NDSU | UPPER GREAT PLAINS TRANSPORTATION INSTITUTE
ADVANCED TRAFFIC ANALYSIS CENTER

Vision Camera Data Collection & Traffic Analysis Enhancements

Final Report

August 2020

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Grand Forks-East Grand Forks MPO

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INTRODUCTION

Prior to this project, the Grand Forks-East Grand Forks MPO and the City of Grand Forks were using approximately 183 (45 intersections) of the city's existing traffic detection cameras for traffic data collection. These cameras were set up during Phases I, II, IIIa and IIIb of the study. Models of cameras at these intersections included Encore, Terra and Duo. Figure 1 shows an example of the view provided by these cameras.

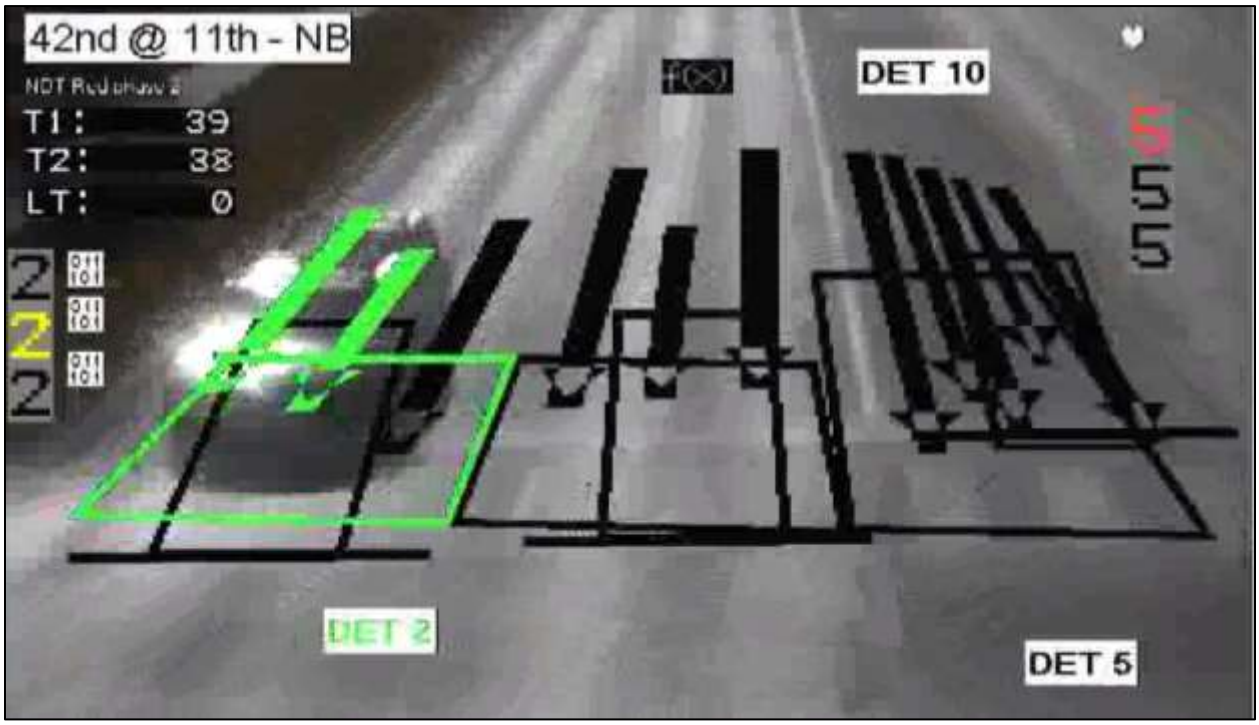


Figure 1. View of older model camera with detection and data collection overlays

The data reported by these cameras are archived in separate databases and can be processed into various reports. As a part of the current project, initially nine intersections are to be set up for traffic data collection. An amendment to the addendum added another six intersections to the list.

OBJECTIVES

As part of this study, 15 intersections with approximately 60 cameras were to be configured to collect traffic volumes and speeds. The intersections included in this phase of the study are listed in Table 1. All of these cameras are the newer VISION models. Figure 2, shows an example of the view from the VISION cameras. Note that not all of the intersections are new intersections. Some of the older-model cameras at existing intersections were upgraded to VISION models.

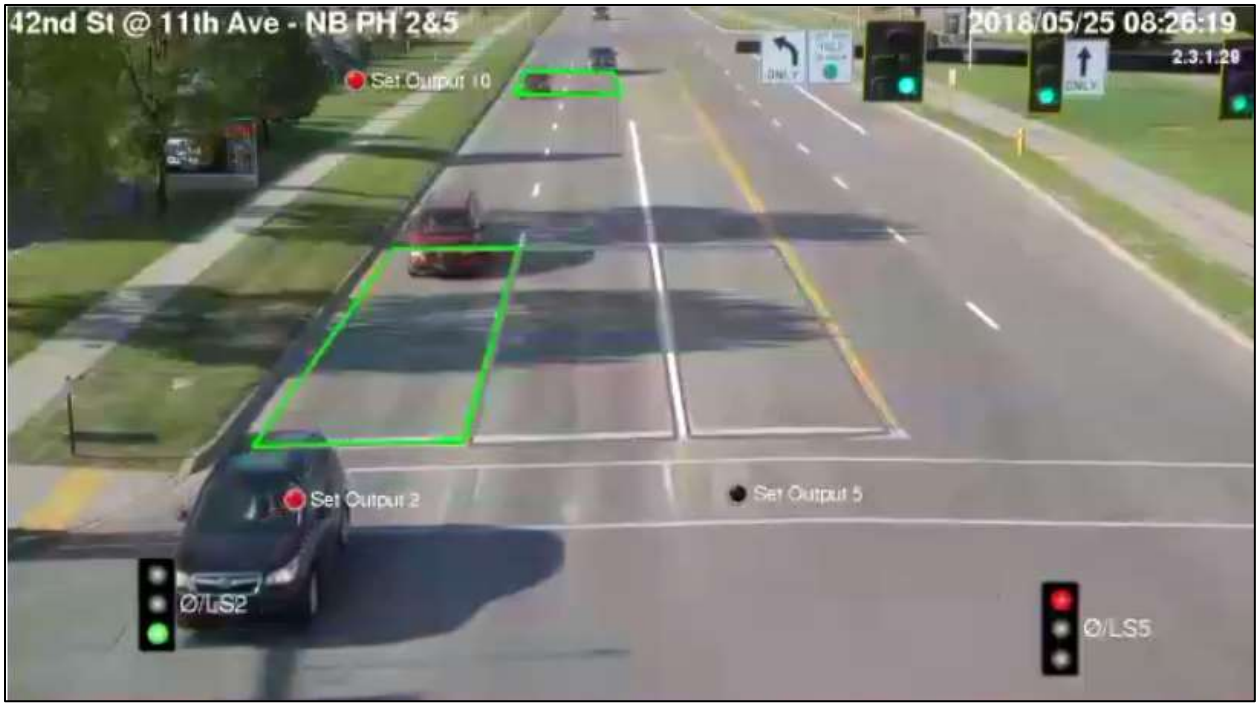


Figure 2. View of newer model VISION camera with detection and data collection overlays

Table 1. Study intersections

#	Main St.	Cross St.
6	Gateway Dr.	N Washington St.
39	S 42nd St.	11th Ave. S
55	S Columbia Rd.	40th Ave. S
56	S Columbia Rd.	36th Ave. S
57	S 42nd St.	Demers Ave.
59	N 42nd St.	University Ave.
60	N 42nd St.	6th Ave. N
61	47th Ave. S	S Columbia Rd.
62	Demers Ave.	S 20th St.
63	Demers Ave.	S 34th St.
64	Demers Ave.	N Columbia Rd.
65*	Demers Ave.	S Washington St.
66	S Washington St.	44th Ave. S
67*	Gateway Dr.	N 55th St.
68*	Demers Ave.	S Columbia Rd.

* This intersection was offline on the central system as of writing of this report.

In addition, the objectives of the study include building enhancements to the existing NDSU Traffic Analysis Tool and to obtain cost estimates for upgrading East Grand Forks signalized intersections to enable similar data collection efforts within the MPO region.

METHODOLOGY

This study was divided into six major tasks:

- Data Polling & Transfer
- VISION Data Reporting
- Data Quality Audits
- East Grand Forks Estimation
- Level of Service Estimation Feasibility Check
- Traffic Analysis Tool Enhancements

These tasks are discussed in detail below:

Data Polling & Transfer

In this task, cameras at intersections were set to collect turning movement counts and mean speeds. The VISION cameras are controlled using a single program, named Supervisor, as opposed to the Autoscope suite of programs used for older cameras (Encore, Terra etc.). Also, in contrast with the functionality of the older cameras where the Data Collector (one of the programs within the Autoscope suite) could append data files after every data interval, the Supervisor program must be manually polled every time the importation of data into the database is desired.

Also, in Supervisor the setup for data collection is deeply intertwined with the traffic detection setup. During the initial data quality audits, it was found that changes to the way the detection setup is done would be required to get usable traffic data. For example, zones spanning multiple lanes within a lane group were created to detect vehicles. In such a setup, a vehicle detected anywhere within the lane group could be set to call a given phase within the traffic signal controller. During the times observed, the setup seemed to work for detection purposes without fail. However, it was found that this arrangement resulted in a significant deterioration in traffic data quality. Apparently, vehicles in adjacent lanes that occupied the detection zone in a continuous fashion due to staggered starts and/or differences in vehicle acceleration parameters rendered the camera unable to distinguish between vehicles and resulted in undercounts.

Moreover, it was found out that multiple zones within the same camera view were named the same (e.g., “Zone”). This made it impossible to distinguish one turning movement at an approach from another at the same approach.

To overcome the challenges, several changes were requested of the camera vendor, Traffic Control Corp., while it set up/reset the VISION cameras. These changes† primarily included:

- Creation of separate per-lane zones for all approaches/intersections equipped with VISION cameras
- Renaming of all zones located at the stop bars to agreed-upon nomenclature (e.g., LT denoting left turn, T2 denoting through lane #2 etc.)
- Recalibration of cameras where, upon visual inspection, the calibration parameters were found to be out of range

The existing data transfer script proved to be sufficient to transfer new raw data from the VISION cameras. The "data saving" location within the Supervisor program was adjusted so that the data transfer script could be left unchanged. Local backup procedures were introduced starting with this phase of the study.‡

Intersection Setup

It was ensured that all of the intersections set up in this phase of the study conformed to the standards used on the rest of the network of signalized intersections. The setups were to include counting of traffic one approach at a time (all intersections had one camera per approach as none of them were too wide to not be within the view of a single camera). Similar to the previously set up intersections, the setup within the confines of each approach was dictated by existing conditions such as intersections geometrics and lane assignment/grouping. For any given approach/intersection, all lane groups with exclusive movements were counted separately using corresponding zones (e.g., T1, T2, and T3 counted traffic within through lanes 1, 2, and 3 respectively). However, in cases of shared lanes, two (or more) movements were combined and counted together in a single zone (e.g., TRT denotes a zone that counts through and right-turning vehicles at an approach). For instance, at the southbound approach of N 42nd St. at 6th Ave. N, the rightmost lane is shared by through and right-turning movements. Therefore, in this case, the right-turn movement has been set to be counted with the through movement and is reported to the same detector station. Refer to Table 2 for detailed information on lane assignments and detector stations set per approach. The updated archive files were saved on the external drive connected to the communications server.

† For more details refer to Appendix 1, which lists most of the changes made to setup.
‡ For more details refer to the Challenges section of this report.

Table 2. Intersection lane assignments and detector setup per approach§

#	Main Street	Cross Street	EB			NB			SB			WB		
			L	T	R	L	T	R	L	T	R	L	T	R
6	Gateway Dr.	N Washington St.												
39	S 42nd St.	11th Ave S.												
55	S. Columbia.	40th Ave S.												
56	S. Columbia.	36th Ave S.												
57	S 42nd St.	Demers Ave.												
59	N 42nd St.	University Ave.												
60	N 42nd St.	6th Ave N.												
61	47th Ave S.	S Columbia Rd.												
62	Demers Ave.	S 20th St.												
63	Demers Ave.	S 34th St.					N/A			N/A				
64	Demers Ave.	N Columbia Rd.					N/A							
65	Demers Ave.	S Washington St.												
66	S Washington St.	44th Ave S.												
67	Gateway Dr.	N 55th St.												
68	Demers Ave.	S Columbia Rd.												

VISION Data Reporting

Data from the VISION cameras downloads in the .csv format as opposed to the .txt format from the older model cameras. Table 3 below shows a simplified view of the relevant .txt format data. Notice that the data is binned at 15-minute intervals. The VISION data format is quite different from format of the older camera data. This is primarily because VISION cameras provide per-vehicle information as opposed to the binned format of the older cameras.

§ Notes:

1. Each arrow corresponds to a lane group and may represent multiple lanes.
2. Each dot represents a separate zone that counts the corresponding movement(s).

The drastic change in the raw data format as reported by the cameras necessitated the creation of a new script that could import the .csv data into the existing SQL database. With the help of the new script, the same traffic analysis reports and data exports can now be created for the VISION-equipped intersections.

Table 3. Sample row of .txt data from file entitled '20171211_0.txt' downloaded from the NB approach at the intersection of 32nd Ave S and 38th St S

CPU Identifier	10054AFFAA464232
Autoscope Description	32nd Ave @ 38th St -- Yes -- NB/NBLT Phases 4&7 -- 172.22.97.7 -- 10.5.0 -- ENCORE -- 10054AFFAA464232 -- Terra Access Point NEMA -- 74 -- Yes -- Yes -- 2 -- 172.22.97.7 -- 172.22.1.254 -- 255.255.0.0 -- 2017,11,20 15:19:52 -- 0
Detector ID	137
Detector Title	NB_LT
Date	12/11/2017
Time	12:00:00 AM
Status	100
Data Interval	15 Minutes
State	-
Volume	1
Arithmetic Mean Speed	15.000

Table 4 below shows a view of the corresponding .csv format data.

Table 4. Sample .csv data from file entitled 'Gateway at Washington - WB Phases 2&5_421798048_20200213_082922.csv' downloaded from the WB approach at the intersection of Gateway Dr and Washington St

02/11/2020 11:23:02 AM	Zone Statistics	575522044	T1	0	0	0
02/11/2020 11:23:02 AM	Exiting Vehicle	1990576100	LT1	10	Left Turn	3522775126

Data Quality Audits

Similar to the previous phases of the study, for each of the cameras setup, random data quality audits were performed. Traffic volumes were collected manually in 15-minute intervals. The manually collected traffic counts were then compared to camera output. Hourly traffic volumes (manual vs camera) were compared using a GEH statistic which is computed as follows:

$$GEH = \sqrt{\frac{(A-M)^2}{(A+M)/2}}$$

Where:

A = Autoscope camera traffic count
M = Manual traffic count

Also, lane group peak hour factors (PHF) were compared for hourly traffic volumes. For intersection turning movement counts, PHF is computed as follows:

$$PHF = \frac{V}{4 \times V_{15}}$$

Where:

V = hourly volume

V_{15} = volume during the peak 15 minutes of flow

Camera Re-calibration/Re-aiming

The camera calibration and zone setup at the following approaches was edited or adjusted:

1. Washington St. at 44th Ave. WB
2. Columbia Rd. at 36th Ave. WB
3. Columbia Rd. at 40th Ave. SB
4. S 42nd St. at Demers Ave. EB
5. S 42nd St. at 11th Ave. S SB, WB
6. N 42nd St. at University Ave. SB
7. N 42nd St. at 6th Ave. N SB
8. 47th Ave. S at S Columbia Rd. SB, WB
9. Demers Ave. at S 20th St. SB
10. Demers Ave. at S Washington St. SB
11. Gateway Dr. at Washington St. SB
12. Demers Ave. at N Columbia Rd. EB
13. Columbia Rd. at 47th Ave. SB, WB

Figure 3 shows the existing zone setup at the southbound approach at the intersection of N 42nd St. and University Ave. At this location, the zones were off center from their corresponding lanes. Figure 4 shows the adjustments made to the zone locations to better accommodate the lanes. This adjustment should reduce double-counting because of the mismatch between the pavement markings and the zone setup.

Figure 5 shows the existing calibration setup at the westbound approach at the intersection of Washington St. and 44th Ave. S. At this particular location, the calibrated lane widths were found to be incorrect. Figure 6 below shows the updated calibration at the same location. The improved calibration of these cameras is expected to improve the traffic counts as well as vehicle presence and passage detection.

Figure 3. Existing zone setup for N 42nd St. at University Ave. southbound

Figure 4. Updated zone setup for N 42nd St. at University Ave. southbound

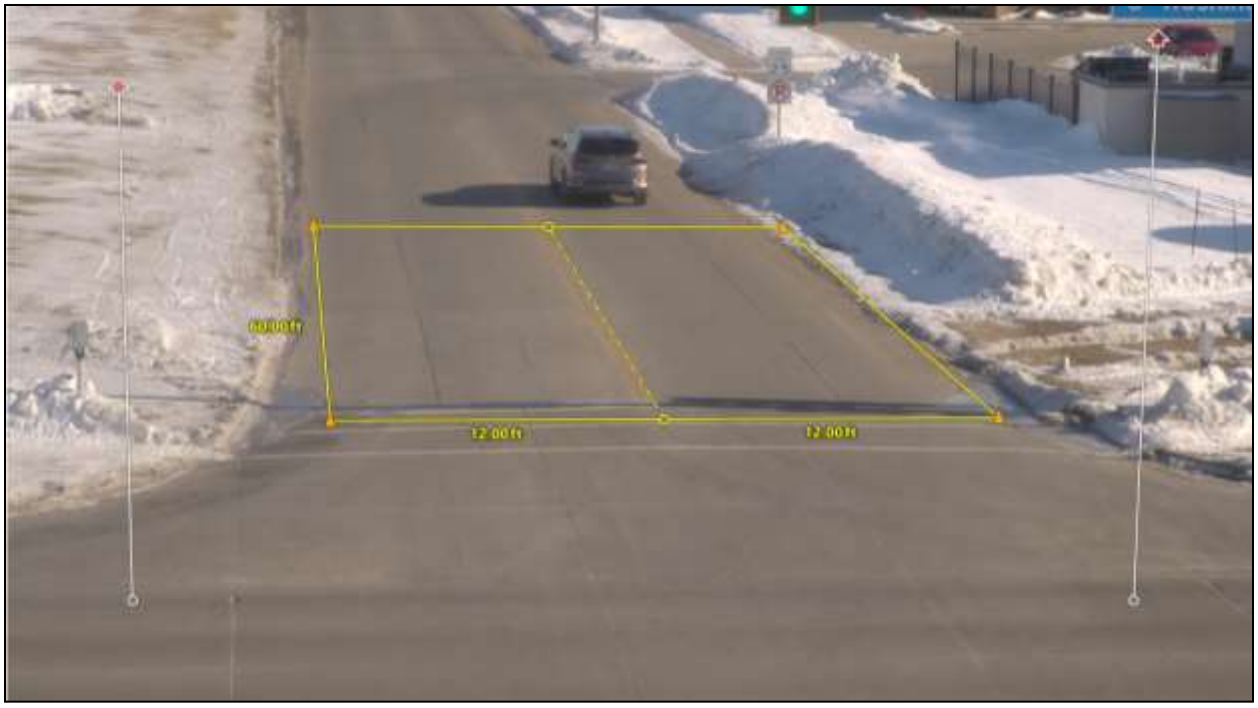


Figure 5. Existing calibration setup at Washington S.t at 44th Ave. S WB approach

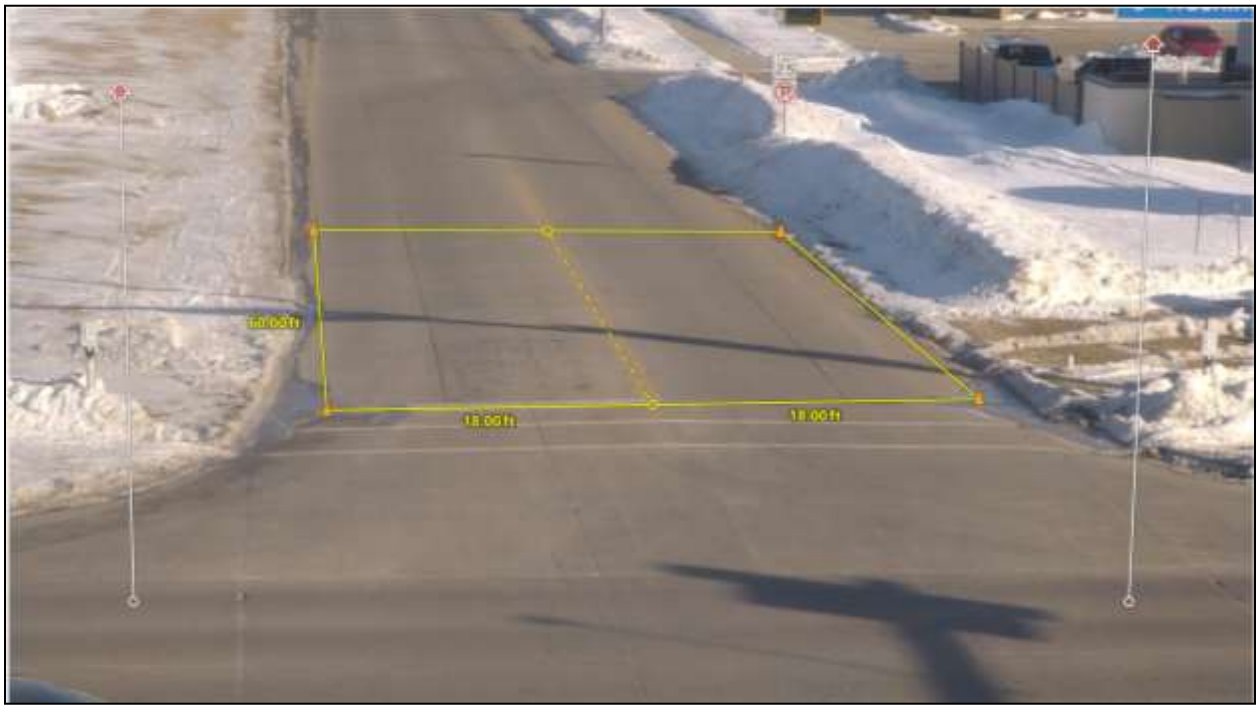


Figure 6. Updated calibration setup at Washington St. at 44th Ave. S WB approach

Data Quality Results

The traffic count data collected by the VISION cameras was found to be more accurate than the data collected by older versions of the cameras. Refer to Table 5 for GEH comparison of manual counts vs. camera counts at one of the study intersections. See Appendix 2 for GEH comparisons of all study intersections.

Table 5. Manual vs. camera traffic count comparison for the intersection of N 42nd St. at University Ave.

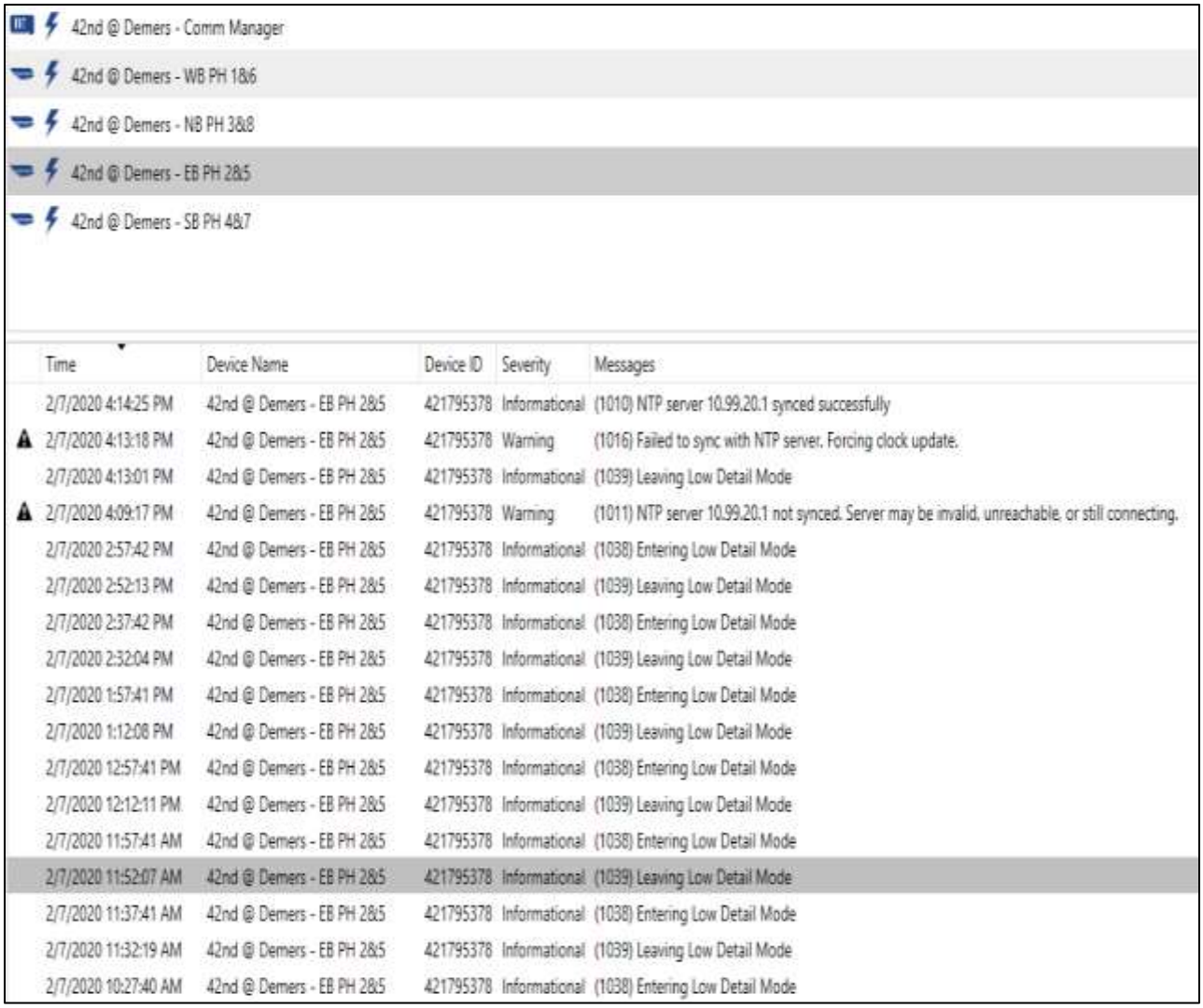
N 42nd St. at University Ave.																
Interval	**Source**	**Southbound**				**Westbound**				**Northbound**				**Eastbound**			
		Right	**Thru**	**Left**	**Total**	**Right**	**Thru**	**Left**	**Total**	**Right**	**Thru**	**Left**	**Total**	**Right**	**Thru**	**Left**	**Total**
15-min interval	**Manual**	17	40	24	81	14	29	34	77	68	56	25	149	20	33	7	60
	Autoscope	17	42	25	84	14	30	36	80	69	57	26	152	21	35	6	62
15-min interval	**Manual**	17	55	11	83	13	17	23	53	28	54	22	104	22	13	4	39
	Autoscope	18	58	11	87	12	18	27	57	27	54	22	103	23	13	4	40
15-min interval	**Manual**	12	37	6	55	8	20	22	50	33	24	8	65	19	21	6	46
	Autoscope	12	36	7	55	11	23	23	57	33	25	8	66	19	21	6	46
15-min interval	**Manual**	14	49	13	76	3	25	22	50	20	55	25	100	24	12	4	40
	Autoscope	12	53	14	79	3	31	23	57	18	49	22	89	25	9	2	36
Hourly Totals	**Manual**	60	181	54	295	38	91	101	230	149	189	80	418	85	79	21	185
	Autoscope	59	189	57	305	40	102	109	251	147	185	78	410	88	78	18	184
	GEH	**0.1**	**0.6**	**0.4**	**0.6**	**0.3**	**1.1**	**0.8**	**1.4**	**0.2**	**0.3**	**0.2**	**0.4**	**0.3**	**0.1**	**0.7**	**0.1**
Manual PHF		0.75	0.88	0.82	0.56	0.89	0.68	0.78	0.74	0.75	0.55	0.84	0.80	0.70	0.89	0.60	0.75
Autoscope PHF		0.73	0.82	0.81	0.57	0.88	0.71	0.82	0.76	0.78	0.53	0.81	0.75	0.67	0.88	0.56	0.75

Cameras at the intersections collected high-quality traffic data similar to that shown in Table 5.

Upon further investigation, it was found that the traffic data quality began to deteriorate during the mid- to late-winter months. This seemed to coincide with certain camera contrast-loss events registered in the operations log following the software/firmware update. These events are not considered severe errors and are marked as informational (e.g., entering/leaving low-detail mode). Figure 7 shows a typical intersection that may be entering low-detail mode. The specific intersection shown is S 42nd St. and Demers Ave. Five

out of the thirteen intersections audited thus far appear to have been impacted by the low-detail mode events. At these intersections, not every turning movement and not every camera was affected. Note that the direction of the camera did not appear to play a significant role. Figure 8 shows the operational log of the system entering low-detail mode. Note that vehicle detection for signal operations was not impacted by such events. Also, all of the data reported during the rest of the year is of exceptional quality. Further scrutiny is necessary in this matter. Recommendations and next steps in this regard are outlined in the corresponding section of the report.

Figure 7. S 42nd St. at Demers Ave. EB camera in-and-out of low detail mode



	Time	Device Name	Device ID	Severity	Messages
	2/7/2020 4:14:25 PM	42nd @ Demers - EB PH 2&5	421795378	Informational	(1010) NTP server 10.99.20.1 synced successfully
⚠	2/7/2020 4:13:18 PM	42nd @ Demers - EB PH 2&5	421795378	Warning	(1016) Failed to sync with NTP server. Forcing clock update.
	2/7/2020 4:13:01 PM	42nd @ Demers - EB PH 2&5	421795378	Informational	(1039) Leaving Low Detail Mode
⚠	2/7/2020 4:09:17 PM	42nd @ Demers - EB PH 2&5	421795378	Warning	(1011) NTP server 10.99.20.1 not synced. Server may be invalid, unreachable, or still connecting.
	2/7/2020 2:57:42 PM	42nd @ Demers - EB PH 2&5	421795378	Informational	(1038) Entering Low Detail Mode
	2/7/2020 2:52:13 PM	42nd @ Demers - EB PH 2&5	421795378	Informational	(1039) Leaving Low Detail Mode
	2/7/2020 2:37:42 PM	42nd @ Demers - EB PH 2&5	421795378	Informational	(1038) Entering Low Detail Mode
	2/7/2020 2:32:04 PM	42nd @ Demers - EB PH 2&5	421795378	Informational	(1039) Leaving Low Detail Mode
	2/7/2020 1:57:41 PM	42nd @ Demers - EB PH 2&5	421795378	Informational	(1038) Entering Low Detail Mode
	2/7/2020 1:12:08 PM	42nd @ Demers - EB PH 2&5	421795378	Informational	(1039) Leaving Low Detail Mode
	2/7/2020 12:57:41 PM	42nd @ Demers - EB PH 2&5	421795378	Informational	(1038) Entering Low Detail Mode
	2/7/2020 12:12:11 PM	42nd @ Demers - EB PH 2&5	421795378	Informational	(1039) Leaving Low Detail Mode
	2/7/2020 11:57:41 AM	42nd @ Demers - EB PH 2&5	421795378	Informational	(1038) Entering Low Detail Mode
	2/7/2020 11:52:07 AM	42nd @ Demers - EB PH 2&5	421795378	Informational	(1039) Leaving Low Detail Mode
	2/7/2020 11:37:41 AM	42nd @ Demers - EB PH 2&5	421795378	Informational	(1038) Entering Low Detail Mode
	2/7/2020 11:32:19 AM	42nd @ Demers - EB PH 2&5	421795378	Informational	(1039) Leaving Low Detail Mode
	2/7/2020 10:27:40 AM	42nd @ Demers - EB PH 2&5	421795378	Informational	(1038) Entering Low Detail Mode

Figure 8. Operational log of S 42nd St. @ Demers Ave.

East Grand Forks Estimation

The signalized intersection within the boundaries of East Grand Forks is under the jurisdiction of Northwest Minnesota Regional District 2 of Minnesota Department of Transportation (MnDOT). These intersections currently operate on a significantly different setup than the City of Grand Forks. The three biggest technological differences lie in:

Traffic Detection

East Grand Forks intersections deploy in-pavement inductive loop detectors as opposed to the camera-based detection technology used in Grand Forks.

Emergency Vehicle Preemption

East Grand Forks intersections are equipped with acoustic-centered Emergency Vehicle Preemption (EVP) which deploys sound-based siren detection technology to detect emergency vehicles. Grand Forks intersections are equipped with optic-centered EVP solution which deploys coded infrared transmitters to detect emergency vehicles.

Data Collection

Currently East Grand Forks intersections are not set up to collect traffic data. For the East Grand Forks intersections to be on par with those in Grand Forks, a phased approach is recommended as discussed in the Recommendations section.

Level of Service Estimation Feasibility Check

The persistent data collection especially at the non-VISION intersections allows level of service estimation. Parameters for such estimation can be set to suggested or custom thresholds. However, during our investigation it was found that the setup at all of the cameras is not consistent as illustrated in Figures 9 and 10. Note that the level-of-service estimation criteria as well as threshold is different, rendering the level-of-service estimate data collected at these intersections unusable. Apparently, the estimation has wide applications as the criteria can be set to either speed or volume/capacity ratio. The speed criteria may be considered for freeway mainlines whereas the volume/capacity ratio criteria are more suited for signalized intersection approaches or midblock arterial locations. Consequently, it was determined that it is feasible to collect level-of-service estimate data from the signalized intersections outfitted with older-model cameras in Grand Forks. However, doing so would require resetting of the parameters of more than 180 devices.

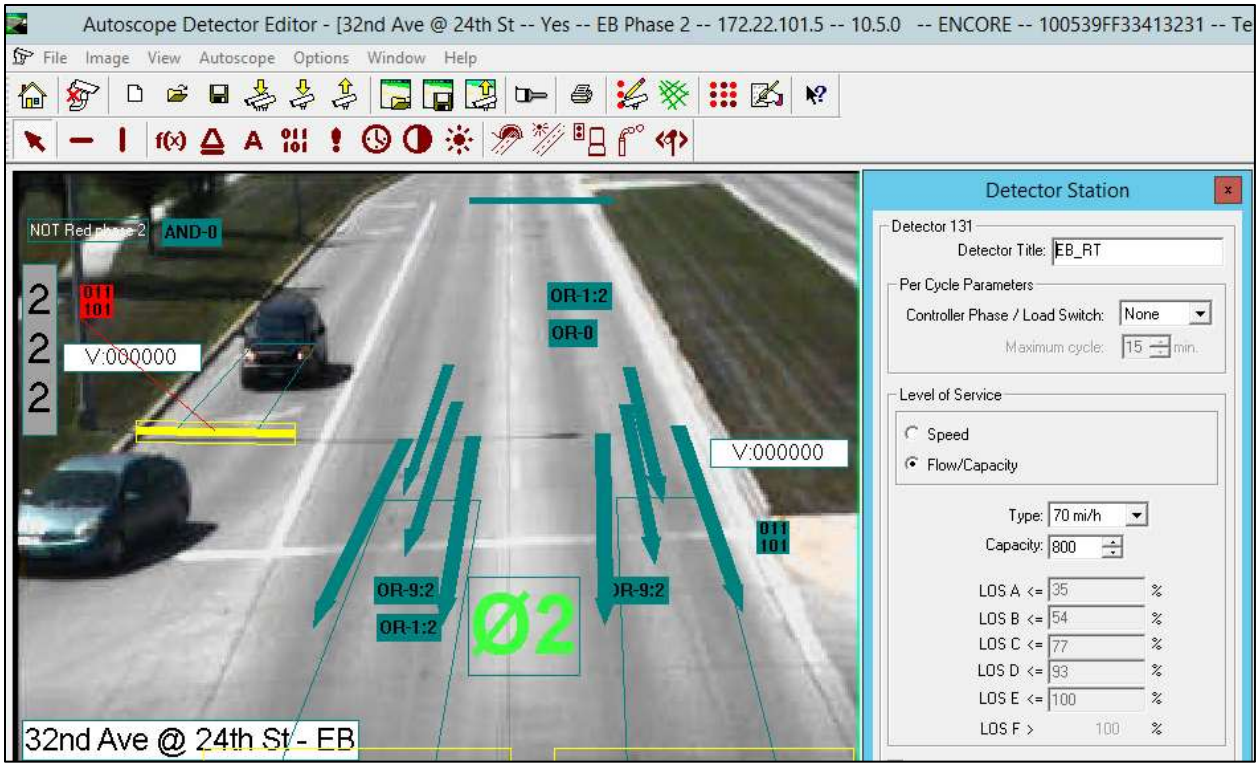


Figure 9. Level of service parameter settings as observed at eastbound 32nd Ave. S at 24th St. S

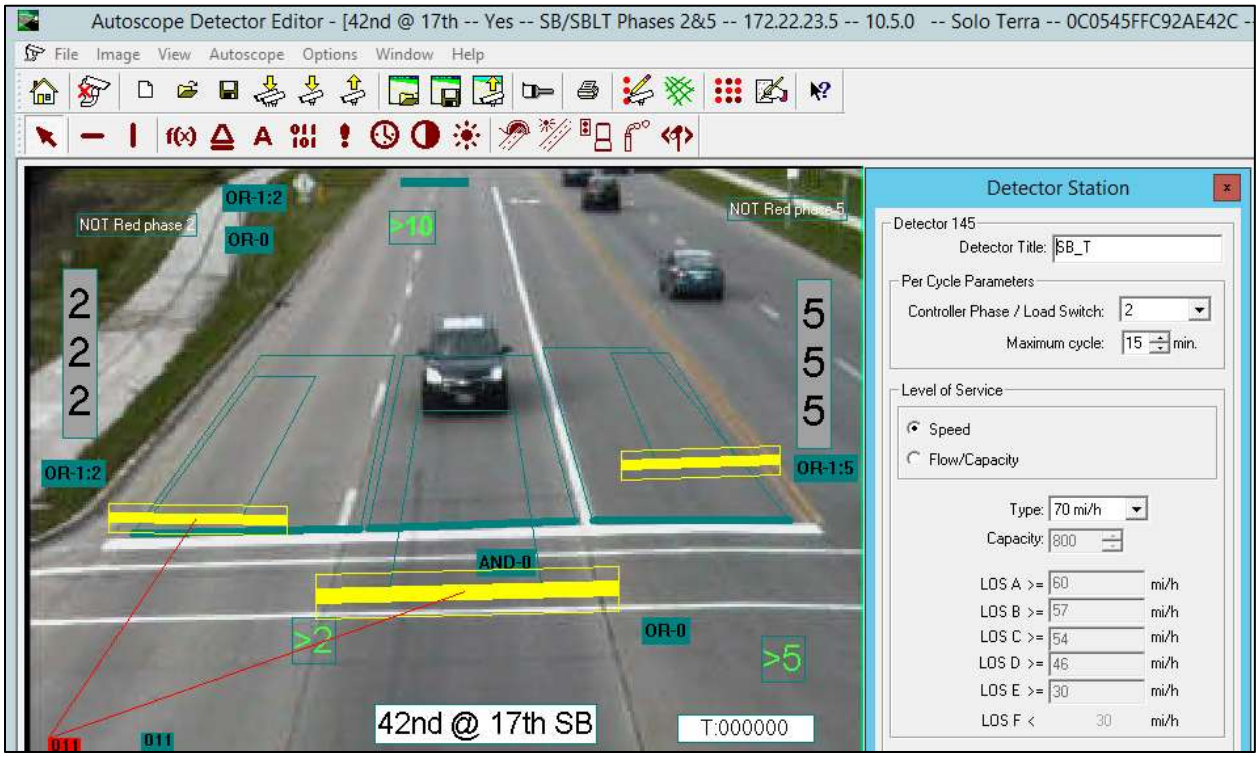


Figure 10. Level of service parameter settings as observed at southbound 42nd St. S at 17th Ave. S

Because all of the detection camera locations in Grand Forks are at signalized intersections, the criteria for level-of-service estimation shown in Table 6 is recommended. Note that these values are for suggestion purposes only and may be adjusted to represent local conditions if deemed different than those represented.

Table 6. Suggested level-of-service thresholds

Level of Service	V/C Ratio
A	< 0.60
B	0.60 – 0.69
C	0.70 – 0.79
D	0.80 – 0.89
E	0.90 – 0.99
F	1.00+

Once the criteria and thresholds have been agreed upon, the detector station setup parameters for all of the non-VISION intersections can be updated to reflect the same thresholds. Also note that the VISION cameras do not have settings for corresponding parameters as they do not estimate level of service as non-VISION cameras do. However, as a follow-up to the level-of-service setup of non-VISION intersection cameras, the same criteria can then be used to estimate level of service at VISION intersections.

Traffic Analysis Tool Enhancements

The NDSU Traffic Analysis Tool enhancements include:

- Email outage notifications
- Corridor reports
- North Dakota Traffic Data Portal
- Speed profile report

These are discussed in detail below.

Email Outage Notifications

An SMTP server along with the new script to periodically check data imported from raw data files was set up to send out email notifications. These include emails sent to stakeholders, engineers, and developers to notify them of potential outages which may have been caused by power disruptions, communication loss etc. These would facilitate prompt restarts of Data Collector and other related programs, minimizing data loss.

Another set of notification is set to be sent only to engineers and developers notifying them of availability of data from intersections newly set for traffic data collection. This would facilitate timely setting up of intersections within the traffic analysis website.

Corridor Reports

The Graphical User Interface (GUI) of the traffic analysis website and the supporting programming was updated to enable collective reporting of the group of intersections along a corridor. This includes the AADT, MADT, and ADT reports. The transportation network has been divided into the following groups/corridors:

1. 32nd Ave. S
2. Demers Ave.
3. Gateway Dr.
4. 42nd St.
5. Columbia Rd.
6. Washington St.
7. Downtown

The homepage of the traffic analysis website now presents the user with an option to either select a single intersection or a corridor using separate drop-down menu items. In the case of corridor reports, the website creates a compressed folder containing individual pdf reports. Note that major intersections along intersecting corridors are included in both groups.

North Dakota Traffic Data Portal

The North Dakota Traffic Data Portal was created using the previous month's annual daily traffic (MADT) which can be compared to the same month of last year. This traffic growth factor calculation/comparison is done for all four (three – in case of T-intersections) legs of the Grand Forks intersections reporting traffic data.

The recalculation and update of the web portal is expected to occur monthly, and currently is a manual task. In the future, semi-automation will be built into the script calculating the growth factors so that it can be run as a scheduled task with automated triggers (e.g., to be run on 1st of a month for the previous month's data).

The ability to compare data in a timely and ongoing fashion affords stakeholders the ability to react to changes in travel demand and patterns in a much more appropriate manner. Currently, annual average daily traffic (AADT) values of the previous year can be compared to those of 2+ years ago. It is anticipated that soon the growth factor recalculation and web portal update will be carried out weekly, ensuring that weekly average daily traffic can be compared as well. The weekly factors will likely be divided into "weekday" and "weekend" categories. Figures 11 and 12 show a view of the web portal displaying MADT comparisons. Note that the colors and their shades depict growth (green) and decay (red) of traffic. The corresponding categories are:

- Dark green — increase of 30% or more
- Medium green — increase of 10% - 20%
- Light green — increase of 0% - 10%
- Yellow — decrease of 0% - 10%
- Orange — decrease of 20% - 30%
- Red — decrease of 30% or more

Figure 11. Sample of color-coded traffic changes at Grand Forks intersections on ND Traffic Data Portal

Figure 12. ND Traffic Data Portal showing last year's AADT and growth factors on selected Grand Forks intersections

Speed Profile Report

A new graph named Speed Profile was added to the traffic analysis website. As the name suggests, it is very similar to the existing Volume Profile in that it plots 15-minute average speed over a 24-hour period. When multiple days are selected for analysis, the speeds for individual 15-minute periods are averaged over the days.

Figures 13, 14, and 15 show the three plots that constitute this report. The first plot has trend lines for all approaches of the intersection followed by the individual plots for the intersecting streets.

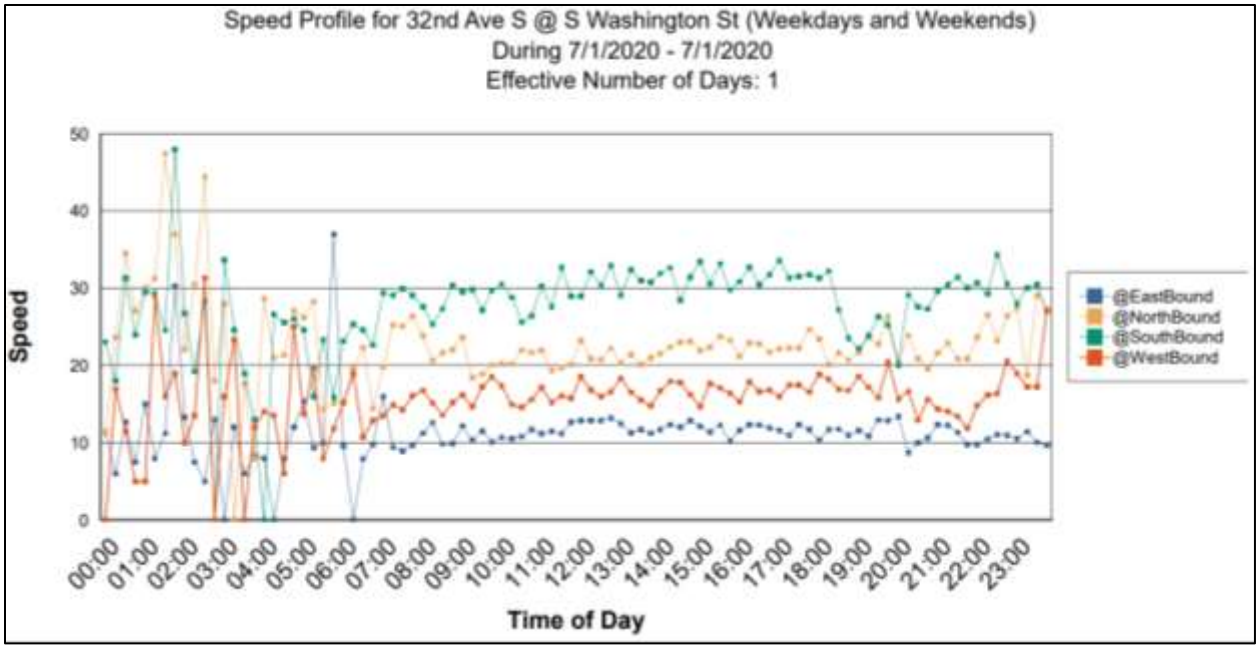


Figure 13. First plot of Speed Profile report showing trend lines for all approaches of the intersection

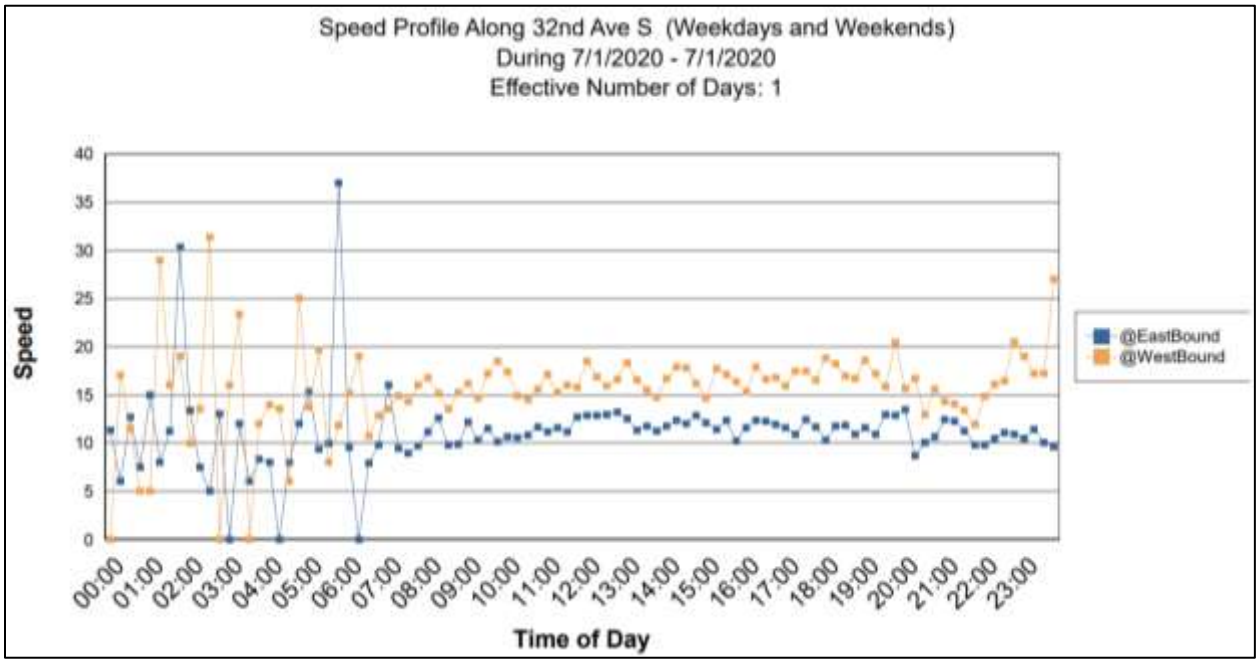


Figure 14. Second plot of Speed Profile showing trend lines for the east-west corridor

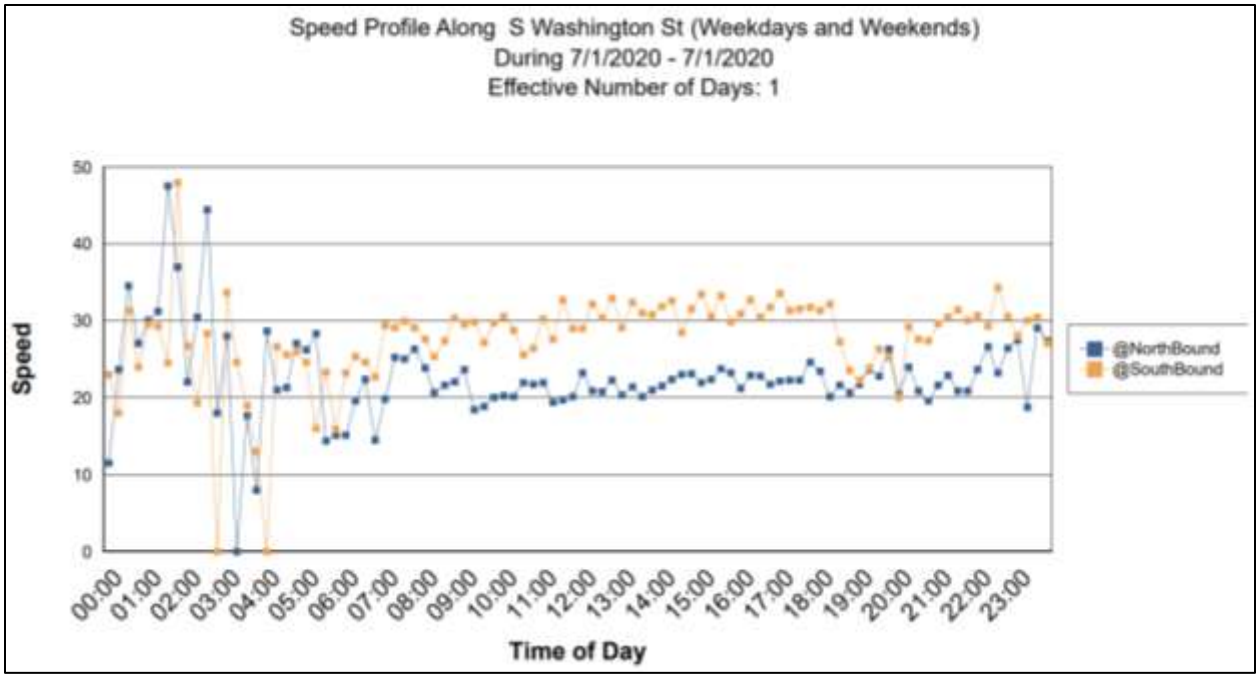


Figure 15. Third plot of Speed Profile report showing trend lines for the north-south corridor

In addition, to quantify network, intersection, and approach operations, this report can also be used to identify potential problem spots and/or times within the system. For example, Figure 15 presents a potential speeding issue along Washington St. during overnight hours around closing time for bars. Such instances warrant further investigation and coordinated efforts between multiple departments including law-enforcement and engineering. Note that the time periods with no traffic show up with a zero average speed on the graph.

CHALLENGES

Various challenges were faced during the current project as discussed below.

Intersection Availability

Intersections were found to be not available online for data collection setup. As noted in the timeline below, only 3 intersections were available to be worked on at the beginning of the project and the last two were brought online mid-year 2020.

Table 7. Timeline of intersections being brought online

Timeline	Number of online intersections
Beginning of the project	3
April – May 2019	4
June – July 2019	6
August – September 2019	8
October – November	9
January – February 2020	13
April – May 2020	15

Delayed Mast Arm Delivery

Tariffs placed on the steel industry affect jurisdictions all across the country, many of which are on the receiving end of the supply chain for steel. As compared to about a year ago, wait times for delivery of mast arms in some cases is being reported to be 10 times longer. In addition, the cost has also increased significantly. Some agencies have resorted to installing temporary wooden poles as they wait for deliveries of permanent mast arms. The delay in mast arm delivery is a reason why two of the intersections are not signalized yet.

Server Replacement

The server used to connect to cameras and setup/download traffic data collection was replaced mid-project. Note that there was no prior notice of such action.

Drive Failure

The external USB data drive where all of the setup files and raw data was being stored failed mid-project and contributed to the biggest interruption so far in the series of data collection studies. Several levels of troubleshooting and data retrieval attempts were made, but were not successful. After the drive was replaced, a backup plan was put in place. All pertinent data is now being backed up at NDSU and a future drive failure event will not be as catastrophic as the one experienced during this project.

Required Setup Changes

The detection criteria and setup needed to be changed as discussed in the Data Polling and Transfer section of this report. This requirement was unexpected and had to be coordinated with a stakeholder previously not involved in the study.

Raw Data Changes

The upgrade of Supervisor software included changes to raw data format which negated the significant progress that had been made in terms of creating a script to read the per-vehicle data into the SQL database as well as the corresponding internal QA/QC processes.

Software/Firmware Mismatch

Until early February 2020 there was a software/firmware mismatch which, in some cases, prevented download and/or set up of cameras.

Server Restarts & Unplanned Shutdowns

Unexpected power outages have marred the series of projects from the beginning. Such events result in data disruptions which, at times, take weeks to resolve. These also result in data loss as is evident from missing days as seen in the Traffic Analysis Tool. Server restarts have caused similar disruptions.

NEXT STEPS/RECOMMENDATIONS

Based on the findings of this study, several next steps have been identified and the corresponding recommendations are discussed below.

East Grand Forks Intersections

For the East Grand Forks intersections, especially those right across the bridges over the Red River, it is highly recommended that the in-field equipment, including traffic signal cabinets, communication devices, emergency vehicle detection technology, and traffic detection technology be changed to match those used in Grand Forks. Also, it is recommended that, although mostly considered isolated, the MnDOT intersections be brought online via fiber interconnect. All of these change-outs and upgrades do not necessarily need to happen at the same time. Considering limited availability of resources, ATAC recommends that the tasks be completed in a phased approach as outlined below. Any of the phases may be combined based on identifiable efficiencies especially if cost savings can be documented. Note that the estimates below may not include installation, turn-on assistance, and/or assistance that mat be required for integration of various technologies because some of these tasks may be completed internally by MnDOT and MnIT.

Phase 1 Camera Based Detection Conversion

It is recommended that the traffic detection technology at all of the East Grand Forks intersections be converted to camera-based detection as is used in Grand Forks, thus enabling the same traffic data collection program to be extended to East Grand Forks. Then, the collected traffic data can be used for highway design, transportation planning, and similar activities, as well as for signal retiming and other traffic operations-related projects. The collected traffic data can also be used to supplement the state's list of 70+ Automatic Traffic Recorder (ATR) sites and consequently utilized in statewide traffic forecasting and analysis efforts. Note that a software update for the existing traffic signal controllers may be required to make them compatible with the newer camera system. This task may be handled internally. The equipment cost estimate per intersection for this phase is detailed in Table 8.

Table 8. Phase 1 Camera based detection change-out cost estimate

Item	Quantity	Cost
ENCORE Camera Mount	4 units	$ 728.00
Autoscope VISION Camera	4 units	$ 21,900.00
Autoscope Vision Communications Manager	1 unit	$ 3,500.00
Terra 18 AWG 3-conductor Power Cable	1400 feet	$ 795.00
Traffic Signal Controller S/W Upgrade	7	TBD
TOTAL	-	$ 26,923.00

Phase 2 System-Wide EVP Change-Outs/Upgrades

It is imperative that jurisdictions in close proximity such as Grand Forks and East Grand Forks work in close collaboration for the benefit of traveling public. To improve traffic safety and reduce emergency vehicle response times, it is important that emergency vehicles from a variety of jurisdictions be able to participate in a signal preemption program and that program must be able to support vehicles from various jurisdictions. The current setup in these two neighboring agencies is a case of mismatched of emergency vehicle preemption technologies. East Grand Forks and the neighboring transportation network to the east, north, and south is essentially a pass-through region for those in northwestern Minnesota needing to get to the Level II trauma

center located in Grand Forks. For the current seven signalized intersections in East Grand Forks to be aligned with 50+ Grand Forks intersections, it is recommended that MnDOT District 4 switch their local emergency vehicle preemption equipment from acoustic- to optic-technology. Note that this would also require equipment installation/upgrades on all participating agency vehicles. The equipment cost estimate per intersection for this phase is detailed in Table 9.

Table 9. Phase 2 EVP change-outs/upgrades cost estimate

Item	Quantity	Cost
Opticom Phase Selector	1 unit	$ 2,795.00
Opticom Detector Head	4 units	$ 1,472.00
Confirmation Beacons	4 units	$ 135.00
TOTAL	-	$ 4,402.00

Phase 3 Cabinet/Controller Upgrades

It is recommended that the intersections be upgraded to the Advanced Traffic Controller Cabinets. This would provide enhanced personnel safety, increased traveler safety, reduced cabinet size, and other modern features. Also, as an interim communication upgrade prior to Phase 4, it is recommended that wireless communications be established. The equipment cost estimate per intersection for this phase is described in Table 10.

Table 10. Phase 3 Cabinet/Controller upgrades cost estimate

Item	Quantity	Cost
Type 350 double wide (120vdc) ATC signal cabinet	1 unit	$ 17,920.00
Sierra wireless airlink modem Raven RV50X	1 unit	$ 565.00
Sierra wireless air link AC power adapter	1 unit	$ 20.00
Antenna for cell modem	1 unit	$ 125.00
Cisco switch	1 unit	$ 1,050.00
Cisco memory card	1 unit	$ 51.00
CISCO AC power module W/IEC Plug	1 unit	$ 240.00
Cobalt rack mount controller	1 unit	$ 4,295.00
TOTAL		$ 24,266.00

Phase 4 Fiber Connection

It is recommended that all of the East Grand Forks intersections be connected to an area *Signs & Signal Shop* or other area governmental facility such as City Hall, from which they could then be connected to the District Headquarters in Bemidji, perhaps via MnDOT's Crookston office. The connection between Bemidji and East Grand Forks would facilitate remote monitoring, troubleshooting, surveillance, and data collection without personnel needing to travel to the site, especially for minor tasks.

Level of Service Criterion/Parameters Reset

ATAC began collecting the level-of-service estimate data from the non-VISION intersections within Grand Forks. Note that most of the intersections are equipped with non-VISION cameras. To make the level-of-service data that is already being collected meaningful and reliably useful,

it is highly recommended that the criteria and parameters be reset at all of the corresponding intersections. If desired, the average speed data can also be taken into consideration to aid in the estimation of level of service.

These lane-group-based parameters (shown in figures 9 and 10) are a small subset of the overall detector and data collection setup. The reset of level-of-service criterion and parameters can be completed in a relatively small timeframe and should not require extensive resources. The advantage of resetting the parameters is that it is a dataset that is already being collected. The only disadvantage is that, even though it would encompass most of the Grand Forks intersections, this step would not cover VISION intersections.

Alternatively, the same level-of-service estimation capabilities can be built into the Traffic Analysis Tool. The advantage in this case is that it would cover all of the intersections regardless of the camera type. However, this may require more resources than the criterion/parameter reset outlined above.

Notwithstanding the method of estimation, it is envisioned that the collected level-of-service data, can be used for before-and-after traffic operations studies (post completion of signal retiming projects), lane reassignment, and construction projects etc. The data can also be used for system-wide performance measure reporting and reliability assessments. As the area continues to grow and attract more residents, the value of such data is expected to increase tremendously.

Lens Maintenance Trigger/Schedule Study

A cursory look at operations logs of communications manager devices and the cameras themselves revealed hundreds of thousands of (mostly informational) events which can be analyzed and presented in a useful manner. It is evident that the current lens cleaning schedule is not enough to keep the system operating error free. It is recommended that the system-wide operations logs be examined in much more detail, keeping in mind the ever-changing and locally unique weather conditions/patterns to see if a correlation can be found. Any correlations/indications would ultimately help in the creation of trigger points for cleaning/maintenance rather than regularly scheduled (e.g. twice yearly) or complaint-driven systems. It is imperative that for the near-ideal upkeep of the system and for the benefit of travelling public, the maintenance schedule be based on analyzed data.

APPENDIX: INTERSECTION TRAFFIC DATA QUALITY AUDITS

6. Gateway @ N Washington St																	
Volume/ Factor	Source	Southbound				Westbound				Northbound				Eastbound			
		Right	Thru	Left	Total	Right	Thru	Left	Total	Right	Thru	Left	Total	Right	Thru	Left	Total
15-min interval	Manual	14	10	15	39	18	67	25	110	23	13	34	70	26	70	9	105
	Autoscope	16	10	18	44	23	58	24	105	24	12	33	69	24	62	5	91
15-min interval	Manual	9	20	15	44	10	65	22	97	25	25	19	69	25	60	11	96
	Autoscope	10	21	18	49	12	61	22	95	31	20	18	69	24	60	12	96
15-min interval	Manual	11	10	17	38	14	60	19	93	47	20	21	88	27	78	15	120
	Autoscope	12	11	20	43	16	59	19	94	51	18	16	85	29	63	14	106
15-min interval	Manual	18	20	14	52	16	67	23	106	47	43	51	141	20	62	7	89
	Autoscope	17	19	13	49	21	57	25	103	49	35	45	129	25	57	9	91
Hourly Totals	Manual	52	60	61	173	58	259	89	406	142	101	125	368	98	270	42	410
	Autoscope	55	61	69	185	72	235	90	397	155	85	112	352	102	242	40	384
	GEH	**0.4**	**0.1**	**1.0**	**0.9**	**1.7**	**1.5**	**0.1**	**0.4**	**1.1**	**1.7**	**1.2**	**0.8**	**0.4**	**1.8**	**0.3**	**1.3**

39. S 42nd St @ 11th Ave S													
Interval	Source	Southbound			Westbound				Northbound			Eastbound		
		Thru	Left	Total	Right	Thru	Left	Total	Right	Thru	Total	Right	Left	Total
15-min interval	Manual	53	5	58	1	14	9	24	7	65	72	0	0	0
	Autoscope	53	7	60	1	17	9	27	9	63	72	0	0	0
15-min interval	Manual	61	10	71	0	13	8	21	10	63	73	1	0	1
	Autoscope	60	10	70	0	14	9	23	10	63	73	1	0	1
15-min interval	Manual	65	8	73	1	10	3	14	5	59	64	1	0	1
	Autoscope	63	7	70	1	10	3	14	5	59	64	1	0	1
15-min interval	Manual	57	8	65	0	16	8	24	6	41	47	1	1	2
	Autoscope	60	8	68	0	20	6	26	6	41	47	1	1	2
Hourly Totals	Manual	236	31	267	2	53	28	83	28	228	256	3	1	4
	Autoscope	236	32	268	2	61	27	90	30	226	256	3	1	4
	GEH	**0.0**	**0.2**	**0.1**	**0.0**	**1.1**	**0.2**	**0.8**	**0.4**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**

55. S Columbia @ 40th Ave S

Volume/ Factor	Source	Southbound				Westbound				Northbound				Eastbound			
		Right	Thru	Left	Total	Right	Thru	Left	Total	Right	Thru	Left	Total	Right	Thru	Left	Total
15-min interval	Manual	7	57	26	90	20	10	3	33	3	42	9	54	15	20	5	40
	Autoscope	8	61	28	97	16	8	4	28	3	42	12	57	14	22	5	41
15-min interval	Manual	8	50	23	81	19	19	3	41	0	42	14	56	24	19	3	46
	Autoscope	8	51	25	84	18	19	4	41	0	37	15	52	24	20	3	47
15-min interval	Manual	9	38	14	61	18	20	3	41	0	38	11	49	16	15	4	35
	Autoscope	9	38	15	62	15	18	3	36	0	32	11	43	16	13	3	32
15-min interval	Manual	8	55	23	86	17	19	3	39	1	40	14	55	20	17	5	42
	Autoscope	8	52	24	84	16	17	2	35	1	39	14	54	21	15	5	41
Hourly Totals	Manual	32	200	86	318	74	68	12	154	4	162	48	214	75	71	17	163
	Autoscope	33	202	92	327	65	62	13	140	4	150	52	206	75	70	16	161
	GEH	**0.2**	**0.1**	**0.6**	**0.5**	**1.1**	**0.7**	**0.3**	**1.2**	**0.0**	**1.0**	**0.6**	**0.6**	**0.0**	**0.1**	**0.2**	**0.2**

56. S Columbia @ 36th Ave S

Volume/ Factor	Source	Southbound				Westbound				Northbound				Eastbound			
		Right	Thru	Left	Total	Right	Thru	Left	Total	Right	Thru	Left	Total	Right	Thru	Left	Total
15-min interval	Manual	4	28	6	38	17	12	3	32	0	74	7	81	7	3	8	18
	Autoscope	4	28	6	38	15	10	3	28	0	81	5	86	7	3	8	18
15-min interval	Manual	4	40	12	56	11	9	6	26	1	74	11	86	8	9	14	31
	Autoscope	5	40	12	57	11	10	5	26	1	70	9	80	8	8	13	29
15-min interval	Manual	8	49	22	79	15	15	2	32	2	62	7	71	7	16	12	35
	Autoscope	8	50	21	79	14	14	2	30	2	63	6	71	8	16	11	35
15-min interval	Manual	13	41	22	76	13	9	4	26	1	40	5	46	4	14	13	31
	Autoscope	15	41	21	77	14	8	4	26	1	38	4	43	5	14	9	28
Hourly Totals	Manual	29	158	62	249	56	45	15	116	4	250	30	284	26	42	47	115
	Autoscope	32	159	60	251	54	42	14	110	4	252	24	280	28	41	41	110
	GEH	**0.5**	**0.1**	**0.3**	**0.1**	**0.3**	**0.5**	**0.3**	**0.6**	**0.0**	**0.1**	**1.2**	**0.2**	**0.4**	**0.2**	**0.9**	**0.5**

57. S 42nd St @ DeMers Ave

Volume/ Factor	Source	Southbound				Westbound				Northbound				Eastbound			
		Right	Thru	Left	Total	Right	Thru	Left	Total	Right	Thru	Left	Total	Right	Thru	Left	Total
15-min interval	Manual	13	36	26	75	16	55	13	84	24	76	20	120	20	78	21	119
	Autoscope	15	38	27	80	16	43	14	73	16	75	19	110	19	84	21	124
15-min interval	Manual	14	55	25	94	16	40	16	72	24	65	18	107	22	44	16	82
	Autoscope	15	57	27	99	16	39	14	69	19	64	21	104	19	43	15	77
15-min interval	Manual	7	38	14	59	18	38	19	75	22	78	17	117	22	51	19	92
	Autoscope	7	40	14	61	18	34	23	75	18	69	17	104	25	49	16	90
15-min interval	Manual	8	67	15	90	18	58	17	93	24	94	26	144	25	69	9	103
	Autoscope	7	65	16	88	19	53	17	89	26	98	30	154	27	74	10	111
Hourly Totals	Manual	42	196	80	318	68	191	65	324	94	313	81	488	89	242	65	396
	Autoscope	44	200	84	328	69	169	68	306	79	306	87	472	90	250	62	402
	GEH	**0.3**	**0.3**	**0.4**	**0.6**	**0.1**	**1.6**	**0.4**	**1.0**	**1.6**	**0.4**	**0.7**	**0.7**	**0.1**	**0.5**	**0.4**	**0.3**

59. N 42nd St @ University Ave

Volume/ Factor	Source	Southbound				Westbound				Northbound				Eastbound			
		Right	Thru	Left	Total	Right	Thru	Left	Total	Right	Thru	Left	Total	Right	Thru	Left	Total
15-min interval	Manual	17	40	24	81	14	29	34	77	68	56	25	149	20	33	7	60
	Autoscope	17	42	25	84	14	30	36	80	69	57	26	152	21	35	6	62
15-min interval	Manual	17	55	11	83	13	17	23	53	28	54	22	104	22	13	4	39
	Autoscope	18	58	11	87	12	18	27	57	27	54	22	103	23	13	4	40
15-min interval	Manual	12	37	6	55	8	20	22	50	33	24	8	65	19	21	6	46
	Autoscope	12	36	7	55	11	23	23	57	33	25	8	66	19	21	6	46
15-min interval	Manual	14	49	13	76	3	25	22	50	20	55	25	100	24	12	4	40
	Autoscope	12	53	14	79	3	31	23	57	18	49	22	89	25	9	2	36
Hourly Totals	Manual	60	181	54	295	38	91	101	230	149	189	80	418	85	79	21	185
	Autoscope	59	189	57	305	40	102	109	251	147	185	78	410	88	78	18	184
	GEH	**0.1**	**0.6**	**0.4**	**0.6**	**0.3**	**1.1**	**0.8**	**1.4**	**0.2**	**0.3**	**0.2**	**0.4**	**0.3**	**0.1**	**0.7**	**0.1**

60. N 42nd St @ 6th Ave N

Volume/ Factor	Source	Southbound			Westbound			Northbound				Eastbound		
		Thru	Left	Total	Thru	Left	Total	Right	Thru	Left	Total	Thru	Left	Total
15-min interval	Manual	47	4	51	6	10	16	4	24	1	29	9	0	9
	Autoscope	41	4	45	6	9	15	4	24	1	29	9	0	9
15-min interval	Manual	35	3	38	6	13	19	4	33	0	37	9	2	11
	Autoscope	33	3	36	6	14	20	4	33	0	37	9	2	11
15-min interval	Manual	31	8	39	13	20	33	4	24	0	28	15	0	15
	Autoscope	31	7	38	13	24	37	1	20	0	21	15	0	15
15-min interval	Manual	42	9	51	10	19	29	4	25	3	32	7	3	10
	Autoscope	43	8	51	10	20	30	3	22	2	27	7	3	10
Hourly Totals	Manual	155	24	179	35	62	97	16	106	4	126	40	5	45
	Autoscope	148	22	170	35	67	102	12	99	3	114	40	5	45
	GEH	**0.6**	**0.4**	**0.7**	**0.0**	**0.6**	**0.5**	**1.1**	**0.7**	**0.5**	**1.1**	**0.0**	**0.0**	**0.0**

61. 47th Ave S @ S Columbia Rd

Volume/ Factor	Source	Southbound				Westbound				Northbound			Eastbound			
		Right	Thru	Left	Total	Right	Thru	Left	Total	Thru	Left	Total	Right	Thru	Left	Total
15-min interval	Manual	0	34	22	56	40	0	2	42	56	0	56	0	0	0	0
	Autoscope	0	34	22	56	40	0	2	42	56	0	56	0	0	0	0
15-min interval	Manual	0	13	23	36	32	1	7	40	36	0	36	0	0	1	1
	Autoscope	0	13	24	37	31	1	6	38	37	0	37	0	0	1	1
15-min interval	Manual	0	16	16	32	23	0	1	24	32	0	32	0	0	0	0
	Autoscope	0	16	16	32	24	0	1	25	32	0	32	0	0	0	0
15-min interval	Manual	0	26	16	42	41	0	10	51	42	0	42	0	0	1	1
	Autoscope	0	27	17	44	40	0	7	47	44	0	44	0	0	1	1
Hourly Totals	Manual	0	89	77	166	136	1	20	157	166	0	166	0	0	2	2
	Autoscope	0	90	79	169	135	1	16	152	169	0	169	0	0	2	2
	GEH	**0.0**	**0.1**	**0.2**	**0.2**	**0.1**	**0.0**	**0.9**	**0.4**	**0.2**	**0.0**	**0.2**	**0.0**	**0.0**	**0.0**	**0.0**

62. DeMers Ave @ S 20th St

Volume/ Factor	Source	Southbound		Westbound			Northbound			Eastbound		
		Thru	Total	Thru	Left	Total	Right	Thru	Total	Thru	Left	Total
15-min interval	Manual	1	1	116	17	133	23	8	31	115	2	117
	Autoscope	2	2	117	17	134	15	8	23	114	2	116
15-min interval	Manual	2	2	109	14	123	24	14	38	100	2	102
	Autoscope	2	2	108	14	122	18	13	31	98	3	101
15-min interval	Manual	1	1	101	20	121	23	10	33	92	0	92
	Autoscope	1	1	101	21	122	23	10	33	95	0	95
15-min interval	Manual	2	2	111	26	137	28	8	36	108	0	108
	Autoscope	3	3	109	27	136	26	7	33	107	0	107
Hourly Totals	Manual	6	6	437	77	514	98	40	138	415	4	419
	Autoscope	8	8	435	79	514	82	38	120	414	5	419
	GEH	**0.8**	**0.8**	**0.1**	**0.2**	**0.0**	**1.7**	**0.3**	**1.6**	**0.0**	**0.5**	**0.0**

63. DeMers Ave @ S 34th St

Volume/ Factor	Source	Westbound			Northbound			Eastbound		
		Thru	Left	Total	Right	Left	Total	Right	Thru	Total
15-min interval	Manual	92	31	123	23	8	31	3	109	112
	Autoscope	92	31	123	24	9	33	3	109	112
15-min interval	Manual	100	29	129	14	5	19	4	134	138
	Autoscope	99	27	126	14	5	19	4	133	137
15-min interval	Manual	109	32	141	19	6	25	7	132	139
	Autoscope	108	31	139	18	5	23	7	133	140
15-min interval	Manual	90	35	125	19	5	24	5	104	109
	Autoscope	91	35	126	19	4	23	5	103	108
Hourly Totals	Manual	391	127	518	75	24	99	19	479	498
	Autoscope	390	124	514	75	23	98	19	478	497
	GEH	**0.1**	**0.3**	**0.2**	**0.0**	**0.2**	**0.1**	**0.0**	**0.0**	**0.0**

64. DeMers Ave @ N Columbia Rd															
Interval	Source	Southbound			Westbound				Northbound			Eastbound			
		Right	Left	Total	Right	Thru	Left	Total	Right	Left	Total	Right	Thru	Left	Total
15-min interval	Manual	3	1	4	30	72	3	105	33	16	49	9	55	0	64
	Autoscope	3	1	4	29	65	5	99	35	15	50	9	56	0	65
15-min interval	Manual	5	6	11	29	62	5	96	36	6	42	13	85	7	105
	Autoscope	4	4	8	27	62	5	94	39	7	46	15	86	7	108
15-min interval	Manual	1	0	1	15	43	1	59	51	13	64	8	79	1	88
	Autoscope	1	0	1	15	43	1	59	49	12	61	12	80	1	93
15-min interval	Manual	7	4	11	24	48	2	74	41	19	60	3	83	4	90
	Autoscope	7	4	11	24	48	2	74	44	17	61	3	84	4	91
Hourly Totals	Manual	16	11	27	112	225	11	348	161	54	215	33	302	12	347
	Autoscope	15	9	24	95	218	13	326	167	51	218	39	306	12	357
	GEH	**0.3**	**0.6**	**0.6**	**1.7**	**0.5**	**0.6**	**1.2**	**0.5**	**0.4**	**0.2**	**1.0**	**0.2**	**0.0**	**0.5**

65. DeMers Ave @ S Washington St																
Volume/ Factor	Source	Southbound				Westbound				Northbound				Eastbound			
		Right	Thru	Left	Total	Right	Thru	Left	Total	Right	Thru	Left	Total	Right	Thru	Left	Total
15-min interval	Manual	22	45	5	72	12	48	73	133	59	77	22	158	22	73	24	119
	Autoscope	22	45	5	72	12	49	63	124	55	62	22	139	19	76	34	129
15-min interval	Manual	16	54	11	81	10	60	59	129	42	86	28	156	19	101	44	164
	Autoscope	14	59	12	85	10	60	57	127	44	89	32	165	19	106	43	168
15-min interval	Manual	30	94	11	135	8	79	81	168	45	120	31	196	21	39	9	69
	Autoscope	29	103	18	150	9	77	74	160	50	120	38	208	20	37	10	67
15-min interval	Manual	48	96	12	156	17	76	30	123	68	140	47	255	13	54	17	84
	Autoscope	48	100	13	161	14	75	33	122	68	146	46	260	10	58	18	86
Hourly Totals	Manual	116	289	39	444	47	263	243	553	214	423	128	765	75	267	94	1107
	Autoscope	113	307	48	468	45	261	227	533	217	417	138	772	68	277	105	1117
	GEH	**0.3**	**1.0**	**1.4**	**1.1**	**0.3**	**0.1**	**1.0**	**0.9**	**0.2**	**0.3**	**0.9**	**0.3**	**0.8**	**0.6**	**1.1**	**0.3**

66. S Washington St @ 44th Ave S

Volume/ Factor	Source	Southbound				Westbound		Northbound			Eastbound	
		Right	Thru	Left	Total	Thru	Total	Thru	Left	Total	Thru	Total
15-min interval	Manual	28	83	16	127	14	14	88	5	93	28	28
	Autoscope	23	75	16	114	16	16	84	5	89	24	24
15-min interval	Manual	16	80	22	118	27	27	71	5	76	30	30
	Autoscope	17	78	22	117	27	27	69	5	74	26	26
15-min interval	Manual	17	86	29	132	21	21	109	2	111	11	11
	Autoscope	15	78	30	123	15	15	111	2	113	8	8
15-min interval	Manual	20	107	24	151	14	14	99	3	102	31	31
	Autoscope	17	94	24	135	17	17	99	3	102	28	28
Hourly Totals	Manual	81	356	91	528	76	76	367	15	382	100	100
	Autoscope	72	325	92	489	75	75	363	15	378	86	86
	GEH	**1.0**	**1.7**	**0.1**	**1.7**	**0.1**	**0.1**	**0.2**	**0.0**	**0.2**	**1.5**	**1.5**

67.Gateway @ 55th St

Interval	Source	Southbound			Westbound				Northbound				Eastbound			
		Thru	Left	Total	Right	Thru	Left	Total	Right	Thru	Left	Total	Right	Thru	Left	Total
15-min interval	Manual	4	0	4	0	70	8	78	12	2	6	20	7	69	0	76
	Autoscope	4	0	4	1	75	6	82	11	2	5	18	9	69	0	78
15-min interval	Manual	2	1	3	1	65	12	78	10	1	4	15	4	67	1	72
	Autoscope	2	1	3	1	70	11	82	10	1	4	15	4	68	1	73
15-min interval	Manual	2	0	2	3	66	16	85	12	2	8	22	6	67	4	77
	Autoscope	2	0	2	4	69	18	91	10	2	8	20	6	66	5	77
15-min interval	Manual	2	0	2	4	76	10	90	15	1	10	26	3	70	2	75
	Autoscope	2	0	2	6	77	10	93	13	3	8	24	3	67	2	72
Hourly Totals	Manual	10	1	11	8	277	46	331	49	6	28	83	20	273	7	300
	Autoscope	10	1	11	12	291	45	348	44	8	25	77	22	270	8	300
	GEH	**0.0**	**0.0**	**0.0**	**1.3**	**0.8**	**0.1**	**0.9**	**0.7**	**0.8**	**0.6**	**0.7**	**0.4**	**0.2**	**0.4**	**0.0**

68. Demers @ Columbia SB															
Interval	Source	Southbound			Westbound			Northbound				Eastbound			
		Right	Thru	Total	Thru	Left	Total	Right	Thru	Left	Total	Right	Thru	Left	Total
15-min interval	Manual	1	1	2	59	26	85	5	0	5	10	25	62	0	87
	Autoscope	2	1	3	60	27	87	5	0	5	10	20	63	0	83
15-min interval	Manual	0	1	1	68	32	100	12	0	5	17	8	79	0	87
	Autoscope	0	1	1	67	32	99	12	0	5	17	8	77	0	85
15-min interval	Manual	3	1	4	96	41	137	4	0	3	7	16	86	2	104
	Autoscope	3	1	4	93	41	134	4	0	3	7	15	81	2	98
15-min interval	Manual	1	5	6	82	36	118	6	1	2	9	14	89	1	104
	Autoscope	1	5	6	80	37	117	6	1	2	9	11	89	1	101
Hourly Totals	Manual	5	8	13	305	135	440	27	1	15	43	63	316	3	382
	Autoscope	6	8	14	300	137	437	27	1	15	43	54	310	3	367
	GEH	**0.4**	**0.0**	**0.3**	**0.3**	**0.2**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**1.2**	**0.3**	**0.0**	**0.8**