Impact of Very Light Jet (VLJ) Flights on Airport Terminal Area

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Outline

- **Future Flights (Demand)**
  - Airline Flights
  - VLJ Flights
  - Legacy GA Flights

- **Airside Facilities (Supply)**
  - Runway
  - Terminal Area
  - En-route

- **Impact on the Terminal Area**
  - Any Congestion/Delays?
  - Any Environmental Issues?

- **Suggestions**

What is Very Light Jet (VLJ)?

Very Lights Jets (VLJ)

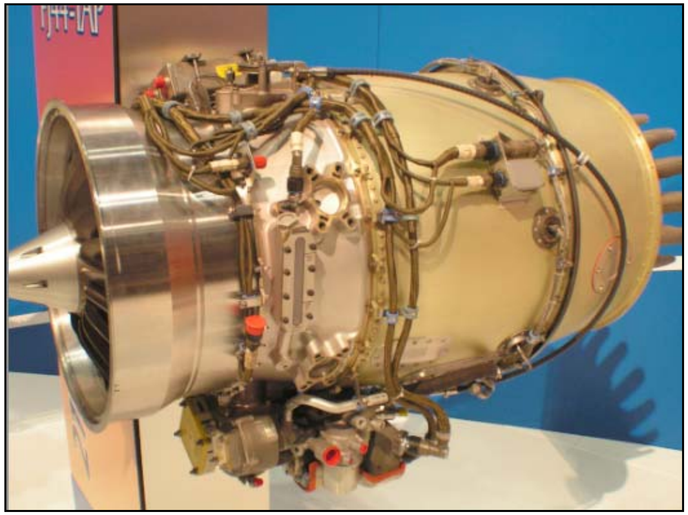
- General purpose category of jet-powered aircraft weighting less than 10,000 lbs
- Aircraft in flight **testing phase**
  - Eclipse Aviation 500 (April 2006)
  - Cessna Mustang (April 2006)
  - Adam 700 (End of 2006)
  - Grob SP (Unknown)
- Aircraft in the **design stage**
  - Embraer Phenom 100 (2008)
  - Spectrum 33 (2008)
  - Diamond Jet (unknown)

Eclipse 500

Cessna Mustang

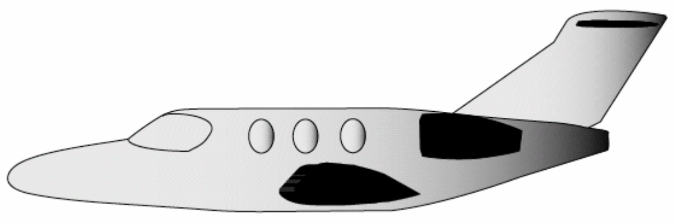
VLJ Engine Manufacturers

- Pratt and Whitney Canada
  - PW 610 (Eclipse 500)
  - PW 615 (Cessna Mustang)
  - PW 617 (Embraer Phenom 100)
- Williams International
  - FJ44 (Adam 700)
  - FJ33 (Spectrum 33)



Williams FJ44 (A.A. Trani 2005)

Typical Very Light Jet Vehicle

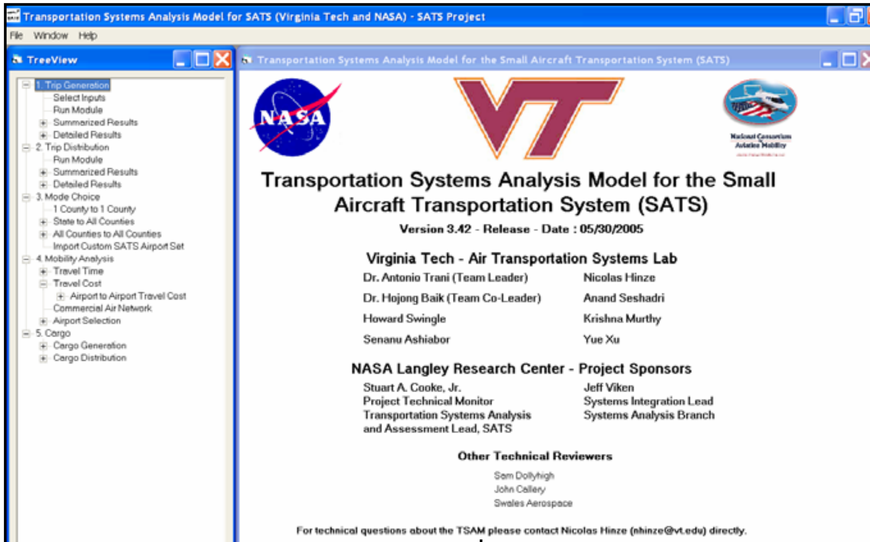


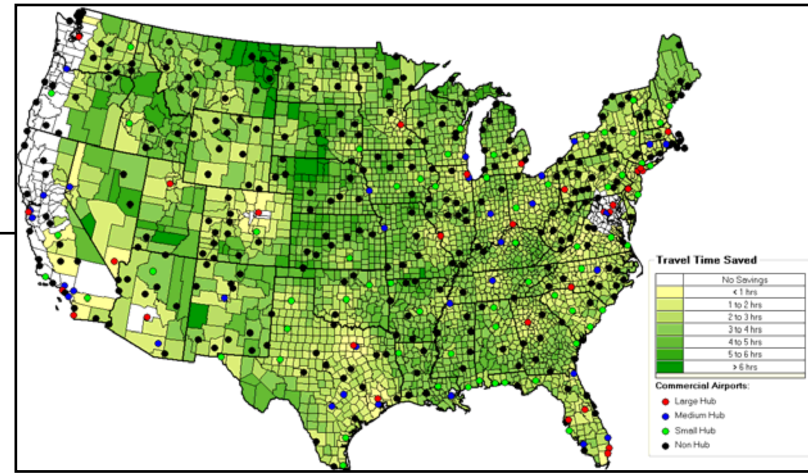
- Pressurized aircraft
- All weather vehicle
- Four revenue seats
- 365 mph cruise speed
- Certified to fly into known icing conditions
- 1,100 nm range (maximum). 700 nm practical with 2 passengers
- Cost per passenger-mile ($1.75 nominal based on life-cycle cost analysis)
- 1.2 million dollars (cost)
- 3,415 public airports (> 3,000 ft. paved runways)
- Low Landing Minima capability provided to all airports using SATS LLM hardware (WAAS-aided)
- **Airport Design Group = A-I**
- **Wake Vortex Classification = Small**

Future Flights* Estimation

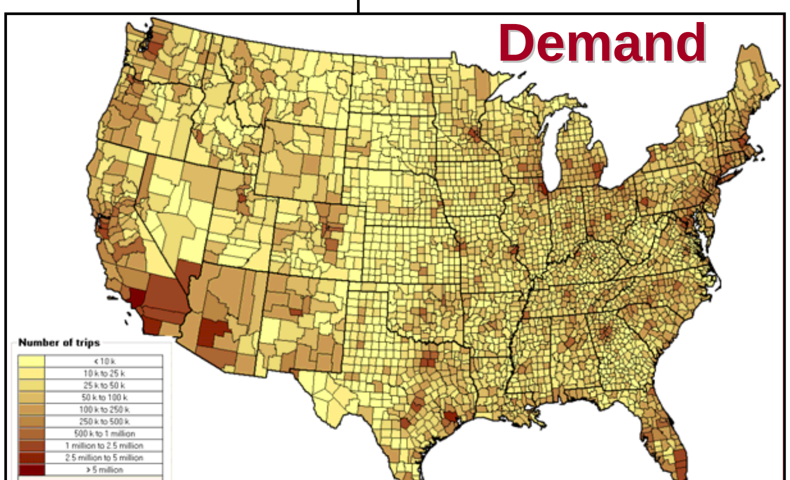
*Flights =
Airline Flights
+ VLJ flights
+ Legacy GA Flights

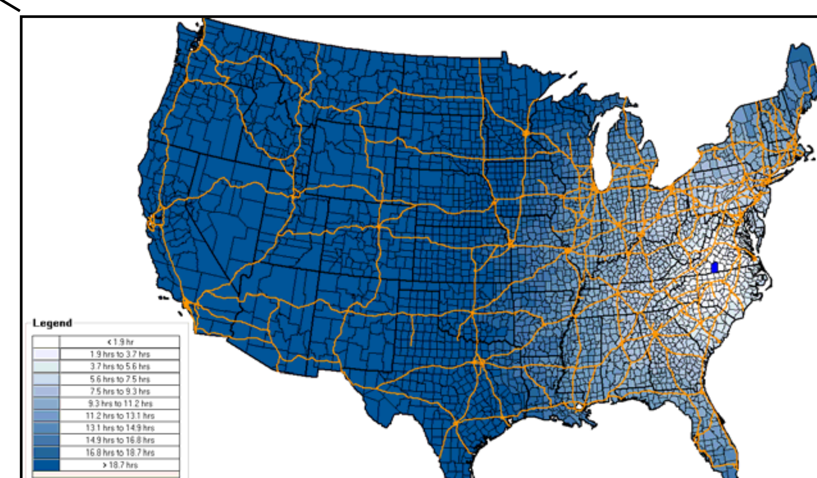
Transportation Systems Analysis Model (TSAM)



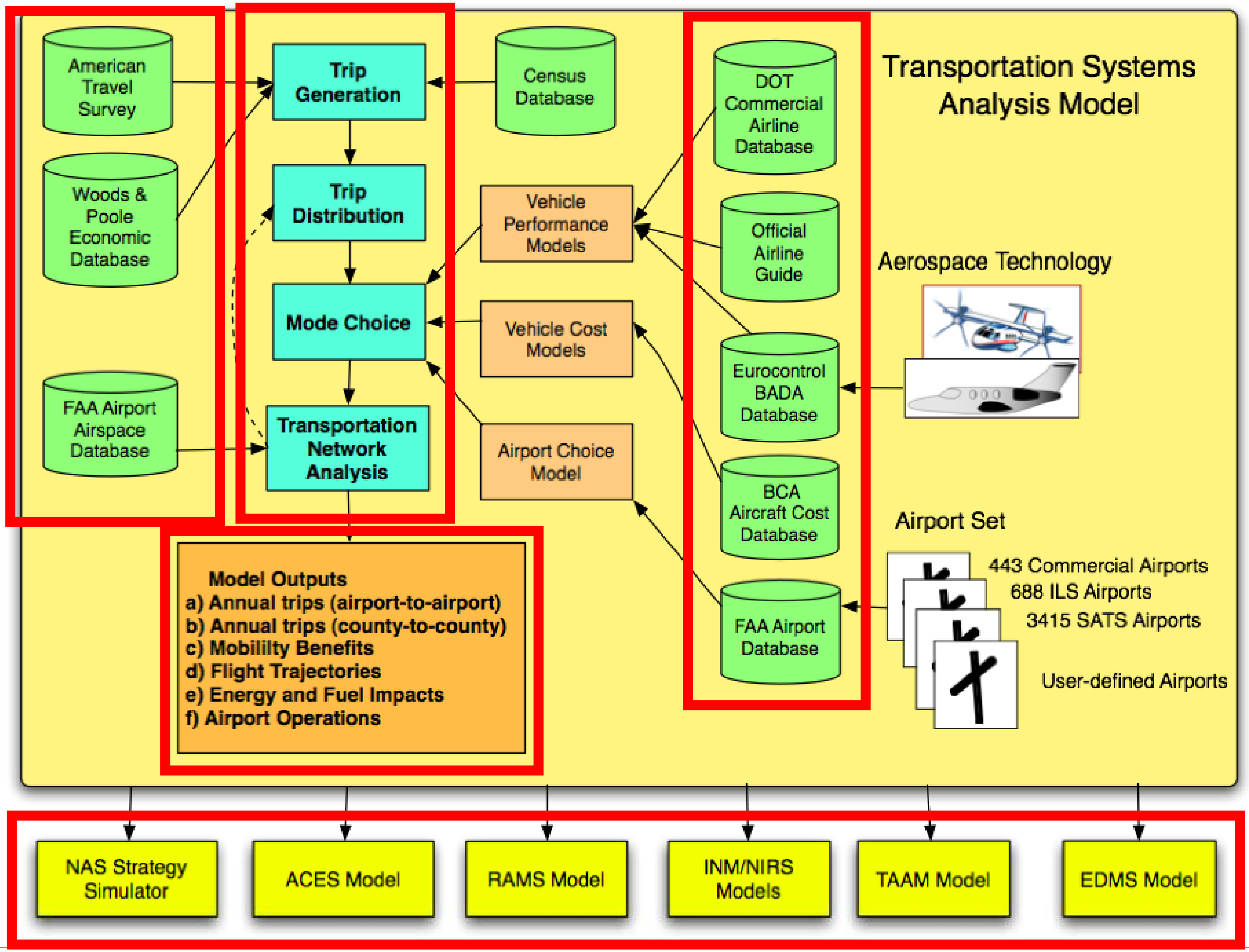


Travel Time Analyses

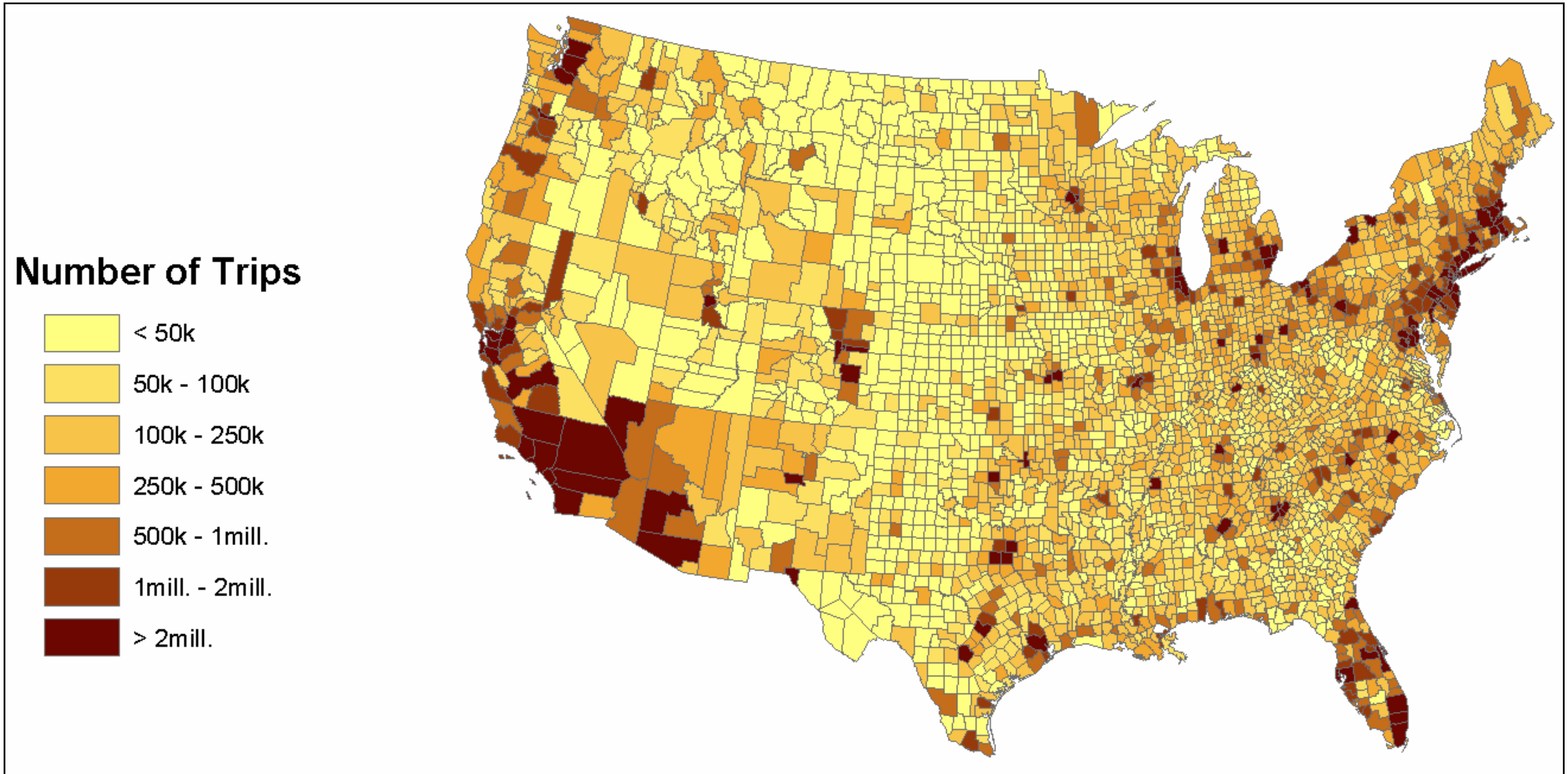




Transportation Systems Analysis Model (TSAM)

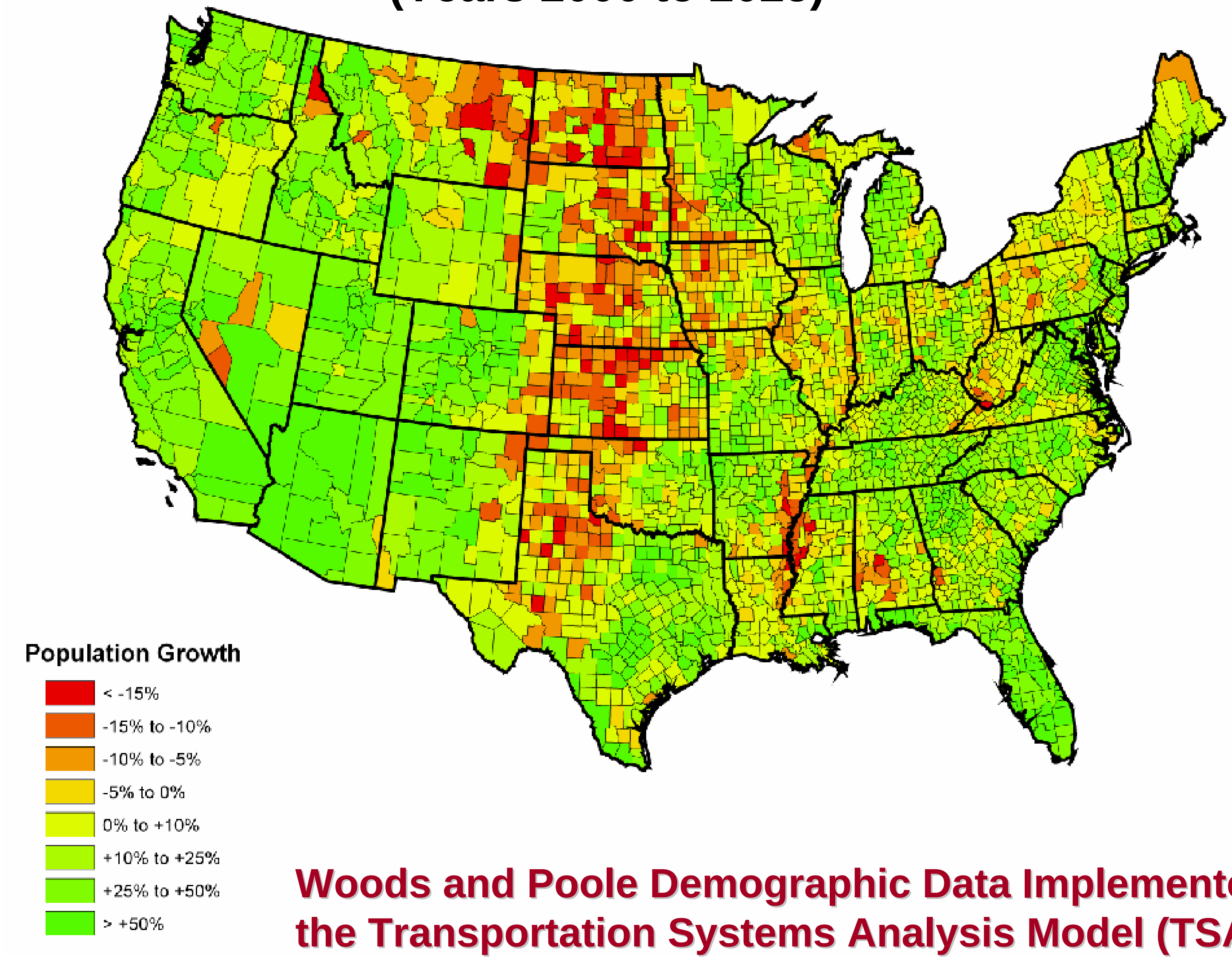


Trip Generation



Total Intercity Trips Generated by County (Business + Non-Business Trips)

Changes in the U.S. Population (Years 2000 to 2025)



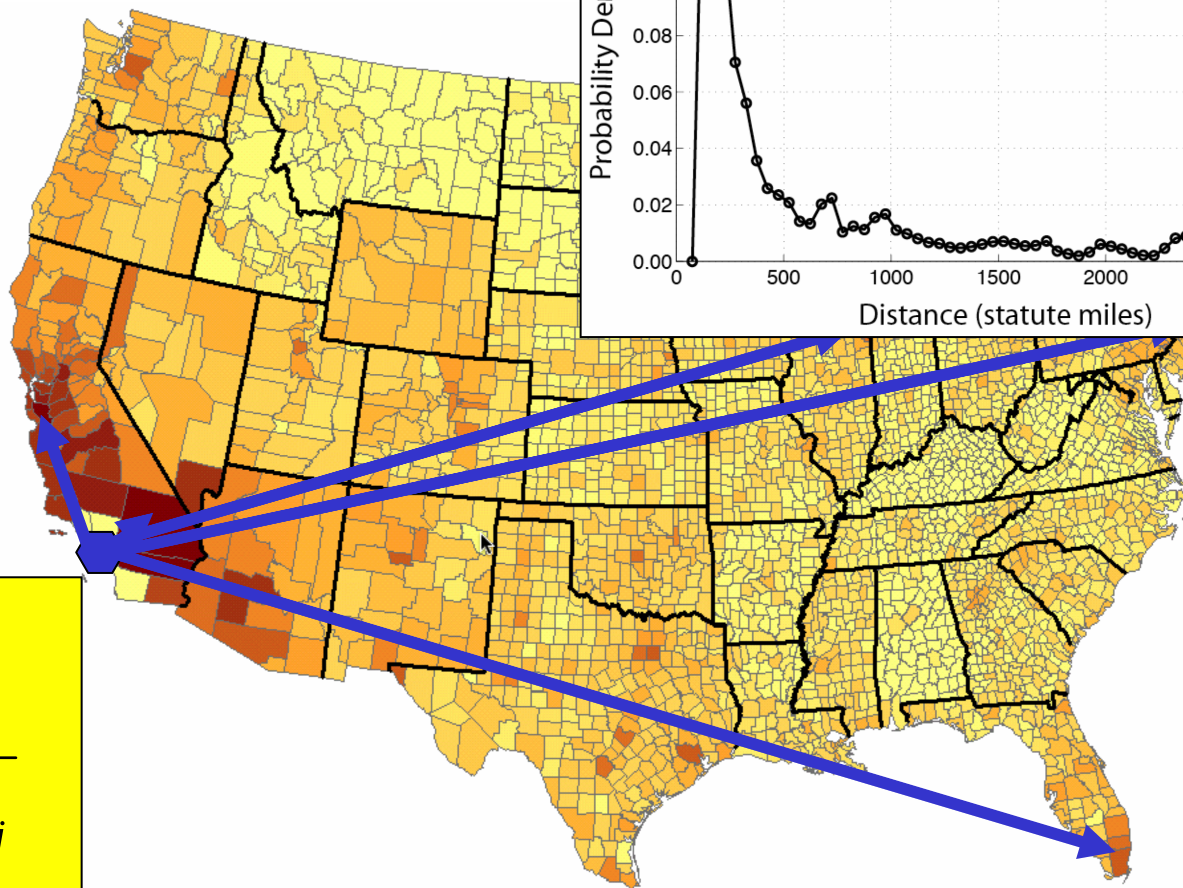
Woods and Poole Demographic Data Implemented in the Transportation Systems Analysis Model (TSAM)

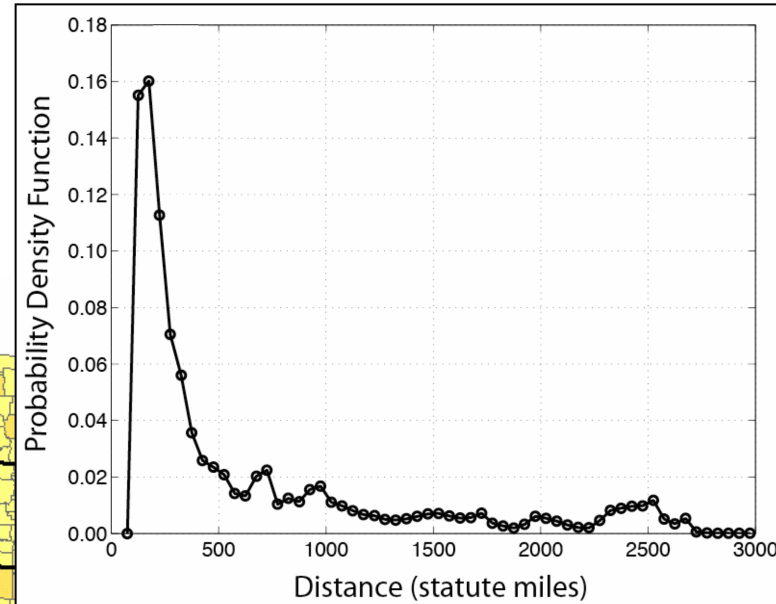
Distribution of Trips (LA County to all)

Annual Trips

Legend

- 0 - 10
- 501 - 1,000
- 25,001 - 50,000
- 500,001 - 1,000,000

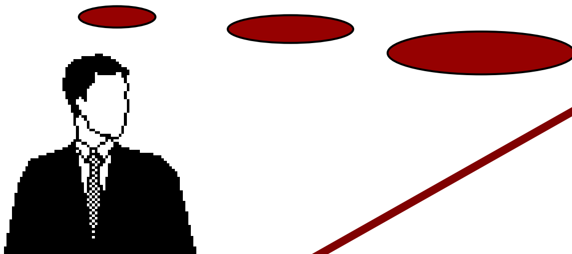




Gravity Model

$$T_{ij} = \frac{P_i A_j F_{ij} K_{ij}}{\sum_j A_j F_{ij} K_{ij}}$$

Mode Choice Analysis



Auto | **VLJ** | **Commercial Aviation**

Route1 Route2... Route n

Includes Airport Choice

Factors considered in mode choice:

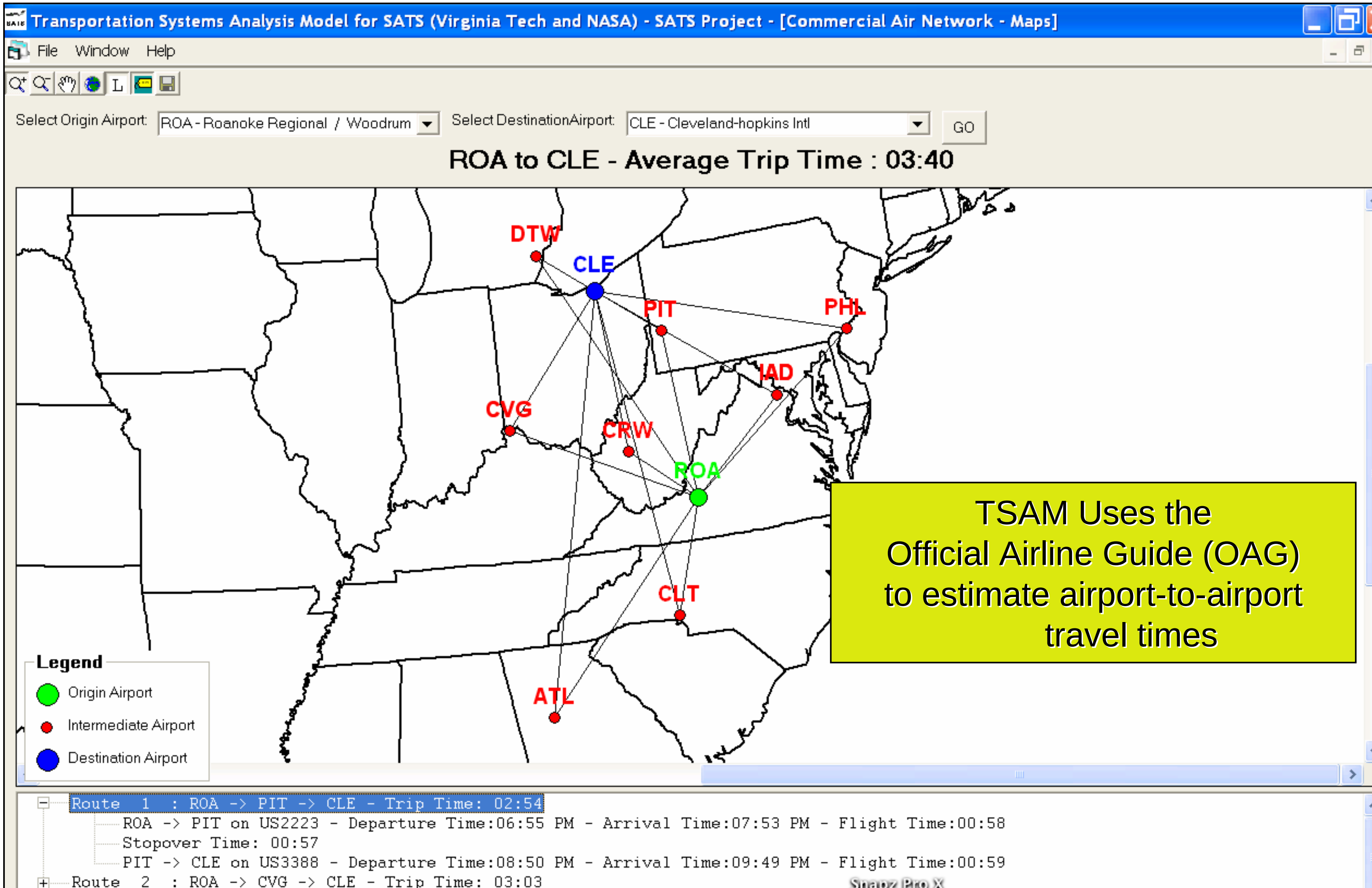
- **Travel time**
- **Travel cost**
- **Value of time**
- **Trip purpose**
- **Travel party size**
- **Route convenience**
- **Mode reliability**

TSAM employs a **Nested Multinomial Logit** Model

Consider a Business Trip from Blacksburg, VA to Cleveland,OH

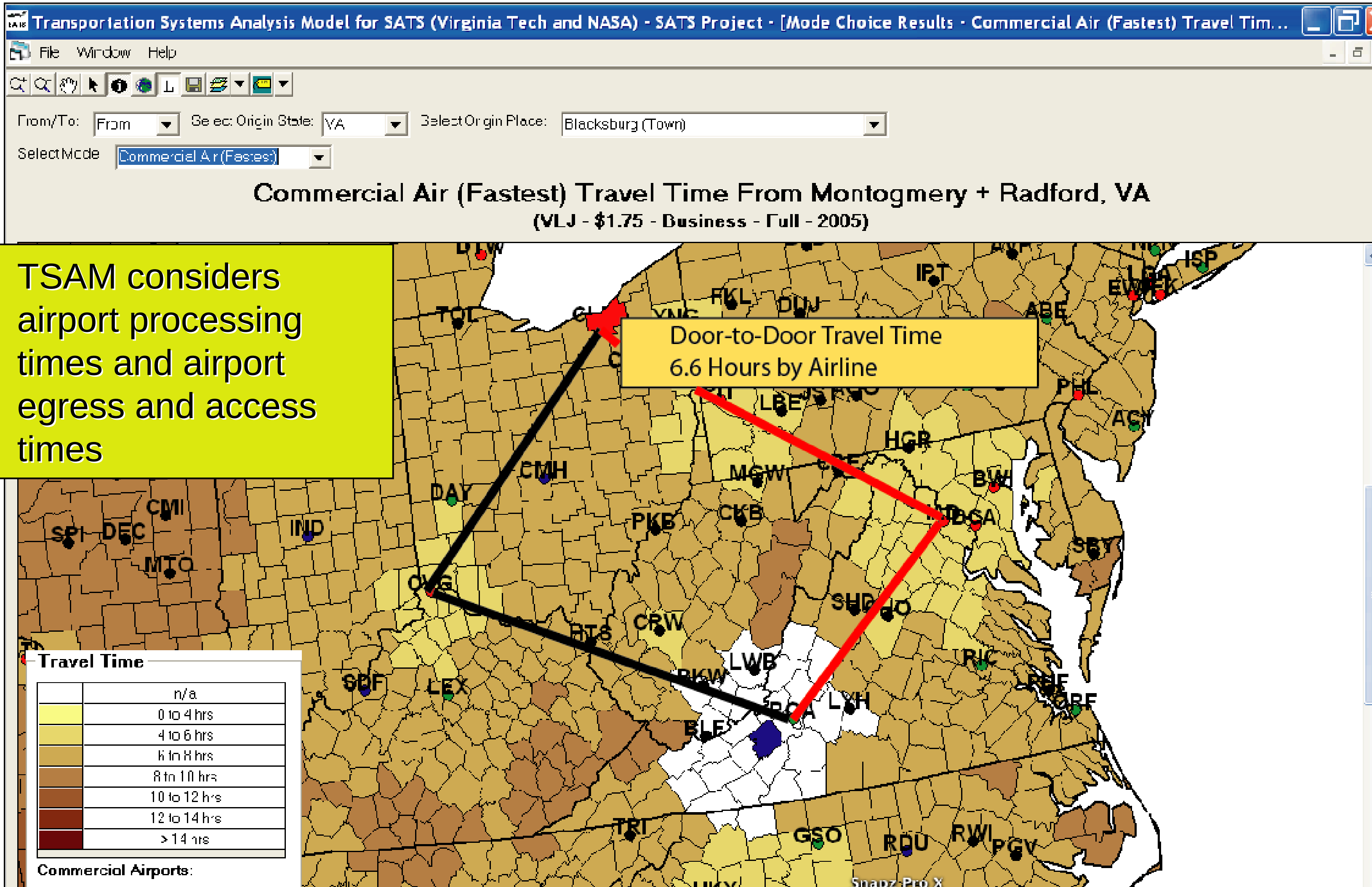
- Suppose three possible travel alternatives are:
  - Auto
  - Commercial Air
  - On-demand service using VLJ aircraft (future NAS)
- To make a mode selection a user might consider:
  - Travel time
  - Travel cost (including lodging and rentals)
  - Duration of stay
  - Value of time
  - Party size

Multi-route Mode Choice Model



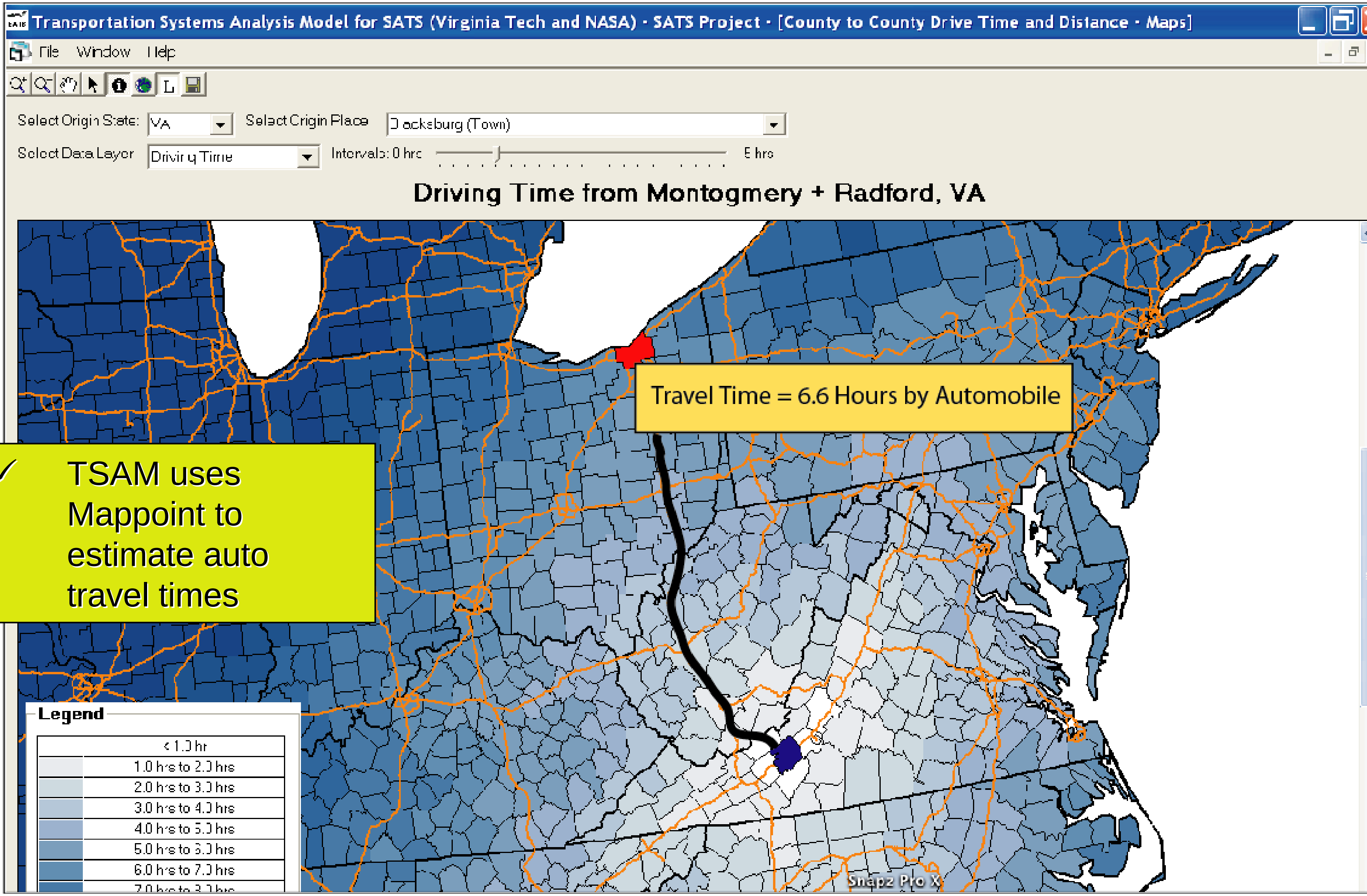
TSAM Uses the Official Airline Guide (OAG) to estimate airport-to-airport travel times

Multi-mode Choice Model
(Door-to-Door Commercial Air Travel Time)



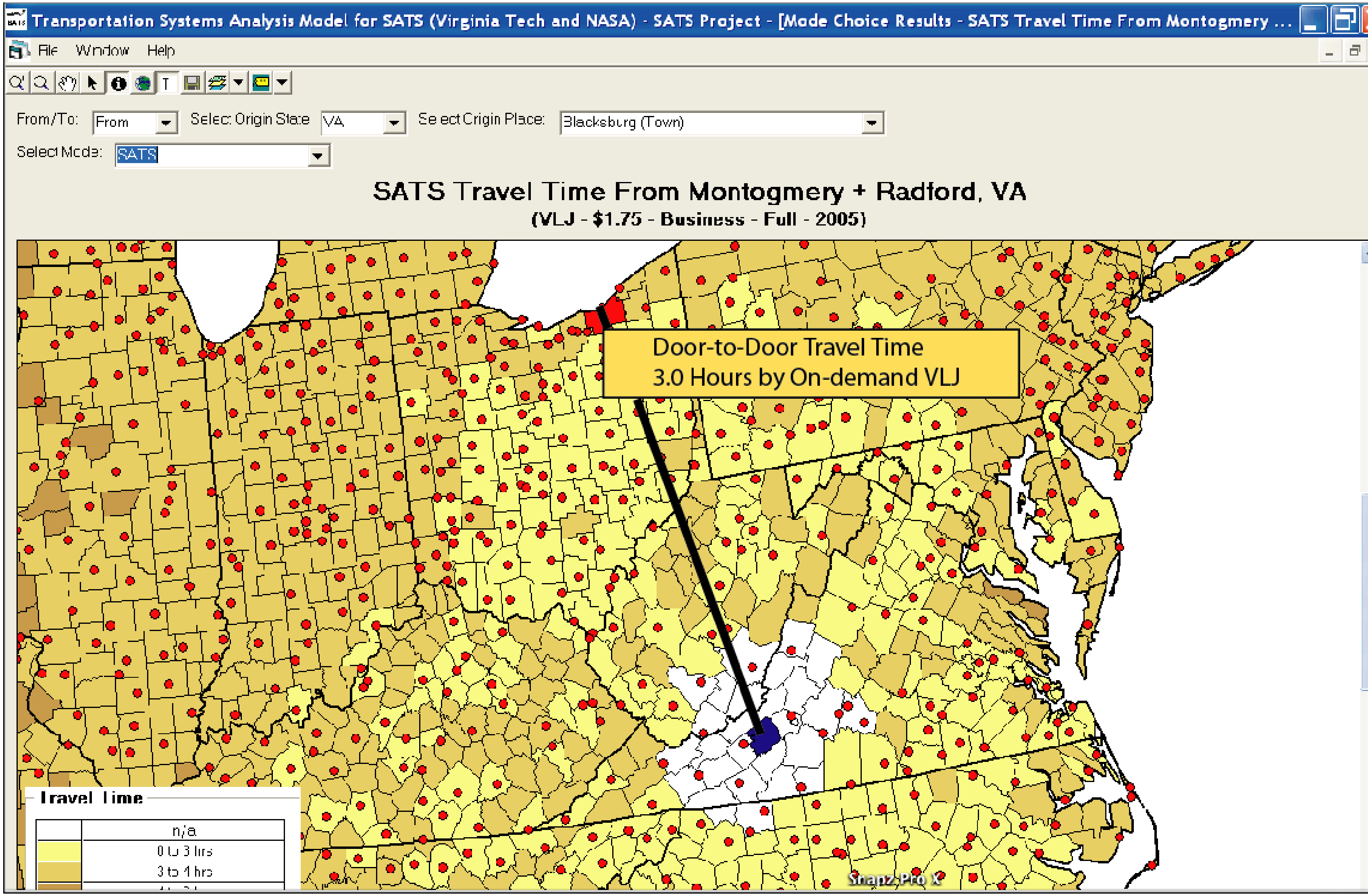
✓ TSAM considers airport processing times and airport egress and access times

Multi-mode Choice Model (Auto)



- ✓ TSAM uses Mappoint to estimate auto travel times

Multi-mode Choice Model (VLJ)



Summary Trip Information

From Blacksburg, VA To Cleveland, OH (391 miles)

Roundtrip Travel Time Savings Using 7 hrs 2 min + 2 extra nights compared to automobile

7 hrs 16 min + 1 extra night compared to fastest airline route

SATS Trip Details

	Origin Airport	Destination Airport	Travel Time (Outbound)	Travel Time (Return)	Travel Cost (Roundtrip)	Average Travel Speed	Cost for Speed	Nights Away
SATS	BCB, Virginia Tech / Montgomery Executive, Blacksburg, VA	BKL, Burke Lakefront, Cleveland, OH	2 hrs 59 min	2 hrs 59 min	$1,093	131 mph	$8.33/mph	0

Car Trip Details

	Origin	Destination	Travel Time (Outbound)	Travel Time (Return)	Travel Cost (Roundtrip)	Average Travel Speed	Cost for Speed	Nights Away
Auto	Blacksburg, VA	Cleveland, OH	6 hrs 30 min	6 hrs 30 min	$493	60 mph	$5.20/mph	2

	Nights Away
Route 1	1
Route 2	1
Route 3	1

	<$30K	<$60K	<$100K	<$150K	>$150K
Auto	82%	76%	65%	52%	51%
Airline	18%	24%	30%	32%	31%
VLJ	**0%**	**0%**	**5%**	**16%**	**18%**

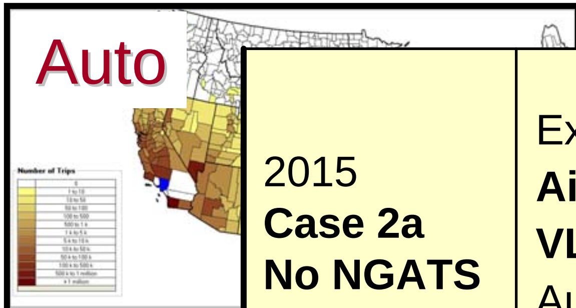
Household

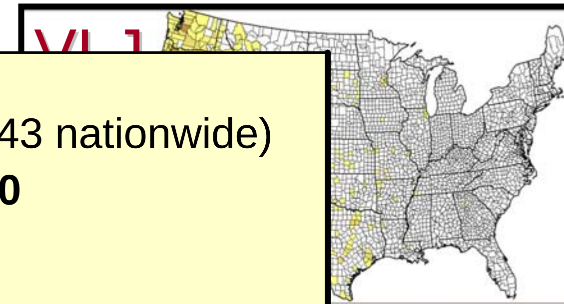
Numbers rounded to nearest percent.

Print Results Close

Intercity Travelers by Mode
(from LA County)

Business Trip



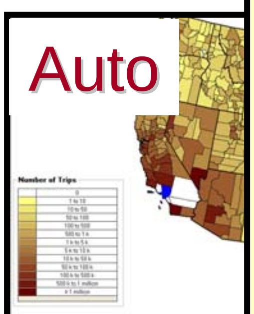


3.4

(2.1%)

2015 **Case 2a** **No NGATS**	Existing commercial airport set (443 nationwide) **Airline Fare Scale Factor = 0.720** **VLJ** Auto cost = $0.37 vehicle-mile Processing times at airports remain the same
2015 **Case 4** **NGATS**	Existing commercial airport set (443 nationwide) **Airline Fare Scale Factor = 0.720** **VLJ** Auto cost = $0.37 vehicle-mile **Processing Times Scaling Factor = 0.75**

ess Trip

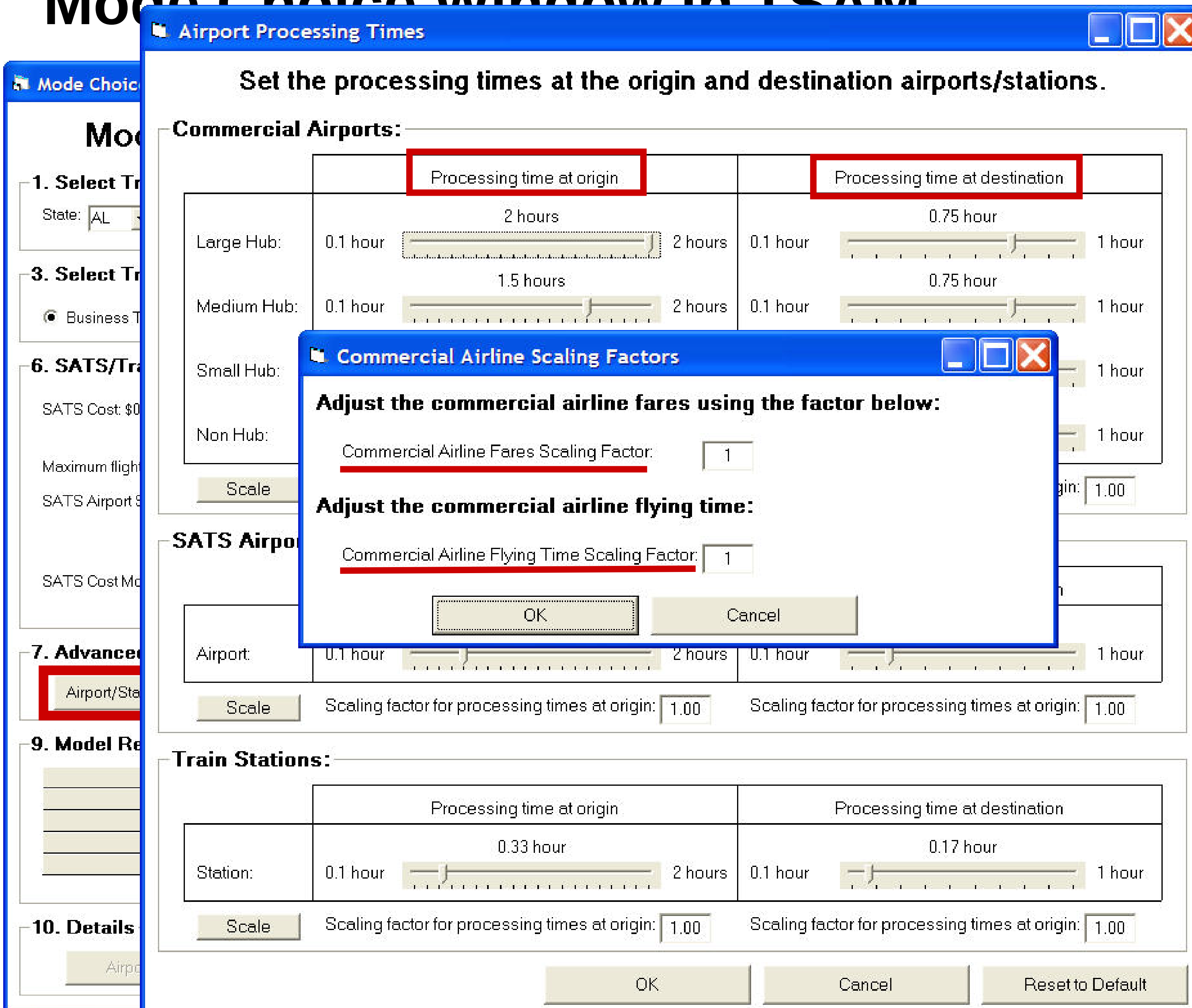


16.6 m

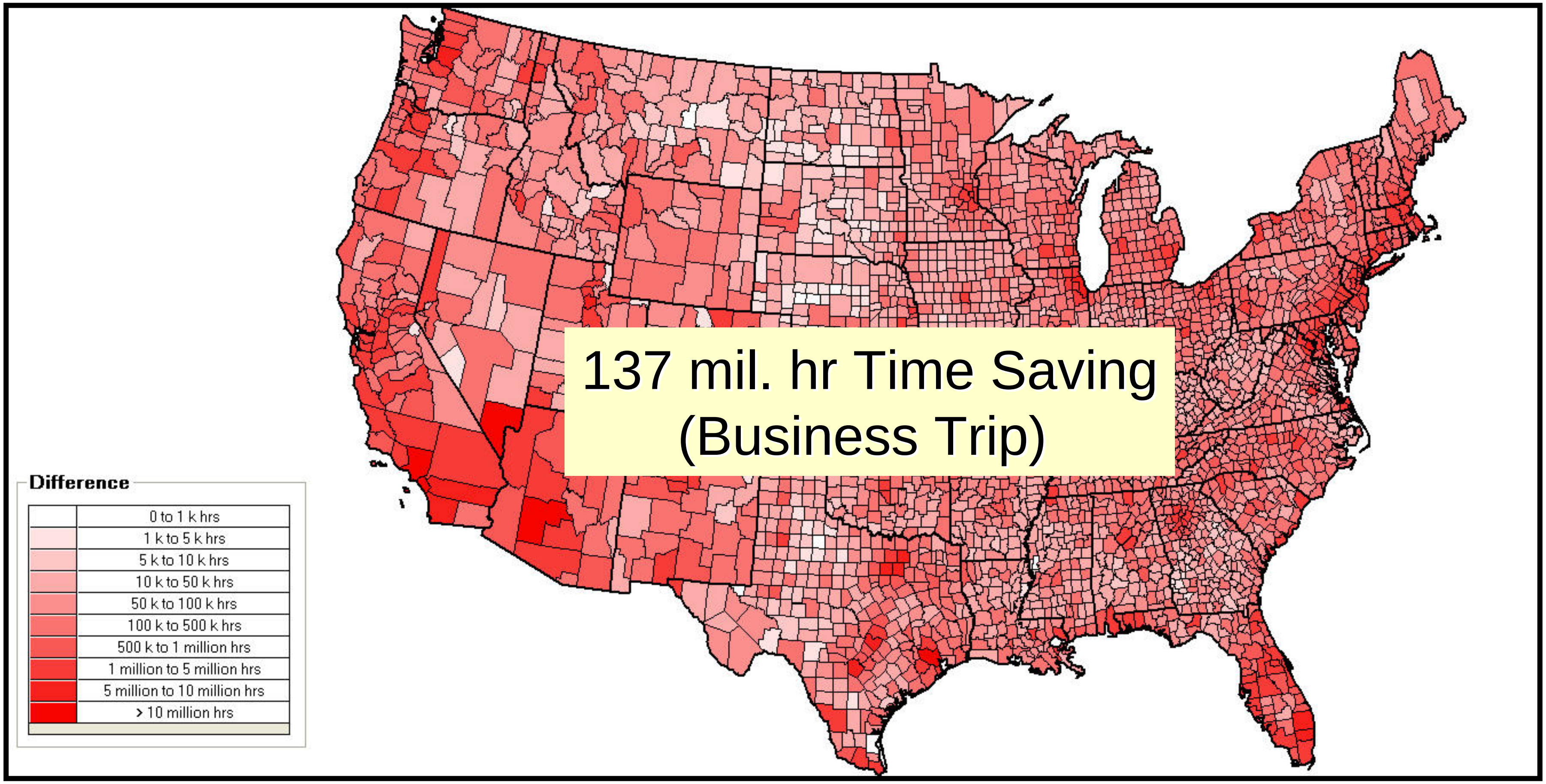
0.1%)

(Captured from Virginia Tech **T**ransportation **S**ystem **A**nalysis **M**odel (TSAM))

Mode Choice Window in TSAM



Travel Time Saving
(Case 2a minus Case 4)



Convert Air Demand to Flights

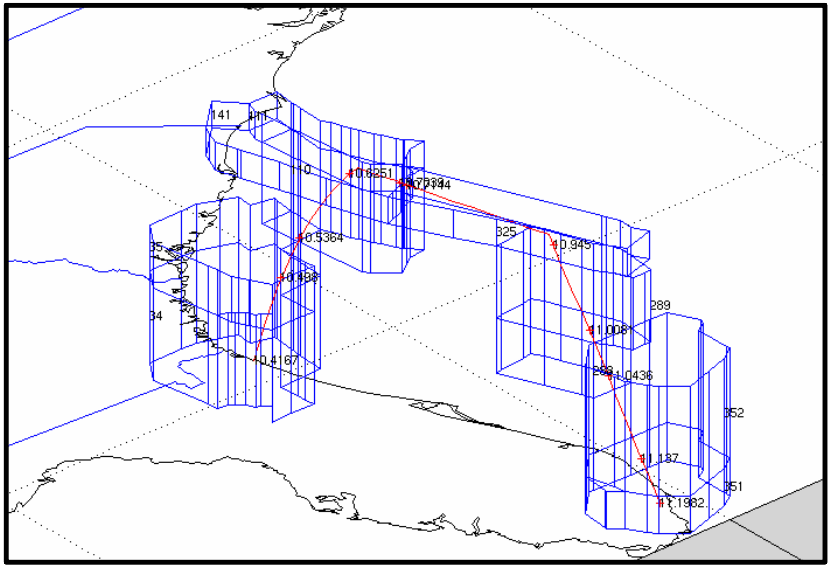
Daily Passengers

Seasonal and Daily Variation

Daily Flights

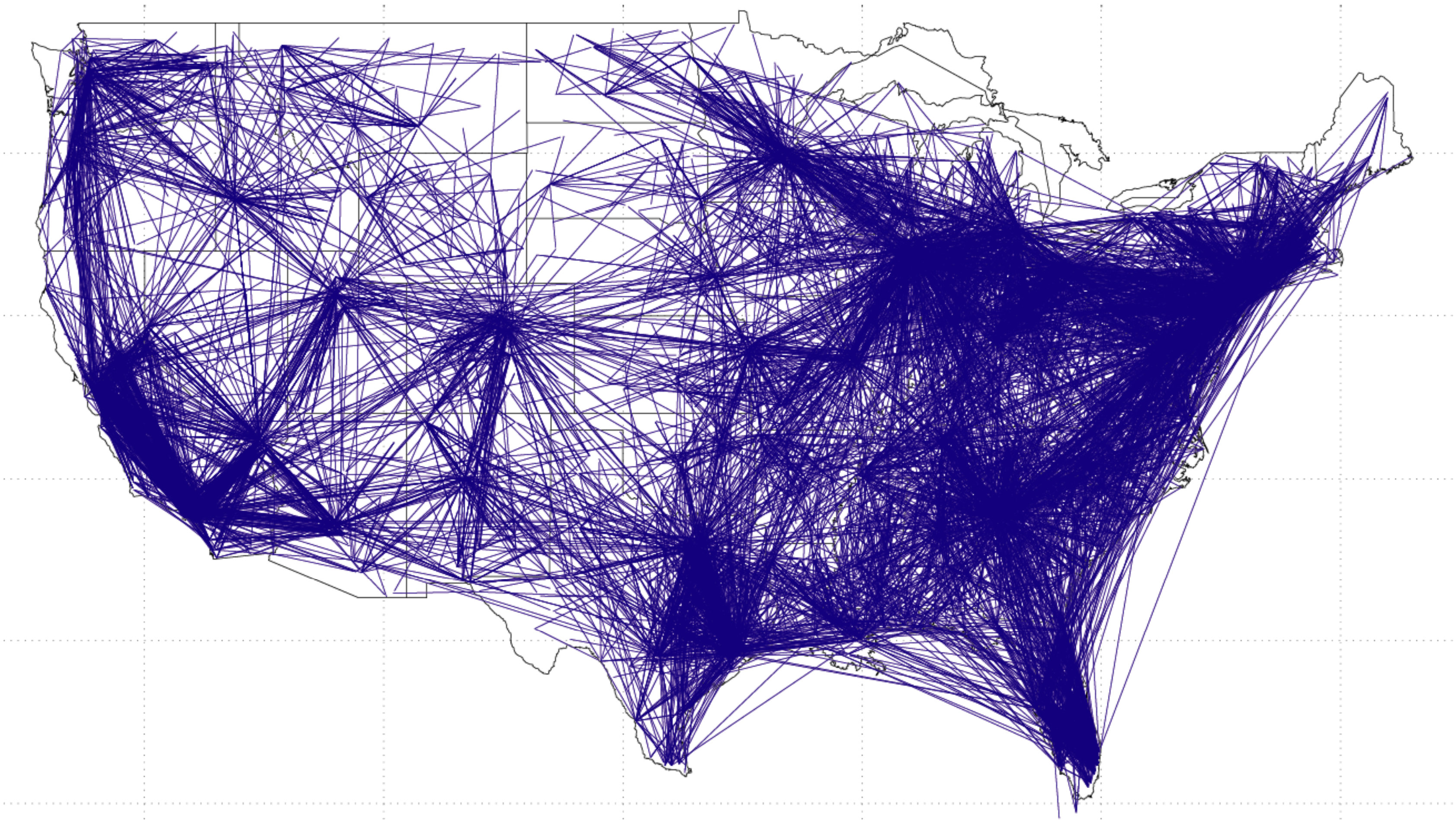
Create Flight Trajectories

Daily Flights



Performance Metrics:
Flight Time,
Fuel Consumption

Spatial Distribution of VLJ Flights
(year 2015)



TSAM is …

- A **strategic planning tool** to estimate the intercity transportation demand that
  - Employs ***socio-economics*** and ***demographics*** of the country,
  - ***County-to-county*** spatial model (complements NSS),
  - ***Multi-modal*** in scope (auto, airline, GA and VLJ) ,
  - Includes ***domestic*** and ***international*** trips
  - Accepts any ***user-defined scenarios***: airport sets, fare, processing time, new technologies, etc.
  - Runs in a standard ***Windows XP*** system, and
  - Use of ***GIS technology*** to present results (70+ maps)

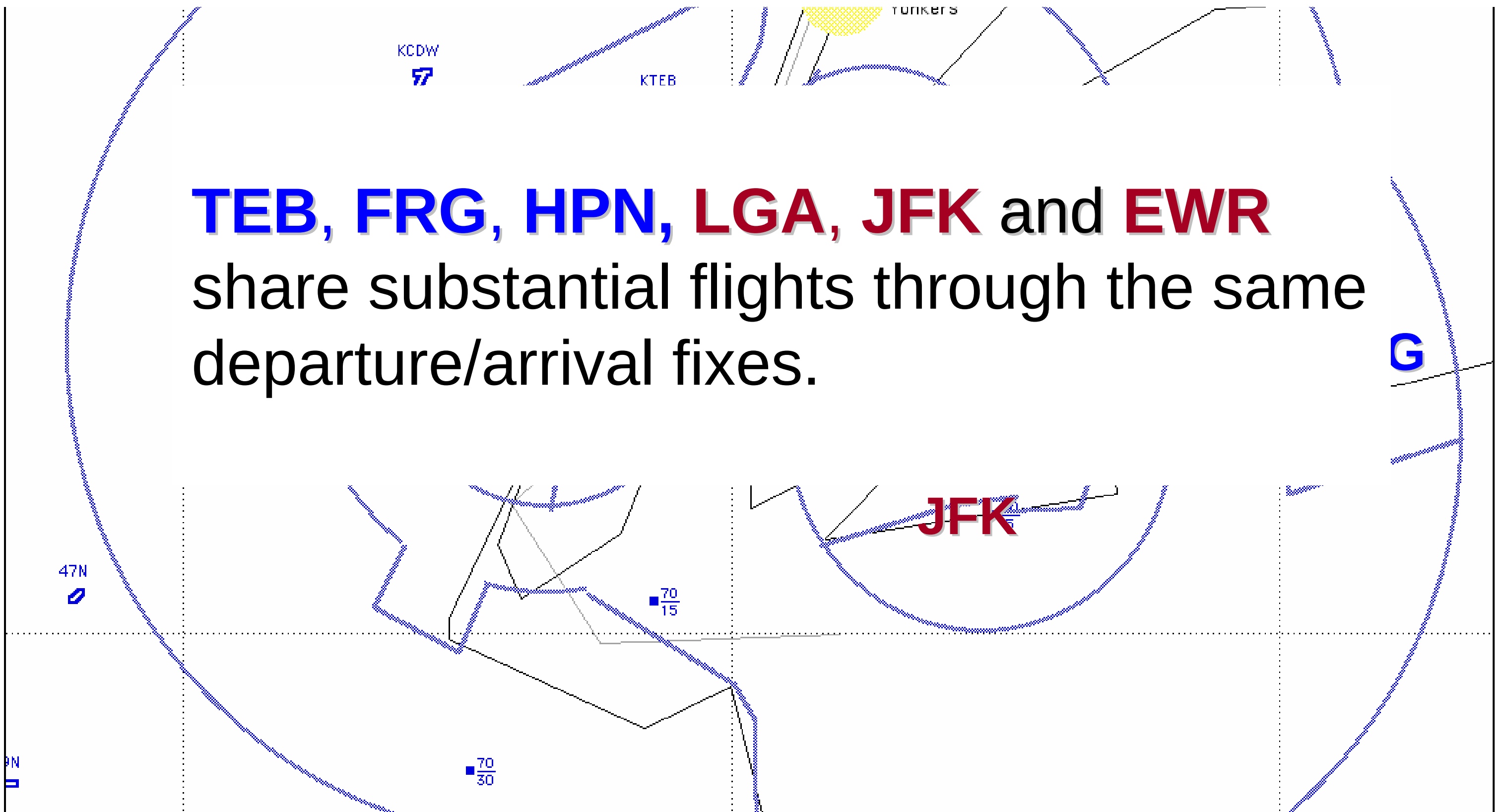
- The current TSAM is **an unconstrained model.**
  - It assumes that there is **no capacity constraints** in runway, terminal area and en route.

- We need **"credible capacity-delay analysis"** to obtain the steady-state solution.

Impact of VLJ Flights in the Airport Terminal Area

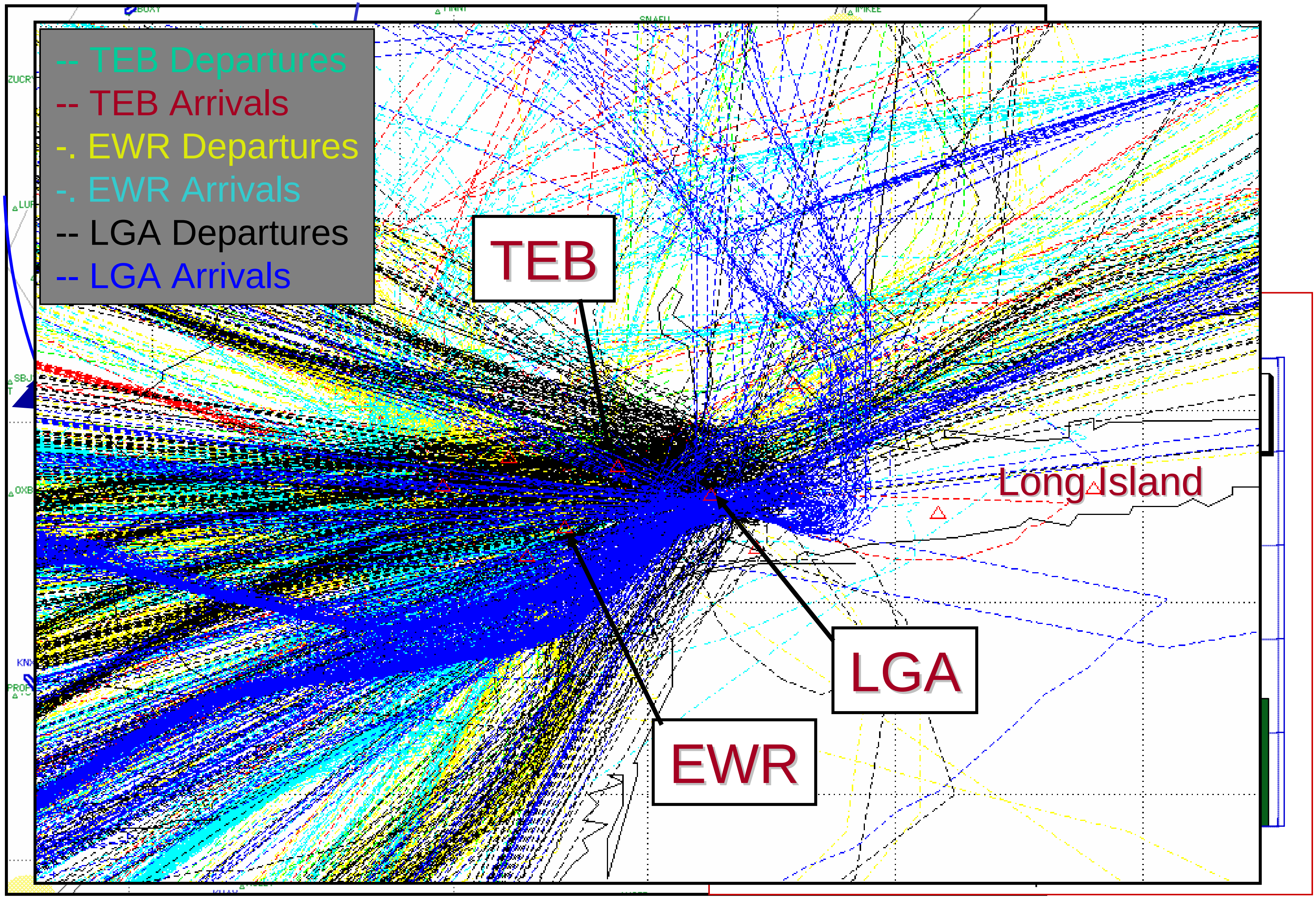
Question 1:

Can VLJ/GA operations at **TEB**, **FRG**, and **HPN** grow at the predicted growth rate with interacting **LGA**, **JFK** and **EWR**?



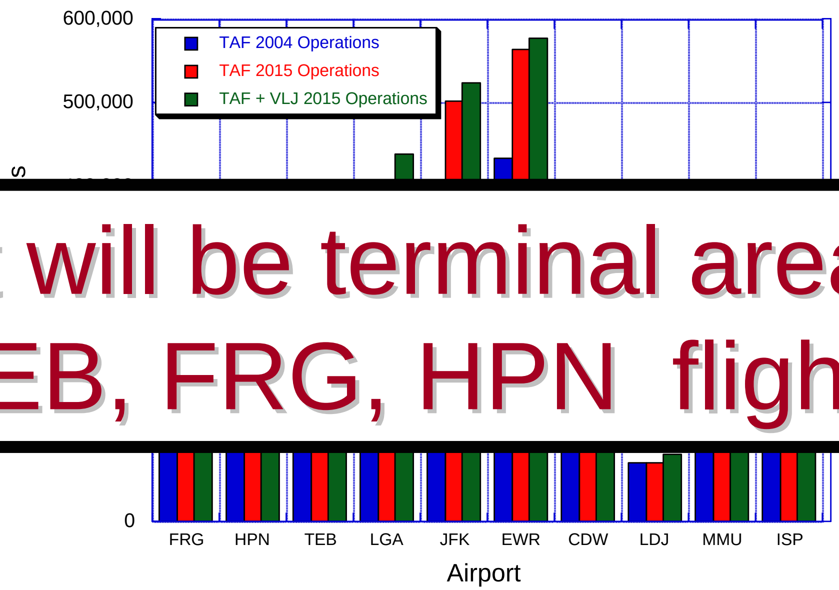
TEB, **FRG**, **HPN**, **LGA**, **JFK** and **EWR** share substantial flights through the same departure/arrival fixes.

Interactions….



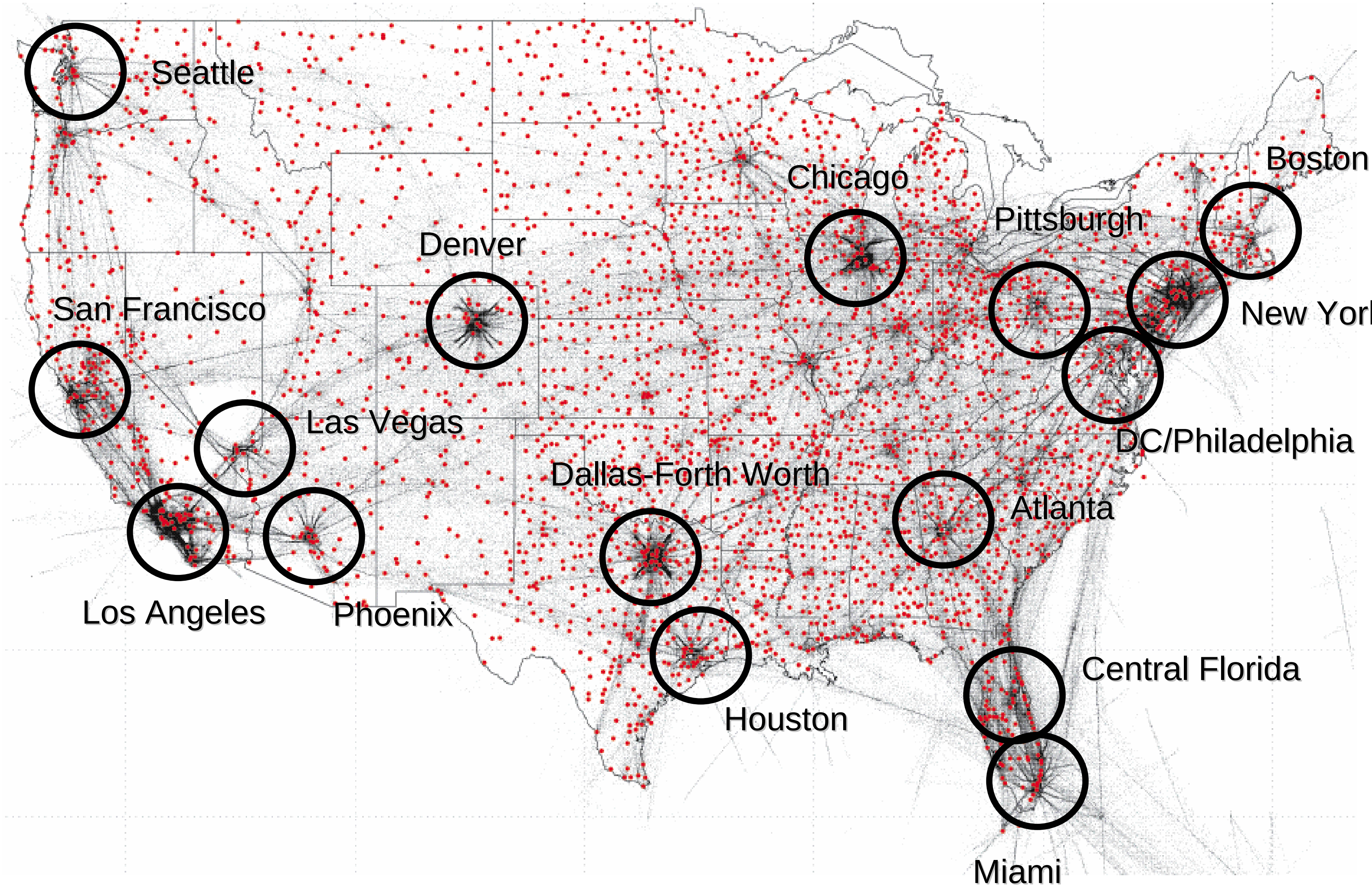
New York Area Terminal Operations

- **In 2004**, there are **2.3 million operations** at 10 New York terminal area airports
- **In 2015**, there could be **2.8 million operations** at the same airports (21% increase)
  - With VLJ operations, the total number of operations could go as high as **3.1 million** in 2015 (34% increase)

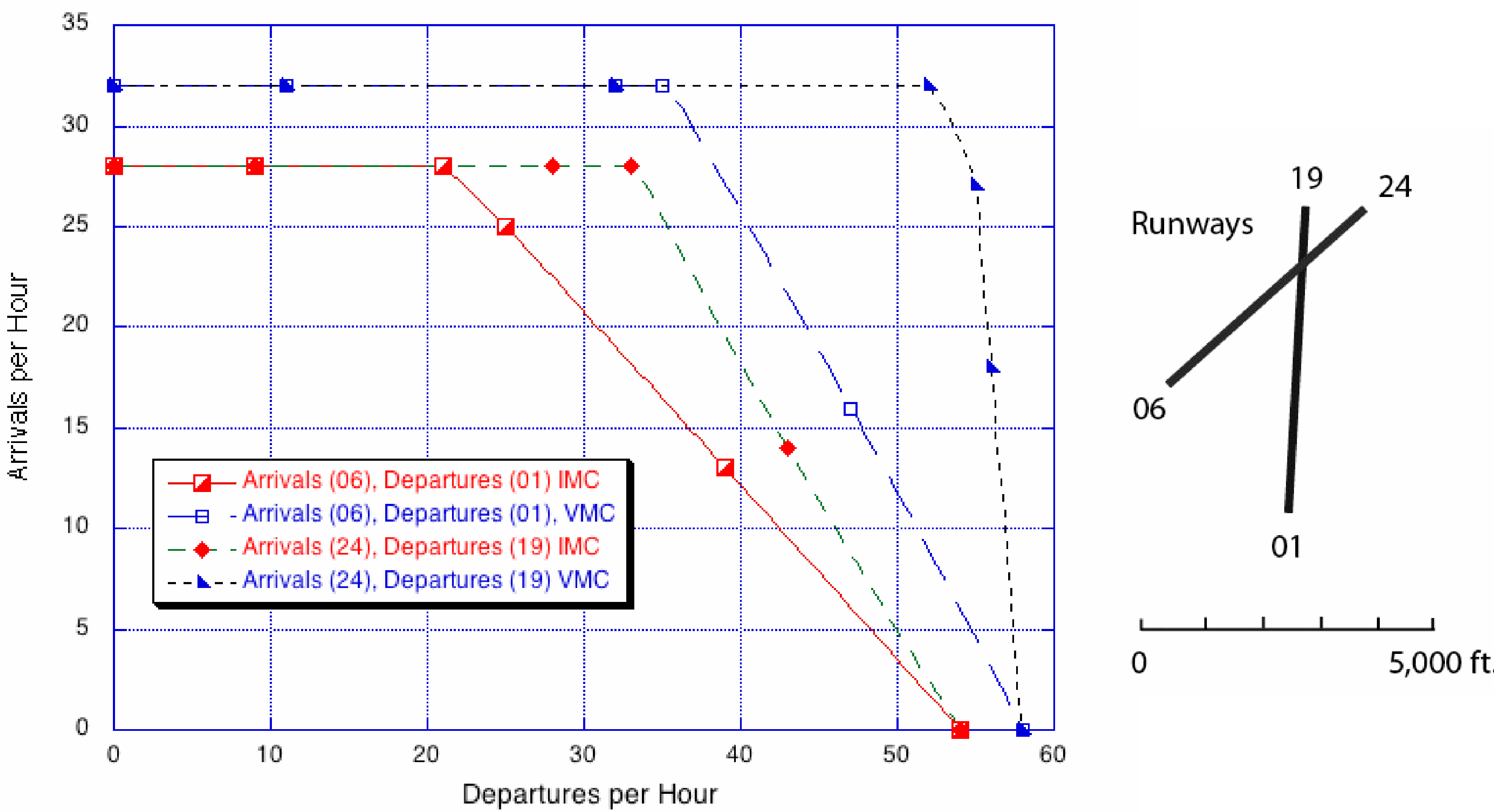


Q: What will be terminal area delays for TEB, FRG, HPN flights?

Terminal Areas of Interest



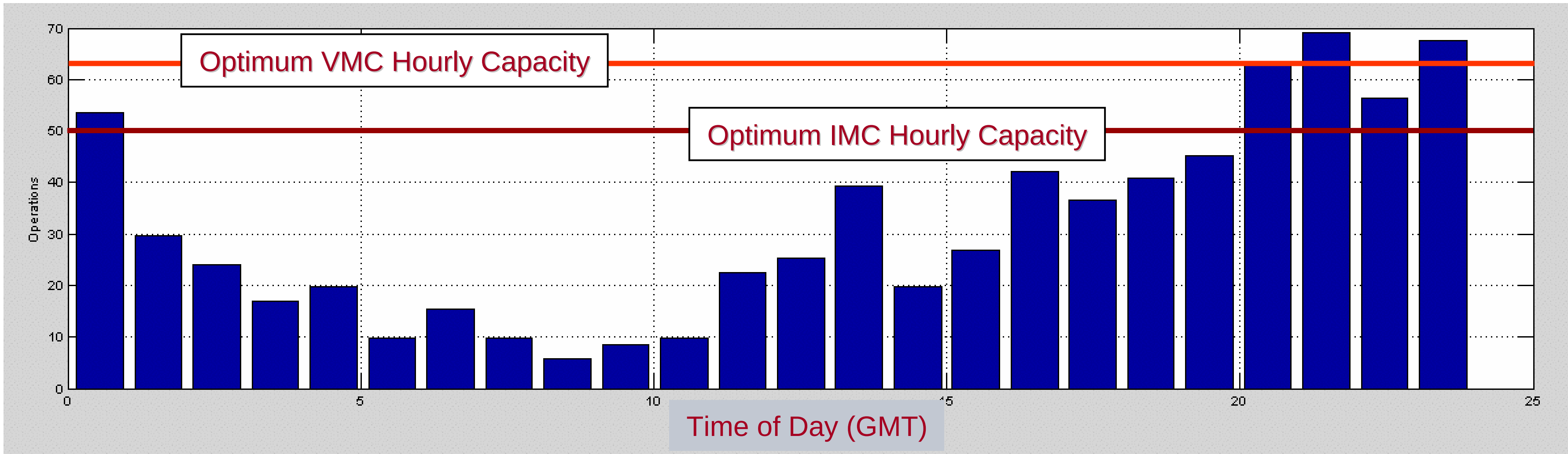
TEB Airport Runway Capacity Envelopes



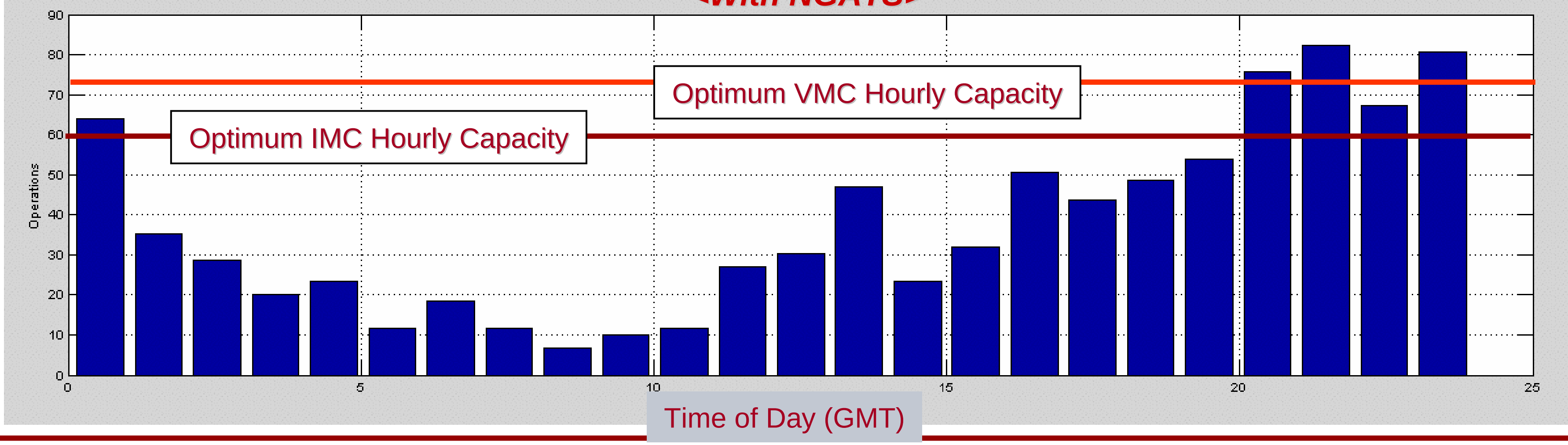
(Analysis with Airport Capacity Model)

Teterboro Future Hourly Demands

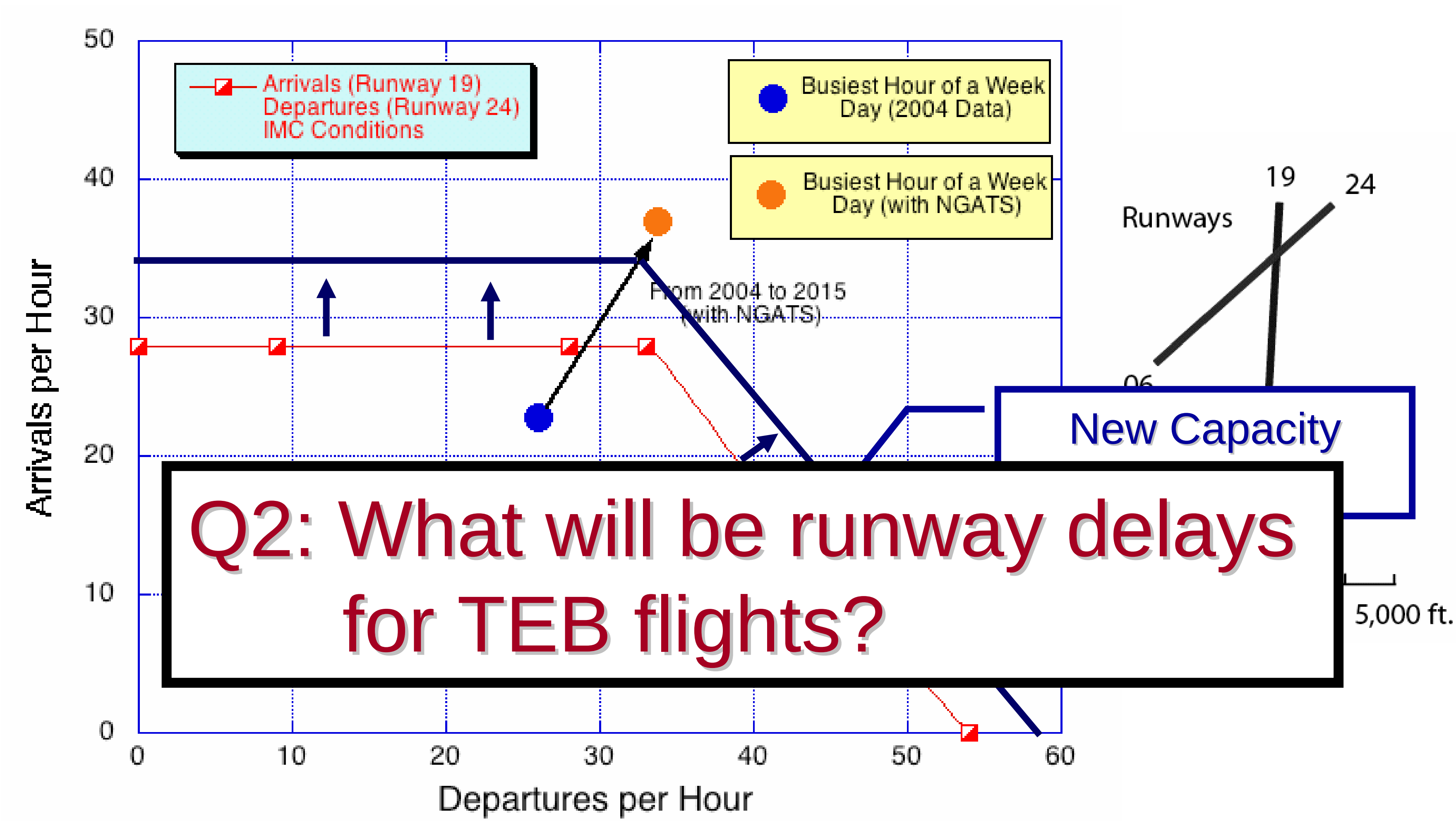
<Without NGATS>



<With NGATS>



Teterboro Capacity Analysis

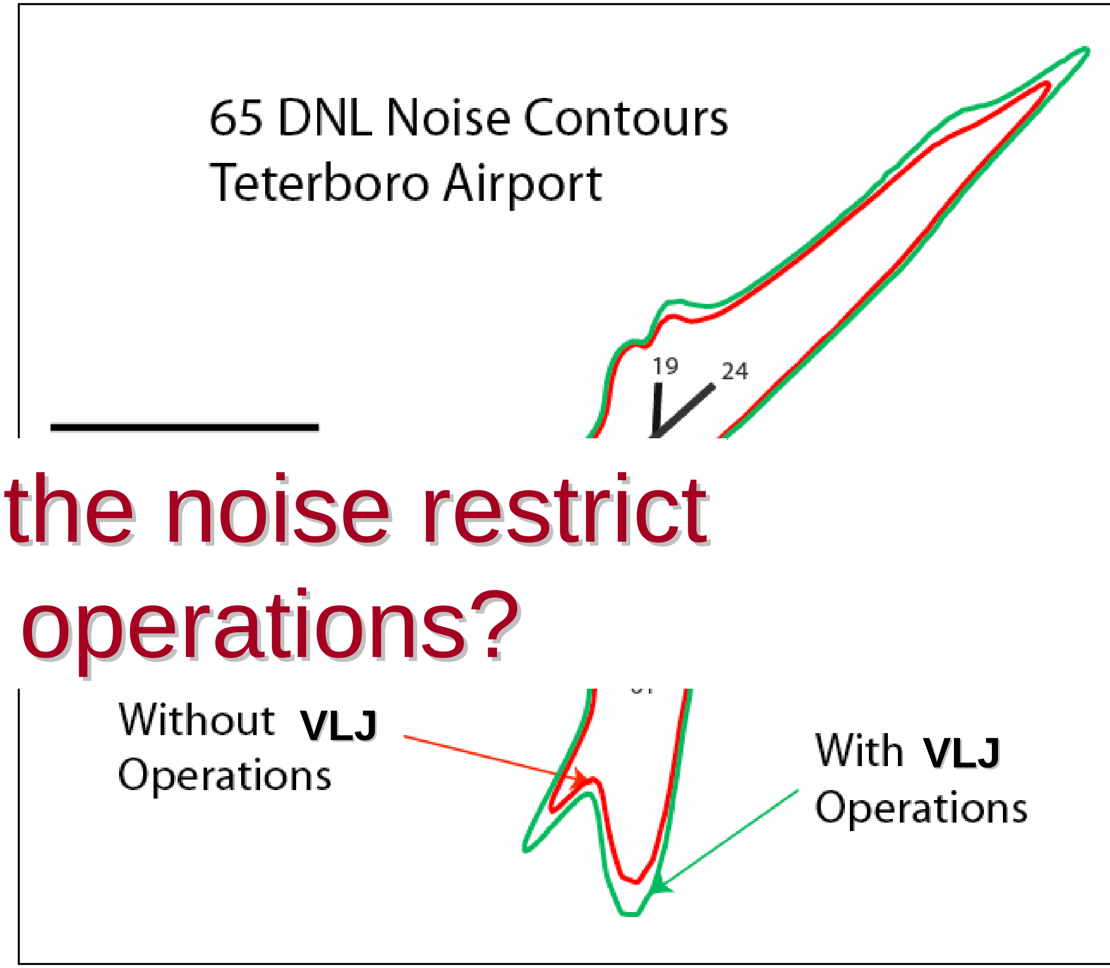


Q2: What will be runway delays for TEB flights?

Impact of VLJ Flights in the Airport Terminal Area (Environmental)

Teterboro Airport
(Noise Analysis using INM)

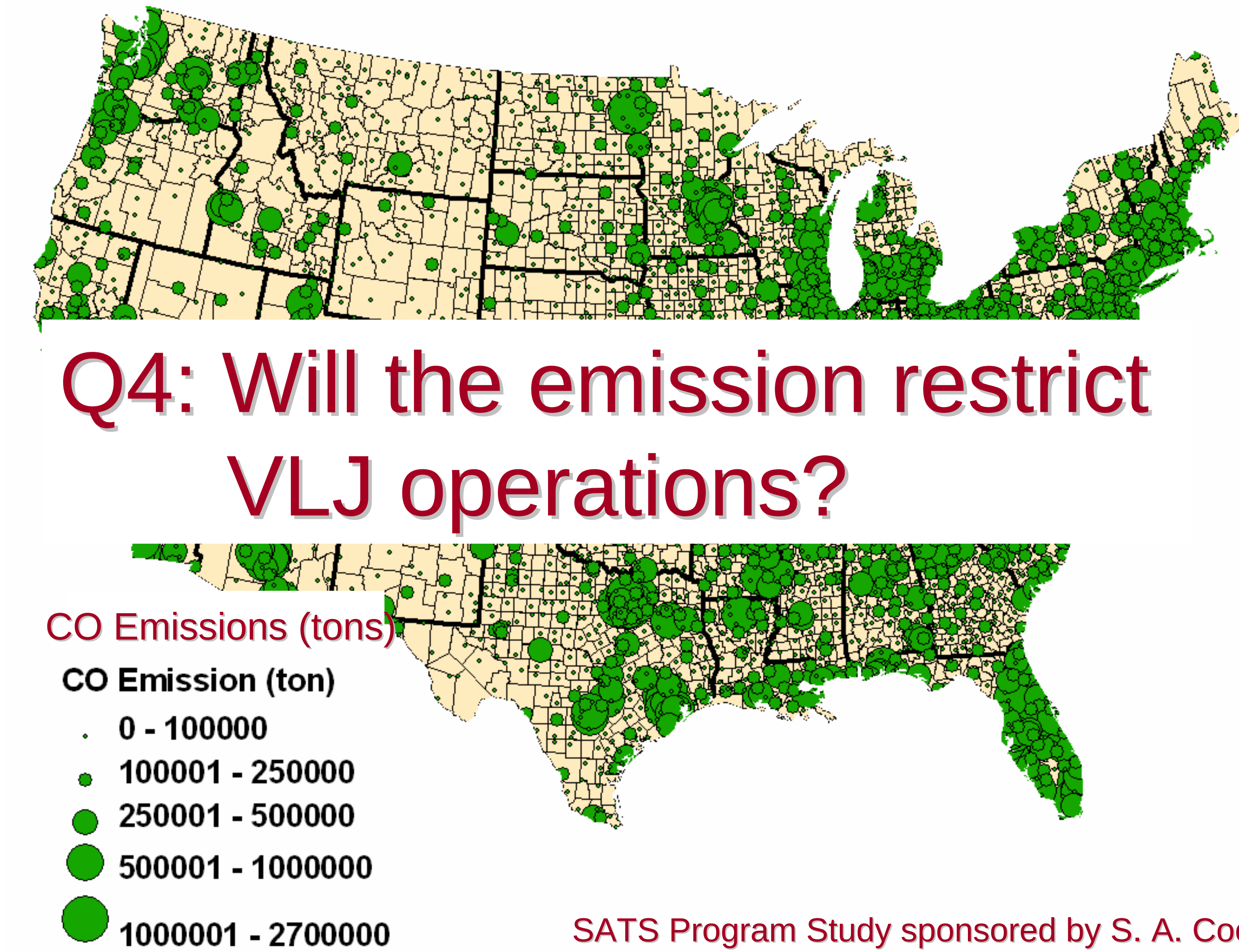
- 180 VLJ operations per year in 2014
- **6-7% increase** in the noise contour area when VLJ operati… added … base o…



Q3: Will the noise restrict VLJ operations?

SATS Program Study sponsored by S. A. Cooke (NASA)

Emission (CO) Analysis using EDMS 4.2



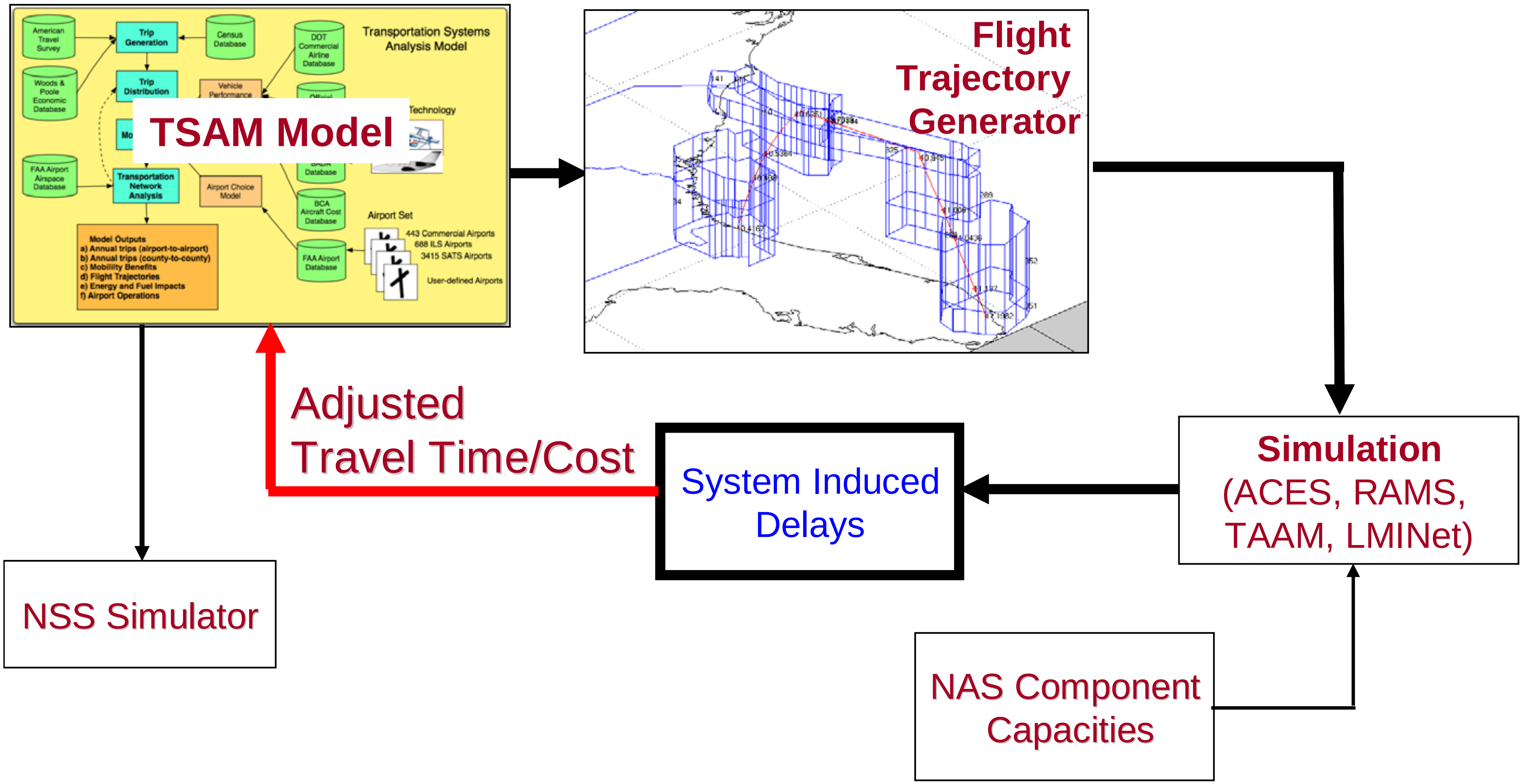
Q4: Will the emission restrict VLJ operations?

CO Emissions (tons)

SATS Program Study sponsored by S. A. Cooke (NASA)

Suggestions

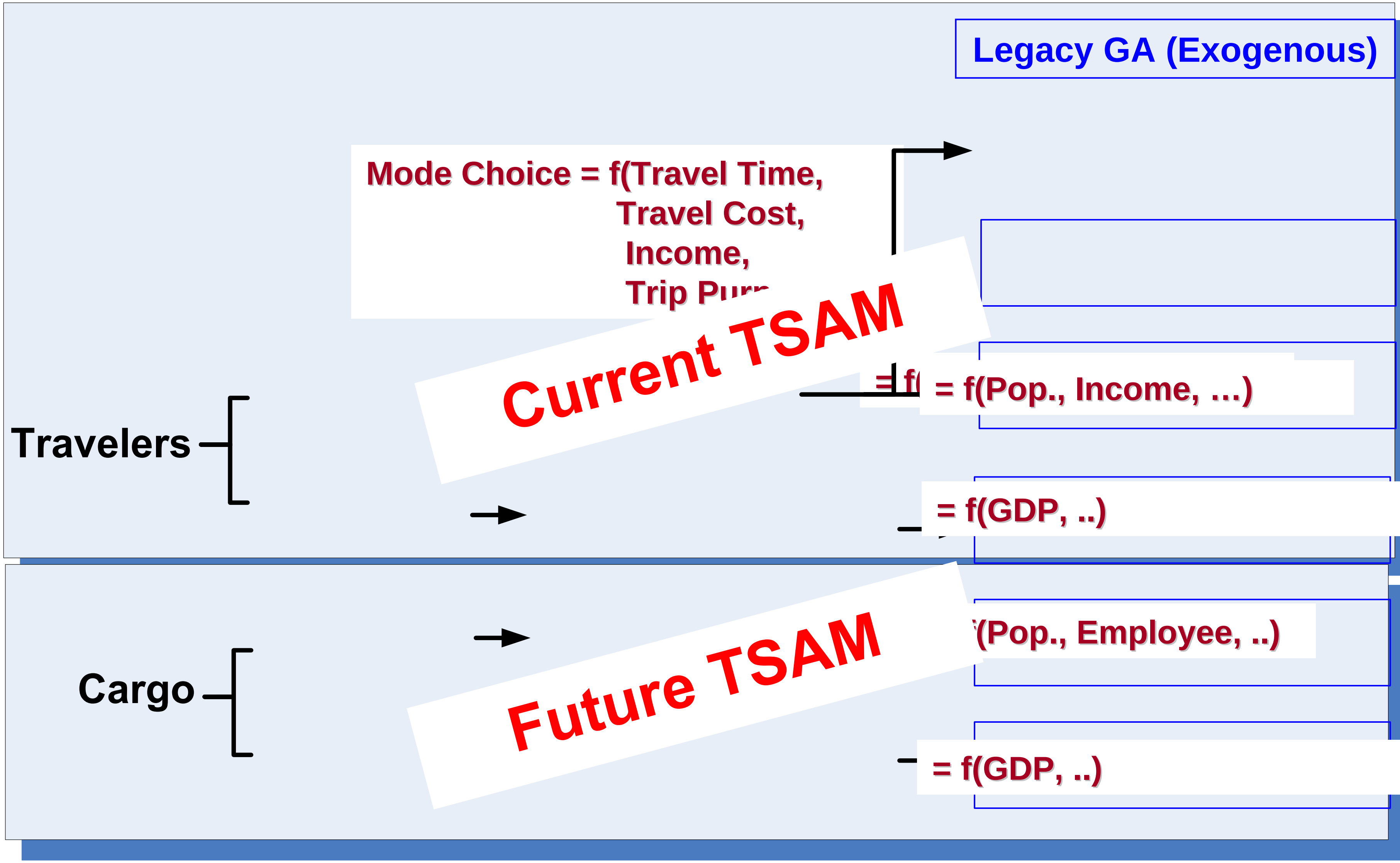
Suggestions



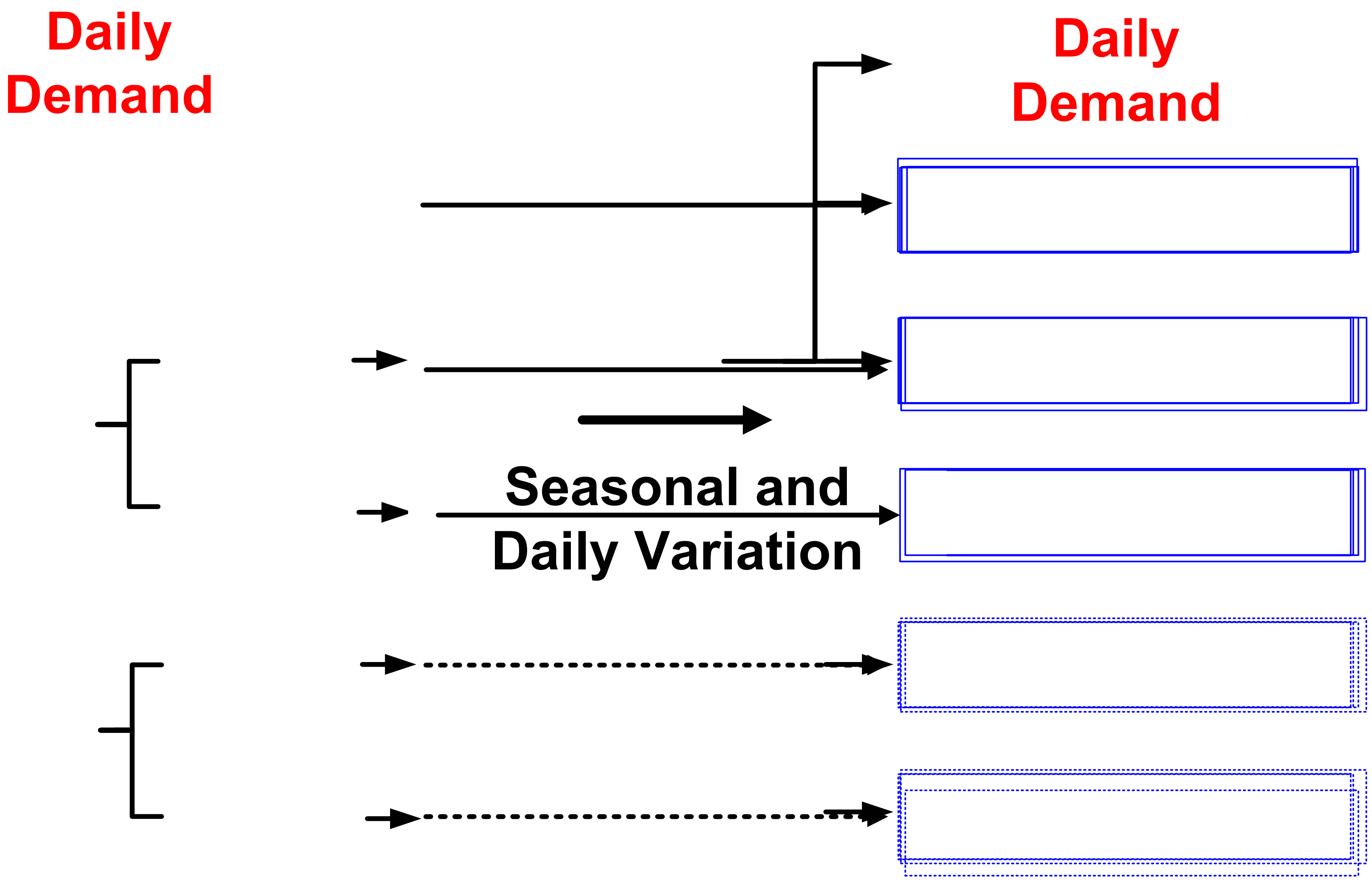
Questions?

Supplements
(TSAM)

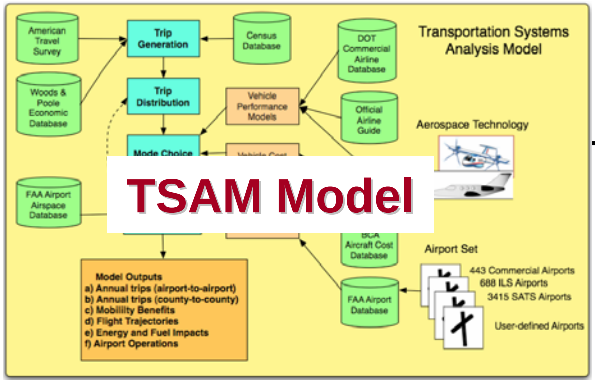
TSAM


Legacy GA (Exogenous)
Mode Choice = f(Travel Time,
Travel Cost,
Income,
Trip Purp
Current TSAM
= f(
= f(Pop., Income, …)
Travelers
= f(GDP, ..)
Cargo
Future TSAM
(Pop., Employee, ..)
= f(GDP, ..)

Convert Air Demand to Flights



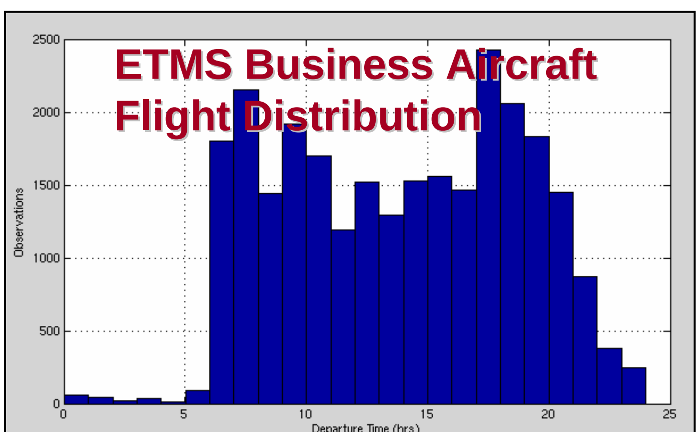
Converting Trips to Flights (On-demand VLJ)

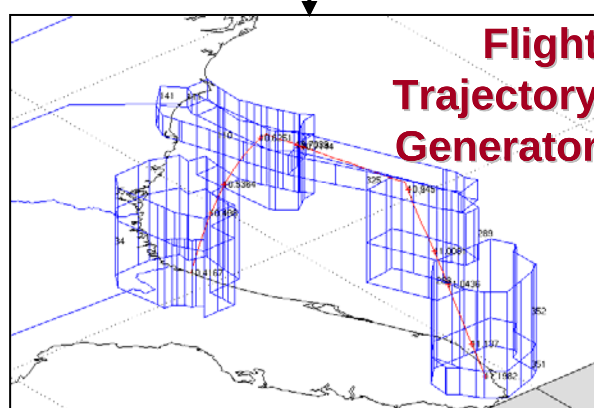


VLJ Annual Person Trips (Airport-Airport) (County-County)

Seasonal Variation (ATS)

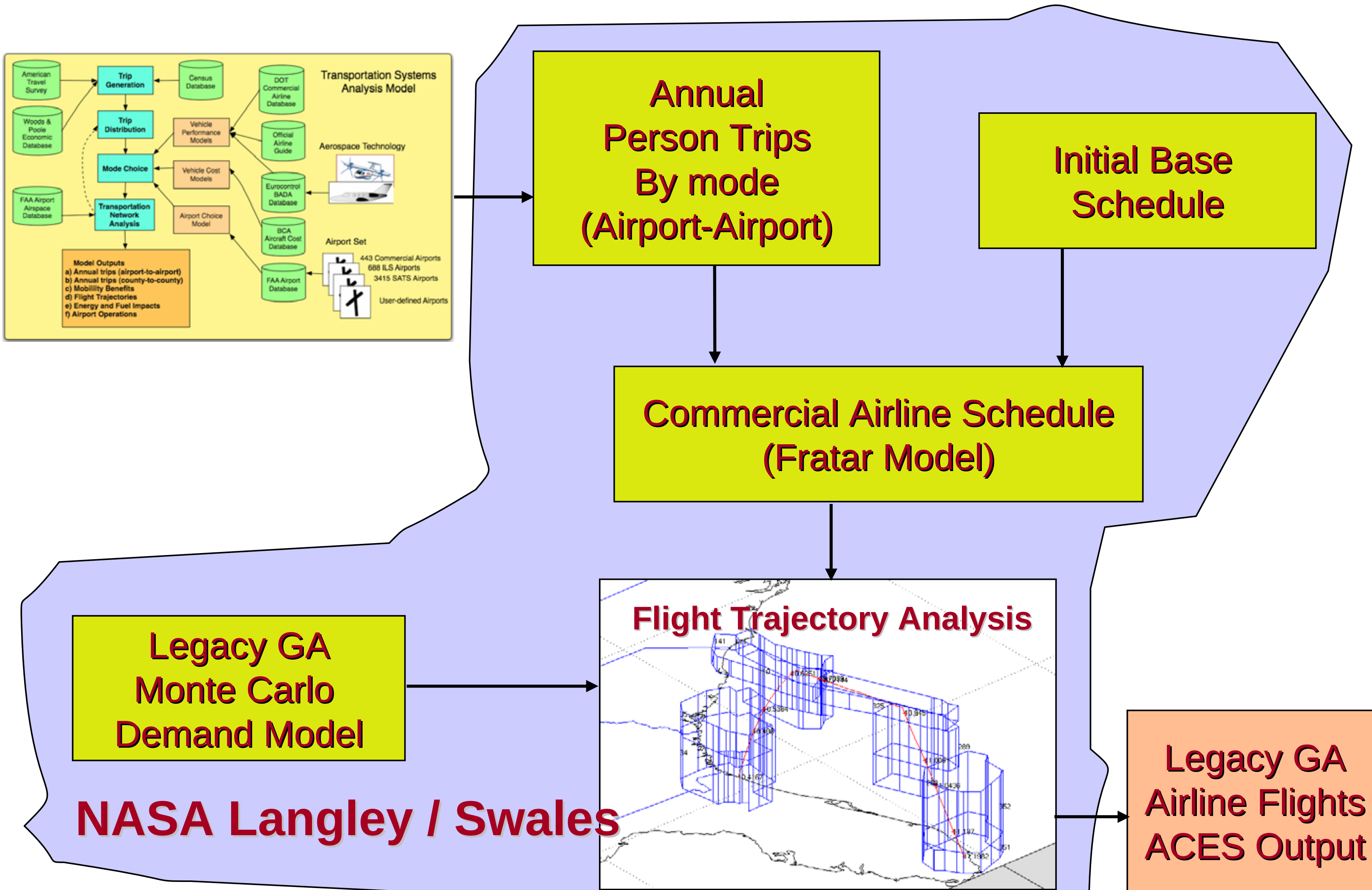
Daily Trip Analysis (Hourly Passenger Demand)





On-demand VLJ ACES Output

Airline Flights and Legacy GA



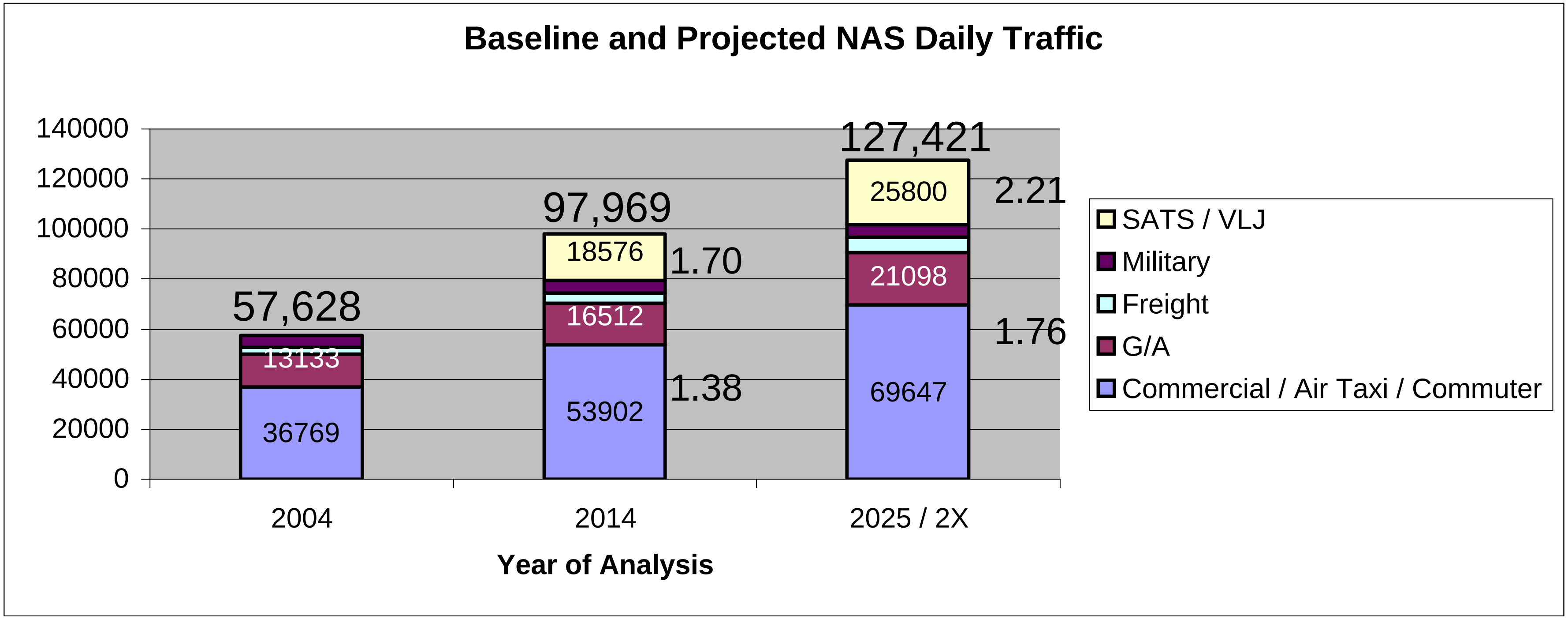
NAS Daily Flights

Baseline NAS: 2004 ETMS

Projections:

2014 - NAS Flights + VLJ

2025 - NAS Flights + VLJ



Supplements
(NGATS Scenarios)

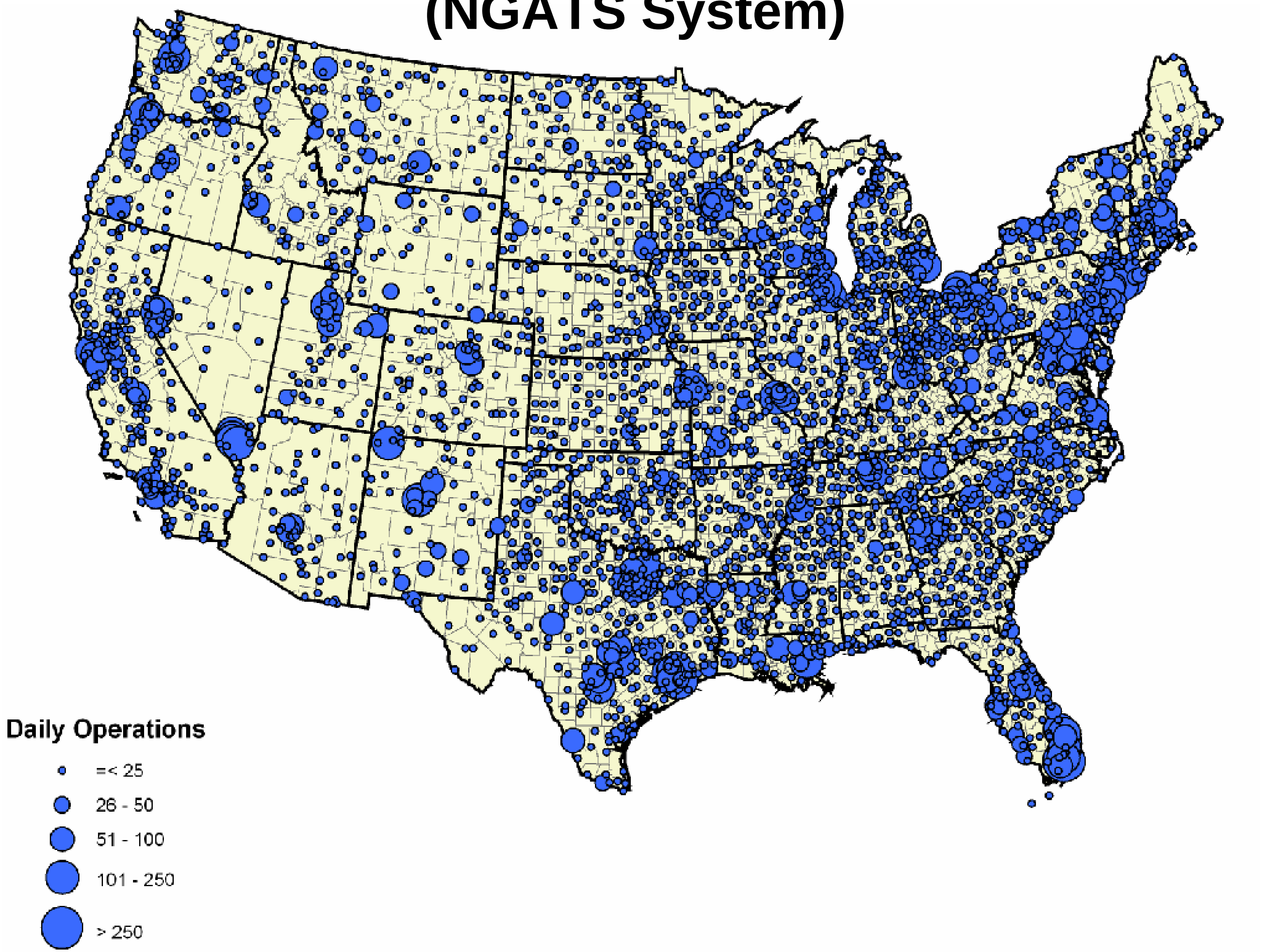
Scenarios Modeled
(Same as the Gulf of Mexico Study)

Scenario	Description
2005 **Case 1**	Airline Fare Scale Factor = 0.800 Current airline network structure Auto cost ($0.37 / veh-mile) No VLJ
2015 **Case 2a** **No NGATS**	Existing commercial airport set (443 nationwide) Airline Fare Scale Factor = 0.720 VLJ Auto cost = $0.37 vehicle-mile Processing times at airports remain the same
2025 **Case 3a** **No NGATS**	Existing commercial airport set (443 nationwide) Airline Fare Scale Factor = 0.650 VLJ Auto cost = $0.37 vehicle-mile Processing times at airports remain the same

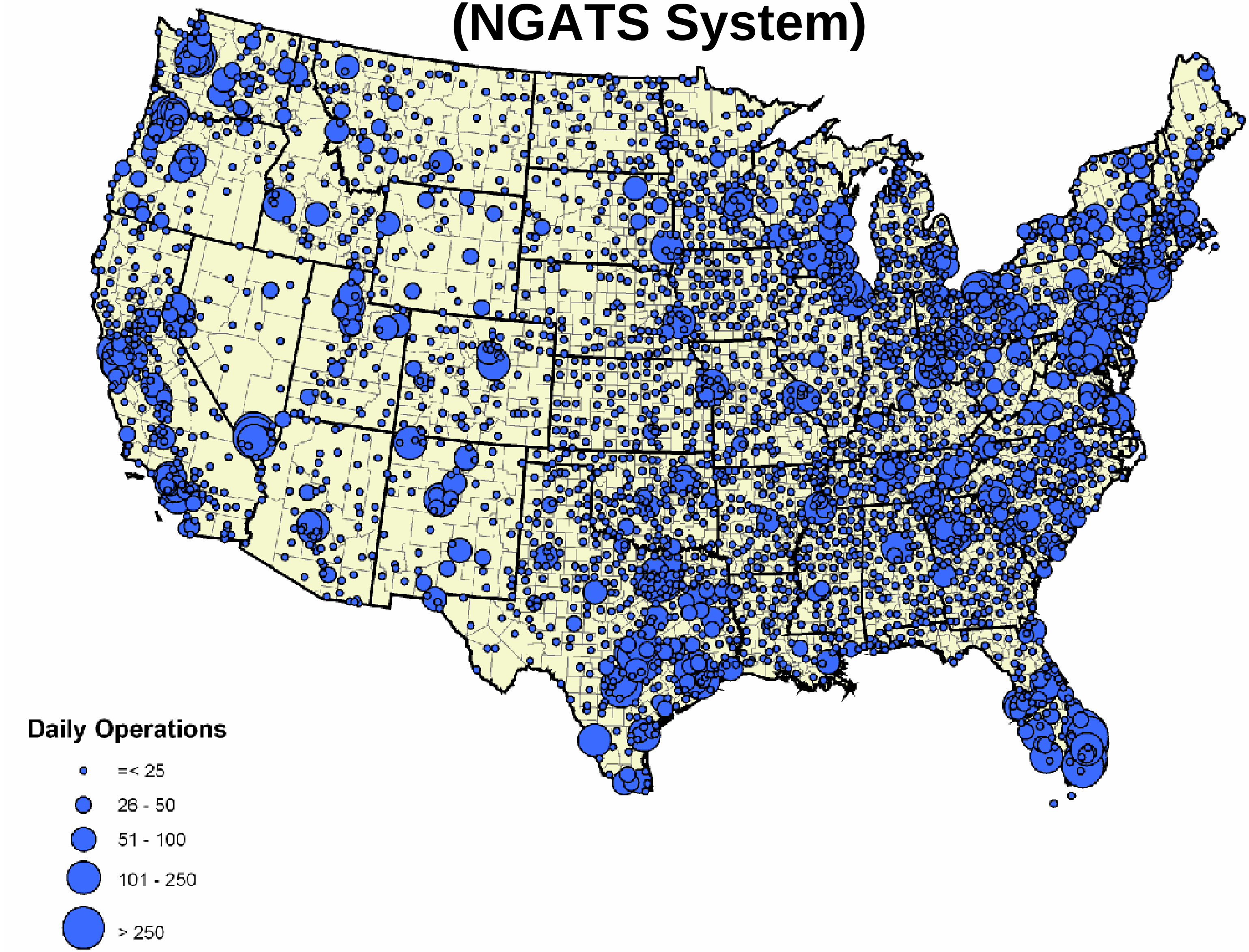
Scenarios Explored
(NGATS Solutions with VLJ)

Scenario	Description
2015 **Case 4** **NGATS**	Existing commercial airport set (443 nationwide) Airline Fare Scale Factor = 0.720 VLJ on-demand services at $1.75 / pass-mile Auto cost = $0.37 vehicle-mile Processing Times Scaling Factor = 0.75
2025 **Case 6a** **NGATS**	Existing commercial airport set (443 nationwide) Airline Fare Scale Factor = 0.650 VLJ on-demand services at $1.75 / pass-mile Auto cost = $0.37 vehicle-mile Processing Times Scaling Factor = 0.50 Airline Travel Times Scaling Factor = 0.95

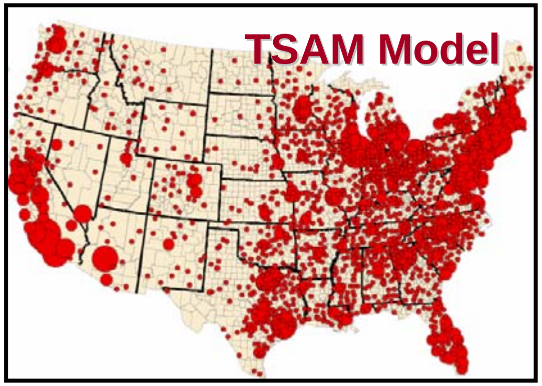
VLJ Daily Airport Traffic in 2015 with OEP Airports
(NGATS System)



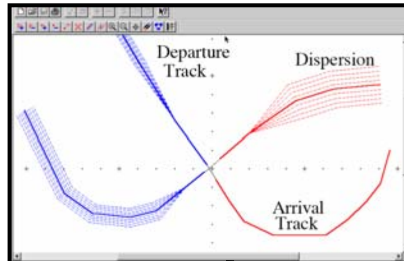
VLJ Daily Airport Traffic in 2025 with OEP Airports (NGATS System)

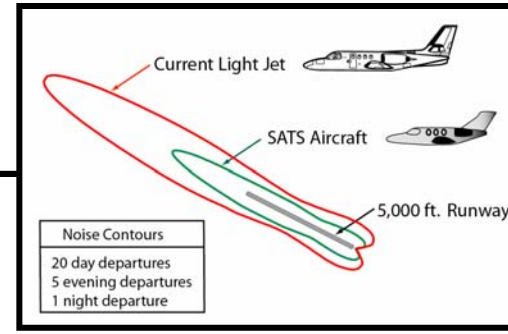


Another GA Airport Growth Consideration Constrained Analysis (Noise Impact)

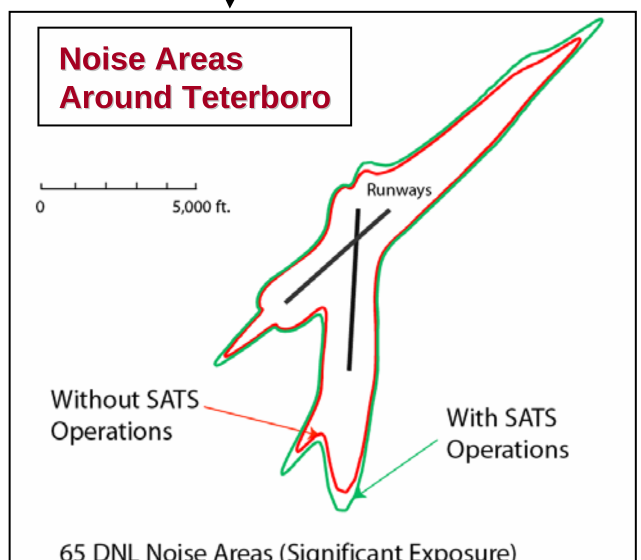


Integrated Noise Model





Airport Demand Function



Noise Impacts to Population

SATS Program Study sponsored by S. A. Cooke (NASA)

Supplements
(VLJ)

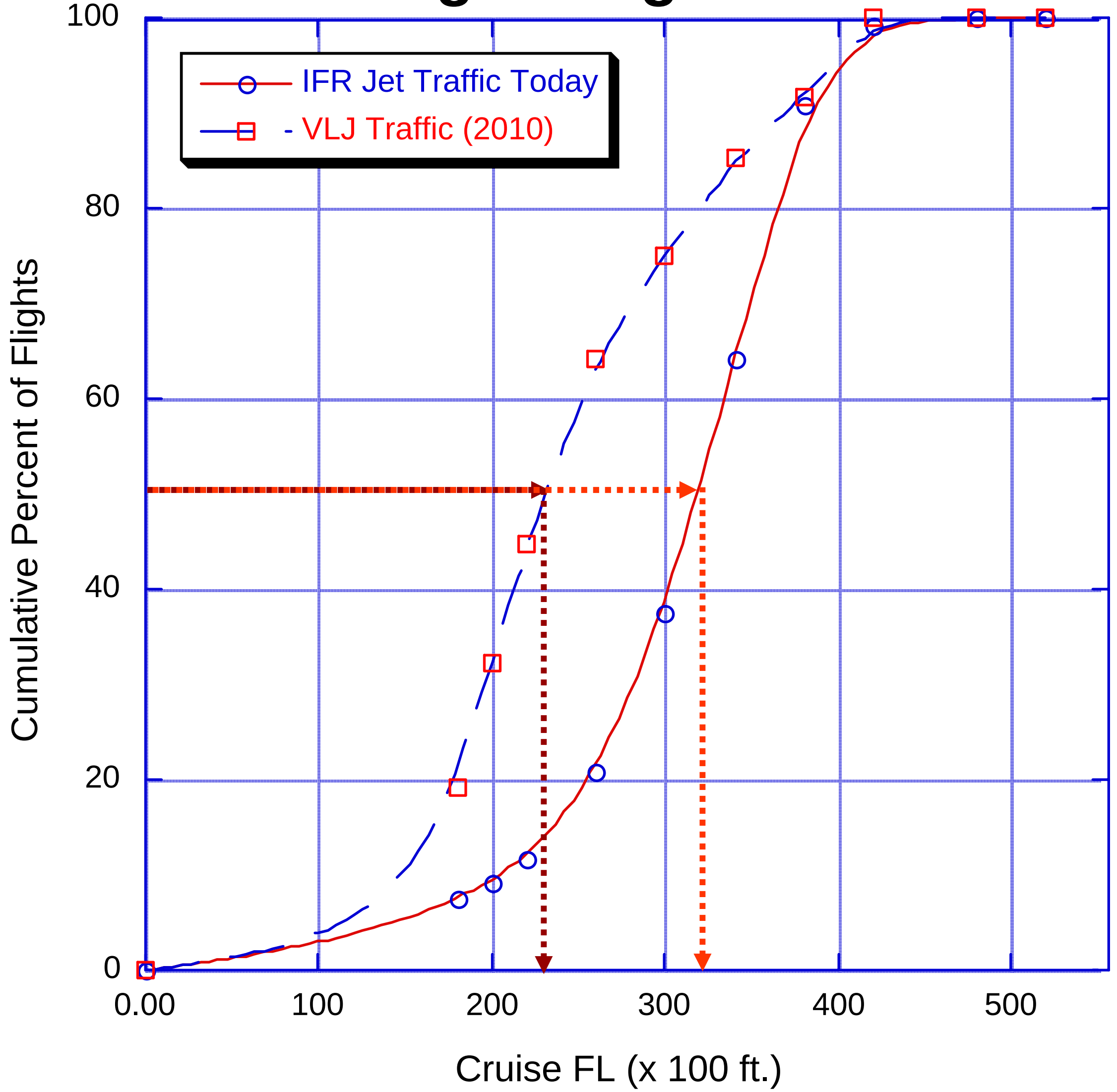
VLJ Traffic Will Fly Below Regular Airline Traffic due to Shorter Stage Lengths

Median Cruise VLJ Flight Level = 230*

Median Cruise FL Cessna CitationJet I = 240**

Median Jet Cruise Flight Level = 320**

*** TSAM Analysis**
**** FAA ETMS Data**



VLJ fares by Region

- From MCATS Study

VLJ Aircraft Fleet Size Projections (with Production Capacity Constraints)

FAA 2005 Forecast

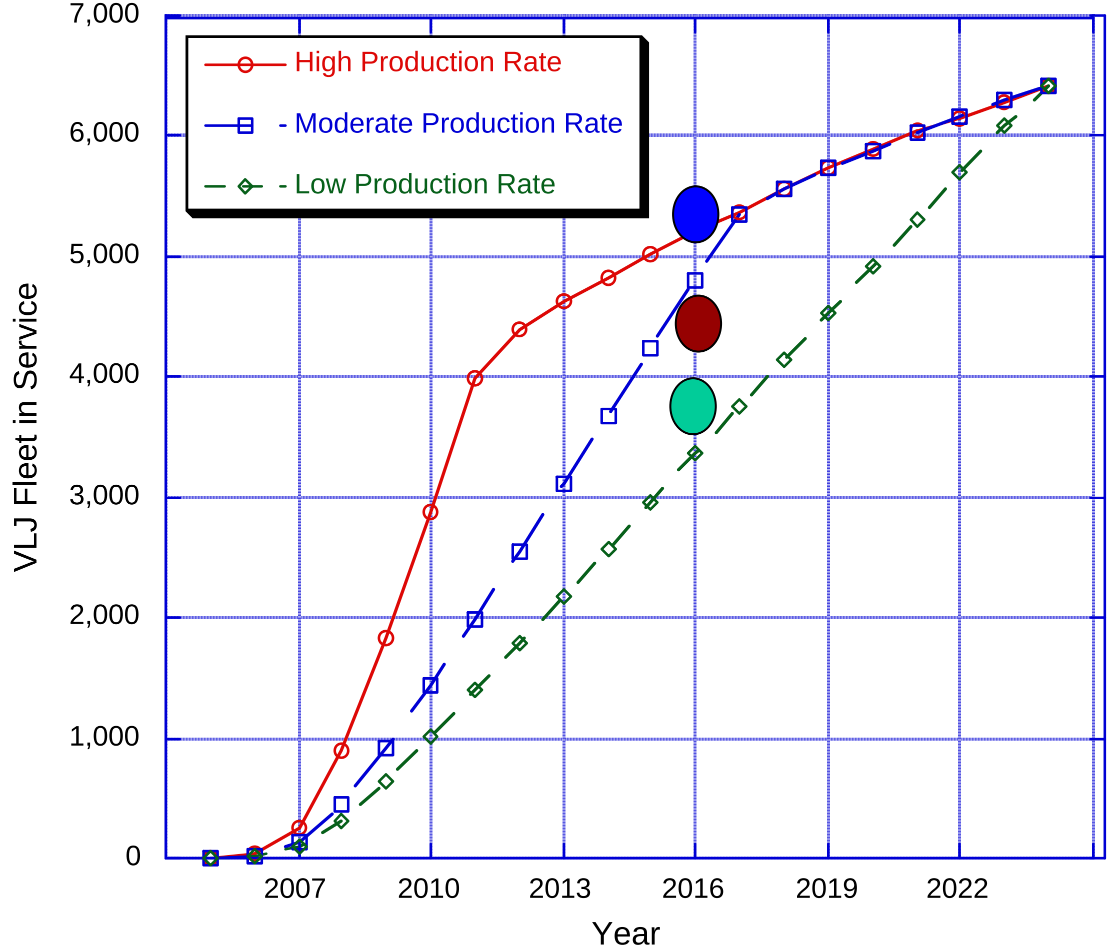
Honeywell Forecast

Embraer Forecast

- Assumes a fixed demographic and socio-economic (WP 2004)

Interpretation

- In 2014 there could be 4,200- 5,000 VLJ aircraft flying in the NAS



Summary of VLJ Forecast Results (TSAM)

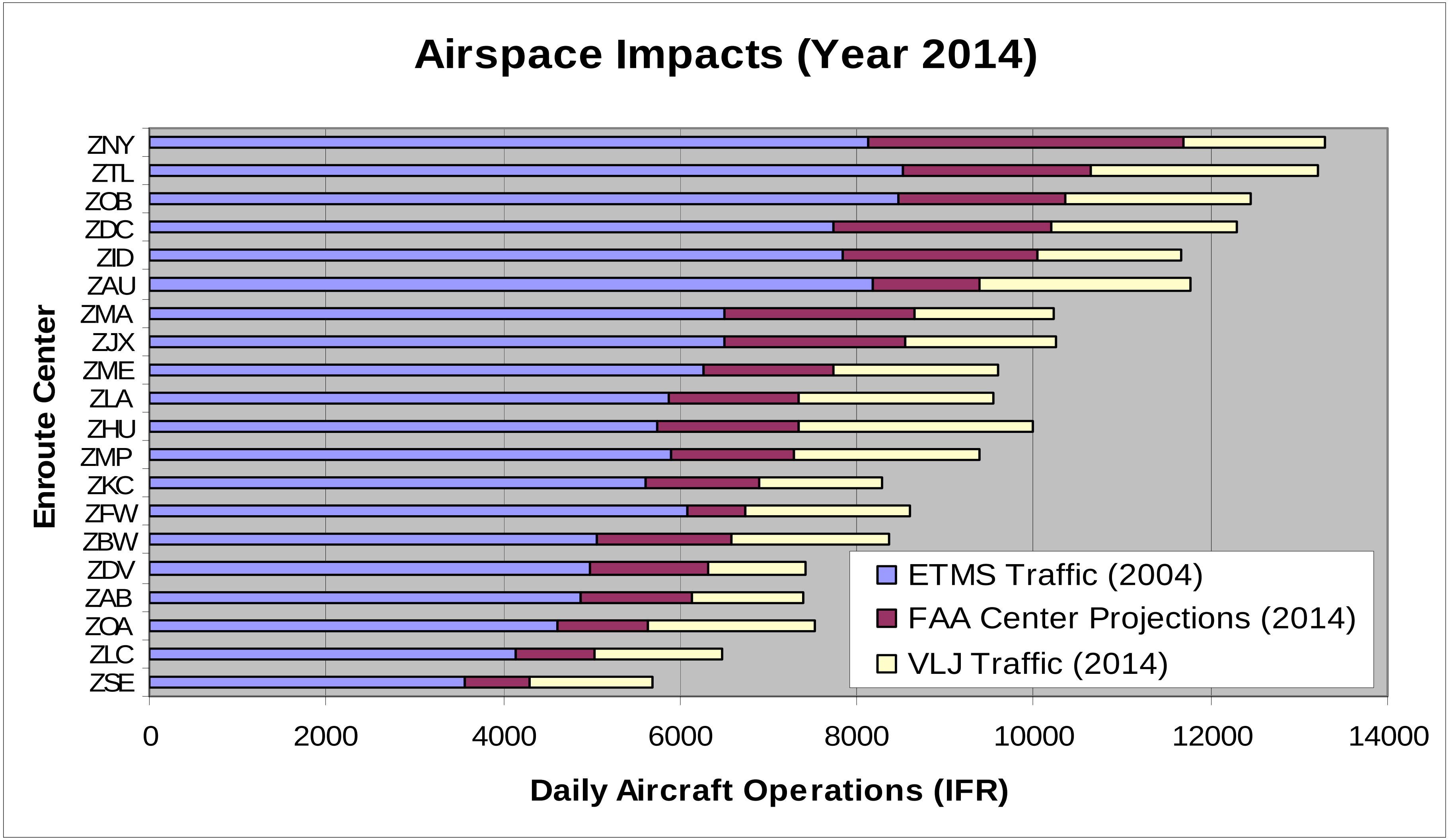
Table A.1 Flight Operations.

Year	Daily VLJ Flights	~ Fleet Required (aircraft) *	Daily Hours Flown by Fleet (hours)	Revenue Hours Flown
2009	7,600*	1,720	6,713	5,594
2012	17,836	4,220	16,638	13,865
2014	18,576	4,540	17,342	14,452
2025	25,800	6,207	24,428	20,357
2047	59,744	14,500	58.400	48,300

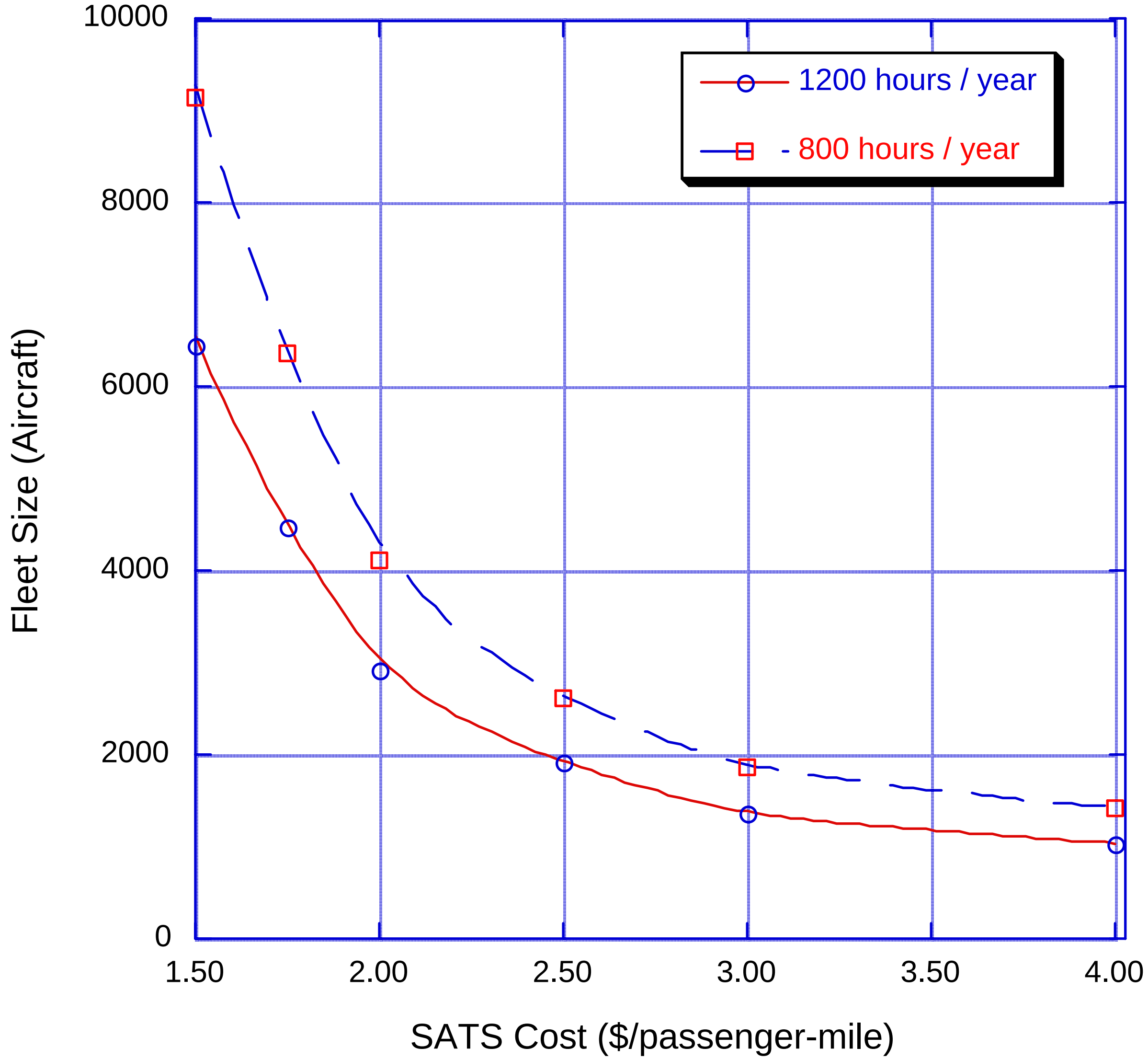
* Refined numbers from Figure 3 after simulation of all VLJ flights.

Notes:
1) Results for year 2047 require large extrapolations of demographic model
2) High production capacity scenario
3) VLJ = $1.75 per passenger-mile, optimistic airline fares, auto = 37 cents/veh-mile

2014 VLJ Air-Taxi NAS Impacts



VLJ Fleet Size vs. Cost for Service



APO View of the VLJ World (March 2005)

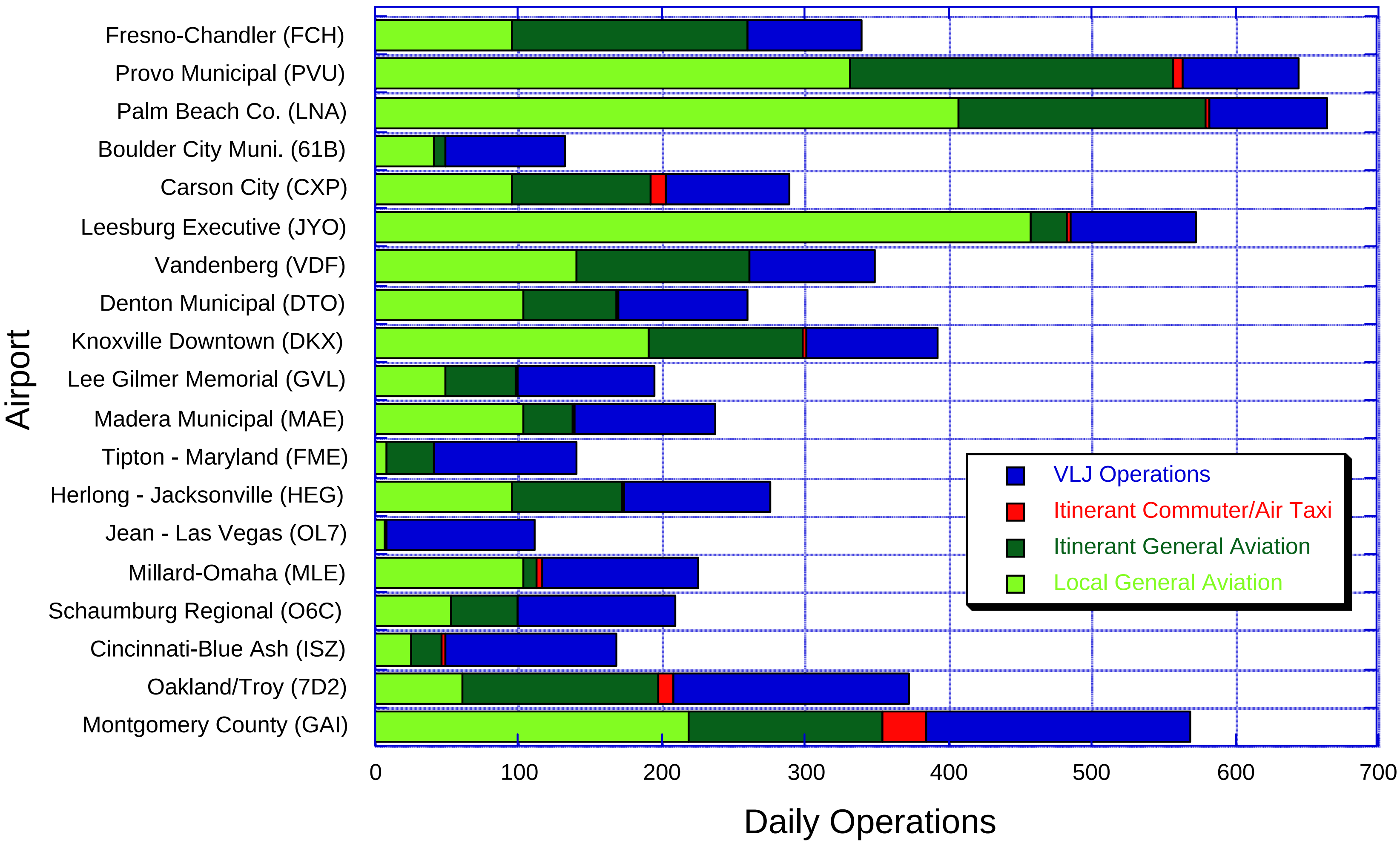
- FAA APO assumes microjets (or VLJs) will be used as standard corporate jets (300-342 hours per year) based on historical trends
  - 4,000 microjets in 2016
  - Low use rate (< ~ 400 hours per vehicle)
- This results in small number of total hours flown since VLJs are assumed to be used in traditional low use roles

Comparison with Virginia Tech Projections

- We have projected that 70-75% of the fleet will go to on-demand services (today Eclipse Aviation claims 67% of the orders are for air taxi services)
  - 4,800 to 5,400 VLJs in 2016
  - High use rates (800-1,200 hours per year)
  - On-demand air taxi services
  - Fractional ownership
- **Conclusion:**
  - APO forecast has substantially fewer hours flown per year for the fleet
  - For NGATS planning we recommend a more "optimistic" view of VLJ demand to be ready for a VLJ wave if it happens

Supplements
(Non-towered Airport)

Impact of VLJ Operations at Non-Towered Airports (2025 scenario)



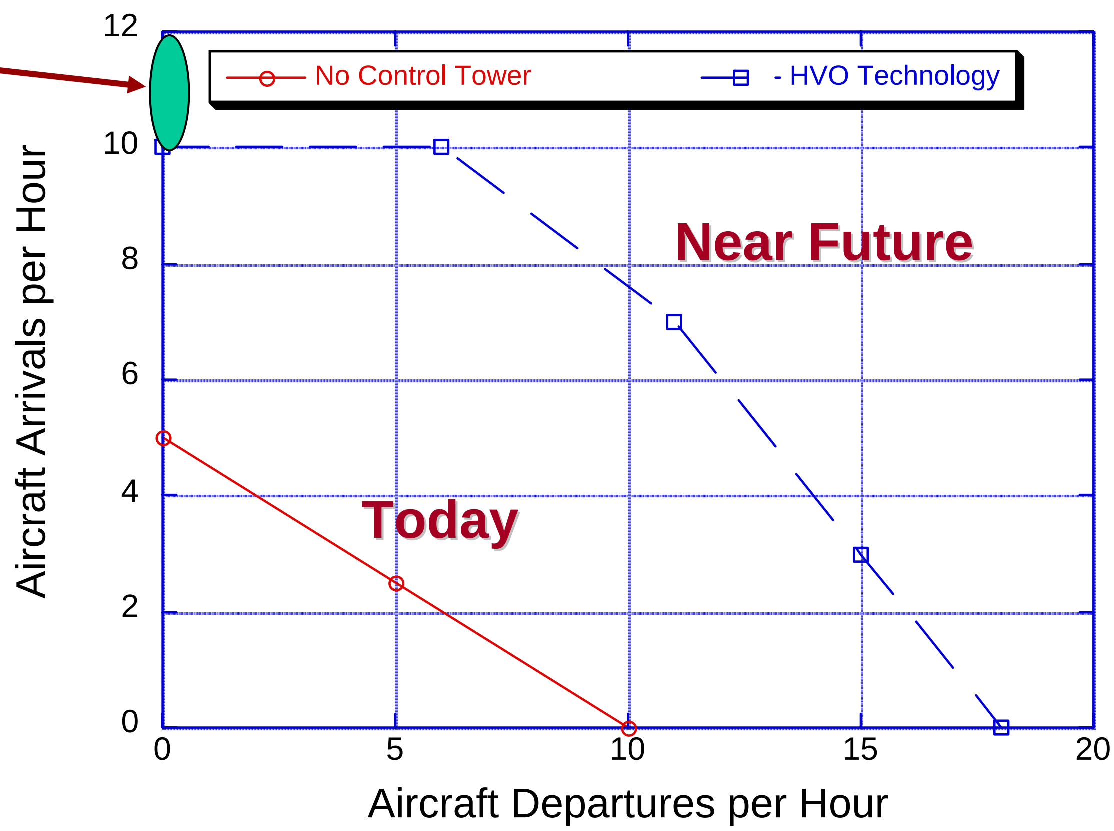
Non-towered Airport Capacity Gains

- The SATS Program successfully demonstrated capacity improvements at airports with no control towers
- Use of Airport Management Module (AMM)
- High-Volume Operations (HVO)

Future Airport Procedures (SATS Program)

- Example of technology implications for non-towered airports
- High-Volume-Operations (HVO) concept (NASA Langley)

Danville Demo (2005)



HVO technology has impact on airport capacity

Technology can Help but to what Extend?

- Conduct RNP 0.3 approaches to two distinct airports using PRM-aided ILS simultaneous spacing criteria

Picture: Leigh-Fisher and Associates, 2003

Supplements
(Future Airline Schedules)

Methodology to Create Future Airline Schedules

- TSAM provides airline demand estimates for 443 domestic airports
- Swales Aerospace has developed a Fratar-based module to predict the future flight schedules (from current schedules) produced by TSAM
- Airplanes are assumed to have an average 70% load factor

Direct Flights

- As demand increases between city pairs in the future, when demand justifies it, direct flights are introduced where non existed previously
- We model this by introducing 2 direct flights (each way) per day when passenger demand exceeds 25k trips per year
- Add 1 morning and 1 evening direct flight each way
- Remove shortest connecting route flights from future schedule (only flights of 2 legs considered)
- 2 direct flights replace 4 connecting flights

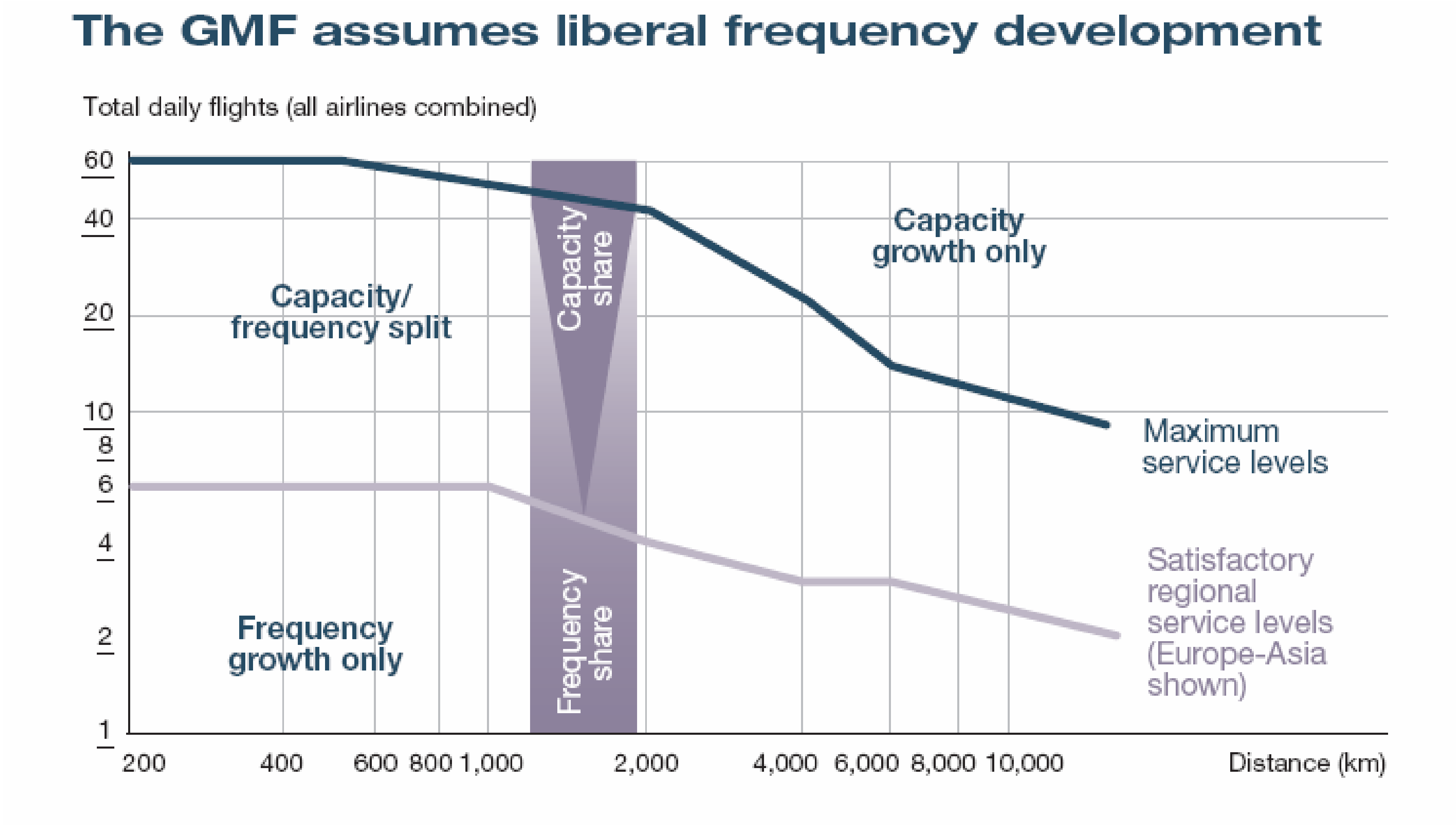
Methodology to Create Future Airline Schedules

Adding Frequency and Larger Aircraft

- Increased passenger demand between airports can be met with a combination of increased flight frequency **and** larger aircraft
- Research by Airbus[1](*next slide*) indicates that airlines will satisfy increased demand by adding the following service (flights refer to *all* airlines combined):
  - Total round trip flights <= 6 - Increase frequency of flights between airports
  - Total round trip flights > 60 - Increase capacity (size) of aircraft
  - Total round trip flights in between: Use a combination of increased frequency and increased capacity.

1) http://www.airbus.com/pdf/media/GMF2004_demand_passenger.pdf

Airbus Global Market Forecast Method



Supplements
(GA)

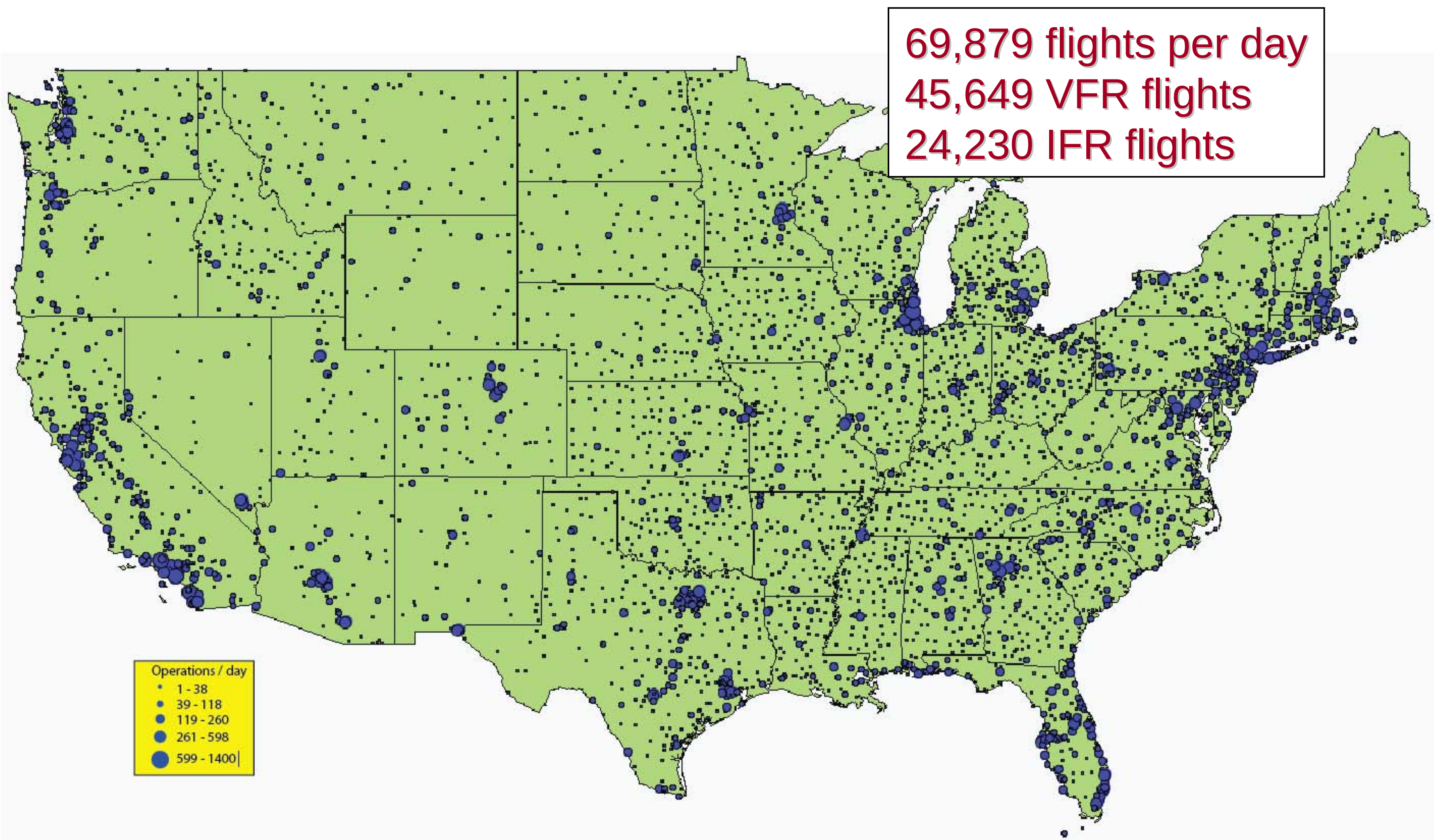
Legacy GA Flights*

- **Model**:
  - Uses baseline values for projected active aircraft and itinerant operations derived from TAF & FAA Airspace Forecasts FY 2004-2016.
  - Includes airports reporting 10 or more itinerant GA operations (per year) in the 2004.
  - Projects a flight “schedule” between 5243 public and private airports using Frata model.
- **Results**:
  - About **65,000** itinerant GA flight per day (average) **in 2005**, and About **76,000** per day **in 2025** (17% increase).
    - Growth mostly due to business jets which will be IFR flights (275% increase)
  - Flight sets:
    - Single-engine VFR, Single-engine IFR,
    - Multi-engine VFR, Multi-engine piston IFR, Multi-engine turbo
    - IFR, Jets (assumed to always be IFR)

*By Swales Aerospace.

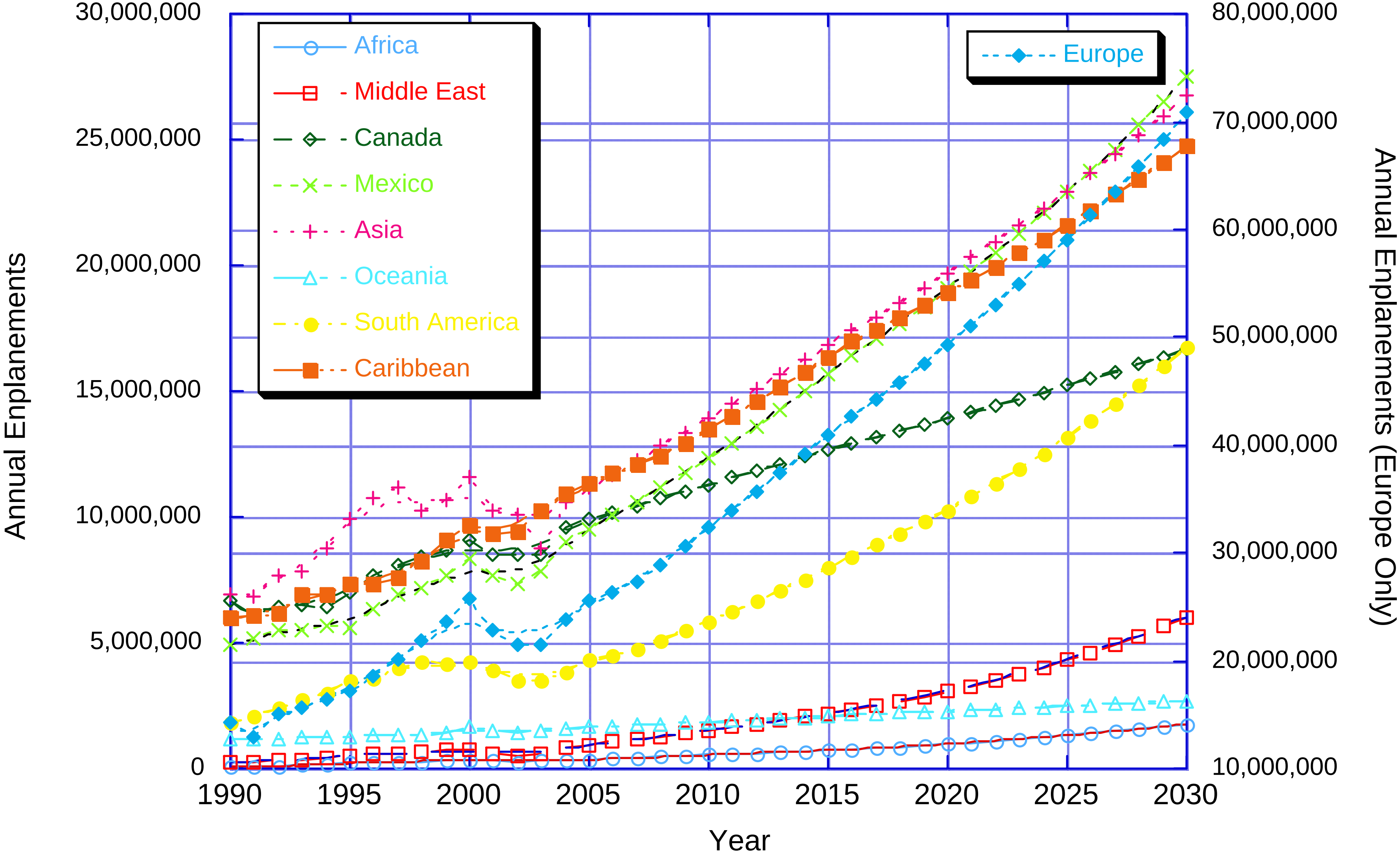
Legacy GA Operations (Swales Aerospace Module)

Year 2015 Analysis (VFR + IFR Traffic)

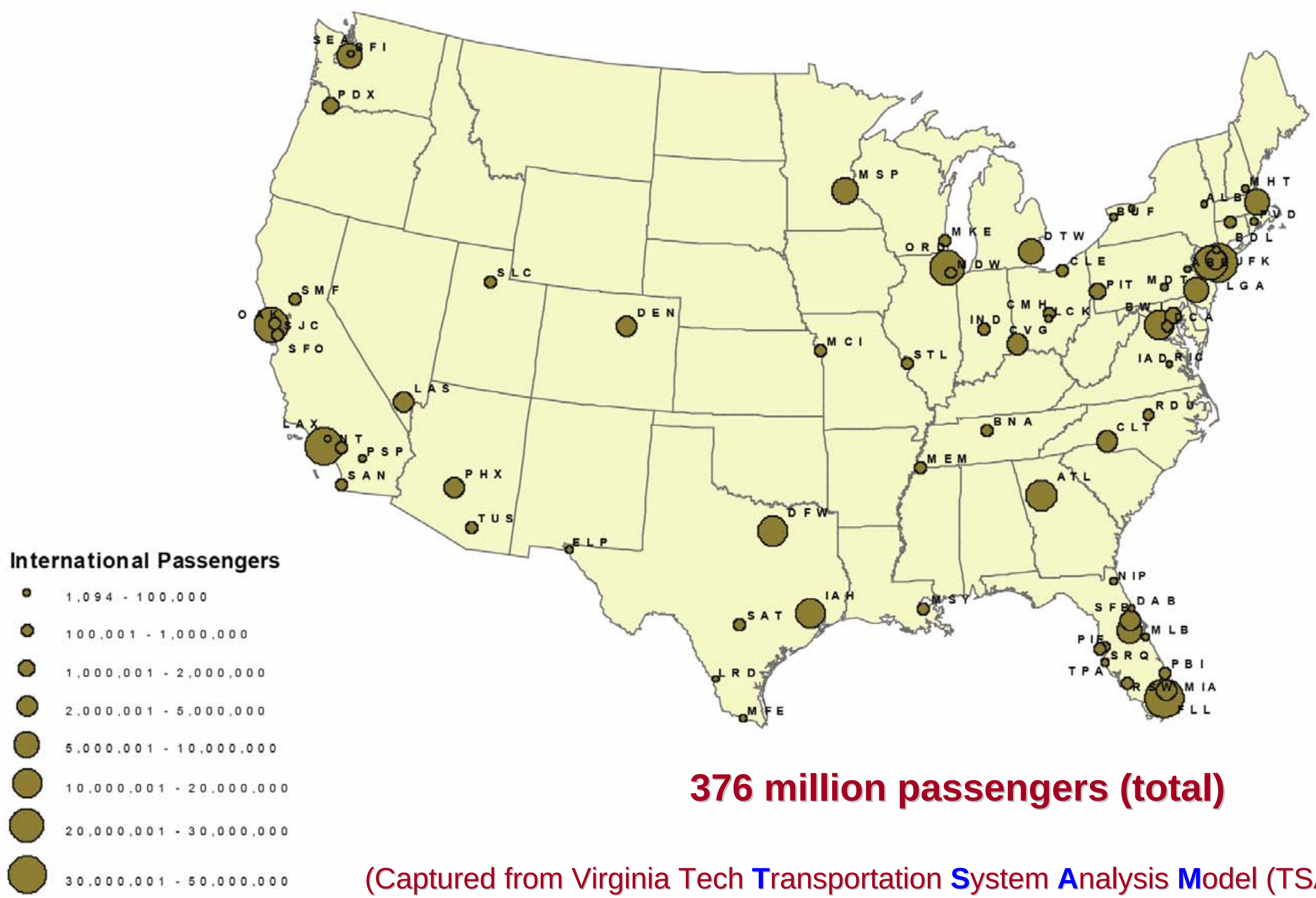


Supplements (International)

Future Airline Travelers: International



Future Airline Travelers: International (2015)



376 million passengers (total)

(Captured from Virginia Tech **T**ransportation **S**ystem **A**nalysis **M**odel (TSAM))

TSAM comparison with Domestic Enplanement Data

2004

TSAM: Business trips 86.7M

Personal trips: 154.0M

Total Commercial Airline Trips: 240.7M

How does this relate to enplanements?

Assumption: ~36% of trips have connection

Each person trip has 2 trips - Depart and Return

TSAM Commercial Enplanements: 654.7M

ATA/FAA Reported Enplanements: 635.5M (3% difference)