

Quarterly Progress Report #22

To the

National Cooperative Highway Research Program
(NCHRP)

On Project 17-54

CONSIDERATION OF ROADSIDE FEATURES IN THE HIGHWAY SAFETY MANUAL

Limited Use Document

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For period
July 1 to September 30, 2016

From
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Introduction

The objective of this research is to develop quantitative measures that can be incorporated into the HSM to evaluate the effects of roadside designs and features on the frequency and severity of lane departure crashes. This report describes the progress achieved in this project in the previous quarter with respect to the tasks identified in the work plan. The following sections will describe the task-by-task progress identifying work items accomplished and any problems encountered in the research.

A section describing the contractual status of the project (i.e., funding, schedule, etc.) appears at the end of the report and the progress summary tables and plots appear in [Attachment A](#). [Attachment B](#) contains responses to panel comments from the last QPR. This quarterly report and attachments as well as all previous QPRs can be found at <http://www.roadsafellc.com/NCHRP17-54/QPR>. In order to comply with NCHRP requirements regarding the Limited Use of project documents, all the attachments are located in a password-protected subdirectory. The password for all the project documents is “HSMROR.”

PHASE I

Task 1. Literature Review

Conduct a literature review of the analysis methods to quantify lane departure crashes including those used in the HSM and RSAP.

The task is complete and documented in the first interim report.

Task 2. Identify CMFs and Data Sources

Identify CMFs and available data sources related to lane departure crashes from completed and ongoing research projects.

The task is complete and documented in the first interim report.

Task 3. Survey of Practice

Survey practitioners, researchers, design consultants and transportation agencies to assess their current model uses and needs as they relate to roadside safety during the planning and design stages. The survey should also solicit input about specific roadside concerns or areas of need regarding additional CMFs.

The task is complete and documented in the first interim report.

Task 4. Compare HSM and RSAP

Document the strengths and weaknesses and differences between the HSM prediction models and RSAP and identify opportunities to provide consistency through updating data sources, base models, or modification factors.

The task is complete and documented in the first interim report.

Task 5. Sample Scenarios

Analyze sample scenarios for comparison between the HSM prediction models and RSAP. These scenarios should consider: rural 2-lane (level, rolling, and mountainous terrain), rural multilane (level, rolling, and mountainous terrain), and urban arterial. Long and short segment lengths as well as planning and design should be considered.

The task is complete and documented in the first interim report.

Task 6. Recommendations for Future Development Efforts

Develop recommendations that as a minimum address: (1) model applicability; (2) appropriateness of continued parallel development of both methods for roadside safety assessment or, if one method should be chosen, for future development efforts; and (3) methods and coding for the possible inclusion of RSAP as a module in the IHSDM.

The task is complete and documented in the first interim report.

Task 7. Prioritized List of Roadside CMFs

Develop a prioritized list of roadside CMFs that should be evaluated for development and possible inclusion in future versions of the HSM.

The task is complete and documented in the first interim report.

Task 8. Interim Report and Meeting

Submit an interim report that includes the findings from Tasks 1 through 7 and an updated work plan for Phase II.

The task is complete and documented in the first interim report.

PHASE II

As part of the development of the Phase II work plan, some of the tasks as presented in the original proposal were re-arranged and re-named to better conform to the work flow decided upon at the Interim Report panel meeting. The following section, therefore, reflects the task numbers, titles and descriptions as shown in the work plan rather than the original proposal.

The research team suggested and the Program Officer agreed that it would be useful to prepare a second interim report for the project that summarized the findings of Phase II (i.e., Tasks 9 and 10) to-date as well as presented a research plan for pursuing Phase III once that funding is awarded. The second interim report was attached to the

June 2014 QPR as [Attachment C14](#) and an interim report panel meeting was held November 7, 2014 in Washington, D.C.

Task 9. Develop Roadside SPFs for Rural Areas

Develop objective roadside SPFs using the HSM protocols for the base conditions outlined in Volumes 2 and 3 of the Highway Safety Manual for rural divided and undivided highways.

This task is now complete.

Task 10a-d. Develop CMFs

Develop objective CMFs for use with the roadside SPFs developed in Task 9 using the HSM protocols for the base conditions outlined in Volumes 2 and 3 of the Highway Safety Manual for rural divided and undivided highways.

This task consists of the following four subtasks as described below:

- a) Field Data Collection
- b) CMFs using Crash Data
- c) CMFs using RSAPv3
- d) Apply Inclusion Rule

Task 10a: Field Data Collection

This task has been canceled.

Task 10b: CMFs using Crash Data

The subtask to develop CMFs from crash data is complete.

Task 10c: CMFs using RSAPv3

The preliminary results for the undivided and divided roadways were documented in [Attachment C19](#).

Task 10d: Apply Inclusion Rule

This subtask is now complete.

PHASE III

A request for continuation funding for a Phase III for this project was forwarded to AASHTO SCOR in the fall of 2013 and approved by SCOR at their spring 2014 meeting. The Phase III contract modification was issued by NCHRP on 4 April 2015. The 2nd Interim Report was submitted with the September 2014 QPR ([Attachment C14](#)). The Phase III tasks are outlined below. Work began in September 2015 with the identification of data sources for Phase III.

Task 11. &15 Modifications to RSAPv3 and Coordination with the IHSDM

Depending on the outcome of Phase I, Task 6, prepare recommendations for potential modifications to the RSAP model and coordinate new roadside SPFs and CMFs with the FHWA IHSDM development team.

As discussed at the second interim report meeting, this task will be postponed until the Phase II and Phase III results can be implemented at the same time.

Task 12. &16 Final Report

Submit a final report documenting the entire research project. CMFs developed from this research should be documented in separate appendices that include, as a minimum, data sources, sample size, and analysis methodology

The research team has started compiling a working draft final report this quarter. Given the incomplete research tasks, this working draft is necessarily incomplete. The purpose of starting this draft now is to compile the research completed to date since many of the initial modeling efforts are complete. We anticipate various chapters will be developed and shared here in the coming quarters.

The team anticipates reviewing the results of each task to develop finalized models. This effort may compel some additional modeling, but will ultimately result in a unified approach to modeling ROR crashes. Finalized modeled were developed and documented this quarter, as part of this effort, for the SPF_{EDGE}. [Attachment E22](#), discussed below, is a working draft of the SPF_{EDGE} chapter for the final report.

The final report will also include documentation of the data sources used in this effort, appended to the final report as an appendix. The documentation of the data sources used in this effort was accomplished this quarter. The working draft of the appendix documenting the data sources is included here as [Attachment F22](#).

Task 13 Develop SPF_{EDGE} for Restricted Environments

The objective of this task is to generate SPF_{EDGE} for both divided and undivided low-speed restricted environments.

The exploration of data available for the modeling of the Phase III SPF_{EDGE} was completed last quarter and documented in [Attachment C21](#). Recall the North Carolina data were requested from HSIS following the second interim report meeting. After working with the data, updated and corrected files were requested and received in September 2015 from HSIS. These updated fields allowed the team to conclude that the North Carolina data would be an effective data source for modeling in Phase III. Through analysis of the data set, additional questions became apparent about the surface

width and inconsistencies in the data. These questions were presented to the HSIS in December 2015 who responded with updated instructions on interpreting the variables.

Inconsistencies persisted in the analysis of the NC data, resulting in a third inquiry to HSIS this quarter (i.e., July 2016). The HSIS team sent a third updated file in July of 2016. The inconsistencies continued to persist. In August 2016, the HSIS team acknowledged that some variables were not captured consistently and there is no remedy for the inconsistencies. Unfortunately, much time has been lost trying to work through these issues. The research team has determined that the NC data cannot be used.

Despite these data setbacks, considerable progress was made this quarter on SPF modeling. Recall this task was for the exploration of high-speed urban environments and low-speed urban and rural environments. SPF_{EDGE} was developed for high-speed urban environments this quarter and is documented in [Attachment C22](#) for both divided and undivided roadways. This attachment simply presents the technical results, with little discussion about modeling techniques or interpretation as these discussions were previously held and we were trying to avoid the need for re-reading and re-writing of the same text.

Full cross-sectional models were also developed for these divided and undivided high-speed urban areas (see [Attachment D22](#)). These full models are typically used to develop geometric CMFs such as those used to represent the influence of curve, grade, or speed limit. It was found that posted speed limit does not present a clear trend for crash frequency. Recall this was previously found for high-speed rural areas under the modeling completed in Phase II.

The research team had suggested reviewing speed as a major design constraint. In light of the evidence presented by these newly developed models (i.e., urban high speed) and the previously developed models (i.e., rural high speed), it can be concluded that speed does not present clear trend toward predicting ROR crash frequency. We therefore recommend removing the posted speed limit limitation from the SPF development.

The full cross-sectional models for high-speed urban areas (see [Attachment D22](#)) do, however, indicate that the highway characteristics of urban and rural areas have differing influence on predicting ROR crash frequency. For example, the coefficient for PT in the rural model is negative while it is positive in the urban model. We therefore further recommended maintaining the distinction between the urban and rural models.

In summary, the research team recommends that divided and undivided SPF_{EDGE} models be considered separately for urban and rural environments. These finalized SPF_{EDGE} models were developed this quarter and are included here as [Attachment E22](#). This task is now complete.

Task 14a-c Develop CMFs

Develop objective CMFs for use with the roadside SPFs developed in Task 13.

This task consists of the following three subtasks as described below:

- Task 14a: Inventory Roadside Features
- Task 14b: Develop Phase III CMF_{ROADWAY}
- Task 14c: Develop Phase III CMF_{ROADSIDE}

Task 14a: Inventory Roadside Features

This subtask was initiated in September 2015.

Task 14b: Develop CMF_{ROADWAY}

Considerable progress was made on this subtask this quarter. CMF_{ROADWAY} for the high-speed urban environments was developed and is documented in [Attachment D22](#). This modeling, however, will be updated to include the final model forms shown in [Attachment E22](#). It is anticipated this remodeling will be completed this quarter so this task is nearing completion and is anticipated to be complete next quarter.

Task 14c: Develop CMF_{ROADSIDE}

This subtask was initiated last quarter. A Slope CMF was developed and documented in [Attachment D21](#). A paper was developed from the results presented to the research panel last quarter and submitted to the 2017 Annual TRB meeting for consideration of presentation and publication. A copy of the draft paper is included here as [Attachment G22](#). Pending the completion of the SPF and CMF modeling and Phase III, the results will be finalized.

Considerable effort will be paid to additional roadside CMFs upon completion of SPF_{EDGE} and CMF_{ROADWAY}. The research team is excited to enter what we consider the most interesting portion of this project. We are anticipating much of our efforts to be spent on this subtask and considerable results in the coming quarters.

Contractual

The project was initiated on April 4, 2011. Phase I was completed after the interim report panel meeting on May 8, 2012. The research team received authorization from the NCHRP Program Officer to proceed with the Phase II work plan on July 12, 2012 and Phase II was officially started at that time. The PI requested a 12-month no-cost time extension from the NCHRP Senior Program Officer in May 2013 and the extension was granted on May 24, 2013. A continuation request was submitted to AASHTO SCOR in November 2013 in order to add Phase III to the project. The continuation request was approved by SCOR in March 2014 and the NCHRP issued the contract modification for Phase III on 4 April 2015. Authorization to proceed with Phase III was received 1 July 2015 from the Program Officer. A second contract modification was processed on July 1, 2014 to extend the contract end date to July 31, 2015 to allow time for the Phase III funding modification to be processed. A contract modification was issued on March 17, 2015 to fully fund the project at \$1,310,000 and extend the contract completion date to November 30, 2016. A 5th contract modification was issued on June 27, 2016 to extend the contract end date to December 31, 2017.

A summary of the progress and fiscal status of the project is shown in [Attachment A](#). [Attachment A](#) has been revised and updated to reflect the financial and schedule changes executed in contract modification #5 (i.e., adding Phase III funding and changing the end-date to December 31, 2017).

The team will continue to reach out to the appropriate AASHTO and TRB committees as the research progresses to keep them informed about the status and findings of the project.

Sincerely,

A handwritten signature in black ink, appearing to read 'M. H. Ray', with a long horizontal stroke extending to the right.

Malcolm H. Ray, P.E., Ph.D.

- Attachment A: [Progress and Fiscal Summary](#)
- Attachment B: [Responses to Panel Comments](#)
- Attachment C: [High Speed Restricted SPF_{EDGE}](#)
- Attachment D: [High Speed Restricted CMF_{ROADWAY}](#)
- Attachment E: [Finalized Rural and Urban SPF_{EDGE}](#)
- Attachment F: [Documentation of Data Sources](#)
- Attachment G: [TRB 2018 Slope CMF Paper](#)