Use of Fluorescent Orange Delineators in Temporary Traffic Control Work Zones

by

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PROBLEM STATEMENT

Road maintenance and reconstruction often present serious safety challenges to highway agencies due to the dynamic and variable work environment which may well be inconsistent with drivers' expectations. As such, proper delineation of travel path through work zones is critical for safe and efficient work zone operations. Currently the Manual on Uniform Traffic Control Devices (MUTCD) only allows white and yellow delineators within temporary traffic control (TTC) work zones (section 6F.80, MUTCD 2009). Field observations suggest that using the conventional white and yellow delineation may not be adequate to effectively delineate traffic through work zones. The proposed research aims to evaluate new alternative fluorescent orange delineation devices for their effectiveness in guiding traffic through work zones. The Montana Department of Transportation (MDT) used the new proposed devices (larger, 6" x 12", retroreflective fluorescent orange delineators) in lieu of the MUTCD approved white delineators in two rural reconstruction projects during summers 2015 and 2016. The new proposed delineation devices satisfy the same retro reflectivity MUTCD requirements for night visibility. Pictures and observations were taken and recorded for the original and proposed delineation devices. MDT project inspectors report the new devices to offer better visibility even when the delineators become dusty and dirty. Traffic control contractors also prefer the larger delineators as they offer an even bigger target value. The fluorescent orange delineators are much more visible during nighttime, adverse weather conditions, and construction activities. Further, road users are familiar with the fluorescent orange color within wok zones which may aid in identifying travelled ways that are not self-explaining. The MUTCD allows the use of devices not described in Chapter 6 of the Manual but this must be based on an engineering study, which is the main impetus for the proposed effectiveness evaluation project.

BACKGROUND SUMMARY

The literature search from stage I showed that the proposed fluorescent orange delineators have not been used in practice nor evaluated in any previous study. However, this section presents a few studies that are deemed relevant in testing the effectiveness of traffic control devices.

A study by McAvoy et al. (2006) evaluated the effectiveness of orange colored drums with orange and white reflectorized stripes used as a delineation treatment in highway work zone traffic control with and without steady burn warning lights through a field experiment and a controlled laboratory experiment using a driving simulator. Driver performance was examined in terms of vehicle operational characteristics including vehicular lateral placement, speed, steering reversals and traffic crash experiences. The statistical analysis performed with the field data and the laboratory data did not indicate any significant difference in driver performance between work zone traffic control with and without steady burn warning lights on drums.

In another study by Oregon Department of Transportation (ODOT) to evaluate 3M Scotchlite linear delineation system, the researchers used spot speed and crash data as measures of effectiveness (Haas 2004). Field observations at the two sites investigated by this study suggest reductions in spot speeds and thus potential safety benefits.

Finley et al. (2011) evaluated the effectiveness of longitudinal channelizing devices in work zones in Texas using instrumented vehicles. Sixty people participated in the closed-course exit ramp study where the channelizing devices were deployed. The researchers recorded the ramp opening detection distance along with a series of questions to participants about the effectiveness of different channelization configurations.

A more recent study (Xu 2016) investigated the safety effects of freeway work zone delineation methods using response time as a surrogate safety measure. In this study, a total of 130 participants were shown computer rendered images of freeway diverges and tasked with identifying the diverge location by clicking on the image with a mouse. Among other findings, study results suggested the potential importance and relevance of response time as a possible surrogate safety measure in the evaluation of innovative traffic control devices.

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BENEFITS AND BUSINESS CASE

Maintaining safety at work zones is a priority for the MDT in their efforts of fulfilling Vision Zero initiative. Specifically, the MDT Work Zone Safety and Mobility Goals and Objectives report published in 2015 outlines Goal 1 as "reduce the number and severity of crashes, injuries and fatalities in construction zones." Effective channelizing devices including delineators are critical in guiding traffic safely through work zones, thus contributing to this important goal. The proposed study will serve as a means for acquiring permission from the National Committee of Uniform Traffic Control Devices (NCUTCD) to use the proposed delineation device which is inconsistent with the standard delineation devices outlined in the MUTCD. Such permission is required before using the new delineation devices at maintenance and construction sites. Further, the proposed research is expected to have a very high pay-off for MDT given the extensive highway network and associated maintenance and reconstruction operations in the state.

OBJECTIVES

The main objective of this project is to assess the effectiveness of new proposed work zone delineation devices for better guiding traffic through work zones. Specifically, the proposed delineation devices are different than those required by the MUTCD in that they are larger in size (6" X 12" versus 4" X 4") and different in color (orange versus white and yellow per MUTCD). The new devices have to meet the same retroreflectivity requirement as other delineation devices approved by the MUTCD. The research hypothesis is we would expect to see fewer road departures with the use of orange delineators vs. white delineators.

This assessment is very important in that it will provide the needed documentation to acquire the NCUTCD approval for using the new devices at maintenance and reconstruction zones.

RESEARCH PLAN

The research plan involves nine tasks to achieve the objectives of the project. These tasks are based on those identified in the research problem statement, ideas discussed during the project technical panel first meeting, and the guidance provided by the MDT research programs. These nine tasks are:

1. Project management
2. State of the art review
3. Selection of Study Sites
4. Data Collection
5. Data Reduction and Processing
6. Data Analysis
7. Assessing benefits of proposed devices
8. Implementation plan
9. Final report

1.0 Project Management

Project Management is essential to ensure a successful project and efficient communication between WTI and MDT. Specific project management activities include:

- A kickoff meeting with the project Technical Panel to occur as soon as practical after a contract is in place. The Technical Panel and the WTI team will discuss the research approach to be taken (as laid out in this section of the proposal), potential information sources and agency contacts, and other items that could assist WTI in executing the project.
- Quarterly progress reports delivered to MDT assessing work accomplished on specific tasks and the percent of each task completed to date.
- Meeting with the project technical panel in person or over the phone at any time during the life of the project. Request for such meetings could be initiated by the research team or the project Technical Panel Chair.
- A final meeting/conference call to present the results of the research to the Technical Panel (following a review and comment period by the panel), if such a meeting is desired and requested by the panel. This meeting would serve to conclude the project, presenting and discussing the findings of the project.

2.0 State of the Art Review

This task will involve an in-depth search and review of literature and other available information pertaining to using non-MUTCD delineation devices or other traffic control devices at work zones. The review will also include the various techniques used in assessing the effectiveness of traffic control devices that are relevant to the work proposed in this research. The approach taken in completing this task will employ a comprehensive literature search through sources including, but not limited to, the Transport Research International Documentation (TRID) database, the EI Compendex database, Federal Highway Administration (FHWA) websites, Transportation Research Board (TRB) websites, Institute of Transportation Engineers (ITE) websites, American Association of State Highway and Transportation Officials (AASHTO) websites, state DOT websites, and other databases (e.g., Google Scholar). Subsections expected to be included in this

task will focus on:

- Proposed non-MUTCD delineation devices found in literature
- Methods and techniques that are used in evaluating the effectiveness of traffic control devices, particularly delineation devices used at maintenance and reconstruction zones.

The literature review will search for peer-reviewed papers and journal articles, agency reports, agency websites, and other relevant documentation and information, including ongoing research that may also be relevant, as identified by the TRID's Research in Progress database. Results from this task will be included in a task report submitted to MDT at the conclusion of this task.

Additionally, at the onset of this task, the research team will work closely with technical panel members in preparing and submitting a request for experimentation of the new proposed devices to the NCUTCD (the National Committee). The approval of this request by the aforementioned Committee is required before the start of field experimentation in this project.

3.0 Selection of Study Sites

In this task, the research team will work closely with the project technical panel to identify work zone sites that are deemed most appropriate for the evaluation study. The evaluation study would involve a control/case evaluation (control: MUTCD vs. case: treatment) which can also be viewed as a before/after evaluation (before the change and after the change). To assess the effectiveness of the new delineation devices, one direct measure and two surrogate measures will be used in this study. The direct measure is the number/frequency of encroachments into the delineated work zone area, while the two surrogate measures are the lateral position of vehicles relative to the delineation devices and vehicle speed. Among the important considerations for study site selection would be project location to ensure that the research team can effectively monitor construction site conditions and data collection equipment for the duration of data collection. Further, the project timeline should allow the research team to collect adequate data at each study site using the MUTCD delineation devices as well as the proposed new devices. It is anticipated that a three-week period for the control (white delineators) and the same period for the treatment (orange delineators) are appropriate to observe the device effectiveness in any comparison study. Of course, this is a rough estimate and an accurate estimate would depend on the amount of traffic using the affected work zone area. The other important consideration in study site selection is the work zone area configuration to allow observation of drivers' behavior being in close proximity to delineation devices. It is envisioned that data collection will take place at two long-term reconstruction projects in summer 2020. Two sites from the following list of candidate sites will be used in this study.

1. Site 1, Project # 6097, Boulder- South: This project is located on state secondary road S-399 south of Boulder, Montana which is classified as a rural collector. The project involves reconstructing two segments on S-399 (Whitetail Road). The project also involves realigning approximately 1200 feet of the Little Boulder Road to improve the existing skewed intersection geometry where it ties into S-399. The Annual Average Daily Traffic (AADT) for this stretch of the road is 110 vehicles per day in 2014, with 3.6 percent heavy vehicles.
2. Site 2, Project # 8790, Livingston – South: This project is located on HWY 89 south of Livingston, Montana between the mileposts 48.9 and 52.5. The project involves extending the two-way-left-turn lane (TWLTL) that is present at the south end of Livingston for an additional 2.7 miles to the intersection of East River Road (S-540). The AADT for this stretch of highway is 5840 vehicles per day in 2014, with around 3% heavy vehicles.
3. Site 3, Project # 5813, JCT S-437 - N & S: This project is located on US 287 highway in Broadwater County between reference markers 95.61 and 102.83. The project is to reconstruct

the existing roadway to meet current standards for 70 mph and to add a passing lane the entire length of the project to reduce traffic platooning. Realignment of the intersection of U.S. 287 and S 437 will also be included. The project site is in generally level terrain and will connect into the US 287 Passing Lanes (CN B377 & CN C377) projects on the north and south ends of the project. The AADT for this segment of US 287 is 3250 vehicles per day in 2011, with heavy vehicles constituting around 13.7% of traffic.

4. Site 4, Project # 8765, Rainbow Point Turn Lane: This project is in Gallatin County on N-50 north of West Yellowstone. This highway is classified as rural principal arterial with an AADT of 2840 vehicles per day in 2014. The project which is located at milepost 4.7 will provide a single left-turn lane into Rainbow Point Road. Rainbow Point Road is a county road that accesses recreational and residential areas north of West Yellowstone in the Hebgen Lake area. The approach will be realigned to improve intersection geometry. The design speed for the project is 70 mph.
5. Site 5, Project # 8107, Yellowstone Park: This project is in Gallatin County on N-50, a rural principal arterial, between West Yellowstone and Big Sky, (RP 10.8 to 31.2). The project begins at the southern boundary of Yellowstone Park and ends at the northern boundary of the park along highway 191, with a total length of 20.3 miles. The project is located approximately 11 miles north of West Yellowstone. The project involves a 0.20' mill & overlay, seal & cover, guardrail improvements, and a 1,500' long digout. The proposed work is intended to improve the longevity of the pavement surface while being an economical alternative. The AADT for this segment of US 191 is 1790 vehicles per day in 2013, with around 22% heavy vehicles.

4.0 Data Collection

This task is critical to the success of the proposed evaluation study. Data of particular importance to this project include: 1) work zone area configuration including all traffic control devices used at the temporary traffic control zone, 2) Detailed information about the construction activity taking place at the work zone that is in close proximity to delineation devices, 3) Any other factors (e.g. encroachments, incidents, accidents, law enforcement, etc.) that is expected to affect drivers' behavior at work zone, 4) weather conditions during the data collection period, and 5) video recording of the section where the delineation devices are used, and 5) speed measurements at the same location of the section being recorded using surveillance cameras. These data are adequate to gather the three measures of effectiveness used in this study and discussed in the previous task while controlling for factors such as weather and traffic accidents that may affect vehicle paths as they pass through the affected area.

The Western Transportation Institute, research team and the MDT Research Program will not be responsible for the procurement and installation of the delineation devices used at study sites in this evaluation study. MDT project construction funding will be used to procure and install delineation devices. The project technical panel is expected to help in getting all necessary approvals from districts and construction sites to facilitate field data collection by the researchers. Further, if needed, the technical panel would help in providing safety debriefing / orientation to data collection personnel before starting work at study sites. The results of this and the previous task (selection of study sites) will be included in an interim report, which will be submitted to the project manager at the conclusion of this task.

5.0 Data Reduction and Processing

In this task, the research team will process raw data collected from study sites and compile it in a format appropriate for subsequent analyses. Outputs from traffic recorders will be downloaded and

used in the speed analysis while video records will be used to examine vehicle lateral position relative to delineation devices. This task is expected to be time consuming especially that lateral position will be assessed for each vehicle or for a large sample of vehicles using the work zone depending on the amount of traffic exposure. Specifically, the extraction of video data will be at the individual vehicle level, i.e. each vehicle will have an independent entry in the database with relevant measures established in this study. The route through the work zone will be divided and marked in the video footage to allow quantitative analysis of the vehicle lateral positions. The number/frequency for motorist encroachments into the delineated area will be gathered using the video records and other incident/accident reports at the construction site as the video footage is unlikely to cover the construction site completely. Speed data will also be processed at the individual vehicle level and combined with data extracted from video records in a single spreadsheet file and format suitable for analysis. Other data gathered in the previous task (weather, light condition, work zone configuration, etc.) will also be included in the analysis spreadsheet file(s).

6.0 Data Analysis

In this task, the three study variables will be analyzed to examine the effectiveness of the proposed delineation devices using all data available to this study that were collected in the previous task. Those variables represent indicators of drivers' behavior in repose to delineation devices such as the lateral vehicle position in relation to delineation devices, number of encroachments into the delineated construction activity areas, and vehicle speed characteristics. Analyses will be conducted by comparing the MUTCD approved delineation devices with the new proposed devices while controlling for factors such as weather, incidents/accidents and the type of construction activity. The data analysis results along with a description of data reduction and processing (task 5) will be included in an interim report, which will be submitted to the project manager at the conclusion of this task.

7.0 Assessing Potential Benefits of Proposed Devices

This task will assess the potential benefits of using the new proposed orange delineator devices by MDT in channelizing traffic work zones throughout the state. Both qualitative and quantitative assessments will be considered in this task. Qualitative assessment of benefits will primarily be based on field observations and findings from the previous task (Data Analysis). On the other hand, the quantitative analysis would include assessing all the economic benefits and costs of the proposed devices. The potential benefits of the proposed delineation devices is the added safety at highway maintenance and reconstruction zones reflected by potential reductions in the number of crashes and casualties. The costs associated with implementing the new devices are expected to be minimal compared with the MUTCD approved devices currently used in practice. At the conclusion of this task, assessment results will be included the *performance measures report* which will be submitted to the project manager.

8.0 Implementation Plan

This task will recommend an implementation plan for possible adoption of the new proposed delineation devices at maintenance and reconstruction zones in Montana. The implementation plan will include specific measures that need to be taken to acquire the MUTCD approval for the application of the new delineation devices. The plan will also include recommendations and guidelines about the appropriate use of the new devices by MDT based on the results of this investigation. The implementation plan will be included in a separate report at the end of this task and will be presented and discussed in a meeting with the project technical panel.

9.0 Final Report

This task will include the preparation and submission of the final report. The final report will include the methods and findings from all prior tasks as well as any recommended actions stemming from these tasks. The section on Task 2.0 results (state of the art review) will include updated information to reflect new studies or reports that may have been published during the duration of the project. A dedicated chapter will also be included for the implementation plan with recommendations and guidelines for the adoption of the new delineation devices. A draft of the final report will be provided to the Technical Panel two (2) months prior to the completion of the project. This will allow enough time for the report to be reviewed by the Technical Panel and comments/suggestions be incorporated in the final report draft in a timely manner. If the Technical Panel desires a final project meeting, then presentation materials for that meeting will also be prepared and provided to the Research Project Manager in advance of the meeting date.

MDT AND TECHNICAL PANEL INVOLVEMENT

MDT involvement in this project will be required as follows:

- The Technical Panel will need to provide input, feedback and guidance on the research plan at the kick-off meeting and on as-needed basis afterwards whenever change or modification to the research plan is deemed appropriate by the research team.
- MDT staff will be asked to field information and data requests on an as needed basis. The two main items currently envisioned to rely on Technical Panel involvement include the identification of study sites along with all pertinent project information, i.e. timeline, temporary traffic control plan, and contact persons to coordinate field data collection, etc.
- The MDT will be responsible in securing approval for research personnel to access and perform project related work at the selected study sites.
- MDT will be responsible for the procurement and installation of the proposed delineation devices at study sites.
- The Technical Panel and Research Staff will review and comment on project deliverables including the final report.

PRODUCTS

The primary products resulting from this work are described below.

- Quarterly Progress Reports will be submitted documenting the work accomplished on specific tasks and the percent of each task completed to date.
- *State-of- the-Art Report:* this report summarizes the results of the state-of-the-art review and will be submitted to the project manager at the conclusion of task 2.
- *Field Data Collection Report:* this report discusses the data collection activities that are described in task 4 as well as a description of study sites that are selected in task 3 of this project. This report will be submitted at the conclusion of task 4.
- *Fluorescent Orange Delineators Evaluation Results:* this report documents the analyses that are done in task 6 of this project as well as a description of data reduction and processing that are discussed under task 5 of the research plan. This report will be submitted at the conclusion of task 6.
- *Performance Measures Report:* this report documents the economic assessment results and will be submitted to the project manager at the conclusion of task 7.
- an *Implementation Report* with content (text and images) provided by the researchers, formatted and published by MDT, detailing any implementation recommendations stemming from the project. This report will be submitted at the conclusion of task 8.
- A *Final Project Report* that presents the results of the overall research effort will be provided to the Technical Panel for review and comment. The Technical Panel's comments will then be addressed, and the report re-submitted as a Final Report. The report will be delivered in both Microsoft Word and Adobe PDF formats and will comply with MDT's report requirements.
- A final report cover page photo (JPG format).
- A Project Summary Report containing a high-level overview of the project and findings from the assessment.
- Contingent upon the desires of the Technical Panel, a Final Report Presentation may, or may not be provided and could either be in-person at MDT Headquarters in Helena, or via teleconference.

IMPLEMENTATION

The Implementation Plan, which will be submitted at the end of task 8 and included as a chapter in the final report, will detail the specific recommendations and guidelines for MDT and local agencies in implementing the results from this project, which is largely dependent on the effectiveness evaluation of the proposed new delineation devices. This plan will be made available to MDT staff who are involved in the maintenance and reconstruction programs within the Department. In addition, the research team will likely disseminate findings from this study to broader audiences, and other interested states via publication in relevant journals and presenting the findings at professional meetings.

SCHEDULE

Table 1 shows the individual task durations and timeline. This project is expected to take 22 months to complete.

Table 1: Project Schedule

	Task	Month																				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Project Management	○																		○		○	
2	State of the Art Review				◇																		
3	Selection of Study Sites																						
4	Data Collection									◇													
5	Data Reduction and Processing																						
6	Data Analysis																◇						
7	Benefit-Cost Analysis																		◇				
8	Implementation Plan																			◇			
9	Final Report																				◇		

○ Meeting ◇ Deliverable

BUDGET

This project is funded by the Montana Department of Transportation (MDT) and the Small City, Rural and Tribal Center on Mobility (SURTCOM) at the Western Transportation Institute (WTI). The total cost of this project will be $205,337.2 as summarized in Table 2. This cost includes all allocated research and support staff time, and other anticipated expenses. The budget involves $14,000 tuition for the graduate research assistant and $3,450 travel expenses intended for data collection site visits, presenting research at the TRB Annual Meeting and 3-4 trips to MDT offices in Helena during the life of the project. The total budget is split between the Montana Department of Transportation ($90,012.7) and SURTCOM ($115,324.5).

Table 2: Summary of Cost by Budget Category – Total Project Budget

Item	Amount
Salaries	$96,920.2
Benefits	$21,604.2
Travel	$3,450.0
3-4 trips to MDT in Helena ($450)	
Data Collection Site Visits ($1200)	
TRB Meeting Presentation ($2000)	
Expendable Supplies	$400.0
GRA Tuition	$14,000.0
Contractual (data collection)	$20,000.0
Total Direct Cost	$156,374.4
Overhead	$48,962.8
Total Project Cost	**$205,337.2**

MDT BUDGET

The total MDT budget for this project is $90,012.7 as shown in Table 3. Pay and benefit rates for research team members are shown in Table 4 while projected expenditures by task are shown in Table 5. Further, projected expenditures by state and federal fiscal years are shown in Tables 6 and 7, respectively.

Table 3: Summary of Cost by Budget Category – MDT Project Budget

Item	Amount
Salaries	$47,762.9
Benefits	$11,397.3
In-state Travel	$1,450.0
3-4 trips to MDT in Helena ($450)	
Data Collection Site Visits ($1000)	
Expendable Supplies	$400.0
GRA Tuition	$0.0
Contractual (data collection)	$11,000.0
Total Direct Cost	$72,010.2
Overhead	$18,002.5
Total Project Cost	**$90,012.7**

Table 4: Hourly and Benefit Rates

Staff Name	Hourly Rate	Benefits Rate
Ahmed Al-Kaisy	$68.25	30.4%
Graduate Student	$15.45	10.0%
Undergraduate RA	$13.63	10.0%
Business Manager	$39.97	33.0%
Technical editor	$23.83	38.0%

Table 5: Cost by Task

Task	Cost	% of Total Cost
Task 1: Project Management	$11,410.00	12.7%
Task 2: State of the Art Review	$11,554.20	12.8%
Task 3: Selection of Study Sites	$4,280.00	4.8%
Task 4: Data Collection	$19,632.90	21.8%
Task 5: Data Processing and Reduction	$9,100.00	10.1%
Task 6: Data Analysis	$14,622.00	16.2%
Task 7: Benefit-Cost Analysis	$6,436.90	7.2%
Task 8: Implementation Plan	$4,630.40	5.1%
Task 9: Final Report	$8,346.30	9.3%
Total	**$90,012.70**	**100.0%**

Table 6: Expenditures by State Fiscal Year

Budget Category	Total	State Fiscal Year		
		2020	2021	2022
Salaries	$47,762.86	$9,552.57	$28,657.71	$9,552.57
Benefits	$11,397.30	$2,279.46	$6,838.38	$2,279.46
Supplies & Minor Equipment	$400.00	$100.00	$200.00	$100.00
Travel	$1,450.00	$700.00	$600.00	$150.00
Tuition	$0.00	$0.00	$0.00	$0.00
Contractual (data collection)	$11,000.00	$5,000.00	$6,000.00	$0.00
Direct Costs	$72,010.16	$17,632.03	$42,296.10	$12,082.03
Overhead	$18,002.54	$3,600.51	$10,801.52	$3,600.51
Total Project Cost	$90,012.70	$21,232.54	$53,097.62	$15,682.54

Table 7: Expenditures by Federal Fiscal Year

Budget Category	Total	Federal Fiscal Year		
		2020	2021	2022
Salaries	$47,762.86	$19,105.14	$23,881.43	$4,776.29
Benefits	$11,397.30	$4,558.92	$5,698.65	$1,139.73
Supplies & Minor Equipment	$400.00	$100.00	$150.00	$150.00
Travel	$1,450.00	$800.00	$500.00	$150.00
Tuition	$0.00	$0.00	$0.00	$0.00
Contractual (data collection)	$11,000.00	$11,000.00	$0.00	$0.00
Direct Costs	$72,010.16	$35,564.06	$30,230.08	$6,216.02
Overhead	$18,002.54	$7,201.02	$9,001.27	$1,800.25
Total Project Cost	$90,012.70	$42,765.08	$39,231.35	$8,016.27

STAFFING

The research team is composed of the Principal Investigator, Dr. Ahmed Al-Kaisy along with one graduate student researcher and one undergraduate research assistant. A short biography of the Principal Investigator is provided below.

Ahmed Al-Kaisy, PhD, PE, is a professor in the Department of Civil Engineering at Montana State University (MSU) and the Program Manager for the Safety and Operations Focus Area at the Western Transportation Institute (WTI). Dr. Al-Kaisy is a registered professional engineer in the state of Montana. Dr. Al-Kaisy has long teaching and research experience in many areas of transportation engineering, including traffic operations and management, traffic flow theory, traffic safety, signal optimization and control, highway design, and intelligent transportation systems. Dr. Al-Kaisy has successfully completed several investigations on the effectiveness of traffic control and active warning devices that are somewhat similar in approach to the proposed investigation. Most recently, Dr. Al-Kaisy has completed an investigation into the effectiveness of a bicyclists active warning systems that was deployed in Colorado National Monument. Another project involved assessing the effectiveness of the Rectangular Rapid Flashing Beacon (RRFB) devices that were installed at pedestrian crossings along Kagy Blvd bordering MSU campus in Bozeman, Montana. An earlier investigation involved examining the effectiveness of different traffic control devices at channelized right-turn lanes at three intersections in Bozeman and Belgrade, Montana. Dr. Al-Kaisy has authored/co-authored more than a hundred refereed publications half of which are fully refereed journal publications. Dr. Al-Kaisy is an active member in many university committees and is affiliated with a number of national and international professional organizations. The resume for the Principal Investigator is provided at the end of this proposal.

The primary role of team members on this project and their level of effort are delineated by task in Table 8.

Table 8: Role and Level of Effort of Research Team Members by Task

Name or Title	Role in Study	Task									
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Ahmed Al-Kaisy	Principal Investigator	110	50	30	30	40	80	42	28	50	**460**
Graduate Student	Data Collection & Analysis	0	240	40	50	200	240	80	60	70	**980**
Undergrad RA	Help in Data Collection & Processing	0	0	0	0	0	0	0	0	0	**0**
Business Manager	Administrative Support	0	2	0	2	0	2	0	2	6	**14**
Support Staff	Technical editing	0	0	0	0	0	0	0	0	16	**16**
	Total	**110**	**292**	**70**	**82**	**240**	**322**	**122**	**90**	**142**	**1470**

The key investigators can commit the time necessary to complete this work in a timely and deliberate manner as shown in Table 9. The level of effort proposed for the principal investigator will not be changed without written consent of MDT.

Table 9: Summary of Commitments for Principal Investigator

Individual	Available Time %	Existing Commitments	
		Commitment	Time, %
Ahmed Al-Kaisy	40	Teaching	40
		MDT Low-Volume Roads Project	15
		Other	5

FACILITIES

The Western Transportation Institute (WTI) is the nation's largest transportation institute focusing on rural transportation issues. The Institute was established in 1994 by the Montana and California Departments of Transportation, in cooperation with Montana State University. WTI has an annual budget exceeding $7 million and a 50-person multidisciplinary staff of professionals, students and associated faculty from engineering (mechanical/industrial/civil), computer science, fish and wildlife, ecology, business, and economics. WTI has conducted research in more than 30 states, at local, state, and federal levels.

As a department in the College of Engineering, WTI is also supported by the College and by the umbrella of MSU administrative, academic, and research resources. The research faculties at WTI are assisted by a backbone of support staff. Administrative staff helps with budgeting, procurement, contracts, and accounting. Communications staff provides technical editing, layout, graphic design, and web page support. Information Technology staff maintains network servers and individual computers, software and hardware. Given the nature of this research project, most of the work will be data/information gathering, analysis, and assessment. The research will be conducted on pc/workstations using software available at WTI and the Civil Engineering Department of the College of Engineering at Montana State University.

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Haas, K. (2004) "Evaluation of 3M™ Scotchlite™ Linear Delineation System" Final Report, SPR 306-291, Oregon Department of Transportation, Salem, Oregon.

McAvoy, D., Schattler, K. and Tapan, D. (2006) "A Study of the Effectiveness of Steady Burn Warning Lights on Drums in Construction Work Zones" Institute of Transportation Engineers, 2006 ITE Annual Meeting and Exhibit Compendium of Technical Papers, Milwaukee, Wisconsin.

Xu, Y., Greenwood, A., Corso, G., Hunter, M. and Rodgers M. (2016) "Safety Effects of Freeway Work Zone Delineation Methods: Response Time as a Surrogate Measure" Advances in Transportation Studies, Rome, Italy, Volume 1, pp. 113-126.

Ahmed Al-Kaisy, PhD, PE

Professor, Department of Civil Engineering
Montana State University, Bozeman, Montana
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ACADEMIC PREPARATION

Post-Doctoral Fellow, McMaster University, Hamilton, Ontario, Canada	1999-2000
PhD Transportation Engineering, Queen's University, Kingston, Ontario, Canada	1999
PhD Course work, Carleton University, Ottawa, Ontario, Canada	1995-1996
BSc, MSc Civil Engineering, University of Baghdad, Iraq	1985

ACADEMIC EMPLOYMENT

Professor, Department of Civil Engineering, Montana State University, Bozeman, Montana, July 2012-present.

Visiting Professor, Department of Civil Engineering, American University of Sharjah, UAE, September 2011-June 2013

Associate Professor, Department of Civil Engineering, Montana State University, Bozeman, Montana, July 2007-July 2012.

Assistant Professor, Department of Civil Engineering, Montana State University, Bozeman, Montana, 2003-2007

Assistant Professor, Civil Engineering Department, Bradley University, Peoria, IL 2001-2003

Post-Doctoral Research Associate, McMaster University, Hamilton, Ontario, Canada 1999-2000

Lecturer, McMaster University, Hamilton, Ontario, Canada 1999-2000

Research Associate, Royal Military College of Canada, Kingston, Ontario, Canada 1996-1999

Research Assistant, Queen's University, Kingston, Ontario, Canada 1996-1999

Teaching Assistant, Queen's University, Kingston, Ontario, Canada 1996-1999

PRINCIPAL AREAS OF TEACHING & RESEARCH

Traffic operations and management, traffic control, intelligent transportation systems, sustainable Transportation Systems, highway geometric design, traffic simulation and modeling, traffic flow theories, transportation safety

RESEARCH GRANTS

- *Downtown Bozeman Parking Inventory and Occupancy Study*, City of Bozeman (Principal Investigator), $30,000 (Completed February 18)
- *Improved Analysis of Two-Lane Highway Capacity and Operational Performance,* National Cooperative Highway Research Program (NCHRP), $550,000 (Co-Principal Investigator, PI: Scott Washburn, University of Florida), (completed March 18)
- *Developing Interdisciplinary Research Initiatives on Smart Cities*, COE Thorson Excellence in Engineering (TEER) Grants program (Co-PI), $25,000 (ongoing)
- *Developing Interdisciplinary Research Initiatives on Smart Cities,* Small Urban, Rural and Tribal Center on Mobility (SURTCOM), Western Transportation Institute (Co-PI), $77,241 (ongoing)
- *Assessment of Montana Road Weather Information System (RWIS),* Montana Department of Transportation (Principal Investigator), $152,000 (completed)
- *Traffic Records and Performance Measure Support,* National Highway Traffic Safety Administration (NHTSA), $182,000 (Co-Principal Investigator, PI: Eric Li from Virginia Tech, prime institution) (completed)
- *Innovative Safety Solutions with Pavement Markings and Delineation,* American Traffic Safety Services Association (ATSSA), (Principal Investigator), $30,000 (completed)
- *Risk Factors Associated with High Potential for Serious Crashes*, Oregon Department of Transportation and FHWA, $160,000 (Principal Investigator), (completed)
- *Evaluation of Variable Speed Limit/Variable Advisory Speed Systems,* Oregon Department of Transportation and FHWA, $165,000 (MSU PI, in partnership with Portland State University, PSU PI: Dr. Robert Bertini) (completed)
- *Montana Weigh-in-Motion (WIM) and Automatic Traffic Recorder (ATR) Strategy,* Montana Department of Transportation and FHWA (Investigator), $205,000 (completed)
- *Traffic Calming for Rural 2-Lane Roads,* Central Federal Land Highway Division, FHWA (Principal Investigator), $80,000 (completed)
- *Evaluation of a Variable Speed Limit System for Wet and Extreme Weather Conditions,* Oregon Department of Transportation and FHWA, (Principal Investigator), $170,000 (phase I completed, phase II pending)
- *Cost Effective Local Road Safety Planning and Implementation,* American Traffic Safety Services Association (ATSSA), (Co-Principal Investigator), $35,000 (completed)
- *Montana Rest Area Usage: Data Acquisition and Usage Estimation,* Montana Department of Transportation, (Principal Investigator), $160,000 (completed)
- *Explore ITS Technologies for Work Zones and Work Zone Impact Areas*, Western Federal Land Highway Division, FHWA (Principal Investigator), $120,000 (completed)
- *Effect of Speed, Alignment and Roadside Features on Crash Experience along a Rural Corridor,* Western Transportation Institute, NSF REU Program, $12,000 (completed)
- *City of Bozeman Parking Study,* City of Bozeman, (Principal Investigator), $28,000 (completed)
- *Effect of Alignment and Sight Distance on Drivers' Speed Selection in the Gallatin Canyon,* Western Transportation Institute, NSF REU Program, $12,000 (completed)

- *Channelized Right-Turn Lanes at Signalized Intersections: Traffic Control Empirical Investigation*, US Department of Transportation through Western Transportation Institute, Bozeman, MT, (Principal Investigator), $25,000 (completed)
- *FWS Traffic Monitoring Assessment and Demonstration Project – Phase I,* Central Federal Lands Highway Division, FHWA, (Principal Investigator), $100,000 (completed)
- *Operational Effectiveness of Passing lanes on Two-Lane Highways,* Western Transportation Institute, UTC Graduate Transportation Award, Bozeman, MT, $69,500 (completed)
- *Use of Rural Transportation Infrastructure in Evacuation Operation for the North Gulf Coastal Region,* Center for Urban Rural Interface Studies, Mississippi State University, National Oceanic and Atmospheric Administration (NOAA), (Co-Principal Investigator), $75,000 (completed)
- *Bozeman Pass Wildlife Channelization ITS Project*, Federal Highway Administration and Montana Department of Transportation, (Co-Investigator), $82,498 (completed)
- *Indicators of Performance on Two-Lane Highways*, Western Transportation Institute, UTC Graduate Transportation Award, $69,500 (completed)
- *Effectiveness of Yield-to-Pedestrian Channelizing Devices,* Pennsylvania Department of Transportation, (Co-Investigator), $50,000 (completed)
- *Development of New Analysis Procedures for Two-Lane Highways,* Western Transportation Institute, UTC Graduate Transportation Award, $47,000 (completed)
- *Static Warning Signs for Occasional Hazards: Survey of Practice,* University Transportation Center, US Department of Transportation through the Western Transportation Institute, Bozeman, MT, (Principal Investigator), $25,000 (completed)
- *The Intelligent Transportation System Lab,* Econolite and MSU, $156,000 (completed)
- *Weather Responsive Signal Control: Practical Guidelines,* Western Transportation Institute, NSF REU Program (completed)
- Single-Lane Two-Way Traffic Control at Maintenance & Reconstruction Zones, Western Transportation Institute, NSF REU Program, $12,000 (completed)
- *A New Approach for Developing Passenger Car Equivalency Factors for Heavy Vehicles on Congested Freeways,* Graduate Research Assistant Sponsored Project Award (GRASP), $35,000 (completed)
- *Nighttime Construction: Evaluation of Construction Operations*, Illinois Transportation Research Center (ITRC), Springfield, Illinois, (Co-Principal Investigator), $150,000 (completed)
- *Nighttime Construction: Evaluation of Lighting for Highway Construction*, Illinois Transportation Research Center (ITRC), Springfield, Illinois, (Co-Principal Investigator), $150,000 (completed)
- *Assessing the Occlusion Effect of Heavy Vehicles on the Visibility of Freeway Guide Signs*, Graduate Research Assistant Sponsored Project Award (GRASP), $35,000 (completed)
- *Assessing the Effect of Peak Hour Factor Approximation on Intersection Delay*, Bradley University Caterpillar Faculty Fellowship, $25,000 (completed)
- *Freeway Capacity at Long-Term Reconstruction Zones*, Natural Sciences and Engineering Research Council of Canada (NSERC), (Investigator), (completed)
- *Quality of Service on Freeway facilities,* Natural Sciences and Engineering Research Council of Canada (NSERC), (Investigator), (completed)

PUBLICATIONS

Refereed Journal Articles

1. **Jafari, A.**, Al-Kaisy, A., and Washburn, S. (2018) "Passing Lane Optimum Length on Two-Lane Highways," Canadian Journal of Civil Engineering (CJCE), in press.
2. **Jafari, A.**[1] and Al-Kaisy, A. (2018) "Investigation of Side-by-Side Passing Lane Length and Spacing on Two-Lane Highways" Journal of Advances in Transportation Studies, in press.
3. Al-Kaisy, A., **Jafari, A.**, Washburn, S., Luttinen, T. and Dowling, R. (2018) "Performance Measures on Two-Lane Highways: Survey of Practice," Research in Transportation Economics, Elsevier, in press.
4. Al-Kaisy, A., **Jafari, A.**, and Washburn, S., Luttinen, T. and Dowling, R. (2018) "Traffic Operations on Rural Two-Lane Highways: a Review on Performance Measures and Indicators," Transportation Research Records, Journal of the Transportation Research Board, Sage Publications, ISSN: 0361-1981, Available at: https://doi.org/10.1177/0361198118774743.
5. Al-Kaisy, A., and Ewan, L. (2017) "Prioritization Scheme for Proposed RWIS Sites: Montana Case Study," Transportation and Transit Systems: *Frontiers in Built Environment*, 3:45. doi: 10.3389/fbuil.2017.00045.
6. Al-Kaisy, A., **Jafari, A.,** and Washburn, S. (2017) "Measuring Performance on Two-Lane Highways: Empirical Investigation," *in Transportation Research Record 2615*, Journal of the Transportation Research Board, DOI is 10.3141/2615-08.
7. Al-Kaisy, A., ***Miyake, G.***[2], Stasczuk, J., and Scharf, D. (2016) "Motorists' Voluntary Yielding of Right of Way at Uncontrolled Mid-Block Crosswalks with Rectangular Rapid Flashing Beacons" *Journal of Transportation Safety and Security*, ISSN: 1943-9962 (Print) DOI: 10.1080/19439962.2016.12- -67827.
8. Al-Kaisy, A., Ewan, L., and **Hossain, F.** "Economic Feasibility of Safety Improvements: Oregon's Low-Volume Roads Case Study," *Journal of Transportation Safety and Security*, Taylor & Francis, ISSN: 1943-9962 (Print) 1943-9970 (Online), DOI: 10.1080/19439962.2016.1212446, pp. 1-14.
9. Ewan, L., Al-Kaisy, A., and **Hossain, F.** (2016) "Safety Effects of Road Geometry and Roadside Features on Low-Volume Roads," *Transportation Research Record 2580*, Journal of the Transportation Research Board, pp. 47-55.
10. Wang, Y., Veneziano, D., Russel, S. and Al-Kaisy, A. (2016) "Traffic Safety along Tourist Routes in Rural Areas," *Transportation Research Record 2568*, Journal of The Transportation Research Board, pp.55-63.
11. Ismeik, M., Al-Kaisy, A. and Al-Ansari, K. (2015) "Perceived Risk of Phoning while Driving: a Case Study from Jordan," *Journal of Safety Science*, Elsevier, volume 78, pp. 1-10.
12. ***Watson, D.***, Al-Kaisy, A. and ***Anderson, N.*** (2014) "Examining the Effect of Speed and Roadway Geometry on Crash Experience along a Rural Corridor," *Journal of Modern Transportation*, Springer, Vol. 22, Issue 2, pp. 84-95.
13. Al-Kaisy, A., ***Krieder, T and Pothering, R.*** (2013) "Speed Selection at Sites with Restrictive Alignment: The US-191 Case Study," *Journal of Advances in Transportation Studies*, Issue 29. pp. 71-82.

[1] Names in bold indicate supervised graduate students.
[2] Names in bold italic indicates supervised undergraduate students.

14. **Ewan, L.**[3], Al-Kaisy, A. and Veneziano, D. (2013) "Weather Sensing and Road Surface Conditions: Is Technology Mature for Reliable ITS Applications?" *TRB Transportation Research Record 2329*, Journal of the Transportation Research Board, pp. 8-16.
15. **Freedman, Z.** and Al-Kaisy, A. (2013) "Investigation of Performance and Lane Utilization within a Passing Lane on a Two-Lane Rural Highway" *The International journal for Traffic and Transport Engineering*, Vol. 3, issue 3, pp. 279-290.
16. Al-Kaisy, A., Veneziano, D. Dorrington, C., and **Kirkemo, Z.** (2012) "Practical Guidelines for Estimation of Rest Area Use on Rural Interstates and Arterial Highways" *Transportation Research Record 2303*, Journal of the Transportation Research Board, pp. 117-124.
17. Al-Kaisy, A. and **Roefaro, S.** (2012) "Channelized Right-Turn Lanes at Signalized Intersections: The U.S. Experience," *Advances in Transportation Studies*, Vol. 26, pp.57-68.
18. Al-Kaisy, A., **Roefaro, S.** and Veneziano, D. (2012) "Effectiveness of Signal Control at Channelized Right Turning Lanes: An Empirical Study" *Journal of Transportation Safety and Security*, Vol. 4, Issue 1, pp. 19-34.
19. Al-Kaisy, A., **Church, B.**, Veneziano, D. and Dorrington, C. (2011) "Investigation of Parking Dwell Time at Rest Areas on Rural Highways," *Transportation Research Record 2255*, Journal of the Transportation Research Board, pp. 156-164.
20. Al-Kaisy, A., **Kirkemo, Z.**, Veneziano, D. and Dorrington, C. (2011) "Traffic Usage of Rest Areas on Rural Highways: A Recent Empirical Study" *Transportation Research Record 2255*, Journal of the Transportation Research Board, pp. 146-155.
21. Al-Kaisy, A. and **Freedman, Z.** (2011) "Estimating Performance on Two-Lane Highways: Case Study Validation of a New Methodology," *Transportation Research Record 2173,* Journal of the Transportation Research Board, pp. 72-79.
22. **Freedman, Z.** and Al-Kaisy, A (2010) "Empirical Examination of Passing Lane Operational Benefits on Rural Two-Lane Highways," *Journal of Transportation Research Forum*, Vol. 49, No. 3, pp. 53-68.
23. Al-Kaisy, A. and **Karjala, S.** (2010) "Car-Following Interaction and the Definition of Free-Moving Vehicles on Two-Lane Rural Highways." *Journal of Transportation Engineering,* ASCE Publications, Vol.136, Issue 10, pp. 925-931.
24. Ismeik, M. and Al-Kaisy, A. (2010) "Characterization of Cell Phone Use while Driving: The Jordan Experience," *Transport*, Taylor & Francis, Vol. 25, Issue 3, pp. 252-261.
25. Al-Kaisy, A., and Nassar, K. (2009) "Developing a Decision Support Tool for Nighttime Construction in Highway Projects" ASCE *Journal of Construction Engineering & Management*, Volume 135, Issue 2, pp. 119-125.
26. Al-Kaisy, A. and **Durbin, C.** (2009) "Platooning on Two-Lane Two-Way Highways: An Empirical Investigation" *Journal of Advanced Transportation,* Volume 43, Number 1, pp. 71-88.
27. Al-Kaisy, A. and **Karjala, S.** (2008) "Indicators of Performance on Two-Lane Rural Highways: An Empirical Investigation" *In Transportation Research Record 2071*, Journal of the Transportation Research Board, pp. 87-97.
28. Nassar, K. and Al-Kaisy, A. (2008) "A Discrete Event Simulation Model for the Effect of Placement Location on Sign Occlusion in Buildings" *Journal of Automation in Construction*, Elsevier, Volume 17, issue 7, pp. 799-808.

29. Al-Kaisy, A. and **Durbin, C.** (2008) "Evaluating New Methodologies for Estimating Performance on Two-Lane Highways" Canadian Journal of Civil Engineering, Volume 35, Number 8, pp. 777-785.
30. Al-Kaisy, A., Hardy, A., and ***Nemfakos, C.*** (2008) "Static Warning Signs of Occasional Hazards: Do They Work?" The Institute of Transportation Engineers, *ITE journal*, pp. 38-42, June 2008.
31. Rakha, H., Ingle, A., Hancock, K., and Al-Kaisy, A. (2007) "Estimating Truck Equivalencies for Freeway Sections" *In Transportation Research Record 2027,* Journal of the Transportation Research Board, pp. 73-84.
32. Al-Kaisy, A. and ***Freedman, Z.*** (2006) "Weather Responsive Signal Control: Practical Guidelines," *In Transportation Research Record 1978,* Journal of the Transportation Research Board, pp. 49-60.
33. Al-Kaisy, A. and ***Kerestes, E.*** (2006) "Evaluation of the Effectiveness of Single-Lane Two-Way Traffic Control at Maintenance & Reconstruction Zones" *Canadian Journal of Civil Engineering,* Vol. 23, No. 9, pp 1217-1226.
34. Al-Kaisy, A. (2006) "Passenger Car Equivalents for Heavy Vehicles at Freeways & Multilane Highways: Some Critical Issues" The Institute of Transportation Engineers, *ITE journal*, March 2006.
35. Hardy, A., **Lee, S.**, and Al-Kaisy, A. (2006) "Effectiveness of Animal Advisory Messages on Dynamic Message Signs as a Speed Reduction Tool: A Case Study in Rural Montana" *In Transportation Research Record 1973,* the Journal of the Transportation Research Board, pp. 64-72.
36. Rakha, H. A., Katz, B., and Al-Kaisy, A. (2006) "Field Evaluation of Truck Weigh-in-Motion Operations," *Journal of Intelligent Transportation Systems,* Taylor & Francis, Volume 10, No. 2. pp. 49-57.
37. Al-Kaisy, A. and Nassar, K. (2005) "Nighttime Construction Issues Revisited," *Journal of Construction Research*, volume 6, part 1, pages 139-156
38. Al-Kaisy, A., **Jung, Y.**, and Rakha, H. (2005) "Developing Passenger Car Equivalency Factors for Heavy Vehicles during Congestion" *Journal of Transportation Engineering,* American Society of Civil Engineers (ASCE), Vol. 131, issue 7, pp 514-524.
39. Al-Kaisy, A., **Bhatt, J.** and Rakha, H. (2005) "Modeling the Effect of Heavy Vehicles on Sign Occlusion at Multilane Highways," *Journal of Transportation Engineering,* American Society of Civil Engineers (ASCE), Volume 131, issue 3, pp. 219-229.
40. Al-Kaisy, A. and **Jung, Y.** (2004) "Examining the Effect of Heavy Vehicles on Traffic Flow during Congestion," *Road and Transport Research,* Vol. 13, No. 4, pp. 3-14.
41. Al-Kaisy, A., **Bhatt, J.** and Rakha, H. (2004) "Assessing the Effect of Heavy Vehicles on the Visibility of Traffic Signs at Multilane Highways," *Journal of Transportation Engineering,* ASCE Publications, Vol. 130, No. 5, pp. 648-657.
42. Al-Kaisy, A. and Hall, F. L. (2003) "Guidelines for Estimating Capacity at Freeway Reconstruction Zones" *Journal of Transportation Engineering,* American Society of Civil Engineers (ASCE), Vol. 129, No. 5, pp. 572-577.
43. Nassar, K., Al-Kaisy, A., and **Abu Hilal, L.** (2003) "Simulation of Asphalt Paving Operations Under Lane Closure Conditions," *Journal of Automation in Construction*, Elsevier Science, Vol. 12, No. 5, pp. 527-541.
44. Al-Kaisy, A., Hall, F. L., and ***Reisman, E.*** (2002) " Developing Passenger Car Equivalents for Heavy Vehicles During Queue Discharge Flow" *In Transportation Research - Part A,* Elsevier Science, Vol. 36, no. 8, pp 61-78.

45. Al-Kaisy, A., and Stewart, J. A. (2001) "New Approach for Developing Warrants of Protected Left-Turn Phase at Signalized Intersections," *In Transportation Research – Part A*, Elsevier Science, Vol. 35, no. 6, pp 561-574.
46. Al-Kaisy, A., and Hall, F. L. (2001) "Examination of the Effect of Driver Population at Freeway Long-Term Reconstruction Zones" *In Transportation Research Record 1776*, Transportation Research Board, pp. 35-42.
47. Hall, F. L., Wakefield, S., and Al-Kaisy, A. (2001) "Freeway Quality of Service: What Matters the Most to Drivers and Passengers" *In Transportation Research Record 1776*, Transportation Research Board, pp. 17-23.
48. Al-Kaisy, A., Zhou, M., and Hall, F. L. (2000) "New Insights into Freeway Capacity at Work Zones: An Empirical Case Study" *In Transportation Research Record 1710*, Transportation Research Board, pp. 154-160.
49. Al-Kaisy, A. and Hall, F. L., (2000) "The Effect of Darkness on the Capacity of Long-Term Freeway Reconstruction Zones," In *Transportation Research Circular E-C018*. pp. 164-175.
50. Al-Kaisy, A., Stewart, J. A., and Van Aerde, M. (1999) "A Simulation Approach for Examining Capacity and Operational Performance at Freeway Diverge Areas" *Canadian Journal of Civil Engineering*, Vol. 26, pp. 760-770.
51. Al-Kaisy, A., Stewart, J. A., and Van Aerde, M. (1999) "Microscopic Simulation of Lane Changing Behavior at Freeway Weaving Sections," *Canadian Journal of Civil Engineering*, Vol. 26, pp. 840-851.
52. Al-Kaisy, A., Ewan, L., and **Hossain, F.** "Development of Crash Risk Index on Low-Volume Rural Roads," Transportation and Transit Systems: Frontiers in Built Environment, in review.
53. Jafari, A., Al-Kaisy, A., and Washburn, S. (2018) "Investigation of Passing Segment Optimal Length on 2+1 Highways," Transportation Research Records, TRB, Washington, DC, in review.
54. Bell, M., Wang, Y., and Al-Kaisy, A. (2018) "Risk Mapping Wildlife-Vehicle Collisions across the State of Montana," Transportation Research Records, TRB, Washington, DC, in review.

Peer-Reviewed Articles in Conference Proceedings

55. **Jafari, A.**, Al-Kaisy, A., and Washburn, S. (2018) "Passing Lane Optimum Length on Two-Lane Highways," Submitted for presentation at the 98th Transportation Research Board Annual Meeting, Washington, DC, 12-16 January 2019.
56. **Jafari, A.**, Al-Kaisy, A., and Washburn, S. (2018) "Investigation of Passing Lane Effective Length on Two-Lane Two-Way Highways," Presented at the 97th TRB Annual Meeting, January 7-11, 2018.
57. **Jafari, A.**, Al-Kaisy, A., and Washburn, S. (2018) "Evaluation of Passing Lane Design Configurations on Two-Lane Highways," Presented at the 97th TRB Annual Meeting, January 7-11, 2018.
58. Al-Kaisy, A., **Jafari, A.**, and Washburn, S. (2018) "Traffic Operations on Rural Two-Lane Highways: a Review on Performance Measures and Indicators," Presented at the 97th TRB Annual Meeting, January 7-11, 2018.
59. Al-Kaisy, A., and **Siddiqui, S.** (2017) "Drivers' Compliance with a Variable Advisory Speed System along an Urban Freeway Corridor," Presented at the 96th TRB Annual Meeting, January 8-12, 2017.

60. **Siddiqui, S.,** and Al-Kaisy, A. (2017) "Assessing the Safety Effects of an Advisory Variable Speed Limit System along an Urban Freeway Corridor," Presented at the 96th TRB Annual Meeting, January 8-12, 2017.
61. **Siddiqui, S.,** and Al-Kaisy, A. (2017) "Effect of Advisory Variable Speed Limit on The Fundamental Flow Diagrams along Urban Freeway," Presented at the 96th TRB Annual Meeting, January 8-12, 2017.
62. Al-Kaisy, A., and Ewan, L. (2017) "Prioritization Scheme for Proposed RWIS Sites: Montana Case Study," Presented at the 96th TRB Annual Meeting, January 8-12, 2017.
63. Al-Kaisy, A., **Jafari, A.,** and Washburn, S. (2017) "Following Status and Percent Followers on Two-Lane Two-Way Highways: Empirical Investigation," Presented at the 96th TRB Annual Meeting, January 8-12, 2017.
64. Al-Kaisy, A., **Jafari, A.,** and Washburn, S. (2017) "Measuring Performance on Two-Lane Highways: Empirical Investigation," Presented at the 96th TRB Annual Meeting, January 8-12, 2017.
65. Al-Kaisy, A., **Jafari, A.**, Washburn, S., Luttinen, T and Dowling, R. (2016) "Performance Measures on Two-Lane Highways: Survey of Practice," Presented at the Transportation Research Board 95th Annual Meeting, January 10-14, 2016.
66. Al-Kaisy, A., Ewan, L., and **Hossain, F.** (2016) "Economic Feasibility of Safety Improvements: Oregon's Low-Volume Roads Case Study," Presented at the Transportation Research Board 95th Annual Meeting, January 10-14, 2016.
67. Ewan, L., Al-Kaisy, A., and **Hossain, F.** (2016) "Safety Effects of Road Geometry and Roadside Features on Low-Volume Roads," Presented at the Transportation Research Board 95th Annual Meeting, January 10-14, 2016.
68. Wang, Y., Veneziano, D., Russel, S. and Al-Kaisy, A. (2016) "Traffic Safety along Tourist Routes in Rural Areas," Presented at the committee meeting for the Transportation Needs of National Parks and Public Lands Committee (ADA40) during the TRB 95th Annual Meeting, January 10-14, 2016.
69. Sangster, J, Rakha, H., and Al-Kaisy, A. (2015) "Comparative Analysis of the Through-about, Roundabout, and Conventional Signalized Intersection Designs" Presented at the TRB 94th Annual Meeting, January 2015.
70. **Ewan, L**., Al-Kaisy, A. and Veneziano, D. (2013) "Weather Sensing and Road Surface Conditions: Is Technology Mature for Reliable ITS Applications?" Presented at the Transportation Research Board 92nd Annual meeting in Washington DC, January 13-17.
71. Al-Kaisy, A., Veneziano, D. Dorrington, C., and **Kirkemo, Z.** (2012) "Usage Estimation at Rest Areas on Rural Interstate and Arterial Highways: Practical Guidelines" Presented at the Transportation Research Board 91st Annual Meeting in Washington, D.C., January 22-26.
72. Al-Kaisy, A. and **Durbin, C.** (2011) "Platooning on Two-Lane Two-Way Highways: An Empirical Investigation" Proceedings of the 6th International Symposium on Highway Capacity and Quality of Service, Stockholm, Sweden, June 28-July 1, Elsevier, Volume 16.
73. Al-Kaisy, A. and **Freedman, Z.** (2011) "Empirical Examination of Passing Lane Operational Benefits on Rural Two-Lane Highways," Proceedings of the 6th International Symposium on Highway Capacity and Quality of Service, Stockholm, Sweden, June 28-July 1, Elsevier, Vol. 16.
74. Al-Kaisy, A., **Roefaro, S.** and Veneziano, D. (2011) "Effectiveness of Signal Control at Channelized Right Turning Lanes: An Empirical Study" Presented at the 90th TRB Annual meeting, Jan. 23-27.
75. Al-Kaisy, A., **Church, B.** Veneziano, D. and Dorrington, C. (2011) "Investigation of Parking Dwell Time at Rest Areas on Rural Highways," Presented at the 90th TRB Annual meeting, Jan. 23-27.
76. Ismeik, M. and Al-Kaisy, A. (2011) "Characterization of Cell Phone Use while Driving: The Jordan Experience," Presented at the 90th TRB Annual meeting, January 23-27.

77. Al-Kaisy, A., **Kirkemo, Z.**, Veneziano, D. and Dorrington, C. (2011) "Traffic Usage of Rest Areas on Rural Highways: A Recent Empirical Study" Presented at the 90th TRB Annual meeting, January 23-27.
78. Al-Kaisy, A. and **Roefaro, S.** (2010) "Channelized Right-Turn Lanes at Signalized Intersections: A Review of Practice," The Fourth International Symposium on Highway Geometric Design, Valencia, Spain, June 1-5.
79. Al-Kaisy, A., ***Kreider, T.*** and ***Pothering, R.*** (2010) "Speed Selection at Sites with Restrictive Geometries: A Case Study," The 20th Canadian Multidisciplinary Road Safety Conference, Niagara Falls, Canada, June 6-9.
80. Al-Kaisy, A. and **Freedman, Z.** (2010) "Estimating Performance on Two-Lane Highways: Case Study Validation of a New Methodology," Presented at the Transportation Research Board 89th Annual Meeting, January 10-14.
81. Al-Kaisy, A., Hardy, A., and ***Nemfakos, C.*** (2009) "Static Warning Signs of Occasional Hazards: Do They Work?" The Canadian Multidisciplinary Road Safety Conference, Saskatoon, Canada, June 7-10.
82. Al-Kaisy, A. and **Karjala, S.** (2008) "Indicators of Performance on Two-Lane Rural Highways: An Empirical Investigation." Presented at the Transportation Research Board 87th Annual Meeting, Washington D.C., January 13-17.
83. Al-Kaisy, A. and **Karjala, S.** (2008) "Car-Following Interaction and the Definition of Free-Moving Vehicles on Two-Lane Rural Highways." Presented at the Transportation Research Board 87th Annual Meeting, Washington D.C., January 13-17.
84. Al-Kaisy, A. and **Durbin, C.** (2007) "Estimating Percent Time Spent Following on Two-Lane Highways: Field Evaluation of New Methodologies" Presented at the Transportation Research Board 86th Annual Meeting, January 21-25.
85. Rakha, H., Hancock, K., and Al-Kaisy, A. (2007) "Estimating Truck Equivalencies for Freeway Sections" Presented at the Transportation Research Board 86th Annual Meeting, January 21-25.
86. Al-Kaisy, A. and **Freedman, Z.** (2006) "Weather Responsive Signal Control: Practical Guidelines," Presented at the Transportation Research Board 85th Annual Meeting, January 22-26.
87. Hardy, A., **Lee, S.**, and Al-Kaisy, A. (2006) "Effectiveness of Animal Advisory Messages on Dynamic Message Signs as a Speed Reduction Tool: A case study in rural Montana" Presented at the Transportation Research Board 85th Annual Meeting, January 22-26.
88. Al-Kaisy, A. and ***Kerestes, E.*** (2005) "Evaluation of the Effectiveness of Single-Lane Two-Way Traffic Control at Maintenance & Reconstruction Zones" Presented at the Transportation Research Board 84th Annual Meeting, Washington, D.C., 9-13 January.
89. Al-Kaisy, A., **Bhatt, J.**, and Rakha, H. (2003) "Modeling the Effect of Heavy Vehicles on Sign Visibility at Multilane Highways," presented at the Transportation Research Board 82nd Annual Meeting in January 2003.
90. Rakha, H. A., Katz, B., and Al-Kaisy, A. (2003) "Field Evaluation of Weigh-in-Motion Screening on Truck Weigh Station Operations," IEEE Intelligent Vehicle Symposium, Columbus, OH, June 9-11.
91. Al-Kaisy, A., **Bhatt, J.** and Rakha, H. (2003) "Assessing the Effect of Heavy Vehicles on the Visibility of Traffic Signs at Multilane Highways," presented at the Transportation Research Board 82nd Annual Meeting in January 2003.
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96. Al-Kaisy, A., Hall, F. L., and ***Reisman, E.*** (2001) "Developing Passenger Car Equivalents for Heavy Vehicles on Congested Freeways: A Capacity-Based Approach" Presented at the Transportation Research Board 80th Annual Meeting, Washington, D.C., January 7-11.
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100. Al-Kaisy, A., and Hall, F. L. (2000) "The Effect of Darkness on the Capacity of Long-Term Freeway Reconstruction Zones," Presented at the Fourth International Symposium on Highway Capacity, Maui, Hawaii, June 27-July 1.
101. Al-Kaisy, A., and Stewart, J. A. (1999) "Warrants for Protected Left-turn Phase at signalized Intersections," Proceedings of the Transportation Research Board 78th Annual Meeting, Washington D.C., January 7-13.

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102. Bertini, R., Downey, M., Al-Kaisy, A., Ewan, L., and Veneziano, D. (2015) Effects of Adverse Weather on Freeway Performance and Potential Performance Benefits From Variable Advisory Speed System, Portland State University Research Symposium, Portland, Oregon.
103. Bertini, R., Downey, M., Al-Kaisy, A., Ewan, L., and Veneziano, D. (2014) "Evaluation of Weather Responsive Variable Advisory Speed System in Portland, Oregon," Proceedings of the 21st World Congress on Intelligent Transport Systems, Detroit, Michigan, September 2014.
104. **Freedman, Z.** and Al-Kaisy, A. (2014) "Investigation of Performance and Lane Utilization within a Passing Lane on a Two-Lane Rural Highway" Presented at the TRB Symposium Celebrating 50 Years of Traffic Flow Theory, Portland, Oregon, August 11-13, 2014.
105. **Ewan L.**, Al-Kaisy, A. and Veneziano, D. (2013) Development of Weather-Responsive Variable Speed Limit System, National Rural ITS Conference, St. Cloud, Minnesota, August 25-28, 2013.
106. Al-Kaisy, A., Veneziano, D. and **Ewan, L.** (2012) "Weather Based Variable Speed Limits" Presented at the Northwest Transportation Conference, Kiewit Center for Infrastructure and Transportation, Oregon State University, Corvallis, Oregon, February 7-9, 2012.
107. ***Watson, D.,*** Al-Kaisy, A., and ***Anderson, N.*** (2012) "Examining the Effect of Speed, Roadside Features and Roadway Geometry on Crash Experience along a Rural Corridor," Presented at the Southeastern Transportation Center Student Poster Session held in conjunction with the Transportation Research Board (TRB) 91st Annual Meeting, January 22-26, 2012.
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HONORS AND AWARDS

- Recipient of the *College of Engineering Excellence in Research Award 2018*
- Nominee for the *College of Engineering Excellence in Research Award 2017*
- Recipient of the Albert Nelson Marquis Lifetime Achievement Award 2017
- Editorial Board Member, Transportation and Transit Systems, Frontiers in Built Environment
- Editorial Board Member, International journal for Traffic and Transport Engineering (IJTTE)
- Recipient of the Iraqi Talent Award, Iraqi Academic Conference, The National Academies, Washington, DC, March 14-15 2009.
- Member, Iraqi American Academic and Professional Community (IAAPC) – Civil Engineering Committee
- Leadership MSU Program 2008-2009
- Recipient of Caterpillar Fellowship, Bradley University 2003
- GRASP Award, Bradley University, 2001 and 2002
- Queen's Graduate Fellowship; 1998-1999
- Queen's Graduate Awards; 1998-1999, 1997-1998, 1996-1997
- Samuel McLaughlin Fellowship; 1997-1998
- Carleton University Graduate Award and Fellowship; 1996-1997
- Sabbatical leave, 2011-2012

Professional Affiliations

- Professional Engineer: State of Montana, License # 18377
- Member, Institute of Transportation Engineers, 2003-present
- Member, American Society for Engineering Education (ASEE), 2008-2010, 2016-present
- Member, TRB Joint Sub-Committee ABG10(1) "Ahead of the Curve: Mastering the Management of Transportation Research"
- TRB University Representative 2004-present
- Canadian Association of Road Safety Professionals, 2004 and 2009-2011
- Member, ROI subcommittee, TRB Visualization in Transportation Committee (ABJ95), 2009
- Transportation Research Board (TRB) individual affiliate 1998-2006
- American Society of Civil Engineers 2001-2003
- Canadian Society of Civil Engineering 1999-2000, 2004-2005
- Member, Council on Undergraduate Research (CUR) 2009-present
- International Society of Iraqi Scientists 2001-present
- Iraqi Society for Higher Education Abroad 2005-present
- Order of the Engineers 2007-present