

1 **ACTIVITY-TRAVEL CHARACTERISTICS OF A LARGE UNIVERSITY POPULATION**

2
3 **Sarah E. Volosin** (*corresponding author*)

4 Arizona State University, School of Sustainable Engineering and the Built Environment
5 Room ECG252, Tempe, AZ 85287-5306. Tel: (480) 965-3589; Fax: (480) 965-0557
6 Email: sarah.volosin@asu.edu

7
8 **Sanjay Paul**

9 Arizona State University, School of Sustainable Engineering and the Built Environment
10 Room ECG252, Tempe, AZ 85287-5306. Tel: (480) 965-3589; Fax: (480) 965-0557
11 Email: sanjay.paul@asu.edu

12
13 **Ram M. Pendyala**

14 Arizona State University, School of Sustainable Engineering and the Built Environment
15 Room ECG252, Tempe, AZ 85287-5306. Tel: (480) 727-9164; Fax: (480) 965-0557
16 Email: ram.pendyala@asu.edu

17
18 **Vladimir Livshits**

19 Maricopa Association of Governments
20 302 N First Avenue, Suite 300, Phoenix, AZ 85003. Tel: (602) 452-5079; Fax: (602) 254-6490
21 Email: vlivshits@azmag.gov

22
23 **Petya Maneva**

24 Maricopa Association of Governments
25 302 N First Avenue, Suite 300, Phoenix, AZ 85003. Tel: (602) 254-6300; Fax: (602) 254-6490
26 Email: pmaneva@azmag.gov

27
28
29
30
31
32
33
34 Word count: 6,273 text + 7 (tables/figures) x 250 = 8,023 equivalent words

35
36 Submitted for Presentation and Publication
37 Committee ABJ30: Urban Transportation Data and Information Systems

38
39 93rd Annual Meeting of the Transportation Research Board

40
41
42 August 1, 2013

1 **ABSTRACT**

2 Metropolitan planning organizations often desire to recognize the presence of large special
3 generators of travel demand in their regions in transportation modeling and planning processes.
4 Universities, especially large universities, can generate a significant amount of travel demand
5 due to a heterogeneous population of travelers with unique behavioral characteristics. The travel
6 behavior characteristics of university populations are not well understood or documented in the
7 literature. This paper attempts to fill this gap by describing daily activity-travel patterns of
8 university students, faculty, and staff for a typical weekday in the middle of a semester. Data for
9 this paper was obtained from a comprehensive web-based travel survey that was administered to
10 students, faculty, and staff of Arizona State University, one of the largest universities in the
11 United States, in April 2012. Travel characteristics, activity participation profiles, and trip
12 chaining behavior are examined for faculty, staff, and student market segments. The results
13 suggest that there is considerable heterogeneity in activity-travel behavior across the university
14 population groups. The data presented in this paper is a first step towards understanding the
15 activity-travel demand of large university special generators, and developing specialized travel
16 models for such entities in a region.

17
18 **Keywords:** college student travel, travel survey data analysis, university population travel,
19 under-studied population, travel characteristics measurement, activity participation

1 INTRODUCTION

2 Many major metropolitan areas around the world are home to one or more large universities
3 which serve as special generators of travel demand. As the transportation planning field migrates
4 towards fine-grained activity-based regional travel models, it is important to have a deep
5 understanding of the activity and travel engagement patterns of all segments of the population.
6 Recent literature has stressed the importance of understanding activity-travel behavior as a
7 means to achieving improved simulations of travel demand (Axhausen and Garling, 2013;
8 Bowman and Ben-Akiva, 2001; Bhat, et al, 2004). However, despite the substantial impact of
9 large urban universities on regional travel patterns, little research has been done and documented
10 on the daily activity-travel patterns of university communities.

11 According to the US Department of Education, 21.7 million United States residents were
12 enrolled in an institution of higher education in 2012 (US Department of Education, 2012).
13 College students (and sometimes faculty as well) are likely to have more flexible schedules and
14 very different living and working arrangements than the typical working adult. College student's
15 schedules are often dictated by set class times and odd work hours, not to mention club and
16 social activities. In addition, college campuses generally reflect a very accessible, mixed-use,
17 and densely populated setting, with classrooms, offices, restaurants, and residential buildings all
18 within close proximity (walkable distance) one another. These unique features of university
19 environments could lead to daily activity-travel patterns for college communities that differ
20 substantially from those of the general population, motivating the need to study these segments
21 and characterize their activity-travel patterns in a detailed way.

22 This study attempts to fill the gap in understanding daily activity-travel behavior of college
23 students, faculty, and staff. The data used for the characterization of university population
24 activity-travel demand in this study was obtained through an online travel survey conducted at
25 Arizona State University (ASU) in the Spring 2012 semester. The following sections of the
26 paper include a literature review of university and student travel, the methodology by which
27 travel data was collected, and an investigation and documentation of travel characteristics,
28 activity participation, and trip chaining patterns for college students, faculty, and staff.

29 LITERATURE REVIEW

30 University communities can be considered under-represented populations in travel surveys for a
31 variety of reasons. Behrens et al. (2008) identify adolescents and those who are "disengaged
32 from broader society" as typical non-respondents to travel surveys. One could easily argue that
33 university students, who often live, work, shop, and eat entirely on a college campus, are in
34 many ways isolated from the broader population. In addition, people who reside in group
35 quarters (like college dormitories) or who change addresses frequently are often omitted from
36 survey sampling frames, due to the difficulty in receiving up-to-date contact information from
37 these groups (Behrens et al, 2008).

38 Several studies have addressed mode choice to and from college campuses by collecting
39 survey data from the university communities. In 1997, researchers conducted a survey of
40 commuting behavior at the University of North Carolina, Chapel Hill. The goal of the survey
41 was to understand the effect of built environment characteristics on commuting mode choice
42 (Rodriguez and Joo, 2004). The study focused only on the journey-to-campus trips for students,
43 faculty, and staff. Findings showed that characteristics of the built environment had a significant
44 effect on the mode choice to campus. A travel survey completed at Ohio State University (OSU)
45 in 2011 was used to predict modes chosen for travel to campus by OSU students, faculty, and
46

1 staff (Akar et al, 2012). The survey, administered online, collected information on typical
2 commute modes to campus and solicited respondent input on various strategies for increasing the
3 usage of alternative modes. The resulting model showed that students were generally more likely
4 than faculty or staff to use alternative modes such as biking and transit to travel to campus. A
5 study concerning sustainable transport development on university campuses showed mode shares
6 for commuting to campus at eight universities in the event that policy actions aimed at increasing
7 the prevalence of non-motorized travel were implemented (Balsas, 2003). This study showed
8 that policy changes on university campuses can significantly increase the mode share of
9 alternative modes of travel for the commute to school.

10 More recently, a few studies have aimed to fill the gap in the understanding of daily
11 travel patterns of students. A study at four major universities in Virginia – two with urban and
12 two with rural settings – implemented a travel diary for college students designed to closely
13 follow the design of the National Household Travel Survey (NHTS) (Khattak et al, 2011). This
14 study compared daily travel patterns of university students to those of the general population
15 from the NHTS Virginia add-on sample. Weekday trip rates for students at all universities were
16 greater than those of the general population. Students in more rural universities had a higher trip
17 rate by walk and bike than those on urban campuses. The general population of Virginia made
18 more home-based work, home-based shopping, and home-based social recreation trips than
19 university students, while students made more non-home-based trips overall. Finally, while the
20 temporal distribution of trips for the general population was fairly evenly spread throughout the
21 day, university student trip departure times showed a clear peak in the middle of the day and a
22 greater proportion of trips after 6:00 PM. In a follow-up study, an online survey instrument that
23 matched the NHTS questionnaire was implemented and tested at Old Dominion University
24 (ODU). Student travel demand was analyzed in relation to home location distance from campus
25 (Wang et al, 2012). The University of California at Davis (UCD) Institute of Transportation
26 Studies (ITS) conducts an annual travel survey of UCD students, faculty and staff (Miller, 2012).
27 This survey takes into account only campus-based travel, but includes students, faculty, and
28 staff, similar to the ASU survey. Because it is conducted every year, the UCD survey offers an
29 opportunity to view university travel demand from a longitudinal perspective.

30 Activity-based approaches to understanding student travel have also emerged in recent
31 studies. Kamruzzaman et al. (2011) reported on a study at the University of Ulster at
32 Jordanstown in Northern Ireland that used a two-day travel diary and GIS representation to
33 evaluate student activity spaces. The study found that the percent of student trips made by car
34 was higher than that for the Northern Ireland average adult, most likely because the percent of
35 students who own a car is greater than that for the general population. Those students who own
36 a car traveled significantly farther than those without a car, as expected. Low income students
37 had greater average activity duration than high income students. Another study of the daily
38 activity patterns of students was published in 2009 based on a 2001 travel survey of students at
39 North Carolina State University located in Raleigh, North Carolina (Eom et al, 2009). The one-
40 day travel diary data revealed that on-campus students had a higher trip rate than off-campus
41 students, consistent with the literature from Virginia schools. Additionally, females made more
42 trips than males, and undergraduates made more trips than graduate students. Compared to
43 unemployed students, those employed full time made fewer trips while those employed part time
44 or with volunteer jobs made more trips.

45 The literature review is evidence of the widespread interest in studying the activity-travel
46 demand characteristics of university populations. Despite the presence of a few studies, there is

1 considerable paucity of data and empirical insights on the activity-travel patterns of college
2 students and university populations in general. This study is aimed at filling this gap in
3 knowledge.

4 5 **ASU TRAVEL SURVEY**

6 The data used in the analysis for this paper comes from the Arizona State University (ASU)
7 Travel Survey, administered between April 4 and 25, 2012. ASU is one of the largest
8 universities in the United States, with 4 large urban campuses spread across the Metropolitan
9 Phoenix Area, serving over 70,000 graduate and undergraduate students. The survey was
10 administered entirely online and was designed to collect data that could be used to update the
11 Maricopa Association of Governments (MAG) regional 4-step model and, eventually, aid in the
12 transition to an activity-based travel demand model for the MAG region. The survey was
13 administered to the entire university community of faculty, staff, and students through the
14 cooperation of the university administration.

15 The survey data was gathered in four parts: (1) respondent affiliation with ASU and socio-
16 demographic information, (2) a one-day travel diary, asking respondents to report trips for the
17 most recent weekday, (3) typical travel to and from ASU and to and from work, and (4) attitudes
18 and perceptions, gathering data that addresses feelings concerning safety and convenience of
19 transit and auto modes. Respondents were asked to complete the travel diary portion of the
20 survey for their most recent weekday. As the message inviting the university community to
21 participate in the survey was sent out on a Wednesday, most responses provide detailed travel
22 diary information for a Tuesday. However, in the case of undergraduate students, only about
23 29% recorded the travel diary for a Tuesday while another 31% recorded the travel diary for a
24 Friday suggesting that a large proportion of this population group waited until the weekend to fill
25 out the survey.

26 Following survey data collection, a rigorous cleaning and filtering process ensued. The
27 filtered dataset was weighted such that distributions of specific demographic variables matched
28 the population distributions obtained from ASU institutional data. Weighting was achieved using
29 the iterative proportional fitting (IPF) and iterative proportional updating (IPU) procedure
30 employed by the PopGen synthetic population generation software (complete details about this
31 procedure may be obtained from Ye, et al, 2009). Weighted respondent characteristics for each
32 segment of the ASU community are presented in Table 1.

33 The data reveals that, while the majority of students are Caucasian, there is a relatively large
34 population of Latino students and staff at ASU. This is not, however, seen in the faculty group.
35 As may be expected, more than 12% of both graduate and undergraduate students have zero
36 vehicle availability, while less than 2% of faculty and staff fall into this category. Graduate
37 students exhibit the highest proportion of individuals reporting zero trips and the average trips
38 rate among all segments. In comparison, only 6% of staff members make zero trips on the travel
39 day. The trip rates shown are calculated by dividing the total number of trips by the total number
40 of respondents in each segment. Undergraduate students have the highest trip rate of any
41 segment, making 4.69 trips per weekday. Compared to, for example, the UCD campus (Miller,
42 2012) many more undergraduate and graduate students at ASU live with family – either with
43 spouses and children, or with parents and siblings. ASU has a large population of students who
44 are also area residents. These residents tend to have social contacts, activities, jobs, and
45 established routines outside of campus life, thus contributing to a relatively high daily trip rate. A
46 substantially higher proportion of students do not have access to a vehicle when compared to

1 faculty and staff market segments. Students are much more likely to live with roommates than
 2 faculty and staff. About 19 percent of undergraduate students live on campus.
 3

4 **Table 1. Description of ASU Travel and Mode Use Survey Respondents (Weighted)**

		Undergraduate Student	Graduate Student	Faculty	Staff	Total
N		58,404	13,850	2,991	6,200	81,445
% of Total Sample		71.7%	17.0%	3.7%	7.6%	100.0%
% Female		50.5%	50.8%	42.0%	58.0%	50.8%
Annual Household Income	< 20 K	71.3%	41.8%	0.7%	0.9%	58.3%
	>= 20 K – 40 K	11.5%	25.7%	2.8%	11.5%	13.6%
	>= 40 K – 60 K	2.8%	10.7%	8.7%	19.5%	5.6%
	>= 60 K – 80 K	1.0%	5.9%	11.2%	18.5%	3.5%
	>= 80 K – 100 K	0.4%	2.9%	13.8%	13.9%	2.4%
	>= 100 K	1.0%	5.0%	50.5%	25.1%	5.3%
Ethnicity	African American	5.2%	3.9%	2.4%	4.4%	4.8%
	Native American	1.9%	1.6%	0.9%	1.9%	1.8%
	Asian	8.6%	19.9%	10.6%	6.7%	10.4%
	Latino / Hispanic	18.8%	10.4%	6.9%	14.0%	16.6%
	White / Caucasian	61.4%	60.8%	78.1%	71.5%	62.6%
	Other	2.2%	1.6%	0.3%	0.6%	1.9%
	No Answer	1.9%	1.9%	0.8%	0.9%	1.8%
Vehicle Availability	0 vehicles	16.6%	12.7%	1.0%	1.8%	14.2%
	1 vehicle	26.2%	33.5%	28.8%	24.0%	27.4%
	2 vehicles	26.7%	36.9%	55.0%	51.6%	31.4%
	3 vehicles	18.7%	11.2%	12.9%	15.9%	17.0%
	4 or more vehicles	11.8%	5.7%	2.3%	6.7%	10.0%
Living Arrangement	On Campus	18.8%	0.6%	0.0%	0.0%	13.6%
	With Family	46.7%	52.0%	80.4%	77.5%	51.2%
	With Roommates	24.7%	26.6%	1.4%	4.8%	22.7%
	Both Family and Roommates	2.8%	2.1%	0.7%	1.7%	2.5%
	Alone	7.0%	18.7%	17.4%	15.9%	10.0%
Work Arrangement	Work on-campus	11.0%	38.8%	100.0%	100.0%	33.3%
	Work off-campus	48.4%	32.7%	0.0%	0.0%	36.2%
	Work on- and off-campus	5.3%	9.4%	0.0%	0.0%	4.7%
	Not working	35.3%	19.0%	0.0%	0.0%	25.8%
% Zero-Trip Makers		13.7%	15.4%	11.1%	6.0%	13.3%
Average Daily Trip Rate		4.69	3.89	4.31	4.57	4.53

5
6

CHARACTERISTICS OF DAILY TRAVEL BEHAVIOR

The travel characteristics of college students have been addressed in a few prior papers (Rodriguez and Joo, 2004; Khattack et al, 2011; Eom et al, 2009; Miller, 2012), especially in the context of student mode choice to and from campus. The descriptions presented here focus on highlighting a few similarities and differences of travel characteristics across different university segments as well as characteristics unique to the university population. Within the scope of this paper, it is impossible to provide comprehensive tabulations of all travel behavior characteristics.

Figure 1 shows the (weighted) time-of-day distribution of trips for undergraduates, graduate students, faculty, and staff.

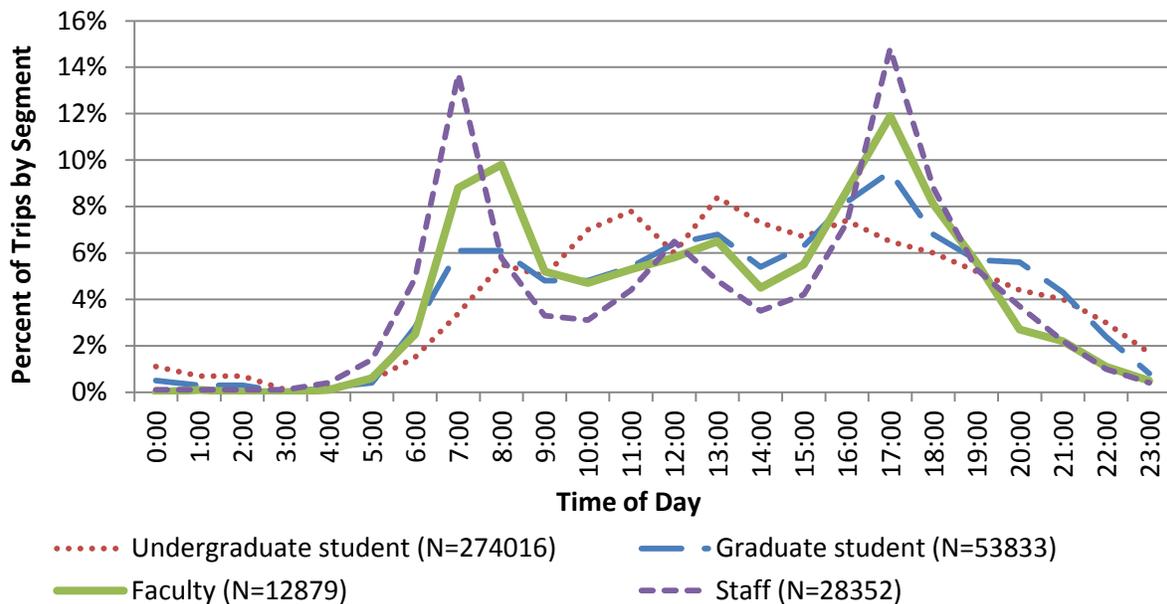


Figure 1. Time of Day Distribution of Travel by Market Segment

This graph is inclusive of all trips, not just those made for ASU-based travel. The time-of-day distribution for staff travel is quite representative of what one would expect of a typical working adult. There are clear peaks in the AM and PM periods (corresponding to commute travel) and a smaller peak during the midday for lunch. Faculty members also tend to have a three-peak structure similar to that seen for staff. However, faculty members' AM and midday peaks are a bit later in the day and the AM and PM peaks are flatter and less sharply defined. Graduate students behave similar to faculty members in their time-of-day choices, except that they have a lower share of AM trips and tend to schedule a larger proportion of trips in the later part of the evening. The larger share of evening trips could be indicative of the 32% of graduate students who are part-time as well as the full-time graduate students who work late into the night in research labs and the library. Part-time students likely work full time during the day and take graduate courses in the evenings to further their careers. Undergraduate students' time of day distribution has very little in common with the other segments. Undergraduates are seen to participate in travel throughout the day with a few small peaks distributed throughout the midday period, presumably coinciding with class start times. The higher proportions of mid-day and evening trips exhibited by undergraduate students are consistent with findings reported by Khattak et al (2011). The "dip" in undergraduate travel during the noon hour is likely due to the

1 fact that many classes on Tuesdays and Thursdays are scheduled from 12:00 – 1:15 PM, forcing
2 students to engage in travel just before or after the traditional lunch time (when most staff
3 members make their midday lunch trips).

4 Previous literature notes that student mode choice tends to vary based on age and level of the
5 student, the setting of the campus (urban or rural), student living arrangements (on or off
6 campus), and student worker status (Khattak et al, 2011; Wang et al, 2012). Table 2 shows the
7 mode choice of students, faculty and staff by trip purpose. In this table, it should be noted that
8 “school” refers to either attending (in the case of students) or teaching (in the case of faculty)
9 class.

10 In this urban campus setting, all segments show a preference for using the drive alone mode
11 to work and work-related trips. As is expected, carpooling (shared ride) is most prevalent for
12 serve-passenger trips. Faculty and staff show high mode shares for walk, particularly for work
13 and work-related trips – presumably because these groups walk for job-related reasons within the
14 campus. As a substantial share of students work off-campus, their walk mode share for work is
15 consequently less than that for faculty and staff. Students use the walk mode most often for
16 school and school-related trips, and all segments use the walk mode for a large proportion of eat-
17 meal trips. This indicates that members of the ASU community tend to eat (lunch) on or near
18 campus. The large mode share of carpooling for social and shopping trips is unique to the
19 undergraduate segment. This is consistent with the earlier statistic in Table 1 that 16.6% of the
20 undergraduate population does not have access to a personal vehicle. For these students, trips
21 farther than walking distance must be completed by transit, bicycle, or carpool.

22 For all segments and purposes, transit makes up an extremely small portion of trips. This is
23 not necessarily typical of the university culture (Miller, 2012), but rather of the built environment
24 and network accessibility in the region. The Greater Phoenix metropolitan area is a sprawling,
25 auto-oriented region where the mode share for transit is quite low. When trips are no longer
26 within walkable distance, then auto modes (drive alone and ride share) capture the lion share of
27 the trips. Light rail and bus appear to have slightly larger shares for “other” trips. These trips
28 may be special event trips (such as going to a ball game or concert) that are conveniently
29 accessed using transit.

30 Table 3 presents average trip durations, trip lengths, and trip rates by purpose for each of the
31 university market segments. Across all segments of the ASU community, the average travel time
32 for a trip is approximately 20 minutes. Even though undergraduate students average slightly
33 shorter times while staff members average slightly longer trip durations, the variability in
34 average travel times is rather modest. Similarly, there is little variability across segments in the
35 time spent traveling to work and work-related activities. The travel times for intra-campus trips
36 are reflective of the short distances traveled. The ASU campuses are arranged such that classes
37 and activity centers are near the geographic center of each campus while student housing is
38 located along the edges. This geographical arrangement explains the longer time that
39 undergraduate students spend on intra-campus trips. The average trip distances are generally
40 consistent with the travel times reported. Even though graduate students spend more time
41 traveling to personal business trips than other groups, the distances traveled are not necessarily
42 longer. This suggests that graduate students use slower modes of travel to reach personal
43 business activity locations. Overall, undergraduate students average the shortest trip distance at
44 6.2 miles.

1 **Table 2. Mode Share by Trip Purpose for Various University Market Segments**

Segment	Trip Purpose	Drive Alone	Shared Ride	Walk	Bicycle	Light Rail	Bus	Total
Under-graduate Student Trips	Work/ Work-Related	61.9%	10.8%	14.3%	5.9%	2.6%	2.9%	100.0%
	School/ School-Related	23.7%	6.5%	45.5%	11.7%	4.5%	4.7%	100.0%
	Eat Meal	22.9%	26.3%	39.7%	6.6%	1.1%	1.0%	100.0%
	Social/ Recreational	32.1%	32.0%	24.7%	6.1%	1.7%	1.5%	100.0%
	Shopping	42.2%	41.8%	9.7%	2.3%	1.1%	2.4%	100.0%
	Personal Business	46.0%	30.3%	15.4%	4.0%	1.1%	2.0%	100.0%
	Serve Passenger	35.3%	62.1%	1.3%	0.1%	0.3%	0.7%	100.0%
	Go Home	43.9%	22.9%	15.9%	8.4%	3.3%	4.1%	100.0%
	Other	33.7%	20.2%	26.4%	3.8%	7.4%	5.7%	100.0%
	All Purposes (100%)	35.6%	20.1%	27.7%	7.8%	3.3%	3.5%	100.0%
Graduate Student Trips	Work/ Work-Related	62.4%	7.6%	15.8%	7.5%	3.0%	3.4%	100.0%
	School/ School-Related	34.5%	6.0%	36.2%	12.4%	3.9%	6.5%	100.0%
	Eat Meal	36.5%	25.0%	29.9%	6.7%	0.3%	1.3%	100.0%
	Social/ Recreational	37.0%	26.7%	23.7%	7.7%	2.0%	1.3%	100.0%
	Shopping	50.6%	30.6%	8.2%	5.7%	1.2%	3.7%	100.0%
	Personal Business	67.9%	19.2%	8.3%	2.7%	0.6%	1.3%	100.0%
	Serve Passenger	39.5%	58.3%	1.4%	0.7%	0.0%	0.0%	100.0%
	Go Home	55.3%	19.1%	5.7%	11.6%	3.1%	5.0%	100.0%
	Other	40.3%	12.0%	25.0%	3.5%	10.2%	7.0%	100.0%
	All Purposes (100%)	47.4%	16.5%	19.3%	8.9%	3.0%	4.3%	100.0%
Faculty Trips	Work/ Work-Related	41.7%	9.3%	35.0%	8.8%	2.7%	1.7%	100.0%
	School/ School-Related	33.2%	3.7%	58.9%	2.2%	0.7%	1.2%	100.0%
	Eat Meal	35.1%	25.7%	33.5%	4.4%	0.6%	0.8%	100.0%
	Social/ Recreational	39.1%	30.1%	16.4%	10.6%	0.0%	0.9%	100.0%
	Shopping	68.0%	25.0%	4.2%	1.1%	0.0%	1.8%	100.0%
	Personal Business	78.7%	14.9%	4.6%	1.9%	0.0%	0.0%	100.0%
	Serve Passenger	38.9%	57.7%	2.4%	1.0%	0.0%	0.0%	100.0%
	Go Home	56.6%	24.5%	4.7%	9.3%	2.0%	3.0%	100.0%
	Other	44.6%	14.4%	23.6%	4.9%	9.0%	3.5%	100.0%
	All Purposes (100%)	47.2%	19.0%	22.9%	6.8%	1.9%	1.8%	100.0%
Staff Trips	Work/ Work-Related	48.8%	10.3%	28.8%	5.0%	2.0%	3.8%	100.0%
	School/ School-Related	30.9%	17.2%	43.4%	5.1%	2.0%	1.5%	100.0%
	Eat Meal	25.7%	26.4%	44.4%	1.9%	0.5%	0.9%	100.0%
	Social/ Recreational	37.5%	28.2%	24.2%	6.2%	1.5%	1.0%	100.0%
	Shopping	67.0%	25.3%	5.1%	1.4%	0.2%	0.8%	100.0%
	Personal Business	68.9%	20.0%	8.2%	2.0%	0.4%	0.4%	100.0%
	Serve Passenger	35.3%	63.9%	0.7%	0.0%	0.0%	0.1%	100.0%
	Go Home	62.8%	25.3%	2.9%	4.3%	1.6%	3.1%	100.0%
	Other	40.6%	16.1%	24.9%	1.3%	7.9%	8.5%	100.0%
	All Purposes (100%)	50.4%	21.1%	19.3%	3.6%	1.9%	3.0%	100.0%

1
2

Table 3. Average Trip Travel Times, Distances, and Trip Rates to Various Activity Types

		Undergraduate	Graduate Student	Faculty	Staff
Trip Duration (minutes)	Work/ Work Related	22.45	23.37	21.82	22.94
	School/ School Related	18.99	19.58	16.48	16.66
	Eat Meal	13.74	14.32	13.16	12.14
	Social/ Recreational	21.18	19.89	18.05	19.64
	Shopping	16.21	14.54	15.30	17.09
	Personal Business	18.00	20.34	15.79	18.69
	Serve Passenger	20.61	19.06	16.97	18.84
	Go Home	22.01	22.08	23.85	24.54
	Other	22.18	22.04	21.56	19.35
	Intra-Campus	8.92	7.49	6.21	7.59
	Inter-Campus	53.10	50.35	38.50	51.52
	To/From Campus	26.54	22.82	27.67	27.43
	Non-Campus Based	20.96	21.41	19.84	19.42
	All Trips	19.73	20.18	20.23	21.00
Trip Distance (miles)	Work/ Work Related	7.8	9.0	9.9	8.3
	School/ School Related	4.7	5.7	4.9	4.4
	Eat Meal	3.5	3.8	3.2	3.1
	Social/ Recreational	7.8	6.4	5.8	5.2
	Shopping	4.5	4.1	5.4	5.7
	Personal Business	8.2	7.8	5.3	6.6
	Serve Passenger	8.1	7.8	7.2	7.2
	Go Home	7.3	9.2	8.3	9.0
	Other	9.0	6.6	7.5	9.0
	Intra-Campus	0.6	0.5	0.4	0.5
	Inter-Campus	18.3	20.8	18.5	20.1
	To/From Campus	7.6	5.9	8.8	10.0
	Non-Campus Based	8.4	9.0	9.7	7.6
	All Trips	6.2	7.1	7.8	7.6
Trip Rate	Work/ Work Related	0.41	0.60	1.58	1.62
	School/ School Related	1.36	0.93	0.33	0.07
	Eat Meal	0.52	0.38	0.27	0.39
	Social/ Recreational	0.31	0.24	0.19	0.20
	Shopping	0.22	0.23	0.19	0.29
	Personal Business	0.20	0.18	0.23	0.29
	Serve Passenger	0.12	0.10	0.30	0.25
	Go Home	1.20	0.99	1.02	1.09
	Other	0.34	0.24	0.20	0.38
	Intra-Campus	1.21	0.52	0.75	0.64
	Inter-Campus	0.04	0.03	0.01	0.04
	To/From Campus	1.35	1.12	1.48	1.71
	Non-Campus Based	2.09	2.22	2.06	2.19
	All Trips	4.69	3.89	4.31	4.57

3
4
5

Trip rates (the third block of the table) are calculated by dividing the total number of trips by the total number of respondents in the respective segment. This means that trip rates account for

1 zero-trip makers. The trip rates for intra-campus trips appear to be rather low for all segments.
2 However, these rates should be viewed in the context of about 13% of respondents reporting zero
3 trips on the travel survey day, and another 31% of respondents who report trips but do not visit
4 an ASU campus at all on the travel survey day. It is also possible that there is some under-
5 reporting of intra-campus trips, as it is quite burdensome to report each and every movement
6 within a campus environment.

8 **CHARACTERISTICS OF DAILY ACTIVITY PARTICIPATION**

9 This section explores the activity participation behavior of the university community. Activity
10 participation information was derived from the trip data collected in the survey. Only those
11 respondents who reported making at least one trip were included in the activity participation
12 analysis (all others are assumed to stay home all day). Trips were included in the activity
13 analysis as “travel” activities (episodes). It was assumed that each respondent began his or her
14 day at home, and each subsequent activity was assigned a purpose corresponding to the
15 destination of the trip leading up to the activity. For example, if trip number one was recorded as
16 a school trip, then activity number one is home stay (assumed), activity number 2 is travel, and
17 activity number 3 is school. Table 4 presents statistics concerning activity participation for each
18 segment of the ASU community.

19 The average daily time expenditure is shown in the table for various activity purposes. In
20 addition, the table shows the percent of day spent each activity purpose, and the percent of all
21 respondents who participated in each activity. A summary of maintenance, discretionary, and
22 mandatory activities is shown at the bottom of the table. In this paper, mandatory activities are
23 the aggregation of all work, school, work-related, and school-related activities, maintenance is
24 combined shopping and personal business, and discretionary is combined social or recreational
25 and eating a meal (outside the home). Mandatory, maintenance, and discretionary activities
26 performed inside the home are not included in these summaries.

27 Since the activity participation dataset was limited to those respondents who made at least
28 one trip, 100% of every segment participated in travel. Also, because the first activity was
29 assumed to be at home for every respondent, 100% of every segment participated in in-home
30 stay activities. Across various segments, the time spent in maintenance activities differed very
31 little. However, the percent of staff members who participated in maintenance activities is
32 greater than for any other segment. This could indicate that staff members are likely to have
33 more responsibilities to the household or family than other segments.

34 As expected, faculty and staff spend a larger portion of their day in mandatory activities than
35 students. In addition, a slightly larger proportion of faculty and staff participate in mandatory
36 activities when compared to students. Staff spends a larger portion of the day in work activities,
37 relative to any other segment. However, one should keep in mind that teaching classes was
38 considered a school activity. Therefore, school and school-related activities are, in fact, work
39 activities for faculty respondents. Based on this interpretation, faculty members spend 32
40 percent of their day on work (and teaching class), while staff spend 33 percent of their day on
41 work.

Table 4. Activity Participation by Segment

Activity	Average Daily Time Spent (min)				Average Portion of the Day Spent				Percent of Segment that Participated			
	UGs*	Grads**	Faculty	Staff	UGs*	Grads**	Faculty	Staff	UGs*	Grads**	Faculty	Staff
All In-Home	826.6	806.0	773.6	721.0	57%	56%	54%	50%	100%	100%	100%	100%
Travel	133.8	107.1	105.5	116.8	9%	7%	7%	8%	100%	100%	100%	100%
Work/Work-Related	130.1	193.7	396.8	471.6	9%	13%	28%	33%	37%	47%	85%	93%
School/School-Related	195.9	211.8	54.7	9.6	14%	15%	4%	1%	74%	63%	21%	5%
Eat Meal (Out of Home)	36.3	30.3	18.5	24.8	3%	2%	1%	2%	43%	37%	25%	32%
Social Recreation/Sport	45.6	36.9	30.7	27.0	3%	3%	2%	2%	24%	22%	18%	17%
Shopping	14.6	16.1	10.9	15.1	1%	1%	1%	1%	19%	21%	19%	24%
Personal Business	18.7	13.2	19.4	21.1	1%	1%	1%	1%	15%	15%	19%	19%
Serve Passengers	6.5	3.2	14.7	8.5	0%	0%	1%	1%	8%	6%	16%	13%
Other Activities	31.9	21.7	15.2	24.4	2%	2%	1%	2%	21%	14%	14%	17%
Total Discretionary	81.9	67.3	49.1	51.8	6%	5%	3%	4%	55%	49%	36%	42%
Total Maintenance	33.3	29.2	30.3	36.3	2%	2%	2%	3%	31%	32%	33%	39%
Total Mandatory	326.0	405.5	451.5	481.1	23%	28%	31%	33%	89%	90%	93%	94%

* Undergraduate students; ** Graduate Students

Perhaps somewhat surprising is the proportion of the day that students spend in the home. Compared to staff members, for example, undergraduate students have a home time allocation proportion that is six percentage points higher (corresponding to 90 additional minutes in home per day). This is rather counter to the notion that students spend their time being social and having fun. This is not to say, however, that students do not spend time being social. Table 4 indicates that 55% of undergraduate students (compared to 36% of faculty) spend some time in discretionary activities each day. This 55% spends on average about 6% of their day on discretionary activities – more than any other segment.

Faculty and graduate students spend just over 7% of their day (about 100 minutes) in travel. In comparison, staff members spend 8% and undergraduate students spend 9% of their day on travel. This could largely be due to the distance between home locations and campus. As noted in Table 3, staff members spend on average more time on a typical home-bound trip than any other segment. The additional travel time for undergraduate students could be indicative of longer distances traveled or, more likely, of simply having a larger trip rate than any other segment. This segment may also be using slower modes (due to a higher level of zero vehicle ownership). Also, undergraduates who live on campus have the flexibility to return home (to the dormitory) in between classes and other responsibilities, which is likely the reason for the larger trip rate seen in Table 3.

An analysis of what each person is doing along the continuous time axis of a day is a useful way to visually understand and compare temporal activity patterns through the course of a day. Figure 2 shows the time-of-day activity engagement profiles different university groups. At each time point, the profiles indicate the percent of each segment engaged in each type of activity. The time axis covers a 24 hour period beginning at 3:00 AM and ending at 2:59 AM on the following day. One can clearly see the times of day when a large proportion of individuals are at home. In general, a vast majority of individuals are at home during the overnight hours although it appears that a small percent of individuals work the night shift or engage in social recreational activities late into the night and the very early morning hours. A small percent of students engage in school related activities in the overnight hours, which is not unexpected.

When compared to faculty and staff, a vast majority of whom are working during the middle of the day, students are found to stay at home in larger proportions, presumably because they neither have school nor work at that time. The non-home, non-mandatory activities (personal business, eating meal, shopping, social/recreation, etc.) are clearly bunched at the end of mandatory activities and before going home in the faculty and staff profiles. This does not hold true, however, for students who seem to distribute their non-home, non-mandatory activities more evenly from about mid-day until very late at night.

The percent of individuals pursuing work and work-related activities at any given time is shown in blue while school and school-related activities are shown just above in red. Students tend to work in the afternoon and distribute school activities evenly throughout the day. Graduate students, however, tend to work a bit earlier in the day and participate in school more in the afternoon and evening (consistent with the large percent of part time graduate students). Faculty members are found to engage in work activities in greater proportions than staff members in the latter part of the day; larger proportions of staff members engage in work activities earlier in the day, showing a clear work “peak” in the AM.

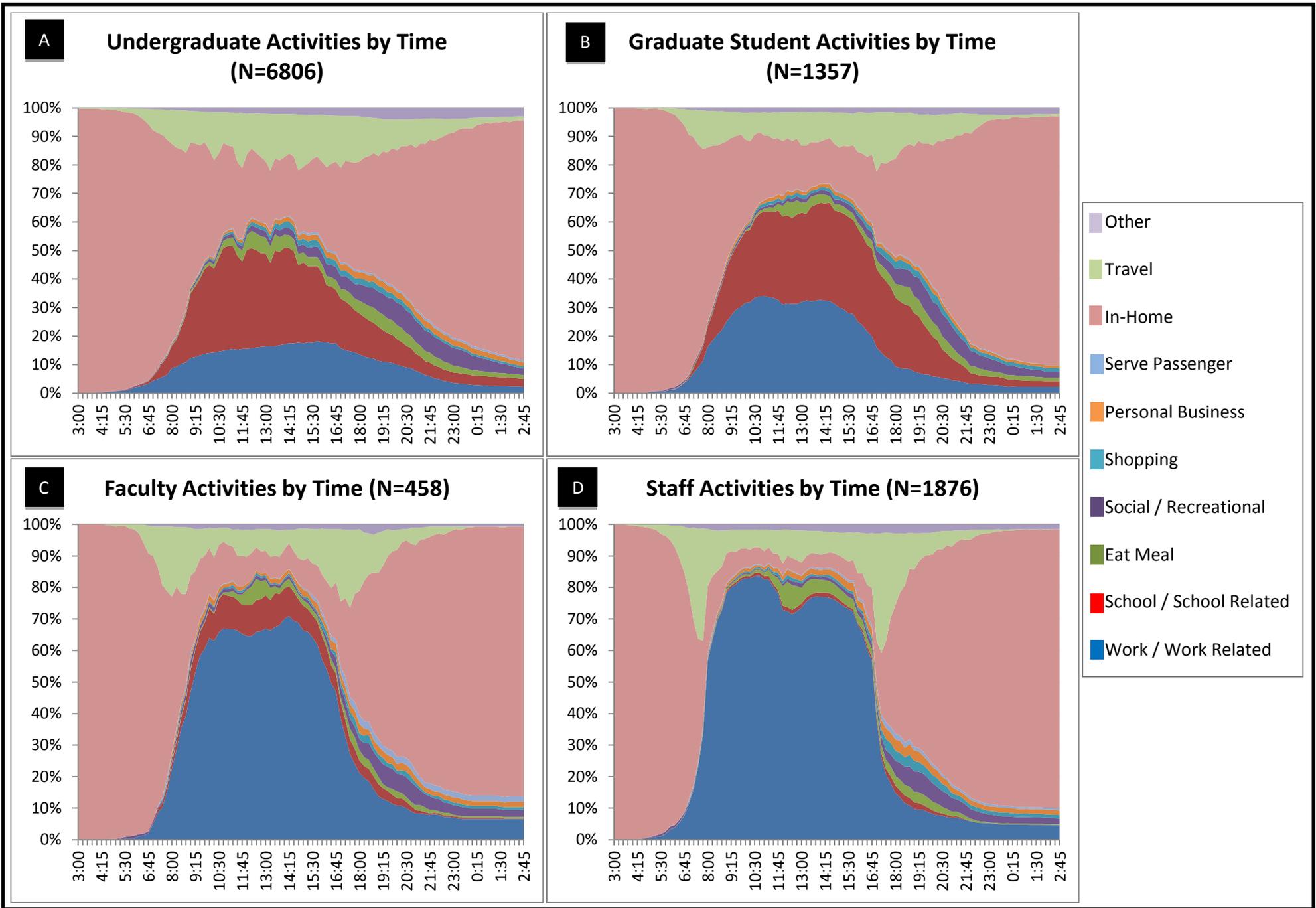


Figure 3. Time-Of-Day Profiles for (A) Undergraduates, (B) Graduate Students, (C) Faculty, and (D) Staff

1 It is worth noting that the cyclical peaks and valleys in the student profile (very clearly
2 discerned in the travel engagement profile at the top of the chart in light green) during the middle
3 of the day may be attributed to ASU class schedules. A typical class at ASU lasts for 75 minutes,
4 with a 15-minute break between the end of one class and the start of the next. The profile for
5 undergraduates shows that students travel during these 15-minute breaks, and then settle back
6 into class or another activity. If one were to visit the ASU campus during a typical semester
7 weekday, one would note the massive surge of students that crowd the campus walkways during
8 these 15-minute breaks between classes. The jagged edge of the travel and activity engagement
9 profiles is remarkably aligned with class start and end times in a typical weekday schedule.

10 11 **CHARACTERISTICS OF TRIP CHAINING**

12 Of particular interest to developers of activity-based models is trip chaining behavior. Models of
13 activity scheduling may be enhanced by understanding the types of trips that occur in a multi-
14 stop chain, the ordering of trip purposes, the length of the tour, and the time allocated to a tour.
15 For the analysis of trip chaining in this paper, home-based trip chains are defined as a series of
16 activities in a closed loop beginning and ending at home. For example, a home-based ASU tour
17 may be one that involves a departure from home, a stop at a coffee shop, proceeding to an ASU
18 campus, and then going back home. This example tour would have two activity locations outside
19 home: coffee shop and ASU. The specific purpose of the trip to ASU is not considered in this
20 analysis. The exception to this is the case of on-campus residential students. For these students,
21 trips to the ASU campus were separated into home (dorm) and all other purposes, so that a trip
22 from the dorm to somewhere else on campus and back to the dorm would be counted as a home-
23 based trip chain.

24 Table 5 presents a summary of home-based trip chaining behavior derived from the ASU
25 travel survey. The data presented is unweighted so that the raw profile may be gleaned from the
26 table. While undergraduate students have the greatest number of tours per trip maker, staff
27 members spend the longest time (duration) on home-based tours. Staff members are likely to
28 spend full work days on campus; couple this with the longer commute times and the longer tour
29 durations can be easily explained. A large proportion of undergraduates, on the other hand, live
30 on campus or in neighborhoods very close to campus; they can make return home trips in the
31 middle of the day, thus resulting in shorter duration home-based trip chains (but a higher
32 frequency).

33 Though faculty and staff seem to have slightly more locations per tour, every segment has
34 between 2.5 and 3.0 out of home stops per tour (on average). About 60% of all home-based tours
35 have a stop at ASU for all groups. Students make more home-based trip chains in a day, but
36 spend on average less time per trip chain. Students generally do not have to stay on campus as
37 long as faculty and staff members do, and the close proximity of the home location to campus
38 allows temporary midday home sojourns.

39 Table 5 provides a breakdown of the “1st stop.” This refers to the location visited
40 immediately after departing home. One can see that a majority travel from home directly to
41 either ASU or work. Faculty, and to a lesser extent staff, are likely to travel for serve-passenger,
42 reflecting drop-off events that tend to occur on the way to and from work. A small portion of “1st
43 stop” types are home, indicating a home-to-home trip. Many of these trips are “walk the dog”
44 type trips, where a person leaves the home, participates in some activity like walking the dog and
45 jogging, and then returns home. For undergraduate students this is also partly comprised of trips
46 from one “home” to another. Undergraduates often stay on campus or in an apartment near

1 campus, but also still consider their parents’ homes as their own. Therefore, undergraduates who
 2 made trips from their dorms to their parents’ homes coded them as “Go Home” trips.

3

4 **Table 5. Analysis of Trip Chaining Behavior**

	Undergraduates	Graduate Students	Faculty	Staff	All	
Number of Home-based (HB) Trip Chains	9486	1606	531	2167	13790	
Avg HB Chains per Person	1.20	1.00	1.02	1.09	1.15	
Avg HB Chains per Trip Makers	1.39	1.18	1.16	1.16	1.31	
Avg HB Chain Duration (min)	353.9	444.8	454.1	521.7	394.7	
Avg Stops/HB Chain	2.59	2.59	2.82	2.90	2.65	
% HB Chains with ASU Stop	62%	58%	58%	62%	61%	
Purpose of the 1st Stop	Work / Work Related (not ASU)	12%	18%	18%	16%	14%
	School / School Related / Campus	52%	47%	40%	46%	50%
	Eat Meal	7%	6%	5%	5%	6%
	Social / Recreational	6%	8%	7%	6%	6%
	Shopping	5%	6%	5%	5%	5%
	Personal Business	4%	5%	6%	5%	4%
	Serve Passenger	4%	3%	12%	9%	5%
	In-Home	4%	2%	2%	2%	3%
	Other	7%	6%	6%	7%	6%
Purpose of Stop Following Last ASU Stop	Work / Work Related (not ASU)	5%	3%	7%	6%	5%
	School / School Related / Campus	1%	2%	1%	0%	1%
	Eat Meal	7%	9%	4%	5%	7%
	Social / Recreational	3%	4%	4%	4%	4%
	Shopping	4%	6%	6%	10%	5%
	Personal Business	3%	3%	5%	8%	4%
	Serve Passenger	2%	2%	7%	6%	3%
	In-Home	67%	67%	63%	54%	65%
	Other	6%	4%	4%	7%	6%
% of Tours that are Home-ASU-Home	17%	15%	15%	14%	16%	

5

6 Table 5 also provides detail on the type of location visited directly after the last ASU stop in
 7 the chain. For all segments, a good majority go straight home from ASU. The proportion of
 8 students reporting that they proceed to eat-meal after the last ASU stop is larger than that for
 9 faculty and staff members. As in the 1st stop on the tour, staff are likely to serve passengers after
 10 leaving ASU. Staff members are more likely than any other segment to run errands after leaving
 11 ASU, indicated by the higher percent of shopping and personal business stops. This supports the
 12 notion that staff may have more family or household responsibilities than any other segment.

13 Activity schedule modelers may be interested to see that 17% of undergraduate and 15% of
 14 graduate student and faculty home-based tours are simple home-ASU-home tours. In other
 15 words, they travel from home directly to ASU and then directly back home again.

16

1 **DISCUSSION AND CONCLUSIONS**

2 This paper describes trip making, activity participation, and trip chaining behaviors of
3 undergraduate students, graduate students, faculty, and staff at Arizona State University, one of
4 the largest universities in North America. Data was collected from the ASU population by means
5 of an online travel survey. Although large universities represent significant special generators of
6 travel demand in many large metropolitan regions, the daily activity-travel behavior of university
7 populations is not well understood. In this paper, detailed analyses of travel characteristics,
8 activity participation, and trip chaining behavior for students, faculty, and staff are presented.
9 Several notable patterns come to light through the analysis presented in this paper.

10 Consistent with the results of other university population surveys, university students travel
11 profile deviates from the typical time-of-day distributions of travel. While the general population
12 displays an AM and PM peak hour of travel and a smaller peak at midday, students distribute
13 their travel much more evenly throughout the day and tend to concentrate trips during the middle
14 of the day. Student travel profiles show a larger percent of trips being made very late at night in
15 comparison to other segments. Though the mode choice of all segments of the population is
16 dominated by driving alone, undergraduate students show a greater share of carpool trips,
17 particularly for social, recreational, and shopping activities. This is probably due in part to the
18 greater share of undergraduate students who do not have access to a personal vehicle and must
19 rely on friends and family to travel to destinations farther than walkable distance.

20 The paper presents detailed tabulations of average trip rates, trip lengths, and trip durations
21 by purpose. In general, it is found that staff members tend to reside farther away from campus
22 locations and drive longer distances to and from work. Staff members spend more time traveling
23 to shopping and personal business locations while faculty members, in general, spend less time
24 than other segments doing any traveling at all, with the exception of the home and work trip
25 times.

26 An examination of daily travel and activity time expenditure patterns suggests that
27 undergraduates spend more time than any other group on discretionary activities. Even though
28 undergraduate students spend a greater amount of travel time on chauffeuring trips than faculty
29 or staff, they are less likely than faculty or staff to participate in these activities; only 8% of
30 undergraduate students participate in serve passenger activities on a typical day. This observation
31 suggests that undergraduates are serving passengers to/from farther distances. Similarly, graduate
32 students spend less time than any other segment participating in personal business activities, but
33 more time traveling to those activities. Graduate students may be willing or need to travel farther
34 for personal business, even though the activities themselves take less time.

35 The analysis reveals some interesting differences between faculty and staff at ASU. A trip
36 chaining analysis shows that a combined 18% of staff members stop at shopping or personal
37 business locations – activities generally thought of as running errands – immediately after their
38 last ASU stop and before returning home. This, coupled with the greater time that staff spend
39 both traveling to and participating in these “errand” activities, indicates that staff members likely
40 take on more household or family maintenance burden than faculty members. Recent literature
41 on the travel patterns of women might suggest that this behavior is more indicative of that of
42 females in households with children (McGuckin and Murakami, 1999); additional investigation
43 is need to fully unravel the complex reasons for the differences between faculty and staff
44 member household responsibilities and associated travel and activity participation behavior.

45 In conclusion, a rich data set on university population travel behavior has been collected by
46 conducting a survey of faculty, staff, and students at Arizona State University. This data has

1 made it possible to analyze and document the daily activity-travel patterns of the university
2 community. The analysis presented in this paper is just a small sample of the possible analyses
3 that could be undertaken using the dataset obtained from the survey. The analysis shows that
4 university communities are considerably heterogeneous with respect to their travel and activity
5 participation, although the different market segments were also observed to show similarities on
6 selected activity-travel characteristics. Universities, especially those with large enrollments,
7 constitute special generators of travel demand and the data analysis reported in this paper is but a
8 first step in the development of comprehensive activity-travel demand models specifically
9 constructed for university environments.

10 REFERENCES

- 11 Akar, G., C. Flynn, and M. Namgung. Travel Choices and Links to Transportation Demand
12 Management. In *Transportation Research Record: Journal of the Transportation Research*
13 *Board*, Vol. 2319, 2012, pp. 77-85.
- 14 Axhausen, K. and T. Garling. Activity-Based Approaches to Travel Analysis: Conceptual
15 Frameworks, Models, and Research Problems. *Transport Reviews*, Vol. 12, No. 4, 2013,
16 pp. 323-341.
- 17 Balsas, C.J.L. Sustainable Transportation Planning on College Campuses. *Transport Policy*, Vol.
18 10, 2003, pp. 35-49.
- 19 Behrens, R., M. Freedman, and N. McGuckin. The Challenge of Surveying “Hard to Reach”
20 Groups. 8th International Conference on Survey Methods in Transport: Harmonization and
21 Data Quality, Annecy, France, May 25-31, 2008.
- 22 Bhat, C.R., J.Y. Guo, S. Srinivasan, and A. Sivakumar. Comprehensive Econometric
23 Microsimulator for Daily Activity-Travel Patterns. In *Transportation Research Record:*
24 *Journal of the Transportation Research Board*, Vol. 1894, 2004, pp. 57-66.
- 25 Bowman, J.L. and M.E. Ben-Akiva. Activity-based Disaggregate Travel Demand Model System
26 with Activity Schedules. *Transportation Research Part A*, Vol. 35, No. 1, 2001, pp. 1-28.
- 27 Eom, J.K., J.R. Stone, and S.K. Ghosh, Daily Activity Patterns of University Students. *Journal*
28 *of Urban Planning and Development*, Vol. 135, 2009, pp. 141-149.
- 29 Kamruzzaman, Md, J. Hine, B. Gunaey, and N. Blair. Using GIS to Visualize and Evaluate
30 Student Travel Behaviour. *Journal of Transport Geography*, Vol. 19, 2011, pp. 13-32.
- 31 Khattak, A., X. Wang, S. Son, and P. Agnello. Travel by University Students in Virginia: Is This
32 Travel Different from Travel by the General Population? In *Transportation Research*
33 *Record: Journal of the Transportation Research Board*, Vol. 2255, 2011, pp. 137-145.
- 34 McGuckin, N. and E. Murakami. Examining Trip-Chaining Behavior: Comparison of Travel by
35 Men and Women. In *Transportation Research Record: Journal of the Transportation*
36 *Research Board*, Vol. 1693, 1999, pp. 79-85.
- 37 Miller, J. Results of the 2011-12 Campus Travel Survey. *University of California, Davis Institute*
38 *of Transportation Studies*, June, 2012, Research Report – UCD-ITS-RR-12-08, URL:
39 http://www.its.ucdavis.edu/?page_id=10063&pub_id=1644
- 40 Rodriguez, D.A. and J. Joo. The Relationship Between Non-Motorized Mode Choice and the
41 Local Physical Environment. *Transportation Research Part D*, Vol. 9, 2004, pp. 151-173
- 42 U.S. Department of Education (2012) Institute of Education Sciences, National Center for
43 Education Statistics, Fast Facts: Back to School Statistics. URL:
44 <http://nces.ed.gov/fastfacts/display.asp?id=372>
- 45

1 Wang, X., A.J. Khattak, and S. Son, What Can Be Learned from Analyzing University Student
2 Travel Demand? In *Transportation Research Record: Journal of the Transportation*
3 *Research Board*. Transportation Research Board of the National Academies, Washington,
4 D.C., Vol. 2322, 2012, pp. 129-137
5 Ye, X., K. Konduri, R.M. Pendyala, B. Sana, and P. Waddell, A Methodology to Match
6 Distributions of Both Household and Person Attributes in Generation of Synthetic
7 Populations. Presented at the 88th Annual Meeting of the Transportation Research Board,
8 Washington, D.C., January 11 – 15, 2009.
9