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Development of a Road Protector Scores Models as an Indicator for Indonesian National Road Safety Performance Assessment from the Perspective of Drivers of Four or More Wheeled Motorized Vehicles

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Keywords
Star Rating Scores; Road Protector Scores; traffic accident; national roads; road attribute.

ABSTRACT
This paper introduces the model of Star Rating Scores (SRS) or Road Protector Scores (RPS) for Indonesian National Roads from the perspective of motorized vehicle drivers with four or more wheels, which are explored from the characteristics of traffic accidents along Indonesia's national roads. This SRS model takes into account 2 different main parameters and 4 main parameters that are the same as the main parameters of the SRS International Road Assessment Program (iRAP) and a total of 51 road attributes. The two main parameters that differ from the SRS iRAP model are the parameters for rear-end collision and head-to-side collision when turning around. While the 4 parameters are the same as head-to-side collision accidents at property access, single accidents run off the road head-on collision accidents, and accidents at intersections. At the initial stages, the National Road SRS model was designed using 51 road attributes. After analyzing using the Importance and Performance Analysis (IPA) method, 43 road attributes were successfully formulated for the SRS National Road model, consisting of 30 likelihood factor attributes, 10 severity factor attributes, 2 external traffic influence factor attributes, and 1 factor attribute operational speed. In addition, it is proven that the SRS National Road model is significantly different from the SRS iRAP model. The three main parameters of the National Road SRS model, namely the rear-end collision parameter, the head-to-side collision parameter when turning direction (U-turn), and the head to side parameter at property access are significantly different from the parameters of the SRS iRAP model.

INTRODUCTION

The road safety performance measures contained in the National General Plan for Road Safety in Pillar-2 of Safe Roads, which was confirmed in Presidential Decree No. 4 of 2021 concerning the National General Plan for Road Safety RUNK for the 2021-2023 period, are realized in a star rating scale. This star rating scale was established as the basis for assessing the achievement of road safety targets in the 2021-2039 RUNK. These targets include all new roads and 75% of national logistics roads by the end of 2030 must meet road safety requirements equivalent to 3 stars on the iRAP scale. This target is basically derived from international programs and has been agreed upon through the 3rd Global Ministerial Conference on Road Safety on Road Safety which was held in Stockholm.

The iRAP star rating safety performance measure is developed through an assessment of road elements (Road Assessment) (iRAP, 2009; iRAP, 2010b; iRAP, 2012). An approach through direct assessment of road elements is considered more realistic compared to the approach developed so far

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which is more oriented towards accident data. The quality and condition of the road and the road environment through the study of road elements greatly determine the star rating given by the road. The better the technical standards implemented, the better the star rating obtained. This concept is used by iRAP, known as assessing road protection for road usersRoad user protection scores (RPS: Road Protector Scores) are determined from several road parameters and attributes. These scores are then ranked into a 5 star rating which describes the overall safety performance of a road section. A 5-star rating indicates the best performance, whereas a 1-star rating indicates poor safety performance.

To calculate the road protection score number of road attributes are required as elements that are expected to contribute to road user safety (iRAP, 2010b; iRAP, 2012). Each attribute has an indicator value called risk value, which is developed from the values of Crash Modification Factors (CMF) (iRAP, 2010b; iRAP, 2012; Elvik et al, 2009; AASHTO, 2010; PIARC, 2003).

The study and development of the RPS or SRS model is generally carried out in developed countries, so this model is likely to be more suitable for countries that have traffic characteristics and road technical standards that are in accordance with those of developed countries. For Indonesia, the utilisation of this model still requires modification due to the different traffic characteristics and road environment from those developed countries. Likewise with the fulfillment of standards and technical specifications for national road sections, not all of which have been fulfilled ideally. This certainly affects traffic movements which ultimately has an impact on traffic accidents on national roads. Therefore, in addition to fulfilling road technical standards and specifications, of course the differences in the characteristics of traffic accidents on these national road sections are seen as influencing the RPS value provided by these roads to road users. This assumption is the premise of this research with the hypothesis that the national road SRS model is different from the iRAP RPS or SRS model that has been practised in many countries.

The RPS or SRS model developed by iRAP is designed for 4 perspectives of road users, namely car occupants, motorcyclists, bicyclists and pedestriansThe model is also designed to utilise the Accident Modification Factor (AMF) or Crash Modification Factor (CMF) values in SRS calculations that have been developed by road safety researchers. The use of CMF in the RPS or SRS iRAP model makes the road protection calculation model very measurable, so that its use is seen as providing many effective technical recommendations from several existing treatment options.

Although this model has been widely used in various countries, it is not yet known to what extent the accuracy and effectiveness of this model can be applied to improve road safety and or reduce the number of accident fatalities on Indonesia's national roads. The SRS model still needs to be adapted to the conditions in Indonesia, given the many traffic and road problems in Indonesia, such as the fulfillment of road standards (geometrics, road quality, signs and markings, facilities for accident-prone groups) that are not yet optimal, mixed traffic (high proportion of motorcycles), traffic behaviour that causes many traffic conflicts, and high side frictions.

Various traffic and road problems in Indonesia are currently seen as factors that will influence the SRS model for conditions in Indonesia, especially for the SRS of Indonesian national roads. In general, this study focuses on the study of the development of influencing factors on the SRS model which is in accordance with the national road conditions along 47,000 km which is referred to as the SRS model of the Indonesian National Road. This SRS model is not only based on an assessment of a number of road elements as part of the National Road SRS calculation model, it is also based on an analysis of traffic accident characteristics from 283,519 accident data on national roads obtained from 2012 to 2019. This accident data is sourced from IRSMS data base of Korlantas POLRI Headquarters as one of the main data used in this research.

LITERATUR REVIEW

The International Road Assessment Programme (iRAP) was launched in 2006 with the support of EuroRAP countries and other local RAPs such as usRAP, AusRAP and KiwiRAP. Initially, the star rating model used by iRAP was SRS iRAP Version 2.1 and Version 2.2, which was assessed from the perspective of four road users, namely vehicle occupants, motorcyclists, bicyclists and pedestrians.

Subsequently, iRAP introduced an updated iRAP SRS known as iRAP SRS Version 3.0. This Version 3.0 star rating model has 78 attributes in total, consisting of 12 non-technical and 66 technical attributes. A significant difference between this model and the previous model is the crash type for the calculation of RPS for passenger car and motorcycle occupants. The difference is in the type of head-on collision which is divided into two different types, namely the type of head-on collision due to loss of control (Head-on Lost Control) and the type of head-on collision that occurs when preceding another vehicle (Head-on Overtaking). Another new crash type is the type that occurs at property access points (Property Access Collision).

The significant difference lies in the SRS iRAP calculation scheme or formula, namely the inclusion of operational speed elements or factors, the external influence of traffic flow and the median traverability factor separately from the accident likelihood and severity factors. Therefore, as a consequence of the changes given to the SRS iRAP calculation in the Version 3.0 star rating model, there are additional attributes in the likelihood factor and attributes in the crash severity factor.

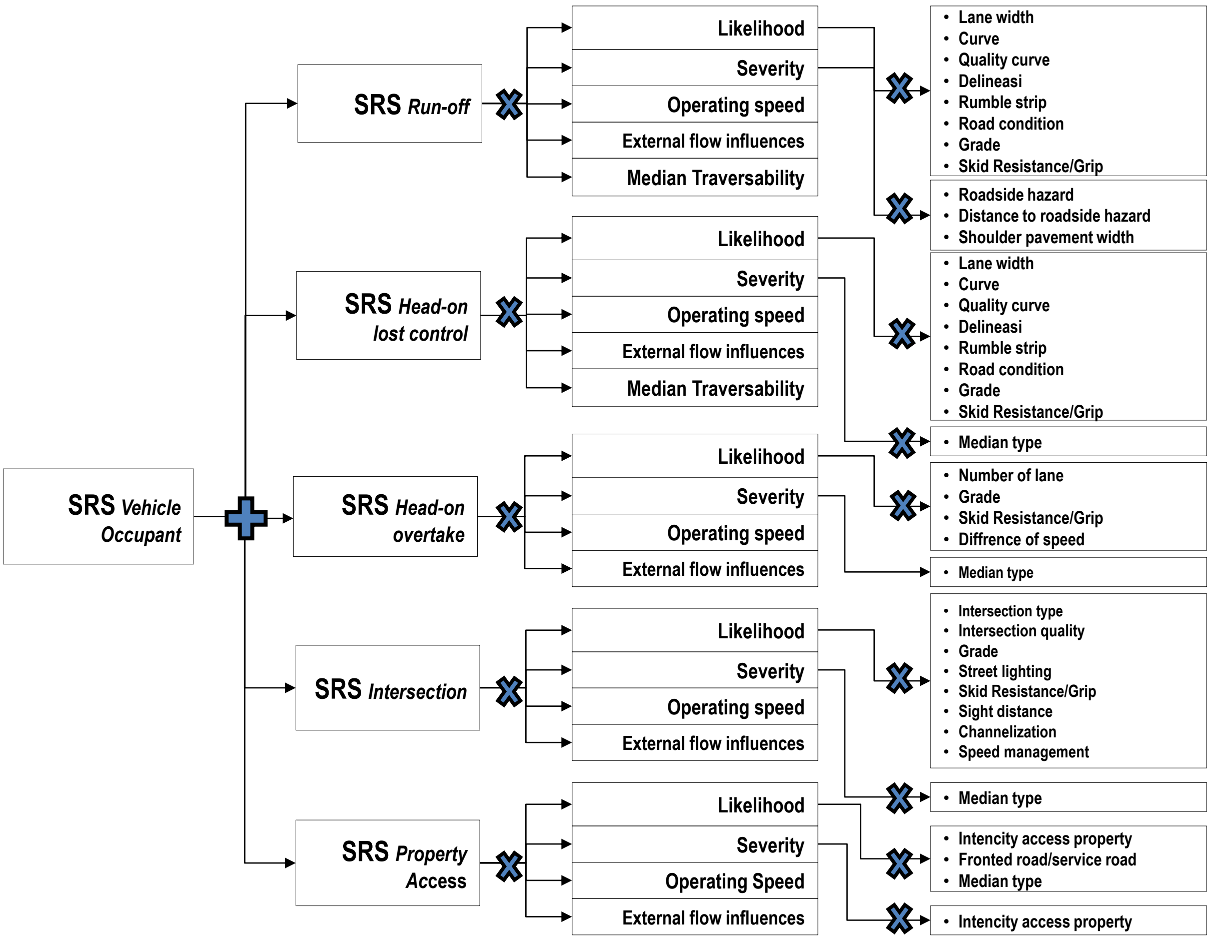
The RPS Version 3.0 model is known as SRS (Star Rating Score) iRAP, which is theoretically the same concept as RPS. The iRAP SRS calculation model includes a wider variety of crash types as shown in Table 1 and remains in the perspective of four road users as in the previously developed Version 2.1 RPS model.

Table 1. Accident Types for the SRS iRAP Model from the Vehicle Occupant Perspective

No.	Vehicle Occupant	Motorcyclist	Bicyclist	Pedestrian
1	Single accident (run-off)	Single accident (run-off)	Single accident (run-off)	Along the road
2	Head-on lost control	Head-on lost control	Along the road	Crossing road-driver side
3	Head-on overtaking	Head-on overtaking	Crossing road	Crossing road-otherside
4	All accident type on Intersection	All accident type on Intersection		
5	Head to side on access property	Head to side on access property		

Source: AusRAP, 2008a; iRAP, 2009

The crash types in the SRS calculation model developed by iRAP as given in Figure 1, are basically developed from various studies of accident characteristics in various countries, particularly in Europe, Australia, America, etc. The use of the SRS model will require adaptation for Indonesian national roads given the differences in traffic characteristics and crash types. The use of the iRAP SRS model is considered to require adaptation for Indonesian national roads since there are differences in traffic characteristics and types of traffic accidents with Indonesian conditions.



Source: AusRAP, 2008a; iRAP, 2009

Figure 1. SRS iRAP Models Version 3.0

The iRAP SRS calculation model for car occupants is given as the sum of each SRS of each crash type, as shown in Equation 1.

$$SRS_{Co} = \sum_{i=1}^{n} SRS_{Ai} \quad \ldots\ldots \quad (1)$$

Each crash type's SRS is calculated using Equation 2.

$$SRS_{Aij} = \prod_{i=1,j=1}^{n} RF_{LiAj} \times \prod_{i=1,j=1}^{n} RF_{Sev_iAj} \times F_{SO} \times F_{EFI} \times F_{MT} \quad \ldots\ldots \quad (2)$$

Where:

SRS_{Co} : SRS Car occupant
SRS_{Aij} : SRS for accident type-j
RF_{LiAj} : Risk factor for attribute likelihood-i accident type-j
RF_{SeviAj} : Risk factors for severity-i accident type-j
F_{SO} : Speed operatuional factor
F_{EFI} : External flow influences factor
F_{MT} : Median traversability factors

In comparison, based on traffic accident data from IRSMS as given in Table 2. front-rear collision crashes on Indonesian national roads reached 72,693 crashes (25.64%) as the highest crash type. In addition to the rear-end collision accident type, the IRSMS data also shows head-on collision accidents 62,229 (21,95%) followed by head-to-side collisions 20,713 (8,01%). These head-to-side collisions were dominated by crashes at property access locations (15,758 crashes) and at specific locations when turning around (6,955 crashes). The other highest accident types were intersection accidents 58,109 (20,50%) and single off-road accidents 14,001 (4,94%). These accident types are categorised as accidents that are predominantly caused by infrastructure factors.

Table 2. Accident Type on National Road 2012-2029

Accident Type		**All Accident**	**Fatality & Serious Injury Accident**
1	Head on Collision	62,229	26,895
2	Rear-end Collision	72,693	29,458
3	Head-to-Side on Property Access	15,758	6,749
4	Head-to-Side on U-Turn	6,955	2,904
5	Side Swipe Collision	7,900	3,198
6	Hit Pedestrian	35,860	16,977
7	All Intersection Accident	58,109	22,852
8	Run off Single Accident	14,001	6,113
9	Hit Vehicle Parking	8,181	3,161
10	Hit permanen object on the road	1,832	601
Total		**283,518**	**118,908**

Based on the crash types shown in Table 2. this study proposes two new crash types as new parameters that are different from the SRS model developed by iRAP. Therefore, in general, the crash types proposed in the National Road SRS model include rear-end collision crashes, head-to-side collision crashes at access property, head-to-side collision crashes during good turning, single off-road accident, head-on collision crashes, and crashes at intersections.

METHODS

Based on the SRS model developed by iRAP, the types of accidents mainly result in deaths (fatal) and serious injuries (serious injuries) as well as road factors that influence accidents and the level of seriousness of accidents. The SRS model developed for national road sections in Indonesia also follows the same concept as that developed by iRAP.

Indonesia has different traffic characteristics, provision of road infrastructure, and road user behavior on each island, which causes the characteristics of traffic accidents to be more varied. Therefore, the study of typical traffic accidents as a cause of fatal accidents and serious injuries is one of the basics for developing the SRS national road model. The initial step of this research was to study the uniformity of accident characteristics in various provinces and islands in Indonesia using statistical tests.

The statistical test used to show the uniformity of accident characteristics using a two sign test known as the Wilcoxon Test. This test is used to determine consistency whether there is a difference between the proportion of accident types from each zone to the average proportion of zone accident types from all traffic accident class categories and fatal accident and serious accident categories on national roads in Indonesia.

The road assessment attributes shown in Table 3 are the results of a study of various previously developed SRS models, which were then combined with the concept proposed for Indonesian road sections Field (Idris et al, 2022). Attributes marked with an asterisk (*) are original attributes developed by iRAP. Meanwhile, the other attributes in the table are additional attributes that are deemed necessary to consider for road and environmental conditions as well as traffic conditions on Indonesian national roads.

Table 3. Proposed Design of Road Assessment Attributes for Indonesian National Road

SRS Rear-end Attributes		**SRS U-Trun Attributes**		**SRS Access Properties Attributes**		**SRS Run-off Attributes**		**SRS Head-on Attributes**		**SRS Intersection Attributes**	
I	**Likelihood**	**I**	**Likelihood**	**I**	**Likelihood**	**I**	**Likelihood**	**I**	**Likelihood**	**I**	**Likelihood**
1	Number of lane	1	Number of lane	1	Road type	1	Road type	1	Road type	1	Intersection type
2	Lane width	2	Lane width	2	Lane width	2	*Lane width)**	2	*Lane width)**	2	Lane width
3	Road shoulder	3	Sight distance	3	*Median type)**	3	Road shoulder	3	Road shoulder	3	*Turn right lane*
4	Shoulder width	4	Grade	4	Sight distance	4	Shoulder width	4	Shoulder width	4	*Sight distance)**
5	R-curve	5	Median type	5	Grade	5	Sight distance	5	Sight distance	5	*Grade)**
6	Quality curve	6	Pavement condition	6	*Frontated road)**	6	*R-curve**	6	*R-curve**	6	*Canalization)**
7	Grade	7	Skid resistance	7	Pavement condition	7	*Quality curve)**	7	*Quality curve)**	7	Pavement condition
8	Superelevasi	8	Road surface condition	8	*Type of access)**	8	*Grade)**	8	*Grade)**	8	Skid resistance
9	Pavement condition	9	Turning sign	9	Skid resistance	9	Superelevasi	9	Superelevasi	9	Road surface condition
10	Skid resistance	10	Speed limit sign	10	Road surface condition	10	*Pavement condition)**	10	*Pavement condition)**	10	Traffict light
11	Road surface condition	11	Road lighting	11	Area types	11	*Skid resistance)**	11	*Skid resistance)**	11	Intersection sign
12	Land use	12	U-turn facility	12	Land use	12	Road surface condition	12	Road surface condition	12	Speed limit sign
13	Roadside occupant	13	Turning lanes	13	Roadside occupant	13	Safety fences	13	Speed limit sign	13	*Speed reducer*
14	On-street parking	14	Turning lane width	**II**	**Severity**	14	Spedd limit sign	14	*Delineation)**	14	*Road lighting*
II	**Severity**	**II**	**Severity**	14	*Intensitas akses)**	15	*Delineation)**	15	*Rumble strip)**	**II**	**Severity**
15	Effective lane width	15	R-Turning	15	Side friction	16	*Rumble strip)**	**II**	**Severity**	15	*Median type)**
16	Intencity properties access	16	Median width	16	On-street parking	**II**	**Severity**	16	*Median type)**	16	Intersection quality
17	Speed diffrence	**III**	**Operating speed**	**III**	**Operating speed**	17	Escape Ramp	17	*Median traversability)**	**III**	**Operating speed**
III	**Operating speed**	17	85%-tile speed	17	85%-tile speed	18	*Roadside hazard)**	18	Effective lane width	17	*85%-tile speed)**
18	85%-tile speed	**IV**	**External flow**	**IV**	**External flow influences**	19	*Distance to roadside*	**III**	**Operating speed**	**IV**	**External flow influences**
IV	**External flow influences**	18	Traffic volume (ADT)	18	*Traffic volume (ADT))**	20	Safety fences condition	19	*85%-tile speed)**	18	Intersection volume
19	Traffic volume (ADT)	19	%-motorcycles	19	%-motorcycles	21	*Median traversability)**	**IV**	**External flow influences**	19	%-motorcycles
20	%-heavy vehicle	20	%-bicycles	20	%-bicycles	**III**	**Operating speed**	20	*Traffic volume (ADT)**	20	%-bicycles
21	%-motorcycles					22	*85%-tile speed)**	21	*%-motorcycles*		
22	%-bicycles					**IV**	**External flow influences**	22	%-bicycles		
						23	*Traffic volume (ADT)**				
						24	%-motorcycles				
						25	%-bicycles				

Notes:)* RPS and SRS iRAP attributes

In total, there are 53 road attributes that are considered for national road sections which include 23 attributes for rear-end collision accidents, 20 attributes for head-to-side collision accidents when turning around, 20 attributes for head-to-side collisions on property access, 25 attributes for run-off the road collisions, 22 head-on collision attributes, and accidents at intersections with 20 attributes. From a total of 53 attributes, all parameters are divided into element likelihood and road geometric attributes (12 attributes), road condition likelihood (2 attributes), traffic management likelihood (3 attributes), road equipment likelihood (5 attributes) turning facility likelihood (3 attribute), likelihood of intersection (5 attributes), severity factor (12 attributes), speed factor (1 attribute), and external factors of traffic flow (4 attributes).

Figure 2 is a design model for calculating road protection scores from a car occupant perspective based on the results of benchmarking road attributes from the various models proposed in this study. This study has used a survey of expert perceptions of several proposed attributes which include likelihood, severity, external factors of traffic flow, and operational speed which are considered to contribute to a type of traffic accident.

There are two stages of the questionnaire used in this study. The first stage of the survey aimed to capture several attributes for each type of accident using snowball sampling with road safety expert respondents. The second phase of the survey aimed to assess the level of importance and level of applicability of the assessed attributes. Several statistical analysis tools such as data adequacy tests, uniformity tests, validity tests, and reliability tests Field (Walpole et al, 1995; Ott, 1991; Sprent, 1991; Siegel, 1997) have been used in this study. The analytical method for the level of importance and applicability attributes of each parameter uses the IPA (Importance and Performance Analysis) method approach (Zeithaml et al, 1990). The IPA method is used to map the importance and aplivability levels to identify the attributes of the proposed road assessment (Zeithaml et al, 1990). The IPA method maps the average attribute weights into 4 quadrants.

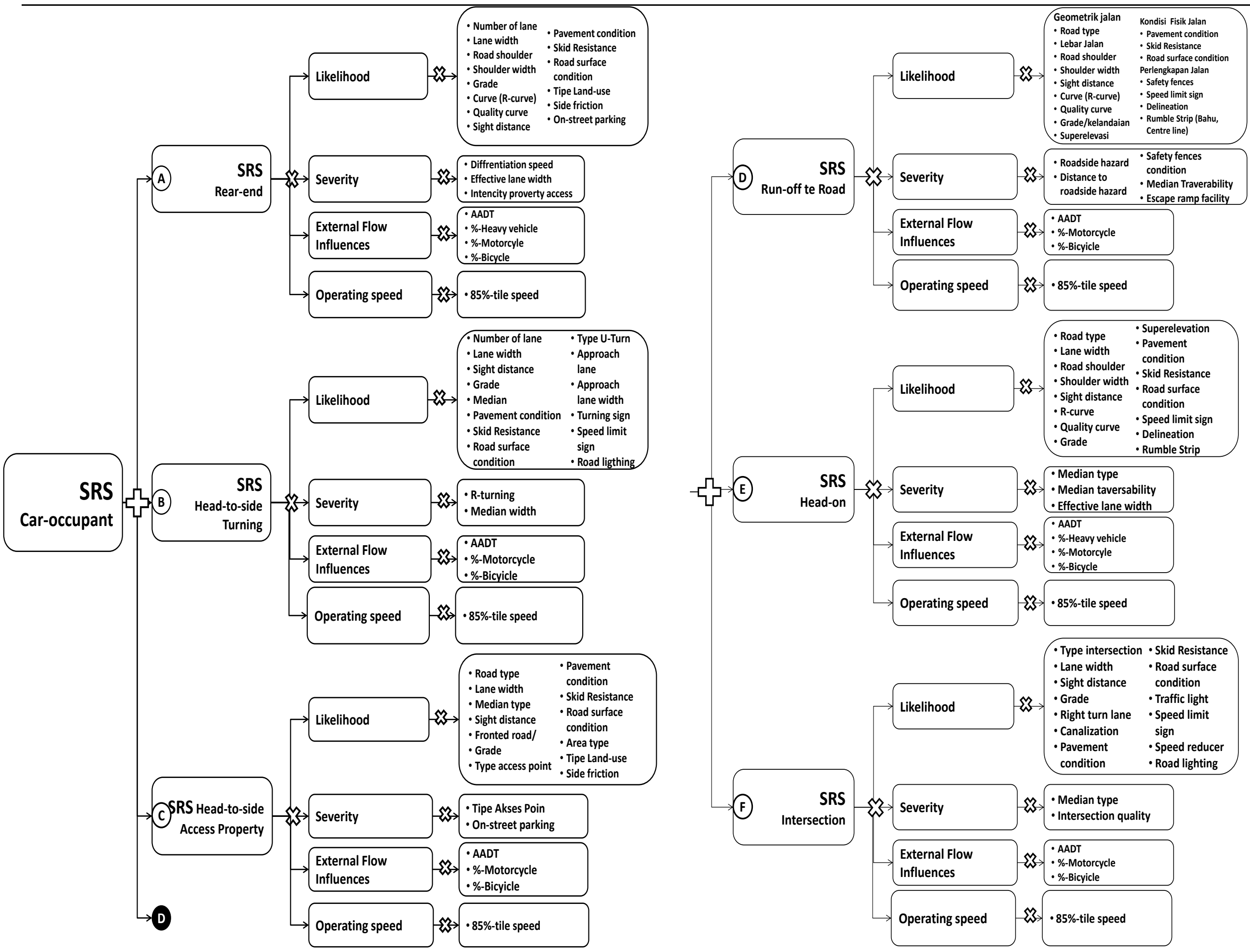


Figure 2. Proposed Initial Design of the SRS Model for National Road from Perspective of Drivers of Four or More Wheeled Motorized Vehicles (Car Occupant)

RESULTS

National Road Accident Characteristics

To test the consistency of typical fatal and serious injury accidents (FIs: Fatality and Serious Injury) between zones and the typicality of all accidents on all national roads in Indonesia, this paper uses the Wilcoxon Paired Sign Rank Test. The null hypothesis (H_o) is that there is no difference between the zone average proportion of fatal accidents and serious injuries from all accidents and the proportion of all typical accidents on national roads. The alternative hypothesis (H_i) is that there is a difference between the proportion of fatal accidents and serious injuries in the zone average of all accidents. The critical value of W or W_{Table} in the Wilcoxon Paired Rating Sign Test for a significance level of α=0.005; α=0.001; α=0.025; and α=0.05 is given as in the Wilcoxon Test Table. While the assessment criteria are given if $W_{Count} > W_{Table}$, then the hypothesis accepts H_o. *Conversely,* if $W_{Count} < W_{Table}$, the hypothesis rejects H_o or accepts H_i.

Table 4. below is a summary of typical data for fatal and serious accidents (FSIs) which juxtaposes the average observation zone (Sumatra, Java, Kalimantan, Sulawesi, Bali & Nusa Tenggara, Maluku, Papua) with typical accidents at all levels of road accidents national. The Wilcoxon test shows that the *calculated* W_{Value} =23 is greater than the W_{Table}=11. This test concludes that there is no significant difference from the typical fatal and serious traffic accidents in each zone with all types of accidents for all accident classes. These results further indicate that the typical accidents in all zones for both Fatal

and Serious Accidents (FSIs) and for all accidents on Indonesian national roads have relatively the same typical.

Table 4. Proportion of Typical FSIs and All Accident Categories on National Roads in 2012-2019

Accident Type		Fatality and Serious Injury (FSIs) Accident (%) by Zone								All Accident (%)
		Sumatera	Jawa	Bali&Nustra	Kalimantan	Sulawesi	Maluku	Papua	Average	
1	Head on Collision	29.52	17.10	22.24	25.11	22.83	38.35	25.46	25.80	24.84
2	Rear-end Collision	21.22	30.14	20.23	18.91	17.36	13.09	20.00	20.13	21.03
3	Head-to-Side on Property Access	5.03	5.90	6.37	5.93	5.26	3.71	2.56	4.96	5.21
4	Head-to-Side on U-Turn	2.51	3.24	1.52	2.62	1.42	0.33	1.08	1.82	2.12
5	Side Swipe Collision	11.97	13.73	16.55	13.61	21.29	21.29	19.85	16.90	15.57
6	Hit Pedestrian	18.20	21.47	18.52	17.03	19.33	6.64	15.43	16.66	18.12
7	All Intersection Accident	5.37	3.70	7.78	7.82	7.00	10.42	8.40	7.21	6.67
8	Run off Single Accident	2.82	1.76	2.91	2.78	2.20	2.21	3.54	2.60	2.56
9	Hit Vehicle Parking	2.86	2.58	3.01	4.53	2.78	2.80	3.17	3.10	3.16
10	Hit permanen object on the road	0.49	0.40	0.87	1.67	0.52	1.17	0.51	0.80	0.73

National Road SRS Model Attribute Analysis

Phase-1 questionnaire data (93 samples) and Phase-2 questionnaire (43 samples) have been tested for adequacy and uniformity of data for a 95% confidence level. Likewise, the validity test based on the Pearson correlation coefficient with an error rate of 5% is also fulfilled. The reliability test has met the *Cronbach Alpha coefficient value* > 0.60. The validity test on the Phase-1 questionnaire data succeeded in eliminating several attributes proposed in the research design. The results are shown in Table 5, which include 20 attributes for rear-end collision, 16 attributes for head-to-side collision when turning around, 18 attributes for head-to-side collision on property access, 24 attributes run-off he road, 21 attributes for head-on collisions, and accidents at intersections with 16 attributes.

Table 5. Road Assessment Attributes Based on Stage-1 Questionnaire Analysis

SRS Rear-end Attributes	SRS U-Trun Attributes	SRS Access Properties Attributes	SRS Run-off Attributes	SRS Head-on Attributes	SRS Intersection Attributes
I Likelihood	**I Likelihood**	**I Likelihood**	**I Likelihood**	**I Likelihood**	**I Likelihood**
1 Number of lane	1 Number of lane	1 Road type	1 Road type	1 Road type	1 Lane width
2 Lane width	2 Lane width	2 Lane width	2 Lane width)*	2 Lane width)*	2 Turn right lane
3 Road shoulder	3 Sight distance	3 Median type)*	3 Road shoulder	3 Road shoulder	3 Sight distance)*
4 Shoulder width	4 Grade	4 Sight distance	4 Shoulder width	4 Shoulder width	4 Grade)*
5 R-curve	5 Median type	5 Grade	5 Sight distance	5 R-curve*	5 Canalization)*
6 Quality curve	6 Pavement condition	6 Frontated road)*	6 R-curve*	6 Quality curve)*	6 Pavement condition
7 Grade	7 Skid resistance	7 Pavement condition	7 Quality curve)*	7 Grade)*	7 Skid resistance
8 Superelevasi	8 Road surface condition	8 Skid resistance	8 Grade)*	8 Superelevasi	8 Road surface condition
9 Pavement condition	9 Turning sign	9 Road surface condition	9 Superelevasi	9 Pavement condition)*	9 Traffict light
10 Skid resistance	10 Speed limit sign	10 Area types	10 Pavement condition)*	10 Skid resistance)*	10 Intersection sign
11 Road surface condition	11 Turning lanes	11 Land use	11 Skid resistance)*	11 Road surface condition	11 Speed limit sign
12 Land use	**II Severity**	12 Roadside occupant	12 Road surface condition	12 Speed limit sign	12 Speed reducer
13 Roadside occupant	12 R-Turning	**II Severity**	13 Safety fences	13 Delineation)*	**II Severity**
14 On-street parking	13 Median width	13 Intensitas akses)*	14 Delineation)*	14 Rumble strip)*	13 Median type)*
II Severity	**III Operating speed**	14 Side friction	15 Rumble strip)*	**II Severity**	**III Operating speed**
15 Effective lane width	14 85%-tile speed	15 On-street parking	**II Severity**	15 Median type)*	14 85%-tile speed)*
16 Intencity properties access	**IV External flow influences**	**III Operating speed**	16 Fasilitas lajur darurat	16 Median traversability)*	**IV External flow influences**
III Operating speed	15 %-motorcycles	16 85%-tile speed	17 Roadside hazard)*	17 Effective lane width	15 %-motorcycles
17 85%-tile speed	16 %-bicycles	**IV External flow influences**	18 Distance to roadside	**III Operating speed**	16 %-bicycles
IV External flow influences		17 %-motorcycles	19 Safety fences condition	18 85%-tile speed)*	
18 %-heavy vehicle		18 %-bicycles	20 Median traversability)*	**IV External flow influences**	
19 %-motorcycles			**III Operating speed**	19 Traffic volume (ADT)*	
20 %-bicycles			21 85%-tile speed)*	20 %-motorcycles	
			IV External flow influences	21 %-bicycles	
			22 Traffic volume (ADT)*		
			23 %-motorcycles		
			24 %-bicycles		

Notes:)* RPS and SRS iRAP attributes

In the same way as in the Phase-1 questionnaire analysis, the results of the statistical analysis test in the Phase-2 questionnaire show data adequacy and data uniformity which meets statistical tests with a confidence level varying between 90%-95%. The validity test with a confidence level of 95% shows that all data on the level of importance and level of application of attributes is categorized as valid. Meanwhile, the reliability for testing the reliability of the instrument has a Cronbach Alpha coefficient value above 0.70; which indicates that the research instrument has reliability that varies between high and very high.

Table 6. shows the results of the IPA analysis between the level of importance and level of application based on the perception survey of road safety experts from various professional groups for the SRS Front-Rear Collision Accident model. There are 7 (seven) attributes mapped into quadrant IV which fall into the category of having a low level of importance and a difficult level of application. The seven parameters include road shoulder width, land use, road side utilization on-street parking, number of accesses, number of motorcyles and bicycles are seen as having no significant effect on the model being developed. Therefore, these seven attributes are not considered in the SRS national road model.

Selected attributes for likelihood include number of lanes, shoulder width, shoulder width, R-curve, quality of curve, Llongitudinal slope of the road (grade), superelevation, road pavement condition. The attribute for severity is the effective width of the road, while the attribute for the selected external flow influences is the number of slow vehicles, while and the attribute 85%-tile speed is the attribute for operational speed.

This rear-end collision parameter is one of the new parameters that was not previously known in the SRS model developed by iRAP. The consideration factor for entering this parameter is because the majority of rear-end crash accidents occur on narrow roads and on roads with type 2/2-UD. The factor of availability of ideal road infrastructure is still very dominant on Indonesian national roads.

Table 6. The IPA Analysis for Attributes of Rear-end Collision Parameters

No.	Road Attributes	Weight of:		Quandrant
		Importance (X)	Aplication (Y)	
1	Number of lanes	4.186	3.372	
2	Lane width	4.140	3.302	
3	Shoulder types	4.116	3.279	
4	Shoulder width	4.023	3.093	Q-IV
5	R-Curve	4.093	3.209	
6	Quality curve	4.140	3.442	
7	Grade (%)	4.372	3.302	
8	Superelevasi (%)	3.977	3.302	
9	Pavement condition	4.186	3.558	
10	Skid resistance	4.163	3.605	
11	Road surface condition	4.163	3.605	
12	Land-use types	3.884	2.814	Q-IV
13	Road-side occupation	3.721	2.907	Q-IV
14	On-street parking	3.791	3.070	Q-IV
15	Lane-width effectives	4.116	3.093	
16	Intencity property access	3.860	2.884	Q-IV
17	Heavy truck (%)	4.047	3.256	
18	Motorcycle volume (%)	3.953	3.023	Q-IV
19	Bicycle volume (%)	3.628	2.953	Q-IV
20	Speed operational	4.233	3.395	
Average		**4.040**	**3.223**	

Table 7. and Table 8. below shows the results of the IPA analysis of the perceptions of road safety experts on a number of attributes of the SRS model for Head-to-side Collision Accidents at two different locations. Table 7 presents the results of the IPA analysis on head-to-side collision accidents during U-turns at various locations on national roads. Table 8 presents the results of the IPA analysis of head-to-side collision accidents at property access locations and other road access.

Furthermore, the results of the IPA analysis in Table 7 show a number of attributes that are in quadrant-IV, namely the condition of the road pavement, the number of motorcycles and the number of bicycles. Attributes that are part of the likelihood of head-to-side collision accidents when turning around include the number of lanes, lane width, sight distance, grade, road median, skid resistance, road surface conditions, facilities and U-turn signs, speed limit signs. The selected severity attributes are R-turnover and median width. The speed factor of vehicles around the U-turn location indicated by the 85%-tile speed is an important attribute to consider. Two attributes related to the external influence of traffic flow, both the number of vehicles and the number of motorcycles, are seen as having no significant effect on the SRS model of head-to-side collision accidents particularly at U-turn locations.

The attributes in Quadrant IV as shown in Table 8 are attributes that are categorized as attributes that are not considered in the SRS model of head-to-side collision accident at road access or property access locations. The attributes in Quadrant IV are median type, road side utilization, volume of motorcycles and bicycles. Attributes that are likely in this model include number of lanes, lane width, sight distance, grade, frontage road, pavement condition, skid resistance, surface condition, land use, and area type. The severity attribute based on IPA analysis for the SRS model of head-to-side collision accident on access roads and property access is the number or intensity (number) of access, side friction, and on-street parking. Another attribute considered in this model is operational speed by the 85%-tile speed.

Parameters of head-to-side collision accident both at road access locations or property access as well as at turning locations are the main problems encountered on national road segments. Uncontrolled road access and property access on national road sections that have arterial functions make these locations high points of conflict that have the potential for traffic accidents.

Likewise, head-to-side collision accident at U-turn locations were also found to be very dominant, especially on roads that do not have ideal U-turn facilities. Many median roads have been opened by the community or local government to meet local needs without considering the required median opening standards. High intensity median openings and median widths that are less than ideal which are often found on national roads designated as arterial roads are listed as dangerous hazard locations.

Table 7. The IPA Analysis for Attributes of Head-to-side Collision Parameters When Turning (U-turn)

No.	Road Attributes	Weight of: Importance (X)	Weight of: Aplication (Y)	Quandrant
1	Number of lane	4.349	3.419	
2	Lane width	4.395	3.326	
3	Sight distance	4.651	3.674	
4	Grade (%)	4.236	3.186	
5	Median types	4.395	3.419	
6	Pavement condition	3.721	3.326	Q-IV
7	Skid Resistance	4.047	3.488	
8	Road-surface condition	3.860	3.465	
9	U-turn sign	4.605	3.977	
10	Speed limit	4.512	3.884	
11	U-turn lane	4.651	3.465	
12	R-Curve of U-turn	4.395	3.442	
13	Median width	4.256	3.302	
14	Motorcycle volume (%)	3.907	3.163	Q-IV
15	Bicycle volume (%)	3.488	2.953	Q-IV
16	Speed operational	4.279	3.535	
Average		**4.234**	**3.439**	

Table 8. The IPA Analysis for Attributes of Head-to-side Collision Parameters on Property Access

No.	Road Attributes	Weight of: Importance (X)	Weight of: Aplication (Y)	Quandrant
1	Road types	4.279	3.209	
2	Lane width	4.116	3.209	
3	Median types	3.884	3.093	Q-IV
4	Sight distances	4.558	3.558	
5	Grade (%)	4.163	3.163	
6	Frontage road	4.372	3.000	
7	Pavement condition	3.698	3.279	
8	Skid resistance	3.953	3.395	
9	Road surface condition	3.953	3.419	
10	Area types	4.070	3.326	
11	Land-use types	4.163	3.233	
12	Road side occupation	3.977	3.140	Q-IV
13	Intencity property access	4.140	2.977	
14	Road side friction	4.233	3.279	
15	On street parking	4.140	3.116	
16	Motorcycle volume (%)	3.721	2.953	Q-IV
17	Bicycle volume (%)	3.279	2.767	Q-IV
18	Speed operational	4.209	3.395	
Average		**4.050**	**3.195**	

Table 9 furthermore shows the results of the IPA analysis of the attributes of the run-off single accident SRS model. Based on the IPA analysis of the Front-Rear crash accident run-off single accident attributes, there are 6 attributes mapped into Quadrant IV. These attributes are grade, emergency escape lane, median traversability, traffic volume, volume of motorcycles and bicycles.

Table 9. The IPA Analysis for Attributes of Run-off Single Accident Parameters

No.	Road Attributes	Weight of: Importance (X)	Weight of: Aplication (Y)	Quandrant
1	Road types	4.186	3.279	
2	Lane width	4.233	3.372	
3	Shoulder types	4.302	3.442	
4	Shoulder width	4.302	3.395	
5	Sight distance	4.209	3.419	
6	R-Curve	4.302	3.279	
7	Quality curve	4.465	3.767	
8	Grade (%)	4.047	3.186	Q-IV
9	Superelevasi (%)	4.326	3.419	
10	Pavement condition	4.000	3.535	
11	Skid resistance	4.070	3.512	
12	Road surface condition	4.279	3.558	
13	Safety fences	4.442	3.581	
14	Road delineation	4.465	3.721	
15	Rumbel Strip	4.302	3.721	
16	Escape Ramp	4.047	3.116	Q-IV
17	Hazard road-side object	4.256	3.395	
18	Distance road-side hazard	4.233	3.302	
19	Safety fences condition	4.372	3.674	
20	Median traversability	3.884	3.326	Q-IV
21	AADT	3.860	3.186	Q-IV
22	Motorcycle volume (%)	3.535	3.070	Q-IV
23	Bicycle volume (%)	3.349	2.837	Q-IV
24	Speed operational	4.186	3.512	
Average		**4.152**	**3.400**	

The likelihood attributes of this SRS model include road type, lane width, tipe of road shoulder, shoulder width, sight distance, R-curve, curve quality of curve, superelevation, road pavement condition, skid resistance, road surface condition, safety fence, delineation, rumble strip. The severity attributes of this model are the roadside hazard object, the distance of the hazard object to the traffic lane, and the condition of the safety fence. The SRS model for a run-off single accident also considers the operational speed factor as an influential factor.

Table 10 below shows several SRS model attributes for head-on collision accident parameters based on IPA analysis. The SRS model of head-on collision accident for this the national road does not distinguish whether the cause is due to loss of control so that it enters the opposite lane or due to failure to anticipate when overtaking another vehicle. This condition is based on the fact that most of Indonesia's national road sections have type's 2/2-UD and 4/2-UD which have not been designed to have an ideal road width and median.

Based on Table 10 several attributes are mapped into Quadrant-IV, namely type road shoulders, shoulder width, grade, superelevation, skid resistance, median traversability, volume of motorcycles and bicycles. In fact, it is still very possible to consider the attributes that have been defined as influential attributes, given the importance and difficulty values are very close to the average value. Thus, the likelihood attributes for head-on collision accidents based on IPA analysis are road type, lane width, R-curve, quality of curve, pavement condition, road surface condition, speed limit signs, delineation, and rumble strip. Meanwhile, the selected severity attributes are road median and effective road width. The attribute of the external flow influence factor in this SRS model is traffic volume (AADT). This head-on accident SRS model incorporates an operational speed factor given by 85%-tile speed as an influencing factor.

Table 10. The IPA Analysis for Attributes of Head-on Collision Parameters

No.	Road Attributes	Weight of:		Quandrant
		Importance (X)	Aplication (Y)	
1	Road types	4.558	3.581	
2	Lane width	4.488	3.535	
3	Shoulder types	4.023	3.233	Q4
4	Shoulder width	4.023	3.209	Q4
5	R-Curve	4.326	3.349	
6	Quality curve	4.372	3.721	
7	Grade (%)	4.093	3.186	Q4
8	Superelevasi (%)	4.093	3.279	Q4
9	Pavement condition	4.023	3.605	
10	Skid resistance	4.070	3.419	Q4
11	Road surface condition	4.023	3.442	
12	Speed limit	4.349	3.674	
13	Road delineation	4.419	3.791	
14	Rumbel Strip	4.209	3.651	
15	Median types	4.372	3.488	
16	Median traversability	4.116	3.349	Q4
17	Lane width effectives	4.488	3.395	
18	AADT	4.186	3.488	
19	Motorcycle volume (%)	3.884	3.233	Q4
20	Bicycle volume (%)	3.372	2.953	Q4
21	Speed operational	4.256	3.558	
Average		**4.178**	**3.435**	

Table 11. below shows the results of the IPA analysis of the SRS model attributes for accidents at intersections. Based on the IPA analysis, a number of attributes are mapped into Quadrant-IV. These attributes are categorized as having a low level of importance and a high level of applicability based on the perceptions of Indonesia road safety experts. The attributes that are not considered in this SRS model are lane width, pavement condition, skid resistance, median type, motorcycles volume, bicycles volume. These six attributes are seen by a number of experts as attributes that have little influence on the SRS model for traffic accidents at intersections.

Attributes that influence the SRS model of intersection accidents which are seen as the likelihood of an accident include right-turning lanes, sight distance, grade, canalization, traffic control lights (APIL), speed limit signs, and speed reduction devices. The median factor based on IPA analysis is seen as not an influential factor considering that traffic accidents on national road sections predominantly occur at small intersections with 2/2-UD road types.

The results of this IPA analysis also show that traffic volume factors including motorcycle and bicycle traffic volume are seen as having no effect on the SRS model of accidents at intersections. It is possible that traffic accidents are dominant at small unregulated intersections. Generally, accidents occur at Y-junctions or T-junctions which have poor visibility. These intersections generally have not been designed ideally because many of them are found on corners that have less than ideal visibility.

Table 11. The IPA Analysis for Attributes of All Intersection Accident Parameters

No.	Road Attributes	Weight of:		Quandrant
		Importance (X)	Aplication (Y)	
1	Lane width	4.047	3.302	Q-IV
2	Right-turning lane	4.372	3.535	
3	Sight distance	4.535	3.698	
4	Grade (%)	4.140	3.140	
5	Channelization	4.419	3.442	
6	Pavement condition	3.721	3.279	Q-IV
7	Skid Resistance	3.767	3.326	Q-IV
8	Road-surface condition	3.791	3.465	
9	Traffic light	4.512	3.884	
10	Intersection sign	4.395	3.953	
11	Speed limit	4.163	3.698	
12	Speed reducer	4.140	3.628	
13	Median types	3.884	3.372	Q-IV
14	Motorcycle volume (%)	3.884	3.163	Q-IV
15	Bicycle volume (%)	3.535	3.000	Q-IV
16	Speed operational	4.093	3.302	
Average		**4.087**	**3.449**	

Discussion

Overall the results of the IPA Quadrant analysis of a number of attributes for each National Road SRS calculation produce a number of attributes from each parameter which are divided into SRS attributes for rear-end collision accident parameters (13 attributes), SRS parameters for head-to-side accidents parameters when turning around (13 attribute); The road attributes are the same for several SRS types of accidents, so that in total 43 attributes were selected for National Road SRS as shown in Table 12.

Table 12. SRS National Road Model Attributes from Car Occupant Perspectives

SRS Rear-end Attributes	SRS U-Trun Attributes	SRS Access Properties Attributes	SRS Run-off Attributes	SRS Head-on Attributes	SRS Intersection Attributes
I Likelihood	**I Likelihood**	**I Likelihood**	**I Likelihood**	**I Likelihood**	**I Likelihood**
1 Number of lane	1 Number of lane	1 Number of lane	1 Road type	1 Road type	1 *Right turn lane)**
2 Lane width	2 Lane width	2 Lane width	2 *Lane width)**	2 Lane width	2 *Sight distance to intersection)**
3 Road shoulder	3 Sight distance	3 Sight distance	3 Road shoulder	3 *R-curve)**	3 *Grade)**
4 Shoulder width	4 Grade	4 Grade	4 Shoulder width	4 *Quality curve)**	4 *Canalization)**
5 Quality of curve	5 Median	5 *Frontated road)**	5 Jarak pandang	5 *Pavement condition)**	5 Pavement condition
6 Grade	6 Skid resistance	6 Pavement condition	6 *R-curve)**	6 Road surface condition	6 Traffict light
7 Superelevasi	7 Road surface condition	7 Skid resistance	7 *Quality curve)**	7 Speed limit	7 Intersection sign
8 Pavement condition	8 Turn sign	8 Road surface condition	8 Superelevasi	8 *Delineation**	8 Speed limit sign
9 Skid resistance	9 Speed limit sign	9 Type of area	9 *Pavement condition)**	9 *Rumble strip)**	9 *Speed reducers)**
10 Road surface condition	10 Turning lane	10 Land-use	10 *Skid resistance)**	**II Severity**	**III Operating speed**
II Severity	**II Severity**	**II Severity**	11 Road surface condition	10 *Median type)**	10 *85%-tile speed)**
11 Efective lane width	11 R-turning	11 *Access intencitys)**	12 Safety fence	11 Efective road width	
III Operating speed	12 Median width	12 Side friction	13 *Delineation)**	**III Operating speed**	
12 85%-tile speed	**III Operating speed**	13 On street parking	14 *Rumble strip)**	12 *85%-tile speed)**	
IV External flow influences	13 85%-tile speed	**III Operating speed**	**II Severity**	**IV External flow influences**	
13 %-Heavy Vehicle		14 85%-tile speed	15 *Roadside hazard)**	13 *Traffic volume (ADT)**	
			16 *Distance to hazard object)**		
			17 Safety fence condition		
			III Operating speed		
			18 *85%-tile speed)**		

Notes:)* RPS and SRS iRAP attributes

Based on the analysis and various statistical tests as well as the analysis of the level of importance and level of applicability and the design of the National Road SRS model, it generally shows the final model of the National Road SRS specifically from the perspective of passenger vehicle users. The final model as shown in Figure 4 has significant differences compared to the SRS iRAP model. The difference between the National Road SRS model and the iRAP SRS model is determined by the type of accident as the main parameter and the attributes of each of these parameters. The National Road SRS model provides two completely new parameters, namely rear-end collision accident parameters and the type of head-to-side collision accident which especially occurs when one of the vehicles makes a U-turn.

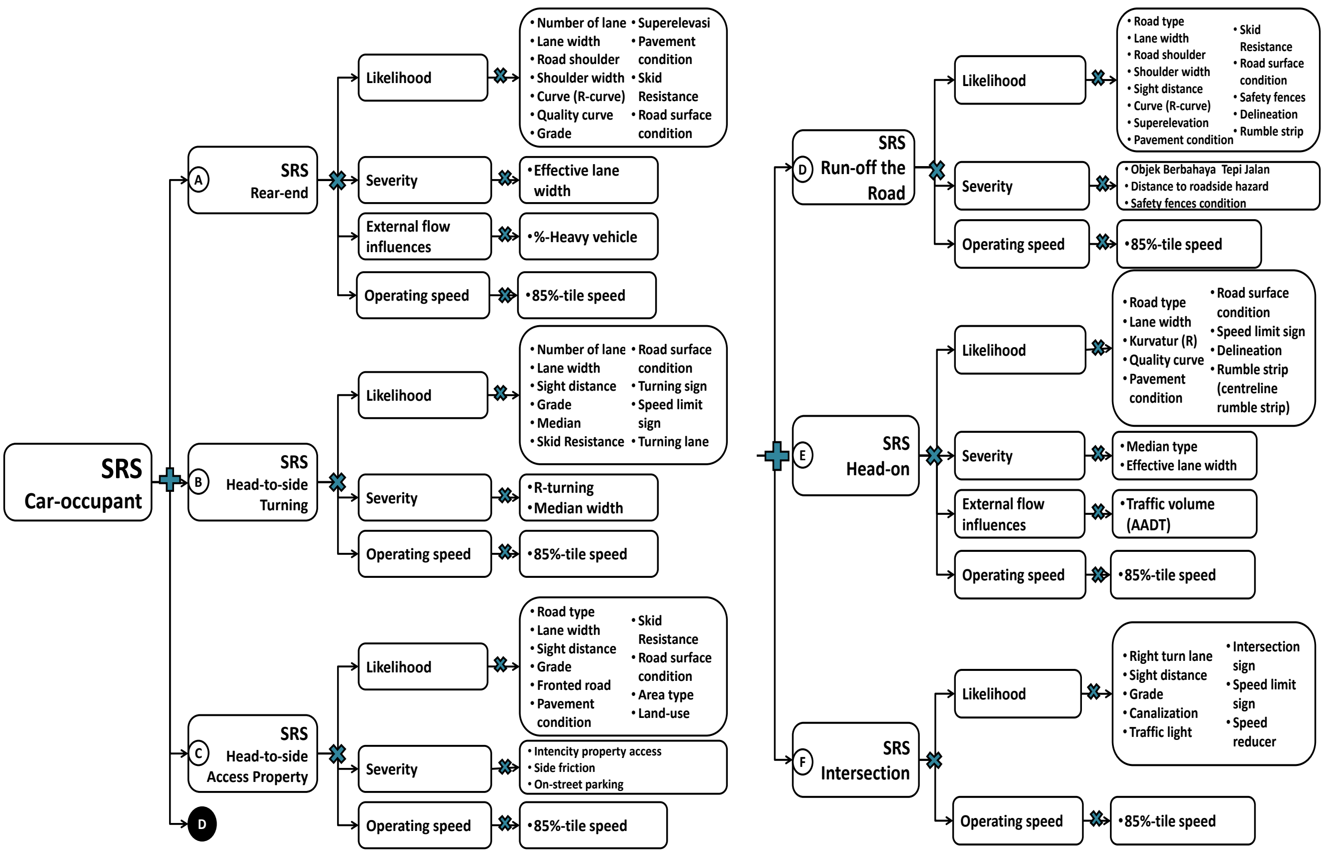


Figure 4. Final Design of SRS Models for National Road From the Perspective of Drivers of Four or More Wheeled Motorized Vehicles (Car Occupant)

In addition to these two parameters, there is one SRS parameter for National Roads which actually has a different type of accident but has the same parameter name i.e. the head-to-side collision accident parameter in property access. The SRS iRAP model property access accident parameters are not specifically stated as to the typical accidents that are dominant at the property access. On the other hand, the access property accident parameters in the National Road SRS model are based on the dominant crash types on national roads, which are head-to-side collisions. Therefore, the accident parameter on property access in the National Road SRS model emphasizes the dominance of typical head-to-side collision accidents on the property access. The inclusion of these three accident parameters in the National Road SRS model brings a number of consequences with new attributes according to the type of accident. For other accident parameters, it was also found that there were several new attributes that were not yet available in the RPS model or the SRS iRAP model. In general, the National Road SRS calculation model specifically from the perspective of passenger vehicle users/riders was generated based on the characteristics of 283,518 traffic crash data and statistical analysis of several attributes selected by Indonesian road safety experts. The model has also been subjected to various statistical analyses.

CONCLUSION

Basically, the Star Rating Scores (SRS) model or Road Protector Scores (RPS) calculation model was developed from typical dominant accidents, especially from the road and environment characteristic. By the same concept, this research also developed the SRS calculation model for Indonesia's national roads, especially from the perspective of motorised vehicle users with four or more wheels, which has also been based on the dominant crash characteristics on national roads. With the same concept, this research also developed the SRS calculation model for Indonesia's national roads, especially from the perspective of motorised vehicle users with four or more wheels, which has also been based on the dominant crash characteristics on national roads.

There are 6 (six) typical accidents that are dominant on national roads which are closely related to the condition of road infrastructure based on an analysis of 283,158 traffic accident data from 2012 to 2019. The six types of accident are rear-end collisions, head-on collisions, head to side collisions both at property access and U-turn locations, single run-off the road accidents, and all accident at intersection.

The SRS model initially considers 2 different main parameters and 4 parameters that are the same as the International Road Assessment Programme (iRAP) SRS main parameters with a total of 51 road attributes. The two main parameters that are different from the iRAP SRS model are rear-end collision and head-to-side collision during turning. The same 4 parameters are head-to-side collision at property accesses, single run-off the road collision, head-on collision, and all accident at intersections.

Based on the Importance and Performance Analysis (IPA) method, 43 road attributes were formulated for the National Road SRS model, consisting of 30 likelihood factor attributes, 10 severity factor attributes, 2 external traffic influence factor attributes, and 1 operational speed factor attribute. Of the 43 attributes, some attributes are used in several SRS models, so that the 43 attributes are divided into SRS rear-end collision with 13 attributes, SRS head-to-side collision when turning 13 attributes, SRS head-to-side collision at property access with 14 attributes, single accident SRS from run-off the road collision with 18 attributes, SRS head-on collision SRS with 13 attributes, and SRS at intersections with 10 attributes.

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