SMART CAMPUS TRANSIT LABORATORY
FOR RESEARCH AND EDUCATION

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ACKNOWLEDGEMENTS AND DISCLAIMER

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1 Introduction

1.1 Background

Increased use of public transportation is an effective means of decreasing roadway congestion and its associated externalities. To increase the use of public transportation under economic and resource constraints, it is important to improve the understanding of public transportation supply characteristics and demand behavior and make use of this understanding to improve planning and operations functions. Analyzing and interpreting *in situ* public transportation conditions that are readily accessible and observable can greatly improve this understanding.

In the past, project investigators worked with The Ohio State University (OSU) Campus Area Bus Service (CABS) and a private technology provider to equip the CABS network with state-of-the-art sensing, communications, and passenger information systems that are presently used to provide real-time bus arrival information to CABS users and ridership and location information to CABS operators and planners. In addition to being used for service planning and operations, automatic vehicle location (AVL) and automatic passenger count (APC) data are downloaded nightly and archived by project investigators. The investigators couple these high-resolution and extensive data with manually collected data and data obtained from web-based surveys for research, education, and outreach.

The physical and data infrastructure and the strong partnership between service providers and project investigators developed over many years have led to the establishment of the OSU Campus Transit Lab (CTL), a unique living lab that supports multiple internally and externally funded activities. This project is devoted to continued general data collection and targeted outreach, research, and educational activities designed to take advantage of existing CTL infrastructure and to sustain and to expand the infrastructure.

1.2 Data acquisition

The CTL investigators continued regular manual and automatic data collection on CABS routes to form databases for present and future research, outreach, and educational activities. Figure 1.2-1 shows the CABS system map for the academic year occurring during the timeframe of this project.

Using the procedure presented in McCord et al. (2010), undergraduate and graduate students continued to board CABS buses to collect direct observations of passenger OD flows on five CABS routes. Table 1.2-1 summarizes the numbers of bus trips and passengers sampled during this project by academic term (quarter), route, and time-of-day period (morning, midday, or afternoon). OD matrices based on route, term, and period can be found in Appendix A. The direct OD flow data, as well as less quantitative observations made by data collectors who were inserted into regular bus operations, are used to validate passenger OD estimation methodologies, to provide information to CABS managers for system planning and operations, and to generate topics for research and outreach studies.
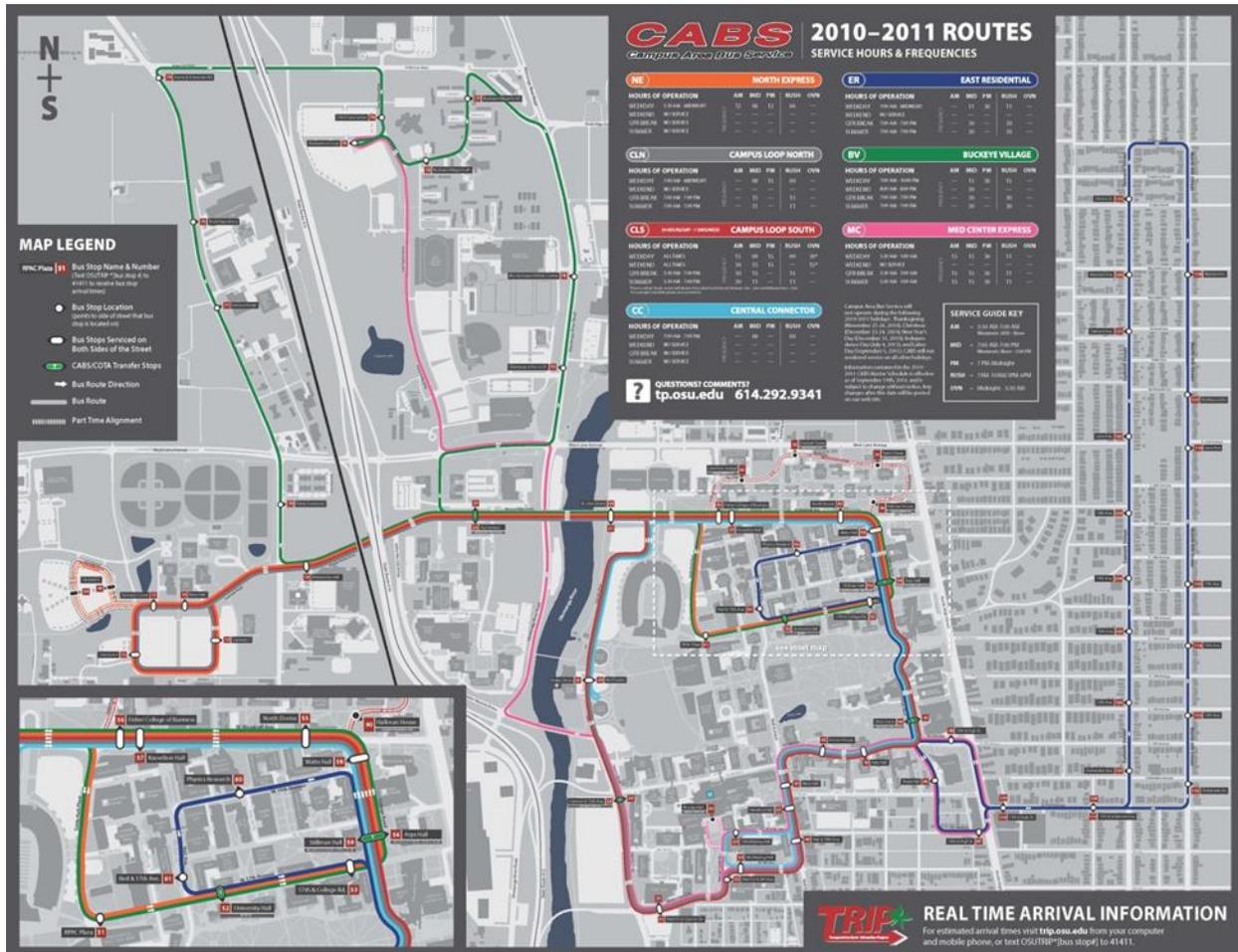
Figure 1.2-1: Ohio State University Campus Area Bus Service (CABS) route map operated in academic year 2010-2011

Table 1.2-1: Summary of numbers of bus trips and passengers sampled to collect OD flow information by academic term and route; CLS: Campus Loop South, CLN: Campus Loop North, NE: North Express, ER: East Residential, CC: Central Connector

Autumn 2010 Academic Term							
	Passengers				*Trips*		
Route	*AM*	*MID*	*PM*	*Sum*	*AM*	*MID*	*PM*	*Sum*
CLS	290	--	433	**723**	6	--	8	**14**
CLN	419	--	506	**925**	8	--	8	**16**
NE	423	--	348	**771**	8	--	8	**16**
CC	148	--	203	**351**	8	--	8	**16**
ER	--	--	--	**0**	--	--	--	**0**
Sum	**1280**	**0**	**1490**	**2770**	**30**	**0**	**32**	**62**

Winter 2011 Academic Term							
	Passengers				*Trips*		
Route	*AM*	*MID*	*PM*	*Sum*	*AM*	*MID*	*PM*	*Sum*
CLS	166	--	406	**572**	4	--	6	**10**
CLN	248	--	393	**641**	6	--	6	**12**
NE	228	--	428	**656**	4	--	6	**10**
CC	111	--	201	**312**	4	--	6	**10**
ER	104	--	288	**392**	3	--	5	**8**
Sum	**857**	**0**	**1716**	**2573**	**21**	**0**	**29**	**50**

Spring 2011 Academic Term							
	Passengers				*Trips*		
Route	*AM*	*MID*	*PM*	*Sum*	*AM*	*MID*	*PM*	*Sum*
CLS	241	655	315	**1211**	4	12	6	**22**
CLN	90	633	299	**1022**	2	14	4	**20**
NE	148	416	189	**753**	4	6	4	**14**
CC	186	--	207	**393**	8	--	8	**16**
ER	--	--	--	**0**	--	--	--	**0**
Sum	**665**	**1704**	**1010**	**3379**	**18**	**32**	**22**	**72**

Cumulative: Autumn 2010 Academic Term - Spring 2011 Academic Term							
	Passengers				*Trips*		
Route	*AM*	*MID*	*PM*	*Sum*	*AM*	*MID*	*PM*	*Sum*
CLS	697	655	1154	**2506**	14	12	20	**46**
CLN	757	633	1198	**2588**	16	14	18	**48**
NE	799	416	965	**2180**	16	6	18	**40**
CC	445	0	611	**1056**	20	0	22	**42**
ER	104	0	288	**392**	3	0	5	**8**
Sum	**2802**	**1704**	**4216**	**8722**	**69**	**32**	**83**	**184**

CTL investigators also continued to obtain and archive the APC and AVL data downloaded from the buses on a nightly basis. A summary of the numbers of bus trips and passengers for which APC information was obtained is shown in Table 1.2-2. High-resolution AVL data were also collected and archived on all of these routes.

Table 1.2-2: Summary of numbers of bus trips and passengers sampled to collect APC information by academic term and route; CLS: Campus Loop South, CLN: Campus Loop North, NE: North Express, ER: East Residential, CC: Central Connector, BV: Buckeye Village

Term	Autumn 2010		Winter 2011		Spring 2011	
Route	**Trips**	**Passengers**	**Trips**	**Passengers**	**Trips**	**Passengers**
CLS	3075	149579	3485	163769	2702	121839
CLN	3289	147860	3629	158676	2908	130113
NE	4881	225703	4905	229203	3840	165883
ER	3068	92076	2829	125325	2293	89476
CC	2736	45239	2043	45026	1414	30780
BV	2520	44173	2249	47263	1827	38075

Estimated OD flow matrices for various routes, terms, and time-of-day periods are produced from these automatically collected data, as needed, for research, outreach, and educational activities. The APC and AVL data are used for a variety of outreach investigations that arise on a one-time basis. In addition, the data are processed on a regular basis to support ongoing research and development investigations and course-based educational activities. Investigations and activities conducted for this project are discussed in the following sections.

1.3 Report overview

This report documents the research, outreach, and educational activities conducted within the context of the OSU CTL, based on recently and previously manually and automatically collected data. Section 2 details various outreach activities between the CTL investigators and various stakeholders. This section also lists technical presentations and papers produced as a result of CTL activities. Section 3 summarizes the various research activities conducted in the CTL within the scope of this project. The data collected and processed by CTL investigators are used to support and develop modules, assignments, and exam questions for use in undergraduate and graduate courses. These educational activities are described in Section 4. Finally, the outreach, research, and educational activities and findings are summarized in Section 5.

2 Outreach and dissemination

2.1 CAR electric bus study

The Center for Automotive Research (CAR) at The Ohio State University was modelling performance of electric buses prior to a planned implementation on campus. Based on a request from CAR, CTL investigators produced bus passenger load and bus speed profiles by location and time-of-day period. The load speed profile for the North Express (NE) route in the Spring 2011 academic term is shown in Figure 2.1-1, and the speed profile for the same route and term is shown in Figure 2.1-2. CTL investigators provided CAR with a series of plots such as those depicted and with the disaggregate data used to produce the plots. These results were used to determine power requirements during anticipated operations on campus.
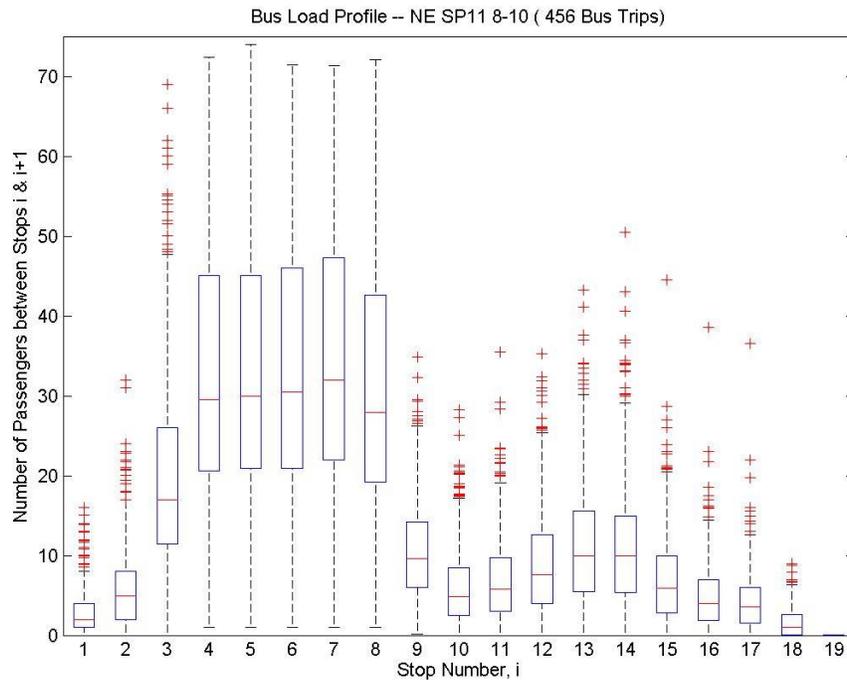
Figure 2.1-1: Bus passenger load profile for North Express (NE) route during Spring 2011 academic term
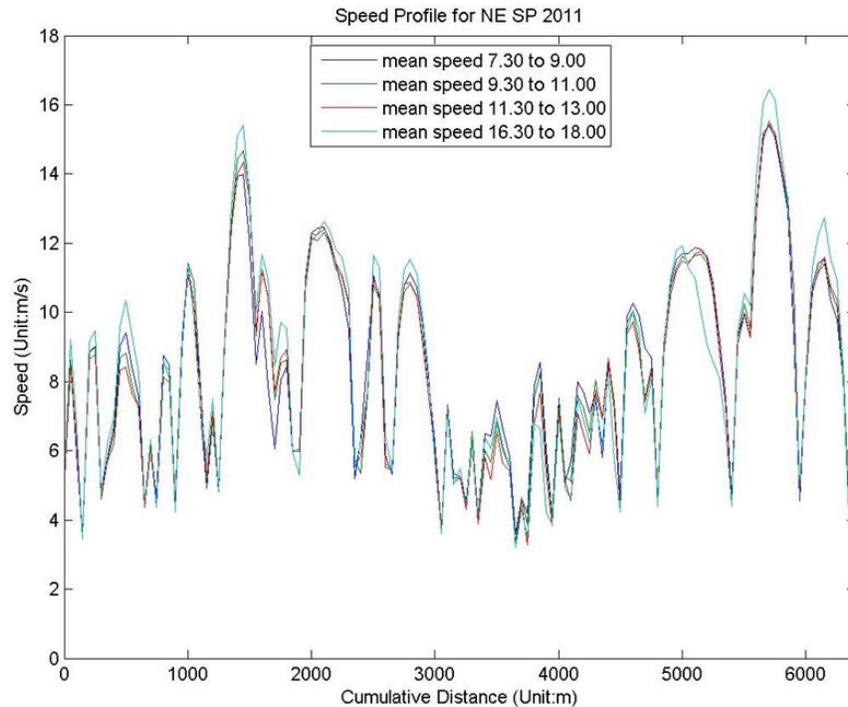
Figure 2.1-2: Bus speed profile for North Express (NE) route during Spring 2011 academic term

2.2 CABS speeding on W. 17th Avenue

OSU Transportation and Parking received complaints about bus speeding on W.17th Avenue in the academic core of the OSU campus. CTL investigators determined and analyzed bus speeds by location and time along this corridor. The results of this analysis concluded that speeding did occur in some isolated instances, but that the speeding was not as widespread as initially believed. The results and conclusions were communicated to and discussed with OSU Transportation and Parking management.

2.3 Animation of bus operations

CTL investigators developed bus movement playback using AVL data from CABS buses. The animations produced by CTL investigators can be used to improve understanding of bus operations and bus bunching, particularly for bus driver and supervisor training. Screenshots of the animation of the CABS AVL data are shown in Figures 2.3-1 and 2.3-2. Demonstrations to CABS operation managers confirmed that these animations can be useful for informal evaluation of bus operations by transit managers.
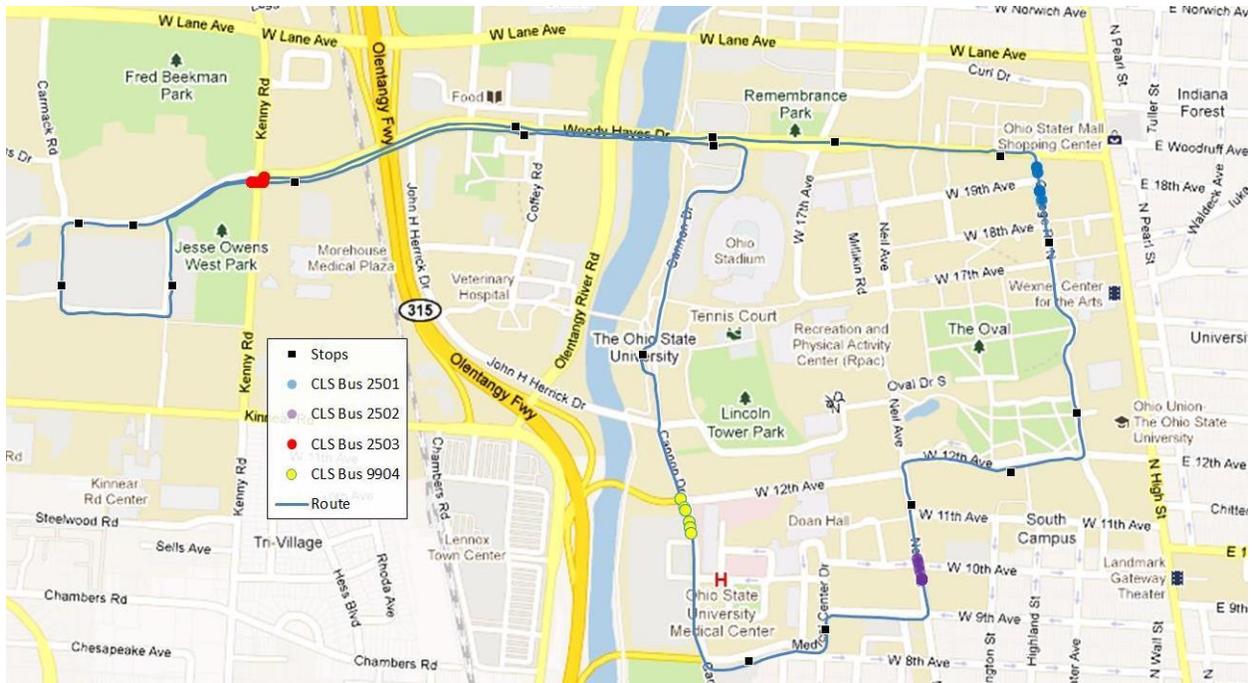
Figure 2.3-1: Screenshot of animation of CABS AVL data for Campus Loop South (CLS) route with four buses operating during Spring 2011 academic term
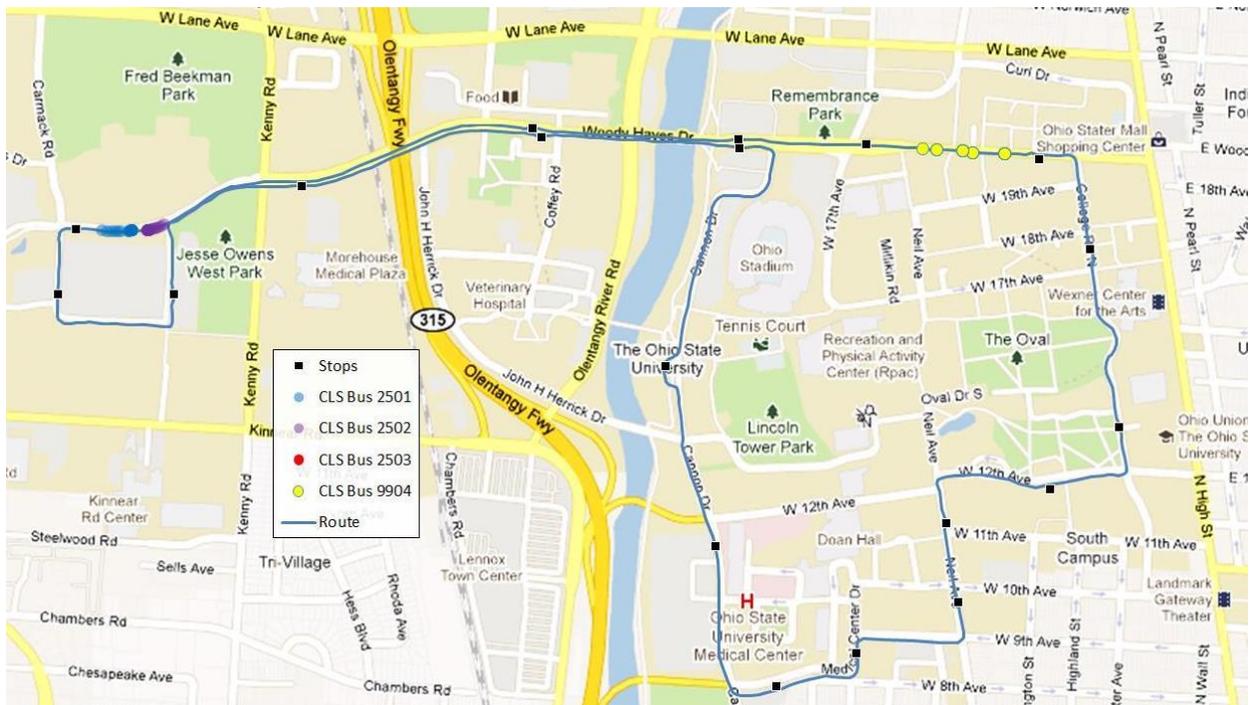
Figure 2.3-2: Screenshot of animation of CABS AVL data for Campus Loop South (CLS) with three buses operating during Spring 2011 academic term: Bus bunching occurring at West Campus

2.4 Web-based survey of transit perceptions and attitudes

Previously, the second wave of a planned two-wave survey of the OSU community was implemented to assess possible changes in transit perceptions and attitudes resulting from the implementation of an advanced passenger information system on the CABS system (Mishalani et al, 2011). CTL investigators were interested in assessing the impact of a real-time passenger information system on the perceptions and attitudes of both users and non-users of CABS by using a "before-and-after" approach, where an identical survey was administered both before and after the implementation of the passenger information system. The questionnaire consisted of 9 demographic questions, 10-13 questions dealing with the subject's mode of transportation to and from campus, and 14 questions about the subject's perceptions and evaluation of CABS service, safety, and roles in reducing traffic and contributing to a "green" campus. This questionnaire was administered to undergraduate and graduate students, faculty, and staff of The Ohio State University and yielded an overall 23.5% response rate.

The survey, primarily conducted for research purposes, yielded results of more immediate relevance to CABS. In the timeframe of this project, a preliminary analysis of the survey results was conducted. Several aspects of the survey deemed pertinent and otherwise unavailable to CABS for planning and operations were communicated in writing and in person to CABS management and staff. In addition to the highly favorable perceptions of CABS services, the environmental, traffic reduction, and safety aspects associated with CABS were emphasized. Specifically, respondents believed CABS promotes a green campus and reduces traffic congestion. These perceptions apply to both users and non-users of CABS. In addition, CABS travelers felt safer when riding CABS than when walking to a CABS stop or waiting for a CABS bus. Travelers felt equally safe when walking to a CABS stop or waiting for a CABS bus. While waiting for a CABS bus, a longer waiting time tended to lower the perception of safety.

2.5 Papers and presentations at conferences

During the timeframe of this project, additional dissemination of important activities and results was accomplished through papers and presentations at technical conferences. The following papers were published:

- McCord, M. R., Mishalani, R. G., Goel, P. K., & Strohl, B. (2010). Empirical comparative assessment of the IPF procedure for determining bus route passenger OD flows. *Transportation Research Record*, *No. 2145*, pp. 59-65.
- Ji, Y., Mishalani, R. G., & McCord, M. R. (2010). *Analytical and empirical investigations of the effect of bus drivers' reactions to schedules on transit operations reliability*. Proceedings of the 12th World Conference on Transportation Research, Lisbon, Portugal.

The following technical presentations were also given:

- Ji, Y., Mishalani, R. G., & McCord, M. R. (2010, July). *Analytical and empirical investigations of the effect of bus drivers' reactions to schedules on transit operations reliability*. 12th World Conference on Transportation Research, Lisbon, Portugal.
- Ji, Y., Mishalani, R. G., McCord, M. R., & Goel, P. K. (2011, January). *Identifying homogenous periods for bus route origin-destination passenger flow patterns based on automatic passenger count data*. Transportation Research Board Annual Meeting, Washington, DC.
- McCord, M. R., Mishalani, R. G., & Goel, P. K. (2010, October). *Overview/update on selected transportation systems research projects*. Presentation to Mid-Ohio Regional Planning Commission at The Ohio State University, Columbus, OH.
- McCord, M. R., Mishalani, R. G., Chen, C., & Ji, Y. (2011, January). *Additional uses of automatically collected bus transit data: Determining passenger OD flows from APC data and recurrent traffic conditions from AVL data*. Invited Presentation to ITS Passenger Transportation Systems and Services Committee at Transportation Research Board Annual Meeting, Washington, DC.
- McCord, M. R., Mishalani, R. G., & Coifman, B. (2011, February). *Bus Transit Research at OSU*. Presentation to ACS Xerox at The Ohio State University, Columbus, OH.
- Mishalani, R. G., McCord, M. R., Goel, P. K., & Strohl, B. (2010, October). *Estimating origin-destinations flows from APC data: Empirical validation using the OSU Campus Transit Lab*. Ohio Transportation Engineering Conference, Columbus, OH.
- Mishalani, R. G., Ji, Y., & McCord, M. R. (2011, January). *Empirical evaluation of the effect of onboard survey sample size on transit bus route passenger OD flow matrix estimation using APC data*. Transportation Research Board Annual Meeting, Washington, DC.
- Reinhold H., McCord, M. R., Mishalani, R. G. (2011, January). *Campus Transit Lab (CTL) for Research, Education, and Outreach*. Presentation to Institute of Transportation Engineers Central Ohio Section, Columbus, OH.

3 Research activities

3.1 Evaluation of IPF-Null method

CTL investigators conducted a comparison of estimated OD flow probabilities using the IPF method with a null base (IPF-Null) against directly observed OD flow probabilities collected in the field, which serve as ground truth for evaluation studies. Figure 3.1-1 shows plots of empirical cumulative distribution functions (ECDFs) of passenger distance traveled (PDT) for the Campus Loop South (CLS) route for the Winter 2011 academic term during the morning peak period. The three plots are ECDFs of PDT determined from directly observed ground truth OD flows, IPF-estimated OD flows using APC data from corresponding bus trips, and IPF-estimated OD flows using APC data from all bus trips during the route-term-period. The corresponding plots of ECDFs of PDT determined from OD flows in the afternoon peak period on the same route and term are shown in Figure 3.1-2. Based on this PDT measure, the

probability flows for cells representing short passenger trips, specifically trips with a distance less than the average stop-to-stop distance between consecutive bus stops, were found to be overestimated by the IPF-Null method, with respect to directly observed OD probability flows.
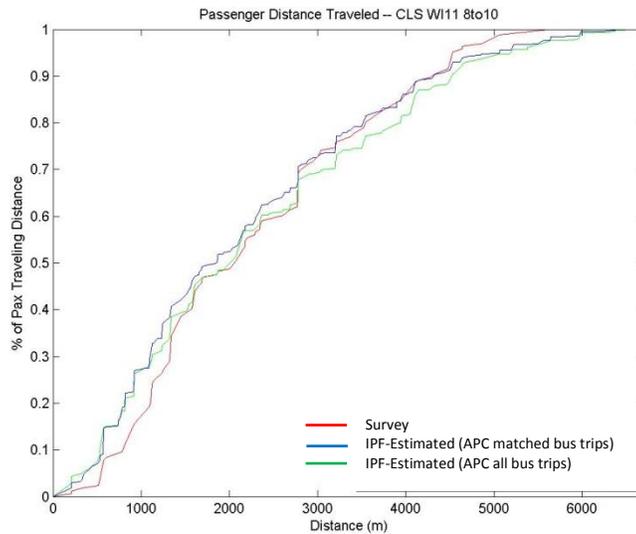
Figure 3.1-1: Plots of empirical cumulative distribution of passenger distance traveled of directly observed OD flows (Survey), IPF-estimated OD flows on corresponding survey bus trips, and IPF-estimated OD flows on all trips during period for Campus Loop South (CLS) route during morning peak period in Winter 2011 academic term
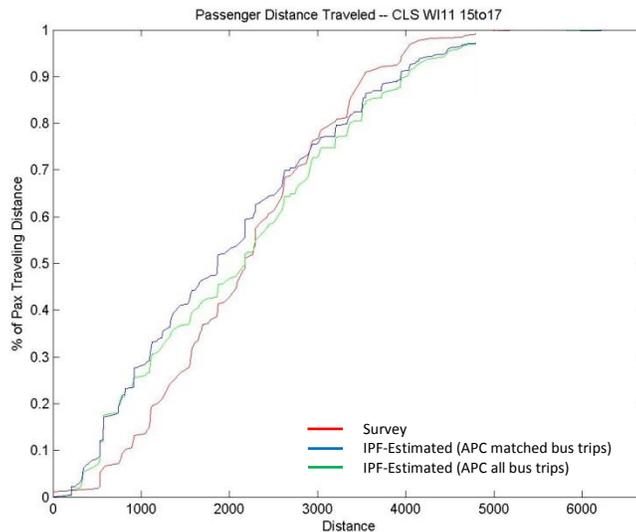
Figure 3.1-2: Plots of empirical cumulative distribution of passenger distance traveled (PDT) of directly observed OD flows (Survey), IPF-estimated OD flows on corresponding survey bus trips, and IPF-estimated OD flows on all trips during period for Campus Loop South (CLS) during afternoon peak period in Winter 2011 academic term

A binary logit model was developed to determine the effect of trip length on deviations between directly observed and IPF-null estimated OD probability flows. The model showed that cells representing considerably short or long passenger travel distances were significantly more likely to have OD probabilities overestimated by the IPF-null method.

3.2 Evaluation of IPF-IB and HEM estimation methods

For another project, CTL investigators developed two new methods – a Heuristic Expectation Maximization (HEM) method and an Iterative Proportional Fitting with Iterative Base (IPF-IB) method – for estimating bus trip-level OD flows. These methods were designed to take advantage of the large quantities of boarding and alighting data that are now available with the regular operational use of APC technologies (Ji, 2011; Ji et al, 2012; Ji et al, 2014). The performance of these methods was being compared to that of the state-of-the-practice IPF-Null method. Directly observed CTL field data, collected on a regular basis, were used to represent the ground truth in the comparative studies. Preliminary results indicated that both the HEM and IPF-IB methods produced OD estimates closer to the directly observed, ground truth flows than did the IPF-Null method.

3.3 Stop grouping method

In a separate project, CTL investigators developed a stop grouping method to aggregate bus stops to reduce the size of the route-level OD probability flow matrix for improved estimation, analysis, and communication of passenger OD flows. Bus route stop-to-stop OD flow matrices are large, which can hinder the understanding of general flow patterns and make accurate estimates of stop-to-stop OD passenger flows difficult. However, reducing the size of the OD matrix by grouping stops arbitrarily or according to land-use characteristics may not capture important passenger flow patterns.

The approach developed by the CTL investigators aimed to determine stop groups that explicitly capture general passenger OD flow patterns. The approach uses a dissimilarity measure to depict the quality of the grouping and heuristic methods to efficiently determine the optimal configuration of stops into groups. Details of the methodology and interpretation of the results can be found in McCord et al. (2012).

In this project, CTL data and an understanding of campus bus passenger flow patterns were used to evaluate an empirical application of this method. The method was applied to CABS OD data from the Campus Loop North (CLN) route. Stop groups determined using the grouping method developed by CTL investigators were evaluated against groupings defined by a domain expert familiar with the OSU community, who aggregated the 17-stop route (after aggregation of four stops serving a park-and-ride facility) into eight stop groups. Figures 3.3-1 and 3.3-2, respectively, which are taken from McCord et al. (2012), depict the stops groupings determined by the domain expert and by the stop-grouping approach

developed, along with the top five passenger OD flows for each group configuration. The stop groupings revealed OD travel patterns that were not as obvious at the stop-level.
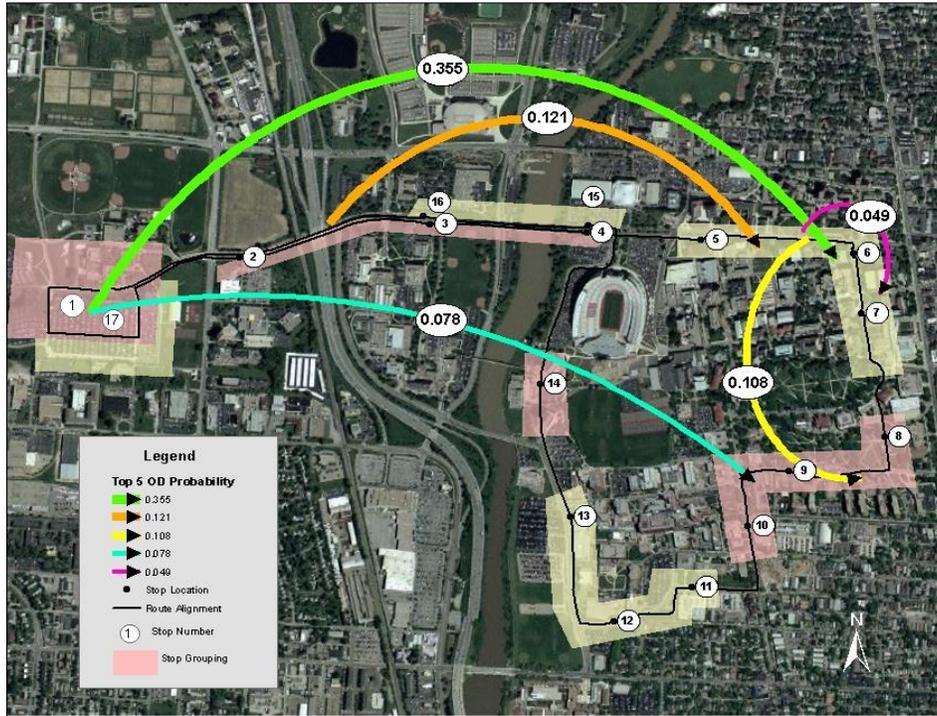
Figure 3.3-1: Stop groups determined by the CABS domain expert for Campus Loop North (CLN) route during morning period; five largest OD flows are indicated
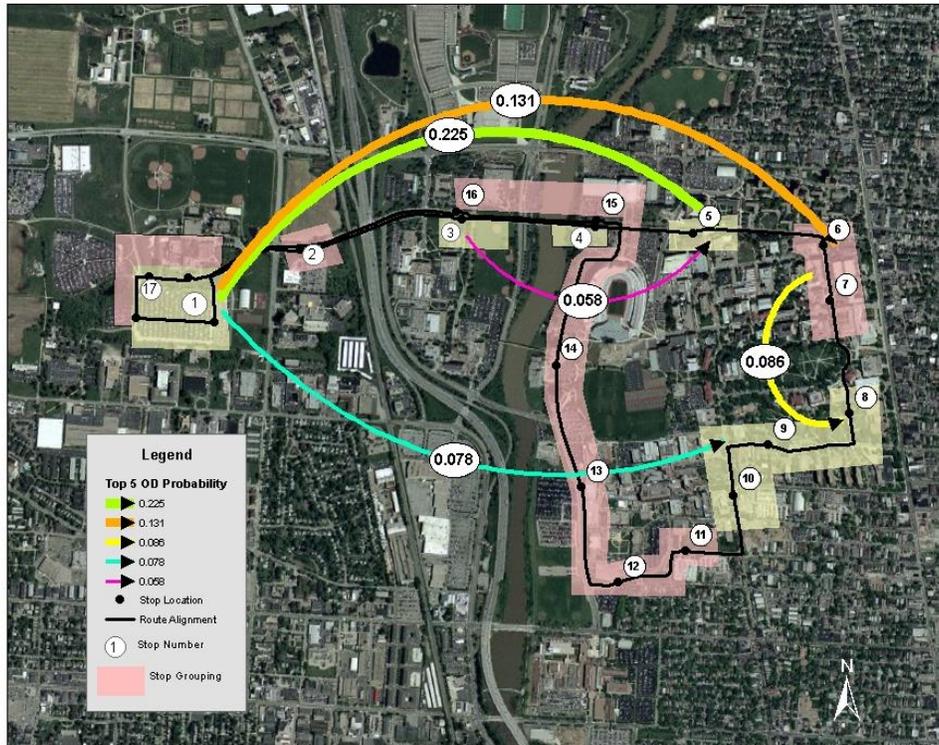
Figure 3.3-2: Stop groups produced by stop-grouping approach for Campus Loop North (CLN) route during morning period; five largest OD flows are indicated

4 Educational activities

The OSU CTL continued to take advantage of the underlying physical and institutional infrastructure of the living transit laboratory and of the automatically and manually collected data on CABS to support the incorporation of transit-related educational activities in existing classes taught by project investigators.

In a large transportation course required of all Civil Engineering undergraduate students, *Civil Engineering 570: Transportation Engineering and Analysis*, a presentation on the CTL had previously been introduced to complement an existing module on scheduled transportation systems (Mishalani et al, 2009). Also introduced was the IPF estimation method for estimating OD passenger flows from boarding and alighting count data. An assignment requiring students to use CTL APC and AVL data to estimate passenger OD flows and travel times between bus stops had been distributed. In addition, questions relating to OD flow estimation and the CTL were developed and included in an exam. For the Winter Quarter 2011 offering of this course, which was in the timeframe of the project reported upon here, refinements of the presentations on the CTL and on determining OD passenger flows from CTL APC data were implemented. An assignment was again distributed requiring students to use CTL APC and AVL data collected on the Campus Loop South route to estimate OD passenger flows, determine stop-to-

stop travel times, and analyze variability in stop-to-stop travel times and dwell times. In addition, a question on OD passenger flow estimation was developed and included in the exam that covered the module on scheduled transportation systems. The assignment and exam question appear in Appendix B.

As part of an outreach effort for CABS decision makers, a linear programming-based approach for bus scheduling was previously developed. (Mishalani et al, 2009). In the Autumn Quarter 2010 offering of *Civil /Environmental Engineering 540: Civil and Environmental Engineering Systems*, which was in the timeframe of the project reported upon here, a lecture on this scheduling approach was introduced. (*Civil /Environmental Engineering 540* was a course required of all Civil Engineering and Environmental Engineering undergraduate students.) The lecture was designed to illustrate a practical application of linear programming, which was a major methodological component of the course, and to present the application in what was intended to be an understandable context for the students. (Previously, the linear programming examples presented in the course had all been "toy," text-book problems.) The implemented lectures emphasized the context of the problem, the role of CTL AVL data in providing inputs to the problem, the importance of the operational constraints, and CABS's use of the numerical outputs. An exam question, which appears in Appendix B, was based on this lecture.

In Spring Quarter 2011, six of the sixteen students in *Civil Engineering 873: Urban Transportation Demand Forecasting*, a graduate-level course regularly taken by Civil Engineering and City and Regional Planning transportation students and occasionally taken by students in other programs, conducted term projects that relied on CTL data and operations. The students presented the context of their projects, their methodology, and their empirical results to the class.

Previously, in Winter Quarter 2010, the CTL was introduced to students in *Civil Engineering 670: Urban Public Transportation* through a project involving field observations and the monitoring of forecasted bus arrival times to stops from the real-time information system, TRIP. The field observed data were used to determine bus headways, dwell times, and passenger waiting times and were compared to forecasted bus arrival times to stops from TRIP. Students were given the opportunity to assess and provide recommendations for the operation of CABS buses based on their analysis of the various data. In the Winter Quarter 2011 offering of *CE 670*, which was in the timeframe of the project reported on here, the project was refined to include observations of passenger boarding and alighting counts at selected bus stops and the incorporation of CTL APC and AVL data from CABS buses. This project also featured the Central Connector route for the first time since its introduction at the start of the Autumn 2010 term. Students compared directly observed boarding and alighting counts and bus arrival times at stops to corresponding APC and AVL data to assess the accuracy of the automatic sensing technologies. The project parts I (data collection) and II (analysis) are included in Appendix B.

In Winter Quarter 2011, an assignment using CTL AVL data was developed for *Civil Engineering 878: Transportation Management Systems*, a graduate-level course taken by transportation students. In this assignment, students manually collected real-time bus arrival times displayed on the TRIP website for multiple buses and stops. The students then matched these predicted arrival times to corresponding arrival times determined from AVL data to evaluate prediction error and critique the advantages and

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disadvantages of TRIP. The assignment, revised based on input from students regarding methods to collect TRIP bus arrival time predictions, is included in Appendix B.

In addition to integration into courses, the CTL context and data formed the basis of important aspects of the following theses and MS reports:

- Chen, Cheng. (2010). *Study of indicators of recurrent congestion on urban roadway network based on bus probes,* MS thesis, The Ohio State University, Civil Engineering.
- Hu, Xudong. (2011). *Transit network assignment, load profile OD contributions, ridership estimation, and stop grouping.* MS project report. The Ohio State University, Civil Engineering.
- Ji, Yuxiong. (2011). *Distribution-based approach to take advantage of automatic passenger counter data in estimating period route-level transit passenger origin-destination flows: Methodology development, numerical analyses and empirical investigations.* PhD dissertation, The Ohio State University, Civil Engineering.
- Strohl, Brandon. (2010). *Empirical assessment of the iterative proportional fitting method for estimating bus route passenger origin-destination flows,* MS thesis, The Ohio State University, Civil Engineering
- Xu, Xiaofei. (2011). *Left-behinds, bus route transfer, route patterns, and headway analyses*. MS project report. The Ohio State University. Civil Engineering
- Zhu, Honglei. (2010). *Simulation of bus operations*. MS project report. The Ohio State University. Civil Engineering.

5 Summary

This report documents the activities conducted within the Campus Transit Lab (CTL) at The Ohio State University for the purposes of research, education, and outreach. CTL investigators used automatically and manually collected data from the OSU Campus Area Bus Service (CABS) to support multiple activities. As a result of specific requests pertaining to the planning and operation of bus service on campus, investigators processed CTL data, analyzed the results, and provided data and interpreted results to CABS and to the Center for Automotive Research. Investigators also communicated to CABS the results of a previously conducted web-based survey that revealed users' and nonusers' perceptions that CABS has a positive effect on the environment and on traffic reduction and assessed users' perceptions of safety associated with using CABS.

CTL data and infrastructure were also used to investigate properties and the accuracy of three methods for estimating OD passenger flows: the state-of-the-practice iterative proportional fitting method (IPF) and two new methods developed to take advantage of the large quantities of boarding and alighting data collected with the regular use of APC technologies.

The CTL was also used for educational activities. Automatically collected AVL data, automatically and manually collected APC data, and the setting and general activities of the CTL were used in lectures, assignments, and exam questions in several undergraduate and graduate-level courses.

6 References

Ji, Yuxiong, 2011. *Distribution-based Approach to take Advantage of Automatic Passenger Counter Data in Estimating Period Route-level Transit Passenger Origin-Destination Flows: Methodology Development, Numerical Analyses and Empirical Investigations.* PhD Dissertation, The Ohio State University, Civil Engineering

Ji, Y., Mishalani, R.G., McCord, M.R., 2012. Transit Route-level Passenger Origin Destination Flow Estimation: Empirical Evaluation of a Heuristic Expectation Maximization Methodology. Proceedings of the 12th Conference on Advanced Systems for Public Transport, Santiago, Chile.

Ji, Y., Mishalani, R.G., McCord, M.R., 2014. Estimating Transit Route OD Flow Matrices from APC Data on Multiple Bus Trips Using the IPF Method with an Iteratively Improved Base: Method and Empirical Evaluation. Journal of Transportation Engineering. DOI: 10.1061/(ASCE)TE.1943-5436.0000647.

McCord, M.R., Mishalani, R.G., Goel, P.K. (2009). *Research and education from a smart campus transit laboratory.* U.S. DOT Region V University Transportation Center, NEXTRANS Project No. 006OY01. Final Report, October 15, 2009.

McCord, M.R., Mishalani, R.G., Goel, P.K., Strohl, B. (2010). *Empirical comparative assessment of the IPF procedure for determining bus route passenger OD flows.* Transportation Research Record, Vol. 2145. pp. 59-65.

McCord, M.R., Mishalani, R.G. & Hu, X. (2012). *Grouping of bus stops for aggregation of route-level passenger origin-destination flow matrices.* Transportation Research Record, Vol. 2277, pp. 38-48

Mishalani, R.G., McCord, M.R., Goel, P.K. (2011). *Smart campus transit laboratory for research and education.* U.S. DOT Region V University Transportation Center, NEXTRANS Project No. 032OY02. Final Report, December 31, 2011.

7 Appendices

Appendix A: Probability OD flow matrices obtained from directly observed OD flows

Table A.1: CLS Autumn 2010 Academic Term, AM Period: 6 Trips, 290 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total
1		0.00%	0.00%	0.00%	0.00%	0.35%	0.35%	0.69%	0.35%	0.00%	0.35%	0.69%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.77%
2			0.00%	0.00%	0.00%	1.38%	0.69%	0.35%	0.69%	0.00%	0.00%	0.00%	1.04%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.15%
3				0.00%	0.00%	0.69%	1.38%	0.35%	2.08%	1.04%	0.69%	1.38%	0.35%	1.04%	1.04%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	10.73%
4					0.00%	3.46%	0.69%	1.38%	6.57%	1.73%	1.73%	1.73%	1.73%	0.69%	1.04%	1.04%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	21.80%
5						0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.04%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.04%
6							0.69%	0.00%	0.69%	0.00%	0.00%	0.69%	0.35%	0.35%	0.35%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.11%
7								0.00%	0.35%	0.69%	1.04%	1.38%	0.35%	0.69%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.50%
8									0.00%	0.69%	0.35%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.04%
9										0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
10											0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.38%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.38%
11												0.00%	0.00%	0.00%	0.00%	0.00%	0.35%	0.69%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.04%
12													0.00%	0.00%	0.35%	2.77%	1.04%	1.04%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.19%
13														0.00%	1.38%	1.38%	0.35%	0.69%	0.00%	1.38%	0.00%	0.00%	0.00%	0.35%	5.54%
14															0.35%	3.46%	1.04%	0.69%	0.35%	1.38%	0.00%	0.00%	0.00%	0.00%	7.27%
15																3.46%	2.08%	1.38%	0.00%	2.77%	0.00%	0.69%	0.35%	0.00%	10.73%
16																	0.00%	0.35%	0.00%	2.08%	0.35%	0.00%	0.00%	0.00%	2.77%
17																		0.00%	0.00%	5.54%	1.04%	0.00%	0.69%	0.35%	7.61%
18																			0.00%	3.46%	0.69%	0.00%	0.69%	1.38%	6.23%
19																				0.35%	0.35%	0.00%	0.35%	0.00%	1.04%
20																					0.69%	0.69%	0.69%	0.00%	2.08%
21																						0.00%	0.00%	0.00%	0.00%
22																							0.00%	0.00%	0.00%
23																								0.00%	0.00%
24																									0.00%
	0.00%	0.00%	0.00%	0.00%	0.00%	5.88%	3.81%	2.77%	10.73%	4.15%	4.15%	5.19%	5.88%	2.08%	4.50%	13.15%	4.84%	6.23%	0.35%	16.96%	3.11%	1.38%	2.77%	2.08%	100.00%

Table A.2: CLS Autumn 2010 Academic Term, PM Period: 8 Trips, 433 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total
1		0.00%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.24%	0.00%	0.00%	0.00%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.71%
2			0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.47%	0.00%	0.00%	0.00%	0.00%	0.47%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.94%
3				0.00%	0.24%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.47%	0.47%	0.71%	0.00%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.35%
4					0.00%	0.47%	0.47%	0.47%	0.94%	0.00%	0.24%	0.00%	0.71%	0.00%	1.18%	0.24%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.94%
5						0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.24%	0.00%	0.00%	0.24%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.71%
6							0.47%	0.94%	0.24%	0.00%	0.47%	0.47%	0.24%	1.41%	0.47%	0.47%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.41%
7								0.00%	0.00%	0.00%	0.24%	0.24%	0.00%	0.24%	0.00%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.94%
8									0.00%	0.00%	0.00%	0.71%	0.00%	0.00%	1.41%	0.00%	0.47%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.59%
9										0.00%	0.00%	0.00%	0.00%	1.41%	0.24%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.24%	0.24%	2.35%
10											0.00%	0.24%	0.24%	0.24%	0.47%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.18%
11												0.00%	0.00%	0.00%	0.47%	0.47%	0.24%	0.24%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	1.65%
12													0.00%	0.47%	0.24%	0.94%	0.24%	0.47%	0.00%	0.00%	0.24%	0.00%	0.00%	0.00%	2.59%
13														0.24%	1.18%	2.35%	2.12%	0.71%	0.24%	0.71%	0.47%	0.00%	1.41%	0.47%	9.88%
14															0.00%	0.47%	0.71%	0.47%	0.24%	0.00%	0.00%	0.47%	1.65%	0.24%	4.24%
15																1.41%	1.88%	1.18%	0.47%	3.29%	1.41%	1.65%	1.18%		14.35%
16																	0.47%	0.71%	0.47%	0.47%	2.12%	2.35%	6.35%	2.59%	15.53%
17																		0.24%	0.24%	0.94%	1.65%	1.18%	1.65%	1.18%	7.06%
18																			0.24%	0.71%	5.65%	1.88%	5.88%	2.35%	16.71%
19																				0.00%	1.65%	0.00%	0.94%	0.00%	2.59%
20																					1.41%	0.24%	1.65%	0.00%	3.29%
21																						0.00%	0.00%	0.00%	0.00%
22																							0.00%	0.00%	0.00%
23																								0.00%	0.00%
24																									0.00%
	0.00%	0.00%	0.24%	0.00%	0.00%	0.71%	1.18%	1.41%	1.18%	0.00%	1.18%	2.35%	1.65%	2.82%	8.24%	6.82%	7.76%	4.00%	2.12%	4.71%	16.47%	7.53%	21.41%	8.24%	100.00%

Table A.3: CLN Autumn 2010 Academic Term, AM Period: 8 Trips, 419 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1		0.00%	0.00%	0.00%	0.00%	0.25%	0.00%	6.62%	2.21%	1.23%	1.47%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	11.76%
2			0.00%	0.00%	0.00%	0.25%	0.00%	4.41%	1.96%	0.49%	0.74%	0.00%	0.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	8.09%
3				0.00%	0.00%	0.25%	0.25%	17.40%	7.60%	4.90%	3.68%	0.74%	0.49%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	35.29%
4					0.00%	0.74%	0.00%	8.09%	1.23%	1.96%	1.23%	0.98%	0.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	14.46%
5						0.00%	0.00%	0.49%	0.49%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.98%
6							0.00%	2.45%	1.23%	0.74%	0.49%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.90%
7								0.00%	0.00%	0.49%	0.00%	0.00%	0.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.74%
8									0.74%	0.25%	2.21%	0.98%	1.23%	0.00%	0.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.64%
9										0.00%	0.00%	0.25%	0.74%	0.00%	0.25%	0.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.47%
10											0.74%	0.25%	0.49%	0.00%	0.25%	0.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.96%
11												0.74%	0.49%	0.49%	0.49%	0.74%	0.74%	0.00%	0.49%	0.49%	0.00%	0.25%	0.25%	5.15%
12													0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.25%	0.00%	0.25%
13														0.00%	0.00%	0.25%	0.49%	0.00%	1.23%	0.49%	0.00%	0.74%	0.00%	3.19%
14															0.00%	0.00%	0.25%	0.00%	0.74%	1.47%	0.00%	0.00%	0.25%	2.70%
15																0.00%	0.25%	0.00%	0.49%	0.00%	0.00%	0.00%	0.00%	0.74%
16																	0.00%	0.25%	0.00%	0.25%	0.00%	0.00%	0.00%	0.49%
17																		0.00%	0.98%	0.00%	0.00%	0.25%	0.00%	1.23%
18																			0.25%	0.00%	0.00%	0.00%	0.00%	0.25%
19																				0.00%	0.00%	0.74%	0.00%	0.74%
20																					0.00%	0.00%	0.00%	0.00%
21																						0.00%	0.00%	0.00%
22																							0.00%	0.00%
23																								0.00%
	0.00%	0.00%	0.00%	0.00%	0.00%	1.47%	0.25%	39.46%	15.44%	9.56%	11.03%	3.92%	4.17%	0.49%	1.23%	1.47%	1.72%	0.25%	4.17%	2.70%	0.00%	2.21%	0.49%	100.00%

Table A.4: CLN Autumn 2010 Academic Term, PM Period: 8 Trips, 506 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1		0.00%	0.00%	0.00%	0.00%	0.20%	0.00%	0.40%	0.00%	0.20%	0.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.20%
2			0.00%	0.00%	0.00%	0.00%	0.00%	0.80%	0.00%	0.00%	0.40%	0.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.40%
3				0.00%	0.00%	0.00%	0.00%	3.59%	1.00%	1.40%	0.80%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.79%
4					0.00%	0.00%	0.00%	2.59%	1.60%	1.00%	1.40%	0.40%	0.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.19%
5						0.20%	0.00%	0.40%	0.40%	0.80%	0.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.40%
6							0.00%	3.59%	1.20%	1.20%	1.80%	0.60%	0.40%	0.00%	0.00%	0.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	8.98%
7								0.00%	0.00%	0.80%	0.60%	0.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.60%
8									0.40%	0.60%	3.39%	0.40%	1.00%	0.40%	0.20%	0.40%	0.00%	0.00%	0.00%	0.20%	0.20%	0.20%	0.00%	7.39%
9										0.00%	3.59%	1.20%	0.80%	0.60%	0.00%	0.00%	0.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.79%
10											4.19%	1.40%	2.00%	0.60%	1.00%	0.40%	0.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	10.18%
11												0.20%	1.60%	0.60%	0.20%	0.00%	1.20%	0.20%	0.00%	0.40%	0.00%	0.80%	0.60%	5.79%
12													0.00%	0.00%	0.00%	0.20%	0.20%	0.00%	0.20%	0.00%	0.60%	0.20%		1.40%
13														0.00%	0.20%	1.40%	0.20%	0.40%	3.59%	0.60%	3.19%	2.79%		12.38%
14															0.00%	0.00%	0.60%	1.00%	2.00%	0.80%	2.99%	0.60%		7.98%
15																0.20%	0.00%	0.00%	1.00%	0.00%	1.20%	0.20%		2.59%
16																	0.20%	0.20%	0.60%	0.20%	0.60%	0.80%		2.59%
17																		0.40%	0.00%	2.20%	1.20%	3.19%	1.60%	8.58%
18																			0.00%	1.20%	0.00%	0.20%	0.00%	1.40%
19																				1.40%	0.00%	2.00%	0.00%	3.39%
20																					0.00%	0.00%	0.00%	0.00%
21																						0.00%	0.00%	0.00%
22																							0.00%	0.00%
23																								0.00%
	0.00%	0.00%	0.00%	0.00%	0.00%	0.40%	0.00%	11.38%	4.59%	5.99%	17.17%	4.39%	6.19%	2.20%	1.40%	1.20%	4.19%	1.80%	1.60%	12.77%	2.99%	14.97%	6.79%	100.00%

Table A.5: NE Autumn 2010 Academic Term, AM Period: 8 Trips, 423 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
1		0.00%	0.00%	0.00%	0.00%	0.24%	0.00%	1.66%	10.19%	1.18%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	13.27%
2			0.00%	0.00%	0.00%	0.47%	0.71%	1.18%	6.16%	1.42%	0.71%	0.71%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	11.37%
3				0.00%	0.00%	1.66%	0.47%	3.08%	18.96%	6.87%	1.42%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	32.46%
4					0.00%	1.18%	0.47%	2.84%	9.48%	3.08%	0.24%	0.24%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	17.77%
5						0.00%	0.24%	0.00%	0.95%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.42%
6							0.47%	0.47%	0.71%	0.71%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.37%
7								1.18%	1.42%	0.95%	0.24%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.03%
8									1.18%	0.71%	0.47%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.47%	0.47%	3.55%
9										0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.24%	1.18%	1.66%	3.08%
10											0.00%	0.00%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.24%
11												0.00%	0.24%	0.00%	1.18%	0.24%	0.47%	0.00%	0.00%	2.13%
12													0.00%	0.00%	3.32%	0.71%	0.47%	0.24%	0.24%	4.98%
13														0.00%	1.18%	0.24%	0.00%	0.95%	0.00%	2.37%
14															0.00%	0.24%	0.24%	0.24%	0.00%	0.71%
15																0.00%	0.00%	0.00%	0.24%	0.24%
16																	0.00%	0.00%	0.00%	0.00%
17																		0.00%	0.00%	0.00%
18																			0.00%	0.00%
19																				0.00%
	0.00%	0.00%	0.00%	0.00%	0.00%	3.55%	2.37%	10.43%	49.05%	15.17%	3.08%	1.42%	0.71%	0.00%	5.69%	1.42%	1.42%	3.08%	2.61%	100.00%

Table A.6: NE Autumn 2010 Academic Term, PM Period: 8 Trips, 348 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
1		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.29%	0.00%	0.00%	0.29%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.57%
2			0.29%	0.00%	0.00%	0.00%	0.00%	0.29%	0.00%	0.00%	0.29%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.86%
3				0.00%	0.00%	0.00%	0.29%	3.45%	0.29%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.02%
4					0.00%	0.29%	0.57%	0.57%	2.59%	0.57%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.60%
5						0.00%	0.00%	0.00%	0.86%	0.86%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.72%
6							0.00%	0.86%	2.01%	2.01%	0.86%	0.29%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.03%
7								0.00%	0.57%	0.29%	0.57%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.44%
8									0.00%	1.44%	0.00%	1.15%	0.00%	0.29%	0.57%	1.44%	0.86%	4.31%	2.59%	12.64%
9										0.29%	1.15%	0.57%	0.00%	1.44%	0.29%	6.03%	2.30%	10.34%	3.74%	26.15%
10											0.00%	0.00%	0.00%	0.57%	0.00%	0.86%	1.15%	1.44%	0.29%	4.31%
11												0.00%	0.29%	0.86%	0.00%	2.01%	1.15%	4.60%	4.02%	12.93%
12													0.00%	1.44%	0.86%	1.72%	1.72%	2.87%	0.57%	9.20%
13														0.00%	1.44%	5.46%	0.86%	4.89%	1.44%	14.08%
14															0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
15																0.86%	0.00%	0.29%	0.29%	1.44%
16																	0.00%	0.00%	0.00%	0.00%
17																		0.00%	0.00%	0.00%
18																			0.00%	0.00%
19																				0.00%
	0.00%	0.00%	0.29%	0.00%	0.00%	0.29%	0.57%	2.01%	9.77%	5.75%	2.87%	2.30%	0.29%	4.60%	3.16%	18.39%	8.05%	28.74%	12.93%	100.00%

Table A.7: CC Autumn 2010 Academic Term, AM Period: 8 Trips, 148 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1		0.00%	0.00%	1.35%	0.00%	4.05%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.41%
2			1.35%	5.41%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.76%
3				0.68%	2.70%	2.03%	2.03%	2.70%	0.00%	0.68%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	10.81%
4					0.00%	5.41%	2.03%	2.70%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	10.14%
5						1.35%	0.68%	4.73%	3.38%	0.68%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	10.81%
6							0.00%	2.70%	2.03%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.68%		5.41%
7								0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
8									0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
9										0.00%	0.00%	0.00%	1.35%	0.00%	0.00%	0.00%	0.00%	0.00%	1.35%
10											0.00%	0.00%	2.03%	0.00%	0.00%	0.00%	0.00%	0.00%	2.03%
11												0.00%	0.68%	7.43%	4.05%	0.00%	0.00%	0.00%	12.16%
12													0.00%	5.41%	0.68%	1.35%	0.00%	0.00%	7.43%
13														5.41%	8.11%	6.08%	2.03%	0.00%	21.62%
14															1.35%	2.03%	0.00%	0.00%	3.38%
15																0.68%	1.35%	0.68%	2.70%
16																	0.00%	0.00%	0.00%
17																		0.00%	0.00%
18																			0.00%
	0.00%	0.00%	1.35%	7.43%	2.70%	12.84%	4.73%	12.84%	5.41%	1.35%	0.00%	0.00%	4.05%	18.24%	14.19%	10.14%	3.38%	1.35%	100.00%

Table A.8: CC Autumn 2010 Academic Term, PM Period: 8 Trips, 203 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1		0.00%	0.00%	0.99%	0.00%	0.99%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.97%
2			2.46%	1.48%	0.00%	0.99%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.93%
3				1.97%	0.99%	3.45%	0.49%	3.45%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	10.34%
4					0.00%	6.40%	1.97%	2.46%	0.49%	0.49%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	11.82%
5						9.85%	0.99%	1.48%	0.00%	0.00%	0.49%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	12.81%
6							0.00%	0.00%	0.00%	0.49%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.49%
7								0.00%	0.49%	0.99%	0.00%	0.00%	0.00%	0.00%	0.00%	0.49%	0.00%	0.00%	1.97%
8									0.49%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.49%
9										0.00%	0.00%	0.99%	0.99%	0.49%	0.00%	0.00%	0.49%	0.00%	2.96%
10											0.00%	0.49%	0.99%	1.97%	0.99%	0.49%	0.00%	0.00%	4.93%
11												0.49%	1.97%	3.45%	4.93%	1.48%	0.99%	0.49%	13.79%
12													0.49%	0.99%	0.00%	0.99%	0.00%	0.00%	2.46%
13														3.94%	7.88%	3.94%	4.43%	0.00%	20.20%
14															0.49%	1.97%	0.99%	2.46%	5.91%
15																0.99%	1.48%	0.49%	2.96%
16																	0.49%	1.48%	1.97%
17																		0.00%	0.00%
18																			0.00%
	0.00%	0.00%	2.46%	4.43%	0.99%	21.67%	3.45%	7.39%	1.48%	1.97%	0.49%	1.97%	4.43%	10.84%	14.29%	10.34%	8.87%	4.93%	100.00%

Table A.9: CLS Winter 2011 Academic Term, AM Period: 4 Trips, 166 Total Passengers

	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		0.00%	0.00%	0.00%	0.00%	0.00%	0.60%	0.00%	1.20%	0.00%	0.60%	0.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.01%
2			0.00%	0.00%	0.00%	0.60%	0.60%	0.60%	0.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.41%
3				0.00%	0.00%	0.00%	0.00%	0.60%	1.20%	2.41%	0.00%	0.60%	3.61%	0.60%	1.81%	1.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	12.05%
4					0.00%	3.61%	3.61%	0.60%	7.23%	0.60%	1.20%	1.81%	3.61%	0.00%	0.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	22.89%
5						0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
6							0.00%	0.60%	0.60%	0.00%	0.00%	0.60%	1.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.01%
7								0.00%	0.00%	0.60%	0.00%	0.00%	0.00%	0.60%	0.00%	1.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.41%
8									0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.60%
9										0.00%	0.00%	0.00%	0.60%	0.00%	0.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.20%
10											0.00%	0.00%	0.00%	0.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.60%
11												0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
12													0.60%	0.00%	0.00%	1.81%	1.20%	1.81%	0.00%	1.20%	0.00%	0.00%	0.00%	0.00%	6.63%
13														0.60%	0.00%	1.20%	4.22%	0.60%	0.60%	1.20%	0.00%	0.00%	1.20%	0.00%	9.64%
14															0.60%	1.20%	3.61%	1.20%	0.00%	1.20%	0.60%	0.00%	0.00%	0.60%	9.04%
15																5.42%	4.22%	4.82%	0.00%	2.41%	0.60%	0.00%	0.00%	0.60%	18.07%
16																	0.00%	0.00%	0.00%	0.60%	0.00%	0.00%	0.00%	0.00%	0.60%
17																		0.00%	0.00%	1.81%	0.60%	0.00%	0.00%	0.00%	2.41%
18																			0.00%	1.81%	0.00%	0.60%	1.20%	0.60%	4.22%
19																				0.60%	0.00%	0.00%	0.00%	0.00%	0.60%
20																					0.00%	0.00%	0.00%	0.00%	0.00%
21																						0.00%	0.00%	0.00%	0.00%
22																							0.00%	0.60%	0.60%
23																								0.00%	0.00%
24																									0.00%
	0.00%	0.00%	0.00%	0.00%	0.00%	4.22%	4.82%	2.41%	10.84%	3.61%	1.81%	3.61%	10.24%	1.81%	5.42%	10.84%	13.25%	8.43%	0.60%	10.84%	1.81%	0.60%	1.20%	3.61%	100.00%

Table A.10: CLS Winter 2011 Academic Term, PM Period: 6 Trips, 406 Total Passengers

	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		0.00%	0.00%	0.00%	0.00%	0.50%	0.00%	0.00%	0.00%	0.00%	0.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.75%
2			0.00%	0.00%	0.00%	0.00%	0.00%	0.25%	0.00%	0.00%	0.25%	0.00%	0.00%	0.00%	0.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.00%
3				0.00%	0.00%	0.25%	0.00%	0.25%	0.00%	0.00%	0.25%	0.25%	0.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.25%
4					0.00%	0.25%	0.75%	0.75%	0.25%	0.00%	0.75%	0.25%	0.25%	0.00%	0.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.74%
5						0.25%	0.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.50%	0.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.25%
6							0.25%	0.00%	0.25%	0.00%	0.00%	0.75%	0.50%	1.25%	0.75%	0.25%	0.00%	0.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.24%
7								0.00%	0.00%	0.25%	0.25%	0.50%	0.50%	0.00%	0.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.00%
8									0.00%	0.00%	0.25%	0.50%	0.25%	1.00%	2.49%	0.75%	0.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.49%
9										0.00%	0.00%	0.00%	0.00%	0.50%	0.50%	1.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.00%
10											0.00%	0.25%	0.25%	0.00%	0.00%	0.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.00%
11												0.00%	0.00%	0.25%	1.00%	0.50%	0.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.00%
12													0.00%	0.25%	0.25%	2.49%	1.00%	1.00%	0.00%	0.00%	0.50%	0.00%	0.00%	0.25%	5.74%
13														0.25%	2.49%	2.99%	2.24%	1.00%	0.25%	0.25%	0.50%	0.00%	1.50%	0.25%	11.72%
14															0.00%	1.75%	0.75%	0.00%	0.75%	0.00%	0.00%	0.00%	0.00%	0.00%	3.99%
15																0.75%	2.99%	0.75%	0.25%	2.00%	2.00%	1.00%	4.49%	0.75%	14.96%
16																	0.00%	1.00%	1.00%	2.24%	2.49%	1.25%	5.49%	2.24%	15.71%
17																		0.00%	0.25%	0.75%	2.74%	1.00%	2.24%	1.50%	8.48%
18																			0.00%	2.00%	1.50%	1.25%	4.49%	1.50%	10.72%
19																				0.00%	0.50%	0.75%	0.75%	0.25%	2.24%
20																					0.25%	0.50%	0.25%	0.75%	1.75%
21																						0.00%	0.00%	0.00%	0.00%
22																							0.00%	0.00%	0.00%
23																								0.00%	0.00%
24																									0.00%
	0.00%	0.00%	0.00%	0.00%	0.00%	1.25%	1.25%	1.25%	0.50%	0.25%	2.00%	2.49%	2.49%	3.74%	8.98%	10.47%	7.98%	4.74%	1.75%	7.98%	10.47%	5.74%	19.20%	7.48%	100.00%

Table A.11: CLN Winter 2011 Academic Term, AM Period: 6 Trips, 248 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
1		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.48%	0.81%	1.21%	0.40%	0.00%	0.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	9.31%
2			0.00%	0.00%	0.00%	0.00%	0.00%	2.02%	0.40%	0.40%	0.40%	0.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.64%
3				0.40%	0.00%	4.05%	0.00%	13.77%	6.88%	2.43%	3.24%	2.02%	1.62%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	34.41%
4					0.00%	2.43%	0.00%	6.88%	2.02%	2.83%	1.62%	0.40%	0.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	16.19%
5						0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.40%	0.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.81%
6							0.00%	4.05%	2.02%	0.40%	0.81%	0.00%	0.00%	0.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.69%
7								0.40%	0.40%	0.81%	0.81%	0.40%	0.40%	0.40%	0.00%	0.00%	0.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.05%
8									0.00%	1.62%	0.40%	0.40%	0.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.83%
9										0.00%	1.21%	0.81%	2.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.05%
10											2.02%	0.81%	0.81%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.64%
11												0.00%	2.02%	0.81%	0.40%	0.40%	0.81%	0.40%	0.00%	0.40%	0.00%	0.81%	0.00%	6.07%
12													0.00%	0.00%	0.00%	0.00%	0.00%	0.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.40%
13														0.40%	0.00%	0.00%	0.00%	0.00%	1.21%	1.21%	0.00%	0.40%	0.40%	3.64%
14															0.00%	0.00%	0.00%	0.00%	0.40%	0.00%	0.00%	0.00%	0.00%	0.40%
15																0.00%	0.40%	0.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.81%
16																	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
17																		0.00%	0.00%	0.81%	0.00%	0.00%	0.00%	0.81%
18																			0.40%	0.00%	0.00%	0.00%	0.00%	0.40%
19																				0.81%	0.00%	0.00%	0.00%	0.81%
20																					0.00%	0.00%	0.00%	0.00%
21																						0.00%	0.00%	0.00%
22																							0.00%	0.00%
23																								0.00%
	0.00%	0.00%	0.00%	0.40%	0.00%	6.48%	0.00%	33.60%	12.55%	9.72%	10.93%	5.67%	8.10%	2.02%	0.40%	0.40%	1.62%	0.81%	2.43%	3.24%	0.00%	1.21%	0.40%	100.00%

Table A.12: CLN Winter 2011 Academic Term, PM Period: 6 Trips, 393 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
1		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.52%	0.77%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.29%
2			0.00%	0.00%	0.00%	0.00%	0.00%	0.52%	0.52%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.03%
3				0.00%	0.00%	0.00%	0.00%	3.61%	1.03%	0.52%	0.26%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.41%
4					0.26%	0.00%	0.00%	1.80%	0.52%	0.52%	0.26%	0.00%	0.52%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.87%
5						0.00%	0.26%	0.26%	0.00%	0.77%	0.52%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.80%
6							0.26%	3.35%	3.35%	1.29%	2.58%	0.00%	0.26%	0.00%	0.00%	0.26%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	11.34%
7								0.26%	0.00%	0.77%	0.26%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.29%
8									0.26%	0.77%	3.09%	0.77%	1.55%	0.77%	0.00%	0.00%	0.26%	0.00%	0.00%	0.26%	0.00%	0.26%	0.00%	7.99%
9										0.00%	3.35%	2.32%	0.77%	0.26%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.26%	6.96%
10											4.90%	0.52%	3.87%	0.77%	0.52%	0.52%	0.77%	0.00%	0.00%	0.00%	0.77%	0.26%	0.26%	13.14%
11												0.00%	2.32%	1.03%	0.00%	0.52%	3.61%	0.52%	0.00%	0.77%	0.00%	2.84%	0.52%	12.11%
12													0.00%	0.26%	0.00%	0.26%	0.00%	0.26%	0.26%	0.00%	0.26%	0.26%	0.26%	1.55%
13														0.52%	0.00%	0.00%	2.32%	0.77%	1.55%	0.52%	0.00%	3.61%	2.58%	11.86%
14															0.00%	0.26%	0.00%	1.29%	0.26%	0.52%	0.00%	1.80%	0.52%	4.64%
15																0.00%	0.00%	0.26%	0.26%	0.52%	0.00%	0.52%	0.26%	1.80%
16																	0.00%	0.00%	0.00%	1.03%	0.00%	0.77%	0.00%	1.80%
17																		0.52%	0.26%	1.80%	1.03%	1.80%	2.58%	7.99%
18																			0.26%	0.77%	0.26%	0.77%	0.26%	2.32%
19																				1.55%	0.26%	0.00%	0.00%	1.80%
20																					0.00%	0.00%	0.00%	0.00%
21																						0.00%	0.00%	0.00%
22																							0.00%	0.00%
23																								0.00%
	0.00%	0.00%	0.00%	0.00%	0.26%	0.00%	0.52%	10.31%	6.44%	4.64%	15.21%	3.61%	9.28%	3.61%	0.52%	1.29%	7.47%	3.35%	2.84%	7.99%	2.32%	12.89%	7.47%	100.00%

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Table A.13: NE Winter 2011 Academic Term, AM Period: 4 Trips, 228 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
1		0.00%	0.00%	0.00%	0.00%	0.88%	0.00%	1.32%	4.85%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.05%
2			0.00%	0.00%	0.00%	0.00%	0.44%	4.85%	0.44%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.73%
3				0.00%	0.00%	1.76%	0.00%	3.52%	22.91%	2.20%	0.88%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	31.28%
4					0.00%	1.32%	0.44%	3.08%	11.01%	2.20%	0.88%	0.44%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	19.38%
5						0.00%	0.00%	0.00%	0.44%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.44%
6							0.00%	0.44%	1.32%	0.00%	0.00%	0.00%	0.44%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.20%
7								0.00%	1.76%	1.32%	0.44%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.52%
8									1.76%	0.44%	0.00%	0.00%	0.00%	0.00%	0.00%	0.44%	0.00%	0.00%	0.00%	2.64%
9										0.00%	0.00%	1.76%	1.32%	0.00%	0.00%	0.00%	0.00%	0.88%	0.00%	3.96%
10											0.00%	0.00%	0.00%	0.00%	0.00%	0.44%	0.00%	0.44%	0.00%	0.88%
11												0.00%	1.32%	0.00%	5.29%	0.44%	0.00%	1.32%	0.00%	8.37%
12													0.44%	0.00%	3.08%	2.64%	0.88%	0.00%	0.00%	7.05%
13														0.00%	2.64%	1.32%	0.00%	0.44%	0.00%	4.41%
14															0.00%	0.88%	0.00%	0.00%	0.00%	0.88%
15																1.32%	0.88%	0.00%	0.00%	2.20%
16																	0.00%	0.00%	0.00%	0.00%
17																		0.00%	0.00%	0.00%
18																			0.00%	0.00%
19																				0.00%
	0.00%	0.00%	0.00%	0.00%	0.00%	3.96%	0.44%	8.81%	48.90%	6.61%	2.20%	2.20%	3.52%	0.00%	11.01%	7.49%	1.76%	3.08%	0.00%	100.00%

Table A.14: NE Winter 2011 Academic Term, PM Period: 6 Trips, 428 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
1		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.70%	1.17%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.87%
2			0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.70%	0.00%	0.00%	0.23%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.94%
3				0.00%	0.00%	0.23%	0.23%	0.70%	4.92%	1.17%	0.23%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.49%
4					0.00%	0.00%	0.70%	0.47%	4.22%	1.17%	1.17%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.73%
5						0.00%	0.00%	0.23%	0.00%	0.23%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.47%
6							0.47%	2.11%	3.04%	1.64%	2.11%	0.23%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	9.60%
7								0.23%	1.87%	0.00%	0.47%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.58%
8									1.41%	0.70%	0.47%	0.70%	0.23%	0.00%	0.23%	1.64%	0.94%	6.79%	2.58%	15.69%
9										0.23%	0.00%	0.00%	0.70%	1.41%	0.47%	6.09%	1.64%	11.24%	6.09%	27.87%
10											0.23%	0.00%	0.00%	0.23%	0.23%	1.17%	0.00%	0.23%	0.00%	2.11%
11												0.47%	0.23%	0.94%	0.94%	1.64%	0.47%	1.41%	1.64%	7.73%
12													0.23%	0.47%	1.17%	1.17%	0.47%	1.17%	0.00%	4.68%
13														0.47%	1.17%	1.17%	0.70%	2.81%	1.64%	7.96%
14															0.00%	1.17%	0.00%	0.00%	0.23%	1.41%
15																0.23%	0.47%	0.70%	0.47%	1.87%
16																	0.00%	0.00%	0.00%	0.00%
17																		0.00%	0.00%	0.00%
18																			0.00%	0.00%
19																				0.00%
	0.00%	0.00%	0.00%	0.00%	0.00%	0.23%	1.41%	4.22%	17.56%	4.92%	4.92%	1.64%	1.41%	3.51%	4.22%	14.29%	4.68%	24.36%	12.65%	100.00%

Table A.15: CC Winter 2011 Academic Term, AM Period: 4 Trips, 111 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1		0.00%	0.00%	0.00%	0.00%	0.00%	0.90%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.90%
2			4.50%	7.21%	0.90%	0.00%	0.00%	0.00%	0.90%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	13.51%
3				0.00%	0.90%	0.00%	0.90%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.80%
4					1.80%	1.80%	1.80%	2.70%	2.70%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	10.81%
5						1.80%	0.90%	1.80%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.50%
6							0.00%	3.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.60%
7								0.00%	0.00%	0.90%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.90%
8									0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
9										0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
10											0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
11												0.00%	0.00%	6.31%	0.00%	0.90%	0.90%	0.00%	8.11%
12													0.00%	1.80%	4.50%	2.70%	1.80%	0.00%	10.81%
13														6.31%	10.81%	5.41%	5.41%	0.00%	27.93%
14															0.00%	0.90%	0.90%	0.00%	1.80%
15																0.00%	14.41%	0.00%	14.41%
16																	0.90%	0.00%	0.90%
17																		0.00%	0.00%
18																			0.00%
	0.00%	0.00%	4.50%	7.21%	2.70%	4.50%	3.60%	9.01%	2.70%	1.80%	0.00%	0.00%	0.00%	14.41%	15.32%	9.91%	24.32%	0.00%	100.00%

Table A.16: CC Winter 2011 Academic Term, PM Period: 6 Trips, 201 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1		0.00%	1.00%	0.50%	0.50%	1.49%	0.00%	0.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.98%
2			1.99%	2.99%	1.99%	1.99%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	8.96%
3				1.00%	1.00%	3.48%	0.50%	1.00%	0.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.46%
4					0.00%	1.49%	1.49%	2.49%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.47%
5						9.45%	1.49%	1.99%	0.00%	0.00%	0.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	13.43%
6							0.00%	1.99%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.50%	0.00%	0.00%	2.49%
7								0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
8									0.00%	0.00%	0.00%	0.00%	0.50%	0.00%	0.50%	0.00%	0.00%	0.00%	1.00%
9										0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
10											0.00%	0.50%	3.98%	3.48%	0.00%	0.00%	0.00%	0.00%	7.96%
11												0.50%	1.99%	8.46%	3.48%	1.00%	0.50%	0.50%	16.42%
12													0.00%	1.00%	3.48%	1.99%	0.00%	0.00%	6.47%
13														5.97%	4.48%	1.00%	1.49%	0.00%	12.94%
14															1.00%	1.99%	3.98%	1.00%	7.96%
15																2.49%	1.00%	0.00%	3.48%
16																	1.00%	1.00%	1.99%
17																		0.00%	0.00%
18																			0.00%
	0.00%	0.00%	2.99%	4.48%	3.48%	17.91%	3.48%	7.96%	0.50%	0.00%	0.50%	1.00%	6.47%	18.91%	12.94%	8.46%	8.46%	2.49%	100.00%

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Table A.17: ER Winter 2011 Academic Term, AM Period: 3 Trips, 104 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	
1		1.87%	0.00%	0.00%	0.00%	0.00%	0.93%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.74%
2			0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3				0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%
4					0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%
5						0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
6							0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%
7								0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
8									0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
9										0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
10											0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
11												0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
12													0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%	0.00%	1.87%	0.93%	0.00%	0.00%	3.74%
13														0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.87%	0.00%	0.00%	0.00%	0.00%	0.00%	1.87%
14															0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.80%	0.00%	0.00%	0.00%	0.00%	0.00%	2.80%
15																0.00%	0.00%	0.93%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%	0.00%	0.00%	0.00%	0.00%	0.00%	1.87%
16																	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%	11.21%	0.00%	1.87%	0.00%	0.93%	0.00%	14.95%
17																		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.74%	0.93%	0.00%	0.00%	0.00%	0.00%	4.67%
18																			0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	8.41%	1.87%	2.80%	3.74%	0.93%	0.00%	17.76%
19																				0.00%	0.00%	0.00%	0.00%	0.00%	0.93%	0.00%	0.00%	0.00%	1.87%	1.87%	0.00%	0.00%	0.00%	0.00%	0.00%	4.67%
20																					0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.80%	0.93%	1.87%	0.00%	0.00%	0.00%	5.61%
21																						0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%	0.00%	0.00%	0.00%	0.00%	0.93%
22																							0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.87%	0.00%	0.00%	0.00%	0.00%	0.00%	1.87%
23																								0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.87%	0.93%	0.93%	0.93%	0.00%	0.00%	4.67%
24																									0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%	0.00%	0.93%	0.93%	0.00%	0.00%	2.80%
25																										0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.87%	3.74%	0.00%	0.00%	0.00%	6.54%
26																											0.00%	0.00%	0.00%	0.00%	0.00%	0.93%	1.87%	0.93%	0.00%	0.00%	3.74%
27																												0.00%	0.93%	0.00%	0.00%	1.87%	2.80%	0.00%	0.00%	5.61%
28																													0.00%	0.00%	0.00%	0.93%	0.00%	0.00%	0.00%	0.93%
29																														0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
30																															2.80%	4.67%	0.93%	0.00%	0.00%	8.41%
31																																0.00%	0.00%	0.00%	0.00%	0.00%
32																																	0.00%	0.00%	0.00%	0.00%
33																																		0.00%	0.00%	0.00%
34																																			0.00%	0.00%
35																																				0.00%
	0.00%	1.87%	0.00%	0.00%	0.00%	0.00%	0.93%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%	0.00%	0.00%	0.00%	2.80%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%	0.00%	2.80%	36.45%	13.08%	20.56%	16.82%	2.80%	0.00%	100.00%

Table A.18: ER Winter 2011 Academic Term, PM Period: 5 Trips, 288 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	
1		0.69%	0.69%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.35%	0.69%	0.69%	0.35%	0.00%	0.00%	0.00%	0.69%	1.04%	0.69%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.90%
2			0.00%	0.00%	0.35%	1.39%	0.00%	0.00%	0.35%	0.35%	1.74%	1.04%	1.74%	1.39%	0.35%	1.39%	0.69%	1.04%	1.39%	0.35%	0.35%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	14.93%
3				0.00%	0.00%	5.90%	0.35%	0.00%	1.74%	0.35%	0.35%	0.69%	1.04%	3.13%	0.00%	1.39%	0.69%	1.39%	1.04%	1.04%	0.00%	0.69%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	19.79%
4					0.00%	2.78%	0.00%	0.35%	0.35%	1.04%	0.00%	1.39%	0.69%	2.43%	0.35%	1.39%	1.04%	0.69%	0.35%	1.39%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	14.24%
5						1.39%	0.00%	0.00%	0.00%	0.69%	0.35%	0.35%	0.35%	1.04%	0.00%	1.04%	0.35%	0.00%	0.35%	0.35%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.25%
6							0.00%	0.35%	0.35%	0.35%	1.04%	1.74%	1.74%	3.47%	0.35%	0.35%	1.04%	0.00%	0.69%	0.00%	1.74%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	13.19%
7								0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
8									0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
9										0.00%	0.00%	0.35%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.35%
10											0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
11												0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.35%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.35%
12													0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.35%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.35%
13														0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
14															0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
15																0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.35%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.35%
16																	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.69%	1.04%	0.00%	0.00%	0.00%	0.00%	1.74%
17																		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.39%	0.00%	0.00%	0.00%	1.39%
18																			0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.69%	1.04%	0.00%	0.00%	0.00%	0.00%	0.00%	1.74%
19																				0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.35%	0.00%	0.00%	0.69%	0.35%	0.00%	1.39%
20																					0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.04%	0.00%	0.00%	0.35%	0.00%	0.00%	1.39%
21																						0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.35%	0.00%	0.00%	0.35%
22																							0.00%	0.00%	0.35%	0.35%	0.00%	0.00%	0.35%	0.00%	0.00%	0.69%	0.00%	0.00%	0.00%	1.74%
23																								0.00%	0.69%	0.00%	0.35%	0.00%	1.04%	0.69%	0.35%	0.35%	0.00%	0.00%	0.00%	3.47%
24																									0.00%	0.00%	0.00%	0.00%	0.00%	0.35%	0.69%	0.35%	0.00%	0.00%	0.00%	2.08%
25																										0.00%	0.00%	0.00%	0.00%	1.39%	0.00%	0.00%	0.00%	0.00%	0.00%	1.39%
26																											0.00%	0.00%	0.69%	0.35%	0.00%	0.35%	0.69%	0.00%	0.00%	2.08%
27																												0.00%	0.00%	0.00%	0.69%	0.00%	0.00%	0.35%	0.00%	1.04%
28																													0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
29																														0.69%	0.00%	0.00%	0.00%	0.35%	0.00%	0.00%	1.04%
30																															2.08%	1.39%	0.00%	0.00%	0.00%	0.00%	3.47%
31																																0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
32																																	0.00%	0.00%	0.00%	0.00%	0.00%
33																																		0.00%	0.00%	0.00%	0.00%
34																																			0.00%	0.00%	0.00%
35																																				0.00%
	0.00%	0.69%	0.69%	0.00%	0.35%	11.46%	0.35%	0.69%	2.78%	2.78%	3.82%	6.25%	6.25%	11.81%	1.04%	5.56%	3.82%	3.82%	4.17%	5.21%	2.43%	1.04%	0.00%	0.00%	0.69%	0.00%	0.69%	1.04%	3.47%	2.08%	6.25%	4.51%	3.47%	2.78%	0.00%	100.00%

Table A.19: CLS Spring 2011 Academic Term, AM Period: 4 Trips, 241 Total Passengers

	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		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.42%	0.00%	0.00%	0.42%	0.00%	0.42%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.25%
2			0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.42%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.83%
3				0.00%	0.42%	0.42%	2.50%	5.42%	1.25%	0.42%	2.50%	3.33%	0.83%	0.83%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	17.92%
4					0.42%	1.25%	0.83%	1.67%	10.42%	0.83%	0.42%	0.83%	1.25%	0.00%	1.25%	0.83%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	20.00%
5						0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.42%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.42%
6							0.42%	0.00%	0.00%	0.00%	1.25%	3.33%	3.33%	0.42%	0.42%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	9.17%
7								0.42%	0.83%	0.00%	0.00%	0.42%	0.42%	0.42%	0.42%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.33%
8									0.00%	0.42%	0.00%	0.00%	0.42%	0.00%	0.42%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.25%
9										0.00%	0.00%	0.00%	0.00%	0.00%	0.42%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.42%
10											0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
11												0.00%	0.00%	0.00%	0.42%	0.00%	0.00%	0.42%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.83%
12													0.00%	0.00%	0.00%	2.08%	0.42%	1.25%	0.00%	0.42%	0.00%	0.00%	0.00%	0.00%	4.17%
13														0.00%	1.67%	2.08%	0.42%	0.42%	0.00%	2.08%	0.42%	0.00%	0.00%	0.00%	7.08%
14															0.00%	2.92%	1.67%	0.83%	0.00%	2.08%	1.67%	0.00%	0.00%	0.00%	9.17%
15																4.17%	2.08%	2.50%	0.83%	4.58%	0.42%	0.42%	0.00%	0.42%	15.42%
16																	0.00%	0.00%	0.00%	0.42%	0.83%	0.00%	0.00%	0.00%	1.25%
17																		0.00%	0.00%	1.25%	0.42%	0.00%	0.00%	0.00%	1.67%
18																			0.00%	1.25%	0.42%	0.42%	0.42%	0.00%	2.50%
19																				1.25%	0.00%	0.00%	0.00%	0.00%	1.25%
20																					1.67%	0.00%	0.42%	0.00%	2.08%
21																						0.00%	0.00%	0.00%	0.00%
22																							0.00%	0.00%	0.00%
23																								0.00%	0.00%
24																									0.00%
	0.00%	0.00%	0.00%	0.00%	0.42%	2.08%	1.67%	5.00%	16.67%	2.50%	2.50%	7.50%	10.00%	1.67%	5.00%	12.92%	4.58%	5.42%	0.83%	13.33%	5.83%	0.83%	0.83%	0.42%	100.00%

Table A.20: CLS Spring 2011 Academic Term, MID Period: 12 Trips, 655 Total Passengers

	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		0.00%	0.00%	0.15%	0.00%	0.31%	0.00%	0.00%	0.15%	0.00%	0.00%	0.00%	0.46%	0.00%	0.46%	0.15%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.70%
2			0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.15%	0.62%	0.15%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%
3				0.00%	0.00%	0.46%	0.31%	0.15%	1.08%	0.31%	0.15%	1.08%	1.39%	0.15%	0.62%	0.15%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.88%
4					0.00%	0.46%	0.15%	0.77%	1.55%	0.00%	0.77%	0.77%	1.70%	0.00%	0.93%	0.31%	0.15%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.59%
5						0.31%	0.00%	0.15%	0.00%	0.00%	0.00%	0.62%	0.00%	0.00%	0.15%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.15%	1.24%
6							0.00%	0.15%	0.62%	0.00%	0.62%	1.86%	1.39%	0.77%	0.93%	0.00%	0.15%	0.00%	0.00%	0.00%	0.00%	0.15%	0.00%	0.00%	6.66%
7								0.00%	0.31%	0.15%	0.00%	0.46%	0.62%	0.15%	0.31%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.01%
8									0.15%	0.31%	0.00%	0.77%	0.00%	0.31%	1.24%	0.15%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.94%
9										0.00%	0.00%	0.00%	0.00%	0.00%	0.15%	0.31%	0.15%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.62%
10											0.00%	0.15%	0.15%	0.46%	0.62%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.15%	0.00%	1.55%
11												0.00%	0.00%	0.00%	0.31%	0.31%	0.15%	0.46%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.24%
12													0.00%	0.31%	0.31%	2.32%	2.17%	0.77%	0.31%	0.15%	0.15%	0.15%	0.31%	0.00%	6.97%
13														0.00%	0.93%	1.55%	0.93%	0.46%	0.31%	0.77%	0.46%	0.15%	0.46%	0.31%	6.35%
14															0.15%	1.24%	1.24%	0.46%	0.00%	0.46%	0.15%				4.33%
15																4.80%	2.63%	2.79%	0.00%	4.02%	1.24%	0.31%	1.24%	1.55%	18.58%
16																	0.00%	1.24%	0.62%	2.48%	1.86%	0.77%	2.48%	0.77%	10.22%
17																		0.00%	0.46%	2.94%	1.86%	0.31%	0.93%	0.46%	6.97%
18																			0.00%	5.26%	1.70%	0.62%	2.94%	1.39%	11.92%
19																				0.00%	0.15%	0.00%	0.00%	0.00%	0.15%
20																					0.62%	0.00%	1.08%	0.46%	2.17%
21																						0.00%	0.00%	0.00%	0.00%
22																							0.00%	0.00%	0.00%
23																								0.00%	0.00%
24																									0.00%
	0.00%	0.00%	0.00%	0.15%	0.00%	1.55%	0.46%	1.24%	3.87%	0.77%	1.55%	5.88%	6.35%	1.86%	6.97%	11.92%	7.59%	6.19%	1.70%	16.25%	8.05%	2.48%	9.91%	5.26%	100.00%

Table A.21: CLS Spring 2011 Academic Term, PM Period: 6 Trips, 315 Total Passengers

	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		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.32%	0.32%	0.00%	0.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.97%
2			0.00%	0.00%	0.32%	0.00%	0.00%	0.00%	0.32%	0.00%	0.00%	0.65%	0.00%	0.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.61%
3				0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.32%	0.65%	0.65%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.61%
4					0.00%	0.32%	0.00%	0.32%	0.97%	0.00%	0.00%	0.00%	0.32%	0.00%	0.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.26%
5						0.00%	0.65%	0.32%	0.00%	0.00%	0.00%	0.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.29%
6							0.00%	0.00%	0.00%	0.00%	0.32%	0.65%	0.32%	0.00%	1.61%	0.32%	0.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.55%
7								0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.32%
8									0.00%	0.00%	0.00%	0.32%	0.00%	0.32%	3.87%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.52%
9										0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.32%	0.65%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.97%
10											0.00%	0.00%	0.00%	0.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.32%
11												0.32%	0.00%	0.00%	0.00%	0.32%	0.32%	0.65%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.61%
12													0.00%	0.00%	0.00%	2.26%	0.65%	0.00%	0.97%	0.00%	0.00%	0.00%	0.00%	0.32%	4.19%
13														0.00%	0.65%	3.23%	2.58%	0.97%	0.00%	1.29%	3.23%	0.65%	0.65%	0.32%	13.55%
14															0.00%	2.58%	0.97%	2.26%	0.65%	0.00%	1.61%	0.00%	0.65%	0.32%	9.03%
15																3.23%	4.52%	1.94%	1.94%	0.65%	5.81%	0.32%	1.94%	0.00%	20.32%
16																	0.32%	0.65%	1.29%	1.29%	3.87%	2.26%	2.58%	2.26%	14.52%
17																		0.32%	0.32%	1.61%	1.61%	0.97%	0.32%		4.84%
18																			0.65%	0.32%	3.55%	1.29%	4.84%	1.29%	11.94%
19																				0.00%	0.65%	0.00%	0.00%	0.32%	0.97%
20																					0.32%	0.65%	0.65%	0.00%	1.61%
21																						0.00%	0.00%	0.00%	0.00%
22																							0.00%	0.00%	0.00%
23																								0.00%	0.00%
24																									0.00%
	0.00%	0.00%	0.00%	0.00%	0.32%	0.32%	0.65%	0.65%	1.29%	0.00%	0.65%	2.90%	1.29%	1.94%	6.77%	12.26%	10.32%	6.77%	5.48%	3.55%	20.65%	6.77%	12.26%	5.16%	100.00%

Table A.22: CLN Spring 2011 Academic Term, AM Period: 2 Trips, 90 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
1		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.44%	0.00%	1.11%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.56%
2			0.00%	0.00%	0.00%	0.00%	0.00%	2.22%	1.11%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.33%
3				0.00%	0.00%	2.22%	0.00%	7.78%	7.78%	1.11%	3.33%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	22.22%
4					0.00%	2.22%	0.00%	12.22%	3.33%	1.11%	2.22%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	21.11%
5						0.00%	0.00%	1.11%	0.00%	0.00%	0.00%	0.00%	0.00%	1.11%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.22%
6							0.00%	2.22%	3.33%	2.22%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.78%
7								1.11%	0.00%	4.44%	2.22%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.78%
8									0.00%	1.11%	5.56%	1.11%	1.11%	1.11%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	10.00%
9										0.00%	0.00%	2.22%	2.22%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.44%
10											2.22%	1.11%	1.11%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.44%
11												0.00%	0.00%	1.11%	0.00%	0.00%	1.11%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.22%
12													0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
13														0.00%	0.00%	0.00%	2.22%	0.00%	0.00%	1.11%	0.00%	0.00%	1.11%	4.44%
14															0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
15																0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
16																	0.00%	1.11%	0.00%	0.00%	0.00%	0.00%	0.00%	1.11%
17																		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
18																			0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
19																				1.11%	0.00%	1.11%	1.11%	3.33%
20																					0.00%	0.00%	0.00%	0.00%
21																						0.00%	0.00%	0.00%
22																							0.00%	0.00%
23																								0.00%
	0.00%	0.00%	0.00%	0.00%	0.00%	4.44%	0.00%	31.11%	15.56%	11.11%	15.56%	4.44%	4.44%	3.33%	0.00%	0.00%	3.33%	1.11%	0.00%	2.22%	0.00%	1.11%	2.22%	100.00%

Table A.23: CLN Spring 2011 Academic Term, MID Period: 14 Trips, 633 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
1		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.43%	0.63%	0.32%	0.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.70%
2			0.00%	0.00%	0.00%	0.16%	1.27%	0.32%	0.16%	0.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.22%
3				0.00%	0.00%	0.48%	0.00%	6.03%	1.27%	2.86%	1.43%	0.79%	0.48%	0.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	13.65%
4					0.00%	1.11%	0.32%	9.05%	1.75%	2.70%	3.17%	0.79%	0.16%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	19.05%
5						0.00%	0.00%	0.95%	0.00%	0.16%	0.16%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.27%
6							0.32%	5.08%	2.86%	1.11%	3.81%	0.63%	0.48%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	14.29%
7								0.16%	0.16%	0.48%	0.16%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.95%
8									1.27%	0.95%	1.59%	0.32%	1.43%	0.16%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.71%
9										0.32%	0.95%	0.63%	1.75%	0.79%	0.00%	0.16%	0.16%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.76%
10											3.33%	0.32%	3.02%	2.54%	0.32%	0.00%	0.48%	0.00%	0.00%	0.16%	0.00%	0.00%	0.16%	10.32%
11												0.32%	2.06%	1.11%	0.00%	0.00%	0.95%	0.00%	0.95%	0.16%	0.00%	0.16%	0.63%	6.35%
12													0.00%	0.00%	0.16%	0.00%	0.48%	0.00%	0.00%	0.16%	0.00%	0.00%	0.16%	0.95%
13														0.00%	0.48%	0.16%	0.79%	0.63%	0.16%	1.27%	0.95%	1.11%	0.32%	5.87%
14															0.00%	0.00%	0.16%	0.16%	0.79%	0.48%	0.00%	0.16%	0.63%	2.38%
15																0.00%	0.00%	0.00%	0.00%	0.48%	0.00%	0.16%	0.16%	0.79%
16																	0.16%	0.00%	0.16%	0.32%	0.00%	0.32%	0.00%	0.95%
17																		0.16%	0.16%	0.63%	0.63%	0.79%	0.16%	2.54%
18																			0.63%	1.27%	0.00%	0.00%	0.00%	1.90%
19																				0.63%	0.16%	1.27%	1.27%	3.33%
20																					0.00%	0.00%	0.00%	0.00%
21																						0.00%	0.00%	0.00%
22																							0.00%	0.00%
23																								0.00%
	0.00%	0.00%	0.00%	0.00%	0.00%	1.59%	0.79%	23.97%	8.25%	9.05%	15.24%	3.81%	9.37%	4.92%	0.95%	0.32%	3.17%	0.95%	2.86%	5.56%	1.75%	3.97%	3.49%	100.00%

Table A.24: CLN Spring 2011 Academic Term, PM Period: 4 Trips, 299 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
1		0.00%	0.34%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.34%	0.34%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.01%
2			0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.34%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.34%
3				0.00%	0.00%	0.00%	0.00%	1.35%	0.67%	1.01%	0.67%	0.34%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.04%
4					0.00%	0.00%	0.00%	0.34%	1.01%	0.67%	2.69%	0.67%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.39%
5						0.00%	0.00%	0.34%	0.00%	0.34%	0.34%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.01%
6							0.00%	3.37%	3.03%	0.00%	3.37%	0.34%	0.34%	0.34%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	10.77%
7								0.00%	0.34%	0.00%	0.34%	1.01%	0.67%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.36%
8									0.67%	0.67%	3.70%	0.00%	1.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.34%	0.00%	6.40%
9										1.68%	8.08%	1.35%	1.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	12.12%
10											4.04%	2.02%	3.37%	0.34%	0.00%	0.00%	1.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	10.77%
11												0.67%	2.36%	0.34%	0.34%	0.00%	0.00%	4.38%	0.34%	0.00%	0.34%	1.01%	0.34%	10.10%
12													0.00%	0.00%	0.00%	0.00%	1.01%	0.00%	0.34%	0.00%	0.34%	1.01%	0.00%	2.69%
13														0.00%	0.34%	0.00%	0.67%	1.01%	1.35%	2.02%	0.34%	2.69%	4.04%	12.46%
14															0.00%	0.00%	0.00%	0.67%	0.00%	0.67%	0.34%	0.34%	0.34%	2.36%
15																0.00%	0.00%	0.00%	0.00%	0.67%	0.00%	0.34%	0.34%	1.35%
16																	0.00%	0.34%	0.00%	0.34%	0.00%	1.35%	0.67%	2.69%
17																		0.34%	0.34%	4.04%	0.34%	2.36%	1.68%	9.09%
18																			0.00%	1.01%	0.00%	0.00%	0.00%	1.01%
19																				1.68%	0.34%	1.68%	0.34%	4.04%
20																					0.00%	0.00%	0.00%	0.00%
21																						0.00%	0.00%	0.00%
22																							0.00%	0.00%
23																								0.00%
	0.00%	0.00%	0.34%	0.00%	0.00%	0.00%	0.00%	5.39%	5.72%	4.38%	23.57%	6.73%	8.75%	1.35%	0.67%	0.00%	7.07%	2.69%	2.02%	10.44%	1.68%	10.44%	8.75%	100.00%

Table A.25: NE Spring 2011 Academic Term, AM Period: 4 Trips, 148 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
1		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.36%	5.44%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.80%
2			0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.68%	2.72%	0.68%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.08%
3				0.00%	0.00%	0.00%	0.68%	8.16%	17.69%	8.16%	2.72%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	37.41%
4					0.00%	0.00%	0.00%	3.40%	2.72%	15.65%	2.04%	0.68%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	24.49%
5						0.00%	0.00%	0.00%	0.68%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.68%
6							0.00%	0.68%	2.04%	0.68%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.40%
7								0.00%	0.00%	0.68%	0.68%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.36%
8									0.00%	0.68%	0.68%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.36%
9										1.36%	1.36%	0.68%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.68%	0.00%	4.08%
10											0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.68%	0.00%	0.00%	0.00%	0.00%	0.68%
11												0.00%	0.00%	0.00%	0.68%	0.00%	0.00%	0.68%	0.00%	0.00%	0.68%	2.04%
12													0.00%	0.00%	0.68%	0.00%	0.68%	0.00%	0.00%	0.68%	0.00%	2.04%
13														0.00%	0.00%	0.68%	0.68%	0.00%	0.00%	0.68%	0.00%	2.04%
14															0.00%	0.68%	0.68%	0.68%	0.00%	0.00%	0.00%	2.04%
15																0.00%	2.72%	0.00%	0.00%	1.36%	0.00%	4.08%
16																	0.68%	0.00%	0.00%	0.00%	0.00%	0.68%
17																		2.04%	0.00%	0.00%	0.00%	2.04%
18																			0.00%	0.00%	0.68%	0.68%
19																				0.00%	0.00%	0.00%
20																					0.00%	0.00%
21																						0.00%
	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.76%	15.65%	44.90%	13.61%	4.08%	0.00%	0.00%	1.36%	0.00%	6.12%	4.08%	0.68%	2.72%	2.04%	100.00%

Table A.26: NE Spring 2011 Academic Term, MID Period: 6 Trips, 416 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
1		0.00%	0.00%	0.00%	0.48%	0.00%	0.24%	0.72%	1.69%	0.48%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.86%
2			0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.45%	1.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.65%
3				0.00%	0.48%	0.48%	0.00%	0.24%	3.13%	8.67%	1.45%	0.00%	0.00%	0.00%	0.00%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	14.70%
4					0.00%	0.48%	1.20%	0.00%	3.61%	12.05%	3.86%	0.24%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	21.69%
5						0.00%	0.00%	0.24%	0.24%	0.24%	0.24%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.20%
6							0.24%	0.48%	1.93%	3.61%	1.20%	0.72%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	8.19%
7								0.00%	0.72%	0.72%	1.45%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.89%
8									0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
9										0.48%	0.96%	0.24%	0.00%	0.00%	0.00%	0.00%	0.48%	0.72%	0.00%	0.00%	0.00%	2.89%
10											0.24%	0.48%	0.00%	0.00%	0.00%	0.00%	0.72%	0.72%	0.24%	2.41%	1.93%	6.75%
11												0.00%	0.00%	0.24%	0.48%	0.72%	1.20%	0.24%	1.20%	0.72%		4.82%
12													0.00%	0.24%	0.72%	0.24%	0.72%	2.65%	0.24%	1.93%	0.24%	6.99%
13														0.48%	0.72%	0.00%	0.96%	1.93%	0.00%	2.65%	1.45%	8.19%
14															0.00%	0.00%	0.96%	1.69%	0.48%	0.72%	0.48%	4.34%
15																0.00%	2.41%	1.20%	1.20%	2.65%	0.48%	7.95%
16																	0.24%	0.24%	0.00%	0.24%	0.00%	0.72%
17																		0.96%	0.24%	0.48%	0.48%	2.17%
18																			0.00%	0.00%	0.00%	0.00%
19																				0.00%	0.00%	0.00%
20																					0.00%	0.00%
21																						0.00%
	0.00%	0.00%	0.00%	0.00%	0.48%	1.45%	1.45%	1.20%	10.36%	28.92%	11.08%	2.17%	0.24%	0.72%	1.69%	0.96%	7.23%	11.33%	2.65%	12.29%	5.78%	100.00%

Table A.27: NE Spring 2011 Academic Term, PM Period: 4 Trips, 189 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
1		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.53%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.53%
2			0.00%	0.00%	0.00%	0.00%	0.53%	0.00%	0.53%	1.06%	1.06%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.17%
3				0.00%	0.53%	0.53%	1.06%	2.65%	2.65%	1.06%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	8.47%
4					0.53%	0.00%	0.00%	0.53%	2.65%	1.06%	5.82%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	10.58%
5						0.00%	0.00%	0.53%	0.00%	1.59%	0.53%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.65%
6							0.53%	1.06%	1.59%	2.12%	1.59%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.53%	0.00%	7.41%
7								0.00%	0.00%	0.53%	0.53%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.06%
8									0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
9										0.00%	3.17%	0.53%	0.00%	0.00%	0.00%	0.00%	0.00%	0.53%	0.00%	0.53%	3.17%	7.94%
10											0.53%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.12%	0.00%	2.12%	3.17%	7.94%
11												0.00%	0.00%	0.00%	0.00%	0.53%	0.00%	0.53%	2.12%	4.23%	3.17%	10.58%
12													0.00%	0.00%	0.00%	0.00%	0.00%	2.12%	0.00%	4.76%	3.70%	10.58%
13														0.00%	0.00%	0.00%	0.00%	2.12%	1.59%	1.06%	3.17%	7.94%
14															0.00%	0.00%	0.53%	1.59%	0.00%	0.53%	0.53%	2.65%
15																0.00%	0.53%	3.17%	0.00%	3.70%	1.59%	8.99%
16																	0.00%	1.59%	0.00%	1.59%	0.00%	3.17%
17																		1.59%	1.59%	1.06%	2.12%	6.35%
18																			0.00%	0.00%	0.00%	0.00%
19																				0.00%	0.00%	0.00%
20																					0.00%	0.00%
21																						0.00%
	0.00%	0.00%	0.00%	0.00%	0.53%	0.53%	1.59%	3.17%	7.41%	7.94%	15.34%	1.06%	0.00%	0.00%	0.00%	0.53%	0.53%	15.34%	5.29%	20.11%	20.63%	100.00%

Table A.28: CC Spring 2011 Academic Term, AM Period: 8 Trips, 186 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1		0.00%	1.08%	0.00%	0.00%	1.61%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.69%
2			3.76%	1.08%	1.61%	1.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.53%
3				2.15%	2.69%	9.68%	3.76%	1.61%	1.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	20.97%
4					1.61%	3.23%	4.30%	5.91%	0.00%	0.54%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	15.59%
5						2.15%	2.15%	1.08%	0.00%	0.54%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.91%
6							0.54%	2.69%	0.54%	0.54%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.30%
7								0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
8									0.54%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.54%
9										0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
10											0.00%	0.00%	0.00%	0.54%	0.00%	0.00%	0.00%	0.00%	0.54%
11												0.00%	1.61%	9.14%	3.23%	1.61%	0.00%	0.00%	15.59%
12													0.00%	3.76%	1.08%	1.08%	0.54%	0.00%	6.45%
13														5.38%	4.30%	4.84%	0.54%	0.00%	15.05%
14															0.00%	0.54%	0.54%	0.00%	1.08%
15																0.00%	3.76%	0.00%	3.76%
16																	0.00%	0.00%	0.00%
17																		0.00%	0.00%
18																			0.00%
	0.00%	0.00%	4.84%	3.23%	5.91%	17.74%	10.75%	11.29%	2.15%	1.61%	0.00%	0.00%	1.61%	18.82%	8.60%	8.06%	5.38%	0.00%	100.00%

Table A.29: CC Spring 2011 Academic Term, PM Period: 8 Trips, 207 Total Passengers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1		0.00%	0.00%	1.46%	0.49%	2.91%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.85%
2			0.00%	0.97%	0.49%	0.49%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.94%
3				0.00%	0.00%	3.40%	1.94%	2.43%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.77%
4					0.00%	2.43%	1.46%	0.97%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.85%
5						7.28%	1.94%	2.91%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	12.14%
6							0.49%	1.46%	1.46%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.97%	0.00%	4.37%
7								0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
8									0.97%	0.00%	0.49%	0.00%	0.00%	0.97%	0.00%	0.00%	0.00%	0.00%	2.43%
9										0.49%	0.49%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.97%
10											0.00%	0.00%	0.49%	0.97%	0.49%	0.00%	0.49%	0.00%	2.43%
11												0.00%	5.34%	6.31%	1.94%	1.46%	0.97%	0.00%	16.02%
12													0.49%	2.91%	1.94%	3.88%	0.49%	0.00%	9.71%
13														6.31%	8.74%	3.88%	3.88%	0.00%	22.82%
14															0.49%	1.46%	1.46%	0.49%	3.88%
15																0.97%	3.40%	0.00%	4.37%
16																	1.46%	0.00%	1.46%
17																		0.00%	0.00%
18																			0.00%
	0.00%	0.00%	0.00%	2.43%	0.97%	16.50%	5.83%	7.77%	2.43%	0.49%	0.97%	0.00%	6.31%	17.48%	13.59%	11.65%	13.11%	0.49%	100.00%

Appendix B: CTL assignments, projects, and exam questions developed and used in courses in academic year 2010-2011

On the following pages, the various course assignments, projects, and exam questions are included. They include:

Exam Question used in *Civil/Environmental Engineering 540: Civil and Environmental Engineering Systems*

Assignment used in *Civil Engineering 570: Transportation Engineering and Analysis*

Exam Question used in *Civil Engineering 570: Transportation Engineering and Analysis*

Part I of Project used in *Civil Engineering 670: Urban Public Transportation*

Part II of Project used in *Civil Engineering 670: Urban Public Transportation*

Assignment used in *Civil Engineering 878: Transportation Management Systems*

Exam III
Date: Wed. Dec. 8, 2010

2. Consider the bus scheduling problem presented in class.

a. (1 pt) The objective of the formulated problem was to minimize the headway. Which of the following is the primary reason for wanting to minimize headways? (*circle one*)

    i. i. To decrease the costs of operating the buses

    ii. To decrease the time that passengers travel while on the bus

    iii. To decrease waiting time for passengers waiting at bus stops

b. (2 pts) Which of the following made this a more complex program than the other problems presented in class? (*circle all that apply*)

    i. There were more constraints in the bus scheduling problem

    ii. A corner point was not guaranteed to be the solution to the bus scheduling problem

    iii. There were more decision variables in the bus scheduling problem

    iv. The iso-Z values were ellipses in the bus scheduling problem

c. (1 pt) What technology was used to provide data that allowed the determination of the right-hand sides of the bus travel time constraints?

d. (4 pts) Which route was found to be the one that was critical in setting the schedule? What indicated that this route was the critical one?

Assignment #2:   CABS OD and travel time analysis from CTL data
Date handed out: Wed. Jan. 12, 2011
Date due: Wed. Jan. 19, 2011

Background

OSU's Campus Area Bus Service (CABS) has been recently instrumented with several sensor systems. These systems allow bus arrival information to be provided to travelers, CABS staff to better operate the service, researchers to study the behavior of bus systems, and students to learn about bus systems in an hands-on manner. For the latter two purposes, 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 high frequency.

A "bus trip" is defined to be one complete traversal by a bus on a route from one end of the route (the starting terminal) to the other end of the route (the ending terminal). The CABS Campus Loop South (CLS) route forms a loop. To simplify the analysis, all four stops on West Campus are grouped to form one stop. As shown in Figure 1 depicting the CLS route, 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 start their trips (*i.e.*, board) east of the grouped West Campus stops, travel westbound through the West Campus stops, and end their trips (*i.e.*, alight) east of the grouped West Campus stops.

Problem 1

APC data on a CLS bus trip are sent to you via e-mail in the form of an Excel file. Different data are being sent to different students, so make sure to work with the data sent to you.

(a) In a well labeled and numbered or lettered appendix, present a hard copy of the data sent to you, including the "header information." In the main body of the report, you should write something like, "The APC data used in Problem 1 appear in Appendix "X".

(b) Apply the Iterative Proportional Fitting (IPF) method to estimate the stop-to-stop origin-destination (OD) passenger flows for the specific bus trip APC data sent to you using Excel (or other software such as MATLAB if you prefer). In additional to the zero entries of the seed matrix discussed in class, a seed value of zero should also be included for flow from stop 4 to 21 reflecting the assumption that no one makes a single trip starting (boarding) at one of the West Campus stops and ending (alighting) back at one of the West Campus stops. Conduct a total of three pairs of 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 a second well-labeled appendix.) Show an example calculation for at least one cell value going through a row and column adjustment.
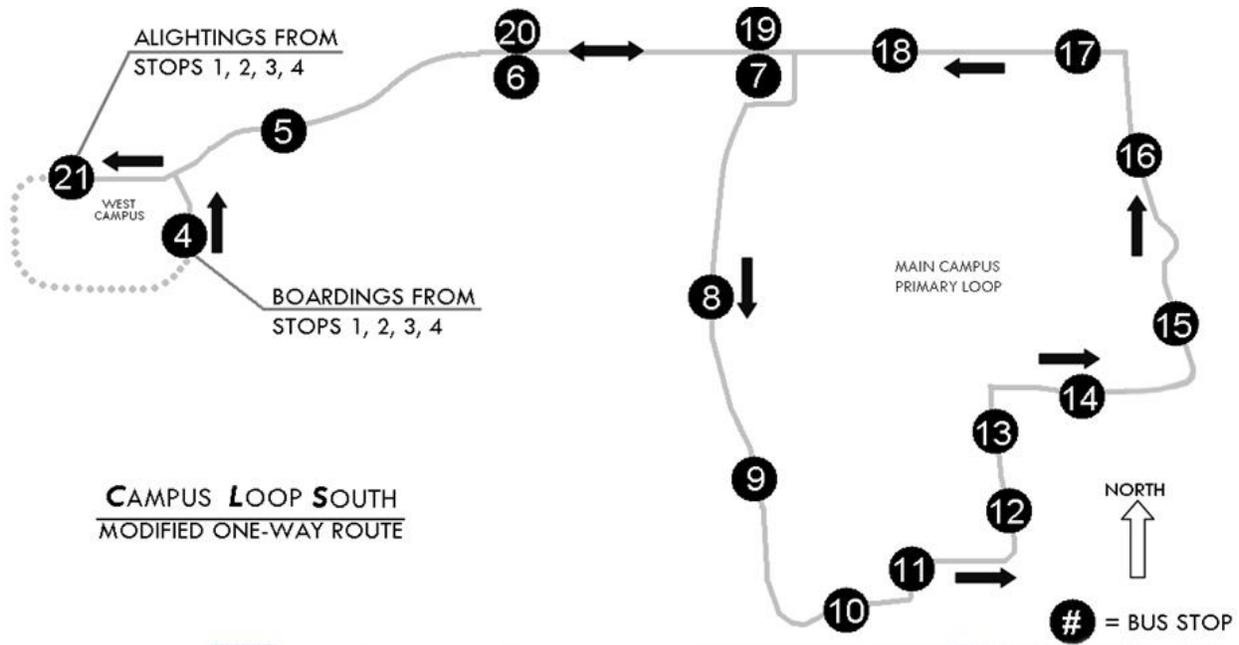
Figure 1: Campus Loop South (CLS) route map

(c) Based on the number of passengers traveling to each destination stop from the West Campus starting terminal (grouped stop 4) determined under (b) 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 your results in a well-labeled table, explain the logic behind your calculations, and use an example calculation to help in the explanation.

Problem 2

AVL data on many CLS bus trips are used to calculate the following: (i) expected (or average) time it takes a bus to travel from one stop to the next (where the travel time equals the arrival time at the next stop minus the departure time from the previous stop) and, (ii) expected (or average) 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 Tables 1 and 2.

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 (stop 4) to each destination stop (stops 5 through 20). Present the results in a well-labeled table, 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.) Present and show your calculation.

Table 1: Expected Stop-to-Stop Travel Times

From Stop	To Stop	Time (sec)
Carmack 1 (4)	Blankenship Hall (5)	116.84
Blankenship Hall (5)	AG Campus (EB) (6)	86.76
AG Campus (EB) (6)	St John Arena (EB) (7)	58.25
St John Arena (EB) (7)	Drake Union (8)	108.92
Drake Union (8)	Cannon and 12th (SB) (9)	105.29
Cannon and 12th (SB) (9)	Med Center and Cannon (EB) (10)	108.95
Med Center and Cannon (EB) (10)	Med Center and 9th Ave (11)	49.85
Med Center and 9th Ave (11)	Neil and 10th Ave (12)	72.42
Neil and 10th Ave (12)	Mack Hall (13)	70.74
Mack Hall (13)	Hale Hall (14)	120.31
Hale Hall (14)	Ohio Union (NB) (15)	121.85
Ohio Union (NB) (15)	Arps Hall (16)	60.28
Arps Hall (16)	North Dorms (17)	105.67
North Dorms (17)	Fisher College (18)	82.55
Fisher College (18)	St John Arena (WB) (19)	68.00
St John Arena (WB) (19)	AG Campus (WB) (20)	58.81

Table 2: Expected Dwell Times

Stop Name (Stop Number)	Dwell Time (sec)
Blankenship Hall (5)	5.45
Ag Campus Eastbound (6)	16.21
St John Arena Eastbound (7)	7.85
Drake Union (8)	12.45
Cannon Dr. & 12th Southbound (9)	9.29
Med Center Dr. & Cannon (10)	6.21
Med Center Dr. & 9th (11)	14.78
Neil Ave. & 10th Ave. (12)	16.60
Mack Hall (13)	21.65
Hale Hall (14)	11.65
Ohio Union Northbound (15)	49.28
Arps Hall (16)	26.38
North Dorms (17)	20.38
Fisher COB (18)	34.02
St. John Arena Westbound (19)	8.28
Ag Campus Westbound (20)	25.74

Problem 4

The stop-to-stop travel times and stop dwell times extracted from AVL data on 130 bus trip used in determining the expected values provided in Tables 1 and 2 are also sent to you via e-mail in the form of an Excel file organized in two separate sheets, one containing the stop-to-stop travel times for the 130 bus trips and the other containing the dwell times for the 130 bus trips. (Note: You do not need to provide these data in your report.)

(a) Calculate the average stop-to-stop travel times and the average dwell times based on the provided AVL information on the 130 bus trips using Excel (or other software, such as MATLAB, if you prefer). (Recall, in Excel you could use the function AVERAGE(…) to calculate the average.) Present your results in two (well-labeled) tables, one for stop-to-stop travel times and the other for stop dwell times, similar to Tables 1 and 2 of this assignment, and verify that the average values you arrived at are the same as those provided in Tables 1 and 2 of this assignment. You should comment in one short, concise sentence whether the numbers correspond or not.

(b) Calculate the standard deviation of the stop-to-stop travel times and the standard deviation of dwell times based on the provided AVL information on the 130 bus trips using Excel (or other software such as MATLAB if you prefer). (Recall, in Excel you could use the function STDEV(…) to calculate the standard deviation.) Present your results in two tables, one for stop-to-stop travel times and the other for stop dwell times – feel free to combine the results of this question with those of part (a) above in the same tables. Either way, make sure to label your tables and column headings clearly.

(c) Based on the results from part (b) above, identify the stop-to-stop segment that has the largest standard deviation of travel time and the stop that has the largest standard deviation of dwell time. Indicate both that segment and that stop on the map of the CLS route. (Consider this a figure, so it should be labeled appropriately. It can be labeled by hand.) A map like that of Figure 1 is sent to you via e-mail for you to print and use in providing your answer to this question.

The Ohio State University   **Winter 2011**
CE 570: Transportation Engineering and Analysis (Tues-Thurs)
Dr. Mark R. McCord and Dr. Rabi G. Mishalani

Midterm #1 (11 February 2011)
There are 50 points on this exam.

One 8 1/2" x 11" piece of paper permitted.
Show all work, write neatly, and organize your answers to obtain full and/or partial credit.

Name   _____

  1   (7 pts)   _____

 2a   (5 pts)   _____

  b   (2 pts)   _____

  c   (3 pts)   _____

 3a   (6 pts)   _____

  b   (2 pts)   _____

 4   (4 pts)   _____

 5a   (1 pt)   _____

  b   (2 pts)   _____

 6a   (1 pt)   _____

  b   (5 pts)   _____

  c   (4 pts)   _____

 7a   (6 pts)   _____

  b   (2 pts)   _____

TOTAL   (50 pts)   _____

2. Consider a bus route consisting of a total of 6 stops where stop 1 is the beginning terminal located at the east end of the city and stop 6 is the ending terminal located at the west end of the city. The direction of flow of buses is from 1 to 6. Assume that passengers do not board and alight at the same stop.

a. (5 pts) APC technology is used to count the number of passengers getting on and off each stop for each bus trip. These counts for a given bus trip are shown in Table 1. Determine the IPF seed values (as we did in class) for the following OD cells: (3,5), (1,6), (4,4), and (5,2). Show your calculation.

Table 1: APC counts for a bus trip

		Alighting stop # (j)						APC ons
		1	2	3	4	5	6	
Boarding stop # (i)	1							31
	2							30
	3							14
	4							8
	5							0
	6							0
APC offs		0	0	6	13	31	33	

b. (2 pts) IPF OD flow estimates are shown in Table 2. Based on these results, determine the number of passenger boarding at stop 1. Show your calculation.

Table 2: IPF OD flow estimates

		Alighting stop # (j)					
		1	2	3	4	5	6
Boarding stop # (i)	1	0.00	0.00	3.05	5.27	10.99	11.70
	2	0.00	0.00	2.95	5.10	10.63	11.32
	3	0.00	0.00	0.00	2.64	5.50	5.86
	4	0.00	0.00	0.00	0.00	3.88	4.13
	5	0.00	0.00	0.00	0.00	0.00	0.00
	6	0.00	0.00	0.00	0.00	0.00	0.00

c. (3 pts) Based on the results shown in Table 2, determined the probability that a passenger *boards* at stop 1 *given* that s/he *alighted* at stop 6.

CE 670 Urban Public Transportation
Winter 2011

Project – Part I: Campus Area Bus Service Operations – Data Collection
Date handed out: Wed. Jan. 19, 2011
Date due: Mon. Jan. 31, 2011

Instructions

This project deals with the service provided by and operations of routes operated by Campus Area Bus Service (CABS). You are to form 6 teams, 4 teams with *four* students per team and 2 teams with *three* students per team. Teams consisting of 4 students should include *up to two* graduate students. Teams consisting of 3 students should include *no more than one* graduate student. Each team must include *at least one* 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 data should be collected such that the *reference stop* shown in Table 1 for each team is observed for a *continuous* 2.5-hour period of time between 7.00a and 7.00p on a weekday. Make sure you record and report the time period you select along with the corresponding date. You are strongly encouraged to schedule your data collection over the class times (3.30-5.18p) on Mon Jan 24 or Wed Jan 26. *The NE-1 and NE-2 teams should not collect data on the same day and time. Similarly, the CC-1 and CC-2 teams should not collect data on the same day and time.*

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://tp.osu.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.

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), and cycle times (times it takes buses to traverse the entire length of a route). You are to also compare the data you collect in the field with automatically collected data you will be provided at a later point.

Team	Route	# of students	Reference Bus Stop (Stop ID)
NE-1	North Express	4	Arps Hall (54)
NE-2	North Express	4	North Dorms (55)
CLN	Campus Loop North	4	Hamilton Hall (33)
CLS	Campus Loop South	4	Ohio Union (NB) (43)
CC-1	Central Connector	3	Knowlton Hall (57)
CC-2	Central Connector	3	Mack Hall (41)

Table 1: Routes and Reference Bus Stop for Each Team

The number of buses scheduled on each team's route is equal to the number of students in each team. However, sometimes the number of buses operating on a route is reduced by one depending on staffing availability. In the event that at the time of data collection all scheduled buses are in operation, each student will be riding one of these buses for the purpose of data collection. Otherwise, the "left-out" student should be stationed at the *reference stop* shown in Table 1 for each team for the duration of the data collection.

Data collection *starts* and *ends* at the reference stop. One member of the team should be designated to collect data while standing at the reference stop as soon as the first member of the team boards the first arriving bus on your route. This designated member will continue collecting data from the reference stop until all team members have boarded successive buses. If the number of buses on the route is as scheduled, this team member then boards the next bus and continues the data collection while riding the bus like the other team members. Otherwise, this designated team member will be the "left-out" student who remains at the reference stop collecting data from that perspective. The data collection ends when the last student who boards makes it back to the reference stop 2.5 hours after the first student boards the reference stop.

Whether riding a bus or observing buses while stationed at the reference stop, the *minimum* data requirements are the following:

- bus number,
- number of passengers on the bus (passenger load) upon starting the data collection on each bus,
- bus arrival and departure times *at each stop* including the time the bus spends letting passengers on and off and the time the bus spends stationary without any boarding and alighting activity should this occur,
- number of passengers boarding and number alighting *at each stop*, and
- passenger loads upon both bus arrival and departure when collecting data from the reference stop.

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 or the instant the bus departs. Should a bus spend more time than needed to allow passengers to board and alight, make a note of this extra time. The doors may or may not remain open in the absence of boarding and alighting activity. What is relevant is to make a distinction between the time for boarding and alighting activity and the time with no such activity before the bus departs. Passenger loads (number of passengers on a bus), and to a lesser extent the number of passengers boarding and alighting, might be difficult to measure at times. In such cases, try to approximation these values as best as you can and indicate that you are conducting an approximation in such cases. Times should be recorded to the nearest second. *Finally, all team members should synchronize their watches shortly before data collection to the time indicated on the TRIP website.*

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, specifying the type of data to collect in the field, and designing and producing data collection forms. It is also highly advisable that team members conduct a dry-run together prior to the actual data collection effort to ensure that nothing has been overlooked, avoid making mistakes during data collection, and maintain consistency during data collection.

Report

For part I the report should include the following:

- description of the field data collection effort,
- route map with reference stop indicated,
- name of student collecting data on each bus and reference stop,
- 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_WI_2011_TeamName_Data.xls>. The "TeamName" is as shown in the first column of Table 1.

CE 670 Urban Public Transportation
Winter 2011
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):

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Winter 2011
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   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 =____.

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Winter 2011
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Evaluation

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4. Please score the team member named above on a scale of 1 to 7
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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 2011

Project – Part II: Campus Area Bus Service (CABS) Operations – Analysis
Date handed out: Wed. Feb. 16, 2011
Date due: Wed. March 2, 2011

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 your 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: Bus Headways and Passenger Wait Times

a. Based on your field observations (*CC-1 and CC-2 teams: please see me for alternate instructions*), determine all the headways at your reference bus stop plus three additional stops of your choosing. The set of four stops should be roughly evenly distributed along the length of the route. You might consider other factors in making your choice. Briefly justify your selection.

b. Estimate the headway probability density function (pdf) using an histogram at each of the four bus stops of part above. Also estimate the headway *empirical* cumulative density function (cdf) at each of the four bus stops. Describe the nature of these functions.

c. 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.

d. Compare the estimated headway pdfs and *cdfs 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 your reference bus stop. 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 adopt.

Problem 3: Bus Running Times

a. Estimate the bus running time (as measured with respect to your reference stop) pdf and cdf (again, using an histogram and an ecdf).

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: AVL and APC data vs. Field Data

In this exercise you are interested in comparing the Automatic Vehicle Location (AVL) and Automatic Passenger Count (APC) data covering the same time period and service you observed in the field. The AVL and APC data will be provided to you in an Excel file via e-mail.

a. Compare the field bus arrival and departure times for the stops you analyzed in Problem 1 to the same information collected through the AVL technology. Assess the accuracy of the AVL data at the individual datum level.

b. Compare the field passenger boarding and alighting counts for the stops you analyzed in Problem 1 to the same information collected through the APC technology. Assess the accuracy of the APC data at the individual datum level.

"At the individual datum level" means that you are to examine differences in the data at the specific bus and stop levels before calculating any summary statistics. That is, you are not to aggregate the data before examining the differences mentioned above.

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 recommend improvements or not, please justify your answer.

CE 670 Urban Public Transportation
Winter 2011
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
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Winter 2011
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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):

CE 670 Urban Public Transportation
Winter 2011
Project – Part II Peer- and Self-Evaluation Form

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   c. Contribution to solution of problem 3:　　　　　　　Score =＿＿.

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CE 878 Transportation Management Systems
Winter 2011

Problem Set #3: Transit Passenger Information Systems
Date handed out: Wed. Feb. 23, 2011
Date due: Wed. March. 9, 2011

Introduction

This problem set deals with evaluating the traveler information provided to prospective OSU Campus Area Bus Service (CABS) passengers and, identifying possible limitations, and proposing improvements. The CABS website `<http://tp.osu.edu/cabs/>` provides static route maps, the locations of all the stops, and scheduled bus headways.

In addition, the Transportation Route Information Program (TRIP) website `<http://tp.osu.edu/cabs/trip.shtml>` provides real-time information on predicted arrival times of buses at stops in a list format and the location of the buses in a map format. The same information is available through a mobile phone texting service and variable message signs at certain bus stops. These predictions are based Automatic Vehicle Location (AVL) data collected at high frequency on an on-going basis on all CABS buses.

Problem 1: Data

For a period of six weekdays starting today, Wed. Feb. 23, and ending Wed. March 2, you are to collect predicted arrival times from the "Estimated Arrival Times" feature of the TRIP website. You will collect data relating to the route-stop combination assigned to you in accordance with Table 1 and the route-stop combination assigned to the student whose name is listed right below your name in Table 1. The student whose name is listed last in Table 1 will collect data relating to his route-stop combination and that of the student whose name is listed first.

The data will consist of a set of series of observations taken several times over the course of the day and across days. Each "series" consists of multiple consecutive observations taken approximately 2 minutes apart where the predicted times until arrival for *all* buses on the route-stop combination of interest are monitored until at least two bus "APPROACHING" events occur.

To reduce the time needed for data collection, you are to collect data on the *two* route-stop combinations according to the assignment discussed above *simultaneously*. To do so, either open two separate browsers one for each route-stop combination, or switch back and forth between the two within the same browser. The next series of observations should be made at least 5 minutes after the end of the first series. You are to collect at least *four* series during each of the six weekdays and attempt to cover the full time-of-day range (during the day and

evening) recognizing that it is not possible to collect data while you are in class or engaged in other regularly scheduled commitments. If you are unable to collect four series on one day, try to compensate on other days such that you target on average four series per day.

You are likely to have collected data only on your assigned route-stop combination on Wed. Feb. 23. Simply add these data to the data set for your analysis. If you happened to have collected data on another route-stop combination on that day as you helped the instructor determine alternative data collection schemes, please share that data with the student analyzing that combination (see details below).

Table 1: Bus route and stop assignment to students

Student Name	Route	Stop Name (ID)
Andrew Bittlemann	North Express (NE)	Carmack 1 (13)
Xiaoyu Gao	North Express (NE)	University Hall (52)
Amy Hearing	North Express (NE)	Arps Hall (54)
Xudong Hu	Campus Loop North (CLN)	Ag Campus (EB) (20)
Ted Reinhold	Campus Loop North (CLN)	Knowlton Hall (57)
Chenbo Shangguan	Campus Loop North (CLN)	Ohio Union (SB) (44)
Xin Wang	Campus Loop South (CLS)	Drake Union (22)
Xiao Wei	Campus Loop South (CLS)	Ohio Union (NB) (43)
Xiaofei Xu	Campus Loop South (CLS)	Ag Campus (WB) (25)

Try to coordinate the timing of your data collection as much as practically possible to avoid collecting data on exactly the same buses at the same time with the student you are sharing a route-stop combination with. You are to provide the data you collect on the route-stop combination you will not be analyzing to the student who is assigned to analyze that route-stop combination. In the event of an overlap in data, make sure to only consider one of the two overlapping series in your analysis. Alternatively, you could merge the two overlapping series to create one series where the records of different time-stamps are maintained and the records with identical time-stamps are removed. As a result of this data collection and sharing scheme, you should end up with on average eight series per day for the route-stop combination you are analyzing (Wed. Feb. 23 notwithstanding).

At the minimum, you are to record the following for each observation you make within each series:

(1) date,
(2) time stamp (as it appears on the TRIP website) when the predicted times until arrival are refreshed, and

(3) predicted times until arrival at your assigned stop for *all* buses on your assigned route,

(4) bus numbers corresponding to the predicted times until arrival of item (3) above, and

(5) time stamp (as it appears on the TRIP website) when the bus "APPROACHING" events occur.

Make sure you record your data in such a manner where you can easily distinguish among series collected on the same day.

In addition to the data you are collecting, you will be provided with AVL inferred bus arrival times at the end of your data collection period.

(1) Provide an explanation of your data collection process and present the format of any tables you might have used to support your data collection.

(2) Match the provided inferred bus arrival times with the corresponding predicted times until arrival you collected. Explain the logic of your matching scheme. Provide the resulting matched data to the instructor <mishalani@osu.edu>. The data must be organized in an Excel file, which should be named <CE878_WI_2011_PS_3_RouteName_StopName_Data.xlsx>.

Problem 2: Evaluation

Match the provided inferred bus arrival times with the corresponding predicted times until arrival you collected. Provide the resulting matched data to the instructor <mishalani@osu.edu>. The data must be organized in an Excel file, which should be named <CE878_WI_2011_PS_3_RouteName_StopName_Data.xlsx>.

Based on the compiled data set, evaluate the quality of the predicted times until arrival. In doing so, consider plotting the computed prediction errors against potentially relevant variables. Discuss the potential problems that may arise as a result of the nature of the errors considering both the passengers' and the information provider's (CABS's) perspectives.

Problem 3: Critique

The time until arrival predictions provided via the TRIP website are based on historical AVL data along with real-time information on the current location of each bus (communicated in real-time to a CABS computer server).

(1) Critique the data basis on which these predictions are made, discussing both advantages and disadvantages.

(2) Discuss the evaluation results you presented in your answer to Problem 1 above in light of your critique.

Problem 4: Proposed Alternatives and Recommendations to CABS

Based on your answers to problems 1 and 2 above:

(1) Develop your own approach to predicting the time until arrival describing and motivating the data you would use and sketching how you would use them to produce predictions.

(2) Present recommendations to CABS relating to the passenger information system they provide.