North Dakota State University Transit Study Report 2018-2019



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The Small Urban and Rural Transit Center (SURTC) changed its name to the Small Urban and Rural Center on Mobility (SURCOM) in January 2020 to reflect the center's expanded focus on all types of personal mobility.

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ABSTRACT

This document contains a report based on two online surveys conducted by the Small Urban and Rural Transit Center (SURTC), Upper Great Plains Transportation Institute, NDSU, during the 2019 spring semester. The first survey captured the NDSU student experience with Metro Area Transit (MATBUS) and students' travel behavior. The survey was administered to NDSU students, and it received 1,180 responses, capturing a significant amount of information regarding student travel behavior, transit use, and opinions about current MATBUS service. The survey obtained information on student transportation modes used to travel to campus, student access to vehicles, factors influencing mode choice, use of transit services, opinions on MATBUS service, thoughts on how to improve service, and willingness to pay for transit services. The second survey was administered to some universities; and feedback on the hourly operational costs of their transit systems, their payment methods, transit system asset ownership, and other characteristics of their campus transit environment was collected.

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EXECUTIVE SUMMARY

NDSU's Facilities Management Department contracted with SURTC to complete an assessment of MATBUS services on the NDSU campus, and to recommend changes that would improve operations and increase rider satisfaction. This assessment was done with data from NDSU (Residence Life and Parking and Transportation) and MATBUS, along with feedback from two surveys (NDSU MATBUS Transit Survey and University Transit System Survey).

The objectives of the study were to:

- Collect and analyze current and previous NDSU MATBUS transit ridership data
- Study the spatial interaction of trips to determine if existing transit routes should be modified
- Study the impact of changes to student residence (location and size) on ridership
- Describe existing levels of transit service on campus
- Identify gaps in existing service and base levels of required transit service
- Develop recommendations for meeting identified mobility needs
- Compare the costs and type of service offered by different transit agencies/groups to determine the best transit service provider for NDSU for fiscal year 2019

Data Collection and Analysis

For this study, the ridership data for NDSU's exclusive MATBUS routes (excluding Route 13U) are collected and analyzed. The ridership data are then combined with some seasonal and non-seasonal attributes from other data sources and then transformed and assembled in one database. Two subsets of the ridership data are created from the database, for daily and weekly ridership, and the data range is set between 2014 and 2018 (four years). The daily ridership subset has 1,461 observations, and the weekly ridership subset has 209 observations. Before the analysis, the authors highlighted the decline of NDSU student enrollment and semester occupancy of NDSU on-campus residents.

The ridership data for routes 31, 32, 33, 34 (34W and 34E), and 35 (+TapRide) are studied using time series analysis. A typical trend pattern (a prominent valley shape or U-shape) is observed in bus route 32–34 trends during the period 2015–2016. However, route 31 and 35 show a different pattern with a continuous ridership decline over the study period. The impact of changes to the seasonal and non-seasonal factors considered in the study is examined using statistical methods. Of 42 predictor factors, 10 are picked for their statistical significance. Multiple linear regression models are built for the analysis of all routes, and the results of the models show that three factors (weekends, holidays, and Burgum Hall resident occupancy) consistently reduce MATBUS ridership. It was also observed that any increase to NDSU University Village Apartment residency or occupancy increases ridership on routes 32 and 34 only. Lastly, on routes 31, 32, 34, and 35, the increase in average daily temperature reduces ridership, while an increase in wind speed increases ridership.

To predict the daily ridership on all routes, the authors built both statistical and machine learning models. The results from the prediction model show that the machine learning models (artificial neural networks) are better in prediction accuracy than the statistical models (regression models). The difference in accuracy is due to the nature of transit demand modeling (which is both an art and a science), which involves the estimation of real-time unknown variables of demand with a certain degree

of rationality. Hence, regression methods can be too simplistic for transit demand or ridership prediction despite their complexities and strengths.

Survey Development and Results

Two surveys were developed to gather relevant information. The first was conducted to gather information from NDSU students. The second survey gathered information from other U.S. campuses that have campus transit service. Both surveys were conducted online in the 2019 spring semester. Using the results from both surveys, the SURTC assessed MATBUS's on-campus service perception, identified some service gaps, and made recommendations for improving MATBUS services on campus.

NDSU MATBUS Transit Survey Result

From the results of the first survey, the authors observed that a majority of survey respondents were 18 to 24 years old, with most identifying as females (~64%) and as undergraduates (~82%). About 44% of the respondents live on campus, and more than half (~58%) live about a mile or less from campus. When asked about access to vehicles, about 84% of respondents owned or had access to a vehicle. Most of the students with vehicle access or ownership lived off campus and stayed five miles or more from the campus. The highest mode share (30.4%) chosen by respondents was transit (MATBUS), followed by walking (30.1%), and then automobile (22.2%). The scooter had the lowest mode share (1% for male and 0% for female). Among respondents who chose the transit mode, the majority identified MATBUS Route 32E and Route 33 as their most used routes, and Route 31 as the least used route.

Regarding the willingness of respondents to walk in temperatures above freezing, it increases continuously until one mile; however, it decreases for temperatures below freezing, and this willingness to walk decreases steadily with an increase in distance. The least willing to walk are respondents who chose the scooter as a transportation mode. In general, female respondents show more willingness to walk for certain distance ranges under certain conditions. For temperatures above freezing, females show more willingness to walk distances less than a mile, and for temperatures below freezing, they show more willingness to walk distances less than 0.75 miles; beyond these ranges, males show more willingness to walk. The willingness to walk was significantly higher for respondents with vehicle access or ownership. As shown in Figure S-1, most work trips are made by part-time workers and by off-campus students. Regarding shopping trips, most of these are made by part-time workers and on-campus students.

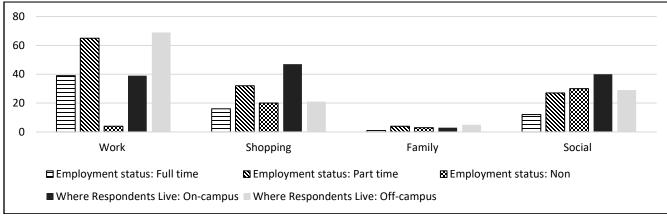


Figure S-1 Employment Status, Residency, and Trip Purpose

For the relationship between mode share and employment, the survey response suggests that respondents identified as part-time workers have the most significant percentage of all modes used. The employment group, with the second largest share of all modes used, is the unemployed group. For the relationship between mode share and a student's resident location, the response from the survey suggests that respondents who live off campus have a higher mode share on automobile, MATBUS, scooter, and walking, compared with on-campus residents (Figure S-2). On the other hand, respondents who lived on campus had a higher mode share for carpooling and bicycle share, compared with off-campus students. The most common trip frequency chosen by the respondents (especially those who reside one to five miles from campus). Most of the respondents who make 2-one-way trips either walk or use the transit mode share the most. The least trip frequency chosen by the respondents is the +5-one-way trip. As shown in Figure S-2, most respondents who use the MATBUS mode are part-time workers and off-campus residents.

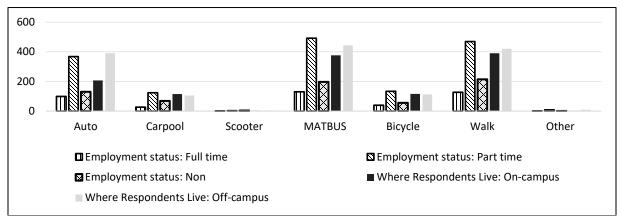


Figure S-2 Relationship of Employment Status and Residence on Mode Share

About 25% of respondents were extremely satisfied with the MATBUS service; and within this group of respondents, more than half (53.33%) reside off campus, with 25% of them living 1 to 5 miles from campus. At least 69.26% of the respondents are satisfied (extremely satisfied or somewhat satisfied) with the MATBUS service. Additionally, 19.03% are indifferent (neither satisfied nor dissatisfied), and 11.71% are dissatisfied with the service. About 1.74% of the respondents are extremely dissatisfied, and

within this group, all (100%) have a driver's license, and 94.74% have access to a vehicle (5.26% have no access to a car). Among these groups, the MATBUS route used most frequently is Route 32W, followed by Route 32E. More than half (57.89%) indicated there are additional stops/locations they want the transportation system to cover. Also, 73.68% think the service span of the MATBUS is inadequate. A majority of these respondents want more services during the early and late hours of the day (Table S-1). A majority of these respondents pointed out the following MATBUS service attributes that should be improved: on-time performance, frequency of service, and reliability of service.

		NDSU MATBUS Service Satisfaction					
		Extremely satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Extremely dissatisfied	
Residence:	On-campus	126	223	83	41	3	
	Off-campus	144	264	125	68	16	
Valid driver's	Yes	250	449	198	100	19	
license:	No	19	38	10	9	0	
Access to a vehicle:	Yes	225	406	188	88	18	
	No	44	81	20	21	1	
Frequent MATBUS	Route 13	98	158	29	39	4	
Routes:	Route 13U	58	120	18	21	2	
	Route 31	44	83	12	10	3	
	Route 32E	133	214	34	56	5	
	Route 32W	69	149	22	41	7	
	Route 33	142	234	33	41	2	
	Route 34	67	126	16	22	1	
	TapRide	17	46	5	11	0	
	None	9	31	123	13	7	
	Other:	4	13	4	5	0	
Desire additional	Yes	47	145	39	52	11	
stops:	No	220	340	162	57	8	
Desire a better	Yes	154	202	62	27	1	
service span:	Maybe	75	176	100	32	4	
	No	36	107	39	50	14	
Desired periods for	Weekdays	28	94	37	33	9	
increased services:	Weekends	52	111	44	35	3	
	Early Morning	21	76	41	27	11	
	Late Nights	83	195	76	55	11	
Transit service	Reliability of			54	62	42	
attributes that	service	30	133	51	62	13	
should be improved:	On-time Performance	86	275	85	75	14	
-	Frequency of Service	86	237	75	65	13	
	Seat Availability	48	80	32	15	4	
	Technology	59	90	43	25	6	

Table S-1 MATBUS Service Satisfaction

The survey had a few questions regarding the new NDSU TapRide service, which is a relatively new ondemand service offered on the NDSU campus, Monday through Friday, from 7:30 p.m. to 11:00 p.m. It was introduced to replace MATBUS Route 35 and provide rides to more remote corners of campus where fewer students go. More than half (59.03%) of respondents have heard of the service, and within this group, 91.14% of them indicated they want more TapRide services (Table S-2).

). Among the respondents who want more services, 77.78% stay on campus, 72.22% of them have a valid driver's license, 50% have access to vehicles, a majority of them walk and use the transit around campus, and 69.44% indicate there are locations on campus too far to walk to (Table S-3).

About 80.4% of respondents stated they were unwilling to pay an activity fee for transit around campus. Among the respondents who indicated a willingness to pay:

- More than half (55.56%) worked part time
- 41.12% were somewhat satisfied with the transit service
- 81.82% have heard of the TapRide
- 42.45% stated the MATBUS service is adequate
- A significant number want the service span to extend to late nights

Among respondents willing to pay a per-semester fee, about 29% of were willing to pay less than \$10; the majority of respondents (43.46%) specified they were willing to pay between \$11 and \$20; and 16.36% of them stated they were willing to pay between \$21 and \$30 (Figure S-3 and Table S-3).

		Willingness to p	
		Yes	No
Level of study:	Undergraduate	176	716
	Graduate	40	159
Employment status:	Full time	43	135
	Part-time	120	520
	Not Working	53	229
Frequent MATBUS Routes:	Route 13	87	241
	Route 13U	61	157
	Route 31	34	118
	Route 32E	96	348
	Route 32W	62	228
	Route 33	98	353
	Route 34	42	190
	TapRide	22	57
	None	18	172
Satisfaction with NDSU MATBUS Services:	Extremely satisfied	81	188
	Somewhat satisfied	88	399
	Neither satisfied nor dissatisfied	20	187
	Somewhat dissatisfied	22	87
	Extremely dissatisfied	3	16
How much respondents are willing to pay	Less than \$10	61	0
per semester:	\$11 to \$20	93	0
	\$21 to \$30	35	0
	\$31 to \$40	11	0
	\$41 to \$50	7	0
	More than \$50	7	0
Would you want more TapRide services on	Yes	18	54
campus?	No	4	3
Do you think that the service span of the	Yes	90	355
MATBUS service is adequate?	Maybe	64	328
	No	58	189
What periods would you want increased	Weekdays	36	167
services?	Weekends	45	202
	Early Morning	34	144
	Late Nights	93	329

Table S-2 Willingness to Pay Per Semester and Service Satisfaction



Figure S-3 What Respondents are Willing to Pay Per Semester

Route Recommendations

The survey respondents were asked to list any additional bus stops they want on campus and locations that are too far to walk. The top 10 locations respondents mentioned are shown below (Table S-3). SURTC recommends that MATBUS modify some of its services, within budget, by modifying some of its route frequencies (increasing them). MATBUS could modify its existing fixed-route service windows and frequencies or by expanding its TapRide service to cover the gaps in the fixed-route service.

Stops (Locations)	Sum	Stop Location								Sum
		Address	13	13U	31	32E	32W	33	34	-
Richard H. Barry Hall	74	811 2nd Ave N	1	1	0	0	0	1	0	3
Fargodome	58	1800 N University Dr	1	1	1	1	1	1	1	7
Library	35	1201 Albrecht Blvd #2080	0	0	1	1	1	0	0	3
Minard Hall	22	1210 Albrecht Blvd	0	0	1	1	1	0	0	3
Wellness Center	21	1707 Centennial Blvd	0	0	1	0	0	0	0	1
Niskanen	16	1805 N University Dr	1	1	0	0	0	1	1	4
West Dining	12	1500 15th Ave N	0	0	1	1	1	0	0	3
Animal Nutrition and Physiology Center	7	1801 15th Ave N	0	0	1	0	0	0	0	1
Renaissance Hall	7	650 Northern Pacific Ave	1	1	0	0	0	0	0	2
Klai Hall	5	711 2nd Ave N	1	1	0	0	0	1	0	3

Table S-3 Locations or Stops Recommended for Service Addition or Improvement

U.S. University Transit System Survey Results

A seven-question survey was developed in Qualtrics, and a survey link was emailed to 53 university campus transit contacts across the United States on March 11, 2019. Responses were received from 32 universities for a 60% response rate, which is quite good. The university size ranged between 12,500 and 44,000 students. Among respondents, 63% (20) reported their school has multiple campuses (clusters of buildings in separate areas), and 94% (17) reported the multiple campuses are served by transit service. Each respondent was asked to check all of the services that apply to their campus. (Table S-4).

Kinds of Transportation Options Available to Campus Community, N=92					
Type of service	Count	Percent			
On-campus circulator/shuttle	25	27			
Shuttles from remote parking lots to campus	18	20			
Regular fixed-route service	25	27			
Accessible service for students with disabilities	24	26			

Table S-4 Kinds of Transportation Options Available to Campus Community

The respondents were asked who operates the campus transit system. There were some campuses with multiple operators, e.g., some are only university-operated agencies; others are university and private contractor operated; a few campuses reported transit agency, university, and private contractor operations. The schools that reported multiple operators also have multiple services, including on-campus circulator/shuttle, shuttle from remote parking lots to campus, regular fixed-routes, and accessible service for students with disabilities.

Table S-5 shows the survey results of who operates the campus transit system. Among respondents, 45% (21) reported the university/college operates the transit agencies.

Who operates the campus transit system (sele	ect all that app	oly)
Operator	Count	Percent
University/college	21	45
Private contractor	14	30
Transit agency	11	23
Other (contracted drivers & maintenance)	1	2
Total	47	100

Table S-5 Campus Transit System Operator

The survey respondents from the 32 campus transit systems reported operating expenses from \$36 an hour with the university owning the buses to a high of \$166 an hour with the transit agency operating the system. Due to the wide range of variance in the survey numbers, it was clear the dollar amounts did not have consistent methods for calculating expenses. Therefore, the National Transit Database was utilized to determine numbers that could be factually comparative.

Table S-6 illustrates the minimum, mean, standard deviation, median, and maximum operating expense per vehicle revenue hour for 89 urban transit agencies located within the Federal Transit Administration's Region 5 (Illinois, Ohio, Minnesota, Wisconsin, Indiana, and Michigan), Region 7 (Missouri, Iowa, Nebraska, and Kansas), and Region 8 (Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming). Fargo's MATBUS calculation is also listed to show the comparison. MATBUS's fully loaded hourly operating expense is \$72.05, as reported in the National Transit Database for 2017. This number is much lower than the mean dollar value of \$109.28 and lower than the median value of \$83.74.

	Vehicle	Vehicle Vehicle N		General	Tatal
	Operations	Maintenance	Maintenance	Administration	Total
MATBUS Fargo	\$34.05	\$13.24	\$2.54	\$22.02	\$72.05
Mean	\$66.10	\$18.11	\$4.92	\$20.16	\$109.28
Standard Deviation	\$145.22	\$39.84	\$16.39	\$47.32	\$247.85
Minimum	\$26.00	\$2.69	\$0.06	\$2.88	\$37.18
Q2	\$42.04	\$11.18	\$1.33	\$10.80	\$71.38
Median	\$50.84	\$13.61	\$2.43	\$14.41	\$83.74
Q3	\$59.33	\$17.01	\$3.96	\$19.46	\$95.36
Мах	\$1,416.32	\$386.90	\$154.01	\$456.67	\$2,413.90

Table S-6 Operating Expense

Other University Student Fees

U-PASS programs vary substantially across the United States. TCRP 2018 reports that funding sources for U-Pass programs often include a combination of student fees, parking permit revenue, parking fine revenue, university general funds, and federal, state, and local operating assistance funds (p. 10). From the TCRP survey, some of the details regarding student fees reported by institutions are presented in Table S-7.

At UC Davis, students pay \$34.30 per each of three quarters, so they pay \$102.90 per year for transit. The rates increased in 2019 by \$13.33, so the cost was \$47.63 per quarter, and then increased to \$58 per quarter; by 2023, the price will increase to \$67.83 per quarter. The price increase was voted on and passed with 92% approval. The cost increase was needed due to the increased minimum wage.

U-Pass Program Student Fees Reported					
City	Name	Price (\$)	Unit		
Milwaukee, WI	University of Wisconsin-Milwaukee	45.10	Per Student Per semester		
Madison, WI	University of Wisconsin – Madison	55.52	Per student per semester		
Bloomington, IN	Indiana University	64.61	Per student per semester		
Hartford, CT	Capital Community College	12.00	Per student per semester		

Table S-7 U-Pass Student Fee

Adapted from TCRP Synthesis 131 College Student Transit Pass Programs. Transit Cooperative Research Program, National Academies of Science, Transportation Research Board, Washington, DC, 2018

Recommendations

It is recommended that NDSU not cut MATBUS service, but rather expand it to meet the student demand, if fiscally possible. The students identified the desire/need for more frequency and access to the Wellness Center, Fargodome, Barry Hall, the library, downtown, Niskanen Apartments, and Minard Hall. MATBUS's hourly operating expenses are less than the median hourly operating costs for 89 transit agencies within the region, so it is unlikely to reduce the hourly cost MATBUS charges NDSU for service. If additional funds are needed to provide more service, NDSU should consider adding a small student fee to help cover the expenses. Although 80% of students who responded to the survey were not in favor of paying a student fee, about 28.5% were in favor of paying \$10 per semester, and 43.46% were willing to pay between \$11 and \$20. Many universities charge a student fee for public transportation services.

INTRODUCTION

The survey of NDSU students focused primarily on travel behavior and student experience with Metro Area Transit (MATBUS) service. The research updates previous studies conducted with NDSU students by SURTC (Mattson, Ripplinger, & Peterson 2010; Hegland & Hough 2003; Peterson & Hough 2003; Peterson, Hough, Hegland, Miller, & Ulmer 2005; Ripplinger & Ulmer, 2005; Ulmer 2005; Ripplinger, Hough, & Easterday 2008; Ripplinger, Hough, & Brandt-Sargent 2009).

The objectives of the study were to:

- Collect and analyze current and previous NDSU MATBUS transit ridership data
- Study the spatial interaction of trips to determine if existing transit routes should be modified
- Study the impact of changes to student residence (location and size) on ridership
- Describe existing levels of transit service on campus
- Identify gaps in existing service and base levels of required transit service
- Develop recommendations for meeting identified mobility needs
- Compare the costs and type of service offered by different transit agencies/groups to determine the best transit service provider for NDSU for fiscal year 2019

The study would take into account the MATBUS/City of Fargo bus service cost, along with that of other public transit services. NDSU and other service providers can use the survey findings to identify programmatic and finance needs related to campus mobility. Finally, all data collected as a part of this study can be used by NDSU and local transit agencies to plan for future services.

CAMPUS TRANSIT RIDERSHIP DATA

NDSU participates in the U-Pass program, which offers unlimited free rides to students on any MATBUS. Some MATBUS routes exclusively serve the NDSU campus: 13U, 31, 32E, 32W, 33, 34, and Tap Ride. See Table 1 for the exclusive NDSU MATBUS routes, their frequencies, and the stops they serve. For this study, ridership data for most of the exclusive routes (all except route 13U) are collected and analyzed. For the analysis, the authors collected data from MATBUS for the NDSU routes and prepared the data for analysis. The ridership data were then combined with some seasonal and non-seasonal attributes from other data sources on one data frame. The data used were set to both daily and weekly ridership frequencies, and the observational range used was between 2014 and 2018 (four years). The ridership of the bus routes studied (Route 31, Route 32E, Route 32W, Route 33, Route 34, and Route 35/TapRide), had 1,461 observations for the daily ridership dataset and 209 observations for the weekly ridership dataset.

Route	Frequency 30 mins	Stops				
13U		NDSU Transit Hub, Family Fare, Renaissance Hall, GTC, Klai Hall, R.H. Barry Hall, Niskanen, University & Centennial				
31	15 mins	Minard Pullout (west), Thorson Hall, Stevens Hall, Wallman Wellness Ctr., Candlewood Suites, Research & Tech Park, Fargodome, High Rises, Loftsgard Hall, Shepperd Arena				
32E	30 mins	Minard Pullout (east), Residence Dining Center, Fargodome, University Village, High Rises, Minard Pullout (west), Dakota Drive & 16th St., Prairie Hall				
32W	30 mins	Minard Pullout (west), West Port on Dakota Dr, Bison Crossing & Prairie Hall, Mina Pullout (east), Residence Dining Center, Fargodome, University Village, High Rises				
33	12 mins 7 mins					
34	20 mins	NDSU Transit Hub, Reed/Johnson Halls, Fargodome, NDSCS - Fargo, Stop-N- Center (SGC), Niskanen Expansion, Centennial Shelter				
TapRide (35)	*N/A	*Main NDSU Campus, *SGC Apartments, *University Village, *Dakota Drive (This is an on-demand service offered on NDSU campus during the academic year on weekdays, from 7:30 pm to 11:00 pm. It provides pick-up and drop-off, "curb-to-curb" service with the use of a mobile phone.)				

Table 1 NDSU MATBUS Route Details

Given the assumption that NDSU college enrollment guarantees some level of transit trips (Chakraborty & Mishra 2013) and profoundly impacts the use of NDSU MATBUS ridership, the authors considered NDSU's annual student enrollment between 2014 and 2018 (Figure 1).

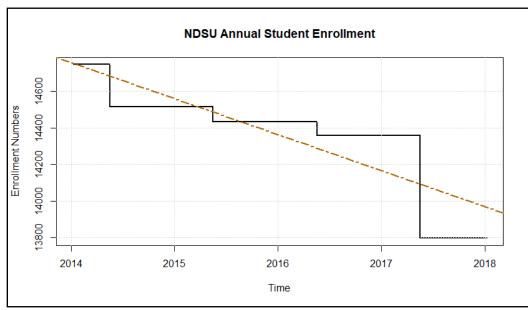


Figure 1 Annual NDSU Student Enrollment

Given that prior research has made known the interdependency of public transit and high-density land use developments, and the impact of housing and residential patterns on transit (Chakraborty & Mishra 2013), the authors considered NDSU student residency (on-campus) in the analysis. The student residence hall and student apartment occupancy trend between 2014 and 2018 is explored (Figure 2). The on-campus residency has declined significantly during these four years, correlating with reduced student enrollment and suggesting a possibility of reduced transit use. In the next section, the trends and seasonality of NDSU MATBUS ridership are discussed for all NDSU exclusive routes.

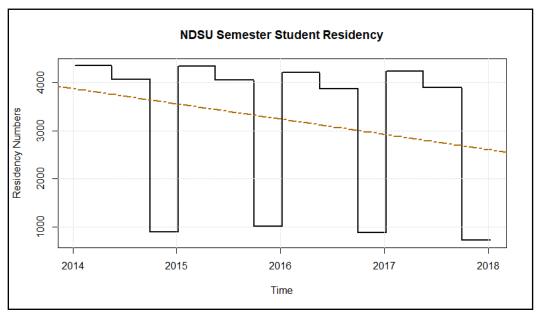


Figure 2 NDSU On-Campus Resident Occupancy (2014 - 2018)

NDSU MATBUS RIDERSHIP AND ANALYSIS

As observed in other daily or weekly transportation indicators, public transit ridership is highly seasonal. Seasonality usually shows long-term variabilities with a repetitive pattern (Bureau of Transportation Statistics 2019); and when the seasonal and irregular components of a ridership time series are separated from the trend (time series decomposition), it is easier to observe the long-term trend of transit ridership. Hence, to better analyze the ridership of all NDSU MATBUS routes, time series analysis and other analytical methods (statistical and machine learning) are used to study the routes and build ridership prediction models. The time series plot of the cumulative ridership of all NDSU exclusive routes in the study shows an overall declining linear trend (Figure 3). The decomposed time series plot (Figure 4) has a trend with a narrow valley between fall and spring semester and a wider one during the summer semester (some NDSU MATBUS routes are only available for spring and fall semester).

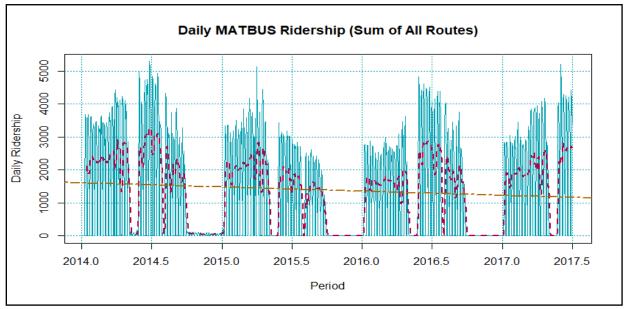


Figure 3 Cumulative NDSU MATBUS Ridership (Routes 31-35/Tap)

The decomposed time series shows that, while the trend is initially continuously downward, it changes to an upward trend at the end of 2015, and continues upward until 2017. However, when the trend is considered linearly (from the start point to the end point), the ridership appears to be on a steady overall decrease (Figure 4).

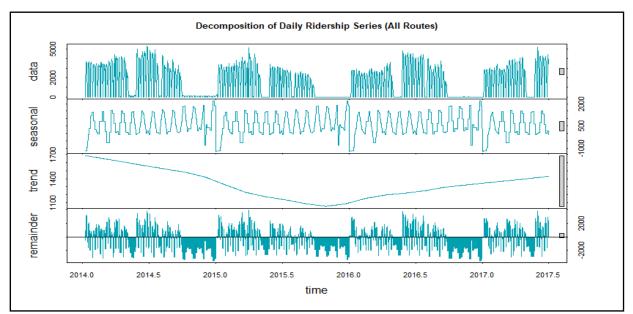


Figure 4 Decomposition of the Cumulative Daily Ridership (Routes 31-35/Tap)

The trend changes within a 600-ridership interval (± 300 daily rides), and the skew on the random effects (reminder) on the daily ridership suggests an overall advantageous tilt in the positive direction. The seasonality shows a recurring seasonal pattern with changes that range between +2,000 rides and -1,000 rides (a 3,000 ridership range). The observed seasonality could inform the decisions of MATBUS or other transit service providers regarding route planning and operations. The hourly ridership of all the routes considered in the cumulative daily ridership is shown in Figure 5 through Figure 9. Route 31 showed increased ridership between 8 a.m. and 11 a.m. (Figure 5) while running at 15-minute intervals, primarily because of students utilizing the park and ride lots near the Fargodome on the north side of the main campus and the T-lot to the south of campus.

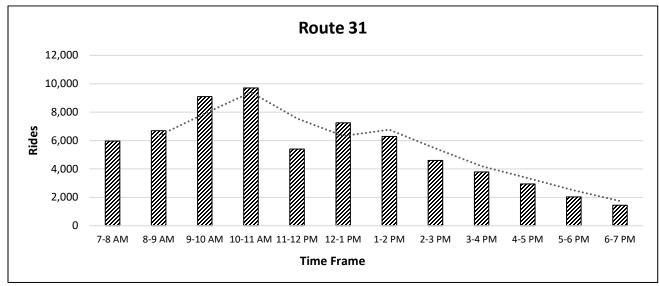


Figure 5 Route 31: Hourly Ridership

Route 32E, which operates at 30-minute intervals, exhibited relatively steady ridership throughout the day (Figure 6) while serving the University Village area, along with the many apartment complexes south of the main NDSU campus. Route 32W ridership is concentrated in the morning hours between 7:30 a.m. and 10 a.m. (Figure 7) while serving the apartment complexes to the southwest of campus along with the University Village area. Route 32W has discontinued afternoon and evening service. Route 33 was the most-used route at NDSU, accounting for more than 40% of ridership during the study time frame. Ridership was heaviest from 9 a.m. to 1 p.m. (Figure 8) but remained consistent from 8 a.m. to 4 p.m. This route serves the downtown campus via the east side of the main NDSU campus along University Avenue with service to University Village. The route runs at 7- to 12-minute intervals from 7 a.m. to 7 p.m. Finally, Route 34 runs at 20-minute intervals between 7:45 a.m. and 4:45 p.m. and saw its most substantial ridership from 8 a.m. to 10 a.m. and noon to 2 p.m. (Figure 9). The route serves the main campus and Fargodome area.

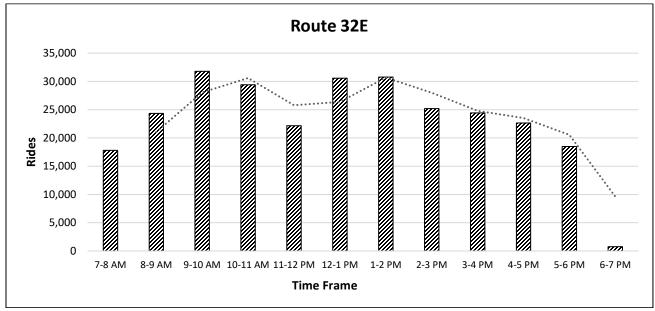


Figure 6 Route 32-East: Hourly Ridership

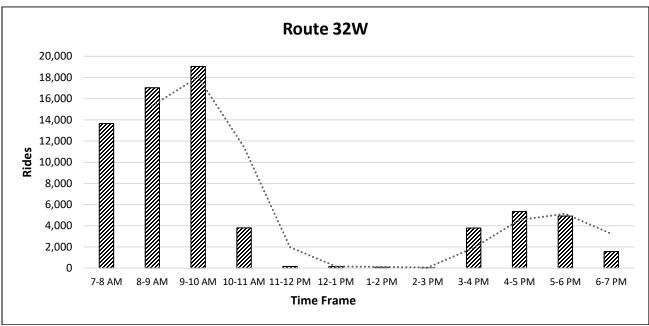


Figure 7 Route 32-West: Hourly Ridership

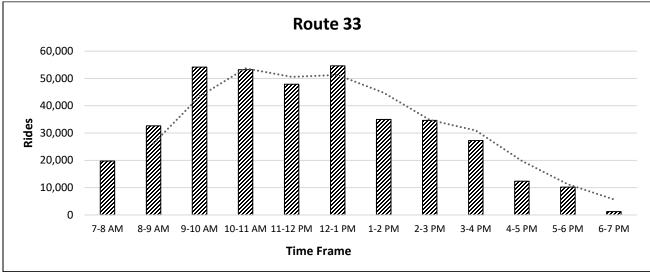


Figure 8 Route 33: Hourly Ridership

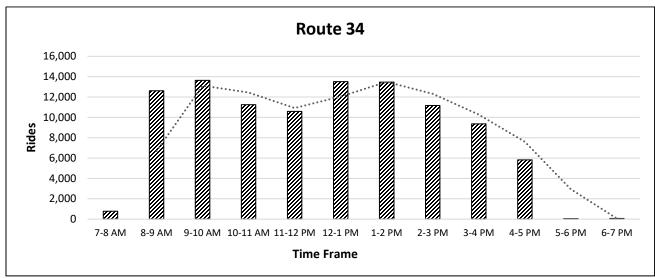


Figure 9 Route 34: Hourly Ridership

MATBUS - Route 31

Figure 10 and Figure 11 show the composite and decomposed time series data for Route 31 daily ridership. As can be seen from the composite time series plot, the trend is linear and goes downward, and the ridership varies depending on the time of year. A closer look at the trend without seasonality and randomness shows that the ridership continually dropped until the middle of 2017. This trend changes within an 80 ridership range or interval (± 40 daily rides from the mean). Figure 11 shows that the random effects (reminder) on the daily ridership numbers skew toward an increase in ridership. Seasonality shows a recurring seasonal pattern with maximum changes that range between +100 rides and -100 rides.

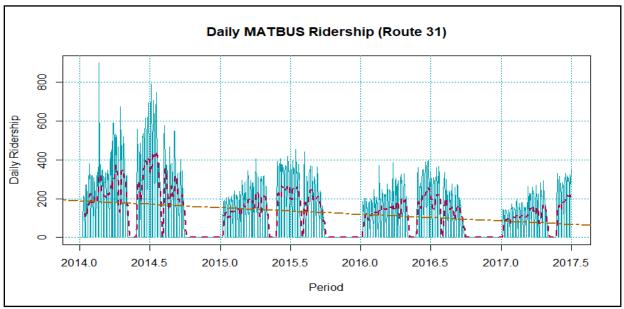


Figure 10 Daily Ridership of Route 31

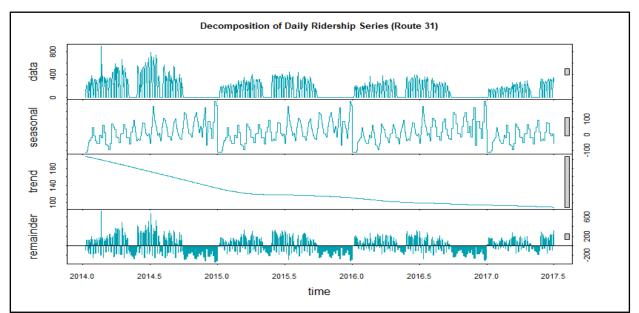


Figure 11 Decomposition of the Daily Ridership of Route 31

MATBUS - Route 32

Figure 12 and Figure 13 show the composite and decomposed time series data of Route 32 daily ridership. As can be seen from the composite time series plot, the trend is slightly upward, and the ridership also varies depending on the time of year. However, the decomposed time series shows a broad valley interrupting the positive trend in 2015. The trend changes within a 200-ride interval (± 100 daily rides).

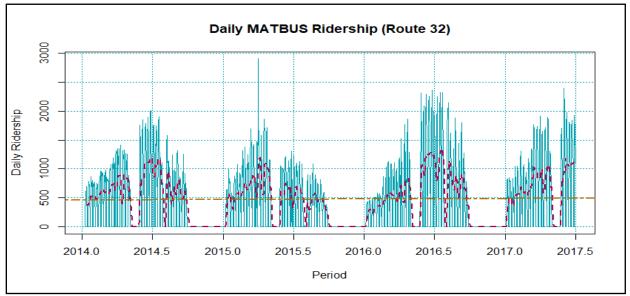


Figure 12 Daily Ridership of Route 32

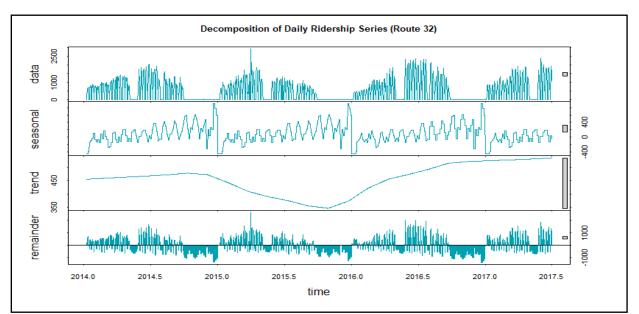


Figure 13 Decomposition of the Daily Ridership of Route 32

Figure 13 also shows that the random effects (reminder) on the daily ridership numbers skew toward an increase in ridership. The seasonality shows a recurring seasonal pattern with maximum changes that range between +400 rides and -400 rides.

MATBUS - Route 33

Figure 14 and Figure 15 show the composite and decomposed time series data of Route 33 daily ridership data. As can be seen from the composite time series plot, the linear trend is declining.

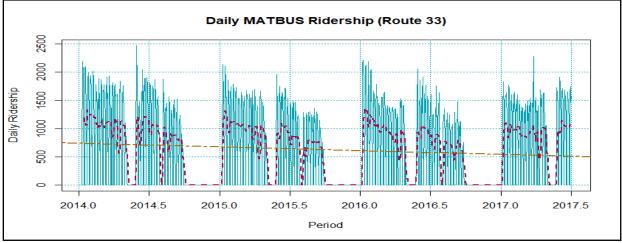


Figure 124 Daily Ridership of Route 33

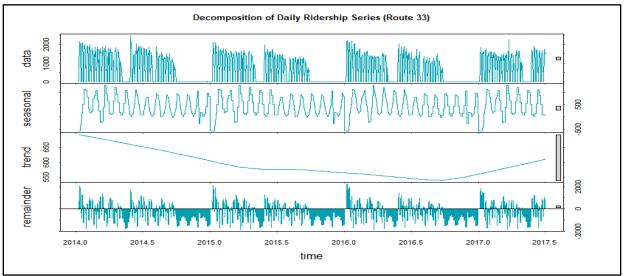


Figure 135 Decomposition of the Daily Ridership of Route 33

However, the decomposed time series shows the trend has a valley- or u-shaped trend. This trend changes within a 100-ride range or interval (± 50 daily rides from the mean). As shown in Figre 15, the random effects (reminder) on the daily ridership numbers skew toward an increase in ridership. The seasonality shows a recurring seasonal pattern with maximum changes that range between +2,000 rides and -2,000 rides.

MATBUS - Route 34

Figure 16 and Figure 17 show the composite and decomposed time series data of Route 34 daily ridership data (average weekly ridership shown with thick dashed lines).

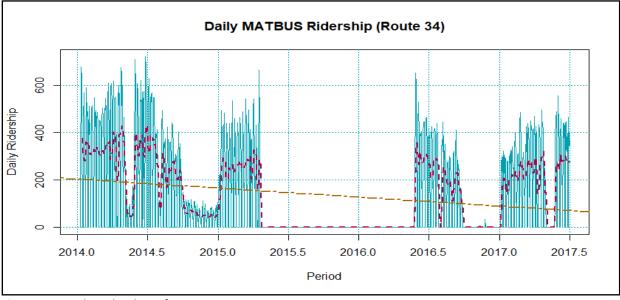


Figure 16 Daily Ridership of Route 34

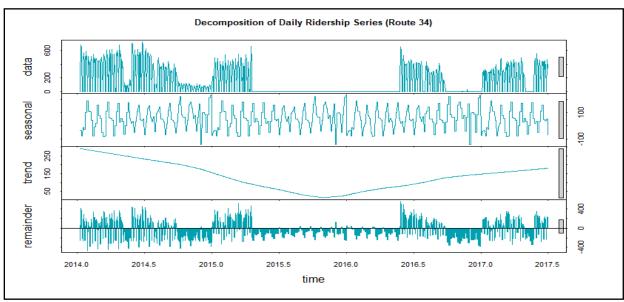


Figure 17 Decomposition of the Daily Ridership of Route 34

As can be seen from the composite time series plot, the linear trend is declining. However, the decomposed time series shows the trend has a valley- or u-shape trend. This trend changes within a 200-ride range or interval (± 100 daily rides from the mean). Figure 17 also shows that the random effects (reminder) on the daily ridership numbers skew advantageously toward an increase in ridership. The seasonality shows a recurring seasonal pattern with maximum changes that range between +400 rides and -400 rides.

MATBUS - Route 35

Figure 18 and Figure 19 show the composite and decomposed time series data of Route 35 daily ridership.

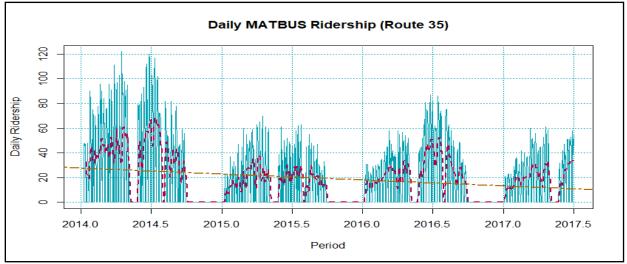


Figure 18 Daily Ridership of Route 35

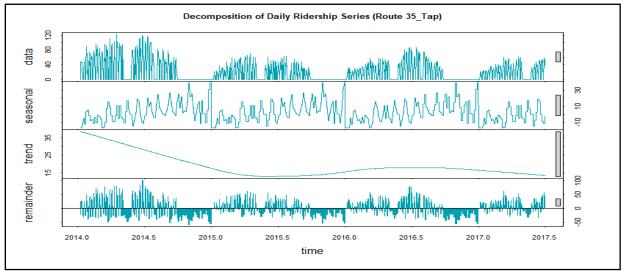


Figure 19 Decomposition of the Daily Ridership of Route 35

As can be seen from the composite time series plot, the linear trend is declining. However, the decomposed time series shows the trend had a steady decline in a valley- or U-shape trend. This trend changes within a 20-ride range or interval (± 10 daily rides from the mean). Figure 19 also shows that the random effects (reminder) on the daily ridership numbers skew advantageously toward an increase in ridership. The seasonality shows a recurring seasonal pattern with maximum changes that range between +30 rides and -10 rides.

RIDERSHIP ANALYSIS AND PREDICTION

Before the analysis for the impact of seasonal and non-seasonal factors on ridership, the ridership data are transformed, and out of 42 predictor variables from the dataset, 15 variables are selected based on their variable inflation factors (VIF) test scores and correlation with other variables (Appendix: Figure A-5 and Figure A-6). Because of the authors' interest in the impact of the changes (demolition and new construction) to University Village Apartment occupancy on ridership, it is added to the selected variables for analysis (Table 2).

Selected Factors	Data Tag (Attribute Name)				
The Observation Date Type	"Day_TypeW_End"				
Holiday	"HolidayYes"				
The Semester	"SemesterSpring + SemesterSummer"				
NDSU Student Enrollment	"Enrollment"				
Maximum Daily Temperature	"T_Max"				
Maximum Wind Speed	"WS_Max"				
Bison Court West	"B_Court_W"				
Burgum Hall	"Burgum"				
Churchill Hall	"Churchill"				
Dinan Hall	"Dinan"				
University Village Apartments	"UV_Apts"				

 Table 2
 Selected Factors for Statistical Analysis

Regression Analysis

For the regression analysis, six models are fitted to the observed ridership using the selected variables. One model is fit for the cumulative ridership of all routes in the study, and five other models are fit for each route. The mathematical equation for the fitted models are shown in Appendix B, Equation A-1 and the model outputs are shown in Appendix B, Figure A-7 through Figure A-18. While the six models show significant relationships between predictor variables and ridership, they do not explain all the variability in ridership and are unable to predict the ridership in all routes to a satisfactory level of confidence (95% CI): (Appendix B: Figure A-21, Figure A-22, Figure A-23, Figure A-24, Figure A-25, and Figure A-26). In Table 3, the impact of the factors on ridership slope is shown for each factor considered for the models; and as the table shows, weekends, holidays, and Burgum Hall residence occupancy have consistently negative impacts on the ridership of all routes considered. Also, any increase in University Village occupancy shows an overall negative impact on the ridership of most routes (Route 31, Route 33, and Route 35). Except for Route 33, the ridership of all routes decreases when there is an increase in temperature and increases when there is an increase in wind speed.

Predictor Variables and Intercept	M00 All Routes	M01 Route 31	M02 Route 32	M03 Route 33	M04 Route 34	M05 Route 35	Consistent Impact across all Models?
(Model Intercept)	[+] ve	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	FALSE
Day Type (Weekend)	[-] ve	[-] ve	[-] ve	[-] ve	[-] ve	[-] ve	TRUE
Holiday (Yes)	[-] ve	[-] ve	[-] ve	[-] ve	[-] ve	[-] ve	TRUE
Semester Spring	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	[+]ve	FALSE
Semester Summer	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	[+]ve	FALSE
Enrollment	[-] ve	[+] ve	[-] ve	[+] ve	[+] ve	[+]ve	FALSE
Maximum Temp.	[-] ve	[-] ve	[-] ve	[+] ve	[-] ve	[-] ve	FALSE
Maximum Wind Spd.	[+] ve	[+] ve	[+] ve	[-] ve	[+] ve	[+] ve	FALSE
Bison Court (West)	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	[+]ve	FALSE
Burgum Hall	[-] ve	[-] ve	[-] ve	[-] ve	[-] ve	[-] ve	TRUE
Churchill Hall	[+] ve	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	FALSE
Dinan Hall	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	[+]ve	FALSE
University Village Apt.	[+] ve	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	FALSE

Table 3 Selected Predictor Factor Impacts

To better predict NDSU MATBUS ridership, the authors switch methods from statistics to machine learning because transit demand/ridership prediction is both an art and a science. Predicting ridership involves estimating real-time unknown variables of demand with a certain degree of rationality, that statistical methods (regression and time series) can be too simplistic for this study despite their complexities and strengths (Profillidis & Botzoris 2019). The limitations of statistical methods exist due to flaws they possess:

- Transit demand methods exhibit non-linear characteristics (regression).
- In time series methods, there can be only one independent variable (time).
- Both methods are based on assumptions that limit the flexibility of transit-demand problems.
- Both methods use limited datasets.
- Both methods use static models that lack the dynamic reflection of human behavior.

To mitigate the flaws of the statistical models, the authors use a machine learning model called a neural network. Two neural networks are built with the same inputs as the regression models and are used to predict the daily ridership of all NDSU MATBUS routes. The neural network (NN) models are used to predict both the overall ridership and the ridership of all five routes. The equation for the NN model used for the predictions are in Appendix B: Equation 2. An NN model with two hidden layers and a linear output is fit using resilient backpropagation ("rprop+ algorithm"). The weights of the NN models are in Appendix C, Table A-3 and Table A-4. The models predict MATBUS transit ridership better than the regression models. See Appendix B: Figure A-33 and Figure A-34 for network configuration; and Figure A-21 through Figure A-26 for daily ridership predictions.

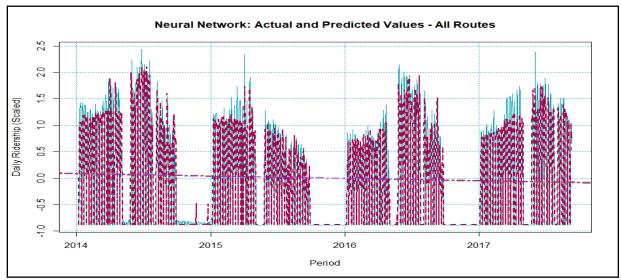


Figure 20 Cumulative Ridership (All Routes) Prediction

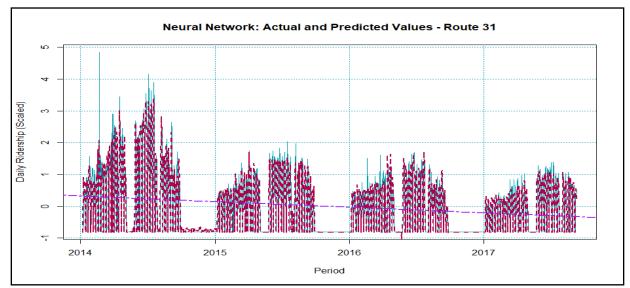


Figure 21 Route 31 Prediction

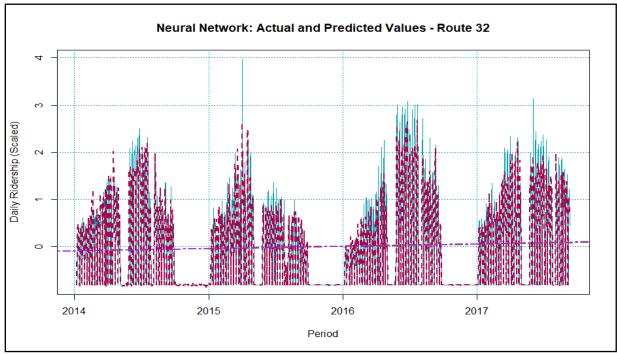


Figure 22 Route 32 Prediction

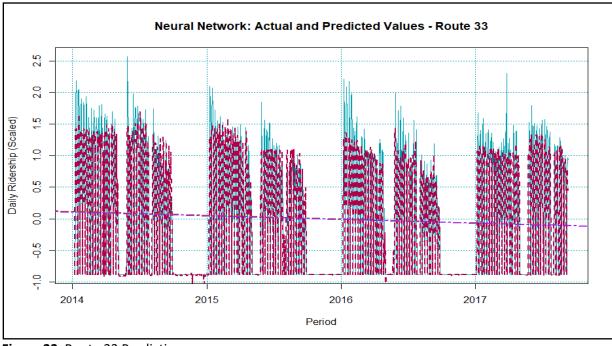


Figure 23 Route 33 Prediction

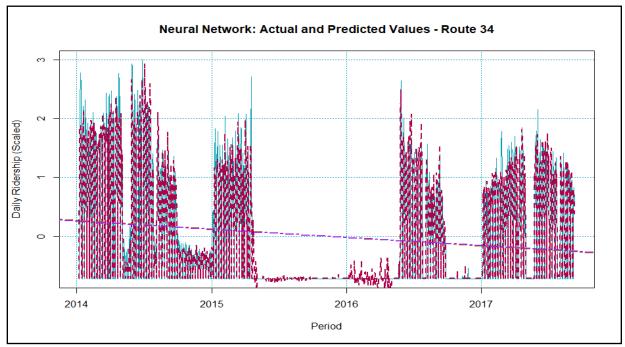


Figure 24 Route 34 Prediction

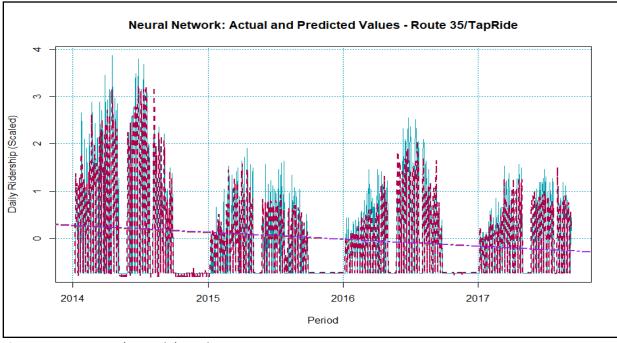


Figure 25 Route 35 (TapRide) Prediction

SURVEY SUMMARY

Profile of Respondents

A significant percentage (82.7%) of respondents was age 18 to 24. None of them were younger than 17, and only 1.1% were 45 or older. Most respondents (64%) were female, and a large proportion of the respondents (81.3%) were undergraduate students (Table 4 and Figure 26). The age profile from a 2014 Transit Center survey is similar to this one. Results from an earlier survey (TransitCenter 2019), suggest that millennials have pro-transit attitudes. However, they face the same factors that tend to pull people away from transit:

- Starting families
- Seeking larger homes
- Moving to less-dense neighborhoods

The decline in college campus transit ridership with age is similar to that observed in cities, where the older people get, the greater the likelihood they live farther from the nearest bus stop and the nearest commercial center. However, the age of riders in this survey is most likely a result of the age distribution of enrolled college students, which is mostly young (18 to 24 years).

		% of Respondents	#of Respondents
Age	Under 17 years old	0.0%	-
	18 - 24 years	82.7%	976
	25 - 34 years	14.3%	169
	35 - 44 years	1.9%	22
	45 - 54 years	0.9%	11
	55 - 64 years	0.1%	1
	65 and above	0.1%	1
	Total	100.0%	1,180
Gender	Male	41.7%	492
	Female	57.3%	676
	Non-binary	0.3%	3
	Prefer not to answer	0.6%	7
	Other (Please Specify)	0.2%	2
	Total	100.0%	1,180
Level of Study	Undergraduate	81.3%	959
	Graduate	17.9%	211
	Other:	0.9%	10
	Total	100.0%	1,180

Table 4 Demographic Characteristics of Respondents

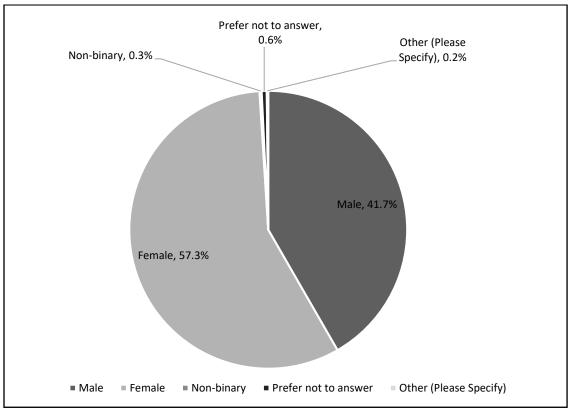


Figure 26 Gender or Respondents

Where Students Live

In the survey, respondents were asked if they live on or off campus and the distance of their residence from campus. About 44% (44.6%) of the students surveyed lived on campus (Figure 27 and Table 5) while the rest (~56%) lived off campus.

Distance from Campus	%	Count
0.25 miles or Less - (0.4 km or Less)	19.34%	128
0.25 to 0.50 miles - (0.4 to 0.8 km)	18.43%	122
0.50 to 1.00 miles - (0.8 to 1.6 km)	20.09%	133
1.00 to 5.00 miles - (1.6 to 8.0 km)	22.51%	149
5.00 to 10.00 miles - (8.0 to 16.0 km)	15.11%	100
10 miles or More - (16 km or More)	4.53%	30
Total:	100%	662

Table 5	Distance from	Campus	(Off-Campus Students)	
Table J	Distance nom	campus	(On campus students)	

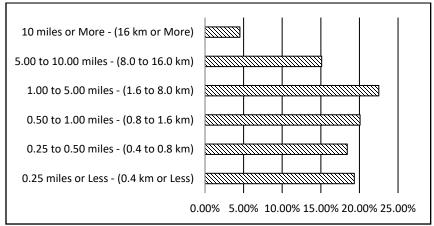


Figure 27 Distance from Campus (Off-Campus Students)

Travel Behavior

The survey contained questions regarding respondents' access to a vehicle, how they often travel around campus, what types of trips they generally make, the factors considered in deciding their mode choice, their willingness to walk in different weather conditions, locations too far to walk, and the number of daily trips they usually take to campus. They were also asked if they use MATBUS transit service, the routes taken by the students who use the MATBUS service, and the obstacles faced by the students not using the service.

Access to a Vehicle

About 84% (84.3%) of respondents own or have access to a vehicle. Off-campus students and students living farther from campus are more likely (by 15%) to have regular access to an automobile (Table 6).

· · · · ·		Acce	Access to a vehicle		
		Yes	Percentage	Total	
Where respondents live:	On-campus	388	76%	512	
	Off-campus	602	91%	662	
	Total:	990	84%	1,174	
How far respondents live	0.25 miles or Less	119	93%	128	
from campus:	0.25 to 0.50 miles	106	87%	122	
	0.50 to 1.00 miles	120	90%	133	
	1.00 to 5.00 miles	134	90%	149	
	5.00 to 10.00 miles	95	95%	100	
	10 miles or More	28	93%	30	

Table 6 Vehicle Ownership or Access to Vehicles

Mode of Transportation Used

Survey responses show that the students use a variety of modes for traveling around campus. Respondents were allowed to indicate all modes of transportation used, and transit (MATBUS) received the most significant share at more than 30% (30.38%). The least used way to get around campus was scooter at 0.3% (Table 7).

Mode Share		
Mode	%	Count
Auto	22.18%	598
Carpool	8.16%	220
Scooter	0.30%	8
Transit - (e.g., MATBUS)	30.38%	819
Bicycle	8.49%	229
Walk	30.08%	811
Other (Please Specify)	0.41%	11
Total:	100%	2,696

 Table 7
 NDSU Student Mode Share

The mode shares varied based on categories, such as gender, where students reside, as well as the bus routes that students use most frequently. Female respondents had the highest auto/vehicle mode share and the highest carpool mode share, but they shared the same walking mode share with respondents who identified as male. Male respondents had the highest mode share for scooters and bicycles. On-campus students were more likely to walk, cycle, and carpool, but were less likely to use auto. The closer students lived to campus, the more likely they were to walk (Table 8 and Figure 28).

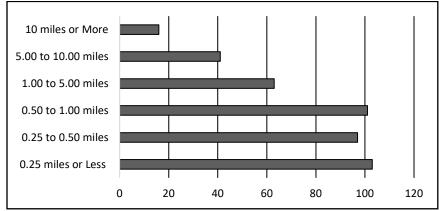


Figure 28 Effect of Residence Distance from Campus to Students' Preference to Walk

		How Respondents Often Travel to or around Campus								
		Auto	Carpool	Scooter	MATBUS	Bicycle	Walk	Othe		
Gender:	Male	231	74	6	341	115	337			
		<u>21%</u>	<u>7%</u>	<u>1%</u>	<u>31%</u>	<u>10%</u>	<u>30%</u>	<u>19</u>		
	Female	361	145	2	471	112	466			
		<u>23%</u>	<u>9%</u>	<u>0%</u>	<u>30%</u>	<u>7%</u>	<u>30%</u>	<u>0</u> 2		
	Non-binary	2	0	0	2	0	1			
	Prefer not to	3	1	0	5	2	6			
	answer									
	Other	1	0	0	0	0	1			
	Total	598	220	8	819	229	811	1		
Student	On-campus	207	115	3	376	116	390			
Residence:		<u>17%</u>	<u>10%</u>	<u>0%</u>	<u>31%</u>	<u>10%</u>	<u>32%</u>	<u>0</u> 2		
	Off-campus	391	105	5	443	113	421			
		<u>26%</u>	<u>7%</u>	<u>0%</u>	<u>30%</u>	<u>8%</u>	<u>28%</u>	<u>1</u> 9		
	Total	598	220	8	819	229	811	1		
Residence	0.25 miles or Less	57	21	3	68	17	103			
Distance	0.25 to 0.50 miles	61	22	1	87	36	97			
from	0.50 to 1.00 miles	75	28	1	106	36	101			
Campus:	1.00 to 5.00 miles	94	17	0	105	20	63			
	5.00 to 10.00 miles	81	15	0	59	4	41			
	10 miles or More	23	2	0	18	0	16			
	Total	391	105	5	443	113	421			
MATBUS	Route 13	145	65	4	280	63	224			
Routes Frequently used:	Route 13U	100	51	1	195	49	161			
	Route 31	89	27	2	138	29	110			
	Route 32E	213	85	3	415	112	334			
	Route 32W	138	47	1	266	76	205			
	Route 33	211	86	2	396	97	316			
	Route 34	120	51	2	212	61	166			
	Tap Ride	25	15	0	67	24	55			
	None	125	34	1	12	21	148			
	Other	12	9	0	19	10	20			

Table 8 Mode Differences for Different Categories

Willingness to Walk

The response from students about their desire to walk under different weather conditions shows that when the temperature is below freezing (Figure 30) their desire to walk is the highest at less than 0.25 miles, and decreases steadily with increased distance. However, when the temperature is above freezing (Figure 29), the willingness to walk is the highest at 1 mile.

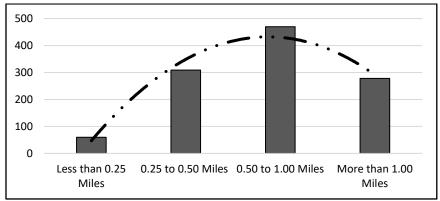


Figure 29 Willingness to Walk (>32F)

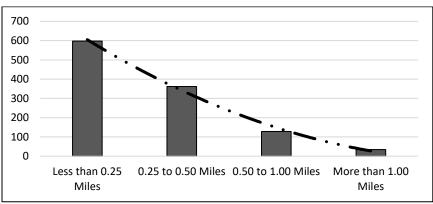


Figure 30 Willingness to Walk (<32F)

Results also show that both males and females follow the same willingness pattern of all respondents for all weather conditions considered. However, for temperatures above freezing, females outnumbered males in their willingness to walk up to a 1-mile distance; but for distances beyond 1 mile, male respondents were more likely to walk. A similar pattern is observed with the female respondents for temperatures below freezing, where males outnumber females beginning at about 0.75 miles. In both cases, up until the turning points, female respondents indicated a higher likelihood to walk than males (Figure 31, Figure 32, and Table 9).

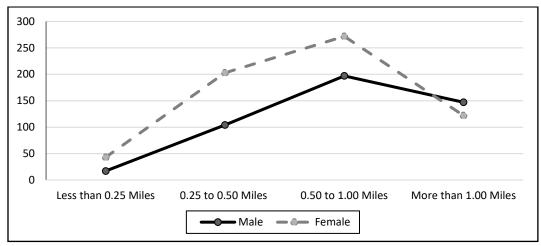


Figure 31 Willingness to Walk When Above Freezing

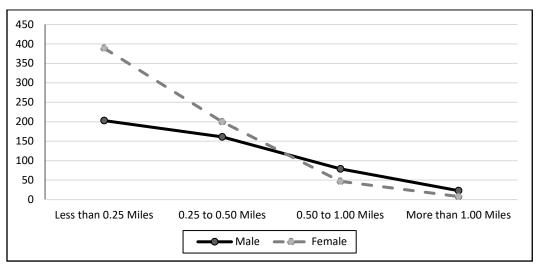


Figure 32 Willingness to Walk When Below Freezing

The results also show that the willingness to walk was significantly higher for respondents with a valid driver's license and, also for respondents with access to a vehicle. The least willing to walk are respondents who use a scooter on and around campus. This survey response shows a difference in responses between males and females, and is consistent with findings from an earlier study (Granié 2009) on the relationships between gender stereotypes and risk-taking. The study found that greater risk-taking occurred among masculine individuals and attributed it to weaker internalization of rules and safety. The study found that sex-stereotype conformity influences the tendency to take risks among pedestrians.

			nable wa nperatu	-			Reasonable walking distance when the temperature is below freezing (<32 F)				
		Less than 0.25 Miles	0.25 to 0.50 Miles	0.50 to 1.00 Miles	More than 1.00 Miles	Total	Less than 0.25 Miles	0.25 to 0.50 Miles	0.50 to 1.00 Miles	More than 1.00 Miles	Total
Age:	18 - 24 years	33	261	399	234	927	480	317	109	21	927
	25 - 34 years	24	40	56	38	158	101	36	17	7	161
	35 - 44 years	3	5	9	3	20	13	3	1	4	21
	45 - 54 years	0	3	6	1	10	3	6	1	1	11
	55 - 64 years	0	0	0	1	1	1	0	0	0	1
	65 and above	0	0	0	1	1	0	0	0	1	1
Gender:	Male	17	104	197	147	465	203	161	79	23	466
	Female	43	203	272	122	640	389	200	47	8	644
	Non-binary	0	0	0	3	3	1	1	0	1	3
	No Answer	0	2	0	5	7	4	0	2	1	7
	Other	0	0	1	1	2	1	0	0	1	2
Class:	Undergraduate	36	256	387	231	910	469	308	107	26	910
	Graduate	23	51	80	45	199	123	51	21	7	202
	Other:	1	2	3	2	8	6	3	0	1	10
Residence:	On-campus	22	124	196	145	487	241	165	63	18	487
	Off-campus	38	185	274	133	630	357	197	65	16	635
Residence	0.25 miles or Less	8	46	43	23	120	60	44	15	1	120
distance from	0.25 to 0.50 miles	6	33	54	22	115	69	33	10	5	117
campus:	0.50 to 1.00 miles	4	23	69	33	129	60	48	20	1	129
	1.00 to 5.00 miles	12	47	56	26	141	95	34	9	5	143
	5.00 to 10.00 miles	6	28	41	21	96	55	31	8	3	97
	10 miles or More	2	8	11	8	29	18	7	3	1	29
Valid	Yes	47	293	445	255	1040	555	344	115	29	1043
driver's license:	No	13	16	25	22	76	43	17	13	5	78
Access to	Yes	44	272	412	220	948	516	312	98	25	951
a vehicle:	No	16	37	58	57	168	82	49	30	9	170

Table 9 Willingness to Walk (Under Different Conditions and Categories)

RESIDENCY, WORK, AND TRAVEL BEHAVIOR

Most survey respondents (56.36%) stay off campus. For these respondents, more than 80% (80.36%) live less than 5 miles from campus, while the rest (19.64%) live more than 5 miles away from the school. The mode with the highest share was MATBUS (Transit), with about 30% (30.75%) of the mode share. A glance at the relationship between mode share and employment (Figure 32 and Table 10) shows that respondents identified as part-time workers have the most significant percentage of the transit mode. Respondents identified as unemployed had the second largest share for all modes, except the scooter. The relationship between mode share and residence shows that respondents who live off campus have a higher mode share on auto, MATBUS, scooter, and walking. Respondents who live on campus had a higher mode share for carpooling and bicycle share (Figure 33 and Figure 34).

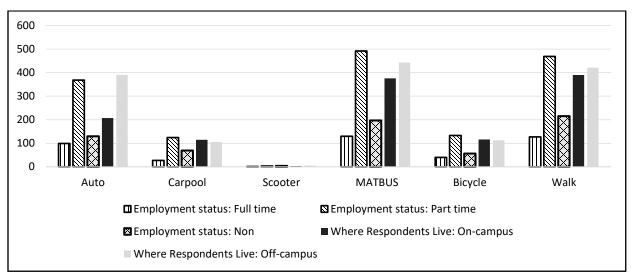
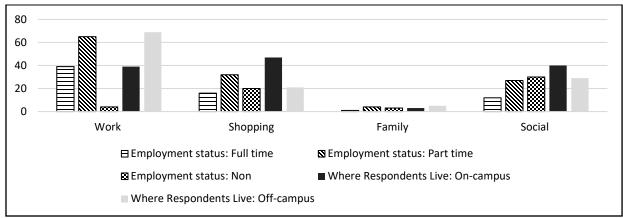


Figure 33 Relationship of Employment Status and Residence on Mode Share





		Employme	nt status:		Where Responde		
		Full time	Part time	Non	On-campus	Off-campus	
Age:	Under 17 years old	0	0	0	0	0	
	18 - 24 years	101	595	280	449	527	
	25 - 34 years	78	72	18	62	107	
	35 - 44 years	9	9	4	2	20	
	45 - 54 years	5	6	0	1	10	
	55 - 64 years	0	0	1	0	1	
	65 and above	0	0	1	1	0	
Distance of	0.25 miles or Less	21	74	33	0	128	
residence	0.25 to 0.50 miles	23	79	20	0	122	
from campus:	0.50 to 1.00 miles	17	83	33	0	133	
	1.00 to 5.00 miles	37	89	23	0	149	
	5.00 to 10.00 miles	20	64	16	0	100	
	10 miles or More	7	18	5	0	30	
Mode of	Auto	99	368	130	207	391	
travel around	Carpool	27	124	69	115	105	
campus:	Scooter	1	3	4	3	5	
	MATBUS	130	492	197	376	443	
	Bicycle	40	133	56	116	113	
	Walk	127	469	215	390	421	
	Other	2	8	1	2	9	
	Total:	186	651	285	487	636	
Types of trips	Work	39	65	4	39	69	
generally	Shopping	16	32	20	47	21	
made with the MATBUS	Family	1	4	3	3	5	
off campus:	Social	12	27	30	40	29	
	Other	14	41	36	41	50	
	No MATBUS	104	480	193	317	461	
The number	0	36	183	87	171	135	
of one-way	1	22	74	36	54	78	
trips generally	2	66	216	91	133	241	
made to and	3	16	47	17	36	44	
from campus:	4	31	83	37	55	96	
	5+	14	44	17	38	37	

Table 10 Employment Status and Respondents Residence

The Frequency of Trips Around Campus

The most reported trip frequency by survey respondents is the 2-one-way trips (33.39%), which is more prevalent with part-time workers who live off campus (especially students who reside 1 to 5 miles from campus) (Figure 35).

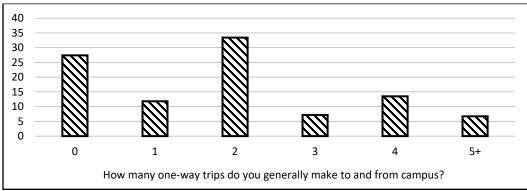


Figure 35 Trip Frequency

Most of the respondents that make 2-one-way trips either walk or use the transit mode share most often. The least common trip frequency chosen by the respondents is the +5-one-way trip (Table 11).

Table 11 Trip Frequency

		campus	5					
		0	1	2	3	4	5+	Total
Employment status:	Full time	36	22	66	16	31	14	185
	Part time	183	74	216	47	83	44	647
	Not Working	87	36	91	17	37	17	285
	Total	306	132	373	80	151	75	1117
Residence	On-campus	171	54	133	36	55	38	487
(on/off campus)	Off-campus	135	78	241	44	96	37	631
	Total	306	132	374	80	151	75	1118
Residence distance	0.25 miles or Less	22	15	43	9	21	8	118
from campus:	0.25 to 0.50 miles	16	11	47	13	21	9	117
	0.50 to 1.00 miles	25	23	49	7	19	6	129
	1.00 to 5.00 miles	35	15	50	9	21	10	140
	5.00 to 10.00 miles	24	13	41	5	13	2	98
	10 miles or More	13	1	11	1	1	2	29
	Total	135	78	241	44	96	37	631
How do students	Auto	159	70	207	40	75	43	594
often travel to or around campus?	Carpool	61	31	66	13	30	18	219
around campus?	Scooter	3	2	0	0	2	1	8
	MATBUS	208	104	271	58	114	61	816
	Bicycle	56	28	67	13	45	20	229
	Walk	223	98	259	55	114	58	807
	Other	4	1	3	0	1	2	11
	Total	306	132	374	79	151	75	1117

MATBUS USE AND SERVICE PERCEPTION

Nearly one-fourth of respondents (24.70%) are extremely satisfied with MATBUS service. Within this group, more than half (53.33%) reside off campus, with 25% of them living between 1 and 5 miles from campus. At least 69.26% of the respondents are satisfied (extremely satisfied or somewhat satisfied) with MATBUS service, 19.03% are indifferent (neither satisfied nor dissatisfied), and 11.71% are dissatisfied with the service (Table 12 and Figure 36).

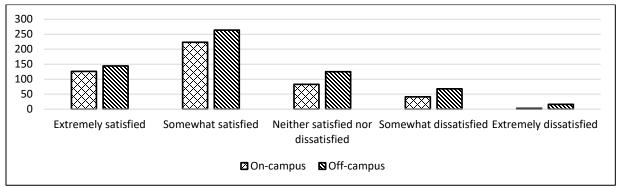


Figure 36 A Measure of Satisfaction within Student Residents (On and Off Campus)

About 1.74% of the respondents are extremely dissatisfied. Within this group, all (100%) have driver's licenses, and 94.74% have access to a vehicle (5.26% have no access to a car). Among this group, the MATBUS route they use most frequently is Route 32W, followed by Route 32E. More than half (57.89%) indicated there are additional stops/locations they want the transportation system to cover. Among respondents, 73.68% think the service span of the MATBUS is inadequate. Most of these respondents want more services during the early and late hours of the day (Table 12). The majority of these respondents identified on-time performance, frequency of service, and reliability of service as the attributes MATBUS should improve.

Table 12 Transit Satisfaction

Student Satisfaction with the NDSU MATBUS Services

		Extremely satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Extremely dissatisfied
Residence:	On-campus	126	223	83	41	3
	Off-campus	144	264	125	68	16
Valid driver's	Yes	250	449	198	100	19
license:	No	19	38	10	9	0
Access to a vehicle:	Yes	225	406	188	88	18
	No	44	81	20	21	1
Frequent MATBUS	Route 13	98	158	29	39	4
routes:	Route 13U	58	120	18	21	2
	Route 31	44	83	12	10	3
	Route 32E	133	214	34	56	5
	Route 32W	69	149	22	41	7
	Route 33	142	234	33	41	2
	Route 34	67	126	16	22	1
	TapRide	17	46	5	11	0
	None	9	31	123	13	7
	Other:	4	13	4	5	0
Desire additional	Yes	47	145	39	52	11
stops:	No	220	340	162	57	8
Desire a better	Yes	154	202	62	27	1
service span:	Maybe	75	176	100	32	4
	No	36	107	39	50	14
Desired periods for	Weekdays	28	94	37	33	9
increased services:	Weekends	52	111	44	35	3
	Early Morning	21	76	41	27	11
	Late Nights	83	195	76	55	11
Transit service	Reliability of service	30	133	51	62	13
attributes that	On-time Performance	86	275	85	75	14
should be improved:	Frequency of Service	86	237	75	65	13
improved:	Seat Availability	48	80	32	15	4
	ocativanaomej	40		95		

Of those responders, 9.97% are somewhat dissatisfied. Within this group, almost all (91.74%) have driver's licenses, and 80.73% have access to a vehicle (19.27% have no access to a car). Among this group, the most frequently used MATBUS route is Route 32W, followed by Route 32E and Route 33. More than half (47.71%) indicated there are additional stops/locations they want the transportation system to cover. Among respondents, 45.87% think the service span of MATBUS is inadequate. A majority of these respondents want more services during the late evening hours and weekends (Table 12). A majority identified on-time performance, frequency of service, and reliability of service as attributes MATBUS should improve.

TapRide Service

The survey had a few questions on the new NDSU TapRide service, which is a new on-demand service offered on the NDSU campus from Monday through Friday, from 7:30 p.m. to 11 p.m. The service was introduced recently to replace Route 35 and to provide rides, without increasing costs, to more remote locations of campus where fewer students go. More than half (59.03%) of the respondents have at least heard of the service. About 91.14% of respondents indicated they want more TapRide services (Table 13). Among the respondents who want more services:

- 77.78% stay on-campus
- 72.22% have a valid driver's license
- 50% have access to vehicles
- Most walk and use the transit around campus
- 69.44% indicate there are locations on campus that are too far to walk

Table 13 Tap Ride Service

Student residence:On-campus204Off-campus209Valid driver's license:YesYes385No27Access to a vehicle:YesYes356No56Locations too far to walk:YesYes209No204How satisfied are you with the NDSU MATBUS Services?Extremely satisfiedNo204How satisfied are you with the NDSU MATBUS Services?Somewhat satisfiedNo200Neither satisfied nor dissatisfied44Somewhat dissatisfied47Extremely dissatisfied10Additional stops/locations for campus circulator to cover?YesNo288Do you think that the service span (hours and days of service) of the MATBUS service is adequate?YesMaybe143No94What periods would you want increased services? (Please select all that apply)WeekdaysWhich of the following transit service attributes should MATBUS improve (select all that apply):Reliability of Service193Seat Availability (Capacity)65Technology86	ness of e service?	 	
Valid driver's license:Yes209Valid driver's license:Yes385No27Access to a vehicle:Yes356No5656Locations too far to walk:Yes209No204How satisfied are you with the NDSU MATBUS Services?Extremely satisfied111Somewhat satisfied200Neither satisfied nor dissatisfied44Somewhat dissatisfied47Extremely dissatisfied10Additional stops/locations for campus circulator to cover?Yes121No288Do you think that the service span (hours and days of service) of the MATBUS service is adequate?Yes176Maybe143No94What periods would you want increased services? (Please 	No	 lo Yes	No
Valid driver's license:Yes385No27Access to a vehicle:Yes356No56No56Locations too far to walk:Yes209No204Extremely satisfied111Somewhat satisfied are you with the NDSU MATBUS Services?Extremely satisfied200No204No204How satisfied are you with the NDSU MATBUS Services?Extremely satisfied111Somewhat satisfied200Neither satisfied nor dissatisfied44Somewhat dissatisfied47Extremely dissatisfied10Additional stops/locations for campus circulator to cover?Yes121No288288176Maybe143No94What periods would you want 	211	11 56	3
No27Access to a vehicle:Yes356No56No56Locations too far to walk:Yes209No204Extremely satisfied111Somewhat satisfied are you with the NDSU MATBUS Services?Extremely satisfied101No200Neither satisfied nor dissatisfied44Somewhat satisfied nor dissatisfied47200Neither satisfied nor dissatisfied47200Neither satisfied nor dissatisfied47200No28810288Do you think that the service span (hours and days of service) of the MATBUS service is adequate?Yes176Maybe143No94What periods would you want increased services? (Please select all that apply)Weekdays75Which of the following transit service attributes should MATBUS improve (select all that apply):Reliability of Service118On-time Performance216Frequency of Service193Seat Availability (Capacity)65193193	384	84 16	4
Access to a vehicle:Yes356No56Locations too far to walk:Yes209No204How satisfied are you with the NDSU MATBUS Services?Extremely satisfied111Somewhat satisfied200Neither satisfied nor dissatisfied44Somewhat satisfied47Extremely dissatisfied47Extremely dissatisfied47Extremely dissatisfied10Additional stops/locations for campus circulator to cover?YesDo you think that the service span (hours and days of service) of the MATBUS service is adequate?YesNo288No94What periods would you want increased services? (Please select all that apply)WeekdaysWhich of the following transit service attributes should MATBUS improve (select all that apply):Reliability of Service 118Matbus improve (select all that apply):65	568	68 52	5
No56Locations too far to walk:Yes209No204How satisfied are you with the NDSU MATBUS Services?Extremely satisfied111Somewhat satisfied200Neither satisfied nor dissatisfied44Somewhat satisfied47Extremely dissatisfied47Extremely dissatisfied10Additional stops/locations for campus circulator to cover?YesDo you think that the service span (hours and days of service) of the MATBUS service is adequate?YesNo288No94What periods would you want increased services? (Please select all that apply)WeekdaysWhich of the following transit service attributes should MATBUS improve (select all that apply):Reliability of Service 193 Seat Availability (Capacity)	27	27 20	2
Locations too far to walk: Ves 209 No 204 How satisfied are you with the NDSU MATBUS Services? Additional stops/locations for campus circulator to cover? Do you think that the service span (hours and days of service) of the MATBUS service is adequate? What periods would you want increased services? (Please select all that apply) Which of the following transit service attributes should MATBUS improve (select all that apply): Yes 200 Neither satisfied 111 Somewhat satisfied 44 Somewhat dissatisfied 47 Extremely dissatisfied 10 Yes 121 No 288 Yes 176 Maybe 143 No 94 Weekends 87 Early Morning 65 Late Nights 72 Reliability of Service 118 On-time Performance 216 Frequency of Service 193 Seat Availability (Capacity) 65	521	21 36	6
No203How satisfied are you with the NDSU MATBUS Services?Extremely satisfied111Somewhat satisfied200Neither satisfied nor dissatisfied44Somewhat dissatisfied47Extremely dissatisfied47Extremely dissatisfied10Additional stops/locations for campus circulator to cover?YesDo you think that the service span (hours and days of service) of the MATBUS service is adequate?YesNo288Do you think that the service span (hours and days of service) of the MATBUS service is adequate?YesNo94What periods would you want increased services? (Please select all that apply)WeekdaysWhich of the following transit service attributes should MATBUS improve (select all that apply):Reliability of ServiceWhich of the following transit apply):Seat Availability (Capacity)	74	4 36	1
How satisfied are you with the NDSU MATBUS Services?Extremely satisfied111Somewhat satisfied200Neither satisfied nor dissatisfied44Somewhat dissatisfied47Extremely dissatisfied47Extremely dissatisfied10Additional stops/locations for campus circulator to cover?YesDo you think that the service span (hours and days of service) of the MATBUS service is adequate?YesNo288No94What periods would you want increased services? (Please select all that apply)WeekdaysWhich of the following transit service attributes should MATBUS improve (select all that apply):Reliability of Service 193 Seat Availability (Capacity)	281	81 50	5
NDSU MATBUS Services?Somewhat satisfied200Neither satisfied nor dissatisfied44Somewhat dissatisfied47Extremely dissatisfied10Additional stops/locations for campus circulator to cover?YesNo288Do you think that the service span (hours and days of service) of the MATBUS service is adequate?YesNo248What periods would you want increased services? (Please select all that apply)WeekdaysWhich of the following transit service attributes should MATBUS improve (select all that apply):WeekendsReliability of Service Frequency of Service118On-time Performance216Frequency of Service193Seat Availability (Capacity)65	314	14 22	2
Somewhat satisfied200Neither satisfied nor dissatisfied44Somewhat dissatisfied nor dissatisfied47Extremely dissatisfied10Additional stops/locations for campus circulator to cover?YesNo288Do you think that the service span (hours and days of service) of the MATBUS service is adequate?YesNo288What periods would you want increased services? (Please select all that apply)WeekdaysWhich of the following transit service attributes should MATBUS improve (select all that apply):Reliability of Service 193 Seat Availability (Capacity)	136	36 15	2
Somewhat dissatisfied47Extremely dissatisfied10Additional stops/locations for campus circulator to cover?YesNo288Do you think that the service span (hours and days of service) of the MATBUS service is adequate?YesNo94What periods would you want increased services? (Please select all that apply)WeekdaysWhich of the following transit service attributes should MATBUS improve (select all that apply):WeekendsReliability of Service Seat Availability (Capacity)118Seat Availability (Capacity)65	236	36 43	3
Extremely dissatisfied10Additional stops/locations for campus circulator to cover?Yes121No288Do you think that the service span (hours and days of service) of the MATBUS service is adequate?Yes176Maybe143143No94What periods would you want increased services? (Please select all that apply)Weekdays75Which of the following transit service attributes should MATBUS improve (select all that apply):Weekformance118On-time Performance216Frequency of Service193Seat Availability (Capacity)65	155	55 4	1
Additional stops/locations for campus circulator to cover?Yes121No288Do you think that the service span (hours and days of service) of the MATBUS service is adequate?Yes176Maybe143No94What periods would you want increased services? (Please select all that apply)Weekdays75Which of the following transit service attributes should MATBUS improve (select all that apply):Weekends87Early Morning Don-time Performance118On-time Performance216Frequency of Service193Seat Availability (Capacity)65	50	50 10	1
campus circulator to cover?No288Do you think that the service span (hours and days of service) of the MATBUS service is adequate?Yes176Maybe143No94What periods would you want increased services? (Please select all that apply)Weekdays75Which of the following transit service attributes should MATBUS improve (select all that apply):Weekends87Early Morning Con-time Performance118On-time Performance216Frequency of Service193Seat Availability (Capacity)65	9	9 0	0
No94Waybe143Maybe143No94What periods would you want increased services? (Please select all that apply)WeekdaysWhich of the following transit service attributes should MATBUS improve (select all that apply):WeekendsReliability of Service118On-time Performance216Frequency of Service193Seat Availability (Capacity)65	135	35 32	1
span (hours and days of service) of the MATBUS service is adequate?Maybe143No94What periods would you want increased services? (Please select all that apply)Weekdays75Weekends87Early Morning Late Nights65Late Nights172Which of the following transit service attributes should MATBUS improve (select all that apply):Reliability of Service118On-time Performance216Frequency of Service193Seat Availability (Capacity)65	453	53 40	6
of the MATBUS service is adequate?Image143No94What periods would you want increased services? (Please select all that apply)Weekdays75Weekends87Early Morning65Late Nights172Which of the following transit service attributes should MATBUS improve (select all that apply):Reliability of Service118On-time Performance216Frequency of Service193Seat Availability (Capacity)65	254	54 11	4
adequate?No94What periods would you want increased services? (Please select all that apply)Weekdays75Weekends87Early Morning65Late Nights172Which of the following transit service attributes should MATBUS improve (select all that apply):Reliability of Service118On-time Performance216Frequency of Service193Seat Availability (Capacity)65	226	26 19	2
What periods would you want increased services? (Please select all that apply)Weekdays75Weekends87Early Morning65Late Nights172Which of the following transit service attributes should MATBUS improve (select all that apply):Reliability of Service118On-time Performance216Frequency of Service193Seat Availability (Capacity)65	110	10 42	1
select all that apply)Weekends87Early Morning65Late Nights172Which of the following transit service attributes should MATBUS improve (select all that apply):Reliability of Service118On-time Performance216Frequency of Service193Seat Availability (Capacity)65	103	03 21	2
Early Morning65Late Nights172Which of the following transit service attributes should MATBUS improve (select all that apply):Reliability of Service118On-time Performance216Frequency of Service193Seat Availability (Capacity)65	111	11 48	1
Which of the following transit service attributes should MATBUS improve (select all that apply):Reliability of Service118On-time Performance216Frequency of Service193Seat Availability (Capacity)65	93	93 17	2
service attributes shouldOn-time Performance216MATBUS improve (select all that apply):On-time Performance193Seat Availability (Capacity)65	198	98 49	2
MATBUS improve (select all that apply): Frequency of Service 193 Seat Availability (Capacity) 65	148	48 22	1
apply):Frequency of service193Seat Availability (Capacity)65	274	74 39	4
Seat Availability (Capacity) 65	232	32 48	4
Technology	104	04 8	0
Technology 86	112	12 23	2

WILLINGNESS TO SUPPORT TRANSIT SERVICE

Among respondents, 80.38% stated they were unwilling to pay an activity fee for transit around campus. For the respondents indicating they were willing to pay:

- More than half (55.56%) worked part-time
- 41.12% were somewhat satisfied with the transit service
- 81.82% have heard of the TapRide
- 42.45% stated that the MATBUS service is adequate
- A significant amount want the service span to extend to late nights

Of the respondents who were willing to pay, 28.50% were willing to pay less than \$10, while (43.46%) of respondents stated they were willing to pay between \$11 and \$20, and 16.36% stated they were willing to pay between \$21 and \$30 (Figure 37 and Table 14).

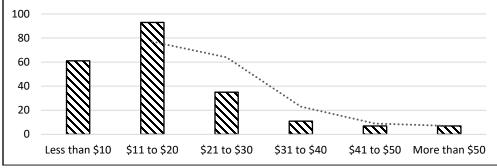


Figure 37 How much are Respondents Willing to Pay per Semester

		Willingness to pa	
		Yes	No
Level of study:	Undergraduate	176	716
	Graduate	40	159
Employment status:	Full time	43	135
	Part-time	120	520
	Not Working	53	229
Frequent MATBUS Routes:	Route 13	87	241
	Route 13U	61	157
	Route 31	34	118
	Route 32E	96	348
	Route 32W	62	228
	Route 33	98	353
	Route 34	42	190
	TapRide	22	57
atisfaction with NDSU MATBUS Services:	Extremely satisfied	81	188
	Somewhat satisfied	88	399
	Neither satisfied nor dissatisfied	20	187
	Somewhat dissatisfied	22	87
	Extremely dissatisfied	3	16
How much are respondents are willing to	Less than \$10	61	0
pay per semester:	\$11 to \$20	93	0
	\$21 to \$30	35	0
	\$31 to \$40	11	0
	\$41 to \$50	7	0
	More than \$50	7	0
Want more TapRide services on campus?	Yes	18	54
	No	4	3
Do you think that the service span of the	Yes	90	355
MATBUS service is adequate?	Maybe	64	328
	No	58	189
What periods would you want increased	Weekdays	36	167
services?	Weekends	45	202
	Early Morning	34	144
	Late Nights	93	329

Table 14 Willingness to pay an Activity Fee for Transit

ROUTE RECOMMENDATION

Respondents were asked to list (a) additional stops they want the campus circulators to cover and (b) locations that are too far to walk. The top 10 locations listed by the respondents are shown in Table 15. (Details of the analysis for the 63 stops mentioned by the respondents are in the Stop Details section of Appendix B.) Most locations identified are within walking distance to stops served by two to seven MATBUS routes. However, two of the locations mentioned by respondents (Wellness Center and Animal Nutrition and Physiological Center) are served by only one MATBUS route, as shown in Table 15.

Stops (Locations)	Sum	Stop Location						Sum		
		Address	13	13U	31	32E	32W	33	34	-
Richard H. Barry Hall	74	811 2nd Ave N	1	1	0	0	0	1	0	3
Fargodome	58	1800 N University Dr	1	1	1	1	1	1	1	7
Library	35	1201 Albrecht Blvd #2080	0	0	1	1	1	0	0	3
Minard Hall	22	1210 Albrecht Blvd	0	0	1	1	1	0	0	3
Wellness Center	21	1707 Centennial Blvd	0	0	1	0	0	0	0	1
Niskanen	16	1805 N University Dr	1	1	0	0	0	1	1	4
West Dining	12	1500 15th Ave N	0	0	1	1	1	0	0	3
Animal Nutrition and Physiology Center	7	1801 15th Ave N	0	0	1	0	0	0	0	1
Renaissance Hall	7	650 Northern Pacific Ave	1	1	0	0	0	0	0	2
Klai Hall	5	711 2nd Ave N	1	1	0	0	0	1	0	3

Table 15 Locations Too Far to Walk or Locations in Need of Stops

The locations served by two to seven routes could have been listed for other reasons, such as service frequency, distance from the stop to the riders, bus capacity, and service span (time/day). To further understand this issue, the service span and ridership (daily/hourly) of the routes accessible from each of these locations are studied. Where available, the service hours of the destination or origin served by the bus stops are also checked (Figure 38-a). The origin-destination matrix of all the bus stops under consideration is computed (Figure 39).

As shown in Figure 37-b, the peak period of Route 31 ridership is offset from the peak period of service periods of the Wellness Center facility. This offset suggests that most wellness center visitors use other modes to commute to and from the facility during its peak hours. Figure 37-c shows the walking distance of 0.1 miles to shelter 248, which most riders are willing to walk. Table 16 shows the desire for respondents to walk compared with other attributes.

Locations too far to walk			Recommended stops		
No	Total	Yes	No	Tota	
21	60	22	36	58	
122	309	97	199	296	
242	470	121	334	455	
167	278	53	220	273	
244	598	183	397	580	
200	362	82	270	352	
87	128	27	95	122	
23	34	2	31	33	
142	329	95	230	325	
92	219	59	158	217	
63	153	44	107	151	
232	446	130	310	440	
156	290	104	184	288	
211	453	126	322	448	
107	232	71	159	230	
24	79	33	46	79	
113	193	33	151	184	
204	413	121	288	409	
314	595	135	453	588	
22	72	32	40	72	
2	7	1	6	7	
244	448	91	354	445	
202	392	93	297	390	
93	247	107	137	244	
96	203	78	125	203	
110	247	86	160	246	
73	178	61	115	176	
183	422	150	269	419	
473	953	243	679	922	
82	170	52	113	165	
No	Total	Yes	No	Tota	
	82 No	82 170	82 170 52 No Total Yes	82 170 52 113 No Total Yes No	

Table 16 Locations Too Far to Walk and Recommended Stops

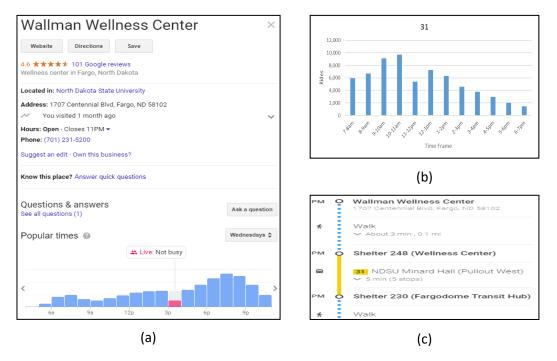


Figure 38 Peak Ridership Hours Compared with Peak Facility Service Hours (Source: Google Maps and MATBUS)

Recommendation for Route 31 (Wellness Center and ANPC Facility)

As shown in Figure 38-a and Figure 38-b, some adjustment to the span of Route 31 to provide transit service during the Wellness Center's peak service period could increase Route 31's ridership. It is important to note that survey results suggest that only a fifth of riders who are dissatisfied with NDSU's MATBUS service are transit dependent. The survey also reveals that 38.77% of respondents who indicate there are locations too far to walk use Route 32E most frequently, and 9.96% of them use the TapRide service. Of the respondents who indicated there are locations too far to walk use Route stops frequently mentioned by the students, an adjustment of NDSU MATBUS service capacity and service frequency could improve these stops (already served by two to seven routes). The most frequent stop mentioned by respondents is Barry Hall, which is served by Routes 13, 13U, 17, and 33 (four routes).

For the stops or locations listed or recommended for route adjustment, a data frame containing all NDSU MATBUS stops (containing existing stops and suggested stops) is created. For each stop, the longitude, the latitude, total number of routes, and route features (frequency, start time, close time) are also added as a record for the stop. These records are now assigned a score (equivalent to the frequency of mention in the survey) for service improvement.

Origin-Destination (O-D) Matrix of all NDSU Stops:

The OD matrix of all stops (63), both existing stops and suggested stops, is shown in Figure 39. The OD matrix shows some inconvenience (indicated in white) in the use of transit for some locations: Beef Cattle Barn, Dairy Barn, Sheep Barn, and Swine Barn. These locations involve some unusual degree of walking in places students do not have a willingness to walk (Location ID Key is in Figure 40).

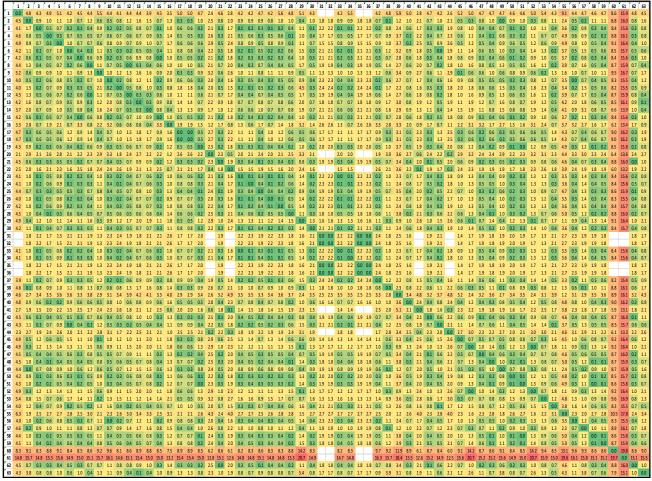


Figure 39 O-D Distance Matrix for all Stops in Miles (White: More Walking Involved/No Direct Link)

These locations are not convenient for NDSU MATBUS riders, especially when connecting from those locations to the following locations (or vice-versa):

- Walmart
- Barry Hall
- Klai Hall
- Renaissance Hall

2 3	14th St. N. & 8th Ave.					Freq
3		V6MV+84 Moorhead, Moorhead Township, MN	46.8833360	-96.7576549	1	0
-	1701 apartments	1701 N University Dr, Fargo, ND 58102	46.9015022	-96.7977306	5	4
4	A. Glenn Hill Center (STEM)	1306 Centennial Blvd, Fargo, ND 58105	46.8931395	-96.8018022	4	4
	AES Greenhouse	58102, 1440 18th St N, Fargo, ND 58105	46.8962279	-96.8075216	1	2
5	Animal Nutrition and Physiology Center	1801 15th Ave N, Fargo, ND 58102	46.8983716	-96.8116683	1	7
6	Askanase Hall	1497 12th Ave N, Fargo, ND 58105	46.8907557	-96.8033292	3	3
7	Bentson/Bunker Fieldhouse	1301 Centennial Blvd, Fargo, ND 58102	46.8947516	-96.8009890	4	1
8	Bison Crossing & CJ/PP	V5RV+45 Fargo, North Dakota	46.8903145	-96.8074043	2	0
9	Candlewood Suites	W53V+C8 Fargo, North Dakota	46.9033171	-96.8065484	1	0
10	Centennial Shelter	V6V2+PP Fargo, North Dakota	46.8942229	-96.7983367	4	0
11	Ceres Hall (NDSU Admissions)	1340 Administration Ave, Fargo, ND 58105	46.8920445	-96.7992261	4	1
12	Prairie (Criminal Justice & Public Policy)	V5RV+45 Fargo, North Dakota	46.8900998	-96.8074255	2	1
13	Dakota Creek Lofts	V5QQ+C9 Fargo, North Dakota	46.8881716	-96.8116121	2	0
14	Dakota Drive & 16th St.	V5PV+CJ Fargo, North Dakota	46.8859916		2	0
15	Engineering - (CM&E Building)	1410 14th Ave N, Fargo, ND 58102	46.8945523		7	2
	Family Fare	V6M2+8J Fargo, North Dakota	46.8838588	-96.7989082	3	0
	Fargodome	W52W+9X Fargo, North Dakota	46.9007801	-96.8027369	4	58
	Fargodome Shelter	W52W+9X Fargo, North Dakota	46.9007801	-96.8027369	4	58
	Gate City Auditorium	1330 Bolley Dr, Fargo, ND 58102	46.8942802	-96.8046535	1	0
	GTC	502 Northern Pacific Ave, Fargo, ND 58102	46.8751186	-96.7858783	2	3
	High Rises	V5WW+HQ Fargo, North Dakota	46.8964574	-96.8030504	3	0
	Klai Hall	Klai Hall, 711 2nd Ave N Room 310, Fargo, ND 58102	46.8783506	-96.7915647	3	5
	Ladd Hall	V5RX+R3 Fargo, North Dakota	46.8923933	-96.8025114	4	1
	Library	1201 Albrecht Blvd #2080, Fargo, ND 58105	46.8909290	-96.8013320	3	35
	Loftgard Hall	V5WW+6Q Fargo, North Dakota	46.8954689	-96.8036473	3	2
	Memorial Union	1401 Administration Ave, Fargo, ND 58105	46.8923988	-96.8013116	4	2
-	Minard Hall		46.8914534	-96.8013116	4	22
		1210 Albrecht Blvd, Fargo, ND 58102		-96.8078121	1	3
	MLC - Matthew Living Center NDSCS - Fargo	1435 18th St N, Fargo, ND 58102	46.8955035		2	0
	-	1305 19th Ave N, Fargo, ND 58102	46.9060119			
	NDSU Animal Science	V5VW+5J Fargo, North Dakota	46.8929792		3	1
	NDSU Beef Cattle Barn	3501-, 3559 19th Ave N, Fargo, ND 58102		-96.8324953	0	1
	NDSU Dairy Barn	3136 19th Ave N, Fargo, ND 58102		-96.8324953	0	1
	NDSU Minard Hall (Pullout East)	V5RX+R3 Fargo, North Dakota	46.8921560		5	22
	NDSU Minard Hall (Pullout West)	V5RX+M2 Fargo, North Dakota	46.8915524		3	22
	NDSU Sheep Barn	3400 19th Ave N, Fargo, ND 58102		-96.8324953	0	1
	NDSU Swine Barn	3211 19th Ave N, Fargo, ND 58102		-96.8324953	0	1
	NDSU Transit Hub	1337 Administration Ave, Fargo, ND 58105	46.8925479		4	0
	Niskanen Expansion	W632+5R Fargo, North Dakota	46.9023605	-96.7977686	2	16
	Northport Hornbacher's	2510 N Broadway Avenue, Fargo, ND 58102	46.9105641	-96.7875450	1	0
	Parking and Transportation Services	V5XR+46 Fargo, North Dakota	46.8981918	-96.8090653	1	2
	R.H. Barry Hall	811 2nd Ave N, Fargo, ND 58102	46.8785110	-96.7933370	3	74
	Reed/Johnson Halls	V5WX+W6 Fargo, North Dakota	46.8972945	-96.8020760	1	0
	Reineke (Fine Arts Center)	V5RW+5C Fargo, North Dakota	46.8905025	-96.8039483	2	0
	Renaissance Hall	V6G5+8R Fargo, North Dakota	46.8756979	-96.7905543	2	7
	Research and Tech Park	W53V+48 Fargo, North Dakota	46.9020997	-96.8068614	1	0
	Residence Dining Center	1919 N University Dr, Fargo, ND 58102	46.9054728	-96.7975942	4	0
	R-Lot (parking)	V5XW+4R Fargo, North Dakota	46.8984603	-96.8023466	4	3
	Robinson Hall	Robinson Hall, Fargo, ND 58105	46.8949798	-96.8073538	1	1
	SHAC (Sheels Center)	W622+8P Fargo, North Dakota	46.9007982	-96.7981790	4	2
	Shepperd Arena	V5VW+MR Fargo, North Dakota	46.8942866	-96.8033569	3	0
_	Stevens Hall	V5VV+PW Fargo, North Dakota	46.8943101	-96.8054637	1	0
_	Stop-N-Go Center (SGC)	1919 N University Dr, Fargo, ND 58102	46.9054728	-96.7975942	1	4
53	Technology Park	W53Q+MP Fargo, North Dakota	46.9042264	-96.8106652	1	1
54	T-Lot (Parking)	V5QV+HX Fargo, North Dakota	46.8897174	-96.8051102	3	1
55	U32 Apartments	1151 32nd Ave N, Fargo, ND 58102	46.9204231	-96.7966306	1	0
56	University & Centennial	V6V2+PP Fargo, North Dakota	46.8941769	-96.7983162	4	0
57	University Village	W623+WR Fargo, North Dakota	46.9018792	-96.7961366	6	3
58	Van Es	V5VV+PW Fargo, North Dakota	46.8941774	-96.8062241	1	1
59	Wallman Wellness Center.	V5VR+MX Fargo, North Dakota	46.8942931	-96.8082031	1	21
	Walmart	4731 13th Ave S, Fargo, ND 58103	46.8646733	-96.8677045	0	1
	Walmart	3757 55th Avenue South, Fargo, ND 58104	46.8014698	-96.8442488	0	1
	West Dining	V5WW+RF Fargo, North Dakota	46.8969883	-96.8038575	4	12
	West Port on Dakota Drive	V5QP+PV Fargo, North Dakota	46.8890783	-96.8130190	2	0

Figure 40 Location ID

Route and Location Analysis

Cluster Analysis

Before route recommendations, the authors explored the characteristics of the stops and routes in the study using cluster analysis. The analysis is used to split the 63 stops (Figure 39) into groups to check for any differences that may exist between the groups with high complaint scores and the ones with low complaint scores (location mention frequency). A centroid model with a vector quantization method (k-means algorithm) is used to split the stops into three groups or clusters (Appendix B, Figure A-1). Results from the analysis show that the attributes of stops with the higher scores (clusters 2 and 3) have some similarities (Appendix B, Figure A-2). They have few to no weekend routes, low bus frequency, and are dependent on Route 31 (mostly or entirely).

Regression Analysis

Using multiple regression analysis, the relationship between the complaint scores (dependent variables) and the bus stop locations and their service characteristics (independent variables) are estimated using statistical techniques for modeling and analyzing all the variables. From the analysis, similar results to the cluster analysis results are observed. Some factors that show a negative correlation with complaint score are the number of routes serving a stop, access to stops, weekend service, service span, and Route 31 (Appendix B, Figure A-3). A three-dimensional plot of all 63 locations with their longitude, latitude, and scores (complaints) is shown in Appendix B: Figure A-4-a.

Random Forest Analysis

Using a random forest algorithm, the importance or weight of the stop location and features (predictor variables) are explored. The results of the model weight summary (Appendix B, Figure A-4-b) shows the importance of the predictor variables. The top seven most essential variables of the model are listed by their significance in descending order below:

- Number of routes on stop/location
- Presence of Route 34
- Minimum service frequency on stop/location (service frequency)*
- Maximum service close time on location (service window)*
- Access to route 13U*
- Access to route 32W
- Weekend service*

The variables observed as significant in the regression analysis are marked with an asterisk (*).

Route Recommendation:

SURTC recommends that MATBUS modify some of its service routes by extending evening services and increasing weekend services within budget. This type of modification can be implemented with some consideration given to route frequencies, which should be increased. MATBUS could achieve this by modifying existing fixed routes (e.g., shifting Route 31's service window and increasing its frequency) or by expanding the TapRide service to cover the gaps in the fixed-route service.

SURVEY RESULTS FROM SELECT U.S. CAMPUS TRANSIT SERVICES

A survey of seven questions was developed in Qualtrics, and a survey link was emailed to 53 university campus transit contacts across the United States on March 11, 2019. Responses were received from 32 universities, yielding a reasonable response rate of 60%. Size of the universities surveyed ranged between 12,500 and 44,000 students. Among respondents, 63% (20) reported their school has multiple campuses (clusters of buildings in separate areas), and 94% (17) reported that multiple campuses are served by transit service. Each respondent was asked to check all of the services that apply to their campus. (Table 17).

Kinds of Transportation Options Available to Campus Community, N=92						
Type of serviceCountPercent						
25	27					
18	20					
25	27					
24	26					
	Count 25 18 25	Count Percent 25 27 18 20 25 27				

 Table 17
 Kinds of Transportation Options Available to Campus Community

The respondents were asked who operates the campus transit system. Some campuses had only university-operated agencies, while others had both transit services operated by both university agencies and private contractors. A few universities reported transit agency, university, and private contractor operations all serving their campuses. The schools that reported multiple operators also have multiple services, including on-campus circulator/shuttle, shuttle from remote parking lots to campus, regular fixed-route, and accessible service for students with disabilities.

Table 18 shows the results of who operates the campus transit system. Among respondents, 45% (21) reported that the university/college operates the transit agencies.

Who operates the campus transit system (select all that apply)					
Operator	Count	Percent			
University/college	21	45			
Private contractor	14	30			
Transit agency	11	23			
Other (contracted drivers & maintenance)	1	2			
Total	47	100			

Table 18 Campus Transit System Operator

The survey respondents from the 32 campus transit systems reported operating expenses from a low of \$36 per hour with the university owning the buses to a high of \$166 per hour with the transit agency operating the system. Because of the wide variance in the survey numbers, it was clear that respondents did not have consistent methods for calculating expenses. Therefore, the National Transit Database was utilized to determine numbers that could be compared.

Table 19 illustrates the minimum, mean, standard deviation, median, and maximum operating expense per vehicle revenue hour for 89 urban transit agencies located within Federal Transit Administration's Region 5 (Illinois, Ohio, Minnesota, Wisconsin, Indiana, and Michigan), Region 7 (Missouri, Iowa, Nebraska, and Kansas), and Region 8 (Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming). Fargo's MATBUS calculation is also listed to show the comparison. MATBUS's fully loaded hourly operating expense is \$72.05, as reported in the National Transit Database for 2017. This number is much lower than the mean dollar value of \$109.28 and lower than the median value of \$83.74.

	Vehicle	Vehicle	Non-Vehicle	General	Total
	Operations	Maintenance	Maintenance	Administration	lotai
MATBUS Fargo	\$34.05	\$13.24	\$2.54	\$22.02	\$72.05
Mean	\$66.10	\$18.11	\$4.92	\$20.16	\$109.28
Standard Deviation	\$145.22	\$39.84	\$16.39	\$47.32	\$247.85
Minimum	\$26.00	\$2.69	\$0.06	\$2.88	\$37.18
Q2	\$42.04	\$11.18	\$1.33	\$10.80	\$71.38
Median	\$50.84	\$13.61	\$2.43	\$14.41	\$83.74
Q3	\$59.33	\$17.01	\$3.96	\$19.46	\$95.36
Max	\$1,416.32	\$386.90	\$154.01	\$456.67	\$2,413.90

Table 19	Operating	Expense	per Vehicle	Revenue Hour
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Created from: United States Department of Transportation. Federal Transit Administration, National Transit Data Base, 2017, Washington, DC.

Other University Student Fees

U-PASS programs vary substantially across the United States. For example, University of California Davis students pay \$34.30 per quarter and have three quarters, so they pay \$102.90 per year for transit. The rates are increasing in 2019 by \$13.33, so the cost will be \$47.63 per quarter and then increase to \$58 per quarter. By 2023, the price will increase to \$67.83 per quarter. The price increase was voted on and passed with 92% approval. The increase was needed because of the increased minimum wage (Palmere 2019).

TCRP 2018 reports that funding sources for U-Pass programs often include a combination of student fees, parking permit revenue, parking fine revenue, university general funds, and federal, state, and local operating assistance funds (p. 10). TCRP surveyed campuses, and some of the details regarding student fees reported by institutions are presented in Table 20.

U-Pass Program Student Fees Reported					
City	Name	Price (\$)	Unit		
Milwaukee, WI	University of Wisconsin-Milwaukee	45.10	Per student per semester		
Madison, WI	University of Wisconsin – Madison	55.52	Per student per semester		
Bloomington, IN	Indiana University	64.61	Per student per semester		
Hartford, CT	Capital Community College	12.00	Per student per semester		

Table 20 U-Pass Student Fee

Adapted from TCRP Synthesis 131 College Student Transit Pass Programs. Transit Cooperative Research Program, National Academies of Science, Transportation Research Board, Washington, DC, 2018.

Recommendation about Current Service (MATBUS)

It is recommended that NDSU not cut MATBUS service but, if fiscally possible, expand it to meet student demand. The students identified the desire/need for more frequency and access to the Wellness Center, Fargodome, Barry Hall, the Library, downtown, Niskanen Apartments, and Minard Hall. MATBUS's hourly operating expenses are less than the median hourly operating costs for 89 transit agencies within the region, so it is unlikely that MATBUS will reduce the hourly cost it charges NDSU for service. If additional funds are needed to provide more service, NDSU should consider adding a small student fee to help cover the expenses. Although most students who responded to the survey were not in favor of paying a student fee, about 20% were in favor of paying. Of the respondents (about 20%) that were in favor of paying, 28.5% were willing to pay less than \$10 per semester, and 43.46% were willing to pay between \$11 and \$20. The survey results from select U.S. campus transit services show that many universities already charge a student fee for public transportation services.

SUMMARY AND CONCLUSIONS

The survey captured NDSU students' experience with Metro Area Transit (MATBUS). It was conducted online and received 1,180 responses, capturing a significant amount of information regarding student travel behavior, transit use, and opinions about current MATBUS service. A considerable proportion of the respondents (84.3%) own or have access to a vehicle, and off-campus students and students living farther from campus were more likely (by 15%) to have regular access to an automobile.

The survey results show that the willingness to walk is significantly higher for respondents with a valid driver's license, and as well for respondents with access to a vehicle. The least willing to walk are respondents who use a scooter on and around campus. The transit mode (MATBUS) had the highest significant share (30.38%). The least-used way to get around campus was scooter (0.3%).

Of the respondents, 1.74% expressed extreme dissatisfaction. Within this group, all (100%) have driver's licenses, and 94.74% have access to a vehicle. In this group, those who use MATBUS frequently use Route 32W the most, followed by Route 32E. More than half (57.89%) indicated there are additional stops/locations they want the transportation system to cover. Of these respondents (dissatisfied), 73.68% think the service span of MATBUS is inadequate. A majority of these respondents want more services during the early and late hours of the day. The majority of these respondents identified on-time performance, frequency of service, and reliability of service as the attributes MATBUS should improve.

Of the students who responded to the survey, 80.38% are unwilling to pay an activity fee for transit on campus. For the respondents who indicated they were willing to pay, more than half (55.56%) worked part time, 41.12% were somewhat satisfied with the transit service, 81.82% had heard of the TapRide, 42.45% stated that the MATBUS service is adequate, and a significant number wanted the service span extended to late nights. Of the respondents who were willing to pay an activity fee for transit, 28.5% are willing to pay less than \$10, 43.46% of them are willing to pay between \$11 and \$20, and 16.36% are willing to pay between \$21 and \$30.

More than half (59.03%) of the respondents have at least heard of the TapRide service, and about 91.14% of these respondents (that have heard about the TapRide service) indicated they want more TapRide services. Among the respondents who want more TapRide services, 77.78% stay on campus, 72.22% have a valid driver's license, and 50% have access to vehicles. Most walk and use the transit around campus, and 69.44% indicated there are locations on campus that are too far to walk.

After studying the locations that were too far to walk or needed more transit services, the authors recommended that MATBUS modify some of its service routes by extending evening services and increasing weekend services within budget. The modification can be implemented with some consideration given to route frequencies, which could be modified to better serve the students. To accomplish this, MATBUS could modify existing fixed routes or expand the TapRide service to cover the gaps in the fixed-route service.

It is recommended that NDSU sustain the MATBUS services and consider expanding them to meet student demands, if fiscally possible. Since MATBUS's hourly operating expenses are less than the median hourly operating costs for 89 transit agencies within the region, it is unlikely that MATBUS will reduce the hourly cost it charges NDSU for service. However, if MATBUS needs additional funds to

provide more services, then NDSU should consider adding a small student fee to help cover the expenses. The survey showed that 80% of students did not favor paying a student fee; of the 20% in favor of paying, 28.5% were willing to pay less than \$10 per semester, and 43.46% were willing to pay between \$11 and \$20. If additional funds are needed to provide more services, NDSU should consider adding a small student fee to help cover the expenses.

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APPENDIX – A: SURVEY QUESTIONS

NDSU - MATBUS TRANSIT SURVEY - 01 10 2019

Start of Block: KEY DEMOGRAPHICS - Who is Using MATBUS?

Q1.1 What is your age?

- Under 17 years old (1)
 18 24 years (2)
- 18 24 years (2)
 25 34 years (3)
- 25 34 years (3)
 35 44 years (4)
- 53 44 years (4)
 45 54 years (5)
- 45 54 years (5)
 55 64 years (6)
- 65 and above (7)

Q1.2 Gender:

- Male (1)
- Female (2)
- Nonbinary (3)
- Prefer not to answer (4)
- Other (Please Specify) (5) _

Q1.3 Please select your level of study:

- Undergraduate (1)
- Graduate (2)
- Other: (3) ____

Q1.4 What is your employment status:

- Full time (1)
- Part-time (2)
- Not Working (3)

Q1.5 Do you reside on/off campus?

- On-campus (1)
- Off-campus (2)

Display This Question:

If Do you reside on/off campus? = Off-campus Q1.6 How far do you live from campus?

- 0.25 miles or Less (0.4 km or Less) (1)
- 0.25 to 0.50 miles (0.4 to 0.8 km) (2)
- 0.50 to 1.00 miles (0.8 to 1.6 km) (3)
- 1.00 to 5.00 miles (1.6 to 8.0 km) (4)
- 5.00 to 10.00 miles (8.0 to 16.0 km) (5)
- 10 miles or More (16 km or More) (6)
- Q1.7 Do you have a valid driver's license?
- Yes (1)
- No (2)

Q1.8 Do you own or have access to a vehicle?

- Yes (1)
- No (2)
- End of Block: KEY DEMOGRAPHICS Who is Using MATBUS?

Start of Block: KEY TRAVEL CHARACTERISTICS - How and Why MATBUS?

Q2.1 How do you often travel to or around campus?(Please select more all modes that apply if you use more than one)

- Auto (1)
- Carpool (2)
- Scooter (3)
- Transit (e.g. MATBUS) (4)
- Bicycle (5)
- Walk (6)
- Other (Please Specify) (7) _

Q2.2 What types of trips do you generally make with the MATBUS off campus?

- Work (To/From Work) (1)
- Shopping (2)
- Family (Personal/Medical) (3)
- Social (Social/Recreational) (4)
- Other (Please Specify) (5) _
- Don't use MATBUS off campus (6)

Q2.3 What are the most important factors when deciding a mode of transportation?

- Convenience (1)
- Weather (2)
- Cost of Parking/Lot Assignment (3)
- Parking Availability (4)
- Travel Time (5)

Q2.4 If you had to walk daily, what would you consider a reasonable walking distance when the temperature is: above freezing (>32 F)

- Less than 0.25 Miles (0.4 km or Less) (1)
- 0.25 to 0.50 Miles (0.4 to 0.8 km) (2)
- 0.50 to 1.00 Miles (0.8 to 1.6 km) (3)
- More than 1.00 Miles (1.6 km or More) (4)

Q2.5 If you had to walk daily, what would you consider a reasonable walking distance when the temperature is: below freezing (<32 F)

- Less than 0.25 Miles (0.4 km or Less) (1)
- 0.25 to 0.50 Miles (0.4 to 0.8 km) (2)
- 0.50 to 1.00 Miles (0.8 to 1.6 km) (3)
- More than 1.00 Miles (1.6 km or More) (4)

Q2.6 How many one-way trips do you generally make to and from campus? (Please Note: A trip to and from campus would be a two-way trip)

- 0 (1)
- 1 (2)
- 2 (3)
- 3 (4)
- 4 (5)
- 5+ (6)

Q2.7 Are there any locations on campus that are too far to walk?

- Yes (1)
- No (2)

Display This Question: If Are there any locations on campus that are too far to walk? = Yes

Q2.8 Please, could you identify the location(s)?

End of Block: KEY TRAVEL CHARACTERISTICS - How and Why MATBUS?

Start of Block: SERVICE GAPS AND WILLINGNESS TO PAY

Q3.1 Which MATBUS Routes do you use frequently? (please select all that apply)

- Route 13 (1)
- Route 13U (2)
- Route 31 (3)
- Route 32E (4)
- Route 32W (5)
- Route 33 (6)
- Route 34 (7)
- TapRide (8)
- None (9)
- Other (Please Specify) (10) ____

Display This Question:

If Which MATBUS Routes do you use frequently? (please select all that apply) = None And Which MATBUS Routes do you use frequently? (please select all that apply) q://QID31/SelectedChoicesCount Is Equal to 0

Q3.2 If you are not using the MATBUS, what factors are keeping you from using the service?

- (Check all that apply)
- Lack of Information (1)
- Lack of Service (2)
- Bus not on schedule (3)
- Ride is too long (4)
- Bus stops too frequently (5)
- Long waits at transfer station (6)
- Inconvenient Service (7)
- Other (Please Specify) (8) _

Q3.3 How satisfied are you with the NDSU MATBUS Services?

- Extremely satisfied (1)
- Somewhat satisfied (2)
- Neither satisfied nor dissatisfied (3)
- Somewhat dissatisfied (4)
- Extremely dissatisfied (5)

Q3.4 Are you willing to pay an activity fee for public transit around campus and the Fargo-Moorhead area?

- Yes (1)
- No (2)

Display This Question:

If Are you willing to pay an activity fee for public transit around campus and the Fargo-Moorhead area? = Yes Q3.5 How much are you willing to pay per semester?

- Less than \$10 (1)
- \$11 to \$20 (2)
- \$21 to \$30 (3)
- \$31 to \$40 (4)
- \$41 to \$50 (5)
- More than \$50 (6)

Q3.6 Are there additional stops/locations that you would like the campus circulator to cover?

- Yes (1)
- No (2)

Display This Question:

If Are there additional stops/locations that you would like the campus circulator to cover? = Yes Q3.7 Please list/suggest additional locations/stops:

Display This Question: If Which MATBUS Routes do you use frequently? (please select all that apply) != TapRide Q3.8 Have you heard about the MATBUS TapRide service?

o Yes (1) o No (2)

0 100 (2)

Display This Question:

If Which MATBUS Routes do you use frequently? (please select all that apply) = TapRide

Q3.9 Would you want more TapRide services on campus?

o Yes (4)

o No (5)

Q3.10 Do you think that the service span (hours and days of service) of the MATBUS service is adequate?

o Yes (1)

o Maybe (2)

o No (3)

Display This Question:

If Do you think that the service span (hours and days of service) of the MATBUS service is adequate? != Yes

Q3.11 What periods would you want increased services? (Please Select all that apply)

- □ Weekdays (1)
- □ Weekends (2)
- Early Morning (3)
- □ Late Nights (4)

Q3.12 Which of the following transit service attributes should MATBUS improve (select all that apply):

- Reliability of service (1)
- On-time Performance (2)
- Frequency of Service (3)
- Seat Availability (Capacity) (4)
- □ Technology (5)

End of Block: SERVICE GAPS AND WILLINGNESS TO PAY

APPENDIX – B: ANALYTICAL DETAILS

K-Means – Cluster Analysis:

In this section, the K-means algorithm is used to split the stops into three clusters (Figure A-1). On the average, the first cluster: cluster 1 has the lowest scores (complaints from respondents), followed by cluster 3, and then cluster 2 (highest score).

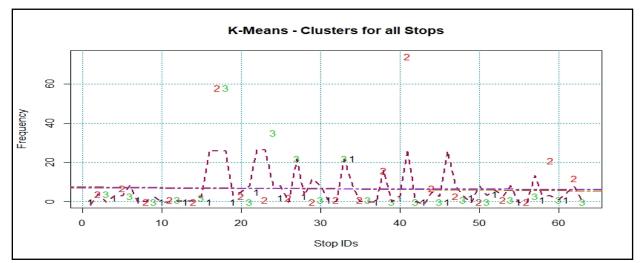


Figure A-1 Location Scores with Clusters Indicated (Three Clusters: 1, 2, and 3)

Results from the cluster analysis show that the attributes of stops with the higher scores (clusters 2 and 3) have some similarities (Figure A-2). They have little to no weekend routes, low minimum bus frequency, and are dependent on Route 31.

```
> clust.result
K-means clustering with 3 clusters of sizes 10, 36, 17
Cluster means:
                 Longitude
     Latitude
                                   rSum R13
                                                      R13U
                                                                    R31
                                                                                 R32E
                                                                                              R32W
                                                                                                             R33
                                                                                                                            R34
                                         1 46.89845364 -96.79677646 2.50000000
2 46.89205657 -96.81016554 1.555555556
                                          1 0.82352941176 0.2352941176 0.3529411765 0.3529411765 0.8235294118 0.64705882353
3 46.89296112 -96.79910813 4.235294118
                                                                          Min.Op
W.Day1 W.End Max.F Min.F Max.Op Min.Op Max.Cl Min.Cl Max.R
1 1.0000000000 1.000000000 60.00000000 25.00000000 0.4897916667 0.2604166667 0.9659722222 0.7929166667 0.4761805556
2 0.833333333 0.000000000 19.72222222 15.27777778 0.4700617284 0.2608217593 0.7016975309 0.6235146605 0.2316358025
3 1.000000000 0.9411764706 60.0000000 8.411764706 0.4880310458 0.2604166667 0.9659722222 0.7198937908 0.4779411765
Clustering vector:
                     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 36 37 38 39 40 41
2 2 3 3 2 2 2 3 3 1 1 2 1 2 3 1 2 2 3 2 2 1 2 2 3 2 2 3 2 2 2 3 2 1 2 3
1 2 3 4 5 6 7
2 3 3 2 2 2 3
42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63
                               2 2
   2
      1 2
            1 3
                   2
                      3
                         2 2
                                     2 1 3
                                               3
                                                 2
                                                     2
                                                        2
                                                            2
                                                               3
 1
Within cluster sum of squares by cluster:
[1]
    276.9049168 7233.7296160 197.7016418
 (between_SS / total_SS =
                            77.7 %)
Available components:
[1] "cluster'
                    "centers"
                                   "totss"
                                                   "withinss"
                                                                  "tot.withinss" "betweenss"
                                                                                                  "size"
                                                                                                                 "iter"
[9] "ifault
```

Figure A-2 Cluster Details for all Stops

Multiple Regression – Analysis:

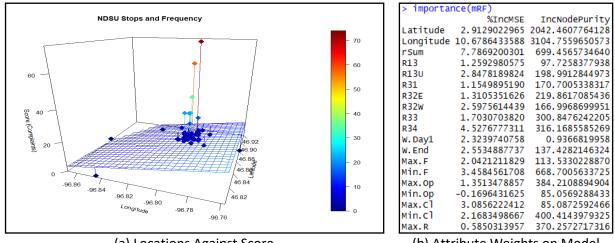
Using multiple regression to study the relationship between the attributes of the dataset, results similar to those of the cluster analysis are observed. As shown in the model summary in Figure A-3, the factors that show a negative correlation with score are listed below. The factors that are also observed in the cluster analysis are marked with an asterisk (*).

- Number of routes serving each stop
- Access to route (13 and 13U)
- Presence of Route 31
- Weekend service*
- Frequency of service*
- Service window*

```
> summary(routeModel)
call:
lm(formula = dataBUS$Freq ~ ., data = var.var)
Residuals:
                         Median
      Min
                   10
                                        30
                                                  Max
-26.332022 -3.047775 -0.216419
                                  1.005261 47.347319
Coefficients: (2 not defined because of singularities)
                Estimate
                            Std. Error
                                       t value Pr(>|t|)
(Intercept) 3629.9613044 40997.5604931 0.08854 0.9298396
Latitude
             -42.2088691 154.8318766 -0.27261 0.7863994
Longitude
              17.0401480
                           387.6095054 0.04396 0.9651291
rSum
              -6.3906528
                            9.1144528 -0.70116 0.4868159
             -11.2868492
                            33.7850863 -0.33408 0.7398728
R13
R13U
             -28,4461390
                            21.8554828 -1.30156 0.1996923
R31
              -4.4461277
                           16.3713965 -0.27158 0.7871878
R32E
               0.8788284
                            16.7097510 0.05259 0.9582884
                           262.1245537 2.72999 0.0090085 **
             715.5982671
R32W
R33
              12.3780019
                           33.9514041 0.36458 0.7171327
R34
                                    NA
                      NA
                                             NA
                                                       NA
            1192.3396047
                           475.0479374 2.50994 0.0157404 *
W.Day1
              -4.0763954
                           20.5843582 -0.19803 0.8439107
W.End
Max.F
              -1.4882204
                             1.5865894 -0.93800 0.3532520
Min.F
              -1.2459587
                             1.0753702 -1.15863 0.2527180
            -1416.9569062
                           525.6639111 -2.69556 0.0098474 **
мах.ор
           -1358.9554368
Min.Op
                           861.1238113 -1.57812 0.1215431
                           101.4625929 0.11659 0.9077062
              11.8292022
Max.Cl
Min.Cl
             -344.7529111
                           168.2015278 -2.04964 0.0462545 *
Max.R
                      NA
                                    NA
                                             NA
                                                       NA
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Figure A-3 Multiple Linear Regression Model Summary

A three-dimensional plot of all 63 locations using their longitude, latitude, and scores (complaints) is shown in Figure A-4-a. The plot shows the average weighting of all complaints sloping negatively toward higher latitudes and lower latitudes and longitudes. Only a few points at the central service locations (NDSU campus area) show a spike in complaint score: Barry Hall, Fargodome, Library, Minard Hall, Wellness Center, Niskanen Expansion.



(a) Locations Against Score Figure A-4 Attribute Impacts on Score

(b) Attribute Weights on Model

Additional Analysis: Random Forest Model

In this section, a random forest model is built to check the importance or weight of the predictor variables. The results of the model weight summary (Figure A-4-b) show that the importance of the predictor variables differs significantly, with stop locations. The stop latitudes have a higher significance (~5 times more) than the stop longitude. The top seven of the other attributes of the model are sorted by their weight or significance in descending order, and are listed below:

- Number of routes on stop/location
- Presence of Route 34
- Minimum service frequency on stop/location (service frequency)*
- Maximum service close time on location (service window)*
- Access to route 13U*
- Access to route 32W
- Weekend service*

The variables that are observed to be significant in the previous analysis are marked with an asterisk (*).

Impact of Changes in Seasonal and Non-Seasonal Factors on Ridership

Before the impact analysis, the predictor variables (seasonal and non-seasonal factors) were scaled so they produce zero mean. Using the standardized data for regression analysis, the intercept is not interpreted as the expected value of ridership when the predictor values are zero. It is unrealistic or unlikely such situations could exist (e.g., wind speed or enrollment equal to zero). Another reason for scaling the dataset is that the massive scale of ridership or enrollment and the small scale of temperature or humidity would be less efficient for model building. For the regression analysis, a data range of 1,342 observations, between August 24, 2014, and August 23, 2018, is used (a four-year range), with 42 predictor variables. However, a correlation chart and a variable inflation factors (VIF) test were used to reduce these variables by eliminating the ones with high correlation. The r command for the multicollinearity test is shown in Figure A-5. Because of the interest of the authors on the impact of the

changes (demolition and new construction) to University Village Apartments on ridership, it is added to the selected variables for analysis (Table A-1 and Figure A-6).

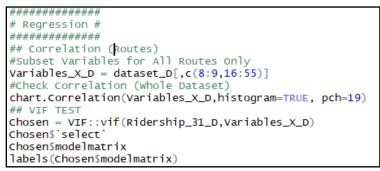


Figure A-5 Code for VIF and Correlation Test

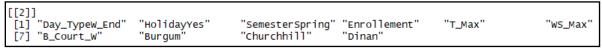


Figure A-6 The list of Suggested Variables from VIF Function

Selected Factors	Data Tag (Attribute Name)
The Observation Date Type	"Day_TypeW_End"
Holiday	"HolidayYes"
The Semester	"SemesterSpring + SemesterSummer"
NDSU Student Enrollment	"Enrollment"
Maximum Daily Temperature	"T_Max"
Maximum Wind Speed	"WS_Max"
Bison Court West	"B_Court_W"
Burgum Hall	"Burgum"
Churchill Hall	"Churchill"
Dinan Hall	"Dinan"
University Village Apartments	"UV_Apts"

Table A-1 Selected Factors for Statistical Analysis

Analysis Using Multiple Linear Regression

A linear equation is fitted to the observed ridership data to better understand the relationship between the predictor variables (seasonal and non-seasonal factors) and the response variable (ridership). One model is fit for all the routes, and five models are fit for each route. In total, six multiple linear regression models are built with all the values of the independent variables associated with a value of the ridership (scaled). The general equation for the models used in Equation 1. **Equation 1**. Multiple Linear Regression Model for Daily Ridership $y = X\beta + \epsilon$

Or								
$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ \vdots \end{bmatrix}$	=	[1 1 1 :	$x_{1,1} \\ x_{2,1} \\ x_{3,1} \\ \vdots$	 $x_{1,15}$ $x_{2,15}$ $x_{3,15}$ \vdots	*	$ \begin{array}{c} \beta_0 \\ \beta_1 \\ \beta_2 \\ \vdots \end{array} $	+	$\begin{bmatrix} \boldsymbol{\varepsilon}_1 \\ \boldsymbol{\varepsilon}_2 \\ \boldsymbol{\varepsilon}_3 \\ \vdots \end{bmatrix}$
y_{1342}		1	$x_{1342,1}$	 $x_{1342,15}$		β_{15}		$\left[\varepsilon_{1342}^{\cdot}\right]$

Where:

- *y* = *daily ridership for weeks* {1,2, ... 1342}
- $x = factors \ considered \ \{1, 2, \dots 15\}$
- $\beta = slopes \{0, 1, \dots 15\}$
- $\varepsilon = standard \ errors \ \{1, 2, \dots 15\}$

Model 00 – Ridership Sum of all Routes

The model (multiple linear regression) summaries for the cumulative ridership is shown in Figure A-7. The model's adjusted R-squared indicates that only 87.55% of the variability of the ridership is explained, which is observed in its predicted ridership (Figure A-8).

```
> summary(m00)
Call:
lm(formula = dataset_D$Ridership_Sum ~ Day_TypeW_End + HolidayYes +
   SemesterSpring + SemesterSummer + Enrollement + T_Max + WS_Max +
    B_Court_W + Burgum + Churchhill + Dinan + UV_Apts, data = Variables_X_D)
Residuals:
              1Q Median
                                30
    Min
                                        Мах
-2.06316 -0.13760 0.01816 0.14891 1.30983
Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)
               3.220e-15 9.633e-03 0.000 1.000000
Day_Typew_End -8.376e-01 1.072e-02 -78.162
HolidayYes -7.936e-01 1.332e-02 -59.597
                                            < 2e-16 ***
                                             < 2e-16 ***
SemesterSpring -9.403e-01 1.437e-01 -6.545 8.47e-11 ***
                          1.771e+00 -5.906 4.45e-09 ***
SemesterSummer -1.046e+01
Enrollement -4.307e-02 2.527e-02 -1.704 0.088551 .
                                     -9.215 < 2e-16 ***
T_Max
              -1.186e-01
                          1.287e-02
WS_Max
              3.580e-02
                          9.720e-03
                                     3.683 0.000239 ***
B_Court_W
              -9.323e-02 2.278e-02 -4.093 4.52e-05 ***
              -3.625e+00 2.965e-01 -12.225 < 2e-16 ***
Burgum
Churchhill
              2.475e-01 5.138e-02 4.816 1.63e-06 ***
Dinan
              -6.750e+00 1.621e+00 -4.164 3.33e-05 ***
UV_Apts
              1.940e-01 4.947e-02 3.922 9.23e-05 ***
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.3529 on 1329 degrees of freedom
Multiple R-squared: 0.8766, Adjusted R-squared: 0.8755
F-statistic: 786.7 on 12 and 1329 DF, p-value: < 2.2e-16
```

Figure A-7 Model 00 Summary

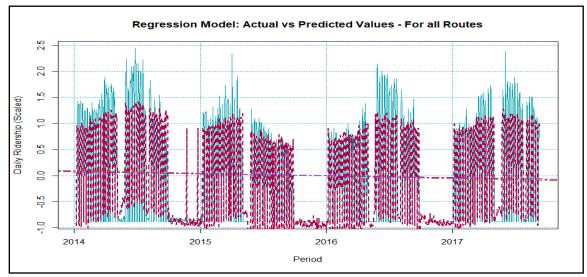


Figure A-8 Model 00 - Ridership Prediction

Model 01 – Ridership of Route 31

The model (multiple linear regression) summaries for the cumulative ridership is shown in Figure A-9. The model's adjusted R-squared indicates that only 80.81% of the variability of the ridership is explained, which is observed in its predicted ridership (Figure A-10)

```
> summary(m01)
Call:
lm(formula = dataset_D$R_R31 ~ Day_TypeW_End + HolidayYes + SemesterSpring
   SemesterSummer + Enrollement + T_Max + WS_Max + B_Court_W +
   Burgum + Churchhill + Dinan + UV_Apts, data = Variables_X_D)
Residuals:
   Min
            1Q Median
                            3Q
                                   Мах
-1.9412 -0.1647 0.0066 0.1835 3.7659
Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)
              -5.479e-15 1.196e-02
                                     0.000 1.000000
Day_TypeW_End -7.710e-01 1.330e-02 -57.960 < 2e-16 ***
                                            < 2e-16 ***
             -7.484e-01 1.653e-02 -45.275
HolidayYes
                                     2.683 0.007387 **
SemesterSpring 4.785e-01 1.783e-01
SemesterSummer 5.101e+00
                          2.198e+00
                                      2.321 0.020464 *
Enrollement
              2.215e-01 3.137e-02
                                     7.059 2.69e-12 ***
                                           < 2e-16 ***
T_Max
              -2.194e-01
                         1.597e-02 -13.735
                                     4.811 1.67e-06 ***
WS_Max
               5.805e-02 1.207e-02
B_Court_W
              4.733e-02
                          2.828e-02
                                     1.674 0.094402
                          3.681e-01
                                    -6.366 2.67e-10 ***
Burgum
              -2.343e+00
Churchhill
              -1.075e-02 6.378e-02 -0.169 0.866177
                                    3.552 0.000395 ***
Dinan
               7.148e+00 2.012e+00
              -9.806e-02 6.140e-02 -1.597 0.110515
UV_Apts
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.438 on 1329 degrees of freedom
Multiple R-squared: 0.8099,
                               Adjusted R-squared: 0.8081
F-statistic: 471.7 on 12 and 1329 DF, p-value: < 2.2e-16
```

Figure A-9 Model 01 Summary

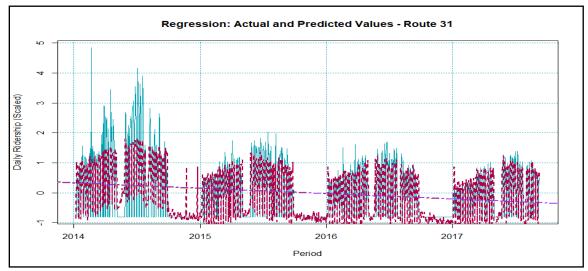


Figure A-10 Model 01 - Ridership Prediction

Model 02 – Ridership of Route 32

The model (multiple linear regression) summaries for the cumulative ridership is shown in Figure A-11. The model's adjusted R-squared indicates that only 78.64% of the variability of the ridership is explained, which is observed in its predicted ridership (Figure A-12).

```
> summary(m02)
call:
lm(formula = dataset_D$R_R32 ~ Day_TypeW_End + HolidayYes + SemesterSpring +
   SemesterSummer + Enrollement + T_Max + WS_Max + B_Court_W +
   Burgum + Churchhill + Dinan + UV_Apts, data = Variables_X_D)
Residuals:
    Min
              1Q
                  Median
                                3Q
                                        мах
-2.33881 -0.25435 -0.00786 0.18962 3.04572
Coefficients:
                Estimate Std. Error t value Pr(>|t|)
               1.076e-14 1.262e-02
                                     0.000
(Intercept)
                                                  1
                                             < 2e-16 ***
Day_TypeW_End -7.720e-01 1.403e-02 -55.005
                                            < 2e-16 ***
HolidayYes
              -7.542e-01 1.744e-02 -43.243
SemesterSpring -1.686e+00 1.882e-01 -8.960
                                            < 2e-16 ***
                                            < 2e-16 ***
SemesterSummer -2.014e+01 2.319e+00 -8.682
                          3.310e-02 -5.758 1.06e-08 ***
Enrollement -1.906e-01
                                            < 2e-16 ***
              -2.277e-01 1.685e-02 -13.514
T_Max
                                     5.802 8.20e-09 ***
WS_Max
              7.386e-02 1.273e-02
                                    -5.852 6.11e-09 ***
B_Court_W
              -1.746e-01
                          2.983e-02
                                            < 2e-16 ***
              -3.717e+00 3.884e-01 -9.572
Burgum
Churchhill
               3.932e-01 6.729e-02
                                      5.844 6.42e-09 ***
              -1.628e+01 2.123e+00 -7.669 3.33e-14 ***
Dinan
               4.271e-01 6.478e-02 6.593 6.22e-11 ***
UV Apts
signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.4621 on 1329 degrees of freedom
Multiple R-squared: 0.7883,
                               Adjusted R-squared: 0.7864
F-statistic: 412.5 on 12 and 1329 DF, p-value: < 2.2e-16
```

Figure A-11 Model 02 Summary

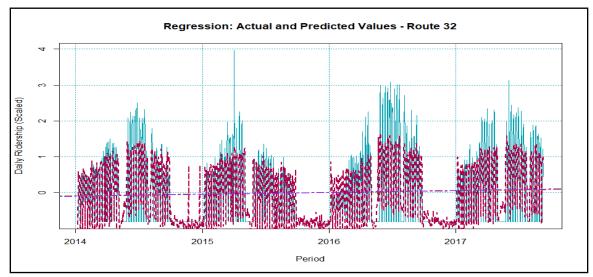


Figure A-12 Model 02 - Ridership Prediction

Model 03 – Ridership of Route 33

The model (multiple linear regression) summaries for the cumulative ridership is shown in Figure A-13. The model's adjusted R-squared indicates that only 86.73% of the variability of the ridership is explained, which is observed in its predicted ridership (Figure A-14).

```
> summary(mO3)
call:
lm(formula = dataset_D$R_R33 ~ Day_TypeW_End + HolidayYes + SemesterSpring +
    SemesterSummer + Enrollement + T_Max + WS_Max + B_Court_W +
    Burgum + Churchhill + Dinan + UV_Apts, data = Variables_X_D)
Residuals:
                   Median
    Min
              1Q
                                30
                                        Мах
-1.89720 -0.08954 0.00625 0.15137 1.56962
Coefficients:
                Estimate Std. Error t value Pr(>|t|)
              -2.537e-15 9.945e-03
(Intercept)
                                      0.000
                                             1,0000
                                             < 2e-16
Day_TypeW_End -8.328e-01 1.106e-02 -75.265
                                                     ***
HolidayYes
             -7.765e-01
                          1.375e-02 -56.479
                                             < 2e-16
SemesterSpring 3.944e-02 1.483e-01
                                      0.266
                                              0.7904
SemesterSummer 2.009e+00
                          1.829e+00
                                      1.099
                                              0.2721
                                      0.076
               1.987e-03 2.609e-02
Enrollement
                                              0.9393
               1.440e-02
                          1.329e-02
                                      1.084
                                              0.2786
т Мах
WS Max
              -7.504e-03 1.004e-02
                                     -0.748
                                              0.4548
              1.001e-02
                          2.352e-02
                                     0.426
                                              0.6704
B_Court_W
                                     -4.405 1.14e-05 ***
Burgum
              -1.349e+00
                          3.062e-01
Churchhill
              -6.248e-03 5.305e-02
                                     -0.118
                                              0.9063
               3.379e+00
                          1.674e+00
                                              0.0437
Dinan
                                      2.019
UV_Apts
              -3.470e-02 5.107e-02 -0.680
                                              0.4969
signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.3643 on 1329 degrees of freedom
Multiple R-squared: 0.8684,
                               Adjusted R-squared: 0.8673
F-statistic: 731.1 on 12 and 1329 DF,
                                     p-value: < 2.2e-16
```

Figure A-13 Model 03 Summary

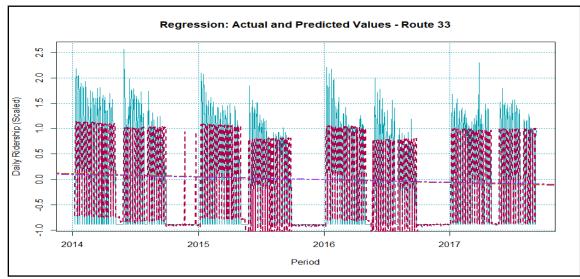


Figure A-14 Model 03 - Ridership Prediction

Model 04 – Ridership of Route 34

The model (multiple linear regression) summaries for the cumulative ridership is shown in Figure A-15. The model's adjusted R-squared indicates that only 70.31% of the variability of the ridership is explained, which is observed in its predicted ridership (Figure A-16).

```
> summary(m04)
call:
lm(formula = dataset_D$R_R34 ~ Day_TypeW_End + HolidayYes + SemesterSpring +
    SemesterSummer + Enrollement + T_Max + WS_Max + B_Court_W +
Burgum + Churchhill + Dinan + UV_Apts, data = Variables_X_D)
Residuals:
                   Median
     Min
               1Q
                                   3Q
                                           мах
-2.08602 -0.31599 -0.04224 0.34607 1.87238
Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)
                1.324e-14 1.487e-02
                                         0.000
                                                 1.0000
Day_TypeW_End -6.621e-01 1.655e-02 -40.011
                                                < 2e-16 ***
HolidayYes
                                                < 2e-16 ***
               -5.851e-01
                            2.056e-02 -28.454
                                                < 2e-16 ***
SemesterSpring -3.011e+00 2.219e-01 -13.571
                                                 < 2e-16 ***
                            2.735e+00 -12.754
SemesterSummer -3.488e+01
Enrollement
                1.255e-02 3.903e-02
                                        0.322
                                                 0.7478
т_мах
               -1.049e-01 1.987e-02
                                        -5.278 1.53e-07 ***
WS_Max
                3.274e-02
                            1.501e-02
                                         2.181
                                                 0.0293 *
               -3.076e-01 3.518e-02 -8.745
                                                < 2e-16 ***
B_Court_W
                                                < 2e-16 ***
               -1.066e+01 4.579e-01 -23.271
Burgum
Churchhill
               8.564e-01 7.935e-02 10.793
                                                < 2e-16 ***
               -2.380e+01 2.503e+00 -9.506 < 2e-16 ***
4.991e-01 7.639e-02 6.533 9.13e-11 ***
Dinan
UV_Apts
signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.5449 on 1329 degrees of freedom
Multiple R-squared: 0.7057,
                                  Adjusted R-squared: 0.7031
F-statistic: 265.6 on 12 and 1329 DF, p-value: < 2.2e-16
```

Figure A-15 Model 04 Summary

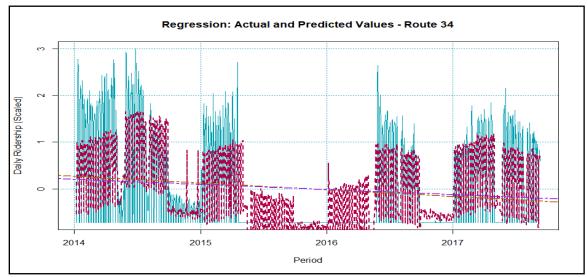


Figure A-16 Model 04 - Ridership Prediction

Model 05 – Ridership of Route 35 (+TapRide)

The model (multiple linear regression) summaries for the cumulative ridership is shown in Figure A-17. The model's adjusted R-squared indicates that only 69.25% of the variability of the ridership is explained, which is observed in its predicted ridership (Figure A-18).

```
> summary(m05)
Call:
lm(formula = dataset_D$R_R35_Tap ~ Day_TypeW_End + HolidayYes +
    SemesterSpring + SemesterSummer + Enrollement + T_Max + WS_Max +
    B_Court_W + Burgum + Churchhill + Dinan + UV_Apts, data = Variables_X_D)
Residuals:
                   Median
    Min
              10
                                30
                                        мах
-2.21364 -0.26305 0.02452 0.24074 2.31174
Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)
               -7.822e-15 1.514e-02
                                      0.000
                                            1.00000
                                             < 2e-16 ***
Day_TypeW_End -7.043e-01 1.684e-02 -41.818
                                                     ***
HolidayYes
              -6.855e-01 2.093e-02 -32.755
                                             < 2e-16
                                     0.798
SemesterSpring 1.802e-01 2.258e-01
                                             0.42502
                                      1.010
SemesterSummer 2.812e+00
                          2.783e+00
                                             0.31251
                                      7.579 6.49e-14 ***
Enrollement
               3.010e-01
                          3.972e-02
                                             < 2e-16 ***
                          2.022e-02 -10.601
т мах
              -2.144e-01
                                     4.890 1.13e-06 ***
WS_Max
               7.470e-02
                          1.528e-02
                                            0.01170 *
B_Court_W
               9.038e-02
                          3.580e-02
                                      2.525
Burgum
               -4.337e+00 4.660e-01
                                     -9.306
                                             < 2e-16 ***
Churchhill
              -1.641e-01 8.075e-02 -2.033
                                             0.04229 *
               7.122e+00
                          2.548e+00
                                     2.796
                                             0.00525 **
Dinan
               -2.464e-01 7.774e-02 -3.170
                                             0.00156 **
UV_Apts
signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.5546 on 1329 degrees of freedom
Multiple R-squared: 0.6952,
                               Adjusted R-squared: 0.6925
F-statistic: 252.6 on 12 and 1329 DF, p-value: < 2.2e-16
```

Figure A-17 Model 05 Summary

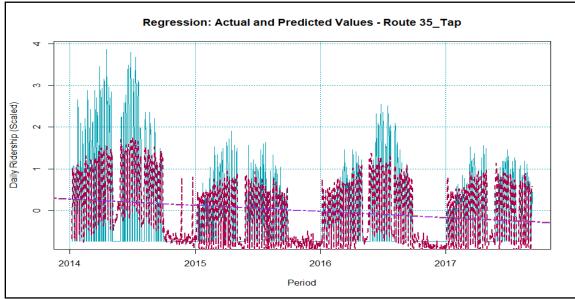


Figure A-18 Model 05 - Ridership Prediction

Inferences from Regression Analysis

While the six models show significant relationships between predictor variables and ridership, they do not explain all the variability in ridership and are unable to predict the ridership in all routes to a satisfactory level of confidence (95% CI). See Figures 22, 24, 28, 30, and 32 for regression model ridership projections. In Table 3, the slope of the impact of the factors on ridership is shown for each factor considered for the models. As can be seen from Table A-2, weekends, holidays, and Burgum Hall residence occupancy have consistent negative impacts on the ridership of all routes considered. Also, the impact of positive changes to University Village Apartment residency or occupancy across all routes is shown as positive for routes 32 and 34, but negative for the rest of the routes. Except for Route 33, all routes are affected negatively with an increase in temperature and positively with an increase in wind speed.

To better predict the ridership of all routes, the authors switch methods from statistics to machine learning. This is done because transit demand modeling is both an art and a science. Modeling ridership involves the estimation of real-time unknown variables of demand with a certain degree of rationality, and both regression and time series methods can be too simplistic despite their complexities and strengths (Profillidis & Botzoris 2019). This is because of certain flaws possessed by these statistical methods.

These flaws include:

- Transit demand methods exhibit non-linear characteristics (regression)
- In time series methods, there can be only one independent variable (time)
- Both methods are based on some assumptions that limit the flexibility that occurs in real transit-demand problems
- Both methods use limited datasets
- Both methods use static models that lack the dynamic reflection of human behavior

To mitigate the flaws of the statistical models, the authors use a machine learning model called a neural network. This neural network is built with the same inputs as the regression models and is used to predict the daily ridership of all NDSU MATBUS routes. In the following sections, two neural network models are used to predict both the overall ridership and the ridership of all five routes.

Predictor Variables and Intercept	M00 All Routes	M01 Route 31	M02 Route 32	M03 Route 33	M04 Route 34	M05 Route 35	Consistent Impact across all Models?
(Model Intercept)	[+] ve	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	FALSE
Day Type (Weekend)	[-] ve	[-] ve	[-] ve	[-] ve	[-] ve	[-] ve	TRUE
Holiday (Yes)	[-] ve	[-] ve	[-] ve	[-] ve	[-] ve	[-] ve	TRUE
SemesterSpring	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	[+]ve	FALSE
SemesterSummer	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	[+]ve	FALSE
Enrollment	[-] ve	[+] ve	[-] ve	[+] ve	[+] ve	[+]ve	FALSE
Maximum Temp.	[-] ve	[-] ve	[-] ve	[+] ve	[-] ve	[-] ve	FALSE
Maximum Wind Spd.	[+] ve	[+] ve	[+] ve	[-] ve	[+] ve	[+] ve	FALSE
Bison Court (West)	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	[+]ve	FALSE
Burgum Hall	[-] ve	[-] ve	[-] ve	[-] ve	[-] ve	[-] ve	TRUE
Churchill Hall	[+] ve	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	FALSE
Dinan Hall	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	[+]ve	FALSE
University Village Apt.	[+] ve	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	FALSE

 Table A-2
 Selected Predictor Factor Impacts

Neural Network Models

In general, neural networks (NN) refer to simplified models that work like the human brain. NNs work by mimicking a large number of interconnected processing units that resemble abstract versions of biological neurons. NNs learn through the examination of individual records and the generation of predictions for each record. NNs also make adjustments to the weights whenever they make an incorrect prediction. This NN process repeats many times, and the network continues to improve its predictions until one or more of its stopping criteria is met.

The NN model in Equation 2 predicts the ridership values (scaled and centered) using the selected predicted variables and some new variables added for more control. The equation for the model developed for the routes is shown below:

. ..

Equation 2. Neural Network Model

Sum Daily Ridership
$$\rightarrow y = f(z) = b + \sum_{i=1}^{d^{(l-1)}} \left(x_i^{(l-1)} w_i^l \right) \rightarrow \cdots$$

Where:

b = bias, x = input to neuron, w = weights, Layers: $\{l \rightarrow 1 \le l \le L\}$, Inputs: $\{i \rightarrow 0 \le i \le d^{(l-1)}\}$, Outputs: $\{j \rightarrow 1 \le j \le d^{(l)}\}$

Neural Network Model 01 - All Routes (Sum)

An NN model with two layers and a linear output is fit. A "rprop+." algorithm with two repetitions is used for model training. The weights of the NN model are in Table A-3. This model predicts the cumulative MATBUS transit ridership of the NDSU routes better than the regression model. See Figure A-19 for Network Configuration and Figure A-20 for Ridership Prediction.

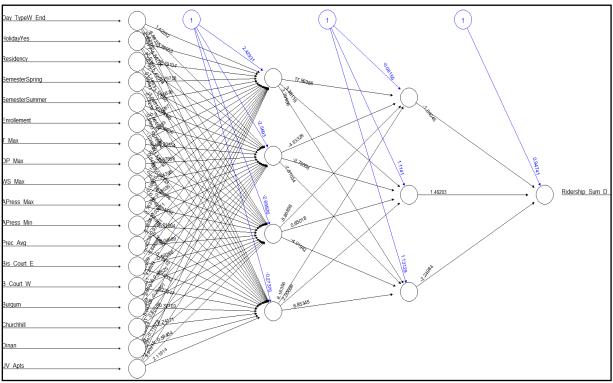


Figure A-19 Neural Network Model for All Routes (Sum)

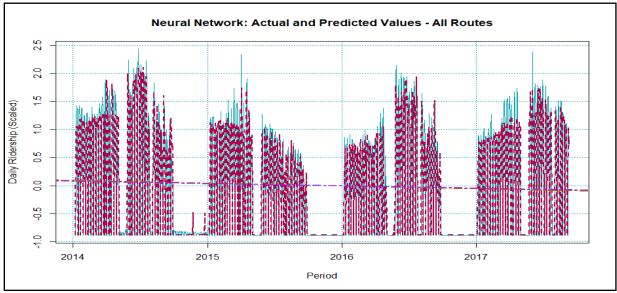


Figure A-20 Cumulative Ridership (All Routes) Prediction

Neural Network Model 02 – for Routes 31 through 35/TapRide

An NN model with two layers and a linear output is fit. A "rprop+." algorithm with two repetitions is used for model training. The weights of the NN model are in Appendix C, Table 22. This model predicts the MATBUS transit ridership of all the NDSU routes separately. See Figure A-21 for Network Configuration and Figure A-22 through Figure A-26 for Ridership Prediction of routes 31 - 35.

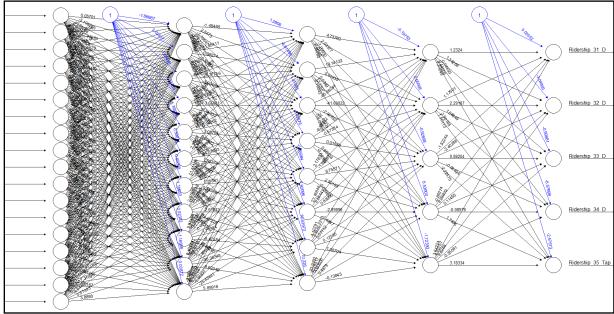


Figure A-21 Neural Network Model for Routes 31 to 35/TapRide

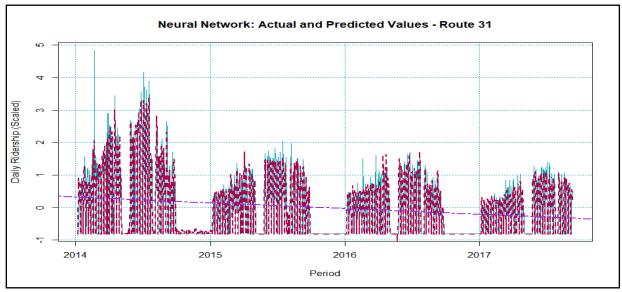


Figure A-22 Route 31 Prediction

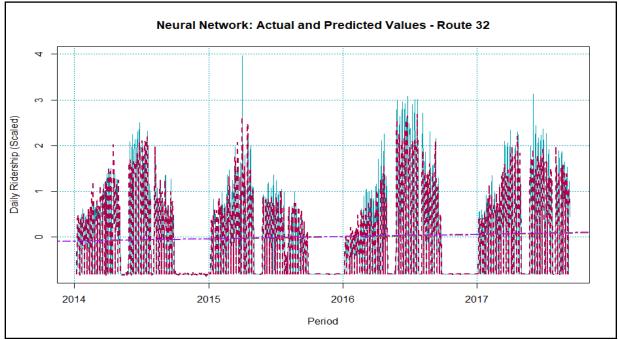


Figure A-23 Route 33 Prediction

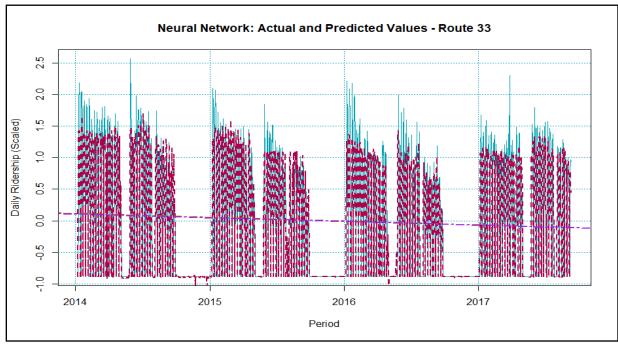


Figure A-24 Route 33 Prediction

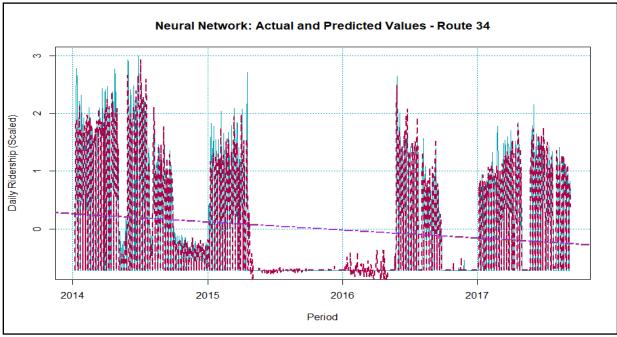


Figure A-25 Route 34 Prediction

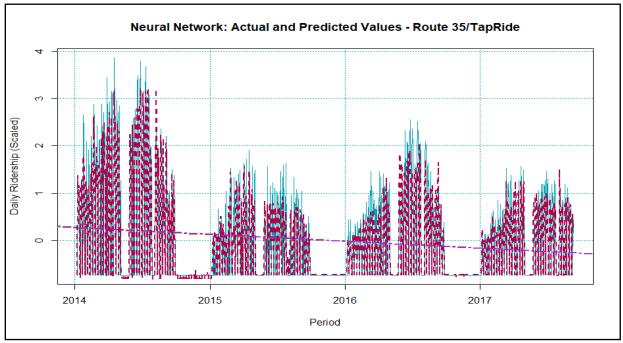


Figure A-26 Route 35 (TapRide) Prediction

APPENDIX – C: NEURAL NETWORK MODEL DETAILS

 Table A-3
 NN Model 01 – All Routes (Sum)

error 30.18634819914 38.7779090716 steps 5343.000000000 0.0263539093 Day_Typex_End.to.1layhid -1.5670089033 1.4281537414 Hidayres.to.1layhid1 -1.5170089033 1.2281537414 Bitagyres.to.1layhid1 -1.13915323063 1.2281537414 SemesterSpring.to.1layhid1 -1.1311547849 1.0033628211 SemesterSpring.to.1layhid1 -1.132311749 0.2239476156 Fanci Lightid1 -1.132311749 0.2239476156 Pres.Awx.to.1layhid1 -0.07715936366 0.14812524694 Pres.Awx.to.1layhid1 -0.2618511724 0.76384260934 Pres.Awx.to.1layhid1 -0.2618511724 0.76384260934 Pres.Awx.to.1layhid1 -0.3806311128 0.27341191515 Churr.w.to.layhid1 -0.38366711128 0.1384260934 B.courr.w.to.layhid2 0.1638480759 -2.56929945855 B.courr.w.to.layhid2 0.1638749551 0.138346371 Diran.to.1layhid2 0.36158749554 -2.6938945151 Diran.to.1layhid2 0.36158749554 -2.6929945855 Dirayhid2 0.361587			â	
reached. threshold 0.099352377 0.0925339093 Steps 5343.000000000 4071.000000000 Difter proves to 1 hayhid1 -1.5670089903 2.2931312864 Heridercy. to. 1 hayhid1 -1.5670089903 2.2931312864 Heridercy. to. 1 hayhid1 -6.5215210760 -2.19103644482 Semesterspring. to. 1 hayhid1 -6.5215210760 -2.19103644482 Semesterspring. to. 1 hayhid1 -0.39116947849 1.10636282517 LPAK. to. 1 hayhid1 -0.39116947849 1.10636282517 Heridercy. to. 1 hayhid1 -0.39116947849 1.10636282517 Heridercy. to. 1 hayhid1 -0.39116947849 1.10636282517 Heridercy. to. 1 hayhid1 -0.7511930866 0.05805971380 Heridercy. to. 1 hayhid1 -0.751193086 0.05805971380 Heridercy. to. 1 hayhid1 -0.751193086 0.05805971380 Heridercy. to. 1 hayhid1 -0.7511930868 0.07341195155 Heridercy. to. 1 hayhid1 -0.7511930868 0.07341195155 Heridercy. to. 1 hayhid1 -0.8547470557 -0.19634815210 Heridercy. to. 1 hayhid1 -0.8547457657 -0.19634815210 Heridercy. to. 1 hayhid1 -0.85474156278 0.1488127464 Heridercy. to. 1 hayhid1 -0.8549035868 0.27341191515 Dinan. to. 1 hayhid1 -0.85474156278 0.456934970643 Heridercy. to. 1 hayhid2 -0.3651378473 0.45693970543 Heridercy. to. 1 hayhid2 -0.36513780759 -2.65293945653 Heridercy. to. 1 hayhid2 -0.3651478751 -0.456732576581 Heridercy. to. 1 hayhid2 -0.3651478751 -0.456732576581 Heridercy. to. 1 hayhid2 -0.3652474774 1.317666138205 Semestersymmer. to. 1 hayhid2 -0.3652474774 1.317666138205 Semestersymmer. to. 1 hayhid2 -0.3653474774 1.317666138205 Semestersymmer. to. 1 hayhid2 -0.3654749764 -0.657325139 Heridercy. to. 1 hayhid2 -0.3654749764 -0.3639526572 Heridercy. to. 1 hayhid2 -0.3654749764 -0.3639526572 Heridercy. to. 1 hayhid2 -0.3654749764 -0.3733576581 Heridercy. to. 1 hayhid2 -0.365474774 1.431364003 Heridercy. to. 1 hayhid2 -0.3756749464 Heridercy. to. 1 hayhid2 -0.3654747474 Heridercy. to. 1 hayhid3 -0.463373475812 -0.48373475812 Heridercy. to. 1 hayhid3 -0.463373475812 -0.48373475812 Heridercy. to. 1 hayhid3 -0.463373475812 -0.48373475812 Heridercy. to. 1 hayhid3 -0.4253436036 Heridercy. to. 1 hayhid3		1	2	
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SemesterSummer.to.1layhid4-0.11451440813-0.99930372575Enrollement.to.1layhid4-0.0959844883-1.35891051639T_Max.to.1layhid40.204800144440.84818166876DP_Max.to.1layhid40.73832578510-0.27736494679ws_Max.to.1layhid4-0.171542350370.15448718780				
Enrollement.to.1layhid4 -0.09598444883 -1.35891051639 T_Max.to.1layhid4 0.20480014444 0.84818166876 DP_Max.to.1layhid4 0.73832578510 -0.27736494679 WS_Max.to.1layhid4 -0.17154235037 0.15448718780			_0 00020272575	
T_Max.to.1layhid40.204800144440.84818166876DP_Max.to.1layhid40.73832578510-0.27736494679wS_Max.to.1layhid4-0.171542350370.15448718780				
DP_Max.to.1layhid4 0.73832578510 -0.27736494679 ws_Max.to.1layhid4 -0.17154235037 0.15448718780				
DP_Max.to.1layhid4 0.73832578510 -0.27736494679 ws_Max.to.1layhid4 -0.17154235037 0.15448718780				
WS_Max.to.1layhid4 -0.17154235037 0.15448718780				
APress_Max.to.ilayn104 -0.33657884617 0.83102130391				
	APTESS_Max.to.llayn104	-0.3305/88461/	0.03102130391	

Prec_Avg.to.llayhid4-0.12721480221-0.11911617461Bis_Court_E.to.llayhid41.28873801294-3.1032462511B_Court_W.to.llayhid42.137801696064.22247278567Burgum.to.llayhid4-0.903445388190.37102931951Churchhill.to.llayhid4-0.276775793752.24171335192Dinan.to.llayhid4-0.8337958590-0.58464158081UV_Apts.to.llayhid4-1.559018316272.11913679459Intercept.to.2layhid1-2.37335180785-0.081551065431layhid.1.to.2layhid1-3.7830751620317.863561606251layhid.2.to.2layhid152.65944448543-4.533280346671layhid.3.to.2layhid1191.545011151988.16356310342Intercept.to.2layhid1191.545011151988.16356310342Intercept.to.2layhid2-3.26444628553.81162653871layhid.1.to.2layhid2-3.26444628553.81162653871layhid.3.to.2layhid2-1.041557540030.650179701381layhid.3.to.2layhid3-0.28962963891.131290405881layhid.4.to.2layhid31.792532438133.399960788301layhid.1.to.2layhid31.792532438133.399960788301layhid.2.to.2layhid315.88318778848-7.810344884501layhid.3.to.2layhid3-0.37810708822-4.019424986471layhid.4.to.2layhid3-0.37810708822-4.019424986471layhid.4.to.2layhid3-0.37810708822-4.019424986471layhid.4.to.2layhid3-0.37810708822-4.019424986471layhid.4.to.2layhid3-0.593261506340.94741178646				
Bis_Court_E.to.1layhid41.28873801294-3.10332462511B_Court_W.to.1layhid42.137801696064.22247278567Burgum.to.1layhid4-0.903445388190.37102931951Churchhill.to.1layhid4-0.276775793752.24171335192Dinan.to.1layhid4-0.83379585990-0.58464158081UV_Apts.to.1layhid4-1.559018316272.11913679459Intercept.to.2layhid1-2.37335180785-0.081551065431layhid.1.to.2layhid1-2.37335180785-0.586561606251layhid.2.to.2layhid1-18.80609541400-5.868981323321layhid.3.to.2layhid1-19.45011151988.16356106425Intercept.to.2layhid1-18.80609541400-5.868981323321layhid.4.to.2layhid1191.54501151988.1635610342Intercept.to.2layhid20.253408258181.114101931791layhid.3.to.2layhid2-3.264446285353.381162653871layhid.3.to.2layhid216.23061831019-2.736080852361layhid.4.to.2layhid2-0.288622963891.31290405881layhid.1.to.2layhid3-0.286622963891.31290405881layhid.1.to.2layhid31.792532438133.399960788301layhid.1.to.2layhid31.37810708822-4.019424986471layhid.4.to.2layhid3-0.37810708822-4.019424986471layhid.4.to.2layhid30.02753255886.85344740691Intercept.to.Ridership_Sum_D0.593261506340.94741178646	APress_Min.to.1layhid4	0.40135274504	0.39686559684	
B_Court_W.to.1layhid42.137801696064.22247278567Burgum.to.1layhid4-0.903445388190.37102931951Churchhill.to.1layhid4-0.276775793752.24171335192Dinan.to.1layhid4-0.83379585990-0.58464158081UV_Apts.to.1layhid4-1.559018316272.11913679459Intercept.to.2layhid1-2.37335180785-0.081551065431layhid.1.to.2layhid152.65944448543-4.533280346671layhid.2.to.2layhid152.65944448543-4.533280346671layhid.3.to.2layhid1191.545011151988.16356310342Intercept.to.2layhid20.253408258181.114101931791layhid.1.to.2layhid2-3.264446285353.381162653871layhid.2.to.2layhid2-3.264446285353.381162653871layhid.3.to.2layhid216.23061831019-2.736080852361layhid.3.to.2layhid2-0.289622963891.131290405881layhid.4.to.2layhid31.792532438133.399960788301layhid.1.to.2layhid31.7810708822-4.019424986471layhid.3.to.2layhid3-0.3781070882-4.019424986471layhid.4.to.2layhid30.02975325586.85344740691Intercept.to.Ridership_Sum_D0.593261506340.94741178646	Prec_Avg.to.1layhid4	-0.12721480221	-0.11911617461	
Burgum.to.1layhid4-0.903445388190.37102931951Churchhill.to.1layhid4-0.276775793752.24171335192Dinan.to.1layhid4-0.83379585990-0.58464158081UV_Apts.to.1layhid4-1.559018316272.11913679459Intercept.to.2layhid1-2.37335180785-0.081551065431layhid.1.to.2layhid1-3.7830751620317.863561606251layhid.2.to.2layhid152.65944448543-4.533280346671layhid.3.to.2layhid1-18.80609541400-5.86898132321layhid.4.to.2layhid1191.545011151988.16356310342Intercept.to.2layhid20.253408258181.114101931791layhid.1.to.2layhid2-3.264446285353.381162653871layhid.2.to.2layhid2-1.04157540030.650179701381layhid.3.to.2layhid2-1.04157540030.6068867031Intercept.to.2layhid3-0.289622963891.131290405881layhid.1.to.2layhid31.792532438133.399960788301layhid.2.to.2layhid31.7810708822-4.019424986471layhid.3.to.2layhid3-0.37810708822-4.019424986471layhid.4.to.2layhid30.02753255886.85344740691Intercept.to.Ridership_Sum_D0.593261506340.94741178646	Bis_Court_E.to.1layhid4	1.28873801294	-3.10332462511	
Churchhill.to.1layhid4-0.276775793752.24171335192Dinan.to.1layhid4-0.83379585990-0.58464158081UV_Apts.to.1layhid4-1.559018316272.11913679459Intercept.to.2layhid1-2.37335180785-0.081551065431layhid.1.to.2layhid1-3.7830751620317.863561606251layhid.2.to.2layhid152.65944448543-4.533280346671layhid.3.to.2layhid1-18.80609541400-5.868981323321layhid.4.to.2layhid1191.545011151988.16356310342Intercept.to.2layhid20.253408258181.114101931791layhid.1.to.2layhid2-3.264446285353.381162653871layhid.2.to.2layhid2-1.041557540030.650179701381layhid.3.to.2layhid2-1.041557540030.650179701381layhid.4.to.2layhid3-0.289622963891.131290405881layhid.1.to.2layhid31.792532438133.399960788301layhid.2.to.2layhid31.7810708822-4.019424986471layhid.3.to.2layhid3-0.37810708822-4.019424986471layhid.4.to.2layhid3-0.37810708822-0.094741178646	B_Court_W to 1layhid4	2.13780169606	4.22247278567	
Dinan.to.1layhid4-0.83379585990-0.58464158081UV_Apts.to.1layhid4-1.559018316272.11913679459Intercept.to.2layhid1-2.37335180785-0.081551065431layhid.1.to.2layhid1-3.7830751620317.863561606251layhid.2.to.2layhid152.65944448543-4.533280346671layhid.3.to.2layhid1-18.80609541400-5.868981323321layhid.4.to.2layhid1191.545011151988.16356310342Intercept.to.2layhid20.253408258181.114101931791layhid.1.to.2layhid2-3.264446285353.381162653871layhid.2.to.2layhid216.23061831019-2.736080852361layhid.3.to.2layhid2-1.041557540030.650179701381layhid.4.to.2layhid3-0.289622963891.131290405881layhid.1.to.2layhid31.792532438133.399960788301layhid.2.to.2layhid315.88318778848-7.810344884501layhid.3.to.2layhid3-0.37810708822-4.019424986471layhid.4.to.2layhid30.029753255866.85344740691Intercept.to.Ridership_Sum_D0.593261506340.94741178646	Burgum.to.1layhid4	-0.90344538819	0.37102931951	
UV_Apts.to.11ayhid4-1.559018316272.11913679459Intercept.to.21ayhid1-2.37335180785-0.0815510654311ayhid.1.to.21ayhid1-3.7830751620317.8635616062511ayhid.2.to.21ayhid152.65944448543-4.5332803466711ayhid.3.to.21ayhid1-18.80609541400-5.8689813233211ayhid.4.to.21ayhid1191.545011151988.16356310342Intercept.to.21ayhid20.253408258181.1141019317911ayhid.1.to.21ayhid2-3.26444628553.3811626538711ayhid.2.to.21ayhid216.23061831019-2.7360808523611ayhid.3.to.21ayhid2-1.041557540030.6501797013811ayhid.4.to.21ayhid3-0.289622963891.1312904058811ayhid.1.to.21ayhid31.792532438133.3999607883011ayhid.1.to.21ayhid31.7810708822-4.0194249864711ayhid.3.to.21ayhid3-0.289622963891.1312904058811ayhid.4.to.21ayhid315.88318778848-7.8103448845011ayhid.4.to.21ayhid30.02975325586.8534474069111ayhid.4.to.21ayhid3-0.37810708822-4.0194249864711ayhid.4.to.21ayhid30.02975325586.8534474069111ayhid.4.to.21ayhid30.02975325586.8534474069111ayhid.4.to.21ayhid30.593261506340.94741178646	Churchhill.to.1layhid4	-0.27677579375	2.24171335192	
Intercept.to.21ayhid1-2.37335180785-0.0815510654311ayhid.1.to.21ayhid1-3.7830751620317.8635616062511ayhid.2.to.21ayhid152.65944448543-4.5332803466711ayhid.3.to.21ayhid1-18.80609541400-5.8689813233211ayhid.4.to.21ayhid1191.545011151988.16356310342Intercept.to.21ayhid20.253408258181.1141019317911ayhid.1.to.21ayhid2-3.264446285353.3811626538711ayhid.2.to.21ayhid216.23061831019-2.7360808523611ayhid.3.to.21ayhid2-1.041557540030.6501797013811ayhid.4.to.21ayhid3-0.289622963891.1312904058811ayhid.1.to.21ayhid31.792532438133.3999607883011ayhid.1.to.21ayhid315.88318778848-7.8103448845011ayhid.3.to.21ayhid3-1.37810708822-4.0194249864711ayhid.4.to.21ayhid30.029753255886.8534474069111ayhid.4.to.21ayhid30.029753255840.94741178646	Dinan.to.1layhid4	-0.83379585990	-0.58464158081	
11ayhid.1.to.21ayhid1-3.7830751620317.8635616062511ayhid.2.to.21ayhid152.65944448543-4.5332803466711ayhid.3.to.21ayhid1-18.80609541400-5.8689813233211ayhid.4.to.21ayhid1191.545011151988.16356310342Intercept.to.21ayhid20.253408258181.1141019317911ayhid.1.to.21ayhid2-3.264446285353.3811626538711ayhid.2.to.21ayhid216.23061831019-2.7360808523611ayhid.3.to.21ayhid2-1.04157540030.6501797013811ayhid.4.to.21ayhid23.206454363632.00668867031Intercept.to.21ayhid3-0.289622963891.1312904058811ayhid.1.to.21ayhid31.792532438133.3999607883011ayhid.2.to.21ayhid315.88318778848-7.8103448845011ayhid.3.to.21ayhid3-1.37810708822-4.0194249864711ayhid.4.to.21ayhid30.029753255886.8534474069111ayhid.4.to.21ayhid30.029753255840.94741178646	UV_Apts.to.11ayhid4	-1.55901831627	2.11913679459	
1layhid.2.to.2layhid152.65944448543-4.533280346671layhid.3.to.2layhid1-18.80609541400-5.868981323321layhid.4.to.2layhid1191.545011151988.16356310342Intercept.to.2layhid20.253408258181.114101931791layhid.1.to.2layhid2-3.264446285353.381162653871layhid.2.to.2layhid216.23061831019-2.736080852361layhid.3.to.2layhid2-1.041557540030.650179701381layhid.4.to.2layhid23.206454363632.00668867031Intercept.to.2layhid31.792532438133.399960788301layhid.1.to.2layhid315.88318778848-7.810344884501layhid.3.to.2layhid3-1.37810708822-4.019424986471layhid.4.to.2layhid30.029753255886.85344740691Intercept.to.Ridership_Sum_D0.593261506340.94741178646	Intercept.to.2layhid1	-2.37335180785	-0.08155106543	
11aýhid.2.to.21aýhid152.65944448543-4.5332803466711ayhid.3.to.21ayhid1-18.80609541400-5.8689813233211ayhid.4.to.21ayhid1191.545011151988.16356310342Intercept.to.21ayhid20.253408258181.1141019317911ayhid.1.to.21ayhid2-3.264446285353.3811626538711ayhid.2.to.21ayhid216.23061831019-2.7360808523611ayhid.3.to.21ayhid2-1.041557540030.6501797013811ayhid.4.to.21ayhid23.206454363632.006688670311ntercept.to.21ayhid3-0.289622963891.312904058811ayhid.1.to.21ayhid31.792532438133.3999607883011ayhid.2.to.21ayhid315.88318778848-7.8103448845011ayhid.3.to.21ayhid3-1.3781070822-4.0194249864711ayhid.4.to.21ayhid30.029753255886.853447406911ntercept.to.Ridership_Sum_D0.593261506340.94741178646	1layhid.1.to.2layhid1	-3.78307516203	17.86356160625	
1laýhid.4.to.2laýhid1191.545011151988.16356310342Intercept.to.2layhid20.253408258181.11410193179llayhid.1.to.2layhid2-3.264446283533.38116265387llayhid.2.to.2layhid216.23061831019-2.73608085236llayhid.3.to.2layhid2-1.041557540030.65017970138llayhid.4.to.2layhid23.206454363632.00668867031Intercept.to.2layhid3-0.289622963891.13129040588llayhid.1.to.2layhid31.792532438133.39996078830llayhid.2.to.2layhid315.88318778848-7.81034488450llayhid.3.to.2layhid3-1.37810708822-4.01942498647llayhid.4.to.2layhid30.029753255886.85344740691Intercept.to.Ridership_Sum_D0.593261506340.94741178646	1layhid.2.to.2layhid1	52.65944448543	-4.53328034667	
Intercept.to.2layhid20.253408258181.114101931791layhid.1.to.2layhid2-3.264446285353.381162653871layhid.2.to.2layhid216.23061831019-2.736080852361layhid.3.to.2layhid2-1.041557540030.650179701381layhid.4.to.2layhid23.206454363632.00668867031Intercept.to.2layhid3-0.289622963891.131290405881layhid.1.to.2layhid31.792532438133.399960788301layhid.2.to.2layhid315.88318778848-7.810344884501layhid.3.to.2layhid3-1.37810708822-4.019424986471layhid.4.to.2layhid320.029753255886.85344740691Intercept.to.Ridership_Sum_D0.593261506340.94741178646	1layhid.3.to.2layhid1	-18.80609541400	-5.86898132332	
1layhid.1.to.2layhid2-3.264446285353.381162653871layhid.2.to.2layhid216.23061831019-2.736080852361layhid.3.to.2layhid2-1.041557540030.650179701381layhid.4.to.2layhid23.206454363632.00668867031Intercept.to.2layhid3-0.289622963891.131290405881layhid.1.to.2layhid31.792532438133.399960788301layhid.2.to.2layhid315.88318778848-7.810344884501layhid.3.to.2layhid3-1.3781070822-4.019424986471layhid.4.to.2layhid30.029753255886.85344740691Intercept.to.Ridership_Sum_D0.593261506340.94741178646	1layhid.4.to.2layhid1	191.54501115198	8.16356310342	
11aýhid.2.to.21aýhid216.23061831019-2.7360808523611ayhid.3.to.21ayhid2-1.041557540030.6501797013811ayhid.4.to.21ayhid23.206454363632.00668867031Intercept.to.21ayhid3-0.289622963891.1312904058811ayhid.1.to.21ayhid31.792532438133.3999607883011ayhid.2.to.21ayhid315.88318778848-7.8103448845011ayhid.3.to.21ayhid3-1.378107088224.0194249864711ayhid.4.to.21ayhid320.029753255886.85344740691Intercept.to.Ridership_Sum_D0.593261506340.94741178646	Intercept.to.21ayhid2	0.25340825818	1.11410193179	
11ayhid.3.to.21ayhid2-1.041557540030.6501797013811ayhid.4.to.21ayhid23.206454363632.00668867031Intercept.to.21ayhid3-0.289622963891.1312904058811ayhid.1.to.21ayhid31.792532438133.3999607883011ayhid.2.to.21ayhid315.88318778848-7.8103448845011ayhid.3.to.21ayhid3-1.37810708822-4.0194249864711ayhid.4.to.21ayhid320.029753255886.85344740691Intercept.to.Ridership_Sum_D0.593261506340.94741178646	1layhid.1.to.2layhid2	-3.26444628535	3.38116265387	
1layhid.4.to.2layhid23.206454363632.00668867031Intercept.to.2layhid3-0.289622963891.131290405881layhid.1.to.2layhid31.792532438133.399960788301layhid.2.to.2layhid315.88318778848-7.810344884501layhid.3.to.2layhid3-1.37810708822-4.019424986471layhid.4.to.2layhid320.029753255886.85344740691Intercept.to.Ridership_Sum_D0.593261506340.94741178646	1layhid.2.to.2layhid2	16.23061831019	-2.73608085236	
Intercept.to.2layhid3-0.289622963891.131290405881layhid.1.to.2layhid31.792532438133.399960788301layhid.2.to.2layhid315.88318778848-7.810344884501layhid.3.to.2layhid3-1.37810708822-4.019424986471layhid.4.to.2layhid320.029753255886.85344740691Intercept.to.Ridership_Sum_D0.593261506340.94741178646	1layhid.3.to.2layhid2	-1.04155754003	0.65017970138	
11ayhid.1.to.21ayhid31.792532438133.3999607883011ayhid.2.to.21ayhid315.88318778848-7.8103448845011ayhid.3.to.21ayhid3-1.37810708822-4.0194249864711ayhid.4.to.21ayhid320.029753255886.85344740691Intercept.to.Ridership_Sum_D0.593261506340.94741178646	1layhid.4.to.2layhid2	3.20645436363	2.00668867031	
11ayhid.2.to.21ayhid315.88318778848-7.8103448845011ayhid.3.to.21ayhid3-1.37810708822-4.0194249864711ayhid.4.to.21ayhid320.029753255886.85344740691Intercept.to.Ridership_Sum_D0.593261506340.94741178646	Intercept.to.21ayhid3	-0.28962296389	1.13129040588	
1 aýhid.3.to.2 aýhid3 -1.37810708822 -4.01942498647 1 ayhid.4.to.2 ayhid3 20.02975325588 6.85344740691 Intercept.to.Ridership_Sum_D 0.59326150634 0.94741178646	1layhid.1.to.2layhid3	1.79253243813	3.39996078830	
1laýhid.4.to.2laýhid3 20.02975325588 6.85344740691 Intercept.to.Ridership_Sum_D 0.59326150634 0.94741178646	1layhid.2.to.2layhid3	15.88318778848	-7.81034488450	
Intercept.to.Ridership_Sum_D 0.59326150634 0.94741178646	1layhid.3.to.2layhid3	-1.37810708822	-4.01942498647	
	1layhid.4.to.2layhid3	20.02975325588	6.85344740691	
	Intercept to Ridership_Sum_D	0.59326150634	0.94741178646	
21ayn1d.1.to.R1dersn1p_Sum_D -1.39000154285 -1.04044518790	2layhid 1.to.Ridership_Sum_D	-1.39000154285	-1.04044518790	
2layhid.2.to.Ridership_Sum_D -2.26938233632 1.46202851189	2layhid.2.to.Ridership_Sum_D	-2.26938233632	1.46202851189	
2layhid.3.to.Ridership_Sum_D 2.18728497451 -2.24984488522		2.18728497451	-2.24984488522	

Table A-4 NN Model 02 – Routes (31 – 35/TapRide)

	1	2	
error	250.435275811697	240.303054849449	
reached.threshold	0.089183042899	0.096717560389	
steps	332792.000000000000	435675.00000000000	
Intercept.to.1layhid1	-1.737854576068		
Day_TypeW_End.to.1layhid1	5.089738951861		
HolidayYes.to.1layhid1	2.029575171014		
Residency.to.1layhid1	-14.111420140599		
SemesterSpring.to.1]ayhid1	0.027103641566		
SemesterSummer.to.1layhid1	-0.534284254368		
Enrollement.to.1layhid1	0.669550526355		
T_Max.to.1layhid1	-9.394261611046	-1.145641460626	
DP_Max.to.1layhid1	4.787719060256	-0.637885653864	
WS_Max.to.1layhid1	-4.209681711498	-0.953640421961	
APress_Max.to.1layhid1	2.325293061989		
APress_Min.to.1layhid1	-5.025942021850		
Prec_Avg.to.1layhid1	-7.509839232999		
Bis_Court_E.to.1layhid1	2.689214802151		
B_Court_W.to.1layhid1	-2.800852695200		
	-1.500825195703		
Burgum.to.1layhid1			
Churchhill.to.1layhid1	2.493834328556		
Dinan.to.llayhidl UV_Apts.to.llayhidl Intercept.to.llayhid2 Day_Typew_End.to.llayhid2 HolidayYes.to.llayhid2 Residency.to.llayhid2 SemesterSpring to llayhid2	1.676400676031		
UV_Apts.to.llayhidl	4.435919454374		
Intercept.to.llayhid2	-1.846252696012		
Day_TypeW_End.to.1layhid2	-4.261296756297		
HolidayYes.to.1layhid2	-0.287444017717	-12.986854458832	
Residency.to.1layhid2	0.239687878281	0.045287480595	
SemesterSpring.to.1layhid2	-0.863536176979	8.026381535511	
SemesterSummer.to.1layhid2	1.166014509937		
Enrollement.to.1layhid2	2.430786596459		
T_Max.to.1layhid2	-1.847962280254		
DP_Max.to.1layhid2	1.157344774100		
WS_Max.to.1layhid2	0.439240711033		
	1.243548168317		
APress_Max.to.11ayhid2			
APress_Min.to.1layhid2	-1.393809763503		
Prec_Avg.to.1layhid2	0.007577179355		
Bis_Court_E.to.1layhid2	1.146027157902		
B_Court_W.to.1layhid2	3.940129993951		
Burgum.to.1layhid2	0.149800121235		
Churchhill.to.1layhid2	1.066335946584		
Dinan.to.1layhid2	-0.445973060643		
UV_Apts.to.11ayhid2	1.943993484831		
Intercept.to.1layhid3	2.112588283023	-1.856377967982	
Day_TypeW_End.to.1layhid3	3.549950165328		
HolidayYes.to.1layhid3	3.608060044489		
Residency.to.1layhid3	-3.170252356962		
Restructey. co. rayinas	5.110252550502	0.704205700200	

SemesterSpring.to.1layhid3	0.943144268030	-1.664187346319	
SemesterSummer.to.1layhid3	0.057140860026	0.753035356864	
Enrollement.to.1layhid3	1.903833032946	-1.228031831109	
T_Max.to.1]ayhid3	-0.183759180049	-0.220329137366	
DP_Max.to.1layhid3	-0.236411038074	0.433334317025	
WS_Max.to.1layhid3	-0.053599164003	-0.019696520664	
APress_Max.to.1layhid3	-0.032710738702	0.222045164731	
APress_Min.to.1layhid3	-0.083290855169	0.117625712974	
Prec_Avg.to.1layhid3	0.013698177967	-0.160737193627	
Bis_Court_E.to.1layhid3	-1.732035092640	-0.686772328731	
B_Court_W.to.1layhid3	3.269377546054	2.678241479801	
Burgum.to.1layhid3	-0.387099440655	-0.566866923334	
Churchhill.to.1layhid3	3.510863894057	-0.713586530806	
Dinan.to.1layhid3	-1.977734405304	-0.369843397110	
UV_Apts.to.1layhid3	0.268819951153	-0.563283659909	
Intercept.to.1layhid4	-1.590636584765	0.323387083769	
Day_TypeW_End to 11ayhid4	-6.692801705792	2.802430639273	
HolidayYes.to.1layhid4	-3.931768144152	2.805989304090	
Residency.to.1layhid4	0.139350712218	0.532932987025	
SemesterSpring.to.1]ayhid4	-2.102209842827	-3.262772051852	
SemesterSummer.to.1layhid4	1.584175376123	1.998698767145	
Enrollement.to.1layhid4	-1.716822199780	6.801761258680	
T_Max.to.1layhid4	0.333875870545	-2.956659915861	
DP_Max.to.1layhid4	-1.540984003897	0.305439571565	
	-1.078027859097		
WS_Max.to.1layhid4		-0.233966006044	
APress_Max.to.1]ayhid4	0.344804054368	0.067589812594	
APress_Min.to.1layhid4	-1.187551416492	2.755837712858	
Prec_Avg.to.1layhid4	0.501096815358	0.087081150036	
Bis_Court_E.to.1layhid4	-4.874021564948	1.004961976923	
B_Court_W.to.1]ayhid4	5.114384867529	0.722044832997	
Burgum to 1]ayhid4			
Burgum.to_1layhid4	-0.233497988192	-0.056530554368	
Churchhill.to.1layhid4	6.930324782858	-1.352819641479	
Dinan.to.1layhid4	-5.471155219033	0.285698651925	
UV_Apts.to.11ayhid4	0.693412695826	-3.549164097119	
Intercept.to.1layhid5	-1.161093376809	5.368990283031	
Day_TypeW_End.to.1layhid5	1.814031391663	-5.265169659845	
HolidayYes.to.1layhid5	-0.994985878733	-7.290887798676	
Residency.to.1layhid5	-0.477243917528	-1.403773766438	
SemesterSpring.to.1layhid5	1.809068732292	-5.809246939918	
SemesterSummer to 11ayhid5	1.619312986426	-0.196841177068	
Enrollement.to.1layhid5	-0.850313479348	-2.494610191079	
T_Max.to.1layhid5	0.951896128686	5.515914016025	
DP_Max.to.1]ayhid5	0.145935465503	-3.604445015929	
WS_Max.to.1layhid5	-0.147551322967	-2.152981004132	
APress_Max.to.1layhid5	-0.181472451748	-0.003533341305	
APress_Min.to.1layhid5	0.350830219984	2.729387396236	
Prec_Avg.to.1layhid5	-0.057617001362	2.882780964708	
Bis_Court_E.to.1layhid5	0.941563651727	-4.703064243684	
B_Court_W.to.1layhid5	-1.568314050151	-13.323712468147	
Burgum.to.1layhid5	-0.716937552452	-1.403738251409	
Churchhill.to.1layhid5	0.601182170761	-9.207372914593	
Dinan.to.1layhid5	0.426754532506	2.225500035755	
UV_Apts.to.1layhid5	2.577801826292	-2.635661431575	
Intercept.to.1layhid6	-0.607630185465	0.356736851298	
Day Typow End to 11auhide			
Day_TypeW_End.to.1]ayhid6	0.895036409840	0.697335434164	
HolidayYes.to.1layhid6	-0.771042727573	-1.958585982293	
Residency.to.1layhid6	-1.446725695934	0.549548926542	
SemesterSpring.to.1layhid6	2.692111301619	3.196658337860	
SemesterSummer.to.1layhid6	2.420255479618	0.568075991704	
Enrollement.to.1layhid6	-1.270019349406	5.090795830988	
		2.124022661879	
T_Max.to.1layhid6	3.824649411026		
DP_Max.to.1]ayhid6	-2.692036947692	2.411631181022	
WS_Max.to.1layhid6	0.986674748894	0.106057205158	
APress_Max.to.1]ayhid6	-1.504698760522	-0.833103805231	
APress_Min.to.1layhid6	2.730008093065	1.801348824224	
Prec_Avg.to.1layhid6	0.620112364183	0.337038587676	
Bis_Court_E.to.1layhid6	-0.240306058173	-2.360326914231	
B_Court_W.to.1layhid6	12.636981961498	1.564607865054	
	-3.248706090681	-1.409109094996	
Burgum.to.1layhid6			
Churchhill.to.1layhid6	1.235431625283	0.593787229837	
Dinan.to.1layhid6	0.348912469567	-0.868680263295	
UV_Apts.to.1layhid6	3.144866089382	-3.857605101831	
Intercept.to.1layhid7	-0.187602058918	-0.955686007039	
Day_TypeW_End.to.1layhid7	-4.368529271686	-1.704130379193	
HolidayYes.to.1layhid7	2.456821652438	-0.556511027153	
Residency.to.1layhid7	-0.193967257792	1.905502078512	
SemesterSpring.to.1layhid7	-0.488042291907	-6.966724437283	
SemesterSummer.to.1layhid7	1.779163925027	-0.335692599994	

Enrollement.to.1layhid71.085049010486-0.768687221794T_Max.to.1layhid7-0.319102773593-3.248038266087DP_Max.to.1layhid70.5345914177470.149273197428WS_Max.to.1layhid7-0.333431780317-1.116886115718APress_Max.to.1layhid7-0.3785759774510.810121719741APress_Min.to.1layhid7-0.470481459495-0.141646052312Prec_Avg.to.1layhid7-0.1649637943190.427593569605Bis_Court_E.to.1layhid7-0.5906236124240.251395434083B_Court_W.to.1layhid73.97907782735-2.66625095212Burgum.to.1layhid7-0.5054570021740.068017843136UV_Apts.to.1layhid7-0.5054570021740.068017843136UV_Apts.to.1layhid7-1.5815576813192.009069281302Intercept.to.1layhid8-25.4582254424761.106333690564Day_Typew_End.to.1layhid8-28213659472791.254958396543SemesterSpring.to.1layhid8-2.8213659472791.254958396543SemesterSpring.to.1layhid85.1418718904252.350162726321Enrollement.to.1layhid87.919201809482-0.01735379593T_Max.to.1layhid89.031700714668-1.03810671085Apress_Max.to.1layhid89.031700714668-1.038101671085Apress_Max.to.1layhid86.762924953920.85675248908Mox_to.1layhid86.762924953920.85675248908Mox_to.1layhid86.762924953920.85675248908Max.to.1layhid86.762924953920.85675248908Apress_Max.to.1layhid86.762924953920.85675248908 <td< th=""></td<>
DP_Max.to.1layhid70.5345914177470.149273197428ws_Max.to.1layhid7-0.333431780317-1.116886115718APress_Max.to.1layhid7-0.3785759774510.810121719741APress_Min.to.1layhid70.470481459495-0.141646052312Prec_Avg.to.1layhid7-0.1649637943190.427593569605Bis_Court_W.to.1layhid7-0.5096236124240.251395434083B_court_W.to.1layhid73.979077982735-2.666295095212Burgum.to.1layhid7-2.32003102512-2.140307421153Churchhill.to.1layhid7-0.5054570021740.068017843136UV_Apts.to.1layhid7-1.5815576813192.009069281302Intercept.to.1layhid8-26.6646311566724.760724788935HolidayYes.to.1layhid8-28213659472791.254958396543SemesterSpring.to.1layhid8-2.8213659472791.254958396543SemesterSummer.to.1layhid874.91920180482-2.300162726321Enrollement.to.1layhid874.91920180482-2.017353579593T_Max.to.1layhid89.1345838875490.121236789380WS_Max.to.1layhid89.1345838875490.121236789380WS_Max.to.1layhid89.031700714668-1.038101671085APress_Max.to.1layhid84.650571293801-0.216328765057Prec_Avg.to.1layhid85.2338295206910.124565374142Bis_Court_E.to.1layhid84.650571293801-0.216328765057Prec_Avg.to.1layhid84.650571293801-0.216328765057Prec_Avg.to.1layhid84.650571293801-0.216328765057Prec_Avg.to.1layhid84.505771293801-0.2163
DP_Max.to.1layhid70.5345914177470.149273197428ws_Max.to.1layhid7-0.333431780317-1.116886115718APress_Max.to.1layhid7-0.3785759774510.810121719741APress_Min.to.1layhid70.470481459495-0.141646052312Prec_Avg.to.1layhid7-0.1649637943190.427593569605Bis_Court_W.to.1layhid7-0.5096236124240.251395434083B_court_W.to.1layhid73.979077982735-2.666295095212Burgum.to.1layhid7-2.32003102512-2.140307421153Churchhill.to.1layhid7-0.5054570021740.068017843136UV_Apts.to.1layhid7-1.5815576813192.009069281302Intercept.to.1layhid8-26.6646311566724.760724788935HolidayYes.to.1layhid8-28213659472791.254958396543SemesterSpring.to.1layhid8-2.8213659472791.254958396543SemesterSummer.to.1layhid874.91920180482-2.300162726321Enrollement.to.1layhid874.91920180482-2.017353579593T_Max.to.1layhid89.1345838875490.121236789380WS_Max.to.1layhid89.1345838875490.121236789380WS_Max.to.1layhid89.031700714668-1.038101671085APress_Max.to.1layhid84.650571293801-0.216328765057Prec_Avg.to.1layhid85.2338295206910.124565374142Bis_Court_E.to.1layhid84.650571293801-0.216328765057Prec_Avg.to.1layhid84.650571293801-0.216328765057Prec_Avg.to.1layhid84.650571293801-0.216328765057Prec_Avg.to.1layhid84.505771293801-0.2163
WS_Max.to.1laýhid7-0.333431780317-1.116886115718APress_Max.to.1laýhid7-0.3785759774510.810121719741APress_Min.to.1laýhid70.470481459495-0.141646052312Prec_Avg.to.1laýhid7-0.1649637943190.427593569605Bis_Court_E.to.1laýhid7-0.5906236124240.251395434083B_Court_W.to.1laýhid73.979077982735-2.666295095212Burgum.to.1laýhid7-2.320033102512-2.140307421153Churchhill.to.1laýhid7-0.5054570021740.068017843136UV_Apts.to.1laýhid7-1.5815576813192.009069281302Intercept.to.1laýhid8-25.4582254424761.106333690564Day_Typew_End.to.1laýhid8-26.6646311566724.760724788935HolidaýYes.to.1laýhid8-2.8213659472791.254958396543SemesterSpring.to.1laýhid821.418718904252.350162726321Enrollement.to.1laýhid821.418718904252.350162726321Enrollement.to.1laýhid811.41824267960-2.520256735872DP_Max.to.1laýhid89.031700714668-1.038101671085APress_Min.to.1laýhid89.031700714668-1.038101671085APress_Min.to.1laýhid85.2332825206910.21236789380APress_Min.to.1laýhid85.2332825206910.216328765057Pres_Max.to.1laýhid85.233282506910.21236789380APress_Min.to.1laýhid84.650571293801-0.216328765057Pres_Min.to.1laýhid85.2332825206910.124565374142Bis_Court_E.to.1laýhid814.1748057728040.84985688949B_COurt_W.to.1laýhid8-25.92073611863 </td
Apress_Max.to.llayhid7-0.3785759774510.810121719741Apress_Min.to.llayhid70.470481459495-0.141646052312Prec_Avg.to.llayhid7-0.1649637943190.427593569605Bis_Court_E.to.llayhid7-0.5906236124240.251395434083B_Court_W.to.llayhid73.979077982735-2.666295095212Burgum.to.llayhid7-2.320033102512-2.140307421153Churchhill.to.llayhid73.427123039146-1.601905297886Dinan.to.llayhid7-0.5054570021740.068017843136UV_Apts.to.llayhid7-1.5815576813192.009069281302Intercept.to.llayhid8-25.4582254424761.106333690564Day_TypeW_End.to.llayhid8-26.6646311566724.760724788935HolidayYes.to.llayhid8-1.17150863264663.920780163692Residency.to.llayhid8-2.8413659472791.254958396543SemesterSpring.to.llayhid821.4182742679600-2.520256735872DP_Max.to.llayhid821.418242679600-2.520256735872DP_Max.to.llayhid8-9.1345838875490.121236789380ws_Max.to.llayhid8-9.1345838875490.121236789380Ws_Max.to.llayhid8-9.1345838875490.121236789380Apress_Min.to.llayhid84.650571293801-0.216328765057Apress_Min.to.llayhid85.233829206910.124565374142Bis_Court_E.to.llayhid84.650571293801-0.216328765057Prec_Avg.to.llayhid84.650571293801-0.216328765057Prec_Avg.to.llayhid84.650571293801-0.216328765057Prec_Avg.to.llayhid84.233829520691
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Prec_Avg.to.1layhid7-0.1649637943190.427593569605Bis_Court_E.to.1layhid7-0.5906236124240.251395434083B_Court_W.to.1layhid73.979077982735-2.666295095212Burgum.to.1layhid7-2.320033102512-2.140307421153Churchhill.to.1layhid7-0.5054570021740.068017843136UV_Apts.to.1layhid7-1.5815576813192.009069281302Intercept.to.1layhid8-25.4582254424761.106336690564Day_TypeW_End.to.1layhid8-26.6646311566724.760724788935HolidayYes.to.1layhid8-28218659472791.254958396543semesterSpring.to.1layhid8-28.847832633180-1.685361997740semesterSpring.to.1layhid85.1418718904252.350162726321Enrollement.to.1layhid874.919201809482-0.017353579593T_Max.to.1layhid89.134583875490.121236789380WS_Max.to.1layhid89.134583875490.12236789380APress_Max.to.1layhid89.031700714668-1.038101671085APress_Min.to.1layhid85.23829206910.214365374142Bis_Court_E.to.1layhid85.238295206910.124565374142Bis_Court_E.to.1layhid814.4748057728040.849856888949B_Court_W.to.1layhid814.4748057728040.84985688949
Bis_Court_E.to.1layhid7-0.5906236124240.251395434083B_Court_W.to.1layhid73.979077982735-2.666295095212Burgum.to.1layhid7-2.320033102512-2.140307421153Churchhill.to.1layhid73.427123039146-1.601905297886Dinan.to.1layhid7-0.5054570021740.068017843136UV_Apts.to.1layhid7-1.5815576813192.009069281302Intercept.to.1layhid8-25.4582254424761.106333690564Day_Typew_End.to.1layhid8-11.7150863264663.920780163692Residency.to.1layhid8-2.8213659472791.254958396543SemesterSpring.to.1layhid85.4418718904252.350162726321Enrollement.to.1layhid874.919201809482-0.017353579593T_Max.to.1layhid89.031700714668-1.038101671085APress_Max.to.1layhid86.7629924953920.856575248908APress_Min.to.1layhid85.2338295206910.124565374142Bis_Court_E.to.1layhid814.1748057728040.84985688949B_Court_W.to.1layhid8-25.920713611863-0.680445167835
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Semesterspring.to.1layhid825.847832633180-1.685361997740semestersummer.to.1layhid85.1418718904252.350162726321Enrollement.to.1layhid874.919201809482-0.017353579593T_Max.to.1layhid821.418242679690-2.520256735872DP_Max.to.1layhid8-9.1345838875490.121236789380wS_Max.to.1layhid89.031700714668-1.038101671085APress_Max.to.1layhid86.7629924953920.856575248908APress_Min.to.1layhid85.2338295206910.12456374142Bis_Court_E.to.1layhid814.1748057728040.849856888949B_Court_W.to.1layhid8-25.920713611863-0.680445167835
SemesterSummer.to.1layhid85.1418718904252.350162726321Enrollement.to.1layhid874.919201809482-0.017353579593T_Max.to.1layhid821.418242679690-2.520256735872DP_Max.to.1layhid8-9.1345838875490.121236789380wS_Max.to.1layhid89.031700714668-1.038101671085APress_Max.to.1layhid86.7629924953920.856575248908APress_Min.to.1layhid84.650571293801-0.216328765057Prec_Avg.to.1layhid85.2338295206910.124565374142Bis_Court_E.to.1layhid814.1748057728040.849856888949B_Court_W.to.1layhid8-25.920713611863-0.680445167835
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B_Court_W.to.1layhid11	1.173573982705	-54.518429936688	
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llayhid.1.to.2layhid6 llayhid.2.to.2layhid6 llayhid.3.to.2layhid6 llayhid.4.to.2layhid6 llayhid.5.to.2layhid6	-7.429629547693 -2.404056797186 -4.021766253326 22.105089912261	0.053386633331 -25.108150883376 -0.064927556235 -2.033082843444	
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Layhi G. Y. to. 2 Layhidó -4. 400507835012 0. 357190461562 Layhi G. Ko. 2 Layhidó -7. 7102044070 -2. 61530025777 Layhi G. Lo. 2 Layhidó -7. 533707303748 -1. 65524458918 Layhi G. Lo. 2 Layhidó -7. 533707303748 -1. 65524458918 Tritercept. to. 2 Layhid7 -3. 060332800756 16. 839717650907 Layhi G. Lo. 2 Layhid7 -3. 050332800756 16. 839717650907 Layhi G. Lo. 2 Layhid7 -3. 050332800756 16. 839717650907 Layhi G. Lo. 2 Layhid7 -4. 050513454165729 -2. 44504271346 Layhi G. Lo. 2 Layhid7 -4. 205611946504 -4. 442376411928 Layhi G. Lo. 2 Layhid7 -4. 205611946504 -4. 442376411928 Layhi G. Lo. 2 Layhid7 -4. 205611946574 -7. 972272683442 Layhi G. Lo. 2 Layhid7 -10. 15741703314 -9. 2723441031238 Layhi G. Lo. 2 Layhid8 -0. 67243466579 13. 66836047700 Layhi G. Lo. 2 Layhid8 -0. 67243466578 13. 66836047700 Layhi G. Lo. 2 Layhid8 -0. 67256395662 13. 25726739478 Layhi G. Lo. 2 Layhid8 -0. 672563956613166 -3. 6702567792				
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3]ayhid.2.to.Ridership_31_D 7.671448039593 1.175012371521				
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3]ayhid.4.to.Ridership_31_D	-2.518383955768	-0.862736860649	
3layhid.5.to.Ridership_31_D	-0.025699795942	3.642240124062	
Intercept.to.Ridership_32_D	-2.570569322427	-3.048693030126	
3]ayhid.1.to.Ridership_32_D	-2.755232869809	1.342686861302	
3layhid.2.to.Ridership_32_D	6.489504964642	2.291869269393	
3layhid.3.to.Ridership_32_D	5.134787276138	-2.402876796456	
3layhid.4.to.Ridership_32_D	-1.449238439726	2.239794561746	
3layhid.5.to.Ridership_32_D	-0.935802981674	4.207570151272	
Intercept.to.Ridership_33_D	-0.055191416219	-0.998613936522	
3layhid.1.to.Ridership_33_D	-0.719818613113	-0.044548600594	
3layhid.2.to.Ridership_33_D	1.706577246877	1.569488314106	
3layhid.3.to.Ridership_33_D	0.977087447870	0.882036715129	
3layhid.4.to.Ridership_33_D	-2.652936790165	0.114548481224	
3layhid.5.to.Ridership_33_D	1.248340645246	3.525602745167	
Intercept.to.Ridership_34_D	-2.074232130674	-0.576985943875	
3layhid.1.to.Ridership_34_D	-4.500452434975	0.449555003197	
3layhid.2.to.Ridership_34_D	5.714545164836	2.901651454001	
3layhid.3.to.Ridership_34_D	3.823800816042	-0.084940664173	
3layhid.4.to.Ridership_34_D	-0.277263266394	-0.089782166273	
3layhid.5.to.Ridership_34_D	1.631739962194	-0.250806580546	
Intercept.to.Ridership_35_Tap_D	0.278970414479	-2.476725290914	
3layhid.1.to.Ridership_35_Tap_D	-0.996357313034	3.202480331666	
3layhid.2.to.Ridership_35_Tap_D	4.297230232433	1.501149149163	
3layhid.3.to.Ridership_35_Tap_D	1.021072388731	-2.224745359462	
3layhid.4.to.Ridership_35_Tap_D	-1.290217957897	1.740495393632	
3layhid.5.to.Ridership_35_Tap_D	-1.098520004058	3.183335548283	
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