Mobility and Energy Impacts of Automated Cars

Analysis using MTC *Travel Model One*

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Research Question

How will automation change the daily travel decisions of individuals and alter overall vehicle miles traveled and energy use?

> *What is the magnitude of the rebound effect from the reduce generalized cost of travel?*

Scope of analysis

- Advanced Level 3 automation
  - *Vehicles must have driver present, but intervention rare*
- Urban travel
  - *Do not consider impacts on intercity travel*
- Status quo for vehicle ownership and form
  - *No shared economy or drastic changes to vehicle design*

Potential energy pathways

Transportation & Land-Use System

Vehicle Design

- size
- performance
- fuel

Transportation System

- available modes
- capacity
- generalized costs of travel

Land Use

- real estate
- local regulation
- spatial distribution

Individual Economic Decisions

Location Choice

Auto Ownership

Activity Plan

Tours / Trip Plan

Time of Day

Mode Choice

Route Choice

Vehicle Operation

Energy, Economic, & Environmental Impacts

Mobility Demand

x

Energy Intensity

↓

Energy Consumption

x

Fuel Choice & Intensity

↓

Emissions & Impacts

Research Focus

Transportation & Land-Use System

Vehicle Design

- size
- performance
- fuel

Transportation System

- available modes
- **capacity**
- **generalized costs of travel**

Land Use

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Energy and Environmental Consequences

Mobility Demand

x

Energy Intensity

↓

Energy Consumption

x

Fuel Choice & Intensity

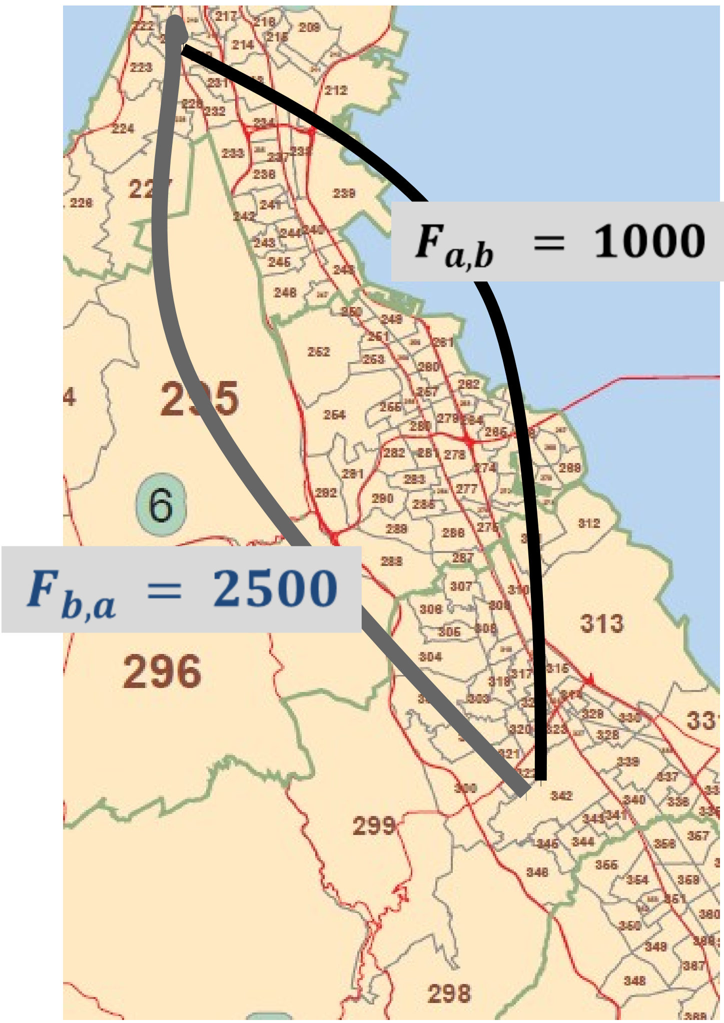
Emissions & Impacts

Methodology

- Model automated vehicle scenarios using San Francisco's Metropolitan Commission's *Travel Model One*
- Simulate the microeconomic travel decisions for every person in the 9 county San Francisco Bay Area
- Use activity-based model approach (ABA)
- Each decision follows a random utility model

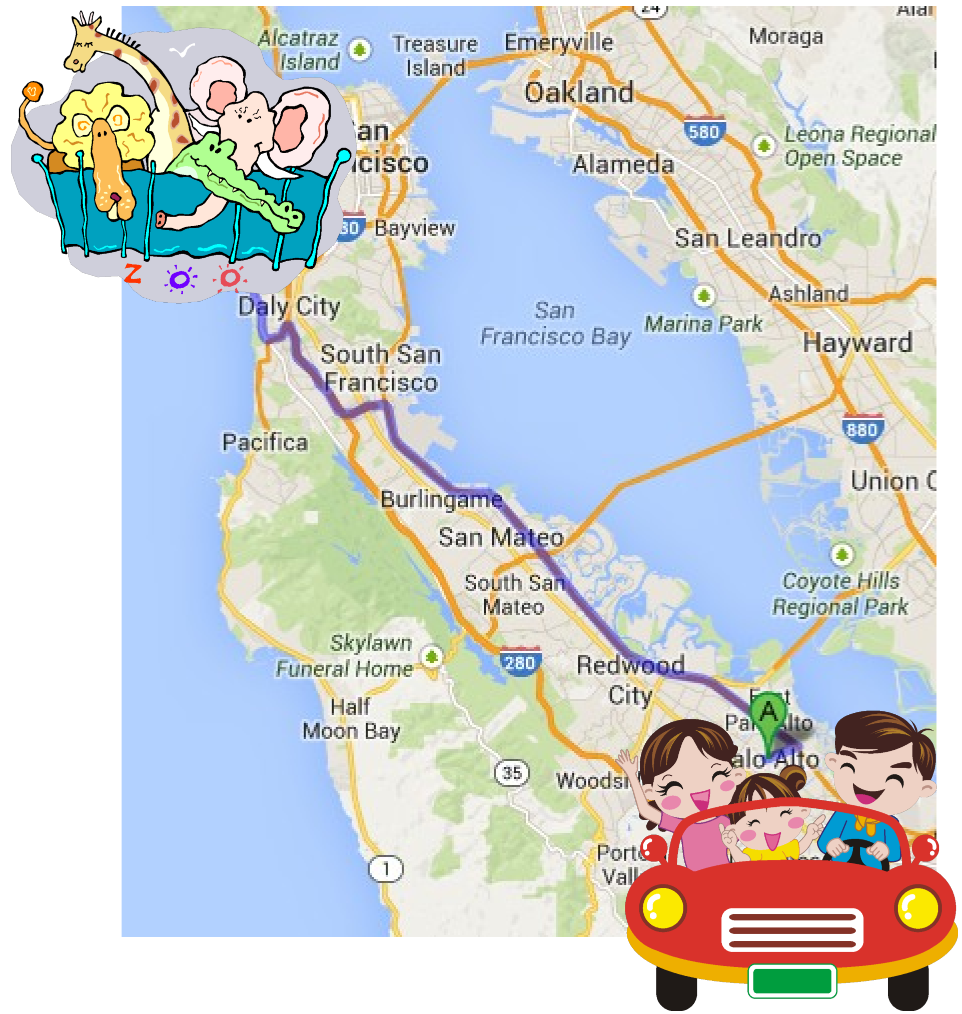
Brief Discussion of Transport Models

Four Stage Models (FSM)



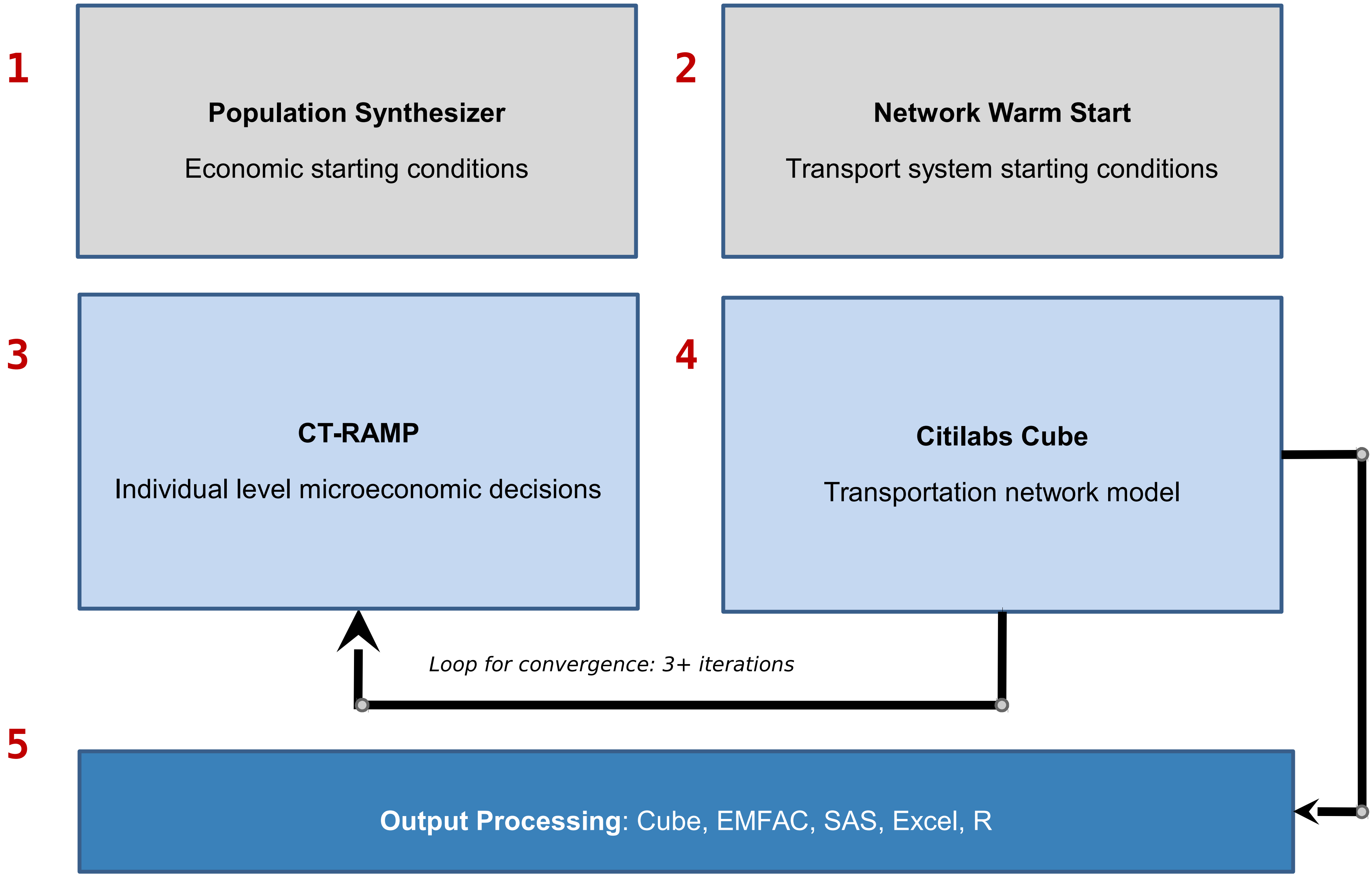
Zones, Aggregates, Physics

Activity-Based Approach (ABA)

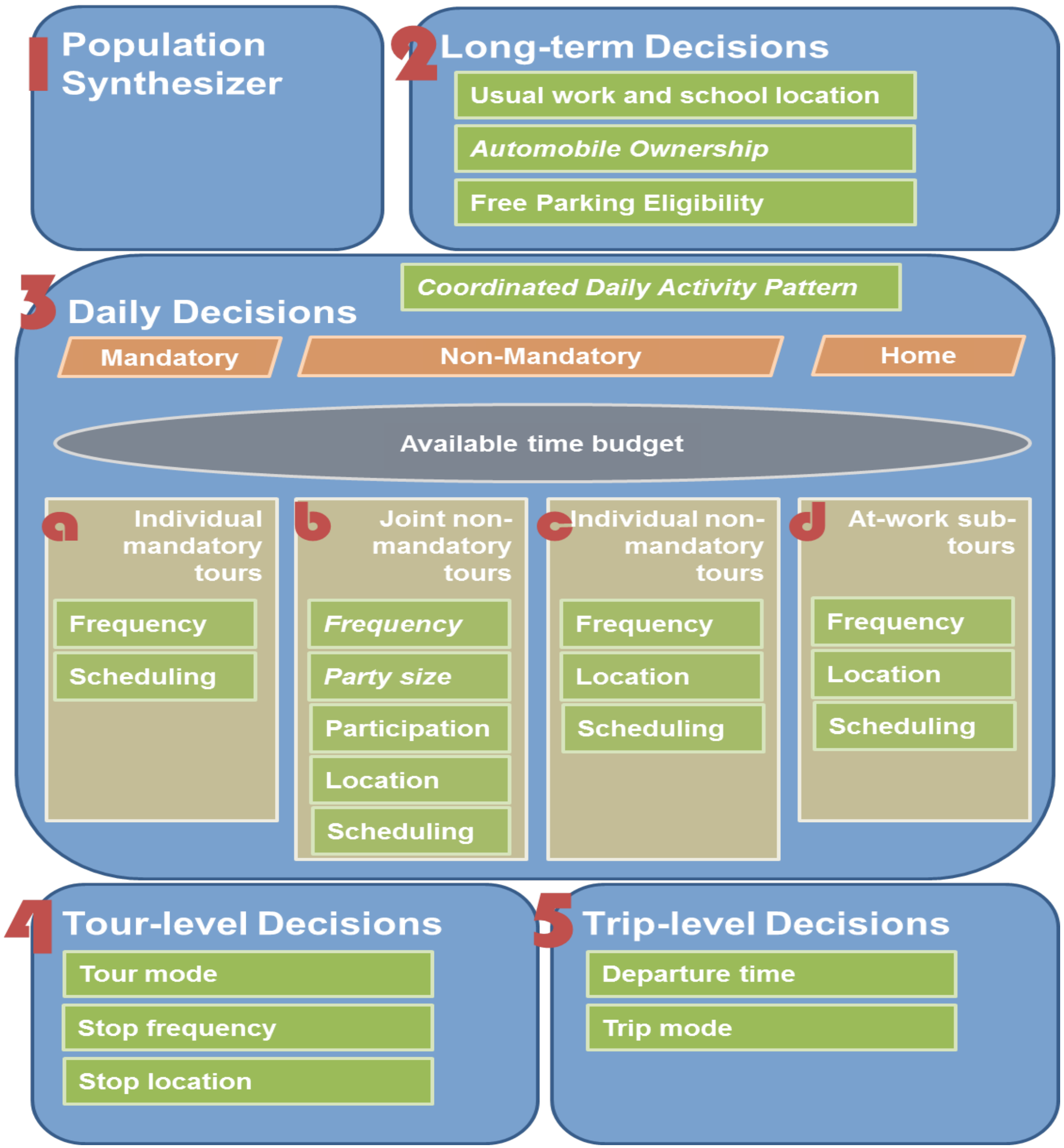


Individuals, Activities, Microeconomics

Travel Model One Logical Overview



CT-RAMP Schematic



Random Utility Model

$$U_{i,j} = V_{i,j}(X_{i,j} \mid \beta_{i,j}) + \epsilon_{i,j}$$

- Person *i* is choosing among discrete alternatives *J* (do I drive or walk)
- V is the deterministic (or representative) utility
- X is the observable factors (individual and alternative attributes)
- β estimated (or assumed) coefficient parameters.
- $\epsilon_{i,j}$ -A random term to capture the effect of unobserved attributes and the idiosyncratic preference person *i* has for alternative *j*

Model Modifications1

- Create scenarios on two primary dimensions:
  1. Value of in-vehicle time
  2. Roadway capacity
- Value of time
  - $V_{i,o,d,m} = c.ivt_m \bullet ivt_{o,d,m} + c.cost_m \bullet cost_{o,d,m}$ + (other terms)
  - i = person, o = origin, d = destination, m = travel mode
  - c.ivt = utility coefficient on travel time, ivt = travel time, c.cost = utility coefficient on $ costs, cost = $
  - We change the coefficient for automated vehicles
  - Affects dozens of decisions for each of millions of individuals
- Capacity
  - Change capacity / speed relationship in Citilabs transport network representation

Scenarios

Model scenarios considered		Roadway Capacity		
		(B) - Base	(L) - Low Base + 10%	(H) - High Base + 100%
In Vehicle Value of Time	(B) - Base	BB	-	BH
	(H) - High quality rail	-	HL	HH
	(L) - ½ current car	-	LL	LH
	(0) - Zero time cost	0B	-	0H

Results

- With automation can expect a short-run increase of 4-8% in daily vehicle miles travelled

Vehicle Miles Traveled *% Change from Base Case*		*Roadway Capacity*		
		Base (B)	*Low (L) + 10%*	*High (H) + 100%*
In Vehicle Value of Time	*(B) Base*	*0%*	*-*	*+2.0%*
	(H) High quality rail	*-*	*+4%*	*+5.2%*
	(L) ½ current car	*-*	*+6.7%*	*+7.9%*
	(0) Zero time cost	*+13.2%*	*-*	*+14.5%*

The unanswered questions...

- Long-term land-use adjustments
- Welfare and equity
- The role of policy
- Level 4 and shared economy (robotaxis)

Thank you!

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