Logit Models to Forecast Nationwide Intercity Travel Demand in the United States

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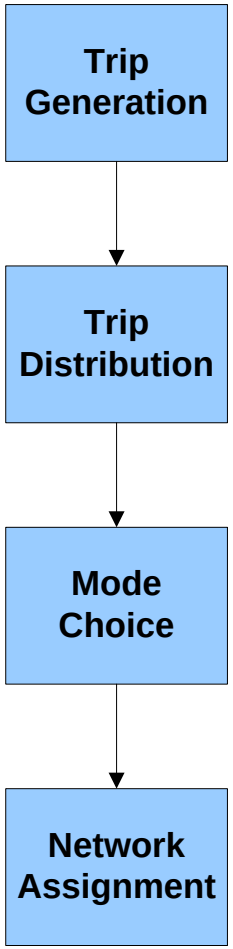
The Transportation Systems Analysis Model (TSAM) is a nationwide, multimodal model predicting intercity travel

- 9 million county pairs (3,076 X 3,076 counties)
- Automobile, commercial air, train, and air taxi travel
- Trips greater than 100 miles (1 Way)
- Business and non-business trips
- 5 household income groups
- 5 types of metropolitan statistical areas
- Demand forecasts to 2040
- Four steps process: trip generation, trip distribution, mode choice, network assignment
- TSAM was initially conceived to quantify demand for NASA's Small Aircraft Transportation System (SATS)

TSAM produces detailed annual outputs for transportation planning purposes from 1995 to 2040

- Automobile:
  - Round trips between counties
  - Vehicle Miles Traveled (VMTs)
  - Fatalities
  - Fuel consumption and emissions
  - Road network link demand
- Commercial Airline:
  - Round trips between counties and airports
  - Enplanements between airports
  - Revenue Passenger Miles (RPMs)
  - Fuel consumption and emissions (In development)
  - Operations and 4-D flight paths (In development)
- Train:
  - Round trips between counties and stations (In development)

TSAM uses the classic four-step transportation systems modeling process



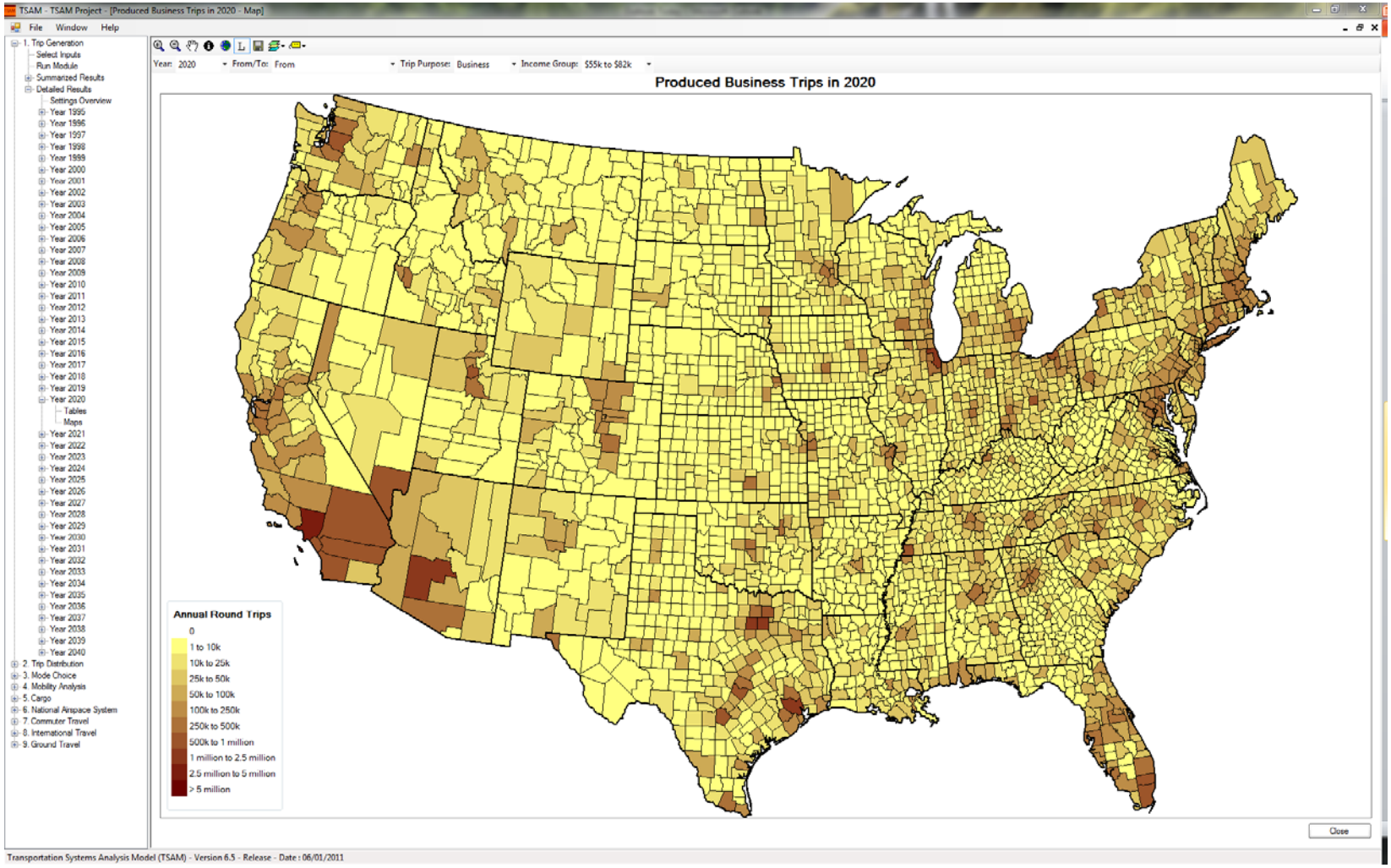
Forecasts produced and attracted person trips by county

Distributes the produced trips between all counties

Calculates the automobile, commercial airline, train, and air taxi demand between all counties

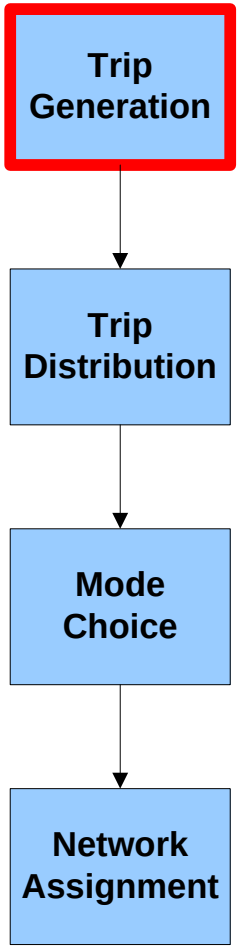
Loads the automobile, commercial airline, train and air taxi demand onto their respective networks

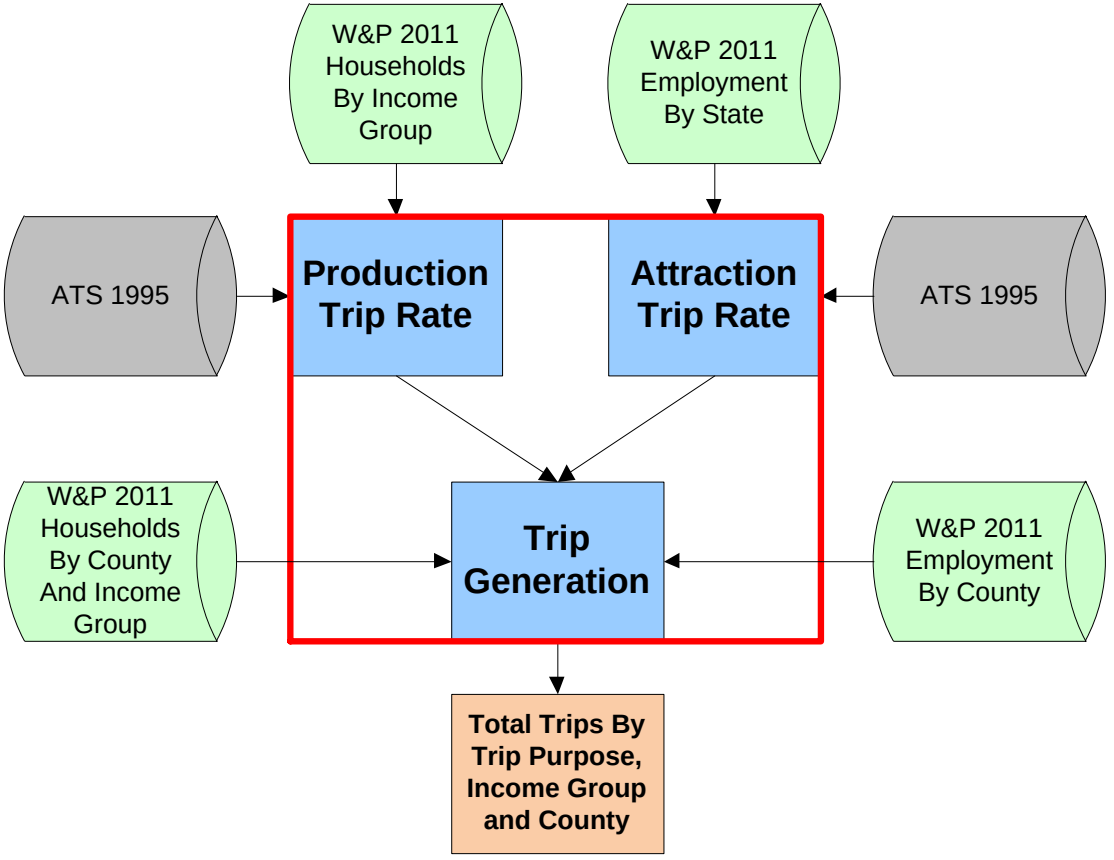
Trip generation forecasts produced and attracted person trips



Produced business trips in 2020 for $55K to $82K income group

Socio-economic forecasts and trip rates are combined to predict trips





* W&P 2011 = Woods & Poole Socio-economic Database 2011

* ATS = American Travel Survey 1995

Trip production rates are derived from the 1995 American Travel Survey (ATS) and household data

- Future produced trips are estimated using projected households per income group and trip production rates per income group
- Nationwide trip production rates by trip purpose, income group and MSA type are derived from the ATS trips and household counts.
- An iterative procedure is used to adjust the nationwide trip production rates at the State level to match the ATS published totals

Business Production Trip Rate (Person Trips/Year/Household)

	<27K	<55K	<82K	<137K	>137K	Total
NYC MSA	0.137	0.470	0.690	0.990	5.262	0.785
Very Large MSAs	0.304	1.049	2.055	2.765	7.853	1.733
Large MSAs	0.735	1.490	2.476	4.305	6.734	2.164
Medium MSAs	1.221	2.064	3.167	5.346	6.629	2.569
Small/NonMSAs	1.391	2.740	3.718	5.091	7.728	2.673
Total	1.026	1.984	2.760	4.216	6.919	2.304

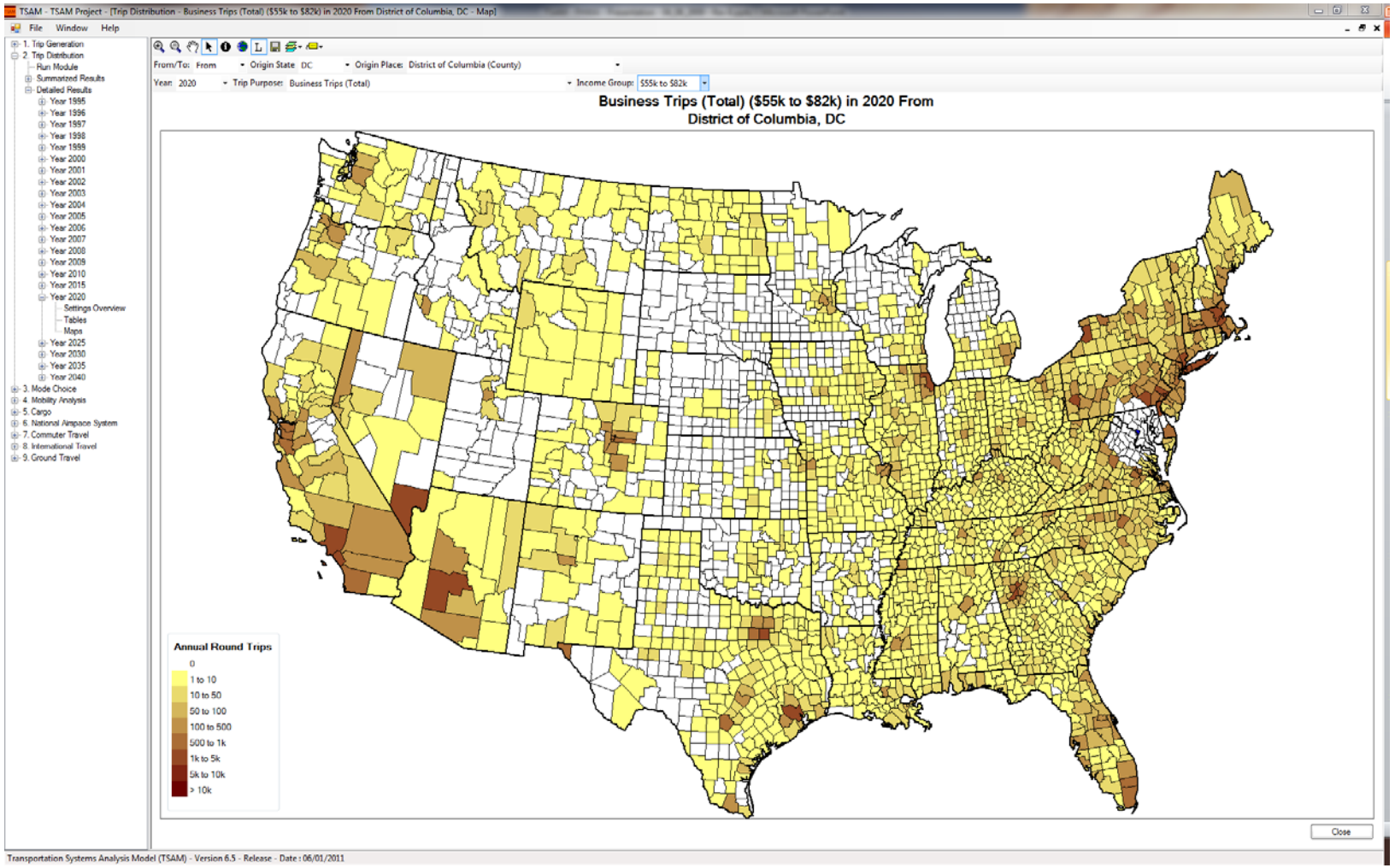
Trip attraction rates are derived from the 1995 American Travel Survey (ATS) and employment data

- Future attracted trips are estimated using projected employment and trip attraction rates per income group
- Nationwide trip attraction rates by trip purpose, income group and MSA type are derived from the ATS trips and employment.
- An iterative procedure is used to adjust the nationwide trip attraction rates at the State level to match the ATS published totals

Business Attraction Trip Rate (Person Trips/Year/Employment)

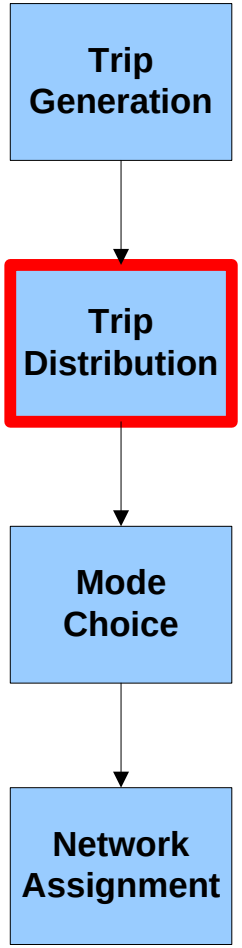
	<27K	<55K	<82K	<137K	>137K	Total
NYC MSA	0.045	0.196	0.429	0.239	0.161	1.070
Very Large MSAs	0.059	0.343	0.307	0.299	0.125	1.132
Large MSAs	0.139	0.445	0.478	0.344	0.158	1.564
Medium MSAs	0.234	0.534	0.429	0.271	0.087	1.556
Small/NonMSAs	0.213	0.681	0.466	0.265	0.073	1.698
Total	0.166	0.509	0.447	0.300	0.118	1.540

Trip distribution assigns the produced trips to each destination county



Distributed business trips in 2020 for $55K to $82K income group from Washington DC

A gravity model distributes the produced trips

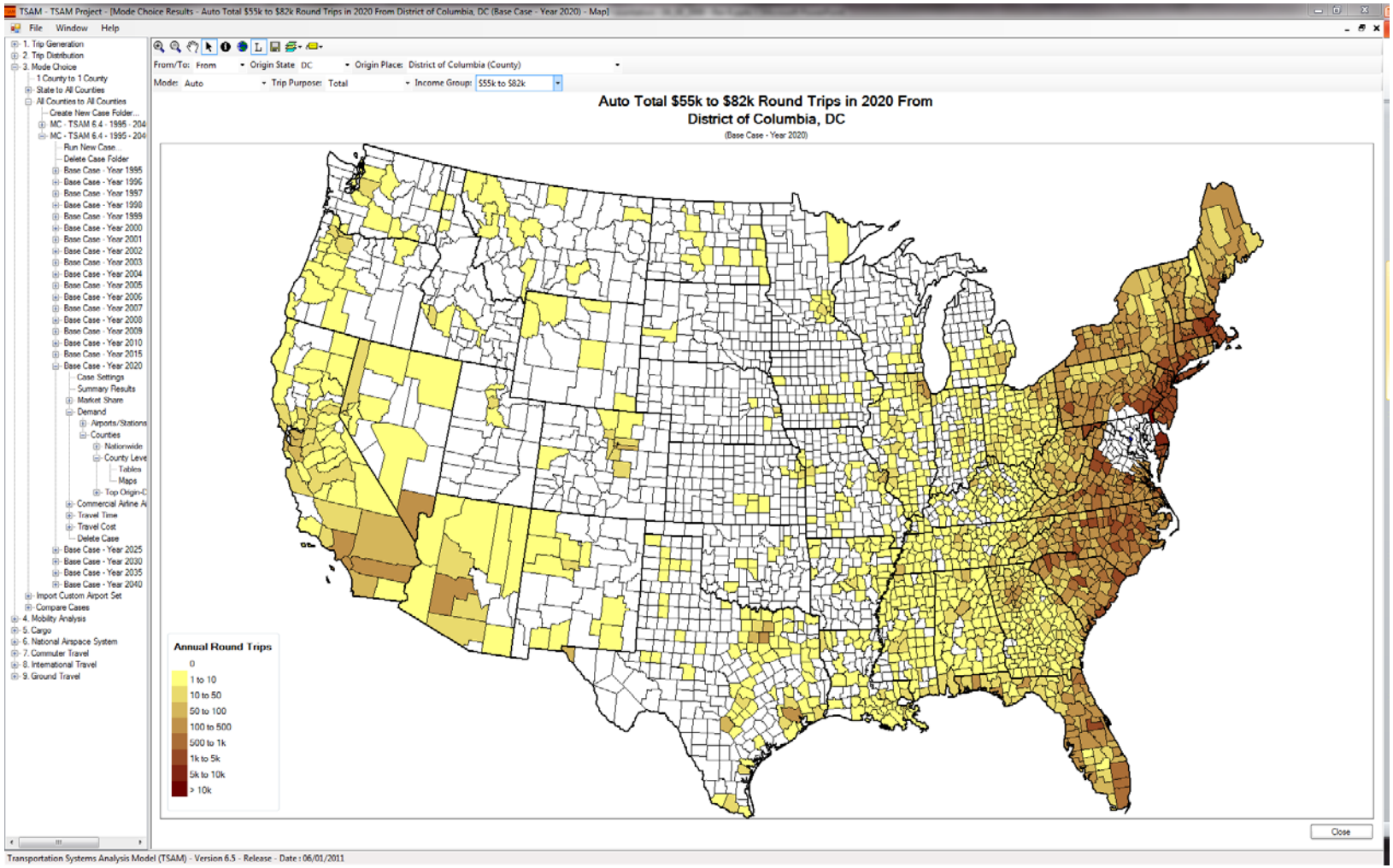


$$T_{ij} = P_i \left[\frac{A_j F_{ijr} K_{ij}}{\sum_{jr} A_j F_{ijr} K_{ij}} \right]$$

T_{ij} = trips from county *i* to county *j*,
P_i = trips produced from county *i*,
A_j = trips attracted to county *j*,
F_{ijr} = the friction factor defined as an inverse function of travel distance for county ij and region r, and
K_{ij} = a socioeconomic adjustment factor for interchange *ij*.

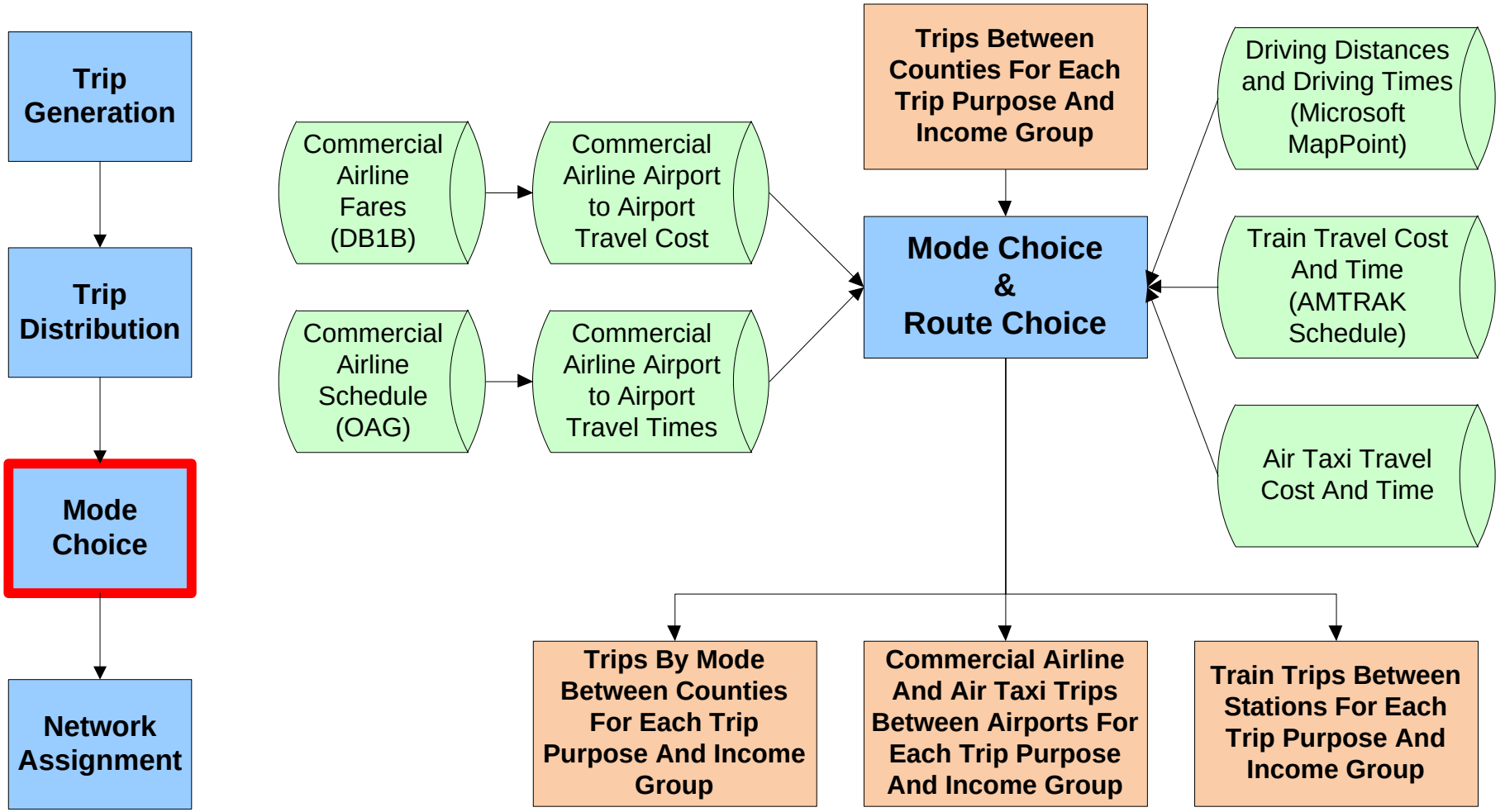
- The trip distribution model is calibrated at the county level for the Fijs and the state level for the Kij using the ATS.
- The output of the trip distribution model is a set of county-to-county trip tables by trip purpose and 5 household income groups.
- Region r are the following 4 types: MSA-MSA, MSA-NonMSA, NonMSA-MSA, and NonMSA-NonMSA. Each region type has different travel behavior.

Mode choice calculates the automobile, commercial airline, train, and air taxi demand



Automobile business trips in 2020 for $55K to $82K income group from Washington DC

The mode-choice model uses travel time and cost to split the distributed trips by mode



The mode choice model uses travel time and travel cost to estimate market share

The mode-choice uses a BoxCox formulation for the utility

$$U_{Auto} = \alpha_{TT} \frac{TT_{Auto}^{\lambda_{TTAuto}} - 1}{\lambda_{TTAuto}} + \alpha_{TC} \frac{TC_{Auto}^{\lambda_{TCAuto}} - 1}{\lambda_{TCAuto}}$$

$$U_{Air} = \alpha_{TT} \frac{TT_{Air}^{\lambda_{TTAir}} - 1}{\lambda_{TTAir}} + \alpha_{TC} \frac{TC_{Air}^{\lambda_{TCAir}} - 1}{\lambda_{TCAir}}$$

Where:

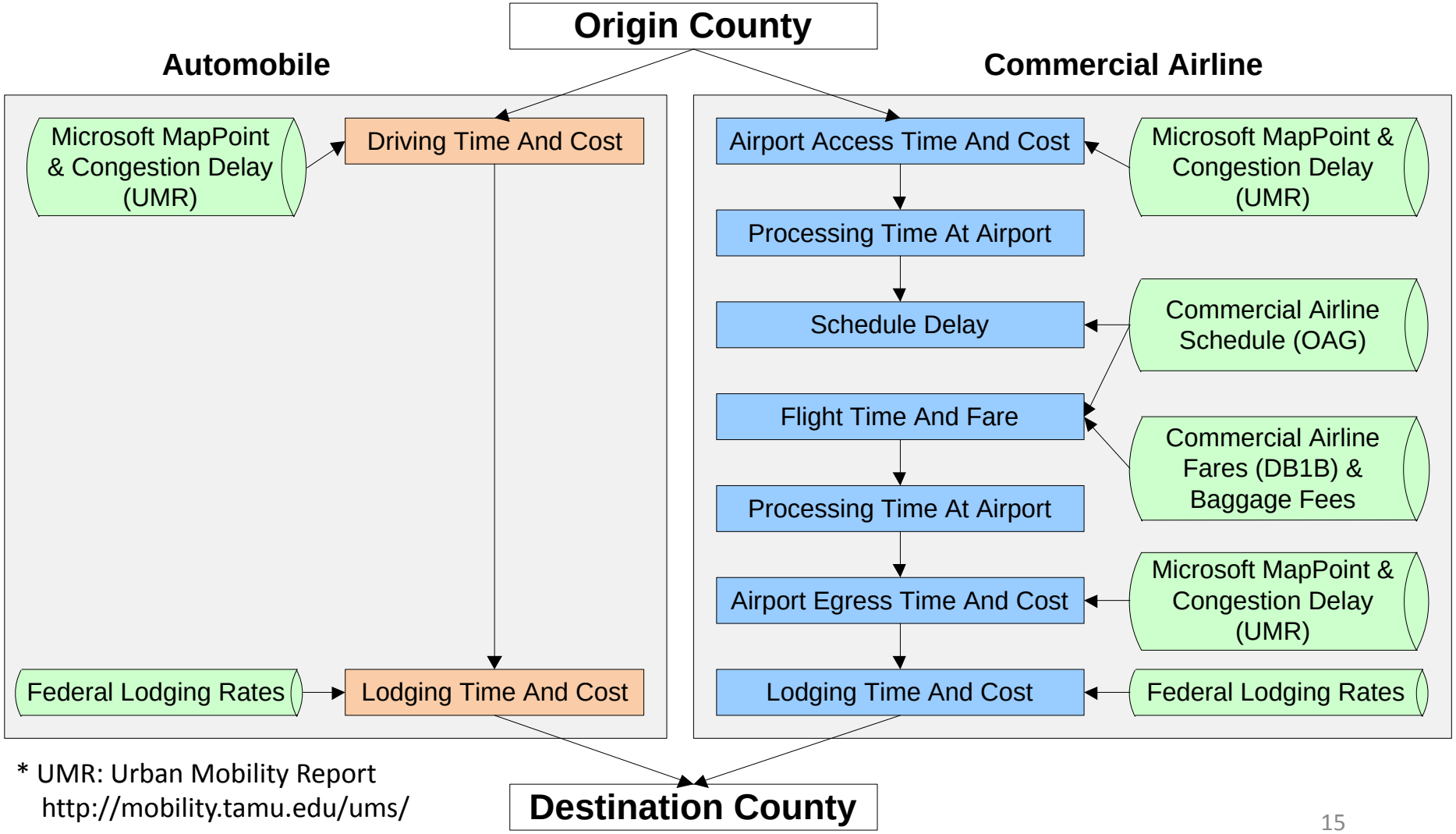
- TT = Door to Door Travel Time
- TC = Door to Door Travel Cost
- α_{TT} = Travel Time Coefficient
- α_{TC} = Travel Cost Coefficient
- All lambdas are specific to TT, TC and Auto, Air.

Multiple inputs are used to estimate market share for airline routes

$$U_i = \alpha_{TT} TT_i + \alpha_{TC} TC_i + \alpha_{DS} DS_i$$

$i = Route\ Number$
TT = Travel Time
TC = Travel Cost
DS = Direct Seats From T100+ T1
α = Coefficient

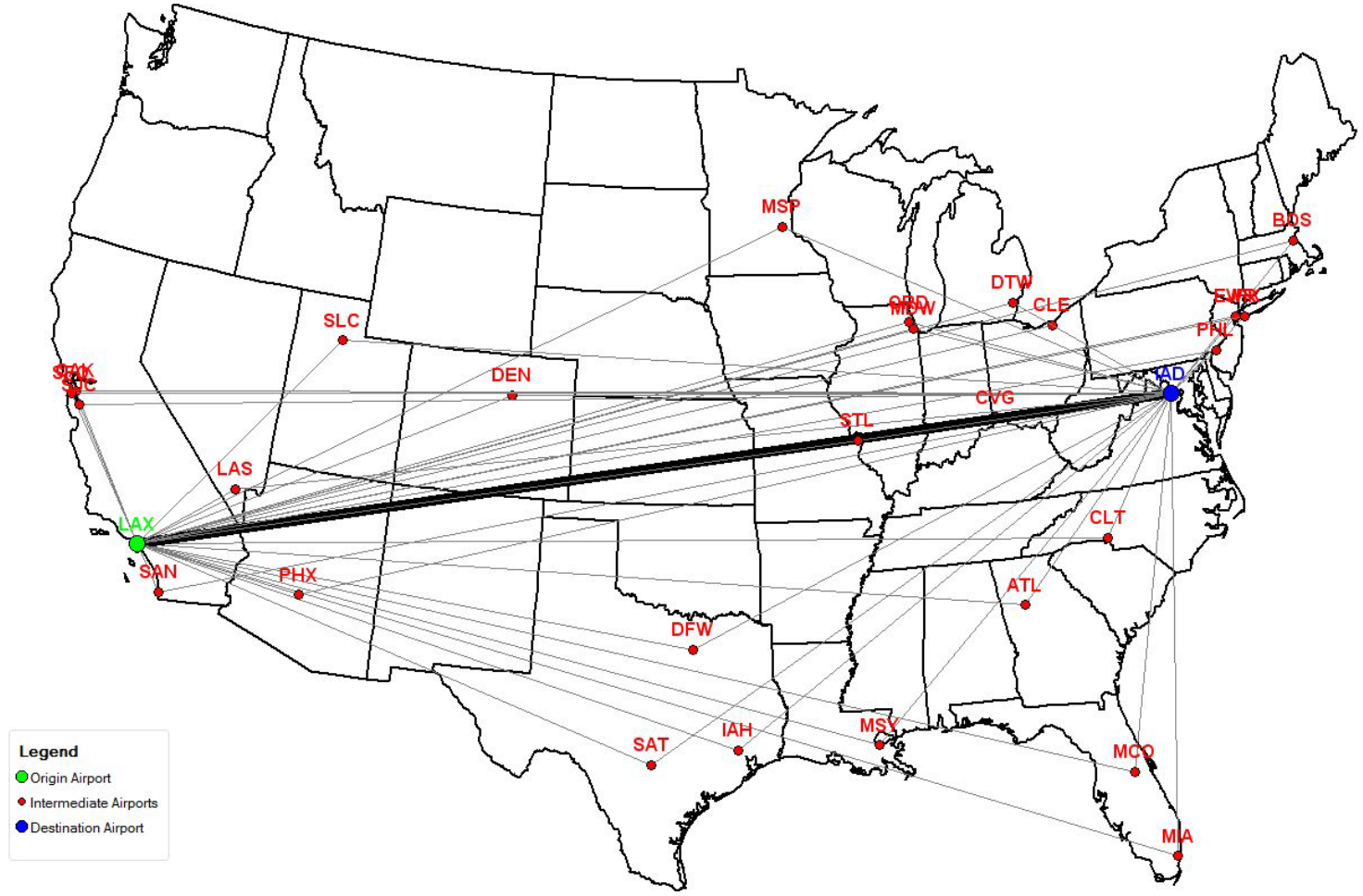
Detailed county-to-county travel time and cost calculations are required for mode choice



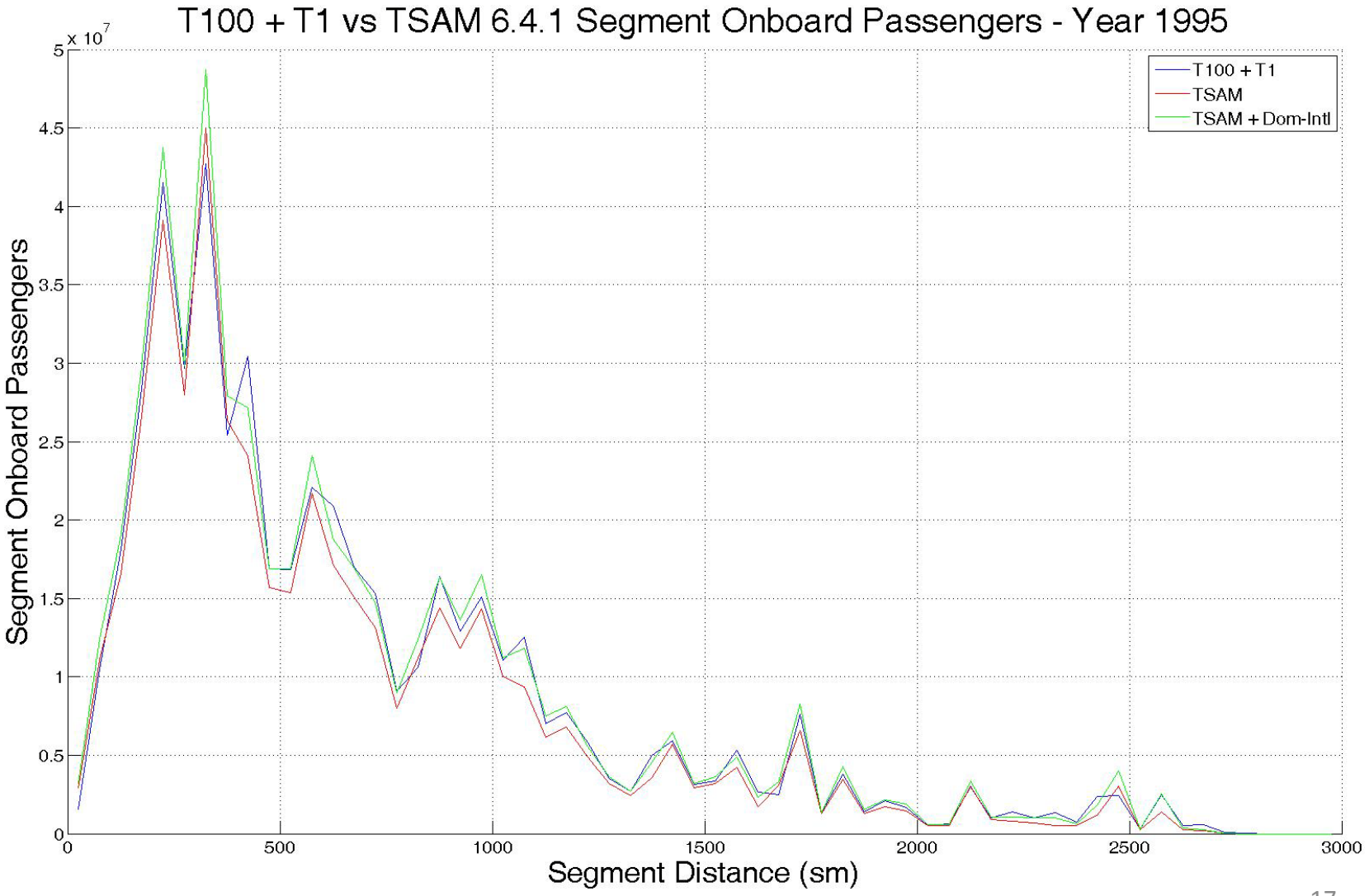
* UMR: Urban Mobility Report
http://mobility.tamu.edu/ums/

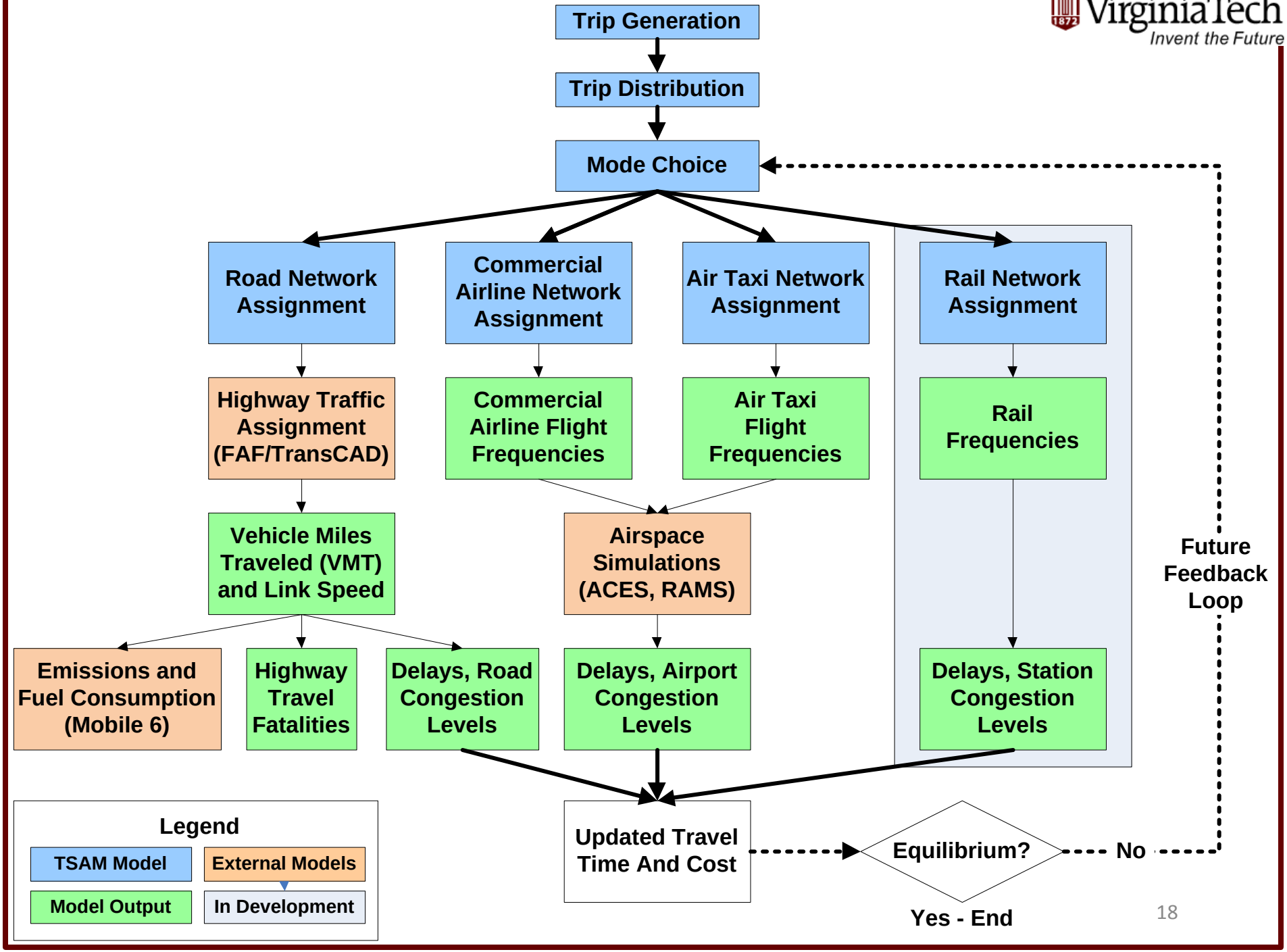
Network assignment loads the commercial airline and air taxi demand onto the network

- Trip Generation
- Trip Distribution
- Mode Choice
- **Network Assignment**



The commercial airline network assignment model calculates the number of segment enplanements

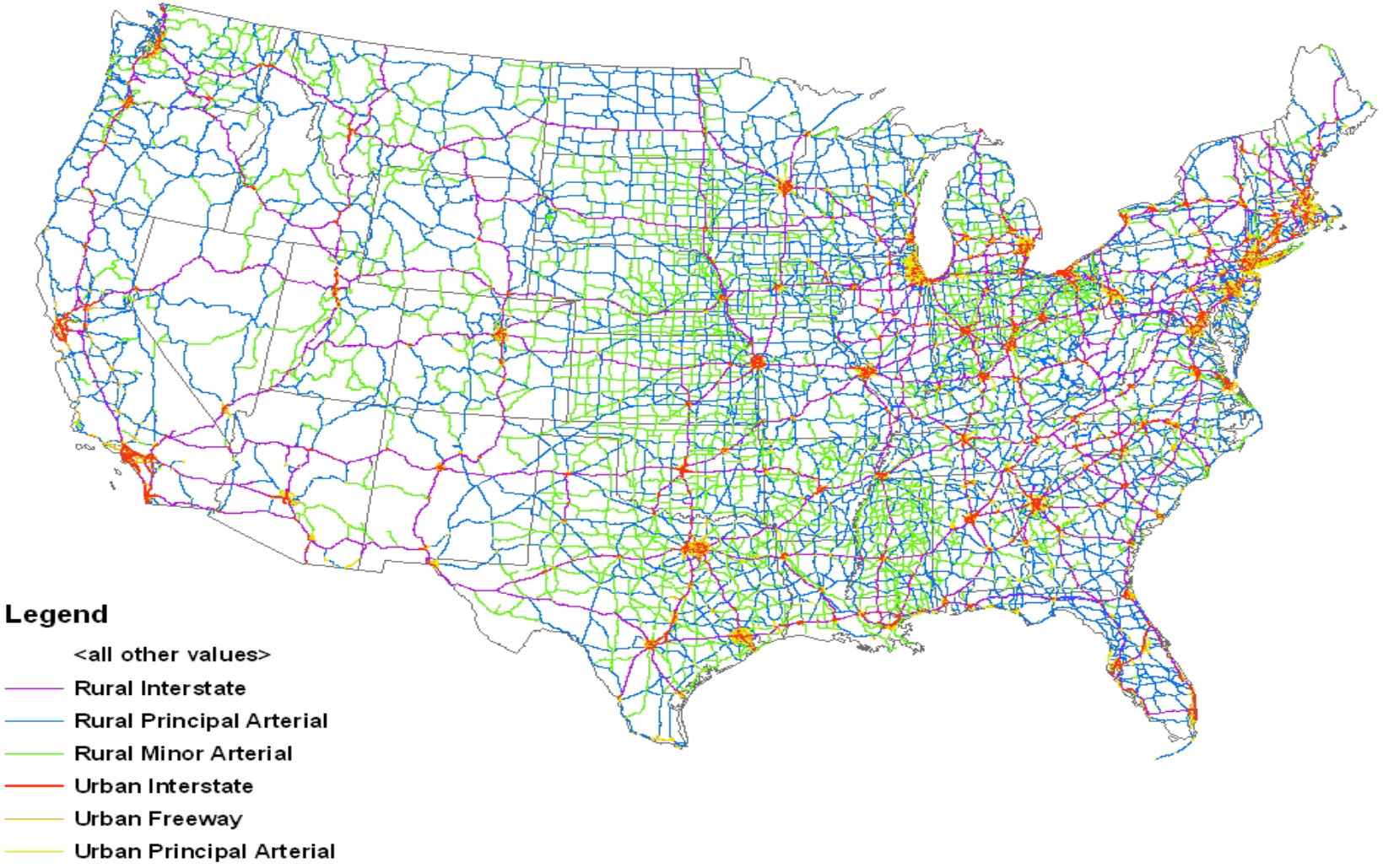



Trip Generation
Trip Distribution
Mode Choice
Road Network Assignment
Commercial Airline Network Assignment
Air Taxi Network Assignment
Rail Network Assignment
Highway Traffic Assignment (FAF/TransCAD)
Commercial Airline Flight Frequencies
Air Taxi Flight Frequencies
Rail Frequencies
Vehicle Miles Traveled (VMT) and Link Speed
Airspace Simulations (ACES, RAMS)
Emissions and Fuel Consumption (Mobile 6)
Highway Travel Fatalities
Delays, Road Congestion Levels
Delays, Airport Congestion Levels
Delays, Station Congestion Levels
Future Feedback Loop
Legend
TSAM Model
External Models
Model Output
In Development
Updated Travel Time And Cost
Equilibrium?
No
Yes - End

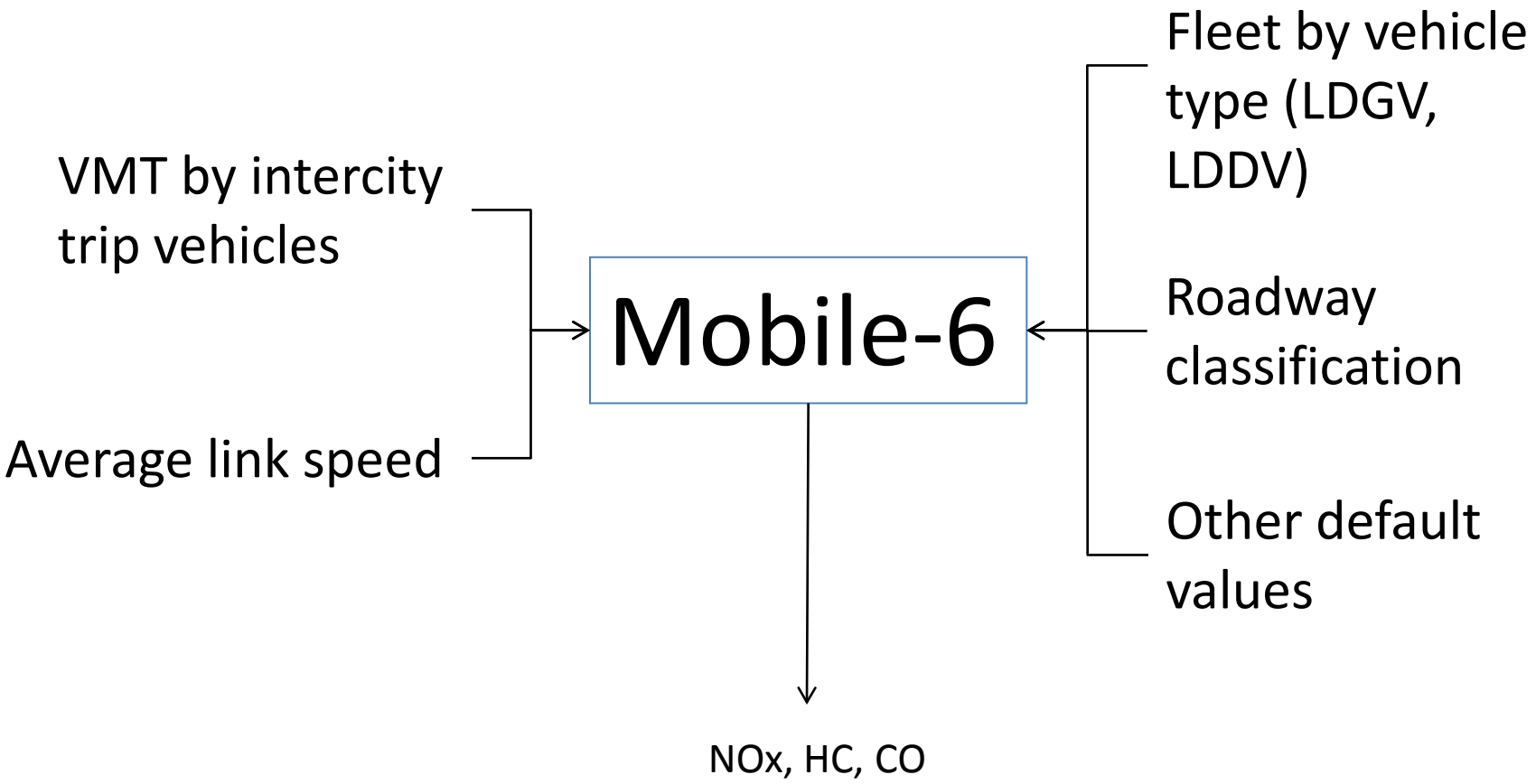
TSAM's ground network enables fuel consumption analysis, emission analysis, and fatality estimation

- The ground network module forecasts automobile link volume, speed, and time
- The Freight Analysis Framework (FAF) is adapted for automobile intercity traffic assignment
- TSAM ground network module components
  - Network Inventory: total 93,000 links, and 87,000 nodes
  - Traffic Analysis Zone (TAZ): 3,076 (county level)
  - TAZ Centroid Connectors: 3,400 (from 1 to 12 connectors for each zone)
  - Network link attributes information (Link ID, From Node and To Node ID, Miles, Number of Lanes, Functional Classification, Speed Limit)

The Freight Analysis Framework (FAF) is adapted for automobile intercity traffic assignment in TSAM

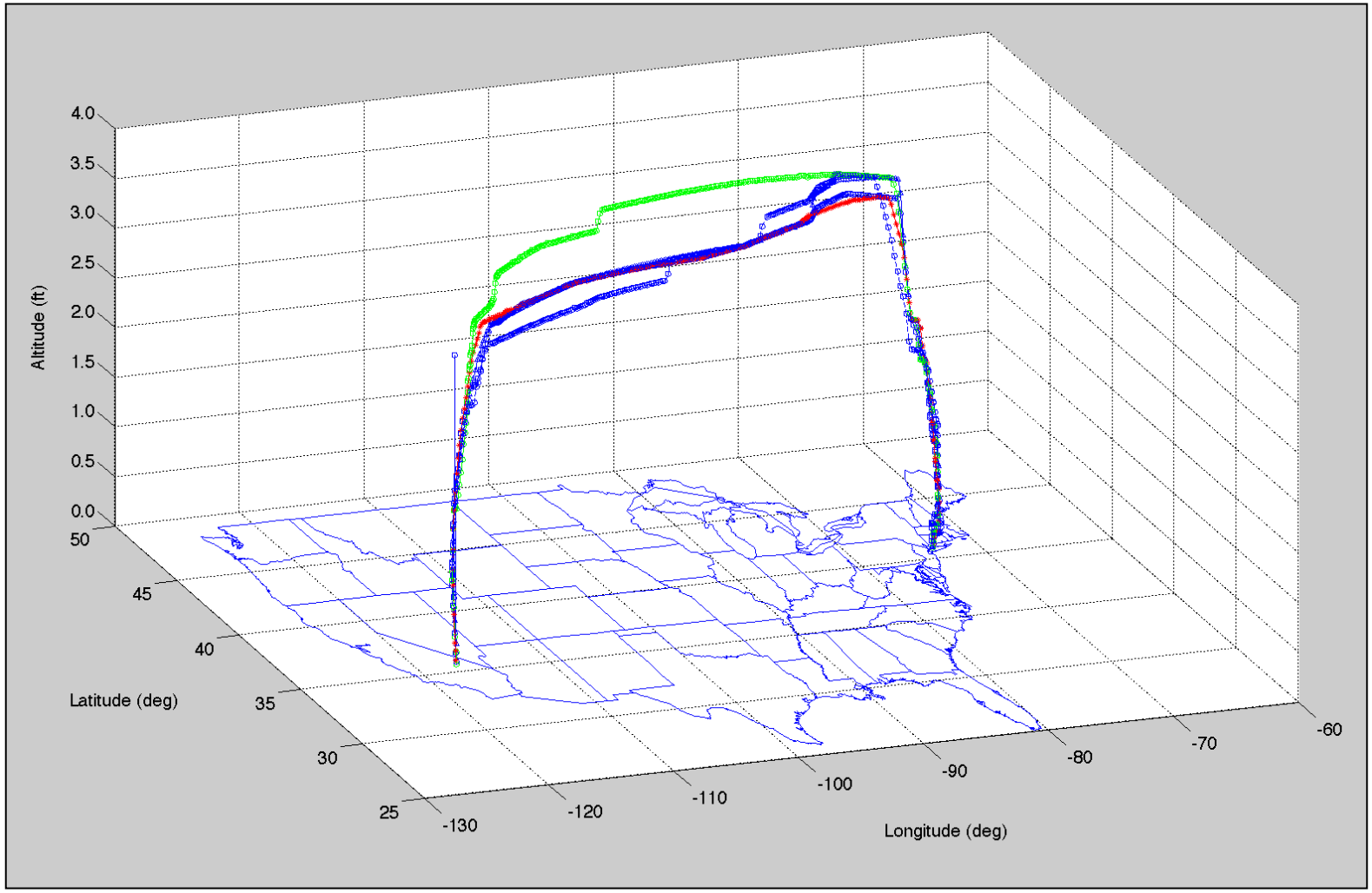


Mobile-6 is used for automobile intercity emissions estimation



VMT: Vehicle Miles Traveled
LDGV: Light Duty Gas Vehicle
LDDV: Light Duty Diesel Vehicle

Eurocontrol's Basic Aircraft Data (BADA) is used to estimate fuel consumption and emissions for complete flight profiles



Access to restricted geographic and demand data could help us improve TSAM

- Mode choice calibration of TSAM would be greatly improved if zip code/county and airport/station information from the American Travel Survey (1995) data were publicly available. This would allow us to improve our travel time and travel cost estimations.
- FAF-2 highway network data and truck O-D flow is crucial for highway traffic assignment, but are not open to public
- A 100% DB1B would be very desirable to improve the calibration of the commercial airline network assignment model and generate more accurate fares between airports.

Improved collection and distribution of future transportation survey data can greatly improve TSAM

- Future transportation surveys should collect and distribute:
  - zip code/county and airport/station information
  - travel time and travel cost information
  - information about the alternative modes considered and their respective travel times and costs.
- A new American Travel Survey is needed. The current base year is 1995. Travel behavior has changed over the past 16 years.
  - NHTS 2009 samples the travel behavior during a designated 24 hour period.
  - ATS surveys the long distance trip behavior over 1 year.

Credits

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  - Stuart Cooke
  - Jeremy Smith
- **ATK**
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