Global Road Safety Facility

Bloomberg Philanthropies
INITIATIVE FOR GLOBAL ROAD SAFETY

iRAP

Speed Variation Analysis – A Case Study for Thailand's Roads

July 2019

Photo: Capture from Google Street Maps of Hathai Rat Road in Min Buri district, Bangkok, Thailand (July 2019)

Executive Summary

Research shows that vehicle speed affects the severity of all road crashes. Higher speed crashes involve more kinetic energy: the more energy that is dispersed in a crash, the more severe that crash will be. Speed also affects the likelihood of a crash occurring in the first place. The likelihood of a serious or fatal crash increases significantly even with small increases in vehicle speed. Field studies demonstrate that a one percent increase in mean average speeds results in a roughly two percent increase in the frequency of crashes involving injury, a three percent increase in severe crashes, and a four percent increase in deaths.

The safety of infrastructure is heavily influenced by traffic speed, to the extent that without a detailed understanding of speed limits and vehicle operating speeds, it is difficult to assess the safety performance of infrastructure at a given location.

This report seeks to highlight the central role of speed management in the Safe System approach and how a simple speed variation can improve safety for all types of road user. At the core of this report lies the experience derived from iRAP assessments undertaken under the Bloomberg Philanthropies Initiative for Global Road Safety (BIGRS) on 867 km of national roads in Thailand and 258 km of streets in Bangkok, between 2015 and 2019. This also involved capacity building activities with local partner, Chulalongkorn University, which led to almost 700 specialists being trained on road safety engineering during this period.

The importance of speed in influencing road user risk is highlighted in two case studies on different road types in Thailand — the Outer Ring Road and Hathai Rat Road in Bangkok — to demonstrate the effects of different speeds on the iRAP Star Ratings. These ratings objectively quantify the likelihood of a crash, and its severity, whereby a person's risk of injury is highest on a 1-star road, and lowest on a 5-star road. Among a series of simulations and results, this report shows that enforcing a 10 kph speed limit reduction could prevent one in three fatal and serious injuries (FSIs) on both those roads.

3 times more fatalities and serios injuries are expected every year with a speed limit of 120 kph compared to 80 kph on Outer Bangkok Ring Road

On the 170 km stretch of the Outer Bangkok Ring Road, at the current speed limit of 90 kph, the iRAP Star Rating results for vehicle occupants show 11 percent of the road length to be rated 4-star, 66 percent 3-star, 21 percent 2-star and two percent 1-star. Following a mere 10 kph increase of the 90 kph speed limit to 100 kph none of the road would be at the 4-star level, while 42 percent would be in the highest risk categories (1 and 2-star). Conversely, a reduction of the enforced speed limit to 80 kph would correlate to an estimated 30 percent reduction in FSIs on that stretch of road, or 36 fewer fatal or serious injuries every year. Today, by contrast, the lack of enforcement of the current speed limit and the adoption of a 120 kph speed limit are estimated to lead to a total of 287 FSIs per year, fully three times worse than would be expected at an operating speed of 80 kph.

10 out of 11 fatalities and serious injuries can be prevented every year with a speed reduction to 40 kph on Hathai Rat Road

On the 2.3 km section of Hathai Rat Road, in Min Buri district, Bangkok, at 80 kph, the raw (not averaged) iRAP Star Rating results for pedestrians show that the entire length is rated 1-star. At 50 kph, 33 percent of the road is at a 3-star, 58 percent a 2-star and 8 percent a 1-star rating. At 40 kph, by contrast, 33 percent of the road length is rated 4-star, 58 percent is 3-star and 8 percent is 1-star. For motorcyclists, at 80 kph, the raw iRAP Star Rating results show 4 percent of the road length to be 3-star, 88 percent 2-star and 8 percent 1-star. At 40 kph, 92 percent of the road length is 5-star, with 4 percent at 4-star and the remaining 4 percent at 1-star rating. The tables below present further details. A reduction in the (enforced) speed limit from 80 kph to 70 kph would lead to a 31 percent reduction in FSIs on the road section, which on average amounts to three fewer serious (including fatal) injuries per year. If, however, the speed limit were halved to 40 kph, this would dramatically reduce FSIs, by approximately 90 percent, thereby saving on average 10 people from serious or fatal injuries every year.

Reducing speeds from 80 kph to 60 kph would lead to a 58 percent reduction in fatalities and serious injuries on Hathai Rat Road

Both case studies demonstrate that road function, traffic mix and the use or development of adjacent land are important factors to be considered when determining appropriate speed limits. The results spotlight the devastating impact of speed on the safety of all road users and will encourage road administration agencies in Thailand to apply the Safe System approach to the setting of enforced speed limits.

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1. Introduction

Road safety is a crucial component of World Bank transport investment projects. Under the aegis of the World Bank and the leadership of Bloomberg Philanthropies, the Global Road Safety Facility (GRSF) is one of the nine international institutions to work together under the Bloomberg Philanthropies Initiative for Global Road Safety (BIGRS).

The Bloomberg Philanthropies' BIGRS (2015–2019) is the second phase of a $125 million partnership program focused on the reduction of road deaths and serious injuries in ten cities and five countries in the developing world. The cities, selected through a competitive process – Accra, Addis Ababa, Bandung, Bangkok, Bogota, Fortaleza, Ho Chi Minh City, Mumbai, Sao Paulo, and Shanghai – receive funding for specialist staff embedded within municipal agencies, as well as comprehensive technical assistance from collaborating organizations, including capacity building for road engineering, social awareness campaigns and enforcement. Meanwhile, the five selected countries – China, India, the Philippines, Tanzania and Thailand – receive support for legislative and policy implementation activities at the national level. Bloomberg has also asked the World Bank GRSF to undertake financial impact studies and assessment of high-risk roads in the selected five selected countries.

Figure 1.1. BIGRS (2015–2019) cities and countries

A 2017 World Bank study[1] under BIGRS shows that, by sharply reducing the number of road traffic injuries and deaths, these five countries could in time attain a substantial concomitant increase in economic growth and national income, while leading simultaneously to clear welfare gains. In Thailand, reducing road traffic mortality and morbidity by 50 percent, and sustaining it over a period of 24 years, could, for example, generate an additional flow of income equivalent to 22.2 percent of 2014 GDP. This throws into perspective the huge economic benefits that these countries could release if through sustained action they were to achieve the UN targets on road safety.

Thailand has one of the highest road traffic death rates in the world, with motorcyclists accounting for 74 percent of these deaths.[2] Bangkok, Thailand's capital and largest city, has a population of 5.7 million and a rapidly growing number of registered vehicles, of which 36 percent are motorcycles. In 2016, more than 850 people died on Bangkok's roads.

Under BIGRS, the World Bank focused on:

- building road safety management capacity;
- improving road infrastructure safety; and
- leverage related road safety investments in countries where the toll of death and injury could be most significantly reduced.

The World Bank is working towards improving road infrastructure and mobility safety for the selected cities together with other BIGRS Safer Streets and Safer Mobility partners, which include the World Resources Institute (WRI) Ross Center for Sustainable Cities (incorporating EMBARQ, the sustainable mobility initiative) and the Global Designing Cities Initiative backed by the (North American) National Association of City Transportation Officials (NACTO-GDCI).

The World Bank has also partnered with the International Road Assessment Programme (iRAP) for the survey and assessment of high-risk road infrastructure in each of the cities and countries, as well as the associated design, implementation, audit and training activities.

This report highlights the centrality of speed management to the Safe System approach and demonstrates how a simple speed variation can dramatically influence the safety of road users. At the core of this report lays the experience from the iRAP assessments undertaken between 2015 and 2019 on 867 km of national roads in Thailand and 258 km of streets in Bangkok, together with capacity building

[1] World Bank (2017). *The High Toll of Traffic Injuries: Unacceptable and Preventable*. © World Bank.
[2] World Health Organization (2018). *Global Status Report on Road Safety, 2018*. Geneva.

activities with local partner, Chulalongkorn University, which led to almost 700 specialists being trained on road safety engineering during this period.

2. Road Safety Strategies

2.1. The Safe System approach

The Safe System approach proposes a road system better adapted to the physical tolerance of its users.[3] Its core principles are in line with the well-known mid-1990s national strategies such as Sweden's Vision Zero and the Sustainable Safety approach adopted in the Netherlands.[4] It was officially endorsed by the Australian Transport Council in 2004 and adopted by all Australian state and territory road authorities. Grzebieta and colleagues have outlined the history of the Safe System approach and its basic rationale.[5]

The crux of the Safe System approach is that while it recognizes the need for responsible road user behavior, it also accepts that human error is inevitable. It therefore aims to create a road transport system that makes allowance for errors and minimizes the consequences – above all, the risk of death or serious injury. This is cogently elaborated by the Australian National Road Safety Strategy contention that: "*Australians should not regard death and serious injury as an inevitable cost of road travel. Crashes will continue to occur on our roads because humans will always make mistakes no matter how informed and compliant they are. But we do not have to accept a transport system that allows people to be killed or severely injured as a consequence*."[6]

The Safe System approach does not seek to exempt road users from compliance with the law. On the contrary, it works best when road users do comply with road laws. In other words, the Safe System approach should be understood as a holistic and graded safety system, such that, for fully compliant road users, it offers the maximum protection against death and serious injury. No road user should expect to die or be seriously injured if, through no fault of their own, they find themselves involved in a

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[3] ITF (2016), *Zero Road Deaths and Serious Injuries: Leading a Paradigm Shift to a Safe System,* OECD Publishing, Paris. https://www.oecd.org/publications/zero-road-deaths-and-serious-injuries-9789282108055-en.htm

[4] World Road Association - PIARC (2015), Road Safety Manual. https://roadsafety.piarc.org/en/road-safety-management-safe-system-approach/safe-system-elements

[5] Grzebieta R.H., Mooren L., and Job S., *Introduction (or Reintroduction) to the Safe System Approach, Roadside Safety Design and Devices*, International Workshop July 17, 2012, Milan, Italy, Ed. R. Troutbeck, Transportation Research Board, Washington DC, Transportation Research Circular Number E-C172, February 2013, http://onlinepubs.trb.org/onlinepubs/circulars/ec172.pdf.

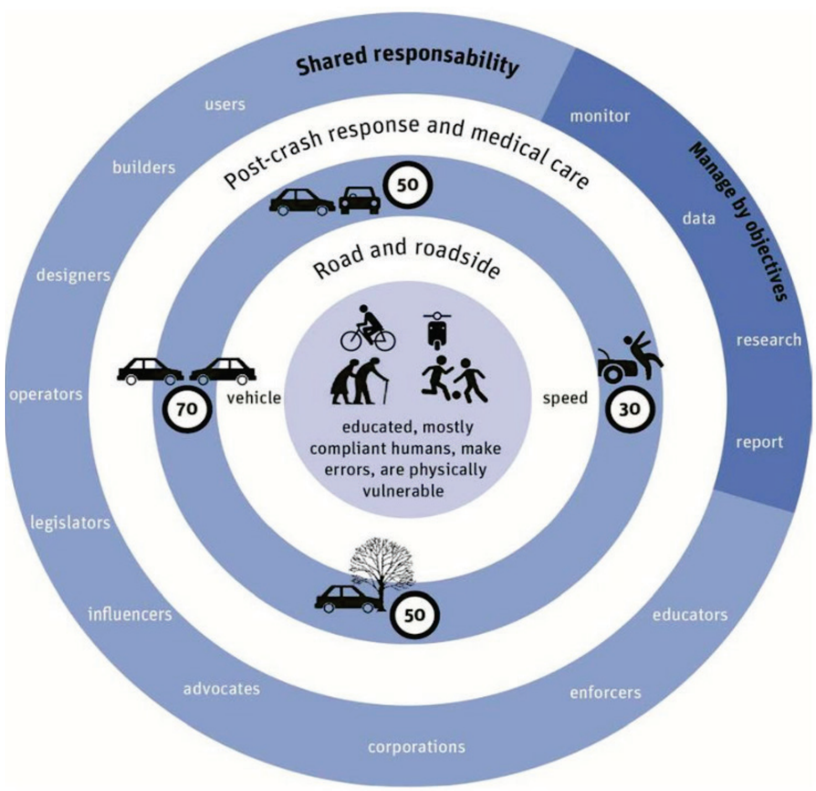
[6] Australian (Federal) Government, Department of Infrastructure and Regional Development, National Road Safety Strategy, Safe System Approach, http://roadsafety.gov.au/nrss/safe-system.aspx.

crash or collision. The system should, however, also serve to reduce risk for a non-compliant road user who is involved in a crash.

In sum, by adopting a total view of the combined factors involved in road safety, the Safe System approach encourages a better understanding of the interaction between the key elements of the road system: road users, roads and roadsides, vehicles and travel speeds. Its three core components are:

- **Safe roads and roadsides** – a transport system designed to make a collision survivable through a combination of design and maintenance of roads and roadsides.
- **Safe vehicles** – the design of vehicles and their safety equipment to include protective systems, such as electronic stability control and airbags.
- **Safe speeds** – the speed limit should reflect the road safety risk to the road users.

Figure 2.1. Conceptualization of the Safe System approach[7]



[7] ITF (2016), ibid.

It is essential that vehicles travel at speeds that suit the function and intrinsic level of safety of the road to ensure that crash forces are kept below the limits that cause death or serious injury. This requires the setting of appropriate speed limits supplemented by effective enforcement and education.

2.2. Evidence-based measures

Evidence-based practice originated in medicine, but it has been translated to a number of policy areas, including road safety. An evidence-based approach first entails looking at all available data on road use, especially on crashes and casualties, to establish that road safety needs to be addressed. It then involves the use of research to support the choice of intervention in a given location.

Evidence-based practice can help to ensure the success of any new or existing intervention, drawing upon knowledge of proven prior success, and cost-effectiveness, in similar contexts elsewhere.

There are four basic types of evidence-based intervention in road safety:

- **Safer Road Users** – through informing and educating users about safe use of the road, and taking action against those who do not comply with the rules.
- **Safer Roads** – through designing, constructing and maintaining roads and roadsides to reduce the risk of crashes, and lessen the severity of injury if a crash does occur.
- **Safer Vehicles** – designing and maintaining vehicles to reduce the risk of crashes, and the severity of injury to motor vehicle occupants, pedestrians, and cyclists if a crash occurs.
- **Safer Speeds** – setting speed limits that take into account the level of risk on the road network and the benefits of lower speeds in reducing the incidence and severity of injury in the event of a crash, together with the corresponding self-explaining infrastructure and enforcement.

According to Wegman and colleagues, evidence-based and data-driven road safety management must be underpinned by ex post and ex ante evaluation (before-and-after study) of individual interventions and broader intervention packages within road safety strategies, as well as the transferability (external validity) of research results.[8]

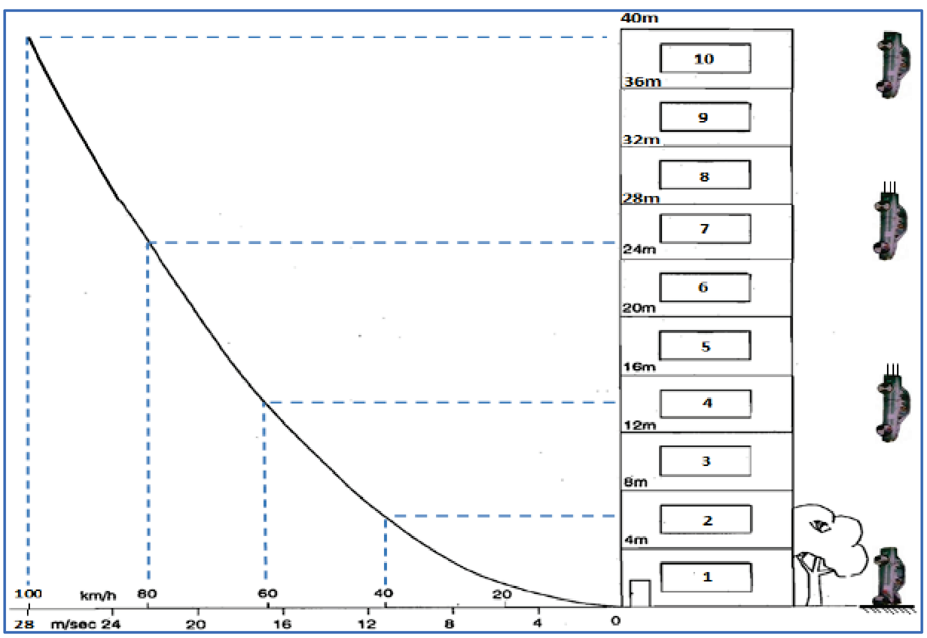
[8] Fred Wegman, Hans-Yngve Berg, Iain Cameron, Claire Thompson, Stefan Siegrist, Wendy Weijermars, *Evidence-based and data-driven road safety management,* International Association of Traffic and Safety Sciences, IATSS Research, Volume 39, Issue 1, July 2017

2.3. Speed management

Vehicle speed affects the severity of all road crashes. Higher speed crashes involve more kinetic energy: the more energy that is dispersed during a crash, the more severe it will be. Speed also affects the likelihood of a crash occurring. The likelihood of being involved in a fatal or serious crash increases significantly with even small increases in vehicle speed. Research shows that a one percent increase in mean average speeds results in a roughly two percent increase in crashes involving injury, a three percent increase in severe crashes and a four percent increase in fatalities.[9] [10]

Cars are now designed so that a person can survive a head-on crash between similar vehicles at collision speeds of up of 70 kph, without serious permanent injury (albeit with a residual 10 percent risk of death). At higher impact speeds, the chance of survival rapidly diminishes. An illustration commonly used in Europe associates the risk of crashing at a given speed with the hypothetical analogous danger posed by an object falling from a given height (figure 2.2**Error! Reference source not found.**).

Figure 2.2. Diagram to compare crash speed on a road with analogous ground impact of an object falling off a ten-story building at the relevant height[11]



[9] International Transport Forum, *Speed and Crash Risk*, Research Report under the International Traffic Safety Data and Analysis Group, 2018. https://www.itf-oecd.org/sites/default/files/docs/speed-crash-risk.pdf

[10] Nilsson, G. (2004). Traffic Safety Dimension and the Power Model to describe the Effect of Speed on Safety, Lund Institute of Technology, Sweden.

[11] Murray N.W., *When it Comes to the Crunch, The Mechanics of Car Collisions*, World Scientific, Singapore, 1994

Management of speed is one of the most powerful, effective, inexpensive interventions available to save crash deaths and serious injuries, and the known relationships between speed and death or injury mean that the benefits of reducing speeds can be predicted even in situations where the crash data are weak.[12]

2.4. Setting local speed limits

In many countries there can be a marked difference between the posted speed limit and the actual speed of vehicles using the road. This is a function of local behavior, traffic flows, local enforcement practice and whether the engineering features of the road (such as traffic calming measures) are designed in accordance with the speed limit.

As well as being the legal limit, speed limits are a key source of information, indicating risks not only for a given road user passing a road sign, but also for all other road users. Speed limits should therefore be evidence-led and self-explaining and seek to reinforce the road user's own assessment of a safe speed to travel. They should encourage self-compliance and be regarded as a maximum permitted speed rather than a target speed. It is important that traffic authorities and police forces work closely together when determining, or even considering, any changes to speed limits. Speed limits should be clearly signed in both directions wherever a change occurs, reinforced if necessary by repeater signs, and they should also meet the needs of all road users and vehicle technologies.

2.5. Traffic speed and mobility

The Safe System challenges the fatalistic view (Bliss, 2013)[13] that road traffic injury is the price to be paid for achieving mobility. It sets a long-term goal of eliminating road crash fatalities and serious injuries, with interim step-wise targets during the intervening years.

Tingvall (2005)[14] observes that mobility has traditionally been regarded as a function of the road transport system for which safety is a price to be paid. However, Vision Zero turns that concept around, instead presenting mobility as a function of safety. The new perspective dictates that no more mobility be generated than that which is inherently safe for the system. This ethical dimension reflects the principles long accepted for workplace safety, whereby health risks cannot be traded away in order to

[12] Job, RFS & Sakashita, S. (2016). Management of speed: The low-cost, rapidly implementable effective road safety action to deliver the 2020 road safety targets. *Journal of the Australasian College of Road Safety, May 2016*, 65-70.
[13] Tony Bliss, Jeanne Breen. *Road Safety Management Capacity Reviews and Safe System Projects Guidelines*. Updated Edition. May 2013. Global Road Safety Facility.
[14] Tingvall, C. *The 7th European Transport Safety Lecture, Europe and its Road Safety Vision – How Far to Zero?* Swedish Road Administration. 2005.

raise productivity. Vision Zero contends that it is the irreducible right of the citizen to be able to use the road transport system in a safe way and that is the main driving force.

Furthermore, a faster journey yields an erroneously perceived time gain, or saving, far in excess of the objective time gain, which is in fact only marginal, especially for shorter trips.[15]

Table 2.1.Extra time taken for a 10 km journey when speed is reduced by 5 kph

Original speed	50 kph	70 kph	90 kph	110 kph	130 kph
Extra time taken (minutes)	1.33	0.66	0.39	0.26	0.18

Source: ETSC, 1995

2.6. Speed in the iRAP Star Rating model

The safety of infrastructure is heavily influenced by the speed of traffic, and without a detailed understanding of speed limits and vehicle operating speeds it is difficult to assess the safety performance of infrastructure at a given location. All iRAP Star Rating assessments are based on the higher of the speed limit and recorded vehicle operating speeds. For further details on the iRAP specifications see *Vehicle Speeds and the iRAP Protocols* (http://irap.org/about-irap-3/research-and-technical-papers).

Speed management is of paramount importance in road safety, and traffic speeds have a significant bearing on the iRAP Star Ratings.

According to the Speed Management Manual,[16] the risk of death or serious injury is minimized in any crash, where:

- vulnerable road users (such as motorcyclists, bicyclists and pedestrians) are physically separated from cars and heavier vehicles;
- traffic speeds are 40 kph or less (as a pedestrian hit by a car traveling at 30 kph has a good chance of survival, whereas at 50 kph that likelihood drops below 20 percent);

[15] European Commission. *Mobility and Transport. Road Safety*. https://ec.europa.eu/transport/road_safety/specialist/knowledge/speed/speed_is_a_central_issue_in_road_safety/speed_and_environment_speed_and_travel_time_en
[16] Global Road Safety Partnership. *Speed management: a road safety manual for decision-makers and practitioners*. Geneva, 2008.

- opposing traffic is physically separated, with roadside hazards such as trees and other fixed objects well managed; and
- traffic speeds are restricted to 70 kph or less on roads where opposing traffic flows are not physically separated, or where roadside hazards exist.

The iRAP analysis provides valuable source data to inform systematic speed management actions associated with the revision and enforcement of speed limits on both urban and rural roads. Effective speed management changes requires the cooperation of multiple agencies and sustained enforcement. Any speed management initiative should be accompanied by relevant changes to the engineering environment to support the desired speeds (such as traffic calming, or lane reduction, known as road diets). For further details refer to the WHO Save LIVES package and the Speed Management Manual:

- http://www.who.int/violence_injury_prevention/publications/road_traffic/save-lives-package/en/
- http://www.who.int/roadsafety/projects/manuals/speed_manual/en/
- https://www.unroadsafetyweek.org/en/solutions/safe-roads
- https://roadsafety.piarc.org/en/road-safety-management-safe-system-approach/safe-system-elements

This report seeks to explore the importance of speed in influencing road user risk and uses two case studies on different road types in Thailand to demonstrate the effects of different speeds on the iRAP Star Ratings and the potential of saving lives.

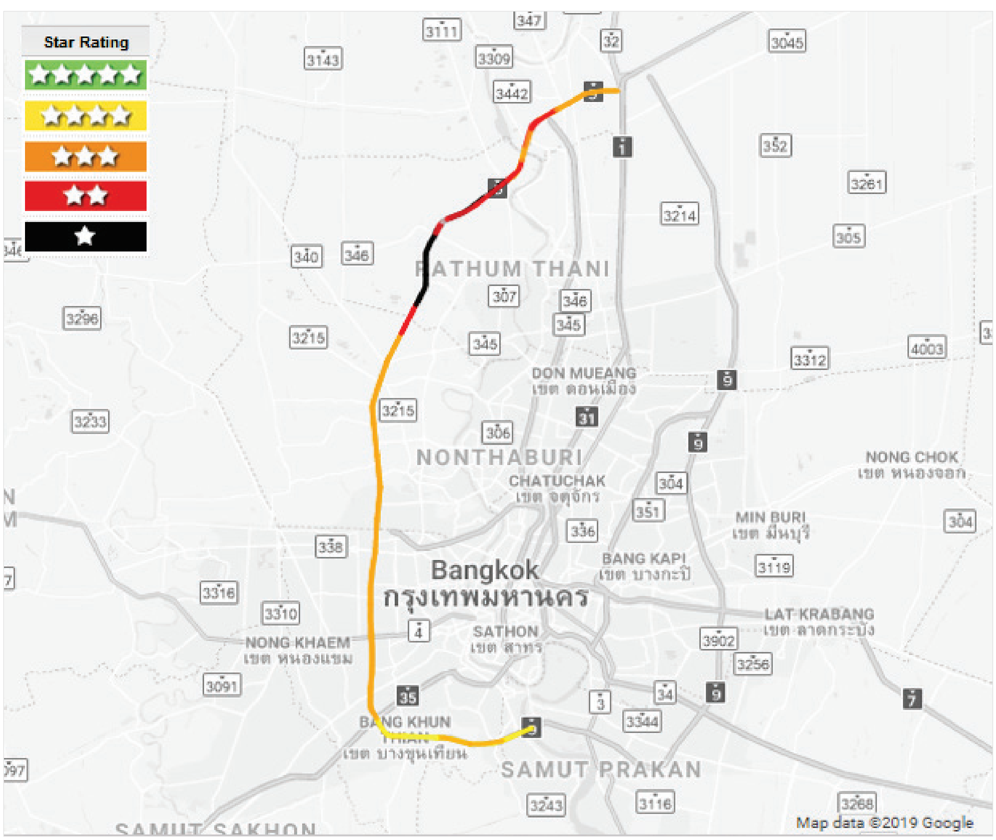
3. Case Study 1: Outer Bangkok Ring Road

3.1. General overview and baseline

One of the ways the iRAP model can be used is showing how speed influences risk. Thus, a 170 km section of the Outer Bangkok Ring Road was selected as a case study, with various speed limit options tested to measure the change in risk (Star Ratings) for vehicle occupants as speeds are modified.

The section of road used in this study covers the western portion of the Outer Bangkok Ring Road (also known as Kanchanaphisek Road), a multi-lane divided road under the Department of Highways at the Ministry of Transport. The section starts from the Prapradaeng area (Route 9, km 0+000) and ends at Bangpa-in interchange (Route 9, km 84+127). This priority corridor was first assessed using the iRAP methodology in 2017. The smoothed (averaged) Star Rating results for vehicle occupants are shown in the figure below, based on vehicle operating speeds.

Figure 3.1. Vehicle Occupant Star Ratings (smoothed) – Western portion of the Outer Bangkok Ring Road, Bangkok, Thailand



This road section is currently subject to a speed limit of 90 kph. However, the speed data collection surveys conducted at the time of the original baseline assessment reveal operating speeds in excess of the 90 kph speed limit for 24 percent of the length of the corridor. Therefore, the original assessment was based on speeds of 90 kph for 76 percent of the length and 100 kph for 24 percent of the length.

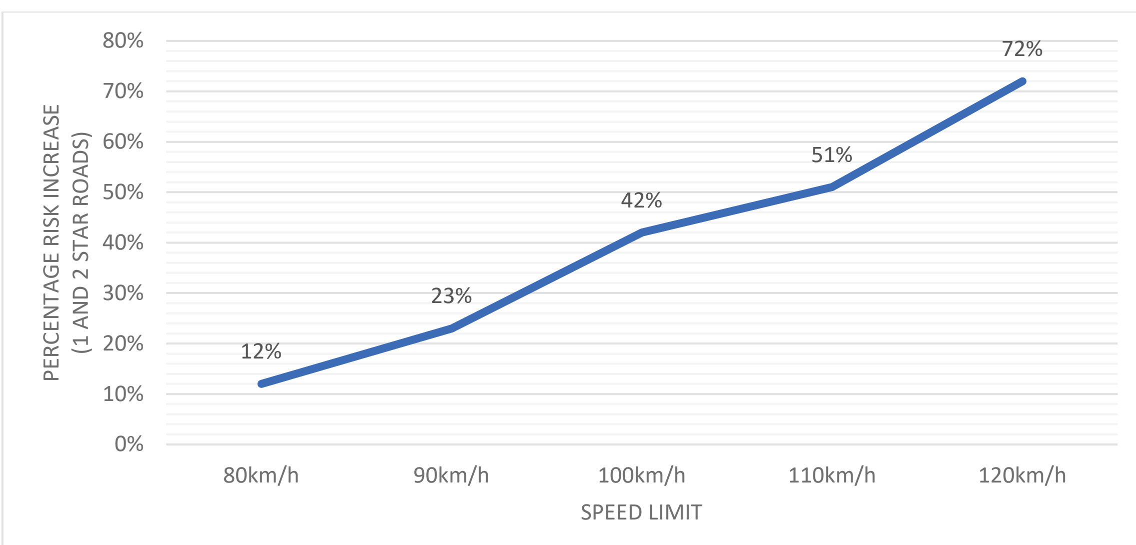
Table 3.1. Operating speeds on the Outer Bangkok Ring Road based on 2017 speed data collection for baseline survey

Operating Speed (85th percentile)	km	%
<30km/h	0.10	0
85km/h	49.00	29
90km/h	80.00	47
100km/h	40.90	24

3.2. Speed variation results

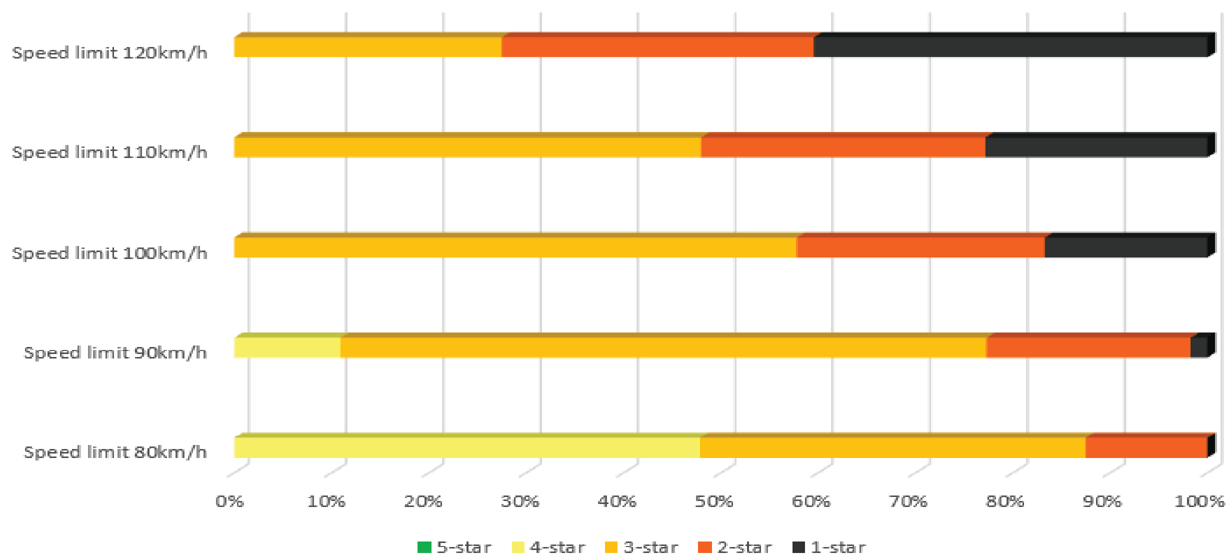
At the current speed limit of 90 kph, the iRAP Star Rating results for vehicle occupants show 11 percent of the road length to be 4-star, 66 percent 3-star, 21 percent 2-star and 2 percent 1-star. With only a 10 kph increase in the speed limit, at 100 kph, the speed analysis testing shows that none of the road length attains a 4-star rating, with 42 percent in the high-risk (1- and 2-star) category. The chart below shows how the proportion of high-risk road increases with speed:

Figure 3.2. Increase in the percentage of high-risk road sections (1–2 stars) for vehicle occupants at various speed limits



The full Star Rating performance for vehicle occupants with speed variations is detailed in the chart below:

Figure 3.3. Speed analysis testing for vehicle occupants on the Outer Bangkok Ring Road



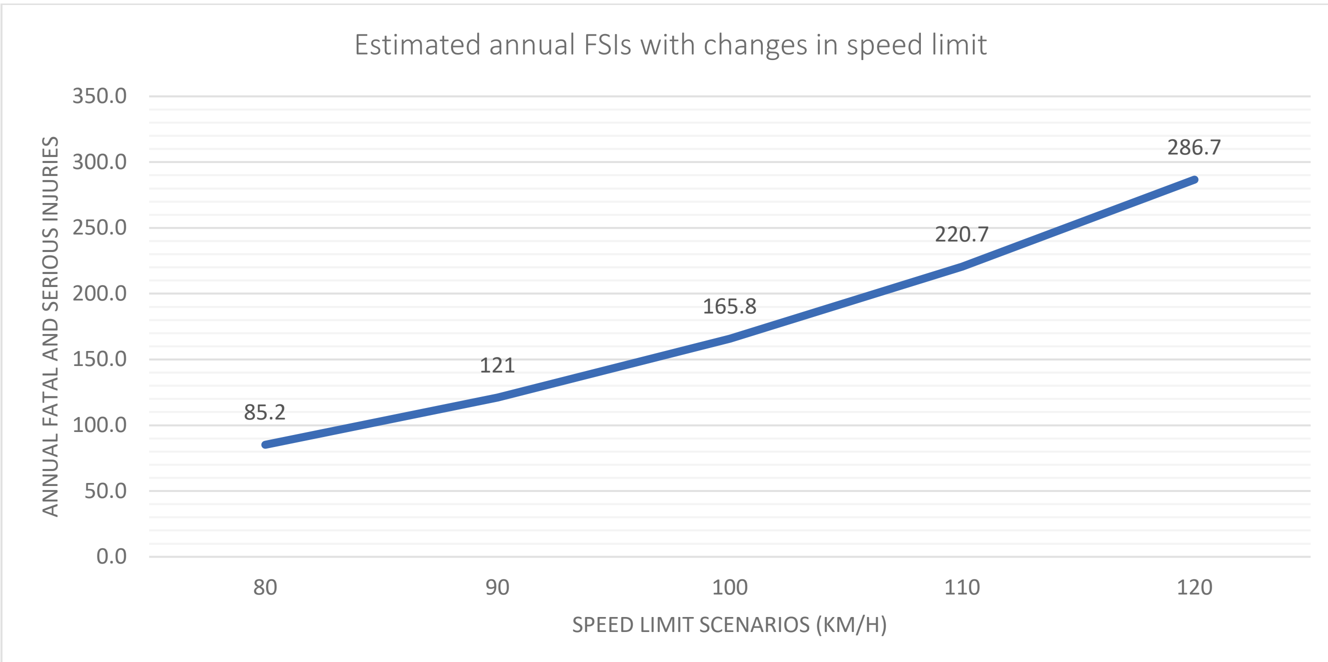
Based on crash data received, during 2014–2016 an average of 11 fatalities took place on the Outer Bangkok Ring Road. With no data available on serious injuries, the analysis was based on a default ratio of 10 serious injury crashes to one fatality.[17] That equates to an estimated 121 FSIs per year using the (90 kph limit) baseline dataset. The results based on the speed variation are shown in the chart and table below.

Table 3.2. Data on FSIs on the Outer Bangkok Ring Road based on speed variation

	Variation	Baseline	Variation	Variation	Variation
Speed limit (kph)	80	90	100	110	120
Annual average fatalities	7.7	11	15.1	20.1	26.1
Annual average serious injuries (estimated)	77.4	110	150.7	200.6	260.6
Annual FSIs	85.2	121	165.8	220.7	286.7
Change in FSIs Outcomes	**-36**	NA	**45**	**100**	**166**
% change from baseline	**-30%**	NA	**37%**	**82%**	**137%**

[17] iRAP. *The True Cost of Road Crashes. Valuing Life and the Cost of a Serious Injury*. http://resources.irap.org/Research/iRAP%20report%20-%20the%20true%20cost%20of%20road%20crashes%20-%20ESP.pdf

Figure 3.4. Estimated annual FSIs with changes in speed limit on the western portion of the Outer Bangkok Ring Road



A reduction of the (enforced) speed limit from 90 to 80 kph would lead to an estimated 30 percent reduction in FSIs on the road section, which equates to 36 fatal and serious injuries prevented (saved) each year. By contrast, the lack of enforcement of the current speed limit, and the adoption of a 120 kph limit, is estimated to drastically increase FSIs to 287, approximately three times more than at an operating speed of 80 kph.

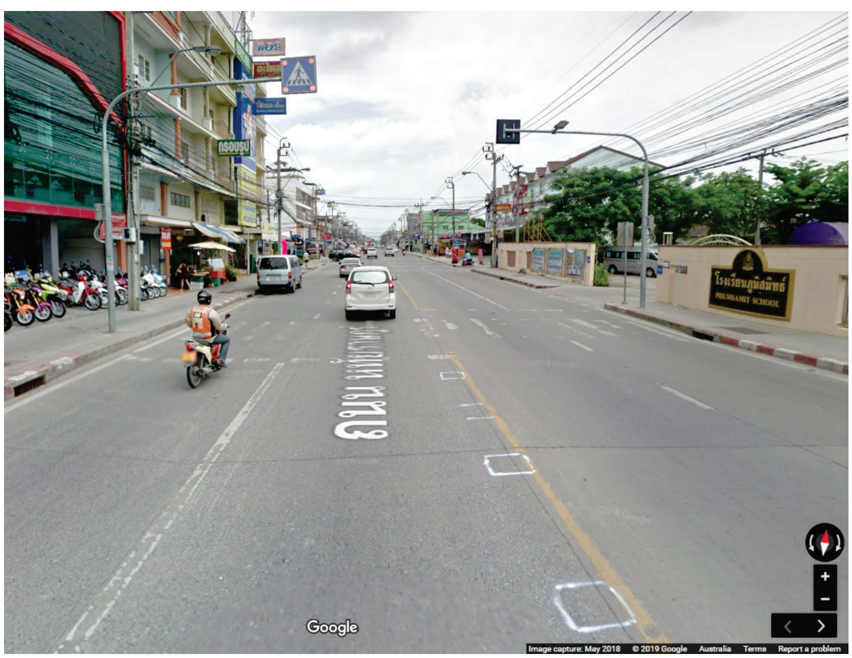
4. Case Study 2: Hathai Rat Road, Bangkok

4.1. General overview and baseline

The iRAP model can be used to show how speed influences risk for all main types of road user including vehicle occupants, motorcycle riders, pedestrians and bicyclists. Using a 2.3 km section of Hathai Rat Road, in Min Buri district, Bangkok, as a case study, various speed limit options were tested to measure the change in risk (Star Ratings) for each of the major road user types present.

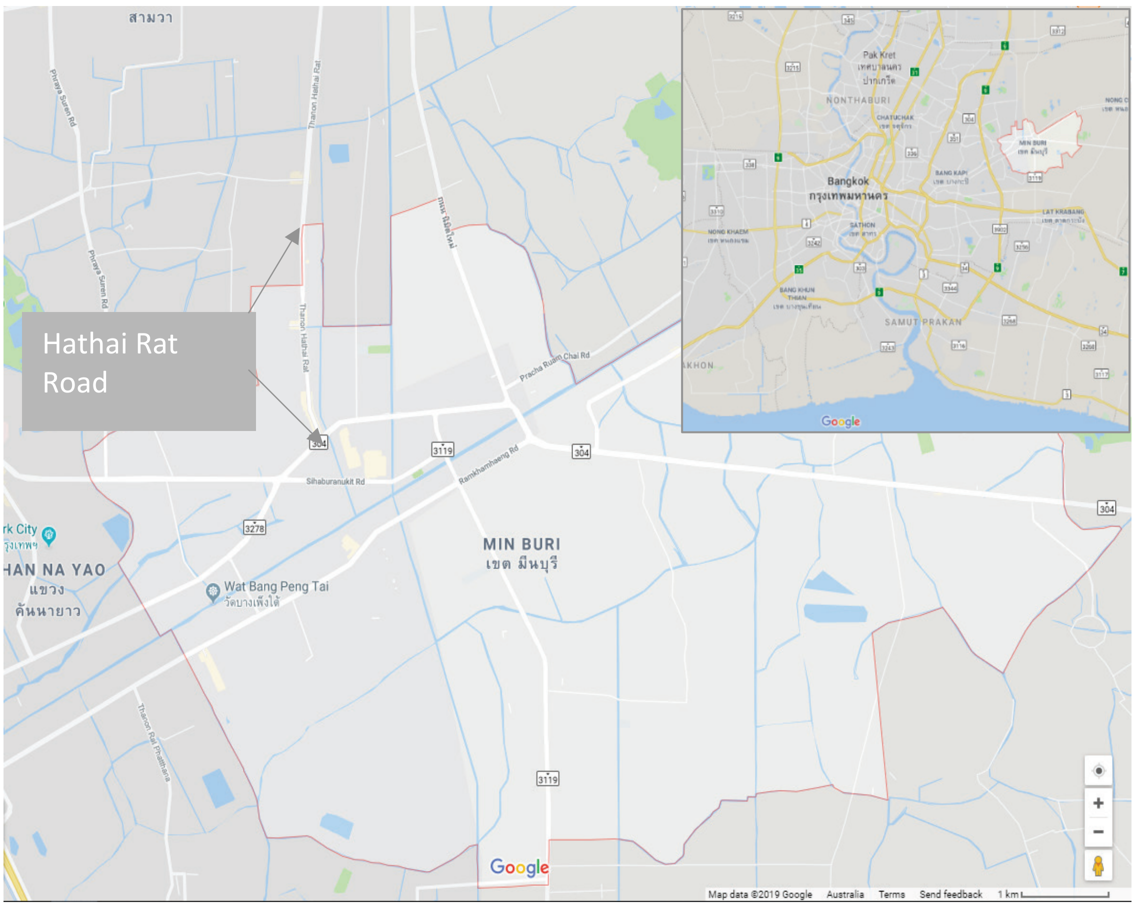
The section used in this study is a four-lane road (two lanes in each direction) starting at the junction with Suwinthawong Road and running north to the district boundary. The southern section is undivided for a length of 1.6 km. The remaining length to the district boundary is a divided carriageway with a physical median strip. This urban road, which is currently subject to a speed limit of 80 kph, runs through a mix of areas devoted to commerce, industry and education, with vulnerable road users along its entire length. Several schools and colleges are located along the road, including Sudjai Wittaya School, Phumsamit School, Priyakorn School and the Minburi Business Administration Vocational College. It has sidewalks on both sides, and two pedestrian crossings without signals are encountered along the route. Although warning signs and flashing indicators are present, the condition of the road markings is poor, as shown in the Street View image shown below.

Figure 4.1. Unsignalized pedestrian crossing in poor condition outside Phumsamit School, Hathai Rat Road, Bangkok (May 2018)



This road was first surveyed using the iRAP methodology in 2017 as part of the Bangkok Metropolitan Administration assessment project on high-risk districts 1-6. The location map below shows Hathai Road within Min Buri district, including the location of that district within Bangkok.

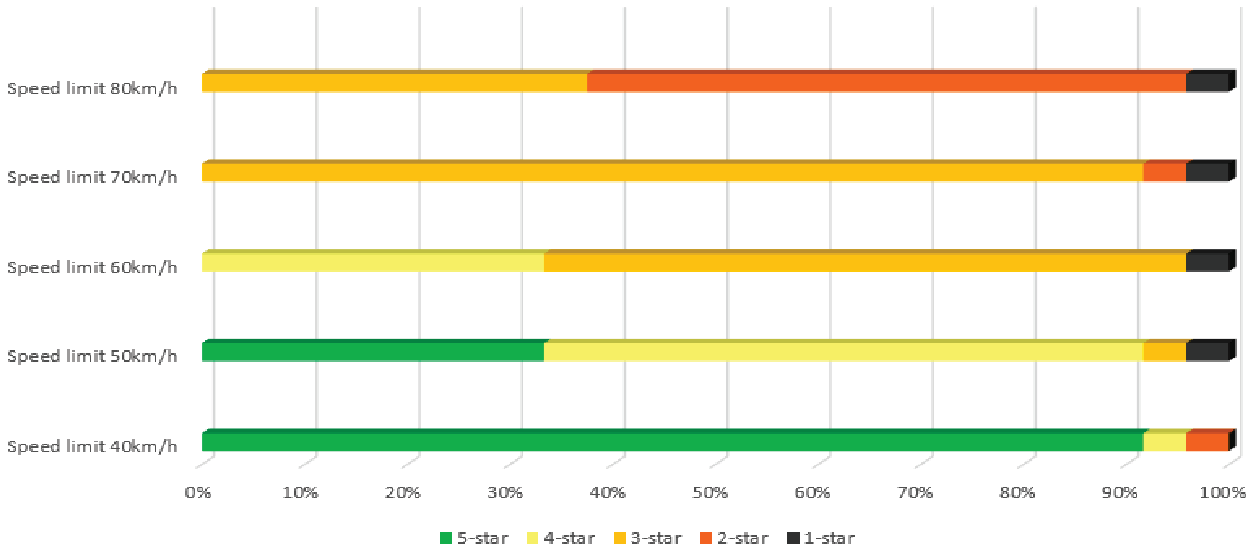
Figure 4.2. Location map showing Hathai Rat Road in Min Buri district, Bangkok



4.2. Speed variation results

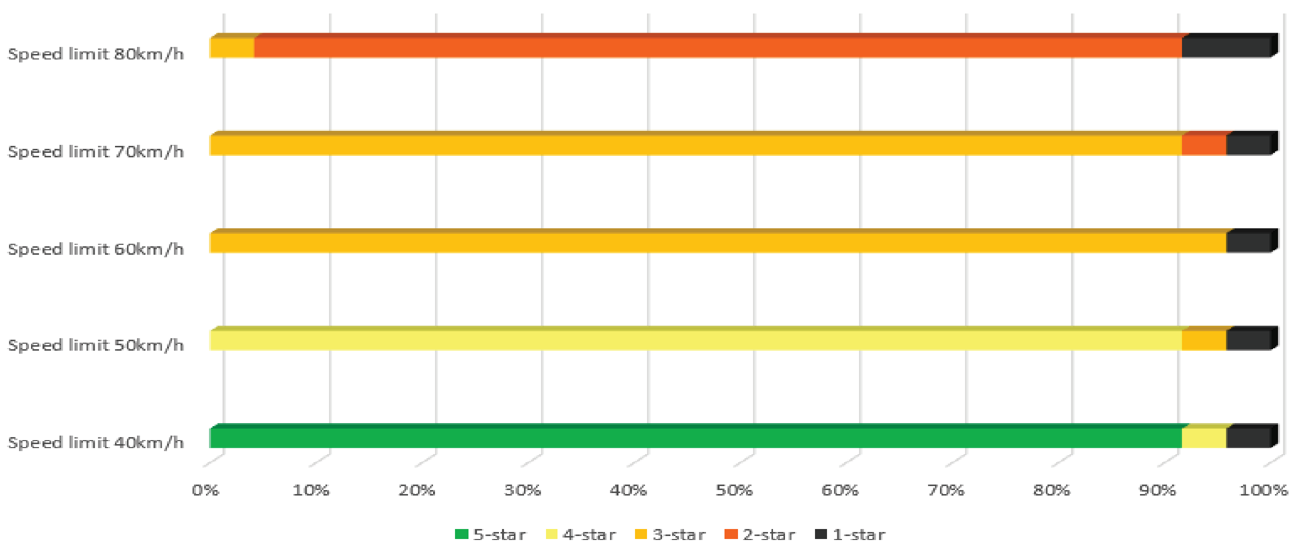
Speed sensitivity modeling was conducted to investigate the change in risk for vehicle occupants, motorcyclists, pedestrians and bicyclists at different speed limits. Raw Star Rating results, namely unaveraged Star Ratings for every 100m segments, have been used in this case study due to the short length of road section being assessed. The results are shown in the charts below.

Figure 4.3. Speed analysis testing for vehicle occupants, Hathai Rat Road



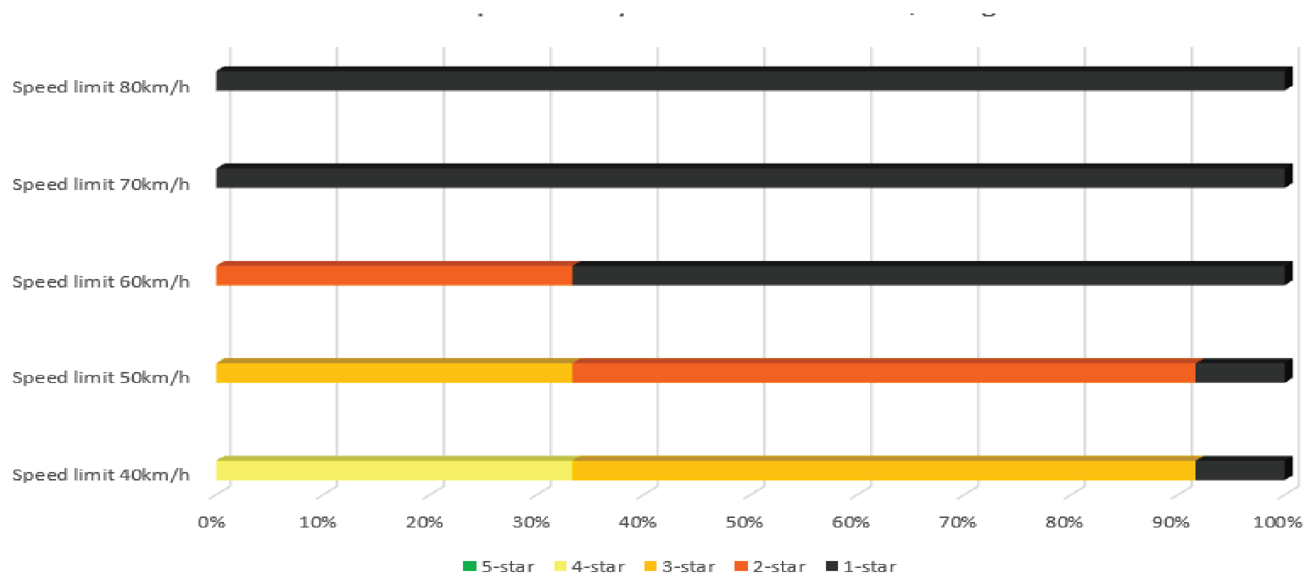
At the current speed limit of 80 kph, the raw iRAP Star Rating results for vehicle occupants show 38 percent of the road length to be 3-star, 58 percent 2-star and 4 percent 1-star. The 1-star segment is located at the major intersection with Suwinthawong Road where the FSI risk for vehicle occupants is the highest. At 40 kph the speed analysis testing shows 92 percent of the road length to be 5-star, 4 percent 4-star and 4 percent 2-star.

Figure 4.4. Speed analysis testing for motorcyclists, Hathai Rat Road



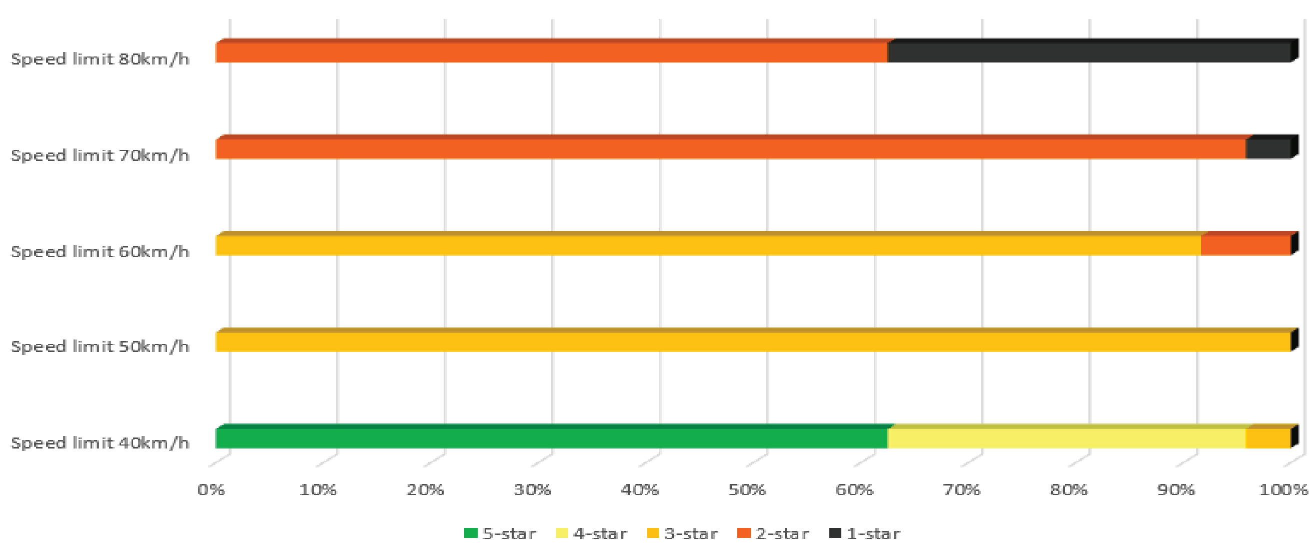
At 80 kph, the raw iRAP Star Rating results for motorcyclists show 4 percent of the road length to be 3-star, 88 percent 2-star and eight percent 1-star. At 40 kph, the results show that 92 percent of the road length is 5-star, four percent 4-star and four percent 1-star.

Figure 4.5. Speed analysis testing for pedestrians, Hathai Rat Road



At 80 kph, the raw iRAP Star Rating results for pedestrians show that the entire length is rated 1-star. At 50 kph 33 percent is 3-star, 58 percent 2-star and eight percent 1-star. At 40 kph the results show that 33 percent of the road length has a 4-star, 58 percent a 3-star and eight percent a 1-star score.

Figure 4.6. Speed analysis testing for bicyclists, Hathai Rat Road



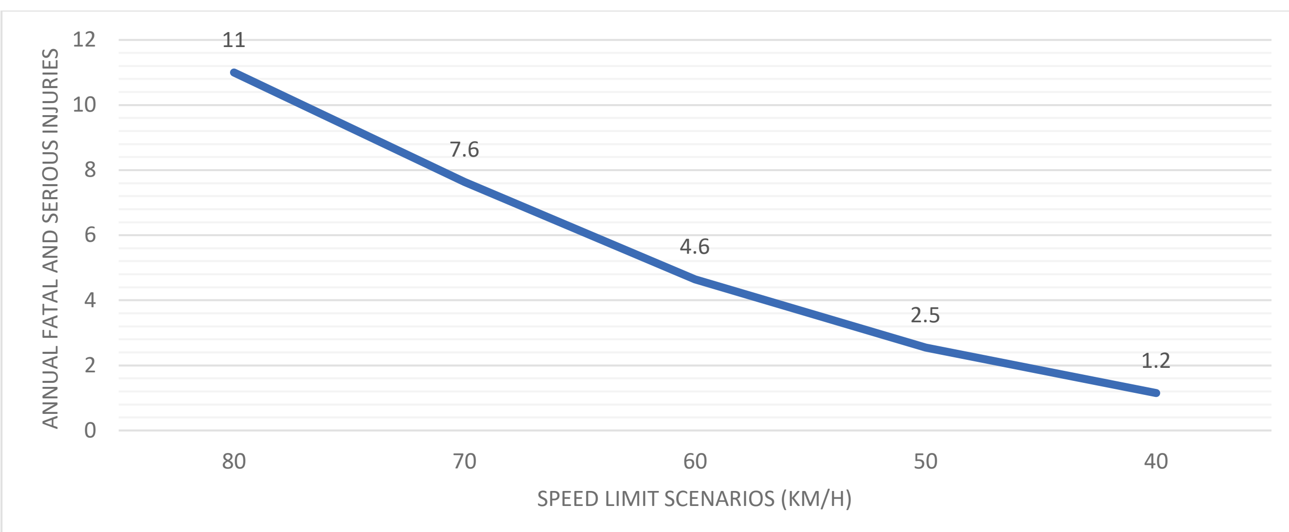
At 80 kph, the raw iRAP Star Rating results for bicyclists show 62 percent of the road length to be 2-star and 38 percent 1-star. At 40 kph the results show that 63 percent of the road length would be 5-star, 33 percent 4-star and four percent 3-star.

Based on the crash data received, during 2014–2016 an average of one fatality took place on Hathai Rat Road. With no data available on serious injuries, the default ratio of 10 serious injury crashes to one fatal was assumed.[18] That amounts to 11 annual FSIs on the 80 kph baseline dataset. The results based on the speed variation are shown in the chart and table below.

Table 4.1. Data on FSIs on the Hathai Rat Road based on speed variation

	Baseline	Variation	Variation	Variation	Variation
Speed limit (kph)	80	70	60	50	40
Annual average fatalities	1	0.7	0.4	0.2	0.1
Annual average serious injuries (estimated)	10	6.9	4.2	2.3	1.0
Annual FSIs	11	7.6	4.6	2.5	1.2
Change in FSIs (outcomes)	NA	**-3.4**	**-6.4**	**-8.5**	**-9.8**
% change from baseline	NA	**-31%**	**-58%**	**-77%**	**-90%**

Figure 4.7. Estimated annual FSIs with changes in speed limit (and associated speeding behavior) on Hathai Rat Road, Bangkok



[18] iRAP. *The True Cost of Road Crashes. Valuing life and the Cost of a Serious Injury*. http://resources.irap.org/Research/iRAP%20report%20-%20the%20true%20cost%20of%20road%20crashes%20-%20ESP.pdf

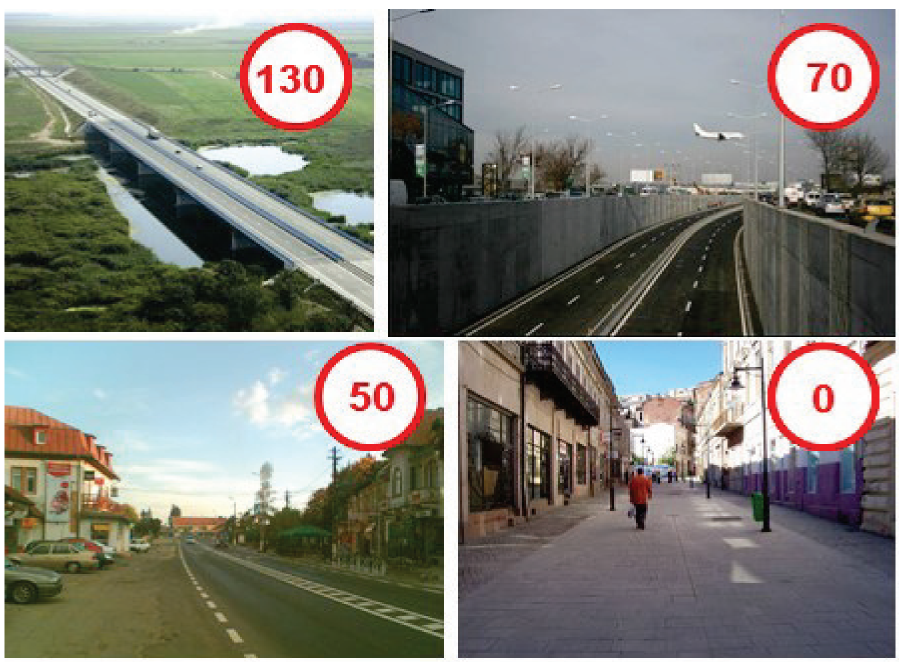
A reduction of the (enforced) speed limit from 80 kph to 70 kph would lead to a 31 percent reduction in FSIs on the road section, which equates to an average of three fatal or serious injuries prevented (saved) each year. A sharper intervention, halving the speed limit to 40 kph, would lead to a roughly 90 percent reduction in FSIs, saving approximately 10 people from serious or fatal injury.

5. Conclusions and recommendations

Appropriate mandatory speed limits should be set to increase the length of road rated at 3-stars or better for all road users. These limits should be consistently marked and well understood by all road users, and thus clearly supportive of the Safe System principles. Complementary engineering is also needed for traffic calming, alongside improved education – plus enforcement.

Speed limit signs will not be respected without **self-explaining roads, enforcement and education!**

Figure 5.1. Speed limits in different types of road environment



The two case studies demonstrate that road function, traffic mix and adjacent land use or development are important considerations when determining appropriate speed limits. For example, undeveloped rural areas with adequate road design standards may be suitable for a limit of 100 kph or even 120 kph, whereas vehicle speeds should be limited in commercial and residential areas or rural towns and villages where pedestrians are likely to be present.

36 fatalities and serious injuries could be prevented each year on the western portion of the Outer Bangkok Ring Road with a 10 kph speed reduction, from 90 to 80 kph

The results of the analysis on the Outer Bangkok Ring Road show that even at 120 kph roads can score 3-stars, particularly where the risks of head-on and run-off crashes are reduced through adequate road design. At the current speed limit of 90 kph, 23 percent of the assessed length is high-risk. Given that vehicles routinely exceed the speed limit, a combination of enhanced speed limit enforcement plus engineering improvements along the current high-risk sections is recommended in order to bring the corridor up to a minimum 3-star standard.

The current speed limit of 80 kph on the Hathai Rat Road is shown to increase the risk of death and serious injury for all types of road user. A revised speed limit of 50 kph would improve more than 95 percent of the road length to 3-stars or better for vehicle occupants, motorcyclists and bicyclists, with 33 percent attaining 3-stars for pedestrians. At key high-use locations, existing pedestrian crossings should be upgraded and additional crossing facilities provided. It would also be much safer for pedestrians at these locations if they had to cross fewer lanes and could benefit from pedestrian refuge islands and traffic calming measures.

Halving the speed will **eliminate 90 percent of fatalities and serious injuries** on Hathai Rat Road.

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