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Accounting for Unique Aspects of Travel Demand Generated by a Large University in Travel Models

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Motivation

- Large universities generate a significant amount of travel
- Universities often treated as special generators
- Modeling of university travel demand is a challenge
 - Insufficient samples of university population (students/faculty/staff) in household travel surveys



LARGEST UNIVERSITY BY ENROLLMENT IN EACH STATE

College Finder

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Motivation

- Travel behavior of university students is different from that of general population
- University students usually under-represented in household travel surveys
 - Hard-to-reach
 - Not likely to respond to long surveys
- Increasing interest in conducting university travel surveys
 - Provide a good data source for model development

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Objectives

- Model the travel patterns of students, faculty, and staff for a large university
- Develop an operational university submodel that can be seamlessly integrated into a regional travel demand model system

History

- Original university submodel development sponsored by Maricopa Association of Governments, MPO for Greater Phoenix, Arizona
- Collected comprehensive travel survey data for Arizona State University with funding from MAG
 - Developed fully operational ASU travel model that was integrated with MAG regional travel demand model system

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Scope of Current Study

Effort undertaken as part of travel model update for **Albuquerque Metropolitan Area**

Travel for University of New Mexico (UNM) and Central New Mexico University (CNM)

UNM and CNM campuses adjacent to one another, spread over **20 TAZ's** and generate **~180,000 trips every day**

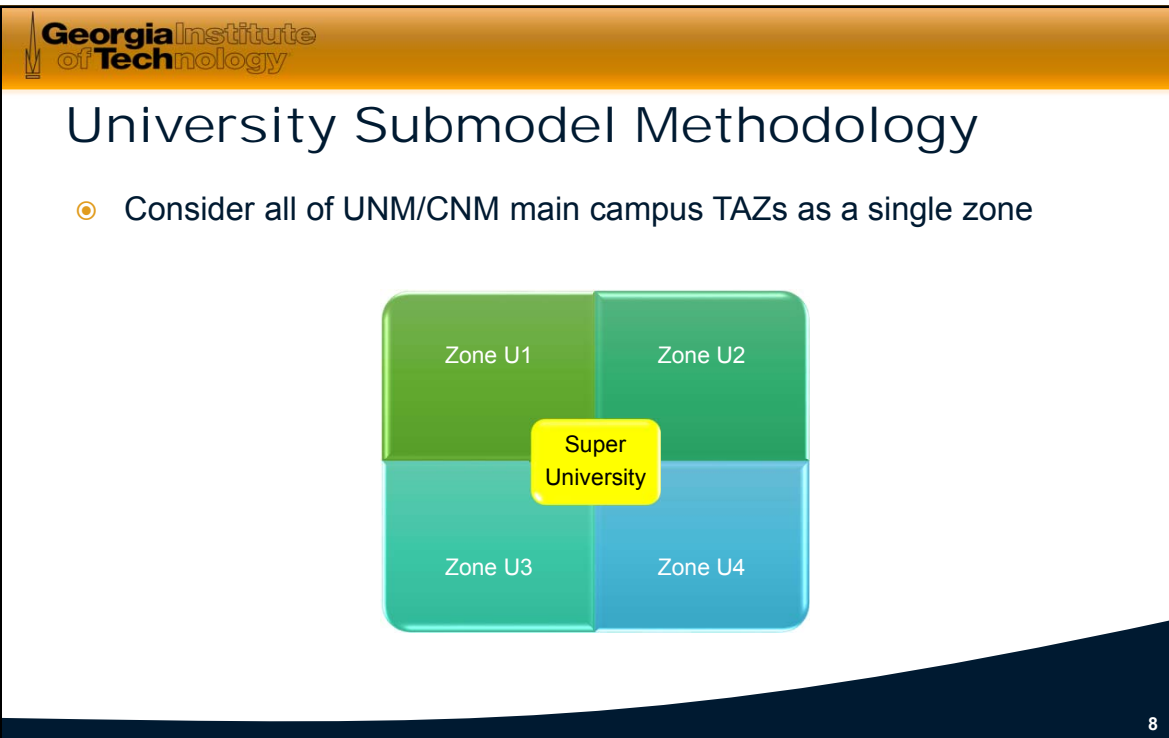
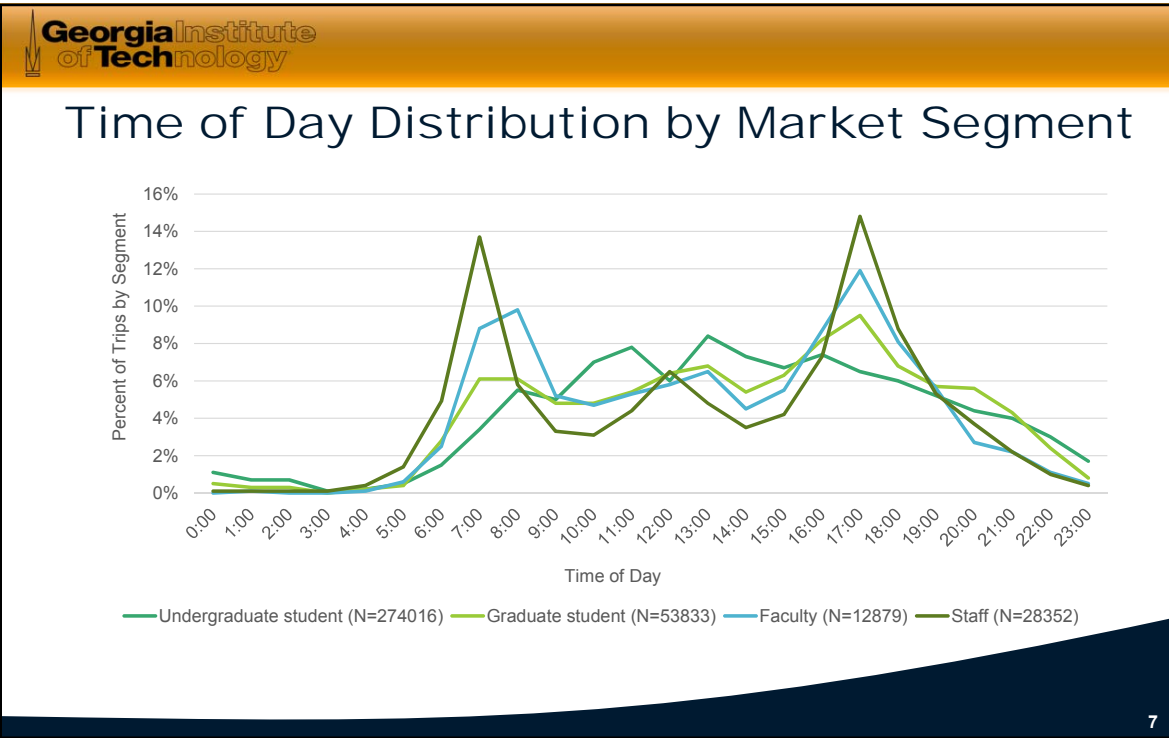


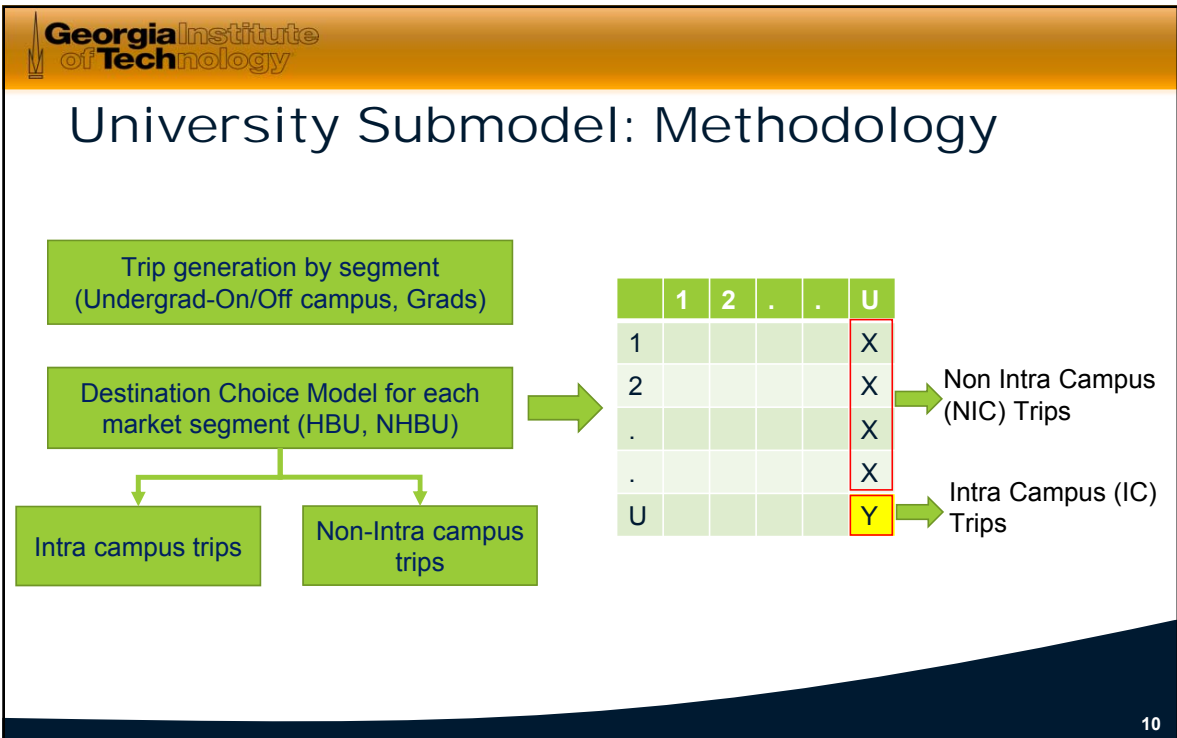
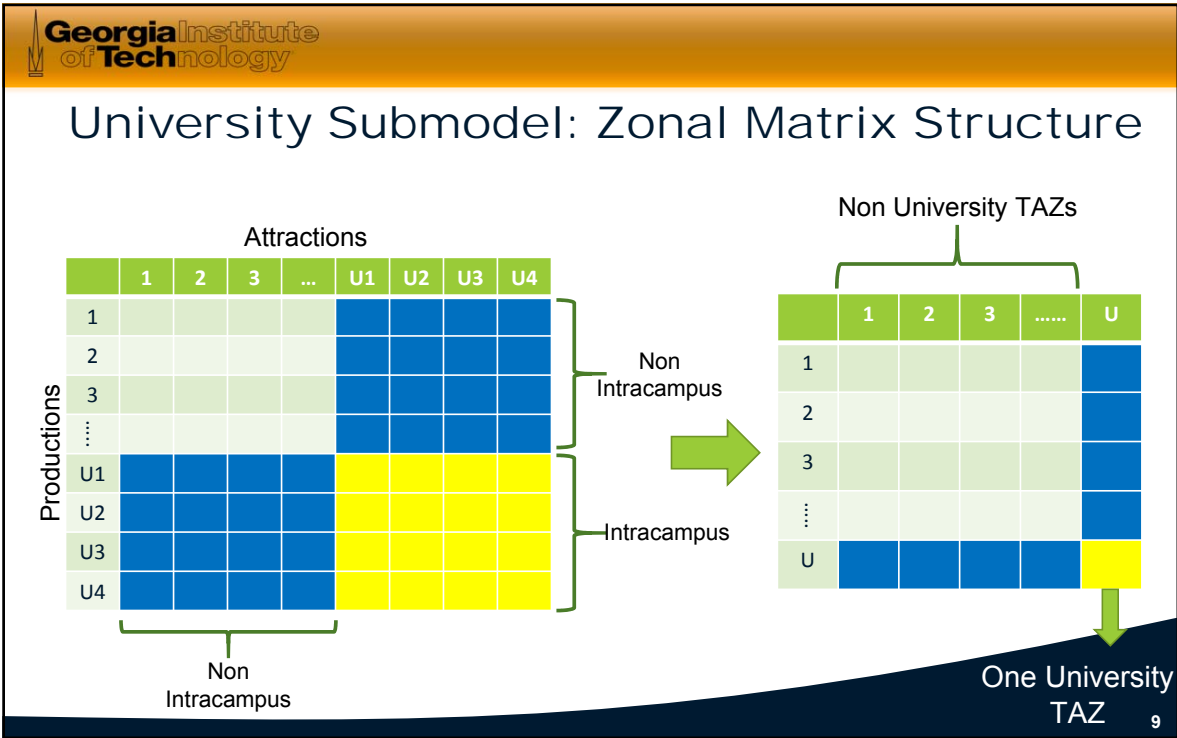
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Data

- Travel diary data not available for UNM and CNM
- Aggregate travel patterns of Students/Faculty/Staff available
- Hence, travel diary data from Arizona State University (ASU) used for model development
- Conducted comparisons at aggregate level to ascertain similarity and differences in travel patterns between university contexts
- ASU travel survey conducted in spring 2012
 - Web-based survey, administered for three weeks
 - More than 12,000 responses from students, faculty and staff

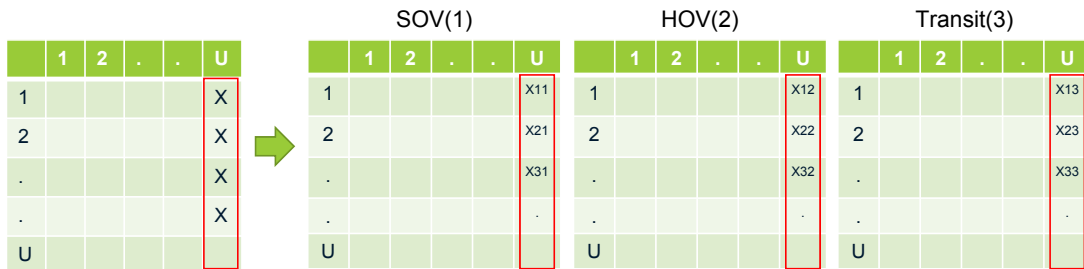
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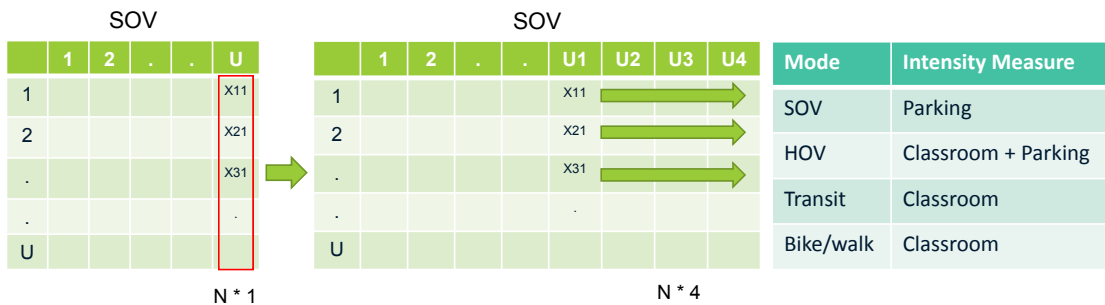
University Submodel: Non Intra-Campus (NIC) Trips

- Apply mode choice models for each of the cells of the destination choice matrix



University Submodel: NIC Trips

- Apportion the attractions to all university zones based on intensity classified by modal alternatives



N = Number of Non-University TAZs

University Submodel: NIC Trips

- Get total attractions to each university TAZ by all modes

SOV					HOV												
	1	2	...	U1	U2	U3	U4		1	2	...	U1	U2	U3	U4		
1				X11	→				1				X11	→			
2				X21	→				2				X21	→			
...				X31	→				...				X31	→			
...									...								
U									U								
				U_{sov1}	U_{sov2}	U_{sov3}	U_{sov4}					U_{hov1}	U_{hov2}	U_{hov3}	U_{hov4}		

$$A_x = \sum_{mode=1}^N U_{mode,x}$$

University Submodel: Intra-Campus (IC) Trips

- Apportion intracampus trips to cells of the zonal matrix based on an intensity measure
- Total NIC attractions can be used as an intensity measure
- Other intensity measures might be considered as well

	U1	U2	U3	U4	Total
U1					A_1
U2					A_2
U3					A_3
U4					A_4
Total	A_1	A_2	A_3	A_4	

Y →

$Y * \left(\frac{A_2 A_4}{\sum Row \sum Column} \right)$

University Submodel: IC Trips

Zone	Intensity
U1	100
U2	200
U3	400
U4	500



	U1	U2	U3	U4	Total
U1	0.0069	0.0139	0.0278	0.0347	100
U2	0.0139	0.0278	0.0556	0.0694	200
U3	0.0278	0.0556	0.1111	0.1389	400
U4	0.0347	0.0694	0.1389	0.1736	500
Total	100	200	400	500	1200

Total Number of Intracampus Trips

1500



	U1	U2	U3	U4	Total
U1	10	21	42	52	125
U2	21	42	83	104	250
U3	42	83	167	208	500
U4	52	104	208	260	625
Total	125	250	500	625	1500

University Submodel

- Depending on whether we are modeling the production or attraction ends at the university, corresponding portions of the matrix are filled

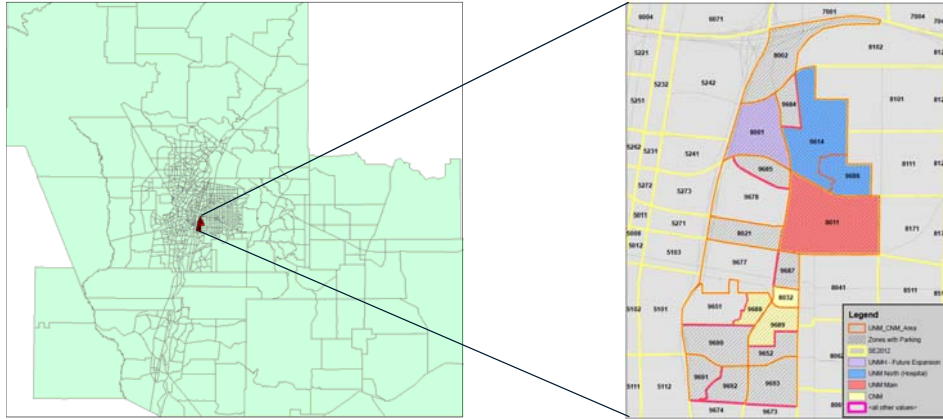
Productions (Dorm based trips)

	1	2	3	...	U1	U2	U3	U4
1								
2								
3								
⋮								
U1								
U2								
U3								
U4								

Attractions

	1	2	3	...	U1	U2	U3	U4
1								
2								
3								
⋮								
U1								
U2								
U3								
U4								

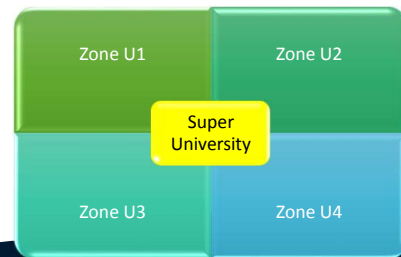
University TAZs



Trip Generation

Trip Generation

- UNM/CNM zones are aggregated and treated as a super university TAZ
- ASU travel survey trip rates adopted to determine trips generated by the super university TAZ
- Multiply trip rates by enrollment and faculty/staff numbers to determine productions/attractions



Trip Rates by Market Segment

Segment	Home-Based University		Non-Home-Based University	
	Peak	Off-Peak	Peak	Off-Peak
Graduate	0.62	0.74	0.71	0.82
Off-Campus Undergraduate	0.48	0.56	0.54	0.86
On-Campus Undergraduate (Dorm Based)	0.93	1.42	0.99	1.66
Faculty	0.99	0.94	0.77	1.12
Staff	1.05	0.90	0.80	1.06

Location Choice

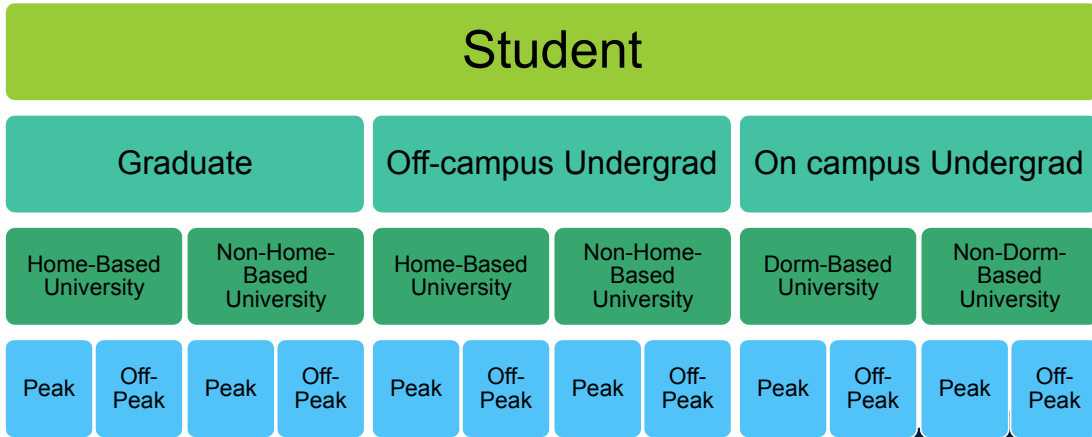
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Location Choice Models

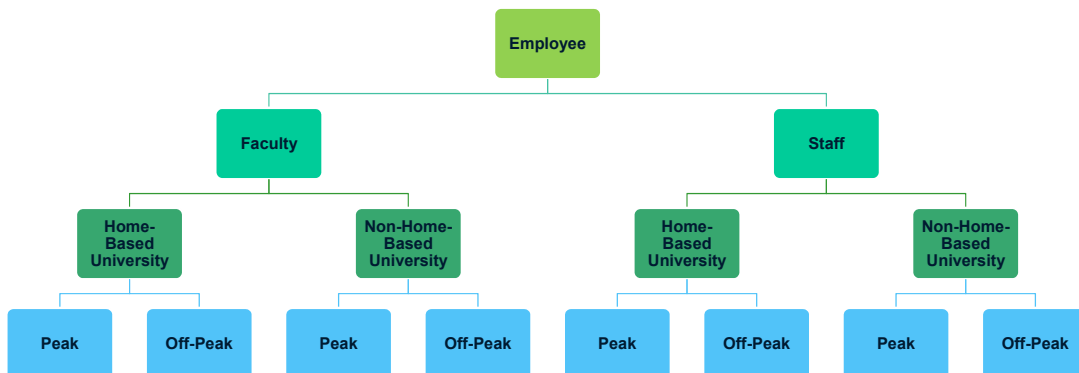
- Trip attractions by purpose serve as input to the location choice models
- Non-university end of university-based travel is modeled
 - Exception: Dorm-based trips
- Model specifications include
 - Land use size descriptors
 - Distance-based variables
 - Logsum terms

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Location Choice Models (Students): Segmentation



Location Choice Models (Faculty/Staff): Segmentation

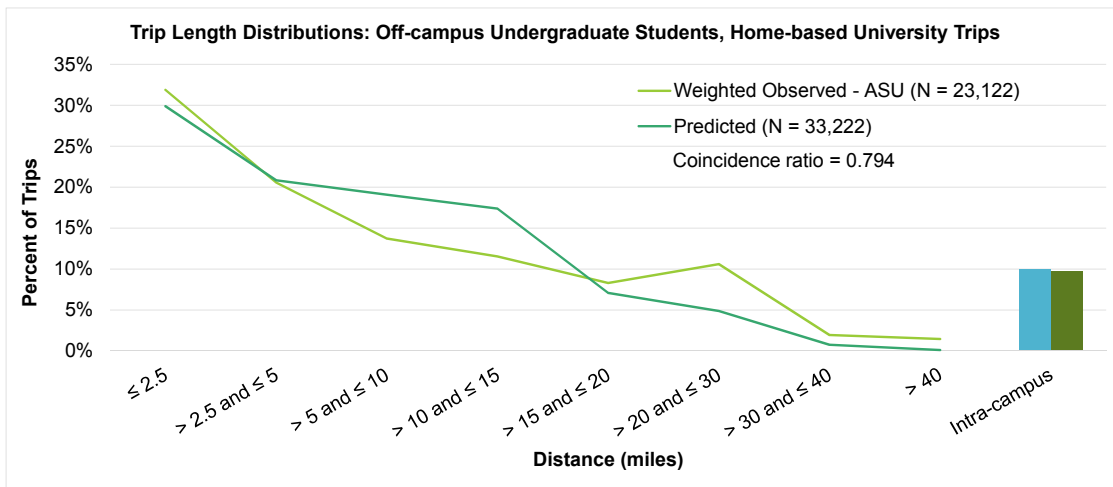


Location Choice Model

Off-Campus Undergraduate Students, Home-Based University Trips

Variable	Coefficient
Off-campus undergraduate logsum (average)	3.6
Residential population	0.000272
Groupquarter population	-0.000244
Total retail employment (in 1000's)	0.00015
Total service employment (in 1000's)	-0.000221
Proportion of households that are multi-family	0.52
Proportion of residential hhlds in the highest income group (3)	1.715
Zone is in the highest population density quartile	0.106
Zone is in the lowest employment density quartile	-0.756
Distance dummy (> 5 and ≤ 10 miles)	-0.655
Distance dummy (> 15 and ≤ 25 miles)	0.575
Share of the zone that is developed	0.00614
Distance dummy (> 1 and ≤ 2.5 miles)	0.5
Intra campus dummy	7.6

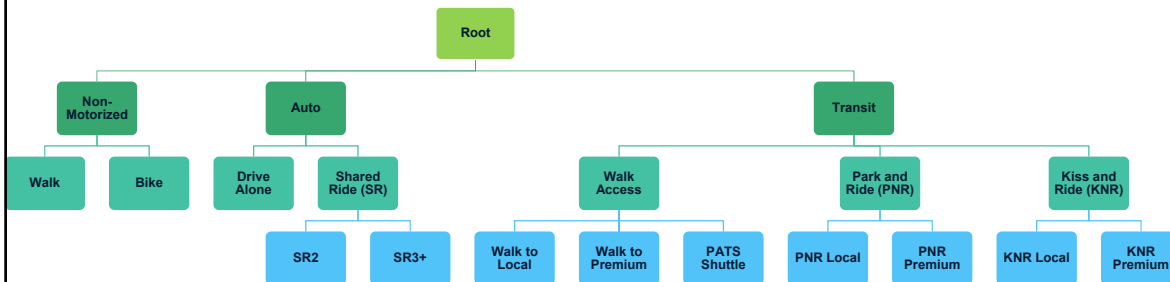
Location Choice Model: Validation



Mode Choice Model

- Model structure same as that of the main regional travel demand model
- Campus Parking and Transit shuttle mode added for university submodel mode choice
 - Mode treated as Walk to Local with \$0 fare
 - PATS shuttle connects remote parking lots and the campus

Mode Choice Model: Structure




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Mode Choice Models: Segmentation


- Graduate
- Undergrad (Off-Campus)
- Undergrad (On-Campus) – Dorm-Based
- Undergrad (On-Campus) – Non-Dorm-Based
- Faculty
- Staff

Peak

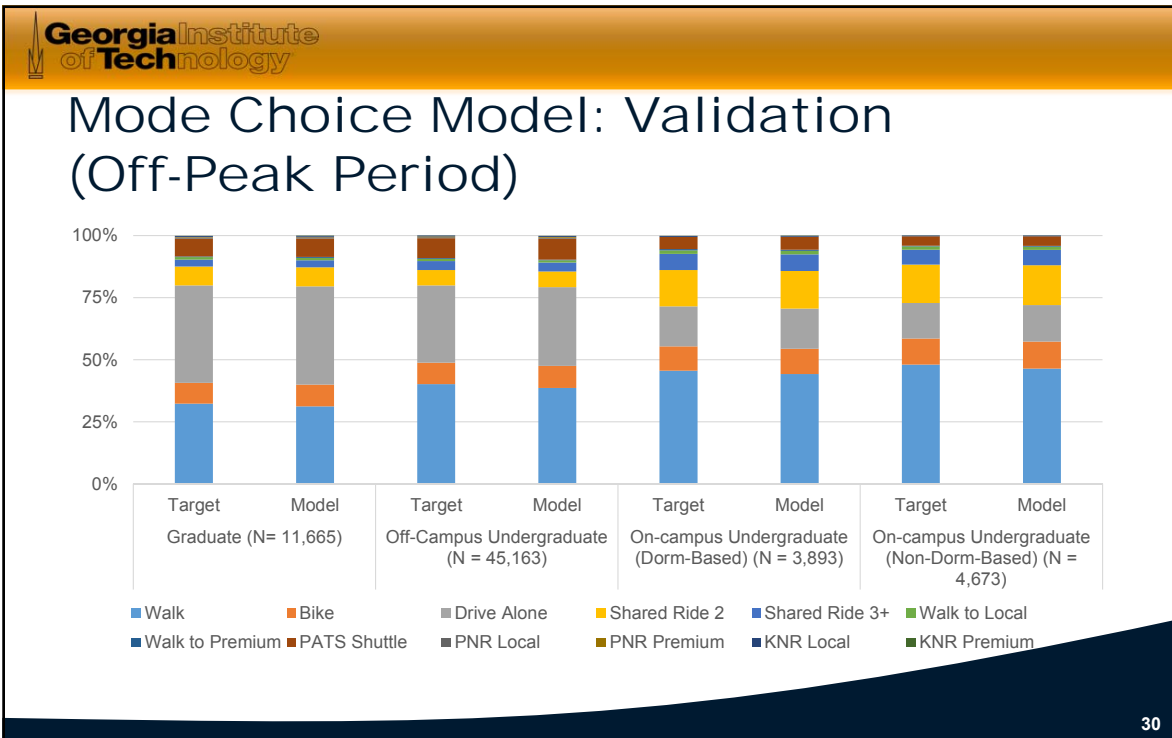


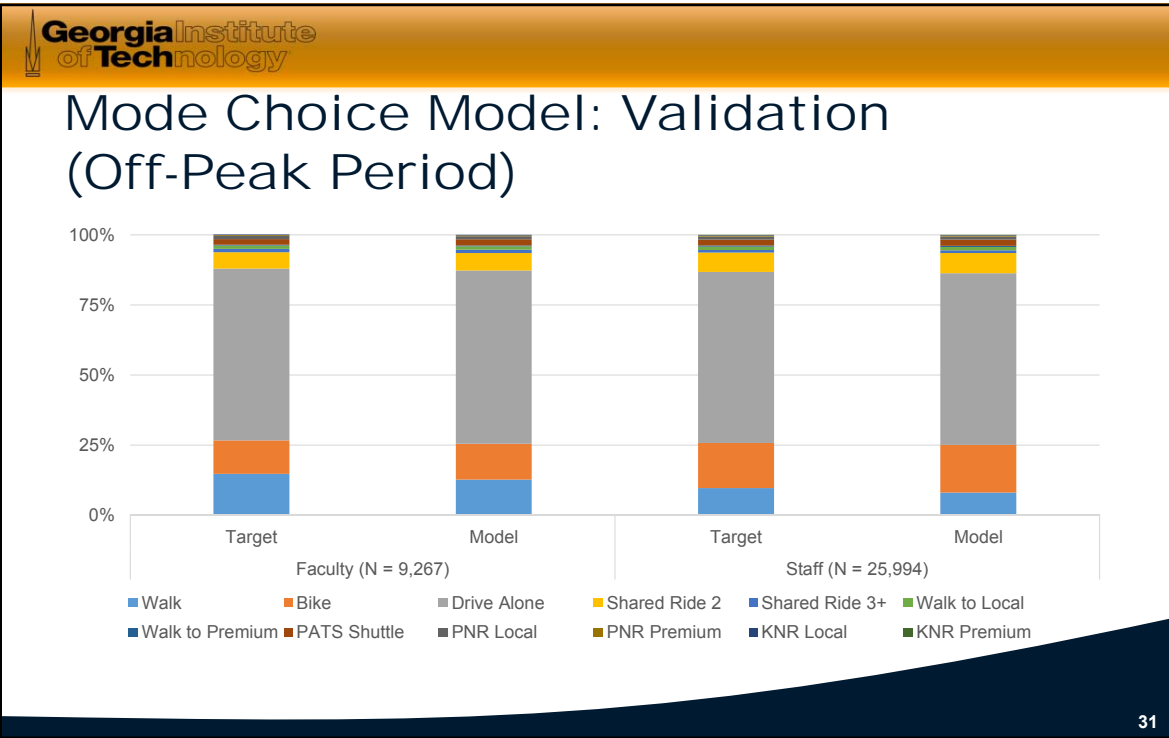
- Graduate
- Undergrad (Off-Campus)
- Undergrad (On-Campus) – Dorm-Based
- Undergrad (On-Campus) – Non-Dorm-Based
- Faculty
- Staff

Off-Peak



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Sensitivity Analyses

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University Parking Attraction Factor (UPAF)

- University parking attraction factor derived

$$UPAF \propto \frac{\textit{Parking Capacity per Capita}}{\textit{Generalized Cost of Parking on Campus}}$$

- With increase in parking capacity per capita, the campus becomes more attractive for motorized modes
- With increase in generalized parking cost, the campus becomes less attractive for motorized modes

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Generalized Parking Cost (GPC)

- The generalized parking cost is a composite factor that considers
 - Average cost of parking in a lot (per day)
 - Distance of the lot from the central UNM zone
 - Capacity of the lot

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UNM Submodel: Parking Attraction Factor (UPAF)

- This factor enters the mode choice utility equation for auto modes (with a differential coefficient)
- The range of UPAF for different values of capacity per capita and generalized cost values was between 0.11 – 0.30
- Sensitivity analysis conducted to study the impact of UPAF on auto mode choice
 - UPAF decreased by 40% from baseline
 - UPAF increased by 40% from baseline

UNM Submodel: Parking Attraction Factor (UPAF)

Effect of UPAF on Off-Peak Trips

UPAF = 0.18				
Segment	Non-motorized	Auto	Transit	PAT-Shuttle
Graduate	4946	5560	300	860
Off-Camp	22976	17306	1103	3779
Dorm-Based	2221	1460	98	204
Non Dorm	2661	1717	121	174
Faculty	2481	6287	300	198
Staff	6581	17944	919	550
Total	41865	50275	2840	5766
UPAF = 0.11 (40% ↓)				
Graduate	5315	5244	380	726
Off-Camp	24156	16339	1305	3362
Dorm-Based	2274	1410	104	196
Non Dorm	2757	1619	129	168
Faculty	2730	6004	372	160
Staff	7165	17272	1120	437
Total	44398	47888	3411	5049
Difference				
Graduate	370	-316	81	-134
Off-Camp	1181	-967	203	-416
Dorm-Based	54	-51	6	-9
Non Dorm	96	-98	8	-6
Faculty	249	-283	73	-38
Staff	584	-672	201	-113
Total	2533	-2387	571	-717

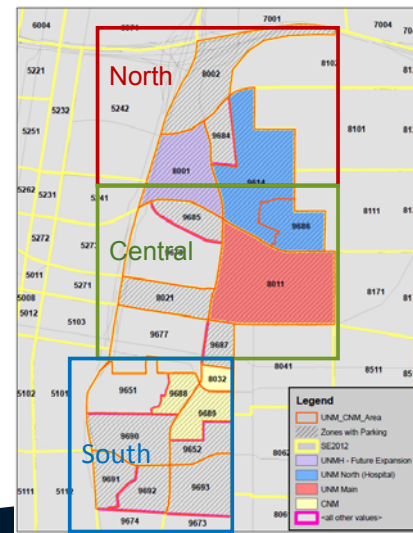
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Faculty	2481	6287	300	198
Staff	6581	17944	919	550
Total	41865	50275	2840	5766
UPAF = 0.25 (40% ↑)				
Graduate	4595	5832	233	1004
Off-Camp	21821	18195	924	4223
Dorm-Based	2164	1514	92	213
Non Dorm	2562	1819	113	180
Faculty	2180	6625	230	232
Staff	5864	18753	720	657
Total	39186	52738	2313	6509
Difference				
Graduate	-350	272	-66	144
Off-Camp	-1155	889	-179	444
Dorm-Based	-56	53	-6	9
Non Dorm	-100	102	-8	6
Faculty	-302	337	-70	34
Staff	-717	809	-199	107
Total	-2679	2463	-527	743

Distinct Treatment of Intra- and Non-Intra-Campus Travel

- Intra- and non-intra-campus trips allocated to university zones differently
- Assessment of flow patterns carried out after the mode choice step
- Zones in the university aggregated into North, Central, and South
- 'Other' zones comprise all non-university zones in the region



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Daily Flows by Mode: Predicted

	North	Central	South	Other	Total	North	Central	South	Other	Total
	Auto					Non-Motorized				
North	0.40%	0.80%	0.70%	0.40%	2.30%	4.00%	9.00%	6.00%	0.00%	19.00%
Central	0.80%	1.50%	1.20%	0.60%	4.00%	9.00%	20.00%	13.40%	0.00%	42.30%
South	0.70%	1.20%	1.00%	0.60%	3.50%	6.00%	13.40%	8.90%	0.00%	28.30%
Other	23.00%	29.90%	37.40%	0.00%	90.30%	2.20%	4.90%	3.30%	0.00%	10.30%
Total	24.90%	33.30%	40.20%	1.60%	N = 93,931	21.20%	47.20%	31.50%	0.10%	N = 71,429
	Transit					Other (PATS Shuttle)				
North	0.10%	0.20%	0.10%	0.60%	1.00%	4.50%	10.00%	6.70%	0.00%	21.10%
Central	0.20%	0.50%	0.30%	1.30%	2.30%	10.00%	22.20%	14.80%	0.00%	47.00%
South	0.10%	0.30%	0.20%	0.90%	1.60%	6.70%	14.80%	9.90%	0.00%	31.40%
Other	20.20%	44.90%	30.00%	0.00%	95.10%	0.10%	0.20%	0.10%	0.00%	0.40%
Total	20.60%	45.90%	30.70%	2.80%	N = 5,330	21.20%	47.20%	31.60%	0.00%	N = 10,305

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- ## Conclusions
- Travel behavior of university populations (especially students) is quite different from that of the general population
 - The study proposes a comprehensive framework aimed at modeling university-based travel for faculty, staff, and students
 - Programmed in open source coding language Python for seamless integration into regional travel demand models
 - Key features of the submodel
 - Extensive market segmentation
 - Separate treatment for intra-campus and non-intra-campus travel
 - Introduction of university parking attraction factor
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Thank You

Trip Rates by Market Segment: ASU Travel Survey

Graduate

Campus	HBASU Peak	HBASU Off Peak	NHBASU Peak	NHBASU Off Peak
Downtown	0.2787	0.3041	0.315	0.3553
Polytechnic	0.1407	0.3358	0.3186	0.4716
Tempe	0.5191	0.6191	0.5885	0.7629
West	0.1097	0.2175	0.2587	0.0671

Off-Campus Undergrad

Campus	HBASU Peak	HBASU Off Peak	NHBASU Peak	NHBASU Off Peak
Downtown	0.4683	0.4699	0.4313	0.7216
Polytechnic	0.5323	0.5886	0.4434	0.669
Tempe	0.5722	0.6447	0.6434	0.9928
West	0.3903	0.4624	0.3976	0.5636

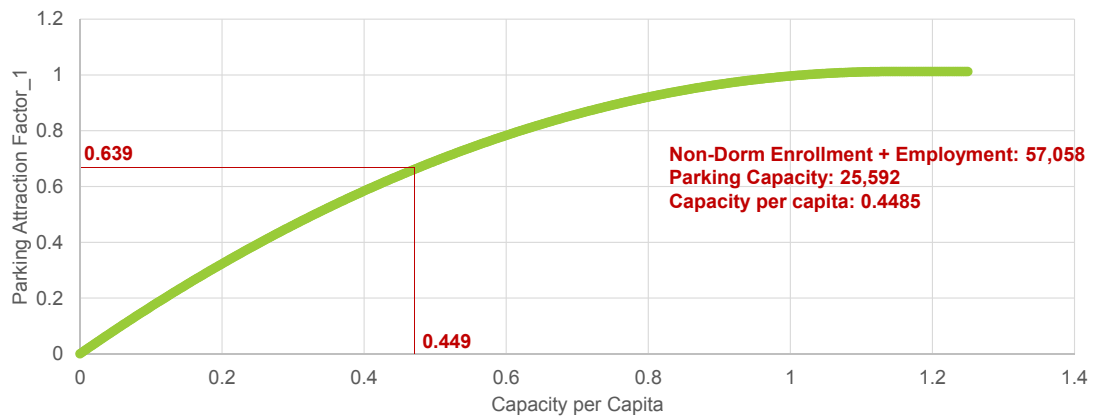
On-Campus Undergrad

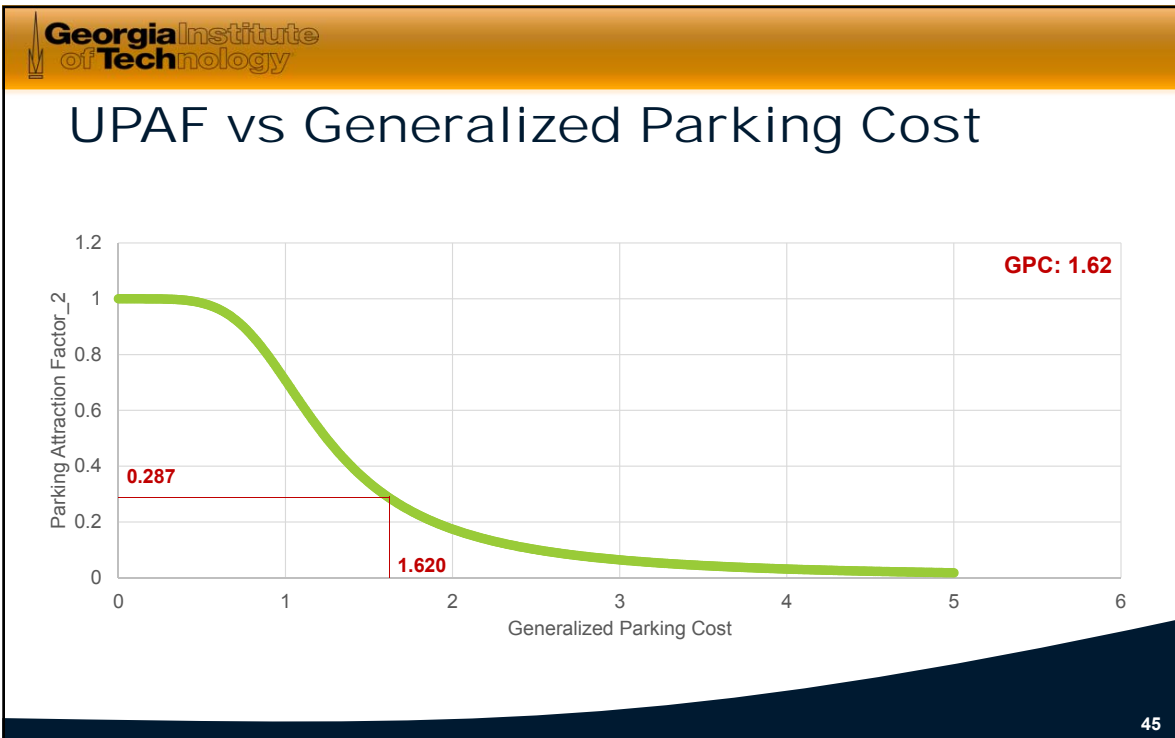
Campus	HBASU Peak	HBASU Off Peak	NHBASU Peak	NHBASU Off Peak
Downtown	1.0361	1.8047	0.817	1.2826
Polytechnic	1.4042	2.2623	0.5903	1.3027
Tempe	1.2952	2.1495	1.0343	1.8676
West	1.2303	1.81	0.5834	1.459

Trip Generation

- Trip rates for faculty and staff trips are determined from ASU travel survey
- Employment numbers for faculty and staff are obtained from UNM/CNM websites
- Trip rates were multiplied by employment numbers for corresponding faculty/staff segments to arrive at trip attractions

UPAF vs Capacity per Capita





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UNM Submodel: Parking Attraction Factor (UPAF)

- University Parking Attraction Factor is structured in such a way that it does not impact the base year mode splits but only impacts the mode choice patterns for alternative parking scenarios
- Different scenarios are being tested to verify the efficacy of UPAF implementation in mode choice model
 - Reflecting appropriate sensitivity of PATS ridership to UPAF

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