

Comparing ASEAN NCAP Ratings between Editions of the Same Models

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Abstract – From a total of 20 car models crash-tested by ASEAN NCAP, seven models from four makes have undergone ASEAN NCAP assessment twice, whereas two car models from two domestic powerhouses had undergone the assessment thrice. This study shall evaluate the improvements to the newer editions which supposedly led to better safety ratings. The focus is on the passive safety systems comprising airbags, seatbelt, and child seats. ASEAN NCAP star rating is mainly based on the Adult Occupant Protection (AOP) and Children Occupant Protection (COP) for passive safety as well as some elements in active safety. The ratings and points earned for the AOP and COP were compared between previous and newer editions of the same car models. An analysis was conducted as to whether or not the different editions used the same protocol. There is a difference between the inaugural and the latest protocols to assess both the AOP and COP. Cars using different protocols were analysed in terms of the chest deflection value, in which the value from the latest protocol shall be calculated using the previous protocol to obtain AOP scores and making the comparison. Overall, the new batch of car models was rated to be safer and mostly the newer edition of the car models obtained better COP scores compared to their predecessors.

Keywords: Crash test, ASEAN NCAP, Adult Occupant Protection (AOP), Child Occupant Protection (COP), Head Injury Criteria (HIC), chest deflection

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1.0 INTRODUCTION

The New Car Assessment Program for Southeast Asia or ASEAN NCAP was established through an agreement between MIROS and Global NCAP on the 7th of December 2011 (Jawi et al., 2013). ASEAN NCAP seeks to raise motor vehicle safety standards in the region and encourage a market for safer cars, by evaluating the crashworthiness of different car variants (Abu Kassim, 2018). Its crash tests were conducted, among others, at the MIROS Provisional CRASE Crash Centre (MIROS PC3, Melaka, Malaysia), Japan Automobile Research Institute (JARI, Tsukuba, Japan), CrashlabTM (New South Wales, Australia) and Korea Automobile Testing and Research Institute (KATRI, South Korea).

ASEAN NCAP's inaugural crash test was held in 2012 at MIROS PC3 (Abu Kassim, 2018). During the first phase, a total of eight cars were assessed. In the second phase, eleven more cars were crash tested. In total, 81 cars have undergone the test conducted by ASEAN NCAP. Interestingly, seven models have been tested twice between October 2012 and April 2018, i.e. Honda City, Honda CR-V, Honda Civic, Mitsubishi Pajero Sport, Toyota Vios, Toyota Rush, and Hyundai i-10. In addition, two models have been crash tested three times, namely the Perodua Myvi and the Proton Saga. Crash tests are normally done twice or three times to improve the star rating, by meeting the requirements of ASEAN NCAP. The star rating is determined by the injury to crash test dummies, which resembling the real-world scenario (Hackney & Kahane, 1995).

This study aims to analyse the improvements made by car manufacturers based on the passive safety score. Passive safety comprises features or components of the vehicle that help reduce the injury outcome of a car crash. Thus, the passive safety system protects occupants during a crash and is as significant as active safety in preventing crash (Karlow et al., 2006). Passive safety system, among others, includes airbags, seatbelt, and child seat – which in ASEAN NCAP covered under what is called the Adult Occupant Protection (AOP) and Child Occupant Protection (COP). In addition, ASEAN NCAP is also practicing the post-test assessment known as “modifier” before the result of the crash test can be finalized (Solah et al., 2014).

ASEAN NCAP has come up with test or assessment protocols, which in this paper the inaugural Protocol 2012-2016 and Protocol 2017-2020 will be referred. The AOP for Protocol 2012-2016 was based on a single rating system constituting the Offset Frontal Test (OFT) and Side Impact Test (SIT). AOP for the current protocol, or Protocol 2017-2020, is based on 50 % of the overall rating consisting of the OFT, SIT and the Head Protection Technology (HPT) evaluation. Furthermore, the COP calculation has changed in the current protocol, but still 36 points remains as the highest score.

2.0 METHODOLOGY

In this paper, the analysis was done using the previously published assessment result; thus, can be regarded as secondary data. From a total of 81 results, 20 were retrieved relating to models which the editions being tested twice or thrice since the establishment of ASEAN NCAP. Based on the 20 results from nine models involving six makers (Table 1), the details of assessment for previous and newer editions of each car model were then compared mainly based on the AOP and COP scores. The number of airbags is also being compared between

editions. Besides, improvement to seatbelts was also analysed since this is the main part that is largely effective in reducing occupant injuries (Ensslen et al.,1985).

As mentioned above, these models were assessed in two versions of ASEAN NCAP protocol, namely Protocol 2012-2016 and Protocol 2017-2020 (will be stated later in the results section). The difference between the old and new protocol is significant because of the difference in the AOP and COP calculation. For example, the inaugural protocol used the Head Injury Criterion 36 (HIC36) (Ahmad et al., 2019), while the latter uses the Head Injury Criterion 15 (HIC15). HIC15 is considered to be more stringent than HIC36 since the lower the HIC value used, the better the car structure in terms of injury protection (Salwani et al., 2015; Mariotti et al., 2019).

Table 1: Models and editions tested twice or thrice in ASEAN NCAP (2012-2018)

Make	Model	Test Year / Protocol		
Honda	City	2012	2014	
	Protocol	2012-2016		
	CR-V	2014	2017	
	Protocol	2012-2016	2017-2020	
	Civic	2013	2016	
	Protocol	2012-2016		
Toyota	Vios	2012	2018	
	Protocol	2012-2016	2017-2020	
	Rush	2015	2018	
	Protocol	2012-2016	2017-2020	
Mitsubishi	Pajero Sport	2013	2016	
	Protocol	2012-2016		
Hyundai	i-10	2012	2015	
	Protocol	2012-2016		
Perodua	Myvi	2013	2014	2017
	Protocol	2012-2016		2017-2020
Proton	Saga	2012	2013	2016
	Protocol	2012-2016		

On the other hand, the inaugural protocol only featured Offset Frontal Test (OFT) and Side Impact Test (SIT) that contribute to the rating system. The new protocol, as mentioned earlier, includes OFT, SIT and Head Protection Technology (HPT) evaluation. These passive safety results are contributing 50 % in AOP and 25 % in COP assessment (Abu Kassim et al., 2017). In addition, the maximum score for frontal impact is 16.00 – divided into four sections with a maximum of four points for each division, namely the neck, chest, head, and knee. The chest deflection calculation is one of the obvious differences in the two protocol versions, i.e. chest deflection of 50mm and above will be given 0 points in the inaugural protocol, while 0 points will be given for chest deflection of 42mm and above in the subsequent protocol. In order to achieve the maximum four points in both protocols, chest deflection must not exceed 22mm. A scale rating is used to obtain the AOP score. Thus, in this study, the chest deflection value in the new protocol shall be employed to the old protocol to make an even comparison.

3.0 RESULTS AND DISCUSSION

This section shall discuss the assessment results for these car makes and models: Honda, Toyota, Mitsubishi, Hyundai, Perodua, and Proton.

3.1 Honda – City, CR-V and Civic

In the inaugural ASEAN NCAP test in December 2012, Honda City was one of the cars tested for the first time. Thus far, six Honda cars were tested by ASEAN NCAP and three out of six cars of the same models have been tested twice, comprising the Honda City, Honda Civic and Honda CR-V. The overall result for these Honda models are shown in Table 2.

3.1.1 Honda City

Honda City was tested at MIROS PC3 Lab for both the previous and newer editions. In December 2012, Honda City scored 15.44 points but the score increased to 15.8 in July 2014. The COP for the previous version was 39.79 while for the newer generation, it increased to 40.53 points. There were two airbags in the previous edition while the number increased to six for the newer one. For the seatbelt system, the Honda City did not make much improvement and has retained the retractor pre-tensioner and load limiter for both the driver and front passenger. Both editions were assessed under the 2012-2016 protocol. Overall, the new generation for Honda City has made significant improvements.

3.1.2 Honda CR-V

The previous Honda CR-V edition was manufactured in 2014. Honda CR-V scored 15.46 points for AOP. COP was at 42.09 thus earning it a 4-star rating. In 2017, the second generation of Honda CR-V was released. It was tested at the Japan Automobile Research Institute (JARI) and obtained 14.76 points for AOP and rated 5-star under the new protocol. Its AOP would increase to 15.56 points if it had used the old protocol (Table 3). The driver's HIC value for the previous edition was 262.07 while for the new generation, it obtained 315.3; thus, HIC value for the previous edition was better than the newer one. The new Honda CR-V scored 44.76 points for COP thus earning 5-Star. The previous edition was equipped with only two airbags while the newer one comes with six airbags.

3.1.3 Honda Civic

Next is the Honda Civic which was released in 2013 and was tested at MIROS PC3 in July 2013. Honda Civic scored 14.63 points for AOP and obtained 5-Star. COP was quite good at 40.09 points. Three years later, the new generation was released and tested at JARI. As a result, it scored 14.75 points for AOP and 42.26 points for COP. Its AOP value increased by 0.12 points. There is no improvement to the airbag system which features two airbags. The old and new edition of the Honda Civic used the same 2012-2016 protocol.

In summary, all the Honda models that underwent the test twice have seen their results improved in both the AOP and COP assessment. Honda City and Honda Civic use the same protocol for both generations while Honda CR-V uses different protocols. For the airbag system, Honda City and Honda CR-V have increased the number of airbags as opposed to the Honda Civic. Overall, Honda has made good improvements.

Table 2: Honda models crash test results

Model	Honda City		Honda CR-V		Honda Civic	
Test Year	2012	2014	2014	2017	2013	2016
Protocol	2012-2016		2012-2016	2017-2020	2012-2016	
No. of Airbags	2	6	2	6	2	2
AOP Point (max. 16.0)	5 (15.44)	5 (15.8)	5 (15.46)	5 (14.76)	5 (14.63)	5 (14.75)
COP Point (max. 49.0)	4 (39.79)	4 (40.53)	4 (42.09)	5 (44.76)	4 (40.09)	4 (42.26)

Table 3: Honda CR-V result – Based on 2012-2016 protocol calculation

Model		Honda CR-V	
Model Year		2014	2017
Type of HIC		36	15
HIC Value	D	262.07	315.3
	P	216.48	299.7
Chest Deflection Value	D	22.68	21.62
	P	15.63	19.50
AOP Point		15.46	15.56

3.2 Toyota – Vios and Rush

Toyota remains the most tested brand or make in ASEAN NCAP to date with 13 models. Among the 13 models, two models had been tested twice which are the Toyota Vios and Toyota Rush (Table 4).

3.2.1 Toyota Vios

The first Vios was tested at MIROS PC3 in December 2012 and scored 13.61 points for AOP while obtaining 23.36 points for COP. The subsequent edition of Vios was tested in November 2017 and scored 12.19 points for AOP and 42.22 points for the COP under the new protocol. The driver's HIC value for the previous edition was 293.65 while for the new edition, it obtained 309.5. The new edition showed improvement to the driver's chest deflection which was 28.32mm while the previous was at 36.72mm (Table 5). AOP for the new edition was 14.81 if it had used the old protocol system. In the first test, the Toyota Vios was fitted with two airbags but the number increased to seven in the new edition.

3.2.2 Toyota Rush

The previous generation of Toyota Rush was tested in August 2015 and received 4-Star for AOP (score 12.47) and COP (score 40.29). The previous edition used the 2012-2016 protocol while the new edition used the 2017-2020 protocol. The new Toyota Rush was tested in April

2018 and earned 5-Star for AOP (12.5) and COP (41.81). AOP for the new generation decreased to 12.37 using the old protocol (Table 5). The new Toyota Rush did not perform well for both driver and front passenger since the chest deflection value was not as good as before. The previous Rush was equipped with two airbags only while the number increased to six airbags in the new one. Seatbelt system retractor pre-tensioner and load limiter had also been installed for both driver and front passenger.

Table 4: Toyota models crash test results

Model	Toyota Vios		Toyota Rush	
Test Year	2012	2018	2015	2018
Protocol	2012-2016	2017-2020	2012-2016	2017-2020
No. of Airbags	2	7	2	6
AOP Point (max. 16.0)	4 (13.61)	5 (12.19)	4 (12.47)	5 (12.5)
COP Point (max. 49.0)	2 (23.36)	5 (42.22)	4 (40.29)	5 (41.81)

Table 5: Toyota Vios and Toyota Rush results – Based on 2012-2016 protocol calculation

Model		Toyota Vios		Toyota Rush	
Model Year		2012	2018	2015	2018
Type of HIC		36	15	36	15
HIC Value	D	293.65	309.5	330.38	510.0
	P	219.90	232.3	330.95	174.0
Chest Deflection Value	D	36.72	28.32	24.01	31.04
	P	31.71	21.83	18.65	23.56
AOP Point		13.61	14.81	12.47	12.37

In summary, the Vios has improved although the same cannot be said of Toyota Rush. The AOP and COP for the Vios has increased while for Toyota Rush, only COP has improved. The AOP for Toyota Rush decreased from previous to new edition due to high chest deflection value. Also, both models had increased the number of airbags.

3.3 Mitsubishi – Pajero Sport

A total of six models from Mitsubishi were tested by ASEAN NCAP. One of them was the Mitsubishi Pajero Sport, which was tested twice as it came out with the latest edition in 2016 (Tan, 2015). The full results for Mitsubishi Pajero Sport are shown in Table 6.

Both editions were tested using the same protocol, i.e. Protocol 2012-1026. Mitsubishi did not upgrade its airbags system as the previous and new generation only have two airbags. The rating for AOP rose from 4-star to 5-star. The AOP for the previous edition was 12.08, while the new edition obtained 15.29 points. The COP improved from 19.56 to 37.04 and it registered a huge positive change from 1-star to 4-star.

Mitsubishi Pajero Sport 2016 comes with double pre-tensioner and load limiter for the driver, and retractor pre-tensioner and load limiter for the front passenger. The double pre-tensioner seatbelt for the driver is standard fitment while it is optional for the passenger. Improvement of the Pajero Sport model was also due to the use of high-tensile steel structure. This quality steel reinforces key areas, thus resulting in weight reduction and improved strength (safety). Mitsubishi Pajero Sport uses an adopted high-efficiency chassis frame that can reduce accident impacts due to high energy absorption.

Table 6: Mitsubishi Pajero Sport crash test results

Test Year	2013	2016
Protocol	2012-2016	
No. of Airbags	2	2
AOP Point (max. 16.0)	4 (12.08)	5 (15.29)
COP Point (max. 49.0)	1 (19.56)	4 (37.04)

In a nutshell, Mitsubishi Pajero Sport has charted an improvement from previous to the newer generation with its AOP also on the rise. COP has improved a lot from 19.56 to 37.04 points. Lastly, the Mitsubishi Pajero Sport uses the same protocol for both generations.

3.4 Hyundai – i-10

Four Hyundai models were tested by ASEAN NCAP between 2012 and 2018. One of the models tested twice was the Hyundai i-10 (Table 7). The previous edition underwent the test in December 2012 at MIROS PC3 Lab and scored 7.31 points for AOP, while COP registered 23.72 points. For the new generation of Hyundai i-10, AOP decreased to 4.4 points. However, its COP increased to 38.69 points and it obtained 4-Star. In terms of airbags, both Hyundai i-10 editions comes with two airbags. The Hyundai i-10 can be considered as “less safe” or “not safe” due to its low AOP score.

Table 7: Hyundai i-10 crash test results

Test Year	2012	2015
Protocol	2012-2016	
No. of Airbags	2	2
AOP Point (max. 16.0)	2 (7.31)	1 (4.4)
COP Point (max. 49.0)	1 (23.72)	4 (38.69)

In summary, Hyundai i-10 did not make significant improvements as AOP decreased from the previous to the newer edition. However, COP improved from 1-Star to 4-Star.

3.5 Perodua – Myvi

To date, four Perodua models have been tested at MIROS PC3 Lab, which includes the Myvi, Alza, Axia and Bezza. The Perodua Myvi model has been tested three times, i.e. in 2013, 2014 (for 2015 model) and most recently in 2017 (Table 8).

The first crash test was in January 2013 resulting in 3-Star with 8.71 points. In November 2014, the second edition Myvi increased the AOP score to 11.55; thus, obtaining 4-star. In October 2017, the Perodua released the latest edition and got 5-star with 14.79 points. The first and second generation of the Perodua Myvi used the old protocol while the current protocol was applied to the 2017 edition of Perodua Myvi. On the other hand, AOP for the newest edition of Perodua Myvi also increased to 11.66 when the inaugural protocol being considered (Table 9).

HIC value for the newest edition is 368.8 and is better than Myvi 2015. Chest deflection values for driver and front passenger have improved as well from the first to the latest generation (Table 9). For the second edition, the AOP score was 11.55, followed by 11.61 for the third edition. The slight AOP increase is due to the slight chest deflection value change. Moreover, the COP increased from 26.23 to 34.83 points for the previous generation while the latest edition of Myvi obtains 43.14 points which gave it 5-star. Also, Myvi has made significant improvements in terms of airbags. In the first and second generations, only two airbags were available. For the third tested edition, Myvi increased the airbags to four.

Table 8: Perodua Myvi crash test results

Test Year	2013	2014	2017
Protocol	2012-2016		2017-2020
No. of Airbags	2	2	4
AOP Point (max. 16.0)	3 (8.71)	4 (11.55)	5 (14.79)
COP Point (max. 49.0)	3 (26.23)	4 (34.83)	5 (43.14)

Table 9: Perodua Myvi results – Based on 2012-2016 protocol calculation

Model		Perodua Myvi		
Model Year		2011	2015	2017
Type of HIC		36	36	15
HIC Values	D	344.53	558.0	368.8
	P	689.64	520.0	282.0
Chest Deflection Values (mm)	D	33.14	25.3	24.87
	P	31.79	26.7	25.37
AOP Point		8.71	11.55	11.61

Overall, Perodua Myvi has greatly improved since its first edition tested by ASEAN NCAP. Its AOP has increased significantly. Furthermore, COP also increased from the first to the third edition. Perodua Myvi has added the number of airbags in its latest edition and thus Myvi 2017 is definitely better than before.

3.6 Proton – Saga

To date, three generations of Proton Saga have been tested by ASEAN NCAP at MIROS PC3. The result of these tests is shown in Table 10.

The first generation of Proton Saga is the Saga FLX which was tested in December 2012, while the second generation was tested in January 2013 under a slightly different name, i.e. Saga FLX+. The first edition was tested in 2012 and only scored 1-Star for AOP. For the second tested edition, the Saga got 3-star with 10.23 points. Since it did not obtain a good rating (3-star and below), the manufacturer Proton improved the car system further and obtained 4-star with 13.33 AOP points in 2016.

COP also registered an increment as the first tested edition of Saga was measured at 23.77, before it increased to 28.23. The latest edition earned 35.0 points and obtained 4-Star. The Proton Saga uses seatbelt pre-tensioner and load limiter for the driver and front passenger. The number of airbags increased from one in the first tested edition to two in second and third editions.

Table 10: Proton Saga crash test results

Test Year	2012	2013	2016
Protocol	2012-2016		
No. of Airbags	1	2	2
AOP Point (max. 16.0)	1 (4.3)	3 (10.23)	4 (13.33)
COP Point (max. 49.0)	2 (23.77)	3 (28.23)	4 (35.0)

All in all, the Proton Saga has made significant improvements. Currently, Proton Saga provides two airbags and both its AOP and COP had also increased. All the tested Proton Saga editions used the same protocol, namely Protocol 2012-2016.

3.7 Overall Discussion

Altogether, five models had used the same protocol for their previous and latest versions, i.e. Honda City, Honda Civic, Mitsubishi Pajero Sport, Hyundai i-10 and Proton Saga. On the other hand, four car models, namely the Honda CR-V, Toyota Vios, Toyota Rush, and Perodua Myvi had experienced different protocol systems. Based on the calculation of the four models using the old protocol, only the Toyota Rush had seen a decline in AOP due to the high value of chest deflection to the front passenger. Chest deflection value is important because it can affect the AOP score.

As regards airbags and seatbelt for the nine models, three had not improved their airbag systems. However, the rest had improved their airbag systems signifying its importance to reduce injuries (Aziz et al., 2018; Ahmad et al., 2019). Mitsubishi Pajero Sport uses the double pre-tensioner and load limiter for driver's seatbelt while the rest use a single pre-tensioner seatbelt for both driver and front passenger. The seatbelt system definitely helps in reducing occupant injuries (Patil et al., 2016).

Moreover, carmakers have made some improvements in terms of child occupant safety. It is important to reduce injury to children during a crash event (Paiman et al., 2018). The highest difference in COP between the previous and new edition was shown by the Toyota Vios with 19.08 points. Another model that improved COP immensely is Hyundai i-10 with an increase of 14.97 points. The lowest point value difference for the COP score between the old and new editions was recorded by Honda City with 0.74 points.

4.0 CONCLUSION











This paper recapitulates the test results of car models from different editions that had undergone the ASEAN NCAP assessment twice or thrice. Those models assessed twice were three Honda models (City, CR-V, and Civic), two Toyota models (Vios and Rush), one Mitsubishi model (Pajero Sport), and one Hyundai model (i-10). Two models from the so-called national carmakers, i.e. Perodua Myvi and Proton Saga, had undergone the assessment thrice. From the ASEAN NCAP's view, it is a very positive sign to the rating program when it can be shown to the consumers that newer editions of the same models are not being left out from being tested again. From the carmakers' perspective, it shows that they are serious about improving their products as what being outlined by ASEAN NCAP since it is relatively a higher requirement than the country's regulations – as in Malaysia's case the Vehicle Type Approval (VTA) by the Road Transport Department. The strategy by the carmaker to keep the same model (or the same model's name) in generations or editions is perhaps due to the acceptance, legacy and “good luck” element, but for ASEAN NCAP the utmost objective is the safety to protect the car occupants. In sum, the editions of the same model could be improved in certain ways, e.g. through the seatbelt system, the number of airbags and different structure material, as shown in the analysis of this study.











REFERENCES

- Abu Kassim, K.A. (2018). *The ASEAN NCAP Story: Reach for the Stars*. Kajang, Selangor: SAE Malaysia.
- Abu Kassim, K.A., Isa, M.H.M., Ahmad, Y., Carmai, J., Santosa, S., Ly, H.A., Konosu, A., & Mustaffa, S. (2017). *Overall Assessment Protocol*. Kajang, Selangor: ASEAN NCAP.
- Ahmad, Y., Yahya, W.J., Abu Kassim, K.A., Koetniyom, S., Carmai, J., & Abd Kadir, H. (2019). Driver head kinematic analysis under frontal offset collision during the rebound phase. *International Journal of Crashworthiness*, 24(6), 606-614.

- Aziz, H.A., Sukadarin, E.H., Suhaimi, N.S., Osman, H., Noordin, M.N., & Shafiee, I. (2018). Applying Analytical Hierarchy Process to evaluate Adult Occupant Protection on body region in ASEAN NCAP Offset Frontal Test domain. *Journal of the Society of Automotive Engineers Malaysia*, 2(3), 267-274.
- Ensslen, A., Schwant, W., & Zieglschmidt, R. (1985). *Can we improve the crash performance of seat belts?* SAE Technical Paper, No. 851202.
- Hackney, J.R., & Kahane, C.J. (1995). *The new car assessment program: Five star rating system and vehicle safety performance characteristics.* SAE Technical Paper, No. 950888.
- Jawi, Z.M., Isa, M.H.M., Solah, S., Ariffin, A.H., Kassim, K.A.A., & Wong, S.V. (2013). New Car Assessment Program for Southeast Asian Countries (ASEAN NCAP) – A new paradigm shift in the ASEAN's automotive ecosystem. *Journal of the Eastern Asia Society for Transportation Studies*, 10, 29-44.
- Karlow, J., Bruce, M., Heudorfer, B., Meißner, D., & Igawa, T. (2006). *Active intervention into passive systems: From passive safety to safe driving.* SAE Technical Paper, No. 2006-21-0080.
- Mariotti, G.V., Golfo, S., Nigrelli, V. & Carollo, F. (2019). Head injury criterion: Mini review. *American Journal of Biomedical Science & Research*, 5(5), 406-407.
- Paiman, N.F., Deros, B.M., Hamzah, A., Kak, D.W., Solah, M.S., & Ahmad, Y. (2018). A study on the use and misuse of child restraint system (CRS) in Malaysia. *Journal of the Society of Automotive Engineers Malaysia*, 2(1), 5-13.
- Patil, K., Reddy, S., & Zafar, N. (2016). *Optimization of seatbelt anchorage mount locations for occupant injury reduction in frontal crash.* SAE Technical Paper, No. 2016-28-0251.
- Salwani, M.S., Sahari, B.B., Ali, A., & Nuraini, A.A. (2015). Assessment of head injury criteria and chest severity index for frontal impact. *Journal of Mechanical Engineering and Sciences*, 8, 1376-1382.
- Solah, M.S., Hamzah, A., Ariffin, A.H., Isa, M.H.M., Rahman, M.K., Jawi, Z.M., Paiman, N.F., Ahmad, Y., & Kassim, K.A.A. (2014). ASEAN NCAP crash tests: Modifier assessment justified. *Applied Mechanics and Materials*, 663, 547-551.
- Tan, P. (2015). *2016 Mitsubishi Pajero Sport – new Triton-based ladder frame SUV makes global debut in Thailand!* Retrieved from <https://paultan.org/2015/08/01/2016-mitsubishi-pajero-sport-new-triton-based-ladder-frame-suv-makes-global-debut-in-thailand/>

Appendix I. Tested Editions of the Same Models

HONDA MODELS		
Honda City		
	2012 at MIROS PC3, Melaka	2014 at MIROS PC3, Melaka
Honda CR-V		
	2014 at MIROS PC3, Melaka	2017 at JARI, Tsukuba, Japan
Honda Civic		
	2013 at MIROS PC3, Melaka	2016 at JARI, Tsukuba, Japan
TOYOTA MODELS		
Toyota Vios		
	2012 at MIROS PC3, Melaka	2018 at JARI, Tsukuba, Japan
Toyota Rush		
	2015 at MIROS PC3, Melaka	2018 at JARI, Tsukuba, Japan

MITSUBISHI MODEL		
Mitsubishi Pajero Sport		
	2013 at JARI, Tsukuba, Japan	2016 at JARI, Tsukuba, Japan
HYUNDAI MODEL		
Hyundai i-10		
	2012 at MIROS PC3, Melaka	2015 at MIROS PC3, Melaka
PERODUA MODEL		
Perodua Myvi		
	2013 at MIROS PC3, Melaka	2014 at MIROS PC3, Melaka
		
	2017 at JARI, Tsukuba, Japan	
PROTON MODEL		
Proton Saga		
	2012 at MIROS PC3, Melaka	2013 at MIROS PC3, Melaka
		
	2016 at Crashlab™, NSW, Australia	