EXHIBIT A
SCOPE OF SERVICES

IMPROVE TRAFFIC VOLUME ESTIMATES FROM MnDOT'S REGIONAL TRAFFIC MANAGEMENT CENTER

BACKGROUND

MnDOT's Regional Transportation Management Center (RTMC) deploys over 6,000 loop detectors and other new types of sensors in the freeway network to collect accurate traffic information. While the RTMC mainly uses the sensor data to measure operational characteristics, Office of Transportation System Management (OTSM) uses the same data to estimate Annual Average Daily Traffic (AADT) using well researched methodologies and Federal Highway Administration (FHWA) guidelines. Implementing previously identified methods or enhancing the algorithms and methods with additional research should lead to a more efficient and transparent means of determining AADTs, and should enhance the ability of the RTMC to strategically target sensor evaluation and repair.

The objective of this project is to quickly identify loop problems in the freeway network in order to obtain more accurate traffic volume data. A software tool will be developed to classify detector health status to healthy, marginal, suspicious, or bad from the daily archived loop data, and its performance will be evaluated utilizing the RTMC repair log and lane closure information.

OBJECTIVE

Better screening of detector data will lead to more accurate estimates of AADT, thus preventing misinformation that can affect planning and safety related decisions. AADT and other traffic statistics for individual locations affect measures such as crash rates, traffic flow analysis, and time-of-day traffic volume used in maintenance planning. MnDOT will accrue benefits in the following areas:

- Decrease Engineering/Administrative Costs (Planning/design costs, paperwork)
- Operation and Maintenance Savings (Materials, labor, equipment, time)
- Technology (Technology transfer, new materials, new methods)
- Ability to calculate more accurate AADT from traffic data sensors

SCOPE

This research will be built on the previous research published in "Chapter 4: Detector Fault Identification Using Freeway Loop Data," of the final report entitled "Data Acquisition and Archiving of Large Scaled Transportation Data, Analysis Tool Developments, and On-Line Data Support". This research identified 12 parameters that can be computed from loop volume and occupancy data, which can be used to classify detector health status through a large decision tree. This approach essentially analyzes loop-detector health status at individual locations by checking thresholds of diagnostic parameters. A new component of the diagnostic principles to be added to the present research is the conservation-of-vehicles principle. This principle states that the maximum difference between the upstream and the downstream location cumulative flows cannot exceed the maximum number of vehicles that can be accommodated on the length of the road between these two locations at jam density. Violation of this principle between two consecutive upstream and downstream detector groups (or stations) indicates that one or more detectors in the group may not be healthy. The goal of this project is to first refine the loop diagnostic algorithms and then to create a software tool that can classify detectors into four health-levels by continuously evaluating the detector data posted by the RTMC. The four health levels are summarized below.

Health Level	Description
1. Healthy	Detectors are producing good, reliable data
2. Marginal	Detectors are not completely healthy, exhibiting transient errors such as occasional over or under counts.
3. Suspicious	Detectors are severely over or under-counting, producing bad, unreliable data. Examples include under counts by a sustained period of missing data or over counts by adjacent lane detection. Detectors in this category require a maintenance visit and may be corrected by sensitivity adjustments.
4. Bad	Detectors are not operational and produce completely wrong data or no data. It is a faulty condition and requires repair or replacement.

Once detector health levels are classified with a sufficient accuracy, verified by maintenance log and lane closure information, OTSM will begin to utilize this information to determine primary, secondary, and tertiary upstream/downstream equivalent detector groups or to exclude bad and suspicious detectors from computation of AADT. As part of this research, how the classification results could be applied in the selection process of the equivalency detector inputs of the SC-TDA and ATR-TDA programs will be studied. The detectors in suspicious and bad categories produce unreliable, bad volume data and require a maintenance visit to repair or replace. The RTMC may use this detector health information to increase the pool of detectors in the healthy and marginal categories and to reduce the number of detectors in the suspicious and bad categories.

ASSISTANCE

MnDOT's RTMC will provide sensor maintenance log and lane closure information to the research team. The RTMC will also provide incident information (accidents and special events) that may affect the normal traffic patterns and thus affecting AADT. OTSM will provide assistance in the process of software development for its usage of data and user interface, and also assistance in how the detector health levels might be effectively or efficiently utilized.

WORK PLAN

Task Descriptions

Task 1: Literature Review and Development of Detector Health Algorithm

Under this task, the University will review and refine existing loop detector diagnostic tools that determine detector health states based on loop volume and occupancy data. The University will next develop and integrate a new algorithm based on the principle of conservation-of-vehicles. The objective of this task is to create a well-researched and theoretically sound algorithm that could reliably diagnose detector health levels. During this task, the University will also gather currently available information on detector types, Global Positioning System (GPS) coordinates of detectors, and other basic infrastructure related information from the RTMC for software implementation in Task 2. In this task, the RTMC will meet with the research team and provide the GPS coordinates of detectors and basic infrastructure related data such as map. MnDOT will also participate in the development detector health algorithm and provide inputs.

Task 2: Evaluation of Detector Health Algorithm on a Corridor Study

Under this task, the University will implement the detector health algorithm developed in Task 1 on a corridor of the Twin Cities' freeway network. This test corridor should preferably include a construction zone and will be selected by MnDOT. By limiting the algorithm implementation only to a single corridor, the University will be able to focus on verification and refinement of the detector health algorithm. During this task, MnDOT will provide lane closure information, detector maintenance logs, and other special events that may affect normal traffic patterns for the study corridor. It is emphasized that the algorithm only uses the loop data to determine detector health levels, and thus maintenance and lane closure information is only used for verification or evaluation of the algorithm performance. Some additional field checks performed by the RTMC staff may be requested to verify algorithm performance verification when detectors potentially needing attention do not show up in the maintenance log.

Task 3: Detector Health Program Implementation on the Entire Freeway Network

The corridor study in Task 2 allows verification and refinement of the detector health algorithm. This task will expand the software implementation to cover the entire Twin Cities' freeway network. Because of the large scale of the network involving thousands of detectors, its complexity will significantly increase, and thus new tools will be needed to alleviate the complexity. This integration will consider incorporation of Geographic Information System (GIS) and database tools to deal with the enormous complexity involved. The University will also explore graphically providing detector health status using color coded shapes in a GIS map. During this task, MnDOT will be responsible to provide lane closure information, detector maintenance logs, and other special events that may affect normal traffic patterns for the entire freeway network.

Task 4: Detector Health Software Verification, Refinement, and Application

A well-defined software development process goes through development of requirements, design of algorithm, implementation, verification, and debugging. Under this task, the University will verify and debug the detector health program implemented in Task 3 as the final step of software development phases. The University will verify the software performance through cross-checks with maintenance data log and construction/incident lane closure information. An analysis of directional balance in volumes will be utilized as a potential red flag for verification of special events and identification of obsolete detectors.

The University will also explore how the program can be used in applications; in particular, the selection processes of detector equivalent groups in SC-TDA and ATR-TDA programs. Lane closure information is critical to accuracy of these programs, and how it can be applied to the current program will be studied. MnDOT will continue to provide lane closure information, detector maintenance logs, and other special events information that may affect normal traffic patterns for the entire freeway network.

Task 5: Compile Report, Technical Advisory Panel Review and Revisions
Under this task, the University will prepare a draft report, following MnDOT's publication guidelines, to document project activities, findings and recommendations. This report will need to be reviewed by the Technical Advisory Panel (TAP), updated by the Principal Investigator to incorporate technical comments, and then approved by Technical Liaison before this task is considered complete. Holding a TAP meeting to discuss the draft report and review comments is strongly encouraged. TAP members may be consulted for clarification or discussion of comments.

Task 6: Editorial Review and Publication of Final Report
During this task, the Approved Report will be processed by MnDOT's Contract Editors. The editors will review the document to ensure it meets the publication standard. This task must be completed within the contract time because the editors will provide editorial comments and request information from the Principal Investigator.

Task Deliverables

Task:	Deliverable(s):
1:	A Report, summarizing the literature review and the formulated algorithm
2:	A Summary, describing the detector-health corridor study results
3:	A Software Package; A Summary, describing the task
4:	A New Version of the Software; A Task Report, summarizing software verification and application study
5:	A Draft Report and Final Report Approved for Publication
6:	Final Published Report

PROJECT SCHEDULE

Task Durations

	2016						2017											
Months:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Task 1	X	X	X	X	X	X	X	X										
Task 2									X	X	X	X	X	X	X	X		
Task 3																	X	X
Task 4																		
Task 5																		
Task 6																		

	2018												2019					
Months:	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Task 1																		
Task 2																		
Task 3	X	X	X	X	X													
Task 4						X	X	X	X	X	X							
Task 5												X	X	X	X	X		
Task 6																	X	X

Deliverable Due Dates

Task:	Draft Deliverable Due Date:	Final Task Approval Date:
1:	December 31, 2016	February 28, 2017
2:	August 31, 2017	October 31, 2017
3:	March 31, 2018	May 31, 2018
4:	September 30, 2018	November 30, 2018
5:	February 28, 2019	April 30, 2019
6:		June 30, 2019

Key Milestones

Key Milestone	Target Date	Description
Implementation of Detector Health Algorithm on a Corridor	August 31, 2017	Success of this project depends on how accurately the algorithm detects the detector health levels, which goes parallel with this milestone.
Implementation of Detector Health Algorithm on the Entire Freeway Network	March 31, 2018	Expanding the software to cover the entire freeway network is a milestone due to enormous increase in complexity.

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