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A pedestrian refuge island in a roadway. Safety for nonmotorists also is part of the NCHRP research portfolio.

of the Highway Safety Improvement Program. *Investigation of Existing and Alternative Methods for Combining Multiple CMFs* (2010) presents issues in the application of multiple CMFs and offers guidance for estimating the effects of combined treatments.<sup>11</sup>

NCHRP Project 20-7(314), Recommended Protocol for Developing Crash Modification Factors, has outlined a process for developing CMFs. The findings describe the necessary documentation and how to address potential biases.

The NCHRP Report 600 series focuses on road user capabilities and on limitations in road design and operations.<sup>12</sup> The guidelines are useful for diagnosing the contributing factors in collisions and for the selection of countermeasures.

## Training and Implementation

Training is a critical component of the HSM.

<sup>11</sup>[www.cmfclearinghouse.org/collateral/Combining\\_Multiple\\_CMFs\\_Final.pdf](http://www.cmfclearinghouse.org/collateral/Combining_Multiple_CMFs_Final.pdf).

<sup>12</sup>[http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp\\_rpt\\_600A.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600A.pdf); [http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp\\_rpt\\_600B.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600B.pdf); and [http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp\\_rpt\\_600C.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600C.pdf).

NCHRP Project 20-7(290), Highway Safety Training Synthesis, surveyed the safety training available and developed a roadmap and central database of the information. NCHRP Project 17-38, Development of Overview Training for the HSM, assisted FHWA and others in preparing to implement the HSM.

The first of many research publications supporting HSM implementation was NCHRP Research Results Digest 329, *Highway Safety Manual Data Needs Guide*.<sup>13</sup> The guide assists users in understanding the data needed for the Part C methodologies and explains the difference between available data and the data needed in the future.

NCHRP Project 17-50, Lead States Initiative for Implementing the HSM, started after the successful Safety Performance Function Summit hosted by Illinois DOT through the efforts of State Safety Engineer Priscilla Tobias; the summit focused on the use of quantitative tools in highway safety. The project has established a dialogue among states that have experience in quantifying safety, to inform other states,

<sup>13</sup>[http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp\\_rtd\\_329.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rtd_329.pdf).

# Roadside Safety Analysis Program, Version 3

## Upgrading a Tool for Roadside Safety Design

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The Roadside Safety Analysis Program (RSAP) was developed to update and enhance the cost-effectiveness analysis algorithms and procedures of the ROADSIDE software package included in the *Roadside Design Guide*, published by the American Association of State Highway and Transportation Officials (AASHTO). The program and its interface recently have undergone an extensive upgrade, incorporating new research results and enhancing the computing capabilities and ease of use.

Version 3 of RSAP (RSAPv3) soon will be available electronically at no charge from AASHTO to purchasers of the *Roadside Design Guide*. The National Cooperative Highway Research Program is preparing to publish a final report that contains a user's manual with detailed, how-to explanations and an engineer's manual tracing the technical background behind the code, as well as the methodologies for the analyses. The software, manuals, and example problems are available on the website of the AASHTO Technical Committee for Roadside Safety.<sup>a</sup>

As the benefit–cost tool for the 2011 edition of the *Roadside Design Guide*, RSAPv3 assists in performing roadside safety eco-



Version 3 of the Roadside Safety Analysis Program (RSAPv3) was developed as a tool for the 2011 Roadside Design

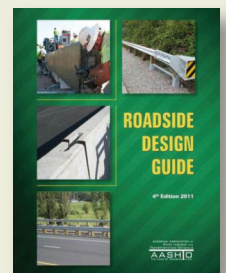
nomics analyses and serves as an alternative to the warranting approach also included in the guide. RSAPv3 incorporates substantive advances in roadside safety in the decade since the previous version; this required rewriting the code and developing new methods and techniques.

An encroachment-based approach, RSAPv3 divides collisions into three independent events:

1. The encroachment, when the vehicle first leaves the road;
2. The traversal of the roadside, where hazards may be located; and
3. The severity of the crash when a vehicle intersects a roadside hazard.

RSAP performs this series of calculations many times, simulating tens of thousands of encroachments for a typical roadway segment and estimating the crash costs of each possible encroachment. After generating all the encroachments and the estimated crash costs, the program produces an estimate of the total crash cost for the segment.

RSAPv3 can evaluate up to five design alternatives on up to



<sup>a</sup><http://design.transportation.org/Pages/RoadsideSafety.aspx>.

and is developing a user guide for the HSM. The FHWA Pooled Fund Study for HSM Implementation is under way to advance the lead states initiative and to expand implementation to all states.<sup>14</sup>

## Toward Future Editions

NCHRP Project 20-7(279), Work Plan for the 2nd Edition of the HSM, is a comprehensive effort to assess future research needs for the manual. Surveys of safety professionals have helped the AASHTO Task Force on the HSM and the TRB Highway Safety Performance Committee prioritize research efforts.

The first edition of the HSM included only a few roadside countermeasures. NCHRP Project 17-54, Consideration of Roadside Features in the *Highway Safety Manual*, recognizes the role of roadside features in crashes and is exploring the differences between the HSM and the NCHRP-developed Roadside Safety Analysis Program (RSAP), including the comparative strengths and weaknesses of each and ways to address the differences. The project also is identifying ongoing roadside research, CMFs research, and needed CMFs

<sup>14</sup>Transportation Pooled Fund 255; [www.pooledfund.org/Details/Study/484](http://www.pooledfund.org/Details/Study/484).

and aims to develop CMFs.<sup>15</sup>

NCHRP Project 17-56, Development of Crash Reduction Factors for Uncontrolled Pedestrian Crossing Treatments, looks to quantify the relationship between pedestrian crashes and crossing treatments. The research will evaluate various crossing treatments and will develop CMFs for crash type and severity.<sup>16</sup>

The ability to assess crash injuries accurately is critical in the selection of appropriate countermeasures; however, police reports of crash injuries often lack accuracy. NCHRP Project 17-57, Development of a Comprehensive Approach for Serious Traffic Crash Injury Measurement and Reporting Systems, is developing a framework for moving to International Statistical Classification of Diseases and Related Health Problems codes and to provide a process for linking crash data with hospital discharge data. The findings may provide a new injury scale for the HSM.<sup>17</sup>

<sup>15</sup><http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2979>.

<sup>16</sup><http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3178>.

<sup>17</sup><http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3179>.

20 highway segments and can compare the benefit–cost ratio of each alternative. The program identifies the alternative that makes best use of the funds.

The encroachment module in RSAPv3 takes into account the frequency of roadside encroachments by highway type and traffic volume. Adjustment factors are included for the effects of horizontal curvature, grade, number of lanes, lane width, access density, and posted speed limit.

RSAPv3 incorporates data on vehicle trajectories during an encroachment. The trajectories are superimposed on the user-entered data for roadside terrain, and the program assesses all possible interactions of trajectories with user-entered hazards.

RSAPv3 replaces the subjective severity index with an objective fatal crash cost ratio based on observed, police-reported crash data. RSAPv3 also accounts for unreported crashes—which can be considered roadside safety successes. The program includes a preloaded selection of crash severity models for many common roadside hazards, such as trees, utility poles, guardrails, and bridge piers.

The final report and its appendices document the methods and procedures in developing RSAPv3 and include a selection of case studies to illustrate use of the program. RSAPv3 provides roadside designers with an effective tool for making decisions about roadside safety designs.

## Resources

Mak, K. K., D. L. Sicking, and B. A. Coon. *NCHRP Report 665: Identification of Vehicular Impact Conditions Associated with Serious Ran-off-Road Crashes*. Transportation Research Board of the National



Photo: Mike Lee

*A median cable barrier on I-470 in Ohio prevented this tractor-trailer from reaching the opposite lanes of the highway in a crash. Roadside traversals are among the collision events analyzed by RSAPv3.*

Academies, Washington, D.C., 2010. [http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp\\_rpt\\_665.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_665.pdf).

NCHRP Project 17-43: Long-Term Roadside Crash Data Collection Program. <http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=1637>.

*Roadside Design Guide, 3rd Edition*. American Association of State Highway and Transportation Officials, Washington, D.C., 2006.

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