EXHIBIT A
SCOPE OF SERVICES

ASSESSING THE IMPACT OF PEDESTRIAN ACTIVATED CROSSING SYSTEM

BACKGROUND

In the past decade several different treatments, aimed at improving pedestrian safety and mobility by positively affecting driver behavior, have been designed and deployed. These include the Pedestrian Hybrid Beacon (HAWK), the Rectangular Rapid Flashing Beacon (RRFB), flashing LED crosswalk signs, and several others. Although prior studies have shown that these systems can have an aggregate positive effect on driver yielding rates, their effects on pedestrian crashes is less clear, and richer insight as to their selection and placement is needed. In Minnesota several sites have had these treatments in place long enough that it may be possible to perform safety analyses. Additionally, the Minnesota Traffic Observatory (MTO) has perfected methods for the collection of long period observations allowing us to investigate the effect of varying conditions such as traffic volume, pedestrian demand, and lighting conditions on driver and pedestrian behavior as well as treatment performance. The University will complete a two-pronged study that will integrate results from a crash record-based safety study with direct, long-term, and staged observations of pedestrian-vehicle interactions at crosswalks with particular treatments. The study will cover a minimum of two sites for each selected treatment with varying roadway characteristics, along with appropriate control sites lacking the target treatment. Finally, on selected sites having the target treatments we propose a traffic conflict study, based on pedestrian and vehicle trajectories, to identify the individual effect each treatment has on crash potential.

OBJECTIVE

As stated in the description of NS380, there is a need for guidance in determining what Pedestrian Activated Crossing (PAC) options are appropriate and in what situations. Additionally, in a recently concluded MnDOT project, where training materials and a course for applying the Highway Capacity Manual Pedestrian Level of Service approach were developed, questions were raised regarding the selection of driver yield rates for intersections with pedestrian activated crossing treatments. This project will provide evidence on the treatments' differences in affecting driver yield rates and driving speed. Guidance on the selection of appropriate treatments will be based on actual observations and include variable traffic and lighting conditions, another point that has not been adequately covered in prior research efforts, which relied on short term observations of staged crossings. The results of this project will inform and assist state, county, and municipal engineers in understanding the impact each of these systems has on pedestrian safety. It will also represent an unbiased comparison of the different treatments, some of which have only vendor-provided, anecdotal evidence of their effectiveness.

SCOPE

Following identification and cataloging of all sites in Minnesota with PAC treatments, the proposed study will follow two interrelated research paths. The first follows and expands the experimental design successfully executed in a prior project dealing with pedestrian safety and mobility on roundabouts. Specifically, this involves the collection of several days' worth of video observations at sites that have the safety treatments installed, as well as at matched sites that do not. At least two sites for each selected treatment with varying roadway characteristics, along with appropriate control sites lacking the target treatment, will be selected for analysis. For selected treatments, depending on the different road geometries that have been installed, the University will consider more (three or even four) sites for comparison as the budget allows. For each site, all instances of pedestrian-vehicle interactions will be identified and detailed information will be extracted. This will include, among other things, the numbers of vehicles that did and did not yield, waiting times for pedestrians to cross, and size of gaps selected and rejected to cross, as well as all observable environmental and traffic conditions. The study will first check if there is a significant difference in the yield rates and other safety-related crossing factors between treated sites and untreated sites. The study will also compare different treatments as well as identify correlations and dependencies with other factors related to the crossing and its environment. Budget permitting, a traffic conflict study on all or a subset of crossing events will help identify the effects each treatment has on crash potential.

The second line of effort for this research involves statistical analyses of pedestrian crash data. If the number of sites treated with a given PAC is sufficient to support reliable estimation of crash modification effects, the University will conduct a before/after study of that PAC treatment. Because safety-related countermeasures are often installed at locations showing atypically high crash experience, special methods are needed to control for regression-to-mean and produce an unbiased estimate of a crash reduction effect.

The University's before/after study will follow the method recommended by Ezra Hauer (1997) which should be sufficient for a resulting estimate to qualify as American Association of State and Highway Transportation Officials (AASHTO)-defined "Proven." The University will identify both a set of locations where different crossing treatments have been installed (treatment group) and a comparable set of locations without any such treatment (reference group). A statistical model that relates crash frequency to traffic volume and other site features will be estimated using reference group data and treatment group data for years prior to the crossing treatment installation. This model will then be used to predict crash experience at the treatment sites that had PAC systems not been installed. The difference between these predicted crash frequencies and the actual after-installation frequencies will then be used to estimate the crash modification effect. The combination of a base-case statistical model and crash reduction factor could be used to predict the expected crash reductions for future crossing treatment installation at additional intersections, and support cost-benefit analyses.

If the number and duration of treated sites is not (yet) sufficient to support estimation of a Crash Modification Factor the University will identify site-related risk factors for pedestrian crashes. A simple example of a risk-factor approach is the observation that while the frequency of fatal crashes on any particular section of county road tends to be low, 40-50% of rural fatal crashes occur on horizontal curves even though curves make up about only 10% of the county road mileage. This suggests that, other things equal, systematically improving the safety on curves should lead to a reduction of fatal crashes. Similarly, identifying traffic or geometry-related risk factors for pedestrian crashes should leads to guides for identifying candidate sites for PCAs. The methodology used will be an adaptation of the matched case-control approach use by Stevenson et al. (1995) to estimate how risk for child pedestrian crashes varied with traffic volumes and speeds.

ASSISTANCE
The Technical Advisory Panel's (TAP) participation is essential to the progress of the project. MnDOT engineers and practitioners will help prioritize the locations of existing and planned PACs and help select the locations for the field studies.

WORK PLAN

<u>Task Descriptions</u>

Task 1: Synthesis of Relevant Literature
The University will produce a working paper that synthesizes and critically reviews the published literature regarding crash reduction effects and driver behavior at intersections with PAC treatments. This will follow MnDOT's Research Services publishing guidelines.

Task 2: Identification of PAC Installations
With the assistance of the TAP members, the University will contact MnDOT's district offices and the Minnesota County and City Engineers Association to identify locations and dates of PAC installations. For this, a survey will be developed so that officials can also help define locations of interest and inform The University of any existing footage that may reduce the effort required in Task 5. These results will be used to compile the treatment and reference group data for the statistical before/after study as well as for the selection of sites for the field study. Based on the results of this task, decisions as to pursue before/after or risk factor analyses will be made in consultation with the project's TAP. The effort in this task will also inform Task 5. The University will provide the TAP with a complete list of PACs in Minnesota along with the geometric and traffic characteristics of each location. This info will be discussed with the TAP in order to define the scope and extend of the field study.

Task 3: Data Collection and Preparation
The University will obtain crash record data, traffic data, and site data for treatment and reference (control) sites. After the data have been acquired, they will be processed to produce the input files for the statistical analyses.

Task 4: Statistical Analyses
For before/after analyses, the University will develop generalized linear models which relate expected crash frequencies to traffic volume and other relevant site characteristics, for pedestrian crossing locations without PAC treatments. Predictions from these models together with observed after-PAC system installation crash frequencies will then be used to estimate crash reduction effects. For risk factor analyses, the University will identify case locations experiencing pedestrian crashes and matched control locations which did not experience crashes. Generalized linear modeling will then be used to estimate how crash risk varies with traffic volume and other relevant site characteristics.

Task 5: Selection of Field Sites
The conversation with the TAP regarding the scope of the field study started in Task 2. Given the desired direction and project budget, the University will finalize the number of sites for each PAC. The University will identify either matched pairs of sites with and without PAC treatments, or sites where it will be possible to turn the treatments on and off. Ten or more sites with PAC treatments will be selected bringing the total site deployment to 30+. The University will collaborate with the TAP to prioritize treatment/geometry combinations.

Task 6: System Installation, Testing and Data Collection
The University will install data collection hardware at the selected crossings and collect observations that characterize pedestrian and driver behavior and choices as they interact. For each crossing a number of staged crossings will also be performed.

Task 7: Field Data Reduction and Analysis
The University will identify all instances of pedestrian-vehicle interactions and detailed observation will be extracted. In addition, for as many cases as possible trajectory models will be fit to individual pedestrian-vehicle pairs, extracting characteristic behavior measures from the trajectory models, and estimate differences in characteristic measures on the crossing approaches with and without PAC treatments. Special attention will be given to the cases where the vehicle was in the dilemma zone when the pedestrian arrived at the crossing and/or the treatment was activated.

Task 8: Compile Report, TAP Review and Revisions
A draft report will be prepared, following MnDOT publication guidelines, to document project activities, findings and recommendations. This report will need to be reviewed by the TAP, updated by the Principal Investigator to incorporate technical comments, and then approved by Technical Liaison before this task is considered complete.

Task 9: 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.

Task Deliverables

Task:	Deliverable(s):
1:	Working Paper, per MnDOT's Research Synthesis Publication Standards
2:	Presentation to TAP; Associated Handouts, Meeting Minutes (for a meeting at end of month 3)
3:	A Two-Page Summary Report
4:	A Summary Report and Presentation to the TAP, as directed by the Technical Liaison
5:	A Two-Page Summary Report
6:	A Two-Page Summary Report
7:	A Summary Report and Presentation to the TAP, as directed by the Technical Liaison
8:	A Draft Report and Final Report Approved for Publication
9:	Final Published Report

PROJECT SCHEDULE

	2015		2016												2017								
Months:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Task 1	X	X	X	X	X																		
Task 2	X	X	X	X	X																		
Task 3				X	X	X	X	X	X														
Task 4								X	X	X	X	X	X	X									
Task 5								X	X	X	X												
Task 6											X	X	X	X	X								
Task 7											X	X	X	X	X	X	X	X	X				
Task 8																		X	X	X	X		
Task 9																						X	X

Task:	**Draft Deliverable Due Date:**	**Final Task Approval Date:**
1:	January 31, 2016	March 31, 2016
2:	January 31, 2016	March 31, 2016
3:	May 31, 2016	July 31, 2016
4:	October 31, 2016	December 31, 2016
5:	May 31, 2016	July 31, 2016
6:	November 30, 2016	January 31, 2017
7:	March 31, 2017	May 31, 2017
8:	May 31, 2017	July 31, 2017
9:	August 31, 2017	September 30, 2017

Key Milestones:

Key Milestones	**Target Date**	**Description**
Identification of PAC installations	1/15/16	All responses indicating present and planned installations of PAC treatments must be collected by this day
Statistical Analyses	12/31/16	Based on data availability a decision will be made by this date as to the type of statistical analysis to be conducted.
Selection of field Sites	9/30/16	TAP approval of selected field deployment site must be secured by this date

THE BALANCE OF THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK