Demand Modeling for Advanced Air Mobility

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Abstract

Urbanization has intensified environmental and congestion challenges, prompting interest in Advanced Air Mobility (AAM) as a sustainable transport solution. This study investigates AAM demand across Tennessee's census tracts using employment-based trip data, statistical methods, and machine learning to forecast demand and calculate the Generalized Cost of Trip (GCT). Results suggest AAM trips are most viable when air travel constitutes over 70% of the GCT and exceeds 250 miles, offering insights for planning and policy development.

Introduction

- Rapid urbanization and dispersed employment centers have intensified congestion, travel delays, and fuel waste, with congestion costs in the U.S. rising from $113 billion in 2020 to $224 billion in 2022, as reported by the 2023 Urban Mobility Report.
- Advanced Air Mobility (AAM), encompassing Urban Air Mobility (UAM) and Regional Air Mobility (RAM), leverages electric and autonomous aircraft to address urban congestion, with UAM focusing on short-range (<150 km) urban trips and RAM serving medium-range (150–800 km) regional routes using existing airport infrastructure.
- This study models AAM demand across Tennessee census tracts using employment-based trip data and public datasets, calculating the Generalized Cost of Trip (GCT) to identify trips best suited for AAM over ground transport using a probabilistic model.

Methodology

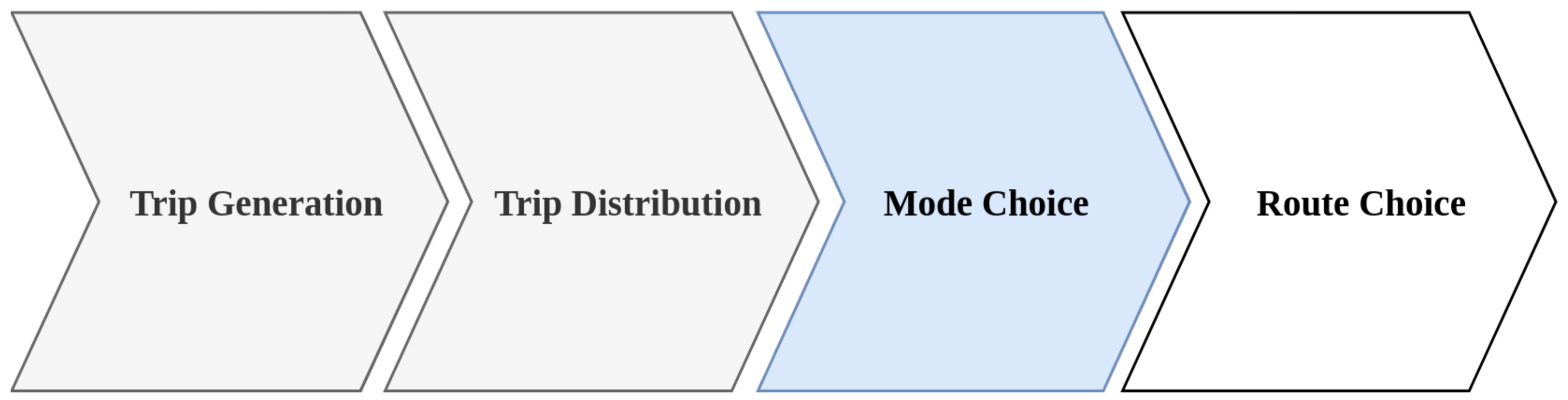

Figure 1. Four Step Model for travel demand modeling

- Trip demand assumptions:
  - All trips are generated to and from the centroid of population of census tracts.
  - AAM trip consists of ground transportation from centroid of origin census tract to the nearest hub airport and then AAM flight to destination airports and finally ground transportation from destination airports to the centroid of destination census tract.

Table 1. Datasets Used in the Research

Name	Details
BTS Monthly Traffic Dataset	Number of fatalities during Transportation
USDA VSL Dataset	Monetary equivalent of reducing one death in population
LODES Dataset	OD pairs in employment basis
BTS DB1BMarket Dataset	Ticket Price for the airlines
IRS Standard Mileage Dataset	Standard Mileage Rates(cents/miles)
FAA Airport Dataset	Block time of the flights
BTS Inter-Airport Distance Dataset	Distance between the airports
Open Source Routing Machine (OSRM)	Distance and Time of Ground transportation
US Bureau of Labor Statistics	Median hourly wages

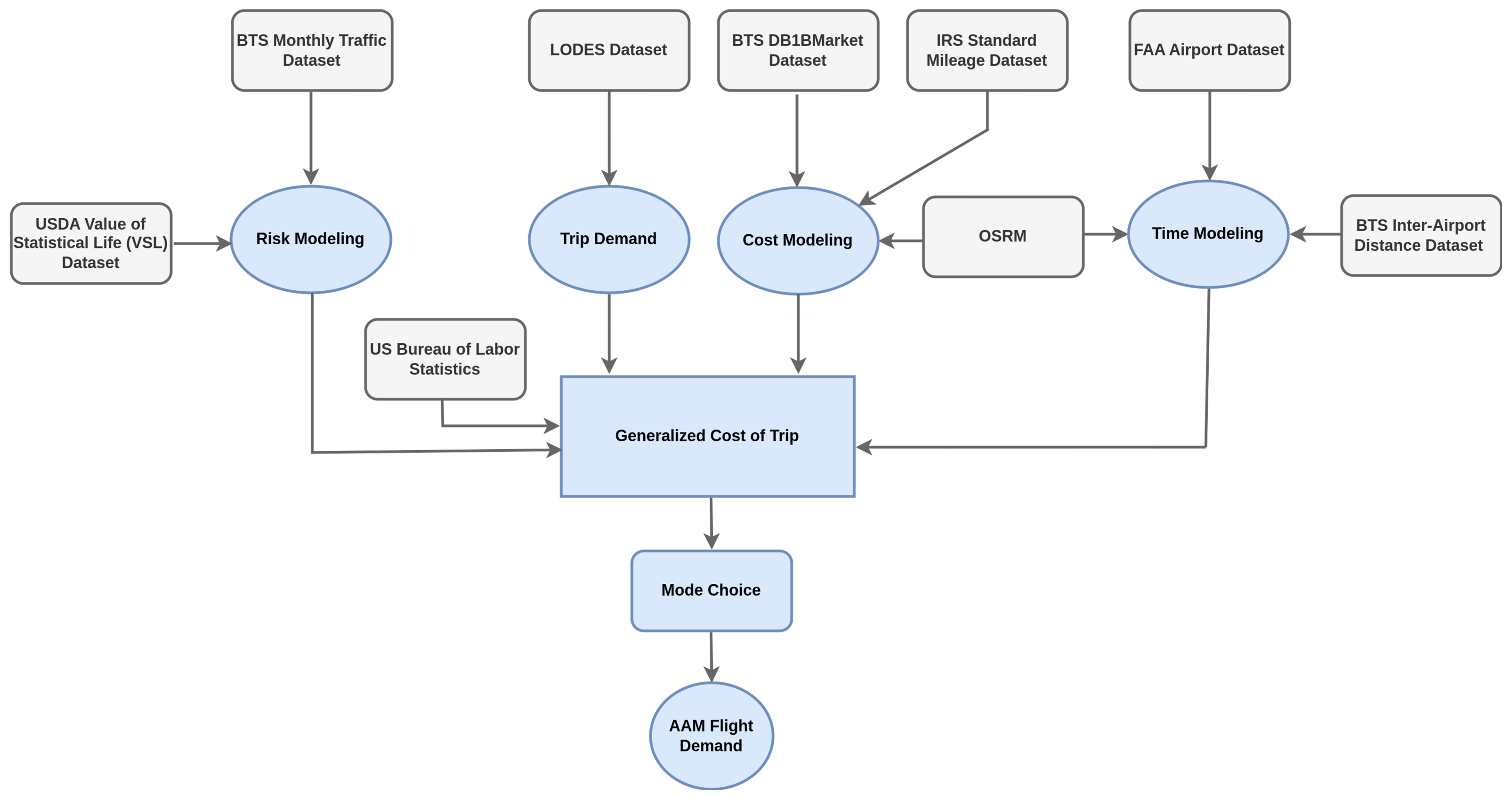

Figure 2. Approach for AAM demand modeling

1. Generalized Cost Modeling (GCT):

$$GCT_m = -C_m - W * T_m - R_m \tag{1}$$

where
- m is mode of transportation either ground or AAM
- C is actual cost of trip per mile per passenger
- W is average median hourly wage of origin and destination census tracts
- T is time of trip
- R is risk of trip

2. Mode Choice:

$$U_{\text{G}} = GCT_{\text{G}} + \epsilon; \quad U_{\text{AAM}} = GCT_{\text{AAM}} + \epsilon \tag{2}$$

where
- U is utility for trip
- ϵ is the error associated

$$P_{\text{AAM}} = \frac{1}{1 + e^{(U_{\text{G}} - U_{\text{AAM}})}} \qquad P_{\text{AAM}} = \frac{1}{1 + e^{(GCT_{\text{G}} - GCT_{\text{AAM}})}} \tag{3}$$

where
- P_{AAM} is Probability of selecting AAM

Evaluation and Results

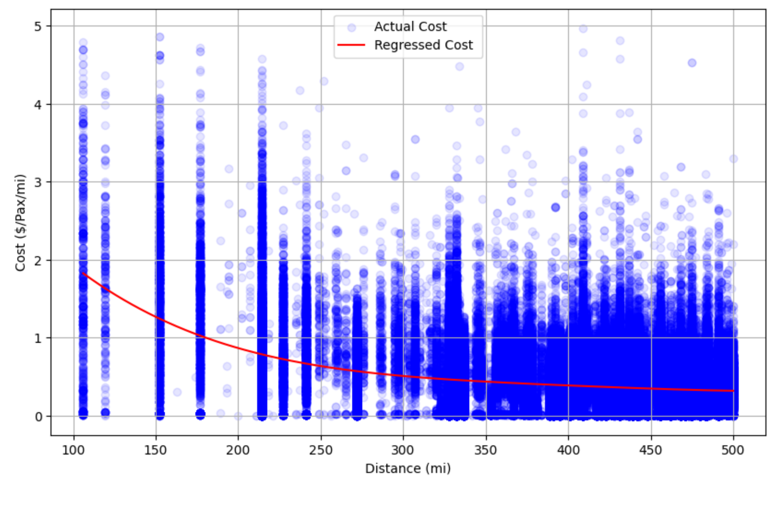

Figure 3. Cost Regression

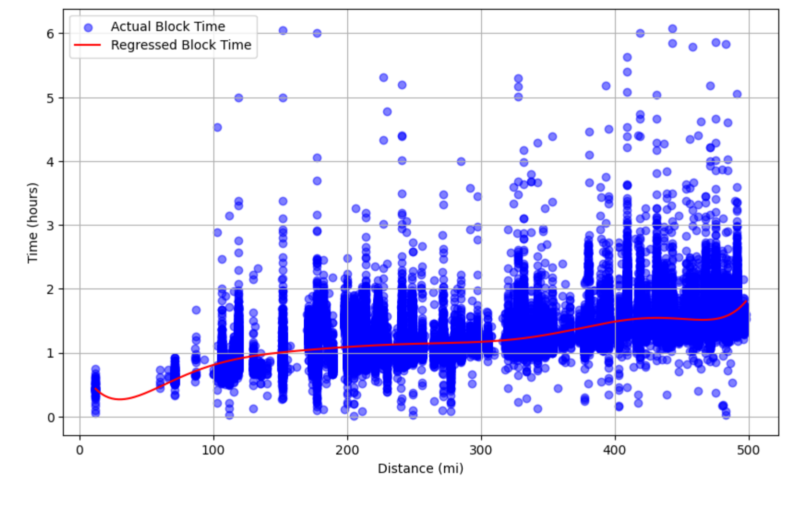

Figure 4. Block Time Regression

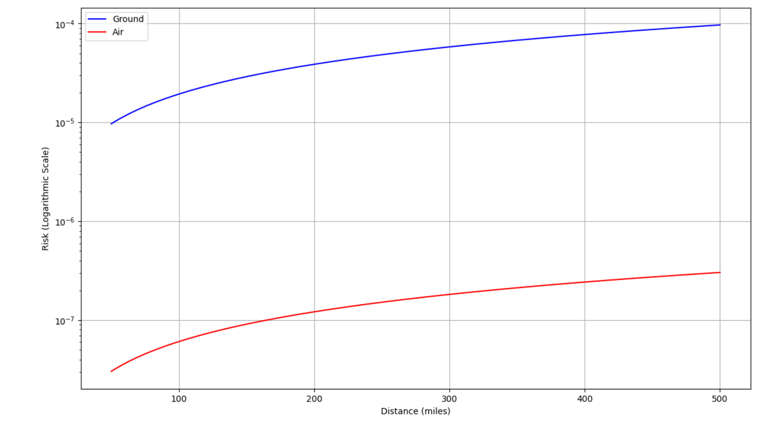

Figure 5. Risk Regression

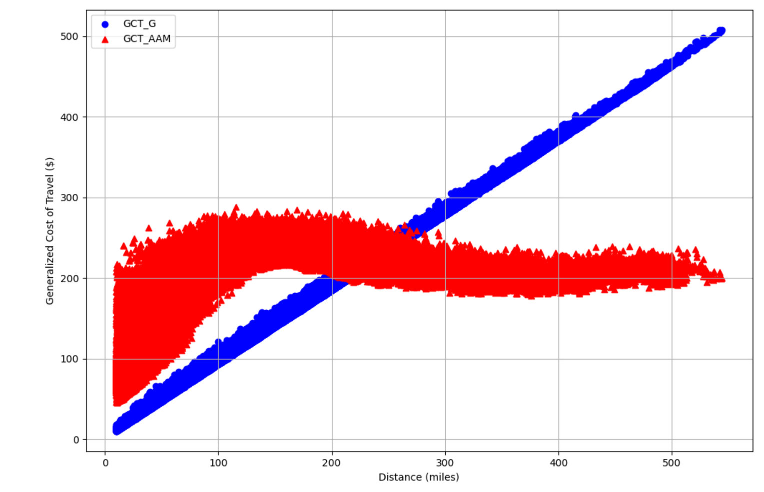

Figure 6. GCT Regression

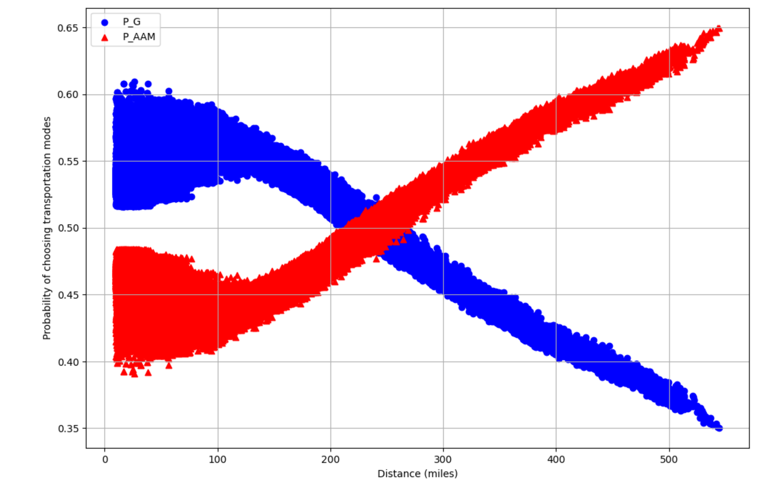

Figure 7. Probability of choosing transportation mode

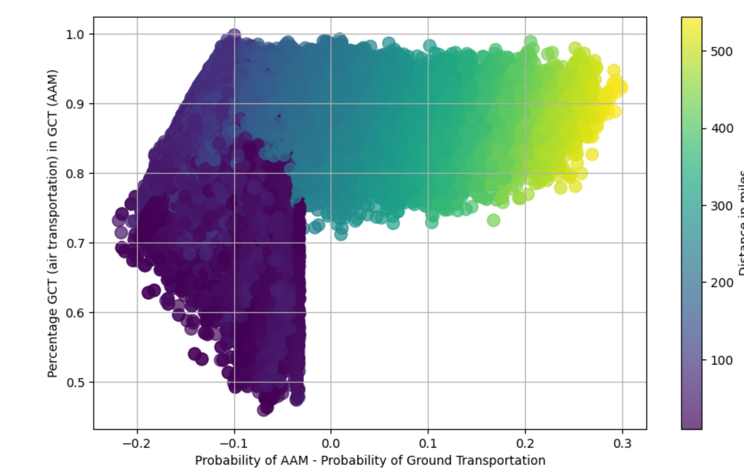

Figure 8. Percentage of GCT_A in GCT_{AAM} vs difference of P_G and P_{AAM}

Table 2. Mean Values for AAM and Non-AAM Trips

Variable	Non-AAM	AAM
GCT by Air Transportation ($)	151.07	182.16
GCT by Ground Transportation ($)	27.30	24.96
Time in Ground Transportation (hours)	0.73	0.67
Distance by Ground Transportation (miles)	23.39	21.40
Distance by Air Transportation (miles)	72.98	273.19
Time in Air Transportation (hours)	0.58	1.18
Distance between OD (miles)	87.88	318.53
Ground Transportation time between OD (hours)	1.86	6.06

Conclusion

In this research paper, the cost, time, and risk models were developed for AAM and ground transportation. These models were subsequently utilized to create the GCT model to predict the likelihood of AAM being chosen as the preferred mode of transportation. The proposed model indicated that, for Tennessee, trip demand generated at the census tract level is more likely to constitute AAM trip demand if air transportation contributes more than 70% to the GCT and if the trip distance exceeds 250 miles. Future research direction will be to estimate the costs for AAM aircraft powered by electric charge and its impact on the GCT and selection of AAM as preferred mode.

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