TECHBRIEF

Surrogate Safety Assessment Model (SSAM)

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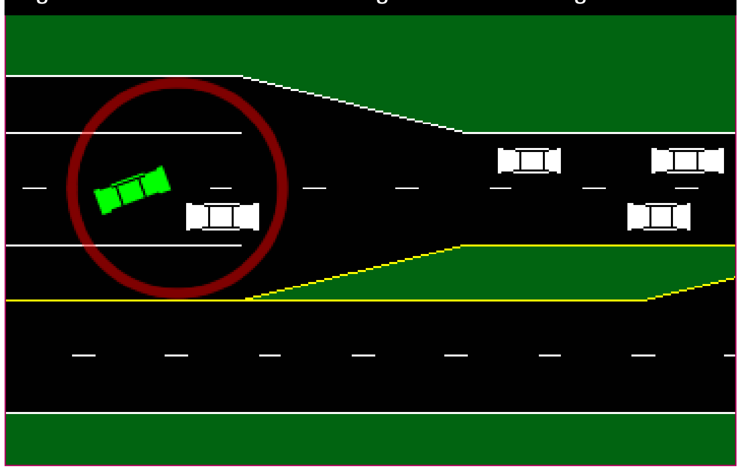
This document is a technical summary of the Federal Highway Administration report, *Surrogate Safety Assessment Model and Validation: Final Report,* FHWA-HRT-08-051.

Objective

The safety of intersections, interchanges, and other traffic facilities is most often assessed by tracking and analyzing police-reported motor vehicle crashes over time. Given the infrequent and random nature of crashes, this process is slow to reveal the need for remediation of either the roadway design or the flow-control strategy. This process is also not applicable to assess the safety of roadway designs that have yet to be built or flow-control strategies that have yet to be applied in the field.

This TechBrief summarizes the research and development of the Surrogate Safety Assessment Model (SSAM), a technique combining microsimulation and automated conflict analysis, which analyzes the frequency and character of narrowly averted vehicle-to-vehicle collisions in traffic, to assess the safety of traffic facilities without waiting for a statistically above-normal number of crashes and injuries to actually occur.

Figure 1. Conflict scenario resulting from a lane change maneuver.



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Introduction

A *conflict* is a scenario where two road users will likely collide without evasive action. Figure 1 illustrates an example of a conflict, where a vehicle is angling across two lanes to the left-turn bay and has abruptly cut in front of another vehicle that must decelerate to avoid collision.

Traffic conflicts have been studied since the late 1960s as a technique to assess the safety of a location, with the understanding that conflict frequency is correlated with the risk of actual collision.

Conflict studies traditionally utilize personnel trained to identify and record conflicts observed at an intersection. In this research, the SSAM software application was developed to automate conflict analysis by directly processing vehicle trajectory data. Researchers specified an open-standard, "universal" vehicle trajectory data format designed to provide the location and dimensions of each vehicle approximately every tenth of a second. It is hoped that in the coming years video processing technology will be capable of automatically extracting vehicle trajectory data adequate for SSAM processing. However, the trajectory file format is currently supported as an export option by four traffic microsimulation models: VISSIM, AIMSUN, Paramics, and TEXAS.

Assessment Method

To assess a traffic facility with SSAM, the facility is first modeled in one of the aforementioned simulation models and then simulated with desired traffic conditions (typically simulating several replications with different random number seeds). Each simulation run results in a corresponding trajectory file, referred to as a TRJ file corresponding to the .trj filename extension. Then, SSAM is used as a post-processor to analyze the batch of TRJ files.

SSAM analyzes vehicle-to-vehicle interactions to identify conflict events and catalogs all events found. For each such event, SSAM also calculates several surrogate safety measures, including the following:

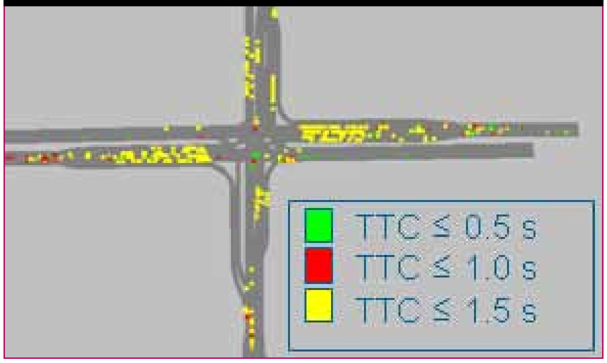
- Minimum time-to-collision (TTC).
- Minimum post-encroachment time (PET).
- Initial deceleration rate (DR).
- Maximum deceleration rate (MaxD).
- Maximum speed (MaxS).
- Maximum speed differential (DeltaS).
- Classification as lane-change, rear-end, or path-crossing event type.
- Vehicle velocity change had the event proceeded to a crash (DeltaV)

SSAM provides the following features:

- A table of all conflicts identified in the batch of analyzed TRJ files, including file, time, location, vehicles identifications, and several measures of conflict severity.
- A summary of conflict counts by type and file, with average values of surrogate measures over all conflicts.
- A filtering mechanism that allows the isolation of subsets of conflicts by ranges of surrogate safety measures, conflict type, network link, or a rectangular region of the network.
- A facility for statistical comparisons of the conflict frequencies and values of surrogate safety measures for two alternative cases or designs using the Student *t* distribution for hypothesis testing.
- A display of the location of conflicts on the network map, with icons of different shapes and colors assignable to different conflict types or severities.

Figure 2 is a screenshot of the map display in SSAM, with conflict icons color coded according to their time-to-collision values.

Figure 2. SSAM user interface displaying conflict locations on map.



Validation

To assess the capabilities of SSAM, researchers conducted theoretical validation, field validation, and sensitivity analysis.

The theoretical validation effort considered 11 pairs of intersection designs (e.g., right-turn bay versus no right-turn bay; SPUI versus diamond interchange; roundabout versus diamond interchange). The relative safety assessments of SSAM were compared to assessments using traditional, theoretical crash-prediction equations. The results yielded interesting insights, though it was often the case that design A had more conflicts than design B, while design B had higher severity conflicts than design A, pointing to the need for further research in interpreting and comparing surrogate safety measures.

The field validation effort was concerned with the absolute accuracy of surrogate safety assessment, in contrast to the relative safety assessments of the theoretical validation. A set of 83 field sites were selected—all were four-leg, urban, signalized intersections—and were modeled in VISSIM and simulated and assessed with SSAM. The conflict analysis results of these intersections were compared to actual crash histories (based on historical insurance claims records) using five statistical tests. This effort also provided an opportunity for benchmark comparison of surrogate safety estimates versus traditional crash-prediction models based on average daily traffic volumes (ADT).

The simulation-based intersection conflicts data provided by SSAM were significantly correlated with the crash data collected in the field, with the exception of conflicts during path-crossing maneuvers (e.g., left turns colliding with opposing through-traffic), which were under-represented in the simulation. Intersection rankings based on total conflict frequency correlated with intersection rankings based on total crash frequency with a Spearman rank coefficient of 0.463 (and similarly for rear-end and lane-change incidents). The relationship between total conflicts and total crashes in this study (shown in figure 3) exhibits a correlation (R-squared) value of 0.41.

Figure 3. Relationship between conflicts and crashes.

$$\frac{Crashes}{Year} = 0.119 \times \left(\frac{Conflicts}{Hour}\right)^{1.419}$$

This correlation of conflicts to crashes is consistent with the range of correlations reported in several studies between ADT and crashes for urban, signalized intersections. This result was achieved despite simulating only morning peak-hour volumes. Crash prediction models based on a yearly average of 24-hour ADT volumes exhibited a correlation (R-squared) value of 0.68 with actual crash frequencies. This study also found a conflict-to-crash ratio of approximately 20,000 to 1, though that ratio varied by conflict type.

The sensitivity analysis effort compared an assessment of five intersections (of the aforementioned 83) conducted separately using each of the four microsimulation models: VISSIM, AIMSUN, Paramics, and TEXAS. Crashes (vehicles driving through each other) were found in all simulations, and SSAM proved particularly useful in revealing questionable simulated behavior (due to user-configuration of the model in some cases and underlying simulation logic in other cases). This has notably prompted some revisions (so far by TEXAS and VISSIM) to improve the behavior of the underlying simulation models.

Recommendations

SSAM provides a compelling new option to assess the safety of traffic facilities using popular microsimulation software. This approach circumvents the need to wait for "abnormally high" crashes to actually occur, allows assessments of hypothetical designs and control alternatives, and is applicable to facilities where traditional, volume-based crash-prediction models (and norms) have not been established. Research is ongoing in this area, and as simulation models and video technology improve, this technique is expected to grow in use.

Additional Information

SSAM documentation is available in two FHWA reports: *Surrogate Safety Assessment Model and Validation: Final Report,* FHWA-HRT-08-051 and *Surrogate Safety Assessment Model (SSAM): Software User Manual,* FHWA-HRT-08-050 (http://www.tfhrc.gov/safety/intersect.htm). The SSAM software is available from Siemens Energy and Automation (http://www.itssiemens.com/research/ssam/).

Researchers—This study was performed by the Intelligent Transportation Systems Business Unit of Siemens Energy and Automation, Inc. (Siemens ITS); Principal Investigators Douglas Gettman, and Steven Shelby. For more information about this research, contact Clayton Chen, FHWA Project Manager, HRDS at (202) 493-3054, clayton.chen@dot.gov.

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