

About the International Transport Forum

The International Transport Forum at the OECD is an intergovernmental organisation with 59 member countries. It acts as a think tank for transport policy and organises the Annual Summit of transport ministers. ITF is the only global body that covers all transport modes. It is administratively integrated with the OECD, yet politically autonomous.

ITF works for transport policies that improve peoples' lives. Our mission is to foster a deeper understanding of the role of transport in economic growth, environmental sustainability and social inclusion and to raise the public profile of transport policy.

ITF organises global dialogue for better transport. We act as a platform for discussion and pre-negotiation of policy issues across all transport modes. We analyse trends, share knowledge and promote exchange among transport decision makers and civil society. ITF's Annual Summit is the world's largest gathering of transport ministers and the leading global platform for dialogue on transport policy.

Our member countries are: Albania, Argentina, Armenia, Australia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Canada, Chile, China (People's Republic of), Croatia, Czech Republic, Denmark, Estonia, Finland, France, Former Yugoslav Republic of Macedonia, Georgia, Germany, Greece, Hungary, Iceland, India, Ireland, Israel, Italy, Japan, Kazakhstan, Korea, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Mexico, Republic of Moldova, Montenegro, Morocco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Serbia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, the United Arab Emirates, the United Kingdom and the United States.

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Executive summary

What we did

This report discusses how transport safety will benefit from innovations in data collection, sharing and analysis. The rise of smartphones, sensors, and connected objects is relentlessly producing more data, whose interpretation is made possible thanks to progress in computing power, data science and artificial intelligence. This represents an opportunity for the transport sector in general, and for transport safety in particular. Drawing from all transport modes, this report places a focus on *road* transport which is responsible for the overwhelming majority of transport fatalities, and where innovative data-driven solutions are clearly needed.

The report examines emerging solutions to better understand crash numbers and crash contributory factors, to address infrastructure problems in a proactive manner, to address road user behaviour and errors, and to benefit from driver assistance systems and cooperative connected solutions. The report envisages solutions to facilitate the sharing of data, which include privacy protection, partnerships and data standards. The work builds on a workshop held in December 2018, and outreach to numerous experts.

What we found

The world lacks reliable data on road crashes and associated injuries. It is yet unclear if and how information technology will entirely solve this problem but we identify several initiatives which certainly help. A Safe System approach is needed to eliminate fatal and serious road crashes and stop road transport from killing an estimated 1.3 billion people each year. A core principle of a Safe System is that crash risk is understood and addressed *proactively*, which is where data plays a central role.

To diagnose traffic safety problems and take action before a serious crash happens, there is a growing focus on the concept of *surrogate safety* metrics based on the occurrence and severity of relevant traffic conflicts, not necessarily collisions, which can involve evasive action such as braking or swerving. In line with this approach, artificial intelligence in video analytics is used to identify conflicts in which a crash was narrowly avoided, also known as close calls, by reviewing days of footage from road-side sensor such as LIDAR and video cameras.

The Internet of Things is already shaping a predictive maintenance model in the rail sector, preventing safety critical failures on tracks and trains. Automatic data collection along the road network is also possible thanks to instrumented floating vehicles and/or smartphones reporting information along the way, including hard braking, poor road surfaces and speed. Active safety systems can also be considered among surrogate safety metrics. They include ABS for anti-lock braking, ESP for electronic stability control and AEB for autonomous emergency braking. The engagement of such systems is some of the most simple yet relevant surrogate safety data a vehicle could produce.

Street imagery, also collected by floating vehicles, supports the assessment of road safety performance, known as star-rating for roads. The next generation of star-rating programs will most likely benefit from more frequent street imagery updates and from computer vision solutions. Drones and satellites will complement the range of data capture solutions and play an increasing role. Such innovations are welcome in the sense that they facilitate the planning of road safety investment and the monitoring of results.

Cooperative ITS technology will enable connected vehicles to openly broadcast not only their position regularly but also warning messages when relevant. Connected vehicles can not only talk to each other's but more importantly maybe report on the system performance, in real time, throughout the entire network, with benefits to all road users, connected or not. Roadside receivers could indeed benefit from those *short range* messages as a rich source of information. It is however unclear if and how network managers will have access to C-ITS messages over the entire road network, the majority of which may not be equipped with roadside receiver.

Much vehicle-related data is available and, if shared in a common format, could enhance road safety. Technologies like automatic crash notification and event data recorders already propose data-driven responses to post-crash problems, namely emergency response and forensic investigation.

A galaxy of telematics solutions exist for fleet management, usage-based insurance, eco-driving and safe driving coaching. Smartphones are becoming increasingly capable, flexible and therefore popular in those applications. This is due to their market penetration, processing power, communication capability and vast number of sensors. To complement *automated* data collection, transport users and workers can choose to voluntarily report close calls, infrastructure defects or unsafe behaviours, often using a smartphone.

Technology not only brings solutions but also new problems. Big Data is not only prone to many of the same errors and biases in smaller data sets, it also creates new ones. It has not emancipated analysts and policy makers from the strictures of statistical rigor. Big data also creates privacy threats, especially with the growing risk of re-identification of individuals in datasets which were previously thought to be anonymised. Information technology can also have negative impacts on safety: drivers can use social driving apps to evade speed enforcement and be distracted by new services (navigation, coaching, C-ITS alerts, infotainment, etc.). Protected by active safety systems, road users may take their eyes away from the road over sustained periods of time. Driver distraction can only get worse in the foreseeable future, as smartphones, smart glasses and vehicle infotainment systems will compete for the driver's attention, with little commercial incentive to shut down during the driving task, and with user pressure to remain entertained during an increasingly assisted driving task.

What we recommend

Develop a platform and a standard for safety-critical vehicle data collection

Requirements on data collection should be imposed on shared vehicles, be it e-scooters, bicycles, motor-scooters or cars. This could include geo-located safety system engagements, falls and crashes, traffic volumes, start and end points, turns, spot speed, wrong way riding and instances of anti-social behaviour. The industry and regulators should together establish standard data reporting formats, to facilitate the processing, de-identification and most meaningful analysis of the data submitted by various operators. Care should be taken however not to impose excessive regulatory pressure on emerging mobility services in comparison to traditional services. An international data standard could actually be beneficial to operators as they wouldn't be confronted with different requirements in each city where they operate. Decentralized Environmental Notification Messages (DENM) could also be integrated to the platform, since such messages are already public broadcast. The platform should ultimately include traffic volumes so as to control for any bias in the use of connected vehicle.

Elaborate privacy protection guidelines

Explicit guidelines should exist so as to help all stakeholders protect personal data but also to offer some reassurance on the legality of data collection and analysis. This reports highlights a wide range of applications which shouldn't be dismissed in fear of privacy breach. Data can identify dangerous speeding hotspots before someone has to be killed; data can reveal ethnic or social inequity among crash victims; employers rely on data to reward careful drivers, etc.

Conduct research to validate and refine the use of surrogate safety metrics

Research should seek to reveal which metrics not only correlate with reported crashes but also have predictive capabilities. Investigations should reveal if some metrics can predict the number of people killed and seriously injured, as opposed to predicting non-serious injuries. Research is also needed to define how surrogate safety metrics should include crash participant fragility, speed, mass and crash angle.

Harness Big Data in spite of Big Biases

Despite all the excitement around Big Data, the road safety profession needs to acknowledge a number of pitfalls. Unless proven otherwise, every data set shall be considered biased towards some user groups, trip purposes, or in any other dimension. The consequences of using data which isn't representative of the whole population shall be assessed to prevent misleading interpretation. Without highly qualified data scientist and statisticians, the risk is high that decision makers will be misled by the opportunistic analysis of seemingly low-cost data.

Review training needs

The adoption of surrogate safety metrics is an occasion to reflect on core statistical training needs which are often lacking in the road safety profession. Understanding the concepts of statistical significance and regression to the mean is essential to prevent data from being misused. Urgent links shall be created with academic partners. In addition, a culture of transparency would allow members of the public to raise concerns would obvious errors be made in the interpretation of data.

Empower transport users and workers through feedback reporting systems

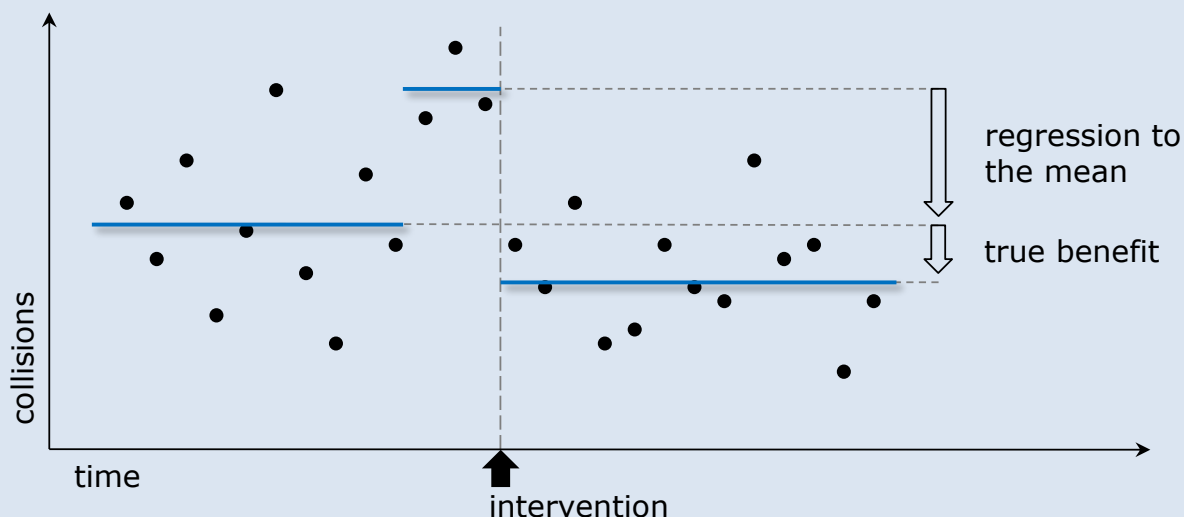
A particular attention should be placed on feedback reporting systems, with the goal to maximise participation. Transport workers should have a trusted channel where to report issues without fear of discrimination. Passengers should be able to contribute to identifying risky behaviours in the bus and taxi industries. Road users should have a platform where to submit video evidence of unsafe driving or photos of road defects. Highway authorities should join forces and provide such platforms, harmonise user experience, share some of the costs and consider open-source solutions.

Make vehicle data available wirelessly for telematics applications

Vehicle telematics could have significant effects on driver behaviour. Solutions increasingly rely on a smartphone to detect vehicle dynamics, in part due to the complexity associated with reading data straight from the vehicle's on-board diagnostic (OBD) port. Establishing a new standard for the wireless dissemination of vehicle information, through existing on-board entertainment connectivity for instance, would encourage the use of valuable data. This protocol should include ABS/ESP/AEB activations for third party apps to monitor the driving conditions, be it for insurance, coaching or other purposes. Would this protocol be designed as a one-way broadcast, hacking risk would be eliminated.

Box 1. Regression to the mean

In most before-and-after studies reported in the road safety literature, remedial measures have been deployed after a period of 'unacceptably high' collision counts. As random fluctuation is a significant factor contributing to these abnormalities, we might expect these counts to subsequently regress towards their underlying mean level: a phenomenon which is called *regression to the mean*.

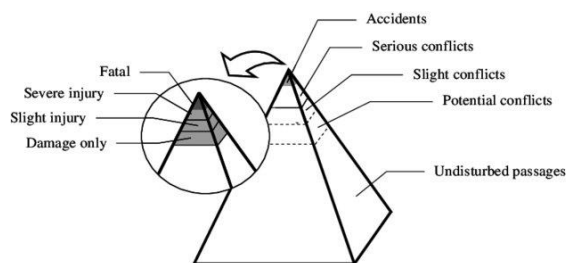


Studies assessing the effectiveness of road safety schemes are notoriously bedeviled by the problem of regression to the mean. On the illustration above, most of the change observed immediately after a road safety intervention would have been observed anyway, even without intervention, simply by regression to the mean.

Source: adapted from Fawcett et al., 2017

A number of researchers argue that road safety analyses can strongly benefit from reliable methods that utilise observable non-crash events as a **surrogate** or a complement to crashes. Relevant non-crash events, also called conflicts or close-calls, often involve evasive action such as braking or swerving. The assumption is that **correlations** exist between crashes and conflicts. Predictive power would therefore be found in the analysis of conflicts. Hyden (1987) describes this relationship with a 'safety pyramid', where the base of the pyramid is formed by normal traffic encounters that are quite safe and frequent, while the tip of the **pyramid** contains the most severe events, such as crashes resulting in injuries or fatalities, that are highly infrequent.

Figure 1. Hyden's safety pyramid



Source: Hyden (1987)

How to distinguish conflicts from undisturbed passages? How to identify most serious conflict? Several metrics exist to quantify how close a situation is to a crash, a concept called proximity, of which two primary metrics were identified by workshop participants:

- Time to collision (TTC) is the time required for two road users to collide if they continue at their present speed and on the same path.
- Post-encroachment time (PET) is the lapsed time between the moment that the first road user leaves the conflict area, and the moment that the second road user reaches the same area

The primary goal of Vision Zero is to avoid **severe crashes**, rather than all crashes. For this reason, traffic conflict indicators should take into account the severity of the injuries resulting from a collision had it occurred. Very few of the existing traffic conflict indicators and techniques take the outcome severity into account in some way (Laureshyn et al., 2017). Without getting into further details, conflict severity indicators should include crash participants **fragility**, speeds, masses and **crash angles**.

Surrogate road safety analysis is set to feed from vast numbers of **CCTV** cameras. Where several cameras share the same field of vision, techniques shall be developed to take advantage of the situation and track movements with a greater accuracy. Stereoscopic camera illustrates the added value of data fusion across multiple sensors. To remove some ambiguous image interpretation and to compute more accurate trajectories, the analysis would also benefit from **LIDAR** sensors coupled with camera images.

A diversity of behaviours can be analysed with computer vision. Compliance in situations where vehicles have to yield to pedestrians can be scored from video analytics (Fu, Miranda-Moreno and Saunier, 2018). Passing distances can be monitored on a specific site to assess cycling safety improvements following changes in the street layout (Götschi et al., 2018)

A precondition to scaled-up surrogate safety is the development of skillful and transparent surrogate safety algorithms. This raises general questions about which training data to feed to surrogate safety AI algorithms and if the explainability of algorithms is retained in scenarios where part of the algorithm is re-written and adapted on the fly.

Box 1. Predicting collision counts at potential road safety hotspots

Road safety practitioners can now use sophisticated statistical modelling techniques to predict accident counts at potential road safety hotspots. Researchers from the Newcastle University in the UK have developed such a tool, involving Bayesian hierarchical model (Fawcett et al., 2017). The tool is called RAPTOR (Reactive Analytic Prediction Toolkit for Road Safety) and is now available within the commercial software Visum Safety.

This informs a more proactive decision-making process about where to implement road safety schemes, for example speed cameras. This is different to the reactive approach currently taken by most organisations responsible for road safety, where such countermeasures are usually deployed after a threshold number of fatalities/serious injuries has been exceeded over some observation period.

Not only is this method more proactive, it can also prevent the situation whereby road safety investments are based on the mis-interpretation of naturally volatile crash figures.

This has resulted in a close collaboration with the municipality of Lisbon, in Portugal, where the prediction models will be used within the context of a wider "Sustainable Mobility Plan" for the city.

Source: Newcastle University