DEVELOPMENT OF AN INTEGRATED TRAIN DRIVER PERFORMANCE MODEL

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ABSTRACT

The purpose of this study was to develop an integrated performance model of train drivers. A human performance measure was developed, integrating several significant factors of the train driver, and a theoretical framework specified for train driver was established from an extensive review of the literatures. This framework formed the foundation of the study in order to understand the significant factors influencing the performance of a train driver. Three main domains of human, activity and context were proposed to represent the key indicators of the train driver's performance.

The evaluation was conducted on train drivers of a major train operating company (TOC) in Malaysia, focusing only on drivers of intercity passenger trains and freight trains. 229 respondents had participated in the quantitative paper-and-pencil survey conducted, and the data obtained was subsequently analysed using SPSS software. An integrated framework was then tested using structural equation modelling (SEM)-PLS approach in theSmartPLS software to determine the relationship among the significant factors of train driver performance. Fourteen factors were hypothesized and tested under the three main domains, namely fatigue, job related tension (internal and external conflict), job satisfactions, occupational stress and sleepiness, which were grouped under human domain; while driving task and job demand represented the activity domain; and lastly, the context domain consisted of the working condition, safety culture, safety issue, working environment and work facilities.

The results indicated that fatigue, job related tension (internal conflict) and occupational stress; under human domain were found to be the significant factors which influence the performance of train drivers. For the activity domain, hypothesis testing proved that driving task, was significant factor. In the context domain; three factors were found to be significant. These include safety culture, working environment and

working condition. To summarize, the study identified a total of seven significant factorswhich include occupational stress, job related tension – internal conflict, fatigue, driving task, work environment, safety culture and working condition. However, the results have failed to support the remaining seven factors of job related tension (external conflict), job satisfactions, sleep, job demand, work facilities, and safety issue.

Significant to this research was that an integrated Malaysian train driver performance model has been successfully developed for identifying the significant factors that influence train driver performance, highlighting the interaction between human factors, human activities and its context. Through this approach, this study has looked at the significant factors in holistic and comprehensive perspective without ignoring other potential domains of factors. Therefore, this model would benefit the rail industry by assisting them in identifying the factor(s) That require close observation and improvement. Thus, the overall performance of the industry would be upgraded and contributes to the betterment of the system and the rail industry.

ABSTRAK

Tujuan kajian ini adalah pembangunan model bersepadu untuk prestasi pemandu keretapi. Suatu ukuran prestasi insani telah dibangunkan, dengan mengintegrasikan beberapa faktor penting berkaitan pemandu keretapi. Lanjutan daripada itu, rangka kerja teori telah dibangunkan terlebih dahulu berasaskan kajian ilmiah yang mendalam. Rangka kerja teori ini telah menjadi asas kepada kajian ini, digunakan untuk memahami faktor – faktor penting yang mempengaruhi pemandu keretapi. Tiga domain utama iaitu manusia, aktiviti dan konteks telah dicadangkan untuk mewakili penunjuk utama di dalam penilaian prestasi pemandu keretapi.

Penilaian telah dijalankan ke atas pemandu keretapi syarikat pengendali keretapi utama (TOC) di Malaysia, yang memfokuskan hanya kepada pemandu – pemandu keretapi penumpang antarabandar dan keretapi barang. Seramai 229 responden telah terlibat di dalam kaji selidik kuantitatif yang menggunakan kertas dan pensil, dan data yang telah dikutip ini, dianalisa menggunakan perisian SPSS. Rangka kerja bersepadu ini kemudiannya diuji menggunakan model persamaan berstruktur (SEM) - dengan pendekatan PLS menggunakan perisian SmartPLS untuk menentukan perkaitan di antara faktor – faktor penting ke atas prestasi pemandu keretapi. Empat belas faktor telah dihipotesis dan diuji di bawah tiga domain utama; iaitu kelesuan, ketegangan berkaitan kerja (konflik dalaman dan luaran), kepuasan bekerja, tekanan pekerjaan dan ketiduran, di mana ianya di kumpulkan di bawah domain manusia. Manakala tugasan pemanduan dan keperluan kerja mewakili domain aktiviti. Yang terakhir adalah domain konteks yang mengandungi keadaan kerja, budaya keselamatan, isu keselamatan, persekitaran kerja dan kemudahan kerja.

Dapatan kajian mendapati kelesuan, ketegangan berkaitan kerja (konflik dalaman) dan tekanan pekerjaan; di dalam kelompok domain manusia adalah signifikan terhadap prestasi pemandu keretapi. Untuk domain aktiviti pula, ujian hipotesis telah

membuktikan bahawa tugasan memandu adalah signifikan terhadap prestasi. Manakala untuk domain konsep; tiga faktor telah didapati signifikan; iaitu budaya keselamatan, persekitaran kerja dan keadaan kerja. Secara kesimpulannya, tujuh faktor didapati signifikan di dalam kajian ini iaitu tekanan pekerjaan, ketegangan berkaitan kerja (konflik dalaman), kelesuan, tugasan memandu, persekitaran kerja, budaya keselamatan dan keadaan kerja. Walau bagaimanapun, dapatan kajian telah gagal untuk membuktikan tujuh faktor lagi mempengaruhi prestasi pemandu keretapi; iaitu ketegangan berkaitan kerja (konflik luaran), kepuasan bekerja dan ketiduran, keperluan kerja, kemudahan kerja dan isu keselamatan.

Adalah menjadi kepentingan terhadap kajian ini di mana model bersepadu pemandu keretapi Malaysia telah dibangunkan dengan jayanya. Ia digunakan untuk menentukan faktor – faktor penting yang mempengaruhi prestasi kerja mereka yang mengetengahkan hubungan di antara faktor manusia, aktiviti manusia dan konteks. Melalui pendekatan ini, kajian ini telah meneliti faktor – faktor penting dengan kaedah yang paling komprehensif dan menyeluruh tanpa mengabaikan sebarang domain yang berkaitan. Oleh yang demikian, model ini akan berfaedah kepada industri keretapi dengan membantu mereka mengenalpasti faktor – faktor manakah yang perlu dipantau dan ditambahbaik. Maka, prestasi keseluruhan industri tersebut akan dapat dipertingkatkan dan menyumbang kepada kejayaan dan kebaikan sistem serta industri keretapi secara amnya.

DEDICATION

To my parents, Md Jalil Maslan and Azizah Osman;

my wife Nor Hamisah Mohamed Nor;

my daughter Nur Arissa and my son Ariz Safiyy

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LIST OF ABBREVIATIONS

ANOVA	:	Analysis of variance
ATC	:	Air traffic control
AVE	:	Average variance extracted
AWS	:	Automatic Warning System
CB-SEM	:	Covariance-based structural equation modelling
CR	:	Composite reliability
CTA	:	Cognitive task analysis
DT	:	Driving task
EEG	:	Electroencephalography
EFA	:	Exploratory factor analysis
EM	:	Expectation Maximization
ESS	:	Epworth Sleepiness Scale
ETS	:	Electric train service
FFS	:	Flinders Fatigue Scale
GLC	:	Government-linked company
HFACS	:	Human Factors Analysis and Classification System
HFE	:	Human factors / ergonomics
HRM	:	Human resource management
ICAO	:	The International Civil Aviation Organization
JCH	:	Job characteristics
JD-R	:	Job Demand-Resources
JRT	:	Job-related tension
KMO	:	Kaiser-Meyer-Olkin measures of sampling adequacy
KPI	:	Key performance indicators
MAR	:	Missing at random
MCAR	:	Missing completely at random
MI	:	Multiple Imputation
NMAR	:	Not missing at random
OED	:	Oxford English Dictionary
OSHEN	:	Occupational Safety, Health and Environment Department
OSPAT	:	Objective performance test
PCA	:	Principal component analysis
PLS	:	Partial least square

PMS	:	Performance Management System
PVT	:	Psychomotor vigilance task
QMS	:	Quality management system
REQUEST	:	Rail Ergonomics Questionnaire
RT	:	Response task
SC	:	Safety culture
SEM	:	Structural equation modelling
SI	:	Safety issue
SOP	:	Standard operating procedure
SPAD	:	Signal passed at danger
SPAD	:	*Suruhanjaya Pengangkutan Awam Darat*
SPSS	:	Statistical Package for the Social Sciences
STR	:	Occupational stress
TOC	:	Train operating company
UK	:	United Kingdom
VAS	:	Subjective alertness tests
WC	:	Working condition
WE	:	Working environment

LIST OF APPENDICES

CHAPTER 1 : INTRODUCTION

1.1 Background

Human factors / ergonomics (HFE) focuses on the interaction of human with their environment. The traditionally concept of HFE has always focused on the interrelationship between three main elements of human-machine-environment. The human element is a major component in any relationship with machine and the environment (Branton, 1987). This relationship can be best described using the human performance model (Wilson, 1990). Developments in HFE has seen the introductions of new terms to redefine machine and environments, in the form of the physical environment (‘things’), the organisational environment and the social environment (Carayon & Smith, 2000; Parsons, 2000; Wilson, 2000). This concept of HFE is applicable in the evaluation of individuals and daily work activities, and has been incorporated in assessment of employees in the industries. Numerous studies have been conducted to evaluate the relationship between human and these major environmental elements. Although the focus of these studies may vary, with some looking on the physical environment while others may address the issue on organisation aspects, their objectives remained the same which is to improve the performance and the well-being of employees by integrating human into a better system (Dul et al., 2012).

Performance is an important aspect for the industry, and is a priority to be achieved either by an individual or an organisation especially in handling complex task or working on demanding situations (Klein et al., 2010). There is a difference in how performance is measured from the viewpoints of human resource management (HRM) and HFE. In HRM, performance is measured based on reward, individual achievement in completion of tasks and determination of certain key performance indicators (KPIs) (Stojadinović et al., 2014). On the other hand, other influential factors are by the HFE to define the performance of employees such as job characteristics, working conditions and the environments (Kahya, 2007). Job performance is a valuable element and an important dependent variable for achieving high quality work output and services (Kahya, 2009). To remain competitive and maintain a high level of job performance, the employee itself is the main focus to be taken care of (Layer et al., 2009).

Performance of the employee and the system is important in the transportation industry, especially in public transportations, where high performance of the organisation would result in increased safety conditions (Haque et al., 2013). Ignorance of the performance of employees may lead to undesirable results. Accidents in the transportation industry frequently occur especially on the road. However, for the railway, ships and aviation industries the frequency of accidents is very low (Evans, 2011), although the occurrence of accidents usually results in a large number of injuries, casualties and devastations. Thus, it is in the interest of these industries to seriously maintain high work performance, improve the safety levels and awareness to avoid catastrophes (Silla & Kallberg, 2012). HFE has been increasingly accepted an important tool to improve human performance and safety at every level, to ensure a safe transportation system (Clarke, 2005; Wickens et al., 2004). In summary, human performance is vital to the transportation industry and requires more attention and awareness to improve safety in order to avoid accidents, injuries and loss of life. This study focuses in the evaluation on the key employee in the train industry, namely the train drivers, and how their work performances contribute to the level of safety in the railway system.

Past studies on evaluation of train driver performance has mostly focused on only one or very few relationships between influencing factors. There has yet to be any effort in integrating these influencing factors, with no studies conducted for train drivers in Malaysia. The recent development of rail industry in Malaysia; with the extension of existing light rapid train (LRT) lines, introduction of Electric Train Service (ETS), newly developed MyRapid Transit (MRT) and later will be high speed rail from Kuala Lumpur to Singapore become great motivation for this study. There is a need to ensure the factors influencing the key personnel of the system; which is the train driver will be addressed and considered at all time. With the new challenges by having great expansion in rail services, the authority and the train operating companies (TOCs) should ensure the safety and efficieny of the overall system. Therefore, this study will attempt to address this limitation by developing an integrated model of train driver performance based on HFE, which would give a holistic and comprehensive detail of driver capacities, capabilities and limitations.

1.2 Problem statement

The performance of train drivers have been studied during the past decade, largely in the United Kingdom after the train accident which happened at Ladbroke Grove on 5th October 1999 (Stanton & Walker, 2011; Sutherland & Groombridge, 2001; Wilson & Norris, 2005a). These studies have focused on causal factors such as cognitive, workload, fatigue, sleepiness and analysis of task. There were also studies on accident analysis, new design of cab, safety and operating system (Darwent et al., 2008; Dorrian et al., 2006, 2007; Edkins & Pollock, 1997; Farrington-Darby, Wilson, et al., 2005; Jay et al., 2008).

However, there are very limited literatures on the performance of train driver as an integrated model which relates the various influencing factors. Past research has focused on assessment of individual influencing factors, overlooking the possibilities of interactions between them. Furthermore, these factors were not categorised systematically, whether based on its common characteristics or on the HFE basic interacting domains of human – machine – environment. Understanding the relationship between the performance of train drivers and factors influencing their performance would enable their integration into the development of a performance model (Baines et al., 2005). The availability of this performance model would offer a holistic approach in evaluation of train driver performance to ensure the safety of the train journey as well as the overall system (Williamson et al., 2011). In addition, the performance evaluation would improve the quality of service, reduce degree of risk and avoid occurrence of accidents. Most studies on train driver performance have been conducted in European countries, especially in the United Kingdom. To date, there has yet to be any study conducted on performance measurement of train drivers in Malaysia.

To develop the integrated performance model for train drivers, an extensive literature survey would be conducted to identify influential key factors upon which a theoretical framework could be established.. A quantitative based method based on the structural equation modelling (SEM) can then be used to test and confirm the relationship among these influencing factors.

1.3 Research objectives

The main objective of this study is to develop an integrated performance model for train drivers. To achieve this aim, the following measurable objectives are appropriately defined:

a) To identify significant factors of human performance in train driving;
b) To establish a framework of train driver performance;
c) To determine the relationships among significant factors which influence train driver performance;
d) To develop an integrated train driver performance model.

1.4 Significance of the Study

To date, it was found that an integrated model of train driver performance has yet to be fully developed, especially in Malaysia. This study attempts to address this limitation by developing an integrated model of train driver performance, by using train drivers in Malaysia as respondents. This model will provide a comprehensive understanding of human performance by incorporating three main domains of human performance; human – activity – context. Past studies have evaluated these factors either individually or with limited interactions between the factors. This model can then be subsequently used by researchers as an important reference point to venture into evaluating other affecting factors of human performance, in different areas of study. In addition, train operating companies (TOC) can utilise this model as a guideline to improve the design of workplace and tasks, train infrastructure as well as raising the level of awareness among employees. This will ensure that the company remains profitable, competitive and safe, and maintains a high level of performance of employees and the organisation. This integrated model provides a holistic understanding of train driver performance, without compromising other criteria in order to ensure that the overall safety and performance is constantly maintained.

This study also provides an alternative approach for integrating a number of variables (factors) into one comprehensive model. A systematic evaluation and analysis procedure using structural equation modelling (SEM) technique is introduced in order to explore newly proposed variables in the model, and to test the significant level of the hypothesis. This SEM technique could be used by researchers for other areas of studies involving improvement and testing of proposed integrated model.

1.5 Scope of the Study

This study consist of three major domains influencing the performance train drivers in Malaysia namely drivers' activities, context and human domains. These domains cover the generic factors of human performance as proposed by Bailey (1996), Baines et al. (2005) and Chang and Yeh (2010). A total of sixty factors were extracted from their studies, although to consider all of the proposed factors in this study, given the constraint of time and resources, is quite impossible. However, the selections of domains and factors for this study are considered sufficient within the scope of the research work. These three domains (activities, context and human) are considered to be sufficient in representing human performance within the timeframe of the research.

The major reference of this study is based on the research by Ryan, Wilson, Sharples, Morrisroe, et al. (2009) on the development of the Rail Ergonomics Questionnaire (REQUEST) instrument with several adaptations and modifications. This comprehensive instrument was designed especially for railway workers and has been refined and developed over a number of years. Additions to the REQUEST instrument were made based on the studies of Strahan et al. (2008), (Johns, 1991, 1992, 1993), Johns and Hoaking (1997), Gradisar et al. (2007), Austin and Drummond (1986) and Dawal et al. (2009).

The present study was conducted on the train drivers of a major train operating company (TOC) in Malaysia. Since all the train drivers were males, there were no data for female respondents. The survey was conducted on intercity passenger and freight train drivers. These types of trains are characterised by their long haul journeys with a minimum of four hours trips, which may have a significant impact on the safety of the rail network.

1.6 Structure of Thesis

This thesis is divided into seven chapters. *Chapter One* provides an introduction of the research topic, with an overview and overall discussion on human performance as well as its importance towards safety. The objectives of the study and its limitations are also discussed in this chapter and the significance of the study is highlighted.

Chapter Two provides a review of existing human performance models, generic models and theoretical frameworks. This chapter also reviews the relevant literature related to the factors that form the proposed relationship of human performance. It concludes with the summary of the importance significant findings from the literature.

Chapter Three reviews the proposed model of human performance for train drivers. The discussion expands on the factors affecting human, workers activities, working environment and safety towards the performance of the driver. Finally, this chapter concluded with the research hypotheses.

Chapter Four illustrates the methods and procedures used in the study. It begins with an explanation of the proposed model, which was developed based on the literature review. The discussion continues on the instrument adaptation and measurement, respondent characteristics and survey implementation, method of data analysis and finally the overview of structural equation modelling (SEM) technique.

Chapter Five presents the results of the survey. It consists of data screening and preparation for SEM applications, reliability analysis and factor analysis. The developed model had been tested for measurement model and validated through structural model; which the hypotheses had been tested.

Chapter Six summarizes the findings, discusses the effects and implications and benchmarks the model with those from other studies.

Chapter Seven concludes the overall findings and offer suggestions for future research.

CHAPTER 2 : LITERATURE REVIEW

2.1 Introduction

This chapter will explore the various literatures that are relevant to the topic of this study. The review will include overviews on the concepts of human performance, their relationship to the railway industry, and an evaluation of existing models and frameworks. In addition, this review will also assist in identifying the research gaps, and summarising the direction of this research.

2.2 Human Performance

Human performance concept provides a framework for understanding and predicting factors affecting the performance of employees, which will contribute positively to the overall success of a complex man-machine system (Pew & Baron, 1983). Traditionally, ergonomics assessments are concerned on the individual level, such as those related to physical work, manual handling, workplaces, and equipment’s used. However, recent trends in ergonomics are focusing on human factors at the system level (Wilson, 2014), which acknowledges the interactions between various components and influencing factors surrounding the employee (Marras & Hancock, 2014). This approach brings the individual factors back together, rather than evaluating them separately. A broad area of ergonomics specialisation is addressed by macroergonomics, which attempts to integrate every aspect of ergonomics into consideration (Karsh et al., 2014).

The integration of influential factors of human performance has been proposed by many researchers. For example, Ryan (1988) has discussed the needs in combining theoretical issues with practical issues in the development of human performance assessment system. Theoretical issues consist of human behaviour, performance indicators, performance measures and logic model, whereas practical issues involve objective safety criteria, objective performance data, sampling and validation. This integration is necessary to correctly develop the model for a complex system environment. Integrating these components of human performance measures would, in theory, accurately represent vulnerabilities brought to the system performance and its outputs (Gore & Jarvis, 2005). Due to the complexity in the system environment, Baines et al. (2005) has categorised the influential factors of human performance into three categories of 'key human centred factors', namely the individual (human), physical environment and organisational environment. This theoretical framework hypothesizes potential factors affecting workers performance would include the major components of microergonomics and macroergonomics within an integrative framework. The formation of theoretical framework has its basis on previous literatures and the usual approach in developing such framework is to first list all potential factors. These identified factors are then screened in accordance to the research objectives and subsequently tested empirically using combinations of qualitative and quantitative techniques.

Some studies have focused on a single factor only, enabling an in depth evaluation of the individual factor. In some cases, even a small, insignificantly perceived factor may have an effect in a considerable manner. For example, Juslén and Tenner (2005) evaluated the effect of human performance with small modifications of the workplace by changing the lighting environment. Subsequent model of the employee performance with respect to the level of lighting was obtained, proving that a small, insignificantly perceived factor can have significant effects on the overall results.

Investigations on human performance factors have been conducted across a wide range of industries, such as in air traffic control systems, design processes in factories, train driving activities and ship navigations (Baines et al., 2005; Gore & Smith, 2006; Gould et al., 2009; Mason et al., 2005). Due to the increasing awareness of the importance of human performance factors, many sectors have incorporated considerations for human performance factors early on during the design stages of systems and work environments.

In principal, human performance centres on two main questions, namely, “what are the appropriate direct worker activities and associated performance measures on which a framework should be based?’ and ‘what factors are most likely to have an impact on these measures?’(Baines et al., 2005).

This study on the development of an integrated train driver performance model aims to provide the necessary information to designers, engineers and the management in understanding human performance for overall system improvements and increasing the level of safety in railway management.

2.3 A brief about train driver in Malaysia

The railway is one of the oldest public transportation in Malaysia, introduced in the late 19th century. Initial development of the nation's railway system was established in 1885 with the introduction of the British steam locomotives for transporting tin from the tin mines in Taiping to Port Weld. These steam engines were later replaced by diesel engines and electrified locomotives, which are being used until today. Currently, there is only one train operating company (TOC) in Peninsular Malaysia, covering more than 1600 km of railway routes throughout the country. In addition, ongoing expansion of the current rail service is expected to increase the number of users and traffic throughout the network. This requires gradual improvements to the overall performance of the railway system either from the individual or the organisation, to ensure smooth and safe running of the system. However, the level of interest in railway is relatively low as compared to aviation and road transportations, most probably due to significantly low number of accidents occurring on the railway system. Nevertheless, safety is a major concern among rail authorities (Wilson & Norris, 2005b). Furthermore, catastrophic events, such as the Ladbroke Grove accident in October 1999 has become a catalyst for increasing the railway safety as well as improvement in human factors application within the rail industry, particularly in the UK (Mills, 2005; Stanton & Walker, 2011; Sutherland & Groombridge, 2001; Weyman et al., 2005).

Train drivers can be divided into three categories as drivers for freight train, passenger train or the commuter train (urban light train). A train driver first would undergo training at the Railway Academy, organised by the TOC. Upon completion of the training, they will be assigned freight train driving duties, to assimilate them with the working conditions. Experienced drivers are entrusted to operate the passenger trains, and is aided with an assistant, to ensure the safely and smooth operation of the locomotive.

A train driver is normally assigned an 8 hours shift per day, for six days a week. A break of at least nine hours is given between every eight hours driving duties. Running bungalows are provided by the TOC as accommodation facilities at designated depots which allow the train drivers to rest between duty periods.

In addition to driving the trains, the drivers are also responsible to oversee any problems during the journey such as occurrence of technical problems, natural disasters and human errors. With safety as their main priority, the drivers would also need to ensure train punctuality and avoidance of delays. Figure 2.1 shows the general overview of the train driver's routine which was developed based on Rules and Regulations Book, Standard Operation Procedure of the train drivers.

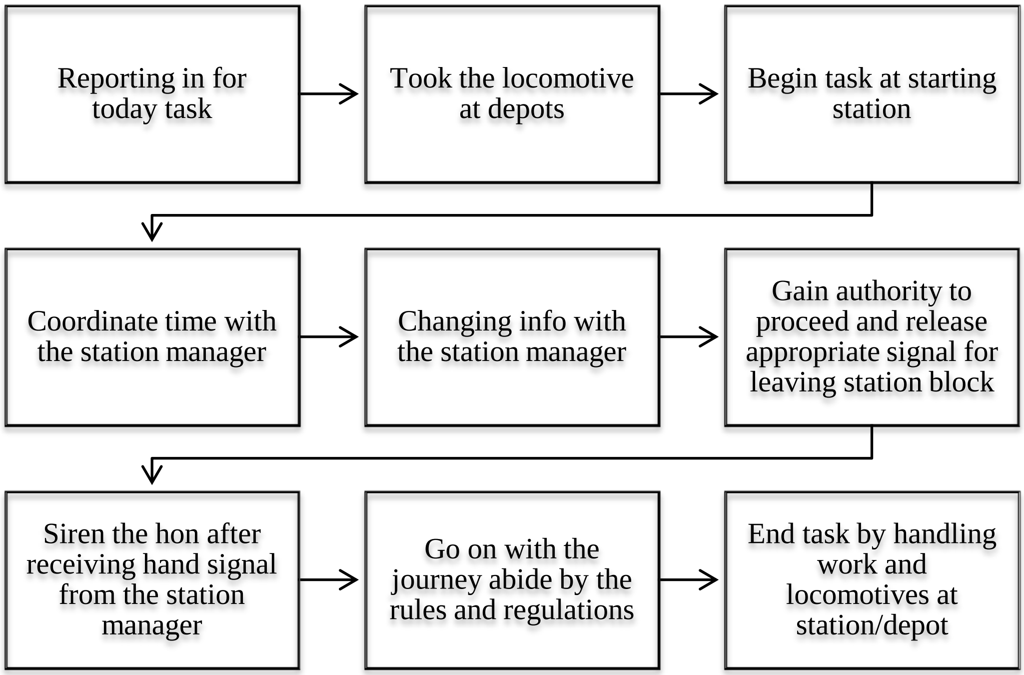

Figure 2.1: Train driving task

2.4 Human performance in the railway system

The train driver is amongst the most important group in the railway system. In Malaysia, even with the introduction of electric trains in 1995, the responsibilities and functions of the drivers are still important. Among the challenges faced by train drivers today are the increasing number of train services on single or double tracks with a variety of freight trains, passenger trains, electric commuter trains and fast electric train (*Electric Train Service – ETS*). These require increased attention of the driver and the crew to avoid any difficulties or accidents throughout the train journey. However, studies on human performance in the railway industry are still in its infancy in Malaysia, and literatures on the subject are thus unavailable. For this reason, most of the literature review for this study has relied on literatures from other countries, especially from western nations.

Performances of workers are important for the designers or engineers during the design or improvement of equipment's, interfaces, jobs or systems (Wilson, 2014). Understanding of the human performance is not only done when the system is in place and working, but can be as early on in design stage, which may reduce the potential of error and improve the design, safety and effectiveness. Human performance in ergonomics is not limited to safety, comfort and satisfaction. It can support the reputation of the organisation, and its business strategy to stay competitive and sustainable (Dul & Neumann, 2009).

In the railway industry, error-free operation is very critical to ensure the safety of the system. Circumstances from any train-related accidents would incur high costs and damage (Evans, 2011). Railway safety does not focus on the train locomotives only, but also expands on aspects of the passengers, track staff, control room staff and other relevant staff. Train drivers are one of the important stakeholders for ensuring safety of passengers, the train locomotives and the system (Wilson, 2006; Wilson & Norris, 2005b). A landmark train accident in Ladbroke Grove in 5th October 1999, with 400 injuries and 31 deaths, has triggered an extensive evaluation of railway safety in the UK. It was reported that human error was the main cause of the accident, due to signal passed at danger (SPAD) and the subsequent head-on collision events (Stanton & Walker, 2011). Although rail ergonomics is evolving slower than other branches of transport ergonomics (Wilson & Norris, 2005b), there is an increase in the level of awareness on the importance of human factors in the railway industry, and is very crucial for improving system reliability, safety and human performance (Clarke, 2005).

Human capabilities and limitations are the main factors which would contribute to the safety of the individual and the system. These factors should be considered during early stages of the design; corresponding to the needs, knowledge and characteristics of the workers (Shahrokhi & Bernard, 2009). Improvements may be delayed if there is lack of understanding on human performance of the organization (Genaidy et al., 2007). Human performance measures are required to be used as a predictor in addressing the increasing demand for improvements in system and safety, or as an objective tool to evaluate the need to improve the design of work, equipment and the environments.

Table 2.1 shows a list of thirty two previous studies over the past twenty five years on human performance in railway since 1986. At least seventeen factors affecting the performance of train drivers were discussed in these studies. Each article have at least discussed two or more factors, except some studies which have deliberated on the general safety and human performance as the main discussion. Interrelations between factors on the performance of the driver were also discussed in order to further understand the influence of factors on one another.

Table 2.1 shows that safety / safety culture was the predominating factor discussed by the researchers (12 out of 32). As highlighted previously, the level of safety is crucial and will always be the highest priority in the railway industry. Three studies have exclusively discussed on safety (Clarke, 1998; Farrington-Darby, Pickup, et al., 2005; Ugajin, 1999). They highlighted the importance of the safety culture to reduce the risk of accidents and to improve the level of safety in the organization. Other researchers have examined the relationship between the safety and shiftwork of the train driver. Joshi et al. (2001) have studied the interactions of the train driver's reaction towards the train control system in shiftwork; and its potential for safety risk. Researchers were also interested to evaluate human performance in relation to the interactions of safety with other factors. For example, (Härmä et al., 2002) studied the effect of irregular shift on sleepiness of the train drivers. This study has not only focused on sleepiness but also has looked into its by-product in the form of fatigue. They have recommended that adjustment on shift system may improve sleepiness problem among train drivers.

Hamilton and Clarke (2005) proposed a model to describe performance of the driver in relation to infrastructure features and operational conditions. Through the proposed model, driver behaviour could be predicted by using performance times for discrete actions. It had also utilised cognitive task analysis (CTA) to predict workload and operator performance time. This study was focused on cognitive and mental workload of the driver. It was hoped to identify human performance problems for the train driver empirically.

The list shown in Table 2.1 summarises the distribution of interest among researchers, which factors were discussed the most and gives a general overview of human performance study involving train driver around the world.

Table 2.1: Previous studies on factors relating to human performance in rail.

	Variables	Cognitive	Mental WL	Physical WL	Alertness	Awareness	Stress	Working task	Vigilance	Fatigue	Environment	Working conditions	Sleep	Shift work	Job rotation/ scheduling	Safety /safety culture	Human performance
1	Austin and Drummond (1986)		X				X		X								
2	Edkins and Pollock (1997)				X				X								
3	Clarke (1998)															X	
4	Ugajin (1999)															X	
5	Felici et al. (2000)	X														X	
6	Joshi et al. (2001)													X		X	
7	Kecklund et al. (2001)		X		X		X						X	X			
8	Härmä et al. (2002)									X			X			X	
9	Hockey and Carrigan (2003)									X						X	
10	Cothereau et al. (2004)										X						
11	McLeod et al. (2005)	X				X											
12	Jansson et al. (2005)	X				X											

***WL = workload**

Table 2.1: Previous studies on factors relating to human performance in rail (cont.)

	Variables	Cognitive	Mental WL	Physical WL	Alertness	Awareness	Stress	Working task	Vigilance	Fatigue	Environment	Working conditions	Sleep	Shift work	Job rotation/ scheduling	Safety /safety culture	Human performance
13	Hamilton and Clarke (2005)				X				X	X						X	
14	Lamond et al. (2005)				X								X				
15	Pickup et al. (2005)		X														
16	Farrington-Darby, Wilson, et al. (2005)															X	
17	Murali (2005)													X		X	
18	Jones et al. (2005)									X							
19	Shepherd and Marshall (2005)																X
20	Dorrian et al. (2006)									X							
21	Luke (2006)													X		X	
22	Philip and Åkerstedt (2006)									X			X				
23	Dorrian et al. (2007)	X				X				X							
24	Chau et al. (2007)													X			

***WL = workload**

Table 2.1: Previous studies on factors relating to human performance in rail (cont.)

	Variables	Cognitive	Mental WL	Physical WL	Alertness	Awareness	Stress	Working task	Vigilance	Fatigue	Environment	Working conditions	Sleep	Shift work	Job rotation/ scheduling	Safety /safety culture	Human performance
25	Jay et al. (2008)									X				X			
26	Darwent et al. (2008)												X				
27	Kumar and P.K. (2008)						X									X	X
28	Baysari et al. (2008)																X
29	Birlik (2009)															X	
30	Koohi (2009)														X		
31	Ku and Smith (2010)									X				X			
32	Dorrian et al. (2011)		X	X						X			X				

2.5 Significant human performance models

Human performance concept offers a comprehensive understanding on the relationship between human and its surrounding (equipment and environment) (Wilson, 1990). Consequently, modelling of human performance enable us to identify human performance problems in an objective and quantifiable manner (Hamilton & Clarke, 2005). The model is an attempt to integrate almost all potential factors together, as a simplified tool which includes every items involved into consideration.

Most researchers have tended to limit their research scope to individual evaluation of factors as discussed in previous section. Few have integrated these factors to be evaluated as a whole package. Prior to developing the integrated human performance model, it is necessary to discuss existing performance model, from which the basic model of the human performance can be improved. From the review, commonality and differences can be listed and the most appropriate model can be subsequently developed.

2.5.1 The cognitive task analysis (CTA) model

Hamilton & Clarke (2005) proposes the CTA (*Cognitive Task Analysis*) model, as shown in Figure 2.2, which emphasizes the interaction of the train driver performance with infrastructure features and operational conditions. It also intended to evaluate the infrastructure and cab drivability as a general tool for drivability assessment.

By utilizing cognitive theory and modeling techniques, this model measures performance of the driver's ability to interact and process the information between infrastructures at the lineside and cab interfaces. Train speed is the major parameter to be measured, as it results from the driver's action as well as perception and cognition.

This model is capable in predicting performance time, workload and error proneness in different operational conditions. The CTA model will benefit signals passed at danger (SPAD) risk management strategies and the designers of cabs and infrastructures.

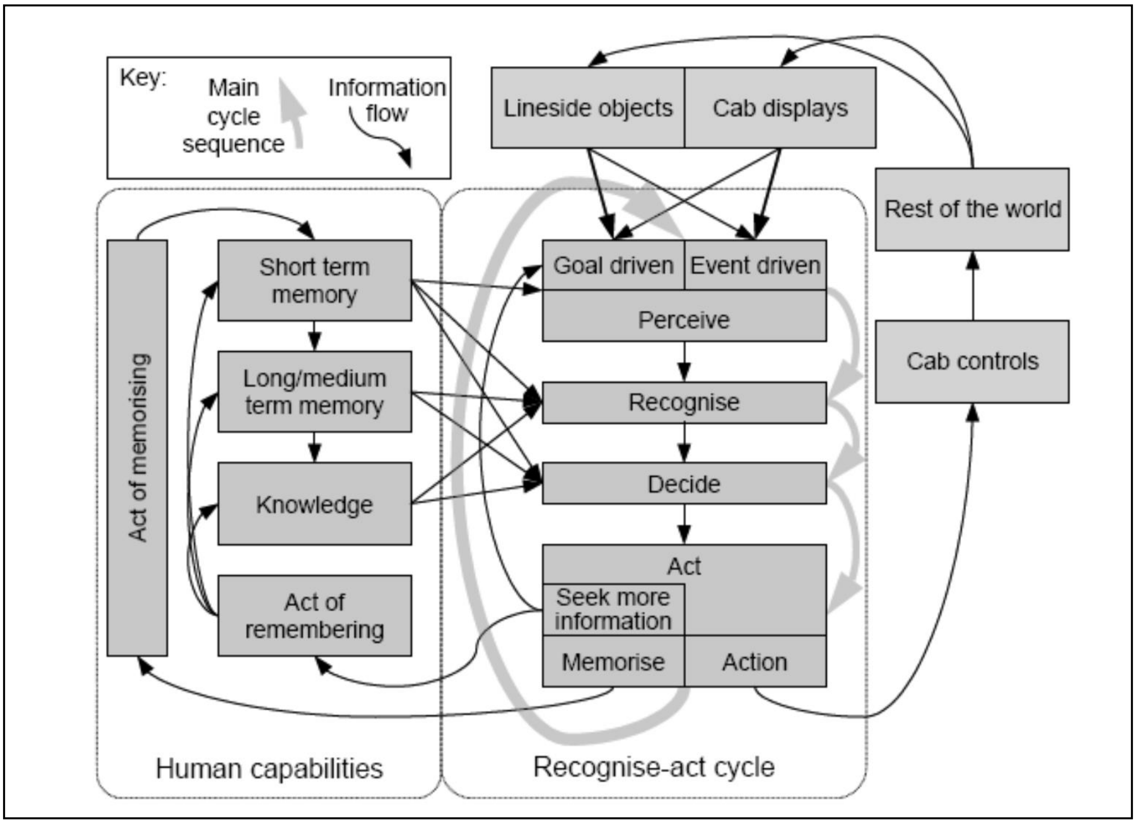

Figure 2.2: Human capabilities and the recognize-act cycle in CTA model (Hamilton & Clarke, 2005)

One advantage of this model is that it is very useful to evaluate existing railway facilities, especially near train stations, road crossing and in the city. It could also be used as an assessment tool for new facilities or simulated for newly proposed facilities. Every detail of facilities along the rail track could be investigated to predict possible distractions or disturbances that could affect the driver's alertness and cognitive workload.

The major setback of this model is that it could not be used for generalisation purposes. This model is most suitable for localised evaluations, based on the designated area of study. In addition, it only focuses one very few aspect of human performance i.e. interaction of mental workload with infrastructure facilities and alertness.

2.5.2 The Situational Model

The Situational Model, developed by McLeod, Walker and Moray (2005), depicts an analysis of train driver performance towards Automatic Warning System (AWS). The objective of this model, shown in Figure 2.3, is to understand and assess the risks of driver unreliability associated with extended use of AWS where existing simple information-processing based models are considered inadequate. The extended AWS may create a number of cognitive complexities to the driver as the system depends on the driver to interpret the alert, since there can be inaccurate signals in-cab visual reminder and time delays for 'active' information which may vary from a few seconds to several minutes.

It is important to understand performance and cognition of the driver in the context and situation at the time a signal is intended to influence driver's behaviours. This situational model is used as a guide to identify factors that might be important influences on the driver’s state of mind leading up to the time the AWS signal is encountered. It is evident that the model focuses on the driving performance at a specific time, in a specific situation and specific content with regards to AWS.

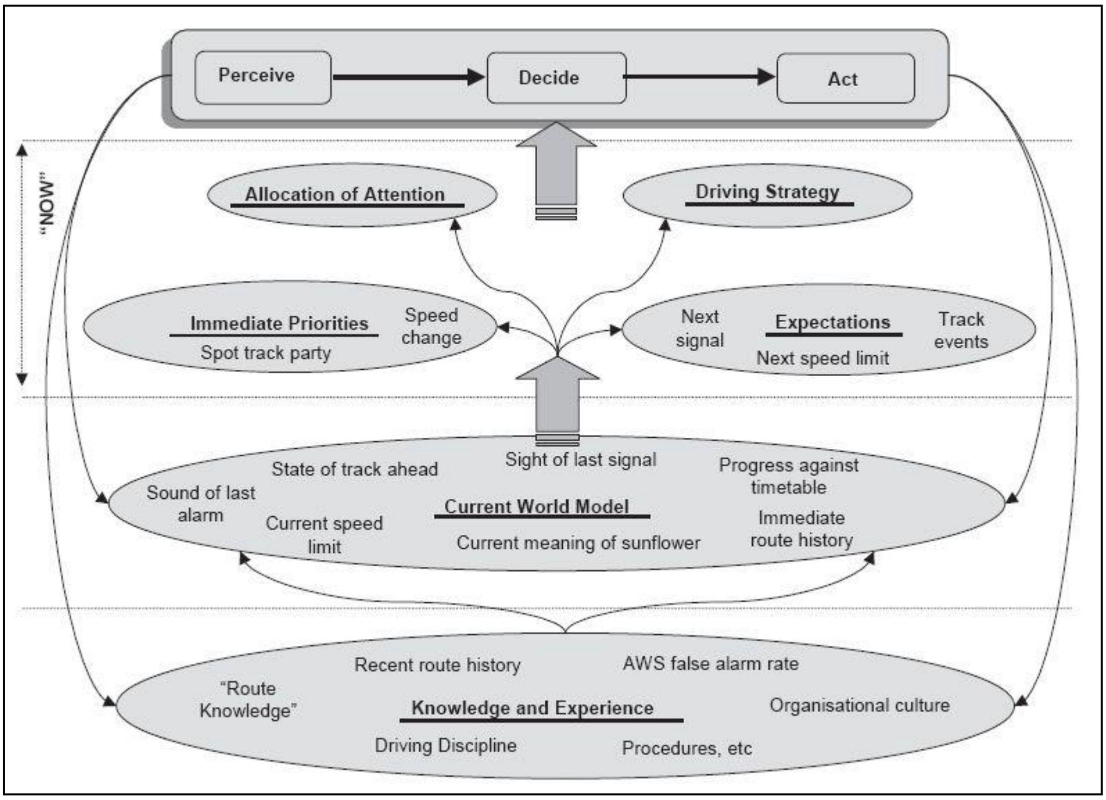

Figure 2.3: Situational model of driver performance in interacting with AWS (McLeod et al., 2005)

Although the model has been claimed as the best method to examine real-time cognition, it has limited usage in assessing the level of risk associated with extended AWS in predicting driver's reliability. It is working model which has been used for predicting real-time cognition of train driver reaction towards AWS in the cab. It differs from information-processing based approaches which unable to predict situational factors, at real-time.

2.5.3 Bailey model (1996)

Bailey (1996) proposed three elements required when predicting human performance, which are a) understanding of the human, b) the activity being performed and c) the context in which it is performed. In this generic model, as shown in Figure

2.4, the human factor becomes the major element, which influences the overall performance either positively or negatively.

Human includes the complex system of sensors, brain processing and responders, which affect a wide range of capabilities. In this generic model, the sensors would include vision and hearing; the brain processing would include the ability to think, reasoning and decision making and the responders would include the functions of arms, fingers and mouth.

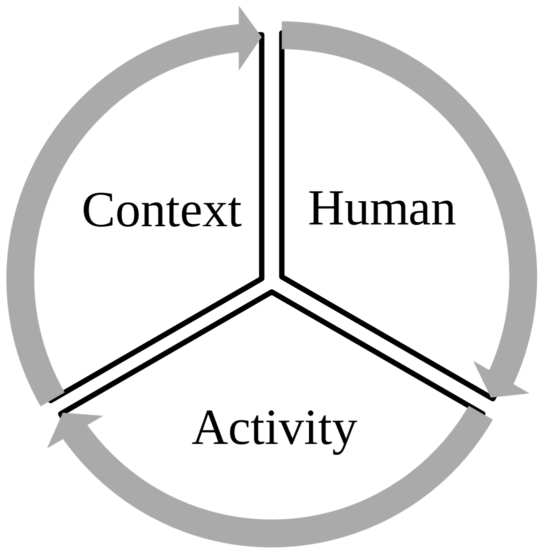

Figure 2.4: Bailey's basic model of human performance (Bailey, 1996)

A system designer can propose the best design but do not have much control on the user (human). Alternatively, they could control certain conditions on their designated activities. Factors affecting activity, which has the potential to degrade performance, should be recognized by the designers. Bailey's model final consideration is context; referring to the conditions in which the particular activity is performed by a human. Significant difference would be observed when the same activity is performed in a different place or weather conditions, which are referred to as context. Thus the Bailey fundamental model does not consider certain part of human. Instead it correlates every aspect for better understanding of human performance.

However, in its fundamental form, the Bailey model is a general hypothetical and theoretical model. Although empirical studies based on the model is yet to be conducted, it agrees well with macroergonomics concept which integrates affecting components with human as the main concern (Imada & Carayon, 2008). Baines et al. (2005) proposed three main key human centered groups in his theoretical framework, which are very similar to the macroergonomics model and concepts. These broad models would possibly suit the evaluations for any kind of human activities, although further studies should be conducted to verify their suitability.

2.5.4 Chang's extended SHEL model (2010)

Chang et al. (2010) examined the interactions of interfaces in air traffic control (ATC) by using extended SHEL model to describe ATC practice systematically. The original SHEL model, introduced by Edwards (1972), had been used by the International Civil Aviation Organization (ICAO) to understand human performance factors in aviation safety. A complete system operates when each of components interacted with each other. The effect of these interactions is provided by the SHEL model, where S (software – rules, procedures, computer programs, symbiology, etc.), H (hardware – machine), E (environment – the situation in which other components must function) and L (liveware -human) are the components of the model. Chang et al. (2010) described the components (S,H,E and L) as the human performance factors while the interactions between human performance factors as the human performance interfaces of the SHEL model. In this extended model, Chang et al. (2010) has also included the organisational aspects in their effort to understand the nature of human error. They tested the liveware (human) component interacting with other components; and have found a significant role in the interactions between controllers and the organisation on the human performance level. Thus it was concluded that the individual differences or peer influences have fewer relevant roles as compared to organisation influences when interacting with the software (S), hardware (H) and environment (E) of the ATC system, as shown in Figure 2.5.

By using questionnaire surveys developed from various literatures, they have measured six constructs and formulated a model based on structural equation modelling (SEM) approach. The model was an effort to integrate the interactions of human with other interfaces (factors/components). The extended SHEL model was used with clearly stated interactions between human – human, which other models did not highlight. In brief, this model can be used to describe the nature of human error, problem identification and investigation into sources of problem. The model by its nature is very critical, since is it used to assess the performance of ATC in the aviation industry. It can be still be applicable to other type of controllers such as in rail control system and building controllers.

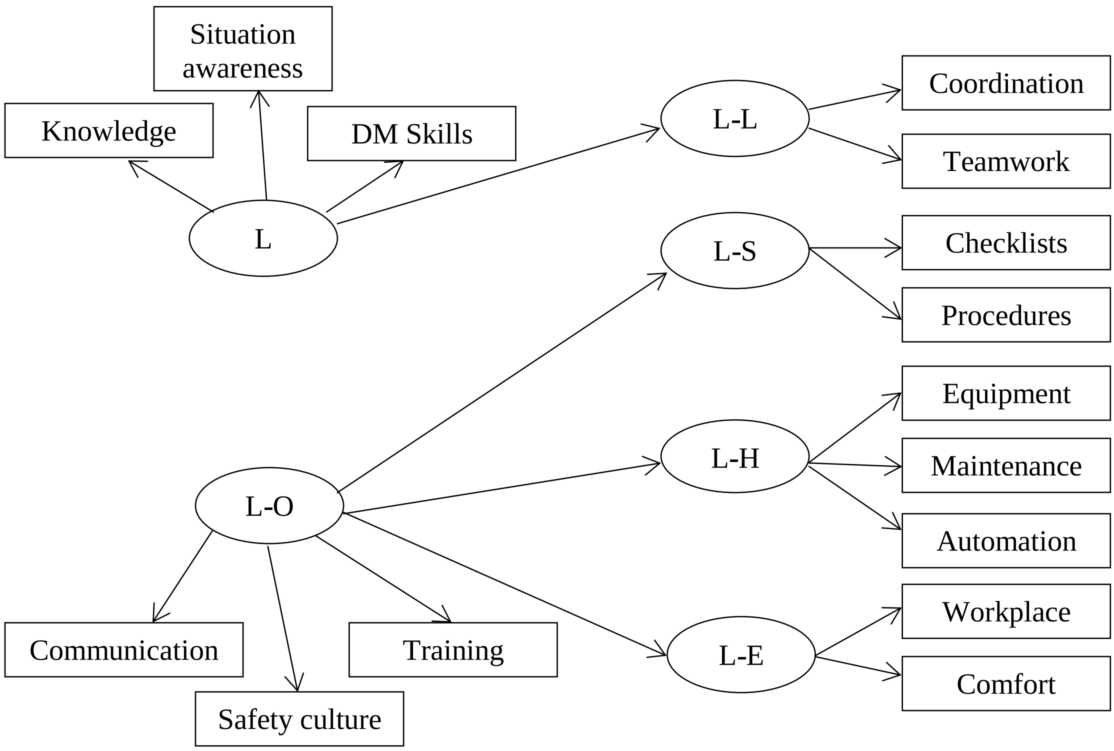

Figure 2.5: The structural model for extended SHEL research model (Chang & Yeh, 2010)

2.5.5 Baines et. al theoretical framework (Baines et al., 2005)

Baines et al. (2005) have developed a human performance modeling framework for manufacturing system designs, as shown in Figure 2.6. This framework enables the human performance modeling during the early stages of manufacturing system designs. Without this evaluation, engineers may overestimate the efficiency and effectiveness of the workers in the system. This framework provides the basis for a modeling tool that facilitates the assessment of key human factors early in the process of manufacturing system design. In the development of this framework, the researchers have considered a wide range of physical and psychosocial factors from over 800 references, and have screened and identified 65 potential factors, which are later referred to as key human centred factors. The factors are then classified into three categories; a) individual factors, b) physical environment and c) organizational environment. This is a qualitative representation of manufacturing worker performance where a functional relationship is the final element of the framework. It will describe the effects on the performance measures based on the changes in the key variables.

This theoretical framework is considered to be significantly better than Bailey (1996) which only proposed major components with limited number of factors. However to investigate every single factor in the proposed list may require hundred of items of questionnaire (for a survey) or prohibitively expensive experimental setup (for an objective measurement). Some key factors in the list may also be controversial to measure, such as gender, salary or IQ performance. Thus, for practical purposes, rationalization of the framework by considering only the factors needed for the area of study, with consideration of limitation such as time, cost and research scope, is considered the best approach.

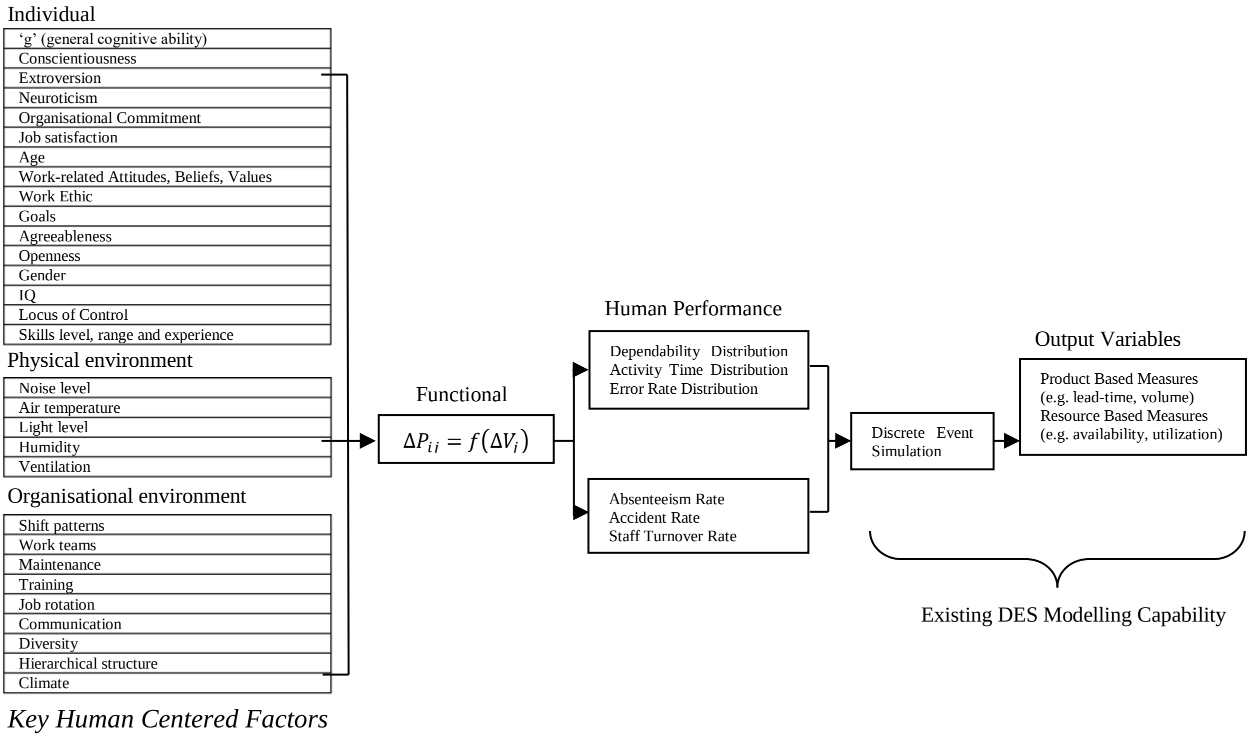

Figure 2.6: The human performance modelling theoretical framework (Baines et al., 2005)

2.6 Comparison of selected human performance models

Three models / frameworks, proposed by Chang and Yeh (2010), Baines et al. (2005) and Bailey (1996), were selected for comparison to provide the basis for the development of the new model for this study. The comparison of the three models is shown in Table 2.2. These models were selected because it's proposed the basic grouping or categorization of factors which covers the three main important areas relating to the major domains of ergonomics, namely, human – environment – machine; compared to other models. The basic categorization provides clear segmentation of influential factors of the human performance; therefore it will aid to develop a comprehensive model which holistically covers every aspects of the human performance.

The comparison was made based on the factors listed and explained by each of model / framework. Then, these factors were grouped depending on similarities of the factors, having the same meaning and context. For example, 'influential factors' used by Baines et al. (2005) and 'interfaces' used by Chang and Yeh (2010) were referring to the same issue.

'Influential factors' of Baines et al. (2005) framework and interfaces in extended SHEL model by Chang and Yeh (2010) were compared and matched side by side with existing major components of Bailey's basic model. Although the terms used seemed different at first, understanding the meaning of the terms has revealed substantial similarities, enabling direct comparison to be made between these models.

Bailey (1996) introduced three main areas in very basic terms. Bailey's model proposed three major components of human performance, which includes human, tasks or activities performed by a human and the environment. This generic model is straightforward with consideration on three different components with strong interactions influencing the performance of a human.

Baines et al. (2005), on the other hand, proposed a framework to includes possible variables, extracted from literatures, which influence performance of employees. The findings were classified into two major components; individual factors and environmental factors. The environmental factor was further divided into two sub-factors of physical and organisational.

The study by Chang and Yeh (2010) uses the conceptual model of ergonomics (SHEL model) proposed by Edward (1972); which builds on the effort done by the International Civil Aviation Organization (ICAO) to understand human performance factors in aviation safety. There were no specific categories but have included interactions between interfaces provided by the SHEL model; S (software – rules, procedures, computer programs, symbiology, etc.), H (hardware – machine) and E (environment – the situation in which other components must function) and L (liveware – human), with the inclusion of O (organisation), in the extended model. This extended

SHEL model with an additional ‘liveware-organisation’ interface addresses the importance of organisational factors to the human performance.

The main factor of human performance studies is the ‘human’ itself. Bailey named it as ‘human’, Baines termed it as ‘individual factors’ while Chang and Yeh (Edward, 1972) referred to it as ‘liveware’. Bailey outlined that human includes a complex system of sensors (vision and hearing), brain processing (the ability to think, reasoning and decision making) and responders (arms, fingers and a mouth). These are the basic and fundamental component of a human performing a job and reacting with the environment. The ‘individual factor’, as described by Baines, contains six major categories - personality, demographics, physiology, cognition, motivation and skills; which is a detailed list of factors affecting human performance for the human component. In contrast, the ‘human’ components in extended SHEL model are the ‘liveware’ and interface of ‘liveware – liveware’. Similar to ‘individual factors’, liveware consider personal attributes of the individual. ‘Liveware – liveware’ interface refers to the relationships between workers (controllers) that are characterised by social psychological aspects of the team, including cooperation, teamwork, leadership, and personality interactions. Researchers are beginning to appreciate the interactions of human with its surroundings; including environment, organisation, machineries, and technologies (Marras & Hancock, 2014). The concept that human interactions are actually part of human factor system discipline is mentioned in recent literatures (Wilson, 2014). Human performance studies could not proceed without the inclusion of the ‘human’ aspect, and it is very challenging since human may limit the system and widens the range of system elements and dimensions that are needed to be considered (Carayon & Smith, 2000).

Alongside the ‘human’ component or domain, ‘activity’ is another important domain which interacts with ‘human’. This was proposed by Bailey et. al (1996) to refer to the activity being performed by a human. As an employee, performing the job is one of the activities to be completed. There are various types of jobs depending on the nature of the business. However, Baines et. al (2005) did not include the *activity* component in the framework developed for the manufacturing activities. In the SHEL model, the interaction between liveware (human) with hardware is termed the human–machine interface/ interaction. It also means the interactions between the workers (controller) and the physical aspects of the system that are provided to perform the designated tasks, including display and control equipment, automation facilities, maintenance and recovery facilities, and visual facilities. This domain is significant to the human performance as it leads to various impacts depending on the demand of the job and how it is performed. It may cause either positive or negative impact on the employee such as productivity, job-related tension, high performance, job satisfaction and stress (Schaufeli & Bakker, 2004).

Baines et. al (2005) proposed a more comprehensive list as compared to Bailey et al (1996). The list comprised of physical and organisational factors which includes the influential items in details. Baines et. al (2005) divided the environmental factors into two categories; physical and organisational, based on its nature. The physical environmental factors relate to the physical environment of the work place such as humidity, temperatures and lighting. This relates directly on physical comfortness, safety, health issue, hazard and ergonomics. Similarly, the extended SHEL model by Chang and Yeh (2010) are comparable to the model by Baines (2005) in their definition of the 'liveware-environment' and 'liveware – organisational' interfaces. There are numerous studies on the topic of physical environmental aspect as it is very influential and significant to the performance of an employee. In contrast, the organisational environment is related to the behaviour, culture and ethics of the organisation. This leads to job satisfaction and other psychological issues which are very significant and relevant nowadays. In addition, the interaction with non – physical aspect of the system including procedures, rules, checklists, documentation, maps and charts, and computer software are considered as part of the evaluation.

Table 2.2 summarises the comparison of these models, highlighting the factor groups that affects the performance of a human at work. The list comprehensively shortlists more than sixty influencing factors which can be applicable to a wide spectrum of industries. To consider all factors in an evaluation may be impractical for a specific study, so it is recommended that the researcher carefully chooses the influential factors most relevant to their particular studies.

Table 2.2: Comparison table of human performance models and frameworks

Bailey et. al (1996)	Baines et. al (2005)		Chang & Yeh (2010)
Human • *includes complex system of sensors, brain processing and responders* • *sensors - vision and hearing;* • *brain processing - the ability to think, reasoning and decision making* • *responders - arms, fingers and a mouth*	**Individual** • *'g' (General cognitive ability)* • *Conscientiousness* • *Extroversion* • *Neuroticism* • *Organizational commitment* • *Job satisfaction* • *Age* • *Work-related attitudes, beliefs, values* • *Work ethic* • *Goals* • *Agreeableness* • *Openness* • *Gender* • *IQ* • *Locus of control* • *Skills, level, range and experience*	• *Lifestyle* • *Sleep patterns* • *Health* • *Biorhythms* • *Circadian rhythms* • *Family status* • *Education* • *Strength/stamina* • *Attention* • *Concentration* • *Ethnicity* • *Religion* • *Adaptability* • *Schemas* • *Diet* • *Agility/dexterity* • *Analytic/creative* • *Form*	**Liveware** • *personal attributes of the individual controller, including knowledge and experience, attitude and behaviour, situation awareness, decision making skills, and health.* **Liveware – liveware** • *the relationships between workers (controllers) that are characterised by social psychological aspects of the team,* • *including cooperation, teamwork, leadership, and personality interactions.*
Activity • *Activity being performed by a human*			**Liveware – hardware** • *referred to as the human–machine interface/ interaction* • *interaction between the workers and the physical aspects of the system that are provided to perform tasks,* • *including monitor and control equipment, automation facilities, maintenance and recovery facilities, and visual facilities.*
Context • *place, time and environment of the particular activity is performed by a human* • *e.g. : there is a very significant different when the same activity performed in different place and weather*	**Physical environment** • *Noise level* • *Air temperature* • *Light level* • *Humidity* • *Ventilation* • *Carbon monoxide* • *Ozone* • *Vibration frequency* • *and intensity* •	• *Daylight/(full spectrum) light* • *Carbon dioxide* • *Noise frequency* • *Oxygen* • *Light frequency/colour* • *Noise duration* • *Lighting/glare* • *Lighting/reflections* • *Noise predictability*	**Liveware – environment** • *the interaction between the controller and the operating environment in which the tasks are performed* • *including workplace design, noise, temperature, lighting, air quality, and relaxation settings.*
	Organisational environment • *Shift patterns* • *Work teams* • *Maintenance* • *Training* • *Job rotation* • *Communication* • *Diversity* •	• *Hierarchical structure* • *Climate* • *Leadership* • *Payment systems* • *Recruitment/orientation* • *Employment security*	**Liveware – organisation** • *the interaction between the controller and the organisational aspects of the system* • *including workload allocation, organisational structure, policies and rules, communication, safety culture, and training.*
			Liveware – software • *the interaction between the controller and the non-physical aspects of the system that are required to perform tasks,* • *including procedures, rules, checklists, documentation, maps and charts, and computer software.*

2.7 Summary

This chapter has provided an essential review of the importance of human performance study in the context of the transportation industries. Several models and frameworks related to the performance of an employee were discussed. Past literatures on human performance of the train drivers provides an understanding of the affecting factors and its interacting effects. It was found that most studies have focused on individual factors, with less attention on the interactions between these influencing factors. Hamilton & Clarke (2005) proposes the CTA (*Cognitive Task Analysis*) model emphasizes the interaction of the train driver performance with infrastructure features and operational conditions. This model could be used as an assessment tool for new facilities or simulated for newly proposed facilities. Meanwhile, the situational model developed by McLeod, Walker and Moray (2005) is used as a guide to identify factors that might be important influences on the driver's state of mind leading up to the time the AWS signal is encountered. Three models / frameworks, proposed by Chang and Yeh (2010), Baines et al. (2005) and Bailey (1996), were selected for comparison to provide the basis for the development of the new model for this study as discussed in Section 2.6.

Several theoretical frameworks were analysed to understand the overall view of the factors which can affect the performance of the train drivers. The literatures also highlighted the need for collective evaluations of the factors, without neglecting other factors which may interrelate. To evaluate individual factors, there are several established methods used by researchers, whether through objective or subjective measurements. Past methods have also shown that a survey using questionnaire is still valid and reliable for collecting the data need to measure the interacting factors of employee's performance (Annett, 2002). The review of the literatures has provided the basis to develop the new integrated framework for this study. Thus, this study proposes a development of an integrated model to focus on the interacting factors influencing the performance of train drivers

CHAPTER 3 : THEORETICAL FRAMEWORK AND HYPOTHESES

3.1 Introduction

This chapter will discuss and develop the research framework which will be used for the remainder of this study. The discussion will also focus on the factors affecting human performance, which are considered as independent variables. Finally, the relevant hypotheses would be formulated accordingly.

3.2 Theoretical Framework

The frameworks of Bailey (1996), Baines et al. (2005) and the model of Chang and Yeh (2010) were referred to in developing the theoretical framework of this study. These models were chosen as a reference because of their clear approach in grouping the factors/variables. The comparison made between the three frameworks has shown matching similarities even though the terminologies used were different.

The three main domains identified are human, workers' activities and context (or working environment) (Bailey, 1996; Baines et al., 2005; Chang & Yeh, 2010). In the context of the performance of train drivers, an additional aspect which should be considered is safety. Consideration of safety awareness is believed to be important for improved performance of the train drivers. Next sections will discuss details of the domains and its factors accordingly.

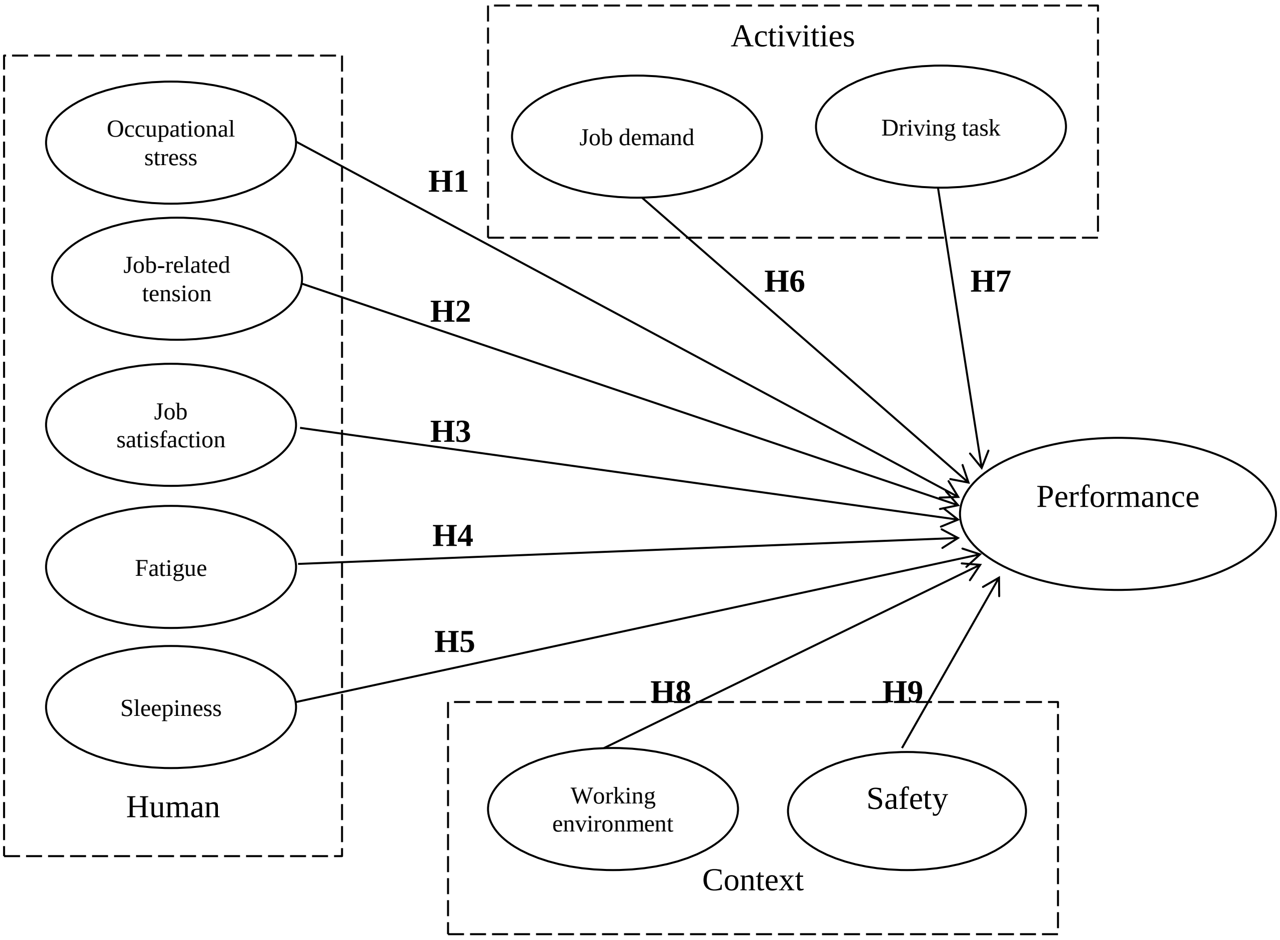

Figure 3.1: The theoretical framework of Malaysian train driver performance

3.3 Factors affecting human

In a complex system, the human itself is the most important component to be measured, as highlighted by the frameworks of Bailey (1996), Baines et al. (2005) and the model developed by Chang and Yeh (2010). The person (human/employee) and the process form a closed loop system to ensure the success of the working system (Wilson, 1995). For this study, five independent variables are chosen which are related to the human domain. The variables are occupational stress, job related tension, job satisfaction, fatigue and sleepiness. These variables are discussed in detail in following sections.

3.3.1 Occupational Stress and Job-related Tension (JRT)

From a psychological point of view, stress is a descriptive term used to describe the feeling of pressure and strain. This term is also referred to in biological sciences, including stress on physiological or biological nature. The physical body would respond accordingly to the stress experienced, for example, responding to extreme environments, temperature, noise, diseases, sleepiness as well as emotions (Bourne & Yaroush, 2003).

Occupational stress or job stress describes the stress caused by working and the job environment (Trivellas et al., 2013). Workers feel the pressure and strain due to environmental factors, leading to experiences of occupational stress. Poor job design, layout setting, and high workload are highly potential stressors (Jou et al., 2013). These stressors contribute to the increase level of stress among workers during their interaction with the work environment and while completing their job tasks. Reactions from this stress will result in job-related tension (JRT), which are workers experiencing stress while working (Yahaya et al., 2009). In addition, job-related tension would cause high employee turnover and decrease in job satisfaction (Boyd et al., 2009).

Interactions between these two elements (worker-work environment) require proper planning. Job design can be used to identify suitable arrangements for the workers to work in the best conditions and environment (Genaidy et al., 2007). The interaction between workers – work environment is critical especially in the transportation industry. The interaction between human (worker) and the environment has been highlighted by (Bailey, 1996; Baines et al., 2005; Chang & Yeh, 2010) . Thus, failure to meet this general requirement would usually create uncomfortable environment and leads to stress of the worker in the form of occupational stress.

As highlighted in the effort-reward imbalance model proposed by Tsutsumi and Kawakami (2004), it is advisable to measure occupational stress simultaneously with job satisfaction. Thus, for this study, the following hypotheses are posited:

H1 ***Occupational stress has a significant effect on the performance of train drivers***

H2 ***Job-related tension has a significant effect on the performance of train drivers***

3.3.2 Job Satisfaction

Job satisfaction is a feeling by an employee towards their job, work environments and other affecting factors such as amount of salary, motivation and working hours (Jou et al., 2013). Rewards as a form of occupational motivation will affect the level of effort given by the employees. Careful consideration in the effort and reward system can provide improved task accomplishment and job satisfaction (Genaidy et al., 2007). Therefore, it is important for the organization to understand what motivates employees and how they are motivated.

Improved working environment will increase level of job satisfaction, which leads to increased human performance. Juslén and Tenner (2005) found that the performance of employee increases as the lighting conditions were upgraded. In addition, it was found that job satisfaction increases with age of employee. Older employee were found to have the ability adapting to the working environment and make the necessary adjustments to satisfy their expectations (Dawal et al., 2009). The tendency of employee to resign will be reduced if the job satisfaction level is increased, which can be brought about with decrease in office conflicts and improved physical work environment (Jou et al., 2013).

Job satisfaction is one of the important construct to measure performance of employees. In the past, job satisfaction was only concerned with the perception and feeling of employees towards their job and working environment. However, in recent years, job satisfaction does not only address the satisfaction of the employee, but is also seen as a measure for the organizational performance as a whole (Genaidy et al., 2007). Thus the following hypothesis is proposed on job satisfaction:

H3 ***Job satisfaction has a significant effect on the performance of train drivers***

3.3.3 Fatigue

In addition to occupational stress, fatigue is also a serious issue for the rail industry which can affect the safety of the railway operations (Desmond & Matthews, 2009; Dorrian et al., 2007). In contrast to stress, which is a feeling caused by pressure or strain, fatigue is the consequence or by-product of physical activities (Williamson et al., 2011). Fatigue is a state between being awake and asleep, and its onset is thought to be gradual, resulting in the person falling asleep. Investigators have directly related drivers' fatigue with safety (Strahan et al., 2008), vigilance, performance and inefficiency of work (Dorrian et al., 2006, 2007).

The nature of driving task includes interacting with the environment, monotonous driving and shiftwork (Dorrian et al., 2011; Fletcher & Dawson, 2001). Shiftwork is a common routine for train driver. Since the duty roster is based on the train schedule, drivers are likely to experience work-related fatigue, which will significantly affect the level of safety (Dorrian et al., 2006). Shiftworks are usually associated with sleep problem and can lead to work-related fatigue if the drivers sleep cycles are irregular (Fletcher & Dawson, 2001).

Fletcher and Dawson (2001) have measured the alertness and performance of 193 train drivers in Australia. Their analysis has shown that fatigue significantly correlated with alertness and performance. Their developed model was able to predict that driver fatigue increases for each consecutive working days, although it could not predict alertness and performance. A high level of alertness was registered for drivers working within the 8 hours of shiftwork. However the score deteriorates if the workshift exceeds 8 hours. The studies have also stressed on the importance of providing sufficient sleep and rest for the drivers after period of shift. The model has given the correlation between fatigue, alertness and performance on the safety of the entire operations.

Subsequent studies have further evaluated the effect of fatigue during train driving, examining the relationship between fatigue, braking behaviour and speeding during speed restrictions (Dorrian et al., 2006, 2007). It was found that fatigue increases over time and resulted in decreased vigilance and efficiency. Highly-fatigued drivers were found to be applying less braking at speed restriction sections and had often exceeded the speed limit by more than 10%. On the other hand, some fatigued drivers were also found to have lowered decision-making ability and were likely to apply over braking which increased fuel consumptions and unnecessary wear on the brake systems. Work-related accidents are the leading cause of work-related injury and death in many countries, and many studies have been carried out to identify the causal factors. Strahan et al. (2008) have studied the relationship between safety-climate, occupational stress and work-related driver fatigue. It was found that fatigue-related behaviour can be predicted through occupational stress measures. This significant predictor can assist the organisation or the company to recognise possible fatigue-related behaviours and risks in their employee and operations. The organisation can then take necessary remedial actions to reduce the stress level of the employee as early as possible (Bourne & Yaroush, 2003).

The relationship between safety and fatigue has been proven by both simulated and actual case studies (Horrey et al., 2011; Williamson et al., 2011). The effect of fatigue is experienced across a wide range of occupations such as in healthcare and medical services (Ross, 2008), manufacturing sector (Dawson et al., 2011), road driving (Kee et al., 2010) as well as train driving (Dorrian et al., 2011; Härmä et al., 2002).

Consequently, the following hypothesis is posited:

H4 ***Fatigue has a significant effect on the performance of train drivers***

3.3.4 Sleepiness

Sleepiness is defined as the tendency to fall asleep whereas fatigue generally indicates a lack of energy (Shahid et al., 2010). Fatigue is reduced after a period of rest while sleepiness is alleviated after sleeping. Sleepiness follows the circadian rhythm with a low level of sleepiness during the morning and high levels during the evening and night (Dahlgren, 2006). Studies of chronic restriction indicated that when the period of restriction is not extended beyond 5 nights, the reduction of sleep to 5–6 hours per night does not typically result in waking behavioural deficits. Individuals could restrict their sleep to 4.7 hours per night for up to 5 nights, or to as little as 2.9 hours per night for 2 nights, before the onset of behavioural deficits (Lamond et al., 2005).

Stone (2005) has noted that it is particularly important to provide sufficient time between consecutive night shifts to allow for a nap prior to the subsequent night shift, especially when sleep after the preceding shift has been insufficient. It is therefore recommended that there should be adequate rest between shifts. A 12-hour minimum rest period is the current requirement, and if adhered to, would be sufficient for most types of work shift. A rest period of 14 hours between consecutive night shifts would be desirable to allow for sufficient recovery. Lack of sleep of less than 5 hours sleep in a 24 hours period will significantly increase the fatigue-relationship and works error Dorrian et al. (2011).

Akerstedt (1995) has indicated the relationship between shift work with sleepiness, and has highlighted the effect of truncated sleep, longer waking time and long hours of work on increased sleepiness. The sleep-wake cycle and its synchronization with light-darkness and biological rhythms is disturbed by the shift work, especially shift at night (Garbarino et al., 2002). In terms of occupational safety, workplace sleepiness should be major concern of the company as the consequences of the sleepiness during work hours result in catastrophic results, such as the 1986 Chernobyl nuclear power plant disaster (DeArmond & Chen, 2009). Various tools have been developed to assess sleepiness such as the Epworth Sleepiness Scale (ESS) by Johns (1991) to assess daytime sleepiness which is widely used by many researchers in evaluation of workplace sleepiness.

Driving a train requires sustained attention of the driver, especially on long-haul train services. The evaluation on train drivers performance would focus on the relationship on hours of work, sleepiness, fatigue and vigilance (Philip & Åkerstedt, 2006). The work of the train driver is characterised by a working norm in shift, monotonous driving, longer working hours and high safety requirements (Dorrian et al., 2011). Accordingly, the following hypothesis is asserted:

H5 ***Sleepiness has a significant effect on the performance of train drivers***

3.4 Workers activities

One of the important aspect which influences human performance is an activity being performed by a human (Bailey, 1996). Activity is referred to as the job or task performed by the employee, usually requested by the superior. In many industries, the task or job is requested and communicated through the standard operating procedure (SOP). Using the SOP, employees will follow the flow of work designed by the management. If the company has a quality management system (QMS) in place, the job will be properly documented in the manual or work procedure as required by the QMS. With this SOP or procedure, the employees are guided and have proper documentation for reference. Chang and Yeh (2010) referred to workers activity as liveware - hardware interaction, referring to the interaction between the workers and the physical aspects of the system.

3.4.1 Job demand

Work activities required by the management or superior can be summarised into the job demand. Job demands refer to “physical, psychological, social, or organizational aspects of the job that require sustained physical and/or psychological (cognitive and emotional) effort or skills and are therefore associated with certain physiological and/or psychological costs” (Schaufeli & Bakker, 2004). A number of research on employee improvements and have utilised the Job Demand-Resources (JD-R) model (Brauchli et al., 2013), and the relationship between job demand – job resources; burnout and work engagement were studied for various types of occupations (Brauchli et al., 2013; Fernet et al., 2004; Janssen et al., 2004; Mauno et al., 2007; Schaufeli & Bakker, 2004; Turner et al., 2012). Job demand may become occupational stressors if the demand and responses are not balanced such as in situations of high demand and requirements with negative responses (Schaufeli & Bakker, 2004). However, there is a lack of information on how job demand directly relates to human performance.

Therefore, in this study, job demand is selected as one of the influential factors on the performance of the train driver. Thus, the following hypothesis is proposed:

H6 ***Job demand has a significant effect on the performance of train drivers***

3.4.2 Driving task

Driving a locomotive requires dynamic control and involves real-time decision-making. Drivers need to be alert and aware of the surroundings and take note of signals, information, rule books requirements and safety messages throughout the journey (Kecklund et al., 2001). Research on train-driving would focus on physical task or mental-related task. Most studies conducted in the past have concentrated on physical workload and fatigue, sleepiness and other factors related to physical effect from train-driving activities as discussed in Section 2.4. However, recent studies have started to explore on mental related effects such as driving attention and alertness, mental workload and other mental stressors (Wilson & Norris, 2005a).

Monotonous driving for a long period may lead to fatigue of the driver, and reduces their vigilance to monitor and respond to events and information received throughout the journey (Jap et al., 2010). A series of studies conducted by Jap et al. (2011) have evaluated the extent of fatigue in monotonous train-driving using electroencephalography (EEG), and have recommended an early detection and prediction system to ensure safety of the driving and the system.

Driving task is hypothesized as having significant relationship with the performance of the train driver. Consequently, the following hypothesis is posited:

H7 ***Driving task has a significant effect on the performance of train drivers***

3.5 Working environment

One important element which may influence the performance of train drivers is the working environment. In this study, the environment factor would be referred to as ‘context’, a similar term used by Bailey (1996). Baines et al. (2005) divided the environment into two (2) aspects; physical and organisational environment. This interrelationship was also highlighted by Curry and McKinney (2006) to be an important element in the investigation matrix of accidents. Past studies have investigated direct relationships either between human-environment or human-machine; without looking at the overall view of human – machine – environment interrelationship. Thus, in this study, the environment (context) factor would be simultaneously evaluated alongside the machine and human factors. The Venn-diagram in Figure 3.2 shows the interrelationship between these three factors (Boff, 2006).

In the transportation industry, the working environment, in particular, the physical environment is a significant stressor. Interactions between the worker and the environment would affect the outcome of the job demand. In the study on bus drivers, Kompier (1996) has found that the drivers would always complain about their workplace conditions including the temperature, level of noise, seat and layout design, high level of vibration and bad illuminations. It shows that the working environment for transportation workers is important as their workplaces are dynamic and are exposed to the natural environment. Results from bad working environment may influence other constructs (i.e. stress, job-related tension etc.) as well as safety (Stanton & Salmon, 2011).

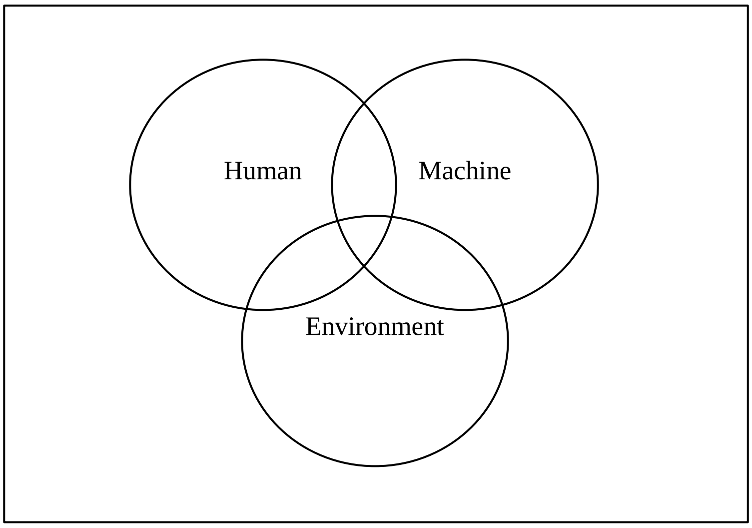

Figure 3.2: Venn-diagram of Human-machine-environment relationship (adapted from Boff (2006))

Chau et al. (2007), in their study on the effect of environmental factors on industrial injuries and accidents among train drivers, have found that a quarter (24.5%) of the causes of occupational injuries were from environmental factors. Environmental factors includes the ground in bad condition, holes in the ground, a slippery ground due to rain, humidity, snow, glazed frost, presence of grease or oil, encumbered ground, stone or object on the ground, sloping ground, bank for railway, restricted work space, reduced visibility during the night, reduced visibility during the daylight (premise poorly lighted), cold, heat, wind, and rain.

It is clearly shown that environmental factors may affect the performance of train drivers and have been discussed previously by several researchers in their models and frameworks (Bailey, 1996; Baines et al., 2005; Chang & Yeh, 2010). Hence, the working environment is hypothesized as having significant relationship with the performance of the train driver.

H8 ***Working environment has a significant effect on the performance of train drivers***

3.5.1 Working hours

The study on fatigue and shiftwork in UK train drivers by Stone (2005) have shown that the duration of the shift length is a key factor leading to fatigue. The research revealed that accident rates in shift workers are 25% higher on twelve-hours shifts as compared to eight-hour shifts. Thus, it is important to restrict the amount of overtime taken at the end of a shift. Furthermore, the impacts of long duty periods on fatigue are likely to be most severe on night and early morning shifts. Long periods of continuous duty, such as in continuous driving without a break, can significantly increase the level of fatigue. It is therefore important to ensure that rest breaks are taken at appropriate times in order to reduce risk. Ideally, breaks should last at least 15 minutes and free from any work-related activities.

Kecklund (1999) stated that as far as workload is concerned, it is important to study the components of shifts over a 24-hours period. One point of particular importance is the influence of working hours on the normal circadian rhythm of wakefulness and sleep. Dahlgren (2006) conducted an experimental study in which participants were followed for one work week with normal hours (8 hours) and another week of overtime with 4 extra hours of regular work (12 hours) without any external stress. The work hours were simply extended in time and work was performed at normal pace. The results have shown that one week of overtime work with a moderate level of workload was not associated with any major effect of physiological stress markers. Nevertheless, sleep was negatively affected, with shorter sleeps during overtime work, and increased problems with fatigue and sleepiness.

3.6 Safety

In the railway system, the safety level is crucial and the demand for a safe environment is ever increasing. A number of studies have discussed on the safety in transportation; including various aspects of safety, safety performance and safety culture (Stanton & Salmon, 2011). Because of its importance, safety in train operating company (TOC) is under the responsibility of the Occupational Safety and Health Department. This study will incorporate safety in the proposed framework together with human factor, activity and the environment.

The driver is the key person who operates the vehicle (vehicle is consider as the machine in this particular case). The tasks as a driver are very demanding since they have to fulfil many requests and requirements of work (Baysari et al., 2009). In addition, they need to maintain their skill of driving, especially passenger trains, and should be alert and vigilant of the environment during monotonous driving (Edkins & Pollock, 1997; McLeod et al., 2005). These requirements of strict safety regulations may conflict with the tight schedule demands. Such activities will lead to mental and physical fatigue, which have been shown to deteriorate performance and safety levels (Williamson et al., 2011). Accidents have been shown to be caused by human due to fatigue and other related causes (Kim et al., 2010; Kirwan, 1990). Therefore, the safety of the train journey and the passengers would mainly depend on the driver. Accordingly, the following hypothesis is asserted:

H9 ***Safety has a significant effect on the performance of train drivers***

3.7 Chapter Summary

This chapter have formulated the theoretical framework and hypotheses of this study. The theoretical framework builds upon three prior models and macroergonomics concepts. The three domains, namely ‘human’, ‘activity’ and ‘context’ are proposed based on the comparison of these three existing models, as shown in Figure 3.3.

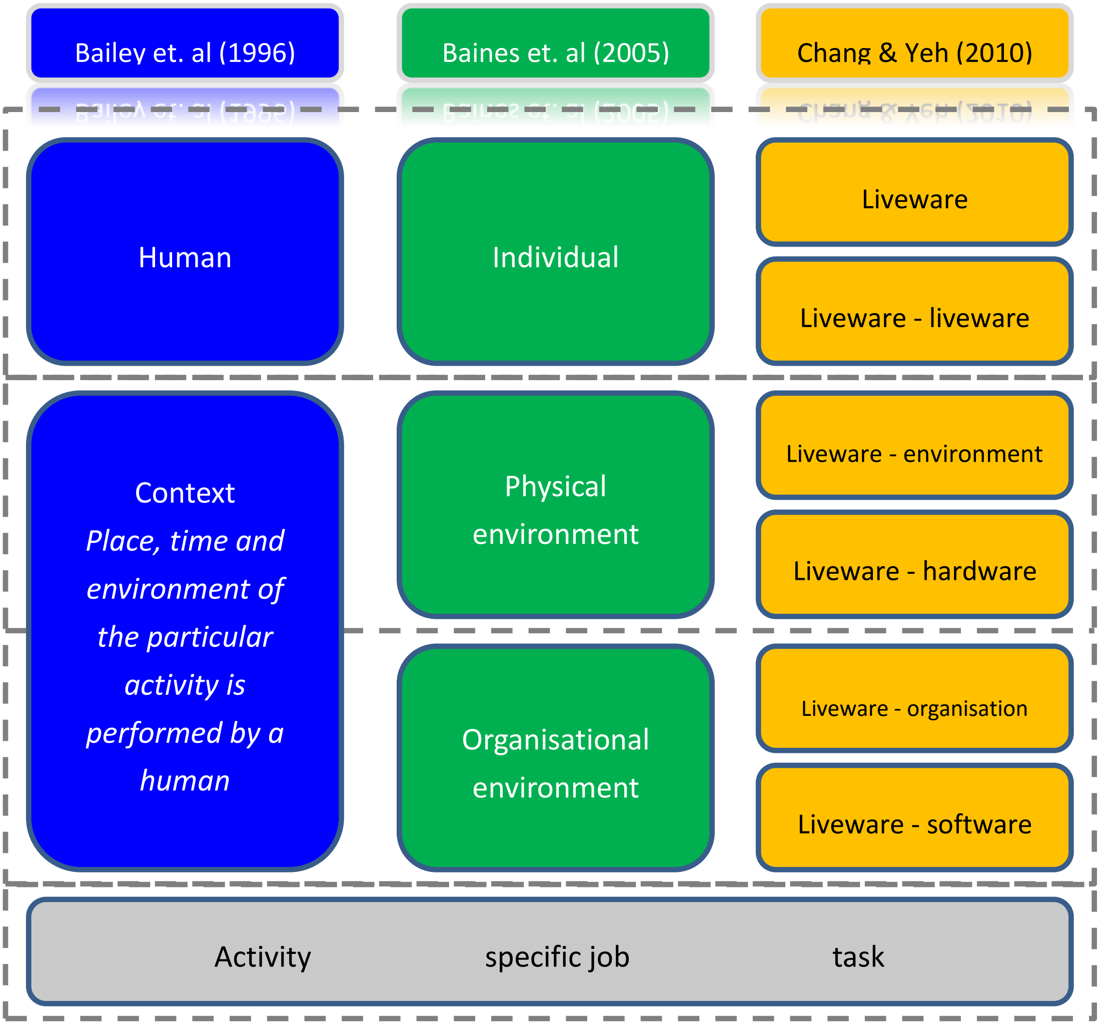

Figure 3.3: Comparison of human performance models / frameworks

Nine hypotheses are proposed for considerations and their results will be discussed in the following chapters. The hypotheses which has significant effect on the train drivers are:

H1 Occupational stress

H2 Job-related tension

H3 Job satisfaction

H4 Fatigue

H5 Sleepiness

H6 Job demand

H7 Driving task

H8 Working environment

H9 Safety

CHAPTER 4 : METHODOLOGY

4.1 Methodological Overview

This study utilises a quantitative research approach, based on eight main steps of the research process (Bordens & Abbot, 2008). The steps, consist of idea, hypothesis development, research design, population and sample, type of measurement, data collection, data analysis and report writing. The preparation phase, outlined in Chapter One and Two, involved a comprehensive literature review to identify current issues on human performance and safety of train drivers in Malaysia and other regions, especially in well developed nations such as from the United Kingdom (UK) and European countries. The theoretical framework for this study was formulated from the analysis and comparison of several existing frameworks and models. This framework and its associated hypotheses were proposed in Chapter Three.

The next phase of the study is to select the most appropriate research design. This phase would involve utilisation of relevant surveys and observation methods consisting of observation and questionnaires distributions. The instruments to measure are determined carefully to measure correlations between variables. The questionnaires are thoroughly reviewed by experts and stakeholders to ensure validity of contents and suitability of the questions before subsequent distribution to target respondents. SPSS and Structural Equation Modeling (SEM) are used to screen, process and prepare the collected data for analysis. These processes will be introduced in this chapter and further explained in Chapter Five.

The final phase of this study will describe the correlation between human performance and other influential factors from which a train driver performance model would be developed using Structural Equation Modeling. Details of the research methodology are illustrated in Figure 4.1.

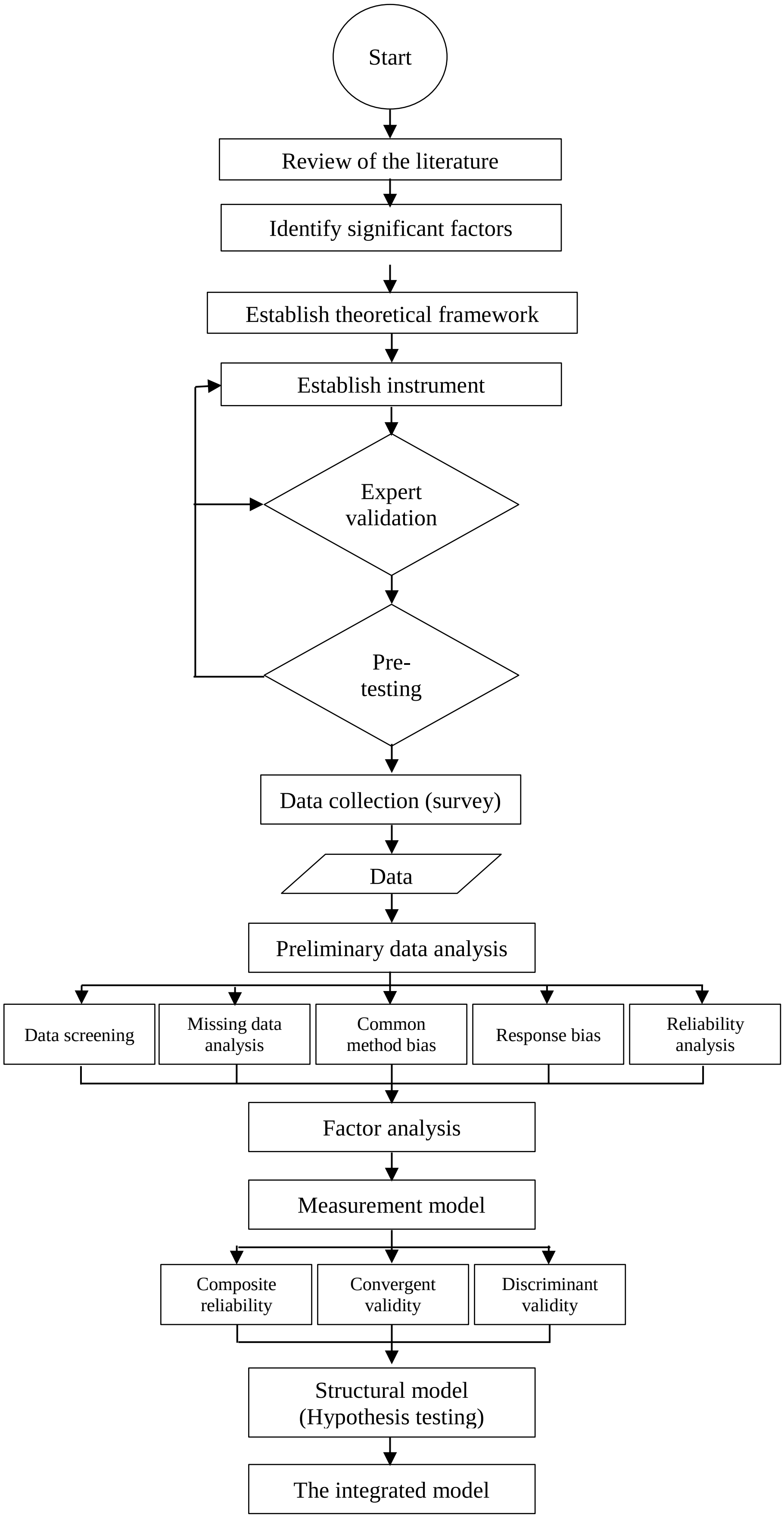

Figure 4.1: The research process flow chart

4.2 Research Design

Research in ergonomics requires appropriate tools for gathering data and information (Dempsey et al., 2005). The choice of tools, such as direct observations, questionnaires, objective and subjective measurements, are selected depending on the problem being investigated (Berlin et al., 2009).

In this study, subjective rating scales would be the main method used to gather responses from the subjects and the environment (Annett, 2002; Wilson & Nigel, 1995). Demand and effects of the employees' wellbeing would be investigated to evaluate their performance (Wilson, 1995). A questionnaire survey would be used to obtain individual responses, which is known to be the best method for collecting perceptions and opinions from the driver with regard to their performance (Ryan, Wilson, Sharples, Morrisroe, et al., 2009).

4.3 The Survey Method

Past researchers have proposed a number of factors which are thought to affect the performance of train drivers. However, to best understand the situation, it is appropriate to obtain the responses and perceptions directly from the train drivers themselves. For this study, the questionnaire-based survey method would be used to collect these information, since the technique has been widely used by past researchers in ergonomic studies (Annett, 2002). The information obtained from a well-designed survey can be a good representation of the overall train driver population (Rattray & Jones, 2007). The results from the survey can then be compared with their performance scores rated by their superior in the Performance Management System (PMS); an Employee Performance Standard Form – for Non-executive as attached in Appendix 1.

4.3.1 Self-administered questionnaire

The survey questionnaire used in this study was developed from the combination of several existing validated measurements of past research. It is a common practise to adopt and adapt existing validated measurements from established sources (Ryan, Wilson, Sharples, Morrisroe, et al., 2009). The advantage of using existing validated questionnaires is that the researcher does not need to reassess the measurements for validity and reliability. In addition, newly collected data can be compared easily with past results. Respondents would answer the questions accordingly and the data gathered would be analysed using Statistical Package for the Social Sciences (SPSS) and Smart PLS software.

The items of the newly adapted instrument were selected from several validated measurements to measure the variables outlined in the theoretical framework. The wordings chosen for the questionnaire items were made simple and understandable for the respondents. It also needs to be logical, neatly organised, systematic and have good structure (Rattray & Jones, 2007). The existing validated measurements, which are worded in English, were carefully translated into Bahasa Malaysia (Malaysian language) and verified by experts to ensure linguistic and contextual accuracy. The translations were necessary since most of the respondents were well-versed only in Bahasa Malaysia.

The final draft of the questionnaire consisted of seven sections, comprising of a demographic section and six sections containing questions related to the constructs. Each respondent were expected to complete the questionnaire within 45 minutes. The outline of the questionnaire is summarized in Table 4.1 and a sample of the questionnaire is attached in Appendix 2 and 3. The instrument consisted of 148-items for measuring nine variables. Table 4.2 depicts the number of items, sources and variables that had been measured by each item.

Table 4.1: Summary of the items of questionnaire for train drivers

Domains	Variables / Indicators	Literature (Sources)	Items (in coding)
HUMAN	Job satisfaction	(Ryan, Wilson, Sharples, Morrisroe, et al., 2009)	JS1 – JS5
		(Ryan, Wilson, Sharples, Morrisroe, et al., 2009)	JS6 – JS8
	Stress / Occupational Stress	(Ryan, Wilson, Sharples, Morrisroe, et al., 2009)	STR1 – STR20
	Job-related tension	(Strahan et al., 2008)	JRT1 – JRT15
	Fatigue	(Gradisar et al., 2007)	Section 5 Q 1 – 7
	Sleep	(Johns, 1991), (Johns, 1992), (Johns, 1993), (Johns & Hoaking, 1997)	Epworth Sleepiness Scale
ACTIVITY	Job demand	(Ryan, Wilson, Sharples, Morrisroe, et al., 2009)	JCH1 – JCH6
		(Austin & Drummond, 1986)	JCH7
	Driving task	(Austin & Drummond, 1986)	DT1 – DT5
CONTEXT	Working environment and working condition	(Ryan, Wilson, Sharples, & Clarke, 2009; Ryan, Wilson, Sharples, Morrisroe, et al., 2009)	WE1 – WE7
		(Dawal, 2005)	WE8 – WE15
		(Austin & Drummond, 1986)	WC1 – WC7
	Safety	(Austin & Drummond, 1986)	SI1 – SI7
		(Ryan, Wilson, Sharples, Morrisroe, et al., 2009)	SC1 – SC15

Table 4.2: Summary of the questionnaire

Section	Description	Number of items
Section 1	Front page with description of study to the respondent	6
	Consent letter	-
Section 2	Part A and B - Job satisfaction	8
	Part C and D – Job characteristics	12
	Part E – Job-related tension	15
	Part F – Occupational stress	20
Section 3	Fatigue	13
Section 4	Part A – Working condition	7
	Part B – Working environment	15
Section 5	Part A – Safety issue	7
	Part B – Safety culture	15
Section 6	Flinders Fatigue Scale	7
Section 7	Epworth Sleepiness Scale	8

A brief description of each section is as follow:

Section 1

This demographic section contains six questions on gender, range of age, duration of employment in the TOC, current position, duration of current post and reporting depot. This information are important to understand the respondents' background for subsequent correlation analysis.

The questionnaire booklet contains a cover letter to explain the purpose of the study and researcher's contact information's. Respondents are required to consent being involved in the survey by filling in the agreement form included with the cover letter. A small token of appreciation was given to all respondents, with the permission of the TOC management, to appreciate their voluntarily involvement in the research and as an incentive for other potential respondents to participate in the survey.

Section 2

This section consists of six sub-sections (Parts A-F) containing fifty five questions, which relates to train driver's workload based on various aspects. Part A and B focus on job satisfaction, Part C and D are on job characteristics, Part E is on job-related tension and lastly Part F focuses on occupational stress.

Section 3

In this section, thirteen questions were presented to assess fatigue. Respondents were asked about their duration of work per week, per trip and per month. In addition, their shift patterns and rest durations were also enquired.

Section 4

Section 4 required the respondents to assess their perception on individual working environment. It is divided into two parts; Part A on working conditions and Part B on working environment.

Section 5

This section includes two parts on safety issues and safety culture. It consists of twenty two questions adopted from Austin and Drummond (1986) and Ryan, Wilson, Sharples, Morrisroe, et al. (2009).

Section 6

This section contains the Flinders Fatigue Scale (FFS) (Gradisar et al., 2007), an established instrument used to measure fatigue experienced by the train drivers. It is a simple, self-administered questionnaire with 7-items and sensitive measure with strong psychometric properties.

Section 7

This section contains daytime sleepiness assessment developed by Johns (1991). This scale is used for the train drivers to rate their chances of dozing off or falling asleep in eight typically different situations.

4.3.2 Pre-testing and expert validation

A survey having good questionnaire design and pilot testing would provide validity and reliability of the instrument (Collins, 2003). Nevertheless, although the survey was developed from adaptation of existing validated questionnaire, there is still the need to test the content, arrangement and structure of the items. Pre-testing would ensure that the respondents understand and be able to fill in their answers (Coluci et al., 2009). In addition, pre-testing allows validation from experts to identify unsuitable and out-of-topic items.

A list of experts was chosen from the academics, authorities and industries to assist in the evaluation of the instrument of both the English and Bahasa Malaysia questionnaires. A summary of their reviews and recommendations is attached in Appendix 4.

The pre-testing stage had also involved trial runs on two personnel from the TOC. The researcher was present with the respondents while they answer the questionnaire, and any feedback and ambiguity in the items were quickly addressed. The pre-test respondents were able to understand the items in the questionnaire, averaging 30-40 minutes to complete the survey.

4.4 Performance measurement

The performance evaluation of train drivers are conducted once a year by their respective superior officers using the Employee Performance Standard Form – Non-executive (PMS – Performance Management System), as attached in Appendix 1. This form is prepared by the Human Resource Department of TOC and is endorsed by the management. It consists of six sections (Section A-F). Section A contains the details of the employee such as the name of employee, designation, reporting depot and evaluator. Section B contains the list of training attended, achievements and contributions to the company. Employee performance is measured in Sections C and D, which includes knowledge of tasks, customer service, attitude, discipline, responsibility, team working, effort and appearance. The evaluation is rated on a scale of 1 to 5; 5-beyond standard; 4-over standard; 3-following standard; 2-below standard and 1-far below standard.

Section E contains medical leaves and non-payable leave. It will also list any disciplinary record for the current year. The marks are summed up in Section F and the total score is calculated to obtain the overall achievement score for that particular year. In this study, the PMS records from 2008 to 2011, corresponding to a 4 years period, were considered in the evaluation.

4.5 Profile of the respondents

The respondents of this study were the employees of the train operating company (TOC). This TOC operates several type of trains; passenger and freight trains using locomotives in Peninsular Malaysia, urban light train from Seremban to Tanjung Malim and electric train services (ETS) from Kuala Lumpur to Ipoh. The TOC also provide long-haul services using diesel locomotives in Peninsular Malaysia.

In this study, only the train drivers for passenger and freight trains were selected due to the nature of long-haul operations. Table 4.3 presents a profile of the 229 respondents. All of the train drivers in the TOC were male with 14.8 percent (34 people) below 25 years old, 25.8 percent (59 people) between 25 to 34 years old, 34.1 percent (78 people) between 35 to 44 years old and 25.3 percent (58 people) are 45 – 56 years old. The retirement age for the drivers is 56 years old. The overall age distribution of the train drivers is shown in Figure 4.2.

Table 4.3: Profile of the respondents

Demographic profile		Frequency	Valid Percent
Gender	Male	229	100
	Female	0	0
Age	<25	34	14.8
	25 - 34	59	25.8
	35 - 44	78	34.1
	45 - 56	58	25.3
	Total	**229**	**100.0**
Duration of work	< 1 year	14	6.2
	1 - 5 years	43	19.0
	6 - 10 years	27	11.9
	11 - 19 years	64	28.3
	> 20 years	77	34.1
	Missing value	3	1.3
	Total	**226**	**100.0**

Over half of the respondents have worked for more than ten years with the TOC. From the 62.4 percent of the respondents having worked more than 11 years, 77 people (34.1 percent) have worked for more than 20 years while 64 people (28.3 percent) have worked between 11 to 19 years as train drivers. Only 14 respondents have less than one year experience. Figure 4.3 shows the distribution of the working years of the respondents, showing that most of the respondents were experienced drivers.

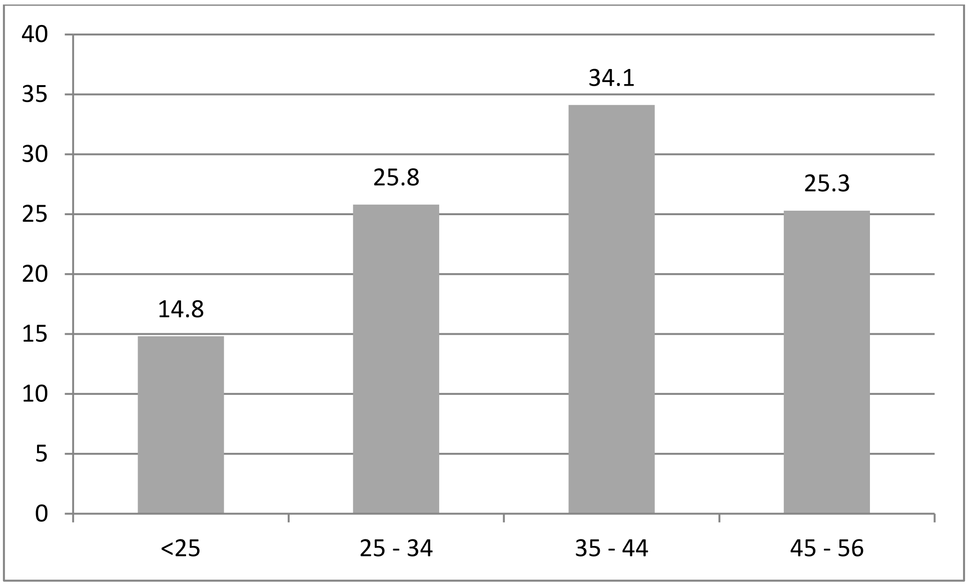

Figure 4.2: Age of the respondents (in percentage)

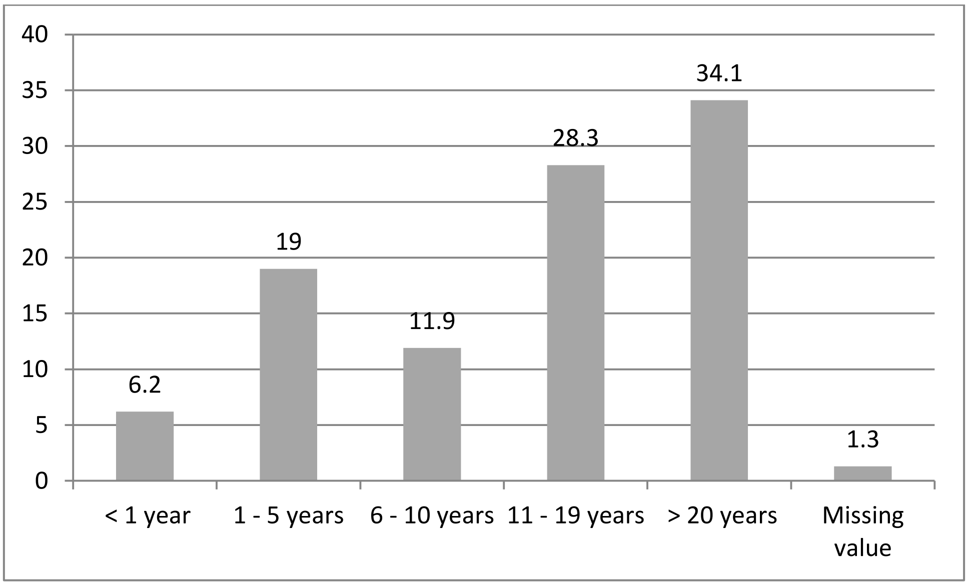

Figure 4.3: Work duration among respondents (in percentage)

A Pearson correlation test was performed to check whether there is a relationship between age and working duration. Table 4.4 shows that there is a significant correlation between age of the train drivers and their working duration with the company, with $r = 0.86$ at $p < 0.01$.

Table 4.4: Pearson correlation test between age and duration of work

		Age
Work duration	Pearson Correlation	.857**
	Sig. (2-tailed)	.000
	N	226

**. Correlation is significant at the 0.01 level (2-tailed).

4.5.1 Sample size

The population of this study is defined as all drivers of the locomotives under the TOC nationwide, except for the drivers of the urban light train from Seremban to Tanjung Malim and electric train services (ETS) from Kuala Lumpur to Ipoh. The drivers are located in ten different depots throughout Peninsular Malaysia, from the most northern state in Perlis until the most southern region in Singapore. The distribution of the train drivers is shown Table 4.5 as reported by Occupational Safety, Health and Environment Department (OSHEN) of the TOC.

Random sampling was performed for distribution of the questionnaire. The sampling were divided into five groups, namely, northern (Prai and Ipoh), central (Kuala Lumpur), southern (Gemas) and eastern (Kuala Lipis) regions. The survey invigilator was stationed at each depot and waited for arrival of train drivers throughout the day. The participation of the train drivers were on a voluntary basis, with no prior instructions or arrangements from the TOC. The results of this random exercise will be discussed in the Section 4.6.

Table 4.5: Distribution of the train drivers

	Depot / Station	State	Total
1	Kuala Lumpur Intercity	Kuala Lumpur	39
2	Kuala Lumpur freight	Kuala Lumpur	66
3	Pelabuhan Klang	Selangor	24
4	Gemas	Negeri Sembilan	90
5	Kempas Baru	Johor	9
6	Singapore	Singapore	6
7	Kuala Lipis	Pahang	28
8	Tumpat	Kelantan	34
9	Ipoh	Perak	114
10	Prai	Pulau Pinang	116
11	Padang Besar	Perlis	22
	TOTAL		548

The surveys were conducted at five depots, since these were the major depots which the train drivers may gather. For example, by stationing at Prai depot, respondents from Padang Besar, Prai and Ipoh were gathered at this depot during their off-duty as illustrated in Figure 4.4.

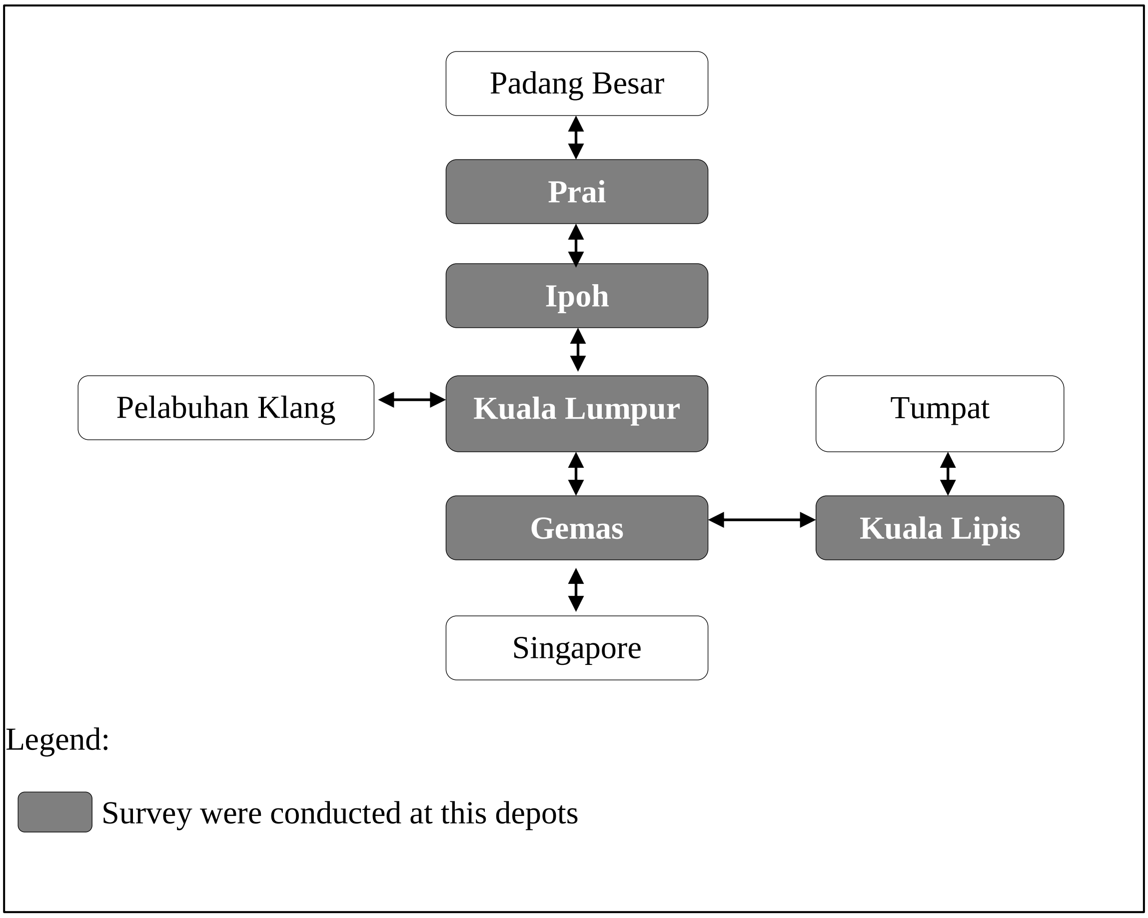

Figure 4.4: Location of the depots and its connections

A sampling method was applied to gather response from the train drivers. The sample size required for this study is calculated based on Bartlett (2001), setting the alpha level at 0.05 with acceptable error at 5% and estimated standard deviation of 0.5, giving :

$$n_0 = \frac{t^2 pq}{d^2}$$

$$n_0 = \frac{(1.96)^2(0.5)(0.5)}{(0.050)^2}$$

$$n_0 = 196$$

Where t = value for selected alpha level of 0.025 in each tail = 1.96.

(the alpha level of 0.05 indicates the level of risk the researcher is willing to take that true margin of error may exceed the acceptable margin of error).

Where (p)(q) = estimate of variance = 0.25.

*(maximum possible proportion (0.5) * 1-maximum possible proportion (0.5) produces maximum possible sample size).*

Where d = acceptable margin of error for proportion being estimated = 0.05

(error researcher is willing to except).

For a population of 548 drivers, the required sample size is 384. However, since the required samples (384) exceeded 5% of the population (548 x 0.05 = 28), the Cochran's (1977) correction formula should be used to calculate the final sample size:

$$n_1 = \frac{n_0}{1 + \frac{n_0}{population}}$$

$$n_1 = \frac{196}{1 + \frac{196}{548}}$$

$$n_1 = 144.4$$

$$n_1 \approx 145$$

Therefore, for population of 548 drivers, the minimum sample size required was 145 respondents.

4.6 Data collection

A self-administered survey, completed individually by the locomotive drivers and junior drivers, was conducted among the train drivers of the TOC. Off-duty respondents from the depots were selected randomly either at the depot's office or at the resting rooms in the 'running bungalow'. The 'running bungalow' is a rest facility, furnished with air-conditioned bedrooms and rest area, for outstation drivers from other depots. The distributed questionnaires were filled immediately by the respondents, with the researcher present at the survey location to provide assistance.

229 respondents had participated in the data collection from five different depots across Peninsular Malaysia. To ensure location accuracy, the response script was labelled accordingly to indicate the survey location (depot) and the count. For example, the code KL003 indicates data was collected at Kuala Lumpur depot and the serial number was 003. To avoid redundancy, the respondent's name was cross-checked with the list of train drivers provided by the company. Table 4.6 depict the distribution of responses collected at five different depots while Table 4.7 shows the origin of the drivers.

Table 4.6: Number of responses collected at different depots

#	Collecting depot	Number of responses collected	Percentage
1	Kuala Lumpur	72	31.4
2	Prai	56	24.5
3	Ipoh	45	19.7
4	Gemas	20	8.7
5	Kuala Lipis	36	15.7
	Total	229	100

Table 4.7: Number of responses based on reporting depots

#	Depot	Responses	Percentage
1	Kuala Lumpur	32	14.0
2	Prai	66	28.8
3	Singapore	2	0.9
4	Ipoh	65	28.4
5	Gemas	33	14.4
6	Tumpat	25	10.9
7	Kuala Lipis	6	2.6
	Total	229	100.0

4.7 Structural Equation Modeling

Structural equation modelling (SEM) technique is used in this study to evaluate the model and to determine the relationships between variables. In general, SEM is divided into two types; covariance-based (CB-SEM) and variance-based partial least squares (PLS-SEM) (Hair, Sarstedt, et al., 2012b). CB-SEM is used for confirming theories while PLS-SEM is a prediction variance-based approach which used in exploratory research to develop theories (Hair et al., 2014; Hair, Ringle, et al., 2012).

For this study, since the research is in the exploratory stage in determining the relationship between variables in measuring the performance of the train driver, the PLS-SEM approach is considered to be the most suitable.

4.8 Preliminary Data Analysis

Preliminary data analysis, in which the raw data is screened and analysed, is required before structural equation modelling (SEM) could be performed. SPSS software is used for preliminary data analysis. The process sequence is summarized in Figure 4.5.

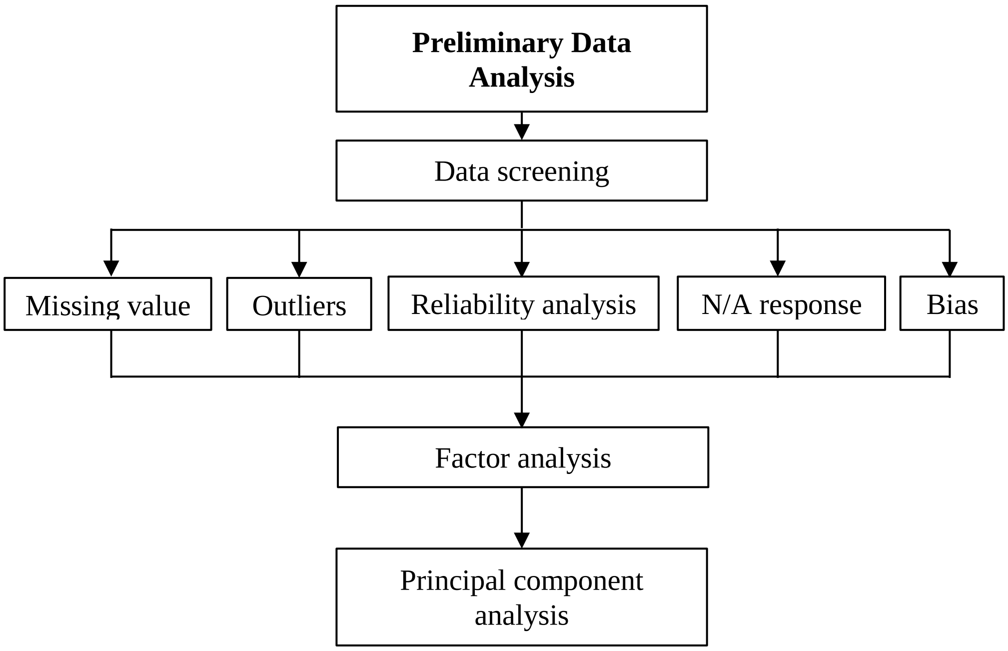

Figure 4.5: Summary of preliminary data analysis

4.8.1 Data Screening

The raw data obtained from the survey was screened for missing values, outliers and not applicable (N/A) responses. This is an important step to ensure data are correctly inserted at the initial phase. In addition, there is a possibility of error in the data entry stage due to the large volume of input data. Normality test was not conducted for data in this research as PLS does not require normal-distributed input data (Haenlein & Kaplan, 2004; Hair, Sarstedt, et al., 2012a).

Screening of the data began with identification of outliers. The presence of outliers would affect the calculation of data variance and factors correlations (Stanimirova et al., 2007; Timm, 2002). Outliers are identified using boxplots (box-whisker diagram) and histograms (Field, 2005). In this study, the number of outliers were not found as the respondents were only had limited choice on the selection scale. Example of histogram and box-whisker diagram are shown in Figure 4.6 and Figure 4.7, indicated the point of outliers which were actually the extreme answer from particular respondent, but their choices of answer were still in the range of Likert-scale choices.

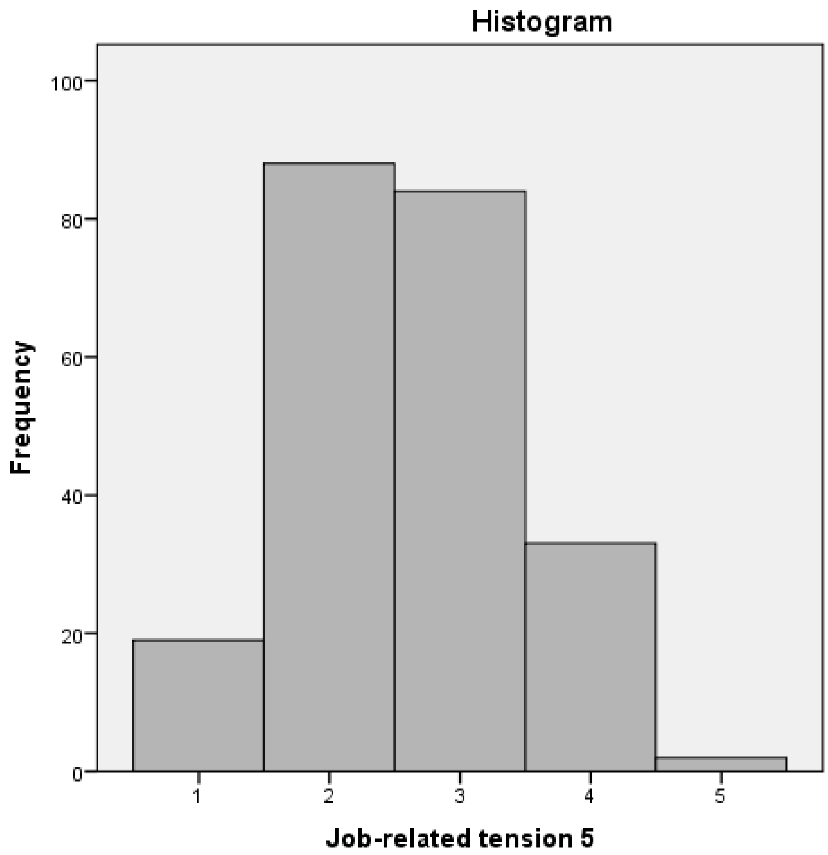

Figure 4.6 : Example of histogram for item JRT 5

Figure 4.7: Example of box-whisker diagram for item JRT 5

There were four constructs containing 'Not Applicable N/A' responses as an addition to the 5–point Likert scale, which are working condition (WC), working environment (WE) and safety culture (SC). Due to different type and class of locomotives, some items might not be applicable for the respondents to answer. The assumption made was that the drivers had at least one-time experience in driving each type of locomotive. The N/A responses were then treated as missing value (Lee et al., 2007).

4.8.2 Treatment of missing data

The presence of missing data is common and unavoidable in any quantitative study (Rubin, 1976). This missing data should be analysed and treated to avoid biased conclusions (Byrne, 2010). Data screening is also recommended prior to presentation of results, as advised by the APA Task Force on Statistical Inference (Wilkinson & Task Force Stat, 1999).

Past strategies on handling missing data includes excluding or deleting the cases with missing data (Baraldi & Enders, 2010; Stanimirova et al., 2007). However, deletion of cases, such listwise and pairwise deletion, would cause loss of important information, reduce statistical power and increase bias of estimation (Nakagawa & Freckleton, 2008). With the advancement in computational power, missing data can be treated using stochastic imputation methods, stochastic regression, expectation-maximization algorithm (EM) and multiple imputation (MI) (Schlomer et al., 2010).

For best practices, Hair et al. (2010), Schlomer et al. (2010) and Wilkinson & Task Force Stat (1999) recommended researchers to report the amount of missing data, the data pattern and the method used for treatment of missing data.

The data from 229 respondents were screened using SPSS software and the percentages of missing responses were measured for each item (Schlomer et al., 2010), as shown in Appendix 5. SPSS is one of most common software used for handling survey data and provides module to assess and evaluate missing data analysis, and these numerous complexes statistical procedures rely on the expectation maximization algorithm to impute missing data is best using SPSS (Hair et al., 2014). It also provides application to perform preliminary data analysis i.e. data screening, common method and response bias, reliability analysis and factor analysis before proceed to SEM approach using Smart PLS (Schlomer et al., 2010). Other than SPSS, artificial neural network (ANN) and genetic algorithm could be used to predict missing value for replacing the ‘emptiness’ of the data but very limited; unable to conduct the missing value analysis (Mussa & Marwala, 2005; Setiawan et al., 2008).

From the table, the percentage of missing value ranges from 0 to 23.1 percent. As reported by Schlomer et. al (2010), there are several cut-off values proposed by different authors; 5% (Schafer, 1999), 10% (Bennett, 2001; Hair et al., 2010) and 20% (Peng et al., 2006). In this study, 7 items were in the range of 5 – 20 % and one item, WE1 was more than 20% (23.1%). Item WE1 was deleted as it exceeded the minimum cut-off value, as suggested by Peng, et al. (2006).

To analyse the pattern of missing data, Little’s MCAR test is used to evaluate each construct to identify randomness and missingness pattern. The three patterns of missingness, introduced by Rubin (1976) and Little and Rubin (1987) as cited in Byrne (2010), are; 1) missing completely at random (MCAR), 2) missing at random (MAR) and 3) not missing at random (NMAR). This missingness pattern was used to determine suitable treatment for missing values. Briefly, MCAR is a process in which the missing-ness of the data is completely independent of both the observed and the missing values, and MAR is a process in which the missing-ness of the data depends on the observed values, but is independent of the missing values. When the missing data mechanism is neither MCAR nor MAR and, in particular, the missing-ness depends on the missing values themselves, the process is called missing not at random (MNAR).

Table 4.8 shows results of missing data randomness on Little (1988) MCAR significance value for each factor. For this test, the null hypothesis is that the data are missing completely at random, and the p value is significant at the 0.05 level. If the value is less than 0.05, the data are not missing completely at random. The data may be missing at random (MAR) or not missing at random (NMAR). A significant null hypothesis (p value > 0.05) is indicative of MCAR. If the significance value is less than 0.05, the data might be MAR or NMAR. Past researcher normally assumed MAR

(Schlomer et al., 2010) for non MCAR factors. In this study, three factors were non-MCAR, namely occupational stress, working condition and performance.

Once the pattern of either MCAR or MAR has been determined, the missing values can be treated using modern missing data technique by either Multiple Imputation (MI) or Expectation Maximization (EM). Multiple data sets with different imputed values are prepared and the analyses are then performed on each data set. This technique provides unbiased estimates for MCAR and MARS data (Baraldi & Enders, 2010; Burns et al., 2011).

Multiple imputation (MI) were performed for factors with MCAR using 25 imputations data sets whereas expectation-maximization algorithm (EM) were utilised for factors with MAR (Baraldi & Enders, 2010; Hair et al., 2010).

Table 4.8: Little's MCAR significance value for each factor

Construct	Little's MCAR significance value	Decision
Job satisfaction	0.377	MCAR
Occupational stress	0.001	MAR
Job-related tension	0.100	MCAR
Fatigue	0.054	MCAR
Sleepiness	0.304	MCAR
Job demand	0.925	MCAR
Driving task	0.506	MCAR
Working environment	0.405	MCAR
Working condition	0.034	MAR
Safety issue	0.760	MCAR
Safety culture	0.832	MCAR
Performance	0.000	MAR

Legend : (MCAR) missing completely at random
(MAR) missing at random (MAR)
(NMAR) not missing at random (NMAR)

4.8.3 Common Method Bias

The research methods may influence construct measurements and that this influence, or method bias, can lead to false conclusions. A common method bias test can be conducted as an evaluation for random and systematic measurement error that affects the estimates of the relationship between measures (Podsakoff et al., 2003). Harman's single-factor test is the most widely used approach to prove the existence of common method bias (Ou et al., 2010; Podsakoff et al., 2003). The assumption by performing Harman's single-factor test was; there will be a common method variance if one general factor explains the majority of the covariance among variables.

To conduct Harman's single factor test, exploratory factor analysis (EFA) with unrotated factor solution was performed for all of the variables. As shown in Table 4.9, the principal factors revealed the presence of eleven factors (column component) with equal variance within the range of 18.5 – 3.1 percent (% of variance column). Cumulatively, it shows that eleven factors had explained 100% of the measured items. Thus, this suggests the non-presence of common method bias.

Table 4.9: Total variance explained

Component	Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	21.808	18.482	18.482
2	17.546	14.870	33.351
3	14.768	12.515	45.866
4	12.937	10.964	56.830
5	10.755	9.115	65.945
6	9.996	8.471	74.416
7	8.785	7.445	81.861
8	6.815	5.775	87.636
9	6.396	5.420	93.056
10	4.529	3.838	96.894
11	3.665	3.106	100.000
12	-	-	100.000
13	-	-	100.000
14	-	-	100.000
15	-	-	100.000

4.8.4 Response bias

Response bias is a general term that refers to conditions or factors that take place during the process of responding to surveys, affecting the way responses are provided. Such circumstances lead to a non-random deviation of the answers from their true value. In this study, non-response bias was not an issue since the survey was distributed directly to the respondent during their 'off-duty' periods at the 'running bungalows'. Ambiguities in any part of the survey can be answered immediately by the researcher present during the administration of the survey. The response was 100 percent since the questionnaire were completed immediately.

A one-way ANOVA was conducted to test for significant difference between locations of surveys at different depots. Since the data were collected from five different depots, five groups of respondents based on their reporting depot were tested for differences. Firstly, a test of homogeneity was conducted to determine whether the variances between depots for the average performance scores are equal. The results have shown homogeneity of variances, as assessed by Levene's Test of Homogeneity of Variance ($p = 0.466$). Hence, there was no statistically significant difference in average performance score between the different depots, $F(4,224) = 2.282$, $p = 0.061$.

The results showed insignificant differences between depots on their average performance scores, thus, implying there were no biases of the data.

4.8.5 Reliability Analysis

Cronbach's alpha coefficient was used to assess the consistency of the measurement items. In general, a Cronbach's alpha value of more than 0.5 is desirable, as suggested by Sekaran, (2003). Table 4.10 summarizes the results of the reliability test, showing the final alpha values for all factors were between 0.529 to 0.917. It is noted that the alpha value for job characteristics construct (JCH) was 0.452 prior to deletion of item JCH4, however omitting JCH4 in the calculations improved the value to 0.529. It can be concluded that the measurements are reliable since the alpha values had exceeded the recommended value of 0.5 for exploratory studies.

Table 4.10: Results of reliability test

Factor	Measurement items	Cronbach's α	Number of items	Number of item deleted	Final number of items
Job satisfaction	JS 1 – JS 8	0.725	8	0	8
Occupational Stress	STR 1 – STR 20	0.917	20	0	20
Job related tension	JRT 1 – JRT 15	0.832	15	0	15
Fatigue	FF 1-4 FF 6-7	0.842	6	0	6
Sleepiness	FSL 1-8	0.731	8	0	8
Job demand	JCH 1-3 JCH 5-7	0.529 (0.452)[a]	7	1 JCH 4	6
Driving task	DT 1- 5	0.563	5	0	5
Work environment	WE 2 - 15	0.675	14	0	14
Working condition	WC 1 – 7	0.720	7	0	7
Safety issue	SI 1 – 7	0.777	7	0	7
Safety culture	SC 1 – 15	0.708	15	0	15
Performance	PMS 2008 - 2011	0.765	4	0	4

[a] initial alpha value

4.9 Chapter Summary

This chapter explains the overall methodology used in this study. Firstly, the theoretical framework and hypotheses were developed based on past models and literatures. The measurement instruments were adapted from past validated instruments, with thorough reviews from experts and stakeholders. A Pencil – and – paper questionnaire based on subjective rating scales approach was taken to collect the data from the respondents.

The targeted respondents were train drivers who drove passenger and freight trains of the TOC. They were randomly picked from five depots along the line of Peninsular Malaysia. A total of 229 samples were collected from the population of 548 drivers.

SPSS software was used for data screening and analysis. Preliminary data analysis containing data screening, treatment of missing data, test for common method bias and response bias was performed. A reliability analysis using Cronbach's alpha coefficient was performed to assess the measurement items' consistency. The relationships among factors will be conducted using SEM software and SmartPLS.

CHAPTER 5 : RESULTS & ANALYSIS

5.1 Introduction

This chapter presents the analysis conducted and the empirical results obtained with regard to the research hypotheses. The initial statistical analysis was conducted using Statistical Package for Social Science (SPSS) version 20.0. This software was used for the data entry, data screening, preliminary data analysis, descriptive statistics of the data and the reliability analysis (Cronbach alpha). Subsequently, structural equation modelling (SEM) technique, using Smart PLS software, was utilised to evaluate the interrelationship among variables and for testing of the hypotheses.

5.2 Factor Analysis

Factor analysis technique is used for data reduction and to evaluate the significance of relationships among variables (Russell, 2002). The objective of factor analysis is parsimony, which attempts to reduce the number of variables but still retains the maximum amount of common variance (Tinsley & Tinsley, 1987).

Principal components analysis with Promax rotation (Russell, 2002) was used to reduce the large number of items in the driver performance measures to a smaller number of reliable factors (Glendon & Litherland, 2001; Lu & Shang, 2005). The items were categorized into three main categories or domains, based on Bailey (1996), Baines, et al. (2005) and Y.H. Chang & Yeh (2010), which were human, activity and context. The principal component analysis can then be performed for each domain instead of analysing the overall items together. Figure 5.1 shows the process flow of the factor analysis.

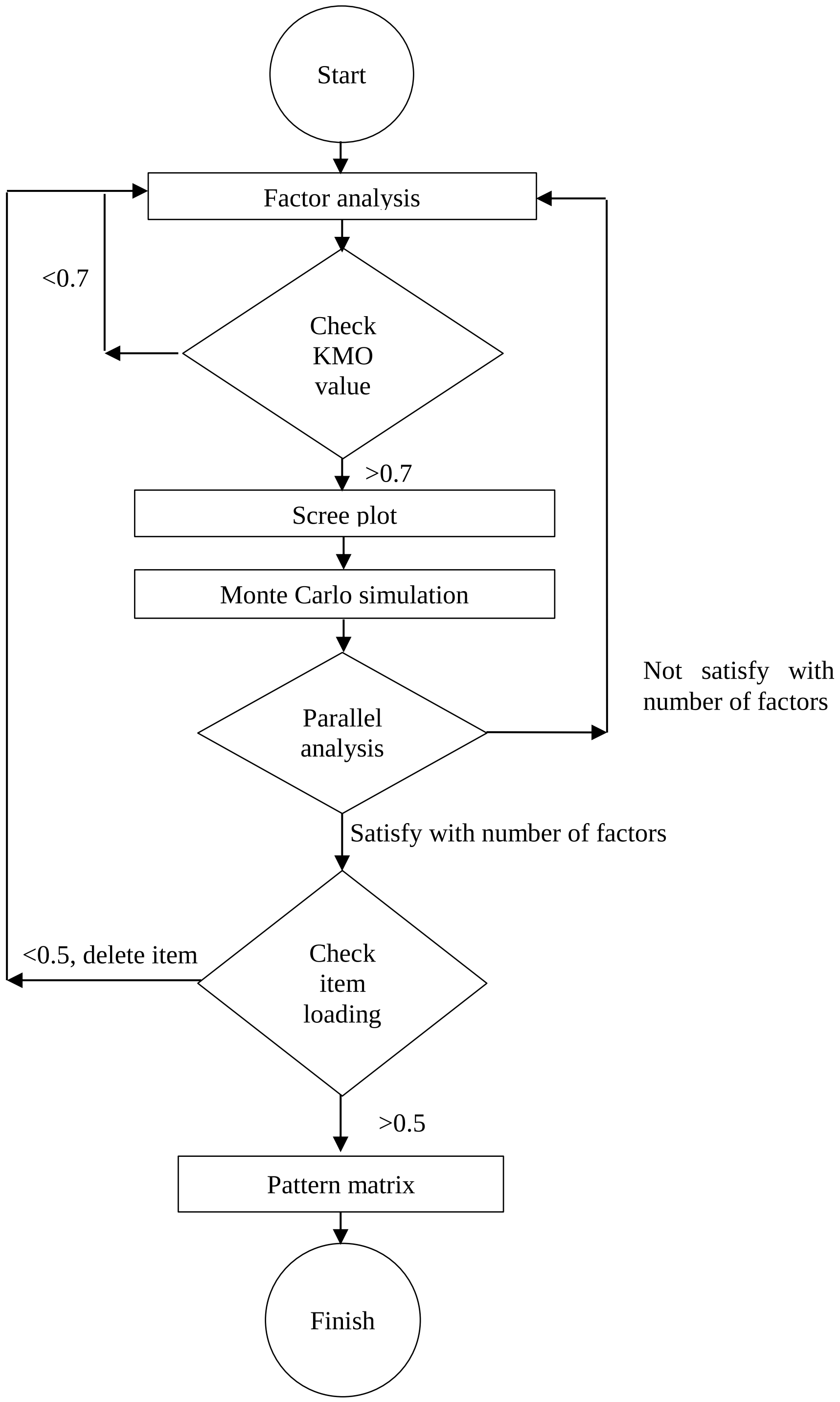

Figure 5.1: Flow chart of factor analysis

Initially, principal component analysis with Promax rotation was perform without fixing the number of factors. From the analysis of Kaiser-Meyer-Olkin measures of sampling adequacy (KMO), the value need to be more than 0.7 (>0.7) which indicated that the data is appropriate for the analysis (Hair et al., 2010). This KMO measures is to identify the factor is stable with enough varibles to adequately measures all of the factors (Field, 2005). The data then plotted using scree plot (Cattell 1966 as mentioned by Reise, et al. (2000)). In general, the number of factors can be identified from the scree plots, but occasionally, the scree plot analysis was unable to indicate the number of factors clearly (Russell, 2002). An improved procedure, called parallel analysis (Reise et al., 2000) is then conducted by comparing the eigenvalues from real data and simulated data. Monte Carlo simulation was used to generate the simulated data. In a parallel analysis, random data sets are generated on the basis of the same number of items as in the real data matrix. Then the scree plot of the eigenvalues (percentage of variance accounted for by a dimension) from the real data is compared with the scree plot of the eigenvalues from the random data (simulated data). The point where the two plots meet provides the researcher with a good idea of the absolute maximum number of factors that should be extracted. The factors are accepted if the eigenvalue of the actual data was greater than the simulated data. Then, the individual factor loadings were checked, if it is less then 0.5, it should be deleted (Field, 2005).

5.2.1 Human domain

In the research model, the human domains consists of five possible factors, namely, job satisfaction, occupational stress, job related tension, fatigue and sleepiness. In this principal component analysis (PCA), fatigue and sleepiness were excluded since these factors were specially designed for particular symptoms of fatigue and sleepiness. The level of fatigue was measured using Flinders Fatigue Scale (Gradisar et al., 2007) while sleepiness by Epworth Sleepiness Scale (Johns, 1991, 1992). So, the principal component analysis was performed only on 43-item of human domain questionnaire data from 229 respondents. Table 5.1 shows the distribution of items in the proposed factors for human domain.

Table 5.1: Factors in human domain

Factors	Measurement items	Number of items	Number of item deleted (initial)	Remarks
Job satisfaction	JS 1 – JS 8	8	0	43-item
Occupational stress	STR 1 – STR 20	20	0	
Job related tension	JRT 1 – JRT 15	15	0	
Fatigue	FF 1-4 FF 6-7	6	0	Not included in PCA
Sleepiness	FSL 1-8	8	0	Not included in PCA

From the initial 43 items analysed, only 36 items were accepted, having loading of more than 0.4 and loaded on five-factor solution. As compared to only two factors proposed in the theoretical framework, namely occupational stress and job satisfaction, the factor analysis technique suggested five-factor solution for an improved interpretation of the human domain. Three factors were proposed for the previous ‘occupational stress’ factor, namely occupational stress, job-related tension (internal conflicts), and job-related tension (external conflicts). Job satisfaction is divided into two factors, namely, job satisfaction 1 and job satisfaction 2.

Table 5.2: Factor analysis of human domain

# analysis	KMO value	No. of factors fixed	Paralel analysis (suggested no of factors	Total variance explained	Items deleted
1	0.853	0	5	62.9%	6
2	0.838	5	5	66.4%	1
3	0.829	5	5	47.8%	0

The 5-factor solution is the best proposed result after items deletion and was measured with item loading, KMO value, and eigenvalue comparison for parallel analysis. Previously, there were 3 factors before the factor analysis. However, 5-factor solution is more suitable based on the factor analysis and review of the items. Factors were renamed based on the items in that particular grouping. Table 5.3 shows the 36 items loaded on five-factors with its individual loading. Figure 5.2 represents the five-factor solution with (1) job satisfaction (JS), (2) job satisfaction 2 (JS2), (3) job-related tension (JRT), (4) job-related tension 2 (JRT2), and (5) occupational stress (STR). The detail of the analysis is described in Appendix 6.

Table 5.3: Five-factor solution for human domain

		Component				
		1	2	3	4	5
1	STR16 Occupational stress 16	0.764	-	-	-	-
2	STR10 Occupational stress 10	0.756	-	-	-	-
3	STR9 Occupational stress 9	0.740	-	-	-	-
4	STR4 Occupational stress 4	0.722	-	-	-	-
5	STR11 Occupational stress 11	0.656	-	-	-	-
6	STR5 Occupational stress 5	0.642	-	-	-	-
7	STR3 Occupational stress 3	0.637	-	-	-	-
8	STR12 Occupational stress 12	0.634	-	-	-	-
9	STR2 Occupational stress 2	0.616	-	-	-	-
10	STR14 Occupational stress 14	0.574	-	-	-	-
11	STR1 Occupational stress 1	0.553	-	-	-	-
12	STR8 Occupational stress 8	0.516	-	-	-	-
13	STR18 Occupational stress 18	0.506	-	-	-	-
14	STR13 Occupational stress 13	0.470	-	-	-	-
15	STR19 Occupational stress 19	0.468	-	-	-	-
16	JRT5 Job-related tension 5	-	0.718	-	-	-
17	JRT13 Job-related tension 13	-	0.663	-	-	-
18	JRT7 Job-related tension 7	-	0.633	-	-	-
19	JRT4 Job-related tension 4	-	0.617	-	-	-
20	JRT12 Job-related tension 12	-	0.583	-	-	-
21	JRT9 Job-related tension 9	-	0.543	-	-	-
22	JRT11 Job-related tension 11	-	0.536	-	-	-
23	JRT3 Job-related tension 3	-	0.479	-	-	-
24	JRT15 Job-related tension 15	-	0.447	-	-	-
25	JS5 Job satisfaction 5	-	-	0.799	-	-
26	JS4 Job satisfaction 4	-	-	0.783	-	-
27	JS2 Job satisfaction 2	-	-	0.756	-	-
28	JS1 Job satisfaction 1	-	-	0.711	-	-
29	JS3 Job satisfaction 3	-	-	0.618	-	-
30	JS6 Job satisfaction 6	-	-	-	0.860	-
31	JS7 Job satisfaction 7	-	-	-	0.835	-
32	JS8 Job satisfaction 8	-	-	-	0.792	-
33	JRT2 Job-related tension 2	-	-	-	-	0.753
34	JRT1 Job-related tension 1	-	-	-	-	0.544
35	JRT8 Job-related tension 8	-	-	-	-	0.417
36	JRT14 Job-related tension 14	-	-	-	-	0.410

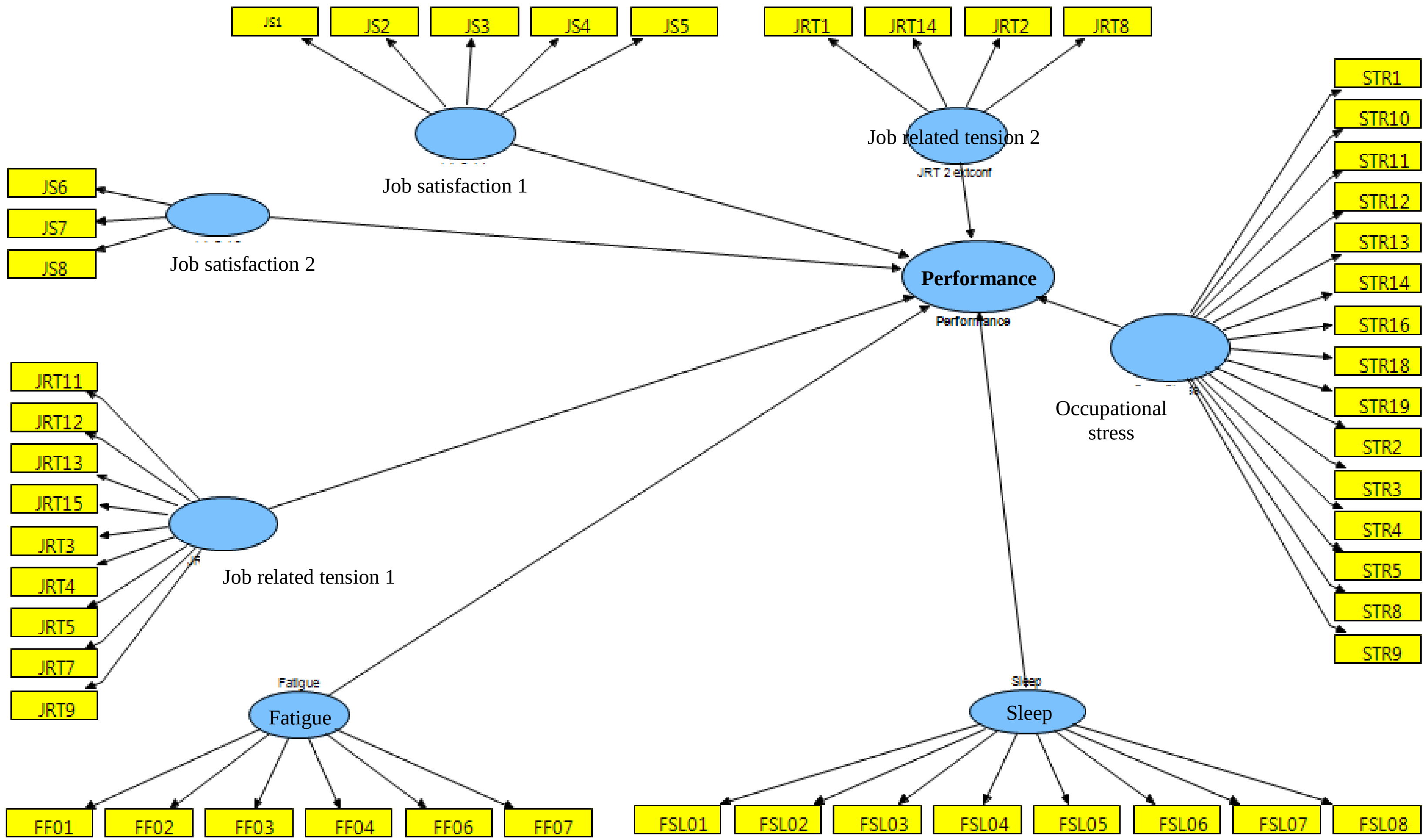

Figure 5.2: Factors of human domain for measuring train driver performance

5.2.2 Activity domain

As proposed in the theoretical framework, measuring performance based on activity of train driver would consist of two possible factors; job demand and driving task. Eleven-item from the activity domain questionnaire data of 229 respondents were evaluated to identify the appropriate number of constructs. Table 5.4 shows the distribution of items in the proposed factors of activity domain. One item, JCH4, was deleted in the preliminary reliability test and is not considered in the subsequent evaluation procedures.

Table 5.4: Factors in activity domain

Factors	Measurement items	Number of items	Number of item deleted (initial)	Remarks
Job demand	JCH 1-3 JCH 5-7	7	1	JCH 4 deleted
Driving task	DT 1- 5	5	0	-

Table 5.5: Factor analysis of activity domain

# analysis	KMO value	No. of factors fixed	Parallel analysis (suggested no. of factors	Total variance explained	Items deleted
1	0.674	0	3	58.2%	0
2	0.674	3	3	49%	2
3	0.63	3	-	53.8%	2
4	0.637	2	-	50.6%	0

Factor analysis was then conducted for the activity domain. Table 5.5 summarizes the four consecutive analyses which were conducted to identify the number of factors and items for the activity domain. After three consecutive analyses with deletion of four items, the criteria of 0.5 loading was retained but with 2-factor solution. The number of items remained was seven, which would initially suggest a 3-factor solutions with two items per factor. However, this would disperse the items and would not be suitable for further analysis (Russell, 2002). Thus, a 2-factor solution is selected, as suggested in the original research framework, which were the driving task and job demand.

The final factor analysis for the activity domain was conducted for seven items, 2-factor solution and a minimum 0.4 factor loading. The Kaiser-Meyer-Olkin measures of sampling adequacy (KMO) value of 0.637 (Hair et al., 2010) indicated the data is regarded to be appropriate for the analysis with 50.6% of the variance.

Table 5.6: Results of the factor analysis of activity domain

	Component	
	1	2
DT2 Driving Task 2	**0.775**	0.024
DT1 Driving Task 1	**0.710**	0.151
DT3 Driving Task 3	**0.682**	-0.221
DT4 Driving Task 4	**0.615**	0.057
JCH2 Job Demand 2	-0.043	**0.788**
JCH1 Job Demand 1	-0.048	**0.724**
JCH5 Job Demand 5	0.155	**0.591**
Eigenvalue	1.978	1.564
Percentage variance (50.6)	28.26	22.35

Table 5.6 summarizes the result of the factor analysis for the activity domain, showing the items are grouped in its own component, i.e. all items marked with DT had loading of more than 0.4 (indicated in bold) in component 1 while items marked with JCH were grouped in component 2. These result confirms that each of these constructs are unidimensional and factorially distinct and that all items used to measure a particular construct are loaded on a single factor.

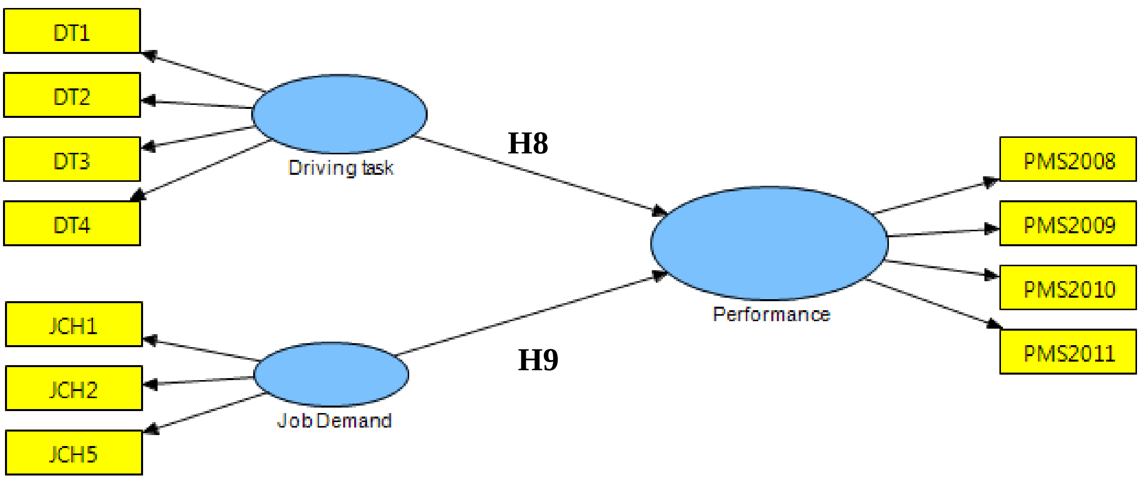

Figure 5.3: Factors of activity domain for measuring train driver performance

Figure 5.3 shows schematically the relationship between factors of activity domain with performance of the train driver. It consists of four items for driving task and three items for job demand. The details of the analysis is described in Appendix 7.

5.2.3 Context domain

Initially, the context domain consisted of two possible factors which were work environment and safety, as proposed in theoretical framework. A principal component analysis with Promax rotation was performed on the 42-item context domain questionnaire data from 229 respondents. Factor analysis procedure was conducted for five iterations on the 42 items to determine the number of appropriate factors for measuring the performance of train drivers.

Table 5.7: Factor analysis of context domain

# analysis	KMO value	No. of factors fixed	Paralel analysis (suggested no. of factors	Total variance explained	Items deleted
1A	0.751	-	7	67.4%	10
1B	0.751	7	-	50.4%	6
2	0.757	7	6	53.1%	4
3	0.758	-	6	50.6%	2
4	0.763	6	-	52.49%	0

Table 5.7 summarize the five consecutive analyses taken to determine the number of factors for the context domain. The final analysis for context domain resulted in the deletion of two items (SC01 and SC11) to arrive at a 6-factor solution and a minimum of 0.4 factor loading. Kaiser-Meyer-Olkin measures of sampling adequacy (KMO) value of 0.763 (Hair et al., 2010) indicated the data is regarded to be appropriate for the analysis with 52.49% of the variance. The details of the analyses are discussed in Appendix 8.

Table 5.8: Results of the factor analysis of context domain

		Component					
		1	2	3	4	5	6
1	WE5 Working env. 5	**.848**	.159	.048	.151	-.079	-.100
2	WE6 Working env. 6	**.742**	-.003	-.082	.092	.008	-.123
3	WE8 Working env. 8	**.665**	-.106	.037	-.196	-.053	.073
4	WE7 Working env. 7	**.619**	-.062	.118	.073	.085	-.034
5	WE10 Working env. 10	**.609**	-.109	.011	-.222	-.200	.047
6	WE4 Working env. 4	**.596**	.056	.136	.179	.143	.006
7	WE2 Working env. 2	**.578**	-.046	-.174	-.123	-.051	.095
8	WE13 Working env. 13	**.538**	-.233	-.029	-.141	.024	-.053
9	WE11 Working env. 11	**.453**	.112	-.068	.076	.287	.034
10	SI02 Safety issue 2	.015	**.824**	-.063	-.014	.073	.048
11	SI04 Safety issue 4	-.065	**.777**	.134	-.162	-.218	-.190
12	SI01 Safety issue 1	.038	**.756**	-.055	-.045	.071	.040
13	SI05 Safety issue 5	-.100	**.729**	-.045	.060	.000	.097
14	WE14 Working env. 14	.005	-.043	**.836**	.172	.150	-.085
15	WE12 Working env. 12	.018	.020	**.771**	.099	.025	-.097
16	WE15 Working env. 15	.045	-.127	**.745**	-.018	-.082	-.066
17	SC14 Safety culture 14	-.027	.049	**.529**	-.321	-.049	.235
18	WE9 Working env. 9	.059	.102	**.431**	-.045	-.052	.202
19	WC4 Working conditions 4	.023	-.077	-.012	**.817**	-.100	-.021
20	WC5 Working conditions 5	.042	-.049	-.076	**.787**	-.146	.130
21	WC2 Working conditions 2	-.005	.019	.254	**.599**	.057	.105
22	SC10 Safety culture 10	.031	.005	.057	-.104	**.791**	.163
23	SC08 Safety culture 8	-.066	-.010	.069	-.080	**.751**	-.136
24	SC13 Safety culture 13	.014	-.014	-.029	-.035	**.550**	.090
25	SC05 Safety culture 5	.071	-.024	-.268	-.122	**.494**	-.160
26	SC09 Safety culture 9	-.274	-.141	.064	-.109	-.016	**.691**
27	WC7 Working conditions 7	-.162	-.127	-.058	.241	.104	**.658**
28	SI06 Safety issue 6	.088	.264	-.055	.018	.062	**.583**
29	WC6 Working conditions 6	.131	.047	-.113	.322	-.138	**.503**
30	WE3 Working env. 3	.360	.062	.141	-.097	.075	**.502**
	Eigenvalue	5.562	2.783	2.587	1.749	1.617	1.448
	Percentage variance (52.49)	18.539	9.277	8.623	5.830	5.389	4.828

Table 5.8 shows the result of the factor analysis for context domain, confirming that each of these constructs is unidimensional and factorially distinct and that all items used to measure a particular construct were loaded on a single factor. Figure 5.4 shows, schematically, the factors constructed from factor analysis which consisted of six factors with 30 items.

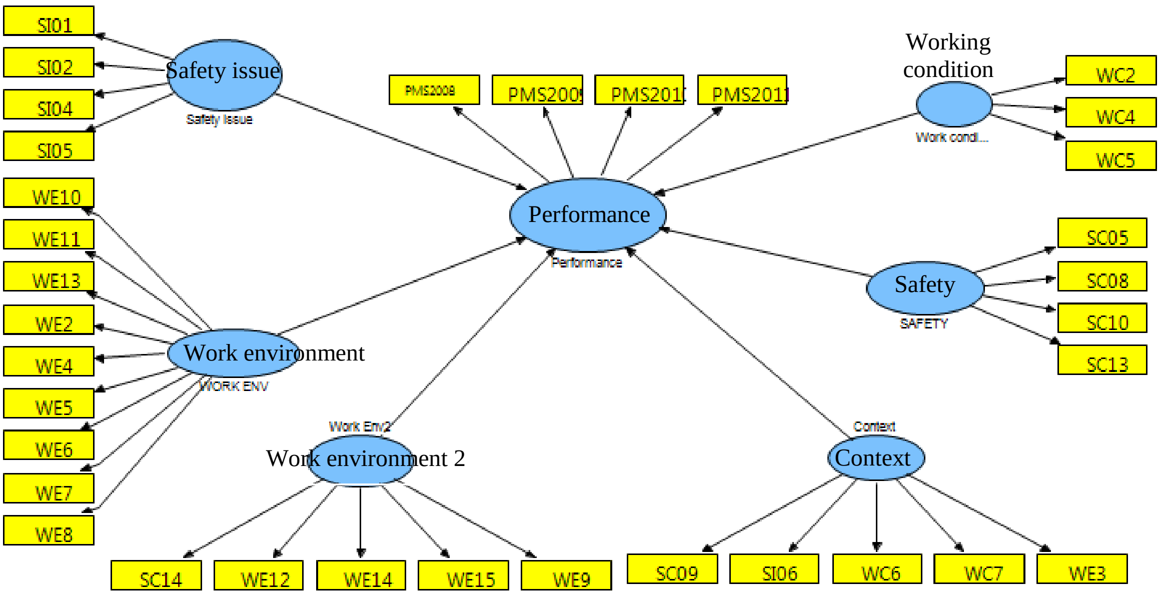

Figure 5.4: Factors of context domain for measuring train driver performance

5.2.4 Summary of factor analysis

From the proposed theoretical model presented in Chapter 3, the data were analysed using factor analysis technique to determine the number of variables (Russell, 2002). Fifteen factors were identified to be influential factors of train driver performance. Figure 5.6 represents the overall fifteen factors which were expected to have positive relationship with the performance of the train driver. Hypotheses from this proposed model will then be tested using structural equation modelling (SEM) to confirm its relationship.

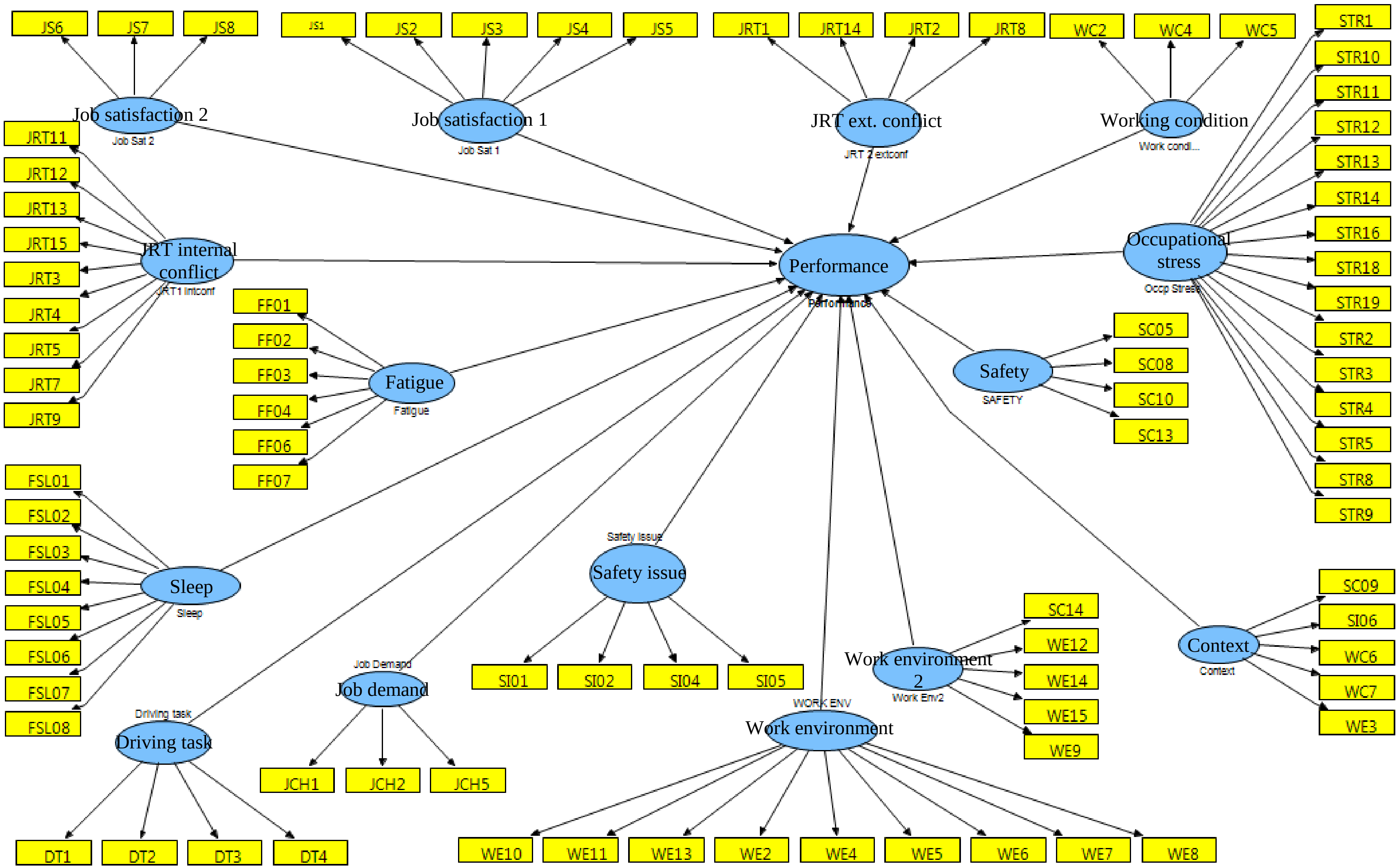

Figure 5.5: Train driver performance model after factor analysis

5.3 Evaluation of the measurement model

A systematic analysis using a partial least square (PLS) approach is used, which presents the results in two steps (Anderson & Gerbing, 1991; Chin, 2010). The first step examined the validity and reliability of the survey items in the measurement model, whereas the second step analyses the structural model. The measurement model consists of composite reliability to evaluate internal consistency, and convergent validity by using average variance extracted (AVE). Discriminant validity was assessed using the Fornell-Larcker criterion and cross loadings.

5.3.1 Internal consistency reliability

Composite reliability is a measure of internal consistency reliability, which can be used instead of the traditional criterion of Cronbach's alpha. Thus, PLS-SEM can utilise composite reliability to prioritize the indicators according to their individual reliability (Hair et al., 2014).

To measure composite reliability, the individual reliability of the items to their respective constructs is first determined. The significant cut-off value was set at 0.5 (Hair et al., 2010) and any item below this value will be deleted. Furthermore, items with the lowest loading in a particular construct or factor was also deleted and the cross-loadings were calculated. Table 5.9 shows the item loadings and cross loadings between items for the first iteration of the analysis. The loadings for each item are highlighted in bold numberings and grey boxes while the items marked for deletion are marked in white bold font and black boxes.

As can be seen in Table 5.9, items with low loading value of 0.5 were marked. In the first iteration of the analysis, items with loadings of 0.5 were individually removed. With each removal, there may be a possibility of increase in loading of the remaining items, thus careful consideration was taken to remove items individually and reassessing the overall loading values.

The cross-loading analysis was conducted for each removal of items. These delete-and-run processes were continued until the third iteration to ensure the items were having significant values. The results of the delete-and-run process are presented in Table 5.10.

Table 5.9: Loading and cross loadings of items to measure composite reliability

Group	Human							Activity		Context						Perfor-mance
Items	Job Sat 2	Job Sat 1	JRT1 intconf	JRT 2 extconf	Occp Stress	Fatigue	Sleep	Driving task	Job Demand	Safety culture	Safety Issue	Work condition	Work facility	Work Env2	Work Env	Perfor-mance
JS6	**0.869**	0.098	-0.020	-0.036	-0.114	0.031	-0.001	0.011	0.053	-0.016	0.066	0.055	-0.078	0.034	0.192	-0.042
JS7	**0.906**	0.075	-0.138	-0.069	-0.055	0.078	0.006	-0.057	-0.009	-0.027	-0.056	-0.055	-0.047	-0.038	0.143	-0.049
JS8	**0.713**	0.001	-0.068	0.021	0.006	0.041	0.013	0.037	-0.060	0.067	-0.047	-0.029	-0.101	-0.013	0.047	-0.018
JS1	0.077	**0.621**	-0.153	-0.190	-0.030	0.213	0.079	-0.258	0.331	0.246	0.087	-0.016	-0.160	-0.274	0.123	-0.039
JS2	0.109	**0.810**	-0.237	-0.191	-0.088	0.292	0.075	-0.170	0.216	0.356	-0.045	-0.068	-0.238	-0.189	0.029	-0.121
JS3	0.034	**0.658**	-0.207	-0.063	-0.002	0.198	0.143	-0.042	-0.001	0.361	-0.118	0.000	-0.138	-0.140	0.043	-0.090
JS4	0.050	**0.849**	-0.305	-0.205	0.003	0.278	0.149	-0.245	0.184	0.333	-0.040	-0.086	-0.200	-0.119	0.001	-0.120
JS5	0.036	**0.769**	-0.228	-0.068	-0.002	0.208	0.137	-0.183	0.154	0.324	0.031	-0.042	-0.206	-0.242	-0.048	-0.054
JRT11	-0.092	-0.227	**0.695**	0.375	0.082	-0.294	-0.199	0.285	-0.064	-0.246	-0.078	0.053	0.149	0.051	0.034	0.147
JRT12	-0.054	-0.173	**0.472**	0.284	0.053	-0.202	-0.078	0.222	0.011	-0.281	-0.032	0.137	0.203	0.120	-0.077	-0.009
JRT13	-0.036	-0.052	**0.507**	0.263	-0.025	-0.233	-0.156	0.323	0.135	-0.093	0.024	0.164	0.077	0.171	-0.024	0.047
JRT15	-0.034	-0.208	**0.578**	0.315	0.051	-0.337	-0.139	0.348	0.094	-0.225	0.070	0.210	0.200	0.212	-0.013	0.136
JRT3	-0.034	-0.177	**0.644**	0.366	0.036	-0.317	-0.063	0.370	0.016	-0.215	0.012	0.126	0.184	0.157	-0.082	0.137
JRT4	-0.053	-0.225	**0.494**	0.294	-0.069	-0.355	-0.061	0.357	0.079	-0.261	0.044	0.131	0.289	0.294	0.052	-0.018
JRT5	-0.086	-0.180	**0.671**	0.288	0.089	-0.297	-0.154	0.385	0.108	-0.236	-0.003	0.145	0.262	0.171	0.042	0.128
JRT7	-0.091	-0.265	**0.695**	0.245	0.124	-0.261	-0.134	0.224	0.095	-0.252	0.045	0.160	0.274	0.117	0.029	0.155
JRT9	0.019	-0.206	**0.522**	0.238	0.007	-0.304	-0.034	0.392	-0.001	-0.234	0.043	0.195	0.226	0.226	-0.066	0.049
JRT1	-0.048	-0.207	0.347	**0.726**	0.056	-0.336	-0.179	0.386	-0.057	-0.124	0.020	0.216	0.093	0.101	-0.126	0.080
JRT14	-0.031	-0.107	0.374	**0.808**	0.079	-0.159	-0.064	0.334	0.040	-0.149	0.022	0.084	0.033	0.099	-0.190	0.098
JRT2	0.009	-0.064	0.232	**0.487**	-0.036	-0.083	-0.034	0.360	-0.076	-0.102	-0.045	0.058	0.025	0.060	-0.172	0.017

Group	Human							Activity		Context						Perfor-mance
Items	Job Sat 2	Job Sat 1	JRT1 intconf	JRT 2 extconf	Occp Stress	Fatigue	Sleep	Driving task	Job Demand	Safety	Safety Issue	Work condition	Work facility	Work Env2	Work Env	Perfor-mance
JRT8	-0.078	-0.214	0.435	**0.316**	-0.005	-0.197	0.072	0.283	-0.031	-0.243	-0.112	0.019	0.087	0.229	-0.256	0.005
STR1	-0.002	0.150	-0.183	-0.094	**0.472**	0.265	-0.005	-0.195	-0.117	0.117	-0.090	0.044	-0.169	-0.159	0.049	0.145
STR10	0.074	0.183	-0.286	-0.220	**-0.114**	0.364	0.072	-0.340	-0.041	0.216	0.025	0.014	-0.151	-0.111	-0.089	-0.019
STR11	0.128	0.265	-0.409	-0.239	**-0.042**	0.414	0.078	-0.332	-0.108	0.365	-0.062	-0.089	-0.263	-0.166	0.089	-0.053
STR12	0.067	0.216	-0.179	-0.147	**-0.071**	0.382	-0.013	-0.259	0.030	0.196	0.003	-0.047	-0.103	-0.159	0.021	-0.020
STR13	0.100	0.250	-0.291	-0.229	**0.025**	0.284	-0.080	-0.333	0.067	0.065	0.064	-0.081	-0.028	-0.182	0.135	0.041
STR14	0.109	0.177	-0.287	-0.232	**-0.285**	0.300	0.083	-0.254	-0.079	0.188	-0.033	-0.055	-0.192	-0.117	0.068	-0.140
STR16	0.152	0.228	-0.336	-0.202	**-0.127**	0.389	0.082	-0.379	0.013	0.236	-0.021	0.009	-0.158	-0.167	-0.046	-0.087
STR18	0.181	0.236	-0.347	-0.153	**-0.207**	0.349	0.112	-0.277	-0.012	0.224	-0.072	-0.133	-0.175	-0.148	-0.061	-0.082
STR19	0.169	0.207	-0.292	-0.147	**0.347**	0.201	0.005	-0.343	0.055	0.154	-0.044	-0.078	-0.135	-0.123	0.050	0.134
STR2	-0.012	0.111	-0.271	-0.162	**0.398**	0.320	0.054	-0.251	-0.171	0.094	-0.042	-0.052	-0.134	-0.164	0.057	0.084
STR3	0.001	0.088	-0.215	-0.252	**-0.007**	0.267	0.071	-0.235	0.009	0.192	-0.031	-0.163	-0.079	-0.080	-0.010	-0.052
STR4	0.042	0.042	0.023	-0.050	**0.560**	0.157	-0.087	-0.126	-0.182	0.107	-0.050	0.017	-0.041	-0.037	0.039	0.164
STR5	-0.077	0.113	-0.185	-0.119	**0.371**	0.185	-0.090	-0.159	-0.055	0.194	0.008	-0.030	-0.171	-0.020	0.007	0.065
STR8	0.055	0.270	-0.286	-0.145	**-0.045**	0.352	0.020	-0.214	-0.048	0.232	-0.037	-0.101	-0.122	-0.160	-0.066	-0.019
STR9	0.090	0.015	-0.189	-0.261	**0.028**	0.318	-0.023	-0.315	-0.050	0.112	0.004	-0.105	-0.039	-0.078	0.045	-0.003
FF01	-0.002	0.325	-0.416	-0.286	-0.008	**0.720**	0.109	-0.389	-0.053	0.308	-0.124	-0.260	-0.149	-0.134	-0.021	-0.048
FF02	0.080	0.243	-0.444	-0.238	-0.086	**0.840**	0.245	-0.343	-0.055	0.236	-0.186	-0.210	-0.200	-0.103	-0.116	-0.171
FF03	0.047	0.241	-0.332	-0.289	-0.043	**0.839**	0.196	-0.420	-0.007	0.198	-0.142	-0.215	-0.197	-0.031	-0.132	-0.213
FF04	-0.095	0.221	-0.293	-0.067	-0.062	**0.532**	0.064	-0.158	0.017	0.126	-0.069	-0.101	-0.169	0.001	-0.083	-0.037
FF06	0.040	0.324	-0.324	-0.212	-0.044	**0.747**	0.092	-0.312	0.009	0.204	-0.120	-0.224	-0.156	-0.104	-0.088	-0.106
FF07	0.085	0.216	-0.307	-0.200	-0.011	**0.726**	0.127	-0.255	0.043	0.165	-0.108	-0.154	-0.139	-0.025	-0.048	-0.107
FSL01	-0.015	0.167	-0.157	-0.162	0.076	0.131	**0.135**	-0.170	-0.024	0.101	0.005	-0.109	-0.006	-0.217	0.033	0.020
FSL02	-0.011	0.123	-0.138	-0.167	-0.118	0.253	**0.793**	-0.146	-0.007	0.045	-0.051	-0.050	0.044	-0.070	-0.113	-0.075

Group	Human							Activity		Context						Perfor-mance
Items	Job Sat 2	Job Sat 1	JRT1 intconf	JRT 2 extconf	Occp Stress	Fatigue	Sleep	Driving task	Job Demand	Safety	Safety Issue	Work condition	Work facility	Work Env2	Work Env	Perfor-mance
FSL03	-0.091	0.146	-0.112	-0.191	-0.119	0.160	**0.398**	-0.109	-0.030	0.063	0.016	-0.038	0.022	0.015	-0.156	-0.029
FSL04	0.031	-0.066	0.155	-0.016	-0.041	0.134	**-0.159**	0.023	-0.067	-0.123	-0.029	-0.011	0.059	0.065	0.050	0.039
FSL05	0.048	0.184	-0.007	0.063	0.021	0.237	**0.238**	-0.057	-0.121	0.021	-0.109	-0.035	-0.110	-0.046	-0.137	-0.002
FSL06	-0.148	0.060	0.128	-0.037	0.004	0.089	**-0.051**	-0.032	0.014	0.045	0.079	-0.037	0.066	0.063	-0.047	0.023
FSL07	0.039	0.098	0.045	0.010	-0.088	0.241	**0.363**	-0.017	-0.063	0.006	-0.104	0.017	0.015	0.024	-0.124	-0.027
FSL08	-0.024	0.065	-0.002	-0.063	-0.026	0.173	**-0.126**	-0.063	0.117	-0.008	0.086	-0.035	0.021	0.121	0.055	0.011
DT1	0.028	-0.068	0.406	0.388	-0.042	-0.224	-0.100	**0.698**	0.069	-0.111	-0.010	0.075	0.124	0.121	-0.088	0.110
DT2	-0.015	-0.270	0.417	0.383	0.029	-0.458	-0.117	**0.766**	0.007	-0.181	-0.039	0.154	0.128	0.206	-0.045	0.110
DT3	-0.009	-0.180	0.281	0.367	0.027	-0.249	-0.026	**0.772**	-0.143	-0.154	-0.007	0.119	0.054	0.158	-0.089	0.138
DT4	-0.086	-0.099	0.332	0.158	-0.069	-0.343	-0.151	**0.522**	-0.004	-0.112	0.027	0.194	0.152	0.117	-0.036	0.065
JCH1	-0.035	0.173	0.077	-0.005	-0.089	-0.003	-0.022	-0.054	**0.722**	-0.049	0.186	0.048	0.056	-0.031	0.050	-0.032
JCH2	0.009	0.174	0.061	-0.053	-0.062	0.011	0.009	-0.056	**0.836**	0.018	0.095	0.090	0.116	0.088	0.094	-0.043
JCH5	0.052	0.101	0.023	0.054	-0.098	-0.053	-0.046	0.050	**0.547**	0.028	0.174	0.051	-0.019	0.130	0.040	-0.026
SC05	-0.038	0.393	-0.408	-0.184	-0.045	0.301	0.071	-0.188	-0.012	**0.808**	-0.048	-0.192	-0.324	-0.257	-0.024	-0.188
SC08	0.027	0.310	-0.145	-0.089	-0.043	0.141	0.044	-0.119	-0.005	**0.756**	0.000	-0.097	-0.215	-0.058	0.037	-0.157
SC10	0.027	0.246	-0.224	-0.190	-0.157	0.178	0.067	-0.171	0.032	**0.688**	-0.005	0.001	-0.205	-0.079	0.093	-0.109
SC13	-0.039	0.242	-0.130	-0.031	-0.006	0.045	0.054	-0.060	-0.011	**0.487**	0.003	-0.045	-0.128	-0.103	-0.093	-0.080
SI01	-0.041	0.053	-0.040	-0.003	-0.057	-0.122	-0.033	-0.080	0.177	0.079	**0.814**	0.136	-0.017	-0.007	0.094	0.068
SI02	0.014	0.024	-0.017	-0.037	-0.011	-0.079	-0.051	-0.044	0.191	0.039	**0.762**	0.144	0.034	-0.020	0.118	0.027
SI04	0.040	-0.137	-0.016	0.006	-0.100	-0.102	-0.036	0.023	0.099	-0.175	**0.661**	0.088	0.035	0.110	0.125	0.032
SI05	-0.004	-0.112	0.100	0.053	0.044	-0.199	-0.141	0.056	0.142	-0.070	**0.806**	0.237	0.138	0.023	0.073	0.063
SC09	-0.044	-0.250	0.299	0.189	0.084	-0.272	-0.015	0.253	0.033	-0.204	0.070	**0.393**	0.222	0.129	-0.013	0.031
SI06	0.057	0.031	-0.028	0.027	0.014	-0.172	-0.061	0.080	0.115	0.051	0.314	**0.612**	0.063	0.042	0.107	0.124
WC6	0.021	-0.031	0.175	0.117	-0.038	-0.185	-0.003	0.131	0.032	-0.234	0.111	**0.625**	0.223	0.043	0.106	0.123

Group	Human							Activity		Context						Perfor-mance
Items	Job Sat 2	Job Sat 1	JRT1 intconf	JRT 2 extconf	Occp Stress	Fatigue	Sleep	Driving task	Job Demand	Safety	Safety Issue	Working condition	Work conditi on	Work Env2	Work Env	Perfor-mance
WC7	-0.153	-0.150	0.275	0.206	0.053	-0.191	0.003	0.160	0.107	-0.173	0.042	**0.680**	0.252	0.089	-0.058	0.149
WE3	0.081	0.054	0.047	0.047	0.110	-0.045	0.042	0.019	-0.031	0.047	0.067	**0.503**	-0.016	0.016	0.176	0.139
WC2	-0.029	-0.202	0.206	0.011	-0.106	-0.164	-0.023	0.089	0.113	-0.273	0.069	0.185	**0.423**	0.282	0.061	0.019
WC4	0.026	-0.090	0.190	0.062	-0.006	-0.201	-0.013	0.084	0.145	-0.202	0.035	0.168	**0.657**	0.105	0.087	0.028
WC5	-0.092	-0.253	0.307	0.078	0.039	-0.206	0.007	0.146	0.061	-0.313	0.061	0.214	**0.986**	0.143	0.081	0.165
SC14	-0.023	-0.136	0.200	0.154	0.103	-0.179	-0.185	0.210	0.100	-0.166	0.133	0.171	0.059	**0.462**	0.040	-0.057
WE12	-0.097	-0.228	0.228	0.031	-0.020	-0.112	-0.006	0.113	0.161	-0.230	0.083	0.095	0.154	**0.695**	0.033	-0.074
WE14	0.032	-0.166	0.163	0.097	0.025	-0.058	-0.045	0.148	0.106	-0.124	0.038	0.098	0.196	**0.867**	-0.012	-0.110
WE15	-0.008	-0.225	0.150	0.182	0.008	-0.086	-0.110	0.176	-0.082	-0.218	-0.077	0.082	0.083	**0.654**	-0.131	-0.059
WE9	-0.065	-0.143	0.142	0.069	0.160	-0.206	-0.159	0.025	0.111	-0.206	0.128	0.225	0.093	**0.037**	0.069	0.061
WE10	-0.010	0.185	-0.214	0.061	-0.022	0.249	0.096	-0.024	-0.018	0.113	-0.125	-0.018	-0.192	-0.126	**-0.375**	-0.063
WE11	0.103	0.207	-0.235	-0.158	-0.022	0.128	0.052	-0.133	0.064	0.243	0.083	0.061	-0.156	-0.107	**0.085**	0.024
WE13	-0.032	0.269	-0.228	0.015	-0.043	0.259	0.153	-0.071	-0.148	0.332	-0.202	-0.089	-0.263	-0.102	**-0.328**	-0.035
WE2	0.104	0.179	-0.161	-0.015	-0.005	0.093	0.033	0.005	-0.093	0.249	-0.110	-0.017	-0.216	-0.219	**0.264**	0.085
WE4	0.201	0.150	-0.104	-0.169	0.053	0.124	-0.181	-0.095	0.063	0.142	0.028	0.127	-0.050	0.018	**0.441**	0.060
WE5	0.125	0.287	-0.352	-0.234	0.001	0.235	0.023	-0.246	0.078	0.157	0.028	0.047	-0.116	-0.082	**0.227**	0.035
WE6	0.148	0.273	-0.323	-0.082	0.017	0.268	0.015	-0.167	-0.015	0.233	-0.041	0.005	-0.227	-0.174	**0.038**	0.010
WE7	0.030	0.120	-0.151	0.049	-0.068	0.197	0.142	0.013	-0.068	0.188	-0.067	-0.051	-0.191	-0.047	**-0.530**	-0.104
WE8	0.130	0.257	-0.204	0.032	-0.021	0.207	0.044	-0.089	-0.032	0.241	-0.131	-0.008	-0.266	-0.145	**-0.217**	-0.015
PMS2008	-0.028	-0.178	0.177	0.028	0.325	-0.141	-0.048	0.083	-0.118	-0.158	0.020	0.157	0.064	-0.078	0.168	**0.763**
PMS2009	-0.054	-0.116	0.224	0.129	0.305	-0.203	-0.117	0.179	0.004	-0.172	0.067	0.185	0.151	-0.106	0.127	**0.816**
PMS2010	-0.053	-0.095	0.147	0.089	0.232	-0.115	-0.126	0.121	-0.032	-0.129	0.071	0.145	0.069	-0.096	0.096	**0.729**
PMS2011	-0.003	0.038	0.050	0.088	0.162	-0.090	-0.042	0.077	0.009	-0.145	0.056	0.162	0.173	-0.130	0.181	**0.678**

Three iterations of the cross-loadings analysis were conducted with a total of 27 deletions in the 1st iteration and a further 6 items in the 2nd iteration. This cross-loadings assessment measures the relationship of each item to other factors. Table 5.11 shows the final result of the items loading, showing that loadings highlighted in bold were measuring a particular factor while others were cross-loadings. This confirms the composite reliability of the items, where all items with high loading were measuring a particular factor but loaded lower on other factors (Ramayah et al., 2011). Loading of the item on its particular construct (factor) should be high, but its contribution to other constructs (factors) should be low (Chin, 2010).

Table 5.10: Loadings and cross loadings after 3-time algorithm

Group	Human						Activity		Context						Perfor-mance
Items	Fatigue	Occp Stress	JRT1 intconf	JRT 2 extconf	Job Sat 1	Job Sat 2	Driving task	Job Demand	Working condition	Safety culture	Safety Issue	Sleep	Work Env2	Work conditi on	Perfor-mance
FF01	**0.718**	0.289	-0.420	-0.277	0.325	-0.002	-0.389	-0.052	-0.253	0.305	-0.122	0.167	-0.139	-0.136	-0.045
FF02	**0.839**	0.283	-0.445	-0.239	0.244	0.081	-0.343	-0.055	-0.194	0.248	-0.183	0.282	-0.094	-0.186	-0.166
FF03	**0.840**	0.265	-0.335	-0.292	0.240	0.048	-0.421	-0.005	-0.203	0.207	-0.141	0.269	-0.067	-0.195	-0.211
FF04	**0.533**	0.124	-0.295	-0.072	0.222	-0.096	-0.158	0.022	-0.092	0.128	-0.066	0.155	-0.001	-0.167	-0.037
FF06	**0.748**	0.237	-0.327	-0.228	0.324	0.040	-0.312	0.012	-0.208	0.212	-0.117	0.187	-0.106	-0.151	-0.106
FF07	**0.725**	0.302	-0.310	-0.208	0.215	0.086	-0.255	0.044	-0.138	0.185	-0.107	0.178	-0.047	-0.133	-0.105
STR1	0.265	**0.801**	-0.193	-0.081	0.150	-0.001	-0.197	-0.116	0.056	0.125	-0.091	0.063	-0.141	-0.156	0.146
STR19	0.201	**0.672**	-0.296	-0.138	0.207	0.170	-0.344	0.053	-0.069	0.153	-0.042	-0.009	-0.110	-0.130	0.140
STR2	0.320	**0.786**	-0.276	-0.161	0.111	-0.011	-0.251	-0.174	-0.040	0.100	-0.040	0.093	-0.139	-0.124	0.085
JRT11	-0.294	-0.147	**0.696**	0.361	-0.227	-0.093	0.286	-0.061	0.046	-0.246	-0.078	-0.165	0.067	0.152	0.146
JRT13	-0.233	-0.208	**0.514**	0.254	-0.051	-0.037	0.325	0.134	0.160	-0.087	0.023	-0.074	0.129	0.070	0.047
JRT15	-0.337	-0.277	**0.570**	0.323	-0.208	-0.035	0.348	0.093	0.195	-0.203	0.067	-0.091	0.189	0.201	0.130
JRT3	-0.316	-0.241	**0.644**	0.346	-0.177	-0.034	0.370	0.011	0.115	-0.228	0.008	-0.049	0.162	0.176	0.134
JRT5	-0.296	-0.314	**0.677**	0.283	-0.180	-0.087	0.386	0.107	0.137	-0.229	-0.002	-0.096	0.160	0.256	0.128
JRT7	-0.260	-0.119	**0.695**	0.239	-0.265	-0.091	0.225	0.101	0.141	-0.271	0.042	-0.016	0.146	0.258	0.154
JRT9	-0.304	-0.228	**0.526**	0.223	-0.207	0.018	0.392	0.001	0.185	-0.236	0.041	-0.001	0.181	0.217	0.050
JRT1	-0.336	-0.130	0.355	**0.732**	-0.206	-0.047	0.386	-0.058	0.207	-0.140	0.018	-0.213	0.092	0.086	0.082
JRT14	-0.159	-0.121	0.371	**0.813**	-0.107	-0.031	0.333	0.038	0.078	-0.145	0.021	-0.071	0.087	0.041	0.096

Table 5.10: Loadings and cross loadings after 3-time algorithm (cont.)

Group	Human						Activity		Context						Perfor-mance
Items	Fatigue	Occp Stress	JRT1 intconf	JRT 2 extconf	Job Sat 1	Job Sat 2	Driving task	Job Demand	Working condition	Safety culture	Safety Issue	Sleep	Work Env2	Work conditi on	Perfor-mance
JS1	0.213	0.144	-0.154	-0.191	**0.620**	0.077	-0.257	0.333	0.005	0.250	0.087	0.052	-0.297	-0.150	-0.039
JS2	0.292	0.171	-0.240	-0.181	**0.806**	0.107	-0.169	0.217	-0.046	0.360	-0.044	0.084	-0.211	-0.231	-0.118
JS3	0.198	0.127	-0.210	-0.074	**0.666**	0.034	-0.042	0.001	0.010	0.347	-0.117	0.127	-0.158	-0.124	-0.093
JS4	0.278	0.208	-0.306	-0.204	**0.847**	0.048	-0.244	0.184	-0.074	0.307	-0.037	0.171	-0.133	-0.193	-0.118
JS5	0.208	0.146	-0.227	-0.068	**0.768**	0.036	-0.182	0.153	-0.029	0.299	0.032	0.123	-0.223	-0.201	-0.053
JS6	0.031	0.023	-0.021	-0.034	0.096	**0.863**	0.011	0.052	0.062	-0.003	0.066	-0.024	0.023	-0.081	-0.040
JS7	0.079	0.110	-0.139	-0.073	0.076	**0.907**	-0.058	-0.012	-0.055	-0.020	-0.055	-0.020	-0.041	-0.047	-0.050
JS8	0.041	0.063	-0.069	0.020	0.001	**0.722**	0.036	-0.063	-0.030	0.062	-0.048	-0.003	-0.055	-0.095	-0.019
DT1	-0.224	-0.239	0.406	0.370	-0.067	0.028	**0.700**	0.062	0.053	-0.112	-0.012	-0.116	0.079	0.131	0.110
DT2	-0.458	-0.235	0.419	0.370	-0.268	-0.014	**0.764**	0.005	0.135	-0.175	-0.040	-0.152	0.180	0.122	0.107
DT3	-0.249	-0.271	0.284	0.346	-0.178	-0.010	**0.768**	-0.142	0.118	-0.164	-0.008	-0.029	0.131	0.050	0.135
DT4	-0.343	-0.257	0.337	0.154	-0.099	-0.086	**0.529**	-0.008	0.182	-0.119	0.024	-0.150	0.102	0.141	0.067
JCH1	-0.002	-0.102	0.075	-0.006	0.172	-0.037	-0.054	**0.750**	0.049	-0.046	0.187	-0.036	-0.013	0.048	-0.036
JCH2	0.011	-0.035	0.060	-0.041	0.172	0.008	-0.056	**0.835**	0.089	0.018	0.095	0.001	0.080	0.110	-0.044
JCH5	-0.053	-0.059	0.029	0.058	0.100	0.051	0.051	**0.513**	0.049	0.031	0.174	-0.040	0.146	-0.024	-0.024
SI06	-0.172	0.029	-0.032	0.022	0.033	0.057	0.081	0.114	**0.610**	0.047	0.310	-0.139	0.027	0.060	0.120
WC6	-0.185	-0.121	0.178	0.121	-0.031	0.019	0.130	0.032	**0.634**	-0.222	0.110	0.022	0.086	0.215	0.124
WC7	-0.190	-0.157	0.279	0.211	-0.149	-0.152	0.161	0.103	**0.678**	-0.204	0.040	-0.008	0.122	0.242	0.150
WE3	-0.045	0.212	0.044	0.059	0.053	0.078	0.020	-0.027	**0.509**	0.071	0.069	0.019	0.016	-0.020	0.140
SC05	0.300	0.196	-0.413	-0.178	0.394	-0.036	-0.188	-0.017	-0.182	**0.810**	-0.047	0.032	-0.270	-0.301	-0.185
SC08	0.141	0.113	-0.149	-0.076	0.310	0.027	-0.119	-0.004	-0.086	**0.793**	0.002	0.045	-0.100	-0.208	-0.158

Table 5.10: Loadings and cross loadings after 3-time algorithm (cont.)

Group	Human						Activity		Context						Perfor-mance
Items	Fatigue	Occp Stress	JRT1 intconf	JRT 2 extconf	Job Sat 1	Job Sat 2	Driving task	Job Demand	Working condition	Safety culture	Safety Issue	Sleep	Work Env2	Work conditi on	Perfor-mance
SC10	0.178	0.060	-0.227	-0.180	0.247	0.027	-0.170	0.029	0.013	**0.695**	-0.004	0.040	-0.082	-0.200	-0.108
SI01	-0.122	-0.025	-0.042	0.003	0.053	-0.042	-0.080	0.177	0.137	0.082	**0.819**	-0.012	-0.021	-0.019	0.069
SI02	-0.079	0.000	-0.018	-0.022	0.023	0.012	-0.044	0.191	0.144	0.046	**0.771**	-0.011	-0.018	0.030	0.030
SI04	-0.102	-0.126	-0.011	0.012	-0.138	0.039	0.023	0.100	0.086	-0.161	**0.666**	-0.011	0.104	0.028	0.034
SI05	-0.199	-0.103	0.100	0.063	-0.113	-0.005	0.057	0.141	0.231	-0.089	**0.794**	-0.119	0.045	0.134	0.061
FSL02	0.254	0.056	-0.135	-0.171	0.124	-0.011	-0.147	-0.006	-0.046	0.041	-0.048	**0.928**	-0.047	0.039	-0.078
FSL03	0.160	0.078	-0.114	-0.185	0.145	-0.091	-0.109	-0.033	-0.032	0.064	0.017	**0.577**	-0.002	0.019	-0.026
FSL07	0.242	-0.023	0.046	0.004	0.098	0.040	-0.016	-0.063	0.019	0.006	-0.103	**0.564**	0.011	0.023	-0.026
WE12	-0.112	-0.143	0.232	0.030	-0.228	-0.098	0.113	0.158	0.086	-0.216	0.085	0.028	**0.781**	0.127	-0.077
WE14	-0.058	-0.136	0.168	0.096	-0.166	0.031	0.147	0.099	0.094	-0.110	0.037	-0.017	**0.908**	0.179	-0.109
WE15	-0.086	-0.145	0.155	0.172	-0.225	-0.009	0.176	-0.089	0.075	-0.237	-0.079	-0.115	**0.704**	0.069	-0.062
WC4	-0.201	-0.156	0.195	0.076	-0.090	0.025	0.085	0.145	0.159	-0.212	0.032	0.029	0.129	**0.649**	0.027
WC5	-0.207	-0.178	0.312	0.075	-0.252	-0.092	0.147	0.063	0.202	-0.311	0.058	0.039	0.161	**0.992**	0.163
PMS2008	-0.141	0.184	0.170	0.024	-0.178	-0.027	0.082	-0.116	0.159	-0.163	0.019	-0.019	-0.058	0.058	**0.754**
PMS2009	-0.203	0.063	0.217	0.132	-0.115	-0.053	0.179	0.005	0.183	-0.173	0.065	-0.055	-0.076	0.157	**0.797**
PMS2010	-0.115	0.147	0.144	0.097	-0.096	-0.053	0.122	-0.036	0.151	-0.127	0.072	-0.080	-0.099	0.079	**0.754**
PMS2011	-0.091	0.125	0.047	0.097	0.037	-0.004	0.077	0.009	0.171	-0.141	0.057	-0.071	-0.092	0.175	**0.687**

5.3.2 Convergent validity

Convergent validity was assessed through factor loadings, composite reliability and average variance extracted (AVE) (Hair et al., 2010). The loading of the items should be greater than 0.5 with composite reliability (CR) values of 0.7 (Hair et al., 2010). The average variance extracted (AVE) proposed by Fornell and Larcker (1981) was to measure the variance amount from the indicators relative to measurement error. For convergent validity, the AVE values should be more than 0.5 (Chin, 2010).

Table 5.11: Results of the measurement model

Domain	Factors	Items	Loading	AVE	CR
Human	Fatigue	FF01	0.718	0.549	0.878
		FF02	0.839		
		FF03	0.840		
		FF04	0.533		
		FF06	0.748		
		FF07	0.725		
	Job related tension (external conflict)	JRT1	0.732	0.598	0.748
		JRT14	0.813		
	Job related tension (internal conflict)	JRT11	0.696	0.586	0.813
		JRT13	0.514		
		JRT15	0.570		
		JRT3	0.644		
		JRT5	0.677		
		JRT7	0.695		
		JRT9	0.526		
	Job Satisfaction 1	JS1	0.620	0.557	0.861
		JS2	0.806		
		JS3	0.666		
		JS4	0.847		
		JS5	0.768		
	Job Satisfaction 2	JS6	0.863	0.696	0.872
		JS7	0.907		
		JS8	0.722		
	Occupational Stress	STR1	0.801	0.570	0.798
		STR19	0.672		
		STR2	0.786		

Table 5.11: Results of the measurement model (cont.)

Domain	Factors	Items	Loading	AVE	CR
Human	**Sleep**	FSL02	0.928	0.504	0.742
		FSL03	0.577		
		FSL07	0.564		
Activity	**Driving task**	DT1	0.700	0.486	0.788
		DT2	0.764		
		DT3	0.768		
		DT4	0.529		
	Job Demand	JCH1	0.750	0.507	0.748
		JCH2	0.835		
		JCH5	0.513		
Context	**Working condition**	SI06	0.610	0.373	0.702
		WC6	0.634		
		WC7	0.678		
		WE3	0.509		
	Safety Culture	SC05	0.810	0.589	0.811
		SC08	0.793		
		SC10	0.695		
	Safety Issue	SI01	0.819	0.585	0.848
		SI02	0.771		
		SI04	0.666		
		SI05	0.794		
	Working Environment 2	WE12	0.781	0.643	0.842
		WE14	0.908		
		WE15	0.704		
	Work Facilities	WC4	0.649	0.703	0.819
		WC5	0.992		
	Performance	PMS2008	0.754	0.561	0.836
		PMS2009	0.797		
		PMS2010	0.754		
		PMS2011	0.687		

Table 5.11 summarizes the results of the measurement model, showing that the values for loadings and CR for all the domains of human, activity and context are generally greater than the cut-off value for loadings and composite reliability (CR). However, two factors of driving task and working condition had AVE values below the cut-off value of 0.5 recommended by Fornell and Larcker (1981). Therefore, there should be a re-examination of the measurement model.

The re-examination is conducted by individual removal of the lowest items for each particular factor and recalculating the PLS algorithm. Items DT4 and WE3 were removed, since they did not meet the AVE minimum value of 0.5. After deletion of item DT4, the AVE values of *driving task* factor and *working condition* improved from 0.486 to 0.579 and from 0.373 to 0.503, respectively.

Table 5.12 presents the results after recalculation, showing that all the constructs have met the recommended values and are thus reliable and valid. The values highlighted in grey boxes shows the improved values after deletion of unreliable items.

Table 5.12: Results of the final measurement model

Domain	Factors	Items	Loading	AVE	CR
Human	Fatigue	FF01	0.718	0.549	0.878
		FF02	0.839		
		FF03	0.840		
		FF04	0.533		
		FF06	0.748		
		FF07	0.725		
	Job related tension (external conflict)	JRT1	0.732	0.598	0.748
		JRT14	0.813		
	Job related tension (internal conflict)	JRT11	0.696	0.586	0.813
		JRT13	0.514		
		JRT15	0.570		
		JRT3	0.644		
		JRT5	0.677		
		JRT7	0.695		
		JRT9	0.526		
	Job Satisfaction 1	JS1	0.620	0.557	0.861
		JS2	0.806		
		JS3	0.666		
		JS4	0.847		
		JS5	0.768		

Table 5.12: Results of measurement model (cont.)

Domain	Factors	Items	Loading	AVE	CR
Human	Job Satisfaction 2	JS6	0.863	0.696	0.872
		JS7	0.907		
		JS8	0.722		
	Occupational Stress	STR1	0.801	0.570	0.798
		STR19	0.672		
		STR2	0.786		
	Sleep	FSL02	0.928	0.504	0.742
		FSL03	0.577		
		FSL07	0.564		
Activity	Driving task	DT1	0.700	0.579	0.788
		DT2	0.764		
		DT3	0.768		
	Job Demand	JCH1	0.750	0.507	0.748
		JCH2	0.835		
		JCH5	0.513		
Context	Working condition	SI06	0.610	0.503	0.702
		WC6	0.634		
		WC7	0.678		
	Safety Culture	SC05	0.810	0.589	0.811
		SC08	0.793		
		SC10	0.695		
	Safety Issue	SI01	0.819	0.585	0.848
		SI02	0.771		
		SI04	0.666		
		SI05	0.794		
	Working Environment 2	WE12	0.781	0.643	0.842
		WE14	0.908		
		WE15	0.704		
	Work Facilities	WC4	0.649	0.703	0.819
		WC5	0.992		
	Performance	PMS2008	0.754	0.561	0.836
		PMS2009	0.797		
		PMS2010	0.754		
		PMS2011	0.687		

5.3.3 Discriminant Validity

Discriminant validity is another assessment of the constructs (factors) to test the validity of the measurement. Discriminant validity tests whether believed unrelated constructs are indeed unrelated. Thus the cross-construct correlations should be very low, whereas it should measure strongly the construct it attempts to reflect (Chin, 2010). The discriminant validity of this study is presented in Table 5.13, showing the average variance extracted (AVE) of the factor (construct), indicated in bold, is much greater than the squared correlations for each constructs. This indicates adequate discriminant validity is achieved. Since the measurement model demonstrated adequate convergent validity and discriminant validity, this indicated that each factor (construct) was unique and captured phenomena not represented by other factors in the model (Hair et al., 2014).

Table 5.13: Discriminant validity of construct

	Work condition	Driving task	Fatigue	JRT 2 extconf	JRT1 intconf	Job Demand	Job Sat 1	Job Sat 2	Occp Stress	Perfor-mance	Safety Culture	Safety Issue	Sleep	Work Env2	Work Facilities
Working condition	**0.503**														
Driving task	0.025	**0.579**													
Fatigue	0.066	0.160	**0.550**												
JRT 2 extconf	0.030	0.223	0.095	**0.598**											
JRT1 intconf	0.046	0.226	0.213	0.219	**0.586**										
Job Demand	0.014	0.002	0.000	0.000	0.006	**0.507**									
Job Sat 1	0.006	0.051	0.106	0.038	0.100	0.045	**0.557**								
Job Sat 2	0.002	0.000	0.004	0.002	0.009	0.000	0.007	**0.696**							
Occp Stress	0.016	0.107	0.115	0.026	0.111	0.008	0.047	0.006	**0.571**						
Performance	0.035	0.024	0.035	0.013	0.041	0.003	0.017	0.002	0.030	**0.560**					
Safety culture	0.035	0.039	0.077	0.034	0.127	0.000	0.180	0.000	0.030	0.041	**0.589**				
Safety Issue	0.041	0.001	0.031	0.001	0.000	0.040	0.002	0.000	0.007	0.005	0.001	**0.584**			
Sleep	0.003	0.015	0.088	0.031	0.014	0.001	0.025	0.001	0.003	0.005	0.002	0.003	**0.506**		
Work Env2	0.013	0.029	0.010	0.013	0.051	0.008	0.060	0.000	0.029	0.011	0.045	0.001	0.001	**0.643**	
Work Facilities	0.063	0.016	0.048	0.006	0.098	0.006	0.059	0.006	0.034	0.023	0.099	0.003	0.002	0.028	**0.701**

*Diagonals (in bold) represent the AVE while the off diagonals represent the squared correlations

5.4 Evaluation of the structural model

Once it has been determined that the factors are reliable and valid, the subsequent process is to analyse the structural model by testing the hypothesis (Anderson & Gerbing, 1991; Chin, 2010). The assessment of the structural model is used to determine whether the concept which has been selected is empirically confirmed.

The modified model consists of three domains with fourteen hypotheses. Table 5.14 lists the hypotheses of the modified model after factor analysis process.

Table 5.14: List of the hypotheses of the modified model

E.g.: (Factor) has a significant effect on the performance of train driver

Domain	Hypothesis	
Human	**H1**	Occupational stress
	H2a	Job related tension (internal conflict)
	H2b	Job related tension (external conflict)
	H3a	Job satisfaction (1)
	H3b	Job satisfaction (2)
	H4	Fatigue
	H5	Sleepiness
Activity	**H6**	Job demand
	H7	Driving task
Context	**H8a**	Working environment
	H8b	Work facilities
	H9a	Safety culture
	H9b	Safety issue
	H10	Working condition

Hypothesis testing was used to examine the path loadings and β-value between constructs of the inner model. Furthermore, bootstrapping technique was implemented with t-statistics to test for significance. Table 5.15 shows the path coefficients' and the results of hypothesis testing.

Table 5.15: Path coefficients' and hypothesis testing

Cluster	Hypothesis		Beta	Standard Error	t-value	Decision
Human	**H1**	Occupational Stress → Performance	0.328	0.074	4.448***	Significant
	H2a	Job related tension (internal conflict) → Performance	0.148	0.074	1.998**	Significant
	H2b	Job related tension (external conflict)→ Performance	-0.043	0.073	0.587	Not significant
	H3a	Job Satisfaction 1 → Performance	-0.042	0.071	0.584	Not significant
	H3b	Job Satisfaction 2 → Performance	-0.045	0.069	0.648	Not significant
	H4	Fatigue → Performance	-0.085	0.073	1.371*	Significant
	H5	Sleep → Performance	-0.026	0.080	0.327	Not significant
Activity	**H6**	Job Demand → Performance	-0.037	0.086	0.428	Not significant
	H7	Driving task → Performance	0.141	0.065	2.170**	Significant
Context	**H8a**	Working environment→ Performance	-0.176	0.073	2.417***	Significant
	H8b	Work facilities → Performance	0.076	0.070	1.089	Not significant
	H9a	Safety culture→ Performance	-0.133	0.065	2.065**	Significant
	H9b	Safety Issue → Performance	0.060	0.084	0.712	Not significant
	H10	Working condition→ Performance	0.120	0.062	1.935**	Significant

Note: *(10%) $p<0.1 = 1.28$; **(5%) $p<0.05 = 1.645$; *** (1%) $p<0.01=2.33$ | One-tailed test

From the seven hypotheses drawn for human domain, three factors were found to be not significant. The non-significant factors were job related tension (external conflict) and two factors of job satisfactions. Fatigue was positively related (t= 1.371, $p<0.1$) with the performance of the train driver. Other factors tested for hypotheses for the human domain were job related tension (internal conflict) ($t=1.998$, $p<0.05$) and occupational stress ($t=4.448$, $p<0.01$) towards performance of the train driver.

For the activity domain, the driving task was found to have positive relationship to performance as its hypothesis is significant ($t = 2.170$, $p<0.05$). Conversely, the job demand was found as a non-significant factor on train driver performance ($t = 0.428$).

The context domain has five factors, from which only three factors had significant hypothesis. The significant factors having direct positive effects on the performance of train drivers wer safety culture ($t=2.065$, $p<0.05$), working environment ($t=2.417$, $p<0.01$) and working condition ($t=1.935$, $p<0.05$). On the other hand, safety issue and working condition were found to be non-significant to the performance of the driver.

Figure 5.6 shows the overall graphical representation of the model. From the fourteen hypotheses tested, only seven were accepted which were found to have a strong influence on the performance of the train driver. These hypotheses are: H1 (occupational stress), H2a (job related tension – internal conflict), H4 (fatigue), H7 (driving task), H8a (work environment), H9a (safety culture) and H10 (working condition).

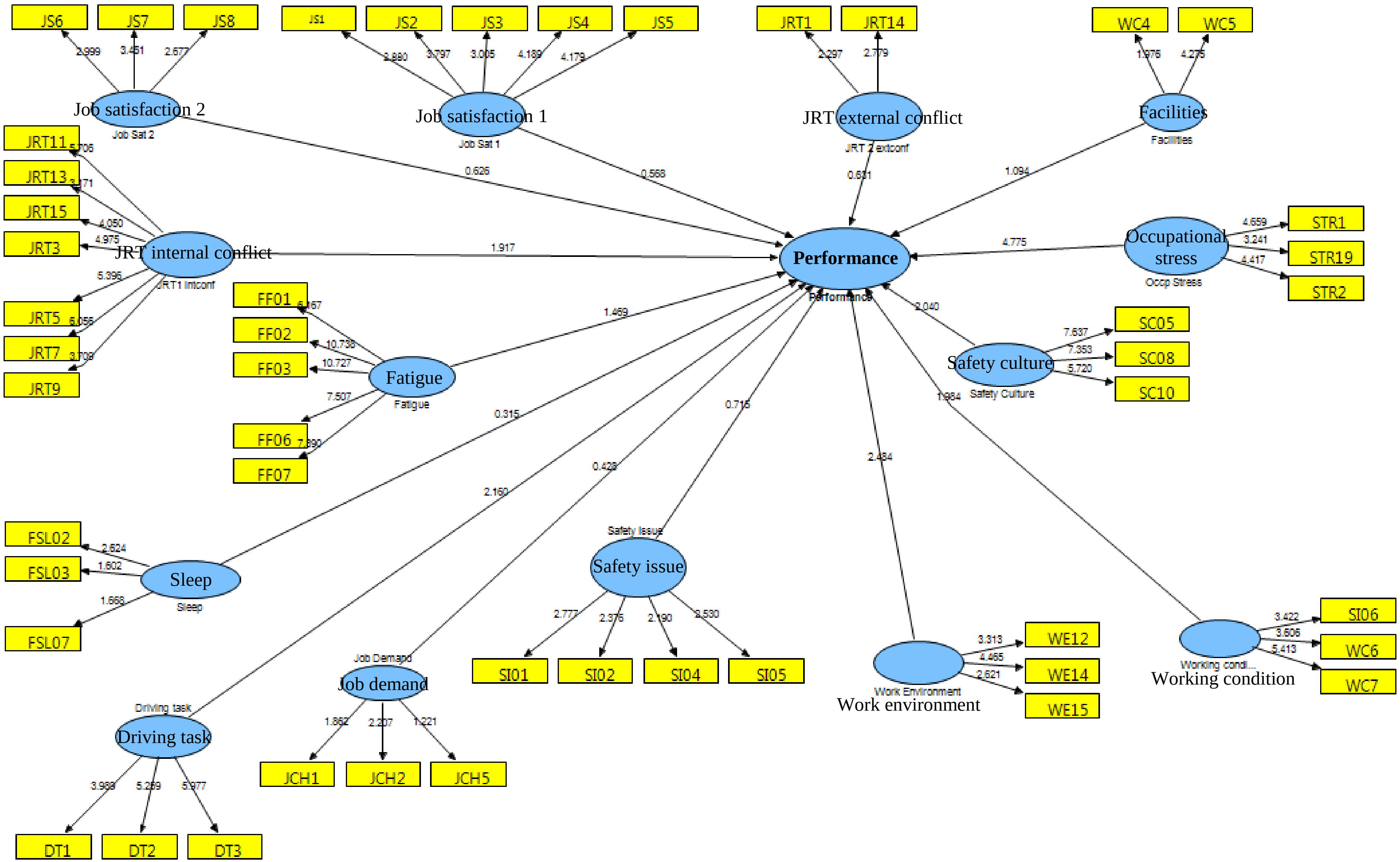

Figure 5.6: Structural model of train driver performance model

5.4.1 The performance model

Fourteen factors were initially evaluated by hypothesis testing, from which seven factors were identified to be significant. Table 5.16 lists the seven factors which influence the performance of train drivers in Malaysia, which are *job-related tension (internal conflict), fatigue, occupational stress, driving task*, *work environment*, *working condition* and *safety*. The integrated performance model of Malaysian train drivers is presented graphically in Figure 5.7.

Table 5.16: Factors affecting performance of the Malaysian train drivers

Cluster	Hypothesis	
Human	**H1**	Occupational stress in Malaysia
	H2a	Job related tension (internal conflict)
	H4	Fatigue
Activity	**H7**	Driving task
Context	**H8a**	Work environment
	H9a	Safety culture
	H10	Working condition

*(Factor) has a significant effect on the performance of train drivers

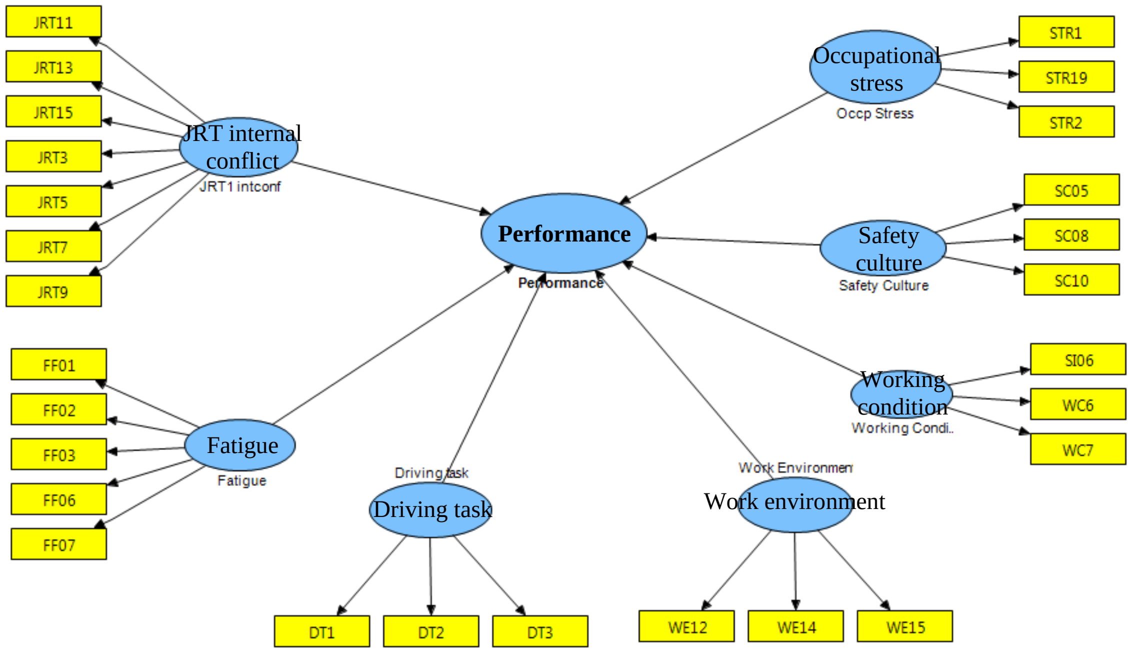

Figure 5.7: Malaysian train driver integrated performance model

The integrated train driver performance model was developed based on SEM-PLS algorithm, utilising shapes (oval and rectangles) and arrows to show the relationship between constructs and indicator variables. A simplified representation is shown in Figure 5.8, consisting of 3 concentric circles. The innermost circle is the main objective of the study on the performance of the train driver. The outermost circle is divided into three to indicate the three domains influencing the performance of the train drivers, which are human, context and activity; as discussed in Chapter Three. The middle circle represents the factors which affects the performance of the train driver. For clarity, the colour schemes for the factors are chosen to be similar to their respective associated domain. This middle circle is dynamic, meaning that for future studies; factors can be inserted or removed to suit the circumstances of that particular study. However, the factors added would still be grouped under the three major domains. The simplified version of the integrated Malaysian train driver performance model is deemed to be easily understood by the general public and could be used as guidance for the management and stakeholders in managing human capital in the TOC.

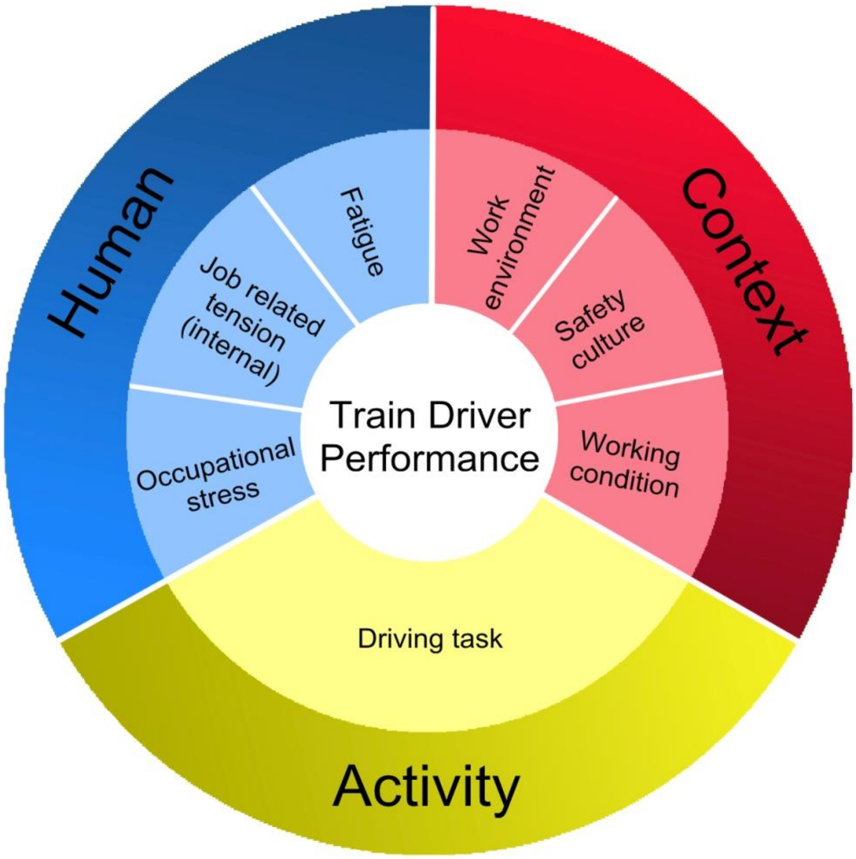

Figure 5.8: An integrated Malaysian train driver performance model

5.5 Summary

Three domains, namely human, activity and context, were proposed to categorise the fourteen factors. The relationships between factors were evaluated iteratively using SEM-PLS. The measurement model was also evaluated through composite reliability, prioritizing the indicators according to their individual reliability. This evaluation technique validated that all items with high loading were measuring a particular factor but were loaded lower on other factors. The convergent validity was also measured and confirmed that the items used were valid, reliable, and correlated positively to measure the same construct (factor). Discriminant validity was performed to assess the validity of the measurements, to ensure that constructs were not measuring other constructs or overlapping constructs. It is expected that the cross-construct correlations should be very low but would measure strongly the construct it attempts to reflect. It was found that all factors have average variance extracted (AVE) values greater than 0.5, indicating that each factor was unique and captured phenomena not represented by other factors in the model.

From the originally proposed structural model having fourteen hypotheses, only seven hypotheses were found to be significant. These are *job-related tension (internal conflict), fatigue, occupational stress, driving task, work environment, working condition* and *safety culture.* The results highlighted that the three domains i.e. human, context and activity with their seven factors are important in developing an integrated train driver performance model for Malaysia.

CHAPTER 6 : DISCUSSIONS AND BENCHMARKING

6.1 Introduction

This chapter is divided into six sections on the summary of the results and discussions of the findings. The developed model of Malaysian train driver performance with factors affecting in particular domains of this study is discussed in the second until fifth sections, while Section Six highlights the benchmarking study. The significant contributions of this study conclude this chapter.

6.2 The developed model of Malaysian train driver performance

A theoretical framework of train driver performance was proposed and developed in the earlier stage of this study. This framework consists of the potential influential factors, identified through extensive review of the literatures, based on the three main frameworks of Bailey (1996), Baines et al. (2005) and the model of Chang and Yeh (2010). Three main domains were introduced to categorise the main key indicators for measuring human performance namely, the human, activity and context for the Malaysian train drivers.

A survey was conducted based on the proposed framework to test the comprehensiveness of the model through fourteen hypotheses. The data analysis was conducted using SPSS and SEM, from which a model was then developed and tested empirically to identify the association between human performance and the three main influential domains; human, activity and context for the Malaysian train drivers.

From the hypothesis testing as reported in Section 5.4, seven out of fourteen hypotheses were found to be significant and supported the relationship suggested in the theoretical framework. The significant factors were occupational stress (H1), job related tension (internal conflict) (H2a), fatigue (H4), driving task (H7), working environment (H8a), safety culture (H9a) and working condition (H10). The remaining seven hypotheses were found to be insignificant. This results show that the performance of the train driver is not only influenced by the individual itself, but also from external factors of job demand, safety and working environment. An integrated model of Malaysian train driver performance was finally developed and proposed as one of the comprehensive model for the study the performance of train drivers as well as for general human performance measure.

The discussion on the factors affecting the performance of the train driver based on its domain will be presented in the next following sections.

6.3 Factors of human domain which affecting train driver performance

This section discusses the results of the hypotheses testing on the relationships between the train driver with factors of the human domain; i.e. occupational stress, job related tension, job satisfaction, fatigue and sleepiness.

In the proposed model, seven hypotheses (H1 – occupational stress, H2a - job related tension (internal conflict), H2b - job related tension (external conflict), H3a and H3b – job satisfaction, H4 – fatigue and H5 – sleepiness) were put forward, representing the influence of 'human' on train driver performance. Mixed results were obtained for the relationship between 'human' and performance. Occupational stress, H1 ($t=4.448$, $p<0.01$); job related tension – external conflict, H2b ($t=1.998$, $p<0.05$) and fatigue, H4 ($t=1.371$, $p<0.1$) were found to have strong correlations with performance. Others were found to be insignificant.

The influence of occupational stress (H1) ($t=4.448$, $p<0.01$) and job-related tension (internal conflicts) (H2a)($t=1.998$, $p<0.05$) on the train driver performance agrees well with the findings of past studies which have reported that occupational stress, caused by poor job design, layout setting, and high workload, are highly potential stressors which contribute to the increase level of stress (Jou et al., 2013). These external factors would intensify the mental pressure on the driver and ultimately affect their performance. In addition, job-related tension is the result from this stress and pressure, particularly caused by external factors (Yahaya et al., 2009). Thus, the stress and tension experienced by the driver were caused by their working environment and conditions, and was not due their own internal factors such as family, financial or relationship at work.

Fatigue (H4) ($t=1.371$, $p<0.1$) was also found to be a significant contributor to the performance level of the train driver. This results is not surprising as fatigue correlated significantly with alertness and performance of the driver (Dorrian et al., 2011; Dorrian et al., 2006, 2007; Fletcher & Dawson, 2001).. There is a relationship between safety, occupational stress and work-related driver fatigue, as reported by past studies on work-related accidents (Strahan et al., 2008). Other researchers have also related fatigue with safety, and have identified its significant influence the performance of the driver (Horrey et al., 2011; Williamson et al., 2011). Fatigue could cause reductions in the interactions between the driver and the train, resulting in an increased risk of accidents (Dorrian et al., 2007). It also reduces the level of alertness of signals, signs and the surroundings while driving (Hamilton & Clarke, 2005; Lamond et al., 2005). As time passes, the level of fatigue will gradually increase and if left unabated, will result in the driver falling asleep (Strahan et al., 2008). Previous studies have mentioned that driving a locomotive is a monotonous and boring task, and it will lead to fatigue and the driver becoming sleepy (Dorrian et al., 2011; Fletcher & Dawson, 2001).

Thus, these findings suggest that the performance of the train drivers were mostly relying on external factors that influenced their behaviours and reactions rather than internal factors. As such, job related tension – internal conflict (H2a), job satisfaction (H3a and H3b) and sleepiness (H5) were found insignificant towards the performance of the train driver.

Sleepiness, H5 (t=0.327) was found insignificant on the performance of the driver. The insignificance of sleepiness is probably due to the set-up of the train schedules and the duration of shifts. Train drivers in Peninsular Malaysia are located at seven different main depots, as reported in sub-chapter 4.6. Based on the observation of the train schedules (shown in Appendix 9), the drivers will drive the locomotive from one depot to the subsequent depot and there will be an exchange of crew members at the depots. The longest shift duration is for the 7 hours 50 minutes journey from Woodlands, Singapore to Kuala Lumpur on the 'Ekspres Rakyat' train route. Upon reaching Kuala Lumpur, there would be a change of crew for the subsequent 5 hours 50 minutes journey from Kuala Lumpur to Butterworth, Pulau Pinang. Similarly, the journey between depots for other routes averaged around 4 hours from one depot to another. Thus the length of shift and working hours is still within the permissible limit outlined in the Malaysia Employment Act 1955 (Amendment 2012). It has been reported that longer working hours were not an influential factor of sleepiness, although workload significantly influences fatigue (Dorrian et al. (2011). The train driver shifts were designed to provide enough sleep and rest, with proper facilities such as air-conditioned room with bathroom at the 'running bungalow' provided for the drivers. Therefore, with enough rest and sleep, the train drivers should not have problems with sleepiness.

Another hypothesis, the internal conflict which leads to job-related tension was also found to be insignificant to the train driver performance. In this study, the internal conflict factor focuses on the emotion and self-perception of the individuals, and differs from job-related tension (external conflict). The job-related tension (external conflict) (H2b) ($t=1.998$, $p<0.05$) has a strong relationship on the performance of the driver, although it appears to contradict with the job-related tension caused by internal conflict (H2a). It was found that an internal conflict which leads to job-related tension was not significant to the performance. In this study, the internal conflict has focused on the emotion and self-perception of the individuals. Thus, the results have indicated that the drivers were confident that they do not have internal conflicts that would affect their performance. This confidence is perhaps due to their understanding of their scope of work, their own capability to perform the job and that they were not concerned with the perception of others towards them. Hence, the results were found to be insignificant.

Another interesting finding was the relationship between job satisfaction and performance of the train driver. It was found that job satisfaction did not have a direct positive effect on the performance of the train driver. Genaidy et al. (2007) suggested that if the effort and reward is balanced, employees will be more satisfied with their job and results in better accomplishment of their work. In this study, almost 60% of the drivers were above 35 years old with over 75% having worked for more than six years. This statistics agrees well with previous study by Dawal et al. (2009) which indicated that satisfaction can be related with the age of the employee, their ability to adapt with the working environment and adjustment of their expectation and level of satisfaction. The TOC in this study is a government-linked company (GLC), which provide good facilities and benefits to their employees such as medical coverage, pension scheme and staff quarters. These benefits can be a major factor for employees to remain loyal with the company and to accordingly adjust their level of satisfaction of the job. Thus, job satisfaction is an insignificant factor of train driver performance.

6.4 Factors of activity domain which affecting train driver performance

In the “activity” domain, the driving task and job demand were hypothesized as important determinants of train driver performance. The hypotheses of job demand (H6) and driving task (H7) were formulated to examine this relationship. The result, as shown in section 5.4, has identified that the driving task (H7) positively influenced the performance of the train driver. ($t=2.170$, $p<0.05$).

This suggests that the train drivers were concerned of their activities while driving; which requires them to be alert and aware of the surroundings and several information along the track (Hamilton & Clarke, 2005). Similar reasoning were given by Kecklund et al. (2001) on the relationship of vigilance with train-driving activity. The train driver's activities in the driving cab include not only controlling of the power throttle, but also to verify that the locomotive is running in good condition, be alert with surrounding environments including illegal trespassers, signals, radio contact with control centre, and to ensure that both crews are always awake and paying attention since driving a locomotive is a boring and monotonous task (Jap et al., 2010). With these burden of responsibilities, the driving task is a significant stressor to the performance of the train driver.

The job demand is a work activity to be completed by the employees, as required by the superior or management (Schaufeli & Bakker, 2004). Surprisingly, the analysis has shown that the job demand was found insignificant, in contrast to the driving task which was significant to the performance of the train driver. Further analysis have shown that the performance of the train driver were more dependent on the immediate demand during the performance of the job, rather than the demand from the management. Demands from the superior and organisation were expected as a normal daily routine for the drivers. However since most of the demand were routine in nature, in which the train drivers are only required to follow their duty roster, be observant of standard operating procedure before driving and to be on standby for incomplete crew members. Furthermore, the company also provide accommodation facilities for those who are not from that reporting depot. The job demand is thus not a stressor to their performance as the demand was balanced and did not have high requirements (Schaufeli & Bakker, 2004).

6.5 Factors of context domain which affecting train driver performance

The literatures have highlighted the environment as one of the important elements influencing performance of the worker. In this study, factors surrounding the train drivers in the 'context' domain were evaluated to determine their relationship to the performance of the train driver. Five hypotheses were identified and posited, representing the 'context' domain which includes work environment, work facilities, safety culture, safety issue and working condition.

Consistent with earlier expectations, the result of this study has shown that the work environment, hypothesized in H8a, is an important variable influencing the performance of the train driver. This is further supported by past findings by Kahya (2007) and Niu (2010), both suggested that working condition, hypothesized in H10, are significant factor affecting performance of the employees.

Work is defined as "something to be done or something to do" (Oxford English Dictionary, 2013). Most literatures have regarded 'working conditions' and 'working environment' as interchangeable terms to refer to the physical surroundings of the workplace (Kahya, 2007; Kecklund et al., 1999). However, in literal terms, the working environment could be defined as "something to be done at the area surrounding a place or a thing" while working conditions refers to "something to be done at certain circumstances" which normally refers to work activities, working time and other working aspects ("Definition of 'condition', first published 1891," 2013; "Definition of 'environment', OED 3rd Edition, June 2011," 2013; "Definition of 'work', first published 1928," 2013). Baines et al. (2005) defined work environment as physical environment which relates to the workplace situation such as noise, temperature, and lighting. On the other hand, the term “organisational environment” was used to refer to the working activities, aspects, job rotation etc. instead of “working condition”. Thus, the approach in this study is to differentiate work environment and working conditions as two separate factors influencing the performance of the train driver.

The analysis of the data has shown that the performance of the train driver is affected by the working environment (H8a). These findings are in agreement with the findings by Kompier (1996) which found that the drivers were always complaining on the comfort level at their workplace. In addition the working environment in the transportation industry is dynamic and are exposed to the natural environment. The hot and humid weather of Malaysia can be discomforting, particularly in locomotives unequipped with air-conditioners. Poor working environment inside the driving cab can also lead to discomfort and uneasiness, which may affect other factors (i.e. stress, job-related tension etc.) as well as safety (Stanton & Salmon, 2011).

The working condition, hypothesized in H10, was also found to be significant to the performance of the train driver. Past research has yet to address the relationship between job characteristics and working conditions on employee’s performance (Kahya (2007). The ‘working condition’ is differentiated from the ‘work environment’, referring more towards the organisational environment, as discussed by Baines et al. (2005). Job rotation and schedule, shift and employment issue are some of the items within this factor (construct).

The analysis has shown that the train drivers agreed that working conditions have an influence on their performance. Their work tasks are based on shift work and dependent on the work schedule designed and provided by their supervisor. Improper management of the shift work and schedule may give rise to dissatisfaction of the job rotation and other job-related procedures and guidelines, and ultimately affect the performance of the train drivers (Taris & Schreurs, 2009).

Similarly, the relationship among colleagues and supervisors also plays an important role. Presence of amicable relationship creates a conducive environment and a nice place to work (Yan & Turban, 2009). The absence of good relationship may lead to other problem such as stress and burn out. Supervisor and the superiors have an important role in creating a conducive working condition. Since the findings from this study suggests that working conditions are significant to the performance of the train drivers, steps can be taken by the superior and the management to improve the working conditions for the drivers.

'Work facilities' was found to be insignificant, in contrast to the significant relationships of the working condition and work environment. The train drivers are required to be at the station one hour before driving, and then would spend most of their time working in the driving cab of the locomotive. Apart from a small number of new locomotives, most of the locomotives were old and not equipped with air-conditioners. The absence of air-conditioners may lead to discomfort, although the findings from this study have found that this was not a significant factor (Austin & Drummond, 1986).This is probably due to the good natural ventilation and air, as the rail tracks are mostly in suburban and rural areas, which are less polluted than in urban environments.

As previously mentioned in Chapter Four, a train journey in Malaysia from one depot to another would take only four to five hours. This work setting ensures that the drivers have ample time to go to the washroom and have their meals in between shifts. Due to the present layout of the single rail track, except for the Seremban - Kuala Lumpur – Ipoh sector having double tracks, the freight trains are required to wait at certain station or depot to give way to the express or passenger trains. During that time, the train driver and crew would also have enough time to ease themselves. In addition, the TOC also provide comfortable air-conditioned accommodation facilities at the depots for them to rest and sleep. Thus, since the train drivers were satisfied with the availability of these basic facilities, the work facilities, as hypothesised in H8b, had no significant relationship with performance of the train driver.

In the railway industry, the issue of safety is very pertinent and can become a threatening event to the TOC (Stanton & Salmon, 2011). This safety issue is related to safety problems caused by external parties, which includes persons on track, illegal trespassing, vandalism and strangers attack (Austin & Drummond, 1986). In this study, it was found that the issue of safety, as hypothesize in H9b, did not have a positive influence on the performance of the train driver.

The current construction of the double track project by the TOC and the government of Malaysia has incorporated extra precaution on public safety (Land Public Transport Commission, 2012). Safety fencing are being built alongside the track to prevent trespassing, especially as the new system is based on electrified locomotives which are much quieter and faster than the diesel counterparts. The track areas are also gazetted as restricted zones to the public, in contrast to past times where the public were able to cross the train tracks, especially in villages. Furthermore, the old diesel locomotives were noisy and noticeable from a distance and the number of train running were small due to the single track system. The double track project also includes upgrading of railway stations with improved facilities to cater for the requirements of the new trains and safety regulations. Safety personnel are promoted as auxiliary police to safeguard critical locations such as the stations, depots and other restricted areas. Bridge crossings or tunnels are also being built at the stations to keep cases of illegal track crossing to a minimum. The safety department of the TOC has also begun safety awareness campaign for the public, especially for villagers in the rural area along the rail track.

Since the issue of safety and safety compliance has been taken into account by the management of the TOC, it was thus found to be insignificant to the performance of the train driver.

Safety culture, as hypothesized in H9a, is another aspect of safety which may have a relationship on human performance. The results, as shown in Section 5.4, support the notion that safety culture influences the performance of the train driver (H9a). The concept of safety culture was initially introduced after the devastating accident of Chernobyl in 1986 (Reiman & Rollenhagen, 2014). The railway industry is considered to be a safety-critical domain (Stanton & Salmon, 2011); therefore it is important for the company to ensure safety in all of its services and stakeholders including passengers, employees and the system itself.

To achieve a situation which is considered safe, there is a need to nurture safety among employees as well as having the commitment from management of the company as part of the organisational culture (Glendon & Stanton, 2000). Furthermore, the requirement of safety is legally required. In Malaysia, the Act 463 Railway Act 1991 ("Railways Act 1991," Latest amendment 2010) outlined the obligatory requirement of safety which requires the TOC to ensure the safety of their services and premises during construction, installation and operation phases. This act is regulated by the Land Public Transport Commission (*Suruhanjaya Pengangkutan Awam Darat* – SPAD)("Suruhanjaya Pengangkutan Awam Darat Act 2010," 2010). To inculcate the safety culture among the employees, the company provides them with the Track Safety Handbook for quick reference. The implementation of related legislations and safety awareness efforts among employees show the importance of embedding the safety culture as part of the organisational culture to be embraced by the employees.

The company should not jeopardize everyone by neglecting safety aspects. As shown in past incidents where a lapse in safety have resulted in catastrophic impact to the industry. For example, the Ladbroke accident (Brambilla & Manca, 2010; Stanton & Walker, 2011) where lives have been lost, have also ruined the reputation of the company, the nation and the confidence of customers.

In addition to the Track Safety Handbook, the TOC in this study has also set up a special department, namely the Department of Occupational Safety, Health and Environment (OSHEN), to cater for every aspects of safety within the company. The officers in the department would be responsible to monitor and investigate the level of safety awareness in the organisation. Furthermore, the department will manage procedures, legislation and campaign on safety in the effort to inculcate safety culture among employees. Thus since the drivers are directly influenced by these efforts by the TOC, it was thus found that that safety culture was a strong influential factors of the train driver performance.

6.6 Benchmarking of the model with other related studies

There are a number of models and frameworks in existence, designed to fulfil the various contexts of particular research. This newly developed model can be compared with past models from the literatures. Table 6.1 shows an overview of the comparison between the proposed model of this study with other existing models and literature on train drivers from around the world.

The comparison is made based on several details. The first column of table shows the authors and the year the article is published, to indicate the timeline of the study. The table also shows brief descriptions of the model or framework, the measurement methods and its sampling factor. The most important comparison is the key indicators selected for each particular model or framework. The comparison can be made on the choice of factors for the domains of human, activity or context.

In most models, the ‘human’ domain was the main focus and interest, indicating the preferential importance of ‘human’ in performance study of employees. However, ‘human’ is a domain containing a large number of factors, inclusive of cognitive, job satisfaction, and gender. Fletcher and Dawson (2001) has developed a work-related fatigue model of 193 train drivers in the UK, focusing on fatigue by evaluating sleepiness and alertness using sleep / work diaries and fatigue model due to hours of work. The emphasis was on physiological factor, i.e. sleepiness and fatigue with relation to hours of work. Performance of the train driver was measured through alertness level and objective performance test (OSPAT). However, this model did not consider the environmental factor (context domain).

Two other models related to railway have focused on the cognitive performance of the train driver; and its relationship with work environment and job-task. In 2005, Hamilton & Clarke (2005), through their Cognitive Task Analysis (CTA) model, investigated cognitive ability of the train drivers in the UK and their reaction with signals and signs along the track to check on signal pass at danger (SPAD) scenario. Similarly, McLeod et al. (2005) have also studied cognitive aspect of train drivers in the UK, focusing on Automatic Warning System (AWS) which was also related to SPAD scenario. These two research work had focused on the cognitive response of the train driver while driving to reduce SPAD incidents.

Six articles from Australia had focused particularly on fatigue of the train drivers. Lamond et al. (2005) studied alertness of fifteen train drivers of Adelaide – Melbourne relay trip by assessing their sleepiness through activity monitoring and sleep diary. Dorrian et al. (2006) have used simulation studies to evaluate the alertness of the train drivers and their fatigue levels. The study was further extended in 2007 to relate fatigue and alertness with incorrect response of cognitive disengagement towards safety of the train driving. Jap et al. (2011) also conducted a simulation study of fifty male train drivers to investigate fatigue using EEG (electroencephalography) activity monitoring. Darwent et al. (2008) have studied on the sleepiness and performance of the long relay train drivers between Adelaide and Perth, focusing on the relationship between sleep and performance of the train drivers. In addition, the work environment and their working condition were also considered. Although three basic influential domains were addressed, it had only considered certain criteria, i.e. sleepiness (human), driving, work environment and working condition. Fatigue during extended rail operations was also investigated by Jay et al. (2008), which utilised a 5-min response task (RT) and 7-point Samn-Perelli Fatigue Checklist on nine male drivers. From the six articles on the evaluation of Australian train drivers, five studies have centred solely on fatigue of the train drivers, using either simulation study or actual driving, focusing on long-haul train operations. Another study was examined sleepiness of the train drivers and its relationship with their driving activities, work environment and working condition. The limitations of these past studies were the sole focus on only fatigue or sleepiness, without consideration to other factors which may also influence the performance of the train drivers. The absence of consideration for other factors can misdirect the research direction and may result in inaccurate conclusions in investigations involving human performance as a whole.

Only one literature did a review of forty rail safety investigations; to understand the contribution of human factors and ergonomics (HFE) to railway accidents. This literature was absolutely discussed on accidents and safety of the rail industry in Australia.

Table 6.1: Benchmarking of the integrated model with previous literatures

Authors	Brief descriptions	Measurement method	Target group, sample	Domain		
				Human	Activity	Context
Fletcher and Dawson (2001)	• Field-based validations of a work-related fatigue model	• Sleep/work diaries, wore actigraphs • Fatigue model • Subjective alertness test (VAS) • Objective performance test (OSPAT)	• 193 train drivers • UK	• Sleepiness • Fatigue • Alertness	• Hours of work	
Hamilton & Clarke (2005) ***CTA Model***	• Train driver performance in interaction with infrastructure features • Development of a human factors SPAD hazard checklist	• Line speed on driver interaction with signals and signs •	• 250 train drivers • UK	• Cognitive	• Driving	• Infrastructure
McLeod et al. (2005) ***Situational Model***	• Train driver performance in interaction with Automatic Warning System (AWS) • AWS provides audible alert for SPAD	• Structured interviews with train drivers	• 20 scenarios of AWS usage • Train drivers • UK	• Cognitive	• Driving	

Authors	Brief descriptions	Measurement method	Target group, sample	Domain		
				Human	Activity	Context
Lamond et al. (2005)	• Train drivers' sleep and alertness during short relay operations	• Activity monitor • Sleep diary • Actiware-sleep software	• 15 drivers • Adelaide – Melbourne relay trip • Australia	• Alertness • Sleepiness	• Driving	
Dorrian et al. (2006)	• Effects of fatigue on train handling during speed restrictions	• Simulation driving • 10-min PVT • 100 mm VAS	• 20 male train drivers from Queensland depots • Australia	• Fatigue • Alertness	• Simulated driving	
Dorrian et al. (2007)	• Effects of fatigue increasing inefficiency and accident risk	• Simulation driving • 10-min PVT • 100 mm VAS	• 20 male train drivers from Queensland depots • Australia	• Fatigue • Alertness	• Simulated driving	• Incorrect responses • Cognitive disengagement • Safety
Darwent et al. (2008)	• sleep and performance of train drivers during an extended freight-haul operation	• Mini-Mitter Actigraph-L activity monitoring devices – to assess sleep/wake states • Sleep diary	• 10 male train drivers • Long relay Adelaide – Perth • Australia	• Sleep • Performance	• Extended freight-haul driving	• Work environment • Working condition
Jay et al. (2008)	• Driver fatigue during extended rail operations	• 5-min response task (RT) – using PVT • 7-point Samn–Perelli Fatigue Checklist	• 9 male drivers • Australia	• Fatigue	•	•

Authors	Brief descriptions	Measurement method	Target group, sample	Domain		
				Human	Activity	Context
Baysari et al. (2009)	• Review of 40 rail safety investigation to understand contribution of HFE to railway accidents	• Report review Adoptation of HFACS (Human Factors Analysis and Classification System)	• Rail safety • Australia	•	•	• Accidents and safety
Jap et al. (2011)	• Comparison of EEG activity among train drivers during monotonous driving	• Simulation driving • EEG activity monitoring	• 50 male train drivers • Australia	• Fatigue • Mental fatigue	•	•
Azlis Sani Jalil (2015)	• Integrated train driver performance model	• 27-items questionnaire	• 229 respondents • Train drivers • Malaysia	• Occupational stress • Job related tension • Fatigue	• Work (driving) task	• Work environment • Working conditions • Safety culture

Subjective measurements are often used in investigation involving performance of workers. The technique is widely used in ergonomics study to understand certain issues in human factors, although whether the approach is acceptable as scientific measurement has been a topic of debate (Annett, 2002). Nevertheless, there are several objective measurements methods that have been used in ergonomics study (Fagarasanu & Kumar, 2002), although their applications have been very limited especially on the number of respondents to be measured. An example of the use of objective measurements is the application of Electroencephalogram (EEG) signals to investigate mental fatigue (Jap et al., 2011; Kar et al., 2010). However, in this study; subjective measurements were mainly used, utilising the paper-pencil questionnaire survey to gather information from 229 train drivers.

In contrast to previously developed models, the proposed model in this study presents an integrative model as discussed in previous chapter. The three main domains of human, activity and context were identified from past literatures and have been evaluated thoroughly. Occupational stress, job related tension and fatigue were the results of improper task-design and poor work environment and working conditions. These factors were investigated simultaneously to study its relationship with the performance of the train driver. In addition, this model includes consideration of the safety culture, whereas other models tend to study safety aspects separately. Thus, this model integrates the various important aspects and factors in a complete package for the evaluation of human performance. The model is characterising to be dynamic, in which factors can be customised within the three main domains to create an improved human performance study in HFE.

In conclusion, the previous referred models mostly from the UK and Australia addressed similar arising issues of their train drivers. Fatigue, driving activity and sleepiness were among factors mostly investigated. Yet, the characteristics of the performance were similar between Malaysia, UK and Australia. However, this integrated model provides better and more complete model evaluating human performance.

6.6.1 Advantages of this model

Major advantages of this model include:

a) Management of the TOC would be able to use this model when designing job task of the train driver. To reduce stress, tension and fatigue, the job task should be well planned and supported with good work environment and working conditions. If these criteria are fulfilled, then the issues on safety can be well addressed and inculcated in the working culture.

b) Investigators may use this model to investigate problems on performance and human behavior while driving. Potential factors affecting performance could then be investigated.

c) To provide an improved work environment, the management could use the model to study the influential factors of work environment or organizational environment of the workplace.

d) To achieve increased performance, safety of the workplace plays an important role. Safety should also be a culture in TOC, in which high performance is obtained within a safe working environment, ensuring job satisfaction and happiness among the train driver.

6.7 Significant contributions of the study

This study has investigated the relationship between the three key factors (domains); namely human, activity and context on the performance of the train driver. In general, the finding from this study adds into the pool of knowledge in the literature, especially in term of the integrative model of the performance of the train drivers. Furthermore, the findings of this study can assist the management of the TOC in their decision making and planning processes in term of improving the performance of the train drivers.

6.7.1 Significant theoretical contributions of the train driver performance

Theoretically, the performance of employee is important to ensure the overall system run smoothly with very minimum risks. This study introduced an integrative framework for understanding key influential factors of the employees' performance, in this case was the train drivers. The newly developed framework highlights the interactions between human factors, human activities and its context. Through macroergonomics approach, this study has looked at the influential factors holistically, without ignoring other potential domains or factors.

By investigating the influence of human factors; namely occupational stress, job-related tension and sleepiness to the performance of train driver, this study helps to understand how job-design contributed to the stress and tension among the train drivers, which also had influenced the level of fatigue. Key indicators for understanding job performance rely on the psychological and physiological factors of the employees, the job routine and contextual factors such work environment and working conditions. An improved work environment and working condition generate less stress and tension, as well as lowering the level of fatigue of the employee. In addition, safety is of upmost priority, especially for public related services. An environment of safety and general feeling of being safe would enhance the performance of employees.

The seven shortlisted factors are interrelated to one another and further investigations could be made on investigating several influential factors simultaneously.

6.7.2 Significant managerial contributions of the train driver performance

From a managerial perspective, this study highlights the importance for the management of TOC to develop and address the relationship between the factors contributing to the employees' performance. This integrative model would benefit the management of TOC in assisting to identify the factor(s) which should be observed and improved based on their actual and existing performance evaluation exercise. As discovered in this study, since the factors can be interrelated, the management should not only rely on the individual factors when evaluating employees' performance. Instead, they should look into the bigger picture during their planning for better performance and improvements. Design of job, shift scheduling, rest time, rest area and facilities, relationship among peers and supervisors are some example of the details which should be considered by the management while planning the job task and evaluating performance of the employee.

Furthermore, it was confirmed by the results of this study that safety culture has a positive influence on the train driver performance. Thus, safety culture should be further enhanced among employees for the benefit of all. If the contributing factors identified in this study are well addressed, then it is expected that the performance of both the employees and the system would improve, giving benefits and increased safety confidence to the company.

6.8 Objectives' achievements of the study

Objectives of this study had been set up at beginning and its drove this study towards achieving it. First objective was to identify significant factors of human performance in train driving. This was achieved through extensive literature related to the train driver performance, mostly in UK and Australia as the basis of the study. From this literature study, a framework was established as a guide for the model development. This achieved the second objective. Once the framework established, it was used to conduct a survey among train drivers to collect their perceptions towards their own performance. The data collected were then analysed to determine the relationship among significant factors of their performance. This achieved the third objective. Finally, the model was developed to integrate those significant factors and to illustrate the performance of the train drivers.

CHAPTER 7 : CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

This study makes a notable contribution to the knowledge on human performance by proposing a model that was empirically tested to investigate the influential factors of train driver performance. A significant relationship was found between the train driver performance and several factors in the human domain, which were the occupational stress, job related tension and fatigue. Furthermore, it has also identified the driving task as one of the influential factors of train driver performance. The work environment, working condition and safety culture in the ‘context’ domain were also having significant relationship with the performance of the train driver. This study was conducted on the train drivers of the major train operating company (TOC) in Malaysia, focusing only on drivers of intercity passenger trains and freight trains.

In this study, several significant contributions were successfully achieved. Firstly, the significant factors affecting the performance of the train driver were identified through an extensive review of the literatures from studies conducted around the world. The lack of available human performance measures which integrates performance influential factors was identified and a theoretical framework specific for train drivers was proposed. This framework formed the foundation of this study in order to understand the influential factors affecting the performance of train drivers. Three main domains were then proposed to establish the empirical basis of the model, namely the human, activity and context to represent the key indicators of the train drivers performance. Based on this theoretical framework, a quantitative paper-and-pencil survey was conducted among 229 respondents. The data collected was analysed using SPSS software and the relationships among significant factors of train driver's performance were determined. Subsequent development of an integrated framework was tested using structural equation modelling (SEM)-PLS approach using SmartPLS software to determine the relationship among the influential factors. Finally, an integrated model of the Malaysian train driver performance was developed and completed. Although evaluation of employee performance has been developed in several past models, the model developed in this study addresses some of the limitations of past models. The newly proposed model integrates the factors affecting the performance of the train driver under the three main domains of human, activity and context. The model indicates that the management should not only focus on the individual employee, but should also be aware of other surrounding factors which may affect their overall performance.

Finally, this study has strengthened the understanding and importance of human performance within the context of public transportation industry, especially for the drivers.

7.2 Recommendations for Future Research

The integrative model developed in this study can be used as a foundation for future studies. Several potential areas for future research could be ventured based on this model. Future work could extend the study to develop a comprehensive integrated human performance model that includes other related influential factors listed by previous literatures such as alertness, health condition, individual’s driving and decision making skills, commitment of the employee and extensive safety climate.

In addition, different geographical areas or context may influence the significance of the factors evaluated. Thus future work could consider reinvestigating factors that were found insignificant in this study such as sleepiness, job satisfaction, safety issues and job demand. Although these factors did not support the hypothesis in this particular study, variations in geographical and context may change the influence of these factors. Different technique of investigation, rather than survey could be performed especially on objective measurement. This will ensure empirical data could be collected and to verify the model developed.

Cross-cultural study could be undertaken for future work to test the integrative model to other groups of employee from different geographical areas. Comparison could then be made between these groups of populations. In addition, the model could also be used to test other types of commercial drivers, such as drivers of buses, trucks or light urban trains. There might be differences on their routine of work, job setting, work environment and even the organizational culture which would differ from the results of this study, from which a significant comparison could be made.

In general, the integrative model developed is a very useful tool for analysing the factors affecting the performance of the employee. Therefore it is important for future research to widen the study to cover other transportation companies for their immediate benefit and advantages; and for the overall improvement of the service to the nation.

REFERENCES

Akerstedt, T. (1995). Work hours and sleepiness. *Neurophysiologie Clinique/Clinical Neurophysiology, 25*(6), 367-375.

Anderson, James C., & Gerbing, David W. (1991). Predicting the Performance of Measures in a Confirmatory Factor Analysis With a Pretest Assessment of Their Substantive Validities. *Journal of Applied Psychology, Vol. 76*(No. 5), 732 - 740.

Annett, John. (2002). Subjective rating scales: science or art? *Ergonomics, 45*, 966-987.

Austin, A., & Drummond, P. D. (1986). Work problems associated with suburban train driving. *Applied Ergonomics, 17*(2), 111-116.

Bailey, Robert W. (1996). *Human performance engineering : designing high quality, professional user interfaces for computer products, applications, and systems* (3rd ed.). New Jersey: Prentice Hall.

Baines, T. S., Asch, R., Hadfield, L., Mason, J. P., Fletcher, S., & Kay, J. M. (2005). Towards a theoretical framework for human performance modelling within manufacturing systems design. *Simulation Modelling Practice and Theory, 13*(6), 486-504.

Baraldi, Amanda N., & Enders, Craig K. (2010). An introduction to modern missing data analyses. *Journal of School Psychology, 48*(1), 5-37.

Bartlett, J. E., II, Kotrlik, J. W., & Higgins, C. (2001). Organizational Research: Determining Appropriate Sample Size in Survey Research. *Information Technology, Learning, and Performance Journal, 19*(1).

Baysari, Melissa T., McIntosh, Andrew S., & Wilson, John R. (2008). Understanding the human factors contribution to railway accidents and incidents in Australia. *Accident Analysis & Prevention, 40*(5), 1750-1757.

Baysari, Melissa T., Caponecchia, Carlo, McIntosh, Andrew S., & Wilson, John R. (2009). Classification of errors contributing to rail incidents and accidents: A comparison of two human error identification techniques. *Safety Science, 47*(7), 948-957.

Bennett, Derrick A. (2001). How can I deal with missing data in my study? *Australian and New Zealand Journal of Public Health, 25*(5), 464-469.

Berlin, Cecilia, Örtengren, Roland, Lämkull, Dan, & Hanson, Lars. (2009). Corporate-internal vs. national standard - A comparison study of two ergonomics evaluation procedures used in automotive manufacturing. *International Journal of Industrial Ergonomics, 39*(6), 940-946.

Birlik, Gülin. (2009). Occupational Exposure to Whole Body Vibration - Train Drivers. *International Scientific Journal of Occupational Health and Safety, 47*, 5-10.

Boff, Kenneth R. (2006). Revolutions and shifting paradigms in human factors & ergonomics. *Applied Ergonomics, 37*(4), 391-399.

Bordens, Kenneth S., & Abbot, Bruce B. (2008). *Reseacrh Design and Methods* (7th ed.). New York: McGraw Hill.

Bourne, L.E., & Yaroush, R.A. . (2003). *Stress and cognition: A cognitive psychological perspective*. Unpublished manuscript, NASA grant NAG2-1561.

Boyd, Nancy G., Lewin, Jeffrey E., & Sager, Jeffrey K. (2009). A model of stress and coping and their influence on individual and organizational outcomes. *Journal of Vocational Behavior, 75*(2), 197-211.

Brambilla, Sara, & Manca, Davide. (2010). The Viareggio LPG railway accident: Event reconstruction and modeling. *Journal of Hazardous Materials, 182*(1-3), 346-357.

Branton, Paul. (1987). In praise of ergonomics - a personal perspective *International Reviews of Ergonomics, 1*, 1-20

Brauchli, Rebecca, Schaufeli, Wilmar B., Jenny, Gregor J., Füllemann, Désirée, & Bauer, Georg F. (2013). Disentangling stability and change in job resources, job demands, and employee well-being — A three-wave study on the Job-Demands Resources model. *Journal of Vocational Behavior*, *83*(2), 117-129.

Burns, Richard A., Butterworth, Peter, Kiely, Kim M., Bielak, Allison A. M., Luszcz, Mary A., Mitchell, Paul, . . . Anstey, Kaarin J. (2011). Multiple imputation was an efficient method for harmonizing the Mini-Mental State Examination with missing item-level data. *Journal of Clinical Epidemiology, 64*(7), 787-793.

Byrne, Barbara M. (2010). *Structural equation modeling with AMOS: Basic concepts, applications, and programming. Multivariate applications series.* (2nd ed.). New York, NY, US: Routledge/Taylor & Francis Group.

Carayon, Pascale, & Smith, Michael J. (2000). Work organization and ergonomics. *Applied Ergonomics*, *31*(6), 649-662.

Chang, Y. H., & Yeh, C. H. (2010). Human performance interfaces in air traffic control. *Applied Ergonomics, 41*(1), 123-129.

Chau, Nearkasen, Gauchard, Gerome, Dehaene, Dominique, Benamghar, Lahoucine, Touron, Christian, Perrin, Philippe, & Mur, Jean-Marie. (2007). Contributions of occupational hazards and human factors in occupational injuries and their associations with job, age and type of injuries in railway workers. *International Archives of Occupational and Environmental Health, 80*(6), 517-525.

Chin, Wynne W. (2010). How to Write Up and Report PLS Analyses: Handbook of Partial Least Squares. In Esposito Vinzi, Vincenzo, Chin, Wynne W., Henseler, Jörg, & Wang, Huiwen (Eds.), (pp. 655-690): Springer Berlin Heidelberg.

Clarke, Sharon (1998). Safety culture on the UK railway network. *WORK & STRESS, 12*(3), 285-292.

Clarke, Theresa. (2005). The Ergonomics Programme at Network Rail. In Wilson, John R., Norris, Beverly, Clarke, Theresa, & Mills, Ann (Eds.), *Rail Human Factors: Supporting the Integrated Railway* (pp. 19 - 21): Ashgate.

Collins, Debbie. (2003). Pretesting survey instruments: An overview of cognitive methods. *Quality of Life Research, 12*(3), 229-238.

Coluci, Marina Z. O., Alexandre, Neusa M. C., & Rosecrance, John. (2009). Reliability and validity of an ergonomics-related Job Factors Questionnaire. *International Journal of Industrial Ergonomics, 39*(6), 995-1001.

Cothereau, C., de Beaurepaire, C., Payan, C., Cambou, J. P., Rouillon, F., & Conso, F. (2004). Professional and medical outcomes for French train drivers after "person under train" accidents: three year follow up study. *Occupational and Environmental Medicine, 61:,* 488-494.

Curry, David, & McKinney, John M. (2006). Utilizing the Human, Machine, and Environment Matrix in investigations. *Journal of Hazardous Materials*, *130*(1–2), 122-127.

Dahlgren, Anna (2006). *Work stress and overtime work – effects on cortisol, sleep, sleepiness and health.* Stockholm University. Retrieved from [23]

Darwent, David, Lamond, Nicole, & Dawson, Drew. (2008). The sleep and performance of train drivers during an extended freight-haul operation. *Applied Ergonomics, 39*(5), 614-622.

Dawal, S. Z., Taha, Z., & Ismail, Z. (2009). Effect of job organization on job satisfaction among shop floor employees in automotive industries in Malaysia. *International Journal of Industrial Ergonomics, 39*(1), 1-6.

Dawal, S.Z. (2005). *A Study of Ergonomics Factors Affecting Job Satisfaction in Work Design for Automotive Industries in Malaysia.* (Ph.D. Ph.D thesis), University of Malaya, Kuala Lumpur, Malaysia.

Dawson, Drew, Ian Noy, Y., Härmä, Mikko, Åkerstedt, Torbjorn, & Belenky, Gregory. (2011). Modelling fatigue and the use of fatigue models in work settings. *Accident Analysis & Prevention, 43*(2), 549-564.

DeArmond, Sarah, & Chen, Peter Y. (2009). Occupational safety: The role of workplace sleepiness. *Accident Analysis & Prevention, 41*(5), 976-984.

Definition of 'condition', first published 1891. (2013). Oxford University Press.

Definition of 'environment', OED 3rd Edition, June 2011. (2013). Oxford University Press.

Definition of 'work', first published 1928. (2013). Oxford University Press.

Dempsey, Patrick G., McGorry, Raymond W., & Maynard, Wayne S. (2005). A survey of tools and methods used by certified professional ergonomists. *Applied Ergonomics, 36*(4), 489-503.

Desmond, Paula A., & Matthews, Gerald. (2009). Individual differences in stress and fatigue in two field studies of driving. *Transportation Research Part F: Traffic Psychology and Behaviour, 12*(4), 265-276.

Dorrian, Jillian, Baulk, Stuart D., & Dawson, Drew. (2011). Work hours, workload, sleep and fatigue in Australian Rail Industry employees. *Applied Ergonomics, 42*(2), 202-209.

Dorrian, Jillian, Roach, Gregory D., Fletcher, Adam, & Dawson, Drew. (2006). The effects of fatigue on train handling during speed restrictions. *Transportation Research Part F: Traffic Psychology and Behaviour, 9*(4), 243-257.

Dorrian, Jillian, Roach, Gregory D., Fletcher, Adam, & Dawson, Drew. (2007). Simulated train driving: Fatigue, self-awareness and cognitive disengagement. *Applied Ergonomics, 38*(2), 155-166.

Dul, Jan, & Neumann, W. Patrick. (2009). Ergonomics contributions to company strategies. *Applied Ergonomics, 40*(4), 745-752.

Dul, Jan, Bruder, Ralph, Buckle, Peter, Carayon, Pascale, Falzon, Pierre, Marras, William S., . . . van der Doelen, Bas. (2012). A strategy for human factors/ergonomics: developing the discipline and profession. *Ergonomics, 55*(4), 377-395.

Edkins, Graham D., & Pollock, Clare M. (1997). The influence of sustained attention on Railway accidents. *Accident Analysis & Prevention, 29*(4), 533-539.

Evans, Andrew W. (2011). Fatal train accidents on Europe's railways: 1980-2009. *Accident Analysis & Prevention, 43*(1), 391-401.

Fagarasanu, Mircea, & Kumar, Shrawan. (2002). Measurement instruments and data collection: a consideration of constructs and biases in ergonomics research. *International Journal of Industrial Ergonomics, 30*(6), 355-369.

Farrington-Darby, Trudi, Pickup, Laura, & Wilson, John R. (2005). Safety culture in railway maintenance. *Safety Science, 43*(1), 39-60.

Farrington-Darby, Trudi, Wilson, John R., & Norris, Beverly J. (2005). Investigating Train Driver Behaviour: The Use of Lineside Information When Regulating Speed. In Wilson, John R., Norris, Beverly, Clarke, Theresa, & Mills, Ann (Eds.), *Rail Human Factors: Supporting the Integrated Railway* (pp. 60 - 69): Ashgate.

Felici, M., Sujan, M. A., & Wimmer, M. (2000). Integration of functional, cognitive and quality requirements. A railways case study. *Information and Software Technology, 42*(14), 993-1000.

Fernet, Claude, Guay, Frédéric, & Senécal, Caroline. (2004). Adjusting to job demands: The role of work self-determination and job control in predicting burnout. *Journal of Vocational Behavior, 65*(1), 39-56.

Field, Andy. (2005). *Discovering Statistics Using SPSS*. London: Sage Publications.

Fletcher, Adam, & Dawson, Drew. (2001). Field-based validations of a work-related fatigue model based on hours of work. *Transportation Research Part F: Traffic Psychology and Behaviour, 4*(1), 75-88.

Garbarino, Sergio , Carli, Fabrizio De, Nobili, Lino, Mascialino, Barbara, Squarcia, Sandro, Penco, Maria Antonietta, . . . Ferrillo, Franco. (2002). Sleepiness and Sleep Disorders in Shift Workers: A Study on a Group of Italian Police Officers. *Sleep, 25*(6).

Genaidy, A., Salem, S., Karwowski, W., Paez, O., & Tuncel, S. (2007). The work compatibility improvement framework: An integrated perspective of the human-at-work system. *Ergonomics, 50*(1), 3-25.

Glendon, A. I., & Stanton, N. A. (2000). Perspectives on safety culture. *Safety Science, 34*(1–3), 193-214.

Glendon, A. I., & Litherland, D. K. (2001). Safety climate factors, group differences and safety behaviour in road construction. *Safety Science, 39*(3), 157-188.

Gore, Brian F., & Jarvis, Peter. (2005, October). *Modeling the complexities of human performance.* In Systems, Man and Cybernetics, 2005 IEEE International Conference on (Vol. 2, pp. 1604-1609). IEEE.

Gore, Brian F., & Smith, Jeffrey D. (2006). Risk assessment and human performance modelling: the need for an integrated systems approach. *International Journal of Human Factors Modelling and Simulation, 1*(1), 119-139.

Gould, Kristian S., Røed, Bjarte K., Saus, Evelyn-Rose, Koefoed, Vilhelm F., Bridger, Robert S., & Moen, Bente E. (2009). Effects of navigation method on workload and performance in simulated high-speed ship navigation. *Applied Ergonomics, 40*(1), 103-114.

Gradisar, Michael, Lack, Leon, Richards, Hayley , Harris, Jodie, Gallasch, Julie, Boundy, Michelle, & Johnston, Anna. (2007). The Flinders Fatigue Scale: Preliminary Psychometric Properties and Clinical Sensitivity of a New Scale for Measuring Daytime Fatigue associated with Insomnia. *Journal of clinical sleep medicine: official publication of the American Academy of Sleep Medicine, 3(7)*, 722-728.

Haenlein, Michael, & Kaplan, Andreas M. . (2004). A Beginner's Guide to Partial Least Squares Analysis. *Understanding Statistics, 3*(4), 283-297.

Hair, Joseph F., Ringle, Christian M., & Sarstedt, Marko. (2012). Partial Least Squares: The Better Approach to Structural Equation Modeling? *Long Range Planning, 45*(5–6), 312-319.

Hair, Joseph F., Black, William C. , Babin, Barry J., & Anderson, Rolph E. . (2010). *Multivariate Data Analysis* (7th ed.): Prentice Hall.

Hair, Joseph F., Sarstedt, Marko, Ringle, Christian, & Mena, Jeannette. (2012a). An assessment of the use of partial least squares structural equation modeling in marketing research. *Journal of the Academy of Marketing Science*, 1-20.

Hair, Joseph F., Sarstedt, Marko, Ringle, Christian M., & Mena, Jeannette A. (2012b). An Assessment of the Use of Partial Least Squares Structural Equation Modeling in Marketing Research. *Journal of the Academy of Marketing Science*, forthcoming.

Hair, Joseph F., Hult, G. Tomas M., Ringle, Christian, & Sarstedt, Marko. (2014). *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM).* USA: SAGE Publications, Inc.

Hamilton, W. Ian, & Clarke, Theresa. (2005). Driver performance modelling and its practical application to railway safety. *Applied Ergonomics, 36*(6), 661-670.

Haque, M. M., Chin, H. C., & Debnath, A. K. (2013). Sustainable, safe, smart—three key elements of Singapore's evolving transport policies. *Transport Policy, 27*(0), 20-31.

Härmä, M., Sallinen, M., Ranta, R., Mutanen, P., & Müller, K. (2002). The effect of an irregular shift system on sleepiness at work in train drivers and railway traffic controllers. *Journal of Sleep Research, 11*(2), 141-151.

Hockey, B., & Carrigan, N. (2003). *Human Factors in Railway Systems : Implications for Safety*.

Horrey, William J., Noy, Y. Ian, Folkard, Simon, Popkin, Stephen M., Howarth, Heidi D., & Courtney, Theodore K. (2011). Research needs and opportunities for reducing the adverse safety consequences of fatigue. *Accident Analysis & Prevention, 43*(2), 591-594.

Imada, Andrew S., & Carayon, Pascale. (2008). Editors' comments on this special issue devoted to macroergonomics. *Applied Ergonomics, 39*(4), 415-417.

Janssen, Peter P. M., Peeters, Maria C. W., Jonge, Jan de, Houkes, Inge, & Tummers, Gladys E. R. (2004). Specific relationships between job demands, job resources and psychological outcomes and the mediating role of negative work–home interference. *Journal of Vocational Behavior, 65*(3), 411-429.

Jansson, Anders , Olsson, Eva , & Kecklund, Lena (2005). Acting or reacting? A cognitive work analysis approach to the train driver task. In Wilson, John R., Norris, Beverly, Clarke, Theresa, & Mills, Ann (Eds.), *Rail Human Factors: Supporting the Integrated Railway* (pp. 40 - 49): Ashgate.

Jap, Budi Thomas, Lal, Sara, & Fischer, Peter. (2010). Inter-hemispheric electroencephalography coherence analysis: Assessing brain activity during monotonous driving. *International Journal of Psychophysiology, 76*(3), 169-173.

Jap, Budi Thomas, Lal, Sara, & Fischer, Peter. (2011). Comparing combinations of EEG activity in train drivers during monotonous driving. *Expert Systems with Applications, 38*(1), 996-1003.

Jay, Sarah M., Dawson, Drew, Ferguson, Sally A., & Lamond, Nicole. (2008). Driver fatigue during extended rail operations. *Applied Ergonomics, 39*(5), 623-629.

Johns, Murray W. . (1991). A New Method for Measuring Daytime Sleepiness: The Epworth Sleepiness Scale. *Sleep, 14(6)*, 540-545.

Johns, Murray W. . (1992). Reliability and Factor Analysis of the Epworth Sleepiness Scale. *Sleep, 15(4)*, 376-381.

Johns, Murray W. . (1993). Daytime Sleepiness, Snoring and Obstructive Sleep Apnea: The Epworth Sleepiness Scale. *Chest, 103*, 30-36.

Johns, Murray W. , & Hoaking, Bruce (1997). Excessive Daytime Sleepiness: Daytime Sleepiness and Sleep Habits of Australian Workers. *Sleep, 20(10)*, 844-849.

Jones, Christopher B., Dorrian, Jillian, Rajaratnam, Shantha M. W., & Dawson, Drew. (2005). Working hours regulations and fatigue in transportation: A comparative analysis. *Safety Science, 43*(4), 225-252.

Joshi, V. V., Kaufman, L. M., & Giras, T. C. (2001). *Human behavior modeling in train control systems.* In Reliability and Maintainability Symposium, 2001. Proceedings. Annual (pp. 183-188). IEEE.

Jou, Rong-Chang, Kuo, Chung-Wei, & Tang, Mei-Ling. (2013). A study of job stress and turnover tendency among air traffic controllers: The mediating effects of job satisfaction. *Transportation Research Part E: Logistics and Transportation Review*(0).

Juslén, Henri, & Tenner, Ariadne. (2005). Mechanisms involved in enhancing human performance by changing the lighting in the industrial workplace. *International Journal of Industrial Ergonomics, 35*(9), 843-855.

Kahya, Emin. (2007). The effects of job characteristics and working conditions on job performance. *International Journal of Industrial Ergonomics, 37*(6), 515-523.

Kahya, Emin (2009). The effects of job performance on effectiveness. *International Journal of Industrial Ergonomics, 39*, 96-104.

Kar, Sibsambhu, Bhagat, Mayank, & Routray, Aurobinda. (2010). EEG signal analysis for the assessment and quantification of driver's fatigue. *Transportation Research Part F: Traffic Psychology and Behaviour, 13*(5), 297-306.

Karsh, Ben-Tzion, Waterson, Patrick, & Holden, Richard J. (2014). Crossing levels in systems ergonomics: A framework to support 'mesoergonomic' inquiry. *Applied Ergonomics, 45*(1), 45-54.

Kecklund, Göran , Åkerstedt, Torbjörn , Ingre, Michael , & Söderström, Marie (1999). *Train drivers' working conditions and their impact on safety, stress and sleepiness: a literature review, analyses of accidents and schedules. National Institute for Psychosocial Factors and Health. Stress Research Report, 288.*

Kecklund, L., Ingre, M., Kecklund, G., Soderstrom, M., Akerstedt, T., Lindberg, E., . . . Almqvist, P. (2001). *The TRAIN - project: Railway safety and the train driver information environment and work situation - A summary of the main results.* In Signalling Safety, London.

Kee, SzeSeen, Tamrin, Shamsul Bahri Mohd, & Goh, YongMeng. (2010). Driving Fatigue and Performance among Occupational Drivers in Simulated Prolonged Driving. *Global Journal of Health Science, 2*(1), 167.

Kim, Dong San, Baek, Dong Hyun, & Yoon, Wan Chul. (2010). Development and evaluation of a computer-aided system for analyzing human error in railway operations. *Reliability Engineering & System Safety, 95*(2), 87-98.

Kirwan, Barry. (1990). Human reliability assessment In Wilson, John R. & Corlett, E Nigel (Eds.), *Evaluation fo Human Work* (2nd edition ed., pp. 921 - 968): Taylor & Francis.

Klein, M. C. A., van Lambalgen, R. M., & Treur, J. (2010, Aug. 31 2010-Sept. 3 2010). *An Agent Model for Analysis of Human Performance Quality.* In Web Intelligence and Intelligent Agent Technology (WI-IAT), 2010 IEEE/WIC/ACM International Conference on.

Kompier, M.A.J. . (1996). *Working paper CONDI/T/WP.2/1996 - Bus drivers: Occupational stress and stress prevention*.

Koohi, Iraj. (2009). Accidents Analysis of Rail Transportation Industry in Iran. *World Applied Sciences Journal, 7*(3), 358-365.

Ku, Chia-Hua, & Smith, Michael J. (2010). Organisational factors and scheduling in locomotive engineers and conductors: Effects on fatigue, health and social well-being. *Applied Ergonomics, 41*(1), 62-71.

Kumar, Amit, & P.K., Sinha. (2008). Human Error Control in Railways. *Jordan Journal of Mechanical and Industrial Engineering, 2*(4), 183 - 190.

Lamond, Nicole, Darwent, David, & Dawson, Drew. (2005). Train drivers' sleep and alertness during short relay operations. *Applied Ergonomics, 36*(3), 313-318.

Land Public Transport Commission, Malaysia. (2012). *Laporan Tahunan 2012 - Penambahbaikan Pengangkutan Awam*.

Layer, J. K., Karwowski, W., & Furr, A. (2009). The effect of cognitive demands and perceived quality of work life on human performance in manufacturing environments. *International Journal of Industrial Ergonomics, 39*(2), 413-421.

Lee, Yi-Fang, Altschuld, James W., & White, Jeffry L. (2007). Problems in needs assessment data: Discrepancy analysis. *Evaluation and Program Planning, 30*(3), 258-266.

Little, Roderick J. A. (1988). A Test of Missing Completely at Random for Multivariate Data with Missing Values. *Journal of the American Statistical Association, 83*(404), 1198-1202.

Lu, Chin-Shan, & Shang, Kuo-chung. (2005). An empirical investigation of safety climate in container terminal operators. *Journal of Safety Research, 36*(3), 297-308.

Luke, T, Brook-Carter,N, Parkes, AM, Grimes, E and Mills, A (2006). An investigation of train driver visual strategies. *Cogn Tech Work*(8), 15–29.

Marras, W. S., & Hancock, P. A. (2014). Putting mind and body back together: A human-systems approach to the integration of the physical and cognitive dimensions of task design and operations. *Applied Ergonomics, 45*(1), 55-60.

Mason, Steve , Baines, Tim , Kay, John M. , & Ladbrook, John (2005). Improving the Design Process for Factories: Modeling Human Performance Variation. *Journal of Manufacturing Systems, 24*(1), 47 - 54.

Mauno, Saija, Kinnunen, Ulla, & Ruokolainen, Mervi. (2007). Job demands and resources as antecedents of work engagement: A longitudinal study. *Journal of Vocational Behavior*, *70*(1), 149-171.

McLeod, Ronald W., Walker, Guy H., & Moray, Neville. (2005). Analysing and modelling train driver performance. *Applied Ergonomics*, *36*(6), 671-680.

Mills, Ann. (2005). The RSSB Human Factors Programme. In Wilson, John R., Norris, Beverly, Clarke, Theresa, & Mills, Ann (Eds.), *Rail Human Factors: Supporting the Integrated Railway* (pp. 13 - 18): Ashgate.

Murali, M.C. . (2005). *The Human Element in Train Safety on Indian Railways*. In International Railway Safety Conference 2005, Cape Town Cape Town.

Mussa, Abdella, & Marwala, T. (2005, 13-16 April 2005). *The use of genetic algorithms and neural networks to approximate missing data in database.* In Computational Cybernetics, 2005. ICCC 2005. IEEE 3rd International Conference on.

Nakagawa, Shinichi, & Freckleton, Robert P. (2008). Missing inaction: the dangers of ignoring missing data. *Trends in Ecology & Evolution, 23*(11), 592-596.

Niu, Shengli. (2010). Ergonomics and occupational safety and health: An ILO perspective. *Applied Ergonomics*, *41*(6), 744-753.

Ou, Carol X.J., Davison, Robert M. , Zhong, Xuepan , & Liang, Yi (2010). Empowering employees through instant messaging. *Information Technology & People, 23*(2), 193-211.

Parsons, K. C. (2000). Environmental ergonomics: a review of principles, methods and models. *Applied Ergonomics, 31*(6), 581-594.

Peng, Chao-Ying Joanne, Harwell, Michael, Liou, Show-Mann, & Ehman, Lee H. (2006). Advances in Missing Data Methods and Implications for Educational Research. In Sawilowsky, Shlomo S. (Ed.), *Real Data Analysis* (pp. 31-78). Greenwich: Information Age.

Pew, Richard W., & Baron, Sheldon. (1983). Perspectives on human performance modelling. *Automatica, 19*(6), 663-676.

Philip, Pierre, & Åkerstedt, Torbjorn. (2006). Transport and industrial safety, how are they affected by sleepiness and sleep restriction? *Sleep Medicine Reviews, 10*(5), 347-356.

Pickup, Laura, Wilson, John R., Norris, Beverley J., Mitchell, Lucy, & Morrisroe, Ged. (2005). The Integrated Workload Scale (IWS): A new self-report tool to assess railway signaller workload. *Applied Ergonomics, 36*(6), 681-693.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*(5), 879-903.

Railways Act 1991, Act 463, Laws of Malaysia (Latest amendment 2010).

Ramayah, T., Lee, Jason, & In, Julie. (2011). Network collaboration and performance in the tourism sector. *Service Business, 5*(4), 411-428.

Rattray, Janice, & Jones, Martyn C. (2007). Essential elements of questionnaire design and development. *Journal of Clinical Nursing, 16*(2), 234-243.

Reiman, Teemu, & Rollenhagen, Carl. (2014). Does the concept of safety culture help or hinder systems thinking in safety? *Accident Analysis & Prevention, 68*(0), 5-15.

Reise, S. P., Waller, N. G., & Comrey, A. L. (2000). Factor analysis and scale revision. *Psychol Assess, 12*(3), 287-297.

Ross, Jacqueline. (2008). Fatigue: Do You Understand the Risks to Safety? *Journal of PeriAnesthesia Nursing, 23*(1), 57-59.

Rubin, D. B. (1976). Inference and missing data. *Biometrika, 63*(3), 581-592.

Russell, Daniel W. (2002). In Search of Underlying Dimensions: The Use (and Abuse) of Factor Analysis in Personality and Social Psychology Bulletin. *Personality and Social Psychology Bulletin, 28*(12), 1629-1646.

Ryan, Brendan, Wilson, John R., Sharples, Sarah, & Clarke, Theresa. (2009). Attitudes and opinions of railway signallers and related staff, using the Rail Ergonomics Questionnaire (REQUEST). *Applied Ergonomics, 40*(2), 230-238.

Ryan, Brendan, Wilson, John R., Sharples, Sarah, Morrisroe, Ged, & Clarke, Theresa. (2009). Developing a Rail Ergonomics Questionnaire (REQUEST). *Applied Ergonomics, 40*(2), 216-229.

Ryan, Thomas G. (1988, 5-9 June 1988). *Human performance measurement: issues and challenges.* In Human Factors and Power Plants, 1988., Conference Record for 1988 IEEE Fourth Conference on.

Schafer, J. L. (1999). Multiple imputation: a primer. *Statistical Methods in Medical Research, 8*(1), 3-15.

Schaufeli, Wilmar B. , & Bakker, Arnold B. . (2004). Job demands, job resources, and their relationship with burnout and engagement: a multi-sample study. *Journal of Organizational Behavior*(25), 293-315.

Schlomer, Gabriel L., Bauman, Sheri, & Card, Noel A. (2010). Best Practices for Missing Data Management in Counseling Psychology. *Journal of Counseling Psychology, 57*(1), 1-10.

Setiawan, N. A., Venkatachalam, P. A., & Hani, A. F. M. (2008, 27-30 May 2008). *Missing Attribute Value Prediction Based on Artificial Neural Network and Rough Set Theory.* In BioMedical Engineering and Informatics, 2008. BMEI 2008. International Conference on.

Shahid, Azmeh, Shen, Jianhua, & Shapiro, Colin M. (2010). Measurements of sleepiness and fatigue. *Journal of Psychosomatic Research, 69*(1), 81-89.

Shahrokhi, M., & Bernard, A. (2009). A framework to develop an analysis agent for evaluating human performance in manufacturing systems. *CIRP Journal of Manufacturing Science and Technology, 2*(1), 55-60.

Shepherd, Andrew, & Marshall, Edward. (2005). Timeliness and task specification in designing for human factors in railway operations. *Applied Ergonomics, 36*(6), 719-727.

Silla, Anne, & Kallberg, Veli-Pekka. (2012). The development of railway safety in Finland. *Accident Analysis & Prevention, 45*(0), 737-744.

Stanimirova, I., Daszykowski, M., & Walczak, B. (2007). Dealing with missing values and outliers in principal component analysis. *Talanta, 72*(1), 172-178.

Stanton, Neville A., & Salmon, Paul M. (2011). Planes, trains and automobiles: Contemporary ergonomics research in transportation safety. *Applied Ergonomics, 42*(4), 529-532.

Stanton, Neville A., & Walker, Guy H. (2011). Exploring the psychological factors involved in the Ladbroke Grove rail accident. *Accident Analysis & Prevention, 43*(3), 1117-1127.

Stojadinović, Zoran , Marinković, Dejan , & Ivković, Branislav (2014). Human resource performance measurement framework for construction projects and companies. *Technical Gazette, 21*(1), 69-78.

Stone, B., McGuffog, A., Spencer, M., Turner, C., & Mills, A. . (2005). *Fatigue and shiftwork in UK train drivers.* In International Conference on Fatigue Management in Transportation Operations, Seattle.

Strahan, Clint, Watson, Barry, & Lennon, Alexia (2008). Can organisational safety climate and occupational stress predict work-related driver fatigue? *Transportation Research Part F: Traffic Psychology and Behaviour, 11*(6), 418-426.

Suruhanjaya Pengangkutan Awam Darat Act 2010, (2010).

Sutherland, C., & Groombridge, L. (2001). The Paddington rail crash: identification of the deceased following mass disaster. *Science & Justice, 41*(3), 179-184.

Taris, Toon W., & Schreurs, Paul J. G. (2009). Well-being and organizational performance: An organizational-level test of the happy-productive worker hypothesis. *WORK & STRESS, 23*(2), 120-136.

Timm, Neil H. (2002). *Applied Multivariate Analysis*: Springer New York.

Tinsley, Howard E., & Tinsley, Diane J. (1987). Uses of factor analysis in counseling psychology research. *Journal of Counseling Psychology, 34*(4), 414-424.

Trivellas, Panagiotis, Reklitis, Panagiotis, & Platis, Charalambos. (2013). The Effect of Job Related Stress on Employees' Satisfaction: A Survey in Health Care. *Procedia - Social and Behavioral Sciences, 73*(0), 718-726.

Tsutsumi, Akizumi, & Kawakami, Norito. (2004). A review of empirical studies on the model of effort-reward imbalance at work: reducing occupational stress by implementing a new theory. *Social Science & Medicine, 59*(11), 2335-2359.

Turner, Nick, Stride, Chris B., Carter, Angela J., McCaughey, Deirdre, & Carroll, Anthony E. (2012). Job Demands–Control–Support model and employee safety performance. *Accident Analysis & Prevention, 45*(0), 811-817.

Ugajin, Hiroshi. (1999). Human Factors Approach to Railway Safety. *Quarterly Report of RTRI, 40*(1), 5-8.

Weyman, Andrew, O'Hara, Rachel, & Jackson, Alan. (2005). Investigation into issues of passenger egress in Ladbroke Grove rail disaster. *Applied Ergonomics, 36*(6), 739-748.

Wickens, Christopher D. , Lee, John D. , Liu, Yili , & Becker, Sallie E. Gordon (2004). *An Introduction To Human Factors Engineering* (2nd Edition ed.): Pearson - Prentice Hall.

Wilkinson, L., & Task Force Stat, Inference. (1999). Statistical methods in psychology journals - Guidelines and explanations. *American Psychologist, 54*(8), 594-604.

Williamson, Ann, Lombardi, David A., Folkard, Simon, Stutts, Jane, Courtney, Theodore K., & Connor, Jennie L. (2011). The link between fatigue and safety. *Accident Analysis & Prevention, 43*(2), 498-515.

Wilson, John R. . (1990). A framework and a context for ergonomics methodology. In Wilson, John R. & Corlett, E Nigel (Eds.), *Evaluation fo Human Work* (2nd edition ed., pp. 1-39): Taylor & Francis.

Wilson, John R. . (1995). Chapter 1 : A Framework and a Context for Ergonomics Methodology. In John R, Wilson & Corlett, E Nigel (Eds.), *Evaluation of Human Work* (2nd. ed.): Taylor and Francis.
Wilson, John R. . (2000). Fundamentals of ergonomics in theory and practice. *Applied Ergonomics, 31*(6), 557-567.
Wilson, John R. . (2006). Interaction with virtual environments. *International Journal of Human-Computer Studies, 64*(3), 157-157.
Wilson, John R. . (2014). Fundamentals of systems ergonomics/human factors. *Applied Ergonomics, 45*(1), 5-13.
Wilson, John R. , & Norris, Beverley J. (2005a). Special issue on rail human factors. *Applied Ergonomics, 36*(6), 647-648.
Wilson, John R. , & Norris, Beverley J. (2005b). Rail human factors: Past, present and future. *Applied Ergonomics, 36*(6), 649-660.
Wilson, John R. , & Nigel, Corlett E. (Eds.). (1995). *Evaluation of Human Work* (2nd ed.): Taylor & Francis.
Yahaya, Azizi , Yahaya, Noordin, Arshad, Kamariah, Ismail, Jasmi, Jaalam, Saini, & Zakariya, Zurihanmi (2009). Occupational Stress and its Effects towards the Organization Management. *Journal of Social Sciences, 5*(4), 390-397.
Yan, Wan, & Turban, Daniel B. (2009). Work, happiness, and unhappiness. *The Journal of Positive Psychology, 4*(2), 193-195.

LIST OF PUBLICATIONS AND PAPER PRESENTED

1 Azlis Sani Jalil, et al. (2009). General fatigue investigation on Malaysian train drivers. International Conference for Technical Postgraduates (Techpos 2009). Kuala Lumpur.

2 Azlis Sani Jalil and Siti Zawiah Md Dawal (2010). Future Human Performance Model for Malaysian Train Driver. IAENG International Conference on Industrial Engineering (ICINDE'10), Hong Kong.

3 Azlis Sani Jalil and Siti Zawiah Md Dawal (2011). Human Performance in Transportation: A Comparative Study of Human Performance Models. The 2011 International Conference on Traffic and Transportation Engineering (ICTTE 2011), Dubai, UAE.

4 Azlis Sani Jalil, et al. (2011). Understanding Human Performance Aspects in Transportation Safety. 2011 2nd International Conference on Mechanical and Manufacturing Engineering (ICME 2011), Putrajaya, Malaysia.

5 Azlis Sani Jalil, et al. (2011). "Sleepiness among train drivers: A case study in Malaysia." Malaysian Journal of Ergonomics (MJEr) Special Issue Special Issue: 21-29.

6 Jalil Azlis-Sani, S. Z. M. D., Norhayati Mohmad Zakwan and Mohd Faizal Mohideen Batcha (2013). Measuring Human Performance of Malaysian Train Drivers : A Factor Analysis. 17th International Conference on Industrial Engineering Theory, Applications and Practice, Pusan National University, Busan, Korea.

7 Jalil Azlis-Sani, S. Z. M. D., Norhayati Mohmad Zakwan and Mohd Faizal Mohideen Batcha (2013). Measuring Human Performance of Malaysian Train Drivers : Developing Model Using PLS Approach. 17th International Conference on Industrial Engineering Theory, Applications and Practice, Pusan National University, Busan, Korea.

8 Jalil Azlis-Sani, S. Z. M. D. a. N. M. Z. (2013). Validity and Reliability Testing on Train Driver Performance Model Using A PLS Approach. The 2nd International Conference on Ergonomics (ICE 2013), Kuala Lumpur, Malaysia.

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Future Human Performance Model for Malaysian Train Driver MA Sani, SZM Dawal International MultiConferences of Engineers and Scientists 2010 Volume III ...	2	2010
Decision making of screw manufacturing for the best environmental and economic combination by using AHP MA Azlan, AA Buja, CK Sia, M Nor, N Hisyamudin, J Azlis-Sani Applied Mechanics and Materials 465, 1065-1069		2014
Validity and Reliability Testing on Train Driver Performance Model Using a PLS Approach J Azlis-Sani, SZM Dawal, Z Norhayati Mohmad Advanced Engineering Forum 10, 361-366		2013
Strategies for Integrating Quality, Environmental, Safety and Health Management Systems M Mohammad, MR Osman, RM Yusuff, I Masood, MS Yahya, J Azlis-Sani Applied Mechanics and Materials 315, 894-898		2013
Measuring human performance of Malaysian train drivers: a factor analysis JA Sani, M Dawal, S Zawiah, MF Mohideen Batcha		2013
Measuring human performance of Malaysian train drivers: developing model using PLS approach JA Sani, M Dawal, S Zawiah, NM Zakwan, MF Mohideen Batcha		2013
Validity and reliability testing on train driver performance model using a PLS approach M Jalil, MA Sani, M Dawal, S Zawiah, N Mohmad Zakuan		2013
Human Performance in Transportation A Comparative Study of Human Performance Models AS Jalil, SZM Dawal, NM Zakwan International Journal of Engineering and Technology (IJET), 111-115		2012
Problem Based Learning in Engineering Subjects with Large Student Enrolment: the Project Management Approach SJ Azlis-Sani Jalil, Mohd Faizal Mohideen Batcha, Ck International Technology, Education and Development Conference (INTED)		2008
Development of Al-Cu-SiCp metal matrix composite for automotive applications M Jalil, MA Sani Universiti Malaya		2005

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Mohd Faizal Mohideen Batcha
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General fatigue investigation on Malaysian train drivers

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***Abstract*- Railway operations require its workers to have high efficiency rate towards improving the performance of the system. It is always the highest priority for every stakeholder. This study initially examines occurrences of fatigue among selected train drivers at the most prominent train operating company (TOC) in Malaysia. Nine train drivers were required to answer pencil-and-paper questionnaire, interviews was conducted with the supervisor, observations and work & sleep log had been performed. It was found that respondents were experienced fatigue during performing their driving task. Researcher also found alertness level of the drivers decreased as the period of the journey prolonged.**

I. INTRODUCTION

Railway is an industry based on the quality of the human resource. The operation of a railway system requires workers to have high efficiency rate towards improving the performance of the whole system. From the perspective of common sense, it is impossible to conceive a plant that is totally 'human-error free' [1]. Thus, engineers today not only could consider about the design and fabrication of the machineries and equipments, but they also required to think about human factors. Consideration of various influential factors potentially will reduce number of accidents either causes by technical difficulties or human error. Ergonomics engineering provides understanding of human performance and reliability which will be very helpful and beneficial.

Fatigue is one of the common problems faced by the train driver; where increased sleepiness and high levels fatigue are commonplace in many shift-work settings [2]. Therefore the improvement of this sector on effectiveness and the worker's health and safety must be improved through the implementation of appropriate measure.

II. FATIGUE

Fatigue is a state between being awake and asleep. Fatigue is generally believed to form gradually; and it will gradually increase, if it continues and increases, it will result in sleep [3]. Several factors had been identified responsible for elevated fatigue among train drivers, including uncertain shift times, long commutes, suboptimal terminal sleeping conditions, and the fact that some train drivers may not have daytime rest before a night shift [4]. Unfavorable shift systems can have wide-ranging effects, both on the personnel concerned, on the efficiency of the organizations for which they work and, most critically, on the safety of the rail system [5].

Dorrian *et. al* (2006) believes that sleep loss and fatigue are becoming recognised internationally as fundamental safety problems in the rail industry [4]. For this reason, they investigated the performance of 20 train drivers during the influence on low, moderate and high fatigue levels at the Queensland Rail Driver Training Centre (DTC), Rockhampton. They were expecting to observe similar, clear declines in simulator driving performance from the literature. It means that driving performance will reduce the efficiency with increasing on fatigue. As predicted, alertness, PVT reaction times, extreme speed violations (25% above the limit) and penalty brake applications increased with increasing fatigue level. In contrast, fuel used, draft (stretch) forces and braking errors were highest at moderate fatigue levels. The researchers concluded there was a substantial decrease in driving safety from the effect of fatigue.

While in UK, a research program conducted by Stone *et. al* (2005) was undertaken to understand the risks of current shift patterns in UK train drivers and develop strategies for risk reduction and control [5]. The main component of the program involved the collection of information from the drivers themselves, by means of two surveys. The first survey was a questionnaire relating principally to the drivers' shift patterns and attitudes to various aspects of shift work. The second survey was in the form of a diary of drivers' sleep and duty, which was completed over 28 consecutive duty periods. An investigation of accident risk based on the occurrence of Signals Passed at Danger (SPADs) was conducted. As the result, the researchers managed to develop guidelines (Coping with Shift Work and Fatigue) which if implemented, would reduce the risks associated with demanding shift patterns.

III. CAUSES OF FATIGUE

As mentioned earlier, researchers identified several factors contributed to the increment of fatigue level among train drivers which were much related to the number of working hours and sleep behavior of the driver. While discussing on working hours; shift systems, long commutes and rest time are among influential issues. Literature also relates the sleep behavior as one of the factors affecting fatigue.

A. Working hours

Stone *et. al* (2005) study on Fatigue and Shift Work in UK train drivers revealed that the duration of the shift length are a key factor leading to fatigue [5]. The research indicates that accident rates in shift workers are 25% higher on 12-hour compared with 8-hour shifts. It is therefore vital to restrict the amount of overtime taken at the end of a shift. Moreover, the impacts of long duty periods on fatigue are

Future Human Performance Model for Malaysian Train Driver

Mohd Azlis Sani & Siti Zawiah Md Dawal

Abstract - **Safety is important as technology advancement increasing daily. Accidents in transportation industry happen every day and given bad impact to the industry. Public transports become an alternative to the urban people, as the traffic congestion getting worse today which will results on increasing number of locomotives, as to fulfill the service demands, at the same time will increase number of train drivers, shifts, rail traffic congestion and other challenges. Another important issue will rise from this situation; safety. It is important for us to understand and investigate the performance of the train driver in order to ensure safety. Human performance and reliability become very important today when error and accident causation sometimes were blamed to the human. The purpose of this paper is to review human performance related to industries as well as the railway industry and discuss the importance of human performance studies for Malaysia train drivers. The review adopts a comprehensive literature review from numerous published sources via journals, books and electronic databases. The paper provides fresh literature on human performance models developed by other researchers to offer innovative ideas and concepts during the process of understanding the existing problems and issues.**

Index terms- human performance, rail ergonomics, human performance modeling, human factors

I. INTRODUCTION

Safety is important as technology advancement increasing daily. Modern machines and vehicles are faster than before in order to cope with the increasing demands. The faster a vehicle runs the higher risk of accident to be occurred. Accidents in transportation industry happen every day and sometimes involved bigger number of injuries, casualties and devastation.

Demand and requirements for safety and safety assurance are escalating. In transportation industries, every stakeholder including passengers, drivers, system operators and controllers and the organization demand to have a safe journey and working environment. As the stakeholders demand for safer environment (working and journey), they also contribute to achieve required level of safety as they play significant role in the system.

Apart from design and overall system operations, human error always been cited as a cause in disaster and accident in various industries including transportation. Human performance and reliability become very significant today when error and accident causation sometimes were blamed to the human [1].

Thus, the aim of this study is to develop a new human performance model tailored for Malaysia train driver.

II. HUMAN PERFORMANCE

Performance of the job, task and a system is widely recognized very important but factors affecting performance were not well understood by researchers and engineers [2]. Job performance and system usually rated through speed or tempo of the output, and the oldest and most widely used rating systems was Westinghouse system evaluating operators skill, effort, conditions and consistency [3]. Previously, human factors was left behind and be considered as independent factors with very less contribution to the overall system performance [4]. In fact, performance modeling software usually used in manufacturing sectors has limitation on the ability to adequately model the people's behavior in manufacturing system [5].

Recently, more investigations on human performance factors are conducted and influence the overall performance measurement and study ranging from the air traffic control system, design process at the factories, train driving activities and ship navigation [2, 5-7]. Awareness on importance of human performance studies are increasing and consideration on human performance factors come earlier during design stage. Previous practices showed study was conducted when system was implemented and established [5]. The development of human performance will enable the consideration of potentially conflicting task demands in a systematic and structured ways as the earliest stages in a design [1].

In principal, study on human performance will raise two questions; 'what are the appropriate direct worker activities and associated performance measures on which a framework should be based?' and 'what factors are most likely to have an impact on these measures?'[2].

Several existing human performance models in transportation (railway, aviation and shipping) and manufacturing are reviewed and presented for better understanding and to compare various factors influences

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Human Performance in Transportation

A Comparative Study of Human Performance Models

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***Abstract*— Human performance model (HPM) is an attempt to integrate and study the factors, and aspects influence the performance of a human during performing a job. Unfortunately, human factors and performance were left behind and be considered as independent factors with very fewer contributions to the system performance. The understanding of human performance will enable the analysis of potentially conflicting task demands in organized and structured ways as the earliest stages in a design. This paper is to address the importance of human performance to be considered in the transportation industry. Three keys human performance models were reviewed and presented for better understanding and to compare various factors influences the performance of a human.**

Keywords- human performance, human performance model, transportation, driver, safety

I. Introduction

Performance of the job and system are very valuable elements for achieving higher quality output and services. However, factors affecting performance of a human were not well understood either by researchers or engineers [1]. Human factors and performance were left behind and leaved as independent factors with very fewer contributions to the overall system performance [2]. In transportation industry, they're more studies on how the accident happened, new design of cockpit, fatigue, sleep behavior, etc.; but yet leaved as an individual study without integrating it by understanding other influential factors. As a result, performance modeling software which typically used in manufacturing sectors has a limitation on the ability to adequate model the people's behavior (human factors)[3].

Recently, more investigations were conducted on human performance factors; it includes from the air traffic control system, design process at the factories, train driving activities and ship navigation [1, 3-5]. Awareness and better understanding on the importance of human performance are increasing and consideration on the influential factors came earlier. It will enable the analysis of potentially conflicting task demands in organized and structured ways as the earliest stages in a design [6]. However, past practices showed the study was conducted when the system was implemented and factor ignorance such as workload, fatigue established. This previous approach may lead to cost increase due to design amendment, human and sleep problem, and risk level increment [7-11].

This paper is to address the importance of human performance to be considered in the transportation industry. Three keys human performance models are reviewed and to compare various factors influences the performance. With this review, commonality and differences can be listed with most consideration on transportation industry and environment.

II. Human Performance Models

Human performance model is an attempt to integrate as much as the researcher could consider and study the factors, and aspects influence the performance of a human. The model also becomes the easier and simpler representation of every item involved in the consideration. Very fewer numbers of researchers included factors affecting performance in a whole package, mostly choose to study in separate issues or factors; which will be more focus and details. Therefore, this research ultimate aim is to integrate every single factor affecting performance of a human (employees) in transportation industry. While as the beginning, this paper intends to discuss some existing performance models, which referred as basic models of human performance. We will discuss the performance model by Bailey (19), Baines et al. (2005) and Chang and Yeh (2010).

A. Bailey's model [12]

Bailey [12] proposed three elements required when predicting human performance. The elements are a) understanding of the human, b) the activity being performed and c) the context in which it is performed as depict in Figure 1. In this generic model, human become major element, which influences the overall performance either positively or negatively.

Human includes complex system of sensors, brain processing and responders, which affect the wide range of capability. In this very generic model, sensors include vision and hearing; the ability to think, reasoning and decision making for brain processing and arms, fingers and a mouth that functioned as responders.

Understanding Human Performance Aspects in Railway Safety

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Abstract:

In public transportation, demand and requirements for safety and safety assurance are escalating. Safety is noteworthy as technology advancement increasing daily. Every stakeholder either involved directly or indirectly need to consider safety as they could impact on the safety of the system. For that reason, safety is vital to the public transportation industry; it requires more attention and awareness in order to avoid accidents, life losses and injuries. Human performance modeling (HPM) is an attempt to integrate and study the factors, and aspects influence the performance of a human during performing a job. Unfortunately, human factors and performance were left behind and be considered as independent factors with very fewer contributions to the system performance.

1. Introduction

Performance of the job are very valuable elements and important dependent variable for achieving higher quality output and services [1]. In order to remain competitive with higher job performance level, human operator is the main focus to be taken care of [2]. However, factors affecting performance of a human were not well understood and studied either by researchers or engineers, and leaved it as individual study [3-4]. This area were left behind and leaved as independent factors with very fewer contributions to the overall system performance [5].

Awareness and better understanding on the importance of human performance are increasing and consideration on the influential factors came earlier. However, past practices showed the study was conducted when the system was implemented and factor ignorance such as workload, fatigue established. For example in railway industry, there are more studies on how the accident happened, new design of cab, fatigue and sleep behavior on existing design and operating system [6-11].

This previous approach may lead to cost increase due to design and system amendment, human and sleep problem, and risk level increment [6-8, 11-12]. Therefore, it is important to understand human performance approach as it will enable the analysis of potentially conflicting task demands in organized and structured ways as the earliest stages in a design [13].

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Sleepiness among train drivers: A case study in Malaysia

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Abstract

To ensure system performance and safety, train drivers need to be highly efficient. It has always been given the highest priority by all stakeholders in railway industry. Awareness and better understanding on the importance of human performance towards productivity and efficiency have increased. Monotonous driving is one of the major contributing factors for sleepiness among train drivers. The objective of the study is to determine the prevalence of sleepiness among train drivers and the importance to address sleepiness problem by the train operating companies (TOC) in Malaysia. 195 male train drivers were selected to answer self-administrated questionnaire to gather information on age and working experience. The Epworth Sleepiness Scale (ESS) was used to measure sleepiness among the train drivers; where the respondents themselves rate their chances to doze off or fall asleep in eight typically different situations. Flinders Fatigue Scale (FFS) was used to measure fatigue among the train drivers. The respondents were locomotive drivers and junior drivers from five different depots across Peninsular Malaysia; who drive locomotives in long haul operations. The results of the analysis are presented to provide better understanding on the sleep-related factors the impact on the performance of train drivers.

Keywords: sleepiness, human performance, train driver, railway, fatigue

1.0 Introduction

Driving a train is a monotonous activity and always found the driver easily dozes off [1]. With similar daily routine and very familiar train route, added with some environmental conditions such as temperature and noise; make the driving become very tiresome and uninteresting. Due to this boredom, it can lead the driver lost his focus. Sustained attention is required for the driver to safely drive the train [2] . It is also essential for the driver to maintain alertness to the signals and surrounding, response to irregular incident along the track and vigilance in order to ensure the train could arrived at its destination safely [3].

Previous researchers revealed that sleepiness and fatigue were among the causes of railway accidents around the world and recognised as fundamental safety problems in railway. It gave very severe impact on social and economic cost [1, 4].

Sleepiness may reduce alertness and attention of a driver towards signals, route condition and braking; and may jeopardize safety of the entire rail networks. It will be very dangerous and can lead to decrement of job performance and possibly cause injuries while working [5, 6]. Åkerstedt [2] also reported reduction of performance during the late night hours especially on works which need more attention and alertness. Accident and nearly

MEASURING HUMAN PERFORMANCE OF MALAYSIAN TRAIN DRIVERS: A FACTOR ANALYSIS

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Abstract: Performance of workers is an important factor for a designer or engineer in designing or improving related equipment, interface, job or system as a whole. Understanding human performance during design stage may reduce potential errors and improve safety aspects as well as effectiveness. Therefore, a study was done to identify factors in measuring human performance of train drivers. A self-administered survey, which was completed by the locomotive drivers and junior drivers, was conducted among train drivers from a local train operating company (TOC) in Malaysia. The survey was conducted in five railway depots across Peninsular Malaysia, namely Perai, Ipoh, Kuala Lumpur, Gemas and Kuala Lipis. A total of 229 responses were returned. Factor analysis technique was used for data reduction and to examine the relationship among variables. Step-by-step procedure of factor analysis was conducted to determine the number of factor solution appropriate for evaluating human performance. The final analysis result using Kaiser-Meyer-Olkin (KMO), which measured the sampling adequacy, was found to be 0.829 with 47.8% total variance. All 36 items had loading more than 0.4 and were loaded on five-factor solution without redundancy. The five-factor solution was the best proposed result upon item deletion and was measured with item loading as KMO value and eigenvalue were used as comparison.

1. INTRODUCTION

1.1 Importance of Human Performance in Railway Industry

Performance of workers is an important factor for a designer or engineer in designing or improving related equipment, interface, job or system as a whole. In railway, error-free system is critical to ensure the system safety. Circumstances from any train-related accident will involve high cost and cause devastation. Railway safety however is not bound to the train itself, but it has many facets including passengers, track staffs, control room staffs, and other staffs. Train drivers are one of the important stakeholders in ensuring safety of passengers, the train, and the system (Wilson, 2006; Wilson & Norris, 2005). Ladbroke Grove accident in 5th October 1999 was disastrous involving 400 injuries and 31 casualties. It was reported that accident was caused by human error, in particular was due to signal passed at danger (SPAD). The price to be paid due to the accident was too high (Stanton & Walker, 2011). Among other industries, rail ergonomics has become a forgotten branch of transport ergonomics as after so many years, rail business still evolves rather slowly compared to others (Wilson & Norris, 2005). However, the level of awareness on the importance of human factors in the railway is increasing and such awareness is very crucial in order to improve system reliability and human performance as well as safety (Clarke, 2005).

Thus, individual and system safety, human capability, human and limitations are the factors that need to be considered during early stage of the system design. These factors correspond to the needs, knowledge, and characteristics of the workers (Shahrokhi & Bernard, 2009). Interaction between human and the machine fails or is ineffective because of incompatibility of the workers. The machine system may not suit with the human characters and needs, thus the system does not work well (Wickens, Lee, Liu, & Becker, 2004). Increasing demand to improve the system and safety requires human performance to be used as a predictor for the design or system to be improved and optimised. Therefore, this paper empirically identifies a number of factors that can be used to measure human performance of train drivers.

MEASURING HUMAN PERFORMANCE OF MALAYSIAN TRAIN DRIVERS: DEVELOPING MODEL USING PLS APPROACH

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Abstract: The purpose of this paper is to address the assessment of validity and reliability of measured items used in survey research of train driver performance. This paper is a continuation from the first part of the research, which identified number of factors to be used on measuring human performance of train drivers and measured the impact of occupational stress and job satisfaction on train driver performance. The structural equation modelling (SEM) techniques and Partial Least Square (PLS) were adopted to assess the goodness of measures of constructs used in the model to examine the performance of the Malaysian train drivers. The measurement process involved assessment of construct validity of the items and followed by convergent validity. Then, the composite reliability was assessed with internal consistency measure of Cronbach's alpha and discriminant validity was tested to assess the validity of the measurement. Statistical results confirmed that occupational stress was an influential factor of performance; however, job satisfaction did not affect the performance of the train driver. The findings of this research are useful for policy makers, train operating company (TOC), and practitioners to improve human performance and safety of railway system.

1. INTRODUCTION

Job performance is an important dependent variable in achieving high-quality output and services (Kahya, 2009). In order to remain competitive with high job performance level, human operator is the main focus to be considered (Layer, Karwowski, & Furr, 2009).

In previous studies, job performance is only indicated through assessing employees' workload where determination of workload plays an important role in designing and evaluating an existing man-machine system (Chang & Chen, 2006; Jung & Jung, 2001). Chang & Chen (2006) state that long-term heavy workload can affect an employee's physical or mental health, performance or productivity, as reported by Ivenson and Pullman (2000). However, job performance does not only rely on workload, but there are other influential factors. Therefore, human who performs the task and who faces and feels the effect of the interaction in man-machine system needs to be investigated.

It is important to understand human as a major component in any relationship with machine and environment (Branton, 1987). Human performance model provides complete understanding on relationship among human, machine, and environment (Wilson, 1990).

Awareness and better understanding on the importance of human performance are increasing and consideration on the influential factors comes earlier. In railway industry, there are many studies on how train accident happens, new design of cab, fatigue and sleep behaviour on existing design and operating system (Darwent, Lamond, & Dawson, 2008; Dorrian, Roach, Fletcher, & Dawson, 2006, 2007; Edkins & Pollock, 1997; Farrington-Darby, Wilson, & Norris, 2005; Jay, Dawson, Ferguson, & Lamond, 2008), but studies on human performance as an integrated understanding of the factors are very limited.

This research generally aimed to study human performance of train driver. It is essential to understand the capability a local train drivers who operate the locomotive. By understanding human factors and performance of the train drivers, it will improve quality of service, reduce degree of risk, and avoid accidents from occurring. Therefore, as interest grows in understanding factors affecting human performance in railway industry, it becomes equally important to understand the influence of human performance on safety outcomes.

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Validity and Reliability Testing on Train Driver Performance Model Using A PLS Approach

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Keywords:human performance, structural equation modeling, reliability, validity, railway

Abstract. The purpose of this paper is to explain the assessment of validity and reliability of measured items used in survey research. The structural equation modeling techniques and Partial Least Square (PLS) will be adopted to assess the goodness of measures of constructs used in a model to examine the performance of the Malaysian train drivers. The measurement process involves assessment of construct validity of the items and followed by convergent validity. Then, the composite reliability was assessed with internal consistency measure of Cronbach's alpha. Lastly, discriminant validity was tested to assess the validity of the measurement. The constructs are not supposed to measure other constructs or overlapping constructs.

Introduction

Human performance. Performances are related to the job or task assigned to the operators unless it is conducted fully automatic by machines or robots. But, most of industries still depend on their human operators including railway, where locomotives are still operated by the train drivers.

Previously, human factors was left behind and be considered as independent factors with very less contribution to the overall system performance[1]. Researchers conducted their studies on individual variable to measure performance, factors affecting performance and effect of performance; either on individual level or organizational level. Most of them relate one or two variables or factors affecting performance with the effect or consequences of the level of performance.

To date, investigations on human performance factors were conducted and influences the overall performance measurement and study ranging from the air traffic control system, design process at the factories, train driving activities and ship navigation [2-5]. Awareness on importance of human performance studies are increasing and consideration on human performance factors

APPENDICES

Appendix 1: Employee Performance Standard Form – for Non-executive

HRM/PMS/NEX

Borang Piawaian Prestasi Kakitangan - Untuk Bukan Eksekutif

Sulit & Rahsia

Tahun : 2010

Seksyen A

Nama :		**No. Perkhidmatan :**	
Gelaran Jawatan : PEMANDU LOKOMOTIF		**Tarikh lantikan ke jawatan sekarang :** 22-May-00	
Bahagian : PERKHIDMATAN KARGO	**Lokasi:** PERAI	**Skim :** A07	**Gred :** G10

Nama Pegawai Penilai : **No. Perkh :**	**Nama Pegawai Penilai Semula :**
Jawatan : PENOLONG FOMEN (G)	**Jawatan :**

Seksyen B

Latihan/Kursus yang pernah dihadiri (2010) :	**Lain-lain pencapaian dan sumbangan terhadap Syarikat :**

ASAL

102002N-Operations-N

HRM/PMS/NEX

Seksyen C : Pengukuran Kecekapan

Perkara di bawah ini adalah sebagai petunjuk prestasi yang telah memenuhi piawaian yang ditetapkan.

Kecekapan	Pegawai Dinilai (Komen)	Markah	Pegawai Penilai (Komen)
1. Pengetahuan Tugas *Kefahaman tugas harian* *Kefahaman kehendak tugas dengan lebih mendalam.*	Setuju	3.5	Faham dengan tugasan nya
2. Perkhidmatan Pelanggan *(Dalaman & Luaran)* *Bersopan & Berbudi Bahasa* *Menerima maklum balas yang positif*	Setuju	3	Bersopan
3. Sikap & Kelakuan *Menampilkan sikap & kelakuan yang positif* *Sanggup menerima perubahan bagi pembangunan kerjaya*	Setuju	3	Sedia menerima
4. Disiplin *Mematuhi aturan & peraturan yang ditetapkan* *Lewat masuk bertugas*	Setuju	3.5	Berdisiplin

Seksyen D : Pilih di antara perkara ini yang berkaitan dengan tugasan harian anda.

5. Tanggungjawab tugas *Boleh mengatur/menyusun tugas mengikut keutamaan* *Boleh menyiapkan kerja/ tugas dalam masa yang ditetapkan* *Menjalankan tugas mengikut spesifikasi yang ditetapkan*	Setuju	3.5	Bertanggungjawab
6. Kerja Berpasukan *Selalu mengambil bahagian dan bekerjasama* *Selalu memberi sumbangan untuk kejayaan*	Setuju	3.5	Bekerjasama
7. Daya Usaha *Berkebolehan untuk mengambil tindakan secara bersendirian* *Berdaya usaha dan proaktif*	Setuju	3.5	Berusaha
8. Ketrampilan Diri *Kemas dan Bersih* *Sentiasa kelihatan menarik*	Setuju	3.5	Kemas

5 Melampaui piawaian	**4** Melebihi piawaian	**3** Memenuhi piawaian	**2** Di bawah piawaian	**1** Jauh di bawah piawaian

HRM/PMS/NEX

Seksyen E : **Cuti Sakit / Rekod Disiplin (Tahun : 2010)**

Cuti Sakit / Cuti Tanpa Gaji			Rekod Disiplin Pada Tahun Dinilai
Klinik Panel	14	Cuti Tanpa Gaji	*(Senaraikan Jenis Hukuman)*
Klinik bukan Panel	/		
Klinik / Hospital Kerajaan			
Wad *(Warded)*			
Jumlah	14		
Nota: (Diisi oleh : Penyelia / Pegawai yang meluluskan cuti)			*Nota: (Diisi oleh : Penyelia)*

Seksyen F : **Penilaian Keseluruhan**
Sila lampirkan lampiran kertas lain sekiranya perlu.

Jumlah Markah

Jumlah Markah [27] / Jumlah Kecekapan x 5 [40] X 100 = [67.5]

Keseluruhan Markah

Pembahagian Markah		Wajaran Keseluruhan
90 & keatas	Melampaui piawaian	A
70 – 89	Melebihi piawaian	B
50 – 69	Memenuhi piawaian	(C)
35 – 49	Dibawah piawaian	D
34 & kebawah	Jauh dibawah piawaian	E

Komen Pegawai Penilai

HRM/PMS/NEX

Komen Pegawai Dinilai

Ruangan untuk Pembangunan Diri
Pegawai Dinilai dan Pegawai Penilaian hendaklah berbincang mengenai peningkatan kerjaya pegawai dinilai supaya kecekapan dan kerjaya beliau dapat di pertingkatkan.

Tindakan diambil : Oleh:

[signature] 25.11.10
Tandatangan/Tarikh
Pegawai Dinilai

[signature] 25.11.10
Tandatangan/Tarikh
Pegawai Penilai

Pegawai Penilai Semula

No komen

[signature]
Tandatangan/Tarikh 30/11/10
Pegawai Penilai Semula

Appendix 2: Questionnaire (Bahasa Malaysia)

VERSI BAHASA

Soal selidik

Soal selidik ke atas prestasi manusia untuk pemandu keretapi Malaysia

---

Tuan / puan yang saya hormati,

Saya Mohd Azlis Sani Md Jalil (nombor staf 00775) seorang kakitangan akademik Universiti Tun Hussein Onn Malaysia sedang melakukan satu kajian bertajuk "*Development of Malaysian Train Driver Performance Model*".

Soal selidik ini bertujuan untuk mengumpul maklumat berkaitan prestasi manusia di kalangan pemandu keretapi di Malaysia. Objektif utama kajian ini adalah untuk menentukan faktor-faktor yang mempengaruhi prestasi seorang pemandu. Kajian ini adalah kerjasama di antara UM dan Jabatan Keselamatan Pekerjaan, Kesihatan dan Persekitaran (OSHEN), KTMB.

Data ini akan menyediakan kebaikan kepada penyelidik dan pihak-pihak berkepentingan di dalam usaha mempertingkatkan prestasi sedia ada. Maklumat yang diperolehi hanya akan digunakan secara sulit, untuk tujuan kajian ini sahaja.

Sila baca dengan teliti dan ambil masa tuan/puan untuk menjawab borang soal selidik ini. Borang ini mengandungi 3 bahagian utama dengan beberapa sub-bahagian di dalamnya. Di mana yang sesuai, bulatkan jawapan atau lengkapkan jawapan di tempat kosong yang disediakan.

Terima kasih untuk masa dan penglibatan tuan/puan.

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1.0 MAKLUMAT UMUM

Sila tandakan (√) untuk jawapan anda di ruangan yang disediakan.

1.	Jantina	☐ Lelaki	☐ Perempuan	
2.	Umur	☐ Bawah 25	☐ 35 – 44	☐ Over 56
		☐ 25 – 34	☐ 45 – 56	
3.	Tempoh bekerja di industri keretapi	☐ Kurang dari 1 tahun	☐ 6 – 10 tahun	☐ 20 tahun atau lebih
		☐ 1 – 5 tahun	☐ 11 – 19 tahun	
4.	Jawatan anda sekarang	☐ *Locomotive inspector*	☐ Pemandu lokomotif	☐ Pengajar
		☐ Lain – lain (sila nyatakan) ________________________		
5.	Tempoh memegang jawatan sekarang	☐ Kurang dari 1 tahun	☐ 6 – 10 tahun	☐ 20 tahun atau lebih
		☐ 1 – 5 tahun	☐ 11 – 19 tahun	
6.	Depoh bertugas	☐ Kuala Lumpur	☐ Ipoh	☐ Tumpat
		☐ Prai (Butterworth)	☐ Gemas	☐ Kuala Lipis
		☐ Singapura		

2.0 BEBANAN TUGAS

Sila bulatkan nombor yang memberikan jawapan terbaik anda.

A. Kod **Adakah anda berpuas hati dengan aspek – aspek berikut di dalam tugasan anda?**

			Sangat setuju	Setuju	Neutral	Tidak setuju	Sangat tidak setuju
1	JS1	Keadaan kerja secara fizikal	1	2	3	4	5
2	JS2	Tugasan anda secara keseluruhan	1	2	3	4	5
3	JS3	Penghargaan yang diperolehi untuk tugasan yang cemerlang	1	2	3	4	5
4	JS4	Tahap tanggungjawab yang diamanahkan kepada anda	1	2	3	4	5
5	JS5	Peluang untuk menggunakan kebolehan anda	1	2	3	4	5

B. **Bulatkan nombor yang menunjukkan tahap anda berpuashati dengan kerja anda.**

			Sangat lebih daripada yang dihajati	Lebih daripada yang dihajati	Munasabah	Kurang daripada yang dihajati	Sangat kurang daripada yang dihajati
1	JS6	Secara umum, saya rasa hari bekerja saya dalam sebulan adalah:	1	2	3	4	5
2	JS7	Secara umum, saya rasa jumlah masa bekerja saya dalam sebulan adalah:	1	2	3	4	5
3	JS8	Secara umum, saya rasa hari bekerja saya secara berturutan adalah:	1	2	3	4	5

C. Sila nilaikan aspek – aspek berikut di dalam tugasan anda

			Sangat setuju	Setuju	Neutral	Tidak setuju	Sangat tidak setuju
1	JCH 1	Saya sentiasa melakukan aktiviti asas yang sama	1	2	3	4	5
2	JCH 2	Saya perlu meneliti beberapa perkara serentak	1	2	3	4	5
3	JCH 3	Saya berurusan dengan masalah yang sukar diselesaikan	1	2	3	4	5
4	JCH 4	Saya jarang terganggu dan sering mempunyai masa terluang semasa bekerja	1	2	3	4	5
5	JCH 5	Saya rasa kerja saya sangat mencabar	1	2	3	4	5
6	JCH 6	Kesilapan di pihak saya akan menggugat keselamatan	1	2	3	4	5

D. Sila nyatakan hingga tahap mana anda bersetuju atau tidak dengan kenyataan – kenyataan berikut.

			Sangat setuju	Setuju	Neutral	Tidak setuju	Sangat tidak setuju
1	JCH 7	Saya memerlukan lebih tumpuan berfikir berbanding daripada apa yang saya suka	1	2	3	4	5
2	DT1	Keretapi beroperasi tidak mengikut jadual perjalanannya.	1	2	3	4	5
3	DT2	Saya menjadi sangat mengantuk apabila memandu	1	2	3	4	5
4	DT3	Saya merasa jemu dan bosan terhadap kerja yang sama (rutin).	1	2	3	4	5
5	DT4	Saya sering memandu ketika waktu puncak	1	2	3	4	5
6	DT5	Saya dibekalkan pindaan jadual waktu pada hari perjalanan	1	2	3	4	5

E. Sila nyatakan hingga tahap mana anda bersetuju atau tidak dengan kenyataan – kenyataan berikut.

			Sangat setuju	Setuju	Neutral	Tidak setuju	Sangat tidak setuju
1	JRT 1	Saya merasakan hanya mempunyai sedikit kuasa (wibawa) untuk melaksanakan tanggungjawab yang diamanahkan kepada saya	1	2	3	4	5
2	JRT 2	Saya tidak jelas dengan skop (ruang lingkup) dan tanggungjawab kerja saya	1	2	3	4	5
3	JRT 3	Saya tidak mengetahui peluang untuk peningkatan atau kenaikan pangkat yang wujud buat saya	1	2	3	4	5
4	JRT 4	Saya merasakan mempunyai beban tugas yang terlalu berat	1	2	3	4	5
5	JRT 5	Saya terfikir tidak berupaya memuaskan hati dengan tuntutan yang bercanggah di kalangan individu sekeliling saya	1	2	3	4	5
6	JRT 6	Saya merasa tidak layak untuk melaksanakan tugasan tersebut	1	2	3	4	5
7	JRT 7	Saya tidak mengetahui apakah pandangan penyelia terhadap saya, dan bagaimana beliau menilai prestasi saya	1	2	3	4	5
8	JRT 8	Pada hakikatnya, saya tidak mendapat maklumat yang	1	2	3	4	5

		diperlukan untuk menjalankan tugas saya					
9	JRT 9	Saya perlu mebuat keputusan kepada perkara – perkara yang mempengaruhi kehidupan orang yang dikenali	1	2	3	4	5
10	JRT 10	Saya merasakan mungkin tidak disukai dan diterima oleh orang – orang yang bekerja di sekeliling saya	1	2	3	4	5
11	JRT 11	Saya merasa tidak berupaya untuk mempengaruhi keputusan dan tindakan penyelia yang akan menjejaskan pekerjaan saya	1	2	3	4	5
12	JRT 12	Saya tidak mengetahui apakah harapan rakan sekerja terhadap saya	1	2	3	4	5
13	JRT 13	Saya terfikir adakah jumlah kerja yang saya lakukan mungkin akan mempengaruhi bagaimana ia akan diselesaikan	1	2	3	4	5
14	JRT 14	Perasaan saya apabila saya terpaksa melakukan kerja yang berlawanan dengan prinsip saya	1	2	3	4	5
15	JRT 15	Perasaan saya apabila kerja yang saya lakukan mengganggu kehidupan keluarga saya	1	2	3	4	5

F. **Sila nyatakan tahap tekanan yang dialami daripada pelbagai sebab.**
Kami menyedari tekanan yang dialami adalah berbeza mengikut masa, tetapi sila jawab dengan penilaian paling baik tentang tugas saya secara umum

			Tiada tekanan langsung		____________________			Terlalu tertekan
1	STR 1	Mempunyai kerja yang terlalu banyak untuk dilaksanakan	0	1	2	3	4	5
2	STR 2	Tertekan dengan masa dan tempoh akhir	0	1	2	3	4	5
3	STR 3	Kesukaran menukar shif kerja saya	0	1	2	3	4	5
4	STR 4	Tidak mempunyai kerja yang mencukupi	0	1	2	3	4	5
5	STR 5	Sentiasa selari dengan teknologi terkini	0	1	2	3	4	5
6	STR 6	Terancam akan kehilangan kerja	0	1	2	3	4	5
7	STR 7	Bosan dan tugasan berulang – ulang	0	1	2	3	4	5
8	STR 8	Apabila membuat keputusan penting	0	1	2	3	4	5
9	STR 9	Terasa terasing	0	1	2	3	4	5
10	STR 10	Mempunyai kekurangan kuasa dan pengaruh	0	1	2	3	4	5
11	STR 11	Kekurangan sokongan dan galakan daripada penyelia	0	1	2	3	4	5
12	STR 12	Kekurangan kakitangan	0	1	2	3	4	5
13	STR 13	Latihan yang tidak mencukupi	0	1	2	3	4	5
14	STR 14	Pengurusan shif yang lemah	0	1	2	3	4	5
15	STR 15	Sedikit peluang untuk pengembangan peribadi dan kerjaya	0	1	2	3	4	5
16	STR 16	Tuntutan kerja ke atas kehidupan peribadi saya	0	1	2	3	4	5
17	STR	Terlalu banyak tugas pentadbiran atau	0	1	2	3	4	5

	17	kertas kerja						
18	STR 18	Terpaksa berhadapan dengan kejadian diluar kawalan saya	0	1	2	3	4	5
19	STR 19	Keyakinan diri yang rendah terhadap syarikat	0	1	2	3	4	5
20	STR 20	Kekurangan komunikasi dan tempat rujukan	0	1	2	3	4	5

3.0 KELESUAN

A. Tandakan (√) untuk jawapan anda atau dengan mengisi tempat kosong

1 FH01 Secara purata berapa jam anda bekerja dalam seminggu (termasuk kerja lebih masa)?

☐ < 20 jam ☐ 20 – 40 jam ☐ 40 – 60 jam ☐ > 60 jam

2 FH02 Secara umum, purata berapa jam untuk menamatkan satu perjalanan (trip)?

☐ 2 – 3 jam ☐ 3 – 6 jam ☐ 6 – 8 jam ☐ > 8 jam

3 FH07 Dalam masa setahun, secara purata berapa hari sebulan anda telah bekerja?

☐ < 10 hari ☐ 10 – 20 hari ☐ 20 – 30 hari

4 FH03 FSH02 Apakah pola kelaziman shif anda?

☐ Awal pagi hingga malam (pusingan ke hadapan) ☐ Hari tetap

☐ Malam hingga awal pagi (pusingan ke belakang) ☐ 12 jam sehari /12 jam semalam

☐ Lain – lain (sila nyatakan) ____________________

5 FH04 FSH05 Dalam masa 12 bulan lepas, apakah shif yang anda bekerja secara berturut-turut tanpa hari rehat?

☐ Awal pagi hingga malam (pusingan ke hadapan) ☐ Hari tetap

☐ Malam hingga awal pagi (pusingan ke belakang) ☐ 12 jam sehari /12 jam semalam

☐ Lain – lain (sila nyatakan) ____________________

6 FSH06 Dalam setahun lepas, berapa kerap anda mendapat rehat kurang 12 jam di antara shif?

☐ Tidak pernah ☐ Jarang – jarang ☐ Kadang kala ☐ Selalu

7 FSH07 Adakah anda fikir anda boleh mendapat tidur yang cukup selepas waktu bekerja siang atau waktu bekerja malam?

☐ Ya ☐ Tidak

8 FSH08 Adakah anda fikir anda boleh mendapat peluang yang cukup untuk berehat semasa bekerja?

☐ Ya ☐ Tidak

9 FSH09 Apakah tahap kelesuan yang dialami akibat kerja yang dilakukan?

☐ Tiada langsung ☐ Sedikit sahaja ☐ Jumlah yang munasabah

☐ Banyak juga ☐ Sangat banyak

10 FSH 10 Bilakah anda mengalami tahap kelesuan tertinggi semasa shif siang dan malam?

Siang hari ☐ Permulaan shif ☐ Semasa shif ☐ Penghujung shif

☐ Sepanjang masa shif ☐ Tidak berkaitan

Malam ☐ Permulaan shif ☐ Semasa shif ☐ Penghujung shif

☐ Sepanjang masa shif ☐ Tidak berkaitan

11 FSH 11 Pada pandangan anda, apakah penyebab kelesuan yang anda alami?

____

12 FSH 12 Dalam 4 minggu ini, adakah anda mengenalpasti sebarang tanda (symptom) masalah fizikal (cth. rasa sakit, tidak selesa atau keletihan melampau) di mana-mana bahagian badan, sama ada semasa atau selepas shif kerja anda?

☐ Ya ☐ Tidak

13 FSH 13 Jika Ya, sila berikan sedikit makluman berkenaan masalah tersebut, dan pada pandangan anda, apakah punca masalah tersebut.

____

4.0 PERSEKITARAN KERJA

A. Sila nyatakan setakat mana anda bersetuju dengan pernyataan – pernyataan di bawah.

			Sangat setuju	Setuju	Neutral	Tidak setuju	Sangat tidak setuju
1	WC 1	Kemudahan komunikasi yang ada tidak lengkap untuk kegunaan semasa kecemasan	1	2	3	4	5
2	WC 2	Piawaian (standard) penyenggaraan ruang pemanduan (cabs) yang lemah	1	2	3	4	5
3	WC 3	Gangguan kepada ruang pemanduan yang kosong (ditinggalkan) oleh individu yang tiada kebenaran masuk	1	2	3	4	5
4	WC 4	Kemudahan tandas yang tidak memuaskan	1	2	3	4	5
5	WC 5	Kemudahan makanan yang tidak memuaskan	1	2	3	4	5
6	WC 6	Anda ambil peduli bahawa keretapi mungkin akan mengalami kerosakan semasa anda memandunya	1	2	3	4	5
7	WC 7	Terpaksa memperuntukkan sebilangan masa untuk berulang alik ke tempat kerja	1	2	3	4	5

B. Bagaimanakah perasaan anda terhadap tempat kerja anda?

			Sangat setuju	Setuju	Neutral	Tidak setuju	Sangat tidak setuju
1	WE 1	Ruang kaki dibawah meja adalah memadai	1	2	3	4	5
2	WE 2	Secara keseluruhan, kerusi adalah selesa	1	2	3	4	5
3	WE 3	Semua peralatan yang saya kerap guna di stesen kerja adalah di dalam had jangkauan saya	1	2	3	4	5

4	WE 4	Semua kertas maklumat yang saya perlukan mudah ditemui	1	2	3	4	5
5	WE 5	Secara umumnya, susun atur stesen kerja saya adalah baik	1	2	3	4	5
6	WE 6	Terdapat ruang yang mencukupi untuk bergerak di ruangan operasi	1	2	3	4	5
7	WE 7	Kawasan kerja ini adalah bebas daripada risiko renjatan (cth. Kabel)	1	2	3	4	5
8	WE 8	Umumnya, saya berasa selesa dengan suhu tempat kerja saya	1	2	3	4	5
9	WE 9	Saya berpeluh dengan banyaknya semasa menjalankan kerja	1	2	3	4	5
10	WE 10	Persekitaran kerja saya sangat senyap dan selesa	1	2	3	4	5
11	WE 11	Saya dapat lihat kerja saya dengan jelas	1	2	3	4	5
12	WE 12	Di sini sangat panas dan saya tidak selesa di sini	1	2	3	4	5
13	WE 13	Saya rasa selesa dan kurang berpeluh	1	2	3	4	5
14	WE 14	Di sini sangat bising dan sukar untuk berkomunikasi di sini	1	2	3	4	5
15	WE 15	Cahaya lampu sangat malap dan sukar untuk melihat dan menjalankan kerja saya	1	2	3	4	5

5.0 KESELAMATAN

A. **Bagaimana anda mengambil berat berkaitan aspek – aspek keselamatan di tempat kerja?**

			Sangat ambil berat	Ambil berat	Neutral	Tidak ambil berat	Sangat tidak ambil berat
1	SI0 1	Anda ambil berat berkenaan vandalisme– cth: ada individu merosakkan keretapi, meletakkan halangan di atas landasan	1	2	3	4	5
2	SI0 2	Anda ambil berat tentang kemungkinan akan mencederakan atau mengakibatkan kehilangan nyawa seseorang	1	2	3	4	5
3	SI0 4	Anda memandu di landasan semasa pekerja penyelenggaraan sedang bekerja	1	2	3	4	5
4	SI0 5	Anda ambil berat berkenaan kemungkinan terjatuh akibat halangan semasa bergerak keluar daripada ruang pemanduan pada waktu malam	1	2	3	4	5
5	SI0 6	Anda ambil berat kemungkinan diserang	1	2	3	4	5
6	SI0 7	Anda ambil berat tentang kemungkinan tergelincir semasa memanjat masuk dan keluar apabila keretapi tidak berada di platform	1	2	3	4	5

B. **Sila nyatakan setakat mana anda bersetuju dengan pernyataan – pernyataan di bawah.**

			Sangat setuju	Setuju	Neutral	Tidak setuju	Sangat tidak setuju
1	SC01	Keselamatan adalah keutamaan di dalam syarikat ini	1	2	3	4	5
2	SC02	Di tempat kerja saya, pihak pengurusan mengabaikan isu-isu keselamatan	1	2	3	4	5
3	SC03	Penyelia meminta bantuan saya untuk menyelesaikan masalah di tempat kerja	1	2	3	4	5
4	SC04	Pengurusan bertindakbalas dengan cepat terhadap sebarang isu keselamatan	1	2	3	4	5
5	SC05	Penyelia selalu memaklumkan kepada saya berkenaan isu – isu berkaitan keselamatan	1	2	3	4	5
6	SC06	Saya digalakkan untuk memberi idea berkenaan keselamatan	1	2	3	4	5
7	SC07	Jika saya melaporkan sesuatu isu keselamatan, saya terasa seperti dipersalahkan kerana masalah tersebut	1	2	3	4	5
8	SC08	Saya boleh mendekati penyelia saya untuk berbincang tentang masalah kerja	1	2	3	4	5
9	SC09	Sering tidak cukup pekerja untuk melakukan tugas dengan cara yang selamat	1	2	3	4	5
10	SC10	Maklumbalas daripada sesuatu kejadian kemalangan adalah baik	1	2	3	4	5
11	SC11	Saya tidak boleh melakukan kerja jika saya terlalu mengikut prosedur dan peraturan	1	2	3	4	5
12	SC12	Adalah tidak mustahil untuk membiasakan diri dengan semua prosedur yang berkaitan dengan kerja saya	1	2	3	4	5
13	SC13	Latihan kerja juga meliputi aspek keselamatan yang kritikal	1	2	3	4	5
14	SC14	Kadang kala, tindakan orang lain membantutkan saya daripada melakukan kerja secara cekap	1	2	3	4	5
15	SC15	Tindakan saya akan mempengaruhi keselamatan orang lain yang menjalankan tugas mereka	1	2	3	4	5

6.0 SKALA KELESUAN FLINDERS

Kami berminat dengan pengalaman anda merasai kelesuan (letih, jemu, kepenatan) dalam masa 2 minggu lepas. Kami tidak bermaksud rasa mengantuk (terasa seperti ingin tertidur). Sila bulatkan maklumbalas yang sesuai berdasarkan perasaan anda secara purata di dalam tempoh 2 minggu ini.

			Tidak sama sekali		Berpatutan		Amat
1	FF01	Adakah kelesuan merupakan masalah bagi anda?	1	2	3	4	5
2	FF02	Adakah kelesuan menyebabkan anda bermasalah untuk menjalankan tugas harian anda (cth.: kerja, sosial, berkeluarga)?	1	2	3	4	5
3	FF03	Adakah kelesuan menyebabkan anda murung?	1	2	3	4	5

4	FF04	Berapa kerap anda mengalamai kelesuan?	0 hari/minggu	1-2 hari/minggu	3-4 hari/minggu	5-6 hari/minggu	7 hari/minggu

5 FF05 Bilakah masa-masa dalam sehari anda selalunya sering mengalami kelesuan? (Sila tandakan √ di dalam kotak (boleh lebih dari 1 kotak))

- ☐ Awal pagi
- ☐ Pertengahan pagi
- ☐ Tengah hari
- ☐ Petang
- ☐ Lewat petang
- ☐ Lewat malam

			Tidak sama sekali		Berpatutan		Amat
6	FF06	Bagaimana teruk kelesuan yang anda alami?	1	2	3	4	5

			Tidak sama sekali		Berpatutan		Amat
7	FF07	Adakah kelesuan anda disebabkan oleh tidur yang kurang nyenyak?	1	2	3	4	5

7.0 SKALA MENGANTUK EPWORTH

Bagaimana anda terlelap di dalam situasi berikut, berbeza dengan hanya merasa letih?

Ia merujuk kepada amalan biasa di dalam kehidupan anda baru – baru ini.

Sekiranya anda tidak melakukannya baru – baru ini, cuba bayangkan bagaimana ia boleh mendatangkan kesan kepada anda.

Guna skala berikut untuk memilih nombor yang paling sesuai untuk setiap keadaan:

0 = tidak akan tertidur

1 = kemungkinan **kecil** akan terlelap

2 = berkemungkinan akan terlelap

3 = kemungkinan **besar** akan terlelap

Ia adalah penting untuk anda menjawab setiap soalan dengan jawapan yang terbaik

	Situasi	Peluang untuk terlelap (0 – 3)
FSL 01	Duduk dan membaca	
FSL02	Menonton TV	
FSL03	Duduk, tidak aktif di tempat awam (cth.: teater atau mesyuarat)	
FSL04	Sebagai penumpang di dalam kereta selama sejam tanpa kereta berhenti rehat	
FSL05	Berbaring untuk berehat pada waktu tengah hari apabila keadaan mengizinkan	
FSL06	Duduk dan berbicara dengan seseorang	
FSL07	Duduk dengan senyap selepas makan tengah hari tanpa alcohol (minuman keras)	
FSL08	Di dalam kereta, apabila kereta berhenti seketika di dalam trafik	

Skala ini diambil dan diguna dengan kebenaran daripada:

M.W. Johns 1990-97

Terima kasih di atas kerjasama tuan/puan.

Appendix 3: Questionnaire (English)

ENGLISH VERSION

Questionnaire

Survey on Human Performance of Malaysian Train Driver

Soal selidik ke atas prestasi manusia untuk pemandu keretapi Malaysia

---

Kepada responden,

Soal selidik ini bertujuan untuk mengumpul maklumat berkaitan prestasi manusia di kalangan pemandu keretapi di Malaysia. Objektif utama kajian ini adalah untuk menentukan faktor-faktor yang mempengaruhi prestasi seorang pemandu. Kajian ini adalah kerjasama di antara UM dan Jabatan Keselamatan Pekerjaan, Kesihatan dan Persekitaran (OSHEN), KTMB.

Data ini akan menyediakan kebaikan kepada penyelidik dan pihak-pihak berkepentingan di dalam usaha mempertingkatkan prestasi sedia ada. Maklumat yang diperolehi hanya akan digunakan secara sulit, untuk tujuan kajian ini sahaja.

Sila baca dengan teliti dan ambil masa anda untuk menjawab borang soal selidik ini. Borang ini mengandungi 3 bahagian utama dengan beberapa sub-bahagian di dalamnya. Di mana yang sesuai, bulatkan jawapan atau lengkapkan jawapan di tempat kosong yang disediakan.

Terima kasih untuk masa dan penglibatan anda.

Dear respondent,

This questionnaire aims to gather information about human performance among train drivers in Malaysia. The main objective of this survey is to determine influential factors affecting performance of the driver. This research is a collaboration between UM and the Department of Occupational Safety, Health and Environment (OSHEN), KTMB.

The data will provide practical benefits to the researcher and stakeholders in order to improve the existing practices. The information provided will only be used with confidentially, strictly for the purposes of this study.

Please read carefully and take your time during answering this survey form. This questionnaire consists of 3 main sections with several sub-sections. Where the appropriate, circle the answer or complete the answer in the space provided.

Thank you for your time and participation.

Researcher/penyelidik :

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1.0 GENERAL INFORMATION

Please tick (√) your answer in the space provided.

1. What gender are you?
   - ☐ Male
   - ☐ Female

2. Please indicate your age group
   - ☐ Under 25
   - ☐ 35 – 44
   - ☐ Over 56
   - ☐ 25 – 34
   - ☐ 45 – 56

3. How long have you been working in the railway industry?
   - ☐ Less than 1 year
   - ☐ 6 – 10 years
   - ☐ 20 years or more
   - ☐ 1 – 5 years
   - ☐ 11 – 19 years

4. Your current post
   - ☐ Locomotive inspector
   - ☐ Locomotive driver
   - ☐ Trainer
   - ☐ Others (please specify) ________________________

5. How long have you been in your current posting?
   - ☐ Less than 1 year
   - ☐ 6 – 10 years
   - ☐ 20 years or more
   - ☐ 1 – 5 years
   - ☐ 11 – 19 years

6. What is your reporting depot?
   - ☐ Kuala Lumpur
   - ☐ Ipoh
   - ☐ Tumpat
   - ☐ Prai (Butterworth)
   - ☐ Gemas
   - ☐ Kuala Lipis
   - ☐ Singapore

2.0 WORKLOAD

Please circle the number which corresponds to your best answer.

A. **Do you satisfy with these following aspects in your job?**

			Very satisfied	Moderately satisfied	Neutral	Moderately dissatisfied	Very dissatisfied
1	JS1	The physical working conditions	1	2	3	4	5
2	JS2	Your job as a whole	1	2	3	4	5
3	JS3	The recognition you get for good work	1	2	3	4	5
4	JS4	The amount of responsibility you are given	1	2	3	4	5
5	JS5	Your opportunity to use your abilities	1	2	3	4	5

B. **Circle the number which corresponds to how satisfied you feel about your job.**

			Much more than I desire	more than I desire	About the right	Less than I desire	Much less than I desire
1	JS6	In general, I feel my working days per month are:	1	2	3	4	5
2	JS7	In general, I feel my working hours per are:	1	2	3	4	5
3	JS8	In general, I feel my working days in the row are:	1	2	3	4	5

C. **Please rate the following aspects of your job.**

			Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	JCH1	I complete the same basic activities most of the time	1	2	3	4	5
2	JCH2	I have to keep track of more than one thing at a time	1	2	3	4	5
3	JCH3	I deal with problems which are difficult to solve	1	2	3	4	5
4	JCH4	I am rarely interrupted and often have spare time in my work	1	2	3	4	5
5	JCH5	I am challenged by my job	1	2	3	4	5
6	JCH6	An error on my part could cause a safety incident	1	2	3	4	5

D. **Please indicate to what extents do you agree or disagree with the following statements.**

			Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	JCH7	More mental concentration required than you would like	1	2	3	4	5
2	DT1	Trains not running according to schedule	1	2	3	4	5
3	DT2	Becoming very drowsy while driving	1	2	3	4	5
4	DT3	Boredom and monotony of the job	1	2	3	4	5
5	DT4	Driving during peak hours	1	2	3	4	5
6	DT5	Being issued time-table alterations on the day of travelling	1	2	3	4	5

E. **Please indicate to what extents do you agree or disagree with the following statements.**

			Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	JRT1	Feeling that you have too little authority to carry out the responsibilities assigned to you	1	2	3	4	5
2	JRT2	Being unclear on just what the scope and responsibilities of your job are	1	2	3	4	5
3	JRT3	Not knowing what opportunities for advancement or promotion exist for you	1	2	3	4	5
4	JRT4	Feeling that you have too heavy a workload	1	2	3	4	5
5	JRT5	Thinking that you will not be able to satisfy the conflicting demands of the various people over you	1	2	3	4	5
6	JRT6	Feeling that you are not qualified to handle the job	1	2	3	4	5
7	JRT7	Not knowing what your immediate supervisor thinks of you, how he or she evaluates your performance	1	2	3	4	5
8	JRT8	The fact that you cannot get information needed to carry out your job	1	2	3	4	5
9	JRT9	Having to decide things that affect the lives of individuals, people that you know	1	2	3	4	5
10	JRT10	Feeling that you may not be liked and accepted by the people you work with	1	2	3	4	5
11	JRT1	Feeling unable to influence your immediate	1	2	3	4	5

	1	supervisor's decisions and actions that affect you					
12	JRT12	Not knowing just what the people you work with expect of you	1	2	3	4	5
13	JRT13	Thinking that the amount of work you have to do may interfere with how well it gets done	1	2	3	4	5
14	JRT14	Feeling that you have to do things on the job that are against your better judgment	1	2	3	4	5
15	JRT15	Feeling that your job tends to interfere with your family life	1	2	3	4	5

F. Please indicate the amount of stress you experience from various causes.

			No stress at all					A great deal of stress
1	STR1	Having too much work to do	0	1	2	3	4	5
2	STR2	Time pressures and deadlines	0	1	2	3	4	5
3	STR3	Difficulty in changing my shifts	0	1	2	3	4	5
4	STR4	Having not enough work to do	0	1	2	3	4	5
5	STR5	Keeping up with new technology	0	1	2	3	4	5
6	STR6	Threat of job loss	0	1	2	3	4	5
7	STR7	Boring and repetitive tasks	0	1	2	3	4	5
8	STR8	Making important decisions	0	1	2	3	4	5
9	STR9	Feeling isolated	0	1	2	3	4	5
10	STR10	Having a lack of power and influence	0	1	2	3	4	5
11	STR11	Lack of support and encouragement from superiors	0	1	2	3	4	5
12	STR12	Staff shortages	0	1	2	3	4	5
13	STR13	Inadequate training	0	1	2	3	4	5
14	STR14	Poor organisation of my shifts	0	1	2	3	4	5
15	STR15	Few opportunities for personal and career development	0	1	2	3	4	5
16	STR16	Demands of work on my home and private life	0	1	2	3	4	5
17	STR17	Too many administrative or paper work tasks	0	1	2	3	4	5
18	STR18	Having to deal with incidents outside my control	0	1	2	3	4	5
19	STR19	Low morale in the company	0	1	2	3	4	5
20	STR20	Lack of consultation and communication	0	1	2	3	4	5

3.0 FATIGUE

A. **Where the appropriate, tick (√) the answer or complete the answer in the space provided.**

1 FH01 On average how many hours do you work perweek (including overtime)?

☐ < 20 hours ☐ 20 – 40 hours ☐ 40 – 60 hours ☐ > 60 hours

2 FH02 In general, on average how many hours does it take to finish a trip? ____________ Hours

☐ 2 – 3 hours ☐ 3 – 6 hours ☐ 6 – 8 hours ☐ > 8 hours

3 FH03 Over the past year, on average how many days per month have you worked?

☐ < 10 days ☐ 10 – 20 days ☐ 20 – 30 days

4 FSH02 What is your typical shift pattern?

☐ Earlies–lates–nights(forward rotation) ☐ permanent days

☐ nights–lates–earlies(backward rotation) ☐ 12 hourdays/12 hournights

☐ Other please specify ____________________

5 FH04 During the past 12 months, what is the most consecutive shifts you worked without a rest day? ___________Shifts

☐ Earlies–lates–nights(forward rotation) ☐ permanent days

☐ nights–lates–earlies(backward rotation) ☐ 12 hourdays/12 hournights

☐ Other please specify ____________________

6 FSH06 During the past year, how often have you had less than 12 hours off between shifts?

☐ Never ☐ Very occasionally ☐ Sometimes ☐ Frequently

7 FSH07 Do you feel that you are able to get adequate sleep after day time or night time working?

☐ Yes ☐ No

8 FSH08 Do you feel that you have adequate opportunity to take breaks whilst at work?

☐ Yes ☐ No

9 FSH09 How much do you suffer from fatigue because of work?

☐ Not at all ☐ Just a little ☐ Moderate amount

☐ Quite a lot ☐ A great deal

10 FSH10 When do you feel that you suffer most from fatigue on day and night shifts?

Days ☐ Start of a shift ☐ middle of a shift ☐ end of a shift

☐ Throughout the shift ☐ not applicable

Nights ☐ Start of a shift ☐ middle of a shift ☐ end of a shift

☐ Throughout the shift ☐ not applicable

11 FSH11 What do you think are the main causes of any fatigue you have?

____

12 FSH12 In the last 4 weeks have you noticed any symptoms of physical problems (e.g.feelings of pain, aches, discomfort or excessive tiredness) in any part of your body, either during or soon after your workshift?

☐ Yes ☐ No

13 FSH13 If Yes, please give brief details of the problem, and what you think may have caused the problem

____

4.0 WORK ENVIRONMENT

A. Please indicate to what extents do you agree or disagree with the following statements.

			Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	WC1	Inadequate communication facilities available for use in emergency situations	1	2	3	4	5
2	WC2	Poor standard of maintenance of cabs	1	2	3	4	5
3	WC3	Interference of unattended cabs by unauthorised persons	1	2	3	4	5
4	WC4	Unsatisfactory toilet facilities	1	2	3	4	5
5	WC5	Unsatisfactory meal facilities	1	2	3	4	5
6	WC6	Concern that the train will break down while you are driving it	1	2	3	4	5
7	WC7	Having to spend a considerable amount of time travelling to and from work	1	2	3	4	5

B. How do you feel about your workplace?

If a statement is not relevant for your workplace please circle the not applicable (NA) box.

			Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	WE1	The legroom underneath the desk is adequate	1	2	3	4	5
2	WE2	Overall, the chair is comfortable	1	2	3	4	5
3	WE3	All the equipment I use frequently at the workstation is within easy reach	1	2	3	4	5
4	WE4	All the paper information I require is easy to find	1	2	3	4	5
5	WE5	Overall, the layout of my workstation is good	1	2	3	4	5
6	WE6	There is sufficient room to move around the operations floor	1	2	3	4	5
7	WE7	The area is free of trip hazards (e.g. cables)	1	2	3	4	5
8	WE8	Generally, I feel comfortable with temperature of my workplace	1	2	3	4	5
9	WE9	I sweat heavily while performing my work	1	2	3	4	5
10	WE10	My work environment is very quiet and comfortable	1	2	3	4	5
11	WE11	I can see my work clearly	1	2	3	4	5
12	WE12	It is very hot and I feel uncomfortable here	1	2	3	4	5

13	WE13	I feel comfortable and less sweating	1	2	3	4	5
14	WE14	It is very noisy and difficult to communicate here	1	2	3	4	5
15	WE15	The light is very dim and it is very difficult to see and perform my work	1	2	3	4	5

5.0 SAFETY

A. How do you concern about safety aspects in your workplace?

			Very unconcern	Moderately unconcern	Neutral	Moderately concern	Very concern
1	SI01	Concern about 'school-boy pranks' - e g, tampering with train, obstacles on track	1	2	3	4	5
2	SI02	Concern about the possibility of killing or injuring persons	1	2	3	4	5
3	SI04	Driving along track where track maintenance workers are working	1	2	3	4	5
4	SI05	Concern about tripping over obstacles when moving about outside the cab at night-time	1	2	3	4	5
5	SI06	Concern about being assaulted	1	2	3	4	5
6	SI07	Concern about slipping when climbing in and out of cab when train not at a platform	1	2	3	4	5

B. Please indicate to what extents do you agree or disagree with the following statements.

			Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	SC01	Safety has a high priority within the company	1	2	3	4	5
2	SC02	In my workplace management ignore safety issues	1	2	3	4	5
3	SC03	My manager consults me to assist in resolving work place problems	1	2	3	4	5
4	SC04	Management react quickly to any safety concerns	1	2	3	4	5
5	SC05	My manager always informs me about relevant safety issues	1	2	3	4	5
6	SC06	I am encouraged to offer ideas on safety	1	2	3	4	5
7	SC07	If I report a safety issue I feel I am blamed for the problem	1	2	3	4	5
8	SC08	I can approach my manager to discuss problems regarding work	1	2	3	4	5
9	SC09	There are not always enough people to do the job safely	1	2	3	4	5
10	SC10	Feedback from any safety incident is good	1	2	3	4	5
11	SC11	I am unable to do my job if I follow procedures and rules exactly	1	2	3	4	5
12	SC12	It is not possible to be familiar with all the procedures relevant to my job	1	2	3	4	5
13	SC13	Training covers the safety critical aspects of the job	1	2	3	4	5
14	SC14	Sometimes the actions of others hinder me from doing my job efficiently	1	2	3	4	5
15	SC15	My actions affect how safely other people can do their job	1	2	3	4	5

5.0 FLINDERS FATIGUE SCALE

We are interested in the extent that you have felt fatigued (tired, weary, exhausted) over the last two weeks. We do not mean feelings of sleepiness (the likelihood of falling asleep). Please circle the appropriate response in accordance with your average feelings over this two-week period.

			Not at all		Moderately		Extremely
1	FF01	Was fatigue a problem for you?	1	2	3	4	5
2	FF02	Did fatigue cause problems with your everyday functioning (e.g., work, social, family)?	1	2	3	4	5
3	FF03	Did fatigue cause you distress?	1	2	3	4	5

4	FF04	How often did you suffer from fatigue?	0 days/week	1-2 days/week	3-4 day/week	5-6 days/week	7 days/week

5 FF05 At what time(s) of the day did you typically experience fatigue? (Please tick box(es))

- ☐ Early morning
- ☐ Mid morning
- ☐ Midday
- ☐ Mid afternoon
- ☐ Late afternoon
- ☐ Late evening

			Not at all		Moderate		Extreme
6	FF06	How severe was the fatigue you experienced?	1	2	3	4	5

			Not at all		Moderate		Entirely
7	FF07	How much was your fatigue caused by poor sleep?	1	2	3	4	5

6.0 EPWORTH SLEEPINESS SCALE

How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired?

This refers to your usual way of life in recent times.

Even if you haven't done some of these things recently try to work out how they would have affected you.

Use the following scale to choose the most appropriate number for each situation:

0 = would never doze

1 = slight chance of dozing

2 = moderate chance of dozing

3 = high chance of dozing

It is important that you answer each question as best you can.

	Situation	Chance of Dozing (0-3)
FSL 01	Sitting and reading	
FSL02	Watching TV	
FSL03	Sitting, inactive in a public place (e.g. a theatre or a meeting)	
FSL04	As a passenger in a car for an hour without a break	
FSL05	Lying down to rest in the afternoon when circumstances permit	
FSL06	Sitting and talking to someone	
FSL07	Sitting quietly after a lunch without alcohol	
FSL08	In a car, while stopped for a few minutes in the traffic	

THANK YOU FOR YOUR COOPERATION

M.W. Johns 1990-97

Appendix 4: Review from experts

		Seksyen 1	Seksyen 2	Seksyen 3	Seksyen 4	Seksyen 5	Keseluruhan
1	Expert 1 (Industry)	Soalan – soalan mencukupi. Mungkin boleh tambah jenis tren yang dipandu	Terdapat banyak soalan yang tidak berkaitan tugas-tugas pemandu lokomotif. Terlalu banyak soalan	Bagus untuk penilaian	Bagus untuk penilaian	Baik & mencukupi untuk penilaian	Secara keseluruhan semua soalan dapat member penilaian kepada objektif kaji selidik ini.
2	Expert 2 (Industry)	Soalan – soalan yang dikemukakan adalah menepati kehendak soal selidik	OK. Tanya lebih detail	OK	OK. Soalan yang menepati kehendak keselamatan di tempat bekerja	OK	Keseluruhan soalan yang diberikan akan membantu KTMB dalam meningkatkan kualiti pengurusan, kesihatan pekerja di tempat kerja.
3	Expert 3 (University - Engineering)	Bahagian ini jika sesuai, masukkan soalan tentang penyakit yang ada pada pekerja semasa mula bekerja, masalah pada pendengaran, penglihatan dll.	Kenapa bah. (A) ada 7 jawapan? Secara keseluruhan boleh diterima tapi ada soalan apabila dibaca tidak berapa jelas.	Ada bahagian tidak jelas soalan atau pilihannya	Ada soalan ayatnya tergantung dan tidak jelas	Boleh diterima	Terjemahan soalan – soalan ini perlu dilakukan lagi kerana apabila baca soalan-soalannya, saya tidak jelas maksudnya dan terpaksa rujuk versi Bahasa Inggeris.
4	Expert 4 (DOSH)		1) Skill (Likert) – tak seragam – Bhg A & E – easy to analysis. 2) Ada soalan yang sukar difahami – soalan yang berulang – ulang dalam bentuk yang berbeza. Terlampau banyak soalan, mengelirukan, objektif soalan tak jelas – Hasil kajian secara keseluruhan??				1) Permudahkan, ringkaskan, be friendly to public understanding (layman) Literature as a guide only – not need to copy 100%, make adjustment to suit your study / project objective.

		Seksyen 1	Seksyen 2	Seksyen 3	Seksyen 4	Seksyen 5	Keseluruhan
5	Expert 5 (University – Management)		1) Likert scale Q2A & Q2B – respondent tend to be confused! 2) Why not standardize? Scared that yo will face difficulty doing the analysis.	Q3A1-3, 11 – suggest to use range. Lebih mudah untuk dianalisis dan responden to answer. Q3B4-5 : think of standardization	Q4A & B : Check again. Isn't better to standardize ?		
6	Expert 6 (University - Engineering)	Baik dan sesuai	1) Kenapa guna skala 7 untuk soalan 2.0 A Elok dijelaskan thema sub kategori untuk B, C dan D.	1) Umumnya baik Ada sedikit kesilapan perkataan cth ada dalam BI	Umumnya baik	Perlukah subjek mengetahui Flinders dan Epworths	Secara umumnya baik dan sesuai walaupun soalannya agak banyak
7	Expert 7 (University – Management)	OK	Sugges corrections for BM & English version – please see the questionnaire attached e) Q2B1, Q2B6, Q2C1-6, Q2D1, Q2D3, Q2D4, Q2D5, Q2E2, Q2E19, Q2E20	• OK	OK	Suggest correction for question no. 7 – English version	Why should Mr John thanking the participants on your behalf?

Appendix 5: Amount of Missing Data

	N	Mean	Std. Deviation	Missing	
				Count	Percent
JS1	227	2.56	.809	2	.9
JS2	225	2.57	.837	4	1.7
JS3	224	2.73	1.113	5	2.2
JS4	227	2.28	.892	2	.9
JS5	226	2.35	.848	3	1.3
JS6	229	2.93	.592	0	.0
JS7	229	2.93	.614	0	.0
JS8	229	3.02	.688	0	.0
STR1	229	2.71	1.137	0	.0
STR2	227	2.64	1.164	2	.9
STR3	227	2.51	1.364	2	.9
STR4	222	1.87	1.187	7	3.1
STR5	227	2.28	1.292	2	.9
STR6	228	3.08	1.542	1	.4
STR7	228	2.09	1.442	1	.4
STR8	228	2.76	1.320	1	.4
STR9	228	1.88	1.429	1	.4
STR10	226	2.41	1.425	3	1.3
STR11	226	2.52	1.415	3	1.3
STR12	227	2.77	1.473	2	.9
STR13	228	2.66	1.343	1	.4
STR14	227	2.87	1.340	2	.9
STR15	228	2.79	1.331	1	.4
STR16	227	2.63	1.378	2	.9
STR17	227	1.78	1.315	2	.9
STR18	227	2.94	1.410	2	.9
STR19	225	2.27	1.340	4	1.7
STR20	227	2.47	1.294	2	.9
JRT1	228	2.66	.987	1	.4
JRT2	228	3.39	.934	1	.4
JRT3	229	3.07	1.159	0	.0
JRT4	227	2.56	.991	2	.9
JRT5	226	2.61	.869	3	1.3
JRT6	228	3.92	.800	1	.4
JRT7	227	2.33	.973	2	.9
JRT8	228	3.44	.896	1	.4
JRT9	226	2.75	.891	3	1.3
JRT10	228	3.22	.913	1	.4
JRT11	228	2.91	.911	1	.4

	N	Mean	Std. Deviation	Missing	
				Count	Percent
JRT12	226	2.63	.886	3	1.3
JRT13	227	2.66	.796	2	.9
JRT14	229	2.90	1.071	0	.0
JRT15	229	3.14	1.077	0	.0
FF01	226	2.98	1.030	3	1.3
FF02	225	2.96	1.127	4	1.7
FF03	225	2.65	1.132	4	1.7
FF04	219	2.30	.704	10	4.4
FF06	225	2.89	.766	4	1.7
FF07	225	3.22	1.020	4	1.7
FSL01	225	.94	.777	4	1.7
FSL02	224	1.07	.839	5	2.2
FSL03	224	.95	.859	5	2.2
FSL04	225	1.38	.998	4	1.7
FSL05	225	1.80	.991	4	1.7
FSL06	224	.29	.634	5	2.2
FSL07	223	1.47	1.008	6	2.6
FSL08	224	.30	.610	5	2.2
JCH1	228	2.13	.715	1	.4
JCH2	225	2.24	.817	4	1.7
JCH3	226	2.70	.887	3	1.3
JCH4	227	3.09	.943	2	.9
JCH5	229	1.64	.671	0	.0
JCH6	229	1.54	.722	0	.0
JCH7	225	2.23	.795	4	1.7
DT1	229	2.59	1.111	0	.0
DT2	222	3.18	1.016	7	3.1
DT3	228	3.40	1.017	1	.4
DT4	224	2.79	.878	5	2.2
DT5	226	2.99	1.052	3	1.3
WC1	226	2.52	.990	3	1.3
WC2	226	1.99	.924	3	1.3
WC3	221	2.68	.954	8	3.5
WC4	216	1.90	.983	13	**5.7**
WC5	205	2.18	.923	24	**10.5**
WC6	226	2.01	.947	3	1.3
WC7	228	2.44	.939	1	.4
WE1	176	2.93	.882	53	**23.1**
WE2	226	3.71	1.084	3	1.3
WE3	209	2.92	.825	20	8.7
WE4	206	2.98	.872	23	**10.0**
	N	Mean	Std.	Missing	

			Deviation	Count	Percent
WE5	208	2.92	.797	21	9.2
WE6	218	2.95	.873	11	4.8
WE7	223	3.26	1.093	6	2.6
WE8	225	3.66	1.019	4	1.7
WE9	226	2.38	.923	3	1.3
WE10	224	4.11	.922	5	2.2
WE11	221	2.81	.889	8	3.5
WE12	221	2.43	1.062	8	3.5
WE13	221	3.63	1.021	8	3.5
WE14	225	2.21	1.039	4	1.7
WE15	222	2.51	1.010	7	3.1
SI01	227	1.45	.596	2	.9
SI02	229	1.38	.562	0	.0
SI04	224	1.52	.708	5	2.2
SI05	227	1.49	.598	2	.9
SI06	228	1.95	.859	1	.4
SI07	227	1.53	.640	2	.9
SC01	229	1.83	1.085	0	.0
SC02	228	2.96	1.132	1	.4
SC03	225	2.65	.766	4	1.7
SC04	229	2.88	1.051	0	.0
SC05	228	2.61	.939	1	.4
SC06	223	2.85	.954	6	2.6
SC07	228	3.13	.971	1	.4
SC08	228	2.32	.894	1	.4
SC09	225	2.61	.854	4	1.7
SC10	228	2.42	.859	1	.4
SC11	229	2.72	1.069	0	.0
SC12	228	2.53	.782	1	.4
SC13	226	2.41	.866	3	1.3
SC14	226	2.42	.862	3	1.3
SC15	225	2.58	.989	4	1.7
JRT1	228	2.66	.987	1	.4
JRT2	228	3.39	.934	1	.4
JRT3	229	3.07	1.159	0	.0
JRT4	227	2.56	.991	2	.9
JRT5	226	2.61	.869	3	1.3
JRT6	228	3.92	.800	1	.4
JRT7	227	2.33	.973	2	.9
JRT8	228	3.44	.896	1	.4
JRT9	226	2.75	.891	3	1.3
	N	Mean	Std.	Missing	
			Deviation	Count	Percent

JRT10	228	3.22	.913	1	.4
JRT11	228	2.91	.911	1	.4
JRT12	226	2.63	.886	3	1.3
JRT13	227	2.66	.796	2	.9
JRT14	229	2.90	1.071	0	.0
JRT15	229	3.14	1.077	0	.0

Appendix 6: Factor analysis for human domain

Initially, principal component analysis with Promax rotation was perform without fixing the number of factors. From the analysis of Kaiser-Meyer-Olkin measures of sampling adequacy (KMO), the value of 0.853 obtained indicated that the data is appropriate for the analysis (Hair et al., 2010).

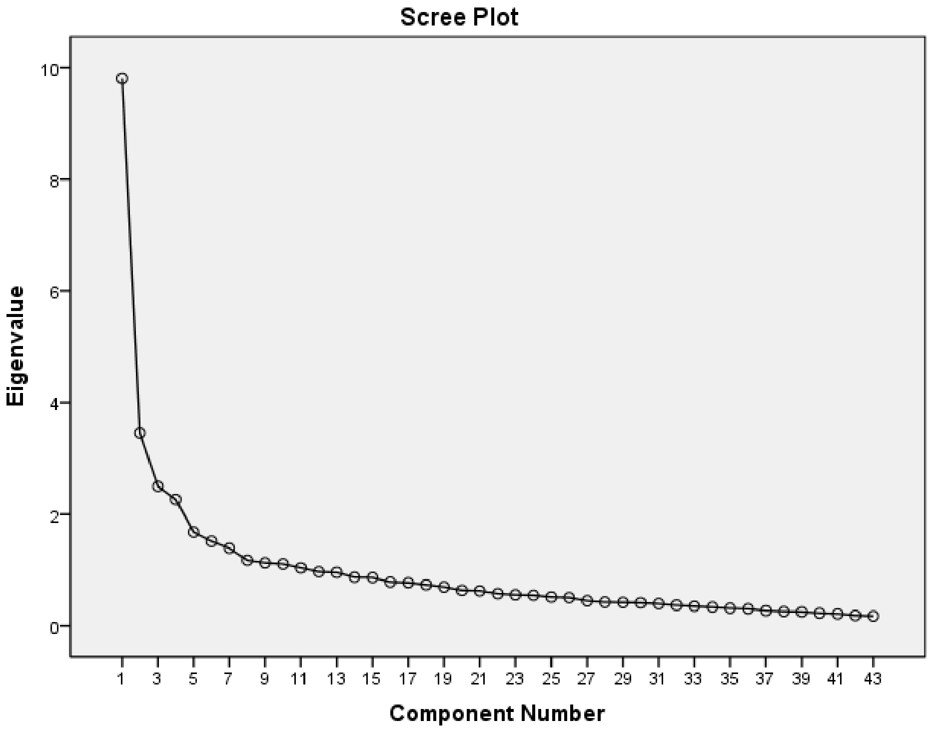

Figure 7.1: Scree plot of human domain

The data of 43-items of human domain were then plotted using scree plot, as shown in Figure 5.1 (Cattell 1966 as mentioned by Reise, et al. (2000)). In general, the number of factors can be identified from the scree plots, but in this case, the scree plot analysis was unable to indicate the number of factors clearly (Russell, 2002). An improved procedure, called parallel analysis (Reise et al., 2000) is then conducted by comparing the eigenvalues from real data and simulated data. Monte Carlo simulation was used to generate the simulated data. In a parallel analysis, random data sets are generated on the basis of the same number of items as in the real data matrix. Then the scree plot of the eigenvalues (percentage of variance accounted for by a dimension) from the real data is compared with the scree plot of the eigenvalues from the random data (simulated data). The point where the two plots meet provides the researcher with a good idea of the absolute maximum number of factors that should be extracted.

Table 5.2 shows the eigenvalue comparison between real data and simulated data, showing eleven factors with eigenvalues greater than 1.0 and the total variance explained was 62.9% of the total variance. The factors are accepted if the eigenvalue of the actual data was greater than the simulated data. From Table 5.2 and Figure 5.2, it can be seen that a 5-factor solution of real data would have larger eigenvalue than the simulated data.

Table 7.1: Parallel analysis of human domain

Factor	Real data			Simulated	Decision
	Eigenvalue	% of Variance	Cumulative %	Eigenvalue	
1	9.804	22.801	22.801	1.9447	Accepted
2	3.457	8.039	30.840	1.8434	Accepted
3	2.498	5.809	36.649	1.7608	Accepted
4	2.264	5.265	41.914	1.6893	Accepted
5	1.679	3.905	45.819	1.6247	Accepted
6	1.515	3.523	49.342	1.5682	-
7	1.391	3.235	52.577	1.5134	-
8	1.173	2.727	55.304	1.4619	-
9	1.128	2.624	57.928	1.4172	-
10	1.107	2.574	60.502	1.3722	-
11	1.038	2.414	62.916	1.3304	-
12	.968	-	-	1.2907	-
13	.958	-	-	1.2517	-
14	.872	-	-	1.2106	-
15	.865	-	-	1.1735	-

However, this suggested solution would be difficult to be interpreted because five items have individual loading of less than 0.4 (Hair et al., 2010) and one item (JRT10) was loaded on two factors with differences of less than 0.1 (Snell and Dean, 1992). Thus, for the subsequent analysis, the items removed were STR20, STR7, STR6, JRT6, STR17 and JRT10.

The next analysis was conducted on the remaining 37 items, which gave a Kaiser-Meyer-Olkin (KMO) value for sampling adequacy of 0.838 and eleven-factor solution with 66.4% total variance. One item, STR15, was loaded less than 0.4 and would be excluded in the subsequent procedure. A parallel analysis comparing eigenvalues between actual and simulated data generated using Monte Carlo simulation still indicated a five-factor solution.

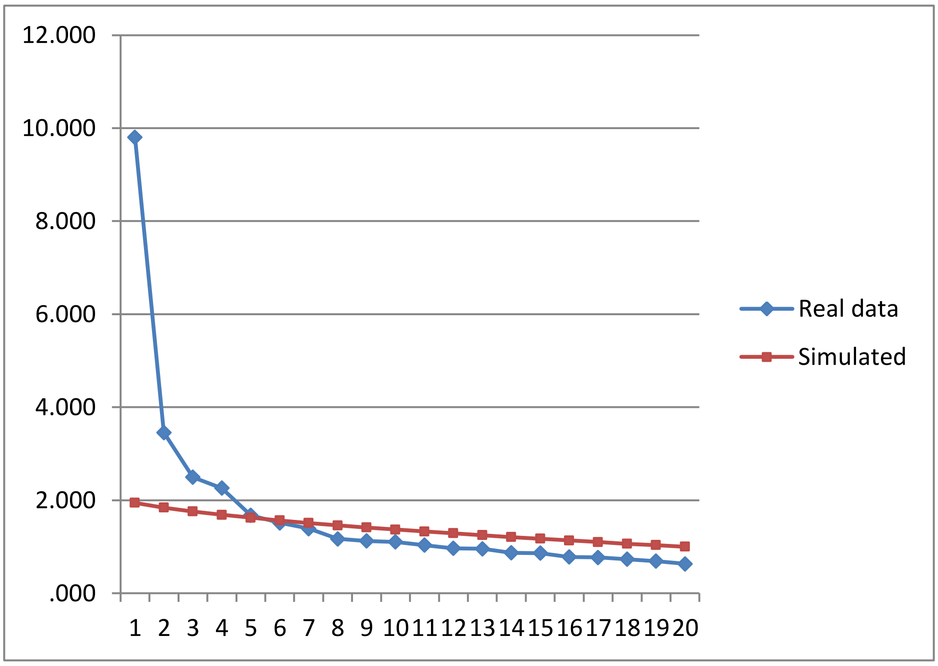

Figure 7.2: Comparison of Eigenvalue between real data and simulated

The third iteration was performed with 36 items (excluding STR15), and was limited to five-factor solution. The measures of sampling adequacy were 0.829 with 47.8% total variance. All 36 items had loading of more than 0.4 (Hair et al., 2010) and were loaded on five-factor solution without redundancy. Table 5.3 shows the summary of factor analysis conducted for the human domain.

A consequent analysis of 37 remaining items with 6-item deletion indicated 0.838 KMO value, 11-factor solution with 66.4% total variance. One item (STR15) was loaded less than 0.4. Comparison on eigenvalue with simulated data generated using Monte Carlo simulation still indicates 5-factor solution.

The third analysis was conducted with 36 items (1-item deletion STR15) and limited to 5-factor solution as depicted in Table A6-1: 5-factors solution. Kaiser-Meyer-Olkin measures of sampling adequacy (KMO) was 0.829 with 47.8% total variance. All 36-items had loading more than 0.4 (Hair et al., 2010) and were loaded on 5-factor solution without redundancy.

Table A6-1: 5-factor solution for Human domain

	1	2	3	4	5
STR16 Occupational stress 16	0.764				
STR10 Occupational stress 10	0.756				
STR9 Occupational stress 9	0.740				
STR4 Occupational stress 4	0.722				
STR11 Occupational stress 11	0.656				
STR5 Occupational stress 5	0.642				
STR3 Occupational stress 3	0.637				
STR12 Occupational stress 12	0.634				
STR2 Occupational stress 2	0.616				
STR14 Occupational stress 14	0.574				
STR1 Occupational stress 1	0.553				
STR8 Occupational stress 8	0.516				
STR18 Occupational stress 18	0.506				
STR13 Occupational stress 13	0.470				
STR19 Occupational stress 19	0.468				
JRT5 Job-related tension 5		0.718			
JRT13 Job-related tension 13		0.663			
JRT7 Job-related tension 7		0.633			
JRT4 Job-related tension 4		0.617			
JRT12 Job-related tension 12		0.583			

JRT9 Job-related tension 9		0.543			
JRT11 Job-related tension 11		0.536			
JRT3 Job-related tension 3		0.479			
JRT15 Job-related tension 15		0.447			
JS5 Job Satisfaction 5			0.799		
JS4 Job Satisfaction 4			0.783		
JS2 Job Satisfaction 2			0.756		
JS1 Job Satisfaction 1			0.711		
JS3 Job Satisfaction 3			0.618		
JS6 Job Satisfaction 6				0.860	
JS7 Job Satisfaction 7				0.835	
JS8 Job Satisfaction 8				0.792	
JRT2 Job-related tension 2					0.753
JRT1 Job-related tension 1					0.544
JRT8 Job-related tension 8					0.417
JRT14 Job-related tension 14					0.410

Appendix 7: Factor analysis for Activity domain

Analysis I

Principal component analysis was performed for the first time for 11-items with Promax rotation. KMO value was 0.674 (Hair et al., 2010) identified the data considered to be appropriate for the analysis. Four-factor solution with 58.2% of the variance was suggested for this data. Then, to confirm number of factors, researcher performed a parallel analysis (Reise et al., 2000) depicted in Table A7-1.

Table A7-1

Factor	Initial Eigenvalues			Simulated	Decision
	Total	% of Variance	Cumulative %	Eigenvalue	
1	2.419	21.993	21.993	1.3629	Accepted
2	1.721	15.646	37.640	1.2578	Accepted
3	1.255	11.406	49.046	1.1912	Accepted
4	1.008	9.167	58.212	1.1114	
5	.862	7.833	66.045	1.0438	
6	.813	7.387	73.432	0.9903	
7	.689	6.267	79.698	0.9247	
8	.632	5.742	85.440	0.8664	
9	.616	5.604	91.043	0.8161	
10	.521	4.736	95.779	0.7469	
11	.464	4.221	100.000	0.6886	

From the parallel analysis, it shows that 3-factor solution was suggested where real data eigenvalues were more than the simulated value. Figure A7-1 also represent the comparison between two types of eigenvalue.

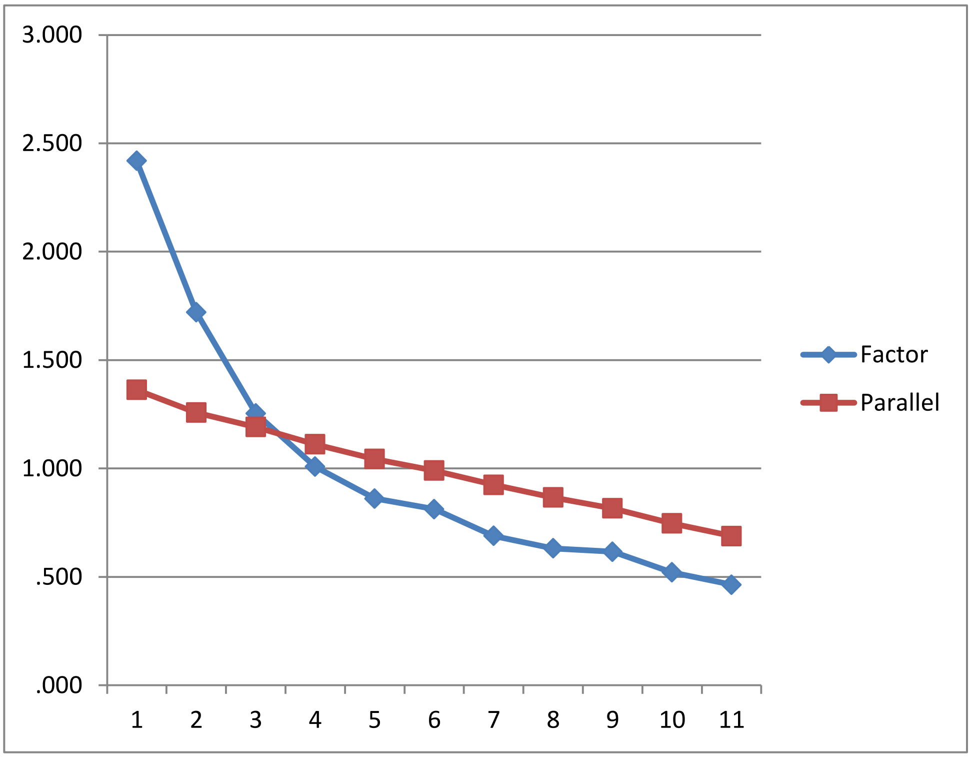

Figure A7-1

All items had loading more than 0.4 (Hair et al., 2010), therefore no deletion of items at this stage. However, this 4-factor solution was not selected as the suggestion using 4-factors was not supported by the parallel analysis (Reise et al., 2000) previously as depicted in Table A7-1 and Figure A7-1.

Table A7-2: Pattern matrix

	Component			
	1	2	3	4
DT3 Driving Task 3	0.867			
DT2 Driving Task 2	0.788			
DT1 Driving Task 1	0.560			
JCH1 Job Characteristics 1		0.812		
JCH2 Job Characteristics 2		0.792		
DT5 Driving Task 5			0.860	
DT4 Driving Task 4			0.491	
JCH3 Job Characteristics 3			0.478	
JCH7 Job Characteristics 7			0.440	
JCH6 Job Characteristics 6				0.817
JCH5 Job Characteristics 5				0.598

Table A7-2 shows the distribution of items among 4 suggested constructs. Construct number 2 and 4 had only 2 items respectively. Yet, this could not be accepted as the minimum number of items for Structural Equation Modeling (SEM) analysis requires minimum of 3 items (Russell, 2002).

So, another analysis with different criteria was conducted to apply data reduction technique. This process were repeated to gain appropriate number of factors with supported by the analysis and the results were examined (Tinsley & Tinsley, 1987).

Analysis II

Another analysis was conducted with the minimum factor loading was set to 0.5 (Hair et al., 2010) and 3-factor solution without any deletion of item. Measuring of sample adequacy (MSA) using KMO value and eigenvalues were same as previous analysis with 0.4-factor loading. It was 49% total variance explained with 3-factor solution.

Table A7-3: Pattern matrix

	Component		
	1	2	3
DT2 Driving Task 2	0.758		
DT3 Driving Task 3	0.711		
DT1 Driving Task 1	0.677		
DT4 Driving Task 4	0.602		
JCH7 Job Characteristics 7			
JCH2 Job Characteristics 2		0.772	
JCH1 Job Characteristics 1		0.679	
JCH5 Job Characteristics 5		0.598	
JCH3 Job Characteristics 3			
DT5 Driving Task 5			0.819
JCH6 Job Characteristics 6			-0.553

With Promax rotation, pattern matrix was generated. Inter-correlated items with 0.5 loading and more were grouped in one particular component or factor. However, 2 items (JCH7 and JCH 3) were loaded less than 0.5 and will be deleted in the next procedure.

Analysis III

Additional analysis was performed as the previous solution was not appropriate because of item loading criteria. The setting was the same as previous with 0.5-factor loading and 3-factor solution with two items, JCH 7 and JCH 3 were deleted. KMO value was 0.63 (Hair et al., 2010) and 53.8% variance explained. From the analysis of partial correlation, measures of sampling adequacy (MSA) in anti-image matrices indicates item DT5 with loading of 0.408, lower than minimum value 0f 0.5. Therefore, this item needs to be deleted. Then, analysis continued with examination of loading on pattern matrix. It was identified item JCH6 was not belong to any factor as it loading was lower than 0.5. Thus, this item also needs to be deleted.

Analysis IV

After 3 consecutive analyses with deletion of 4 items, researcher decided to retain the criteria of 0.5 loading but with 2-factor solution. Remaining items available were 7 after 4 deletion in previous analysis, it might disperse the items if the researcher remaining 3-factor solution. Each factor might have 2 items, and this is not suitable for further analysis (Russell, 2002). As a result, the researcher decided to maintain 2 factors as suggested in original research framework for activity domain which are *Driving Task (DT)* and *Job Demand (JCH)*.

Final analysis for activity domain was conducted with 7 items, 2-factor solution and minimum 0.5 factor loading. Kaiser-Meyer-Olkin measures of sampling adequacy (KMO) value of 0.637 (Hair et al., 2010) indicated the data deemed to be appropriate for the analysis with 50.6% of the variance.

Table A7-4: Results of the Factor Analysis

	Component

	1	2
DT2 Driving Task 2	**0.775**	0.024
DT1 Driving Task 1	**0.710**	0.151
DT3 Driving Task 3	**0.682**	-0.221
DT4 Driving Task 4	**0.615**	0.057
JCH2 Job Characteristics 2	-0.043	**0.788**
JCH1 Job Characteristics 1	-0.048	**0.724**
JCH5 Job Characteristics 5	0.155	**0.591**
Eigenvalue	1.978	1.564
Percentage variance (50.6)	28.26	22.35

Table S depicts the result of the factor analysis. These result confirm that each of these constructs is unidimensional and factorially distinct and that all items used to measure a particular construct loaded on a single factor.

Appendix 8 : Factor analysis for context domain

Analysis I

Principal component analysis was performed for 42-items with Promax rotation. KMO value was 0.751 (Hair et al., 2010) identified the data considered to be appropriate for the analysis. Thirteen-factor solution with 67.4% of the variance was suggested for this data.

From the analysis of partial correlation, measures of sampling adequacy (MSA) in anti-image matrices indicates item SC15 with loading of 0.447 and item SC12 with loading of 0.370; lower than minimum value of 0.5. Therefore, these items need to be deleted. Then, analysis continued with an examination of loading on pattern matrix. It was identified 8 items were not belong to any factor as it loading was lower than 0.5. There were WE4, WC1, SI07, SC03, SC06, WC2, WC7 and SC14. Thus, these items need to be deleted.

Parallel analysis was carried out to confirm number of factors as suggested by Reise, et al. (2000). Comparison table of real and simulated Eigenvalues depicted in Table A8-1. Seven-factor solution was suggested as Eigenvalue of real data were more than simulated Eigenvalue. However, researcher needs to conduct another analysis with 10-item deletion as suggested.

Table A8-1

Factor	Initial Eigenvalues			Simulated	Decision
	Total	% of Variance	Cumulative %	Eigenvalue	
1	7.401	17.622	17.622	1.9268	Accepted
2	3.384	8.057	25.679	1.8167	Accepted
3	3.177	7.565	33.245	1.7385	Accepted
4	2.009	4.784	38.029	1.6716	Accepted
5	1.875	4.464	42.493	1.6103	Accepted
6	1.776	4.229	46.722	1.552	Accepted
7	1.539	3.665	50.387	1.4997	Accepted
8	1.403	3.340	53.727	1.4535	
9	1.365	3.250	56.977	1.4041	
10	1.190	2.833	59.810	1.365	
11	1.147	2.730	62.540	1.3163	
12	1.058	2.519	65.059	1.2753	
13	1.001	2.384	67.443	1.2376	

Analysis II

Analysis I suggested to delete 10 items for the following analysis. However, researcher found the number of deleted items was too high. Therefore, researcher decided to conduct similar analysis with original 42-items but setting 7-factor solution as suggested previously through parallel analysis and minimum of 0.4 item loading (Hair et al., 2010).

Measuring of sample adequacy (MSA) using KMO value was 0.751. It was 50.39% total variance explained with 7-factor solution.

Then, partial correlation analysis, measures of sampling adequacy (MSA) in anti-image matrices indicates 2 items were lower than minimum value of 0.5; SC15 and SC12. Analysis continued with an examination of loading on pattern matrix. It was identified 3 items were not belong to any factor as it loading was lower than 0.4. There were SC02N, SC04 and WC1. Another 2 items; WE3 and SC03 were loaded on 2 factors.

However, item WE3 was not deleted because the differences of the loading were more than 0.1. Therefore, these items (SC15, SC12, SC02N, SC04, WC1 and SC03) need to be deleted.

Analysis III

Analysis III was performed as the previous solution was not appropriate because of item loading criteria. Six items (SC15, SC12, SC02N, SC04, WC1 and SC03) were deleted. KMO value was 0.757 (Hair et al., 2010) and 53.1% variance explained with 7-factor solution. Inspection of loading on pattern matrix indicated 4 items; WC3, SC07N and SC06 were lower than 0.4 and not belong to any of the factor. At the same time, item SI07 was loaded on 2 factors with differences less than 0.1 and should be deleted. Therefore, these 4 items should be deleted for the next analysis.

Because of number of items reduced (42 items to 36 items); another parallel analysis was conducted to determine appropriate number of factor-solution. Six-factor solution was suggested by the parallel analysis as shown in Table A8-2.

Table A8-2

Factor	Initial Eigenvalues			Simulated	Decision
	Total	% of Variance	Cumulative %	Eigenvalue	
1	6.355	17.654	17.654	1.8318	Accepted
2	3.233	8.981	26.634	1.7315	Accepted
3	2.969	8.247	34.882	1.6485	Accepted
4	1.869	5.191	40.072	1.5834	Accepted
5	1.683	4.675	44.747	1.5215	Accepted
6	1.597	4.437	49.184	1.4655	Accepted
7	1.411	3.918	53.102	1.4125	

Analysis IV

Fourth analysis was performed with deletion another 4 items (SI07, WC3, SCo7N and SC06) after analysis III with 6-factor solution. KMO value was 0.758 (Hair et al., 2010) and 50.6% variance explained. Inspection of loading on pattern matrix indicated two items; SC01 and SC11 were lower than 0.4 and not belong to any of the factor. Therefore, these 2 items should be deleted for the next analysis.

As items were reduced by deletion another 4 items, parallel analysis was conducted to confirm number of appropriate factor-solution. From the analysis, number of factor-solution; six was unchanged.

Table A8-3

Factor	Initial Eigenvalues			Simulated	Decision
	Total	% of Variance	Cumulative %	Eigenvalue	
1	5.797	18.116	18.116	1.7772	Accepted
2	2.823	8.823	26.939	1.6724	Accepted
3	2.651	8.286	35.225	1.5864	Accepted
4	1.765	5.516	40.741	1.522	Accepted
5	1.661	5.191	45.932	1.463	Accepted
6	1.497	4.680	50.611	1.407	Accepted

Analysis V

Final analysis for context domain was conducted with deletion of 2 items (SC01 and SC11), 6-factor solution and minimum 0.4 factor loading. Kaiser-Meyer-Olkin measures of sampling adequacy (KMO) value of 0.763 (Hair et al., 2010) indicated the data deemed to be appropriate for the analysis with 52.49% of the variance.

Table A8-4

	Component					
	1	2	3	4	5	6
WE5 Working env. 5	**.848**	.159	.048	.151	-.079	-.100
WE6 Working env. 6	**.742**	-.003	-.082	.092	.008	-.123
WE8 Working env. 8	**.665**	-.106	.037	-.196	-.053	.073
WE7 Working env. 7	**.619**	-.062	.118	.073	.085	-.034
WE10 Working env. 10	**.609**	-.109	.011	-.222	-.200	.047
WE4 Working env. 4	**.596**	.056	.136	.179	.143	.006
WE2 Working env. 2	**.578**	-.046	-.174	-.123	-.051	.095
WE13 Working env. 13	**.538**	-.233	-.029	-.141	.024	-.053
WE11 Working env. 11	**.453**	.112	-.068	.076	.287	.034
SI02 Safety issue 2	.015	**.824**	-.063	-.014	.073	.048
SI04 Safety issue 4	-.065	**.777**	.134	-.162	-.218	-.190
SI01 Safety issue 1	.038	**.756**	-.055	-.045	.071	.040
SI05 Safety issue 5	-.100	**.729**	-.045	.060	.000	.097
WE14 Working env. 14	.005	-.043	**.836**	.172	.150	-.085
WE12 Working env. 12	.018	.020	**.771**	.099	.025	-.097
WE15 Working env. 15	.045	-.127	**.745**	-.018	-.082	-.066
SC14 Safety culture 14	-.027	.049	**.529**	-.321	-.049	.235
WE9 Working env. 9	.059	.102	**.431**	-.045	-.052	.202
WC4 Working conditions 4	.023	-.077	-.012	**.817**	-.100	-.021
WC5 Working conditions 5	.042	-.049	-.076	**.787**	-.146	.130
WC2 Working conditions 2	-.005	.019	.254	**.599**	.057	.105
SC10 Safety culture 10	.031	.005	.057	-.104	**.791**	.163
SC08 Safety culture 8	-.066	-.010	.069	-.080	**.751**	-.136
SC13 Safety culture 13	.014	-.014	-.029	-.035	**.550**	.090
SC05 Safety culture 5	.071	-.024	-.268	-.122	**.494**	-.160
SC09 Safety culture 9	-.274	-.141	.064	-.109	-.016	**.691**
WC7 Working conditions 7	-.162	-.127	-.058	.241	.104	**.658**
SI06 Safety issue 6	.088	.264	-.055	.018	.062	**.583**
WC6 Working conditions 6	.131	.047	-.113	.322	-.138	**.503**
WE3 Working env. 3	.360	.062	.141	-.097	.075	**.502**
Eigenvalue	5.562	2.783	2.587	1.749	1.617	1.448
Percentage variance (52.49)	18.539	9.277	8.623	5.830	5.389	4.828

Table A8-4 depicts the result of the factor analysis. These result confirm that each of these constructs is unidimensional and factorially distinct and that all items used to measure a particular construct loaded on a single factor.

Appendix 9: Train timetable

North - South Route Timetable

Category: Timetable Published: Wednesday, 23 October 2013 Written by Super User

STESEN / STATION \ TREN / TRAIN, NO TREN / TRAIN NO	EKSPRES RAKYAT 2	SENANDUNG LANGKAWI 20	EKSPRES RAKYAT 1	SENANDUNG LANGKAWI 21
HATYAI		10:30*		16:00*
PADANG BESAR		**09:30**		19:00
ARAU		08:56		19:37
ALOR STAR		08:14		20:18
GURUN		07:38		20:53
SUNGAI PETANI		07:04		21:26
BKT MERTAJAM		06:25		22:01
BUTTERWORTH	22:00	05:30	08:00	22:28
BKT MERTAJAM	21:37	05:01	08:20	23:20
Nibong Tebal		04:34		23:49
PARIT BUNTAR	21:09	04:24	08:52	23:59
Bagan Serai		04:08		00:15
TAIPING	20:20	03:14	09:42	01:11
KUALA KANGSAR	19:49	02:36	10:13	01:47
Sungai Siput		02:03		02:09
IPOH	19:02	01:11	11:02	02:49
BATU GAJAH	18:48	00:55	11:17	03:14
KAMPAR	18:30	00:37	11:35	03:31
Tapah Road		00:21		03:46
Sungkai		00:02		04:05
Slim River		23:39		04:27
Behrang		23:27		04:36
TANJUNG MALIM	17:33	23:14	12:36	04:48
Kuala Kubu Bharu		22:56		05:07
RAWANG		22:28		05:34
Sungai Buloh		22:07		05:55
Kuala Lumpur	16:14	21:34	13:54	06:25
KL SENTRAL	**15:50**	21:30	14:00	06:30
SEREMBAN	14:37		15:27	
Rembau				
PULAU SEBANG/TAMPIN	13:53		16:16	
Batang Melaka				
GEMAS	13:06		17:06	
SEGAMAT	12:27		17:43	
Labis	11:54		18:17	
Bekok				
Paloh	11:15		18:53	
KLUANG	10:46		19:21	
KULAI	09:42		20:22	
Kempas Baru	09:10		20:55	
JB SENTRAL	08:35		21:17	
WOODLANDS	08:30		22:00	

STESEN / STATION \ TREN / TRAIN, NO TREN / TRAIN NO	SINARAN SELATAN 12	SENANDUNG SUTERA 24	SINARAN SELATAN 13	SENANDUNG SUTERA 25
KL SENTRAL	22:00	07:30	08:30	22:30
KAJANG	21:20	06:55	09:08	23:03
SEREMBAN	20:35	06:10	09:53	23:48
Rembau	20:09		10:15	
PULAU SEBANG/TAMPIN	19:43	05:24	10:37	00:34
Batang Melaka				
GEMAS	18:48	04:27	11:22	01:23
SEGAMAT	18:12	03:48	12:01	02:27
Labis	17:19	03:06	12:45	03:10
Bekok	17:00		13:06	03:29
Paloh	16:43		13:25	03:48
KLUANG	16:15	02:06	13:54	04:17
KULAI	15:07	01:02	15:11	05:25
Kempas Baru	14:37	00:30	15:43	05:57
JB SENTRAL	14:05	23:35	16:05	06:18
WOODLANDS	14:00	23:30	16:30	07:00

STESEN / STATION \ TREN / TRAIN, NO TREN / TRAIN NO	EKSPRES ANTARABANGSA 35	EKSPRES ANTARABANGSA 36
BANGKOK	1445*	1330*
Bangsue	1505*	1255*
Nankhon Pathon	1600*	1128*
Ratchaburi	1642*	1030*
Petchaburi	1719*	0940*
Huan Hin	1810*	0840*
Chumphon	2145*	0448*
Surat Thani	0040*	0200*
Thung Song Jn	0250*	0015*
HAT YAI	0650*	2109*
PADANG BESAR	0855	1800
ARAU	1034	1723
ALOR STAR	1117	1641
SG. PETANI	1226	1533
BKT MERTAJAM	1306	1449
BUTTERWORTH	1330	1430

Stesen Akhir / *End Station*

Stesen Bermula / *Origin Station*

* **Waktu Thailand** / *Thailand Time*

Tertakluk kepada Akta Pengangkutan Awam Darat 2010/
Subject to Public Land Transport Act 2010

East - South Route Timetable

Category: Timetable Published: Wednesday, 23 October 2013 Written by Super User

STESEN / STATION — NO TREN / TRAIN NO — TREN / TRAIN	SHUTTLE 82	SHUTTLE 84	SHUTTLE 86	TRANSIT 92	SHUTTLE 81	TRANSIT 91	SHUTTLE 83	SHUTTLE 85
TUMPAT	14:30	19:00	21:30	22:30	04:00	06:00	07:30	15:30
Kg. Kok Pasir	14:23	18:50					07:34	15:33
Palekbang								
WAKAF BAHARU	14:12	18:12	21:08	22:13	04:18	06:16	07:48	15:46
Bunut Susu	14:03	18:01			04:23		07:54	15:52
Kg. Machang								
PASIR MAS	13:53	17:49	20:16	21:54	04:34	06:33	08:04	16:02
Chica Tinggi	13:46							16:08
To' Uban	13:40	17:35			04:45		08:15	16:13
Sg. Keladi	13:34	17:28					08:21	16:18
Bukit Panau	13:29	17:22					08:27	16:23
TANAH MERAH	13:20	17:12	19:50	21:03	05:04	06:59	08:35	16:31
Kg. Paloh Rawa								
TEMANGAN	13:04	16:35	19:20		05:22		08:50	16:46
Sg. Nal	12:52							16:53
KRAI	12:43	16:14	19:00	20:28	05:44	07:33	09:23	17:08
Pahi	12:31	16:03						17:17
MANEK URAI	12:22	15:54	18:42	19:47	06:04	07:53	09:44	17:29
Kg Baru Sg.M'kuang	12:06	15:38	18:27		06:15		10:16	17:40
Ulu Temiang	12:00	15:32	18:20		06:20		10:22	17:47
Kg. Baru Bkt Abu	11:54	15:26	18:14		06:25		10:28	17:53
BUKIT ABU	11:45	15:18	17:34		06:36		10:36	18:04
Kuala Gris	11:35	15:10	17:26		06:45		10:45	18:14
DABONG	11:26	15:01	17:20	18:53	06:54	09:09	10:54	18:22
KEMUBU	10:54	14:48	17:07		07:07		11:05	18:35
Sri Jaya	10:50	14:43			07:33			18:52
Sri Mahligai	10:46	14:39	16:59		07:39		11:22	18:58
Sri Bintang	10:42	14:35			07:45			19:04
Sg. Tasin	10:37	14:30			07:51			19:11
Jerek Baru	10:32	14:26	16:48		07:58		11:44	19:19
Bertam	10:26	14:20			08:04			19:26
BERTAM BARU	10:21	14:15	16:40		08:10	10:04	12:00	19:32
LIMAU KASTURI	10:10	14:04	16:28		09:00		12:15	19:45
Sg Sirian	10:03	13:57			09:05			19:53
Kg. SG. Sirian	09:59	13:53	16:18		09:11			20:01
Sg. Koyan		13:48			09:17			
Pan Malayan	09:52	13:43			09:23			20:19
GUA MUSANG	09:14	13:30	16:00	17:34	09:36	11:06	13:00	20:35
Lapan Tupai								
Mentara Baru			15:41					20:56
MERAPOH	08:47		15:33		09:55			21:11
Telok Gunong	08:39		15:26		10:00			21:18
Kubang Rusa			15:19		10:05			21:25
SUNGAI TEMAU	08:22		15:03		10:16			21:38
CHEGAR PERAH	08:11		14:52		10:30			21:54
Aur Gading			14:42		10:37			22:02
Dura			14:37					
Kg. Berkam	07:55		14:32		10:50			
Bukit Belong	07:49		14:26		10:57			22:22
Telang			14:20		11:04			
PADANG TUNGKU	07:41		14:13		11:15			22:42
KUALA LIPIS	07:30		14:00	15:39	11:30	13:07		23:00
KERAMBIT				15:11		13:44		
Mela				14:57		13:58		
JERANTUT				14:31		14:20		
Jenderak				14:15		14:54		
KUALA KRAU				14:02		15:08		
Kerdau				13:45		15:25		
MENTAKAB				13:33		15:37		
MENGKARAK				13:02		16:11		
TRIANG				12:47		16:26		
KEMAYAN				12:30		16:43		
BAHAU				11:47		17:27		
GEMAS				10:47		18:12		
SEGAMAT				10:10		19:28		
LABIS				09:37		20:01		
BEKOK				09:18		20:19		
PALOH				08:49		20:34		
KLUANG				08:21		21:01		
RENGAM				07:58		21:23		
LAYANG-LAYANG				07:47		21:34		
KULAI				07:16		22:34		
KEMPAS BARU				06:47		23:03		
JB SENTRAL				06:05		23:23		
WOODLANDS				06:00		00:00		

STESEN / STATION — NO TREN / TRAIN NO — TREN / TRAIN	SENANDUNG TIMURAN (MTT) 26	SENANDUNG WAU 28	SENANDUNG WAU 29	SENANDUNG TIMURAN (MTT) 27
TUMPAT	12:00	10:30	18:00	20:00
WAKAF BAHARU	11:42	10:08	18:17	20:19
PASIR MAS	11:25	09:47	18:35	20:38
TANAH MERAH	10:58	09:15	19:04	21:10
KRAI	10:22	08:35	19:43	21:49
DABONG	09:21	07:34	20:57	23:01
GUA MUSANG	08:07	06:15	22:13	00:17
KUALA LIPIS	06:12	04:18	00:02	02:06
JERANTUT	05:08	03:09	01:08	03:14
KUALA KRAU	04:42			03:46
MENTAKAB	03:55	02:14	02:05	04:12
TRIANG	02:56			05:00
BAHAU	01:54			06:01
GEMAS	01:00	23:25	04:45	06:46
PULAU SEBANG/TAMPIN		22:36	05:54	
SEREMBAN		21:50	06:39	
KAJANG		21:05	07:23	
KL SENTRAL		20:30	08:00	
SEGAMAT	00:21			07:45
LABIS	23:47			
BEKOK	23:26			
PALOH	23:07			
KLUANG	22:38			09:22
RENGAM	22:14			
LAYANG-LAYANG	22:01			09:57
KULAI	21:30			10:51
KEMPAS BARU	20:40			11:23
JB SENTRAL	20:05			11:45
WOODLANDS	20:00			12:30

(Red) **Stesen Akhir** / *End Station*

(Green) **Stesen Bermula** / *Origin Station*

TRANSIT — **Tambang Tren Transit adalah tertakluk kepada tambang perjalanan kelas 2**
Transit Train Fares are subject to 2nd class fares

SHUTTLE — **Tambang Tren Shuttle adalah tertakluk kepada tambang perjalanan kelas 3**
Shuttle Train Fares are subject to 3rd class fares

Tertakluk kepada Akta Pengangkutan Awam Darat 2010/
Subject to Public Land Transport Act 2010

Appendix 10: Epworth Sleepiness Scale (ESS) Permission Email

3/1/2011 Print

From: Murray Johns (MJohns@optalert.com)
To: azlissani@yahoo.com;
Date: Tue, February 8, 2011 2:30:41 PM
Cc: Reception@optalert.com;
Subject: Epworth Sleepiness Scale (ESS)

Mohd Azlis Sani Md Jalil
You have my permission to use the ESS free of charge in your research project at the University of Malaya (PhD in Ergonomics).
Good luck with it.
Dr Murray Johns

Appendix 11: Letter to experts

En Suhaimi Ali,
Department of Occupational Safety, Health and Environment,
Keretapi Tanah Melayu Berhad,
Ibu Pejabat Korporat,
Jalan Sultan Hishamuddin,
50621 Kuala Lumpur.

9th March 2011

Dear Sir,

Questionnaire Evaluation by Expert

I am a Ph.D. (Ergonomics) student at Faculty of Engineering, University of Malaya and currently conducting a research for development of a human performance model for Malaysian train drivers. The objective of this study is to evaluate effects of workload and fatigue on performance and safety of the train driver. This study will help to improve and as an effort to solve existing problems and drawbacks in the railway industry.

As an expert in railway industry, I do appreciate your interest in my research. Your comments and suggestions during the evaluation will be very beneficial to this study. Your participation is highly appreciated.

I will send a hard copy, and replies envelop via mail and should be reached to you very soon.

It will be grateful if you may response before 22nd of March 2011 as I could resume with the next stage of the study.

Thanking you in advance for your time and participation.

Yours sincerely,

Mohd Azlis Sani Md Jalil
Dept. of Engineering Design & Manufacturing,
Faculty of Engineering,
University of Malaya,
50603 Kuala Lumpur.
Email : azlissani@yahoo.com

cc. Associate Prof. Dr Siti Zawiah Md Dawal
Project Supervisor

Appendix 12: Evaluation form for expert

Evaluation form for expert / *Borang Penilaian Pakar*

Please evaluate and comments the questionnaire provided to you.
Sila nilaikan dan komen borang soal selidik yang disediakan kepada anda.

Section 1.0 General Information / *Seksyen 1.0 Maklumat Umum*

Section 2.0 Workload / *Seksyen 2.0 Beban tugas*

Section 3.0 Fatigue / *Seksyen 3.0 Kelesuan*

Section 4.0 Safety / *Seksyen 4.0 Keselamatan*

Section 5.0 Established survey instrument / *Seksyen 5.0 Instrumen kaji selidik terdahulu*

Overall / *Keseluruhan*

Appendix 13: Appreciation letter to experts

En. Husdin bin Che Amat,
Director
Industrial Hygiene and Ergonomics
Department of Occupational Safety and Health
(Ministry of Human Resource)
Level 2, 3 & 4, Block D3, Complex D
Federal Government Administrative Centre
62530 W. P. Putrajaya.

3rd June 2011

Dear Sir,

Letter of Appreciation

This letter is to express my appreciation on behalf of my supervisor, Associate Prof. Dr Siti Zawiah Md Dawal for your feedbacks, comments and participation in evaluation of my survey instrument.

Your comments and suggestions are very beneficial to this study. Your participation is highly appreciated.

Thank you very much.

Yours sincerely,

Mohd Azlis Sani Md Jalil
Dept. of Engineering Design & Manufacturing,
Faculty of Engineering,
University of Malaya,
50603 Kuala Lumpur.
Email : azlissani@yahoo.com

cc. Associate Prof. Dr Siti Zawiah Md Dawal
Project Supervisor

Appendix 14: Letter to TOC for field study at depots

Kepada;

En. Zakaria Sulong,
Pengurus Besar,
Department of Safety, Health and Environment (S.H.E),
Keretapi Tanah Melayu Berhad,
Ibu Pejabat Korporat,
Jalan Sultan Hishamuddin, 50621 Kuala Lumpur.

PERMOHONAN MENJALANKAN KERJA LAPANGAN DI DEPOH – DEPOH KTMB

Dengan segala hormatnya, perkara di atas adalah dirujuk.

2. Pihak kami ingin merakamkan penghargaan kepada pihak tuan yang selama ini telah memberikan kerjasama yang sangat baik di dalam penyelidikan berkaitan "*Development of Malaysian Train Driver Performance Model*".

3. Justeru itu, bagi meneruskan penyelidikan ini, saya ingin memohon kebenaran pihak tuan bagi pelajar Ph.D. kami untuk menjalankan kerja lapangan di Depoh – depoh KTMB seperti maklumat berikut:

Nama penyelidik	: Mohd Azlis Sani Md Jalil
No. Matrik	: KHA 080044
No. KP	: 780103 – 01 – 5839

4. Dilampirkan jadual perancangan kerja lapangan yang akan dilakukan. Tarikh dan tempat adalah tertakluk kepada kebenaran daripada pihak tuan. Penyelidik kami boleh dihubungi melalui nombor 019 – 211 2692 atau email azlissani@yahoo.com.

5. Kami amat berharap permohonan ini mendapat perhatian seterusnya kelulusan daripada pihak tuan. Kerjasama tuan kami amat hargai dan di dahului dengan ucapan terima kasih.

Sekian. Terima kasih.

Prof. Madya Dr Siti Zawiah Md Dawal

Appendix 15: Letter to TOC for field study at the locomotives

Kepada;

Tuan Haji Sarbini bin Tijan,
Pengurus Besar Operasi,
Keretapi Tanah Melayu Berhad,
Ibu Pejabat Korporat,
Jalan Sultan Hishamuddin, 50621 Kuala Lumpur.

PERMOHONAN MENJALANKAN KERJA LAPANGAN DI LOKOMOTIF

Dengan segala hormatnya, perkara di atas adalah dirujuk.

2. Kami ingin merakamkan penghargaan kepada pihak KTMB yang selama ini telah memberikan kerjasama yang sangat baik di dalam penyelidikan berkaitan "*Development of Malaysian Train Driver Performance Model*" khususnya semasa kaji selidik yang dijalankan di depoh-depoh sebelum ini.

3. Justeru itu, bagi meneruskan penyelidikan ini, saya ingin memohon kebenaran pihak tuan bagi pelajar Ph.D. kami untuk menjalankan kerja lapangan di lokomotif – lokomotif seperti maklumat berikut:

Nama penyelidik : Mohd Azlis Sani Md Jalil
No. Matrik : KHA 080044
No. KP : 780103 – 01 – 5839

4. Dilampirkan jadual perancangan kerja lapangan yang akan dilakukan. Tarikh dan tempat adalah tertakluk kepada kebenaran daripada pihak tuan. Penyelidik kami boleh dihubungi melalui nombor 019 – 211 2692 atau email azlissani@yahoo.com.

5. Kami amat berharap permohonan ini mendapat perhatian seterusnya kelulusan daripada pihak tuan. Kerjasama tuan kami amat hargai dan di dahului dengan ucapan terima kasih.

Sekian. Terima kasih.

Prof. Madya Dr Siti Zawiah Md Dawal
Penyelia

s.k. Tuan Haji Abdul Mokti bin Zakaria
Pengurus Besar,
Department of Occupational Safety, Health & Environment (OSHEN),
Keretapi Tanah Melayu Berhad.

Appendix 16: Consent letter

1 Mac 2011.

Kepada responden yang dihormati,

Tuan,

JEMPUTAN UNTUK MENGAMBIL BAHAGIAN DI DALAM KAJI SELIDIK

Saya adalah seorang pelajar Ph.D (Ergonomik) di Fakulti Kejuruteraan, Universiti Malaya dan pada masa ini sedang menjalankan kajian pembangunan model prestasi manusia terhadap pemandu keretapi di Malaysia. Objektif kajian ini adalah untuk menilai kesan – kesan beban tugas dan kelesuan ke atas prestasi dan keselamatan pemandu keretapi. Kajian ini diharapkan dapat membantu mempertingkatkan dan juga sebagai suatu usaha untuk menyelesaikan masalah yang terjadi di dalam industri dewasa ini.

Sebagai seorang yang berpengalaman, saya amat menghargai keterlibatan tuan di dalam kajian saya ini. Saya memerlukan sedikit pertimbangan tuan untuk menjawab soalan – soalan di dalam borang soal selidik yang disediakan. Data – data terkumpul adalah rahsia dan hanya akan digunakan untuk tujuan akademik sahaja.

Adalah menjadi harapan saya jika tuan dapat memberikan kerjasama dan pertimbangan tuan.

Sekian. Terima kasih.

Yang benar,

Mohd Azlis Sani Md Jalil,
Pelajar Ph.D (Ergonomik),
Jabatan Kejuruteraan Rekabentuk dan Pembuatan,
Fakulti Kejuruteraan,
Universiti Malaya,
50603 Kuala Lumpur.
Email : azlissani@yahoo.com

sk. Prof. Madya Dr Siti Zawiah Md Dawal
Penyelia Projek

Appendix 17: Consent form

Bil:

Surat Keizinan oleh Responden

Tajuk projek : Pembangunan Model Prestasi Manusia untuk Pemandu Keretapi Malaysia

(Development of Malaysian Train Driver Performance Model)

Penyelidik : Mohd Azlis Sani bin Md Jalil

Penyelia : Prof. Madya Dr Siti Zawiah Md Dawal

Tujuan :
Kajian ini dilakukan untuk mengkaji kesan – kesan bebanan tugas dan kelesuan terhadap prestasi dan keselamatan pemandu keretapi. Kaji selidik ini akan mendapat data hasil daripada pandangan dan persepsi pemandu keretapi yang telah berpengalaman di dalam industry ini. Hasil daripada dapatan kaji selidik ini, model prestasi manusia akan dibangunkan. Kaji selidik ini adalah sebahagian daripada kajian kedoktoran (Ph.D.)

Prosedur :
Responden perlu menjawab soalan – soalan yang dikemukakan di dalam borang kaji selidik. Borang ini mengandungi 5 bahagian utama dan dianggarkan masa menjawab adalah selama 30 minit. Responden perlu memilih jawapan yang dirasakan amat sesuai dan tiada betul atau salah untuk kesemua jawapan tersebut.

Risiko :
Tiada sebarang risiko kepada responden semasa atau selepas menjawab soalan – soalan ini.

Kerahsiaan :
Maklumat responden adalah dijamin rahsia. Setiap jawapan adalah rahsia dan borang soal selidik yang telah dijawab akan hanya ditanda dengan nombor kod. Hanya data yang telah diproses dan dianalisis akan digunakan. Nama responden tidak akan digunakan dalam sebarang laporan.

Sukarela :
Keterlibatan responden di dalam kaji selidik ini adalah secara sukarela, tanpa sebarang paksaan.

Hak untuk menarik diri :
Responden mempunyai hak untuk menarik diri daripada kajian ini pada bila – bila masa.

Kebenaran responden

Saya telah membaca dan memahami Surat Keizinan untuk kaji selidik ini. Dengan ini, saya secara sukarela bersetuju untuk mengambil bahagian di dalam kaji selidik ini.

Responden,

TT:___________________________

Nama: ________________________

No. kakitangan : _______________

Tarikh : _______________________

Penyelidik,

____

Mohd Azlis Sani Md Jalil

No. matrik : KHA 080044

Tarikh : ___________________