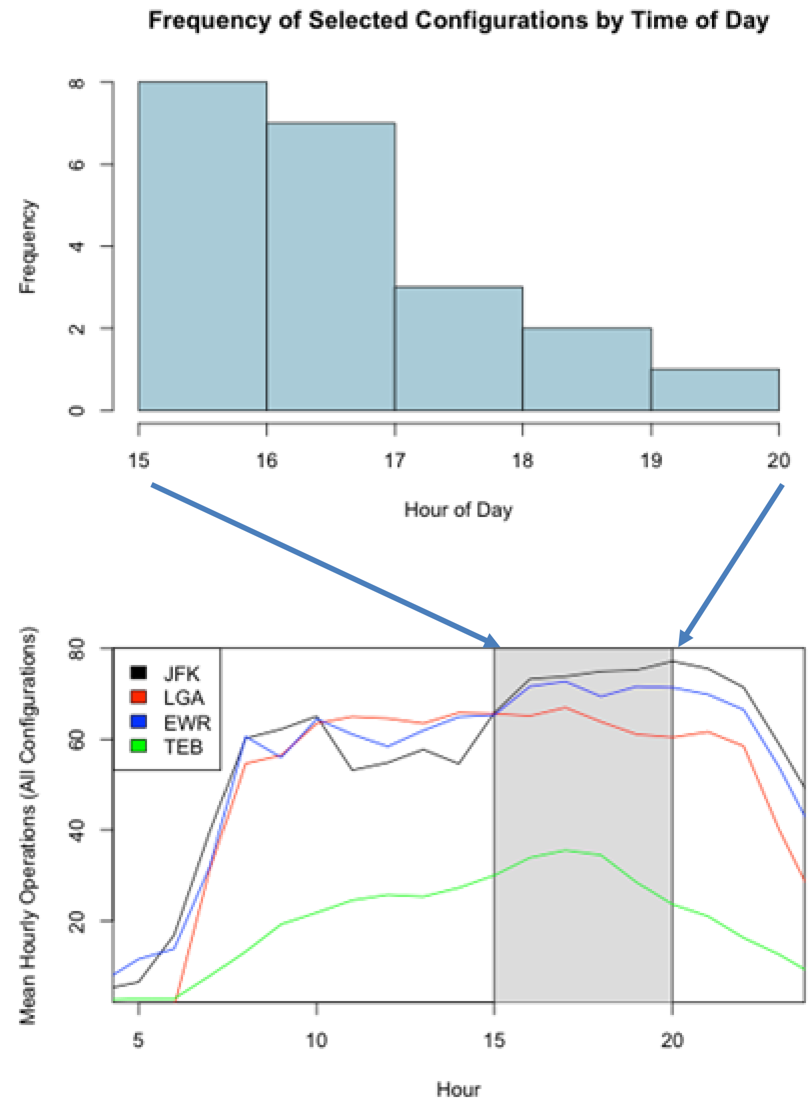
- **Data points that represent the system operating at maximum load were selected for further analysis**
- **The 5% selection margin was added to increase the sample size beyond the 8 Pareto-optimal points**
- **These points are unlikely to be limited by weather or schedule**



Dominant Configuration

- **One configuration dominates**
- **Observations occurred under excellent VMC conditions**
- **Predominantly from the April-September period**



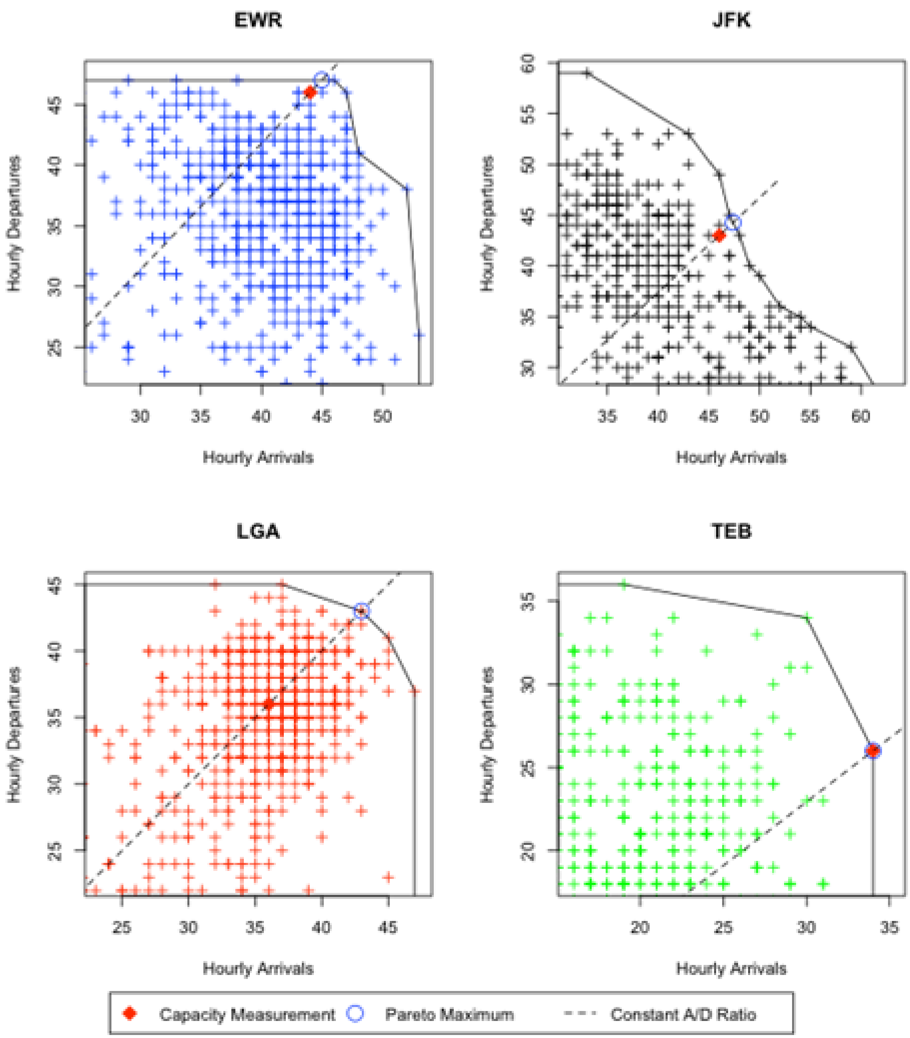


Calculating the Capacity Gap

For each data point:

1. **Calculate the ratio of arrivals to departures at each airport**
2. **Find the pareto-optimal arrival and departure rate for this ratio in this configuration**
3. **Add the individual airport pareto maxima together**
4. **Compare the calculated maximum to the measured maximum for the airspace**

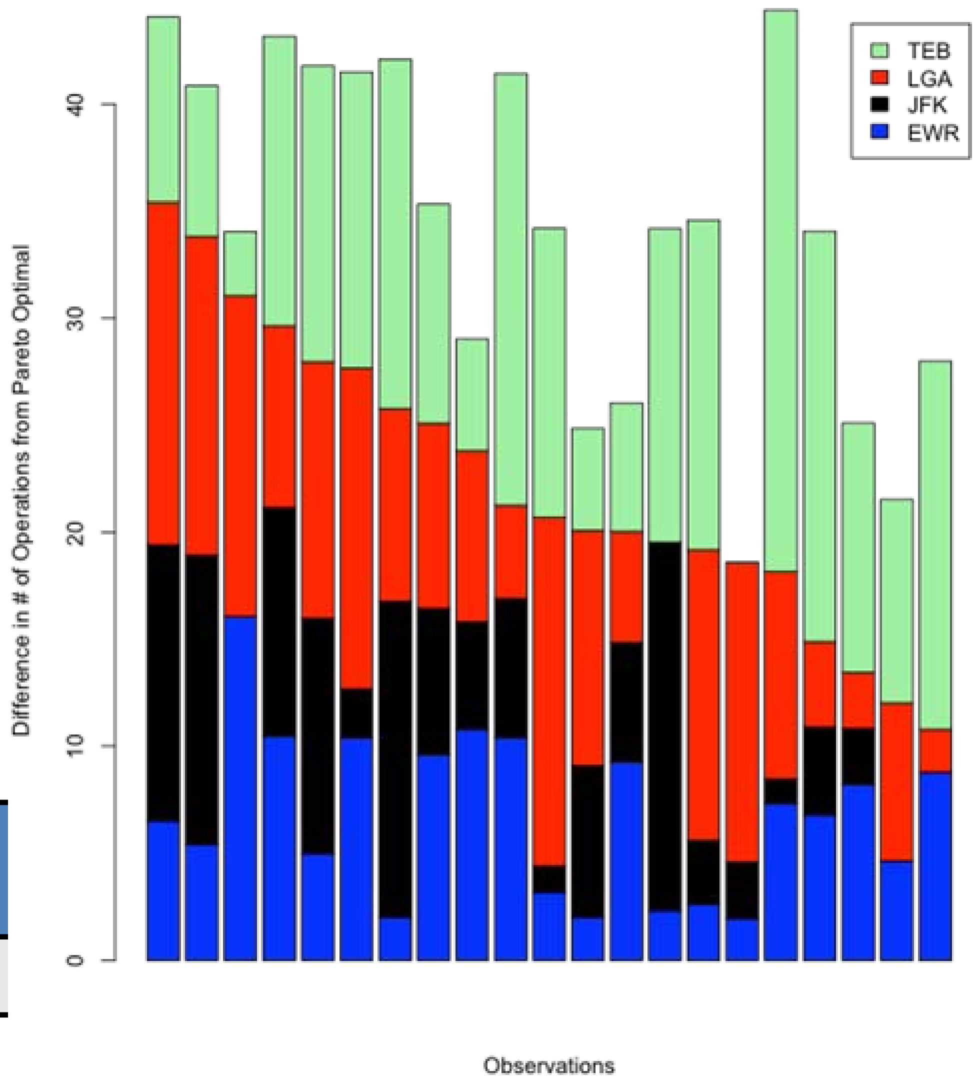
Example Calculation of Capacity Gap for One Data Point



Results

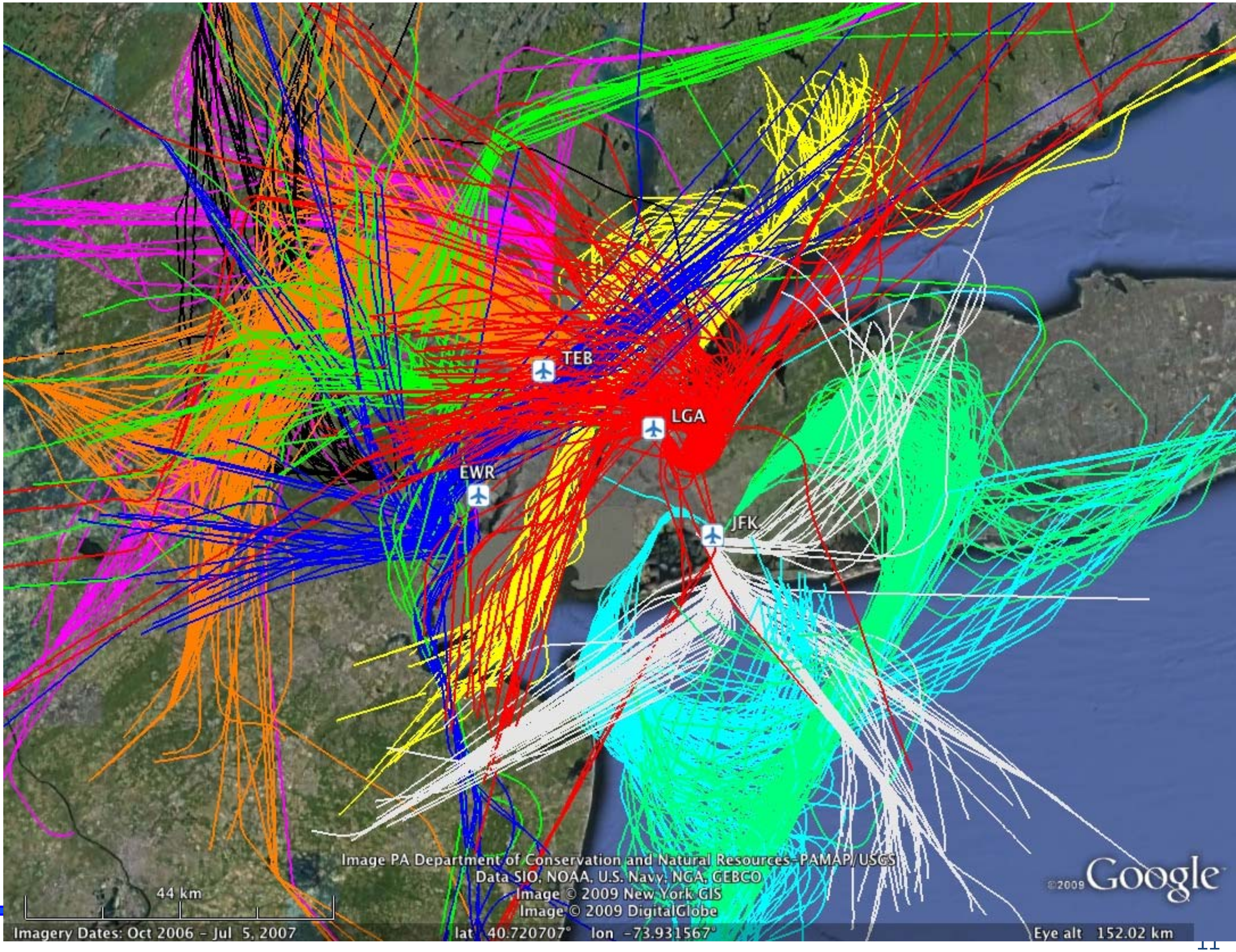
- **The closest observation is 20 operations from its de-conflicted maximum**
- **Most data points have a significantly larger gap (mean 34.2 operations)**
- **The different composition of the gap highlights the trade-offs made by TRACON between airports**

	EWR	JFK	LGA	TEB
Mean Gap	6.8	6.1	9.4	11.9

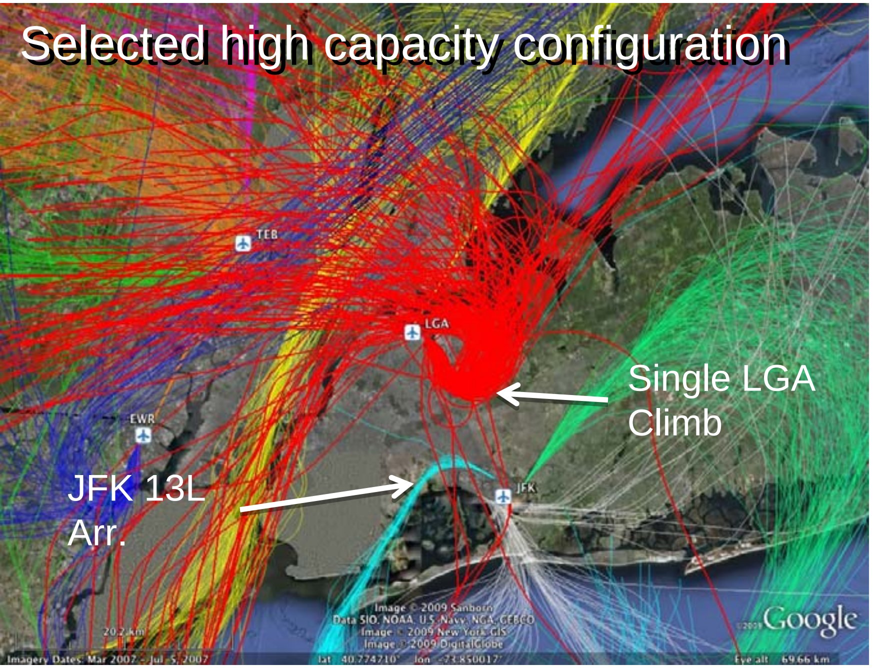


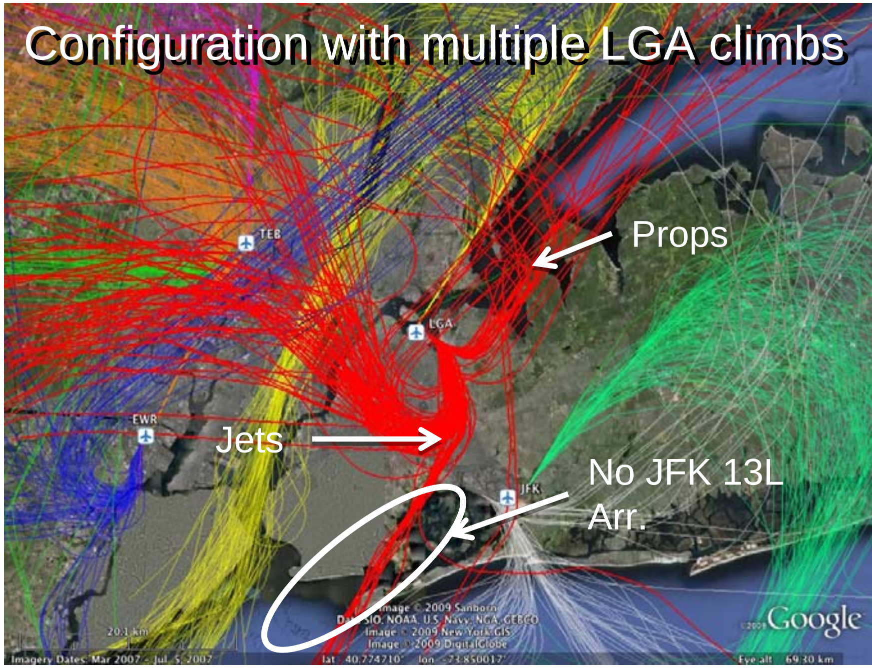
PDARS Visualization

EWR 11 Arr.
EWR 22L Arr.
EWR 22R Dep.
JFK 22L Arr.
JFK 13L Arr.
JFK 13R Dep.
LGA 22 Arr.
LGA 13 Dep.
TEB 19 Arr.
TEB 24 Dep.



LGA-JFK Interaction



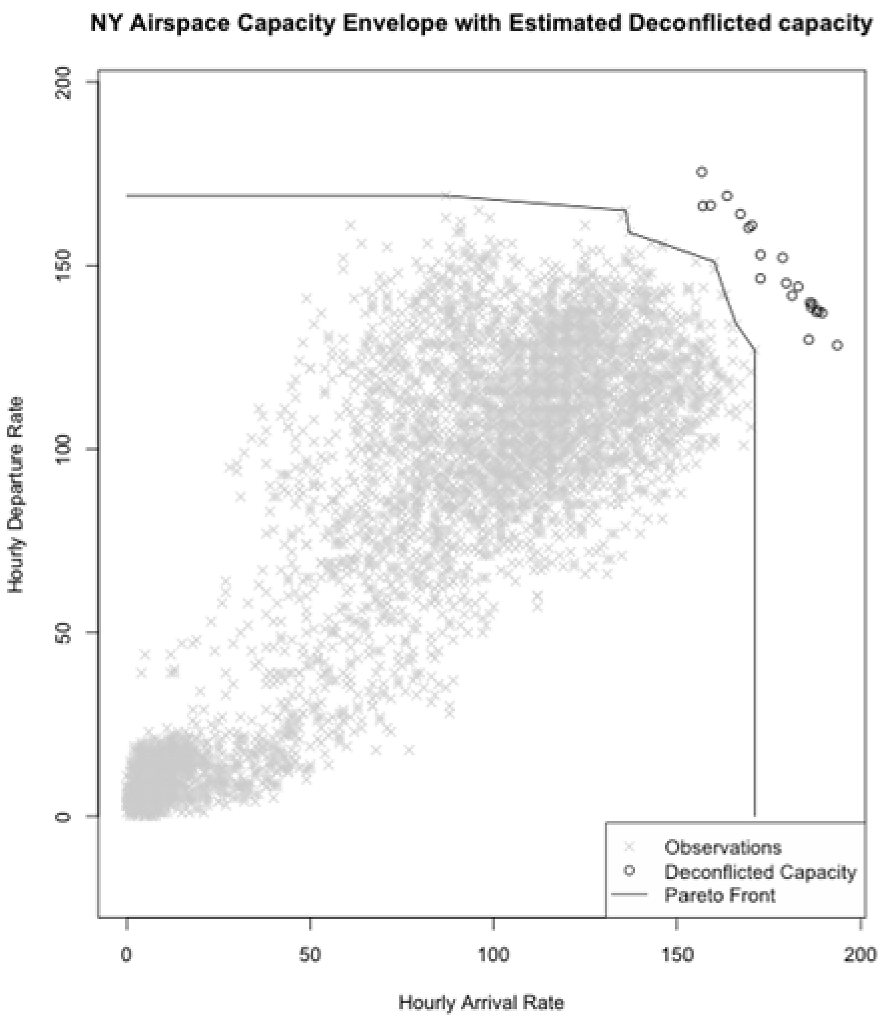


- **JFK 13L arrivals limit LGA to a single departure climb**
- **Jet departures behind props must wait in order to maintain spacing during the climb**

- **Multiple climb procedures allow prop traffic to be separated soon after takeoff**
- **JFK cannot use 13L/R for arrivals**

Results – Comparison with Observations

- **Plotting the calculated "de-conflicted" airspace capacity shows a modest but clear difference from the observed capacity**
- **The variation in the de-conflicted capacity is due to the differences in efficiency of the different arrival-departure ratios used at each airport for each data point**



Future Work

- **In order to understand how to reduce theinteraction between the NY airports several more configurations must be run through this model**
  - Comparing airport preferred configurations to airspace preferred configurations will help identify inefficient procedures
  - Also examine low capacity procedures used at off-peak times which are known to be inefficient
- **The initial configuration presented here was easy to select due to its proximity to the pareto bound**
  - <u>Even this highest capacity configuration shows evidence of a capacity gap</u>
- **Expand work to other multi-airport systems such as northern and southern California**

Questions?

Backup Slides

Approach

- **Use operational (ASPM) data to quantify the inefficiencies found in different configurations of the New York airspace.**
- **Capacity envelopes are found for the system of airports as well as each individual airport under a chosen runway configuration**
- **Points on or close to the Pareto maximum are theorized to be only constrained by interaction effects between airports**
    - This assumes that each airport is observed at least once in an un-constrained state
- **Using this knowledge examine flight track (PDARS) data and identify which procedures are likely constraining the airspace capacity.**

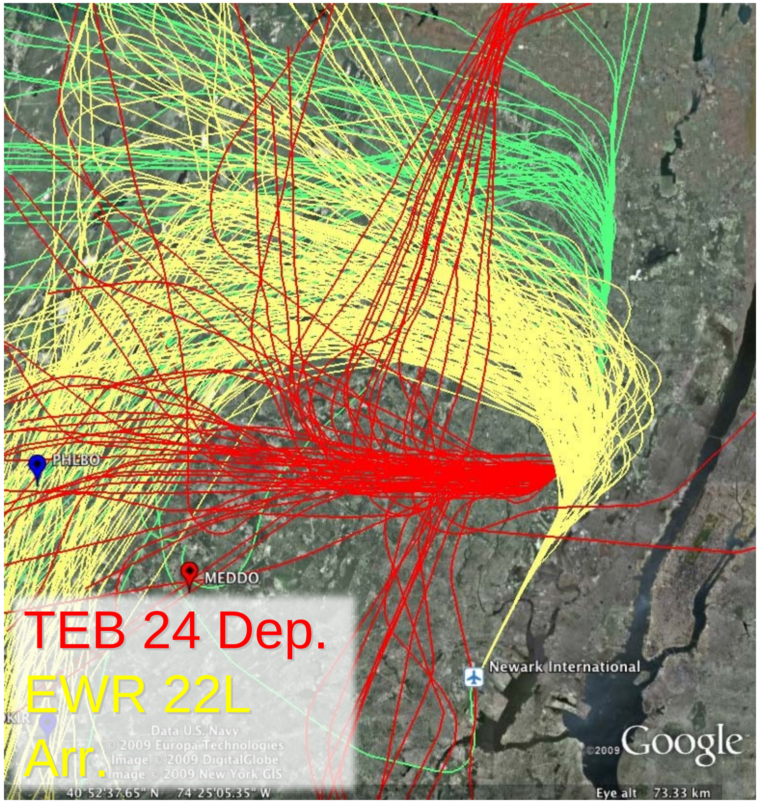
- **ASPM – FAA, Aviation System Performance Metric, is a convenient consolidation of various operational performance databases**
- **PDARS – Performance Data Analysis and Reporting System, FAA & NASA, provides distilled radar and flight plan data**

Limitations of the Model

- **This model cannot (yet?) measure interaction effects that are always present since they will restrict the “de-conflicted” airport Pareto envelopes as well as the conflicted airspace-wide envelope.**

Example:

- **TEB 24 Departures always prevent arrivals to EWR 22R**
- **There is no way to measure the capacity arrivals to EWR 22L since these operations never occur**



ASPM Data

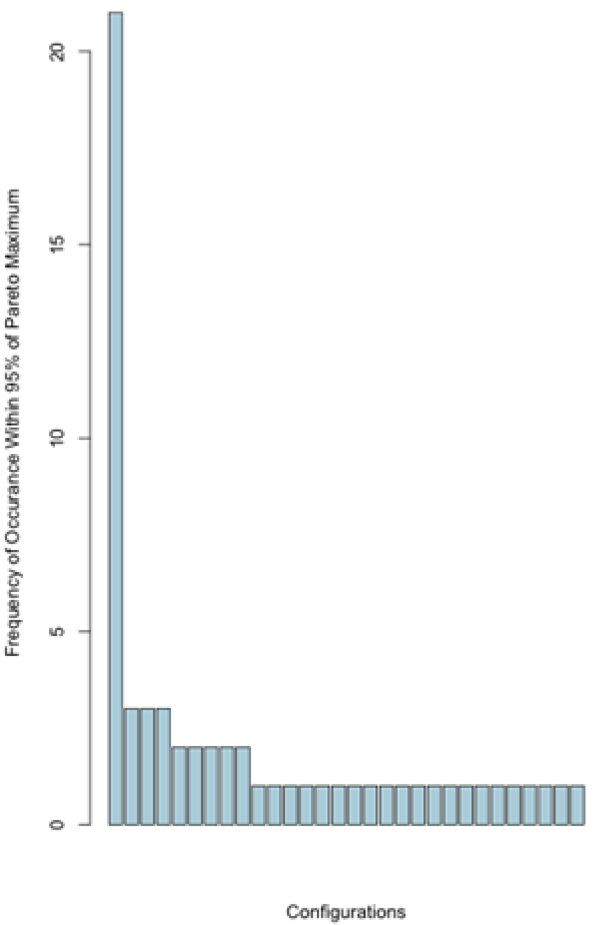
SchDep	SchArr	Dep	Arr	Tot	Cap	Conf	Wx	TaxiOut	TaxiIn	Temp	WindDir	WindSp	Ceil_00s	Vsby_stmi	WxCond	WxImp
32	13	39	15	54	77	22L | 22R	IAC	24.65	9.58	-	10	7	3	1.75	RA BR	Moderate
22	22	19	21	40	77	22L | 22R	IAC	18.27	7.48	51	70	4	6	1.5	-RA BR	Moderate

Sample ASPM data

- **Two years (2007-2008) of ASPM data was used**
- **Fields used (for each airport):**
  - Arrivals, Departures, Configuration, Weather (IFR/VFR)
- **Airport configuration (as defined in this research):**
  - Runways used for arrivals
  - Runways used for departures
  - Weather conditions at the airport: VFR or IFR
- **Airspace configuration:**
  - The combination of the four airport configurations
- **Only stable airspace configurations were used in this analysis**
  - 35% of 17544 total observations were a stable configuration

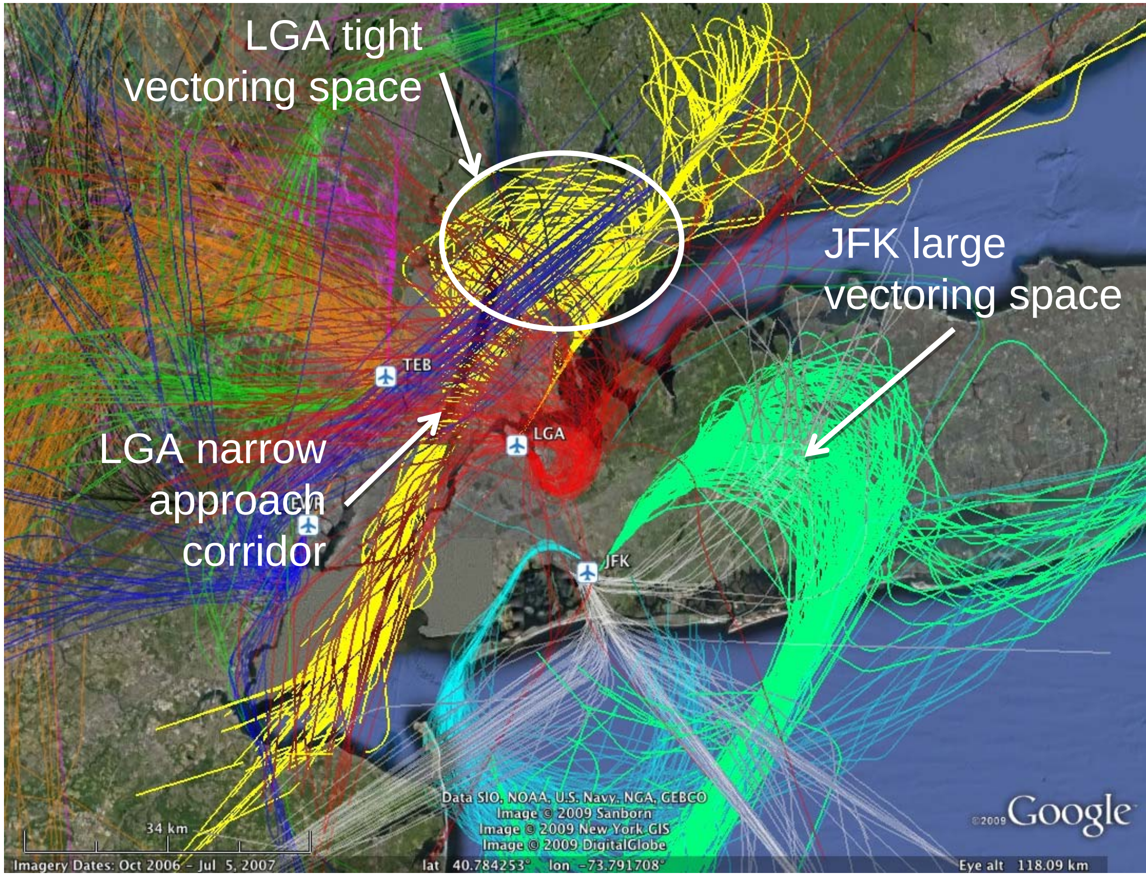
High Throughput Configurations

- **61 (1%) of the 6067 stable configurations were within 95% of the pareto optimal capacity boundary**
- **Of these configurations one emerged as dominant, contributing 21 data points**
- **A single airspace configuration is required because the individual airport capacity envelopes are configuration specific**
  - Mixing two or more configurations would add a difficult to separate variable to the analysis



LGA Tight Approach Vectors?

- **Space available for vectoring to LGA 22 appears smaller than that for JFK 22s**
- **This may cause controllers to adopt a more conservative spacing of aircraft into the final approach airspace**



Results - Adjusted