

PROACTIVE METHODS FOR ROAD SAFETY ANALYSIS

“Don’t wait for accidents to happen.”

— International Co-operation on Theories and Concepts in Traffic Safety (ICTCT)

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Background

Road traffic crashes are the cause of 1.25 million deaths and tens of millions of serious injuries and disabilities annually.¹ The human, economic, and social losses from road traffic crashes are immense. With growing motorization of emerging economies coupled with rapid urbanization, the road safety epidemic is anticipated to grow to become the seventh leading cause of death by 2030.¹ To date, the universal metric for road safety has been historical crash data, specifically, crash frequency and severity, which are direct measures of safety. Road safety is, in fact, characterized by the “absence of unintended harm to living creatures or inanimate objects”.²

Shortcomings of Crash Data

While it is natural to rely on historical crash data to characterize road safety, the shortcomings of safety analyses based on crash data are widely recognized.

- **Crashes are rare events** – It takes a long time to collect a sufficient amount of crash data to produce reliable estimates of safety.³ Usually, road safety analysts need three to five years of data to achieve some level of statistical significance. Even then, the estimation accuracy of crash frequency and severity is sometimes far from desirable;⁴
- **Crashes are random by nature** – The phenomenon of ‘regression-to-the-mean’ prevails, where if one year has an unusually high number of crashes, one could expect that the number of crashes will go down in the next year.³ Compounded with the rarity of crashes, this increases the need for long observation periods;
- **Not all crashes are reported** – The level of underreporting depends on the crash severity and types of road users involved.³ Underreporting is usually negatively correlated with increasing crash severity;
- **Limited information of the crash failure mechanism**⁵ – It is difficult to understand the mechanisms and multiple factors that lead to crashes as crash reports are skewed towards the

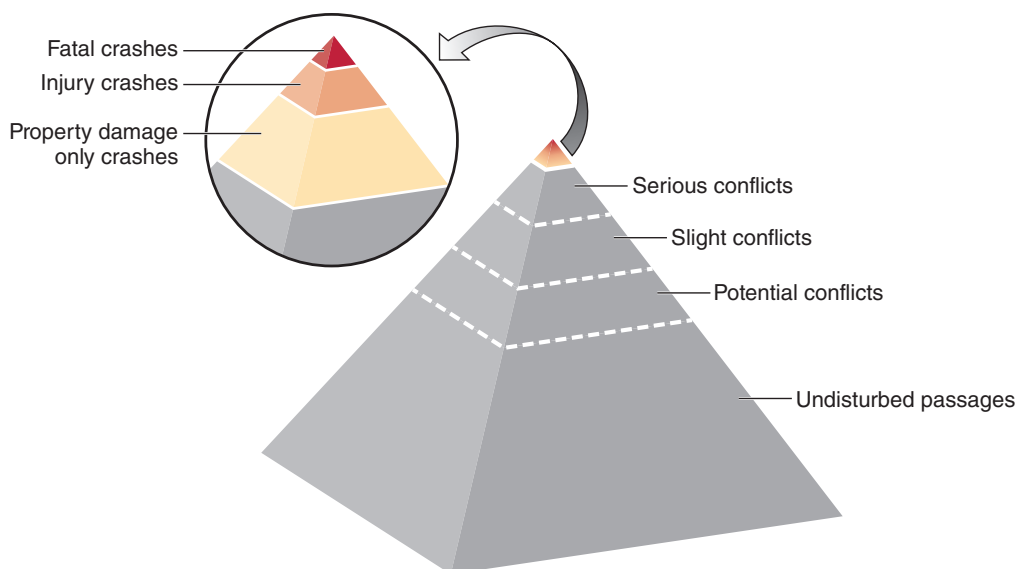


FIGURE 1 Hydén's Safety Pyramid (adapted from Hydén 1987^{12,16}).

attribution of responsibility, not the search for the causes that led to a crash;⁶ and

- **Reactive approach** – Paradoxically, road safety analysts need to wait for crashes to happen in order to prevent them.⁶ There is a need for proactive methods for road safety analysis that do not rely on the occurrence of crashes.⁶

Concept of Surrogate Measures of Safety

Surrogate measures of safety encompasses all the measures of safety that do not rely on crash data and instead are meant to be an alternative or a complement to analyses based on crash records.⁷ In comparison to crash-based methods, methods that rely on surrogate measures of safety are proactive (and thus more ethical as there is no need to wait for crashes to occur), and in some conditions more time-efficient, informative, and even accurate.⁷

Ideally, a surrogate measure of safety should satisfy the following:³

- To be relatively frequently observed in traffic. This shortens the time necessary for data collection and allows quick safety evaluation studies to be made before the actual accidents occur;
- To be objective and reliable;
- To have clear logical and strong statistical relations to accidents. This is an important condition for the validity of a surrogate measures of safety; and
- There should be some degree of similarity between the most severe traffic situations described by a safety indicator and accidents, which allows analysts to study the process of accident development without an actual crash or injury.

Traditional Traffic Conflict Techniques

The first surrogate measures of safety were based on the observation of near-accidents and traffic conflicts in the 1950-60s.^{8,9} The most developed and widely used surrogate measure is the number of severe traffic conflicts. A commonly agreed definition of a traffic conflict is “an observable situation in which two or more road users approach each other in space and time to such an extent that there is a risk of collision if their movements remain unchanged”.¹⁰ A key advantage of traffic conflicts is that they occur more frequently than traffic crashes, which results in a significantly shorter study period to establish statistically significant results.¹¹ As the process of a severe conflict is almost identical to that of a crash, traffic conflicts provide insight into the failure mechanisms that lead to road collisions.¹² The intuitive notion that conflicts are potential crashes but of a lower degree of danger suggests that there exists a continuum between conflicts and crashes.¹³ In 1987, Hydén illustrated this concept with a “safety pyramid” as demonstrated in Figure 1.¹² The base of the pyramid represents the undisturbed passages which constitute normal and safe traffic and the lowest level of severity.⁷ At the other end, the very top of the pyramid consists of the most severe events such as fatal or injury crashes and that are very infrequent compared to the total number of the events. If the form of the relation between the severity and frequency of the events is known, it is theoretically possible to calculate the frequency of the very severe but infrequent events (accidents) based on known frequency of less severe, but more easily observable events (conflicts).

Many indicators have been proposed to measure the severity of conflicts, the most commonly used being time-to-collision, post-encroachment time, and indicators related to speed and acceleration.⁷

In the 1970s, traffic conflict techniques received significant attention, which led to the development of numerous conflict observation and interpretation techniques.⁷ Countries that developed their own techniques included Austria, Canada, Finland, France, Germany, the Netherlands, Sweden, the United Kingdom, and the United States.¹⁴ These early traffic conflict techniques involved a team of human observers trained to recognize, assess, and record the frequency and severity of traffic conflicts.¹⁵ Manual conflict observation can be resource- and time-intensive as well as subject to inter-observer variability.¹⁵ These reasons led to the decline of the popularity of traffic conflict techniques in the 1990s.

Emerging Methods and Surrogate Measures of Safety

Recent technological advancements have allowed substantial strides in both the hardware and software necessary to collect and analyze non-crash traffic events with fewer resources.¹⁶ A suite of sensor and global positioning system technologies is becoming increasingly affordable and efficient. Furthermore, recent computer vision, simulation, and machine-learning capabilities have allowed automation of traffic event analysis. Some of the notable methods for surrogate measures of safety include:

- **Video-based surrogate measures of safety** – Video sensors are inexpensive, easy to install, and provide rich traffic description¹⁷ including pre-conflict/crash traffic information. Video-based techniques rely on computer vision to automatically or semi-automatically extract the positions and speeds of all road users, from which the majority of severity indicators can be derived;
- **Vehicle and user-based safety analysis** – With the increasing availability of data from sensors in vehicles and smart phones, road user safety can be analyzed continuously over time and aggregated spatially for network screening;^{18,19} and
- **Simulation-based safety analysis** – There have been several attempts to derive surrogate measures of safety from traffic simulation models, e.g., the Surrogate Safety Assessment Model sponsored by Federal Highway Administration.²⁰

Future of Surrogate Measures of Safety

The future development of surrogate measures of safety can be directed towards:

- **Investigation of the potential for new sensor types and sensor fusion** – Thermal cameras, lidars, sensors on drones, vehicles and vulnerable road users are becoming more and more common and affordable;
- **Better understanding of the whole safety pyramid** – How the levels of severity relate to safety in light of new facilities

and designs of traffic infrastructure and increased presence of vulnerable road users (cyclists, pedestrians) in traffic environments;

- **Vehicle automation and its effects on methods for safety analysis** – With vehicles becoming automated and much safer, the extreme rarity of crashes will make surrogate measures of safety the only tool for safety analysis; and
- **Big data analysis** – With the availability of enormous amounts of data from the above sources (video, vehicle, smart phones, and simulations) come new challenges to analyze such big data. New methods to aggregate data at the user or traffic event level, then at the site level, are explored and need validation.

Role of Standards

The need for harmonization and standardization of terms, definitions, and techniques for surrogate measures of safety has been recognized for decades. In fact, the International Cooperation on Theories and Concepts in Traffic Safety (ICTCT) was established in 1977 to accomplish just this. Since then, ICTCT has organized multiple International Joint Calibration Studies of Traffic Conflict Techniques to conduct comparability, validity, and reliability studies.

The new and emerging techniques of surrogate safety demonstrate enormous potential in widespread adoption. Yet there is a lack of validity studies for these new techniques. Standards are needed today:

- To provide common terms and definitions to the main concepts and subjects of interest;
- To define methods to calculate surrogate measures of safety and perform a safety study based on these measures; and
- To define criteria of validity for surrogate measures of safety.

SAE's Surrogate Measures of Safety Committee

SAE has recently established the Surrogate Measures of Safety Committee. This committee is responsible for adapting, developing and maintaining SAE Standards, Recommended Practices and Information Reports for use in methods to study road safety using measures that do not rely on accident data, i.e., do not require waiting for accidents to happen.

The scope of this committee includes but is not limited to:

- The collection, maintenance and use of relevant road, road user, and vehicle data;
- The theories, analytical techniques, and evaluation methodologies for improving the understanding of road safety; and

- The application of these theories, techniques and methods to identify road user, vehicle and/or road-based treatments that will enhance road safety.

The committee also acts as a liaison to the other organizations involved with surrogate measures of safety.

The Surrogate Measures of Safety Committee is actively seeking individuals in government, researchers, consulting firms, and other interested parties to participate in this committee.

Contact Information

To learn more or get involved in SAE's Surrogate Measures of Safety Committee, please contact:

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