

ERGONOMIC DESIGN PARAMETERS FOR MALAYSIAN CAR  
DRIVERSEATING POSITION

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## DEDICATION

This thesis work is dedicated to my late father Allahyarham Hj. Abdul Rashid Bin Hj. Shariff for inspiring me to proceed this work. This work also dedicated to my beloved mother Hajah Romisah Binti Hj. Shamsuddin, wife Rozita Binti Mohd Yusoff, children Za'im Hareez, Zia'ul Afiq, Zaffri Haziq and Zety Batrisyia for their prayers, patience, supports and encouragement.

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## ABSTRACT

A key element in an ergonomically designed driver workspace of a car is the correct identification of seating position and posture accommodation. Current practice by the automotive Original Equipment Manufacturer (OEM) is to utilize the Society of Automotive Engineering (SAE) standard practice and guidelines in the design process. However, it was found that utilizing such guidelines which were developed based on the American population, do not fit well with the anthropometry and stature of the Malaysian population. This research seeks to address this issue by reviewing the existing standard practices of Design Package and Ergonomic for seating position and accommodation used by a Malaysian automotive manufacturer, Perusahaan Otomobil Nasional (PROTON), and to subsequently propose a new design parameters which better fit the Malaysian population. In the first stage, 210 respondents participated in the anthropometry measurement study to determine the range of sizes for the Malaysian population. In addition, 62 respondents were involved for the driver seating position and accommodation study in the vehicle driver workspace buck mock-up survey and measurements. The results have shown that the Malaysian population are generally shorter if compared with the SAE J833 standard specification, especially for the lower body segments. From the accommodation study, it was found that the Malaysian driver preferred to seat forward, which is probably due to the shorter limb dimensions in the thigh length, buttock length, knee length and foot length. In second stage, questionnaire survey and measurement were used to develop a new design parameters and standards for driver seating positioning and accommodation model based on the Malaysian population. Statistical regression analysis was used to assist in this design parameters development. The statistical model developed was validated by comparing the calculated value of Seating Reference Point of X axis (SgRPx) with actual measurement values measured during respondents sitting in the mock-up. The result shows the difference between the calculated and measured values was within 10 %, indicating that the equation is acceptable. The findings of research are expected to enhance and improve the design guidelines / standard reference for the local automotive industry.

## ABSTRAK

Elemen utama bagi ruang pemandu di dalam kereta yang direka bentuk secara ergonomik adalah ketepatan penentuan posisi serta postur kedudukan tempat pemanduan. Berdasarkan amalan masa kini oleh kebanyakan Pengilang Peralatan Asli (OEM) kereta menggunakan rujukan amalan piawaian dan garis panduan dari *'Society of Automotive Engineering'* (SAE) di dalam proses rekabentuk dan pembangunan kereta. Walaubagaimanapun, penggunaan piawaian tersebut yang dibangunkan berdasarkan populasi pemandu di Amerika didapati adalah kurang sesuai untuk digandingkan dengan antropometri dan susuk tubuh untuk populasi di Malaysia. Oleh itu, kajian ini dilakukan bertujuan untuk mengenalpasti isu-isu tersebut dengan menilai semula amalan piawaian di dalam rekabentuk Pakej dan Ergonomik untuk posisi dan postur kedudukan yang telah diguna pakai oleh pengilang kereta nasional Malaysia PROTON, dan seterusnya mencadangkan satu parameter rekabentuk baru yang lebih sesuai untuk digandingkan spesifikasi populasi pemandu di Malaysia. Pada peringkat pertama, seramai 210 peserta telah terlibat untuk kajian pengukuran antropometri bertujuan mengenal pasti jurang saiz ukuran-ukuran pemandu di Malaysia. Sebahagian dari 62 peserta kajian tersebut juga turut terlibat dalam kaji selidik dan pengukuran kedudukan pemanduan di dalam ruang pemandu kereta menggunakan *'buck mock-up'*. Hasil kajian menunjukkan pemandu Malaysia pada umumnya berukuran lebih rendah berbanding spesifikasi standard *'SAE J833'* terutama pada segmen anggota bawah badan. Untuk kajian kedudukan pemanduan pula didapati pemandu Malaysia lebih selesa untuk duduk lebih ke hadapan di kerusi pemandu. Ini berkemungkinan disebabkan anggota bawah badan yang lebih pendek seperti peha, punggung, lutut dan tapak kaki. Di peringkat kedua kajian pula melibatkan pembangunan garis panduan dan parameter rekabentuk baharu untuk kedudukan pemanduan mengikut spesifikasi populasi pemandu Malaysia berdasarkan data yang terhasil dari data soal selidik dan pengukuran sebelum ini. Statistik analisis regresi telah digunakan dalam membangunkan parameter rekabentuk baharu tersebut. Model parameter rekabentuk yang dibangunkan telah disahkan dengan membandingkan nilai pengukuran sebenar yang diukur semasa subjek di dalam *'mock-up'* dan nilai yang terhasil melalui kiraan menggunakan model baharu Titik Penanda Kedudukan Pemanduan pada paksi X (*SgRPx*). Keputusan kajian menunjukkan nilai diantara pengukuran dan pengiraan tersebut berada dalam lingkungan 10%, yang mana nilai tersebut boleh diterima pakai dalam kajian. Oleh itu, hasil dari kajian ini diharapkan dapat memperbaiki garis panduan piawaian Rekabentuk sebagai rujukan untuk industri otomotif di Malaysia.

## TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	<b>DECLARATION</b>	ii
	<b>DEDICATION</b>	iii
	<b>ACKNOWLEDGEMENT</b>	iv
	<b>ABSTRACT</b>	v
	<b>ABSTRAK</b>	vi
	<b>TABLE OF CONTENTS</b>	vii
	<b>LIST OF TABLES</b>	xii
	<b>LIST OF FIGURES</b>	xv
	<b>LIST OF ABBREVIATIONS</b>	xix
	<b>LIST OF APPENDICES</b>	xx
<b>1</b>	<b>INTRODUCTION</b>	<b>1</b>
	1.1 Introduction to Research	1
	1.2 Background of Problem	3
	1.3 Problem Statement	5
	1.4 Research Questions	5
	1.5 Research Objective	6
	1.6 Research Scope	7
	1.7 Significant of Study	7
	1.8 Expected of Research Findings	8
	1.9 Outline of Thesis	8
<b>2</b>	<b>LITERATURE REVIEW</b>	<b>10</b>
	2.1 Introduction	10
	2.2 PROTON's Automotive Ergonomic Motivation	10
	2.3 Market Feedback of PROTON Cars	13

2.4	Overview of Automotive Ergonomic	18
2.5	Vehicle Design Package	20
2.6	Postural Joint Angle Factors	23
2.7	Anthropometric Factors	27
2.8	Standard Design Guideline in Design Package	29
2.9	Society Automotive Engineers (SAE) Recommended Practices	31
2.9.1	SAE Accommodation Model-SAE J1517 (Driver Selected Seat Position)	35
2.10	Review of Methods	37
2.10.1	Experimental Environment and Method Measurement	38
2.10.2	Respondents	39
2.11	Summary and Conclusion	41
<b>3</b>	<b>METHODOLOGY</b>	<b>43</b>
3.1	Introduction	43
3.2	Research Methodology Outline	43
3.2.1	Research Methodology Process Flow	46
3.3	Anthropometric Measurement	49
3.4	Digital Human Modelling (DHM)	54
3.5	Seating Position and Postural Study	56
3.5.1	Subjective Measurement	58
3.5.2	Objective Measurement	59
3.5.2.1	3D Photogrammetric Process	60
3.6	Statistical Analysis	64
3.6.1	Descriptive Analysis	65
3.6.2	Correlation Analysis	65
3.6.3	Box Plot	66
3.6.4	Regression	67
3.6.4.1	Linear Regression	67
3.6.4.2	Multiple Regression	68
3.7	Model Development and Validation	68
3.7.1	Model Development	69

	3.7.2 Model Validation	69
<b>4</b>	<b>ANTROPOMETRICAL AND POSTURAL SURVEY RESULT AND DISCUSSION</b>	<b>71</b>
	4.1 Introduction	71
	4.2 Anthropometric Study	71
	4.2.1 Demographic of Respondents	71
	4.2.1.1 Analysis of Anthropometric Percentiles	76
	4.2.1.2 Male Anthropometry Result Data	76
	4.2.1.3 Female Anthropometry Result Data	78
	4.3 Digital Human Manikin Model Construction	80
	4.4 Discussion on the Anthropometrics Study	82
	4.4.1 Comparison of Malaysia Manikin Model - Male and Female	85
	4.4.2 Table Summary Comparison with SAE J833 (Human Dimension)	90
	4.4.3 Impact of Different Anthropometry on Vehicle Design Package	94
	4.4.4 Summary Comparison with Published Global Population Anthropometry	99
	4.5 Results of the Accommodation Study	103
	4.5.1 Demographics Information	103
	4.5.2 Posture Accommodation Result	107
	4.6 Postural Measurement	108
	4.6.1 Postural Result for Male Respondents	108
	4.6.2 Postural Result for Female Respondents	112
	4.6.3 Postural Comfort Questionnaire	115
	4.6.3.1 Seat and Body Mapping Questionnaire	115
	4.6.3.2 Correlation Analysis Result between the Postural Accommodation Measurements and Subjective Comfort Survey	121
	4.7 Discussion on Postural Accommodation Study	123
	4.7.1 Postural Joint Angle	124
	4.7.2 Seating Position Distance	126



	4.7.3 Body Segment Comfort / Discomfort	129
	4.7.3.1 Body Comfort / Discomfort	129
	4.8 Body Symmetry	131
	4.9 Driver Workspace Correlation Factor	131
	4.10 Summary	133
<b>5</b>	<b>SEATING ACCOMODATION GUIDELINE MODEL DEVELOPMENT AND VALIDATION</b>	<b>135</b>
	5.1 Introduction	135
	5.2 Seating Accommodation Model Development	136
	5.2.1 Definition of Seating Accommodation Model	136
	5.2.2 Model Parameters	136
	5.2.3 Model Assumption and Limitation	139
	5.3 Driver Seating Accommodation Model	139
	5.4 Discussion on Seating Accommodation Model	143
	5.5 Seating Accommodation Model Validation	146
	5.5.1 Model Validation Development Process	146
	5.5.2 Design and Fabrication of Mock-up Build-up	147
	5.5.3 Data Collection Process	147
	5.5.4 Data Result and Analysis	149
	5.5.4.1 Anthropometry measurement	149
	5.5.4.2 Postural Study	150
	5.5.4.3 Model Assessment	151
	5.5.4.4 Model Validation Discussion	155
	5.6 Limitations of the Validation Process	159
	5.7 Conclusion	159
<b>6</b>	<b>CONCLUSIONS</b>	<b>161</b>
	6.1 Introduction	161
	6.2 Conclusion of Findings Based on the Research Objectives and Questions	161
	6.3 Limitation and Restriction	164
	6.4 Industrial Impact of Research Findings	165
	6.5 Recommendation for Future Work	166

**REFERENCES**

**168**

Appendices A - I

185 - 248

## LIST OF TABLES

<b>TABLE NO.</b>	<b>TITLE</b>	<b>PAGE</b>
2.1	Comparison of joint posture angle according to different population	26
2.2	SAE Standard Practices for Passenger Car Interior Design (Roe,1993; SAE 1998; Reed <i>et al.</i> , 1999; Shi, Xia and Paul Gunther, 2011)	32
2.3	Summary of research on driver seating position	40
3.1	Anthropometry measurement apparatus	52
3.2	The point's definition for each measurement	59
3.3	Summary analytical analysis	64
4.1	The numbers of male respondents by age range	72
4.2	The numbers of male respondents by race	72
4.3	The numbers of male respondents by weight	73
4.4	The numbers of female respondents by age groups	74
4.5	The numbers of female respondents by race	74
4.6	The numbers of female respondents by weight	75
4.7	Measurements of anthropometric dimensions of 105 male respondents in the standing posture	76
4.8	Measurements of anthropometric dimensions of 105 male respondents in the sitting posture	77
4.9	Measurements of anthropometric dimensions of 105 female respondents in the standing posture	78
4.10	Measurements of anthropometric dimensions of 105 female respondents in the sitting posture	79
4.11	Average body ratio at standing posture	87
4.12	Average body ratio at sitting posture	88

4.13	Body ratio comparison Malaysia and SAE J833 - Standing posture	92
4.14	Body ratio comparison Malaysia and SAE J833 - Sitting posture	93
4.15	Body segment correlation in passenger driver workspace	96
4.16	Anthropometry dimension at standing posture	101
4.17	Anthropometry dimension at sitting posture	102
4.18	Male respondents by age range	103
4.19	Male respondents by race	104
4.20	Female respondents by age range	104
4.21	Female respondents by race	105
4.22	Respondents driving experiences (years)	106
4.23	Respondents driving experiences per day	107
4.24	Descriptive analysis of male joint angle measurement	109
4.25	Descriptive analysis of male driving positioning measurement	109
4.26	Driving posture study for male drivers by percentile	110
4.27	Descriptive analysis of female joint angle measurement	112
4.28	Descriptive analysis of female driving positioning measurement	113
4.29	Driving posture study for female drivers by percentile	113
4.30	Joint Posture Angle -Male and Female	115
4.31	Descriptive analysis of male survey of body mapping comfort and discomfort parameters	116
4.32	Descriptive analysis of female measurement survey of body mapping comfort and discomfort parameters	117
4.33	Percentage comparison of body mapping on comfort and discomfort	119
4.34	Correlation analysis result between postural angle measurement and body mapping for male respondents	122
4.35	Correlation analysis result between postural angle measurement and body mapping for female respondents	123
4.36	Comparison joint angle of male and female (Malaysian)	124
4.37	Comparison joint angle from previous research	125

4.38	Comparison of seating position distance - Male and female	126
4.39	Body segment most discomfort and most comfort in driver workspace	130
4.40	Body symmetry comparison for Malaysia driver	131
4.41	Correlation factor for Malaysia driver in driver workspace	132
5.1	Vehicle and seat variable for posture prediction definition	137
5.2	Stepwise regression model summary	140
5.3	ANOVA (Model 4)	141
5.4	Coefficients (Model 4)	141
5.5	Normality test for Anthropometry	142
5.6	Normality test for postural study	142
5.7	Comparison research model	145
5.8	Anthropometry data according to percentile	149
5.9	Results of postural measurement	150
5.10	Summary of the results for mean and std. deviations of postural measurement	151
5.11	Results measured vs predicted (calculation) - wireframe buck mock-up	153
5.12	Result predicted SAE 1517 model seating distance	154
5.13	Summary result of research and SAE 1517 - measured vs predicted	156

## LIST OF FIGURES

<b>FIGURE NO.</b>	<b>TITLE</b>	<b>PAGE</b>
1.1	Automotive ergonomic overview	4
2.1	PROTON market strategy flow	12
2.2	New product development process (PROTON new product introduction, 2014)	13
2.3	JD Power report of Prevé model for driver workspace (PROTON Preve Post-Launch Evaluation Study - 2013)	15
2.4	JD Power report of Prevé model for driver workspace (PROTON Preve Post-Launch Evaluation Study - 2013)	15
2.5	PROTON Domestic market share (Malaysia Automotive Association (MAA), 2014)	17
2.6	Ergonomic consideration related to characteristic of the driver and vehicle (Adapted from Bishe, 2012)	19
2.7	Automotive ergonomic key area in PROTON standard practice (PROTON ergonomic design flow)	20
2.8	Factors affecting sitting comfort and discomfort (Adapted from Kyung, 2007)	23
2.9	Driver posture defining joints angle (Lee <i>et al.</i> , 2008)	25
2.10	H-Point manikin template (SAE J826, 2008)	33
2.11	Schematic of relationships among SAE recommended practices in driver workspace (Adapted from Reed <i>et al.</i> , 1999)	34
2.12	SAE Task- Oriented Percentile and Accommodation model (Adapted from Reed <i>et al.</i> , 1999)	34
2.13	SAE J1517 equations (Phililippart <i>et al.</i> , 1984; SAE 1517, 1998)	36

2.14	SAE J1517 Accommodation Graph Curve (Adapted from Philippart <i>et al.</i> , 1984)	36
3.1	Design research methodology (Blessing <i>et al.</i> , 1998)	44
3.2	Research methodology	45
3.3	Research methodology process flow	48
3.4	Anthropometric measurement protocol	51
3.5	Percentile measurement process flow	54
3.6	Example of 3D human model manikin (Standing posture)	55
3.7	Angle measurement points	57
3.8	Definition of driver workspace following a SAE nomenclature	58
3.9	Point measurement for driver seating position and posture measurements	60
3.10	Analysis for obtaining the data for postural angle and segment length	61
3.11	Example of two images used for 3D photogrametric analysis	62
3.12	The points of angle and distance measurements are assigned	62
3.13	Selected measurements to be displayed in a table	63
3.14	Shows the measurement result of 3D photogrametric analysis	63
3.15	Box plot measurement	67
3.16	Schematic of model development and validation (Adapted Reed, 2002)	69
4.1	The age range of male respondents percentage	72
4.2	The race of male respondents by percentage	73
4.3	The weight of male respondents (in kg) by percentage	73
4.4	The age range of female respondents by percentage	74
4.5	The race of female respondents by percentage	75
4.6	The weight of female respondents by percentage	75
4.7	Malaysia human model - male	81
4.8	Malaysia human model - female	81

4.9	Height comparison of Malaysia manikin 5 <sup>th</sup> percentile, 50 <sup>th</sup> percentile and 95 <sup>th</sup> percentile, male and female	82
4.10	Standing posture anthropometric measurements	83
4.11	Sitting posture anthropometric measurements	84
4.12	Manikin comparison between SAE J833 and Malaysia	94
4.13	SAE recommended standard practice in driver workspace	95
4.14	Driver position comparison between SAE J833 and Malaysian model	98
4.15	Manikin comparison of 95 <sup>th</sup> percentile male SAE J833 and 5 <sup>th</sup> percentile female Malaysia in driving position	99
4.16	Male respondents percentage by age range	103
4.17	Male respondents percentage by race	104
4.18	Female respondents percentage by age range	105
4.19	Female respondents percentage by race	105
4.20	Respondents driving experiences (years)	106
4.21	Respondents driving experiences per day	107
4.22	Result of driving posture study for male respondents by percentile	111
4.23	Descriptive analysis result of driving posture study of females 5 <sup>th</sup> percentile, 50 <sup>th</sup> percentile and 95 <sup>th</sup> percentile measurement	114
4.24	Graph percentage comparison of body mapping on comfort and discomfort	120
4.25	Graph SAE J1517 overlay with Malaysia 5 <sup>th</sup> percentile driver seating position	127
4.26	Graph SAE J1517 overlay with Malaysia 50 <sup>th</sup> percentile driver seating position	128
4.27	Graph SAE J1517 overlay with Malaysia 95 <sup>th</sup> percentile driver seating position	128
4.28	Graph SAE J1517 overlay with 5 <sup>th</sup> , 50 <sup>th</sup> and 95 <sup>th</sup> Malaysia percentile driver seating position	129
5.1	SAE predicted driving posture model (SAE1517, 1998)	137
5.2	Model development process flow	138
5.3	Validation process flow	147



5.4	Frame mock-up for data collection	148
5.5	Respondent in driving position	148

## LIST OF ABBREVIATIONS

3D	-	Three Dimensional
AHP	-	Accelerator Heel Point
ANSUR	-	Army Anthropometric Survey
ASEAN	-	Association of Southeast Asian Nations
ASME	-	American Standards of Mechanical Engineers
ASTM	-	American Society for Testing and Materials
BOF	-	Ball of Foot
BS	-	British Standard
CAESAR	-	Civillian America and European Surface Anthropometry Resource
DHM	-	Digital Human Modeling
GCIE	-	Global Cars Manufacturer Information Exchange
GM	-	General Motors
ISO	-	International Organization for Standardization
JIS	-	Japanese Industrial Standard
MAA	-	Malaysia Automotive Association
MENA	-	Middle East and North Africa
MIROS	-	Malaysian Institute of Road Safety
OEM	-	Original Equipment Manufacturer
SAE	-	Society of Automotive Engineers
SgRP	-	Seating Reference Point
SIRIM	-	Scientific and Industrial Research Institute of Malaysia
UAE	-	United Arab Emirate
VSCS	-	Vehicle Seat Comfort Survey

**LIST OF APPENDICES**

<b>APPENDIX</b>	<b>TITLE</b>	<b>PAGE</b>
A	Anthropometric Measurement Parameters	185
B1	Standing Position	199
B2	Standing Posture	200
B3	STANDING POSTURE	201
B4	Standing Posture	202
B5	Standing Posture	203
B6	Sitting Posture	204
B7	Sitting Posture	205
C	Demographic Questionnaire	206
D	Local Discomfort Rating Questionnaire	207
E	Body Part Discomfort Chart	209
F	Detail Steps of Tema Analysis	210
G1	Normality Test – Anthropometry	222
G2	Normality Test – Posture	226
G3	Egression Statistical Data	237
H	Calculation – Predicted	245
I	Calculation SAE J1517 Model	247

## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Introduction to Research**

One of the major objective of ergonomics is to design equipment that will achieve the best possible fit between the user/driver and the equipment/vehicle, so ensure the user's safety, comfort, convenience, improved performance and efficiency, and reduced fatigue (Openshaw and Taylor, 2008; Bishe, 2012). The keywords that frequently describe ergonomics are comfortable as well as safe environment. (Sanders and McCormick, 1992; Helander, 1995).

Woodcock and Flyte (1998) have mentioned in their study that 60% of respondents felt that their needs for ergonomics were not met and 72% felt that their needs of ergonomic information would increase in the future. Similar trends are observed across a wide variety of products from home products, office equipments and motor vehicles. The need for ergonomic principles have grown ever since the beginning of the automotive industry, and today it is a major factor in modern car design. The implementation of ergonomics goes beyond the use of common sense or subjective evaluations since there are specific methods and objective means from which results can be calculated (Buti, 2001).

In today's highly competitive automotive industry, car manufacturers are incorporating, as much as possible, their customer's expectations and requirements for a comfortable vehicle into their car designs. For example, to accommodate the human driver's need and expectations, the driver's workspace and its interface should be designed to consider the driver's accommodation, perception and

behaviors associated with the driving task. Ergonomic factors such as anthropometric variability (body dimensions), strength, motion envelopes, reaction times, fatigue, task loads, visibility and symbol perceptions should be considered. Thus, design for anthropometric concerns are usually the common starting point for driver workspace design.

In general, the measurements of the human body dimensions, also known as anthropometry, is essential when dealing with variations in products or workplace. Ethnic diversity is also a significant factor that may affect the anthropometric data and the scope of applications. As mentioned by Grandjean (1988), since the attitude of the human trunk, arms and legs as natural posture and movements is a necessary part of efficient work, it is essential that the workplace be suited to the body of the operator. Factors that may cause significant variations of human body sizes are gender and races which are the two main variations in body sizes that should be considered in the design process.

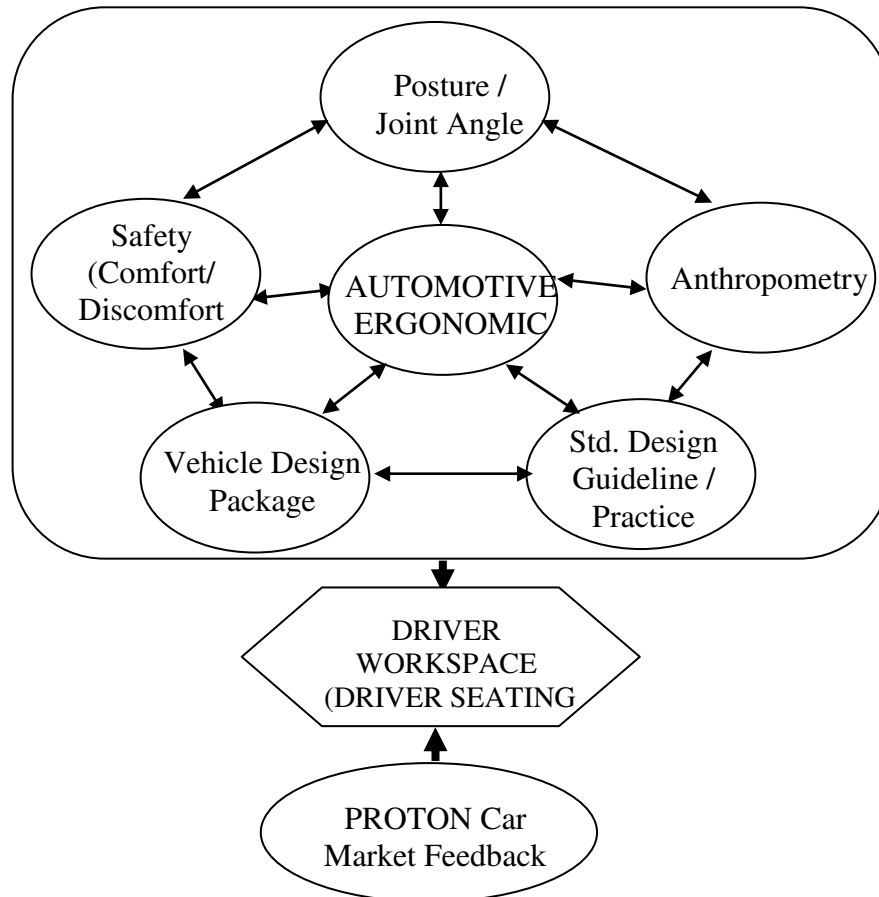
Traditionally, in vehicle ergonomic design, designers often refer to the Society of Automotive Engineer (SAE) two dimensional accommodation tools to design various vehicle components such as the seat position, reach envelopes, head contours and eye ellipse (Roe, 1993). Examples of SAE's recommended practices and guidelines are SAEJ1517 (Driver Selected Seat Position), and SAE J833 (Human Physical Dimension). However, these practices are based on collected data obtained from the driver population data of U.S Army personnel anthropometry survey (Gordon *et al.*, 1989). Furthermore, since some of the SAE practices were based on studies conducted in the 1960s, caution should be made for direct implementation of these guidelines, which may not address changes in anthropometry over the years.

In the context of the local automotive ergonomic design in Malaysia, the question now is whether these SAE practices are able to accommodate the Malaysian population. Thus, this research aims to understand the applicability of current standards and to establish a new design guideline for the Malaysian population on Driver Seating Position and Accommodation in Driver Design Package process.

## 1.2 Background of Problem

Ergonomic is one of the important areas which the design engineer should consider during vehicle design activities. The objective of having ergonomic element in the design is to ensure the product is harmonized and meets the expectations of the customers. One particular importance in automotive design is the ergonomics of the driver workspace, specifically the seating position. It is essential to ensure that the driver seat is in the right position and posture in order to obtain a comfortable and healthy driving experience. The quality of ergonomic in a driver workspace is mostly determined by factors such as interior design (e.g. fit, support, and aesthetics), vehicle package geometry (harmonic location of components and parts i.e. Seat, Steering, Pedals) and postural comfort (Kyung, 2008).

Figure 1.1 shows the factors that are important issues in driver workspace design, such as postures, anthropometry, comfort and discomfort. Finding of past studies have shown that badly designed driver workspace may affect the driver's health and safety, for example the development of several musculoskeletal disorders in the Neck, Shoulder, Back (Ebe and Griffin, 2001; Kelsey and Hardy, 1975; Magnusson and Pope, 1998; Schneider and Ricci, 1989) and also due to frequent exposures to improper of seated postures in the car (Cho and Yoon, 2001; Raiput and Abbound, 2007).



**Figure 1.1** Automotive ergonomic overview

PROTON as Original Equipment Manufacturer (OEM) in the Malaysian car industry has to ensure that their products are competitive in the automotive market. As part of product improvement activities, the company always seeks to revisit various design standards that are being used in the design process. This study on the development of a localized design standard for driver accommodation is based on several customers' feedback of recent PROTON models on vehicle ergonomics, especially on the driver workspace.

Generally, there are several design practices and standards that are being referred to by automotive OEM in the industry. The most established and comprehensive design standard practice is from SAE Recommended practices. These standard guidelines and practices have been widely used by various automotive OEMs, including PROTON, as design reference and guideline for vehicle design developments, especially in designing the vehicle interior dimensions. This standard

has been established since the 1960s when General Motor (GM) developed its first SAEJ826 2D template manikin to study the driver seat position. (Lee *et al.*, 2008).

However, these guidelines were developed based on the American population. Thus, it may be different for some ergonomic dimensions for other regions of the world. The current standard design practice in ergonomic design at PROTON is dependent on SAE guidelines, thus it may compromise the needs and requirements of the Malaysian population. To date there is no established guideline based on the Malaysian or ASEAN population for driver workspace specifically the driver seating position and accommodation. Thus, it is essential to develop and establish a localized guidelines of driver workspace design based on the population of Malaysia.

### **1.3 Problem Statement**

Ergonomic in driver workspace is a key factor in vehicle design to ensure the driver achieves the right posture and comfort, hence reducing fatigue. It is one of the important criteria for PROTON's product from market point of view. Nevertheless based on market feedback and design issues, it is discovered that existing design parameter or reference could not meet the current target customer and market specification. By having the suitable design parameter ensures the driver workspace design is able to satisfy market requirements and target customers. Therefore, the aim of this study is to evaluate the existing standard (SAE J1517) applied in PROTON to improve driver seating position in ergonomic design.

### **1.4 Research Questions**

Based on the Research Objective and main issues addressed in the research background, the following research questions are formulated.



1. Is the SAE suitable for use in designing cars for the Malaysian population (RQ1)? [Based on Research Objective 1 (RO1)]. This research question is further detail in the following sub-questions.
  - 1.1. How different is the SAE guideline with respect to accommodating anthropometry of the Malaysian population (RQ1.1)?
  - 1.2. How different is the SAE guideline with respect to accommodating the Malaysian driver's postures (RQ1.2)?
2. What is the new driver seating position model to accommodate the Malaysian population (RQ2)? [Based on Research Objective 2 (RO2)]. This research question is also further details in the following Research sub- questions.
  - 2.1. What are the critical parameters for Malaysian driver seat positioning model (RQ2.1)?
  - 2.2. What are the relationships between these critical parameters (RQ2.2)?
3. Can the new model effectively accommodate Malaysian driver (RQ3)? [Based on Research Objective 3 (RO3)].

This research will seek to establish the answer to these Research Questions that would affect the seating and driving posture and how it will optimize the comfort level during driving.

## **1.5 Research Objective**

To develop a new ergonomic design guideline for the Malaysian population, the following objectives are defined for this study:

Objective 1 : To investigate the applicability of current design practices in accommodating Malaysian driver (RO1).

Objective 2 : To develop the driver workspace model for vehicle Design Package on Seating Position and Accommodation (RO2).

Objective 3 : To validate driver workspace model for vehicle Design Package on Seating Position and Accommodation (RO3).

## **1.6 Research Scope**

The research scope will cover two main areas of 1) Driver Anthropometry and 2) Driver Seating Position and Accommodation. The anthropometry study focuses on establishing the Malaysian driver anthropometry according to MS ISO 15535:2008 standard, the general standard requirement for Establishing Anthropometry Databases. Analysis involves the anthropometric comparison with SAE J833 on body segment dimensions and ratio. Secondly is the evaluation of Malaysian Driver Seating Position and Accommodation and consequently study the suitable driving position for Malaysian driver in a sedan car against the SAE Seating Accommodation guideline. The research determines the driver posture angle and seating position of Malaysian driver and comparisons with SAE J1517 design practice guideline are made. The analysis finding and result are discussed accordingly.

## **1.7 Significant of Study**

The results from this research will provide a localized ergonomic design and human driver posture approach and guideline for automotive industry in Malaysia. This will directly benefit Original Equipment Manufacturer (OEM) such as PROTON and Perodua, and also automotive suppliers and vendors for vehicle components such as seats, brakes and airbag. Furthermore, it will be useful for government agencies such as Department of Standards Malaysia (Standard Malaysia), Malaysian Institute of Road Safety Research (MIROS) and Scientific and Industrial Research Institute of Malaysia (SIRIM), in which the results of this study can be included in future automotive policies and guidelines.

## **1.8 Expected of Research Findings**

The expected outcomes of this research are as follow:

1. Development of a database of the Malaysia driver Anthropometry data according to Percentile in comparisons with the SAE Anthropometry data (based on America Population).
2. Identification of the range of comfort driving postures of Malaysia driver in passenger vehicle.
3. Establishment of comfort driving posture of Malaysia driver as standard reference for vehicle interior ergonomic study and components design (such as seats and pedals).
4. Establishment of the Malaysia Driver Seating Position and Accommodation Model for Malaysian driver.

## **1.9 Outline of Thesis**

This thesis is organised into six chapters. The first chapter outlines the general introduction, background of problem on Anthropometry issues in interior design specifically in PROTON design ergonomic study, objective of the research, scope of research and finally the expected findings from this research.

The second chapter provides the definition, overview and critical review of past literatures related to the research topic such as the Ergonomic and Interior Design Package, Anthropometry and Seat Posture Design. This chapter also will discuss existing SAE Tool standard related to the research topic.

Chapter Three describes the research methodology taken which will include anthropometry survey, apparatus and respondents measurements. The mock-up preparation for comfort posture survey and data collection is also described.

The results and discussion on the applicability to accommodate the design parameters is elaborated in Chapter Four. This Chapter also discusses the results of the anthropometry and seating accommodation postures of the Malaysian driver.

In Chapter Five, the discussion focuses on the development model for the Malaysian driver seating accommodation design parameters based on the research data and analysis carried out. The comparison and subsequent validation of the developed model with the actual vehicle mock-up survey measurements are presented.

Finally, Chapter Six concludes the research, which includes an overview of the achievement of the study, its contribution to both academic and industrial body of knowledge, its limitation and recommendations for future research work.

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