SAFER ROADS THROUGH BETTER DESIGN

Using the Interactive Highway Safety Design Model

Improving roadway safety continues to be at the forefront of all stages of project development, including planning, alternatives analysis, design, construction, and operations. Advanced analysis methods and tools have been developed to help practitioners improve safety. One tool available now to estimate a project's substantive safety is the Interactive Highway Safety Design Model (IHSDM). IHSDM supports performance-based practical design (PBPD) via implementation of *Highway Safety Manual* (HSM) Part C predictive methods and can be an integral part of the Road Safety Audit process.

The IHSDM contains six modules: Crash Prediction, Design Consistency, Intersection Review, Policy Review, Traffic Analysis, and Driver/Vehicle. This FREE software package helps users identify areas of safety concern within a given facility, and IHSDM outputs assist agencies in determining how to best invest limited resources to improve safety performance. Results from the model help project developers identify and justify safety-related design decisions.

Who should use the IHSDM?

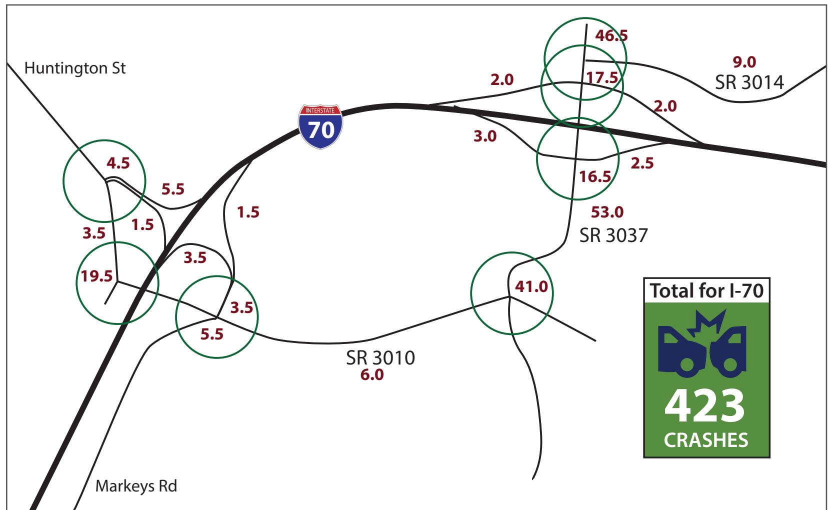
- **Project analysts, designers, and managers**
- **State and local highway agencies and their consultants**
- **Transportation research and academic communities**

Using the Crash Prediction Module to Implement HSM Part C Methods

Since 2010, practitioners have used the HSM to estimate predicted crash frequency and severity based on the characteristics of a particular roadway.[1] The IHSDM's crash prediction module (CPM) – which incorporates the most current analytical methods – directly implements Part C of the HSM to:

- Predict crash frequency for highway segments, intersections, and interchanges;
- Evaluate the safety effects of highway improvements and treatments;
- Compare relative safety performance of design alternatives; and
- Assess the safety and cost-effectiveness of design decisions.[2]

Predicted Crashes from 2018 to 2038



Predicted crash frequency by segment for an example highway project alternative.

The CPM has the ability to evaluate all roadway types covered in HSM Part C, including rural two-lane highways, rural multilane highways, urban/suburban arterials, freeway segments, and freeway ramps/interchanges (including ramps, collector-distributor roads and ramp terminals). It estimates the frequency and severity of expected crashes at a location based on its geometric design and traffic characteristics.[3]

Why use the IHSDM CPM to implement HSM Part C methods?

- ✓ Applies to all facility types covered in HSM Part C.
- ✓ Offers the ability to import data from CAD files rather than enter in data by-hand.
- ✓ Automatically segments highways for evaluation using HSM Part C segmentation rules.
- ✓ Uses the Empirical-Bayes process.
- ✓ Implements the calibration procedures described in the Appendix to HSM Part C.
- ✓ Allows agencies to enter their own Safety Performance Functions.
- ✓ Graphically displays crash and roadway data outputs, allowing users to quickly and easily identify potential safety concerns.

Supporting Performance-Based Practical Design

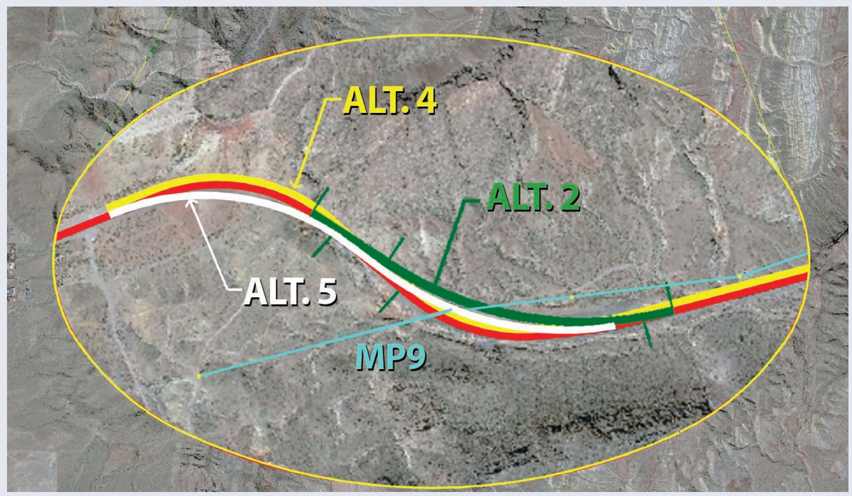
In recent years, agencies have established increasingly flexible project design criteria. The Federal Highway Administration (FHWA) has encouraged PBPD in an effort to ground cost-saving design decisions in a performance-management framework.[4] Several agencies have used the IHSDM to evaluate and optimize their design decisions as they address a project's purpose and need. The IHSDM helps engineers balance short- and long-term project goals while considering operational and safety performance.

For example, a designer determines that the elimination of shoulders and a reduction in lane widths from 12 ft. to 10 ft. will add space for a needed turn lane without the need to acquire right-of-way. Using the IHSDM Crash Prediction Module (CPM), the designer can weigh the overall safety impacts of reducing lane and shoulder widths (which may increase lane departure crashes) and adding a turn lane (which may reduce crashes for turning vehicles).

Nevada SR 147:
Evaluating Safety Performance Using the IHSDM

The Nevada DOT (NDOT) used the IHSDM CPM to apply the HSM predictive method on a rural two-lane section of Nevada State Route (SR) 147 for a 20-year period (2013-2033). The agency targeted this 7-mile corridor because over an 8-year period, there were 39 crashes, including 7 fatal crashes. A high number of crashes occurred at a single reverse curve at milepost (MP) 9. The IHSDM CPM allowed the agency to evaluate and prioritize safety improvement alternatives by estimating expected crash totals for each alternative. NDOT evaluated six safety improvement project alternatives:

1. Add centerline rumble strips for the entire length of project.
2. Improve horizontal geometry for a single curve at MP 9, including shoulder and roadside improvements.
3. Improve superelevation to bring it into compliance with AASHTO recommendations.
4. Add a climbing lane in one direction for a 3.1 mile section, including shoulder and roadside improvements.
5. Redesign the entire reverse curve at MP 9, including shoulder and roadside improvements.
6. Widen shoulders from 1 ft. to 5 ft. and improve roadside conditions for the entire length of project.



Graphical Representation of Alternates 2, 4, and 5 for Reverse Curve at MP 9.

Analysts entered data for the existing condition and for each alternative into the IHSDM CPM to predict the crashes for the next 20 years based on the geometry, projected traffic volumes, and crash history. Projected reductions in the number of total crashes for the study period ranged from 1 crash for Alternative 3 to 19 crashes for Alternative 6.

NDOT compared the reductions in expected crashes to the treatments' cost and performed an economic analysis, including benefit-cost (B/C) ratios, for each alternative. Analysts calculated the monetary value of the crash reduction based on the Nevada 2012 societal cost for crashes. Alternative 1 exhibited the highest B/C ratio (28.4).

	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6
Reduction in Total Crashes	5.4	4.9	1.0	14.2	5.8	19.2
Cost	$66,000	$1,475,000	$945,000	$5,696,000	$2,358,000	$12,114,000
B/C Ratio	28.4	2.6	0.8	1.8	1.8	1.2

This project was presented at the TRB 2013 Annual Meeting. A poster of the project is available for download here: http://www.ihsdm.org/w/images/c/c5/022013_TRB_Poster_NDOT_Final_Mosley.pdf.

How does the IHSDM CPM differ from traditional spreadsheet tools?

Compared to other tools such as the Interchange Safety Analysis Tool – Enhanced (ISATe), the IHSDM CPM provides significant benefits by:

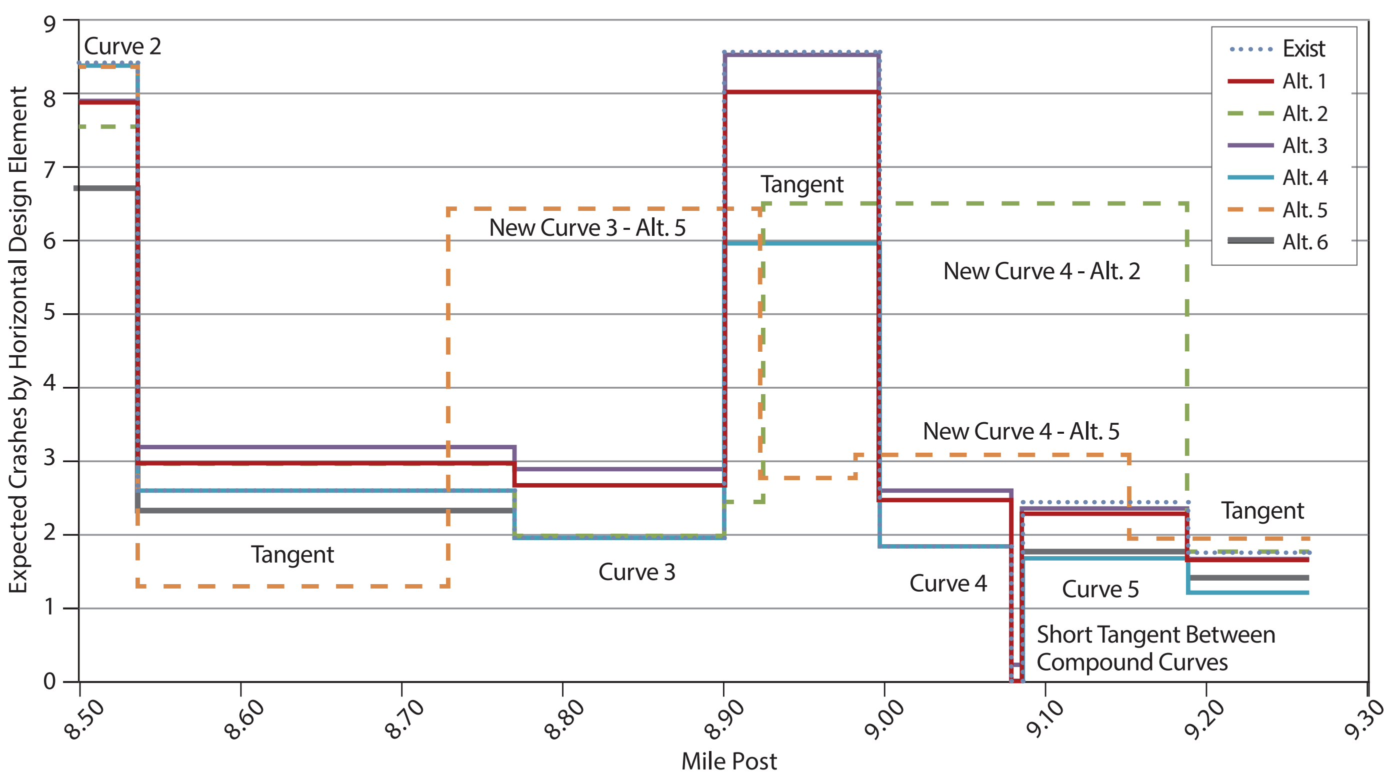
- ***Automatically segmenting*** highways for evaluation through "station-based" data input and analysis,
- Offering more robust reporting capabilities than traditional tools,
- Analyzing both freeway and non-freeway network components (e.g., cross-roads, connectors, local roads, and intersections), and
- Graphically displaying which design features will yield the greatest safety benefit.

The IHSDM CPM also allows the user to ***import project alignment data*** from highway design software via LandXML. Data can be input and analyzed using two methods:

Station-based: automatically segments the highway into homogeneous segments, saving time and reducing the likelihood of user error.

Site-based: functions similar to a spreadsheet tool and is especially useful for projects where detailed, station-based geometry is not available.

Nevada SR 147 Expected Crashes for Curves near MP 9

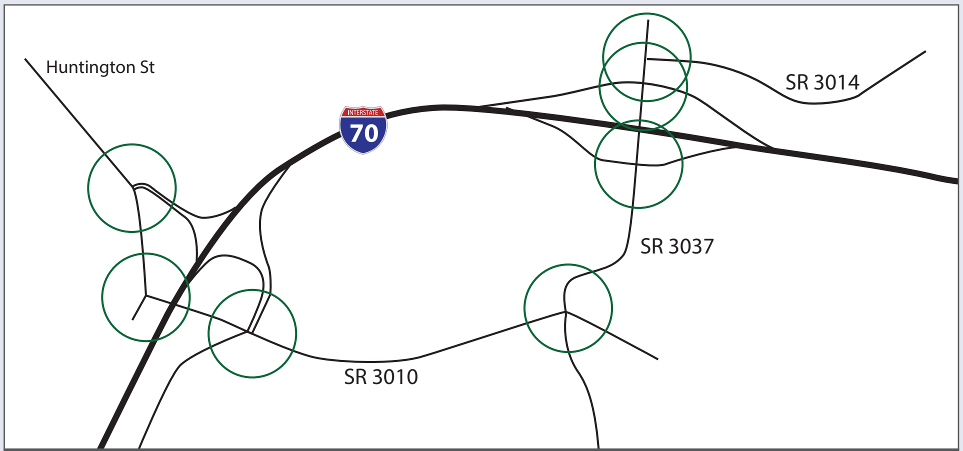


Output derived from IHSDM results graphically displays changes in the expected number of crashes for each alternative.

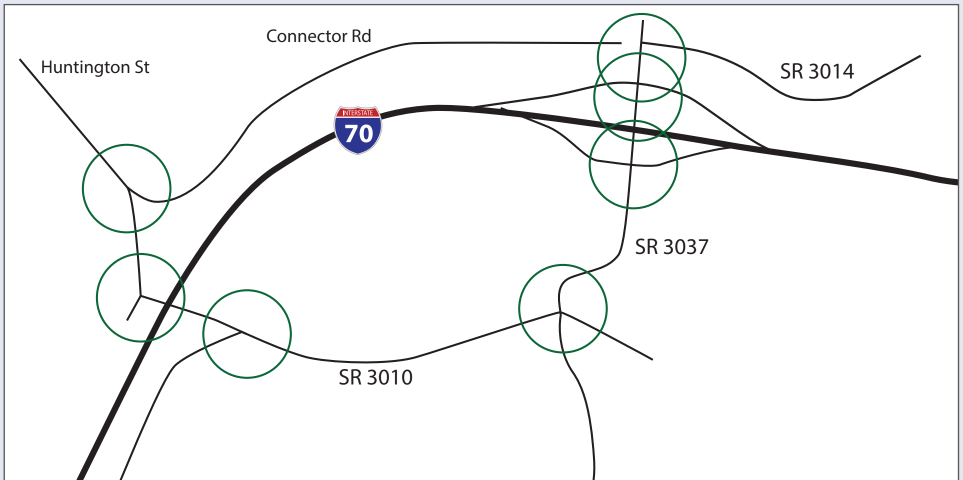
Using the IHSDM to Evaluate Alternative Interchange Designs

The Pennsylvania Department of Transportation (PennDOT) submitted a Conceptual Point of Access (CPOA) request to the FHWA Pennsylvania Division Office for a section of I-70 in Western Pennsylvania, which encompasses two closely spaced interchanges. The CPOA eventually focused on two primary alternatives:

- **Alternative 2A** retained and redesigned the two closely spaced interchanges with some I-70 mainline improvements.
- **Alternative 3** removed one of the interchanges, redesigned the other, and included a new connector road and local roadway network improvements.



Plan view of Alternative 2A in IHSDM Highway Viewer



Plan view of Alternative 3 in IHSDM Highway Viewer

While both alternatives appeared to be acceptable based on engineering and operations review, the FHWA Interstate System Access Informational Guide requires "that the proposed change in access does not have a significant adverse impact on the safety and operation of the Interstate facility."

The FHWA Geometric Design Laboratory (GDL) compiled the necessary data – including average annual daily traffic (AADT), crash data, and alternative geometric elements – to evaluate the alternative designs for a 20-year period (2018-2038). Analysts used the IHSDM CPM to evaluate each entity (freeway segments, ramps, ramp terminals, crossroads, and intersections) for both alternatives. Alternative 2A was superior to Alternative 3 in expected safety performance, in that:

- Expected crashes over 20 years for Alternative 2A were approximately 10 percent fewer than for Alternative 3.
- An analysis of fatal and injury (crashes) showed that Alternative 2A would experience an estimated 15 percent fewer of these crashes than Alternative 3.

This project was presented at the TRB 2016 Annual Meeting. A poster of the project is available for download here: http://ihsdm.org/w/images/c/c8/P16-1759_PA_Use_of_IHSDM_for_I-70_Safety_Analysis.pdf.

Using the IHSDM in Road Safety Audits

In addition to agencies using the IHSDM to improve highway design safety, practitioners have found that the IHSDM is a useful tool during the Road Safety Audit (RSA) process. When RSA teams use the IHSDM modules prior to their assessment, the outputs can help practitioners flag potential problems for detailed field investigation and point them to measures that may mitigate safety issues identified during the RSA. The IHSDM can also help focus an RSA team's efforts, maximizing the efficiency and productivity of the audit process.

In a recent series of RSAs conducted in Montana, Oregon, and Rhode Island, IHSDM results enabled the RSA teams to identify potential crash factors in advance of the RSA and to calculate the effects of potential countermeasures in terms of expected crashes, predicted operating speeds, stopping sight distance, etc. It also improved the potential for the RSA team to identify and prioritize those locations that pose the greatest risk of future crashes, not just locations with a history of reported crashes.[5]

The RSA team identified several benefits of using the IHSDM in the RSA process. The model:

- ✓ Helps RSA teams focus their efforts, especially on longer corridors where completion of an RSA would be time and cost prohibitive.
- ✓ Offers a quantitative methodology to assess safety that:
  - Enables the RSA team to identify potential crash factors, or combinations of crash factors, that may not be readily visible or apparent.
  - Calculates the effects of potential countermeasures in terms of reduced crashes.
  - Maximizes the potential for the RSA team to identify and prioritize those locations that pose the greatest crash risk.

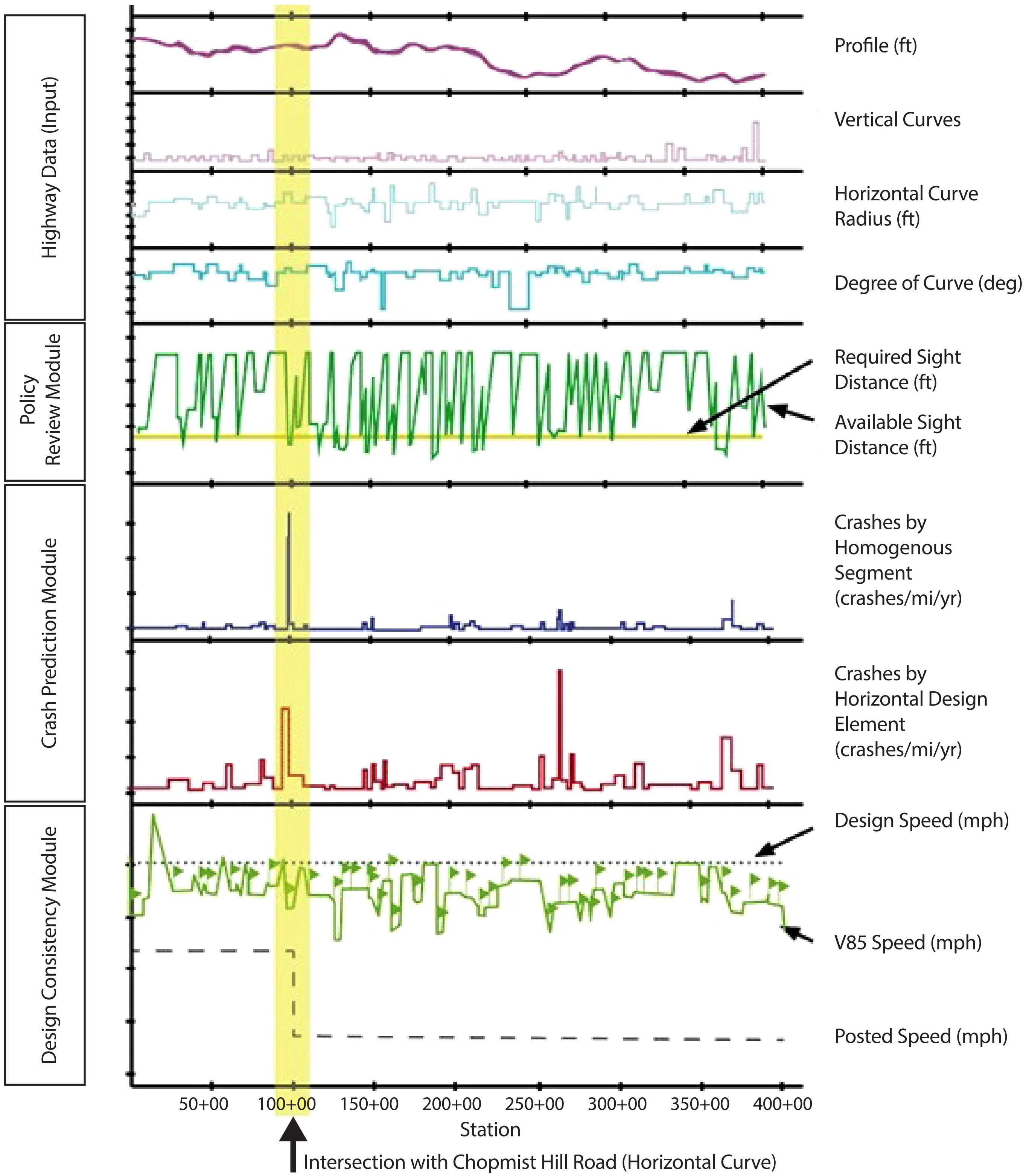
Pairing the IHSDM with RSAs

FHWA and the Oregon Department of Transportation (ODOT) partnered to conduct an RSA along US Highway 97 in south central Oregon, between Modoc Point and Algoma in Klamath County. ODOT noted the presence of narrow shoulders, steep cut and fill slopes, and fixed objects within the clear zone, including barriers, guardrail, and guardrail end terminals that did not meet current standards.

The RSA team reviewed safety conditions on US 97 using recent crash data, local and RSA team inputs, and the IHSDM. The IHSDM enabled the RSA team to graphically compare the existing available stopping sight distance and the stopping sight distance associated with the proposed design. It also predicted crashes along the future roadway based on its geometric characteristics and projected traffic volumes. The IHSDM highlighted locations where drivers may need to decelerate to safely negotiate a horizontal curve, thereby assisting in the prioritization of locations for RSA team review.

The ability to quantify values associated with design issues (e.g., stopping sight distance) and to estimate future crash frequencies based on the road redesign enhanced the value of the RSA by demonstrating the magnitude of the safety issues identified by the RSA team. Without the IHSDM estimates, the RSA team could identify–but could not necessarily quantify–expected changes in safety parameters such as operating speeds or expected crash frequencies. Quantifying these parameters and frequencies provided all parties (the RSA team, Design Team, and Owner) a higher level of confidence in the magnitude and importance of the safety issues identified in the RSA.

RSA IHSDM Output



This IHSDM output visually flags potential problem locations for further investigation by practitioners. The output corresponds to a RSA performed on US Highway 2 in Kalispell, Montana.

Additional Resources and Available Training

The most recent version of the IHSDM – HSM Predictive Method Release can be downloaded for free at: http://www.ihsdm.org after completing a brief online registration and providing e-mail contact information.

Federal Highway Administration's Geometric Design Laboratory (GDL) at the Turner-Fairbank Highway Research Center provides free technical support for IHSDM users.

Website: https://www.fhwa.dot.gov/research/tfhrc/labs/geometric/

Contact: IHSDM.Support@dot.gov and (202)493–3407

Free training on HSM Part C as well as tools such as the IHSDM.

Website: http://safety.fhwa.dot.gov/rsdp/training.aspx

Contact: Gene Amparano

Road Safety Audit Case Studies: Using IHSDM in the RSA Process shows full results of three RSA case studies and is located at: http://safety.fhwa.dot.gov/rsa/case_studies/fhwasa14071/.

More resources are available in the IHSDM Library at: https://www.fhwa.dot.gov/research/tfhrc/projects/safety/comprehensive/ihsdm/libweb.cfm.

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1 American Association of State Highway and Transportation Officials, "An Introduction to the Highway Safety Manual," n.d. Available at: http://www.highwaysafetymanual.org/Documents/HSMP-1.pdf.

2 Federal Highway Administration, Office of Research and Technology, "Interactive Highway Safety Design Model (IHSDM): Modules" web page. Available at: https://www.fhwa.dot.gov/research/tfhrc/projects/safety/comprehensive/ihsdm/modules.cfm.

3 Federal Highway Administration, Office of Research and Technology, "Interactive Highway Safety Design Model (IHSDM): Crash Prediction Module" web page. Available at: https://www.fhwa.dot.gov/research/tfhrc/projects/safety/comprehensive/ihsdm/crashweb.cfm.

4 Federal Highway Administration, Office of Design,"Performance-Based Practical Design – Frequently Asked Questions" web page. Available at: https://www.fhwa.dot.gov/design/pbpd/general_information/faqs.cfm.

5 Adapted from Rebecca Crowe, "Interactive Highway Safety Design Model Helps RSA Teams Identify Issues," Safety Compass, Volume 9 Issue 1. Available at http://safety.fhwa.dot.gov/newsletter/safetycompass/2015/winter/#s5.

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Every Day Counts (EDC), a State-based initiative of FHWA's *Center for Accelerating Innovation*, works with State, local and private sector partners to encourage the adoption of proven technologies and innovations aimed at shortening and enhancing project delivery.