

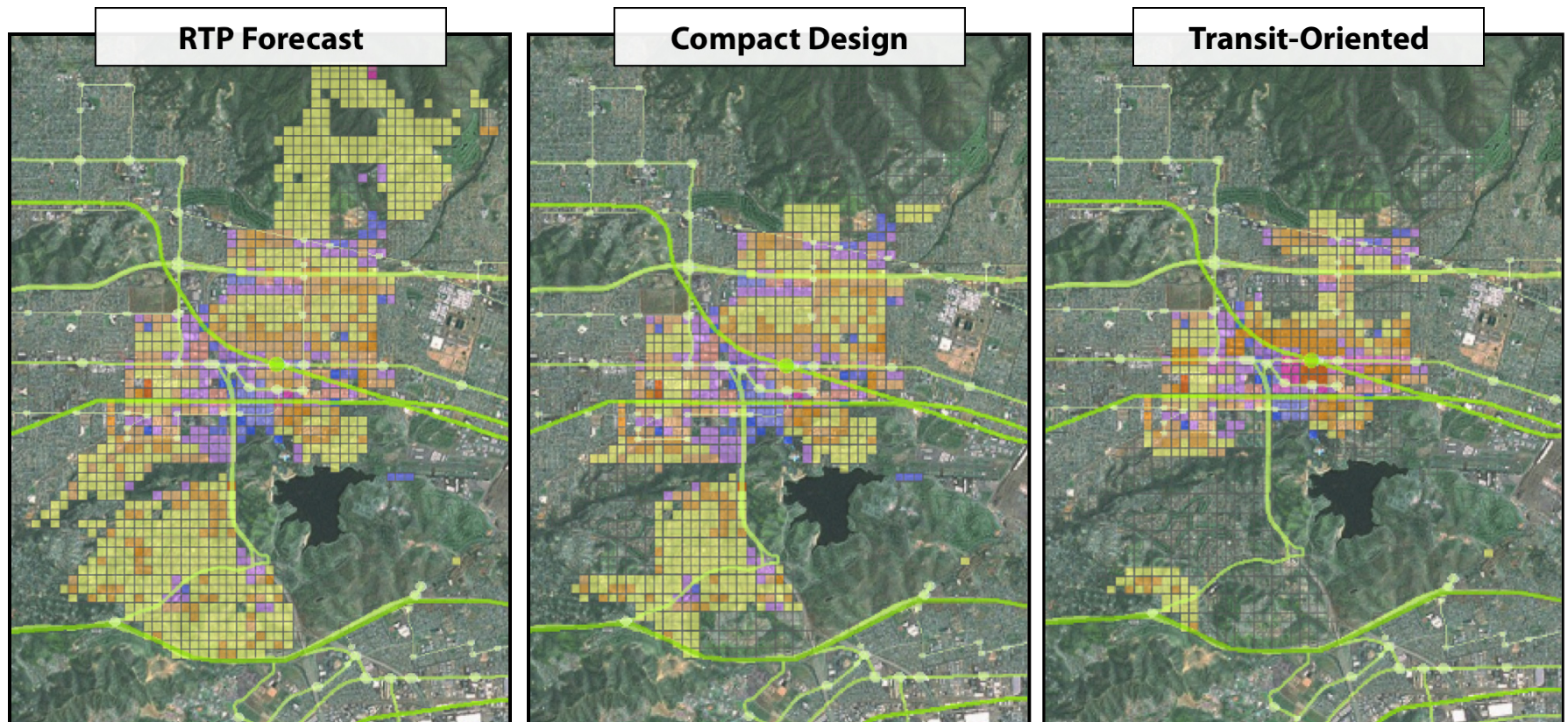


**ET+**

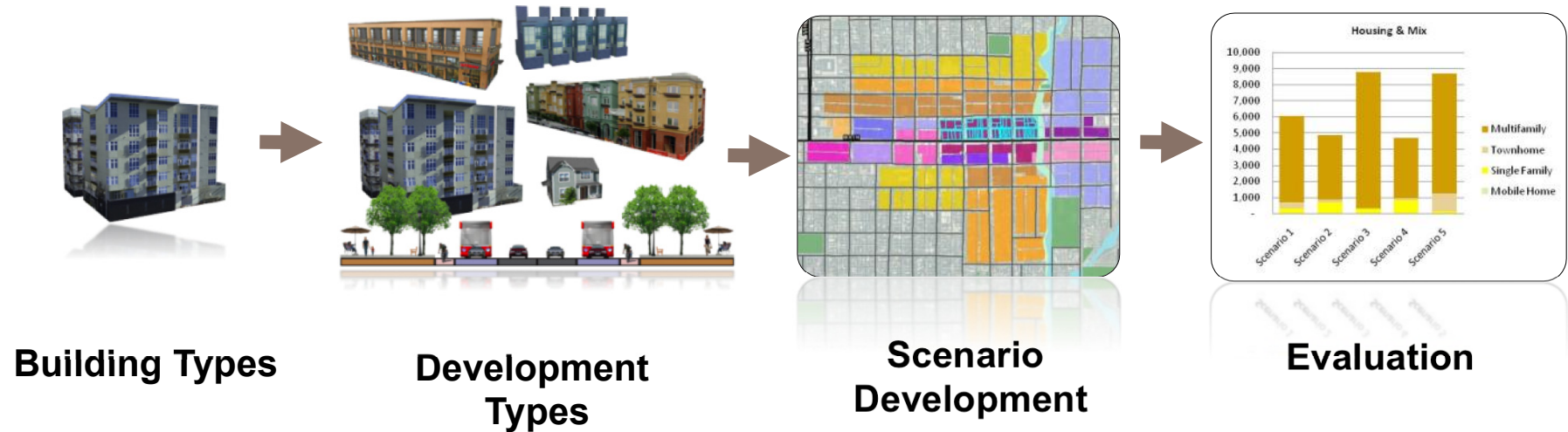
**Metropolitan Research Center – University of Utah**  
**Fregonese Associates**  
**Envision Utah**  
**Salt Lake County**  
**Wasatch Front Regional Council**

# Compare Multiple Scenarios

- Test land use policies
- Experiment with new development patterns



# Scenario Building Process



4

**Step 4: Compare the scenarios and monitor the impact of land use decisions in real-time.**

# Scenario Indicators:

- *Anything we can know about a building, we can know about a scenario...*
  - Housing and Jobs: mix and density
  - Jobs-Housing Balance
  - Land Consumption: vacant, agricultural, infill
  - Impervious Surface
  - Open Space
  - Housing Affordability
  - Resource Usage: energy and water
  - Waste Production: water, solid, carbon
  - Transportation: travel mode choice, vehicle miles traveled
  - Fiscal Impact: local revenue and infrastructure costs
  - Balanced Housing Index: how scenario housing mix matches expected future demographic profile

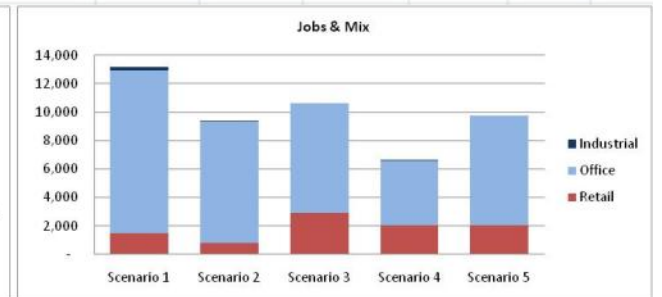
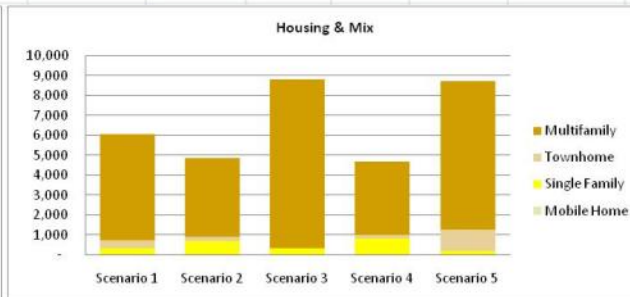
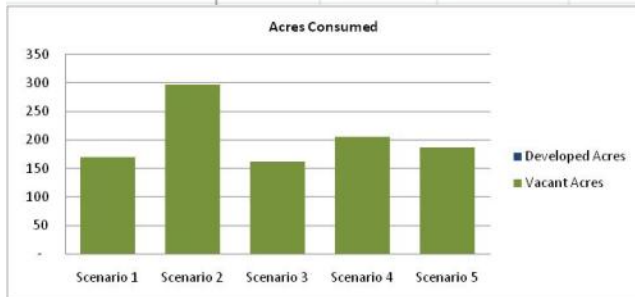
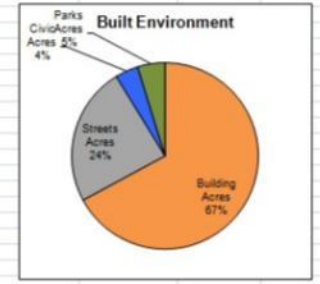
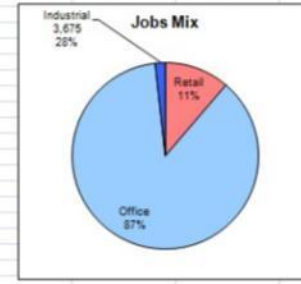
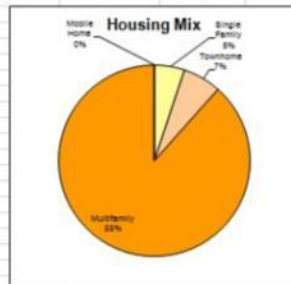
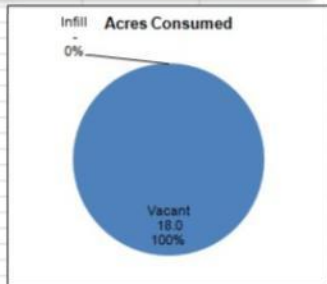


# Monitor Indicators in Real-time

## Detailed Tables

Enter Scenario Name or Theme	Acres Consumed			Total Acres	Total Housing Units	Housing Mix				Total Jobs	Employment Mix			Built Environment			
	Total Vacant Acres	Total Developed Acres	Discounted Developed Acres ("ReDev %")			Single Family	Townhome	Multifamily	Mobile Home		Retail	Office	Industrial	Building Acres	Streets Acres	Civic Acres	Parks Acres
Urban Core	13.6	-	-	13.6	2,179	-	-	2,179	-	11,838	888	10,950	-	9.26	3.40	0.54	
City Center	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Town Center	3.4	-	-	3.4	343	-	-	343	-	121	121	-	2.32	0.85	0.14		
Village Center	3.2	-	-	3.2	132	-	-	132	-	113	113	-	2.17	0.80	0.13		
Mixed-Use Corridor	5.7	-	-	5.7	149	-	-	149	-	199	199	-	3.80	1.42	0.23		
Main Street	4.0	-	-	4.0	2,567	-	-	2,567	-	-	-	-	2.65	0.99	0.16		
City Neighborhood	24.5	-	-	24.5	344	-	344	-	-	-	-	-	16.44	6.14	0.98		
Town Neighborhood	4.0	-	-	4.0	50	-	50	-	-	-	-	-	2.67	1.00	0.16		
Village Neighborhood	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Suburban Residential	35.9	-	-	35.9	210	210	-	-	-	-	-	-	24.07	8.62	1.44		
Rural Residential	34.3	-	-	34.3	100	100	-	-	-	-	-	-	22.96	8.23	1.37		
Office Park	1.9	-	-	1.9	-	-	-	-	-	487	-	487	1.30	0.47	0.08		
Regional Retail	5.6	-	-	5.6	-	-	-	-	-	98	98	-	3.74	1.28	0.22		
Strip Commercial	2.1	-	-	2.1	-	-	-	-	-	62	62	-	1.42	0.49	0.08		
Flex Park	3.7	-	-	3.7	-	-	-	-	-	27	-	27	2.51	0.86	0.15		
Industrial Park	27.5	-	-	27.5	-	-	-	-	-	201	-	201	18.42	6.32	1.10		
<b>Totals</b>	<b>169.5</b>	<b>-</b>	<b>-</b>	<b>169.5</b>	<b>6,073</b>	<b>310</b>	<b>394</b>	<b>5,370</b>	<b>-</b>	<b>13,145</b>	<b>1,480</b>	<b>11,437</b>	<b>228</b>	<b>114</b>	<b>41</b>	<b>7</b>	
						5.1%	6.5%	88.4%	0.0%		11.3%	87.0%	1.7%	67.1%	24.1%	4.0%	

## Quick Reference Graphs



# Apps (requiring travel inputs in green)

- Predictive Growth Model
- Building and Land Use Types
- Building Energy Consumption
- 7D Transportation Impacts
- Return of Investment
- H + T Costs
- Air Quality and Climate Impacts
- Fiscal Impact
- Public Health

# Apps (requiring travel inputs in green)

- Employment Growth
- Employment Resilience
- Development Capital
- Redevelopment Timing
- Water Consumption
- Transportation Safety
- Workforce Housing
- LEED-ND Application
- Public Assets

# 7D App



Through pioneering research, University of Utah faculty have modeled the effects of **density** (built space per acre), **diversity** (land-use mix), **distance** to transit, **destination** accessibility, land-use connectivity through **design, development** scale, and **demographics** – the 7Ds, on internal capture of trips within mixed-use developments (MXDs); external trips by walking, transit, and private vehicle; and vehicle miles traveled (VMT).

**ET+** will be expanded to include all trips and will develop interactive coefficients to calculate internal capture, walk, transit, and private vehicle trips, and VMT for comparison to current conditions and future scenarios advancing 7D interactions.



# 7D Analysis - Innovations



- Pooled household travel data for MXDs in six diverse regions
- Identified 239 MXDs through a bottom-up survey process
- Included internal capture, mode choice for external trips, and trip length as travel outcome measures

# Additional Innovations



- Estimated large number of 7D variables consistently across regions
- Modeled travel relationships hierarchically
- Validated results through comparison to traffic generation counts at an independent set of mixed use sites in various parts of the U.S.

# Six Diverse Regions



- Atlanta
- Boston
- Houston
- Portland
- Sacramento
- Seattle

# Regions Based on Data Availability



- Provide XY coordinates for trip ends, so we could zero in on individual sites when studying travel patterns to, from, and within MXDs
- Provide individual parcel data, so we could study land-use mix down to the parcel level

# Identifying MXDs



- Top-Down GIS-Based Approach
  - VS.
- Bottom-Up Expert-Based Approach

# New MXD Definition



- ...A ***mixed-use development*** or district consists of two or more land uses between which trips can be made using local streets, without having to use major streets. The uses may include residential, retail, office, and/or entertainment. There may be walk trips between the uses.


# Example – RiverPlace (Portland)



Internal capture = 36%  
Walking – 14%  
Transit – 9%  
Auto Trips – 7.7 miles



# 239 MXDs



<b>Metro</b>	<b>Survey Year</b>	<b>MXDs</b>	<b>Mean Acreage per MXD</b>	<b>Total Trip Ends</b>	<b>Mean Trip Ends per MXD</b>
<b>Atlanta</b>	<b>2001</b>	<b>24</b>	<b>287</b>	<b>6,167</b>	<b>257</b>
<b>Boston</b>	<b>1991</b>	<b>59</b>	<b>175</b>	<b>3,578</b>	<b>61</b>
<b>Houston</b>	<b>1995</b>	<b>34</b>	<b>401</b>	<b>1,584</b>	<b>47</b>
<b>Portland</b>	<b>1994</b>	<b>53</b>	<b>116</b>	<b>6,146</b>	<b>116</b>
<b>Sacramento</b>	<b>2000</b>	<b>25</b>	<b>179</b>	<b>2,487</b>	<b>99</b>
<b>Seattle</b>	<b>1999</b>	<b>44</b>	<b>207</b>	<b>15,915</b>	<b>362</b>
<b>Total</b>		<b>239</b>	<b>211</b>	<b>35,877</b>	<b>150</b>



# Multiple Outcome Measures



- INTERNAL – Dummy variable indicating that the trip remained within the development
- WALK – Dummy variable indicating that the travel mode on a trip is walking (1=walk mode, 0=other)
- TRANSIT - Dummy variable indicating that the travel mode on a trip is public bus or rail (1=transit, 0=other)
- TDIST - Network trip distance between origin and destination locations for an external private vehicle trip, in miles

# 7D variables consistently defined



- **Density**
- **Diversity**
- **Design**
- **Destination Accessibility**
- **Distance to Transit**
- **Development Scale**
- **Demographics**

# Individual Level Variables



- HHSIZE – Number of members of the household
- VEHCAP – Number of motorized vehicles per person in the household
- BUSSTOP – Dummy variable indicating that the household lives within  $\frac{1}{4}$  mile of a bus stop (1=yes, 0=no)

# MXD Level Variables



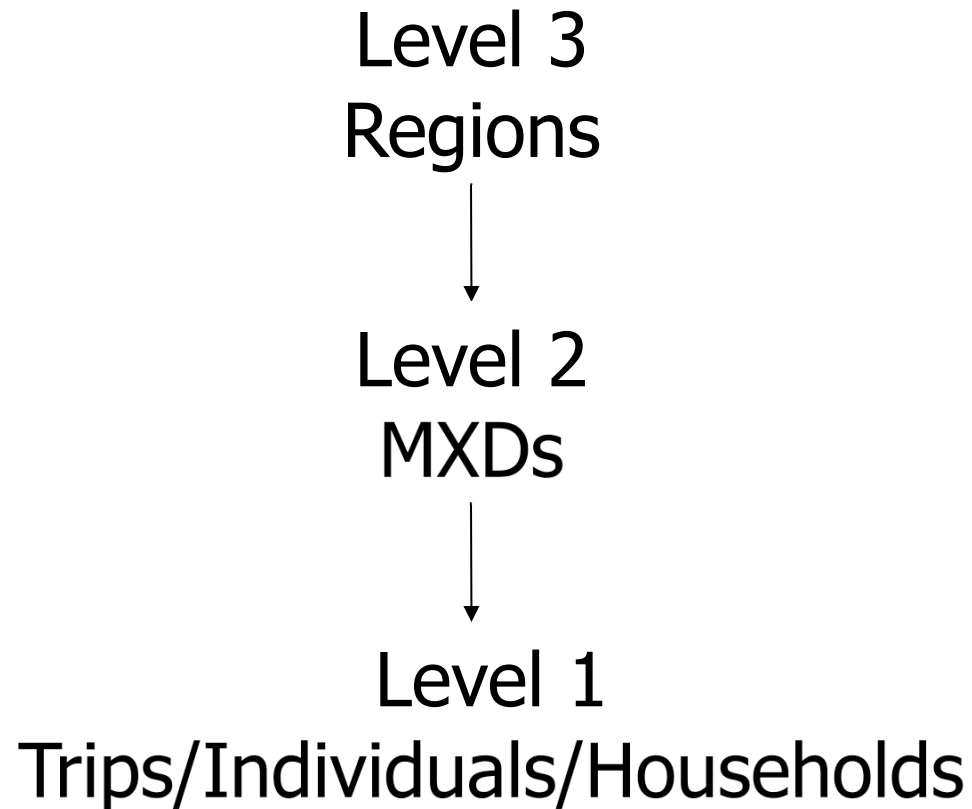
- ACTDEN – Population + employment density per square mile
- JOBPOP – Balance of jobs to population within the MXD
- LANDMIX – Entropy index that captures the variety of land uses based on acreage
- INTDEN - Number of intersections within the MXD per square mile of gross area
- EMPMILE – Total employment within one mile of the traffic analysis zones intersecting the MXD
- EMP30T – Total employment within 30 minutes by transit of traffic analysis zones intersecting the MXD
- STOPDEN – Number of bus stops within the MXD per square mile of gross area
- RAIL – Rail station located within the MXD (1 = yes, 0=no)

# Region Level Variables



- REGPOP – Population within the region
- REGEMP – Employment within the region
- REGACT – Activity within the region  
(population + employment)
- SPRAWL – Measure of overall regional  
sprawl from same source

# Hierarchical Modeling



# Log odds of internal capture (log-log form)

	Home-Based Work			Home-Based Other			Non-Home Based		
	Coeff	t-ratio	p-value	Coeff	t-ratio	p-value	Coeff	t-ratio	p-value
<b>constant</b>	-1.75			-2.43			-5.72		
<b>EMP</b>							0.208	3.28	0.002
<b>AREA</b>				0.486	3.61	0.001	0.468	4.58	<0.001
<b>JOBPOP</b>	0.389	2.62	0.010	0.399	4.55	<0.001			
<b>INTDEN</b>				0.385	1.92	0.055	0.638	4.95	<0.001
<b>HHSIZE</b>	-1.33	-6.03	<0.001	-0.867	-13.0	<0.001	-0.237	-4.54	<0.001
<b>VEHCAP</b>	-0.990	-4.15	<0.001	-0.590	-8.19	<0.001	-0.163	-3.00	0.003
pseudo-R2		0.01			0.20			0.30	

# Log odds of walking on external trips (log-log form)

	Home-Based Work			Home-Based Other			Non-Home Based		
	Coeff	t-ratio	p-value	Coeff	t-ratio	p-value	Coeff	t-ratio	p-value
<b>constant</b>	-5.55			-10.96			-15.09		
<b>AREA</b>				-0.415	-4.27	<0.001			
<b>ACTDEN</b>				0.370	2.74	0.007	0.377	3.12	0.003
<b>JOBPOP</b>	0.226	2.46	0.015	0.219	3.83	<0.001			
<b>INTDEN</b>							0.803	5.05	<0.001
<b>EMPMILE</b>	0.385	3.12	0.002	0.450	5.05	<0.001	0.440	5.09	<0.001
<b>HHSIZE</b>	-1.57	-6.29	<0.001	-0.486	-5.05	<0.001	-0.281	-2.59	0.010
<b>VEHCAP</b>	-1.84	-7.00	<0.001	-0.768	-7.62	<0.001	-0.242	-2.13	0.033
pseudo-R2	0.19			0.51			0.64		



# Log odds of using transit on external trips (log-log form)

	Home-Based Work			Home-Based Other			Non-Home Based		
	Coeff	t-ratio	p-value	Coeff	t-ratio	p-value	Coeff	t-ratio	p-value
<b>constant</b>	-4.32			-6.08			-2.69		
<b>ACTDEN</b>				0.324	2.89	0.005			
<b>INTDEN</b>	1.12	4.44	<0.001						
<b>EMP30T</b>	0.209	2.98	0.004				0.134	3.29	0.002
<b>HHSIZE</b>	-1.14	-6.31	<0.001	-0.958	-8.48	<0.001			
<b>VEHCAP</b>	-1.68	-8.56	<0.001	-1.09	-8.24	<0.001	-0.340	-3.74	<0.001
<b>BUSSTOP</b>	0.357	2.08	0.037	0.467	4.04	<0.001			
pseudo-R2	0.47			NA			NA		

# Distance of external automobile trips (semi-log form)

	Home-Based Work			Home-Based Other			Non-Home Based		
	Coeff	t-ratio	p-value	Coeff	t-ratio	p-value	Coeff	t-ratio	p-value
<b>constant</b>	6.54			4.33			8.99		
<b>AREA</b>	1.07	2.92	0.004						
<b>JOBPOP</b>	-0.298	-1.88	0.061	-0.356	-2.38	0.018	-0.282	-2.05	0.041
<b>INTDEN</b>							-0.832	-2.06	0.041
<b>EMP20A</b>				-0.697	-4.79	<0.001	-0.823	-5.69	<0.001
<b>EMP30A</b>	-1.19	-6.05	<0.001						
<b>HHSIZE</b>	2.76	8.08	<0.001	0.772	5.06	<0.001	0.520	2.58	0.010
<b>VEHCAP</b>	2.76	7.26	<0.001	1.48	9.22	<0.001	1.06	5.12	<0.001
pseudo-R2	0.11			0.03			0.05		

# Primary Determinants of Reduction in External Auto Trips



- The total and the relative amounts of population and employment on the site
- The site size and activity density
- The amount of employment within walking distance of the site
- The pedestrian-friendliness of the site (small block size)
- The access to employment within a 30 minute transit ride of the site.
- The size of households and their auto ownership

# Model Validation

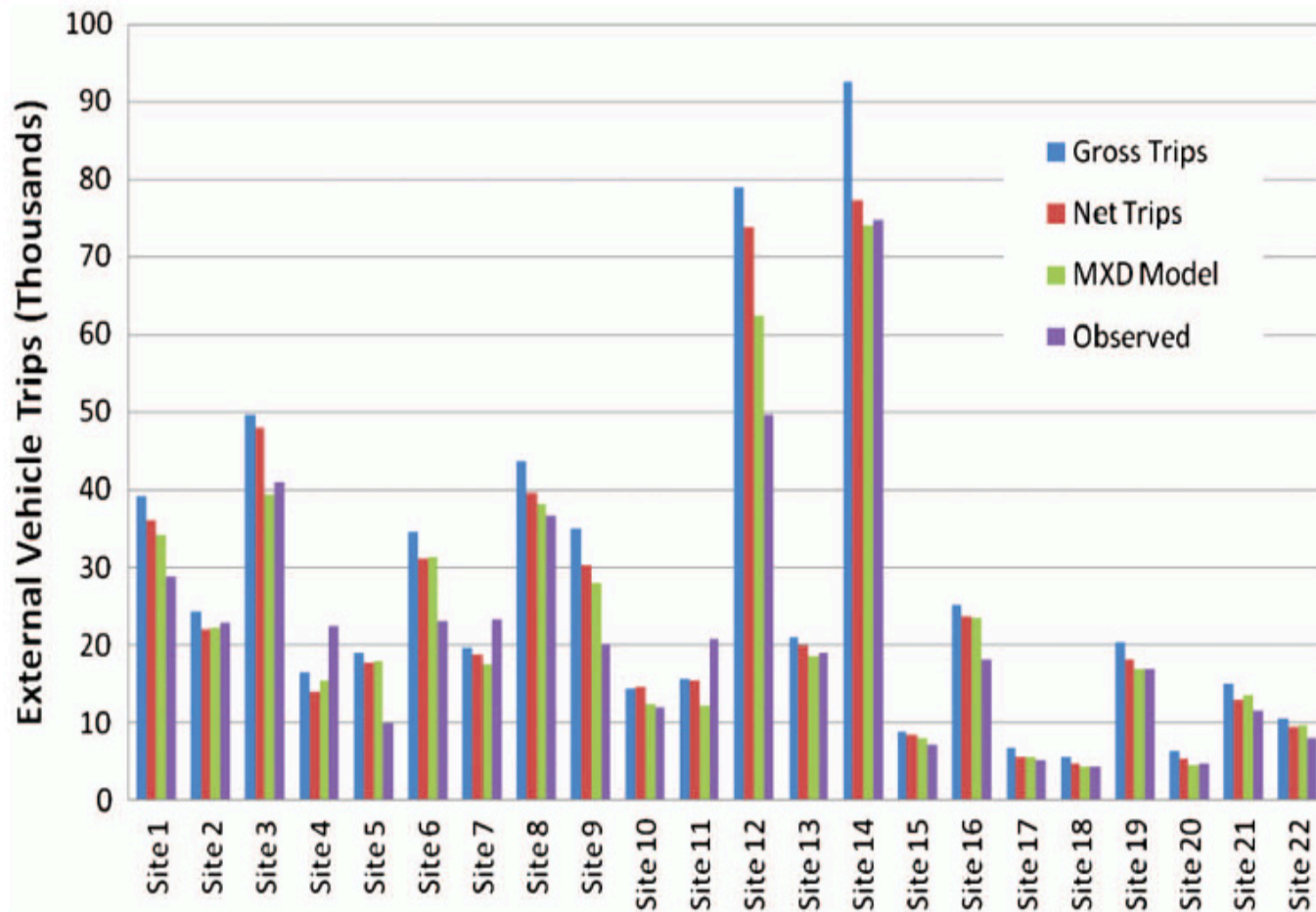



Fig. 5. (Color) Comparison of external vehicle trips across methods

# New Tasks



Extension of 7D Analysis to Austin,  
Minneapolis, and Salt Lake Regions

Include All Trips from All Regions in Final  
Modeling Exercise



# **Linked Spreadsheets for Traffic Impact App**

## **Totally Transparent**

# Extract D Variables from ET Output

7DTripGen\_09292011.xlsx - Microsoft Excel

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A128 Vehicles per Capita (linear)

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Brown = Inputs for 7D Model	Existing			Scenario 1			Scenario 2			Scenario 3		
2	Orange = Inputs for Trip Generation				Baseline - Existing			Scenario A - Existing			Scenario B - Existing		
112													
113	Fiscal				\$/yr	\$/acre		\$/yr	\$/acre		\$/yr	\$/acre	
114	Property Tax Revenue				\$ 54,516,567	\$ 1,284,372.32		\$ 474,577,962	\$ 3,202,503.77		\$ 304,593,559	\$ 2,499,730.61	\$
115	Sales Tax Revenue				\$ 3,927,095	\$ 92,519.62		\$ 21,975,955	\$ 148,296.14		\$ 19,922,443	\$ 163,499.00	\$
116													
117	Sustainability	Per HH	Per Emp		Per HH	Per Emp		Per HH	Per Emp		Per HH	Per Emp	
118	Energy Use (Million BTU/Yr)				59.5	103.9		58.8	93.6		59.4	96.9	
119	Carbon Emissions (Tons/Yr)				5.5	9.7		5.5	8.7		5.5	9.0	
120	Landscaping Water Use (G/Day)				79.1			118.5			113.3		
121	Internal Water Consumption (G/Day)				40.4	92.7		40.5	99.1		42.2	96.7	
122	Waste Water (G/Day)				68.9	45.2		69.3	47.0		71.7	46.3	
123	Solid Waste (lbs/Day)				1.7	4.0		1.7	3.8		1.8	3.9	
124													
125	Vehicle Ownership per Household												
126	Vehicles per Household												
127	Vehicles per Capita (log-log)		0.55			0.57			0.58			0.59	
128	<b>Vehicles per Capita (linear)</b>		<b>0.55</b>			<b>0.61</b>			<b>0.68</b>			<b>0.66</b>	
129													
130	Vehicle Miles Traveled per Household												
131	Vehicles per Household												
132													
133	Travel Mode Split												
134	Drive Alone Trip		0%			0%			0%			0%	

Summary 7D - Scenario 1 7D - Scenario 2 7D - Scenario 3 7D - Scenario 4 7D Inputs ProvoSUMMARY

Ready 70%

9:54 AM 10/6/2011

# Compute Travel Outputs

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L37  $=-5.55+0.226*P39+0.385*P41-1.57*P42-1.84*P43$

	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD			
23					intden	163.4921	5.096764							intden	163.4921	5.096764								
24					hhsz	1.232346	0.208919	use census data						hhsz	1.317167	0.275483	use census data							
25		HBO		40%	vehcap	0.676364	-0.39102	use census data			HBO		40%	vehcap	0.657502	-0.41931	use census data			HBO				
26		LOG ODD:	-1.17838								LOG ODD:	-1.2935								LOG ODD:	-1.25			
27		ODDS	0.307778								ODDS	0.27431								ODDS	0.284			
28	IC Share	PROB	0.235344								IC Share	PROB	0.215262							IC Share	PROB	0.221		
29																								
30		NHB		40%							NHB		40%							NHB				
31		LOG ODD:	-0.21275								LOG ODD:	-0.28817								LOG ODD:	-0.23			
32		ODDS	0.808354								ODDS	0.749631								ODDS	0.788			
33	IC Share	PROB	0.447011								IC Share	PROB	0.428451							IC Share	PROB	0.440		
34																								
35	External Trips									External Trips											External Trips			
36		HBW									HBW										HBW			
37		LOG ODD:	-1.5818		area	0.63	-0.46204				LOG ODD:	-1.67623		area	0.63	-0.46204				LOG ODD:	-1.61			
38		ODDS	0.205605		actden	54950.49	10.91419				ODDS	0.187077		actden	37057.1	10.52022				ODDS	0.198			
39	Walking	PROB	0.170541		jobpop	0.26	-1.34248				Walking	PROB	0.157595		jobpop	0.22	-1.52819			Walking	PROB	0.165		
40					intden	163.4921	5.096764							intden	163.4921	5.096764								
41	ymnt	HBO			empmile	23819	10.07824	data from TAZ employment			HBO			empmile	23819	10.07824	data from TAZ employment			HBO				
42		LOG ODD:	-2.29003		hhsz	1.232346	0.208919				LOG ODD:	-2.4871		hhsz	1.317167	0.275483				LOG ODD:	-2.39			
43		ODDS	0.101263		vehcap	0.676364	-0.39102				ODDS	0.083151		vehcap	0.657502	-0.41931				ODDS	0.091			
44	Walking	PROB	0.091952								Walking	PROB	0.076768							Walking	PROB	0.08		
45																								
46		NHB									NHB									NHB				
47		LOG ODD:	-2.4123								LOG ODD:	-2.57269								LOG ODD:	-2.4			
48		ODDS	0.089609								ODDS	0.07633								ODDS	0.083			

Summary 7D - Scenario 1 7D - Scenario 2 7D - Scenario 3 7D - Scenario 4 7D Inputs ProvoSUMMARY

Ready 100%

10:02 AM 10/6/2011



# Modify ITE Trip Rates

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A1

Table A 7D Trip Generation - Scenario 1 (Baseline)													
Land Use	Daily	Trips						In/Out Percentages					
		AM Peak Hour			PM Peak Hour			AM			PM		
		In	Out	Total	In	Out	Total	In	Out	check	In	Out	check
Townhouse	443	6	30	36	28	14	42	17%	83%	100%	67%	33%	100%
Multi-Family Residential	15,804	256	1,024	1,280	943	508	1,450	20%	80%	100%	65%	35%	100%
Mobile Home	618	9	34	43	36	22	57	20%	80%	100%	62%	38%	100%
<b>Residential Sub-Total</b>	<b>19,209</b>	<b>315</b>	<b>1,222</b>	<b>1,537</b>	<b>1,156</b>	<b>631</b>	<b>1,786</b>						
<b>HBW Trip Modifications</b>													
Total Trips	4,802												
Calculated Internal Trips	459												
Governing Internal Trips	459												
Presumed Maximum Trip Productions	459												
Internal Trips													
Total	459												

Summary 7D - Scenario 1 7D - Scenario 2 7D - Scenario 3 7D - Scenario 4 7D Inputs ProvoSUMMARY

Ready 100%

10:06 AM 10/6/2011

# Summarize Traffic Impacts

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Cut Copy Paste Format Painter Clipboard

Arial 10 Bold Italic Underline Font Color Background Color

Wrap Text Merge & Center Alignment

General Number Conditional Formatting Styles Insert Delete Format Cells AutoSum Fill Clear Sort & Filter Find & Select Editing

Security Warning Automatic update of links has been disabled Options...

A27

Table E 7D Trip Generation - Summary				
Land Use	Scenario			
	Scenario 1 (Baseline)	Scenario 2 (Scenario A)	Scenario 3 (Scenario B)	Scenario 4 (Scenario C)
<b>Walk Trips</b>				
Internal	2,698	6,989	5,469	6,153
External	3,893	11,793	8,218	9,744
<b>Total</b>	<b>6,591</b>	<b>18,782</b>	<b>13,686</b>	<b>15,897</b>
<b>Transit Trips</b>				
Internal	-	-	-	-
External	3,716	11,263	7,747	9,155
<b>Total</b>	<b>3,716</b>	<b>11,263</b>	<b>7,747</b>	<b>9,155</b>
<b>Vehicle Trips</b>				
Internal	5,879	14,487	11,886	13,203
External	38,256	110,012	78,365	90,832
<b>Total</b>	<b>44,135</b>	<b>124,499</b>	<b>90,251</b>	<b>104,035</b>
<b>VMT</b>				
Internal	3,127	7,808	6,316	7,034
External	243,866	701,990	501,734	582,541
<b>Total</b>	<b>246,993</b>	<b>709,798</b>	<b>508,050</b>	<b>589,575</b>

Summary 7D - Scenario 1 7D - Scenario 2 7D - Scenario 3 7D - Scenario 4 7D Inputs ProvoSUMMARY

Ready 100%

10:11 AM 10/6/2011



# Outreach [T4.0]

**4.00 ET+ Education and Training.** We will train professionals and students in the use of ET+. Completion of the professional education course will lead to a University of Utah-issued professional education certificate. We will also incorporate ET+ into our GIS and related courses.