Systems Models for the NAS Strategy Simulator

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TSAM Modeling Team

NEXTOR Research Seminar
FAA Headquarters

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Organization

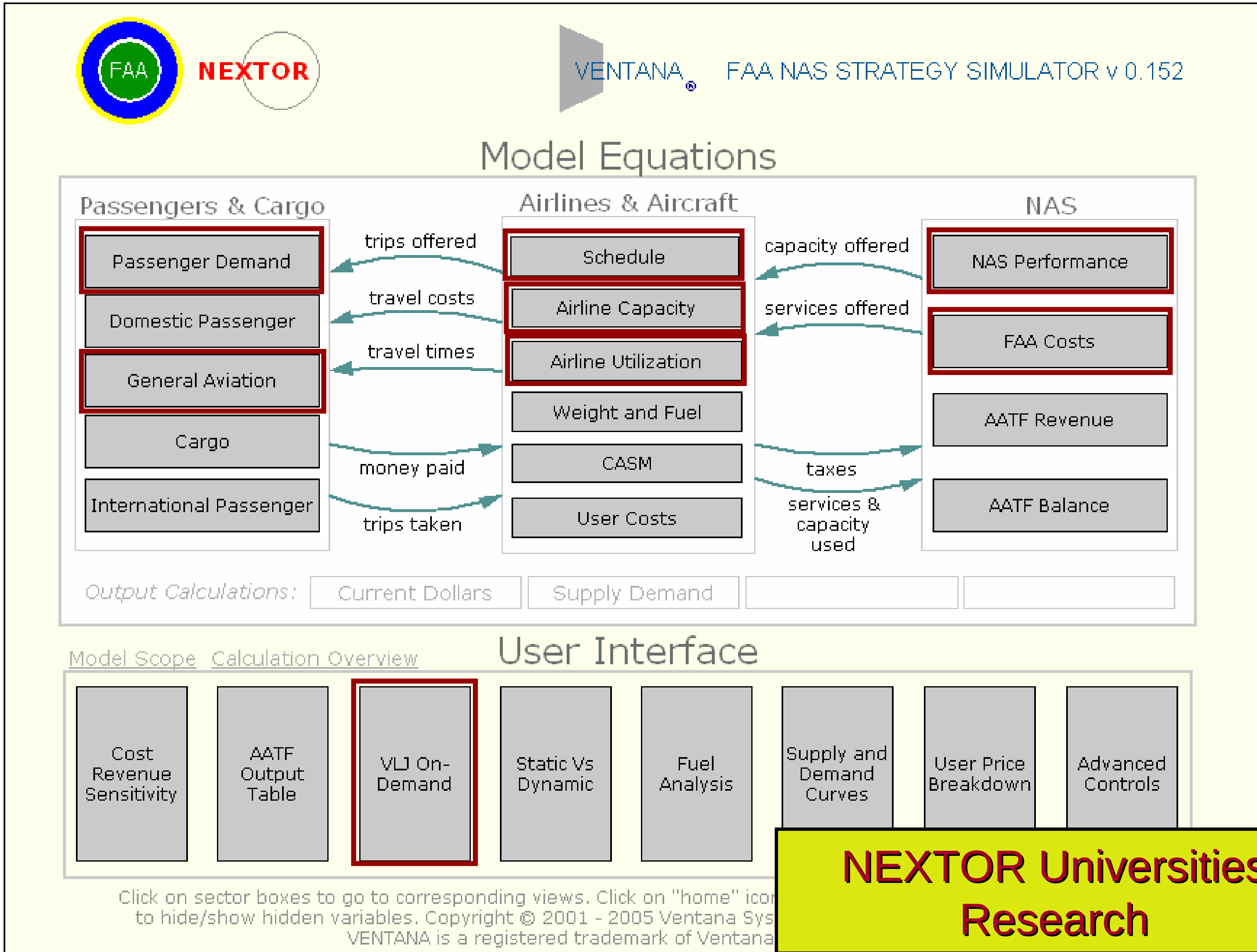
- Brief statements about the NAS Strategy Simulator
- Transportation Systems Analysis Model (TSAM)
- Connections to NAS Strategy Simulator
- Applications
  - Very light jet demand analysis
  - NGATS benefits
  - FAA taxes
- Conclusions

Brief Statements About the NAS Strategy Simulator (NSS)

NAS Strategy Simulator (NSS)

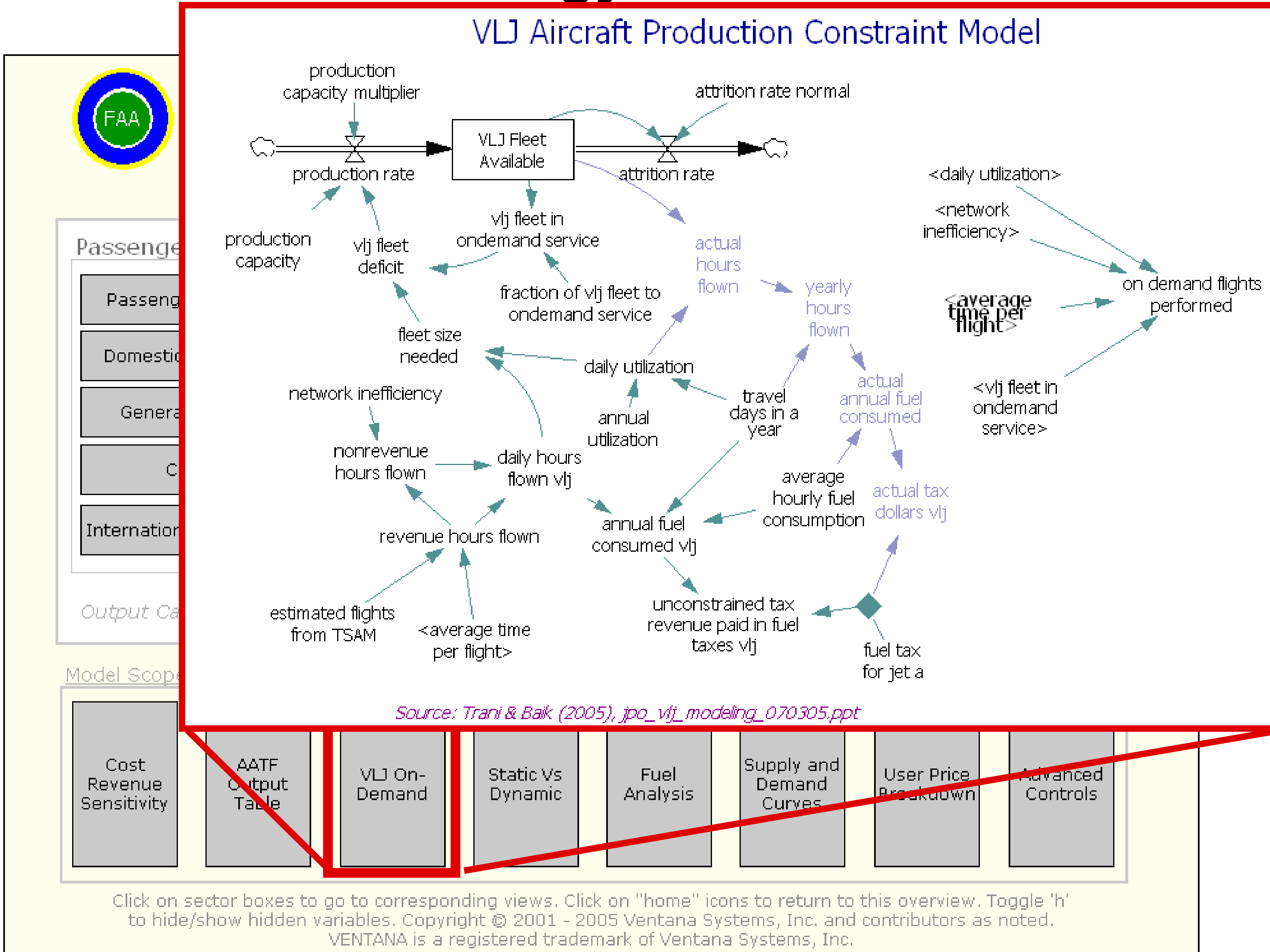
- A strategic decision tool to study the effects of macro-level policies
- Developed by FAA and Ventana
- NEXTOR universities have participated in the effort developing sub-models and providing background information to justify causal relationships
- NSS requires detailed analyses to understand cause-effect relationships

NAS Strategy Simulator



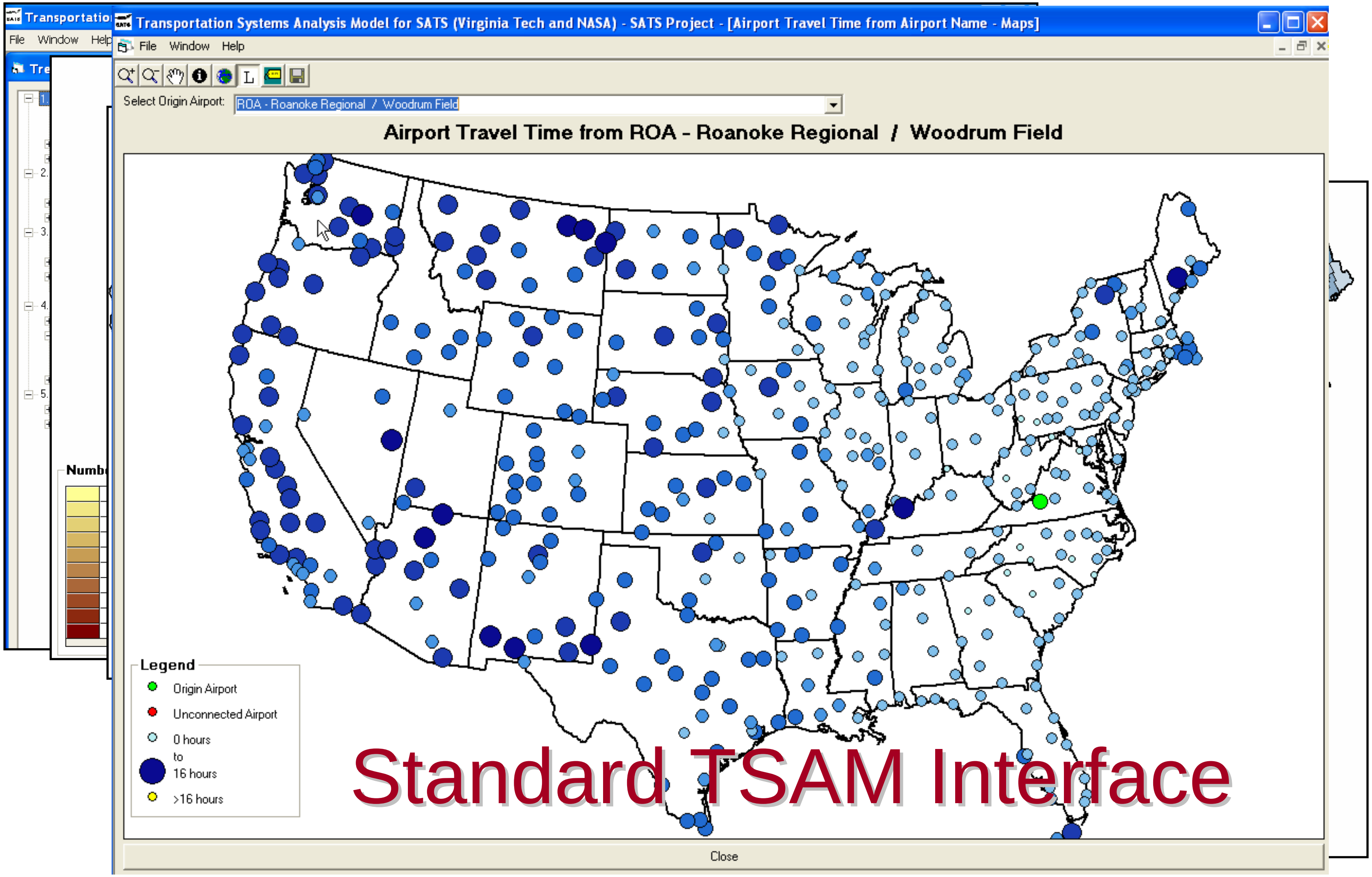
NEXTOR Universities Research

NAS Strategy Simulator



Transportation Systems Analysis Model (TSAM)

Transportation Systems Analysis Model (TSAM) Framework

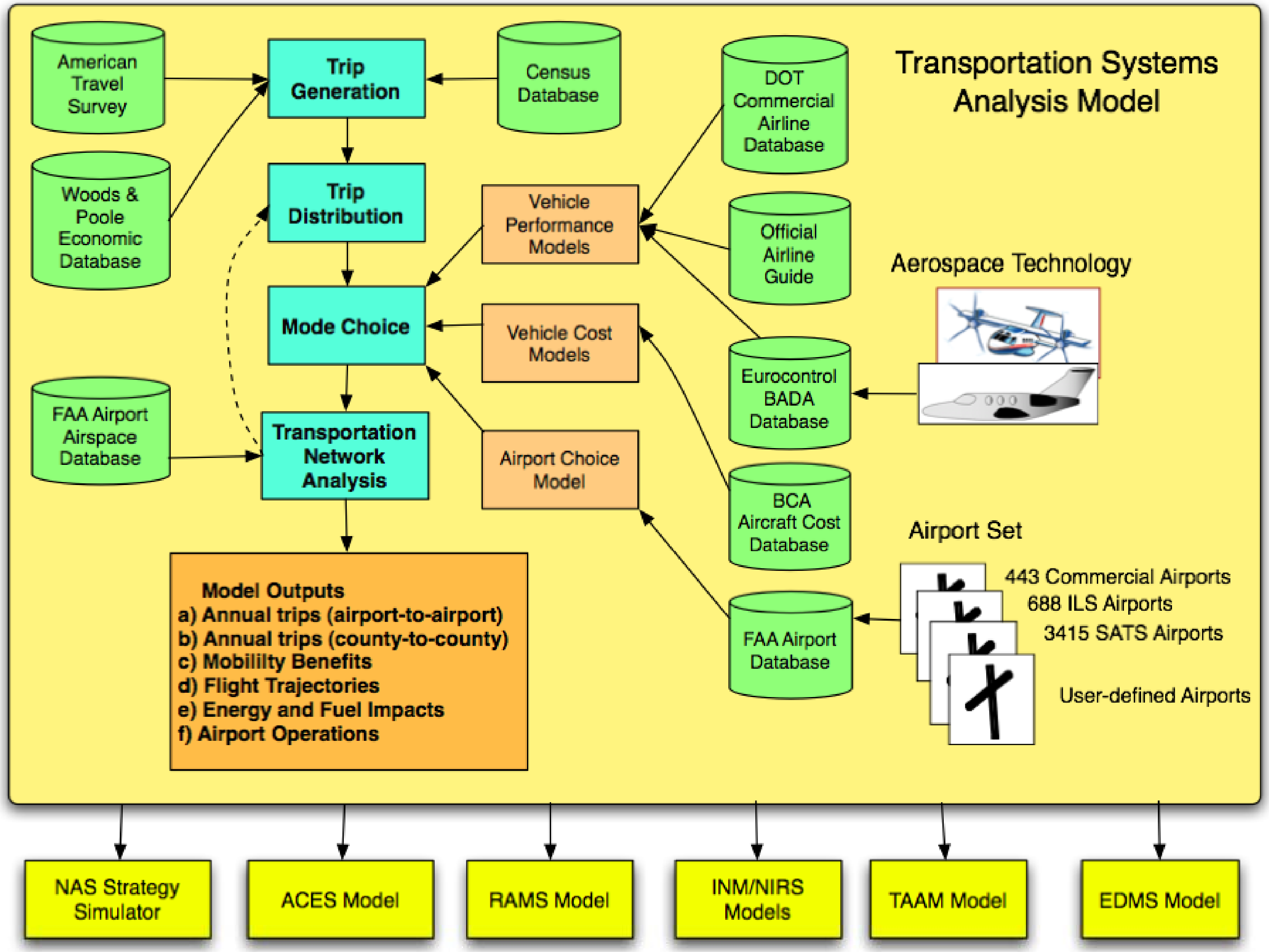


Standard TSAM Interface

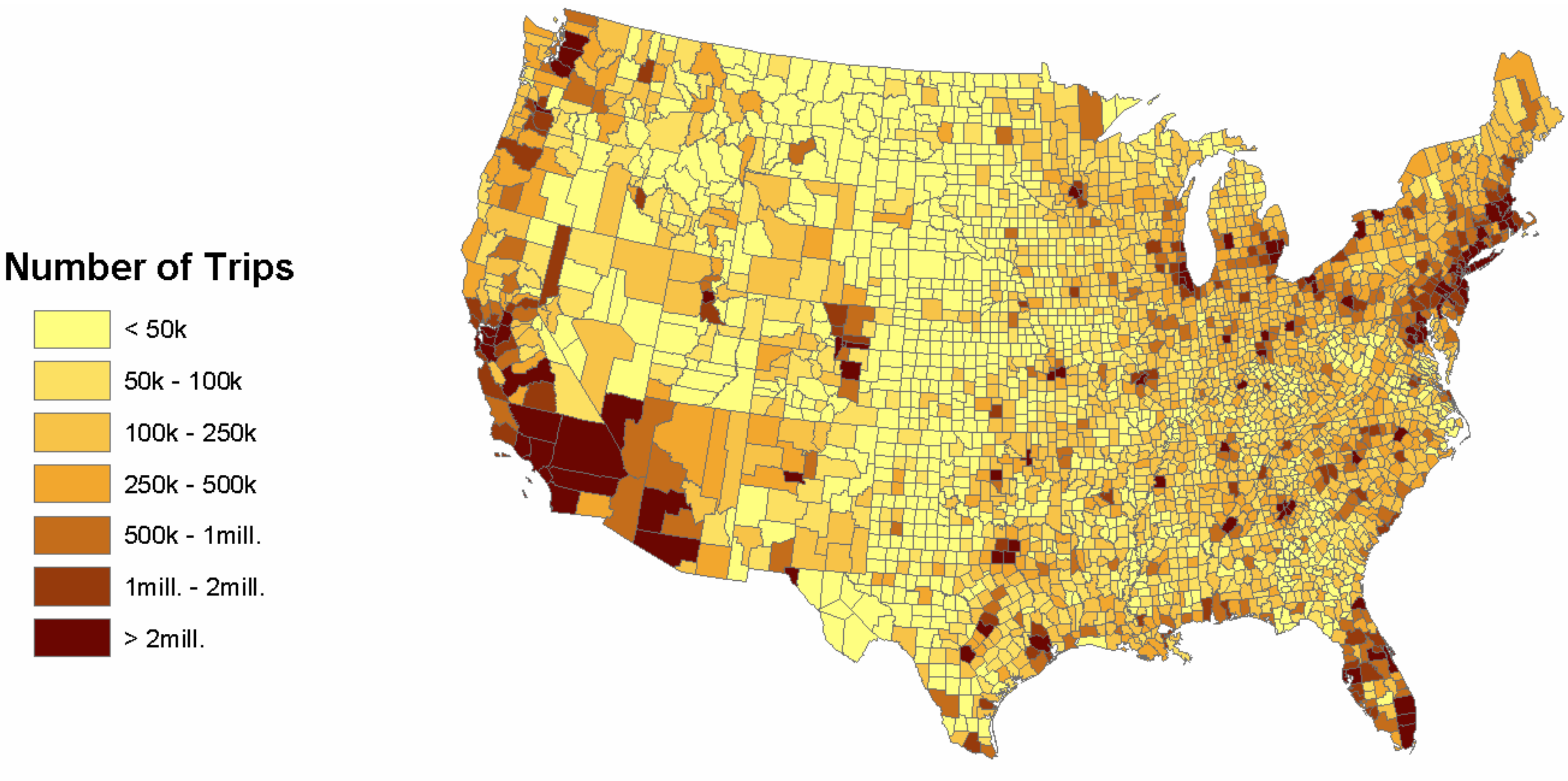
Background of the Model

- A strategic planning tool to predict **all** intercity transportation demand (**auto, airline, GA and SATS**) and national level impacts (county-to-county)
- Employs socio-economics and demographics of the country
- County-to-county spatial model (complements NSS)
- Multi-modal in scope (commercial air, auto, and new technologies). Predicts how people make choices and decisions for intercity travel
- Accepts any user-defined airport sets
- While TSAM was created the predict the impact of SATS, the framework predicts auto and airline trips as well
- Runs in a standard Windows XP system
- Use of GIS technology to present results (70+ screens)
- **Contact:** Mr. Stuart Cooke (NASA), TSAA Technical Lead (757-864-7087 at NASA Langley Research Center) or Jeff Viken, NASA Systems Analysis Branch (757-864-2875)

Transportation Systems Analysis Model (TSAM)

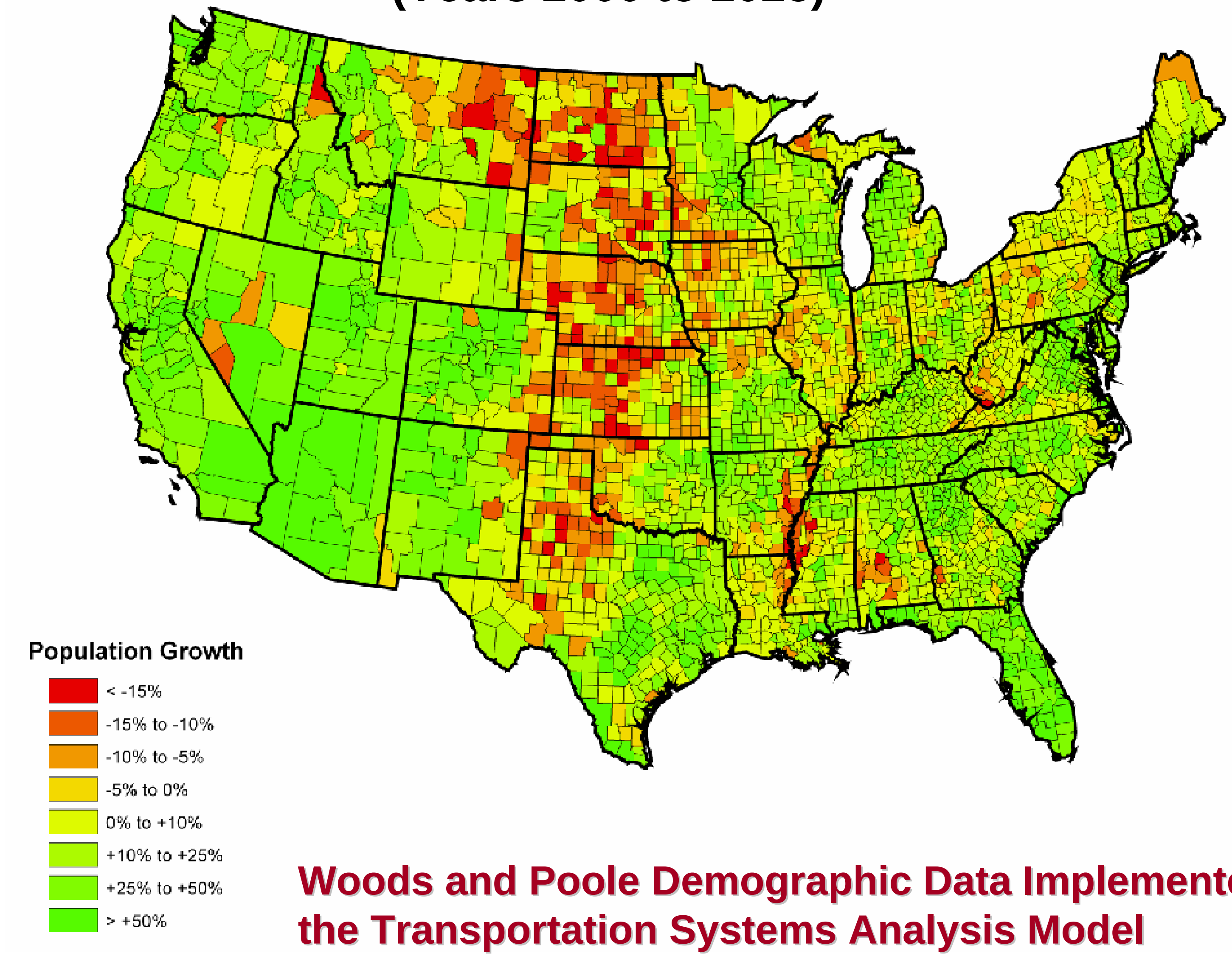


Trip Generation



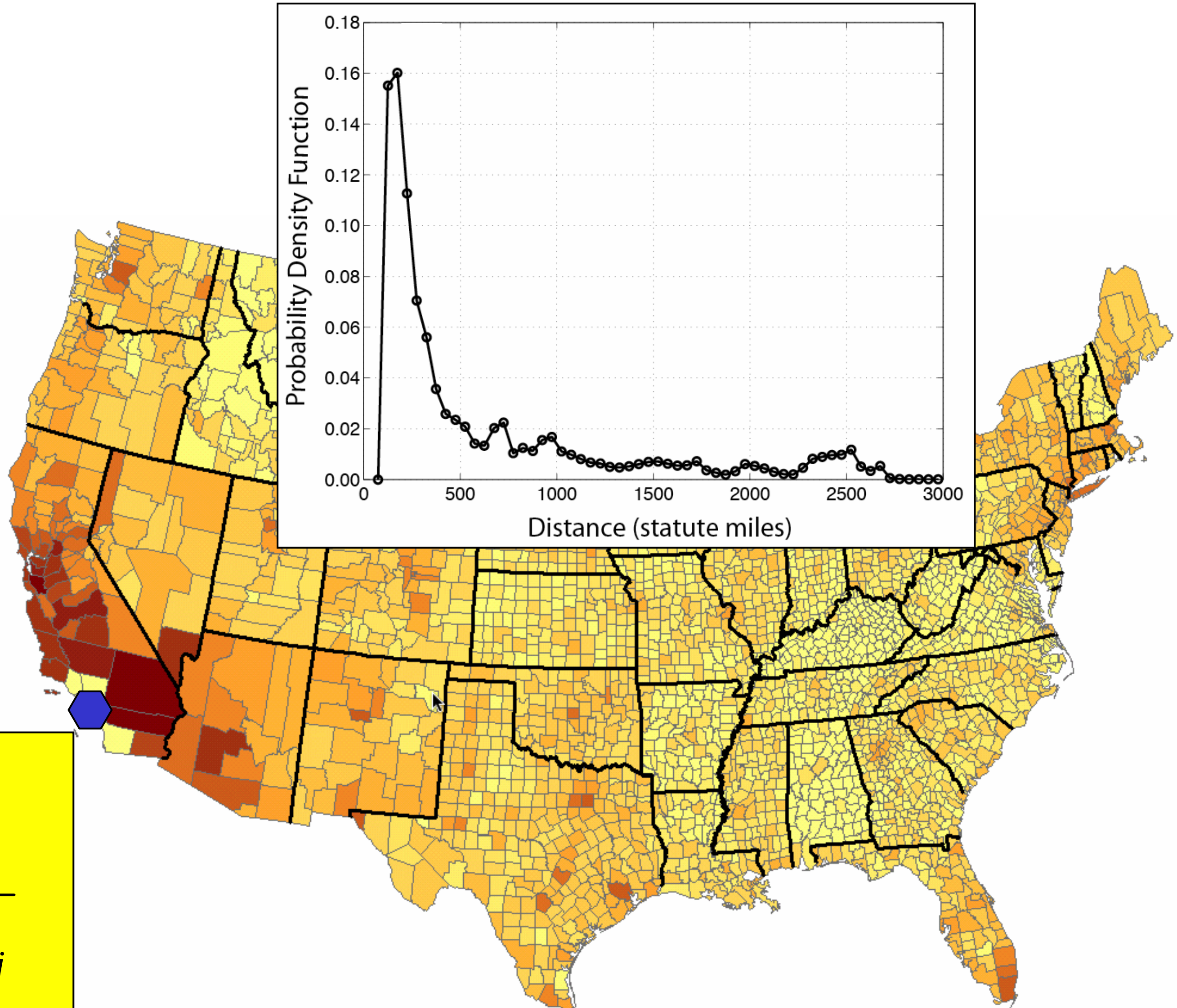
Total Intercity Trips Generated by County (Business + Non-Business Trips)

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



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

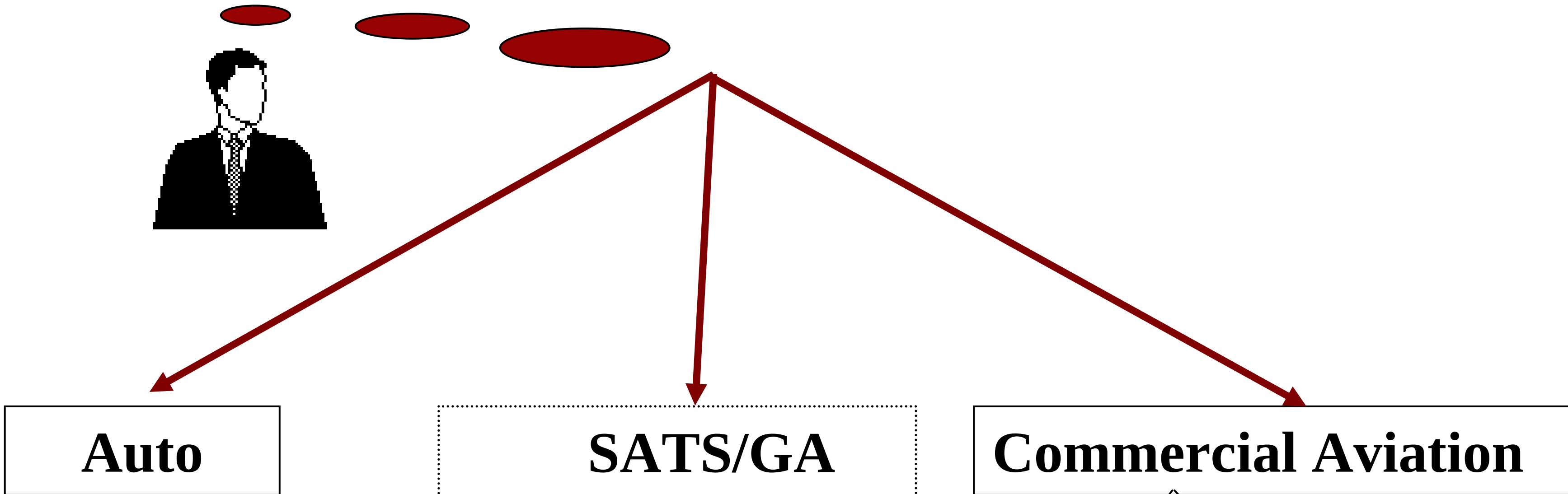
Distribution of Trips (LA County to all)



Gravity Model

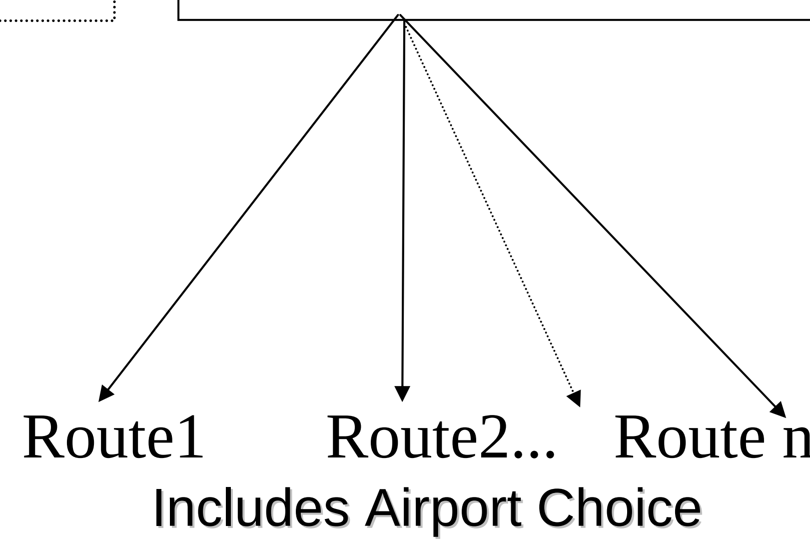
$$T_{ij} = \frac{P_i A_j F_{ij} K_{ij}}{\sum_j A_j F_{ij} K_{ij}}$$

Mode Split Analysis



Factors considered in mode split:

- **Travel time**
- **Travel cost**
- **Value of time**
- **Route convenience**
- **Trip type**
- **Mode reliability**

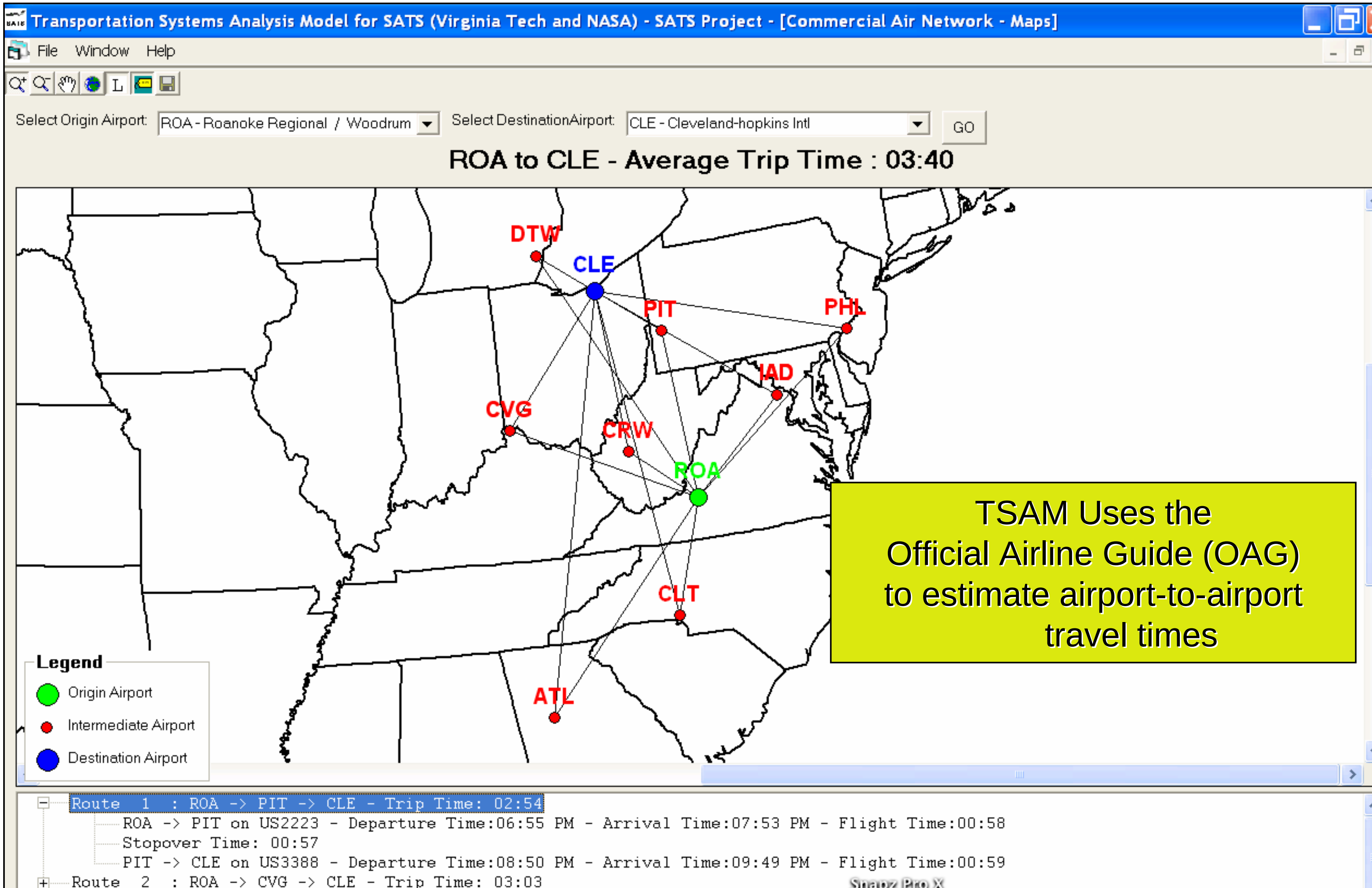


TSAM employs a Nested Multinomial Logit Model

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

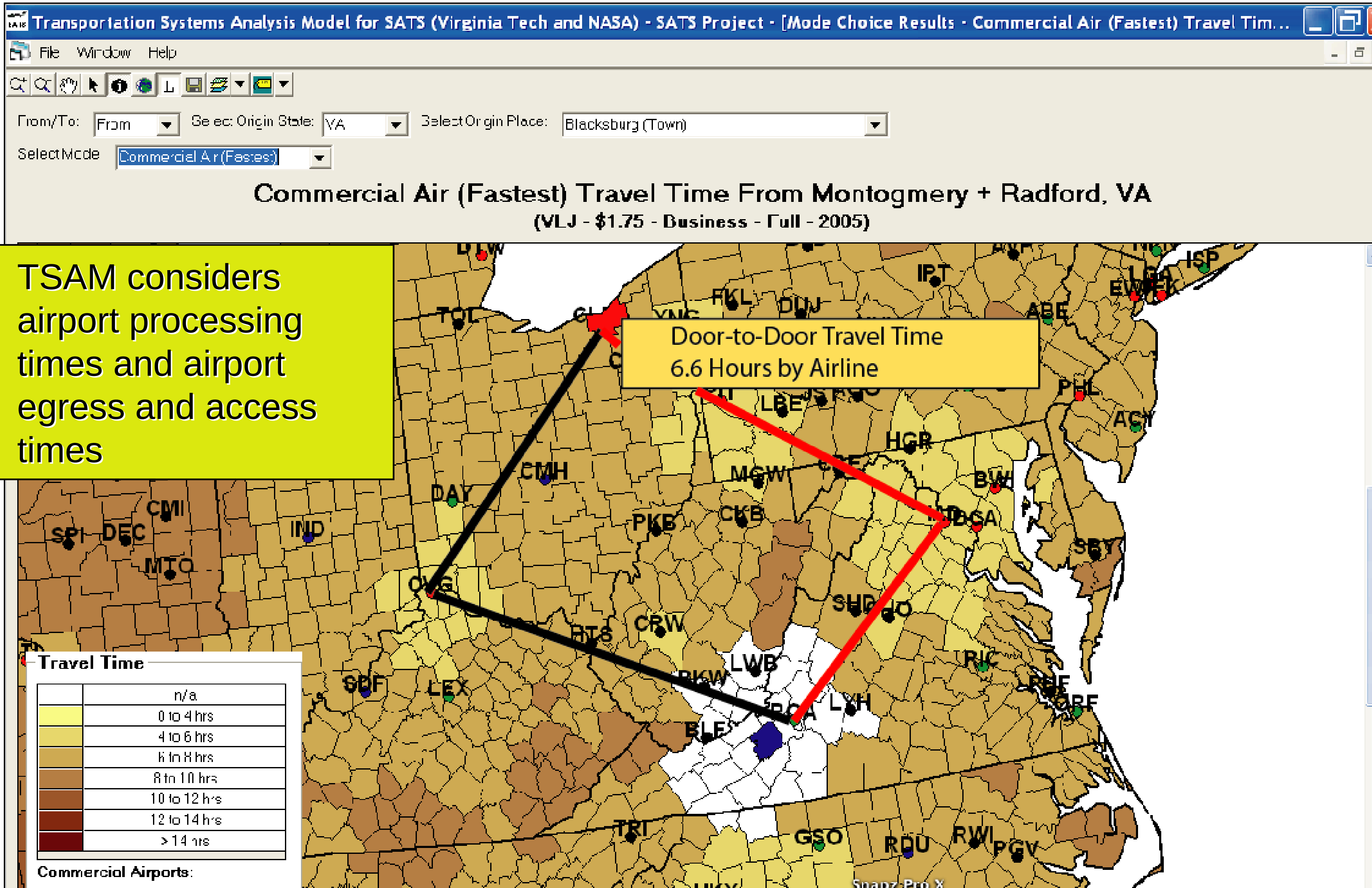
- Suppose three possible travel alternatives are:
  - Auto
  - Commercial Air
  - On-demand service using VLJ aircraft (future NAS)
- To make a mode selection a user might consider:
  - Travel time
  - Travel cost (including lodging and rentals)
  - Duration of stay
  - Value of time

Multi-route Mode Choice Model



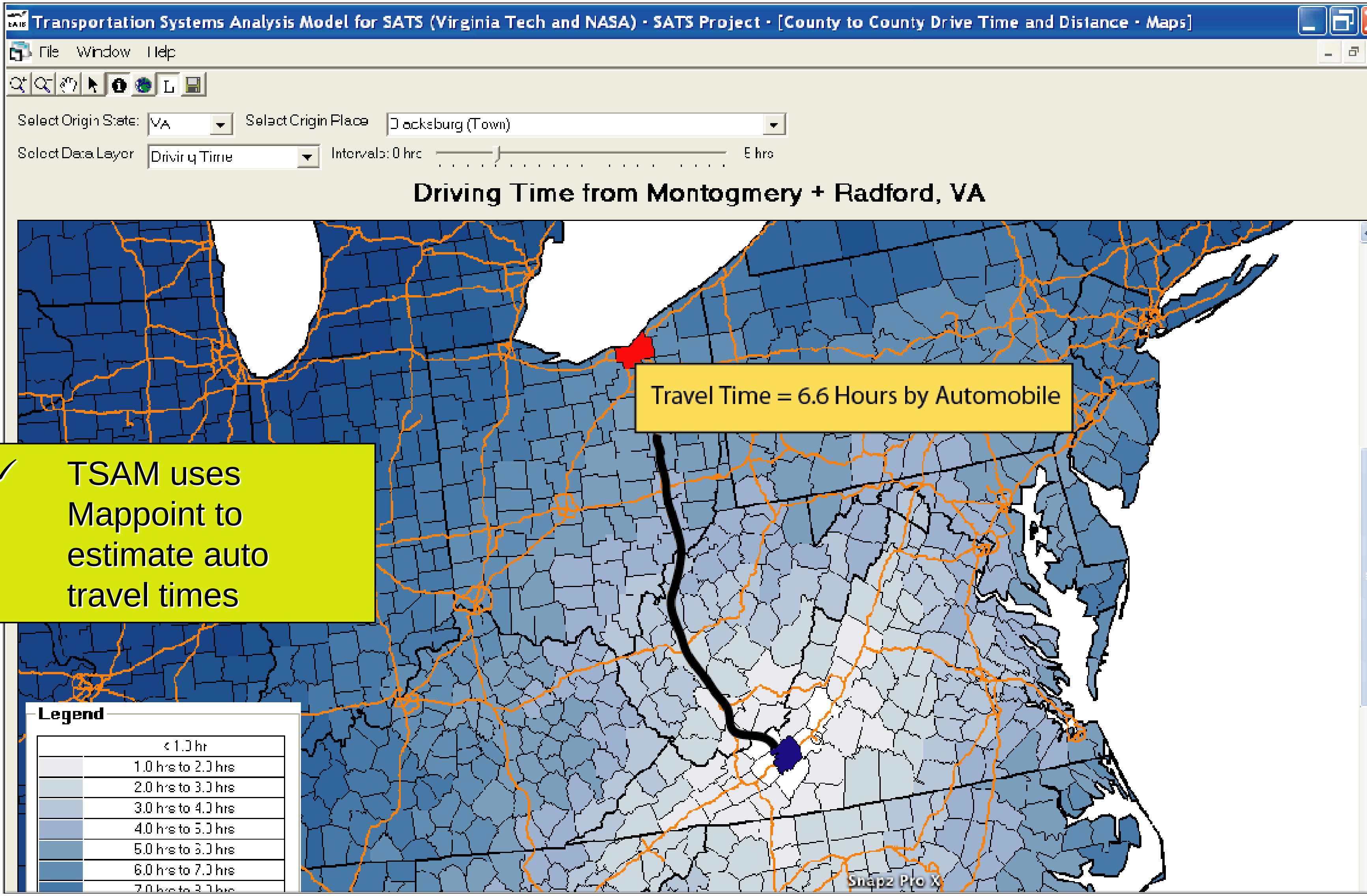
TSAM Uses the
Official Airline Guide (OAG)
to estimate airport-to-airport
travel times

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



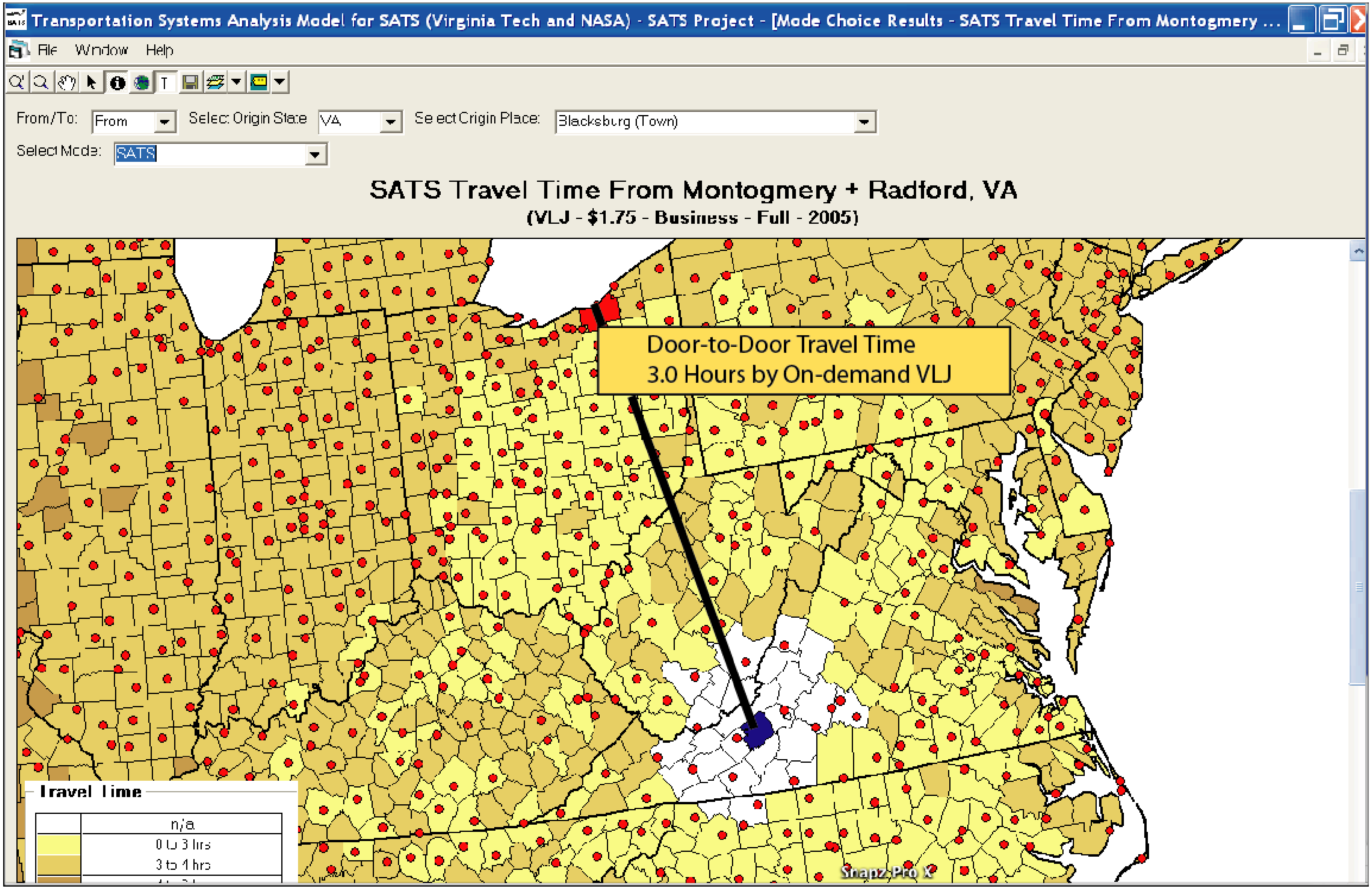
- ✓ TSAM considers airport processing times and airport egress and access times

Multi-mode Choice Model (Auto)



- ✓ TSAM uses Mappoint to estimate auto travel times

Multi-mode Choice Model (SATS)



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

Commercial Air Trip Details

	Origin Airport	Destination Airport	Travel Time (Outbound)	Travel Time (Return)	Travel Cost (Roundtrip)	Average Travel Speed	Cost for Speed	Nights Away
Route 1	ROA, Roanoke, VA	CLE, Cleveland, OH	6 hrs 37 min	6 hrs 36 min	$526	59 mph	$7.39/mph	1
Route 2	ROA, Roanoke, VA	CAK, Akron, OH	6 hrs 50 min	7 hrs 15 min	$528	57 mph	$7.65/mph	1
Route 3	CLT, Charlotte, NC	CLE, Cleveland, OH	7 hrs 38 min	7 hrs 12 min	$638	51 mph	$10.71/mph	1

Market Share Details*

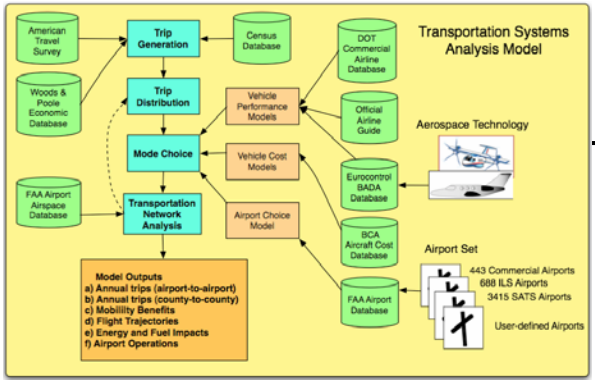
Household Income Group	<$30K	$30K - $60K	$60K - $100K	$100K - $150K	>$150K
Auto	82 %	76 %	64 %	53 %	51 %
Airline	18 %	24 %	30 %	32 %	31 %
SATS	0 %	0 %	5 %	16 %	18 %

*Numbers rounded to nearest percent.

Print Results

Close

Converting Trips to Flights (On-demand VLJ)

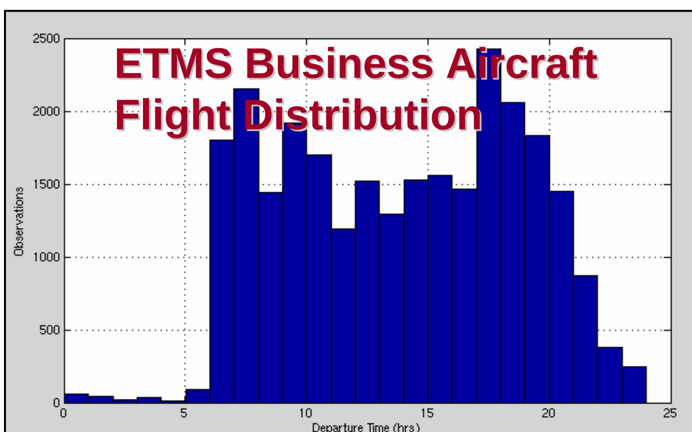


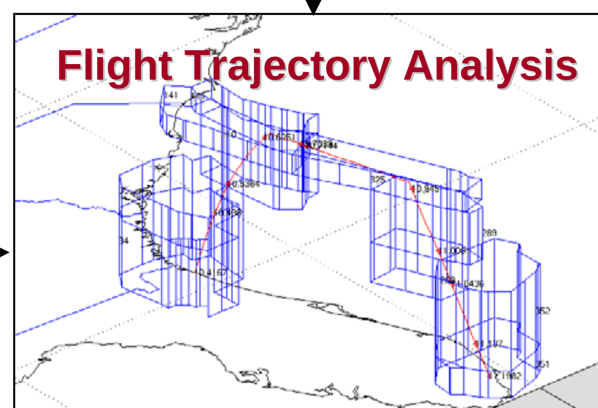
TSAM Model

Annual
Person Trips
By mode
(Airport-Airport)
(County-County)

Seasonal Travel
Effects (ATS)

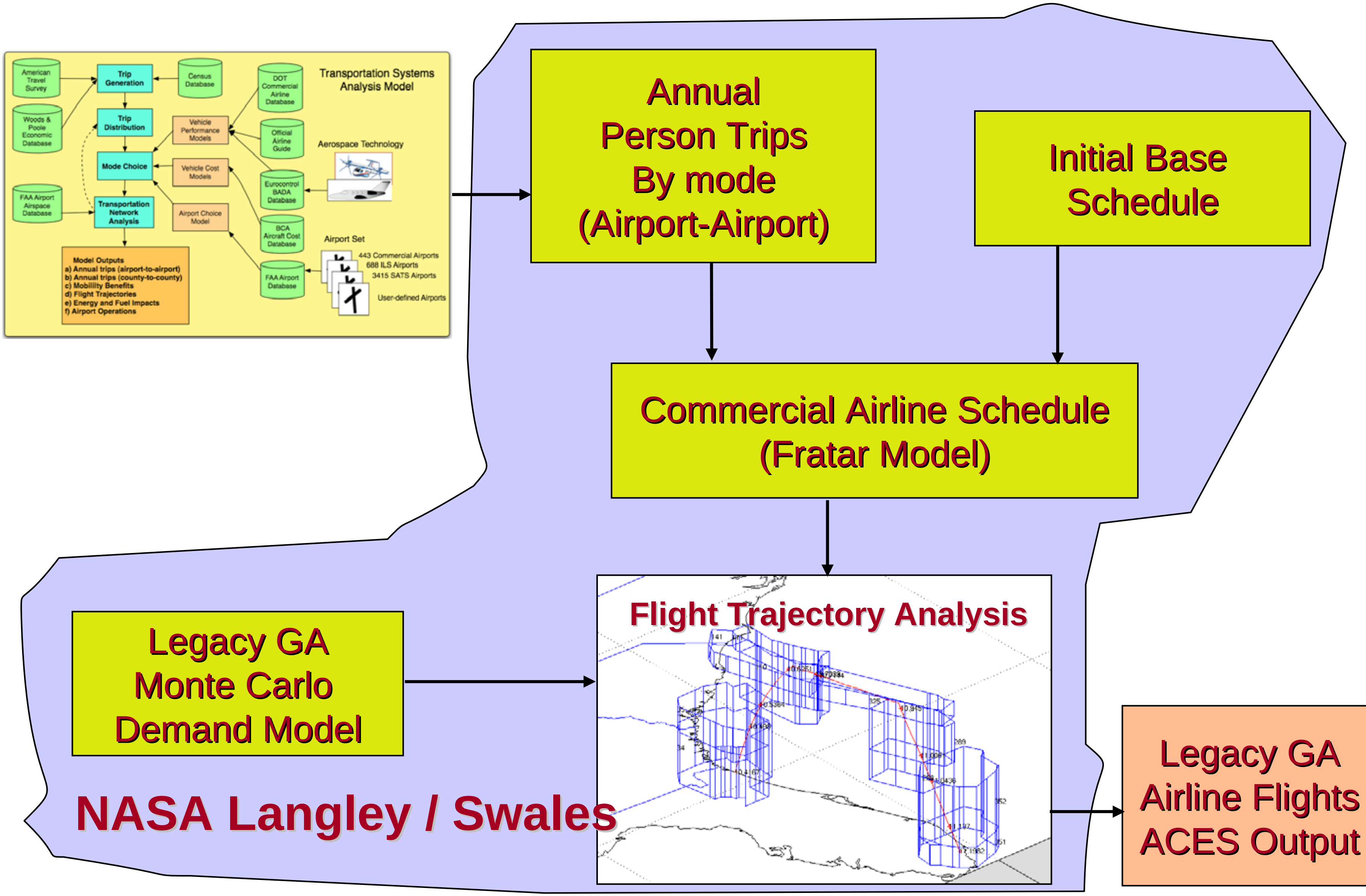
Daily Trip Analysis
(Hourly Passenger Demand)





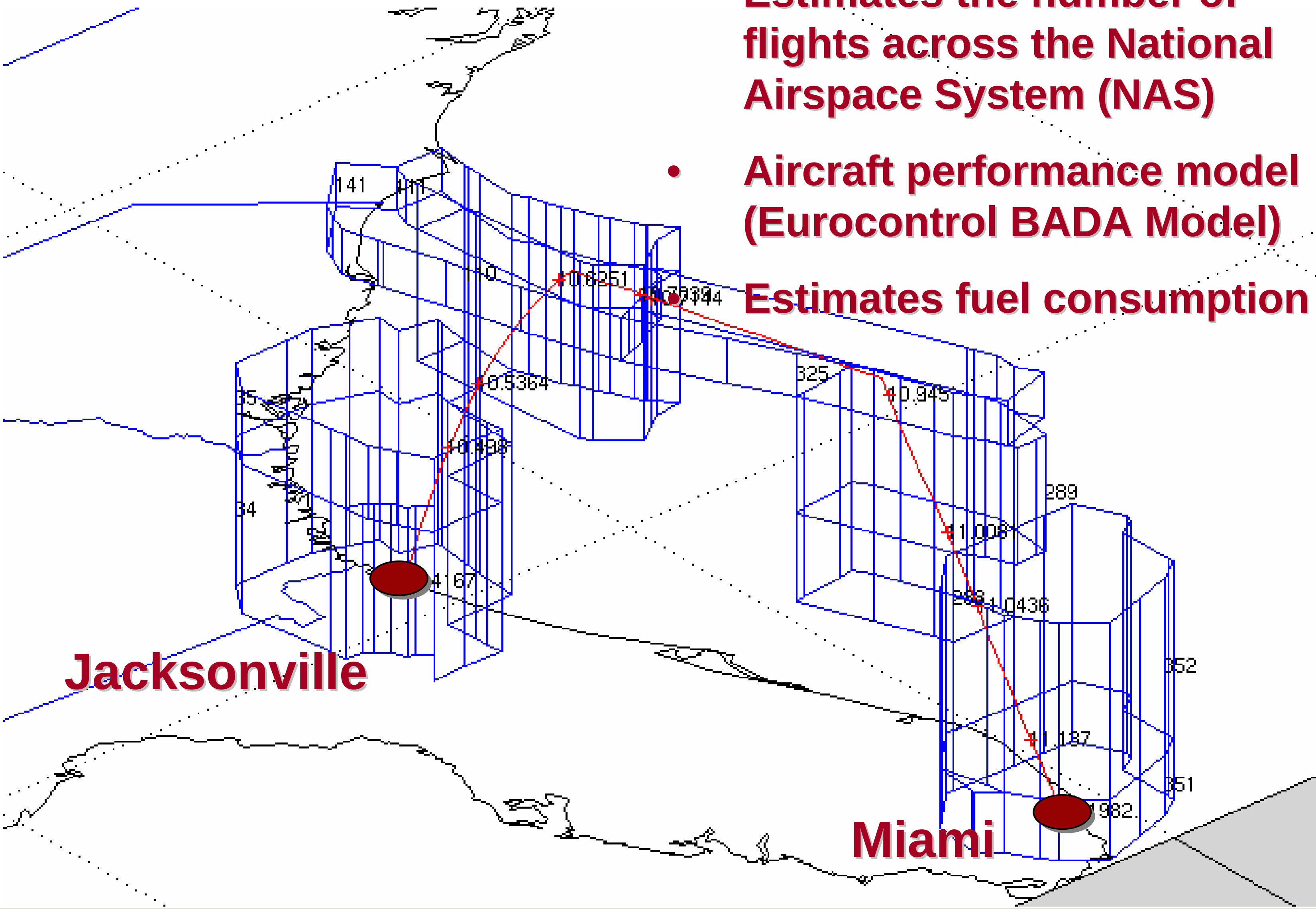
On-demand VLJ
ACES Output

Airline Flights and Legacy GA



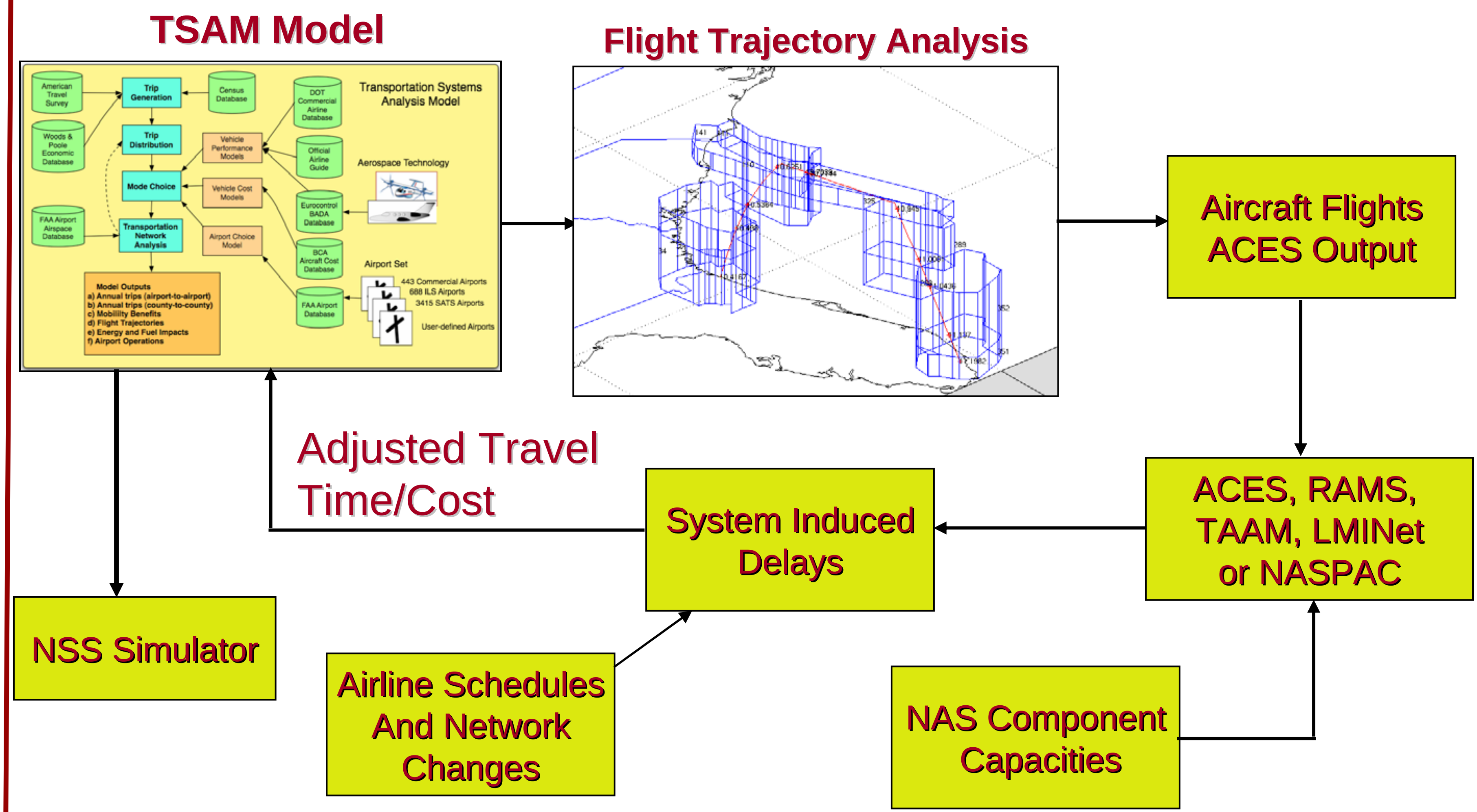
Traffic Assignment (Sample Flight)

- Estimates the number of flights across the National Airspace System (NAS)
- Aircraft performance model (Eurocontrol BADA Model)
- Estimates fuel consumption

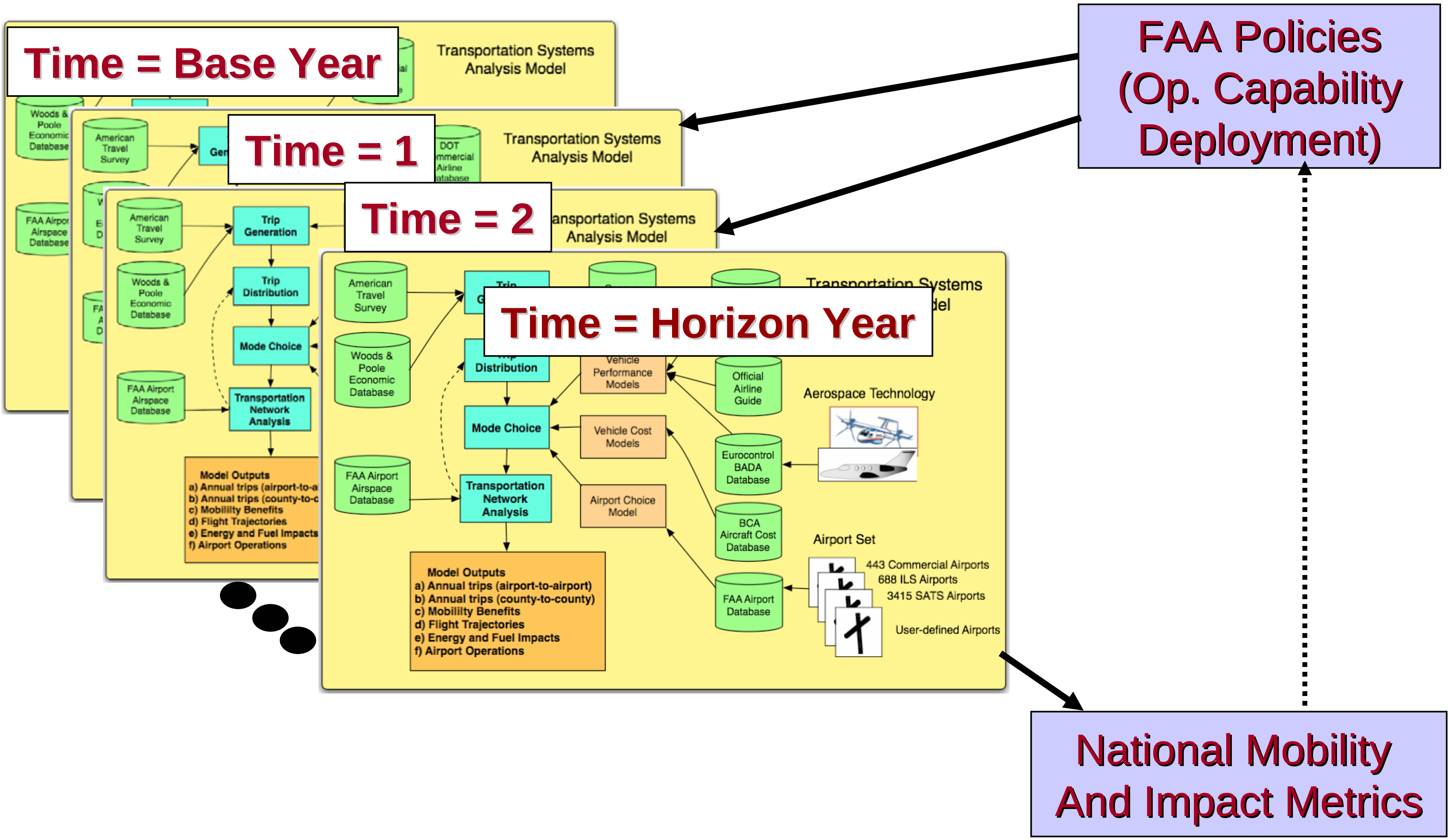


Closing the TSAM Loop with Airspace/Delay Models

TSAM can measure directly the effect of system delays in the demand for air transportation



TSAM Implementation Scheme



Transportation Systems Analysis Model (TSAM) Demand

- TSAM can make future projections (to 2030) for the following:
  - Commercial airline demand and operations
  - Legacy General Aviation operations
  - SATS / VLJ / Air-Taxi both demand and operations (Emergent travel mode)
  - International Commercial Airline demand and operations

Applications

Impact of VLJ Operations in the NAS

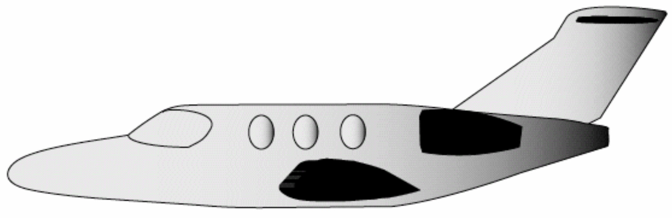
Very Lights Jets

- 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

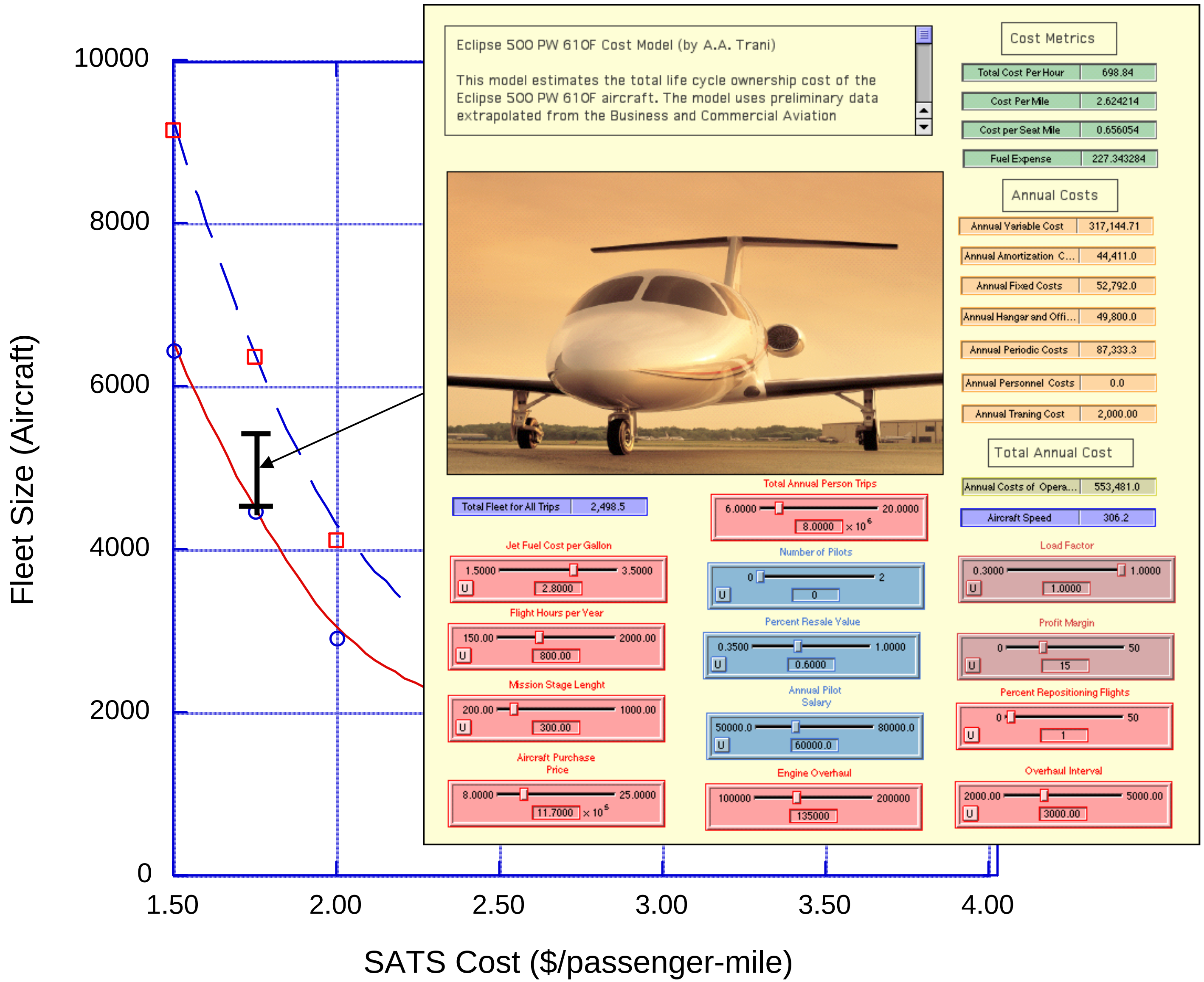
Cessna Mustang

Typical Very Light Jet Vehicle Modeled



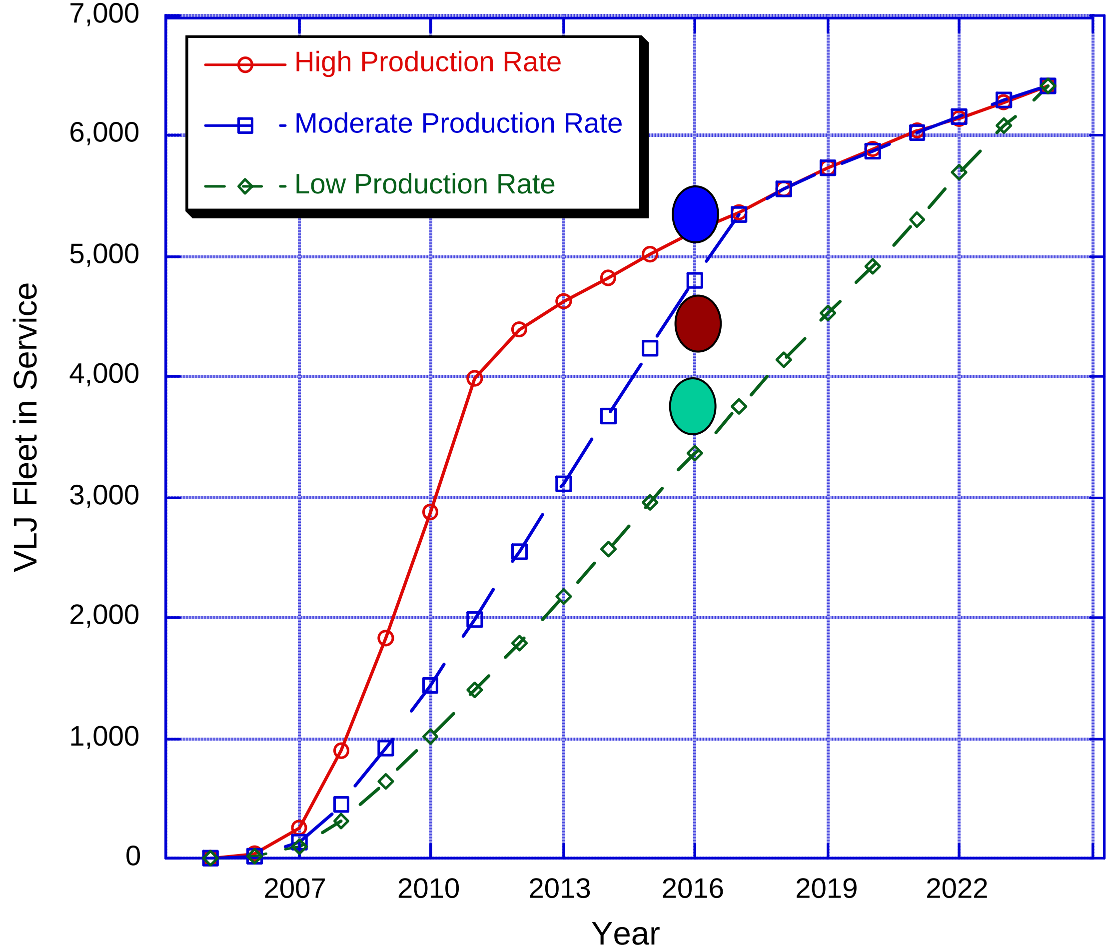
- Pressurized aircraft
- All weather vehicle
- Four revenue seats
- 365 mph cruise speed
- Certified to fly into known icing conditions
- 700 nm practical with 2 passengers (4 seats total + pilots)
- Cost per passenger-mile ($1.75 nominal based on life-cycle cost analysis)
- 1.2 million dollars (cost)
- 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**

On-demand VLJ Fleet Size vs. Cost for Service



VLJ Aircraft Fleet Size Projections (with Capacity Constraints)

- FAA 2005 Forecast
- Honeywell Forecast
- Embraer Forecast

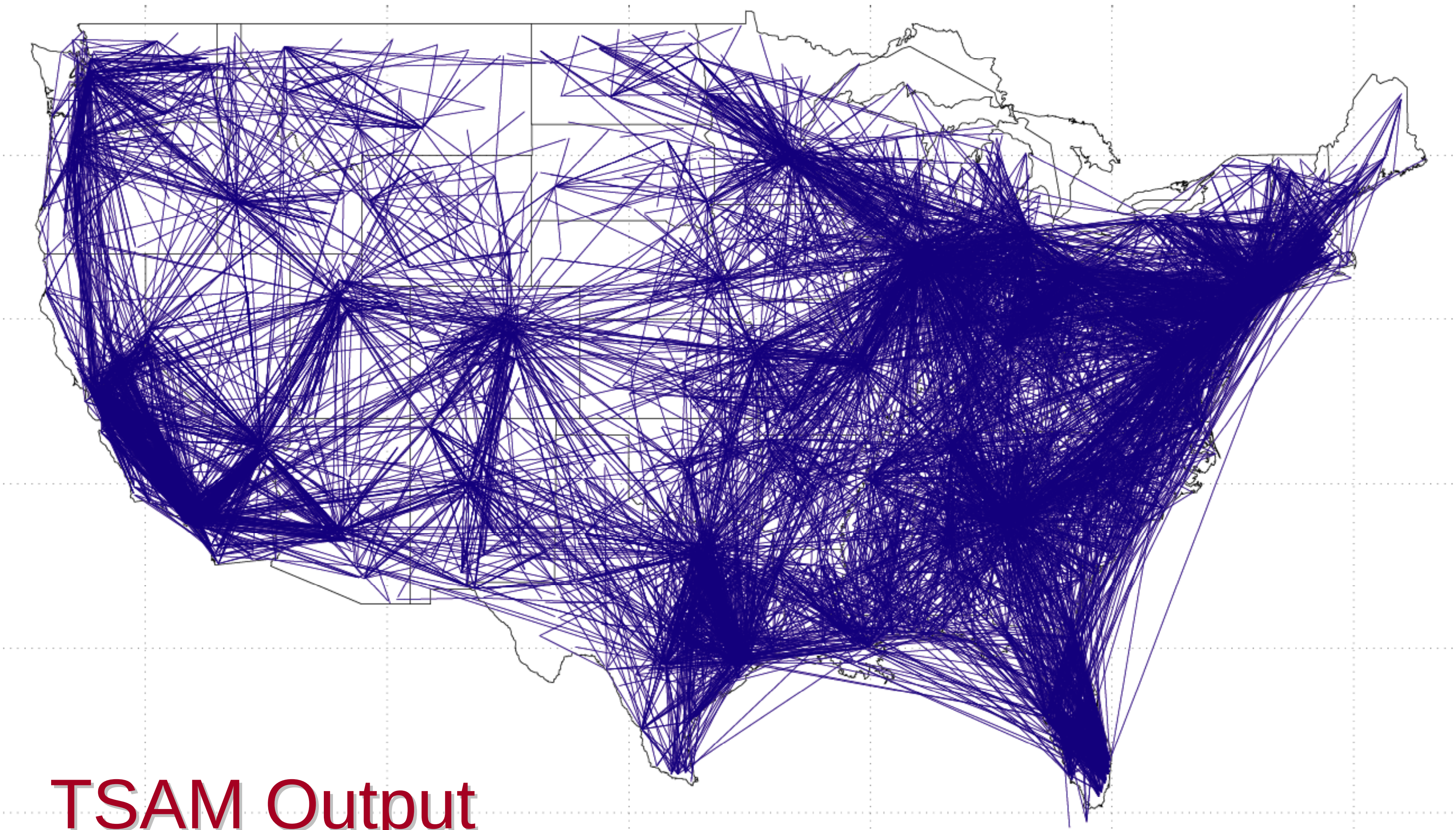


- Assumes a fixed demographic and socio-economic (WP 2004)

Interpretation

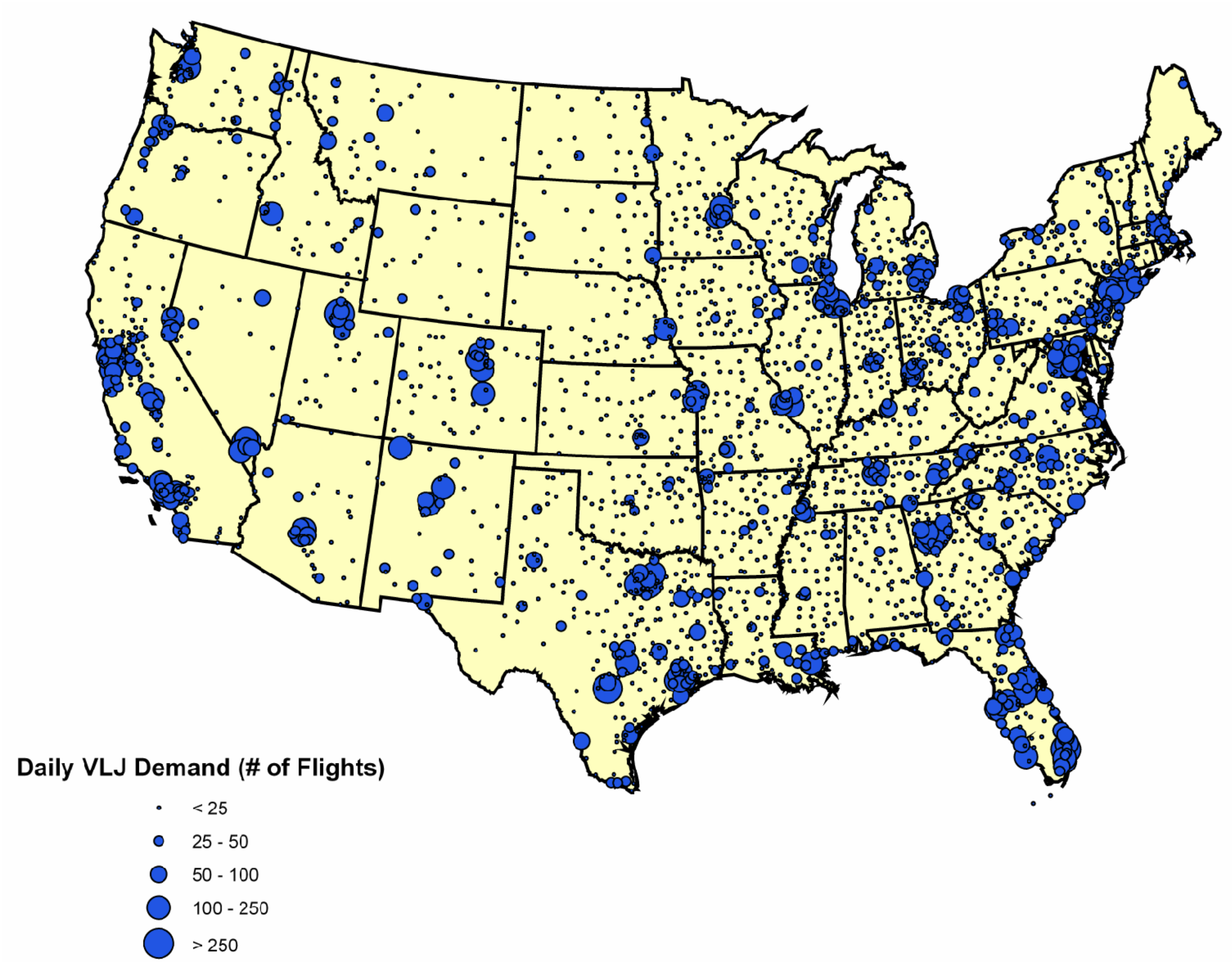
- In 2015 there could be 4,200- 5,000 VLJ aircraft flying in the NAS

Spatial Distribution of SATS (VLJ) Operations (2014)



TSAM Output

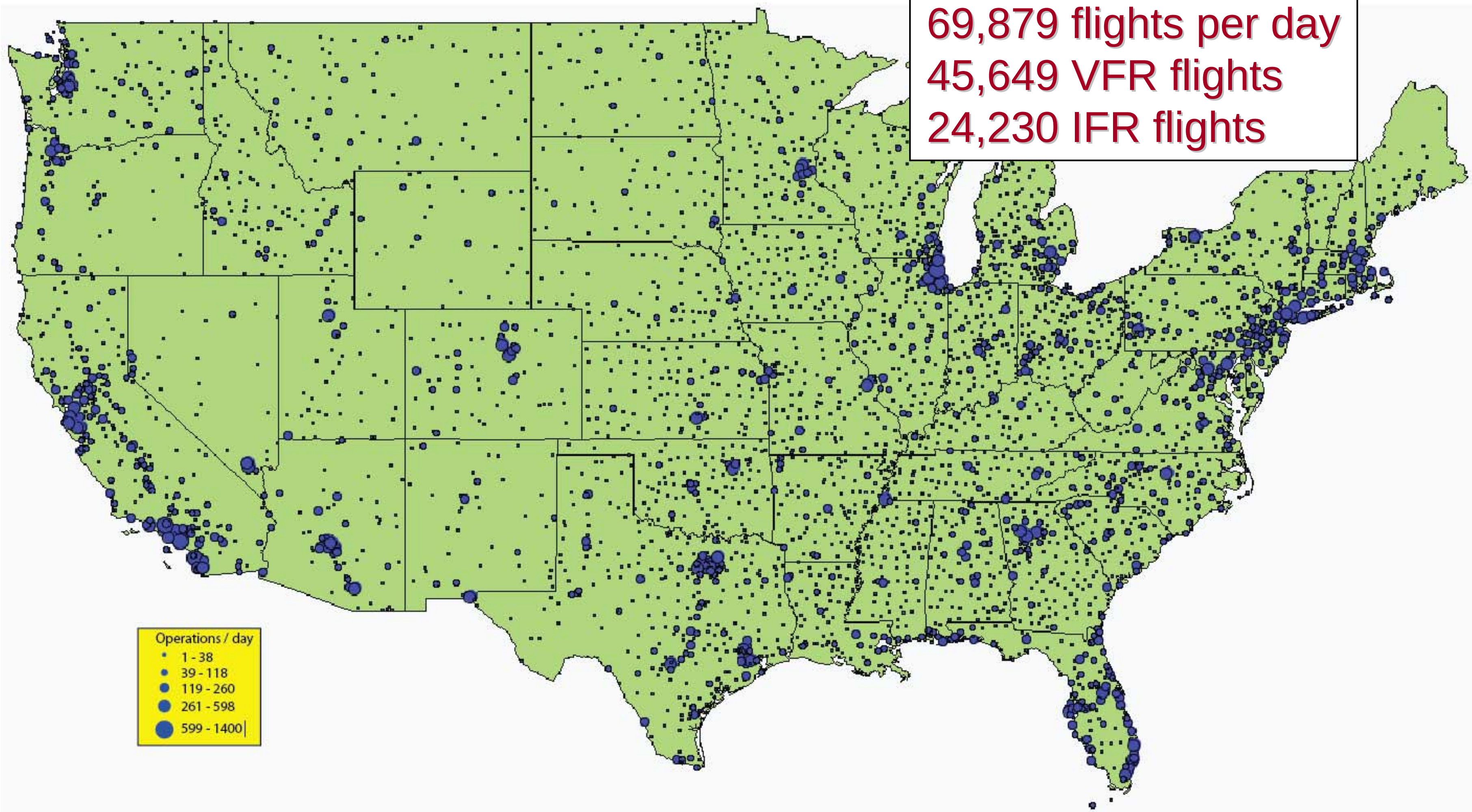
VLJ Traffic in 2025 with OEP Airports



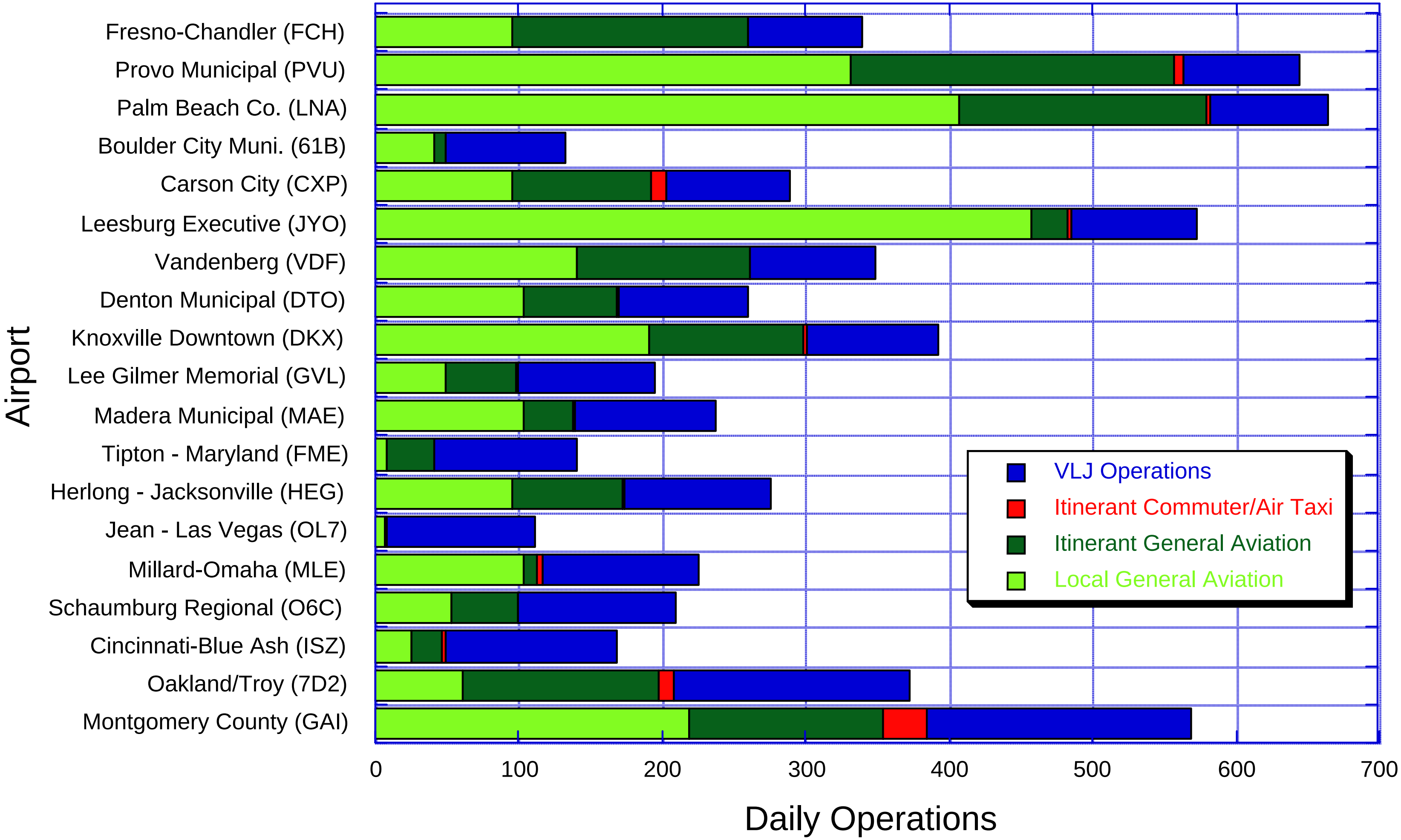
Legacy GA Operations
(Swales GA Analysis Module)

Year 2015 Analysis (VFR + IFR Traffic)

69,879 flights per day
45,649 VFR flights
24,230 IFR flights



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

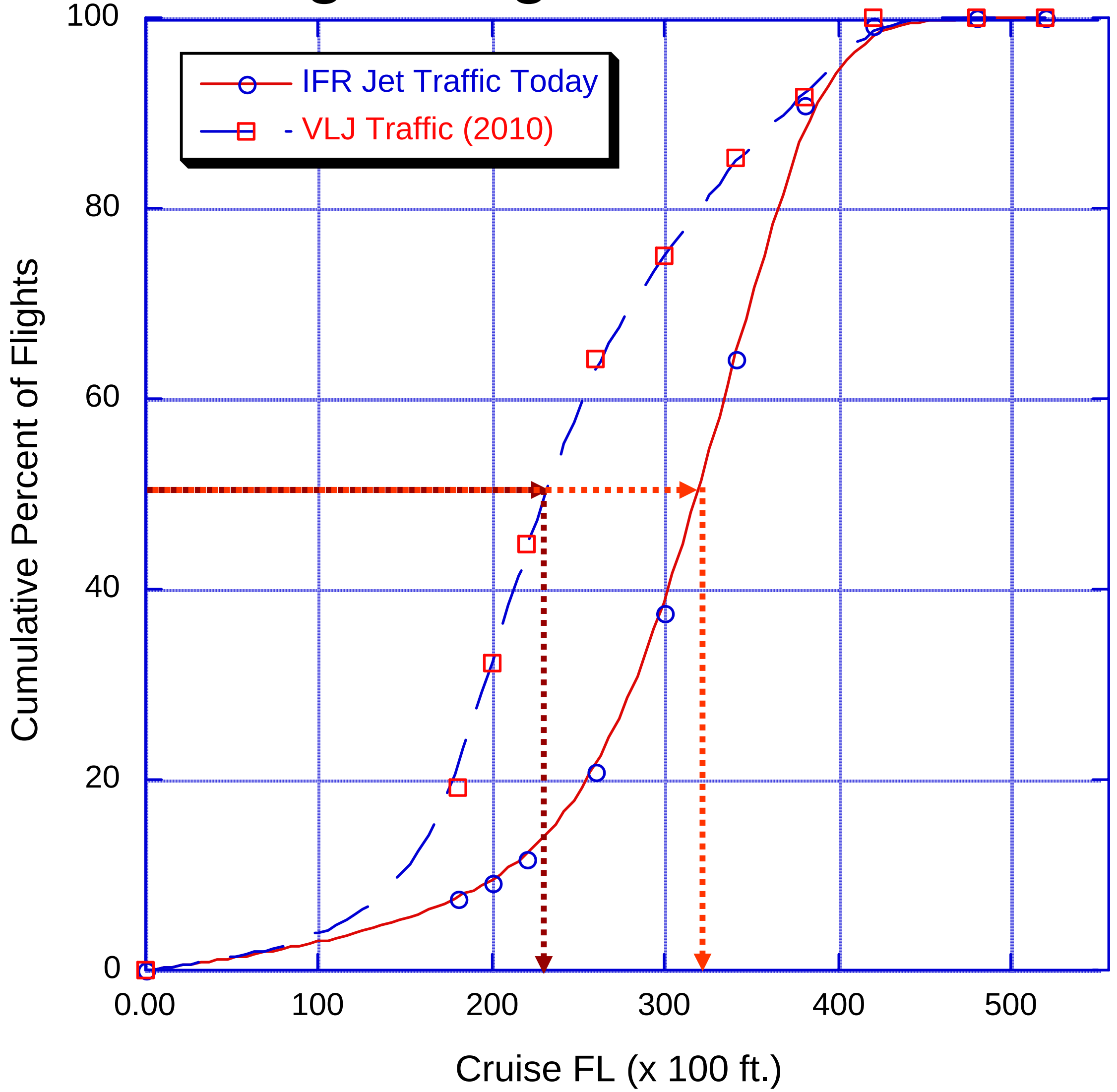


VLJ Traffic Will Fly Below Regular Airline Traffic due to Shorter Stage Lengths

Average Cruise VLJ Flight Level = 230*

Average Cruise FL Cessna CitationJet I = 240**

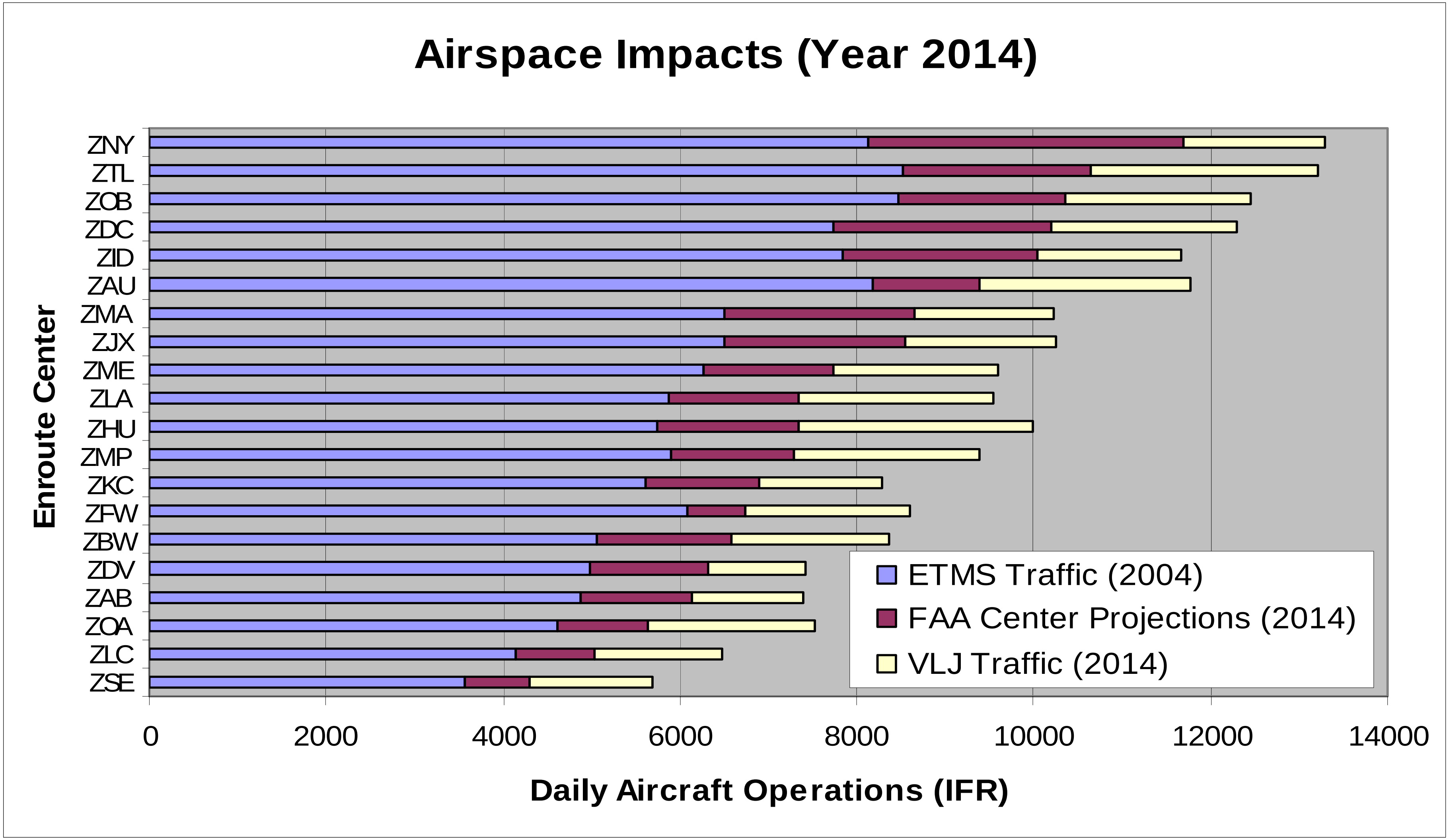
Average Jet Cruise Flight Level = 320**



*** TSAM Analysis**

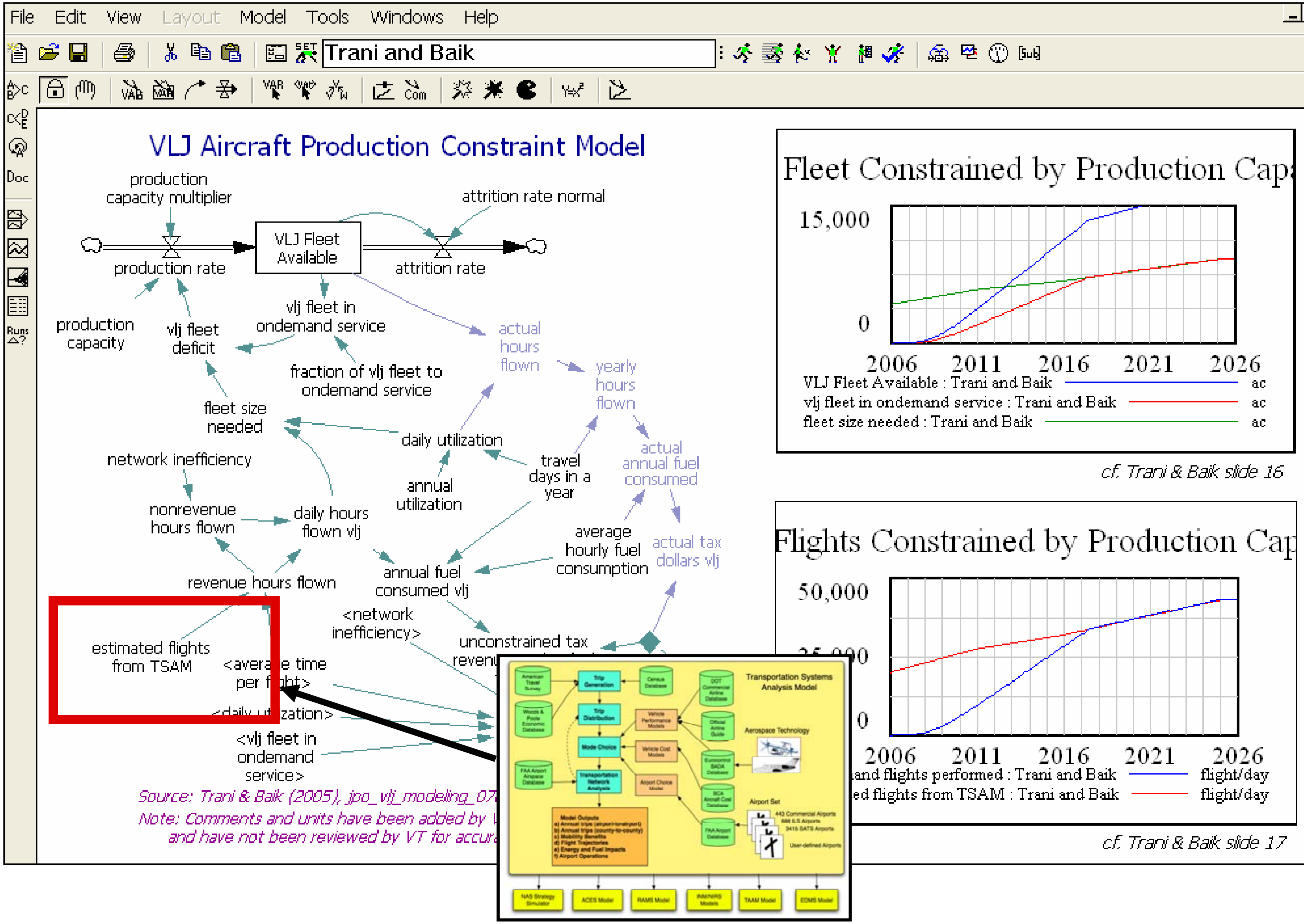
**** FAA ETMS Data**

2014 VLJ Air-Taxi NAS Impacts

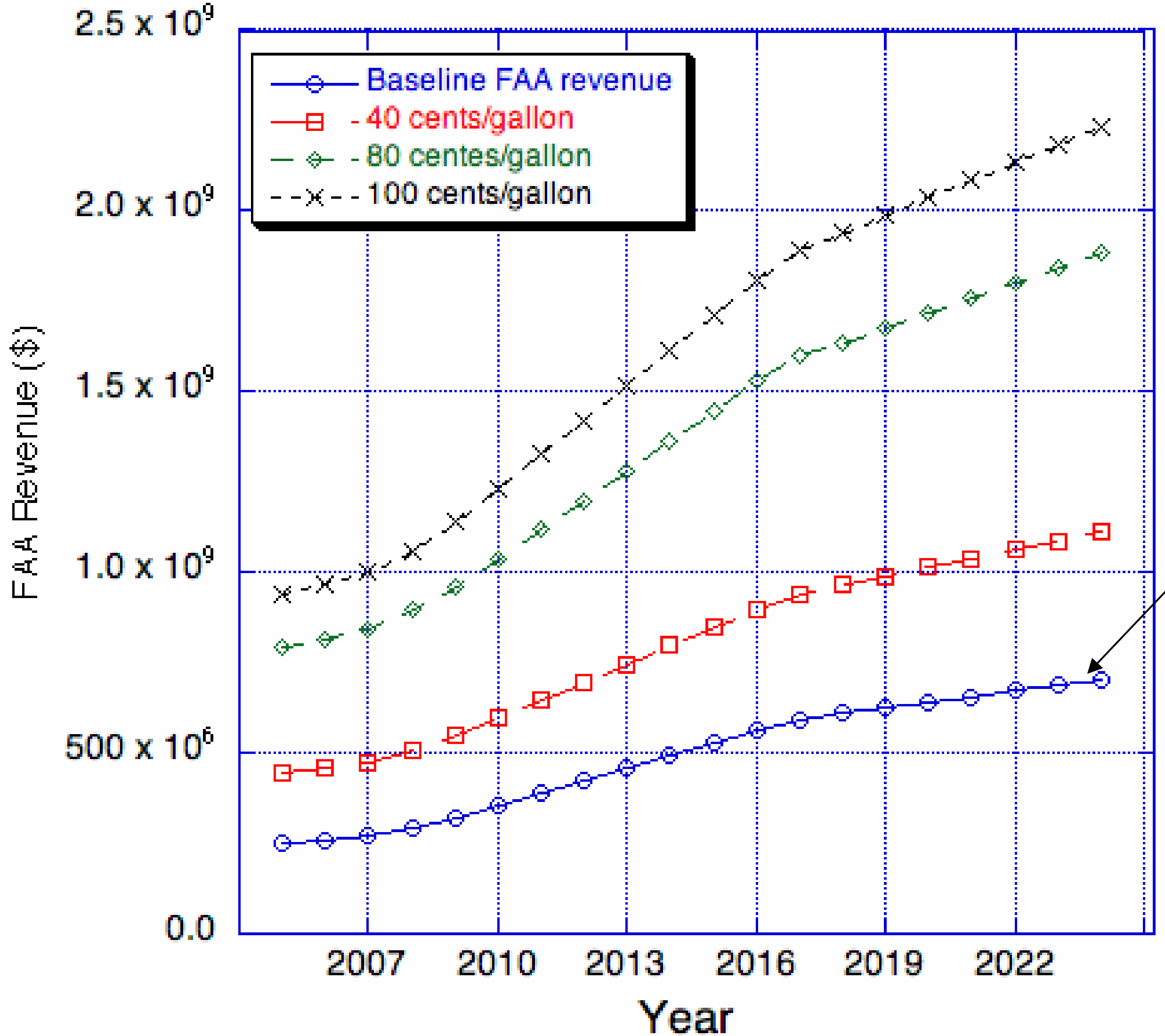


Connections Between TSAM and NSS Strategy Simulator

Implementation into Vensim by Ventana



Predicted FAA Revenue for Various GA Fuel Tax Schemes



VLJ traffic is included

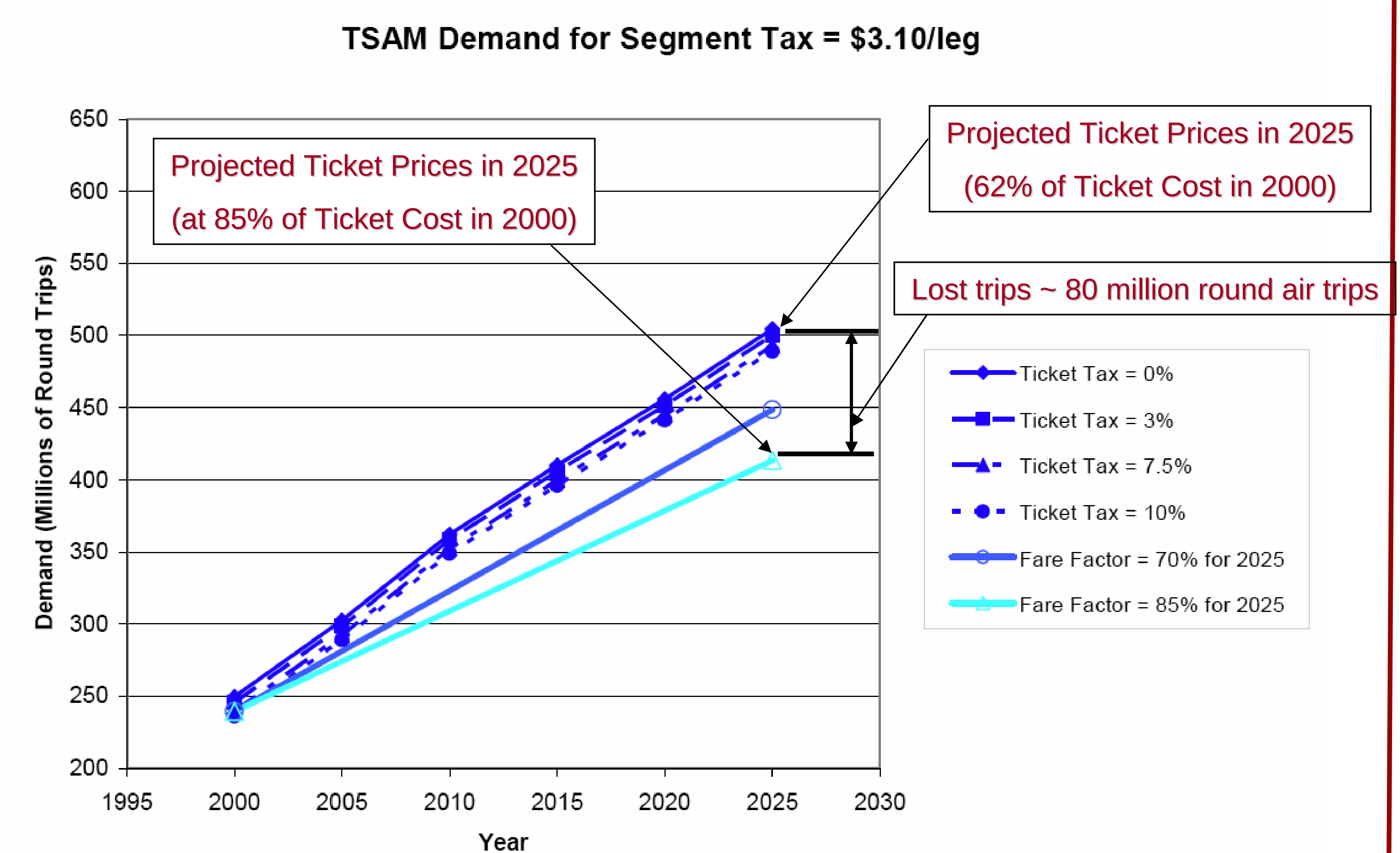
In this analysis

21.8 and 19.3 cents/gallon

For Jet and Avgas users

Impact of Ticket Taxes and Airline Fare Yields in Air Transportation Demand

Airline Demand as a Function of Ticket Taxes



Stephanie Chung's M.S. Thesis (Virginia Tech 2005)

Demand Analysis to Support JPDO Future NAS Demand Predictions

Modeling NGATS in TSAM

- **Airport capacity improvements**
  - Airport landside improvements
    - Reduced travel times from access point to aircraft gate
  - Airside improvements
    - Improved airport capacity (reduces scheduled delay in system)
- **Airspace technology improvements**
  - Reduced flight times by virtue of improved ATM structure and more fuel optimal trajectories
- **Controlling parameters in the TSAM model**
  - **Airline Fare Scaling Factor (AFSF)** : Regulates fares charged by airlines to flying public
  - **Airport Processing Time Scaling Factor (PTSF)** : Controls the processing times at the airport
  - **Airline Travel Time Scaling Factor (ATTSF)** : Regulates flight time of every flight from an origin to a destination airport
- These parameters are controlled through a user interface in the model
- Parameters for competing modes (auto and GA) are left constant in this analysis since we are trying to understand the effect of NGATS in the unconstrained demand function

NGATS Objective

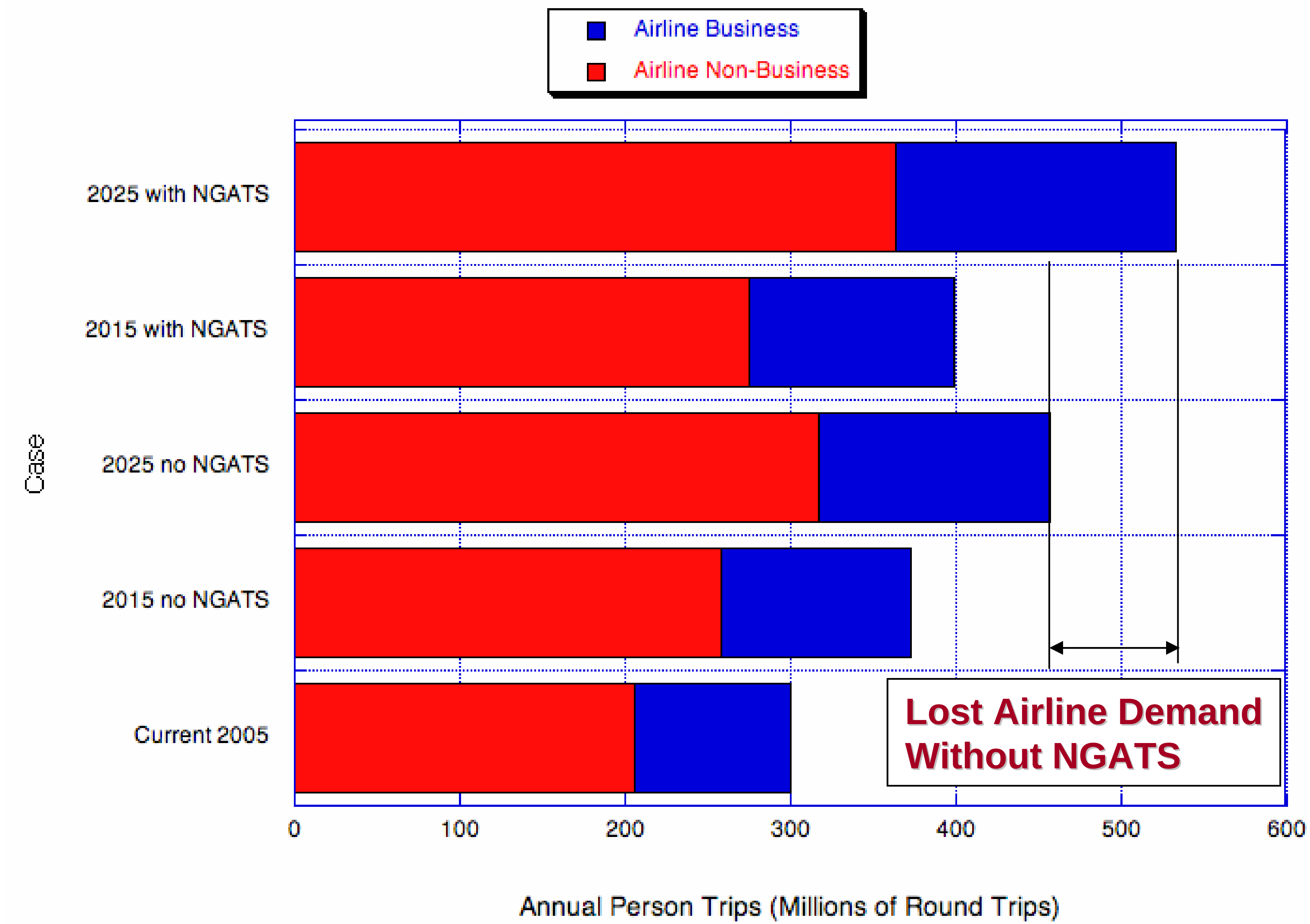
- Expand Capacity - Reduce transit time and increase predictability (domestic curb-to-curb time cut by 30%)

- This objective was approximated by reducing airport transit time by 50% and scheduled flight time by 5%
- Airport transit times:

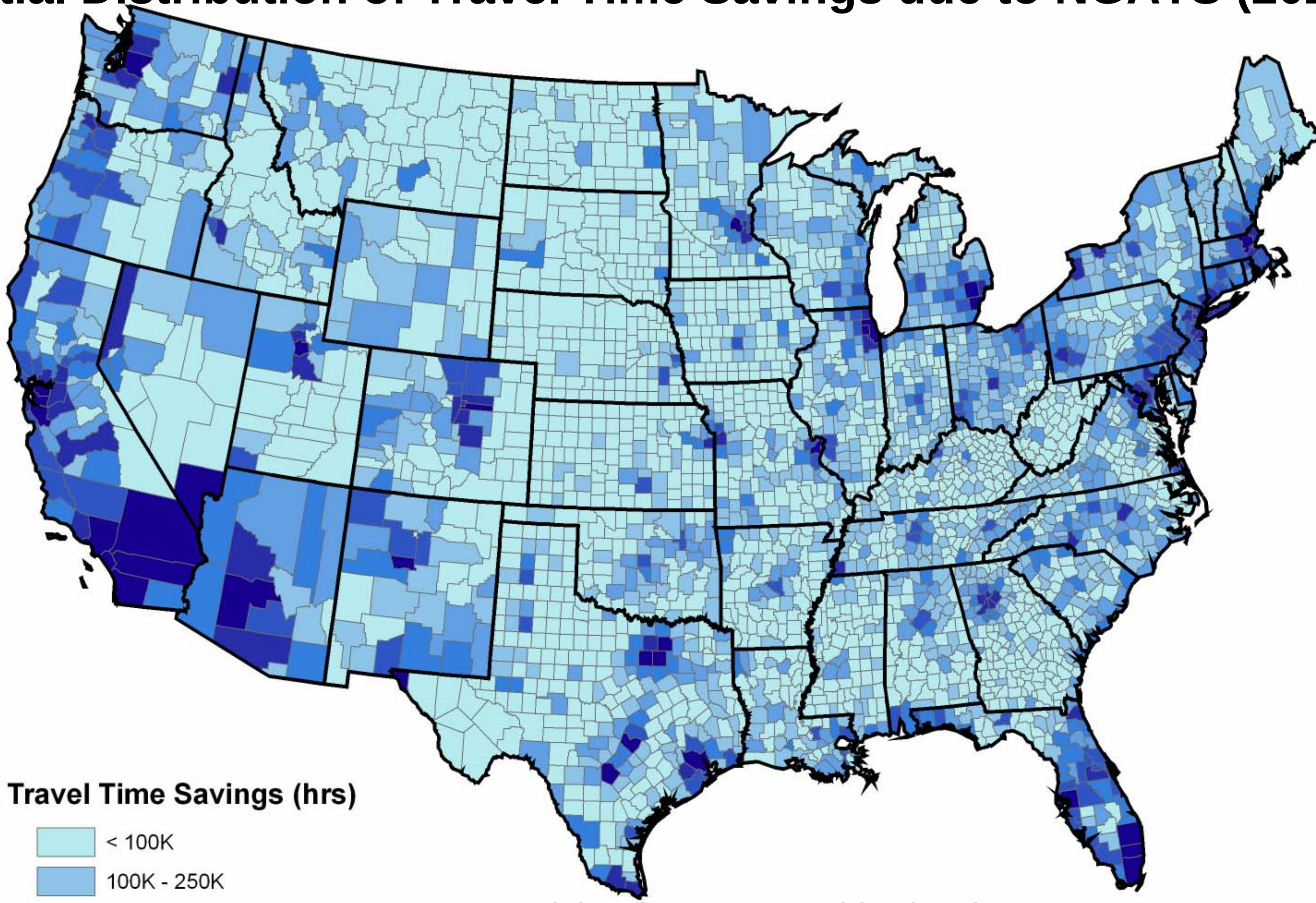
Airport transit times:	Origin Airport	Destination Airport
Large hubs	2.0 hrs to 1.0 hrs	45 min to 23 min
Medium hubs	1.5 hrs to 45 min	45 min to 23 min
Small hubs	1.25 hrs to 38 min	30 min to 15 min
Non-hubs	1.0 hrs to 30 min	30 min to 15 min

- A 5% reduction in scheduled flight time only partially removes the delay (padding) already built in today's schedules

Airline Demand Will Benefit from NGATS



Spatial Distribution of Travel Time Savings due to NGATS (2025)



398.3 million hours saved by business travelers
845.7 million hours saved by personal travelers
40.9 billion dollars (using FAA economic values)

Sam Dollyhigh (Swales) calculations using TSAM

Concluding Remarks

- TSAM is a flexible intercity transportation framework
- TSAM projects the national demand for **all forms of air travel** from socio-economic and population characteristics by county
- TSAM can compute the demand for a completely new mode of travel diverted from existing travel modes
- TSAM provides a foundation to conduct various types of studies:
  - Cost-benefit of FAA technology investments in NAS
  - Airport priority investments
  - Demand changes with airline and FAA policies
  - Noise and emission impacts
  - Impact of government policies in travel behavior
- Detailed systems analysis models like TSAM complement the FAA NAS Strategy Simulator

NASA LaRC Staff Contributing to Model Development/Analyses

- **Stuart Cooke** - SATS TSAA Level 2, Aeronautics Research Directorate
- **Jeff Viken** - SATS TSAA Level 3, ASAB
- **Sam Dollyhigh** - Swales Aerospace
- **John Callery** - Swales Aerospace
- **Jeremy Smith** - Swales Aerospace

National Aeronautics and Space Administration

SWALES AEROSPACE

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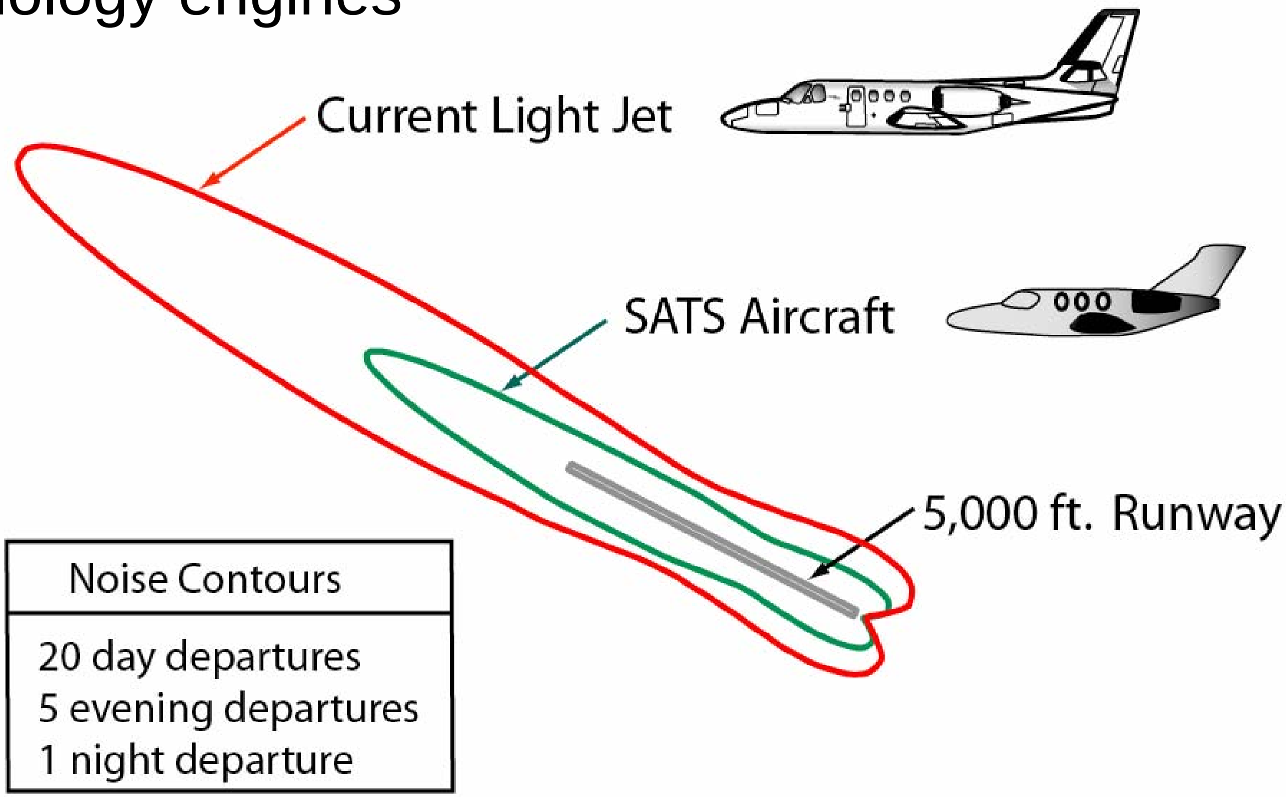
- Mr. Nick Hinze
- Graduate Research Assistants
  - S. Ashiabor
  - X. Yue
  - A. Seshadri
  - K. Murthy

Backup Slides

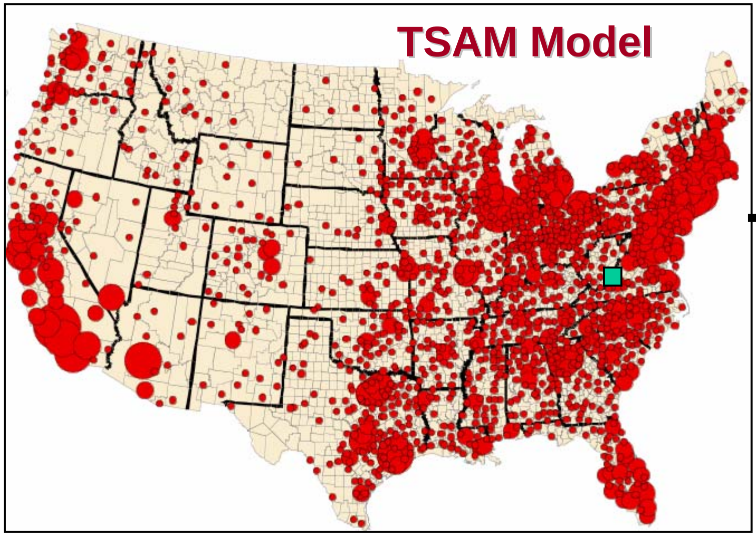
Measuring Environmental Impacts using TSAM and INM and EDMS

VLJ Noise Characteristics

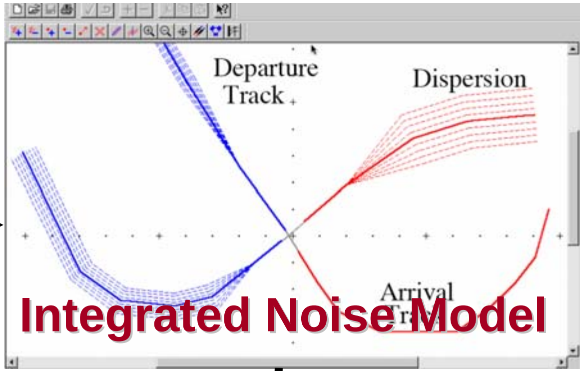
- Low noise characteristics
- Low thrust engines (1,000 - 1,300 lb.)
- New technology engines

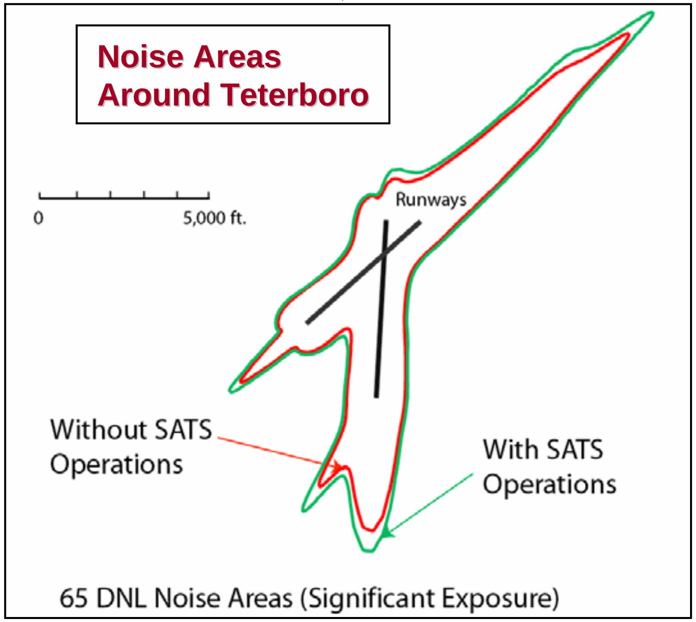


Noise Impact Analysis



Airport Demand Function

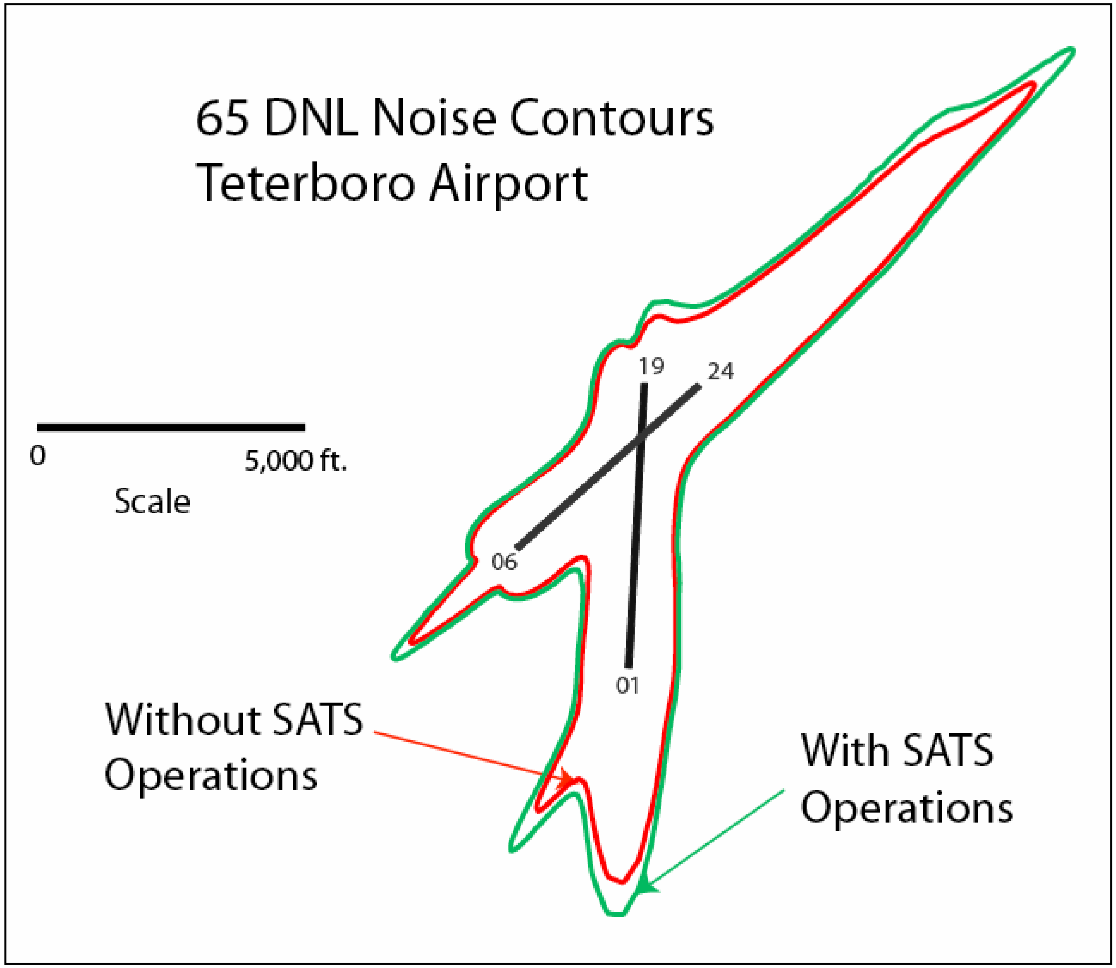




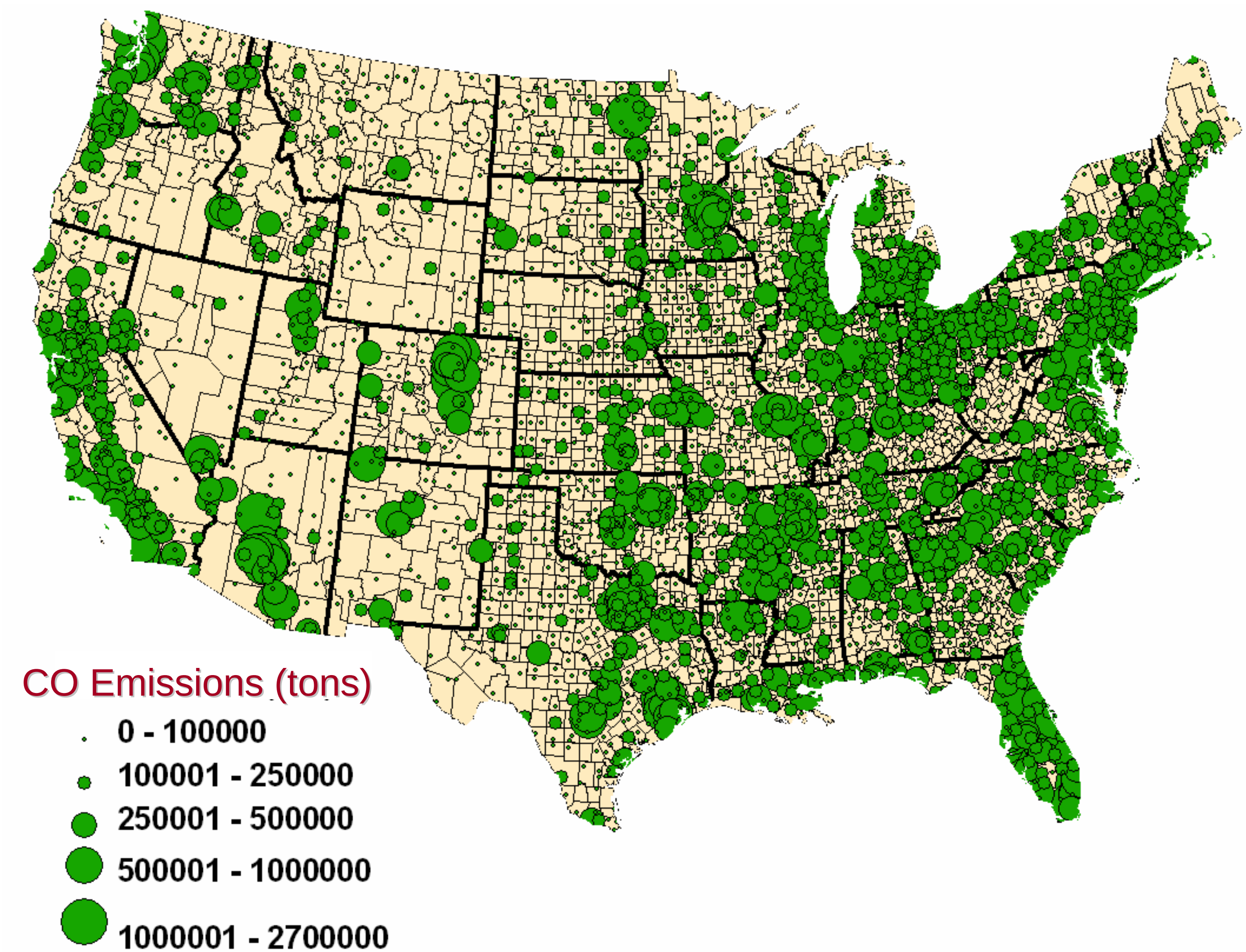
Noise Impacts to Population

Teterboro Airport (metropolitan airport)

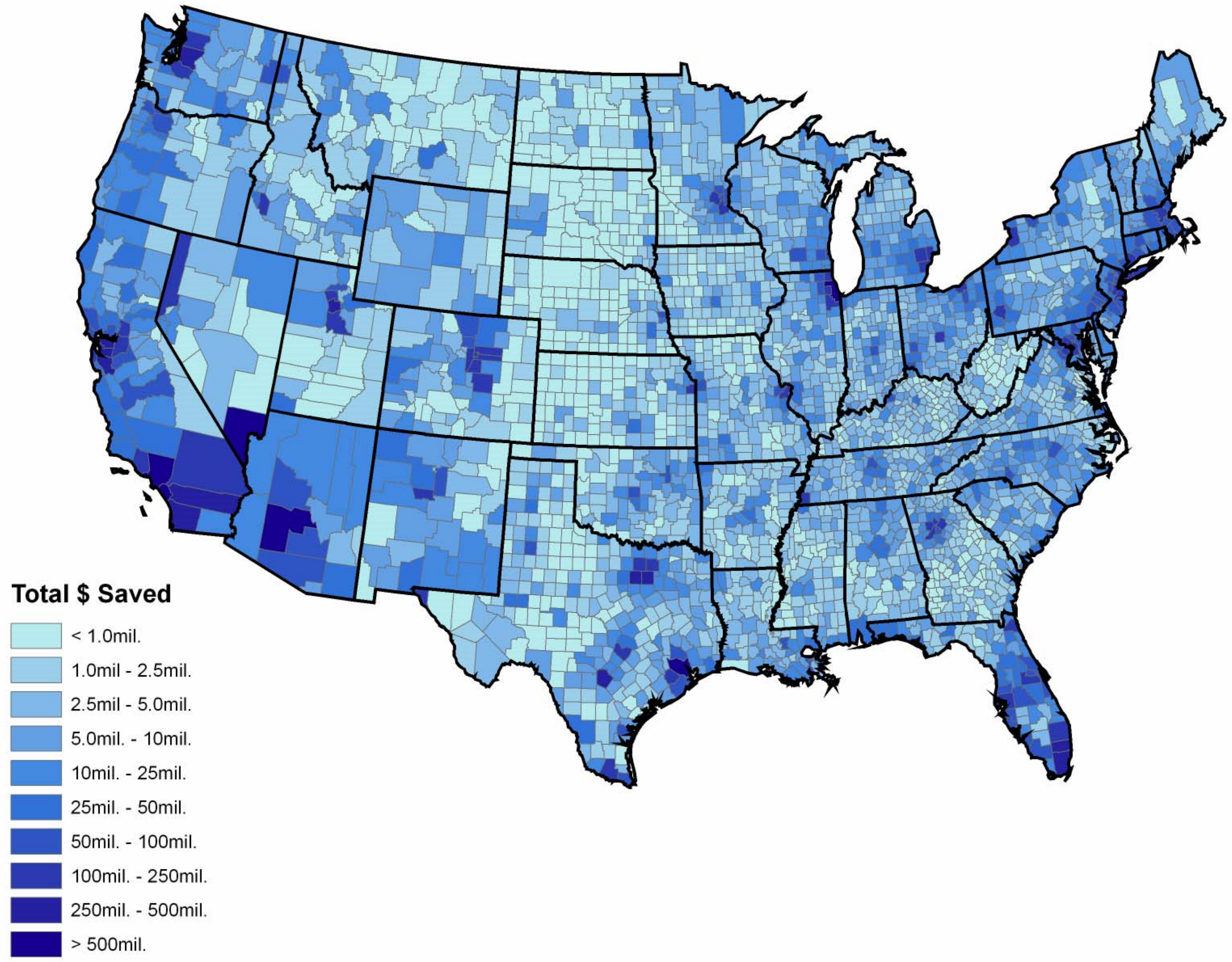
- Up to 180 VLJ operations per day in 2014
- 5-7% increase in the noise contour area when VLJ operations are added to the airport base operations



Nationwide Emissions (with EDMS 4.2) Using TSAM



Travel Time Savings ($40.9 Billion)



VLJ Daily Demand Map in TSAM

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

VLJ Flights from a single Airport in TSAM

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.