USDOT Region V Regional University Transportation Center Final Report

NEXTRANS Project No. 032OY02

Smart Campus Transit Laboratory for Research and Education

By

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DISCLAIMER

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USDOT Region V Regional University Transportation Center Final Report

TECHNICAL SUMMARY

<u>NEXTRANS Project No. 032OY02</u> <u>Final Report, December 31, 2011</u>

Smart Campus Transit Laboratory for Research and Education

Introduction

A joint effort by the Ohio State University (OSU) Transportation and Parking Services, OSU College of Engineering, OSU Department of Civil and Environmental Engineering and Geodetic Science, and Clever Devices has recently succeeded in equipping the OSU Campus Area Bus Service (CABS) with state-of-the-practice sensing, communications, and passenger information technologies that have achieved operational status. CABS serves over four million passengers annually on a fleet of approximately thirty buses and operated six interconnected routes during the academic year 2009-2010. In addition to improving level of service for passengers, the technologies installed on the CABS system provide extensive data on operating performance and ridership characteristics. Because of the relatively complex campus bus transit system, the advanced technologies in operational use, the physical proximity of the system to researchers, educators, and students, the good working relations that have developed over the past decade between CABS managers and transportation researchers and course instructors, and the desire for CABS to support "the academic mission" of the university, the CABS physical and institutional infrastructure has formed the foundation of the OSU Campus Transit Lab (CTL). The objective of this project was to take advantage of this living campus lab for research, education, and outreach activities related to bus transit planning and operations.

Findings

Automatic passenger counter (APC) data, automatic vehicle location (AVL) data, and "onboard" origin-destination (OD) passenger flow data were collected using the CTL. A web-based survey of the perceptions and preferences of the OSU campus community toward transit and transportation services was also conducted. The data were processed and archived for present and future studies.

The data were used to conduct empirical analyses and validations of multiple research investigations. In one research study, CTL APC data were used to validate a methodology, developed by the project investigators under a separate study, that identifies time-of-day periods of homogeneous OD flow patterns. The extensive *in situ* observations obtained on the CTL and familiarity with campus passenger flow patterns allowed a validation of the results. Specifically, the differences in periods automatically identified with the new methodology were seen to correspond to known changes in spatial patterns of campus bus passenger flows throughout the day. It was also seen that the changes could not be identified by identifying changes in passenger volumes. In a second research study, the manually collected OD flow data were used to quantify the effect of onboard OD survey sample size in improving the accuracy of OD flow estimates produced from boarding and alighting data, which are increasingly available from APC technologies. The improvement offered by increased sample size was seen to depend strongly on the structure of the OD flow pattern. A third research study used CTL AVL data to investigate the contribution of drivers' reactions to schedules in affecting service reliability. The results indicate that the drivers' reactions to the schedule are helpful in improving service reliability. In addition the magnitudes of these improvements and the deterioration in reliability due to factors outside the control of the drivers were quantified. CTL AVL data were also used to support an investigation, conducted in a different project, of the potential of using buses to identify times and locations of recurring traffic congestion. Analysis of the web-based survey data revealed that bus transit service is valued by both users and nonusers of the service and that the transportation community values the contribution of the service toward promoting a "green" campus and in reducing campus traffic.

CTL APC and AVL data also formed the basis of modules and assignments in two transportation courses. In a required undergraduate course introducing transportation to 119 undergraduate Civil Engineering students, a description of the CTL was incorporated in an existing module on mass transit, and OD estimation from boarding and alighting data was introduced and reinforced in an assignment using CTL APC data. In addition, CTL travel time data were used with the OD estimates to allow calculation of expected origin-to-destination passenger travel times on a CTL route. In an elective course on public transportation taken by 19 undergraduate and graduate students in Civil Engineering and City and Regional Planning, a discussion of the role of APC and AVL data in public transportation was based on the use of these technologies in the CTL. Students collected data on the CTL, analyzed the data to address specific service and operations questions, compared the manually collected data on bus arrival times at stops to predictions derived from the automatically collected bus location data, and made recommendations for operations based on the resulting data analyses and comparisons.

The unique data and grounded expertise developed through the various CTL research and development activities also allowed project investigators to assist CABS decision makers. The manually collected OD flow data were used to quantify specific bus passenger travel patterns in support of CABS deliberations on the desirability of adding a new campus bus route. CTL collected vehicle location and time data were processed to produce inputs when scheduling the new route. A linear program-based formulation of the scheduling problem that allowed coordination of the schedule of the new route with schedules of existing routes was also developed and run, and the results were used to produce base schedules for Autumn Quarter 2010 service.

Recommendations

The research, education, and outreach activities conducted demonstrate the value of a campus-based, living transit laboratory. The data provided from operational use of the OSU Campus Transit Lab's (CTL) state-of-the-practice Automatic Passenger Counter (APC) and Automatic Vehicle Location (AVL) systems and from targeted manual data collections on the CTL are forming unique bus transit databases and have already supported multiple transit operations and planning research studies and the development of course modules and exercises in required and elective transportation courses. The opportunity for graduate students to design and participate in regular data collection activities and to process, analyze, and interpret the extensive data has also contributed to the educational thrust of the CTL. The CTL is based on OSU's Campus Area Bus Service (CABS), which provides high volume, geographically expansive, and complex campus bus transit service. The working relations between the project investigators and CABS managers facilitate collaboration that provides a grounded setting for research and educational activities and allows CABS to receive otherwise difficult-to-obtain information from project investigators.

Further research, education, and outreach activities are recommended to take advantage of the CTL and to facilitate the identification of ways to improve the living lab. Publicizing the existence and value of the CTL and its potential for inter-university collaborative activities is also recommended.

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Section 1: Introduction

A joint effort by the Ohio State University (OSU) Transportation and Parking Services, OSU College of Engineering, OSU Department of Civil and Environmental Engineering and Geodetic Science, and Clever Devices has recently succeeded in equipping the OSU Campus Area Bus Service (CABS) with state-of-the-practice sensing, communications, and passenger information systems that have achieved operational status. CABS carries over four million passengers annually on a fleet of approximately thirty buses and operated six interconnected routes during the academic year 2009-2010 (see Figure 1-1).

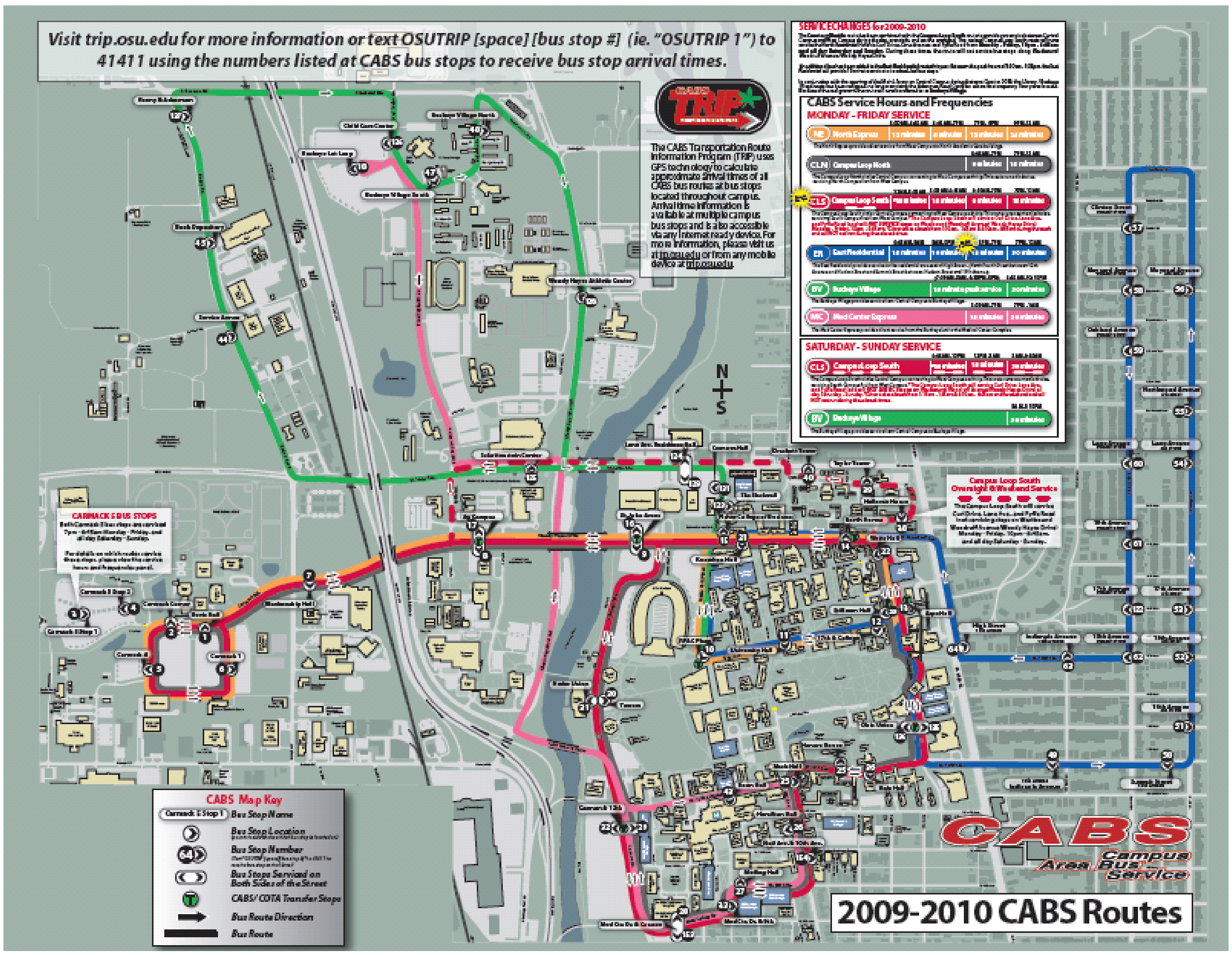


Figure 1-1: **Ohio State University Campus Area Bus Service route map operated in academic year 2009-2010**

In addition to improving level of service for riders, the technologies installed on the CABS system provide extensive data on operating performance and ridership characteristics. Because of the technologically advanced sensing, communications, and information systems, the relatively complex campus transit service provided, the physical proximity of the system to researchers, educators, and students, the good working relations that have developed over the past decade between CABS managers and transportation researchers and course instructors, and the desire for CABS to support “the academic mission” of the university, the project investigators have been developing the CABS physical and institutional infrastructure into the foundation of a living campus lab. The OSU Campus Transit Lab (CTL) has supported research studies and the development of course modules. The CTL has also allowed interaction between project investigators and CABS managers in addressing practical CABS needs. We describe progress in these areas in this report.

Section 2: Problem

The overall problem to be addressed is one of taking advantage of the physical and institutional infrastructure underlying the OSU Campus Transit Lab (CTL) in support of transit related research, education, and outreach.

Section 3. Approach

Manually and automatically collected boarding and alighting data, automatically collected vehicle location data, *in situ* observations of bus operations, and web-based survey data formed the basis of the CTL research, education, and outreach activities undertaken in this project. We designed the data collection efforts to provide archived data bases that can support a wide range of activities, some of which may not even be defined at present. We also tailored our data collection efforts to support contemporary CABS needs and already defined projects. We determined CABS needs through regular interactions with a CABS operations manager and occasional discussions with the director of the OSU Transportation and Parking Services. Research activities were derived from our year 1 project (McCord, et al., 2009) and from methodological developments being pursued in other projects. We designed the educational activities around existing classes taught by project investigators. In the next section, we describe the multiple efforts undertaken in more detail.

Section 4. Methodology

4.1 Outreach and Support of Other Projects

We collected data to form general data bases for present and future research and education activities. We also worked with CABS managers to assist in areas of present need.

4.1.1 Manual Collection of OD Flow Data

Using the procedure presented in last year’s report (McCord, et al., 2009), we continued to collect direct observations of passenger origin-destination (OD) flows on several CABS routes. As will be discussed below, the direct OD flow observations are used to validate OD estimation methodologies and to provide information to CABS managers for system planning and operations.

Student data collectors ride the buses on a regular basis (approximately eight bus trips per week) and distribute cards to boarding passengers that contain a preprinted designation of the boarding stop. When alighting, the passengers return the cards to the student data collectors, who file the cards according to alighting stop. The correspondence of boarding stop information printed on a card and alighting stop information obtained from the filing of the card allows the determination of the OD pair for the passenger's trip. After completing data collection, the students summarize the numbers of passengers traveling among the various OD pairs for each trip surveyed and record estimates of the numbers of passengers not surveyed and other noteworthy information. (A passenger may not be surveyed because he or she refuses to accept or return a card or because the trip was too crowded to allow a card to be distributed to the passenger.) Results are discussed in Section 5.1.1.

4.1.2 Origin-destination Passenger Flow-based Outreach

The manually collected origin-destination (OD) flow information was used to inform CABS managers of flow patterns in an outreach function and to test various OD estimation procedures in a research function. We discuss the research use of the results in Sections 4.2 and 5.2. Of particular note for the outreach function was the use of the OD flows by CABS managers in assessing the desirability of adding a new bus route in Autumn Quarter 2010.

Three routes – Campus Loop North (CLN), Campus Loop South (CLS), and North Express (NE) – were the primary routes serving the main campus prior to Autumn Quarter 2010. An important function of these routes was and continues to be the transport of passengers between the major park-and-ride lot on West Campus and locations on main campus. Indeed, passengers boarding or alighting at West Campus constitute a large proportion of the OD flows on these routes. However, CABS managers believed that there was also an important proportion of passengers traveling between locations on main campus. The extra time traveling to and from West Campus increases the cycle time of these routes, thereby increasing the headway and the waiting time for all passengers, in general, and main campus riders, in particular. (The waiting times are a larger proportion of the relatively short travel times associated with trips from and to locations on main campus.) To better serve the main campus passengers, CABS decision makers were considering adding a new route, the Central Connector (CC). The CC route would run on main campus and follow part of the CLN route in one direction and part of the CLS route in the other direction (see Figure 4.1.2-1).

CABS decision makers had no quantitative information to support their hypothesis that that there was a sufficiently large amount of "main campus" flow to warrant the addition of the CC route. They therefore used our OD data for this purpose, as discussed in Section 5.1.2.

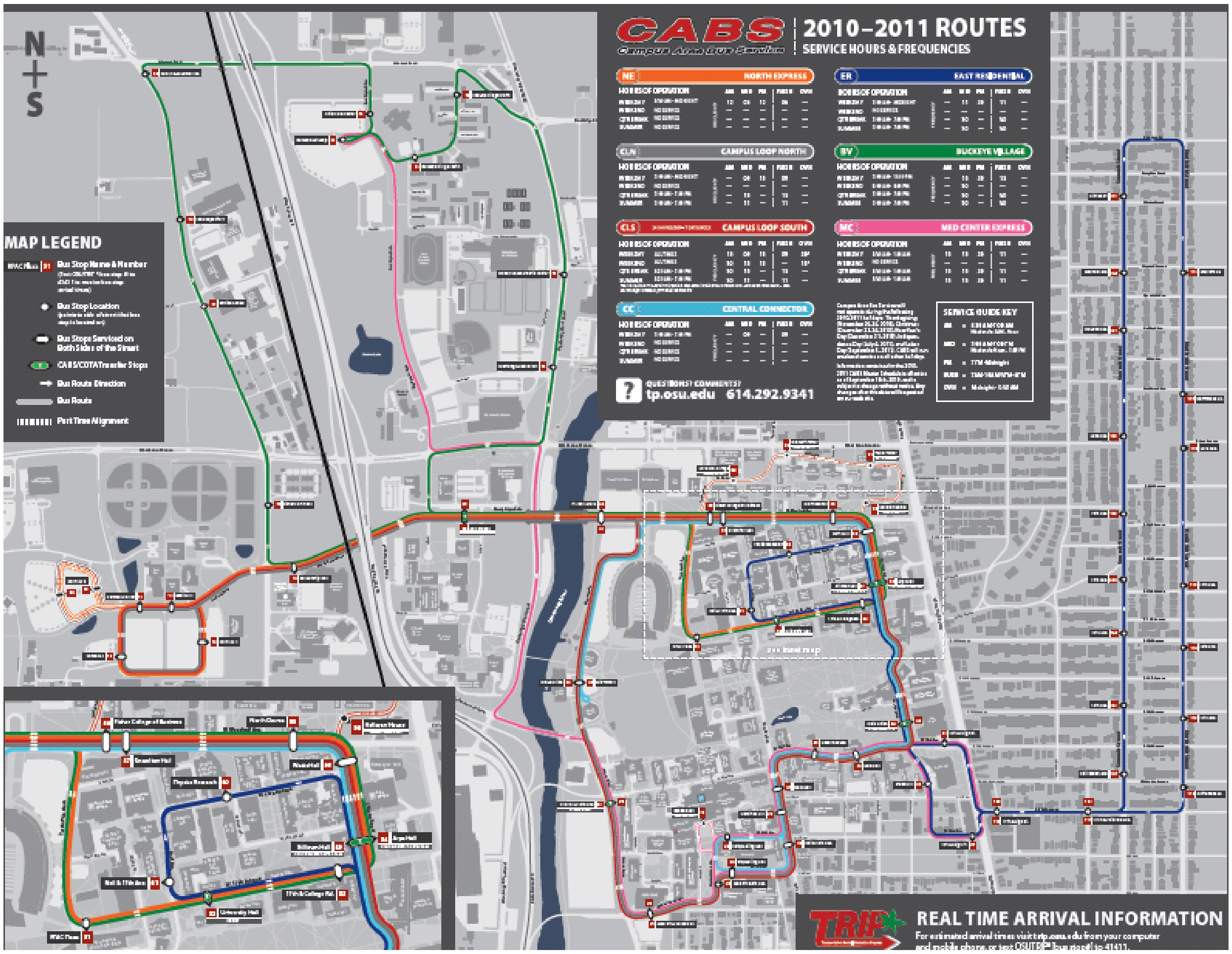


Figure 4.1.2-1: **Proposed (and eventually implemented) Autumn Quarter 2010 CABS routes, illustrating the alignment of the Central Connector (CC) route**

4.1.3 Bus Route Scheduling

As discussed in Section 5.1.2, it was decided to add the new Central Connector (CC) route in the Autumn Quarter 2010 to better serve OD pairs within the main campus. Portions of the CC route were to overlap portions of the existing CLN route, and other portions of the CC route were to overlap portions of the existing CLS route.

To produce a schedule for the CC route, travel times between specified pairs of points on the proposed route needed to be estimated. Since portions of the proposed CC route were to overlap with portions of the existing CLN and CLS routes, we used vehicle location information in the bus Automatic Passenger Count (APC) data records to produce these times and provided these quantitative results to CABS decision makers. Specifically, we worked with a CABS operations manager to determine time points between which he wanted to estimate travel times. We then produced distributions of times for the segments between the time points and chained segments (including dwell times and holding times at the stops) to determine distributions for longer portions of the proposed CC route. Results are discussed in Section 5.1.3.

Given the fixed number of buses proposed on the CC route and the times between time points, it was straightforward to produce a schedule of the CC route if no other constraints were to be imposed. The cycle times on the CLN and CLS routes were equal, but the cycle time on the shorter CC route would be lower. Furthermore, the number of buses to be scheduled would not necessarily be the same on all routes. Therefore, the inter-route headways between routes serving common portions of the network would be changing through time if no additional constraints were imposed. The changing headways can be detrimental both from a perspective of passenger perception and from a perspective of operations (*e.g.,* more than one bus trying to service a stop at the same time).

CABS managers, therefore, wished to investigate the impact of a schedule that maintained equal inter-route headways on common portions of the routes. At the time, CABS was considering purchasing scheduling software. However, the "manual, spreadsheet assisted" process they had previously used was to be used again to produce schedules for Autumn Quarter 2010. Adding the additional "equal inter-route headway" constraint would not have been easy with the previously used approach. We, therefore, assisted CABS in this task by developing a linear programming (LP) formulation of the problem and providing mangers with results using the travel times we had previously determined as inputs. We discuss the LP formulation and our application to produce schedules for CABS in Section 5.1.3.

4.1.4 Processing and Archiving Automatically Collected Data

The CABS buses in operational use produce large quantities of automatic passenger count (APC) and automatic vehicle location (AVL) data on a regular basis. The APC data have been used for several outreach, research, and instructional studies. Plans are being made to use the AVL data for additional research, education, and outreach activities in future projects. Some of the research studies are supported by efforts on this project, and some are funded from another source. The AVL data support a portion of a Federal Transit Administration (FTA) project in which investigators are developing and validating approaches that use bus AVL data to infer times and locations of recurrent traffic patterns. Effort in the past year was devoted to processing CABS APC and AVL data for use in multiple studies and beginning to develop a data infrastructure for ongoing processing and archiving of the data.

The AVL (log) and APC (state) data are collected and stored using onboard technologies. The data are off-loaded to the CABS data server automatically on a daily basis. Nightly, the new data are copied from the CABS data server onto the Campus Transit Lab (CTL) data server.

Each bus daily generates a compressed (zipped) text file containing APC data. We make a copy of the original data and save the copy on the CTL server. We then unzip the copy, import the relevant information from the text file into MATLAB flies, and process the data for multiple possible users. Once the APC data are in MATLAB files, we must identify the stop to which each record refers. We use route segment and stop sequence information provided to accomplish this task.

Preparing AVL data for general use requires more effort. Furthermore, AVL data files are much larger than APC data files. First, we identify the route that the bus was servicing when a record was generated by referencing the corresponding APC file for the same bus and day. We must identify the starting and ending times of bus service on a route because buses may change routes during the day. Once we identify the route served, we use ArcGIS to remove data points that are far off the route (either because the bus is travelling on a different street segment or because of poor GPS location data). Finally we translate the location information to a distance along the route by projecting the latitude/longitude location onto a shapefile of the route path. The projection operation is presently a time-consuming, manual process that will need to be automated in the future. After the projection step, MATLAB files are organized by route and time period. Since we are dealing with a large amount of data, storing the AVL data in a relational database will be beneficial for locating and accessing what is needed for multiple users.

4.1.5 Web-based Survey of Campus Community Transit Perceptions and Preferences

We had previously planned a two-wave survey of the OSU community to assess possible changes in the community's perceptions and attitudes resulting from the implementation of the advanced passenger information system on the CABS system. The study was to serve as an empirical case study of perceptions and attitudes of a relatively high-tech and educated population toward technologies in transit. The first wave of the survey, completed before the installation of real-time passenger information system provided insights on factors that influence transportation choices and traveler satisfaction, in general, and benchmark data for investigating possible changes in perceptions and attitudes resulting from the implementation of the passenger information system, based on data to be collected in the second wave of the survey. We provided a summary of the first wave of the survey in McCord et al. (2009). In the activities covered in this report, we designed the Wave 2 instrument and collected and archived responses. As reported in Sections 4.2.4 and 5.2.4, we also investigated responses to some questions of interest.

Since we were interested in assessing the impact of a real-time passenger information system on perceptions and attitudes of the users and non-users toward transit using a "before-and-after" approach, we designed the questionnaire for the Wave 2 survey to follow the general pattern of Wave 1 survey instrument. The wording of a few questions was modified slightly to reflect the current survey's timing, and a few new questions were added. Like the Wave 1 survey, the Wave 2 survey was web based [using Lime Survey]. We again signed a contract with The Ohio State University Statistical Consulting Service (SCS) to implement our survey design, to code the revised questionnaire for online implementation, to collect the responses, and to provide an Excel database of responses after deleting any identifying personal information.

Given that the marginal cost of surveying each additional subject in a web-based survey is very small, we decided to sample more students (1500 more undergraduate students and 1500 more graduate students) in Wave 2 than in Wave 1, with the expectation of reaching a larger number of respondents in each of the four categories. SCS obtained a random sample of e-mail addresses of students (undergraduate and graduate) from the OSU Office of the Registrar and of the faculty and staff from the Office of Human Resources. The sample of subjects was invited to voluntarily participate in the survey.

The revised questionnaire consisted of 9 demographic questions, 10-13 questions (depending on the subject's response on certain questions, which would then prompt follow-up questions) dealing with the subject's mode of transportation to and on campus, and 14 questions about the subject's perceptions and evaluation of CABS service, safety, and externalities, such as CABS' role in contributing to reduction of traffic on campus and in making the campus "green". In all, there were up to 36 questions that a respondent could answer. It was estimated that a subject would require no more than 8 minutes to complete the survey.

As the study involved human subjects, the Wave 2 survey protocol required approval by the OSU Institutional Review Board (IRB) for human subject research. Since the Wave 2 questionnaire was not the same as the Wave 1 questionnaire, conducting the Wave 2 survey required a new approval. The research protocol describing the revised questionnaire and the process to be followed to ensure that the privacy of the respondents would be protected were submitted for approval on April 30, 2010. The submitted protocol also included the e-mail message to be sent to the invited survey participants and the web-based questionnaire. IRB requested further clarification on why Wave 2 was being conducted, since Wave 1 had similar questions. We sent our response to this query on May 13, 2010. The project investigators received an exemption from continued oversight soon after. SCS administered the on-line survey following this approval. Subjects were given approximately five weeks to complete the survey. Individuals who had not responded after the first four weeks were sent an e-mail reminder by SCS. Responses were received during the period of May 21, 2010 to June 28, 2010.

4.2 Research Activities

We used automatically and manually collected CTL data to support several research investigations reported in this section. In addition, we analyzed responses to specific questions of interest in the web-based survey,

4.2.1 Evaluating the Identification of Homogeneous OD Passenger Flow Periods

In a separate project, we developed a modified cluster analysis based method to identify time-of-day periods of homogeneous probability bus route origin-destination (OD) passenger flow matrices (Ji et al., 2011b). Probability OD flow matrices represent the probabilities that a random passenger travelling on the route during the period will travel from the various origin stops to the various destination stops on the route. Since travel patterns are known to vary throughout the day, OD flow matrices would be expected to vary throughout the day, as well. The method developed to identify periods of homogeneous OD flow uses extensive trip boarding and alighting data to estimate trip-level OD matrices. Such data are now feasible to obtain with Automatic Passenger Counter (APC) technologies. The trip-level OD matrices are aggregated into "elemental" matrices representing flow patterns for relatively short time periods, and the "elemental matrices" are used as inputs to a traditional clustering procedure that is modified to ensure that a cluster indicating a period of homogeneous OD flow spans a continuous time period during the day. Details of the methodology can be found in Ji et al. (2011b).

In this project, we used our CTL data and our understanding of campus bus passenger flow patterns to evaluate an empirical application of the method. We also applied a similar method we developed using passenger volumes, rather than estimated normalized OD flow matrices, to illustrate the need to consider passenger volumes and the spatial distribution of the passenger flows separately. We discuss the empirical results in Section 5.2.1.

4.2.2 Investigating the Effect of Onboard OD Survey Sample Size in Estimating APC-derived OD Flows

Bus passenger route-level origin-destination (OD) flows have traditionally been estimated from costly and labor-intensive onboard surveys. Using the types of OD estimation methods we have been developing and testing, the availability of Automatic Passenger Counter (APC) data on many bus transit systems offers the possibility to enhance the quality of the onboard survey data at little marginal cost. In this study, we investigated the value of estimating route-level passenger OD flows from APC data and onboard OD survey data with a specific focus on the effect of onboard OD survey sample size. Specifically, we used the manually collected OD flow data on the Campus Loop South, Campus Loop North, and North Express routes in Spring Quarter 2010 to form "true" probability OD matrices for the routes and quarter. We then considered four different "estimates" of these true matrices:

- A "null" OD matrix, where each feasible origin-destination pair is assigned equal probability
- An OD matrix formed by using the Iterative Proportional Fitting (IPF) method (see, e.g., McCord et al., 2010, 2009; Ben-Akiva, et al., 1985; Deming and Stephan, 1940) with inputs consisting of the boarding and alighting data associated with the manually collected Spring 2010 OD flow data and a null "base" OD matrix
- An OD matrix formed directly from manually collected OD flow data in Autumn Quarter 2009 (used to emulate a matrix obtained directly from an onboard survey)
- An OD matrix formed by using the IPF method with inputs consisting of the boarding and alighting data associated with the manually collected Spring 2010 OD flow data and a "base" OD matrix formed from the Autumn Quarter 2009 "onboard survey" data (used to emulate the updating of an onboard survey with APC data)

The OD matrices formed from the Autumn Quarter 2009 "onboard survey" data, used either to estimate the Spring Quarter 2010 matrices directly or as input to the IPF method with Spring Quarter 2010 boarding and alighting data, were constructed from varying amounts of data to represent various sample sizes. We then compared the various estimates to the "true" OD matrices to assess the value of increasing sample size in onboard surveys. Details of the methodology are presented in Mishalani et al. (2011). Empirical results are presented in Section 5.2.2.

4.2.3 Assessing the Impact of Bus Drivers’ Operations Control Actions on Service Reliability

Previously, we developed a method to match bus Automatic Vehicle Location (AVL) data with service schedules to support planning and operations analysis studies (Ji et al., 2009, 2011a; McCord et al., 2009). In the project reported in this report, we took advantage of the AVL data matched to schedules to investigate the effects on service reliability of bus drivers’ reactions to schedules and bus status. Transit service reliability is an important determinant of the level of service experienced by passengers and influences system operating cost. Bus drivers play a key role in translating a schedule to an actual service and, as a result, can influence the resulting reliability. Therefore, understanding drivers’ behaviors is useful for a variety of purposes, such as designing bus schedules and developing real-time operations control strategies.

We examined the hypothesis that drivers may deliberately lengthen or shorten dwell times at stops or adjust speeds between consecutive stops, depending on whether buses are ahead of or behind schedule. We derived an analytical relationship between the progression of reliability from stop to stop and drivers’ possible reactions to the schedule and used AVL data collected on a CTL route to explore these reactions in an empirical study. Details of the methodology are presented in Ji et al. (2011a). Empirical results are discussed in Section 5.2.3.

4.2.4 Travelers’ Attitudes and Perceptions of CABS Transportation Services

We investigated responses to selected questions in our Wave 2 survey dealing with perceptions and attitudes of the campus community regarding the quality and value of CABS service. In the future, we intend to rigorously compare responses obtained in Wave 2 (after implementation of the traveler information system) to responses obtained in Wave 1 (before implementation).

4.3 Educational Activities

Educational activities were provided to students working on the project through the opportunity to design and collect onboard origin-destination data and to work with large sets of automatically produced APC and AVL data.

The CTL was also used to develop and implement modules and assignments in two OSU courses, *CE 570: Transportation Engineering and Analysis* and *CE 670: Urban Public Transportation*. *CE 570* is an undergraduate course required of all undergraduate Civil Engineering students. *CE 570* had an enrollment of 119 students in Winter Quarter 2010. *CE 670* is an elective course for undergraduates in Civil Engineering. It is also taken by almost all graduate students in the transportation option of the Civil Engineering graduate program and is a required course for the Dual (Civil Engineering and City and Regional Planning) MS Degree Program in Urban Transportation. *CE 670* had an enrollment of 19 students in Winter Quarter 2010. Details of the developments are presented in Section 5.3.

Section 5. Findings

5.1 Outreach and Support of Other Projects

5.1.1 Manual Collection of OD Flow Data

Manually collected, trip-level OD passenger flow OD information has been obtained for approximately 95% of passengers on the trips surveyed. Since the data are collected regularly by teams of data collectors, this data set is quite extensive. Indeed, it is the most extensive set of bus transit OD data to our knowledge. We note that the ability to collect this type of data on such a regular basis is a result of the good collaboration between CABS managers and the project investigators and of the proximity of the CTL data collection site to the student data collectors.

The numbers of trips and passengers for whom OD pairs were observed using this method are presented in Table 5.1.1-1. The data are arranged by academic quarter and contain information on observations from both year 1 (Autumn Quarter 2008-Summer Quarter 2009) and year 2 (Autumn Quarter 2009-Summer Quarter 2010). It can be seen that data collection efforts greatly increased from year 1, when the data collection protocols were being developed, to year 2, when the effort moved toward operational implementation.

OD flow information for each trip can be provided upon request. Trip-level OD passenger flow information is used for educational purposes (see Section 5.3) and forms the basis of some research studies (McCord, et al., 2010; Strohl, 2010) However, it is often useful to aggregate OD information. We convert the observed OD passenger volumes to OD passenger probabilities, which represent the probabilities that a passenger randomly sampled from among the passengers for whom OD flows were observed traveled from the specified origin to the specified destination. We do this by aggregating the observed volumes by OD pair for the period of interest and dividing by the total number of observations in the specified period. In Appendix A we present probability matrices for morning and afternoon periods by route and quarter.

Table 5.1.1-1: Numbers of trips and passengers for which OD flow information was obtained, by quarter and route; CLS: Campus Loop South, CLN: Campus Loop North, NE: North Express

Winter Quarter 2009								
	Passengers				*Trips*			
Route	***Total***	***AM***	***Mid-day***	***PM***	***AM***	***Mid-day***	***PM***	***Route Trips***
CLS	989	816		173	13		5	18
Spring Quarter 2009								
	Passengers				*Trips*			
Route	***Total***	***AM***	***Mid-day***	***PM***	***AM***	***Mid-day***	***PM***	***Route Trips***
CLS	879	773		106	13		2	15
CLN	84	84			2			2
Autumn Quarter 2009								
	Passengers				*Trips*			
Route	***Total***	***AM***	***Mid-day***	***PM***	***AM***	***Mid-day***	***PM***	***Route Trips***
CLS	669	669			10			10
CLN	1258	1258			24			24
NE	882	882			16			16
Spring Quarter 2010								
	Passengers				*Trips*			
Route	***Total***	***AM***	***Mid-day***	***PM***	***AM***	***Mid-day***	***PM***	***Route Trips***
CLS	1373	789		584	12		14	26
CLN	1194	694		500	12		12	24
NE	618	618			14			14
Cumulative: Winter Quarter 2009 - Spring Quarter 2010								
	Passengers				*Trips*			
Route	***Total***	***AM***	***Mid-day***	***PM***	***AM***	***Mid-day***	***PM***	***Route Trips***
CLS	3910	3047		863	48		21	69
CLN	2536	2036		500	38		12	50
NE	1500	1500			30			30
Overall	**7946**	**6583**		**1363**	**116**		**33**	**149**

5.1.2 Origin-destination Passenger Flow-based Outreach

As discussed in Section 4.1.2, CABS managers used our manually collection OD flow data to investigate their hypothesis that that there was sufficient "main campus" bus passenger flow to warrant the addition of the Central Connector (CC) route being considered. From the Appendix A data, it was determined that approximately 20% of CLN and CLS passengers had both origin and destination on main campus during the preceding year.

CABS decided to add the CC route in Autumn Quarter 2010 to serve main campus better. It is likely that the CC route would have been added whether or not CABS decision makers had access to our OD data. The prior belief was that there was sufficient "intra-main campus" demand to justify the increased service. However, we were informed that the OD flow information, which was not otherwise available, reassured CABS managers in their choice and would be useful in justifying the addition of CC to upper levels of the administration and to the public.

5.1.3 Bus Route Scheduling

We provided entire distributions of timepoint-to-timepoint bus times to CABS with tabulation of selected percentile times. Percentile values of cycle and timepoint-to-timepoint times can be found in Appendix B.

We were also successful in formulating the scheduling problem as a linear program (LP) and running the LP to produce schedules for CABS that included the "equal inter-route headway" constraint. To maintain the uniformity of operations, the intra-route headways (*i.e.*, the headways between consecutive buses on the same route) would be scheduled to be equal. All other things equal, the expected passenger waiting time for buses at stops is reduced when the variance of the headways is reduced. To minimize the variability in headways between CC and CLN buses serving the same OD pairs (and similarly for headways between CC and CLS), the schedule should be such that the Inter-route headways (*e.g.*, the headways between a CC bus and the next arriving CLN bus) would also be equal. That is, if consecutive CLN buses depart a stop served by CLN and CC buses traveling in the same direction at times t, $t+H_{CLN}$, $t+2H_{CLN}$, $t+3H_{CLN}$, …, where H_{CLN} is the scheduled headway of CLN buses, then the expected waiting time for passengers who could be served by either CLN or CC at the stop would be minimized by having CC buses depart the stop at times t, $t+H_{CLN}/2$, $t+3H_{CLN}/2$, $t+5H_{CLN}/2$,,…. Similar relations can also be established for departure times of CLS and CC buses and of CLN and CLS buses from stops where the routes depart in the same direction.

The departure time from a stop is equal to the arrival time at the stop plus the dwell time at the stop (where dwell time includes holding time), and the arrival time at a stop is equal to the departure time from the stop immediately upstream plus the travel time between the upstream stop and the stop of interest.

It would be desirable to minimize the common intra-route headways, which would minimize the waiting time for a randomly arriving passenger without any schedule information. (CABS schedules are headway-based, with no departure time information provided to the passengers.) It is also noted that, given a fixed number of buses for the route, minimizing the intra-route headway would minimize the cycle time of the route. (The cycle time of the route can be determined as the product of the number of buses on the route and the headway of buses on the route.) Minimizing the cycle time would be desirable because a lower cycle time would lead to lower in-vehicle times, all other things being equal.

The relations presented above are all linear, and the scheduling problem can be formulated as a linear program, where the objective function to be minimized is the common headway (which would be equivalent to using an objective function consisting of the cycle time for the route), and the constraints consist of

- Definitional relations between cycle times and travel and dwell times and between cycle times and headways, given a fixed number of buses
- Lower bounds on feasible travel times and desired dwell times
- Prescribed relations between scheduled departure times at stops for different routes to ensure even departure spacing, given definitional relations between departure times at stops and timepoint-to-timepoint travel times and dwell times

An illustrative formulation for the specific CABS problem is presented in Appendix C.

We produced results for CABS using as input both the 50th percentile time point-to-time point travel times we had developed from the empirical data and the 85th percentile time point-to-time point travel times. An illustrative schedule using the 50th percentile values is presented in Appendix D. We also advised CABS that using the 50th percentile times for scheduling would run the risk of buses often falling behind schedule with little buffer to absorb these delays. On the other hand, using 85th percentile values would increase the cycle times, and surprisingly long cycle times resulted on the CLN and CLS routes. To avoid the long cycle times, CABS decided to initialize operations using the schedule derived from the 50th percentile values. (Ultimately, bus driver shortages forced CABS to adjust schedules on a fairly constant basis after CC was implemented.)

5.1.4 Processing and Archiving Automatically Collected Data

We are still developing protocols for regular processing and systematic archiving of the automatically produced APC and AVL data. Nevertheless, the data processed to date were used to support several studies. The boarding and alighting data obtained from the APC data were used in various research studies and educational activities (see, Sections 4.2, 4.3, 5.2, and 5.3). In addition, the time fields in the APC data records were used to determine the timepoint-to-timepoint bus times when developing CABS schedules and in educational exercises (see Sections 4.1.3, 4.3, 5.1.3, and 5.3). The AVL data were used to support investigations, conducted in another project, of the potential to use AVL-equipped buses to provide indications of recurring traffic congestions.

5.1.5 Web-based Survey of Campus Transit Perceptions and Preferences

Response numbers and rates to our Wave 2 survey are provided in Table 5.1.5-1 by category of respondents. We received responses from approximately 1000 individuals in each category. (We note that national opinion polls receive responses from ~1000-1200 individuals.) This size of survey is enough to produce reliable estimates of attributes of interest (an error rate of ~+/- 5% in a binary response) under the assumption that the non-respondents have similar opinions as the respondents (*i.e.*, that there is no non-response bias). The response rates in the four categories are similar to those obtained in Wave 1 (see, McCord et al., 2009). A comparison of the response rates in the Wave 1 survey with several recent surveys of the OSU community was reported in McCord et al. (2009). Our response rates are similar for undergraduate students and at least as high for faculty, staff and graduate students. The data collection process was fairly smooth. At the end of July 2010, SCS provided us with a data dictionary and anonymously coded response data

Table 5.1.5-1: CTL transportation survey: Wave 2 response numbers and rates

Group	Surveyed*	Responses	Response Rate
Faculty	4500	1165	26.90%
Staff	4500	1525	35.22%
Grad Students	4500	1061	24.50%
UG Students	7500	990	13.72%
Overall	21000	4741	23.46%

*A very small number of e-mails bounced back due to change in address. Response rates are correct to one decimal place.

5.2 Research Activities

5.2.1 Evaluating the Identification of Homogeneous OD Passenger Flow Periods

In Figure 5.2.1-1, which is taken from Ji et al. (2011b), we depict five periods of homogeneous OD passenger flow patterns and five periods of homogeneous passenger volumes. The results were produced using APC data on the Campus Loop South (CLS) bus route. Among other things, the results indicate a long period of relatively constant passenger volume from 9 am to 3 pm, but three distinct OD passenger flow patterns during this period. In Figure 5.2.1-2, which is also taken from Ji et al. (2011b), we depict the four OD flows with greatest probabilities during these three periods and contrast these with the four OD flows with greatest probabilities that would have been produced if the 9 am-3 pm period was treated as one homogeneous period. Details of the empirical findings and how our understanding of flow patterns on the CTL assisted us in arriving at these findings can be found in Ji et al. (2011b).

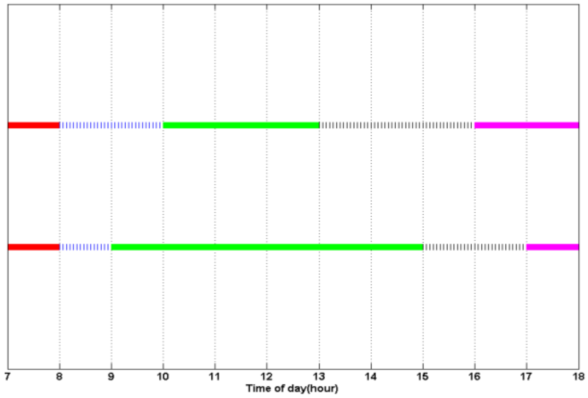


Figure 5.2.1-1: Identified homogeneous periods for Campus Loop South route based on probability OD passenger flow matrices (top) and on passenger volumes (bottom) (from Ji et al., 2011b)

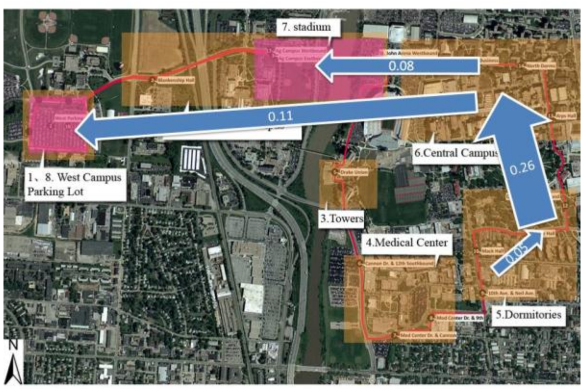
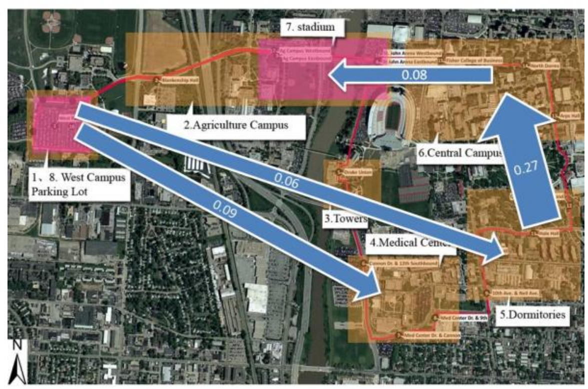
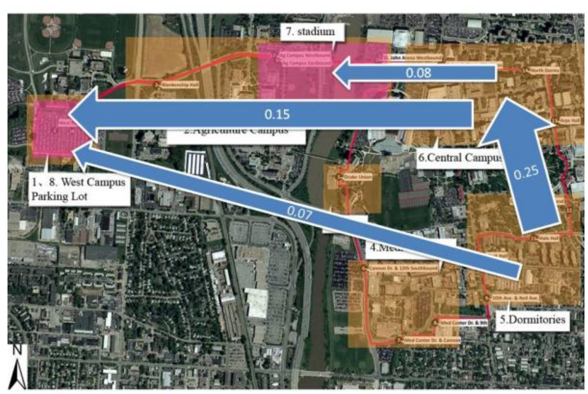
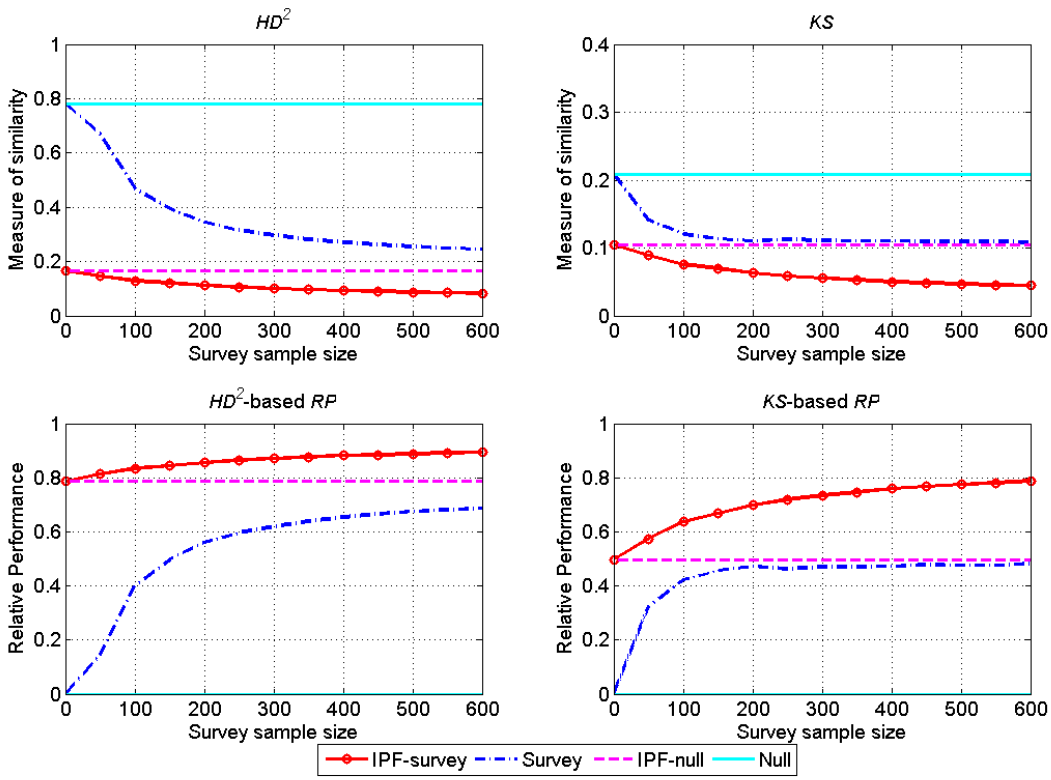
(a) Top Four OD Pairs in period 9am-3pm.	(b) Top Four OD Pairs in Period 9am-10am.
	
(c) Top Four OD Pairs in Period 10am-1pm.	(d) Top Four OD Pairs in Period 1pm-3pm.
	

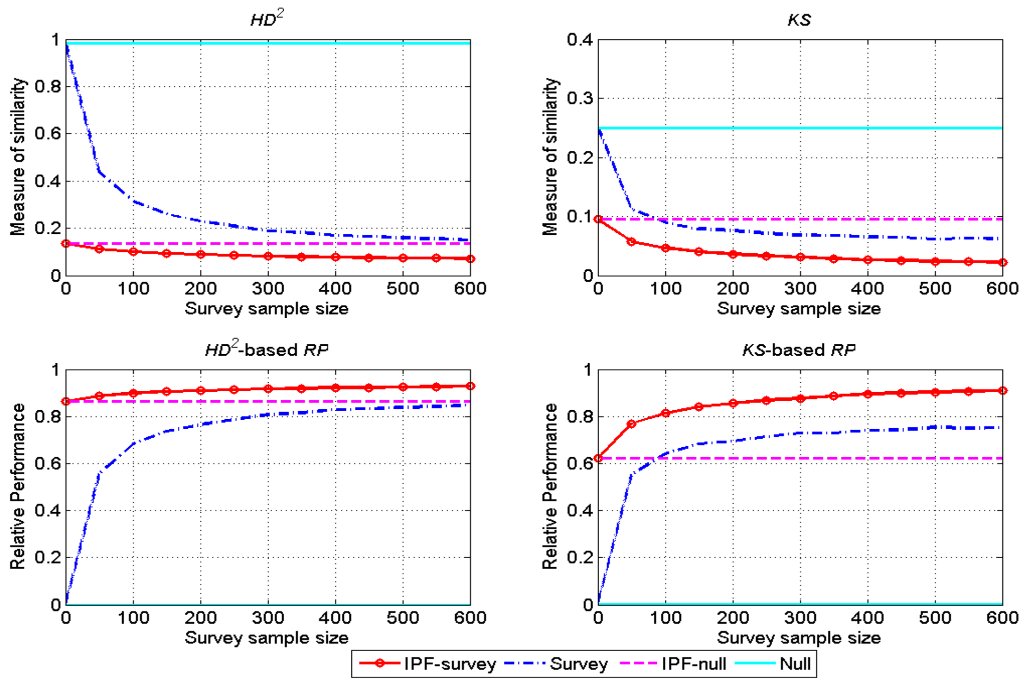
Figure 5.2.1-2: Four OD Pairs with greatest probabilities in each of three homogeneous OD periods identified during the 9am-3pm homogeneous volume period and when considering the aggregate 9am-3pm period (from Ji et al., 2011b)

5.2.2 Investigating the Effect of Onboard OD Survey Sample Size in Estimating APC-derived OD Flows

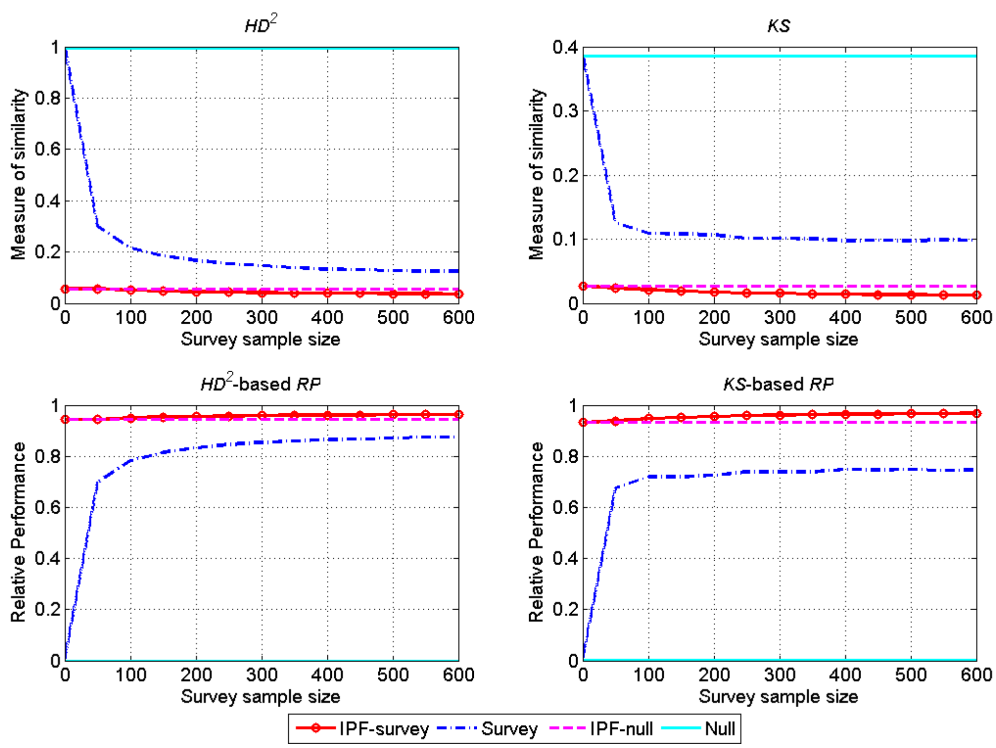
We used OD data collected on three CTL bus routes to investigate the value of combining APC counts with onboard OD survey data as a function of survey sample size (see Section 4.2.2). Two measures of discrepancy (the Hellinger Distance Squared HD^2 measure and the Kolmogorov–Smirnov *KS* measure) between the estimated and the true matrices, along with the associated "relative performance" *RP* measures (McCord, et al. 2010; McCord et al.. 2009) obtained as a function of on-board survey sample size for the Campus Loop South, Campus Loop North, and North Express routes are presented in Figure 5.2.2-1, which are taken from Mishalani et al., (2011). (Lower HD^2 and *KS* values are better than higher values, and higher *RP* values are better than lower values.)



(a) Campus Loop South Route Results



(b) Campus Loop North Route Results



(c) North Express Route Results

Figure 5.2.2-1 Discrepancy and relative performance measures of OD estimates for various CTL routes; *Null*: Null OD matrix; *IPF-Null*: OD matrix obtained using APC data and iterative proportional fitting (IPF) method with null base matrix; *Survey*: OD matrix obtained from survey data only; *IPF-Survey*: OD matrix obtained using APC data and IPF with survey data-derived base matrix (from Mishalani et al., 2011)

The extensive results produced confirmed the encouraging estimation performance seen in a previously conducted, smaller study when using APC data with no onboard OD survey (McCord et al., 2010; McCord, et al, 2009). In addition, and as expected, the results showed that incorporating onboard OD survey data with APC data produced OD flow estimates that are better than those produced when only using the APC data, and that increasing the sample size of the onboard OD survey improved the quality of these estimates. However, the results indicated that the magnitude of the improvement depended strongly on the OD flow structure of the given bus route. Increasing sample size resulted in less appreciable improvements for routes with more concentrated OD flows than for routes with more evenly distributed OD flows. Details of the finding are described in Mishalani et al. (2011).

5.2.3 Assessing the Impact of Bus Drivers' Operations Control Actions on Service Reliability

The results indicate that the drivers' reactions to the schedule are helpful in improving service reliability. We also quantified the magnitudes of the improvements in reliability resulting from such reactions and the deterioration of reliability resulting from various exogenous factors. More specifically, we estimated that, on average, 43% of the improvement in service reliability resulted from drivers' reactions to the schedule at time points (by holding), 17% of the improvement resulted from drivers' reactions to the schedule at other stops (by lengthening or shortening the dwell time), and 40% of the improvement resulted from driver's reactions to the schedule (by adjusting the travel times along roadways between consecutive stops). On the other hand, we estimated that, on average, 21% of the deterioration in service reliability was related to the arrival time deviation and dwell time at time points, 28% was related to the arrival time deviation and dwell time at other stops, and 51% was related to the departure time deviation from stops and the travel time to the immediately subsequent stops. More details are provided in Ji et al. (2010) and Ji and Mishalani (2011).

5.2.4 Travelers' Attitudes and Perceptions of Transportation Services

We investigated survey responses to travel behavior, perception, and evaluation questions from the Wave 2 Survey. The reported results are based on analysis that indicates statistical significance where applicable.

Approximately 55% of our respondents were females and 45% males. However, approximately 39% of faculty respondents, 67% of staff respondents, 57% of graduate student respondents and 57% of undergraduate student respondents were females. An overwhelming proportion of our subject population commutes to campus, as approximately only 27% and 3%, respectively, of the undergraduate and graduate respondents live on-campus. The respondents represent a cross-section of the campus community, which is spatially distributed across the large OSU campus (consisting of a core surrounding by spread-out areas) as well as various academic and administrative groups. About 16% of the respondents were affiliated with regional campuses. These individual would be expected to be unfamiliar with CABS service.

Travel mode behavior

Some interesting highlights about the travel mode behavior of our respondents are as follows:

- Approximately 61% of respondents never use CABS, 26% ride CABS occasionally, and 13% ride CABS regularly.
- Approximately 89% of the respondents have a car in the Columbus area.
- As shown in Table 5.2.4-1, approximately 85% of the faculty and staff drove a car to campus, while approximately 39% of the students drove a car. Approximately 28% of the students walked to their campus destinations.
- Approximately 69% of the respondents who do not have a car in Columbus consider CABS to be valuable or highly valuable to their travel needs, compared to approximately 36% of those who have cars.
- Approximately 52% of the respondents were familiar with one or more routes on CABS service, whereas approximately 44% knew that CABS existed but were not familiar with any of its routes. Approximately 4% did not know that CABS existed.
- Approximately 27% of the respondents who never use CABS were familiar with one or more routes on CABS service, as compared to approximately 90% of the respondents who use CABS only occasionally and 99% of the respondents who use CABS regularly.

Table 5.2.4-1: Transportation-to-campus mode choices for Students and Faculty/Staff

Category	Travel Mode	Drive alone	Share a car	COTA	CABS	Motor Cycle	Bike	Walk
Students	%	39	6.3	9.2	8.6	0.6	7.9	28.2
Students	Counts	770	125	181	170	12	155	556
Faculty/Staff	%	85.2	3.3	2.1	1.6	0.5	4	3.2
Faculty/Staff	Counts	2098	81	52	39	12	100	79

Perceptions and evaluation analysis

Like the Wave 1 survey, the Wave 2 survey contained fourteen statements designed to elicit respondents' attitudes toward CABS. The respondents were asked to respond to each question using a 5-point scale, labeled as 1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, and 5: Strongly agree. These statements, paraphrased below, can be classified into three perception categories as follows:

- Category 1: Environmental Issues (EQ 1 - 2)
  - EQ1- Having CABS service reduces the amount of car traffic on campus...
  - EQ2- Providing bus service around campus should be part of OSU's efforts to promote a green campus…

- Category 2: Safety Issues (EQ 4 - 6)
  - EQ4 - I feel safe walking to CABS stops…
  - EQ5 - I feel safe waiting for CABS buses…
  - EQ6 - I feel safe riding CABS buses.

- Category 3: CABS Service Quality Issues (EQ 7 - 13)
  - EQ7 - CABS bus drivers are professional…
  - EQ8 - CABS buses are comfortable…
  - EQ9 - CABS routes are reasonable…
  - EQ10 - My travel time to reach my destination using CABS is reasonable…
  - EQ11 - My waiting time for CABS buses is reasonable…
  - EQ12 - Accessing information about CABS service (e.g., routes, frequency of service, hours of operation) is easy…
  - EQ13 - CABS is reliable…

Of the remaining two statements, EQ3 is concerned with the value of CABS to individual travel needs, and EQ14 is concerned with an overall satisfaction with CABS.

Response rates to EQ 1-3 were very high (greater than 75%). The other statements – which relate to specific aspects of CABS, such as safety, CABS service quality issues, and overall evaluation of CABS – received response rates between 60% and 65%, even though only 39% of the respondents use CABS occasionally or regularly. Thus, even non-users have opinions and perceptions about CABS, which could result from the visibility of the campus transit system itself or from “word of mouth.” The distribution of the 5-point responses across the fourteen statements is summarized in Table 5.4.2-2. The first row in the table lists the five possible responses to these questions. Each statement with an (EQ#) is associated with two rows in the table. The first (second) row provides the proportion (number) of individuals responding to the statement in each of these categories.

Some of the interesting observations that can be made based on this table and from an analysis of association between individual responses on each pair of variables are the following:

- CABS’ value to individual travel needs received a lower rating than did other evaluation items. 33% of respondents do not believe CABS is valuable to their travel needs (those who choose 1 or 2), while only 43% believe CABS is valuable (those who choose 4 or 5). Further analysis showed that these percentages are 36% and 39% respectively, for those who have cars, whereas those who do not have cars tend to respond very highly (10% and 82% respectively).
- CABS received its highest rating in response to its contribution to promoting a green campus. Only 4% of respondents do not recognize CABS’ role in promoting a green campus (those who choose 1 or 2), while 89% recognize such a role (those who choose 4 or 5).
- Responses to statements about safety issues (EQ 4,EQ5,EQ6) are highly associated with each other; that is, an individual respondent is likely to provide a similar rating to all three of these statements. Among these three issues, safety of walking to a CABS stop and safety of waiting for a CABS bus have strongest pair-wise association (i.e., 0.83), which correspond to safety outside the vehicle. The other two pairs, corresponding to safety while riding on the vehicle and while outside the vehicle, have a bit lower, but still strong pair-wise association (i.e., ~0.65).

Table 5.2.4-2: Summary of responses on perception and evaluation questions

	Response category				
Evaluation question	1	2	3	4	5
EQ1	0.02 76	0.07 291	0.17 664	0.45 1792	0.29 1150
EQ2	0.02 80	0.02 68	0.08 328	0.36 1547	0.53 2265
EQ3	0.11 417	0.22 803	0.25 915	0.21 796	0.21 802
EQ4	0.02 51	0.02 76	0.18 561	0.42 1317	0.36 1128
EQ5	0.01 46	0.03 97	0.19 590	0.42 1303	0.34 1059
EQ6	0.01 36	0.02 46	0.15 468	0.39 1182	0.43 1294
EQ7	0.01 35	0.03 100	0.25 717	0.43 1246	0.28 796
EQ8	0.01 36	0.04 131	0.28 829	0.46 1359	0.20 575
EQ9	0.02 45	0.05 150	0.24 691	0.48 1385	0.21 607
EQ10	0.03 93	0.08 230	0.27 759	0.44 1240	0.18 509
EQ11	0.03 85	0.11 301	0.31 873	0.41 1147	0.14 406
EQ12	0.02 73	0.10 302	0.28 838	0.38 1141	0.21 614
EQ13	0.02 45	0.05 140	0.27 776	0.45 1276	0.21 607
EQ14	0.01 41	0.03 101	0.25 753	0.48 1440	0.21 636

In addition, we found the following results, grouped by pertinent category:

Satisfaction with CABS' service

- People who use CABS more often were more satisfied with CABS service.
- The overall perception of CABS service tended to get highest ratings (~80%) from those who walk, take COTA or CABS to campus, a bit lower ratings (70%-75%) from those who share a car, ride a bike or motor bike, and even lower ratings (61%) from those who drive a car to campus.
- People who spend more than one hour/day on the Internet were slightly more satisfied with CABS' information accessibility than those who spend less than one hour/day on the Internet.

CABS' contribution to environment and traffic reduction

- Of the people who said CABS had little value to their travel needs, more than 75% nevertheless expressed an appreciation of CABS' positive environmental contribution towards a green campus and more than 60% expressed an appreciation of its contribution to reducing traffic on campus.
- The people who park on West Campus had a slightly greater appreciation of CABS' positive environmental contribution and of its contribution to traffic reduction than the people who park close to their office or classes on main campus.
- Undergraduate students had a slightly lower appreciation of CABS' positive environmental contribution than did the other groups.
- The frequency of using CABS had little impact on people's positive appreciation of CABS' environmental contribution.
- People appreciated CABS' positive environmental contribution more than CABS' traffic reduction contribution.
- People who use or have used metropolitan public transportation (MPT) appreciated CABS' positive contribution to the environment and to traffic reduction more than those who do not or have not used such public transportation.

CABS usage

- People who used or are using MPT were relatively more likely to use CABS on campus.
- People who came to campus by CABS or COTA or who walked to campus were more likely to use CABS while on campus than those who came to campus by other modes.
- People who came to campus by bike were more likely to use CABS while on campus than those who drove to campus, but less likely to use CABS while on campus than those who came to campus by CABS or COTA or who walked to campus.

CABS safety

- People feel safer when riding CABS than when walking to a CABS stop or when waiting for a CABS bus.
- People feel equally safe when they are walking to a CABS stop or waiting for a CABS bus.
- While waiting for a CABS bus, a longer waiting time tends to lower the safety perception.

Overall evaluation

The responses to the overall evaluation item (EQ14) are better associated to EQ 9, 10, 11, 13 (*i.e.*, with association more than 0.50). These items have similar coefficients in a multidimensional scaling analysis. Thus, a person is likely to give higher overall evaluation of CABS if he or she appreciates the reasonableness of CABS routes, travel times, waiting times, and reliability.

5.3 Educational Activities

In Winter Quarter 2009, we had presented an overview of the CTL in *CE 570* at the end of the course, and students used data obtained manually to calculate average travel times, conditional upon boarding a CABS stop. In Winter Quarter 2010, we incorporated a more extensive presentation of CTL near the beginning of the course to complement an existing module on mass transit. In addition, we introduced OD passenger flow estimation from boarding and alighting data. We presented the iterative proportional fitting (IPF) method of OD estimation and developed and distributed an assignment requiring students to estimate OD passenger flows from CTL APC data for the CABS Campus Loop South (CLS) route. In addition, the assignment required the use of CTL AVL data to estimate times from a specified CLS stop to downstream stops and the combined use of the OD passenger flow and time estimates to determine the expected onboard time for a random passenger boarding the CLS route at the specified stop. The assignment is presented in Appendix E. In addition, we developed and included questions on OD flow estimation and on the CTL in one of the exams. These questions also appear in Appendix E.

In Winter Quarter 2010, we introduced CTL to the students in *CE 670*. Among other things, we discussed the use of APC and AVL data. One of the uses of the AVL data discussed was the ability of the data to support the prediction of the times buses are expected to arrive at downstream stops and the communication of this information to prospective travelers in real time. CTL has this capability in the form of the Transportation Route Information Program (TRIP), which consists of a web- and texting-based information provision system. *CE 670* includes an extensive team project, which spans the quarter. Part I of the project involves collecting data in the field using the CTL. Part II involves using the collected data to solve and address specific problems and questions. We added a problem to Part II relating to TRIP. Specifically, students were required to assess the accuracy of the TRIP bus arrival time predictions by comparing the predictions to field observed bus arrival times. In addition, the last problem of Part II of the project provides the students with an opportunity to identify service and operating concerns based on their analyses, and to then make improvement recommendations. Parts I and II of the project statements are included in Appendix E.

Section 6. Conclusions

The research, education, and outreach activities conducted demonstrate the value of a campus-based, living transit laboratory. The data provided from operational use of the OSU Campus Transit Lab's (CTL) state-of-the-practice Automatic Passenger Count (APC) and Automatic Vehicle Location (AVL) systems and from targeted manual data collections on the CTL are forming unique bus transit databases and have already supported multiple research studies in transit-related operations and planning and formed the basis of course modules and exercises in required and elective transportation courses. The opportunity for students to design and participate in regular data collection activities and to process, analyze, and interpret the extensive data has also contributed to the educational thrust of the CTL. The CTL is based on the operating OSU Campus Area Bus Service (CABS), which provides high volume, geographically expansive, and complex university bus transit service. The working relations between the project investigators and CABS managers allow collaboration that provides otherwise difficult-to-obtain information to CABS and a “grounded” setting for research and educational activities.

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Appendix A
Probability OD Flow Matrices Obtained from Directly Observed OD Flows

	CLS Winter Quarter 2009 AM - Total Passengers Surveyed - 816																								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	
1	0	0	0	0	0	0	0	0	0.0024	0.0012	0.0024	0	0	0.0012	0.0012	0.0012	0	0	0	0	0	0	0	0	0.0097
2	0	0	0	0	0	0.0024	0.0012	0.0024	0.0012	0	0	0.0012	0	0	0	0	0	0	0	0	0	0	0	0	0.0085
3	0	0	0	0	0.0012	0.0109	0.0061	0.0036	0.0206	0.0036	0.0085	0.0097	0.0291	0.0024	0.0024	0.0024	0	0	0	0	0	0	0	0	0.1005
4	0	0	0	0	0.0012	0.0085	0.0048	0.0182	0.0436	0.0048	0.0085	0.0085	0.0182	0.0024	0.0012	0	0	0	0	0	0	0	0	0	0.1199
5	0	0	0	0	0	0	0.0012	0.0012	0	0	0.0012	0	0.0012	0	0.0012	0.0012	0	0	0	0	0	0	0	0	0.0073
6	0	0	0	0	0	0	0.0024	0.0036	0.0121	0	0.0012	0	0	0	0	0	0.0012	0	0	0	0	0	0	0	0.0206
7	0	0	0	0	0	0	0	0.0061	0.0048	0.0024	0.0036	0.0048	0.0085	0.0012	0.0036	0.0036	0	0	0	0	0	0	0	0	0.0387
8	0	0	0	0	0	0	0	0	0	0	0	0.0085	0.0061	0.0048	0.0024	0.0061	0.0048	0.0024	0	0	0	0	0	0	0.0351
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0012	0.0012	0.0024	0	0	0	0	0	0	0	0	0.0048
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0012	0	0.0036	0	0	0	0	0	0	0	0	0.0048
11	0	0	0	0	0	0	0	0	0	0	0	0	0.0012	0	0.0024	0.0061	0.0024	0.0012	0	0.0024	0	0	0	0	0.0157
12	0	0	0	0	0	0	0	0	0	0	0	0	0.0012	0.0048	0.0061	0.0387	0.0218	0.0218	0.0012	0.0121	0.0024	0	0.0012	0	0.1114
13	0	0	0	0	0.0024	0	0	0	0	0	0	0	0	0.0036	0.0048	0.0278	0.0182	0.0097	0.0012	0.0024	0.0024	0	0	0.0036	0.0763
14	0	0	0	0	0	0	0	0.0012	0	0	0	0	0	0	0.0048	0.0351	0.0339	0.0303	0.0024	0.0085	0	0	0.0036	0	0.1199
15	0	0	0	0	0.0012	0	0	0	0	0	0	0	0	0	0	0.0460	0.0387	0.0266	0.0024	0.0218	0.0012	0.0024	0.0036	0	0.1441
16	0	0	0	0	0	0	0	0.0012	0.0012	0	0	0	0	0	0	0	0.0012	0.0012	0.0048	0.0242	0.0036	0.0048	0.0073	0.0121	0.0617
17	0	0	0	0	0.0012	0	0	0.0012	0	0	0	0	0	0.0012	0	0	0	0.0036	0.0048	0.0484	0.0073	0.0036	0.0024	0	0.0738
18	0	0	0	0	0.0012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0194	0.0085	0.0048	0.0048	0.0024	0.0412
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0012	0.0012	0	0	0.0012	0.0036
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0012	0.0012	0	0	0.0024
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0085	0.0218	0.0157	0.0387	0.0860	0.0121	0.0254	0.0327	0.0654	0.0242	0.0315	0.1743	0.1223	0.0969	0.0169	0.1404	0.0278	0.0169	0.0230	0.0194	1.0000

	CLS Winter Quarter 2009 PM - Total Passengers Surveyed - 173																								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	
1	0	0	0	0	0	0.0057	0	0	0	0	0	0.0057	0	0	0	0	0	0	0	0	0	0	0	0	0.0114
2	0	0	0	0	0	0.0057	0.0057	0.0114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0229
3	0	0	0	0	0	0.0057	0	0	0.0171	0	0	0	0.0057	0	0	0	0	0	0	0	0	0	0	0	0.0286
4	0	0	0	0	0.0057	0.0114	0.0057	0.0057	0.0114	0	0.0171	0.0057	0.0057	0.0114	0	0	0	0	0	0	0	0	0	0	0.0800
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
6	0	0	0	0	0	0	0	0	0	0	0	0.0114	0.0114	0.0114	0	0.0057	0	0	0	0	0	0	0	0	0.0400
7	0	0	0	0	0	0	0	0	0	0	0	0.0114	0.0057	0	0.0057	0	0	0	0	0	0	0	0	0	0.0229
8	0	0	0	0	0	0	0	0	0	0	0.0057	0	0.0057	0.0171	0	0.0514	0.0171	0	0	0	0	0	0	0	0.0971
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0057	0	0.0229	0.0286	0.0114	0	0	0	0	0	0	0.0686
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0057	0.0343	0.0171	0	0	0.0057	0.0114	0.0057	0.0286	0.0114	0.1200
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0229	0.0286	0.0057	0	0.0229	0.0057	0.0171	0	0	0.1029
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0400	0.0286	0.0171	0	0.0229	0	0	0	0	0.1086
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0114	0	0.0057	0.0057	0.0229	0	0.0171	0.0400	0.1029
17	0	0	0	0	0.0057	0	0	0.0057	0	0	0	0	0	0	0	0	0	0	0	0.0229	0	0	0.0057	0.0171	0.0571
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0171	0.0229	0.0114	0.0343	0.0057	0.0914
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0114	0	0.0114	0	0.0057	0.0286
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0057	0	0.0114	0	0.0171
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0114	0.0286	0.0114	0.0229	0.0286	0.0000	0.0229	0.0343	0.0343	0.0457	0.0114	0.1771	0.1314	0.0343	0.0057	0.1086	0.0686	0.0457	0.0971	0.0800	1.0000

	CLS Spring Quarter 2009 AM - Total Passengers Surveyed - 773																								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	
1	0	0	0	0	0	0.0013	0	0	0.0065	0.0013	0.0013	0	0.0026	0	0	0	0	0	0	0	0	0	0	0	0.0129
2	0	0	0	0	0	0.0065	0	0.0013	0.0013	0	0	0.0013	0.0039	0	0	0	0	0	0	0	0	0	0	0	0.0142
3	0	0	0	0	0.0013	0.0091	0	0.0078	0.0285	0.0026	0.0103	0.0013	0.0362	0	0.0013	0.0013	0	0	0	0	0	0	0	0	0.0996
4	0	0	0	0	0.0039	0.0103	0	0.0168	0.0440	0	0.0078	0.0065	0.0336	0.0026	0.0013	0	0	0	0	0	0	0	0	0	0.1268
5	0	0	0	0	0	0.0039	0	0.0013	0.0013	0	0	0.0013	0.0013	0.0013	0.0013	0	0	0	0	0	0	0	0	0	0.0116
6	0	0	0	0	0	0	0	0	0.0103	0	0.0026	0.0039	0.0013	0.0039	0	0	0	0	0	0	0	0	0	0	0.0220
7	0	0	0	0	0	0	0	0.0065	0.0168	0	0.0052	0.0078	0.0233	0.0013	0.0013	0.0013	0	0	0	0	0	0	0	0	0.0634
8	0	0	0	0	0	0	0	0	0	0.0013	0	0.0065	0	0.0039	0.0039	0.0168	0	0.0026	0	0	0	0	0	0	0.0349
9	0	0	0	0	0	0	0	0	0	0	0	0	0.0013	0	0.0013	0.0078	0	0	0	0	0	0	0	0	0.0103
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0013	0.0039	0.0013	0.0013	0	0	0	0	0	0	0.0078
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0039	0	0.0091	0.0026	0	0	0	0	0	0	0	0.0155
12	0	0	0	0	0	0	0	0	0	0	0	0	0.0013	0.0013	0.0039	0.0543	0.0168	0.0116	0.0013	0.0039	0.0013	0	0.0013	0	0.0970
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0026	0.0246	0.0194	0.0116	0.0026	0.0065	0.0039	0	0	0.0026	0.0737
14	0	0	0	0	0.0013	0	0	0	0	0	0	0	0	0	0	0.0401	0.0129	0.0181	0.0078	0.0065	0	0.0013	0	0	0.0880
15	0	0	0	0	0.0013	0	0	0	0	0	0	0	0	0	0	0.0453	0.0246	0.0582	0	0.0285	0.0052	0.0026	0	0	0.1656
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0052	0.0091	0.0168	0.0052	0.0026	0.0116	0.0052	0.0556
17	0	0	0	0	0.0052	0	0	0.0026	0	0	0	0	0	0	0	0	0	0	0.0026	0.0233	0.0039	0.0026	0.0026	0	0.0427
18	0	0	0	0	0.0013	0	0	0	0	0	0	0.0013	0	0	0	0	0	0	0.0026	0.0168	0.0052	0.0052	0.0078	0.0091	0.0492
19	0	0	0	0	0	0	0	0.0013	0	0	0	0	0	0	0	0	0	0	0	0.0026	0.0026	0	0	0	0.0065
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0013	0.0013	0.0026
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0142	0.0310	0.0000	0.0375	0.1087	0.0052	0.0272	0.0298	0.1048	0.0181	0.0181	0.2044	0.0776	0.1087	0.0259	0.1048	0.0272	0.0142	0.0246	0.0181	1.0000

	CLS Spring Quarter 2009 PM - Total Passengers Surveyed - 106																								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
2	0	0	0	0	0	0	0	0	0.0189	0	0.0094	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0283
3	0	0	0	0	0.0094	0	0	0	0	0	0.0094	0	0.0094	0	0	0	0	0	0	0	0	0	0	0	0.0283
4	0	0	0	0	0	0	0	0.0094	0	0	0.0377	0.0094	0	0	0	0	0	0	0	0	0	0	0	0	0.0566
5	0	0	0	0	0	0	0	0	0	0	0	0.0094	0.0094	0	0	0	0	0	0	0	0	0	0	0	0.0189
6	0	0	0	0	0	0	0	0.0094	0.0094	0	0	0.0094	0.0094	0.0189	0	0	0	0	0	0	0	0	0	0	0.0566
7	0	0	0	0	0	0	0	0.0094	0	0	0.0094	0.0094	0	0	0	0	0	0	0	0	0	0	0	0	0.0283
8	0	0	0	0	0	0	0	0	0	0.0094	0.0094	0.0377	0	0.0094	0.0189	0.0189	0.0094	0	0	0	0	0	0	0	0.1132
9	0	0	0	0	0	0	0	0	0	0.0094	0	0	0	0	0.0189	0.0094	0	0	0	0	0	0	0	0	0.0377
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0189	0.0189	0	0	0	0	0	0	0	0.0377
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0094	0	0	0	0.0094
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0094	0.0377	0.0283	0.0094	0	0.0094	0	0	0	0	0.0943
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0660	0.0283	0.0283	0.0094	0	0	0	0.0094	0	0.1415
14	0	0	0	0	0.0189	0	0	0	0	0	0	0	0	0	0.0094	0.0189	0.0094	0.0283	0	0.0094	0	0.0094	0.0189	0	0.1226
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0094	0.0094	0.0189	0.0094	0	0	0.0094	0.0566
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0094	0.0094	0.0189	0	0.0094	0.0472
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0189	0	0	0.0283	0	0	0.0472
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0094	0.0377	0.0094	0	0.0189	0.0755
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0283	0.0000	0.0000	0.0283	0.0283	0.0189	0.0755	0.0755	0.0283	0.0283	0.0566	0.1698	0.0943	0.0755	0.0377	0.0566	0.0660	0.0660	0.0283	0.0377	1.0000

	CLS Autumn Quarter 2009 AM - Total Passengers Surveyed - 669																								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	
1	0	0	0	0	0	0.0015	0.0030	0.0030	0.0045	0	0.0015	0.0030	0	0	0	0	0	0	0	0	0	0	0	0	0.0164
2	0	0	0	0	0	0.0030	0	0.0030	0.0015	0	0	0	0.0030	0	0	0	0	0	0	0	0	0	0	0	0.0105
3	0	0	0	0	0.0015	0.0045	0.0045	0.0149	0.0344	0.0090	0.0149	0.0060	0.0164	0.0045	0.0030	0.0045	0.0015	0	0	0	0	0	0	0	0.1196
4	0	0	0	0	0.0045	0.0149	0.0149	0.0120	0.0478	0.0045	0.0060	0.0179	0.0359	0.0030	0	0.0015	0	0	0	0	0	0	0	0	0.1629
5	0	0	0	0	0	0	0.0030	0.0015	0	0	0.0015	0	0	0	0.0015	0	0	0	0	0	0	0	0	0	0.0075
6	0	0	0	0	0	0	0.0060	0.0135	0.0135	0	0.0015	0.0105	0.0179	0.0015	0.0045	0.0030	0	0	0	0	0	0	0	0	0.0717
7	0	0	0	0	0	0	0	0.0015	0.0224	0.0045	0.0060	0.0045	0.0149	0	0	0	0	0	0	0	0	0	0	0	0.0538
8	0	0	0	0	0	0	0	0	0	0.0015	0.0015	0.0045	0.0075	0.0060	0.0090	0.0075	0.0015	0.0015	0	0	0	0	0	0	0.0404
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0030	0.0015	0.0045	0.0075	0.0015	0	0	0	0	0.0015	0	0.0194
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0060	0	0	0	0	0	0	0	0	0.0060
11	0	0	0	0	0	0	0	0	0	0	0	0	0.0030	0.0015	0.0030	0.0045	0.0105	0.0015	0	0	0	0	0	0	0.0239
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0015	0.0045	0.0224	0.0314	0.0090	0	0.0120	0	0	0.0015	0	0.0822
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0015	0.0030	0.0254	0.0135	0.0045	0	0.0060	0.0045	0	0.0030	0.0015	0.0628
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0329	0.0254	0.0164	0.0015	0.0030	0.0015	0.0030	0	0.0060	0.0897
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0299	0.0209	0.0149	0.0045	0.0164	0.0045	0.0015	0	0.0015	0.0942
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0060	0.0015	0.0030	0.0135	0	0.0030	0.0060	0.0030	0.0359
17	0	0	0	0	0.0015	0	0	0.0015	0	0	0	0	0	0	0	0	0	0	0	0.0269	0.0030	0.0015	0	0.0015	0.0359
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0254	0.0015	0.0060	0.0149	0.0045	0.0523
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0015	0	0	0	0	0	0.0015	0.0045	0	0	0.0030	0.0105
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0015	0.0030	0.0045
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0075	0.0239	0.0314	0.0508	0.1241	0.0194	0.0329	0.0463	0.0987	0.0239	0.0299	0.1420	0.1181	0.0508	0.0090	0.1046	0.0194	0.0149	0.0284	0.0239	1.0000

	CLS Spring Quarter 2010 AM - Total Passengers Surveyed - 789																								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	
1	0	0	0	0	0.0013	0.0013	0	0.0076	0.0013	0.0013	0.0038	0.0038	0.0013	0.0013	0	0	0.0013	0	0	0	0	0	0	0	0.0241
2	0	0	0	0	0	0.0013	0	0.0013	0	0	0	0.0013	0.0038	0.0013	0	0	0	0	0	0	0	0	0	0	0.0089
3	0	0	0	0	0.0013	0.0152	0.0038	0.0215	0.0025	0.0076	0.0076	0.0089	0.0139	0.0025	0.0051	0.0025	0	0	0	0	0	0	0	0	0.0925
4	0	0	0	0	0.0013	0.0177	0.0114	0.0545	0.0051	0.0089	0.0101	0.0203	0.0304	0.0051	0.0038	0.0013	0	0	0	0	0	0	0	0	0.1698
5	0	0	0	0	0	0	0.0063	0.0013	0	0.0013	0.0025	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0114
6	0	0	0	0	0	0	0.0013	0.0101	0	0	0.0038	0.0025	0.0013	0	0.0013	0	0	0	0	0	0	0	0	0	0.0203
7	0	0	0	0	0	0	0	0.0063	0	0.0051	0.0025	0.0013	0.0101	0.0013	0.0013	0	0	0	0	0	0	0	0	0	0.0279
8	0	0	0	0	0	0	0	0	0	0	0	0.0013	0.0038	0.0025	0.0051	0.0013	0.0025	0	0	0	0	0	0	0	0.0165
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0013	0	0	0	0	0	0	0	0.0013
10	0	0	0	0	0	0	0	0	0	0	0	0	0.0013	0	0	0	0.0025	0.0013	0	0	0	0	0	0	0.0051
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0025	0.0063	0.0038	0.0013	0	0	0	0	0	0	0.0139
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0038	0.0406	0.0089	0.0139	0	0.0025	0.0013	0.0013	0	0	0.0722
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0025	0.0127	0.0089	0.0038	0	0.0038	0.0025	0.0013	0.0025	0.0025	0.0406
14	0	0	0	0	0.0013	0	0	0	0	0	0	0	0	0	0	0.0418	0.0266	0.0177	0	0.0165	0.0038	0.0013	0.0025	0	0.1115
15	0	0	0	0	0	0	0	0.0013	0	0	0	0	0	0	0	0.0152	0.0330	0.0190	0.0013	0.0431	0.0152	0.0025	0.0013	0.0063	0.1381
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0013	0.0025	0.0025	0.0203	0.0139	0.0038	0.0063	0.0013	0.0520
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0013	0.0583	0.0139	0	0.0051	0.0013	0.0798
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0368	0.0177	0.0063	0.0241	0.0025	0.0875
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0038	0	0	0.0025	0	0.0063
20	0	0	0	0	0.0013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0114	0	0.0038	0.0038	0.0203
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0063	0.0355	0.0228	0.1039	0.0089	0.0241	0.0304	0.0393	0.0659	0.0139	0.0253	0.1217	0.0900	0.0596	0.0051	0.1850	0.0798	0.0165	0.0482	0.0177	1.0000

	CLS Spring Quarter 2010 PM - Total Passengers Surveyed - 584																								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	
1	0	0	0	0	0	0	0	0	0	0	0	0.0017	0.0017	0.0017	0	0	0.0017	0	0	0	0	0	0	0	0.0068
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
3	0	0	0	0	0	0	0.0051	0.0068	0	0	0.0017	0.0034	0.0034	0.0017	0.0034	0	0	0	0	0	0	0	0	0	0.0257
4	0	0	0	0	0	0.0017	0.0017	0.0051	0	0	0.0034	0.0017	0	0.0017	0.0034	0.0017	0	0	0	0	0	0	0	0	0.0205
5	0	0	0	0	0	0	0.0017	0.0051	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0068
6	0	0	0	0	0	0	0	0.0034	0	0.0017	0.0051	0.0171	0.0017	0	0	0	0	0	0	0	0	0	0	0	0.0291
7	0	0	0	0	0	0	0	0.0017	0	0	0.0034	0.0017	0	0.0034	0	0	0	0	0	0	0	0	0	0	0.0103
8	0	0	0	0	0	0	0	0	0	0	0.0017	0.0171	0.0034	0.0103	0.0308	0.0086	0.0086	0	0	0	0	0	0	0	0.0805
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
10	0	0	0	0	0	0	0	0	0	0	0	0	0.0017	0	0.0068	0.0068	0.0034	0	0	0	0	0	0	0	0.0188
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0051	0.0171	0.0068	0.0051	0	0	0	0	0	0	0.0342
12	0	0	0	0	0.0017	0	0	0	0	0	0	0	0.0017	0	0.0068	0.0154	0.0188	0.0034	0.0017	0	0.0017	0	0.0086	0.0017	0.0616
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0017	0.0240	0.0120	0.0360	0.0086	0.0051	0.0034	0.0068	0.0017	0.0205	0.0034	0.1233
14	0	0	0	0	0.0034	0	0	0	0	0	0	0	0	0	0.0051	0.0137	0.0394	0.0137	0.0034	0.0034	0.0051	0.0034	0.0034	0.0034	0.0976
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0017	0.0240	0.0565	0.0223	0.0086	0.0086	0.0154	0.0017	0.0086	0.0120	0.1592
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0086	0.0120	0.0103	0.0154	0.0086	0.0223	0.0137	0.0908
17	0	0	0	0	0	0	0	0.0017	0	0	0	0	0	0	0	0	0.0017	0.0017	0.0086	0.0051	0.0240	0.0137	0.0274	0.0034	0.0873
18	0	0	0	0	0.0051	0	0	0.0017	0	0	0	0	0	0	0	0	0	0	0	0.0068	0.0445	0.0086	0.0479	0.0137	0.1284
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0051	0.0034	0.0051	0	0.0137
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0034	0.0017	0.0051
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0103	0.0017	0.0086	0.0257	0.0000	0.0017	0.0154	0.0428	0.0137	0.0205	0.0873	0.0993	0.1729	0.0634	0.0394	0.0377	0.1182	0.0411	0.1473	0.0531	1.0000

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
	CLN Spring Quarter 2009 AM - Total Passengers Surveyed - 84																							
1	0	0	0	0	0	0	0	0	0	0.0119	0.0238	0	0	0	0	0	0	0	0	0	0	0	0	0.0357
2	0	0	0	0	0	0.0119	0	0.0119	0.0119	0.0238	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0595
3	0	0	0	0	0	0.0357	0	0.1190	0.0833	0	0.0238	0.0119	0	0	0	0	0	0	0	0	0	0	0	0.2738
4	0	0	0	0	0	0.0595	0	0.0595	0.0357	0.0714	0.0238	0	0.0357	0	0	0	0	0	0	0	0	0	0	0.2857
5	0	0	0	0	0	0	0	0.0119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0119
6	0	0	0	0	0	0	0	0.0238	0	0.0238	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0476
7	0	0	0	0	0	0	0	0	0	0.0476	0.0119	0.0119	0.0119	0	0	0	0	0	0	0	0	0	0	0.0833
8	0	0	0	0	0	0	0	0	0	0	0.0119	0	0	0	0	0	0	0	0	0	0	0	0	0.0119
9	0	0	0	0	0	0	0	0	0	0	0	0.0238	0.0238	0	0.0119	0.0119	0	0	0	0	0	0	0	0.0714
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0238	0	0	0	0	0	0	0	0	0	0.0238
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0119	0	0	0	0	0	0	0	0	0	0.0119
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0238	0	0	0	0.0238	0.0476
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0119	0	0	0	0.0119
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0119	0	0	0	0	0.0119
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0119	0.0119
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.1071	0.0000	0.2262	0.1310	0.1786	0.0952	0.0476	0.0714	0.0357	0.0119	0.0119	0.0000	0.0000	0.0357	0.0119	0.0000	0.0000	0.0357	1.0000

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
	CLN Autumn Quarter 2009 AM - Total Passengers Surveyed - 1258																							
1	0	0	0	0	0	0	0	0.0207	0.0048	0.0048	0.0040	0.0016	0.0016	0	0	0	0	0	0	0	0	0	0	0.0374
2	0	0	0	0	0	0.0016	0.0008	0.0310	0.0119	0.0064	0.0048	0.0016	0.0032	0	0	0	0	0	0	0	0	0	0	0.0612
3	0	0	0	0	0	0.0048	0.0048	0.1502	0.0548	0.0445	0.0231	0.0056	0.0032	0	0	0.0008	0	0	0	0	0	0	0	0.2917
4	0	0	0	0	0.0008	0.0151	0.0024	0.1192	0.0477	0.0326	0.0215	0.0072	0.0079	0.0008	0	0	0.0008	0	0	0	0	0	0	0.2560
5	0	0	0	0	0	0	0	0.0079	0.0016	0.0008	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0103
6	0	0	0	0	0	0	0	0.0072	0.0072	0.0024	0.0016	0.0008	0.0016	0	0	0	0	0	0	0	0	0	0	0.0207
7	0	0	0	0	0	0	0	0.0024	0.0040	0.0064	0.0024	0.0040	0.0024	0	0	0	0	0	0	0	0	0	0	0.0215
8	0	0	0	0	0	0	0	0	0.0048	0.0064	0.0159	0.0079	0.0079	0.0040	0	0	0.0008	0	0	0	0	0	0	0.0477
9	0	0	0	0	0	0	0	0	0	0.0008	0.0056	0.0270	0.0278	0.0079	0.0064	0.0087	0.0032	0	0	0	0	0	0	0.0874
10	0	0	0	0	0.0008	0	0	0	0	0	0.0056	0.0151	0.0119	0.0048	0	0.0048	0.0064	0	0	0	0	0	0	0.0493
11	0	0	0	0	0	0	0	0	0	0	0	0.0008	0.0064	0.0008	0	0.0032	0.0048	0.0016	0.0016	0	0	0.0024	0.0008	0.0223
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0008	0.0008	0.0008	0.0040	0.0008	0.0008	0	0	0.0008	0.0008	0.0095
13	0	0	0	0	0.0008	0	0	0	0	0	0	0	0	0	0	0.0032	0.0064	0	0.0087	0.0024	0.0024	0.0024	0.0024	0.0286
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0008	0.0056	0	0.0048	0.0032	0	0.0016	0.0024	0.0183
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
16	0	0	0	0	0.0008	0	0	0	0	0	0	0	0	0	0	0	0	0.0008	0.0016	0.0024	0	0.0008	0.0008	0.0072
17	0	0	0	0	0	0	0	0.0008	0	0	0.0008	0	0	0	0	0	0	0.0016	0.0032	0.0024	0.0016	0	0.0127	0.0231
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0008	0	0	0.0016	0.0008	0.0032
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0024	0.0008	0	0.0016	0.0048
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0032	0.0215	0.0079	0.3394	0.1367	0.1049	0.0851	0.0715	0.0739	0.0191	0.0072	0.0223	0.0318	0.0048	0.0215	0.0127	0.0048	0.0095	0.0223	1.0000

	CLN Spring Quarter 2010 AM - Total Passengers Surveyed - 694																							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	
1	0	0	0	0	0.0014	0.0014	0	0.0346	0.0086	0.0101	0.0115	0.0043	0	0	0	0	0	0	0	0	0	0	0	0.0720
2	0	0	0	0	0	0.0014	0	0.0303	0.0086	0.0043	0.0072	0.0029	0	0	0	0	0	0	0	0	0	0	0	0.0548
3	0	0	0	0	0	0.0029	0	0.1412	0.0375	0.0346	0.0259	0.0043	0.0043	0	0	0	0	0	0	0	0	0	0	0.2507
4	0	0	0	0	0.0014	0.0130	0	0.1037	0.0303	0.0303	0.0202	0.0058	0.0072	0.0014	0.0014	0	0	0	0	0	0	0	0	0.2147
5	0	0	0	0	0	0	0	0.0086	0.0029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0115
6	0	0	0	0	0	0	0	0.0159	0.0086	0	0.0086	0.0014	0.0014	0	0	0	0	0	0	0	0	0	0	0.0360
7	0	0	0	0	0	0	0	0	0.0130	0.0058	0.0072	0.0014	0	0	0	0	0	0	0	0	0	0	0	0.0274
8	0	0	0	0	0	0	0	0	0.0101	0.0130	0.0274	0.0043	0	0	0	0	0.0029	0	0	0	0	0	0	0.0576
9	0	0	0	0	0	0	0	0	0	0.0029	0.0058	0.0245	0.0533	0.0029	0	0	0	0	0	0	0	0	0	0.0893
10	0	0	0	0	0	0	0	0	0	0	0.0072	0.0072	0.0130	0.0115	0.0014	0	0.0072	0	0	0	0	0	0	0.0476
11	0	0	0	0	0	0	0	0	0	0	0	0.0014	0.0043	0.0014	0.0014	0	0.0029	0	0.0014	0.0014	0.0014	0	0.0014	0.0173
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0014	0	0	0.0029	0.0029	0	0.0029	0	0.0014	0	0.0115
13	0	0	0	0	0	0	0	0	0	0	0	0	0.0014	0	0.0014	0	0.0058	0.0014	0.0029	0.0144	0	0.0101	0.0159	0.0533
14	0	0	0	0	0	0	0.0014	0	0	0	0	0	0	0	0	0	0.0029	0	0.0029	0.0043	0	0	0.0029	0.0144
15	0	0	0	0	0	0	0	0	0	0	0	0.0014	0	0	0	0	0	0	0.0014	0.0029	0	0.0029	0	0.0086
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0014	0.0014	0.0115	0	0.0086	0.0014	0.0245
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0014	0	0.0014
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0029	0	0.0014	0.0029	0.0072
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0029	0.0187	0.0014	0.3343	0.1196	0.1009	0.1210	0.0591	0.0850	0.0187	0.0058	0.0000	0.0245	0.0058	0.0101	0.0403	0.0014	0.0259	0.0245	1.0000

	CLN Spring Quarter 2010 PM - Total Passengers Surveyed - 500																							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	
1	0	0	0	0	0	0	0	0.0040	0.0100	0.0020	0.0020	0.0060	0.0020	0	0	0	0	0	0	0	0	0	0	0.0260
2	0	0	0	0	0	0	0	0.0060	0.0020	0.0020	0.0020	0	0	0	0	0	0	0	0	0	0	0	0	0.0120
3	0	0	0	0	0	0.0040	0	0.0520	0.0080	0.0040	0.0060	0	0.0020	0	0	0	0	0	0	0	0	0	0	0.0760
4	0	0	0	0	0	0	0.0020	0.0260	0.0140	0.0060	0.0160	0	0	0	0	0	0	0	0	0	0	0	0	0.0640
5	0	0	0	0	0	0	0	0.0040	0.0020	0	0.0060	0.0020	0	0	0	0	0	0	0	0	0	0	0	0.0140
6	0	0	0	0	0	0	0.0020	0.0520	0.0300	0.0100	0.0160	0.0040	0.0040	0	0	0	0.0020	0	0	0	0	0	0	0.1200
7	0	0	0	0	0	0	0	0	0.0020	0.0060	0.0080	0.0020	0	0	0	0	0	0	0	0	0	0	0	0.0180
8	0	0	0	0	0	0	0	0	0.0020	0.0100	0.0400	0.0160	0.0300	0.0020	0.0020	0	0.0040	0	0	0	0	0.0020	0	0.1080
9	0	0	0	0	0	0	0	0	0	0.0020	0.0300	0.0400	0.0240	0	0	0	0.0040	0	0	0	0	0	0	0.1000
10	0	0	0	0	0	0	0	0	0	0	0.0180	0.0180	0.0240	0.0080	0.0060	0	0.0220	0	0	0	0	0.0020	0	0.0980
11	0	0	0	0	0.0020	0	0	0	0	0	0	0	0.0080	0.0060	0.0020	0	0.0220	0	0	0.0080	0	0	0.0040	0.0520
12	0	0	0	0	0	0	0	0	0	0	0	0	0.0020	0	0	0	0.0120	0.0040	0.0020	0.0020	0.0040	0.0020	0	0.0280
13	0	0	0	0	0	0	0	0.0020	0	0	0	0	0	0	0	0.0040	0.0280	0.0080	0	0.0100	0.0020	0.0280	0.0160	0.0980
14	0	0	0	0	0.0020	0	0	0	0	0	0	0	0	0	0	0	0	0.0040	0.0020	0.0080	0	0.0120	0.0120	0.0400
15	0	0	0	0	0	0	0	0.0020	0	0	0	0	0	0	0	0	0	0.0040	0	0.0040	0.0060	0.0180	0.0040	0.0380
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0020	0	0	0.0020	0.0020	0.0060
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0040	0.0040	0.0360	0.0260	0.0200	0.0060	0.0960
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0020	0	0	0	0.0020
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0020	0	0.0020	0	0.0040
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0040	0.0040	0.0040	0.1480	0.0700	0.0420	0.1440	0.0880	0.0960	0.0160	0.0100	0.0040	0.0940	0.0240	0.0100	0.0720	0.0380	0.0880	0.0440	1.0000

	NE Autumn Quarter 2009 AM - Total Passengers Surveyed - 882																			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	
1	0	0	0	0	0	0	0.0011	0.0068	0.0499	0.0068	0	0.0011	0	0	0	0	0	0	0	0.0658
2	0	0	0	0	0	0.0045	0.0034	0.0091	0.0283	0.0102	0.0023	0.0023	0	0	0	0	0	0	0	0.0601
3	0	0	0	0	0.0011	0.0045	0.0023	0.0351	0.1610	0.0420	0.0204	0.0079	0	0	0.0011	0	0	0	0	0.2755
4	0	0	0	0	0	0.0079	0.0034	0.0385	0.1349	0.0283	0.0057	0.0011	0	0	0	0	0	0	0	0.2200
5	0	0	0	0	0	0	0	0.0034	0.0034	0.0011	0.0011	0.0011	0	0	0	0	0	0	0	0.0102
6	0	0	0	0	0	0	0	0.0079	0.0113	0.0079	0.0023	0.0034	0	0	0	0	0	0	0	0.0329
7	0	0	0	0	0	0	0	0.0034	0.0204	0.0102	0.0011	0.0011	0	0	0	0	0	0	0	0.0363
8	0	0	0	0	0	0	0	0	0.0057	0.0045	0.0034	0.0045	0	0	0.0011	0.0011	0	0.0023	0.0023	0.0249
9	0	0	0	0	0	0	0	0	0.0011	0.0045	0.0011	0.0068	0	0.0011	0.0079	0.0091	0.0045	0.0147	0.0147	0.0658
10	0	0	0	0	0	0	0	0	0	0	0	0	0.0011	0.0011	0.0011	0.0011	0.0011	0.0125	0.0034	0.0215
11	0	0	0	0	0	0	0	0	0	0	0	0.0034	0	0.0023	0.0136	0.0079	0.0023	0.0068	0.0034	0.0397
12	0	0	0	0	0	0	0	0	0	0	0	0	0.0011	0.0057	0.0374	0.0147	0	0.0091	0.0057	0.0737
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0238	0.0102	0.0034	0.0159	0.0079	0.0612
14	0	0	0	0	0.0011	0	0	0	0.0011	0	0	0	0	0	0	0	0	0.0011	0.0011	0.0045
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0045	0	0.0023	0.0011	0.0079
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0023	0.0170	0.0102	0.1043	0.4172	0.1156	0.0374	0.0329	0.0023	0.0102	0.0862	0.0488	0.0113	0.0646	0.0397	1.0000

	NE Spring Quarter 2010 AM - Total Passengers Surveyed - 618																			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	
1	0	0	0	0	0	0.0016	0	0.0065	0.0469	0.0113	0.0032	0	0.0016	0	0	0	0	0	0	0.0712
2	0	0	0	0	0	0.0032	0.0032	0.0097	0.0356	0.0113	0.0032	0	0	0	0	0	0	0	0	0.0663
3	0	0	0	0	0	0.0210	0.0049	0.0631	0.1909	0.0340	0.0113	0.0032	0	0	0	0	0	0	0	0.3285
4	0	0	0	0	0	0.0113	0.0065	0.0599	0.1521	0.0372	0.0194	0.0032	0	0	0	0	0	0	0	0.2896
5	0	0	0	0	0	0	0	0	0.0032	0	0	0.0016	0	0	0	0	0	0	0	0.0049
6	0	0	0	0	0	0	0.0016	0.0049	0.0081	0.0016	0.0016	0.0016	0	0	0	0	0	0	0	0.0194
7	0	0	0	0	0	0	0	0	0.0259	0.0049	0.0049	0	0	0	0	0	0	0	0	0.0356
8	0	0	0	0	0	0	0	0	0.0049	0.0065	0	0.0016	0	0	0.0016	0.0032	0	0	0	0.0178
9	0.0016	0	0.0016	0.0016	0	0	0	0	0	0	0	0.0016	0.0016	0.0016	0.0016	0	0	0.0113	0.0016	0.0243
10	0	0	0	0	0	0	0	0	0	0	0	0	0.0016	0	0	0	0	0	0	0.0016
11	0.0016	0	0.0016	0	0	0	0	0	0	0	0	0	0.0016	0.0032	0.0210	0.0016	0.0032	0.0016	0.0016	0.0372
12	0.0016	0	0	0	0.0016	0	0	0	0	0	0	0	0.0032	0	0.0372	0.0081	0.0016	0	0	0.0534
13	0	0	0.0016	0	0.0016	0	0	0	0	0	0	0	0	0.0016	0.0227	0.0032	0	0.0049	0.0016	0.0372
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0016	0	0	0	0	0.0016
15	0	0	0.0016	0.0016	0	0	0	0	0	0	0	0	0	0	0	0	0.0016	0.0065	0	0.0113
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
	0.0049	0.0000	0.0065	0.0032	0.0032	0.0372	0.0162	0.1440	0.4676	0.1068	0.0437	0.0129	0.0097	0.0065	0.0858	0.0162	0.0065	0.0243	0.0049	1.0000

Appendix B

Selected Percentile Values of Cycle Times and Timepoint-to-Timepoint Travel Times Obtained from CABS Automatic Passenger Count Data for Use in Scheduling Analysis of New Central Connector Route

TableB-1: Cycle Time Percentile Values for Campus Loop North (CLN), Campus Loop South (CLS), Central Connector in Counter Clockwise Direction (CC-CCW), Central Connector in Clockwise Direction (CC-CW), and Total Central Connector (CC total) based on CABS Automatic Passenger Count Data

7am -9 am

Cycle Times					
	CLN	CLS	CC_CCW	CC_CW	CC_total
50% percentile	31.4	30	9.8	11.4	21.2
85% percentile	34.6	32.7	11.5	12.8	24.3
90% percentile	35.55	33.4	11.8	13.2	25
95% percentile	36.65	35.2	12.55	13.8	26.35

9am-5 pm

Cycle Times					
	CLN	CLS	CC_CCW	CC_CW	CC_total
50% percentile	30.7	30.5	10.8	12.8	23.6
85% percentile	33.7	32.9	12.1	14.2	26.3
90% percentile	34.6	33.65	12.5	14.6	27.1
95% percentile	35.95	35.25	13.1	15	28.1

Table B-2: Percentile Values for Timepoint-to-Timepoint Times without Dwell Times on Campus Loop North (CLN), Campus Loop South (CLS), and Central Connector (CC) based on Automatic Vehicle Location Data

7am – 9am

CLN	BEVIS	CMCK1	AGEB	KNWTN	STLMN	OUSB	MEILG	TOWER	AGWB	BEVIS	Sum
50% percentile		3.8	3.5	1.4	3.4	0.7	5.2	5.7	3.4	2.3	29.4
85% percentile		4.5	4.1	2.3	4.5	0.8	6	7.6	4.2	3.1	37.1
90% percentile		4.6	4.3	2.4	4.8	0.8	6.15	8.2	4.45	3.3	39
95% percentile		4.9	4.7	2.5	5.3	0.9	6.45	9.45	4.75	3.5	42.45

CLS	BEVIS	CMCK1	AGEB	DRAKE	MDCT9	OUNB	ARPS	NDRMS	AGWB	BEVIS	Sum
50% percentile		3.3	3.5	3	5.4	5.3	1.6	1.7	3.8	2.3	29.9
85% percentile		4.55	4.2	3.4	8.05	6.7	2	2.3	4.7	3	38.9
90% percentile		4.9	4.3	3.7	8.8	7.1	2.2	2.4	4.95	3.3	41.65
95% percentile		5.5	4.6	4.2	9.9	7.8	2.6	2.6	5.6	3.65	46.45

CC	TOWER	KNWTN	STLMN	OUSB	9TH&MEILING	10TH&MEILING	OUNB	ARPS	NDRMS	TOWER
50% percentile		No data	3.4	0.7	5.2	No data	5.3	1.6	1.7	No data
85% percentile		No data	4.5	0.8	6	No data	6.7	2	2.3	No data
90% percentile		No data	4.8	0.8	6.15	No data	7.1	2.2	2.4	No data
95% percentile		No data	5.3	0.9	6.45	No data	7.8	2.6	2.6	No data

9am – 5pm

CLN	BEVIS	CMCK1	AGEB	KNWTN	STLMN	OUSB	MEILG	TOWER	AGWB	BEVIS	Sum
50% percentile		3.9	3.4	1.9	4.2	0.8	5.7	4.7	3.6	2	30.2
85% percentile		4.7	4	2.4	5.4	1	6.4	5.9	4.2	2.5	36.5
90% percentile		4.9	4.3	2.5	5.7	1.1	6.6	6.45	4.4	2.7	38.65
95% percentile		5.3	4.5	2.8	6.3	1.3	6.8	7.65	4.7	3	42.35

CLS	BEVIS	CMCK1	AGEB	DRAKE	MDCT9	OUNB	ARPS	NDRMS	AGWB	BEVIS	Sum
50% percentile		3.5	3.3	3.2	3.4	5.6	2.1	1.9	4.7	1.9	29.6
85% percentile		5.2	4	4	4.4	6.7	2.8	2.5	5.6	2.6	37.8
90% percentile		5.6	4.2	4.3	4.75	7	3	2.7	5.8	2.7	40.05
95% percentile		6.55	4.7	5	5.4	7.5	3.5	2.9	6.2	3	44.75

CC	TOWER	KNWTN	STLMN	OUSB	9TH&MEILING	10TH&MEILING	OUNB	ARPS	NDRMS	TOWER
50% percentile		No data	4.2	0.8	5.7	No data	5.6	2.1	1.9	No data
85% percentile		No data	5.4	1	6.4	No data	6.7	2.8	2.5	No data
90% percentile		No data	5.7	1.1	6.6	No data	7	3	2.7	No data
95% percentile		No data	6.3	1.3	6.8	No data	7.5	3.5	2.9	No data

Appendix C
Illustrative Linear Programming Formulation
of CABS Scheduling Problem

The following illustrates the LP formulation of the scheduling problem. To facilitate communication of the important aspects, the formulation presented abstracts the route by considering only three stops on each route. The stops selected in the abstracted formulation are those where pairs of routes begin to overlap.

C.1 Background

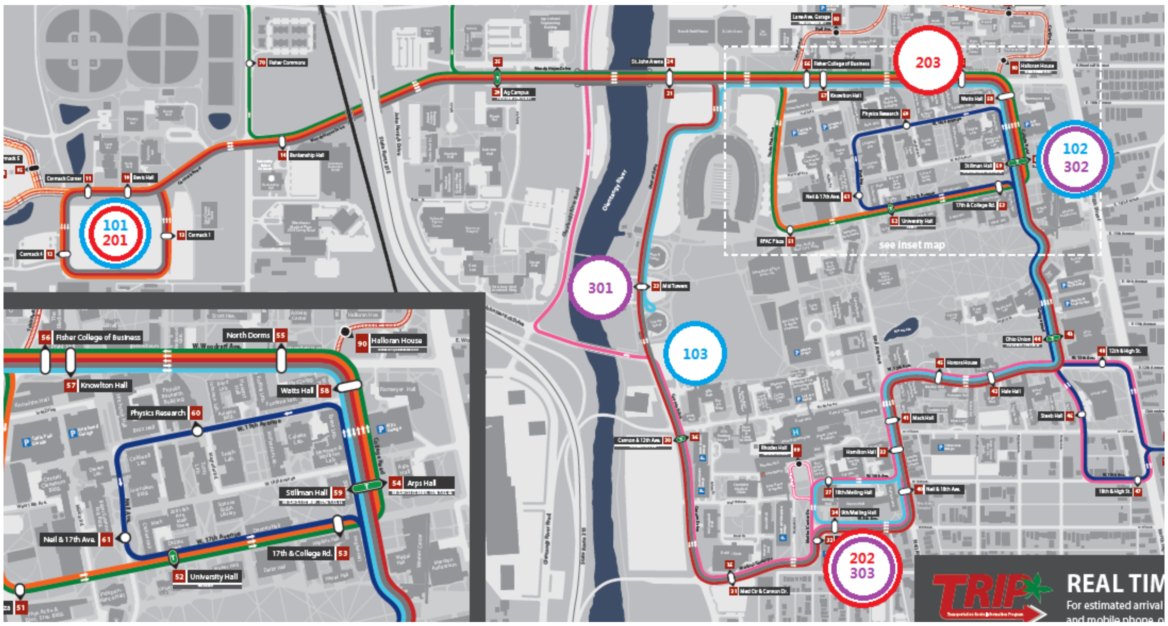


Figure C-1: Network structure and stop locations for illustrative LP formulation

There are three routes in the bus network: CLN(Campus Loop North), CLS(Campus Loop South) and CC (Central Connector). All routes have three stops, and each route has one stop in common with each other route. For CLN and CLS, there are four buses scheduled and for CC there are three buses scheduled. All routes have the same headway and the inter-headway between CLN and CLS at stop 101 is equal to half of the route headway. Similarly, the inter-headway between CLN and CC at stop 102 and between CLS and CC at stop 201 must be equal to half of the route headway.

Definitions for all variables:

> **TXi** is the travel time from stop *i* to stop *i+1* for route *X* (*N* for CLN (Campus Loop North), *S* for CLS (Campus Loop South) and *C* for CC (Central Connector));
> **DXi** is the dwell time at stop *i* for route *X*.
> **RTX** is the cycle time for Route *X*.
> **H** is the headway of each route.

STX is the time that the bus leaves the first stop for route *X*. (*STN*, the initial departure time for CLN from the first stop, is arbitrarily set to zero.)

Table C-2: Lower bound of travel times and dwell times for illustrative LP formulation

CLN					
C-Stop No.		101	102	103	101
Travel time	Notation		TN1	TN2	TN3
	Minimum value		9.2	15.4	5.6
Dwell time	Notation		DN1	DN2	DN3
	Minimum value		0	0	0
CLS					
Stop No.		201	202	203	201
Travel time	Notation		TS1	TS2	TS3
	Minimum value		13.4	9.6	6.6
Dwell time	Notation		DS1	DS2	DS3
	Minimum value		0	0	0
CC					
Stop No.		301	302	303	301
Travel time	Notation		TC1	TC2	TC3
	Minimum value		6.2	7	12.6
Dwell time	Notation		DC1	DC2	DC3
	Minimum value		0	0	0

C.2 Linear program formulation

Min H

Subject to:

Definitional relations between cycle times and travel and dwell times and between cycle times and headways, given a fixed number of buses

The running time of a given route can be defined as the summation of all the travel times between two consecutive stops and the dwell time at all stops, which lead to the following equations:

$$\sum_{i=1}^{3}(TNi + DNi) = RTN \tag{C1}$$

$$\sum_{i=1}^{3}(TSi + DSi) = RTS \tag{C2}$$

$$\sum_{i=1}^{3}(TCi + DCi) = RTC \tag{C3}$$

where

TXi is the travel time from stop *i* to stop *i+1* for route *X (N* for CLN (Campus Loop North)*, S* for CLS (Campus Loop South), and *C* for CC (Central Connector));
DXi is the dwell time at stop *i* on route *X*.
RTX is the cycle time for Route *X.*

Given *M* buses running on a given route with fixed headway, an observer at one stop would observe the same bus after observing *M-1* other buses. The observer would also observe the same bus after every *M* headways, providing a relation between the cycle time and the headway. In this problem, equal headways are to be imposed for CLN, CLS, and CC. The default scheduled numbers of buses on the routes were four, four, and three for CLN, CLS, and CC, respectively. Equations (C4) to(C 6) are obtained.

$$RTN = 4H \tag{C4}$$

$$RTS = 4H \tag{C5}$$

$$RTC = 3H \tag{C6}$$

where H is the headway of each route.

Lower bounds on travel times and dwell times

The timepoint-to-timepoint travel times and the dwell time have lower bounds, for example those given in Table C-1.

Constraints for CLN:

$$TN1 \geq 9.2 \tag{C7}$$

$$TN2 \geq 15.4 \tag{C8}$$

$$TN3 \geq 5.6 \tag{C9}$$

$$DN1 \geq 0 \tag{C10}$$

$$DN2 \geq 0 \tag{C11}$$

$$DN3 \geq 0 \tag{C12}$$

Constraints for CLS:

$$\mathrm{TS1} \geq 13.4 \qquad (C13)$$
$$\mathrm{TS2} \geq 9.6 \qquad (C14)$$
$$\mathrm{TS3} \geq 6.6 \qquad (C15)$$

$$\mathrm{DS1} \geq 0 \qquad (C16)$$
$$\mathrm{DS2} \geq 0 \qquad (C17)$$
$$\mathrm{DS3} \geq 0 \qquad (C18)$$

Constraints for CC:

$$\mathrm{TC1} \geq 6.2 \qquad (C19)$$
$$\mathrm{TC2} \geq 7 \qquad (C20)$$
$$\mathrm{TC3} \geq 12.6 \qquad (C21)$$

$$\mathrm{DC1} \geq 0 \qquad (C22)$$
$$\mathrm{DC2} \geq 0 \qquad (C23)$$
$$\mathrm{DC3} \geq 0 \qquad (C24)$$

Prescribed relations between scheduled departure times at stops for different routes to ensure even departure spacing, given departure, travel, and dwell time relations

The inter-route headways between CLS and CLN, between CLS and CC, and between CC and CLN should equal half the headway of each route. Although CLS and CLN travel in different directions in central campus, they depart the same starting point on West Campus and they also serve the same stops before and after traveling around central campus. Hence, the departure time of one route from the common West Campus stop (where the routes are considered to begin) should be H/2 after the departure time of the other route from the West Campus stop. Considering Campus Loop North to begin at time 0:

$$\mathrm{STN} = 0 \qquad (C25)$$
$$\mathrm{STS} = \mathrm{H}/2 \qquad (C26)$$

Recall that STX is the departure time from the first stop for a bus on route X.

The path of CC, when traveling in the clockwise direction, coincides with the path of CLN on central campus. To ensure equal inter-route headways, the departure times are constrained at time point 102/302 (for CLN/CC).

$$\sum_{\mathrm{i}=1}^{1}(\mathrm{TNi} + \mathrm{DNi}) - \frac{\mathrm{H}}{2} = \mathrm{STC} + \sum_{\mathrm{i}=1}^{1}(\mathrm{TCi} + \mathrm{DCi}) \qquad (C27)$$

Similarly, the path of CC. when traveling in the counter-clockwise direction, coincides with the path of CLS on central campus. The equal inter-route headways are ensured by constraining the departure times at time point 202/303 (for CLS/CC):

$$\mathrm{STS} + \sum_{\mathrm{i}=1}^{1}(\mathrm{TSi} + \mathrm{DSi}) - \frac{\mathrm{H}}{2} = \mathrm{STC} + \sum_{\mathrm{i}=1}^{2}(\mathrm{TCi} + \mathrm{DCi}) \qquad \text{(C28)}$$

where the departure time *STS* for CLS from its first stop (time point 201 on West Campus) was constrained to be related to the departure the time of CLN from its first stop (time point 101 on West Campus) in (C25) and (C26), and the departure time *STC* for CC from its first stop (time point 301 at the Towers) is constrained to provide equal departure spacing with CLN in (C27) and with CLS in this relation (C28).

Appendix D
Schedule Produced using 50th Percentile Timepoint-to-Timepoint Travel Time Values to Integrate Campus Loop North (CLN), Campus Loop South (CLS), and Central Connector (CC) Routes

Exhibit D-1: Four-bus Campus Loop North (CLN) schedule

Headway	7a-9a	9a-5p	5p-9p						
	0:08:30	0:09:00	0:08:30			No. of buses		4	

CLN1	BEVIS	CMCK1	AGEB	KNWTN	STLMN	OUSB	MEILG	TOWER	AGWB
1	7:00:00	7:03:00	7:06:30	7:08:30	7:12:00	7:13:00	7:18:30	7:23:00	7:28:45
2	7:34:00	7:37:00	7:40:30	7:42:30	7:46:00	7:47:00	7:52:30	7:57:00	8:02:45
3	8:08:00	8:11:00	8:14:30	8:16:30	8:20:00	8:21:00	8:26:30	8:31:00	8:36:45
4	8:42:00	8:45:00	8:48:30	8:50:30	8:54:00	8:55:00	9:00:30	9:05:00	9:10:45
5	9:16:00	9:19:30	9:23:30	9:25:30	9:29:30	9:30:30	9:36:30	9:42:30	9:48:00
6	9:52:00	9:55:30	9:59:30	10:01:30	10:05:30	10:06:30	10:12:30	10:18:30	10:24:00
7	10:28:00	10:31:30	10:35:30	10:37:30	10:41:30	10:42:30	10:48:30	10:54:30	11:00:00
8	11:04:00	11:07:30	11:11:30	11:13:30	11:17:30	11:18:30	11:24:30	11:30:30	11:36:00
9	11:40:00	11:43:30	11:47:30	11:49:30	11:53:30	11:54:30	12:00:30	12:06:30	12:12:00
10	12:16:00	12:19:30	12:23:30	12:25:30	12:29:30	12:30:30	12:36:30	12:42:30	12:48:00
11	12:52:00	12:55:30	12:59:30	13:01:30	13:05:30	13:06:30	13:12:30	13:18:30	13:24:00
12	13:28:00	13:31:30	13:35:30	13:37:30	13:41:30	13:42:30	13:48:30	13:54:30	14:00:00
13	14:04:00	14:07:30	14:11:30	14:13:30	14:17:30	14:18:30	14:24:30	14:30:30	14:36:00
14	14:40:00	14:43:30	14:47:30	14:49:30	14:53:30	14:54:30	15:00:30	15:06:30	15:12:00
15	15:16:00	15:19:30	15:23:30	15:25:30	15:29:30	15:30:30	15:36:30	15:42:30	15:48:00
16	15:52:00	15:55:30	15:59:30	16:01:30	16:05:30	16:06:30	16:12:30	16:18:30	16:24:00
17	16:28:00	16:31:00	16:34:30	16:36:30	16:40:00	16:41:00	16:46:30	16:51:00	16:56:45
18	17:02:00	17:05:00	17:08:30	17:10:30	17:14:00	17:15:00	17:20:30	17:25:00	17:30:45
19	17:36:00	17:39:00	17:42:30	17:44:30	17:48:00	17:49:00	17:54:30	17:59:00	18:04:45
20	18:10:00	18:13:00	18:16:30	18:18:30	18:22:00	18:23:00	18:28:30	18:33:00	18:38:45
21	18:44:00	18:47:00	18:50:30	18:52:30	18:56:00	18:57:00	19:02:30	19:07:00	19:12:45
22	19:18:00	19:21:00	19:24:30	19:26:30	19:30:00	19:31:00	19:36:30	19:41:00	19:46:45
23	19:52:00	19:55:00	19:58:30	20:00:30	20:04:00	20:05:00	20:10:30	20:15:00	20:20:45
24	20:26:00	20:29:00	20:32:30	20:34:30	20:38:00	20:39:00	20:44:30	20:49:00	20:54:45

CLN2	BEVIS	CMCK1	AGEB	KNWTN	STLMN	OUSB	MEILG	TOWER	AGWB
1	7:08:30	7:11:30	7:15:00	7:17:00	7:20:30	7:21:30	7:27:00	7:31:30	7:37:15
2	7:42:30	7:45:30	7:49:00	7:51:00	7:54:30	7:55:30	8:01:00	8:05:30	8:11:15
3	8:16:30	8:19:30	8:23:00	8:25:00	8:28:30	8:29:30	8:35:00	8:39:30	8:45:15
4	8:50:30	8:53:30	8:57:00	8:59:00	9:02:30	9:03:30	9:09:00	9:13:30	9:19:15
5	9:25:00	9:28:30	9:32:30	9:34:30	9:38:30	9:39:30	9:45:30	9:51:30	9:57:00
6	10:01:00	10:04:30	10:08:30	10:10:30	10:14:30	10:15:30	10:21:30	10:27:30	10:33:00
7	10:37:00	10:40:30	10:44:30	10:46:30	10:50:30	10:51:30	10:57:30	11:03:30	11:09:00
8	11:13:00	11:16:30	11:20:30	11:22:30	11:26:30	11:27:30	11:33:30	11:39:30	11:45:00
9	11:49:00	11:52:30	11:56:30	11:58:30	12:02:30	12:03:30	12:09:30	12:15:30	12:21:00
10	12:25:00	12:28:30	12:32:30	12:34:30	12:38:30	12:39:30	12:45:30	12:51:30	12:57:00
11	13:01:00	13:04:30	13:08:30	13:10:30	13:14:30	13:15:30	13:21:30	13:27:30	13:33:00
12	13:37:00	13:40:30	13:44:30	13:46:30	13:50:30	13:51:30	13:57:30	14:03:30	14:09:00
13	14:13:00	14:16:30	14:20:30	14:22:30	14:26:30	14:27:30	14:33:30	14:39:30	14:45:00

14	14:49:00	14:52:30	14:56:30	14:58:30	15:02:30	15:03:30	15:09:30	15:15:30	15:21:00
15	15:25:00	15:28:30	15:32:30	15:34:30	15:38:30	15:39:30	15:45:30	15:51:30	15:57:00
16	16:01:00	16:04:30	16:08:30	16:10:30	16:14:30	16:15:30	16:21:30	16:27:30	16:33:00
17	16:36:30	16:39:30	16:43:00	16:45:00	16:48:30	16:49:30	16:55:00	16:59:30	17:05:15
18	17:10:30	17:13:30	17:17:00	17:19:00	17:22:30	17:23:30	17:29:00	17:33:30	17:39:15
19	17:44:30	17:47:30	17:51:00	17:53:00	17:56:30	17:57:30	18:03:00	18:07:30	18:13:15
20	18:18:30	18:21:30	18:25:00	18:27:00	18:30:30	18:31:30	18:37:00	18:41:30	18:47:15
21	18:52:30	18:55:30	18:59:00	19:01:00	19:04:30	19:05:30	19:11:00	19:15:30	19:21:15
22	19:26:30	19:29:30	19:33:00	19:35:00	19:38:30	19:39:30	19:45:00	19:49:30	19:55:15
23	20:00:30	20:03:30	20:07:00	20:09:00	20:12:30	20:13:30	20:19:00	20:23:30	20:29:15
24	20:34:30	20:37:30	20:41:00	20:43:00	20:46:30	20:47:30	20:53:00	20:57:30	21:03:15

CLN3	BEVIS	CMCK1	AGEB	KNWTN	STLMN	OUSB	MEILG	TOWER	AGWB
1	7:17:00	7:20:00	7:23:30	7:25:30	7:29:00	7:30:00	7:35:30	7:40:00	7:45:45
2	7:51:00	7:54:00	7:57:30	7:59:30	8:03:00	8:04:00	8:09:30	8:14:00	8:19:45
3	8:25:00	8:28:00	8:31:30	8:33:30	8:37:00	8:38:00	8:43:30	8:48:00	8:53:45
4	8:59:00	9:02:00	9:05:30	9:07:30	9:11:00	9:12:00	9:17:30	9:22:00	9:27:45
5	9:34:00	9:37:30	9:41:30	9:43:30	9:47:30	9:48:30	9:54:30	10:00:30	10:06:00
6	10:10:00	10:13:30	10:17:30	10:19:30	10:23:30	10:24:30	10:30:30	10:36:30	10:42:00
7	10:46:00	10:49:30	10:53:30	10:55:30	10:59:30	11:00:30	11:06:30	11:12:30	11:18:00
8	11:22:00	11:25:30	11:29:30	11:31:30	11:35:30	11:36:30	11:42:30	11:48:30	11:54:00
9	11:58:00	12:01:30	12:05:30	12:07:30	12:11:30	12:12:30	12:18:30	12:24:30	12:30:00
10	12:34:00	12:37:30	12:41:30	12:43:30	12:47:30	12:48:30	12:54:30	13:00:30	13:06:00
11	13:10:00	13:13:30	13:17:30	13:19:30	13:23:30	13:24:30	13:30:30	13:36:30	13:42:00
12	13:46:00	13:49:30	13:53:30	13:55:30	13:59:30	14:00:30	14:06:30	14:12:30	14:18:00
13	14:22:00	14:25:30	14:29:30	14:31:30	14:35:30	14:36:30	14:42:30	14:48:30	14:54:00
14	14:58:00	15:01:30	15:05:30	15:07:30	15:11:30	15:12:30	15:18:30	15:24:30	15:30:00
15	15:34:00	15:37:30	15:41:30	15:43:30	15:47:30	15:48:30	15:54:30	16:00:30	16:06:00
16	16:10:00	16:13:30	16:17:30	16:19:30	16:23:30	16:24:30	16:30:30	16:36:30	16:42:00
17	16:45:00	16:48:00	16:51:30	16:53:30	16:57:00	16:58:00	17:03:30	17:08:00	17:13:45
18	17:19:00	17:22:00	17:25:30	17:27:30	17:31:00	17:32:00	17:37:30	17:42:00	17:47:45
19	17:53:00	17:56:00	17:59:30	18:01:30	18:05:00	18:06:00	18:11:30	18:16:00	18:21:45
20	18:27:00	18:30:00	18:33:30	18:35:30	18:39:00	18:40:00	18:45:30	18:50:00	18:55:45
21	19:01:00	19:04:00	19:07:30	19:09:30	19:13:00	19:14:00	19:19:30	19:24:00	19:29:45
22	19:35:00	19:38:00	19:41:30	19:43:30	19:47:00	19:48:00	19:53:30	19:58:00	20:03:45
23	20:09:00	20:12:00	20:15:30	20:17:30	20:21:00	20:22:00	20:27:30	20:32:00	20:37:45
24	20:43:00	20:46:00	20:49:30	20:51:30	20:55:00	20:56:00	21:01:30	21:06:00	21:11:45

CLN4	BEVIS	CMCK1	AGEB	KNWTN	STLMN	OUSB	MEILG	TOWER	AGWB
1	7:25:30	7:28:30	7:32:00	7:34:00	7:37:30	7:38:30	7:44:00	7:48:30	7:54:15
2	7:59:30	8:02:30	8:06:00	8:08:00	8:11:30	8:12:30	8:18:00	8:22:30	8:28:15
3	8:33:30	8:36:30	8:40:00	8:42:00	8:45:30	8:46:30	8:52:00	8:56:30	9:02:15

4	9:07:30	9:10:30	9:14:00	9:16:00	9:19:30	9:20:30	9:26:00	9:30:30	9:36:15
5	9:43:00	9:46:30	9:50:30	9:52:30	9:56:30	9:57:30	10:03:30	10:09:30	10:15:00
6	10:19:00	10:22:30	10:26:30	10:28:30	10:32:30	10:33:30	10:39:30	10:45:30	10:51:00
7	10:55:00	10:58:30	11:02:30	11:04:30	11:08:30	11:09:30	11:15:30	11:21:30	11:27:00
8	11:31:00	11:34:30	11:38:30	11:40:30	11:44:30	11:45:30	11:51:30	11:57:30	12:03:00
9	12:07:00	12:10:30	12:14:30	12:16:30	12:20:30	12:21:30	12:27:30	12:33:30	12:39:00
10	12:43:00	12:46:30	12:50:30	12:52:30	12:56:30	12:57:30	13:03:30	13:09:30	13:15:00
11	13:19:00	13:22:30	13:26:30	13:28:30	13:32:30	13:33:30	13:39:30	13:45:30	13:51:00
12	13:55:00	13:58:30	14:02:30	14:04:30	14:08:30	14:09:30	14:15:30	14:21:30	14:27:00
13	14:31:00	14:34:30	14:38:30	14:40:30	14:44:30	14:45:30	14:51:30	14:57:30	15:03:00
14	15:07:00	15:10:30	15:14:30	15:16:30	15:20:30	15:21:30	15:27:30	15:33:30	15:39:00
15	15:43:00	15:46:30	15:50:30	15:52:30	15:56:30	15:57:30	16:03:30	16:09:30	16:15:00
16	16:19:00	16:22:30	16:26:30	16:28:30	16:32:30	16:33:30	16:39:30	16:45:30	16:51:00
17	16:53:30	16:56:30	17:00:00	17:02:00	17:05:30	17:06:30	17:12:00	17:16:30	17:22:15
18	17:27:30	17:30:30	17:34:00	17:36:00	17:39:30	17:40:30	17:46:00	17:50:30	17:56:15
19	18:01:30	18:04:30	18:08:00	18:10:00	18:13:30	18:14:30	18:20:00	18:24:30	18:30:15
20	18:35:30	18:38:30	18:42:00	18:44:00	18:47:30	18:48:30	18:54:00	18:58:30	19:04:15
21	19:09:30	19:12:30	19:16:00	19:18:00	19:21:30	19:22:30	19:28:00	19:32:30	19:38:15
22	19:43:30	19:46:30	19:50:00	19:52:00	19:55:30	19:56:30	20:02:00	20:06:30	20:12:15
23	20:17:30	20:20:30	20:24:00	20:26:00	20:29:30	20:30:30	20:36:00	20:40:30	20:46:15
24	20:51:30	20:54:30	20:58:00	21:00:00	21:03:30	21:04:30	21:10:00	21:14:30	21:20:15

Exhibit D-2: Four-bus Campus Loop South (CLS) schedule

Headway	7a-9a	9a-5p	5p-9p						
	0:08:30	0:09:00	0:08:30		No. of buses		4		
CLS1	BEVIS	CMCK1	AGEB	DRAKE	MDCT9	OUNB	ARPS	NDRMS	AGWB
1	7:04:15	7:07:15	7:10:45	7:14:15	7:20:00	7:25:00	7:27:00	7:29:00	7:33:00
2	7:38:15	7:41:15	7:44:45	7:48:15	7:54:00	7:59:00	8:01:00	8:03:00	8:07:00
3	8:12:15	8:15:15	8:18:45	8:22:15	8:28:00	8:33:00	8:35:00	8:37:00	8:41:00
4	8:46:15	8:49:15	8:52:45	8:56:15	9:02:00	9:07:00	9:09:00	9:11:00	9:15:00
5	9:20:30	9:24:00	9:28:00	9:31:30	9:37:00	9:43:00	9:45:30	9:48:00	9:52:30
6	9:56:30	10:00:00	10:04:00	10:07:30	10:13:00	10:19:00	10:21:30	10:24:00	10:28:30
7	10:32:30	10:36:00	10:40:00	10:43:30	10:49:00	10:55:00	10:57:30	11:00:00	11:04:30
8	11:08:30	11:12:00	11:16:00	11:19:30	11:25:00	11:31:00	11:33:30	11:36:00	11:40:30
9	11:44:30	11:48:00	11:52:00	11:55:30	12:01:00	12:07:00	12:09:30	12:12:00	12:16:30
10	12:20:30	12:24:00	12:28:00	12:31:30	12:37:00	12:43:00	12:45:30	12:48:00	12:52:30
11	12:56:30	13:00:00	13:04:00	13:07:30	13:13:00	13:19:00	13:21:30	13:24:00	13:28:30
12	13:32:30	13:36:00	13:40:00	13:43:30	13:49:00	13:55:00	13:57:30	14:00:00	14:04:30
13	14:08:30	14:12:00	14:16:00	14:19:30	14:25:00	14:31:00	14:33:30	14:36:00	14:40:30
14	14:44:30	14:48:00	14:52:00	14:55:30	15:01:00	15:07:00	15:09:30	15:12:00	15:16:30
15	15:20:30	15:24:00	15:28:00	15:31:30	15:37:00	15:43:00	15:45:30	15:48:00	15:52:30
16	15:56:30	16:00:00	16:04:00	16:07:30	16:13:00	16:19:00	16:21:30	16:24:00	16:28:30
17	16:32:15	16:35:15	16:38:45	16:42:15	16:48:00	16:53:00	16:55:00	16:57:00	17:01:00
18	17:06:15	17:09:15	17:12:45	17:16:15	17:22:00	17:27:00	17:29:00	17:31:00	17:35:00
19	17:40:15	17:43:15	17:46:45	17:50:15	17:56:00	18:01:00	18:03:00	18:05:00	18:09:00
20	18:14:15	18:17:15	18:20:45	18:24:15	18:30:00	18:35:00	18:37:00	18:39:00	18:43:00
21	18:48:15	18:51:15	18:54:45	18:58:15	19:04:00	19:09:00	19:11:00	19:13:00	19:17:00
22	19:22:15	19:25:15	19:28:45	19:32:15	19:38:00	19:43:00	19:45:00	19:47:00	19:51:00
23	19:56:15	19:59:15	20:02:45	20:06:15	20:12:00	20:17:00	20:19:00	20:21:00	20:25:00
24	20:30:15	20:33:15	20:36:45	20:40:15	20:46:00	20:51:00	20:53:00	20:55:00	20:59:00

CLS2	BEVIS	CMCK1	AGEB	DRAKE	MDCT9	OUNB	ARPS	NDRMS	AGWB
1	7:12:45	7:15:45	7:19:15	7:22:45	7:28:30	7:33:30	7:35:30	7:37:30	7:41:30
2	7:46:45	7:49:45	7:53:15	7:56:45	8:02:30	8:07:30	8:09:30	8:11:30	8:15:30
3	8:20:45	8:23:45	8:27:15	8:30:45	8:36:30	8:41:30	8:43:30	8:45:30	8:49:30
4	8:54:45	8:57:45	9:01:15	9:04:45	9:10:30	9:15:30	9:17:30	9:19:30	9:23:30
5	9:29:30	9:33:00	9:37:00	9:40:30	9:46:00	9:52:00	9:54:30	9:57:00	10:01:30
6	10:05:30	10:09:00	10:13:00	10:16:30	10:22:00	10:28:00	10:30:30	10:33:00	10:37:30
7	10:41:30	10:45:00	10:49:00	10:52:30	10:58:00	11:04:00	11:06:30	11:09:00	11:13:30
8	11:17:30	11:21:00	11:25:00	11:28:30	11:34:00	11:40:00	11:42:30	11:45:00	11:49:30
9	11:53:30	11:57:00	12:01:00	12:04:30	12:10:00	12:16:00	12:18:30	12:21:00	12:25:30
10	12:29:30	12:33:00	12:37:00	12:40:30	12:46:00	12:52:00	12:54:30	12:57:00	13:01:30
11	13:05:30	13:09:00	13:13:00	13:16:30	13:22:00	13:28:00	13:30:30	13:33:00	13:37:30
12	13:41:30	13:45:00	13:49:00	13:52:30	13:58:00	14:04:00	14:06:30	14:09:00	14:13:30
13	14:17:30	14:21:00	14:25:00	14:28:30	14:34:00	14:40:00	14:42:30	14:45:00	14:49:30
14	14:53:30	14:57:00	15:01:00	15:04:30	15:10:00	15:16:00	15:18:30	15:21:00	15:25:30
15	15:29:30	15:33:00	15:37:00	15:40:30	15:46:00	15:52:00	15:54:30	15:57:00	16:01:30
16	16:05:30	16:09:00	16:13:00	16:16:30	16:22:00	16:28:00	16:30:30	16:33:00	16:37:30
17	16:40:45	16:43:45	16:47:15	16:50:45	16:56:30	17:01:30	17:03:30	17:05:30	17:09:30
18	17:14:45	17:17:45	17:21:15	17:24:45	17:30:30	17:35:30	17:37:30	17:39:30	17:43:30
19	17:48:45	17:51:45	17:55:15	17:58:45	18:04:30	18:09:30	18:11:30	18:13:30	18:17:30
20	18:22:45	18:25:45	18:29:15	18:32:45	18:38:30	18:43:30	18:45:30	18:47:30	18:51:30
21	18:56:45	18:59:45	19:03:15	19:06:45	19:12:30	19:17:30	19:19:30	19:21:30	19:25:30
22	19:30:45	19:33:45	19:37:15	19:40:45	19:46:30	19:51:30	19:53:30	19:55:30	19:59:30
23	20:04:45	20:07:45	20:11:15	20:14:45	20:20:30	20:25:30	20:27:30	20:29:30	20:33:30
24	20:38:45	20:41:45	20:45:15	20:48:45	20:54:30	20:59:30	21:01:30	21:03:30	21:07:30

CLS3	BEVIS	CMCK1	AGEB	DRAKE	MDCT9	OUNB	ARPS	NDRMS	AGWB
1	7:21:15	7:24:15	7:27:45	7:31:15	7:37:00	7:42:00	7:44:00	7:46:00	7:50:00
2	7:55:15	7:58:15	8:01:45	8:05:15	8:11:00	8:16:00	8:18:00	8:20:00	8:24:00
3	8:29:15	8:32:15	8:35:45	8:39:15	8:45:00	8:50:00	8:52:00	8:54:00	8:58:00
4	9:03:15	9:06:15	9:09:45	9:13:15	9:19:00	9:24:00	9:26:00	9:28:00	9:32:00
5	9:38:30	9:42:00	9:46:00	9:49:30	9:55:00	10:01:00	10:03:30	10:06:00	10:10:30
6	10:14:30	10:18:00	10:22:00	10:25:30	10:31:00	10:37:00	10:39:30	10:42:00	10:46:30
7	10:50:30	10:54:00	10:58:00	11:01:30	11:07:00	11:13:00	11:15:30	11:18:00	11:22:30
8	11:26:30	11:30:00	11:34:00	11:37:30	11:43:00	11:49:00	11:51:30	11:54:00	11:58:30
9	12:02:30	12:06:00	12:10:00	12:13:30	12:19:00	12:25:00	12:27:30	12:30:00	12:34:30
10	12:38:30	12:42:00	12:46:00	12:49:30	12:55:00	13:01:00	13:03:30	13:06:00	13:10:30
11	13:14:30	13:18:00	13:22:00	13:25:30	13:31:00	13:37:00	13:39:30	13:42:00	13:46:30
12	13:50:30	13:54:00	13:58:00	14:01:30	14:07:00	14:13:00	14:15:30	14:18:00	14:22:30
13	14:26:30	14:30:00	14:34:00	14:37:30	14:43:00	14:49:00	14:51:30	14:54:00	14:58:30
14	15:02:30	15:06:00	15:10:00	15:13:30	15:19:00	15:25:00	15:27:30	15:30:00	15:34:30

15	15:38:30	15:42:00	15:46:00	15:49:30	15:55:00	16:01:00	16:03:30	16:06:00	16:10:30
16	16:14:30	16:18:00	16:22:00	16:25:30	16:31:00	16:37:00	16:39:30	16:42:00	16:46:30
17	16:49:15	16:52:15	16:55:45	16:59:15	17:05:00	17:10:00	17:12:00	17:14:00	17:18:00
18	17:23:15	17:26:15	17:29:45	17:33:15	17:39:00	17:44:00	17:46:00	17:48:00	17:52:00
19	17:57:15	18:00:15	18:03:45	18:07:15	18:13:00	18:18:00	18:20:00	18:22:00	18:26:00
20	18:31:15	18:34:15	18:37:45	18:41:15	18:47:00	18:52:00	18:54:00	18:56:00	19:00:00
21	19:05:15	19:08:15	19:11:45	19:15:15	19:21:00	19:26:00	19:28:00	19:30:00	19:34:00
22	19:39:15	19:42:15	19:45:45	19:49:15	19:55:00	20:00:00	20:02:00	20:04:00	20:08:00
23	20:13:15	20:16:15	20:19:45	20:23:15	20:29:00	20:34:00	20:36:00	20:38:00	20:42:00
24	20:47:15	20:50:15	20:53:45	20:57:15	21:03:00	21:08:00	21:10:00	21:12:00	21:16:00

CLS4	BEVIS	CMCK1	AGEB	DRAKE	MDCT9	OUNB	ARPS	NDRMS	AGWB
1	7:29:45	7:32:45	7:36:15	7:39:45	7:45:30	7:50:30	7:52:30	7:54:30	7:58:30
2	8:03:45	8:06:45	8:10:15	8:13:45	8:19:30	8:24:30	8:26:30	8:28:30	8:32:30
3	8:37:45	8:40:45	8:44:15	8:47:45	8:53:30	8:58:30	9:00:30	9:02:30	9:06:30
4	9:11:45	9:14:45	9:18:15	9:21:45	9:27:30	9:32:30	9:34:30	9:36:30	9:40:30
5	9:47:30	9:51:00	9:55:00	9:58:30	10:04:00	10:10:00	10:12:30	10:15:00	10:19:30
6	10:23:30	10:27:00	10:31:00	10:34:30	10:40:00	10:46:00	10:48:30	10:51:00	10:55:30
7	10:59:30	11:03:00	11:07:00	11:10:30	11:16:00	11:22:00	11:24:30	11:27:00	11:31:30
8	11:35:30	11:39:00	11:43:00	11:46:30	11:52:00	11:58:00	12:00:30	12:03:00	12:07:30
9	12:11:30	12:15:00	12:19:00	12:22:30	12:28:00	12:34:00	12:36:30	12:39:00	12:43:30
10	12:47:30	12:51:00	12:55:00	12:58:30	13:04:00	13:10:00	13:12:30	13:15:00	13:19:30
11	13:23:30	13:27:00	13:31:00	13:34:30	13:40:00	13:46:00	13:48:30	13:51:00	13:55:30
12	13:59:30	14:03:00	14:07:00	14:10:30	14:16:00	14:22:00	14:24:30	14:27:00	14:31:30
13	14:35:30	14:39:00	14:43:00	14:46:30	14:52:00	14:58:00	15:00:30	15:03:00	15:07:30
14	15:11:30	15:15:00	15:19:00	15:22:30	15:28:00	15:34:00	15:36:30	15:39:00	15:43:30
15	15:47:30	15:51:00	15:55:00	15:58:30	16:04:00	16:10:00	16:12:30	16:15:00	16:19:30
16	16:23:30	16:27:00	16:31:00	16:34:30	16:40:00	16:46:00	16:48:30	16:51:00	16:55:30
17	16:57:45	17:00:45	17:04:15	17:07:45	17:13:30	17:18:30	17:20:30	17:22:30	17:26:30
18	17:31:45	17:34:45	17:38:15	17:41:45	17:47:30	17:52:30	17:54:30	17:56:30	18:00:30
19	18:05:45	18:08:45	18:12:15	18:15:45	18:21:30	18:26:30	18:28:30	18:30:30	18:34:30
20	18:39:45	18:42:45	18:46:15	18:49:45	18:55:30	19:00:30	19:02:30	19:04:30	19:08:30
21	19:13:45	19:16:45	19:20:15	19:23:45	19:29:30	19:34:30	19:36:30	19:38:30	19:42:30
22	19:47:45	19:50:45	19:54:15	19:57:45	20:03:30	20:08:30	20:10:30	20:12:30	20:16:30
23	20:21:45	20:24:45	20:28:15	20:31:45	20:37:30	20:42:30	20:44:30	20:46:30	20:50:30
24	20:55:45	20:58:45	21:02:15	21:05:45	21:11:30	21:16:30	21:18:30	21:20:30	21:24:30

Exhibit D-3: Three-bus Central Connector (CC) schedule

	7a-9a	9a-5p	5p-9p		
Headway	0:08:30	0:09:00	0:08:30	No. of buses	3

CC1	TOWER	KNWTN	STLMN	OUSB	9TH&MEILING	10TH&MEILING	OUNB	ARPS	NDRMS
1	7:02:15	7:04:15	7:07:45	7:08:45	7:14:15	7:15:45	7:20:45	7:22:45	7:24:45
2	7:27:45	7:29:45	7:33:15	7:34:15	7:39:45	7:41:15	7:46:15	7:48:15	7:50:15
3	7:53:15	7:55:15	7:58:45	7:59:45	8:05:15	8:06:45	8:11:45	8:13:45	8:15:45
4	8:18:45	8:20:45	8:24:15	8:25:15	8:30:45	8:32:15	8:37:15	8:39:15	8:41:15
5	8:44:15	8:46:15	8:49:45	8:50:45	8:56:15	8:57:45	9:02:45	9:04:45	9:06:45
6	9:10:30	9:12:00	9:16:00	9:17:00	9:23:00	9:23:30	9:29:30	9:32:00	9:34:30
7	9:37:30	9:39:00	9:43:00	9:44:00	9:50:00	9:50:30	9:56:30	9:59:00	10:01:30
8	10:04:30	10:06:00	10:10:00	10:11:00	10:17:00	10:17:30	10:23:30	10:26:00	10:28:30
9	10:31:30	10:33:00	10:37:00	10:38:00	10:44:00	10:44:30	10:50:30	10:53:00	10:55:30
10	10:58:30	11:00:00	11:04:00	11:05:00	11:11:00	11:11:30	11:17:30	11:20:00	11:22:30
11	11:25:30	11:27:00	11:31:00	11:32:00	11:38:00	11:38:30	11:44:30	11:47:00	11:49:30
12	11:52:30	11:54:00	11:58:00	11:59:00	12:05:00	12:05:30	12:11:30	12:14:00	12:16:30
13	12:19:30	12:21:00	12:25:00	12:26:00	12:32:00	12:32:30	12:38:30	12:41:00	12:43:30
14	12:46:30	12:48:00	12:52:00	12:53:00	12:59:00	12:59:30	13:05:30	13:08:00	13:10:30
15	13:13:30	13:15:00	13:19:00	13:20:00	13:26:00	13:26:30	13:32:30	13:35:00	13:37:30
16	13:40:30	13:42:00	13:46:00	13:47:00	13:53:00	13:53:30	13:59:30	14:02:00	14:04:30

17	14:07:30	14:09:00	14:13:00	14:14:00	14:20:00	14:20:30	14:26:30	14:29:00	14:31:30
18	14:34:30	14:36:00	14:40:00	14:41:00	14:47:00	14:47:30	14:53:30	14:56:00	14:58:30
19	15:01:30	15:03:00	15:07:00	15:08:00	15:14:00	15:14:30	15:20:30	15:23:00	15:25:30
20	15:28:30	15:30:00	15:34:00	15:35:00	15:41:00	15:41:30	15:47:30	15:50:00	15:52:30
21	15:55:30	15:57:00	16:01:00	16:02:00	16:08:00	16:08:30	16:14:30	16:17:00	16:19:30
22	16:21:45	16:23:45	16:27:15	16:28:15	16:33:45	16:35:15	16:40:15	16:42:15	16:44:15
23	16:47:15	16:49:15	16:52:45	16:53:45	16:59:15	17:00:45	17:05:45	17:07:45	17:09:45
24	17:12:45	17:14:45	17:18:15	17:19:15	17:24:45	17:26:15	17:31:15	17:33:15	17:35:15
25	17:38:15	17:40:15	17:43:45	17:44:45	17:50:15	17:51:45	17:56:45	17:58:45	18:00:45
26	18:03:45	18:05:45	18:09:15	18:10:15	18:15:45	18:17:15	18:22:15	18:24:15	18:26:15
27	18:29:15	18:31:15	18:34:45	18:35:45	18:41:15	18:42:45	18:47:45	18:49:45	18:51:45
28	18:54:45	18:56:45	19:00:15	19:01:15	19:06:45	19:08:15	19:13:15	19:15:15	19:17:15
29	19:20:15	19:22:15	19:25:45	19:26:45	19:32:15	19:33:45	19:38:45	19:40:45	19:42:45
30	19:45:45	19:47:45	19:51:15	19:52:15	19:57:45	19:59:15	20:04:15	20:06:15	20:08:15
31	20:11:15	20:13:15	20:16:45	20:17:45	20:23:15	20:24:45	20:29:45	20:31:45	20:33:45
32	20:36:45	20:38:45	20:42:15	20:43:15	20:48:45	20:50:15	20:55:15	20:57:15	20:59:15

CC2	TOWER	KNWTN	STLMN	OUSB	9TH&MEILING	10TH&MEILING	OUNB	ARPS	NDRMS
1	7:10:45	7:12:45	7:16:15	7:17:15	7:22:45	7:24:15	7:29:15	7:31:15	7:33:15
2	7:36:15	7:38:15	7:41:45	7:42:45	7:48:15	7:49:45	7:54:45	7:56:45	7:58:45
3	8:01:45	8:03:45	8:07:15	8:08:15	8:13:45	8:15:15	8:20:15	8:22:15	8:24:15
4	8:27:15	8:29:15	8:32:45	8:33:45	8:39:15	8:40:45	8:45:45	8:47:45	8:49:45
5	8:52:45	8:54:45	8:58:15	8:59:15	9:04:45	9:06:15	9:11:15	9:13:15	9:15:15
6	9:19:30	9:21:00	9:25:00	9:26:00	9:32:00	9:32:30	9:38:30	9:41:00	9:43:30
7	9:46:30	9:48:00	9:52:00	9:53:00	9:59:00	9:59:30	10:05:30	10:08:00	10:10:30
8	10:13:30	10:15:00	10:19:00	10:20:00	10:26:00	10:26:30	10:32:30	10:35:00	10:37:30
9	10:40:30	10:42:00	10:46:00	10:47:00	10:53:00	10:53:30	10:59:30	11:02:00	11:04:30
10	11:07:30	11:09:00	11:13:00	11:14:00	11:20:00	11:20:30	11:26:30	11:29:00	11:31:30
11	11:34:30	11:36:00	11:40:00	11:41:00	11:47:00	11:47:30	11:53:30	11:56:00	11:58:30
12	12:01:30	12:03:00	12:07:00	12:08:00	12:14:00	12:14:30	12:20:30	12:23:00	12:25:30
13	12:28:30	12:30:00	12:34:00	12:35:00	12:41:00	12:41:30	12:47:30	12:50:00	12:52:30
14	12:55:30	12:57:00	13:01:00	13:02:00	13:08:00	13:08:30	13:14:30	13:17:00	13:19:30
15	13:22:30	13:24:00	13:28:00	13:29:00	13:35:00	13:35:30	13:41:30	13:44:00	13:46:30
16	13:49:30	13:51:00	13:55:00	13:56:00	14:02:00	14:02:30	14:08:30	14:11:00	14:13:30
17	14:16:30	14:18:00	14:22:00	14:23:00	14:29:00	14:29:30	14:35:30	14:38:00	14:40:30
18	14:43:30	14:45:00	14:49:00	14:50:00	14:56:00	14:56:30	15:02:30	15:05:00	15:07:30
19	15:10:30	15:12:00	15:16:00	15:17:00	15:23:00	15:23:30	15:29:30	15:32:00	15:34:30
20	15:37:30	15:39:00	15:43:00	15:44:00	15:50:00	15:50:30	15:56:30	15:59:00	16:01:30
21	16:04:30	16:06:00	16:10:00	16:11:00	16:17:00	16:17:30	16:23:30	16:26:00	16:28:30
22	16:30:15	16:32:15	16:35:45	16:36:45	16:42:15	16:43:45	16:48:45	16:50:45	16:52:45
23	16:55:45	16:57:45	17:01:15	17:02:15	17:07:45	17:09:15	17:14:15	17:16:15	17:18:15
24	17:21:15	17:23:15	17:26:45	17:27:45	17:33:15	17:34:45	17:39:45	17:41:45	17:43:45
25	17:46:45	17:48:45	17:52:15	17:53:15	17:58:45	18:00:15	18:05:15	18:07:15	18:09:15
26	18:12:15	18:14:15	18:17:45	18:18:45	18:24:15	18:25:45	18:30:45	18:32:45	18:34:45
27	18:37:45	18:39:45	18:43:15	18:44:15	18:49:45	18:51:15	18:56:15	18:58:15	19:00:15
28	19:03:15	19:05:15	19:08:45	19:09:45	19:15:15	19:16:45	19:21:45	19:23:45	19:25:45
29	19:28:45	19:30:45	19:34:15	19:35:15	19:40:45	19:42:15	19:47:15	19:49:15	19:51:15
30	19:54:15	19:56:15	19:59:45	20:00:45	20:06:15	20:07:45	20:12:45	20:14:45	20:16:45
31	20:19:45	20:21:45	20:25:15	20:26:15	20:31:45	20:33:15	20:38:15	20:40:15	20:42:15
32	20:45:15	20:47:15	20:50:45	20:51:45	20:57:15	20:58:45	21:03:45	21:05:45	21:07:45

CC3	TOWER	KNWTN	STLMN	OUSB	9TH&MEILING	10TH&MEILING	OUNB	ARPS	NDRMS
1	7:19:15	7:21:15	7:24:45	7:25:45	7:31:15	7:32:45	7:37:45	7:39:45	7:41:45
2	7:44:45	7:46:45	7:50:15	7:51:15	7:56:45	7:58:15	8:03:15	8:05:15	8:07:15
3	8:10:15	8:12:15	8:15:45	8:16:45	8:22:15	8:23:45	8:28:45	8:30:45	8:32:45
4	8:35:45	8:37:45	8:41:15	8:42:15	8:47:45	8:49:15	8:54:15	8:56:15	8:58:15
5	9:01:15	9:03:15	9:06:45	9:07:45	9:13:15	9:14:45	9:19:45	9:21:45	9:23:45
6	9:28:30	9:30:00	9:34:00	9:35:00	9:41:00	9:41:30	9:47:30	9:50:00	9:52:30
7	9:55:30	9:57:00	10:01:00	10:02:00	10:08:00	10:08:30	10:14:30	10:17:00	10:19:30
8	10:22:30	10:24:00	10:28:00	10:29:00	10:35:00	10:35:30	10:41:30	10:44:00	10:46:30
9	10:49:30	10:51:00	10:55:00	10:56:00	11:02:00	11:02:30	11:08:30	11:11:00	11:13:30
10	11:16:30	11:18:00	11:22:00	11:23:00	11:29:00	11:29:30	11:35:30	11:38:00	11:40:30
11	11:43:30	11:45:00	11:49:00	11:50:00	11:56:00	11:56:30	12:02:30	12:05:00	12:07:30
12	12:10:30	12:12:00	12:16:00	12:17:00	12:23:00	12:23:30	12:29:30	12:32:00	12:34:30
13	12:37:30	12:39:00	12:43:00	12:44:00	12:50:00	12:50:30	12:56:30	12:59:00	13:01:30
14	13:04:30	13:06:00	13:10:00	13:11:00	13:17:00	13:17:30	13:23:30	13:26:00	13:28:30
15	13:31:30	13:33:00	13:37:00	13:38:00	13:44:00	13:44:30	13:50:30	13:53:00	13:55:30
16	13:58:30	14:00:00	14:04:00	14:05:00	14:11:00	14:11:30	14:17:30	14:20:00	14:22:30
17	14:25:30	14:27:00	14:31:00	14:32:00	14:38:00	14:38:30	14:44:30	14:47:00	14:49:30
18	14:52:30	14:54:00	14:58:00	14:59:00	15:05:00	15:05:30	15:11:30	15:14:00	15:16:30
19	15:19:30	15:21:00	15:25:00	15:26:00	15:32:00	15:32:30	15:38:30	15:41:00	15:43:30
20	15:46:30	15:48:00	15:52:00	15:53:00	15:59:00	15:59:30	16:05:30	16:08:00	16:10:30
21	16:13:30	16:15:00	16:19:00	16:20:00	16:26:00	16:26:30	16:32:30	16:35:00	16:37:30
22	16:38:45	16:40:45	16:44:15	16:45:15	16:50:45	16:52:15	16:57:15	16:59:15	17:01:15
23	17:04:15	17:06:15	17:09:45	17:10:45	17:16:15	17:17:45	17:22:45	17:24:45	17:26:45
24	17:29:45	17:31:45	17:35:15	17:36:15	17:41:45	17:43:15	17:48:15	17:50:15	17:52:15
25	17:55:15	17:57:15	18:00:45	18:01:45	18:07:15	18:08:45	18:13:45	18:15:45	18:17:45
26	18:20:45	18:22:45	18:26:15	18:27:15	18:32:45	18:34:15	18:39:15	18:41:15	18:43:15
27	18:46:15	18:48:15	18:51:45	18:52:45	18:58:15	18:59:45	19:04:45	19:06:45	19:08:45
28	19:11:45	19:13:45	19:17:15	19:18:15	19:23:45	19:25:15	19:30:15	19:32:15	19:34:15
29	19:37:15	19:39:15	19:42:45	19:43:45	19:49:15	19:50:45	19:55:45	19:57:45	19:59:45
30	20:02:45	20:04:45	20:08:15	20:09:15	20:14:45	20:16:15	20:21:15	20:23:15	20:25:15
31	20:28:15	20:30:15	20:33:45	20:34:45	20:40:15	20:41:45	20:46:45	20:48:45	20:50:45
32	20:53:45	20:55:45	20:59:15	21:00:15	21:05:45	21:07:15	21:12:15	21:14:15	21:16:15

Appendix E

CTL Assignments and Exam Questions Developed and Used in Courses in Academic Year 2009-2010

Exhibit E-1: Assignment used in *CE 570: Transportation Engineering and Analysis*

The Ohio State University
Winter Quarter 2010
CE 570: TRANSPORTATION ENGINEERING AND ANALYSIS

Assignment #2: CABS OD flow estimation using the IPF method
Date handed out: Thurs. Jan. 14, 2010
Date due: Thurs. Jan. 21, 2010

Background

OSU's Campus Area Bus Service (CABS) has been recently instrumented with several sensor systems for the purpose of providing bus arrival information to travelers, allowing CABS staff to better operate the service, and allowing researchers to study the behavior of bus systems. For the latter purpose, the instrumented system serves as a field lab known as the Campus Transit Lab (CTL).

There are two main sensor systems we are concerned with in this assignment: Automatic Passenger Counters (APC) and Automated Vehicle Location (AVL) systems. APC systems measure the number of passengers boarding and alighting at each bus top. AVL systems measure the location and time of each bus at a certain frequency.

A "bus trip" is defined to be one complete traversal by a bus of a route from one end of the route (the starting terminal) to the other end of the route (the ending terminal). In the case of the CABS Campus Loop South (CLS) route, the route forms a loop. To simplify the analysis, all four stops on West Campus are grouped to form one stop. As shown in the attached schematic diagram of the CLS route (on p. 3), stop 4 represents the grouping of all boardings at stops 1 through 4 and is considered to be the starting terminal of the route, and stop 21 represents the grouping of all alightings at stops 1 through 4 and is considered to be the ending terminal of the route. This simplification is reasonable because it is very unlikely for travelers to both start and end their trips east of the grouped West Campus stops.

The following three problems build upon one another and, therefore, you should solve them sequentially.

Problem 1

APC data on 13 CLS bus trips are sent to you via e-mail in the form of an Excel file. Data on each bus trip is organized in a separate sheet. You are to work on the bus trip that corresponds to your last name beginning letters as follows:

Last Name	Sheet	Last Name	Sheet
A to Bri	1	Mc to Ni	8
Bro to C	2	No to R	9
D to F	3	Sa to Sm	10
G to Hen	4	Sn to Su	11
Her to J	5	T to Wei	12
K to Lap	6	Wel to Z	13
Lar to Mar	7		

(a) Apply the Iterative Proportional Fitting (IPF) method to find the stop-to-stop origin-destination (OD) passenger flows for the bus trip assigned to you using Excel (or other software such as MATLAB if you prefer). Follow a total of 3 pairs or iterations where each pair consists of one row and one column adjustment (i.e., conduct iterations 1a, 1b, 2a, 2b, 3a, and 3b). Present the passenger flow estimates you arrive at upon completing iteration 3b in the form of a table (matrix). (Include the results of all the iterations in an appendix.) Show an example calculation for at least one cell value going through a row and column adjustment.

(b) Based on the number of passengers traveling to each destination stop from the West Campus starting terminal (grouped stop 4) determined under (a) above, determine the probability that a passenger who boarded at the West Campus starting terminal will alight at each destination stop (i.e., stops 5 through 20). Present all your results and explain the logic behind your calculations showing sample examples.

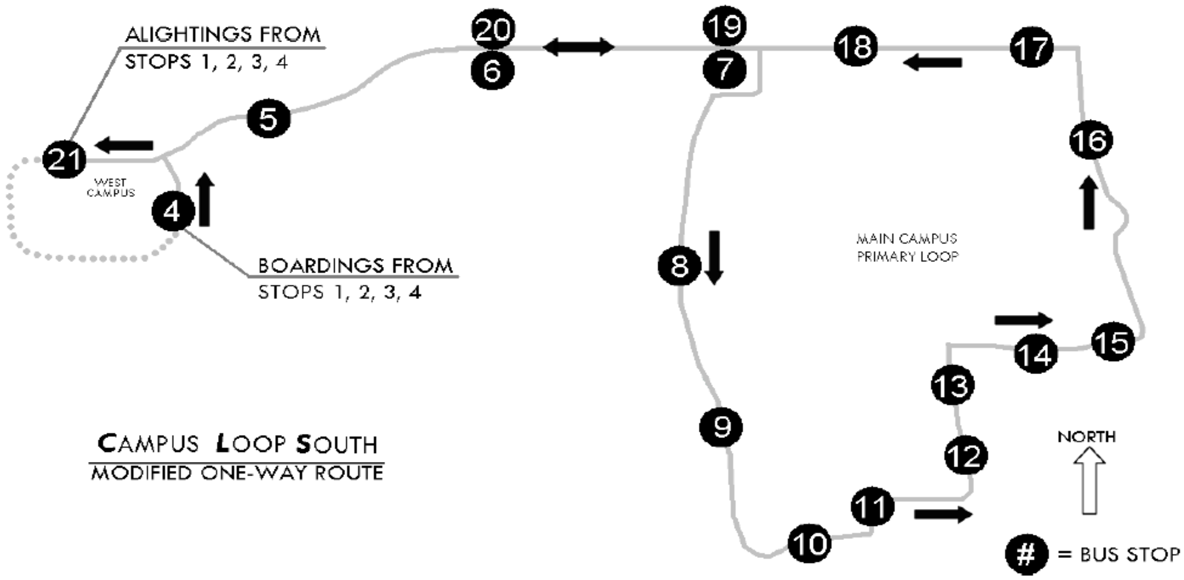
Problem 2

AVL data on many CLS bus trips are used to calculate the following: (i) expected time it takes a bus to travel from one stop to the next (where the expected travel time equals the arrival time at the next stop minus the departure time from the previous stop) and, (ii) expected dwell time at each stop (where dwell time equals the departure time from a stop minus the arrival time to that same stop). The results are shown in the attached two tables (on p. 4).

For each destination stop, determine the expected time *in minutes* that it takes a passenger to arrive at her or his stop once the bus has left the West Campus starting terminal. That is, find the expected line-haul time from West Campus to each stop. Explain the logic behind your calculations and show at least one example calculation.

Problem 3

Using your solutions from Problems 1 and 2 above, find the expected line-haul time for a random passenger boarding at the West Campus starting terminal. (The expected line-haul time represents the expectation considered across all possible destination stops.) Show your calculation.


ALIGHTINGS FROM
STOPS 1, 2, 3, 4
BOARDINGS FROM
STOPS 1, 2, 3, 4
WEST CAMPUS
MAIN CAMPUS PRIMARY LOOP
CAMPUS LOOP SOUTH
MODIFIED ONE-WAY ROUTE
NORTH
= BUS STOP
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4

Expected Stop-to-Stop Travel Times

From Stop	To Stop	Time (sec)
West Campus (stop 4)	Blankenship Hall	105.8
Blankenship Hall	Ag Campus Eastbound	73.7
Ag Campus Eastbound	St John Arena Eastbound	58.0
St John Arena Eastbound	Drake Union	106.4
Drake Union	Cannon Dr. & 12th Southbound	104.8
Cannon Dr. & 12th Southbound	Med Center Dr. & Cannon	128.8
Med Center Dr. & Cannon	Med Center Dr. & 9th	40.6
Med Center Dr. & 9th	Neil Ave. & 10th Ave.	76.3
Neil Ave. & 10th Ave.	Mack Hall	68.3
Mack Hall	Hale Hall	108.3
Hale Hall	Ohio Union Northbound	29.2
Ohio Union Northbound	Arps Hall	92.8
Arps Hall	North Dorms	84.9
North Dorms	Fisher COB	80.8
Fisher COB	St. John Arena Westbound	77.7
St. John Arena Westbound	Ag Campus Westbound (stop 20)	57.0

Expected Dwell Times

Stop Name (Stop Number)	Dwell Time (sec)
Blankenship Hall (5)	5.8
Ag Campus Eastbound (6)	10.2
St John Arena Eastbound (7)	12.3
Drake Union (8)	20.0
Cannon Dr. & 12th Southbound (9)	12.5
Med Center Dr. & Cannon (10)	5.9
Med Center Dr. & 9th (11)	9.1
Neil Ave. & 10th Ave. (12)	16.5
Mack Hall (13)	17.7
Hale Hall (14)	13.3
Ohio Union Northbound (15)	23.0
Arps Hall (16)	36.3
North Dorms (17)	20.2
Fisher COB (18)	5.9
St. John Arena Westbound (19)	10.0
Ag Campus Westbound (20)	30.6

Exhibit E-2: CTL exam questions used in *CE 570: Transportation Engineering and Analysis* Exam 1 (9 February 2010)

2a. (6 pts) You are using the IPF method to estimate bus trip passenger origin-destination flows from boarding and alighting counts on a simple bus trip with four stops. After some iteration you produced the results shown in Table 2a.

Table 2a. Trip-level passenger OD flows produced after some iteration of the IPF method for a four stop bus route

		Alighting Stop				Board-ing Counts
		1	2	3	4	
Boarding Stop	1	–	4	5.1	7.6	18
	2	–	–	5.9	8.9	14
	3	–	–	--	2.5	2
	4	–	–	--	–	0
Alighting Counts		0	4	11	19	

Assume that you want to conduct one more iteration (step) of the IPF algorithm (that is, a step in which you use a row *or* a column factoring, *whichever is appropriate*). What would be the estimated flow *from stop 2 to stop3* after this iteration (step)? (You only need to estimate the flow for the one origin-destination pair.)

b. (3 pts) After completing the IPF method for the same bus trip, the OD matrix shown in Table2b was produced.

Table 2b. Trip-level passenger OD flows produced after completing the IPF method for a four stop bus route

		Alighting Stop				Board-ing Counts
		1	2	3	4	
Boarding Stop	1	–	4	5.5	8.5	18
	2	–	--	5.5	8.5	14
	3	–	--	–	2.0	2
	4	–	--	–	–	0
Alighting Counts		0	4	11	19	

What is the probability that a random passenger who boarded at Stop 2 on this trip would alight at Stop 3?

5. (1 pt) Which of the following are the *two* technologies presently in operation on OSU Campus Area Bus Service buses? *Circle two answers.*

WIM APC AFC RFID AVL

Exhibit E-3: Part I of assignment used in *CE 670: Urban Public Transportation*

CE 670 Urban Public Transportation
Winter 2010

Project – Part I: Campus Area Bus Service Operations – Data Collection
Date handed out: Mon. Jan. 25, 2010
Date due: Fri. Feb. 5, 2010

Instructions

This project deals with the operations and service of routes operated by Campus Area Bus Service (CABS) and will require forming 2 teams with *three* students per team and 3 teams with *four* students per team. Each team must include no more than two Civil Engineering graduate students and no more than one City and Regional Planning graduate student.

The project consists of two parts: (I) data collection, and (II) analysis. Each team should submit a comprehensive report addressing each part. The reports should reflect the team's own *independent* work.

In addition, each team member should submit one "Peer- and Self-evaluation Form" in relation to each of the other members of the team (three copies of this form are included at the end). Please submit these completed forms to me separately (i.e., do not include them with your team's report). *The individual team member project grade will be partly based on this submission.*

Data Collection

Each team will study a specific route as indicated in Table 1. Field and on-line data should be collected for a *continuous* 2.5-hour period of time on the assigned route between 7.00a and 6.45p on a weekday. Make sure you record and report the time period you select along with the corresponding date. As is also shown in Table 1, two or three specific bus stops are to be studied by each team.

The CABS web site provides route maps, the locations of all the stops, and scheduled headways (durations between bus arrivals). Visit this site at `<http://www.tp.ohio-state.edu/cabs/>` to access this information. In addition, the Transportation Route Information Program (TRIP) provides real-time information on expected arrival times of buses at stops in a list format and the location of the buses in a map format. Visit this site at `<http://tp.osu.edu/cabs/trip.shtml>` to access this information.

Simultaneously, one member of the team will collect data from the TRIP website on the team's identified stops and all other members of the team will collect data in the field, each position at one of the team's identified stops.

You are collecting data in order to analyze and estimate models of passenger waiting times, stop dwell times (stationary times spent at stops by buses), running times (times it takes buses to traverse the entire length of a route), and real-time information accuracy.

Team	Route	# of students	Bus Stops (Stop ID)
NE-1	North Express	3	Carmack 1 (6), Arps Hall* (13)
CLS-1	Campus Loop South	4	Carmack 4 (5), Ag Campus Eastbound* (8), Neil Ave. & 10th Ave. (154)
CLS-2	Campus Loop South	4	Carmack 1 (6), Drake Union (31), North Dorms* (14)
CLN-1	Campus Loop North	4	Bevis Hall (1), Knowlton Hall* (21), Meiling Hall (27)
CLN-2	Campus Loop North	4	Carmack 4 (5), Stillman Hall* (23), Towers (30)

*Stop at which you will study bus dwell times (times spent stationary) in part II

Table 1: Routes and Bus Stops for Each Team

The *minimum* data requirements are the following:

- bus number,
- bus arrival and departure times at each stop including holding time,
- approximate passenger loads upon both arrival and departure,
- approximate number of passengers boarding and number alighting, and
- when applicable, the time a bus remains stationary at a stop after the passengers have completed boarding and alighting.

Bus arrival times observed in the field should be based on the first door to open and departure times on the last door to close. Should a bus spend more time than needed to allow passengers to board and alight, make a note of this extra time. Passenger loads (number of passengers on a bus), and to a lesser extent the number of passengers boarding and alighting, will be difficult to measure but an approximation is possible. Each team should devise a way to also collect as much of the desired data relating to the team's identified stops from the TRIP website using the list format, the map format, or both. *The procedure followed should be explained, motivated, and well documented in the report.*

Each team should collect data at *each* of the stops *simultaneously*. Therefore, each team member stationed in the field will need to spend 2.5 hours collecting data at a single bus stop. The team member stationed on an internet-connected computer will spend the same time observing and recording data from TRIP. All the team members should synchronize their watches just before data collection.

Well before collecting any data, however, it is strongly recommended that members of each team meet to organize their data collection effort in terms of addressing matters such as deciding on the period of time during which data will be collected, deciding on the time resolution regarding time measurements, assigning the team members to stops in the field and on-line, specifying the type of data to collect in the field and on-line, and designing and producing data collection forms. It is also highly advisable that team members conduct a dry-run together at some campus bus stop and on-line prior to the actual data collection effort to ensure that nothing has been overlooked and to avoid making mistakes during data collection.

Report

For part I the report should include the following:

- description of the field and on-line data collection effort,
- route map with data collection stops indicated,
- name of student collecting data at each stop and on-line,
- sample data collection forms,
- description of the data collected,
- tabulation of the collected raw data, and
- raw data saved in Excel and e-mailed to the instructor `<mishalani@osu.edu>`.

The report should be *single-sided* and *double-spaced* with *1-inch margins* (all sides). The Excel file should be named as follows: `<CE670_WI2010_TeamName_Data.xls>`. The "`TeamName`" is as shown in the first column of Table 1.

CE 670 Urban Public Transportation
Winter 2010
Project – Part I Peer- and Self-evaluation Form

Instructions

The purpose of this evaluation form is for each one of you to have a chance to evaluate the performance of your teammates with regard to various aspects of their contribution to this project. Also, this is to provide you with an opportunity to assess your own performance in providing constructive feedback to your team-mates as you work together on this problem set.

I urge you to provide feedback to your teammates as your work progresses. Your objective is to aim for providing a positive evaluation of each other at the end of the process. You should submit these evaluation forms (one in relation to each of your team-mates) to me independently of your team's report. Nevertheless, I encourage you to discuss your evaluation with your teammates. This, however, is only a recommendation and is not a requirement.

Evaluation

1. Your name:
2. Your team's name:
3. Name of team member you are evaluating:
4. Please score the team member named above on a scale of 1 to 7 (1 = unacceptable, 2 = poor, 3 = mediocre, 4 = fair, 5 = good, 6 = very good, 7 = excellent) with regard to the following:
   a. Contribution to and performance on data collection preparation: Score =____.
   b. Contribution to and performance on data collection form design: Score =____.
   c. Contribution to and performance on actual data collection: Score =____.
   d. Contribution to and performance on report writing: Score =____.
   e. Teamwork spirit and cooperative attitude: Score =____.
   f. Leadership skills: Score =____.
   g. Overall performance and contribution: Score =____.
5. Now please give yourself a score with regard to your effort in providing constructive feedback, when and if needed, to the above named team member during the progress of your work together: Score =____.
6. Please provide below your written comments on any of the items above if you have any (use the back side of this sheet or another sheet if you need additional space):

page 4 of 6

CE 670 Urban Public Transportation
Winter 2010
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   b. Contribution to and performance on data collection form design: Score =____.
   c. Contribution to and performance on actual data collection: Score =____.
   d. Contribution to and performance on report writing: Score =____.
   e. Teamwork spirit and cooperative attitude: Score =____.
   f. Leadership skills: Score =____.
   g. Overall performance and contribution: Score =____.
5. Now please give yourself a score with regard to your effort in providing constructive feedback, when and if needed, to the above named team member during the progress of your work together: Score =____.
6. Please provide below your written comments on any of the items above if you have any (use the back side of this sheet or another sheet if you need additional space):

CE 670 Urban Public Transportation
Winter 2010
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   a. Contribution to and performance on data collection preparation: Score =____.
   b. Contribution to and performance on data collection form design: Score =____.
   c. Contribution to and performance on actual data collection: Score =____.
   d. Contribution to and performance on report writing: Score =____.
   e. Teamwork spirit and cooperative attitude: Score =____.
   f. Leadership skills: Score =____.
   g. Overall performance and contribution: Score =____.
5. Now please give yourself a score with regard to your effort in providing constructive feedback, when and if needed, to the above named team member during the progress of your work together: Score =____.
6. Please provide below your written comments on any of the items above if you have any (use the back side of this sheet or another sheet if you need additional space):

Exhibit E-4: Part II of assignment used in *CE 670: Urban Public Transportation*

CE 670 Urban Public Transportation
Winter 2010

Project – Part II: Campus Area Bus Service (CABS) Operations – Analysis
Date handed out: Wed. Feb. 17, 2010
Date due: Wed. March 3, 2010

Instructions

In part II of this project, continue to work with your team and use the data you collected in part I to address the various problems. Each team should submit a comprehensive report describing the analysis and results. If you need to refer to any materials you submitted in your part I report, please include those materials again in the part II report.

The report should be *single-sided* and *double-spaced* with *1-inch margins*, and use a *font size of 12*. Once again, the report should be the team's own *independent* work.

In addition, each team member should submit one peer- and self-evaluation form (three copies of this form are included at the end) in relation to each of the *other* member(s) of the team. Please submit the forms to me separately (i.e., do not include them with your team's report). *The individual team member project grade will be partly based on this submission.*

Problem 1: Passenger Wait Times

a. Based on your observations, determine all the headways at each of the bus stops you have collected data on. Estimate the headway probability density function (pdf) using a histogram at each of the bus stops. Describe the nature of these density functions (pdfs).

b. Based on your estimates of the headway means and variances, determine the mean passenger waiting time at each of the four bus stops. Compare *half* the estimated mean headway with the mean passenger waiting time for each bus stop. Discuss the significance of this comparison and interpret your results.

c. Compare the estimated headway pdfs *across* the stops. Compare the mean passenger waiting times *across* the stops. Interpret your results.

Problem 2: Bus Dwell Times

In this exercise you are to formulate and estimate one or more bus dwell time functions (models), which describe bus dwell times for the bus stop labeled with an asterisk (*) in Table 1 of part I corresponding to the route you are analyzing. The dwell time is the time a vehicle requires to discharge and take on passengers at a stop including opening and closing doors and the holding time (i.e., the *additional* time spent standing beyond the time necessary to allow passengers to board and alight).

a. Use ordinary least squares regression for your estimation (using Excel is recommended, but you may use any other statistical software tool). Justify your choice of explanatory variables and model specification. Present interesting models you have estimated but may decide not to support or recommend for adoption. Depending on the nature of your data, consider developing models for dwell time and models for dwell time *less* the holding time.

b. Critically assess the quality of your estimated model(s) and justify your decisions regarding the models you chose to adopt and the ones you decided not to.

Problem 3: Bus Running Times

a. Estimate the bus running time pdf using a histogram.

b. Is the number of busses assigned to the route you are studying reasonable given the published headways? Make any necessary assumptions and justify your answer.

Problem 4: Bus arrival times

In this exercise you are interested in comparing the bus arrival times at stops as observed in the field and as "observed" via the TRIP website.

a. List and discuss reasons for possible discrepancies between field- and TRIP-observed bus arrival times.

b. Using the field and TRIP data you collected, compare the field- and TRIP-observed bus arrival times. Interpret your results in light of your answer to part a above and other pertinent considerations.

Problem 5: Recommendations

a. Based on your answers to the above questions, what are the problems or issues that you think CABS should be made aware of?

b. Based on your answer to part (a) above, what are the recommendations you have for CABS with regard to improving operations, service, and passenger information provision, if any? Whether you have recommend improvements or not, please justify your answer.

CE 670 Urban Public Transportation
Winter 2010
Project – Part II Peer- and Self-Evaluation Form

Instructions

The purpose of this evaluation form is for each one of you to have a chance to evaluate the performance of your team-mates with regard to various aspects of their contribution to this project. Also, this is to provide you with an opportunity to assess your own performance in providing constructive feedback to your team-mates as you work together on this problem set.

I urge you to actually provide feedback to your team-mates as your work progresses. Your objective is to aim for providing a positive evaluation of each other at the end of the process. You should submit these evaluation forms to me independently of your team's report. Nevertheless, I encourage you to discuss your evaluation with your team-mates. This, however, is only a recommendation and is not a requirement.

Evaluation

1. Your name:
2. Your team's name:
3. Name of team member you are evaluating:
4. Please score the team member named above on a scale of 1 to 7 (1 = unacceptable, 2 = poor, 3 = mediocre, 4 = fair, 5 = good, 6 = very good, 7 = excellent) with regard to the following:
   a. Contribution to solution of problem 1: Score =____.
   b. Contribution to solution of problem 2: Score =____.
   c. Contribution to solution of problem 3: Score =____.
   d. Contribution to solution of problem 4: Score =____.
   e. Contribution to and performance on report writing: Score =____.
   f. Teamwork spirit and cooperative attitude: Score =____.
   g. Leadership skills: Score =____.
   h. Overall performance and contribution: Score =____.
5. Now please give yourself a score with regard to your effort in providing constructive feedback, when and if needed, to the above named team member during the progress of your work together: Score =____.
6. Please provide your written comments on any of the items above if you have any (use the back side of this sheet or another sheet if you need additional space):

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