Development of Malaysia Driver Score – MIROS Pilot Study

HIZAL HANIS BIN HASHIM
AKMALIA BINTI SHABADIN
NUUR SAKINAH BINTI AZMAN
MUHAMMAD RUHAIZAT BIN ABD GHANI

MALAYSIAN INSTITUTE OF ROAD SAFETY RESEARCH (MIROS)| Lot 135, Jalan TKS 1, Taman Kajang Sentral, 43000 Kajang, Selangor

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1. Background

Road crashes may be resulted from human factors, environment and/or design of roads and vehicles. However, human factor often plays as one of the greatest roles in causing road crashes, especially for those involving commercial vehicles (Abang Abdullah and Von, 2011). Based on yearly road crash statistics released by PDRM, on average, 80% of the causes for road crashes are due to human errors, while another 13% were due to environmental factors and remaining 7% were from vehicle defects.

The percentage of drivers and riders involved in road crashes by type of human faults for the year of 2017 is presented in table 1 below (PDRM, 2018). Not at fault was excluded from this table hence providing only investigated fault for road crashes. For fatal road crashes, dangerous turning (13%), speeding (12.8%) and careless driving (12%) were among the highest percentage, aside for other offences which were not specified (14.4%). For overall casualties road crashes, dangerous turning (13.8%), careless driving (9.3%), speeding (9.1%) and dangerous overtaking (8.4%) were among the high contributing factors for human fault.

Table 1 Percentage of Drivers/Riders Involved In Road Crashes By Type of Human Faults, 2017

Type of Faults	Fatal (%)	Serious (%)	Minor (%)	Total (%)
Careless at Entrance / Exit	6.4	6.5	5.4	6.1
Negligent signaling	5.9	6.3	2.5	4.9
Overloading (Goods)	1.6	3.7	1.6	2.2
Overloading (Passengers)	3.0	4.4	3.3	3.5
Wrong Parking	4.1	5.1	3.8	4.3
Drugs	0.0	0.1	0.1	0.1
Careless Driving	12.0	9.4	6.1	9.3
Dangerous Driving	6.1	6.0	5.0	5.7
Dangerous Turning	13.0	11.7	16.3	13.8
Dangerous Overtaking	6.4	10	9.4	8.4
Driving Too Close	6.8	5.9	9.3	7.4
Speeding	12.8	6.8	6.5	9.1
Not Conforming to T/Light	7.6	9.2	4.8	7.1
Others Offences	14.4	14.7	25.7	18.3
Total	100	100	100	100

As identified in the table above, violations and faults such as dangerous turning, careless driving and speeding can be reduced by implementing driver monitoring and warning devices. Intelligent Transportation Systems (ITS) presents various technologies to assist human drivers. ITS technologies can be used to facilitate and enhance road safety and one of the ways is by reducing the human fault (Qureshi and Abdullah, 2013). In essence, ITS technologies may be categorized into two types: Intelligent Infrastructure Technologies and Intelligent Vehicle Technologies. Intelligent Infrastructure Technologies are ITS technologies based within road or transportation infrastructure, while Intelligent Vehicle Technologies are ITS technologies essentially located within, or as part of, a vehicle (Lin, 2003).

A series of studies was conducted by Horrey, Lesch, Dainoff, Robertson and Noy (2012) to evaluate the on-board safety monitoring system in the US. The studies found that there was a reduction in risky driving behaviour and an increase in seat-belt usage. The findings also showed a 37% and 52% reduction in safety-related events per 10,000 miles in two different commercial carriers, whereas a 30% crash reduction was found for fleet drivers.

Meanwhile, a study by Toledo, Musicant and Lotan (2008) on in-vehicle data recorders for monitoring and feedback on drivers' behaviour used the Individual Risk Index calculation method in their data analysis to obtain risk classification for drivers. Based on the risk index, drivers are classified in three categories which are Green (moderate behavior), Yellow (Intermediate behavior) and Red (risky behavior). The main purpose of this classification is to provide a simpler system to report risk indices that will be understandable to layman drivers. In addition, this study also applied the blind phase method as part of the research methodology.

Pradhan, Lin, Wege, and Babel (2017) conducted a study on the effects of behavior-based driver feedback systems on commercial long-haul operator safety to compare the driving behaviour among commercial vehicle drivers who received feedback from their safety managers as compared to drivers who did not receive feedback. This study applied the research methodology of blind testing during which both drivers and their managers did not receive any feedback although data was recorded, followed by a period of time during which the system was activated, and ended with an extended period of the blind phase. The study found a decline in the rate of risky events among drivers who received supervisor feedback and a significant improvement in their driving behaviour compared to the drivers who did not receive any feedback.

Part of ITS solutions is the Advanced driver-assistance systems, or ADAS. ADAS are systems to help the driver in the driving process. The use of ADAS are generally intended to increase road safety by monitoring driving behaviour such as Lane Departure Warning (LDW), Forward Collision Warning (FCW) and headway monitoring. Common ADAS systems use video processing technology to monitor the surrounding area.

With exception to motorcycles, installation of ADAS is applicable for vehicles such as passenger and commercial vehicles. Table 2 below shows the percentage of drivers (passenger and commercial vehicles only) involved in road crashes by type of human faults for the year of 2017.

Table 2 Percentage of Drivers Involved In Road Crashes By Type of Human Faults, 2017

Type of Faults	Fatal (%)	Serious (%)	Minor (%)	Total (%)
Careless at Entrance / Exit	8.4	8.9	11	9.2
Negligent signaling	7.1	7.9	2.9	6.2
Overloading (Goods)	1.9	5	2.6	2.9
Overloading (Passengers)	3.6	6	6.4	5
Wrong Parking	5.1	6.9	4.9	5.5
Drugs	0	0.1	0	0
Careless Driving	9.4	6.8	4	7.3
Dangerous Driving	6.4	6.9	8.5	7.1
Dangerous Turning	14.3	13.5	20.3	15.6
Dangerous Overtaking	5.4	12	9.7	8.4
Driving Too Close	7.7	6.6	7.7	7.4
Speeding	11.8	5.4	0	5.8
Not Conforming to T/Light	6.6	8.5	3.3	6.3
Others Offences	12.6	5.5	23.2	13.2
Total	100	100	100	100

The overall trend for passenger and commercial vehicles type of faults is quite similar to the overall trend as presented in Table 1. Based on functionality of ADAS, those type of faults as highlighted in orange in Table 2 can be tackled by ADAS. These are speeding, driving too close and negligent signalling. In addition, ADAS has the potential to also reduce other factors, such as highlighted in yellow in Table 2. They are dangerous turning, careless driving, careless at entrance/exit, dangerous turning and dangerous overtaking. In total, ADAS has the potential to reduce by up to 67% of driver faults for all casualty crashes and by up to 70% for fatal crashes.

Based on the potential of ADAS in reducing driver faults, MIROS has conducted a study with Atilze to determine the feasibility of using this device to reduce road crashes and establish driver profiling in the country. This study utilises the Advanced Driver Assistance System (ADAS) to monitor and record driver behaviour specifically on the aspect of dangerous turning, speeding and careless driving.

Table 3 Percentage of Lorry/Bus Drivers (Commercial Vehicles) Involved In Road Crashes By Type of Human Faults, 2015

Type of Faults	Fatal (%)	Serious (%)	Minor (%)	Total (%)
Careless at Entrance / Exit	3.9	0	4.5	0.1
Negligent signaling	3.4	0	0	0
Overloading (Goods)	0.4	0	0	0.1
Overloading (Passengers)	0	0	0	0
Wrong Parking	5.2	10	6.1	0
Drugs	0	0	0	0
Careless Driving	27	22.5	31.8	0.3
Dangerous Driving	6.9	7.5	4.5	0
Dangerous Turning	4.3	2.5	3	0
Dangerous Overtaking	3	2.5	1.5	4.9
Driving Too Close	2.6	5	10.6	32.4
Speeding	3.4	15	18.2	25.7
Not Conforming to T/Light	2.6	7.5	1.5	0.4
Others Offences	37.3	27.5	18.2	36.1
Total	100	100	100	100

Table 4 Percentage of Private Passenger Vehicle Involved In Road Crashes By Type of Human Faults, 2015

Type of Faults	Fatal (%)	Serious (%)	Minor (%)	Total (%)
Careless at Entrance / Exit	2.6	0.9	4.2	0
Negligent signaling	1.1	0.9	0.6	0
Overloading (Goods)	0	0	0	0
Overloading (Passengers)	0	0	0	0
Wrong Parking	0.8	0.9	2.1	0
Drugs	0	0	0	0
Careless Driving	33.3	30.5	31.6	0.2
Dangerous Driving	9.8	2.8	3	0
Dangerous Turning	2.7	5.2	9.9	0
Dangerous Overtaking	6.3	9.9	4.8	5.3
Driving Too Close	4.7	4.7	6.9	38.5
Speeding	6.1	16	10.5	35
Not Conforming to T/Light	3.1	3.3	2.1	1
Others Offences	29.5	24.9	24.4	19.8
Total	100	100	100	100

2. Methodology

Hardware Installation

The Advanced Driver Assistance System (ADAS) and On-board Diagnostics Device (OBD) was installed in 20 different vehicles based on the vehicle compatibility with these devices. Data collection was then conducted in two different phases which are the blind mode and the unblind mode. In blind mode, the ADAS will only record the violations conducted by the drivers while in the unblind mode, the ADAS records and alert the drivers using sound and visual display. Blind mode began on 30th March 2018 and ended on 25th April 2018 whereas unblind mode began on 30th April 2018 and ended on 4th July 2018.

To measure the effect of ADAS alert even when the system is not around, reblind phase was conducted from 6th July 2018 to 31st July 2018. During this phase, ADAS is still collecting driver's violation but without the alert sound and visual display. This can help to determine if the driver's has improved their overall driving even when the alert and warning system is not activated.

ADAS Installation

Example of ADAS Visual Display

Figure 1: ADAS Installation

Respondent Demographic

A total of 20 respondents participated in this project consisting of 9 males and 11 females. The age of the respondents ranged from 27 years old to 54 years old. Respondent selection was made based on their vehicle compatibility with the ADAS device, such as vehicle model, vehicle age and engine capacity.

For the purpose of this study, the age and engine capacity of the respondents were grouped into two categories; below 40 years old and above 40 years old; and below 1.4cc and above 1.4cc. Table 3 below shows the respondent distribution according to age group and engine capacity:

Table 5 Demographic distribution of respondents

Demographic Variable	Category	Frequency
Gender	Male	9
	Female	11
Age	Below 40 years old	15
	Above 40 years old	5
Engine Capacity	Below 1.4cc	4
	Above 1.4cc	16

Further analysis was conducted to determine the average number of violations by gender, age group and engine capacity as displayed in Table 4 below. From the table, it can be seen that on average, the number of violations conducted by males were higher compared to females. In terms of age group, respondents aged above 40 years old conducted more violations compared to those aged 40 years and below. Respondents who drove a vehicle with an engine capacity of less than 1.4cc conducted more violations compared to those who drove vehicles with an engine capacity of more than 1.4cc.

Table 6 Average number of violations by demographic variable

Demographic Variable	Category	Average Number of Violations
Gender	Male	12,750
	Female	7,810
Age	Below 40 years old	8,609
	Above 40 years old	14,302
Engine Capacity	Below 1.4cc	12,800
	Above 1.4cc	9,341

Survey Questionnaire

Part of the study is to identify the drivers' behaviour change towards the warning sound of ADAS installed in the respondents' cars and through the questionnaires distributed to the respondents.

The first component of the questionnaire consists of the respondent's demographic details such as gender, age, involvement in road accidents and driving experience.

The second component of the questionnaire aims to explore the sensation seeking level of the respondent and consists of 20 questions. The questions were translated from Zuckerman's (1964)

Sensation Seeking Scale, and asks respondents to select from two options as shown in Table 1 below.

Table 7 Sensation seeking component

Item No.	Item
1A	Saya selalu berharap untuk menjadi seorang pemanjat gunung professional
1B	Saya tidak dapat memahami kenapa sesetengah manusia menyabung nyawa untuk memanjat gunung
2A	Seorang yang waras akan mengelak melakukan sebarang aktiviti berbahaya
2B	Kadang-kadang saya suka melakukan perkara yang sedikit menakutkan
3A	Saya berhajat untuk menyertai aktiviti ski air (water skiing)
3B	Saya tidak berhajat untuk menyertai aktiviti ski air (water skiing)
4A	Saya berminat untuk mencuba aktiviti luncur air (surfboarding)
4B	Saya tidak berminat untuk mencuba aktiviti luncur air (surfboarding)
5A	Saya tidak berminat untuk belajar menerbangkan pesawat
5B	Saya berminat untuk belajar menerbangkan pesawat
6A	Saya lebih gemar permukaan air berbanding dalam air
6B	Saya berminat untuk melakukan aktiviti menyelam scuba
7A	Saya tidak akan sesekali melompat daripada kapal terbang samada memakai payung terjun atau tidak
7B	Saya berminat untuk mencuba aktiviti payung terjun
8A	Saya berminat untuk terjun daripada papan anjal yang tinggi
8B	Saya tidak suka perasaan semasa berdiri di atas papan anjal yang tinggi, atau mendekatinya
9A	Pelayaran jarak jauh menggunakan kapal kecil adalah sesuatu yang bodoh
9B	Saya berminat untuk berlayar jarak jauh di dalam kapal yang walaupun kecil tetapi layak berlayar di lautan
10A	Berski laju menuruni cerun gunung yang tinggi adalah cara yang baik untuk mendapat kecederaan
10B	Saya fikir saya akan berasa teruja dan seronok dengan berski laju menuruni cerun gunung yang tinggi

The third component of the questionnaire asks the respondent's anger level and uses a 5-point Likert scale (Not angry – Very angry) as shown below:

Table 8 Driving anger component

No	Situasi
1.	Sebuah kenderaan sering memotong (mencilok) kenderaan di jalan raya.
2.	Kenderaan bergerak perlahan ketika melalui jalan berbukit dan tidak mahu memberi laluan kepada kenderaan lain.
3.	Pemandu di hadapan anda mengundurkan kenderaannya tanpa memerhatikan terlebih dahulu kenderaan anda yang berada di belakangnya.
4.	Pemandu melanggar lampu isyarat merah atau tidak menghiraukan papan tanda "Berhenti".
5.	Anda melepasi alat radar perangkap kelajuan.
6.	Pemandu enggan memberi peluang kepada anda untuk memotong kenderaannya.
7.	Pemandu meletakkan kenderaannya (parking) dengan perlahan atau terlalu lambat sehingga menyebabkan kesesakan lalu lintas.
8.	Anda terperangkap dalam kesesakan lalu lintas.
9.	Pemandu menunjukkan isyarat lucah terhadap cara pemanduan anda.
10.	Pemandu yang membunyikan hon kenderaanya kerana cara anda memandu.
11.	Penunggang motosikal menunggang di tengah jalan raya sehingga menghalang pergerakan trafik.
12.	Pegawai polis memberhentikan kenderaan anda.
13.	Trak membawa muatan pasir atau batu yang terkena kenderaan anda.
14.	Penglihatan anda ketika memandu dihalang oleh sebuah kenderaan besar yang lain di hadapan anda.

3. Results

Overall Violation

The duration of days for both blind and unblind period was set at 27 days respectively. A decrease in overall violations during unblind mode was observed with 20% reduction as shown in Figure 2 below. However, during the re-blind period, the number of violation has increased by 26.2%. In comparison to the first blind mode, the number of violations increased by 1%.

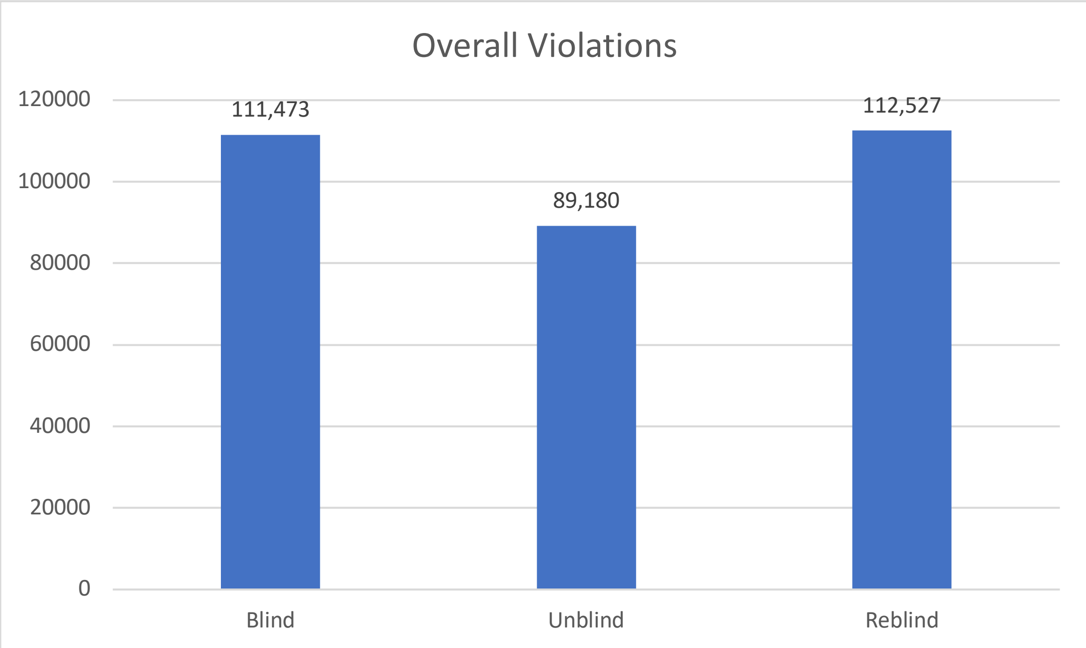

Figure 2 Overall violations by blind, unblind and re-blind mode

Four types of faults were analysed according to blind, unblind and re-blind mode as shown in Figure 3 below. All types of faults showed a reduction in the number of violations conducted during unblind mode as compared to blind mode. During the re-blind mode, the number of violations increased for all types with exception to Forward Collision Warning (FCW). During unblind mode, the biggest reduction of 49% can be seen for Lane Departure Warning (LDW) whereas the smallest reduction of 9% is observed for FCW. For LDW, most of the violations were for Direction 1 with 12,857 as compared to Direction 2 with 11,832. Shifting to re-blind mode, highest increased were observed for LDW, with a staggering increase of 82.1%. This is followed by speeding (23.4%) and HMW (17.6%). FCW recorded a reduction by 5.6%.

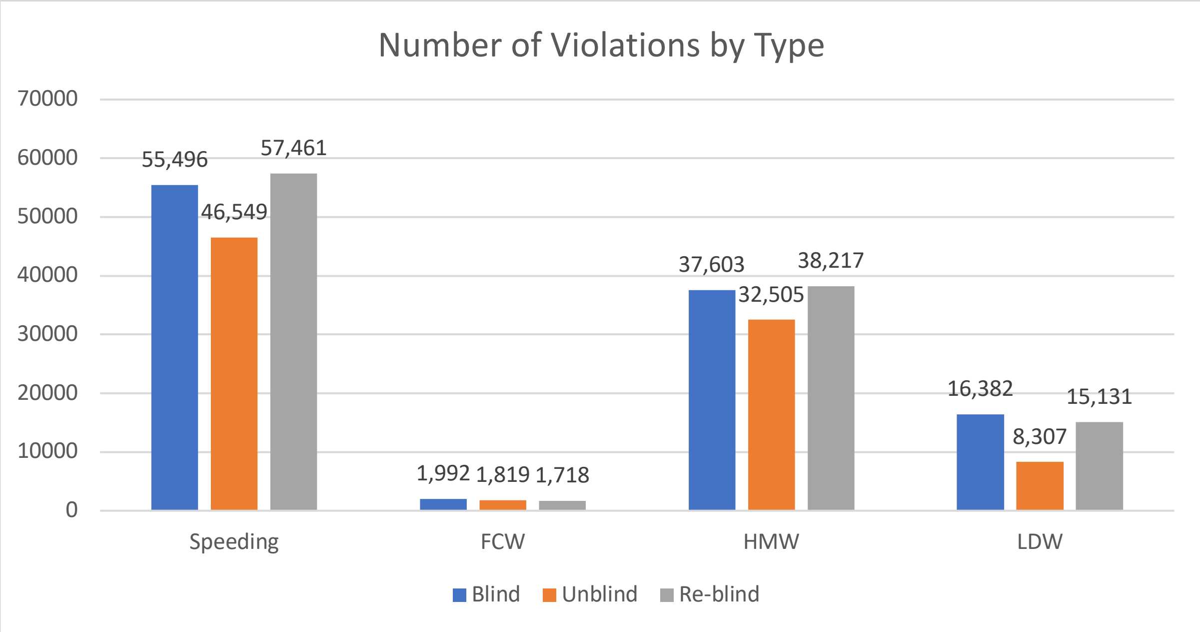

Figure 3 Number of violations conducted by type for blind, unblind and re-blind mode

An in-depth analysis was conducted to analyse the number of violations conducted by each respondent according to the type of fault during blind, unblind and re-blind mode.

Speeding

Figure 4 below shows the number of violations conducted by each respondent for externally detected speeding. Most of the respondents showed a decrease in the number of violations conducted during unblind mode with an average of 16%. However, the number of violations increased by 23.4%. In comparison to the first blind mode, the re-blind mode saw an increase of 3.5%.

The setup of the system when alerting drivers in the event of speeding is slightly different compared to other violations whereby the drivers would be prompted with an alert sound. This may not encourage the driver to slow down and adhere to the speed limit. Thus, this could explain why the reduction in speeding violations is not as high as expected.

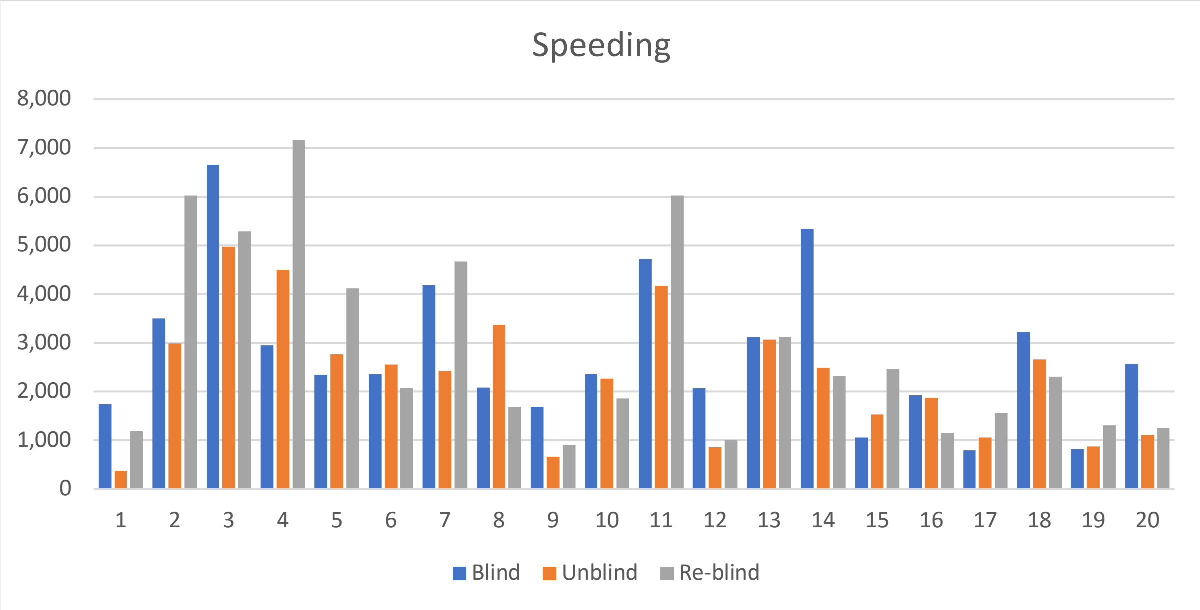

Figure 4 Number of violations conducted by each respondent for externally detected speeding

Forward Collision Warning

Figure 5 below shows the number of violations conducted by each respondent for forward collision warning. More than half of the respondents showed a decline by 9% in the number of violations conducted during unblind mode. The reduction continues further during the re-blind period by 5.6%. In comparison to the initial blind mode, FCW saw a reduction by 13.8% during the re-blind mode.

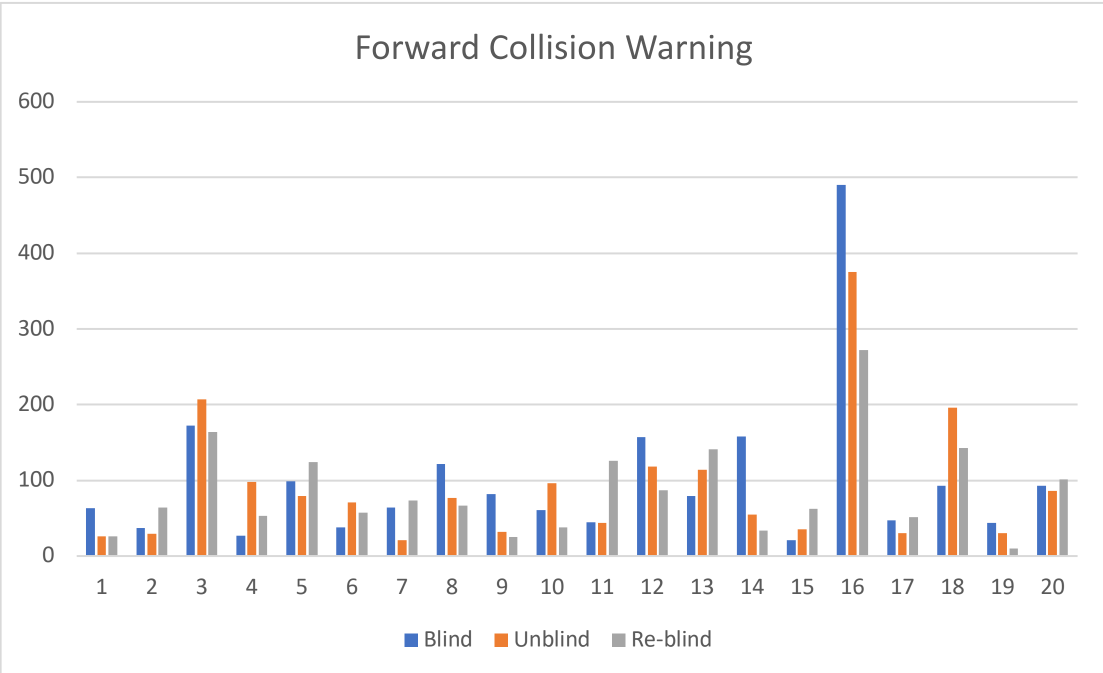

Figure 5 Number of violations conducted by each respondent for forward collision warning

Headway Monitoring Warning

Meanwhile, a reduction of 14% can be seen in the number of violations conducted by each respondent for headway monitoring during unblind mode. In re-blind mode, the number of violations rose by 17.6% as shown in Figure 6 below. In comparison to the blind mode, re-blind mode shows an increase of 1.6%.

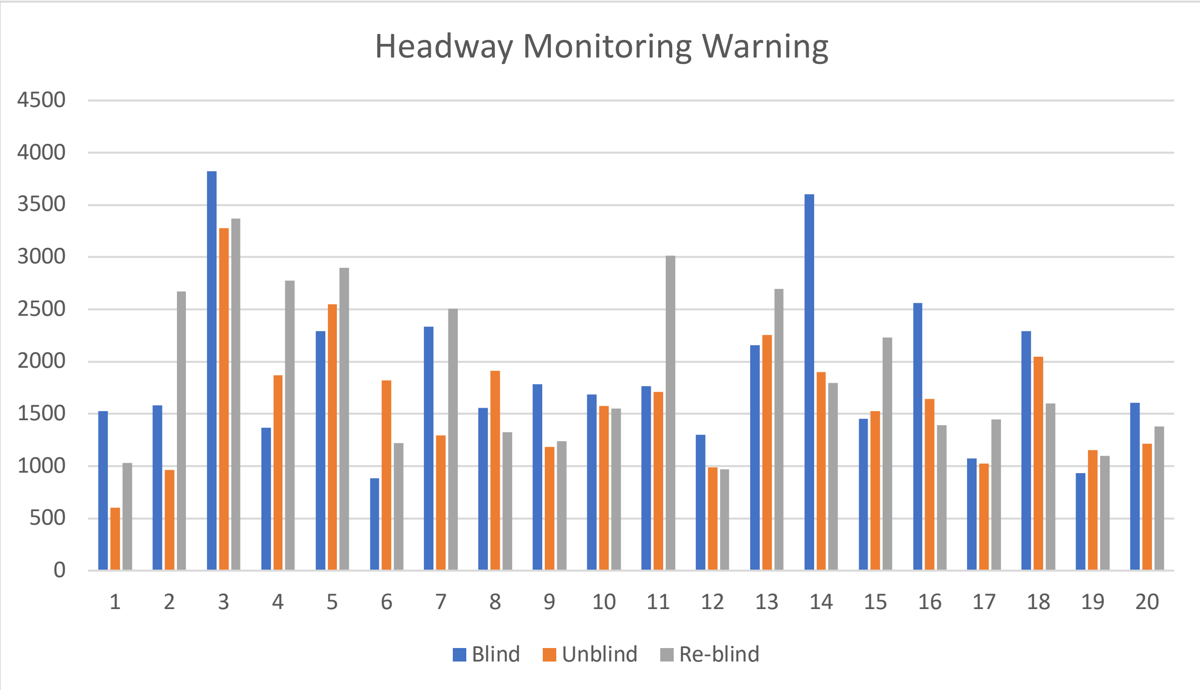

Figure 6 Number of violations conducted by each respondent for headway monitoring

Lane Departure Warning

Figure 7 below shows a reduction of 49% in the number of violations conducted by each respondent for lane departure warning during unblind mode. In re-blind mode, the number of violations increased to a higher value by 82.1%. However, when compared to the initial blind mode, the number of violations shows a reduction by 7.6%.

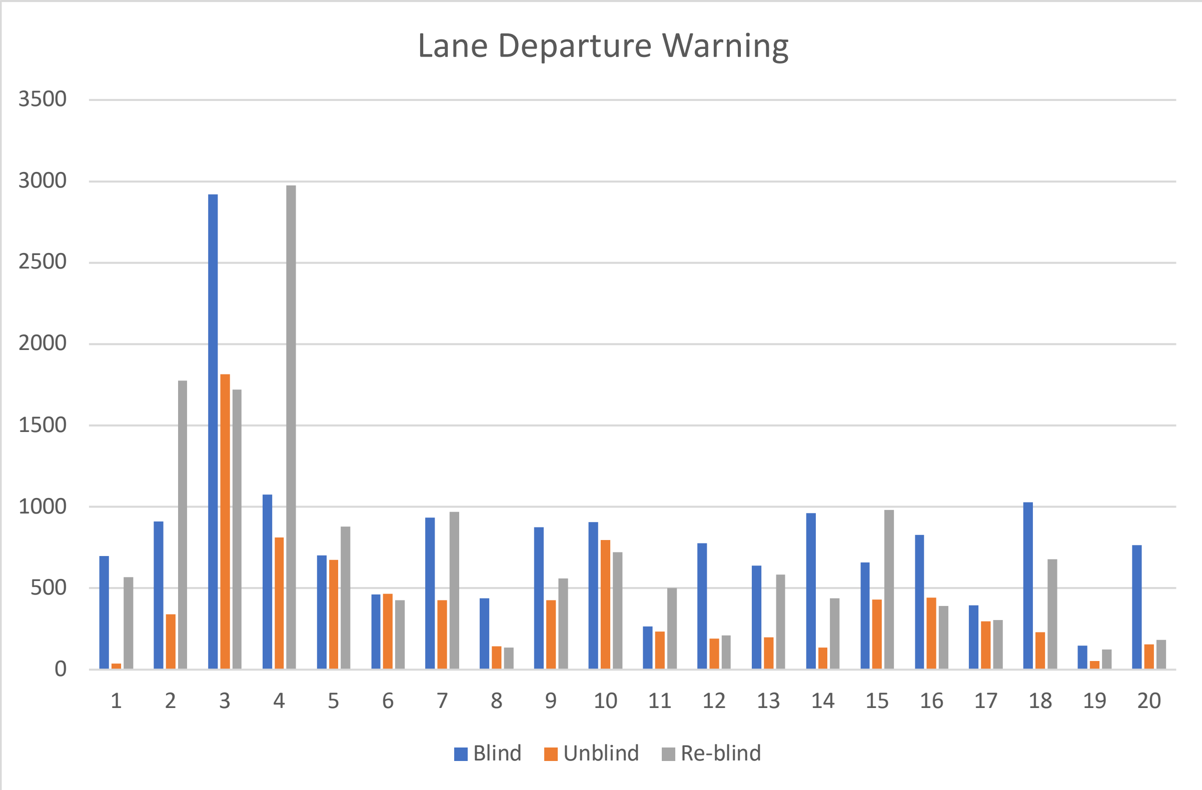

Figure 7 Number of violations conducted by each respondent for lane departure warning

The installation and implementation of the ADAS device has shown a reduction in the number of violations conducted and has improved the overall driver behaviour, when the warning and alert system is turned on. This is proven through data comparison between the blind and unblind mode in this study. During the unblind mode, ADAS would warn and prompt drivers whenever they are detected to be conducting a violation, thereby encouraging them to drive safer on the roads. In re-blind mode, when the warning system is turned off, the number of violations saw an increase. Therefore, ADAS warning system is proven to effectively reduce the number of driving violations.

Driving Behaviour

Demographics of the Drivers

A total of 15 respondents participated in this project consisting of 4 males and 11 females. The age of the respondents ranged from 27 years old to 39 years old. Respondent selection was made based on their vehicle compatibility with the ADAS device, such as vehicle model, vehicle age and engine capacity. The respondent's willingness to participate in the study was also taken into consideration.

For the purpose of this study, the age and engine capacity of the respondents were grouped into two categories; below 40 years old and above 40 years old; and below 1.4cc and above 1.4cc. Table 9 below shows the respondent distribution according to age group and engine capacity.

Table 9 Demographics of the Respondents

Demographic Variable	Category	Frequency
Gender	Male	4
	Female	11
Age	26-30 years old	3
	31-35 years old	7
	36-40 years old	5
Engine Capacity	Below 1.4cc	4
	Above 1.4cc	11

The Personality of the Drivers

Due to missing data, only 8 respondents (3 males, 5 females) were analysed for their personality, specifically sensation seeking and their anger level while driving. The sensation seeking scores of the respondents are shown in the following table according to their gender:

Table 10 Sensation seeking score of the respondents

No.	Respondent	Gender	Score
1.	Respondent 1	Female	10
2.	Respondent 2	Female	8
3.	Respondent 3	Male	8
4.	Respondent 4	Male	6
5.	Respondent 5	Male	4
6.	Respondent 6	Female	1
7.	Respondent 7	Female	1
8.	Respondent 8	Female	0

From Table 10, it can be seen that the respondents with the highest scores are females; Respondent 1 and Respondent 2 with a score of 10 and 8 respectively. The sensation seeking score of the male respondents ranged from 8 to 4, followed by the remaining three female respondents scoring from 0 to 1 and are thus low sensation-seekers.

Meanwhile, the anger level of the respondents according to their gender are shown in the Table 11 below.

Table 11 Anger level of the respondents

No.	Respondent	Gender	Anger Level
1.	Respondent 1	Female	Low
2.	Respondent 2	Female	Medium
3.	Respondent 3	Male	High
4.	Respondent 4	Male	High
5.	Respondent 5	Male	Medium
6.	Respondent 6	Female	High
7.	Respondent 7	Female	Low
8.	Respondent 8	Female	High

Table 6 shows that two male respondents and two female respondents have a high level of anger when driving, one male and one female respondent have a medium level of anger while driving and the remaining two female respondents have a low level of anger.

Influence of Warning Sound Towards Driving Behaviour

The duration of days for both blind and unblind phase was fixed at 27 days respectively. Assuming the participants travelled the same distance during both periods, a decrease in overall violations during unblind mode was observed by 20% as shown in Figure 2 previously. This shows that the presence of the IVTD helped to influence the drivers' driving behaviour. However, when the warning sound was turned off again, the number of violations increased.

4. Scoring Model

Scoring Model for Advanced Driver Assistance System (ADAS)

Parameter selection

Table 12 below shows the percentage of commercial vehicle drivers involved in road accident by type of faults for the year 2013 until 2015. Based on the table below, the most type of faults that have been made by drivers during the accident were careless driving, speeding, dangerous driving, wrong parking, and driving too close. The parameters that will be selected will be based on the common type of faults and technology's capability to track them.

Table 12 Number of commercial vehicle drivers involved in road accident by type of faults

Type of Faults	2015 (%)	2014 (%)	2013 (%)
Careless at Entrance / Exit	4	2	0
Negligent Signalling	2	0	0
Overloading (Goods)	0	0	0
Overloading (Passengers)	0	0	5
Wrong Parking	6	6	2
Drugs	0	1	0
Careless Driving	27	27	6
Dangerous Driving	6	5	2
Dangerous Turning	4	3	15
Dangerous Overtaking	3	7	8
Driving Too Close	4	4	10
Speeding	8	13	28
Not Conforming to T/Light	3	1	3
Others Offences	32	34	20

Definition of Parameters

Based on the common type of faults and technology's capability to track them, the three types of violation that been considered in the study were Forward Collision Warning (FCW), Lane Departure Warning (LDW) and Speeding (SPD). The headway monitoring was not included due to the factor that in urban driving setting, the following distance is normally close and other vehicle might cut into the front of the vehicle without leaving enough gap in between. In addition, FCW which is included as one of the parameter, is the result of headway monitoring when it gets to close and high probability of front collision.

Scoring Calculation Formula

i. Scoring Weightage

The scoring weightage was derived from the road crash data in Table 12. Table 13 below shows the percentage based on parameters that will be used to calculate the driver score.

Table 13 Number of drivers involved in road accident by type of faults

Year	**FCW**	**LDW**	**SPD**
2015	4	10	8
2014	4	5	13
2013	10	15	28
Total	18	29	49
Average of 3 years	6	10	16
Weightage	**19%**	**30%**	**51%**

ii. Scoring Calculation

Based on the weightage set for each type of violation, the score will be calculated based on below:

Score = 100 – (FCW Penalty Score + LDW Penalty Score + SPD Penalty Score)

where, FCW Penalty Score = $\frac{FCW}{KM\ Travelled}\ X\ 19$, maximum score is 19

LDW Penalty Score = $\frac{LDW}{KM\ Travelled}\ X\ 30$, maximum score is 30

SPD Penalty Score = $\frac{SPD}{KM\ Travelled}\ X\ 51$, maximum score is 51

iii. Simulation of scoring results based on pilot study

Based on the scoring calculation established, driving data that were obtained from pilot study between MIROS and Atilze were used to simulate the scoring performance of the respondents. Figure 8, 9 and 10 below shows the distribution of violations by type of violations for each KM the respondents travelled. The average number of FCW per KM is 0.036, average number of LDW per KM is 0.312 and average number of SPD per KM is 1.028. By examining these distributions, it will set a foundation to identify the number of violations that respondents normally commit and to identify the number of violations for the less risky drivers and the most risky drivers. These are useful when deciding the scoring range.

Based on these 3 types of violations, the highest were speeding, lane departure warning and forward collision warning. Based on these distributions, for every 100 KM travelled, the average number of speeding violations were 101 times, lane departure warning of 32 times and forward collision warning of 4 times.

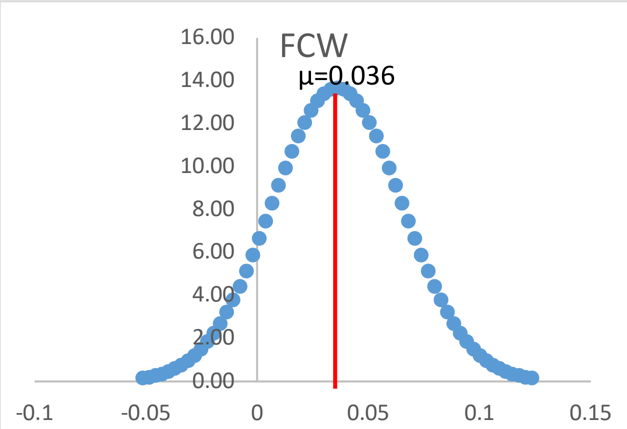

Figure 8 Distribution of Violations for Forward Collision Warning (FCW)

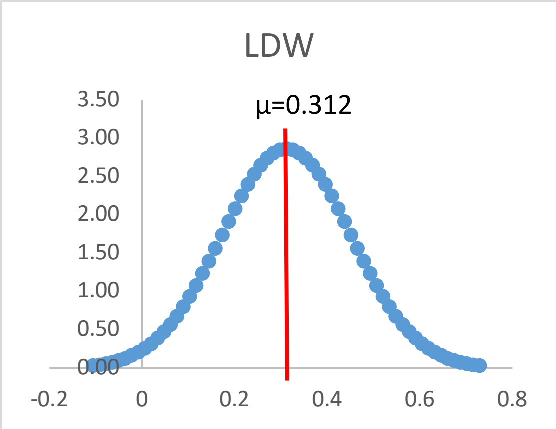

Figure 9 Distribution of Violations for Lane Departure Warning (LDW)

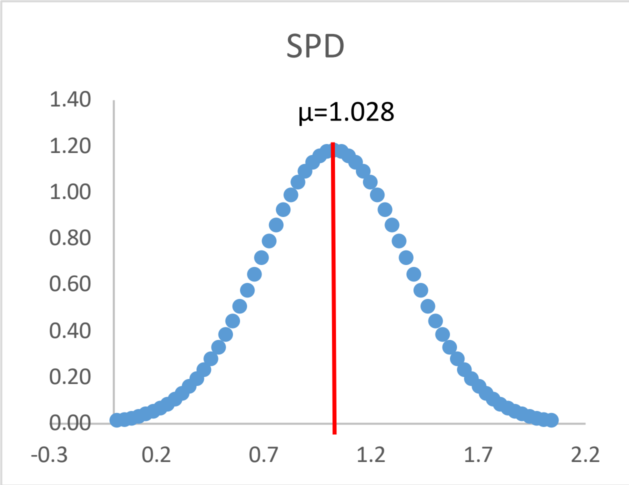

Figure 10 Distribution of Violations for Speeding Violation (SPD)

A sample respondent scoring results are shown in Table 14 below.

Table 14: Scoring calculation for a Sample Respondent

Duration	Respondent		
	FCW	**LDW**	**SPD**
Week 1 (28 Mar-3 Apr)	35	341	784
Week 2 (4-10 Apr)	8	15	70
Week 3 (11-17 Apr)	3	6	36
Week 4 (18-24 Apr)	27	507	649
Week 5 (25 Apr-1 May)	8	34	221
Week 6 (2-8 May)	8	9	17
Week 7 (9-15 May)	4	4	20
Week 8 (16-22 May)	7	7	22
Week 9 (23-29 May)	3	4	36
Week 10 (30 May-5 June)	7	6	47
Total	110	933	1902
KM Travelled	3,463		
Per KM	0.032	0.269	0.549
Penalties	0.6	8.1	28.0
Penalty Limit	19	30	51
Total Score	**63.3%**		

The respondent above participated in the study from 28th March 2018 to 5th June 2018. Based on the 10-week, the respondent travelled for 3,463 KM and committed a total of 2,945 number of violations. The average number of violations per 100 KM were 4 times for forward collision warning, 27 times for lane departure warning and 55 times for speeding. Penalties were applied based on each type of violations and their weightage.

Based on the scoring calculation, the respondent obtained a total score of 63.3% for the 10-week period. The calculation can also be made for each trip that the respondent made, following similar calculation method.

The final score for all respondent are depicted in Table 15 below. The score is colour coded and it is based on high (represented in green), medium (represented in orange) and low (represented in yellow) score. Intervention can be conducted for those who are in the yellow category such as driver re-training program, advocacy and penalty. Those in the green category can be rewarded for their safe driving behaviour.

Table 7 Simulation of Final score of all respondents

Respondent	Final Score (%)		Respondent	Final Score (%)
C01	63.3		C11	46.1
C02	39.4		C12	35.8
C03	32.3		C13	42.9
C04	31.8		C14	58.7
C05	39.1		C15	65.1
C06	38.9		C16	34.2
C07	39.0		C17	64.1
C08	42.6		C18	45.1
C09	42.3		C19	69.2
C10	35.2		C20	39.4

Scoring Band:

High Score	57.1% – 100%
Medium Score	33.3% - 57.09%
Low Score	0% - 33.29%

Scoring Model for On-Board Diagnostic Device (OBD)

Parameters selection

Table 16 below shows the percentage of private vehicle drivers involved in road accident by type of faults for the year 2013 until 2015. Based on the table below, the most type of faults that have been made by drivers during the accident were careless driving, speeding, dangerous turning, dangerous overtaking and driving too close. The parameters that will be selected will be based on the common type of faults and technology's capability to track them.

Table 8 Number of private vehicle drivers involved in road accident by type of faults

Type of Faults	2015 (%)	2014 (%)	2013 (%)
Careless at Entrance / Exit	3	3	1
Negligent Signalling	1	0	0
Overloading (Goods)	0	0	0
Overloading (Passengers)	0	0	4
Wrong Parking	1	1	0
Drugs	0	0	0
Careless Driving	32	29	7
Dangerous Driving	6	6	1
Dangerous Turning	6	5	32
Dangerous Overtaking	6	7	7
Driving Too Close	6	6	4
Speeding	9	16	26
Not Conforming to T/Light	3	3	3
Others Offences	27	23	13

Definition of Parameters

Based on the common type of faults and technology's capability to track them, the three types of violation that been considered in the study were Harsh Braking (HB), Harsh Cornering (HC) and Over Speeding (SPD). The harsh acceleration was not included due to the factor that this action rarely increases the risk of accident.

Scoring Calculation Formula

i. <u>Scoring Weightage</u>

The scoring weightage was derived from the road crash data in Table 16. Table 17 below shows the percentage based on parameters that will be used to calculate the driver score.

Table 9 Number of drivers involved in road accident by type of faults

Year	**HB**	**HC**	**SPD**
2015	6	6	9
2014	6	5	16
2013	6	5	6
Total	18	16	31
Average of 3 years	6	5	10
Weightage	28	24	48

ii. <u>Scoring Calculation</u>

Based on the weightage set for each type of violation, the score will be calculated based on below:

Score = 100 – (HB Penalty Score + HC Penalty Score + SPD Penalty Score)

where, HB Penalty Score = $\frac{HB}{KM\ Travelled}\ X\ 28$, maximum score is 28

HC Penalty Score = $\frac{HC}{KM\ Travelled}\ X\ 24$, maximum score is 24

SPD Penalty Score = $\frac{SPD}{KM\ Travelled}\ X\ 48$, maximum score is 48

iii. <u>Simulation of scoring results based on pilot study</u>

Based on the scoring calculation established, driving data that were obtained from pilot study between MIROS and Atilze were used to simulate the scoring performance of the respondents. Figure 11, 12 and 13 below shows the distribution of violation for respondents by type of violations. The average number of HB per KM is 0.017, average number of HC per KM is 0.110 and average number of SPD per KM is 0.036. By examining these distributions, it will set a foundation to identify the number of violations that respondents normally commit and to identify the number of violations for the less risky drivers and the most risky drivers. These are useful when deciding the scoring range.

Based on these 3 types of violations, the highest were harsh cornering, over speeding, and harsh braking. Based on these distributions, for every 100 KM travelled, the average number of harsh cornering was 11 times, over speeding was 4 times and harsh braking was 2 times.

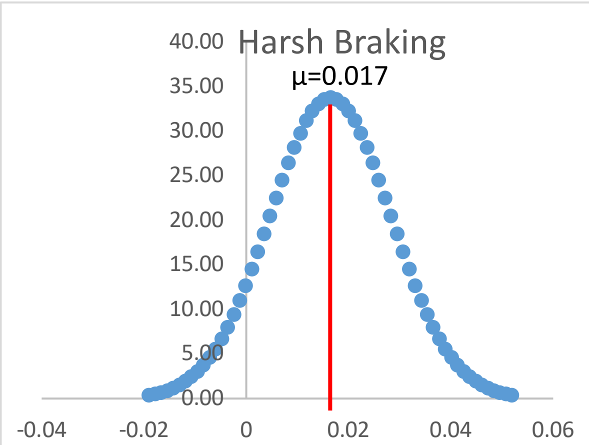

Figure 11 Distribution of Violations for Harsh Braking (HB)

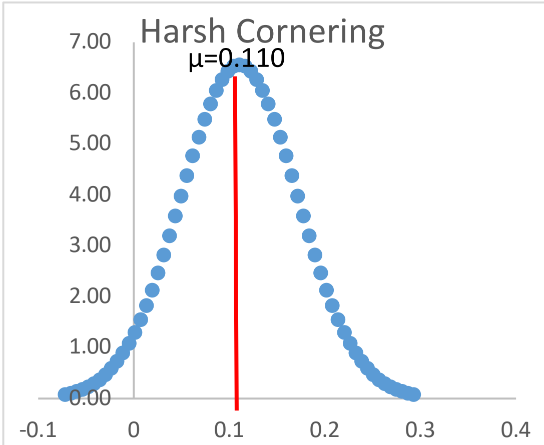

Figure 12 Distribution of Violations for Harsh Cornering (HC)

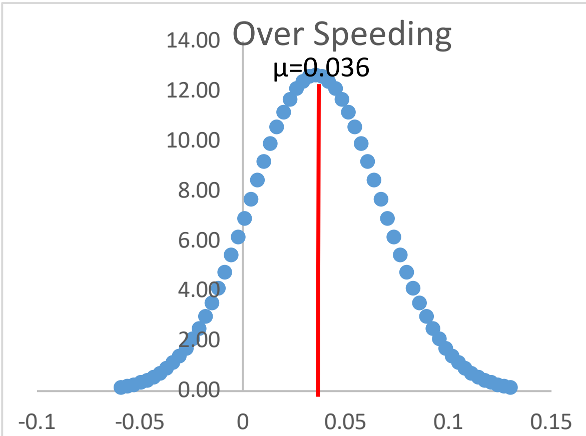

Figure 13 Distribution of Violations for Speeding Violation (SPD)

A sample respondent scoring results are shown in Table 18 below.

Table 10 Simulation of scoring calculation

Respondent	**HB**	**HC**	**SPD**
Total Violation	126	1312	89
KM Travelled	6336.03		
Per KM	0.02	0.21	0.01
Penalties	0.6	5.0	0.7
Penalty Limit	28	24	48
Total Score	93.8%		

The respondent above participated in the study from 28th March 2018 to 30th August 2018. Based on the 22 weeks, the respondent travelled for 6,336 KM and committed a total of 1,527 number of violations. The average number of violations per 100 KM were 2 times for harsh braking, 21 times for harsh braking and 1 time for speeding. Penalties were applied based on each type of violations and their weightage.

Based on the scoring calculation, the respondent obtained a total score of 93.8% for the 22-week period. The calculation can also be made for each trip that the respondent made, following similar calculation method.

The final score for all respondent are depicted in Table 19 below. The score is colour coded and it is based on high (represented in green), medium (represented in orange) and low (represented in yellow) score. Intervention can be conducted for those who are in the yellow category such as driver re-training program, advocacy and penalty. Those in the green category can be rewarded for their safe driving behaviour.

Table 11 Simulation of Final score of all respondents

Respondent	Final Score (%)	Respondent	Final Score (%)
C01	93.8	C11	98.7
C02	95.8	C12	94.5
C03	94.0	C13	95.6
C04	93.3	C14	94.1
C05	93.3	C15	99.2
C06	93.1	C16	96.4
C07	97.5	C17	95.3
C08	95.8	C18	95.4
C09	93.8	C19	94.1
C10	95.5	C20	94.8

Scoring Band:

(green)	High Score	96.9% – 100%
(orange)	Medium Score	93.5% - 96.89%
(yellow)	Low Score	0% - 93.49%

5. Proposed Implementation Plan

Overall Framework

In order for driver score to be calculated, each vehicle will need to be equipped with In-Vehicle Telematics Device (IVTD). IVTD will actively collect all driving parameters needed based on the vehicle types to calculate the driver score. Data will be transmitted and shared to a centralized data sharing platform where all data from IVTD will be collated and stored.

Next, data will be pre-processed to ensure standardization before driver score calculation is made. The data scrubbing is done based on the vehicle type to ensure accuracy in the data and as the driver score calculations would also depends on the vehicle type. Normalization process will systematically identify drivers that are in the top, middle and low range. As seen in the pilot study, the overall score might be in the high range (93 – 100%) for all participants. Therefore, the normalization stage will curve the score in order to obtain the normal distribution of scores and allow to identify the top, middle and low range.

Driver score will be calculated for each individual trip and accumulated trip, and the driver score details in a form of driver score card will be made available for viewing to the driver and other relevant consented parties.

Figure 14 below shows the overall framework.

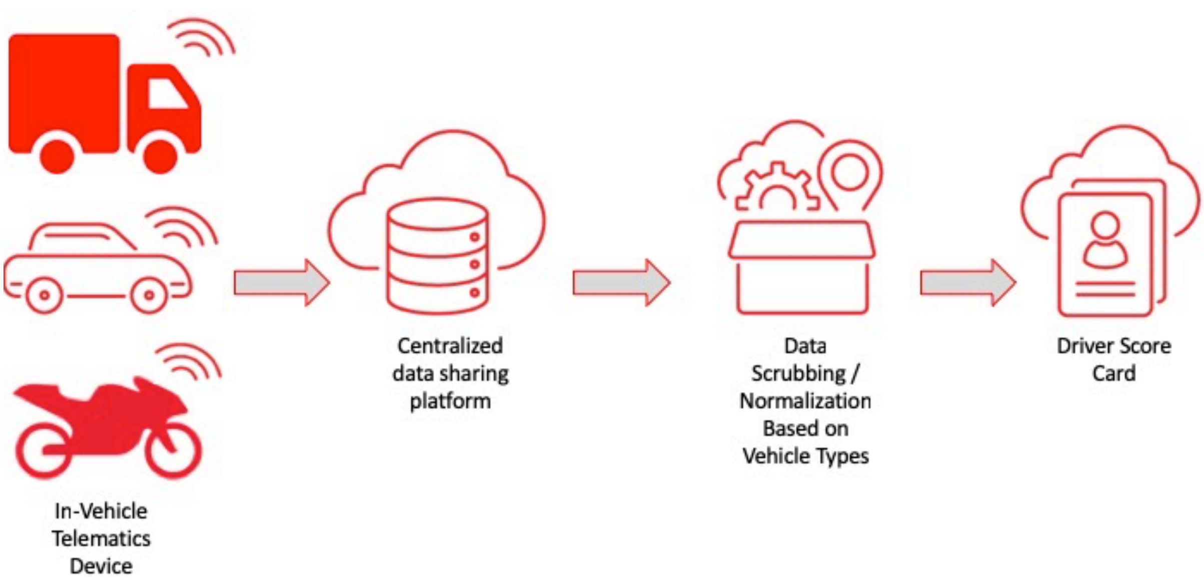

Figure 14 Overall Framework of Malaysia Driver Score

Implementation

Device

In-vehicle telematics device is needed to monitor the driving behaviour. The device must be installed in a location that is suitable to collect the driving data. To avoid power interruption and service disconnection, both built-in and in-vehicle battery are preferred. Figure 15 shows the requirement of IVTD installation in the vehicle.

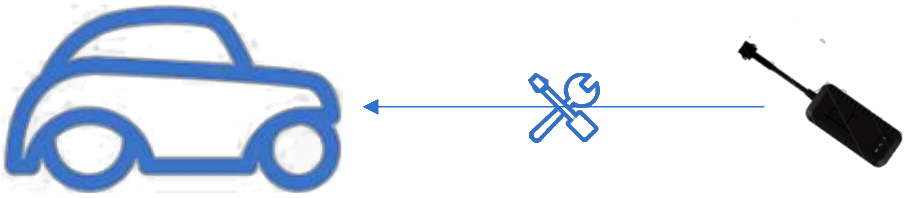

Figure 15 Requirement of In-vehicle Telematics Device

The installation of IVTD must be done by a specialist to ensure that the location of the device is optimal to give driving data. The specialist will have to go through all functional testing before fixing the device at the chosen location. Some of the testing needed are as below:

i. GSM signal reception (data transfer)
ii. Sensors test (accelerometer, gyroscope, etc.)
iii. Power supply (both built-in and in-vehicle battery)
iv. Fixed properly to avoid dislocate
v. Strategic places where it will not be easily reachable by the driver/passenger to avoid device tempering

The device also must be able to retrieve and log data as shown in Table 20 below.

Table 20 Type of Data, Value and Unit for IVTD

No.	Type of Data	Value/Unit
1	Acceleration	m/s^2
2	Gravity / orientation	g
3	Geolocation	Latitude, longitude
4	Date & time	Day, Month, Year, Hour, Minute, Second

Compatibility

The IVTD device proposed is not similar with other telematics devices that require attachment to the on-board diagnostic port. This will help to solve compatibility issue as it can acquire reading from few sensors such as accelerometer, gyroscope, geolocation, and date/time. There is no requirement to get data from on-board diagnostic port such as odometer, speedometer, engine temperature, turn signal indicator, and headlamp indicator. All of these data will not be used in calculating the driver score.

The device should ideally be able to send the logged data to the centralized data sharing platform, either in real-time or after the trip ends. Therefore, connectivity plays an important role to expedite data transfer. Typically, internet connectivity via cellular data communication is the preferred method. Internal storage is also needed to store the logged raw data before transferring to the platform.

Data collected by IVTD should also adhere to a specific format to ensure data processing can done without any error. Table 21 below shows sample records of data recording for IVTD. Raw data from each event must be logged and stored in the device as a backup for a period of time, in addition to sending them to the platform. The raw data will be process at the platform to generate the driver score. Below is the sample format of raw data.

Table 21 Sample Record of Data for IVTD

Timestamp	EventType	Acceleration X	Acceleration Y	Acceleration Z	Gravity X	Gravity Y	Gravity Z	Latitude	Longitude
11/11/2018 11:22:32	HA	13	9	10	10	9	11	2.976872	101.796383
11/11/2018 11:24:21	HA	14	10	8	9	10	11	2.976808	101.793830
11/11/2018 11:25:45	HB	10	11	12	10	15	11	2.981222	101.743211
11/11/2018 11:26:55	HC	10	15	11	11	12	10	2.973590	101.721832
11/11/2018 11:29:09	HB	11	9	10	10	16	11	2.974597	101.690611
11/11/2018 11:32:33	HB	10	12	11	11	-14	11	2.974872	101.668172

Reward/Penalty

With the liberalization of the motor insurance tariff, broader risk factors can now be taken into account when determining premiums. Through the implementation of MDS, driving behaviour can be monitored and objectively assessed by the insurers and authorities. Poor driving behaviour may indicate higher risk for road crashes thus resulting in claims. Therefore, the premium for this group may be set to a higher value (penalty). Meanwhile, good driving behaviours indicate lower risk for road crashes and claim. Good driving behaviour can be incentivize in the form of premium discounts and other privileges.

The reward/penalty system is recommended to encourage drivers to maintain good behaviour while they are driving. Based on the driver score, drivers can be grouped into 3 categories, which are safe drivers, moderate drivers and risky drivers. For example, based on the results from this pilot study, safe drivers obtain scores ranging from 68.7% to 100%, while moderate drivers have score of 36% - 68.6% and risky drivers from 0% - 35.9%. Safe drivers will be eligible to receive rewards while risky drivers can be intervened with programs such as driver re-training program and road safety awareness.

6. Discussion and Conclusion

The Malaysia Driver Score (MDS) is a scoring model to assess and score a driver's driving characteristics through the use of In-Vehicle Telematics Device (IVTD). MDS can be an effective tool to cultivate, nurture and promote safe driving behaviour among Malaysian drivers by providing objective and real-time driving behaviour assessment. Drivers can obtain their overall driving score and improve their driving by examining the risky driving behaviours as identified by MDS. By improving the overall driving behaviour, it is expected that the number of crashes especially those due to driver errors can be further reduced.

As driving behaviours may differ by the type of vehicles, each type of vehicles should utilize different scoring model based on relevant parameters collected by IVTD. For example, motorcycles will have different scoring models as compared to those driving a car or heavy vehicles. The scoring models will be based on the type of faults that lead to road crashes based on the type of vehicles.

Based on this study, the use of technology such as ADAS is proven to be most beneficial for LDW with the highest percentage of reduction in the number of violations conducted. This is followed by speeding, headway monitoring and FCW. Based on mode of operation, ADAS is most beneficial when the alert and warning system is turned on, as shown by the results during blind, unblind and re-blind period. In addition, OBD II provides tracking of driving behaviours and although it does not warn the driver immediately when risky driving behaviour was detected, the report that later generated from data gathered by the device is useful to identify risky behaviours during the trip. Drivers can greatly benefit by improving their driving behaviours as highlighted by the report and authorities/companies can monitor their employees driving behaviour easily and effectively. Altogether, IVTD promises improvement in driving behaviour and will make driving behaviour monitoring a breeze.

A nationwide driver profiling system should be established to effectively monitor driver behaviour. Based on the parameters and scoring method used, each driver can easily monitor their driving performance and compared with other drivers on the road. The scoring calculation can be enhanced over time when more drivers participate and improve their driving behaviour. One method to achieve this is by having a centralized database where all driving behaviours are kept and monitored by the authority. By updating the bell curve (violations distribution) based on real-time driver's behaviour, it can motivate all participants to improve their driving behaviour so that they can be at the left side of the curve (best drivers).

On the government side, MDS will allow monitoring and improvement of driving behaviour by the creation of driver profiling. Driver profiling is useful to understand the correlation and causation of road crashes and monitor individual and group driving behaviour over a period of time. Key road safety issues can be identified and targeted interventions can be planned and executed effectively. In addition, driving data that is collected will enable scientific research and studies to be conducted to further improve the road safety situation in the country.