Transferability of Activity-Based Travel Demand Model to Small/Medium Size Region

Presentation Prepared for AASHTO 2015 GIS-T Symposium
Des Moines, Iowa

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Date: April 22, 2015

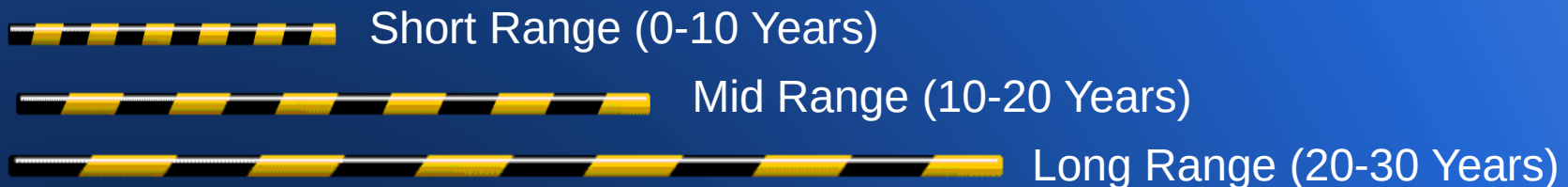
What is Travel Demand Model?

An Analysis tools that provides a systematic framework for replicating the travel demand (TRB, 2015).

TRB (2015). “Activity-Based Travel Demand Models: A Primer.” Strategic Highway Research Program 2 Washington, D.C.

Why Travel Demand Model?

- Transportation Investment Decision

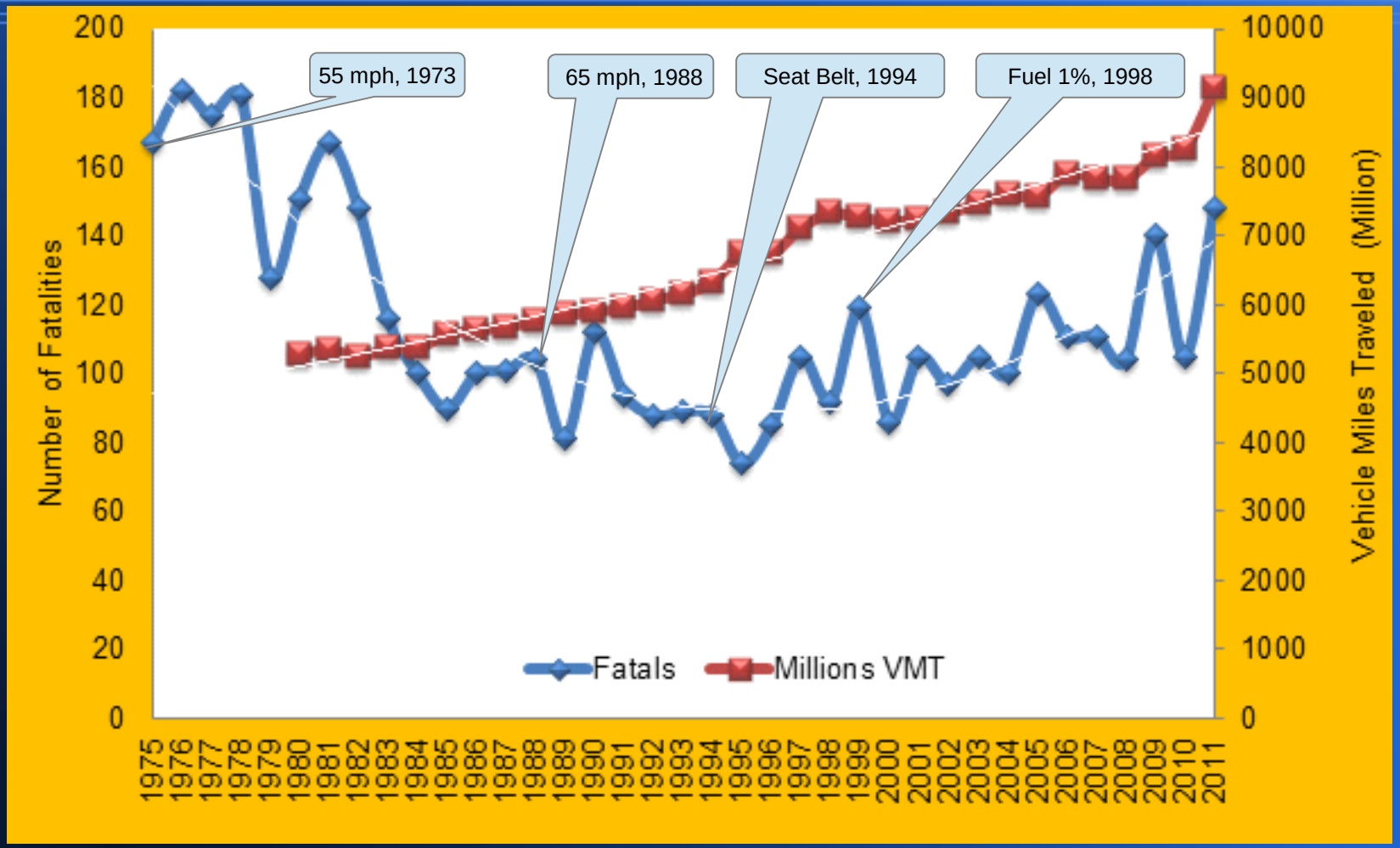


- Meet the travel demand
- Effect of socioeconomic and land use characteristics
- Secure institutional funding
- Safe and efficient transportation
- Comply with laws and regulations (MAP 21, ISTEA 1991)

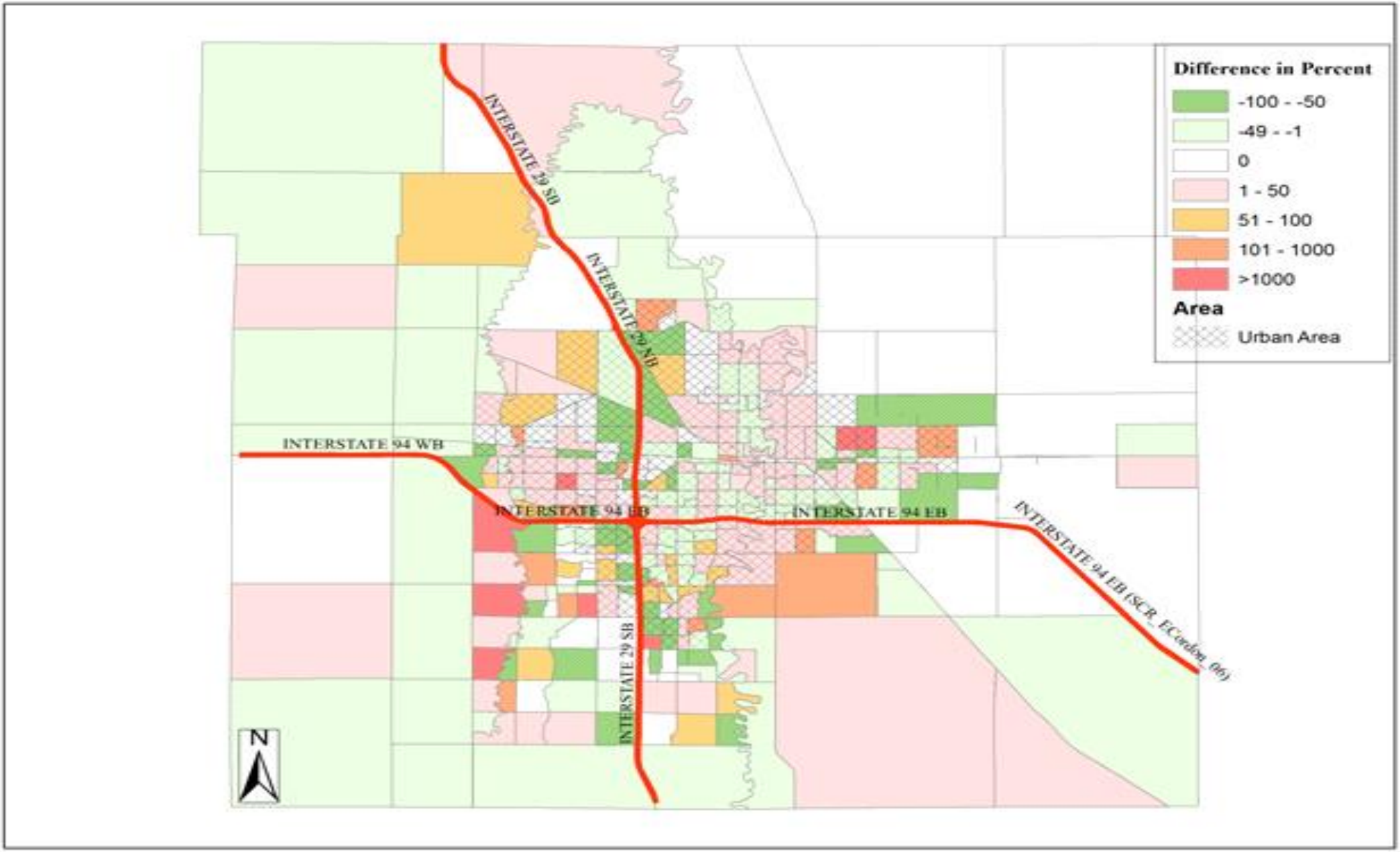
Who Requires Travel Demand Model?

- Metropolitan Planning Organizations (Federal Law, Populations 50,000)
- State Department of Transportation
- Local Agencies (City Government)

Why Fargo-Moorhead Metropolitan Area?



Population Differences 2000-2010?

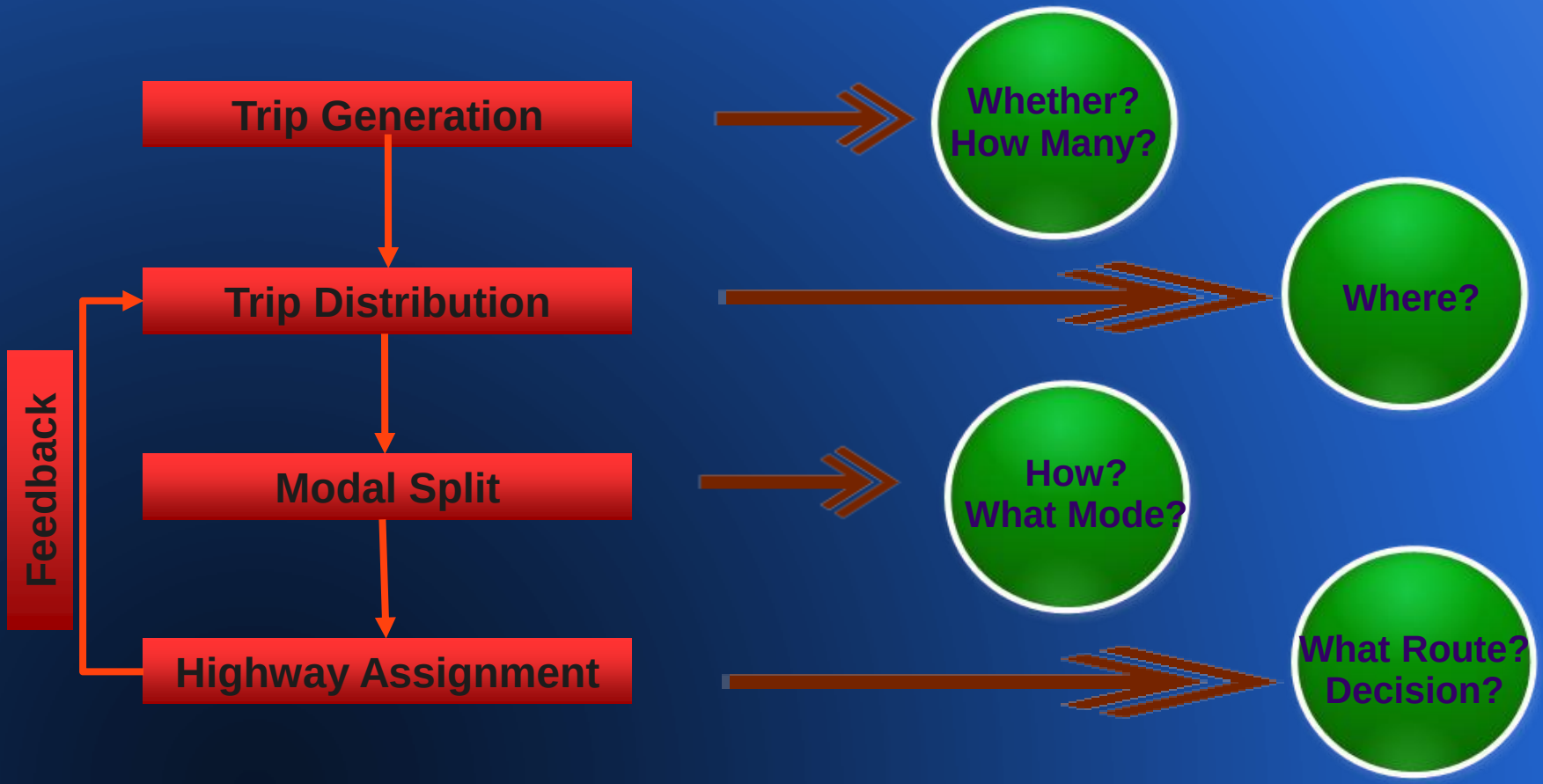


Why Fargo-Moorhead Metropolitan Area?

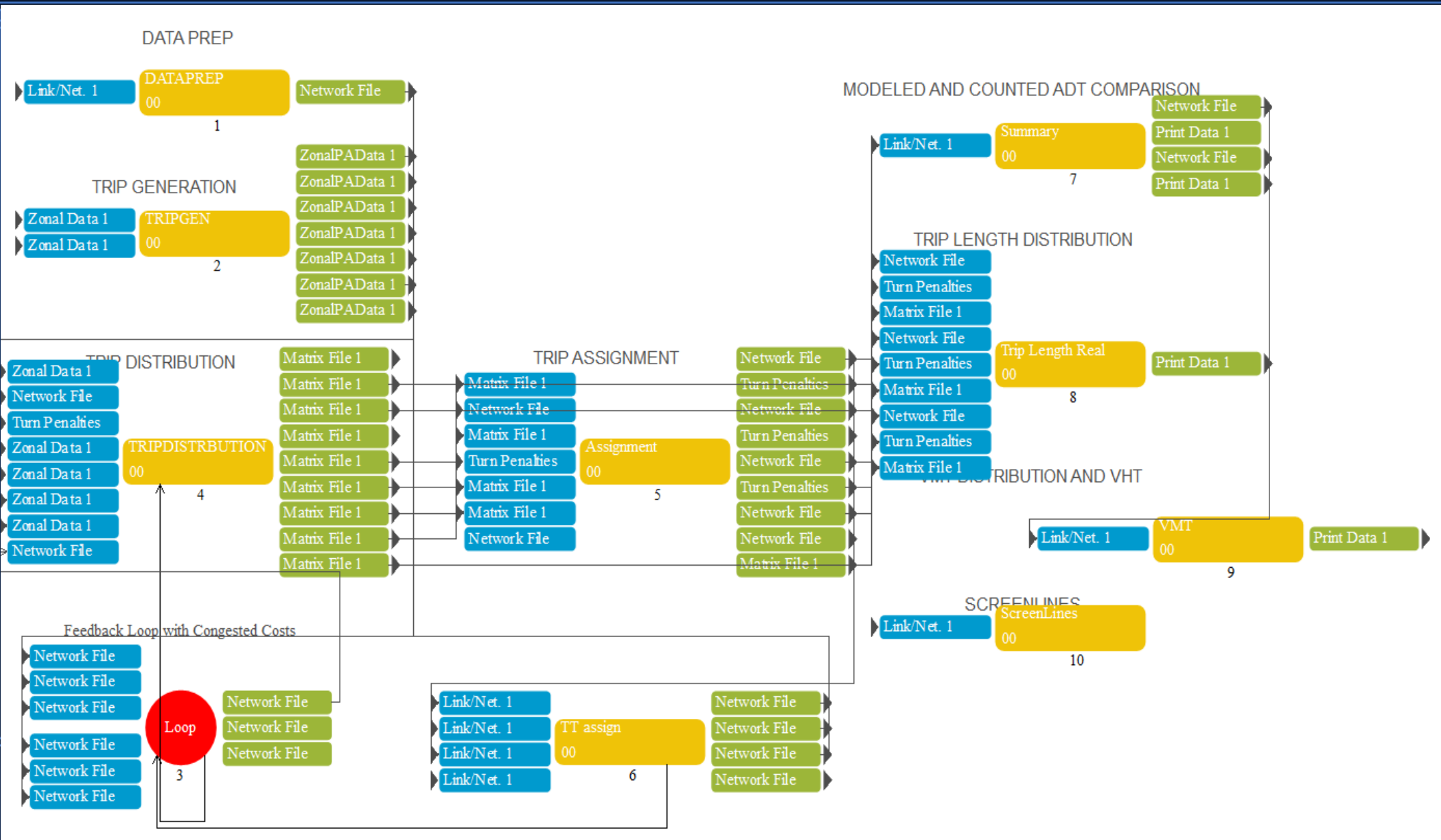
- Rapid surging population growth of Fargo-Moorhead metro area will be 40% more in 2040 than 2010 [1].
- Annual Average Economic Growth 2.5%
- Rapid development of South Fargo and West Fargo
- 95% of the workers, who lives in Cass and Clay counties works within Cass and Clay County may affect the radial commuting pattern
- Federal law requires as of population threshold and funding

[1]. Fargo-Moorhead Metropolitan Council of Governments. (2014). *2014 Long Range Transportation Plan.* Fargo, ND.

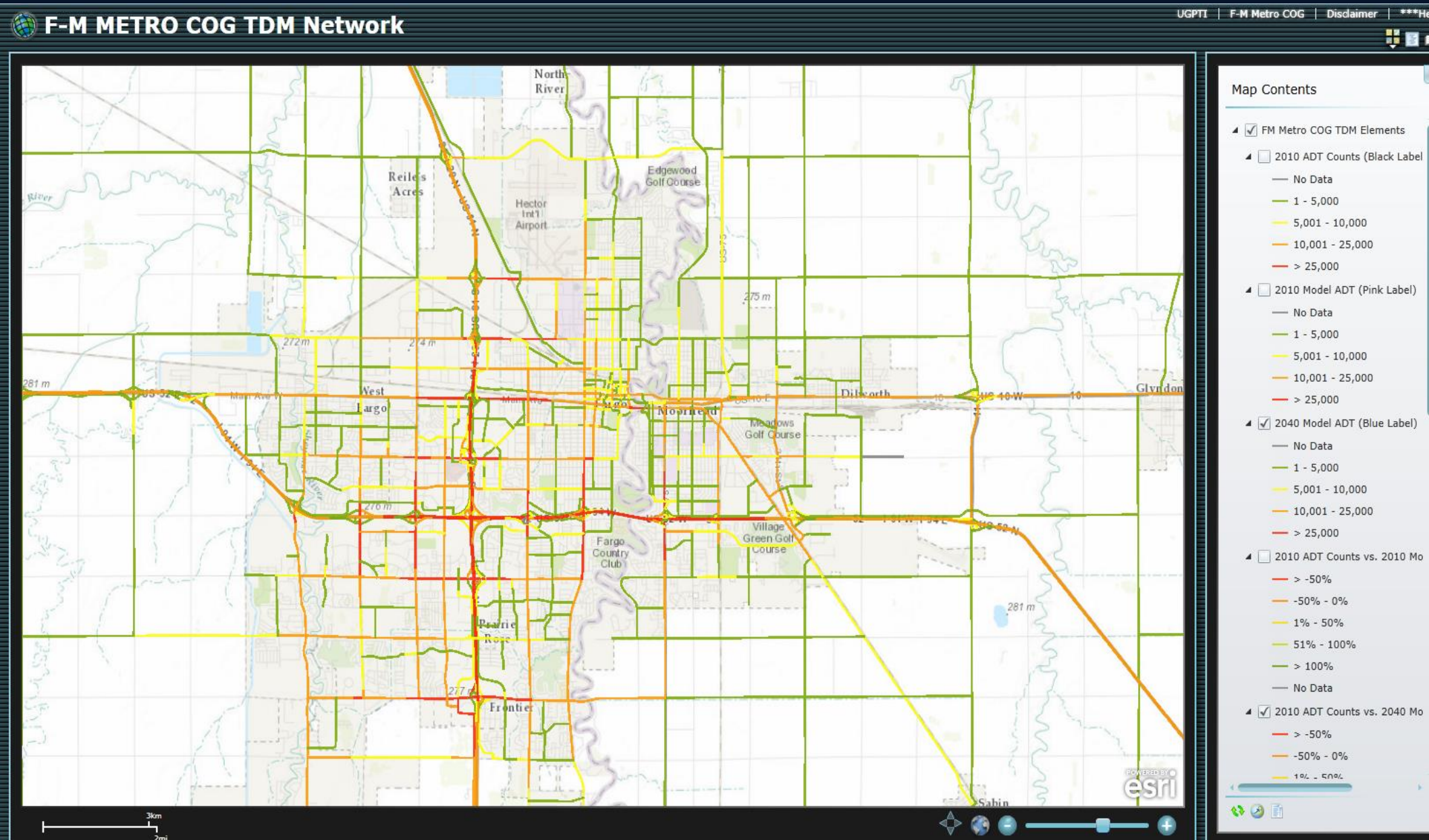
4-Steps TDM Framework



Framework Work of 4-Step TDM



Framework Work of 4-Step TDM?



Results of 4-Steps Model

- Model significantly capture the transportation scenarios
- Model significantly replicates within an acceptable value, 75% of observed traffic
- Showed strong correlations between model volume and traffic counts (R-Square=89%)
- Strong coincidence ration of 0.65
- VMT +/- 2% error ranges

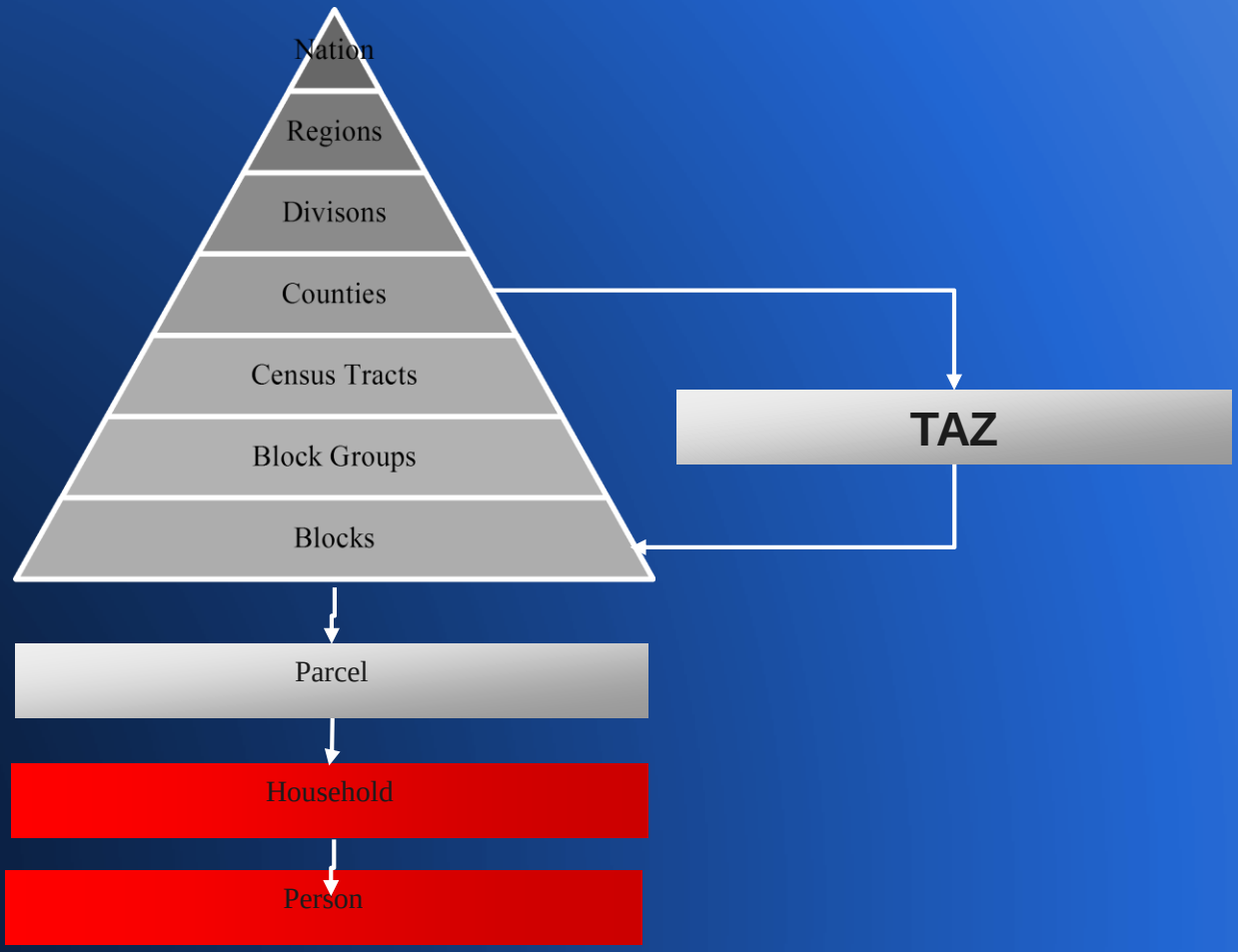
ABM Over Traditional Method

- Difficult to evaluate alternative investments: Better
- Spatial resolution (zonal level-low): Person and Household
- Temporal resolution (few period): Dynamic
- Low Person and household details information: More
- Demographic aggregation in zonal level: Person/Household
- Lacking transport derived demand: Derived
- Lack person/household discrete travel behavior: Replicate
- Lack Time and space interaction: Integrate

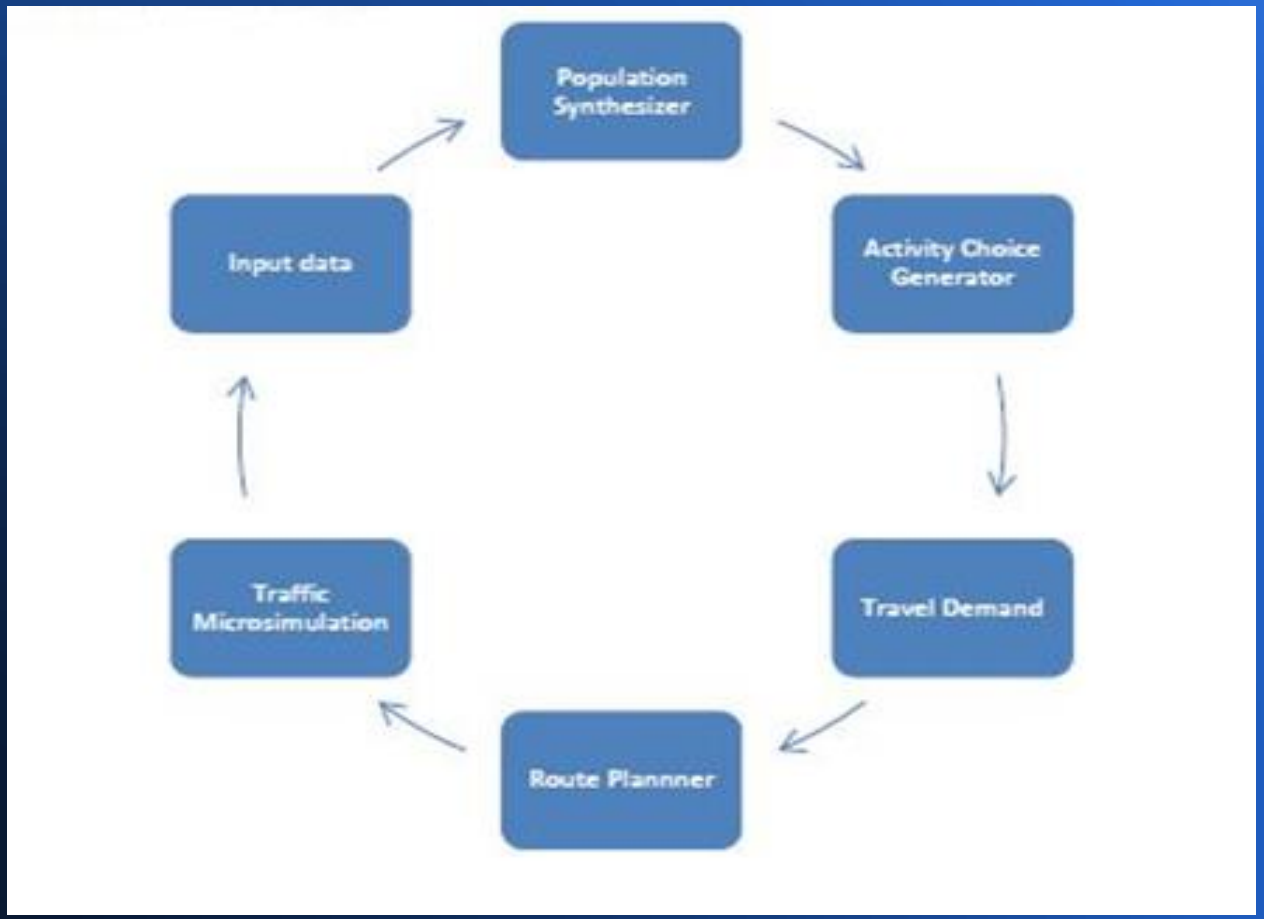
Research Objective

- Generation of Synthetic Populations for Developing Activity Based Travel Demand Model of Fargo-Moorhead Metro Council of Governments (FM Metro COG).

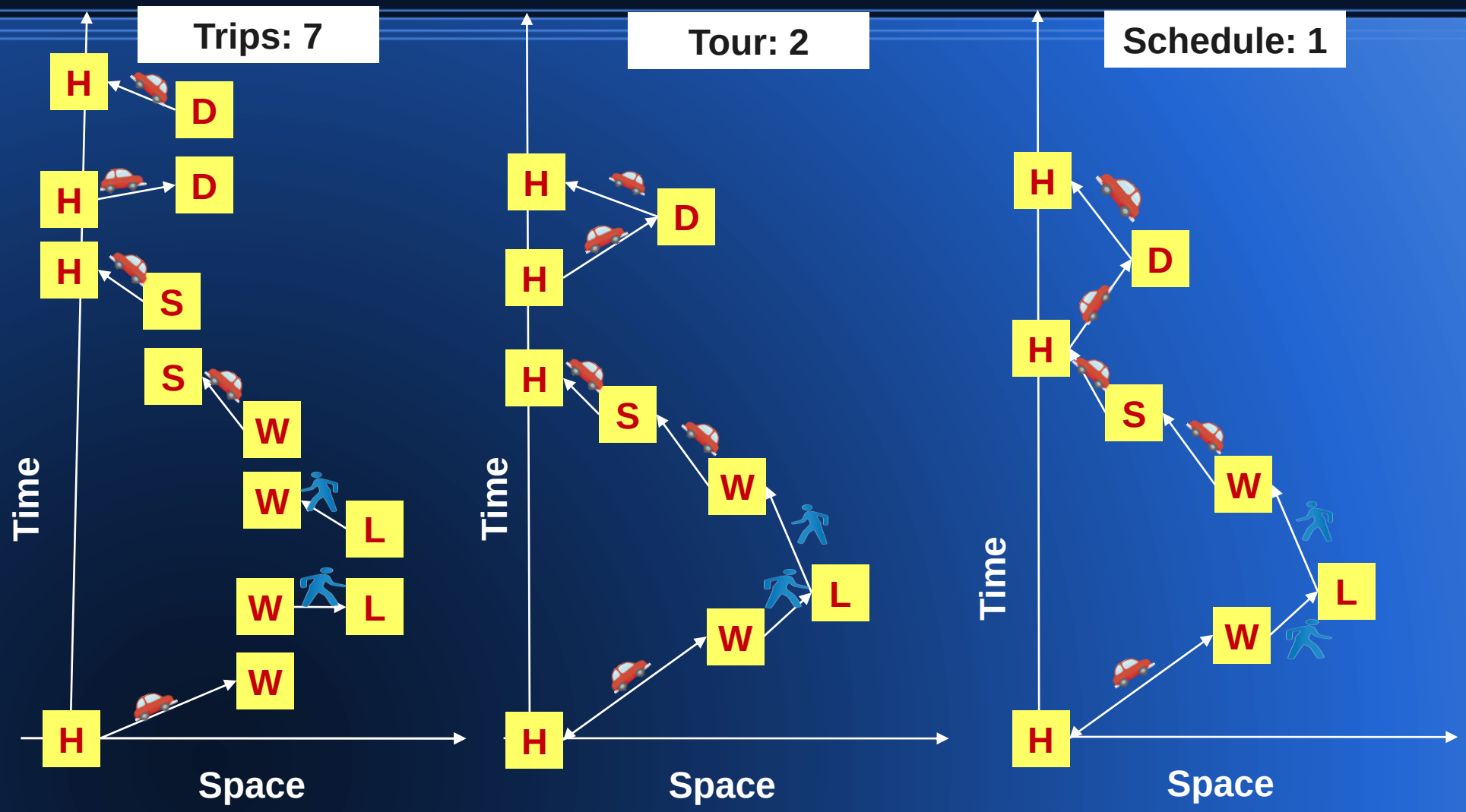
Level of ABM Modeling?



Conceptual Framework of ABM Modeling?



Concept of Activity-Based Model



Discrete Choice

- Travel Behavior consistent or inconsistent?

: Consistent and Inconsistent Both

- Is it random? Yes or No?

:Yes

- If random then how can we estimate?

:Probability

- How to capture this complex human behavior?

:Discrete choice

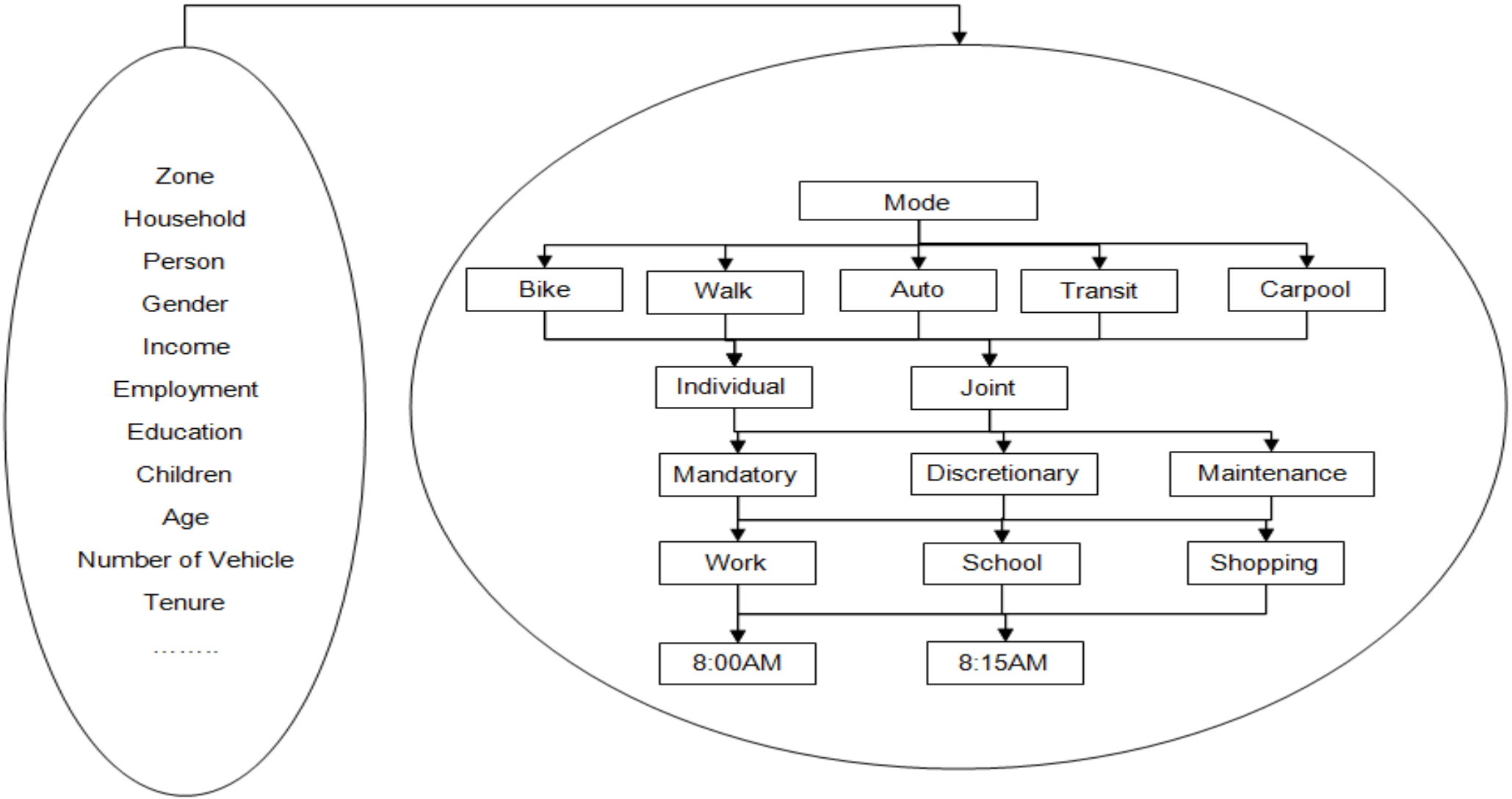
Discrete Choice

Elements of Choice Process

- Decision Maker (Individual, Household, Organizations)
- Alternatives (Modal Choice: Auto, Bike, Transit)
- Attributes of Alternatives (Alternative Specific and generic: Travel Time, Travel Cost, Waiting Time)
- Attributes of Alternatives (Decision Maker Characteristics: Income, Gender, Employment)
- Decision Rule (Utility Maximization, Ranking)

Koppelman, F.S. and Bhat, C. (2006). A Self Instructing Course in Mode Choice Mode Choice Modeling: Multinomial and Nested Logit Model. http://www.caee.utexas.edu/prof/bhat/COURSES/LM_Draft_060131Final-060630.pdf

Example Choice Process

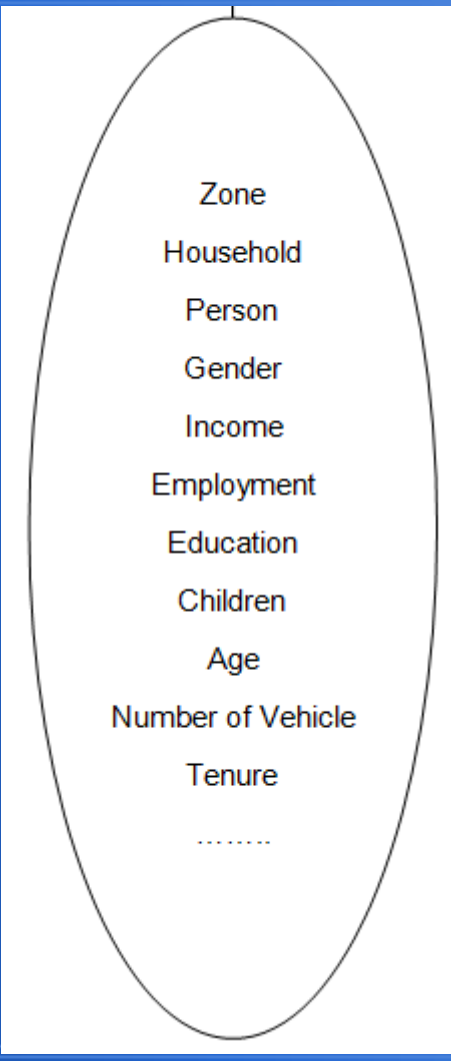


Population Synthesis

Data Collections

- How can we have this socioeconomic data?
    1. U.S. Census-Decennial?
    2. Local Survey Data?
    3. National Survey?
    4. PUMS 5%-ACS

Whole populations or what percentage?



Components of Population Synthesis

1. PUMS Data (ACS)
2. Iterative proportional fitting (Beckman et al. 1996)
3. Monte Carlo Simulation
4. Validations

Methodologies

- Iterative proportional fitting (More than 2-dimension)

Marginal Distribution

		Income				
		1	2	3	4	Total
Household	1	?	?	?	?	Y1
	2	?	?	?	?	Y2
	3	?	?	?	?	Y3
	4	?	?	?	?	Y4
	Total	X1	X2	X3	X4	XY

Sample Distribution

		Income				
		1	2	3	4	Total
Household	1	A1	A2	A3	A4	A5
	2	B1	B2	B3	B4	B5
	3	C1	C2	C3	C4	C5
	4	D1	D2	D3	D4	D5
	Total	E1	E2	E3	E4	E5

Methodologies

Resolve Issues of Iterative proportional fitting

1. Zero Cell Problem
2. Zero Marginal Problem
3. Rounding Problem
4. Household level

Zero Cell Problem

		Income				
		1	2	3	4	Total
Household	1	A1	A2	A3	A4	A5
	2	0	B2	B3	0	B5
	3	C1	C2	0	C4	C5
	4	D1	0	D3	D4	C6
	Total	E1	E2	E3	E4	E5

Zero Marginal Problem

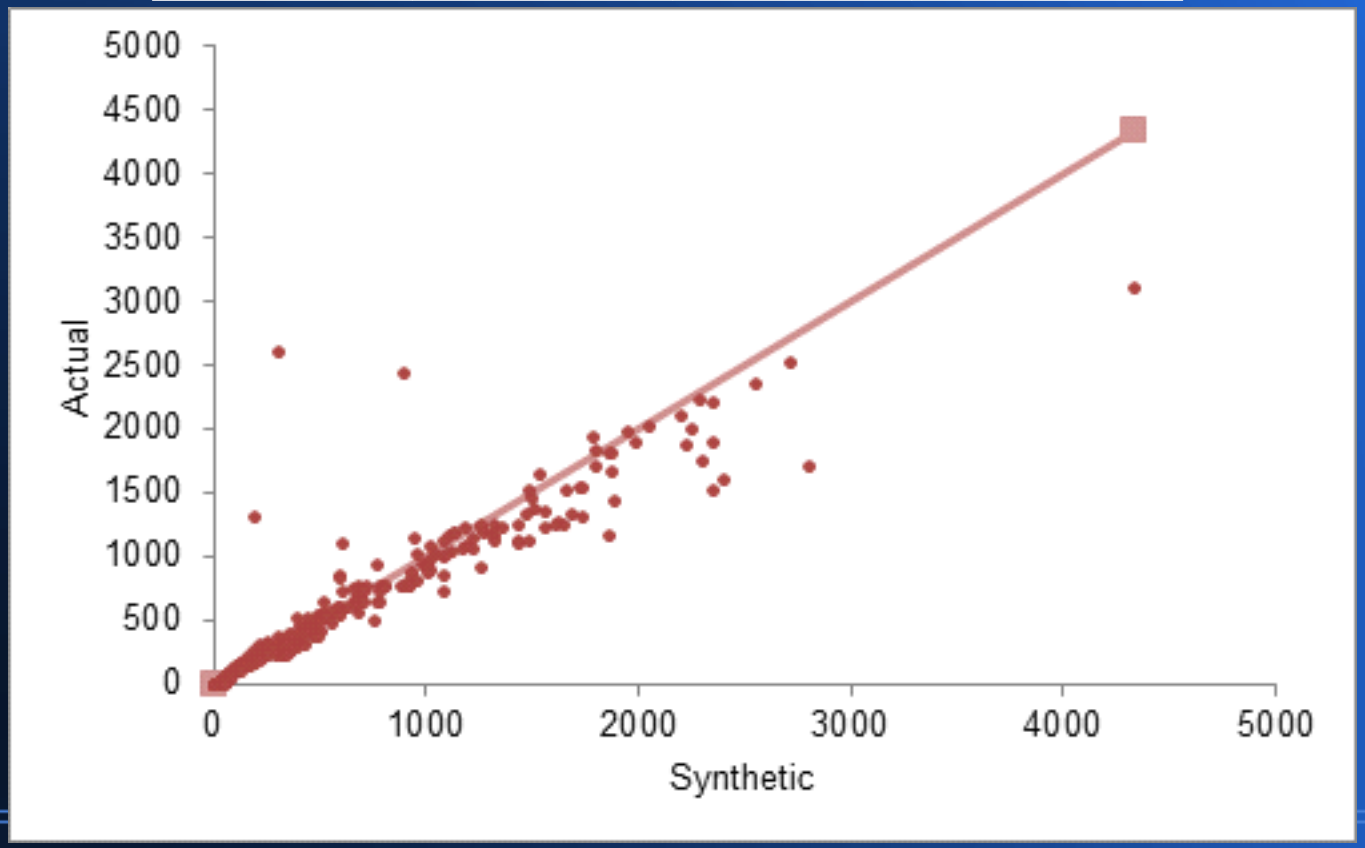
		Income				
		1	2	3	4	Total
Household	1	A1	A2	A3	A4	A5
	2	A2	B2	B3	A5	B5
	3	0	0	0	0	0
	4	D1	C3	D3	D4	C6
	Total	E1	E2	E3	E4	E5

Monte Carlo Simulations Results

Division	Variables	Dimension	Categories
Common level:			
	Zone ID Number	1	Unique Identifier
Household level:			
	Household ID Number	1	Unique Identifier
	Household Size	4	1, 2, 3, 4+
	Number of Vehicle	7	0, 1, 2, 3, 4, 5, 6
	Household Income	5	Less than 15K, 15K-30K, 30K-50K, 50K-75K, More than 75K
Person level			
	Person ID Number	1	Unique Identifier
	Sex	2	Male, Female
	Age	18	Less than 5, 5-9, 10-14, 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74, 75-79, 80-84, More than 84
	Employment Status	4	1, 2, 3, 4
	Individual Income	5	Less than 15K, 15K-30K, 30K-50K, 50K-75K, More than 75K

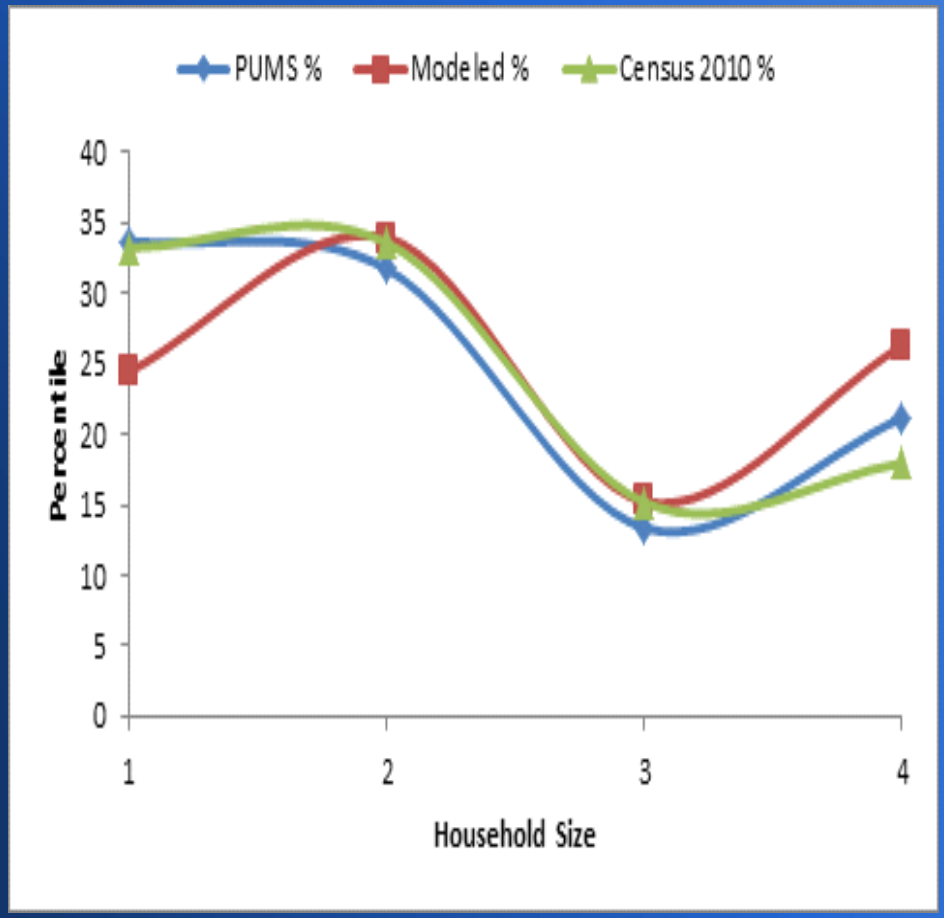
Monte Carlo Simulations Results

Observations	Synthetic	Error	Percent Error
183,721	199,897	16,176	8.8%



Monte Carlo Simulations Results

	Total	HH1	HH2	HH3	HH4+
Actual	77,298	25,697	25,967	11,736	13,898
Model	77,039	18,866	26,146	11,743	20,284
Difference	-259	-6,831	179	7	6,386
Error	-0.34%	-26.58%	0.69%	0.06%	45.95%



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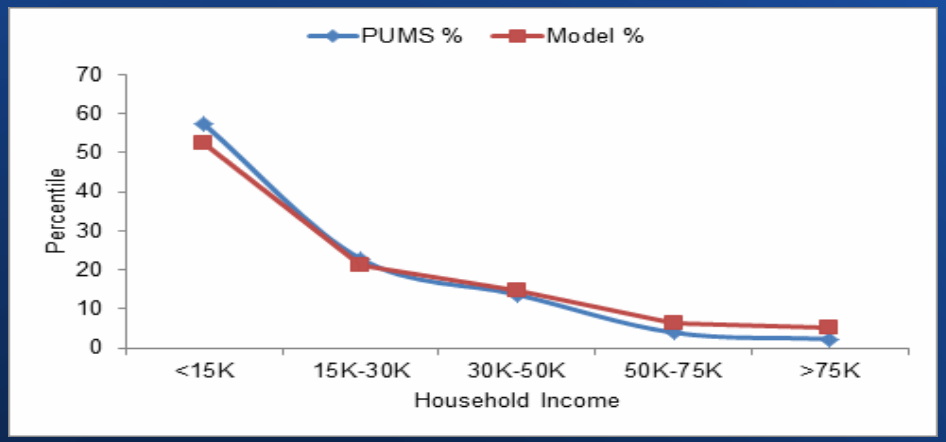
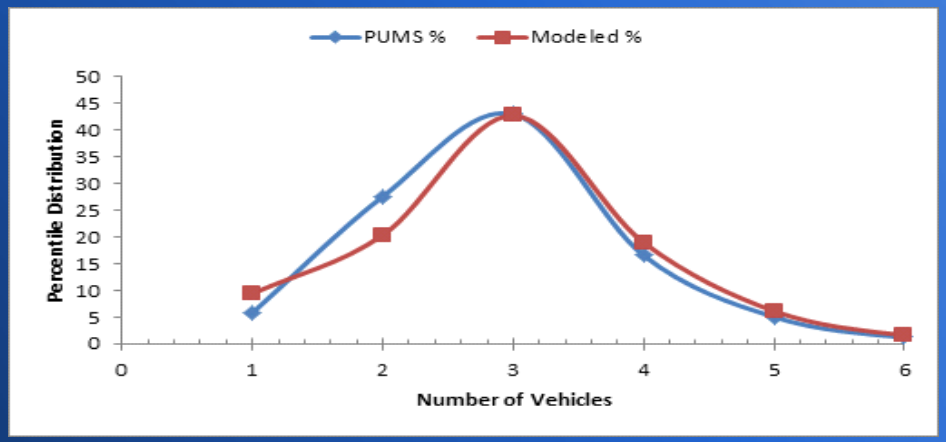
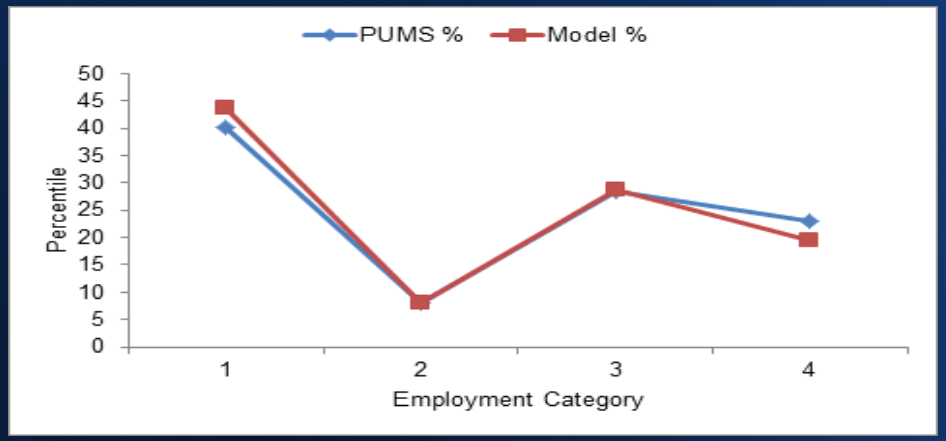
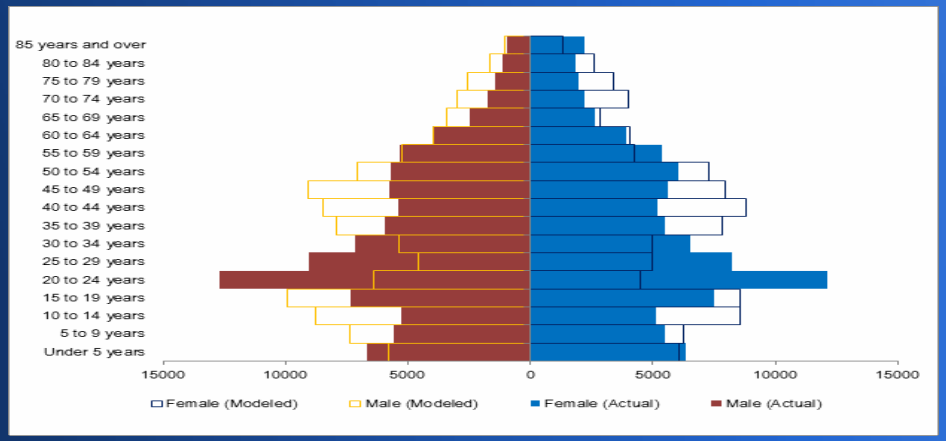




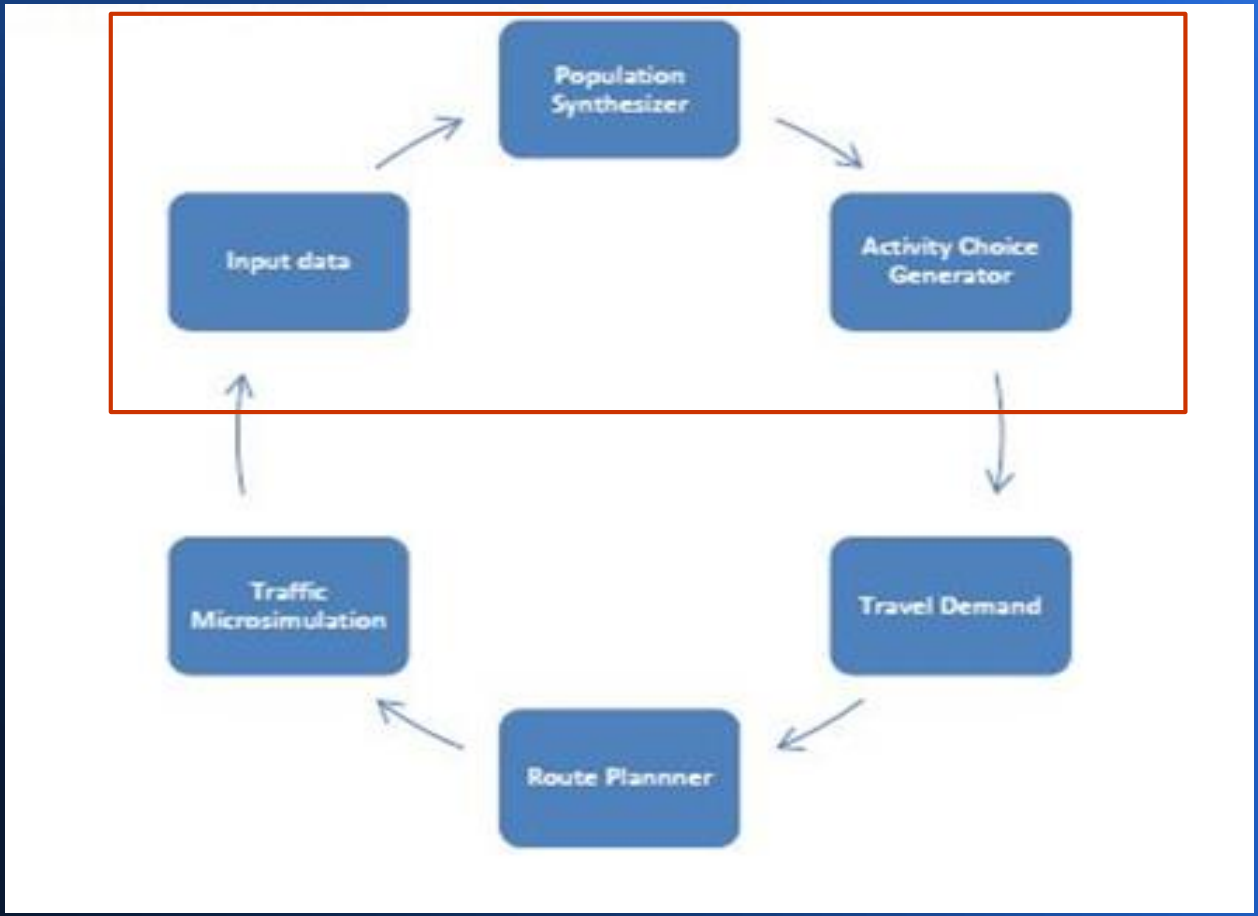




Conclusions

- Synthetic populations can be utilized reliably for activity based travel demand model
- In the absence of survey data, synthetic populations data could be used for many transportation decision making process
- Care should be taken while using gender related sub-model into the decision making
- Iterative proportional fitting rounding error does not have significant effect on synthetic populations
- More accurate synthetic populations could be developed if the 5% PUMS Sample data collected by American community Survey may consider Metropolitan Planning Area boundary as the base instead of Public Use Microdata Area (PUMA) boundary. (PUMA is larger than the MPA).

Next Phase


Population Synthesizer
Activity Choice Generator
Travel Demand
Route Plannner
Traffic Microsimulation
Input data

Acknowledgments

- Fargo-Moorhead Metropolitan Council of Governments
- Advanced Traffic Analysis Center - UGPTI
- Department of Construction Management and Engineering, NDSU
- Department of Civil and Environmental Engineering, NDSU
- Special thanks to Dr. Matthew L Stone (CME) and Dr. Diomo Motuba (ATAC-UGPTI)
- Special thanks to Dr. Yong Bai (Chair-CME), Dr. EunSu Lee (UGPTI), Dr. Ying Huang (CEE), Mr. Bradley Wentz (Director-ATAC, DOTSC), Dr. Peter Oduor (GEO)
- Thanks to Ingrid Scarski and Ann Denney (CME Staff)

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