

**THE EFFECTIVENESS OF THE NATURALISTIC DRIVING STUDIES IN
IMPROVING DRIVER BEHAVIOUR**

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DECLARATION

I, **Khangwelo Muronga**, hereby declare that the dissertation, entitled: **The effectiveness of the Naturalistic Driving Studies in improving driver behaviour**, which I have submitted for the **Magister Technologiae: Business Information Systems** degree, at Tshwane University of Technology, is my own original work and that it has not previously been submitted to any other institution. All sources used or quoted are indicated and acknowledged by means of a comprehensive list of references.

A handwritten signature in black ink, appearing to read 'Khangwelo Muronga', is written over a horizontal line.

Khangwelo Muronga

Date:

DEDICATION

In loving memory of my mother **Rachel Nnzudzeni Muronga**

The Divine One has blessed

ACKNOWLEDGEMENTS

Genesis 49 – The blessings of the Son are from the Father. I would like to give thanks and praise to God the Father, the almighty for His merciful blessings. Allow me to extend my thanks and appreciation to my father **Rembuluwani Jeremiah Muronga**, for his encouragement and guidance; with his blessings I succeeded.

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ABSTRACT

The Naturalistic Driving Studies (NDS) are research methods that have the ability to improve existing methods for collecting data about driver performance and driver behaviour in normal driving conditions. The purpose of this research is to evaluate the effectiveness of the NDS in improving driver behaviour and adherence to road rules by making use of the elements of the theory of planned behaviour as a framework. To achieve the purpose of the study, it was necessary for the research to be conducted in two phases. The first phase of the research involved data collection through questionnaires, to address opinions of the NDS users in relation to its effectiveness since implementation. The second phase involved making use of data already collected by a company operating in the heavy vehicle industry that made use of NDS technology to monitor driver behaviour.

Analysis of naturalistic driving data in normal driving conditions provides a possibility of big data sets that can be used to understand the characteristics that could lead to vehicle crashes and/or near crashes. The results of the study showed that the technology used is able to arrive at expected conclusions and set objectives. Making use of the Theory of Planned Behaviour, the study managed to illicit responses from both drivers and management, who both showed that they are happy with the NDS as it provides them with information that can improve driving ability as well as offer security to drivers, as the system also offers warning to prevent or counter high-jacking and theft of cargo. The study also recommends that more organisations should embark on making use of this technology in order to improve road safety. Researchers are also recommended to make use of the data to learn more about driver behaviour so as to use the knowledge to implement effective road safety strategies and initiatives.

List of Abbreviations

NDS	Naturalistic Driving Study
ICT	Information and Communication Technology
WHO	World Health Organisation
RTMC	Road Traffic Management Corporation
GDP	Gross Domestic Products
GSR	Global Status Report
SADC	Southern African Development Community
ITS	Intelligent Traffic Systems
IS	Information Systems
TPB	Theory of Planned Behaviour

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CHAPTER 1

1. INTRODUCTION AND BACKGROUND

1.1 Background

The right to life and the protection of life is a constitutional right in South Africa. In acknowledgement of this right, The Road Traffic Management Corporation (RTMC) spent about R800 million on initiatives to encourage road safety in South Africa during the 2012/2013 financial year. This was mainly motivated by the fact that the rate of road traffic fatalities had reached unacceptably high level (Peters, 2014). Peters also confirmed that The National Transport Survey (focused on households) of 2013 indicates that the percentage of car ownership had risen from 22.9% in 2003 to 32.6% in 2013; and this means more vehicles on our roads which could be the reason for the increasing fatal crashes on South African roads.

The increasing road fatalities, amongst other challenges faced by the Ministry of Roads Safety in South Africa, has led to considerations of Information and Communication Technologies (ICTs) such as mobile technologies, as necessary to enable safer mobility on South African roads, as these ICTs could collect and communicate valuable information to road users. The adoption and use of ICT is, however, not new to the transportation sector, as research indicates that it was first introduced during the 1990s (Giannopoulos, 2004, Jitsuzumi, Mitomo & Oniki, 2000) but has evolved since and brought about concepts such as intelligent vehicles, smart vehicles, real time traffic monitoring, offering intelligence in traffic data collection and real time advice to motorists and authorities, and providing information such as expected traffic volumes and traffic congestion on specific road sections (Giannopoulos, 2004).

Recent focus has been on improving driver behaviour as a means to counter the road fatalities, and one recent domain which exploits the use of ICTs in that regard is that of Naturalistic Driving Studies (NDS) - which refers to an unassuming approach of studying driver behaviour with the aim of allowing researchers to detect and analyse how the vehicle driver, the vehicle itself, the road and other traffic relate to each other in normal circumstances, in conflict situations and in actual crashes (van Schagen, Welsh, Backer-Grondahl et al., 2011, Shankar,

Jovanis, Agüero-Valverde et al., 2008). Making use of NDS can be beneficial to transport operators, policy makers and commercial organisations (Dozza, González, 2013).

The information collected from these studies assists researchers to better understand the driving conditions, road safety situations as well as the driver's handling of the vehicle. This is illustrated in the study conducted by (McLaughlin, Hankey & Dingus, 2008), where they tested all the attributes influencing driver options during crashes and in near crashes. NDS studies could potentially provide valuable data collection methods for both transportation policy makers, commercial organisations and road users as the collected data can be extremely valuable for the analysis of safety critical events. As the vanguard of ICT adoption, the developed world has explored the use of NDS and studies conducted in such contexts indicate that the use of NDS technologies, such as in-vehicle monitoring devices, is the best way to study and understand driver behaviour (Taylor, Pradhan, Divekar et al., 2013, Espié, Boubezoul, Aupetit et al., 2013).

In South Africa, insurance companies such as Discovery and Hollard have bought into NDS and they make use of Data Acquisition Devices (DAS) to collect data about the kilometres the insured vehicle has travelled and this is used to calculate insurance premiums as well as to monitor safety behaviour of the drivers. South African researchers from the Council for Scientific and Industrial Research (CSIR) have also recognised the importance of ICT for road safety research studies and have started making use of NDS (Muronga, Venter, 2014). Key from their findings is the assertion of the NDS capability to improve road safety, recorded in the paper entitled 'Naturalistic driving data: managing and working with large databases for road and traffic management research'.

Although NDS are used worldwide to collect valuable data from drivers, and some of these studies focused on risky driving practices and road environment factors that can influence driver behaviour, there is limited literature of such studies in developing countries. Even though there was the study by CSIR, and Venter (2014) acknowledges that these studies can be used to learn more about driver behaviour - which in turn can assist in driver training to improve road safety in South Africa – NDS's actual adoption success in changing driver behaviour and their impact on reducing fatalities in South Africa is still not clearly covered in the existing body of knowledge (Venter, 2014). This is important as ICT implementations reportedly fail in achieving their intended objectives. According to (Geels, Smit, 2000) there are about seven

pitfalls or reasons why ICT fails in traffic and transportation projects, with two of them being social needs and practical problems.

In concurrence with the above assertion (Nawi, Rahman & Ibrahim, 2011, Gichoya, 2005), among other scholars, indicate that several private and public sector organisations around the world invest a great deal of money on ICT; most of these projects, especially in government, fail for various reasons - including but not limited to: lack of feasibility studies conducted; inadequate estimation of work; low quality of the end product; and the technology used not being in-line with current technology (Nawi, Rahman & Ibrahim, 2011). Richard Heeks agrees that even though not all ICT projects will succeed this gap can be limited by conceptualised and rigorous studies by academic researchers, especially in developing economies. Thus a study on the success or failure of NDS in achieving its intended objectives is essential, and more importantly - its effect on driver behaviour (Heeks, 2010).

1.2 Problem Statement

Although there are several studies that promote the benefits of NDS adoption as a tool to monitor and prevent some of the challenges faced by the transportation industry, there is limited studies that indicate success in practice, and if indeed NDS achieves the intended objectives (Venter, 2014, Jovanis, Aguero-Valverde, Wu et al., 2011). The technology has the potential to facilitate the learning about South African driver behaviour, which in turn can assist with improving road safety in South Africa. However, additional research into the application of this technology is needed. With South Africa being a rainbow nation, which means diverse cultures, beliefs and value systems –as recorded in the document entitled ‘Defining culture, heritage and identity’ (SA History Online, 11 February 2016) - understanding driver behaviour and how NDS can be used to influence behaviour is essential as it can potentially decrease road fatalities.

Therefore, this study tries to conduct an in-depth examination of the effectiveness of NDS in improving driver behaviour and adherence to road rules, which can reduce road fatalities in South Africa. The findings might assist decision makers in deciding if NDS is the best way to go in learning about driver behaviour, before government and other institutions invest millions of rands on this technology. This is important as IT projects, according to Geels & Smit (2000)

and Heeks (2010), mostly fail and their ROI cannot be justified due to failure of meeting the intended objectives.

1.3 Research Objectives

The main objective of this study is to evaluate the effectiveness of NDS in improving driver behaviour and adherence to road rules, with the aim of recommending means that can improve the success and effective use of NDS in South Africa. Specific objectives include:

1. To establish the sequence of incidents recording by the technology on vehicles that already have the in-vehicle device installed.
2. To compare the sequence of decision making of drivers after a period of time with the technology installed in the vehicles.
3. To determine if the intended objectives by companies that have installed the technology were achieved.
4. To determine the driver's perceptions and experience about NDS and its role in improving road safety.

1.4 Research Questions

The main research question is: *How effective is NDS in improving driver behaviour and adherence to road rules?*

Related questions are:

1. What is the effect of NDS on driver behaviour in terms of safe driving practices?
2. What are the important factors that determine success of NDS to companies that have installed NDS to monitor driver behaviour?
3. What are driver's perceptions and experience about NDS and its role in improving road safety?

1.5 Significance of the Study

NDS is a fairly new concept in traffic and transportation research, and in South Africa research related to NDS is limited (Venter, 2014). This study could contribute in bridging the gap in

NDS research by investigating the effectiveness of NDS in learning about South African driver behaviour in relation to road safety. The study will also recommend means in which NDS can be implemented successfully in South Africa.

NDS methodology has in the past years proven to be valuable in providing rich contextual information about the driver, the vehicle and driving environment (Labuschagne, Pallet, 2010). The methodology has so far been applied twice within the South African context. This study aims to close the gap in the body of knowledge by adding more information in relation to NDS in the South African context. The result of the study also provides a further view of the kind of knowledge that can be derived from NDS data as explained in Chapter 5, which is a step further from just collecting the data.

1.6 Delimitations of the Study

The research study was limited to vehicles that are already fitted with NDS, such as Data Acquisition System (DAS). The organisation of choice is based in South Africa but with operations across the SADC region. The selection of participants focused on drivers who have been driving for more than two years, and have the technology installed in their vehicles. Data collected from the technology was limited to trips from local delivery vehicles to cross border delivery vehicles; this was done to have adequate data in terms of long distance and short distance commercial drivers.

The focus of the study on these two types of drivers has implications on the results in terms of knowledge that could have been missed from driver behaviour of non-commercial purposed drivers. The volume of data collected was massive and would have taken the researcher much longer to analyse all the data sets. However, the selected data sets were adequate and valid to achieve the objectives of the study.

1.7 Key Terminology and Concepts

This section briefly discusses key terminology and concepts, providing a preliminary literature review of these concepts. This study focuses its key discussions on the use of ICT in transportation research, mainly on NDS and its effectiveness in improving driver behaviour and influencing behavioural changes. The term **Information and Communication**

Technology (ICT) in education refers to: the study of the technology used to handle information and aid communication and includes areas such as telephony, broadcast media and all types of audio and video processing in transmission (2010). For the purpose of this study the terms refer to a similar definition, but including mobile communication (such as cell phones and GPS devices) via satellite and any other networked connection. This term was devised by Stevenson in a report to the United Kingdom government in 1997 and since then has appeared in a number of documents. The use of ICT has influenced governments to make use of the technology in improving gross domestic products growth (Wang, 1999).

The term **Gross Domestic Products** refers to: the value a country's overall output of goods and services at market prices, excluding net income from abroad (Business Dictionary,). In this study the term was taken as is, and used in reference to how much money was spent, and how many goods and/or services were sold in relation to how much profit was earned by a particular country. In this study we talk of GDP in the SADC region, the term **Southern African Development Community (SADC)** refers: to the regional economic community comprising of 15 member states; namely: Angola, Botswana, Democratic Republic of Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe. These member states joined forces in 1992, with the aim of committing themselves to a regional Integration and poverty eradication within Southern Africa through economic development and ensuring peace and security (SADC,). One of the objectives of the SADC can be achieved through improving transport systems.

Transport systems include the use of intelligent traffic systems, the term **Intelligent Traffic Systems (ITS)** refers to systems that comprises of a traffic control centre, a traffic information service centre, a cellular mobile communication system, a road toll collection system and an in-vehicle terminal, which are connected with each other via a communication network (Feng, 2006). For the purpose of this study the meaning refers to the same thing, but with an exclusion of the road toll collection system and with an inclusion of audio and video cameras as part of the in-vehicle technology, that makes use of an information system. The term **Information Systems** was defined by Vladimir Zwass as; an integrated set of components for collecting, storing, and processing data and for providing information, knowledge, and digital products (Zwass, 2016). This study involves the use of these information systems in the learning and understanding of driver behaviour.

The study of human motor skills started more than 130 years ago, where the ability to transfer skills, retain skills and the differences in individual's learning abilities were discussed (Adams, 1987). These studies gave rise to the focus on learning concepts of individual differences and individual reaction in certain situations in order to examine personalities (Mischel, 1973). This field of study formed part of the social learning and personality development research, which discussed topics such as moral behaviour, non-conformity, imitation and methods of changing behaviour (Miller, 1962). Methodologies from these studies were adopted to learning about driver behaviour as well, and the bustle in driver behaviour studies was more visible in the 1970s (Michon, 1985).

1.7.1 Naturalistic Driving Studies

Laporte (2010) states that Naturalistic Driving Studies (NDS) have two categories of studies, namely the field operational tests (FOTs) and natural observation research. These studies collect observations about the driver's interaction with the vehicle and the vehicle's surroundings, as well as driver performance, safety and acceptance of driving rules (Dozza, González, 2013). However, it can be argued that the FOTs are not really NDS as there is limited naturalistic observations; these studies are very similar in approach in terms of measuring and recording driver and vehicle behaviour (Laporte, 2010). More information regarding this concept is discussed in Chapter 2.

1.7.2 Instrumented vehicles

Instrumented vehicles are vehicles equipped with computer-based data acquisition systems that collect data about the vehicle operations as well as vehicle environment including driver, passengers and the external surroundings (Jovanis, Aguero-Valverde, Wu et al., 2011). This computerised equipment includes but is not limited to GPS loggers, video cameras and data recorders. The technology records information such as GPS position, acceleration, seatbelt use, steering angle, driver eye movements, etc. (Chan, Pradhan, Pollatsek et al., 2010).

1.8 Conceptual Framework

The Theory of Planned Behaviour (TPB) was developed by Ajzen in 1988 and proposes a model to measure how human actions are guided (Ajzen, 1991). NDS focuses its attention on the behaviour of drivers and how they make and alter decisions in relation to the road

environment and their behavioural norm; therefore for the purpose of this study, the elements of TPB (see Figure 1.1 below) were deemed suitable and were used as a framework to explain and track driver behaviour and behavioural changes. For the purpose of this study, behavioural change refers to the driver being able to take advice from the NDS technology or the reports produced by the technology; this can be analysed by assigning behaviour to a particular TPB construct. Chapter 2 explains the use in detail. TPB constructs have been used before by other authors to explain pedestrian and driver intentions to violate traffic rules (Guttman, Lotan, 2011, Forward, 2009).

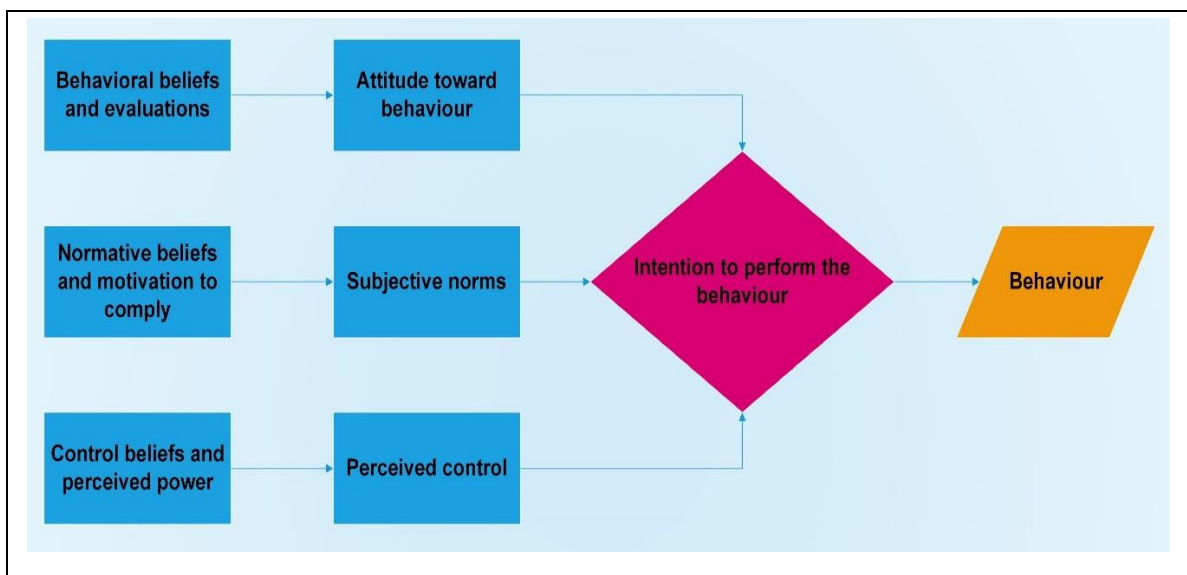


Figure 1.1: Theory of Planned Behaviour (Ajzen, 1991)

NDS, assumes that a person’s intention to perform a certain behaviour is determined by three motivational influences: attitude, subjective norms and perceived behavioural control (Renzi, Klobas, 2008). In simple terms people participate in certain behaviours if the anticipated outcome of the behaviour is supposed to be of benefit to the individual. The choice of the theory is relevant for NDS as the data is both in qualitative and quantitative formats.

TPB has been used for both qualitative and quantitative studies even though it is less common in qualitative studies (Renzi & Klobas, 2008). This study aims to assess the effect of implemented NDS technology on driver behaviour by applying the TPB to evaluate driving behaviour in terms of driving violations such as drinking and driving, dangerous overtaking, use of mobile devices while driving, speeding and lane discipline. This is consistent with the use of TPB in terms of behavioural control and influence of control beliefs (Forward, 2009). Participants will be studied in two stages: first from the first few months when the NDS was

installed in their vehicles, and then again from their behaviour six months beyond having the technology in their vehicles.

1.9 Research Methodology

There is more to research than just collecting data; it involves answering a question that has not been answered and creating new knowledge (Goddard, Melville, 2004). By following a scientific process to describe, address, illustrate and explain some phenomena, one is conducting research and the procedure that one follows to achieve this is called research methodology (Cassim, 2011, Mouton, 2011). There are basically two forms of research methodologies: qualitative and quantitative research methods (Mugenda, Mugenda, 2003, Ross, Israel, 2002). To achieve the intended objectives of this study, both methodologies were applied in a mixed method approach. A combination of two data collection methods was used, i.e. a questionnaire (Appendix A) for quantitative data and document analysis for qualitative data. More about the methodology is explained in Chapter 4.

1.9.1 Research philosophy

Creswell (2009) uses the term ‘worldviews’ instead of ‘philosophy’: worldviews are a general orientation about the world and about the nature of the research that a researcher is conducting. The paradigms are divided into four categories: pragmatism, social constructivism, promotion/participatory, and post-positivism (Creswell, 2009). A pragmatic research philosophy will be applied in this research based on the research problem and the objectives. Pragmatism is regarded as the heart of grounded theory, which is mostly used in qualitative studies (Corbin, Strauss, 2014). It also makes it simple for different methods, worldviews, prepositions, and different data collection and analysis methods to be used (Creswell, Klassen, Plano Clark et al., 2011).

1.9.2 Research approach and strategy

Quantitative research focuses more on facts and causes of behaviour, and the results are presented in a statistical format (Kothari, 2004). In quantitative research, the prominence is on the measurement and analysis of relationships between variables (Leedy, Ormrod, 2005, Kothari, 2004). For this study, a qualitative research approach will be used which will allow the use of existing data as collected by various organisations during their NDS. The qualitative

method will be applied within a case study design strategy. According to Yin (2013), a case study refers to an empirical investigation of an existing event in an environment. Case studies can be single or multiple-case (Yin, 2013). For this study, a multiple case study approach will be employed for an in-depth understanding of effect of NDS and its success in improving driver behaviour.

1.9.3 Sampling and population

Sampling is backed up by the fundamental idea that believes that by choosing some of the elements in a population, conclusions may be derived about the entire population (Cooper, Schindler & Sun, 2006). Sampling is the statistical process of selecting a representative part of a population for the purpose of studying the sample. For this study, purposive sampling which involves the selection of the participants or elements to be observed on the basis of one's own understanding about which ones will be the most useful or representative (Babbie, 2005), will be applied. The criteria will be based on those drivers that have been on NDS installed vehicles and those officials that deal with data that is drawn from NDS. Thus the study will include MIS specialists, Data Analysis and drivers. As the population of NDS installed vehicles is unknown, but believed to be only a fraction, a total of 100 participants were used for the questionnaire, while about 15 participants were interviewed.

1.9.4 Data collection

This study will use multiple methods, such as questionnaires, and content analysis as primary data collection instruments, as outlined below.

Content Analysis: the study will apply content analysis where data captured during the NDS will be analysed to determine the driver behaviour. Content includes text, videos and other data that is available.

Structured-Questionnaires: a questionnaire in this study will be used to provide evidence of patterns amongst the larger sample to support the interviews and the content analysis data. In this research study, a structured questionnaire was used, where participants responded to prompts (Likert scales) by selecting from predetermined answers designed as per the theoretical foundations of this study. The questionnaires were hand delivered, and were collected from the participants by the researcher.

1.9.5 Data analysis

Data analysis allows the researcher to organise and bring meaning to large amounts of data (Creswell, 2009). The main analysis for this study is content analysis of the NDS data, where images, videos and text will be used. In addition, the content analysis will be applied on the collected data in line with the TPB theory, where descriptive statistics will be used to analyse the questionnaires for further qualitative interpretation. Both qualitative and quantitative tools were used, such as statistical application/software packages like Microsoft Excel, while for qualitative data video analysis software supplied by DriveCam was used.

1.10 Ethical Considerations

NDS is very experimental in nature and, thus, ethical considerations are very critical. However, the researcher was not installing the device but rather was using the data and experiences about the already installed devices. Naturalistic studies involving human beings are very sensitive and it is very important, therefore, to respect the privacy of participants, as well as giving the participants an opportunity to give their consent to participate in the study (Laporte, 2010). For more information on ethics and participants consent please see Chapter 4, sub-Section 4.4 and Appendix B.

1.11 Chapter Outline

This study consists of six chapters, with Chapter 1 being the introduction to the study. Chapter 1 provides the introduction and context of the study, covering what the entire study is meant to cover. Chapter 2 covers the literature review and the theoretical background, and the underlying theoretical frameworks are covered in Chapter 3. The employed research methods and study designs are discussed in Chapter 4. Chapter 5 and Chapter 6 present the research findings, analysis and discussion as well as conclusion and recommendations.

Therefore, the following is the study chapter outline.

Chapter 1: Introduction to the study

This chapter gives background information in relation to the research study. This includes the objectives of the study as well the problem that gave birth to the research questions. It also

provides a background on naturalistic driving studies and their relationship to information and communication technology and transportation research.

Chapter 2: Literature review

The literature review has three main purposes. First it gives a brief overview of the road safety issues and its impact on the economy of countries, as well the effect of fatal road crashes. Road crashes are responsible for about 1.3 million deaths globally and they impact governments negatively as they cost governments about 3% of Gross Domestic Product (GDP); in Africa this number is slightly higher at 5% of GDP.

Secondly, it gives an overview of how information and communication technology has been used in transportation research, giving rise to terms such as intelligent traffic systems, self-drive vehicles, etc. Thirdly, it gives an overview of how NDS, which is the main topic of this research, was introduced in transportation and ICT research, as well as an overview of other studies conducted by other researchers.

Chapter 3: Theoretical frameworks

This chapter gives an overview of the research theories that have been applied in the study and how they relate to the study of human behaviour. The chapter also presents the Theory of Planned Behaviour as the framework underpinning the study and its relevance to achieving the objectives.

Chapter 4: Research methodology and design

This chapter provides an overview of the reasons that motivated the researcher to undertake this research as well as an overview of how data was collected and analysed to achieve the set objectives. Mixed methods were applied, both qualitative and quantitative, to collect and analyse the data. This chapter also provides an explanation of how the DriveCam system works, with regards to content analysis, and how the information is transferred into quantitative tables for analysis and grouping of driver behaviour.

Chapter 5: Research findings and results

This chapter gives an overview of the information and findings from the collected data. It shows that from the two types of drivers evaluated, the local delivery drivers made more triggers in terms of identified behaviour. More than 1 400 behaviours were recorded by the

system, and the results showed that a risky behaviour of 12.2% was coming from the local distribution drivers. Although about 1 700 behaviours were recorded for the cross border drivers only about 9% risky behaviour was recorded.

Chapter 6: Summary, conclusion and recommendations

To conclude the study, recommendations and suggestions for future studies are made in this section. This chapter further gives a summary of the importance of road safety, as well as its impact on the economy and families. The study further recommends that the technology be implemented on a grander scale, and by more companies, in order to improve safer driving and safety on our roads.

1.12 Chapter Summary

This chapter gave a brief overview of the whole study by providing the background of road safety issues in the world as well as in the South Africa and the SADC region. This chapter also provided the significance and motivation of the study, as well as the problem statement, objectives and the research questions that will elicit needed information to achieve the objectives. The purpose of the research study is to evaluate the effectiveness of the NDS in improving driver behaviour and adherence to road traffic rules.

In the next chapter a detailed discussion of the NDS, including where it has been studied by other researchers, is provided as a part of the literature review. The literature review also gives a background to some theoretical frameworks as well as the motivation for choosing the TPB as the underpinning theory for this study.

CHAPTER 2

2. LITERATURE REVIEW

2.1 Introduction

Road traffic accidents are regarded as the biggest problem in human progress; they are the main cause of injury, which could lead to permanent disability or death (Scott-Parker, Goode, Salmon et al., 2016, Lasota, Staniszewska, Tarchalska-Kryńska et al., 2015). The World Health Organisation (WHO) estimates road traffic fatalities as the ninth leading cause of death worldwide and is estimated to cause about 1.3 million deaths each year (WHO, 2015) and cost governments worldwide about 3% of GDP, with low-middle income countries at 5% (Aeron-Thomas, Jacobs, 2011). Road traffic fatal crashes are a significant contributor to deaths in the world and in Africa and by 2020-2030 it is estimated that fatal crashes will move from ninth position to fifth position as contributor to death (Parkinson, Kent, Aldous et al., 2013, Ameratunga, Hajar & Norton, 2006). Africa is expected to experience the greatest increase of road traffic fatalities by 2030, and as Southern Africa has the most number of vehicles the region will be the most affected (Aeron-Thomas & Jacobs, 2011).

In South Africa human error has been highlighted as the most significant contributor to road traffic crashes (Gainewe, Masangu, 2010, Botha, Van der Walt, 2006). Even though the human factor is a significant contributor to road traffic fatalities, it is the least investigated (Plaatjies, 2010). To bridge the gap in researching human behaviour as a contributor to road traffic crashes, South African researchers conducted a Naturalistic Driving Study, funded by the CSIR, to monitor driver behaviour and the driver environment (Muronga & Venter, 2014). This study made use of ICT to collect and store data about driver behaviour.

ICT is not a new term in transportation research, according to Giannopoulos (2004). ICT systems were introduced in the field of transportation during the early 1990s. These brought about concepts such as intelligent vehicles, smart vehicles, and real time traffic monitoring - offering intelligence in traffic data collection and real time advice to motorist and authorities,

and providing information such as expected traffic volumes and traffic congestion on specific road sections (Giannopoulos, 2004).

2.2 Road Safety

The WHO published the Global Status Report (GSR) on Road Safety in 2015, which contained information from 180 member countries, covering 97% of the world population, using a standardized methodology for data collection for comparative analysis (2015). This report highlighted that road traffic fatalities are the leading cause of mortality in the world (see Figure 2.1) and although it is the leading cause, most of the traffic crashes are predictable and preventable.

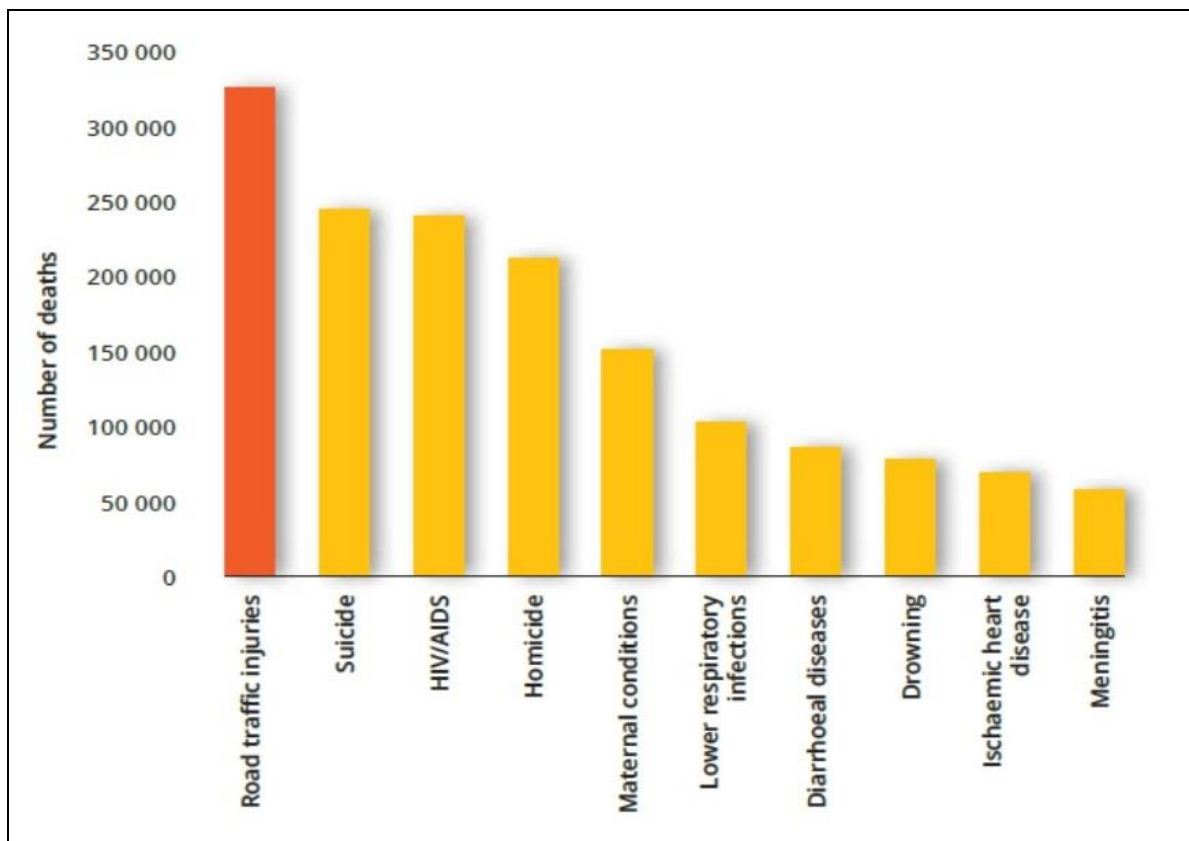


Figure 2.1: Top 10 causes of death among people aged 15 to 29 years (GSR, 2015)

World-wide, road traffic crashes are a leading cause of death as shown in figure 2.1, and it mostly affects young people of between 15 to 29 years of ages. This rise mostly affects low- and middle-income economies where urbanisation and motorisation are the drivers of economic growth. Even though motorisation is a positive factor for economic growth, road fatalities place a heavy burden on the economy as well as households (Sleet, Baldwin, Dellinger

et al., 2011). The GSR on Road Safety (2015) also highlights the following as a proven cost effective way for making roads safer (Global Status Report on Road Safety, 2015):

- Road safety management
- Safer roads and mobility
- Safer vehicles
- Making road users safer
- Improved post-crash response and hospital care.

These five cornerstones are part of what is known as the road safety system, which is seen as the most appropriate system in guiding the management of road safety (Road-Safe,). This system advises countries that in order to produce road safety outcomes, strong management in all aspects of road safety is of importance. The cornerstones are based on the fact that people have limitations and also make mistakes and, therefore, safety principles need to be established to reduce road deaths (World Road Association,).

The system encourages the following principles:

- Safe road use, by improving the behaviour of the road user;
- Safe roads and road surroundings, by improving road infrastructure design;
- Safe speeds, by ensuring that speed limits and travel speeds are appropriate for the road infrastructure;
- Safe vehicles, by improving safety of the vehicle on the road;
- Improved post-crash activities, by improving the emergency response rate, the collection of correct patient information and improving hospital care and access.

The (Global Status Report on Road Safety, 2015) indicated that countries that implemented evidence-based interventions in line with the five objectives have shown improvements in the reduction of road traffic injuries.

2.2.1 Road traffic safety in the Africa region

As already mentioned, road crashes kill about 1.3 million people per year globally and cost governments about 3% of GDP, but in developing countries this number is about 5%. In Africa, about 43 countries of the 47 WHO member states participated in the GSR on Road Safety 2015,

and the results indicate a 26.6 per 100 000 fatality rate, which is about 246 000 deaths. Africa has the highest number of road traffic deaths, the global rating is 17.4 (Global, 2015). This report reiterated that it is of importance that African countries implement effective road safety programmes that are supported by legislation as road safety laws improve road user behaviour, which leads to a reduction in road traffic crashes, injuries and deaths.

2.2.2 Road traffic safety in the SADC

SADC is an acronym for Southern African Developing Community. South Africa is a member state of what is referred to as the SADC region. The region is made up of 15 member states. For the purpose of this study, only six member states are included on the figures, these are the countries that are neighbouring South Africa, which is the focal of the study. The published GSR (2015) shows that in the region, South Africa has the highest number of road fatalities as recorded between 2010 and 2011.

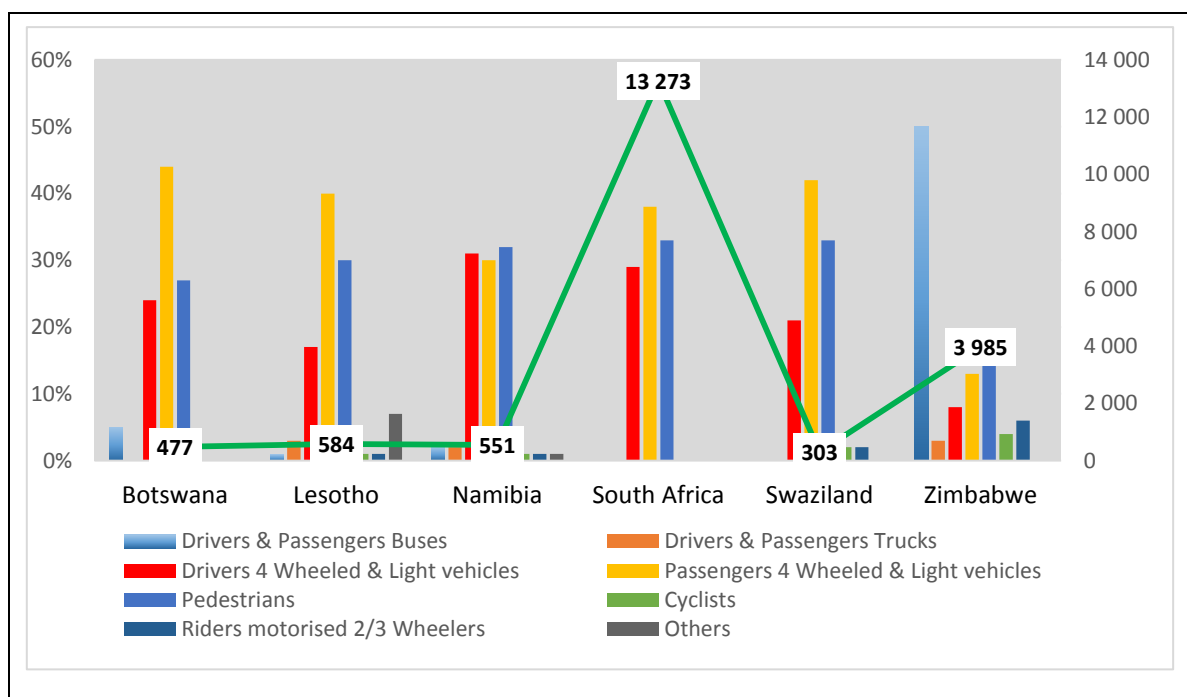


Figure 2.2: Estimated deaths by road user category, SADC region (GSR, 2015)

As compared to a similar report published in 2009, South Africa improved from 33.2 per 100 000 in 2009 to 25 per 100 000 in 2015, but the more than 13 000 deaths are still too many. The report also shows that in the SADC region most fatalities include a high number of drivers and passengers of 4 wheeled light vehicles, followed by pedestrians. This adds more burden to the economy. Evidence shows that the current and future burden of road traffic crashes is carried

mostly by those countries that have low affordability to meet the economic, health service and social challenges.

The recorded GDP loss for South Africa as published in the 2015 is estimated at 7.8%. This is way higher than the 3% average for other countries worldwide (Global Status Report on Road Safety, 2015). Noting that SADC countries are still developing countries, this burden will reduce the prospects of the broader vision of sustainable development and poverty alleviation (Bliss, Breen, 2012). Therefore, more work is needed in terms of implementing sustainable and effective information systems for road safety. Research has proved that evaluation of trends in traffic crashes is a unique tool that can provide information that can be used to action programmes for reducing road traffic crashes (Lagarde, 2007). Information and communication technology (ICT), can be used to provide effective information systems as it can offer a broad array of possible safety systems in road transportation – providing, for example, collision avoidance warning or interventions (Gifford, 2010).

2.2.3 Road safety in South Africa

South Africa, as a developing country, has a very high rate of road traffic accidents with an unacceptable number of fatalities of more than 14 000 annually (Anonymous) costing the government about R3 billion each year. This number came down by about 200 fatalities in the GSR of 2015. This results in serious social and economic costs for the country, as families lose members who could be bread winners (South African Government, 2013). The same government information showed that the most causes of accidents are human behaviour related: excessive speeding, drinking and driving, drinking and walking as well as driver fitness and/or fatigue.

South Africa as a member state of the WHO also adopted the United Nations General Assembly resolution which proclaimed 2011 to 2020 as a Decade of Action for Road Safety. This resolution states that member states will improve road safety in five areas, namely: road safety management, safer roads and mobility, safer vehicles, safer road users and post-crash responses (WHO,). With the adoption of the Decade of Action for Road Safety in 2010, government acknowledged in 2014 that road traffic fatalities and injuries have reached an unacceptably high level (Peters, 2014) and more needs to be done to reduce this fatalities, with ICT being a consideration. The growing popularity in the past decade of ICT advancement has created

major interest in the research community on the benefits and impact of ICT in policy making (Cohen-Blankshtain, Rotem-Mindali, 2016). Researchers have hypothesized that these advancements in ICT will have a positive impact on how transport systems are facilitated for improved mobility (Cohen-Blankshtain, Rotem-Mindali, 2016, Castells, 2011, Graham, Marvin, 2001).

2.3 Information and Communication Technology (ICT) in Transport

Worldwide, transportation information systems take many different names such as Intelligent Traffic Systems (ITS) in the United States, and Advanced Mobile Traffic Information and Communication System (AMTICS) in Japan. They, however, provide similar offerings (Garcia-Ortiz, Amin & Wootton, 1995). Information Technology (IT) is affecting Transportation and Traffic management in various ways mainly in commercial vehicle operations, assisting with vehicle monitoring and maintenance scheduling, and record keeping (Golob, Regan, 2001). As already mentioned, ICTs can be very useful and adequate in achieving organisational goals, but if thorough investigations are not done, organisations can fail to realise return on ICT investment.

ICT impact assessments need to be conducted; linking this with organisations' objectives, policies and value chain strategies might assist with economic growth (Heeks, 2010). If proper assessments are conducted before ICT implementation, the benefits are endless with current technologies such as big data and internet. Objects can communicate with each other as well as with people making it easy for organisations to implement systems such as healthcare monitoring systems, smart recycling systems and intelligent transportation systems (Mitton, Simplot-Ryl, 2011).

Other authorities, such as Transport for London, took advantage of the benefits offered by these technologies and implanted what is known as the Integrated Transport Smart Card (ITSC). The ITSC allows public transport users to make use of a credit card like card to load money onto the card and use it to pay for any public transport mode in the city of London (Blythe, 2004). In transport safety vehicle manufactures have started implementing ICT technologies that allow vehicle to vehicle communication, also known as context awareness. This technology gives vehicles the ability to monitor its surroundings and identify any hazards. This information is also communicated to other vehicles with similar technology (Bagchi, White, 2005).

Researchers have acknowledged that there are more than 1000 activities that are associated with the vehicle driving task, and vehicle manufactures have tried to implement various on-board computer technologies such as speed counting, indicating lights, automated braking systems, etc. to assist the driver with some of the tasks (Young, Birrell & Stanton, 2011, Walker, Stanton & Young, 2001, McKnight, Adams, 1970). Researchers have realised that it is not enough for vehicles to handle all the driving tasks through technology, and as already mentioned, human behaviour is the main factor when it comes to safe driving. Researchers started exploring and learning about how drivers make decisions when driving, and this focus gave rise to the term Naturalistic Driving Studies (Valero-Mora, Tontsch, Pareja-Montoro et al., 2010, Klauer, Neale, Dingus et al., 2005, Neale, Klauer, Knipling et al., 2002).

Some people might say why not find other means of transportation that are safer than vehicles, means that will reduce traffic accidents. However, not all countries can afford not to have vehicles (Miyatake, Tanaka, Sakano et al., 2013) and South Africa is no exception. Therefore, vehicles are here to stay, and finding better ways to improve road safety is of paramount importance. The research community is focused on improving driver behaviour for driver safety through investigation of the causes of road accidents (Doerzaph, 2004). As drivers have to execute a continuous number of decision whilst driving, making use of naturalistic data has the advantage of revealing natural behaviour in driving contexts (Neale, Perez, Doerzaph et al., 2006).

2.4 Naturalistic Driving Studies (NDS)

Studies related to road safety research and transportation are limited in Africa and developing countries (Lagarde, 2007). Achieving road safety results will require more investment in infrastructure, vehicle fleets and related investments (Bliss & Breen, 2012). The road transport system consists of three main physical characteristics:

- a) road users,
- b) the vehicle, and
- c) the vehicle surroundings (Naci, Chisholm & Baker, 2009).

Driving is a complicated operation that requires eye, hand and foot coordination and at the same time having an awareness of the road environment (Masuri, Isa & Tahir, 2012).

Naturalistic Driving Studies (NDS) can assist in providing data that can be analysed to understand driving abilities and driver behaviour (Muronga, Venter, 2014).

Naturalistic Driving Studies, also known as naturalistic annotations, is a new method among already applied traffic research methods and provides information that was difficult or even impossible to obtain through current or normal research methods (Winkelbauer, Eichhorn, Sagberg et al., 2010). Under this naturalistic approach, the road user behaviour is studied unassumingly in a natural setting for a long period of time. In the United States, the approach has proven its potential to contribute substantially to the understanding of the processes resulting in crashes and near misses (McLaughlin *et al.*, 2008; Van Schagen *et al.*, 2011).

The final report of PROLOGUE, deliverable D4.2, defines NDS as research studies commenced to provide more information about driver behaviour during every day trips by recording details of the driver, the vehicle and the surroundings through unobtrusive data gathering equipment and without experimental control; with the aim of allowing researchers to detect and analyse the relationship between the driver of the vehicle, the vehicle, the road and other traffic in normal situations, in near crashes and also in actual crashes (Van Schagen *et al.*, 2011).

According to Venter (2014) the term ‘naturalistic driving studies’ refers to an unassuming approach to studying driver behaviour. The methodology assists researchers to study driver behaviour by monitoring the driving task and road environment as well as advice on actions that the driver takes preceding crashes or near crash events or incidents (Venter, 2014).

2.4.1 Overview of relevant Naturalistic Driving Studies in the world

PROLOGUE: Deliverable D4.2 (van Schagen *et al.*, 2011)

PROLOGUE is an abbreviation for ‘Promoting Real Life Observations for Gaining Understanding of road user behaviour in Europe’. The main objective of PROLOGUE was to assess the usefulness and feasibility of a large scale European Naturalistic Driving Study.

The study made use of five small scale field trails which were directed at the following objectives:

- To discover the potential and get a better understanding of the technological aspects of NDS research.
- To give a better understanding of the strengths and weaknesses of various approaches.
- To showcase the probable usefulness of naturalistic annotations for road safety studies.

The field tests were conducted in Austria, Greece, Israel, Netherlands and Spain and the technology and the subjects of the studies were not necessarily the same, as shown on Table 2.1. The objectives were also different.

Data was collected using various tools, such as Data Acquisition System (DAS) based on the G-forces system, on the study about novice and experienced drivers conducted in Israel. The Israel study also collected data from new drivers with 2-4 years' experience.

	Data collection & storage	Data reduction & interpretation	System integration	Relation NDS data & self-reports	Evaluation of interventions	Areas of interest
Austria	X	X		X	X	Driver training
Greece	X	X		X	X	Active Safety technology
Israel	X	X	X	X	X	Novice drivers
Netherlands	X	X	X			Cyclists
Spain	X	X				In-vehicle information systems

Table 2.1: Overview of the main elements of the PROLOGUE field trails

The results were compared with when the drivers first got their licences. A total of 32 drivers participated and the results showed that there were no significant differences in driving behaviour from when the drivers got their licence. The study conducted in Netherlands specifically focused on the vulnerable group of cyclists and their interaction with motorised vehicles. The trial was conducted at an intersection where potential conflicts between motorised drivers and cyclist were likely to occur. The result showed that on that particular intersection, the problems occurred when road users arrived when the light had just turned red and when the light had just turned green for users to proceed.

In short, the PROLOGUE field trials confirmed the potential and value that can be derived from NDS research.

SHRP2 Study (Gordon *et al.*, 2013)

America's highway system is crucial to meeting the mobility and economic needs of local communities, regions, and the citizens of the United States of America. The Second Strategic Highway Research Program (SHRP2) was authorized in August 2005 as part of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). The programme is under the management of the Transportation Research Board (TRB) on behalf of the National Research Council (NRC). Participation in the SHRP 2 programme is conducted under a memorandum of understanding between the American Association of State Highway and Transportation Officials (AASHTO), the Federal Highway Administration (FHWA), and the National Academy of Sciences - the parent organization of TRB and NRC. The programme provides for competitive, merit-based selection of research contractors; independent research project oversight; and dissemination of research results (Gordon, Kostyniuk, Green *et al.*, 2013).

The SHRP2 study is aimed at reducing the injuries and highway fatal crashes through naturalistic driving study involving about 3 000 volunteer drivers. According to Gordon *et al.* (2013) the study involved two analytical models; the models were developed to focus on the statistical relationship between what influences near crashes and actual crashes and on the formulation of exposure-based risk measures, using surrogate measures. The substitute measures examined ranged from simple measures such as lane position and time to crossing the lane, to more complicated measures such as how long it takes the driver to adjust the vehicle to the yaw angle that is level to that of the road.

This study was grounded on the belief that mechanisms behind normal driving variations, especially those during disturbed lane keeping, are not different from those leading to a single vehicle road departure crash. These program gave rise to a number of research studies and conference papers such as studies by: (Oneyear, Hallmark, Carney *et al.*, 2016, Seaman, Lee, Angell *et al.*, 2016, Paone, Bolme, Ferrell *et al.*, 2015, Seshadri, Juefei-Xu, Pal *et al.*, 2015), and for one to critically analyse the Sharp2 program, one would have to get involved directly and make use of the data collected or studies all the emanating studies from the program.

The researchers collected data about driver behaviour including how the driver interacts with vehicle and roadway characteristics. Since its commencement in 2005, the research programme has seen a number of different NDS studies being designed. These have included different types of studies such as those involving commercial operators, young drivers and others for vehicle insurance purposes, etc. (Venter, 2014).

The 100-Car NDS (Dingus et al., 2006)

One of the important counter measures to dealing with road fatalities is to understand the factors that cause crashes or pre-crashes. These Dingus *et al.* (2006) believed can be solved by learning about driver performance, driver behaviour, driving environment, driving contexts and other factors that are associated with critical incidents leading to near crashes or crashes. The Virginia Tech Transportation Institute (Virginia TTI) created a Naturalistic Driving Studies database. The database's main goal was to collect important data about crashes and near crashes that can assist in developing strategies to avoid or reduce crashes.

The database stored data collected to study driver behaviour from 100 cars installed with a Data Acquisition System (DAS). The 100 car study was the first of its kind in Virginia to collect large scale naturalistic driving data from the majority of drivers using their own vehicles, about 78 out of 100 drivers. The primary objective of the study was to provide data relating to pre-crash incidents for understanding causes of crashes (Dingus, Klauer, Neale et al., 2006, Neale, Perez, Doerzaph et al., 2006). The data provided the following data sets:

- about 2 million vehicles miles,
- almost 43 000 hours of data,
- 241 primary and secondary drivers participated
- about more than a year of data collected for each vehicle.

The technology collecting the data installed by Virginia TTI was engineered to be rugged, durable, expandable and unobtrusive. These technologies included seventh generation computer hardware and software, consisting of a Pentium-based technology that received and stored data from sensors installed in the vehicle. This technology also had a sub-system consisting of five cameras monitoring the driver's face, the side view of the vehicle, the forward

view, the passenger side, and another one recording the driver’s hands and surrounding areas. The complete system was recording the following attributes:

Event Category	Definition
Crashes	Any contact between the subject vehicle and another vehicle, fixed object, pedestrians, cyclists, animals etc.
Near Crashes	Defined as a conflict situation requiring a rapid, swerve evasive manoeuvre to avoid a crash
Incidents	Conflict requiring an evasive manoeuvre, but of lesser magnitude than a near crash

Table 2.2: The focal attributes of the 100 car NDS study

The results of the study provided information from 82 crashes, 761 near crashes and 8 295 incidents; with an error margin of about 13 occurrences that either happened when the vehicle was being started or when the system was refreshing.

The results of the 100 car NDS was concluded after about 2 million vehicle miles we recorded and about 43 000 hours of data, over a period of 12 to 13 Months for each vehicle. The technology-related concerns on this study were that some crashes, near crashes and incidents occurred while the system was initialising after the vehicle ignition was started and on other instances the data was incomplete due to equipment related reasons (e.g. camera failure). The successfully recorded data was sufficient for the study to reach intended results.

FMT study (Dinges, Maislin, Brewster et al., 2005)

A study was conducted in the US and Canada to study the effectiveness of fatigue management technologies using NDS on truck drivers. The study focused on three hypotheses to be tested and out of the three the results showed that only one came out negative, meaning the technology was effective. The truck drivers did not like the technology, however, as evidence showed that they would prefer to be trained on how to manage fatigue than to be controlled by a technology (Dinges, Maislin, Brewster et al., 2005).

Australian 400 Car-NDS (Regan, Williamson, Grzebieta et al., 2013)

Another study was conducted in Australia with the aim to understand what drivers do when they drive in normal and safety critical situations. The study noted more advantages of making use of NDS as the method overcomes a range of limitations associated with traditional approaches to data collection and analysis. It also noted a few disadvantages: one being that the driver behaviour may be influenced by knowledge that they are being watched and, therefore, very large sample sizes are needed to yield sufficient results (Regan *et al.*, 2013).

The Michigan TRI study (Sayer, Devonshire & Flanagan, 2007)

The University of Michigan Transportation Research Institute conducted an NDS research involving 78 drivers, and only 36 drivers were used for study analysis. The reasons for excluding the 48 other drivers were not clearly defined or explained. In the study, researchers collected about 18 000 video clips from the field operational tests (FOT). The study was able to meet its intended objectives and technology difficulties were not clearly stated or explained, if any were observed (Sayer, Devonshire & Flanagan, 2007).

EMS Study (Levick & Swanson, 2005):

Maimonides Medical Centre in New York was involved in an NDS conducted in Arkansas. The study was to determine if emergency vehicle drivers’ risky behaviour could be improved by making use of on-board computer monitoring devices, with real time auditing feedback. The study involved 36 vehicles from the Metropolitan Emergency Medical Services (EMS) and data was collected over a period of 18 months, with more than 250 drivers monitored.

The technology installed in the EMS vehicles operated as illustrated in Table 2.3. The in-vehicle computer unit monitored a number of pre-defined parameters every second, providing real time auditory feedback to the driver as warnings (Levick, Swanson, 2005).

Speed	Cold (non-emergency 75/78 mph)	15 sec warning period 75 / 78 mph
	Hot (emergency with lights and sirens)	84 / 88 mph
Cornering	Lower Over Force	39%
	High Over Force	55%

Seat Belt Distance		2 / 10 th mile (.2mile)
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Table 2.3: Predefined parameters of the EMS study

The system parameters being monitored included vehicle speed; the system issued a warning of hot or cold, hard acceleration and braking, cornering velocity and g-forces, use of emergency lights and sirens, use of front seat belts, turn signals, and parking brake. The results of the study indicated that there was an improvement in driver behaviour after the installation of the monitoring devices. The benefits were also visible in the vehicle maintenance costs. Other observations indicated that the technology was well accepted by EMS personnel after the implementation as there was no rebellion or vandalism of the installed technology.

Issues of concern from the EMS study were related to call volume over the study period; the results could not clearly indicate whether improved driver behaviour increased or decreased emergency reaction time, as this is an important factor in an emergency service. A further study will be required to investigate the reaction time as well as the ethical issues concerning the installation of on-board computers in an emergency services vehicle.

IT and Lorry Driver Study (de Croon *et al.*, 2004)

Research has shown that people who are aware of being observed tend to adjust their behaviour to suit the perceived feedback, especially if the information about their behaviour will be given to someone of authority (Wouters, Bos, 2000). This raises questions about the validity of the data collected, but it also gives a positive assumption that if these devices are used as a way to alter behaviour it might yield expected results as clearly indicated by the results of the Amsterdam study (de Croon, Kuijer, Broersen *et al.*, 2004).

A study was conducted in Amsterdam to investigate the effect of on-board computer systems on Dutch truck drivers. The study involved about 650 drivers who were studied over a period of 18 months. The participants were first studied over a period of about 12 months without being aware that they are being monitored and then studied again for about 6 months, being aware of the application of the on-board computer system. The final results of the study indicated that the application of the on-board computer system affected the truck drivers negatively in terms of their job control and commitment to the organisation. Recommendations

of the study were that in the application of these kinds of studies attention should be given to how the application of the on-board computers is implemented and used.

2.5 NDS Research in South Africa

In South Africa, insurance companies have bought into the naturalistic driving studies and make use of data acquisition devices to collect data about the kilometres the insured vehicle has travelled, and this is used to calculate insurance monthly premiums. Logistics companies, specialising in heavy cargo such as timber and car carriers, have also installed NDS technology. For the purpose of this study the logistics companies were of interest, mainly because these companies have subscribed to the Road Transport Management System, which encourages road safety initiatives such as driver behaviour, driver training and coaching, etc.

2.5.1 CSIR NDS study

The CSIR study involved two Data Acquisition Systems (DAS) installed in four participant's vehicles over a period of six months (see Figure 2.). The aim of the study was to monitor driver behaviour with the hope that the collected data could be useful in the road safety research studies (Muronga & Venter, 2014). Though making use of technology that collects data in real traffic situations ensures that the results are more directly related and applicable to use in similar situations and thus enhancing the intelligence of decision makers and planners (Healey, Picard, 2005), the users will have to first develop data analysis tools that can integrate various data formats that are collected.



Figure 2.3: NDS technology of the CSIR study (Muronga & Venter, 2014)

According to Muronga and Venter (2014), the DAS system was obtained and installed in four participants' vehicles over a period of six months for each of the parent/child combinations; the drivers volunteered to be monitored. The research process is illustrated in Figure 2.. The technology was installed in the participants' own vehicles. The volunteer driver activated the system by switching the ignition on and driving the vehicle. All vehicle elements were recorded. The system also continuously recorded image material of the driving environment and driver. Every time an incident (e.g. speeding; drastic breaking; overtaking, etc.) occurred the incident actor would be activated. The incident was recorded in both video (.avi) and text (.csv) files simultaneously and this was recorded on a secure digital card (SD Card) for storage. The researcher then collected the cards from the vehicle periodically to transfer the data to an external hard disk or server.

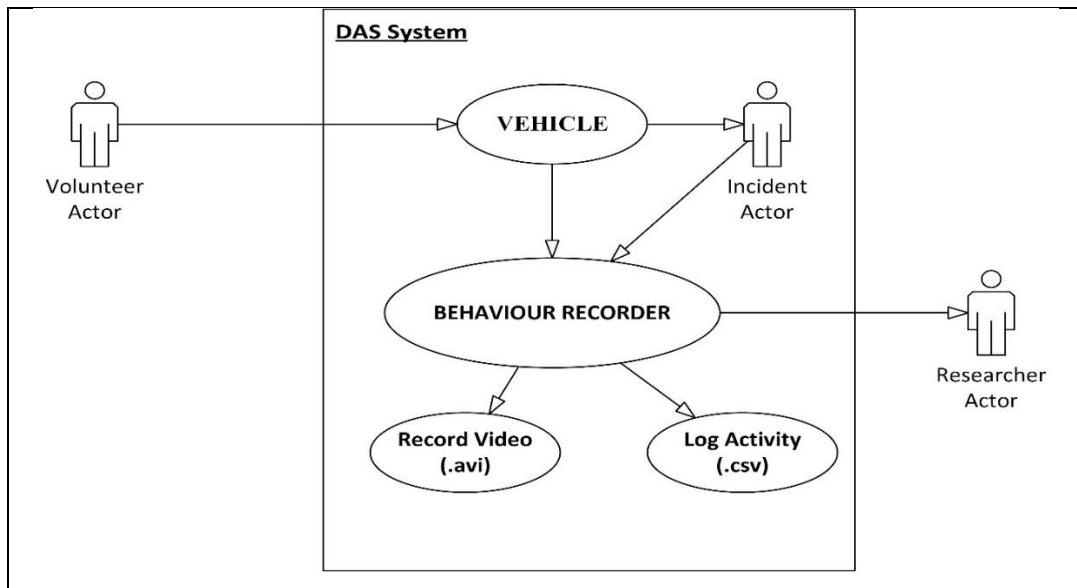


Figure 2.4: DAS System Use Case (Muronga and Venter, 2014)

There are two processes that are involved in the recording of the driver behaviour, when a DAS system is used as illustrated in Figure 2.. The first process records the video of the incident, storing it as an audio video interleaved file (.avi); the second process writes the description of the incident on a text file (.csv), including GPS logs. The data will then be transferred to an external storage facility and this needs to be done periodically to avoid data overwriting. The external storage will then be used as an analysis database.

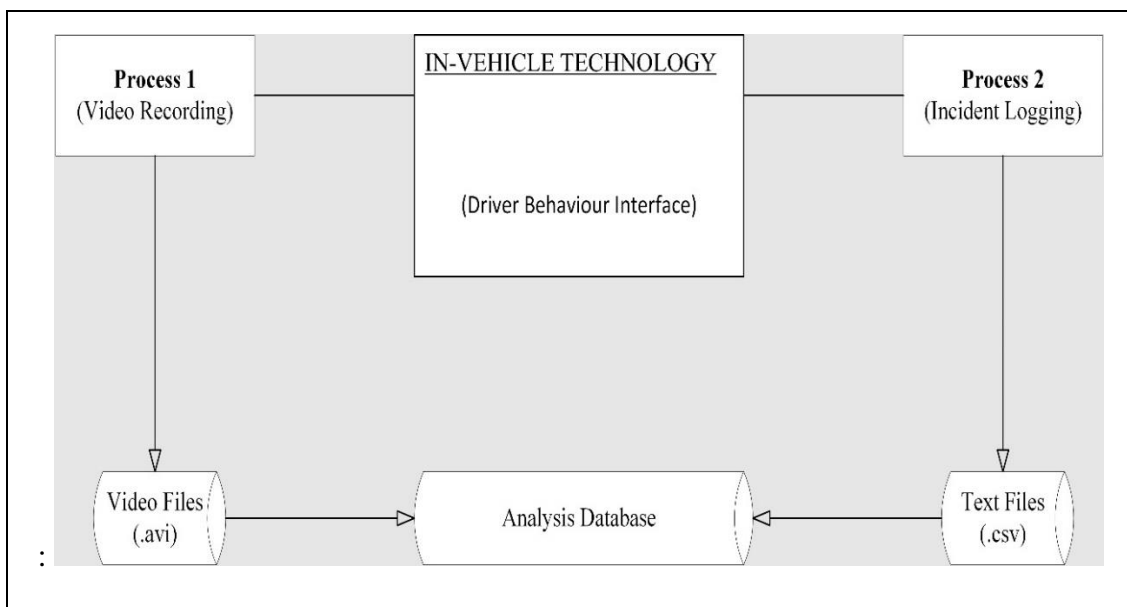


Figure 2.5: DAS System Data Flow (Muronga and Venter, 20014)

The researchers who conducted the CSIR study faced a major problem when it came to the data collected. The volumes of data went into terabytes very quickly, the different types of data

made it almost impossible to analyse and the challenges that arose from working with this data warranted an investigation into strategies of how to manage this large database. There was a need to integrate different datasets, to reduce the amount of time it took to standardise the data and to prepare it for eventual analysis. Even with these challenges, the CSIR study revealed that NDS is a useful tool to collect data about driver behaviour and can assist authorities to learn about the causes of road accidents and then implement strategies that can counter the road safety threats (Muronga & Venter, 2014).

2.5.2 Discovery DQ-Track

Vitality-drive is a driver behaviour programme that gives an insured driver a reward for driving well. This influences drivers to improve their driving knowledge and awareness, and they make sure that the car is safe to drive. The better the driver, the greater the rewards they receive. Members also benefit from vehicle and passenger safety features, such as stolen vehicle tracking and recovery devices, when they choose to install the DQ-Track device in their vehicle. DQ-Track uses a scientific technology that collects data and calculates what they call a 'Driver Quotient' which is calculated according to member's driver performance score, driving knowledge and awareness and how safe the car is to drive in terms of vehicle maintenance (Discovery Insurance, 2016).

The objectives of the DQ-Track implemented by Discovery Insurance is to create a nation of great and better drivers by encouraging safe driving through an award programme that gives points for improving your driving and safety precautionary measures. If you drive well, you will earn DQ Points and the more DQ Points you earn the greater your rewards will be.

2.5.3 Hollard 'Pay as You Drive'

'Pay as You Drive' is a motor insurance plan from Hollard Insurance Company. The technology uses a Data Acquisition System which is installed in the insured vehicle when the insurance policy is activated. The DAS collects data about the kilometres the vehicle has travelled and compares this with allocated kilometres the particular vehicle is expected to travel a month, and then calculates a premium based on whether the allocated kilometres were exceeded or not. To put it in plain language, the less you drive each month, the less you pay on your monthly insurance premiums - which means that you only pay for the actual kilometres you drive (Hollard Insurance, 2016). The objective of the technology is to ensure that the driver

pays insurance premiums based on the kilometres they travel and this is expected to cost the driver less in premiums as compared to standard insurance packages.

2.5.4 DriveCam

DriveCam is a tablet like device, developed by Lytx DriveCam Enterprise in the USA. The device is used by companies that have fleets of vehicles to monitor their drivers in a normal driving setup (Woodyard, 2003). The device is installed inside the vehicle in front of the rear view mirror, see Figure 2., with the camera lens facing outward capturing activity within a 10 degrees' radius, just about the same vision as that of the driver. The on-board microphone records any sound inside and outside of the vehicle.



Figure 2.6: DriveCam Device

The device is also instrumented with sensors that trigger during an event, and records it in response to the predefined events such as unexpected acceleration, hard breaking, a bump, a dangerous hard turn or an actual collision. The video and sound record 15 seconds before and

after a trigger point is saved, and then the DriveCam green light will turn red indicating that something has happened. The complete process of the Lytx DriveCam is illustrated in Figure 2..

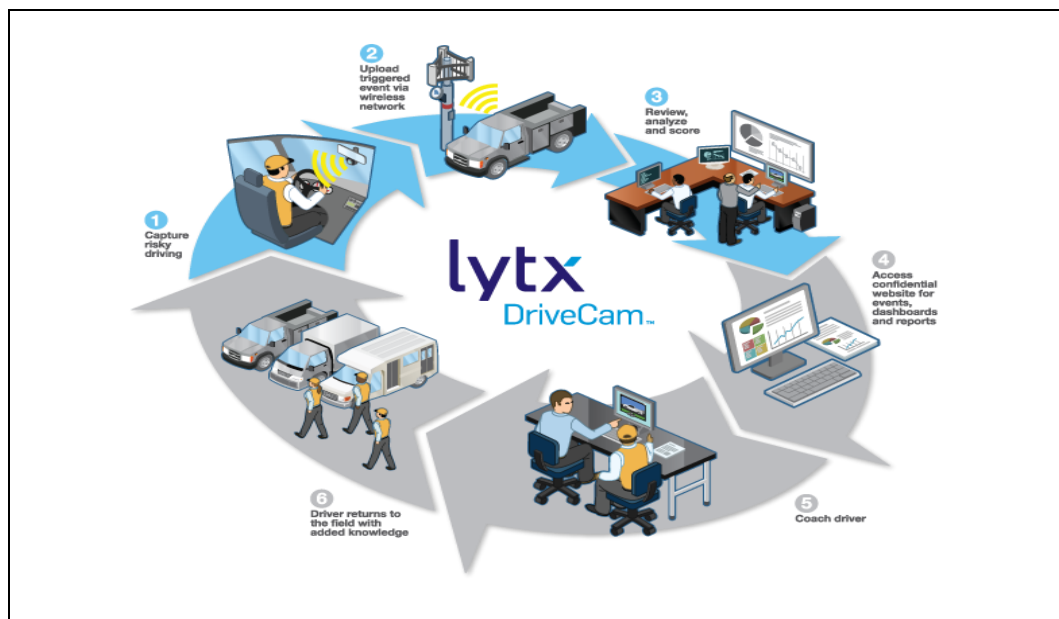


Figure 2.7: Lytx DriveCam process flow (Wallace, 2005)

The driver also has an option to activate the system manually for events such as suspected high jacking or theft if people jump into the vehicle, or in times of road rage incidents. The information collected by the device is saved into a computer and analysed, and then predefined statistics are sent to the DriveCam management of that particular vehicle or fleets of vehicles. DriveCam is regarded as the most comprehensive safety programme designed to reduce unsafe driving behaviours and improve fleet performance with video-based coaching. The technology combines leading predictive analytics, robust reporting and prioritization to help fleet operators improve driver performance and help prevent costly collisions and reduce road fatalities.

2.6 Chapter Summary

In this chapter, the focus has been on ICT and transport research, especially on the use of ICT during NDS research. Some of the topics discussed include the definitions of NDS, current NDS implementation and use in globally and in South Africa, as well as some issues regarding road safety and its impact on the economy.

As demonstrated in this chapter, it is evident that there is an increase in the use of on-board electronics: in-vehicle units and intelligent traffic systems for purposes of naturalistic driving

studies. These studies evaluate and investigate driver behaviour in terms of adherence to set rules, road traffic laws, etc. The results from these studies are used for various purposes, such as improving transportation intelligent systems, insurance premium calculations, improved driver behaviour for road safety, etc. Based on the literature review, NDS is proving to be a good tool for collecting driver behavioural data and this data can be used by researchers to create a knowledge base.

It is too early to make a definite assessment of the usefulness and effectiveness of Intelligent Traffic Systems (ITS) in Naturalistic Driving Studies, as most of the technology has been very successful in data collection and are largely hardware driven. More technologies are being developed in the transportation arena, but their main objective is to collect large amounts of data; however, how these data are transformed into information and how this information is transformed into knowledge or is distributed is not clearly defined (Crainic, Gendreau & Potvin, 2009).

In South Africa, insurance companies have bought into the naturalistic driving studies and make use of data acquisition devices to collect data about the kilometres the insured vehicle has travelled and this is used to calculate insurance monthly premiums. The logistics companies in South Africa, especially those making use of heavy vehicles to transport goods, have also bought into the idea of naturalistic driving studies, as part of the Road Transport Management System (RTMS). RTMS as an industry-led self-regulatory arrangement that encourages heavy vehicle operators to take ownership of road safety programmes and promotes the use of driver monitoring technology to collect data about driving behaviour with the aim of implementing interventions to improve safe driving (Nordengen, Prem & Mai, 2008).

CHAPTER 3

3. THEORETICAL FRAMEWORK

3.1 Introduction

The previous chapter discussed the use of the Naturalistic Driving Studies and how the studies are used to improve road safety. The discussions in the previous chapter introduced the use of information and communication technology in transport research and how through the years' technology has been used to improve driving ability and safer vehicle performance. The chapter also discussed some industrial and academic research that made use of Naturalistic Driving Studies, in other countries as well as in South Africa. This chapter presents the Theory of Planned Behaviour as the theoretical framework underpinning this research study.

There are various theories that can be applied to study driver behaviour. Theories may include unconventional theories, sociological and psychological theories. The different theories are applied in accordance with the intended outcome of a research study. Driver behaviour in relation to this research includes the use of technology or ICT in studying and understanding the behaviour of drivers. An overview of various theories that could have been used in this study is given in the coming paragraphs.

3.2 Technology Acceptance Model (TAM)

The Technology Acceptance Model, known as TAM was developed by Fred Davis Junior in the 1980s. The aim of developing TAM was to get a theoretical framework that could be used to determine the effect of system characteristics of user acceptance of computer-based information systems (Davis, 1985). The theory was developed with two major objectives:

- To improve the understanding of user acceptance process, providing new theoretical understandings into the successful design and implementation of information systems.

- To provide the theoretical basis for practical user acceptance testing framework that would allow system owners and system developers to evaluate new systems before full implementation.

The conceptual framework provides three characteristics as illustrated in 3.1. These characteristics help describe motivational processes mediating between system features and user behaviour.

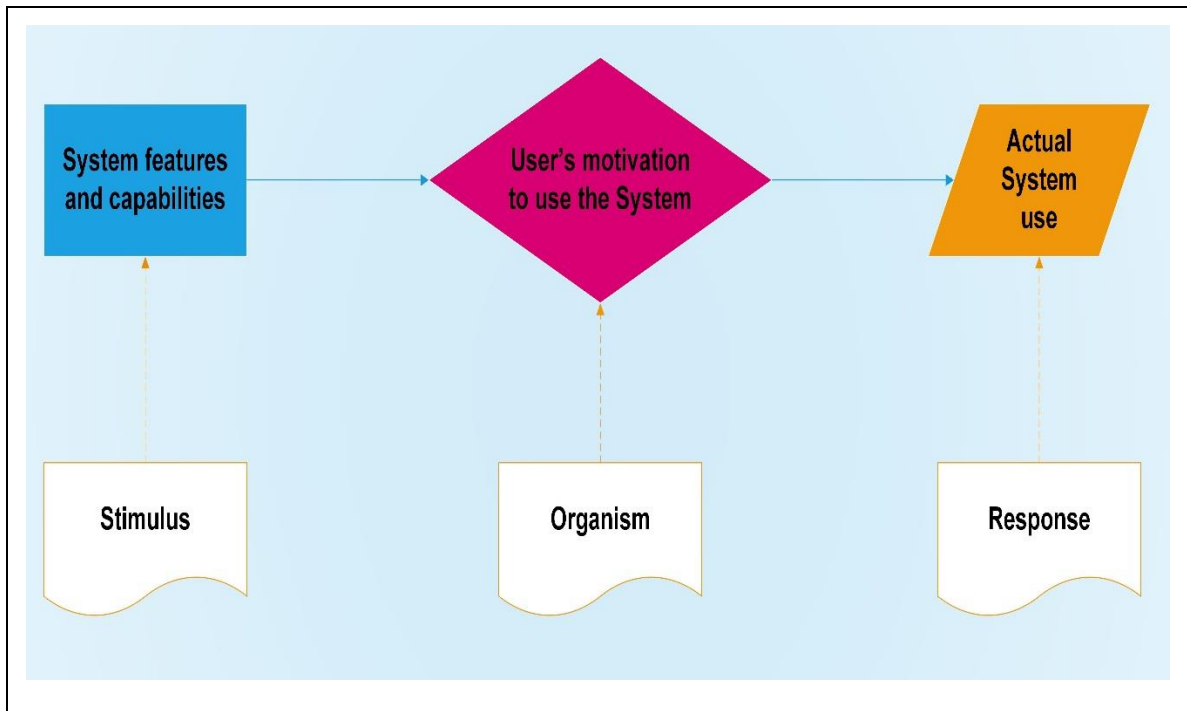


Figure 3.1: TAM Conceptual Framework (Davis Jr, 1986)

The conceptual framework is owned and controlled by Management Information Systems practitioners such as system designers, developers, managers, etc. They make sure that prototypes and samples of a system are developed so as to use them to test the acceptability of the new system by users (Legris, Ingham & Collerette, 2003). It is important that the actual use of a new system is not overlooked to prevent new system rejection by users (Davis Jr, 1986). The objectives of the framework should address the following questions:

- What are the major motivational variables that mediate between the characteristics of the system and the actual system use by the end-users?
- How are these variables informally related to each other, to the system characteristics, and to the user behaviour?

- How can user motivation be measured before the organisation can implement the new system in order to evaluate if the users will accept the system when implemented?

Based on the conceptual framework a model was developed, Figure 3.2, hence the name Technology Acceptance Model. Researchers that have used TAM are in agreement that it is a fact that usefulness and ease of use are primary drivers of user intentions to accept and make use of new technology.

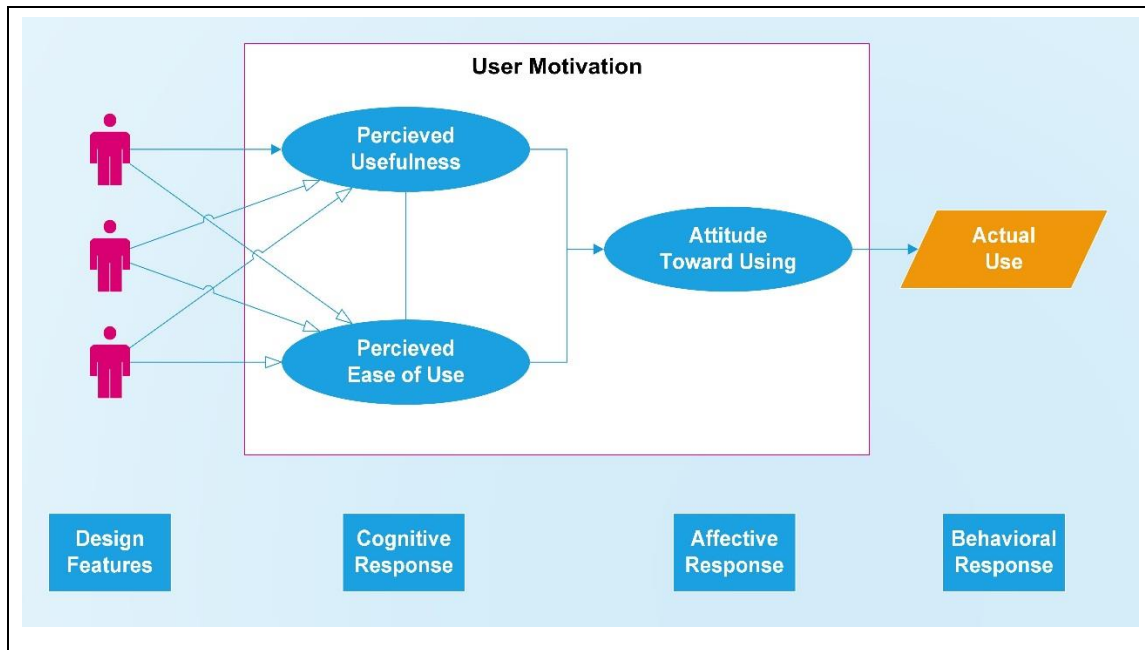


Figure 3.2: Technology Acceptance Model (Davis, 1989)

TAM as an information systems theory that models how users are motivated to accept and use a technology suggests that when users are offered a new technology, a number of factors encourage their decision as to how they want to use the system, and when it will be beneficial for them to use it. As explained by (Davis, 1989):

- Perceived usefulness (PU) – is the degree to which a person will be certain of the fact that using a particular system would enhance their performance of a particular task.
- Perceived ease-of-use (PEOU) – is the degree to which a person will be certain of the fact that using a particular system would not be too difficult or require much free effort.

From the short overview of TAM, it is clear that the theory and model can be a useful tool to study expected user behaviour. But the theory is more valid when studying subjects that will be interacting with a particular system directly, and for the purpose of this study users where

not interacting with the system and, therefore, the theory could not have been useful in achieving the intended goals.

3.3 The Health Belief Model (HBM)

The Health Belief Model was developed in the 1950s as a psychological model that attempted to explain and predict health behaviours. It is one of the first theories of health behaviour. Since its development, HBM has become one of the most widely used conceptual frameworks in health behaviour related research (Champion, Skinner, 2008). The HBM was designed to explain and predict how people make health behaviour related choices by focusing on the attitudes and beliefs of individuals (Figure 3.3).

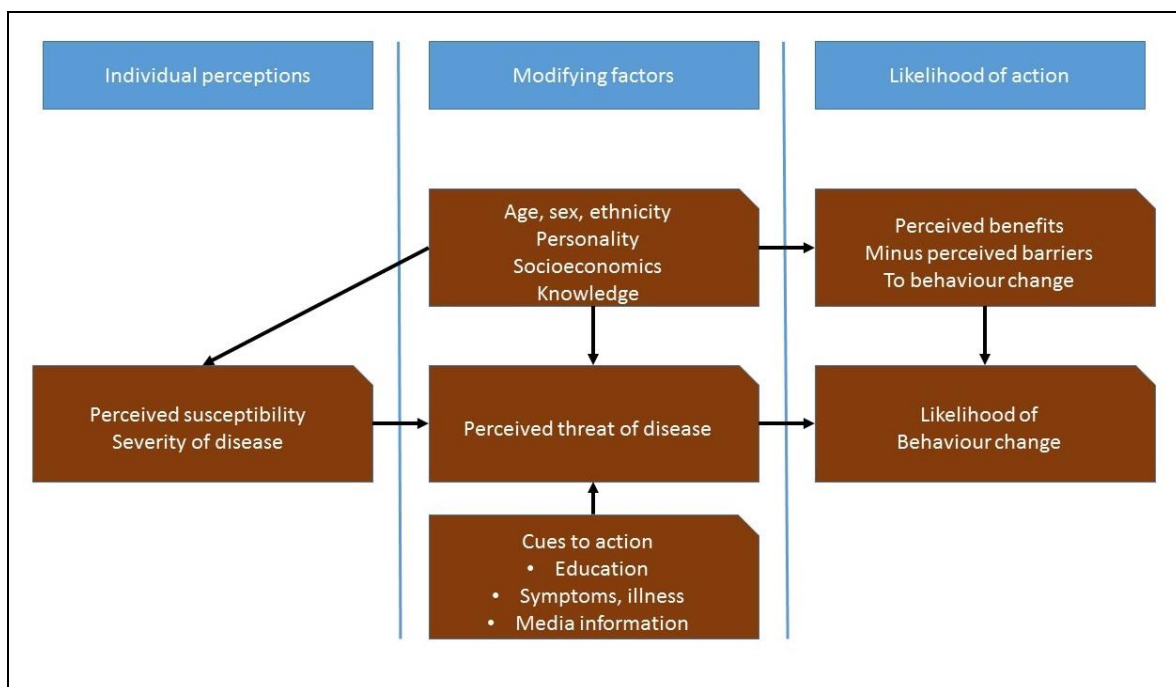


Figure 3.3: Elements of the Health Belief Model (Hochbaum, Rosenstock & Kegels, 1952)

The original HBM consisted of four key constructs relating to perceived threat and net benefits: explicitly perceived susceptibility, perceived severity, perceived benefits, and perceived barriers. It was specifically attempting to forecast whether an individual chooses to participate in a healthy action in order to reduce or prevent any chance of getting sick due to a particular disease or dying early as result of a disease (Nejad, Wertheim & Greenwood, 2005).

- Perceived susceptibility refers to an individual’s understanding of how likely it is for them to acquire a particular disease.

- Perceived severity is related to an individual's understanding of how bad or detrimental the consequences of the conditions of a particular disease are.
- Perceived threat is brought about by the combination of perceived susceptibility and severity of a disease.

The last two constructs of perceived benefits and perceived barriers characterize the net benefits. According to Champion and Skinner (2008), two constructs were added in addition to the five above, and these are cue to action and self-efficacy. Cue to action refers to those factors that will prompt an individual to change a behaviour, and self-efficacy refers to a person's understanding of their ability to perform a particular behaviour and the person's confidence thereof.

This model is not new to transportation research and has been used by other scholars to study road user behaviour (Tavafian, Aghamolaei, Gregory et al., 2011, Şimşekoğlu, Lajunen, 2008, Lajunen, Räsänen, 2004). Although these studies provided understanding of the factors that influenced road user behaviour, the model was not suitable for this research as its constructs focus more on users who are interacting with the system.

3.4 Social Learning Theory

Social Learning Theory by Albert Bandura says that learning is an intellectual process that takes place in a social situation and can occur purely through observation or direct instruction, even in the absence of motor reproduction or direct reinforcement (Bandura, McClelland, 1977). The theory seems to be the most popular framework to explain driver behaviour (Scott-Parker, Watson, King et al., 2012, Akers, Krohn, Lanza-Kaduce et al., 1979) and is rooted in the belief that the primary learning instrument in social behaviour is supported by the past conditions that were formed by the consequences of that particular behaviour (Akers, Krohn, Lanza-Kaduce et al., 1979); and the consequences could be positive or negative.

Social behaviour is motivated by actual imitation of peers and or people that one values as important, such as parents, friends and famous figures (Scott-Parker, Watson, King et al., 2012, Krohn, Skinner, Massey et al., 1985, Akers, Krohn, Lanza-Kaduce et al., 1979). This behaviour is fuelled through reward and recognition or avoided because of the negative consequences. The more a person understands the behaviour as good or acceptable, the more the possibility

of the person adopting that behaviour. Even though the social learning theory is widely used to study human behaviour, in this study it would not add value as its focus is based on understanding past experiences, and the NDS focuses more on adopted habits rather than just peer influences. Therefore, the theory was not preferred as the theory underpinning this study.

3.5 Theory of Reasoned Action (TRA)

The Theory of Reasoned Action (TRA) developed by (cite) posits that human behaviour is the result of behavioural intentions, which are derived from two main sources: attitude towards a particular behaviour and subjective norms (see Figure 3.4) (Luarn, Lin, 2005).

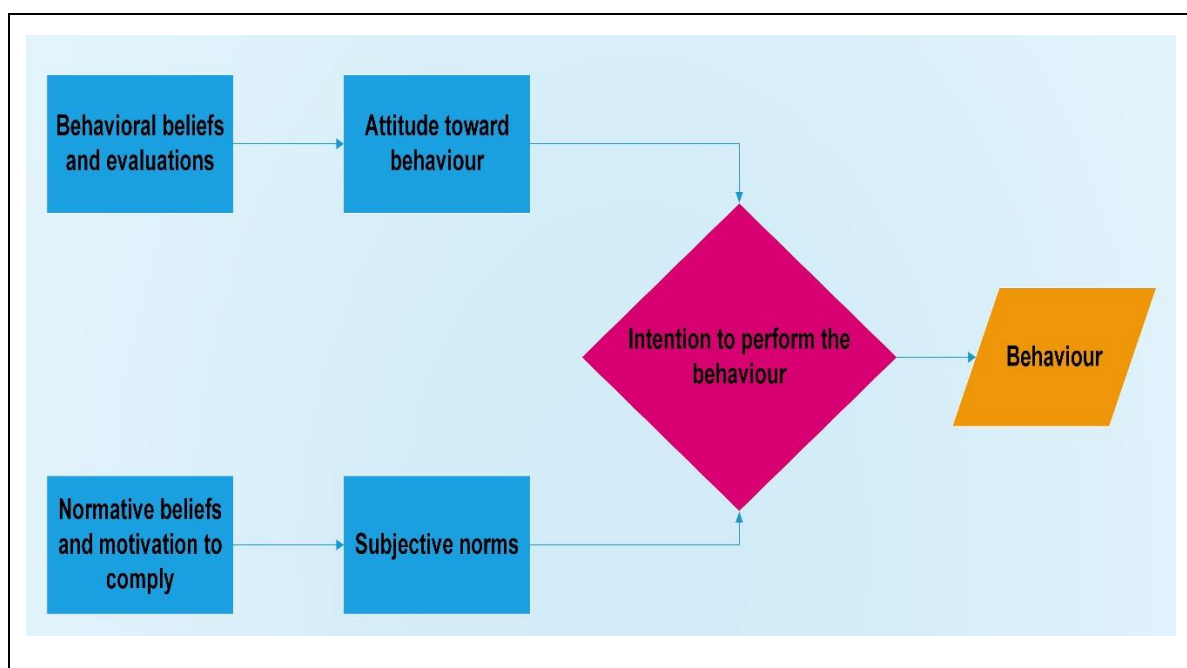


Figure 3.4: The Theory of Reasoned Action (Fishbein, 1979)

Intention comes before behaviour and is an indication of a person's willingness to perform a particular behaviour; attitude towards a behaviour is a person's positive or negative feelings about performing a particular behaviour; and subjective norms are beliefs about what others think a person should do - and the degree to which a person's behaviour is motivated by the opinions of others.

TRA suggests that stronger person intentions towards a behaviour leads to increased effort towards performing the behaviour, which further increases the probability for the behaviour to be performed (Madden, Ellen & Ajzen, 1992, Vallerand, Deshaies, Cuerrier et al., 1992). The

theory has been used in various research studies as a framework for probing explicit kinds of behaviour. Other researchers have used the theory to study behaviours that are associated with health behaviour, high risks and dangerous situations. The theory can also be used where behaviour is examined objectively without linking it to any intention, but most studies looked at intention - as intention is the cornerstone of the theory (Yousafzai, Foxall & Pallister, 2010).

3.6 Theory of Planned Behaviour (TPB)

The Theory of Planned Behaviour was developed by (Ajzen, 1985) as an extension of the Theory of Reasoned Action (see Figure 3.1). According to the theory, human behaviour is directed by three kinds of thoughts, namely: beliefs about the likely consequences of the behaviour and the evaluations of these consequences (behavioural beliefs), beliefs about the normative opinions of others and incentive or drive to comply with these feed these opinions (normative beliefs), and the additional concept of perceived control contemplates situations where difficulties occur that are outside of a person's ability to control (control beliefs) (Ajzen, 1991, Cuenen, Brijs, Brijs et al., 2016).

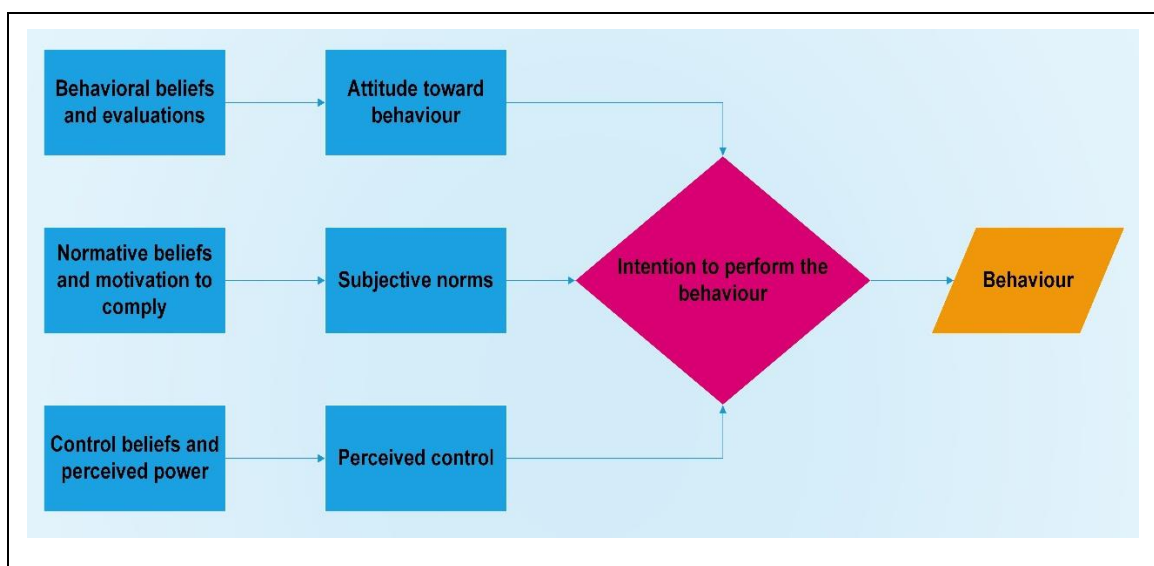


Figure 3.5: The constructs of the Theory of Planned Behaviour (Ajzen, 1991)

The theory further posits that in their respective collection, behavioural beliefs give rise to a positive or negative attitude towards a particular behaviour; normative beliefs result in perceived social pressure or subjective norm, and control beliefs give rise to perceived behavioural control. In combination, attitude towards the behaviour, subjective norm, and perception of behavioural control lead to the development of a behavioural intention (Cuenen,

Brijs, Brijs et al., 2016, Markl, 2016, Wundersitz, Hutchinson & Woolley, 2010, Elliott, 2004). In simple words, the more favourable the attitude and subjective norm and the greater the perceived control, the stronger should be the person's intention to perform the behaviour in question. The relationship of the theory in NDS research is explained in detail below:

3.6.1 The constructs of Theory of Planned Behaviour (Ajzen, 1991)

- **Attitude toward the behaviour:** is a person's overall assessment of a particular behaviour. It is expected to have two components which work together (Montano, Kasprzyk, 2015). These are beliefs about consequences of the behaviour (behavioural beliefs: making use of NDS to learn about driver behaviour can lead to an improved driving behaviour) and the corresponding positive or negative decisions about each of these features of the behaviour (outcome evaluations: consent is desirable by drivers before being monitored).
- **Subjective norms:** are a person's own evaluation of the social pressure to perform the expected behaviour. These are beliefs about how other people, who may be in some way of importance to the person, would like them to behave (normative beliefs). In NDS this could be pressure from the management and/or clients that the driver believes he is expected to meet, and certain behaviour standards (Ajzen, 2015, Montano, Kasprzyk, 2015).
- **Perceived behavioural control:** is the extent to which a person feels able to enact the behaviour. It has two aspects: how much a person has control over the behaviour and how confident a person feels about being able to perform or not perform the behaviour. In NDS, this could be the confidence that the driver has in driving the particular mode of vehicle safely and in accordance with expected results (Ajzen, 2015, Kautonen, Van Gelderen & Tornikoski, 2013).

In the study, the researcher has adopted the Theory of Planned Behaviour (TPB) as a basis for using the components of the NDS Technology and processes in influencing and/or changing driver behaviour. TPB as a theoretical framework guided the study to investigate the effectiveness of NDS in improving driver behaviour and the adherence of drivers to road rules. NDS focuses its attention on the behaviour of drivers and the elements of the Theory of Planned Behaviour will be used to explain and track the behavioural changes.

TPB constructs have been used before by other researchers to explain transport related behaviours and intentions of drivers and pedestrians to violate traffic rules. Even though it is less common in qualitative studies, other researchers have used it in both qualitative and quantitative studies (Guttman, Lotan, 2011, Renzi, Klobas, 2008, Forward, 2009). Different researchers agree that there are personal variables that are of importance in the study of safe behaviour on our roads, and the most cited and preferred theory is the TPB (Cuenen, Brijs, Brijs et al., 2016, Delhomme, De Dobbeleer, Forward et al., 2009, Elliott, 2004). These researchers found that a combination of behavioural intention, which can be moderated by attitudes, subjective norms and perceived behavioural control are very good in predicting behaviour and anticipated behaviour.

The theory was chosen for this research because the study is interested in finding out how effective the NDS is in improving driver behaviour and driver adherence to road traffic rules. The theory, as mentioned by cited researchers above, posits that any person, given full control over a certain behaviour, is expected to act as intended as soon as an opportunity is given. The theory also agrees that for behaviours that a person does not have full control over, it can be determined by considering the perceived behavioural control together with the intention of the behaviour.

This was found to be useful and contributing to the study more than the other theories, as when it comes to driving ability there are situations that the driver has full control over and those the driver has no control over. The researcher was interested in evaluating how the drivers' behaviour in situations where they have control, such as the choice to stop at a stop sign or red traffic light. Other situations could be where the driver has to choose a safe following distance or reduce speed in conditions that are not safe even if the speed limit is higher. There are situations where the driver has no full control as other drivers can influence the decisions. TPB was found to be helpful in addressing all these situations and assisting the researcher in achieving the intended goals.

3.7 Chapter Summary

This chapter gave the background to the Theory of Planned Behaviour as the theoretical framework followed in this research study. The chapter also examined the key constructs (attitude towards a behaviour, subjective norms and perceived behaviour control) that are used

in TPB, and how they lead to an individual's intention to perform a certain behaviour. These were used to analyse the behaviour of a logistics company operating in South Africa and in the neighbouring countries.

The chapter also gave a brief overview of other theories such as the Technology Acceptance Model and The Health Belief Model, which are suitable for studying user behaviour and not new to transportation research; but both were not the right theories for this study as they are strong in studying participants that are interacting with a particular system directly. In this study the participants were not interacting with the system directly. The social learning theory was also considered; this theory focuses its attention on behaviour that is influenced mostly by past experiences but for this study the researcher wanted to focus on adopted habits rather than just peer influences.

The Theory of Reasoned Action was a close contender, as it posits that human behaviour is the result of behavioural intentions, which are derived from two main sources: attitude towards a particular behaviour and subjective norms. However, the theories' roots are focused on a person's intention, and its probability in influencing a behaviour; therefore, the theory was not suitable for achieving the objectives of this study. The Theory of Planned Behaviour was, therefore, selected as the theory underpinning this study.

CHAPTER 4

4. RESEARCH METHODOLOGY AND RESEARCH DESIGN

4.1 Introduction

The previous chapter discussed various theoretical frameworks that could have been used to complete this study. It further discussed the Theory of Planned Behaviour as the framework that was chosen for this study. This section discusses aspects of research methodology, including research philosophy, research approach, research strategy, data collection methods, as well as aspects of data analysis adopted in this study.

There are many reasons that can motivate a person to embark on a research. For every research study the researcher should address several major questions such as how to research, what to research, and the main one, why research? There are many valid reasons why a researcher gets involved in research, but whatever the reason the researcher has to choose a methodology to be followed during the research (Holden, Lynch, 2004). In this study, the researcher was faced with two main worries: the first one was that a lot of people are dying due to road traffic crashes, and the second one was that there are many projects that are being implemented to try and reduce these crashes, but how effective are they? With the researcher coming from an information systems background, it was important to look at what ICT is doing to contribute to the reduction of road fatalities. The researcher also wanted to evaluate the effectiveness of the NDS as it is the current initiative in road safety.

Researchers such as (Babbie, 2005, Kumar, Phrommathed, 2005) define research as a systematic, neutral and unprejudiced process of discovering answers to an enquiry which is undertaken within a framework of a set of philosophies or approaches. The process comprises creative work on a systematic basis, which follows particular procedures, methods and techniques that have been tested for their validity and reliability by other researchers, with the aim to establish novel facts, and gather and analyse information making use of scientific methods in order to enhance our understanding of the facts and add new knowledge to the body of knowledge (Leedy, Ormrod, 2005).

A research methodology, on the other hand, can be referred to as science of studying how research is carried out, and a process or technique used to collect and analyse data to create knowledge (Petty, Thomson & Stew, 2012). Welman *et al.* (2005) agree and they define research methodology as an organised system of practice that is made up of sequences, actions and structures that are utilised to manage and execute a research process. The objective of a research methodology should be to explain in a systematic way how the research process was conducted (Williams, 2011). Researchers, such as Bruce Lindsay, recommend that the research methodology includes enough evidence that can convince a peer to repeat the study following that particular methodology and arrive at similar results (Lindsay, 1995). This chapter thus presents the adopted research methodology concepts, starting in the next section with the research philosophy that was followed.

4.2 Research Philosophy

A research philosophy can be defined as an understanding of the way in which data about a phenomenon should be collected analysed and reported on (Holden, Lynch, 2004). One of the things that makes research difficult to conduct is the confusion in classification of research philosophies, such as doxology, ontology, epistemology, etc. (Mkansi, Acheampong, 2012). Creswell (2009) uses the term ‘worldviews’ instead of ‘philosophy’; worldviews are a general orientation about the world and about the nature of the research that a researcher is conducting. Worldview, in short, can be said to be a set of fundamental beliefs about certain aspects about reality that influence how a person views, thinks, and knows the particulars of reality (Klapwijk, 1989).

Some researchers suggest that there is no difference between worldview and philosophy, as they all share the same paradigms and, therefore, worldview is simply reduced to scientific philosophy (Wolters, Marshall, Griffioen et al., 1989, Klapwijk, 1989). However, it is beyond the scope of this study to discuss the terms in detail. The paradigms are divided into four categories (Creswell, 2009): post-positivism, social constructivism, encouragement and/or participatory, and pragmatism. A pragmatic research philosophy was applied in this research based on the research problem and the objectives; the study focused on how drivers behave in certain situations and this could only be determined by examined data that focused on drivers during their natural driving state. It also makes it simple for different methods, worldviews,

propositions, and different data collection and analysis methods to be used (Creswell, Klassen, Plano Clark et al., 2011).

4.3 Research Approach and Strategy

To achieve the objectives of this study, use was made of a mix of two research approaches: qualitative and quantitative approaches. A combination of both approaches is in line with other researchers' approaches (Creswell, 2013, Tashakkori, Teddlie, 2010, Johnson, Onwuegbuzie, 2004). Quantitative research focuses more on facts and causes of behaviour, and the results are presented in a statistical format (Kothari, 2004). In quantitative research, the emphasis is on the measurement and analysis of relationships between variables (Leedy, Ormrod, 2005, Kothari, 2004). For this study, the main strategy was a qualitative research approach which was applied in a content analysis process.

A qualitative approach, also known as naturalistic evaluation approach, focuses attention on research methods that describe and evaluate the effectiveness or performance of programmes in their natural environment (Mouton, 2011). The qualitative method was applied within a case study design strategy. According to Yin (2013), a case study refers to an empirical investigation of an existing event in an environment; and case studies can be single case or multiple case. For this study, a single case was used for an in-depth understanding of the effectiveness of NDS and its success in improving driver behaviour.

4.3.1 Sampling method

The fundamental idea behind sampling is that by choosing some of the elements in a population, conclusions may be drawn about the entire population (Cooper & Schindler, 2006). Sampling is the statistical process of selecting a representative part of a population for the purpose of studying the sample (Yin, 2013, Patton, 2005). Other researchers believe that for qualitative studies, the sample is generally smaller as the sampling follows a saturation method (Glaser, Strauss, 2009, Ritchie, Lewis & Elam, 2003). In other words, when adding more participants to a study who no longer add value or yield different results, the sample has saturated.

For this study, purposive sampling was applied. This involves the selection of research attributes to be studied on the basis of the researcher's own judgment about which ones will be

the most useful or representative (Babbie, 2005). The organisation that participated in the study was a convenient selection, as the organisation had already implemented NDS. It also was based in the province of residence of the researcher and was willing to offer its data and participate in the study. The criteria for questionnaire was based on those drivers that have been driving an NDS installed vehicle and those officials that deal with data that is drawn from NDS technology; to be specific, this study used data collected by DriveCam technology. Thus the study includes MIS specialists that work on DriveCam as Data Analysts, and also drivers.

Qualitative research can be time consuming, and working with a large data set is often impractical (Mason, 2010). For the qualitative data, as the population of NDS installed vehicles was unknown and believed to be only a fraction, a total of 100 vehicles were envisaged for the NDS data to be collected from, but 137 vehicles participated - which also meant that data from 137 drivers were analysed. For the quantitative data, only 15 participants were selected to be issued with questionnaires, but 19 questionnaires were returned - 16 from drivers and 3 from MIS specialists. After analysing about 2 533 thesis papers, the study concluded that for content analysis a minimum of 15 participants was a trend and for naturalistic enquiry a maximum of 26 participants was found to be the trend; the saturation process was also applied in the studies (Mason, 2010, Glaser, Strauss, 2009). Therefore, the sample was deemed to be more than sufficient for this study as it was in line with other research studies.

4.3.2 Data collection

This study used a multiple method which included questionnaires, informal interviews and content analysis as primary data collection instruments.

4.3.2.1 Content analysis and naturalistic enquiry

Content analysis is regarded as the longest well established method of examining text. It can be defined as the study of documented human communications (Kohlbacher, 2006, Babbie, Mouton, 2001). These texts could include books, art, images, sounds, symbols, numerical records, etc. (Churchill, Walter, 2013). Content analysis dates back to the 18th Century with three distinct approaches (summative, conventional and directed) used to interpret replicable and valid interpretations from data to the context; this makes it belong to naturalistic enquiry (Elo, Kyngäs, 2008, Hsieh, Shannon, 2005).

The study applied content analysis where data captured during the NDS was analysed to determine driver behaviour. Content such as text, and predictive analysis spreadsheets that were automatically generated by the DriveCam system and the processes of how the DriveCam system works was explained in Chapter 2. The system has a built in predictive analysis tool that interprets video images, matching this with incident triggers that record relevant data every time a pre-defined incident occurs.

4.3.2.2 Structured questionnaires

Questionnaires are a method for producing, recording and assembling information relevant to the area of interest (Leedy and Ormord, 2001). They are made up of items that include a set of pre-defined questions, where the user completes the sections by providing answers or feelings to it (Kumar, 2005). The study made use of a structured questionnaire as it helped the study to elicit the opinions of NDS users as well as those of the drivers participating in the study. This is in line with other studies (Dalal, Khodyakov, Srinivasan et al., 2011, Garmer, Ylven & Karlsson, 2004). The questionnaire was designed with three sections: Section One required demographic information - this was done to satisfy the researchers' curiosity with regards to the type of drivers participating in the study. Section Two was aimed at drivers to elicit their opinions regarding NDS. The last section, Section Three, was aimed at management or staff members in charge of coordinating NDS programmes so as to gather information about the technical and management issues regarding the NDS.

The aim of Section Two was to collect information about drivers' opinions in connection with NDS research and Section Three was aimed at collecting information from management about the performance of the NDS in their organisation. The researcher distributed 50 questionnaires to a company that is a member of the Road Transport Management System (RTMS). As already mentioned, RTMS as an industry led self-regulatory initiatives that encourage heavy vehicle operators to take ownership of road safety programmes that promote the use of driver monitoring technology to collect data about driving behaviour, with the aim of implementing interventions to improve safe driving.

From the 50 questionnaires, only 19 were returned without errors; this was sufficient as the study aimed for 15 minimum questionnaires. From the 19 returned questionnaires, 16 were from the drivers and 3 from the MIS coordinators; the results thereof are reported in the next

chapter. The study used evidence-based patterns amongst larger samples to support the content analysis data. The structured questionnaire made use of a structure where participants responded to prompts (Likert scales) by selecting from pre-determined answers designed as per the theoretical foundations of this study. The questionnaires were hand delivered and were collected from the participants by the researcher, with the assistance of the management of the companies evaluated.

4.3.2.3 Unstructured (Informal) interviews

Unstructured interviews are part of qualitative interviews, used as a data gathering tool in qualitative research. They should be viewed as more than just a data gathering tool, but as a way to assist the research to see the world and learn from it (Rubin, Rubin, 2011, Myers, Newman, 2007). In this research, informal interviews were conducted with the specialists responsible for the MIS behind the NDS technology to gather information about how the system is used, what it is used for and the performance thereof.

4.3.3 Data analysis

Data analysis allows the researcher to organise and bring meaning to a large amount of data (Creswell, 2009). The main analysis for this study is Content Analysis of the NDS data. To analyse content data, the researcher has to break down the text into units, categorising and giving headings to similar interpretations to develop a coding scheme (Holloway, Wheeler, 2013, Downe-Wamboldt, 1992, Weber, 1990). For this study, the aim was to analyse images, videos, and audios by coding the content into a list of concepts as illustrated in Table 5.5: DriveCam Trigger Attributes). The concepts were transcribed as coded in the DriveCam technology, as this technology included a predictive analysis tool that analyses the video images and text files and then produce a spreadsheet with all the concepts already included as triggers. The process that the DriveCam technology follows is illustrated in Figure 2.7 and explained as follows (please see Table 2.2 for concepts descriptions):

- **Step 1** – the system captures a risky driving behaviour; this behaviour is pre-defined and therefore could be anything that the management deems risky, from sudden breaking to driving and eating, etc.
- **Step 2** – the triggered event is stored in a storage device located inside the vehicle and at the same time sent over wireless technology from the vehicle to a web-server.

- **Step 3** – when the data is stored in a web-server, predictive analysis is conducted using pre-defined queries and to improve productivity, a team of specialised data analytics also conduct manual reviews, analysis and scoring of events. Scoring of events refers to each event being given a severity or seriousness score, which later is collected as favourable or unfavourable points allocated to each driver.
- **Step 4** – the management of each participating organisation gets access to a confidential website for events, dashboards and reports.
- **Step 5** – the participating organisation is then expected to conduct driver training and coaching to improve the driving of those drivers allocated with unfavourable scores.
- **Step 6** – the drivers are expected to return to driving with new knowledge and skills on how to practise safe driving.

The researcher only had to analyse the data in the spreadsheet to produce information that assisted the study to reach conclusions. In addition, the content analysis was applied on the collected data in line with the TPB theory as well as the reports produced by the management from historical data that was not included for direct analysis. Microsoft Excel was used to analyse the data, by coding the concepts and categories rating information into a spreadsheet. By assigning a column in a table to each concept considered and on each row assigning a case or rating, it was possible to store content data into a spreadsheet for further analysis. Microsoft excel can handle multiple attributes and allows for various dashboards or display techniques for qualitative data (Bazeley, 2013, Meyer, Avery, 2009).

4.4 Research Ethics

Research ethics aim to fulfil two objectives, namely: to tell researchers how they should act in a given situation of their study and to explain and give reasons why they should act in that way (Schüklenk, 2005). Ethics also assist in protecting individuals, the environment and communities by offering reasons that can potentially increase the benefits of doing good in the world (Israel, Hay, 2006). Researchers are involved in the process of recording and retaining participant's artefacts, conducting the study in a particular environment and sharing the results of the study; all this processes have ethical issues that should be outlined and the researcher should complete a research ethics form for the research ethics committee (Ludin, 2011,

Guillemin, Gillam, 2004). For this research study, please see Appendix C: Information Leaflet and Informed Consent for relevant ethics documentation.

This research study involved observing human behaviour in a naturalistic setting. Naturalistic studies are normally very experimental in nature and thus ethical consideration is very critical. However, the researcher was not observing the participants directly nor was he responsible for installing the devices that were used to observe the participants, but rather made use of the data that was already collected by devices. However, because the study involved personal information, the researcher had to obtain informed consent from the employers of the participants as well as the participants themselves. (Please see Appendix C: Information Leaflet and Informed Consent for more detailed information and signatures.)

4.5 Chapter Summary

This chapter discussed the research methodology followed to achieve the objectives of this research study. Both qualitative and quantitative data collection tools were applied, with qualitative data analysis processes. A pragmatic research philosophy was applied in this research. Based on the research problem and the objectives, the study focused on how drivers behave in certain situations, and this could only be determined by examined data that focused on drivers during their natural driving state.

This chapter also gave an overview of the research strategy, sampling methods and data analysis. As the study involved human participants, relevant ethics documentation and processes were followed, noting that naturalistic studies are very experimental in nature and the protection of human participants is of importance. Documentation for the ethics process is found in Appendix B. In the next chapter the results of this study are presented.

CHAPTER 5

5. RESEARCH FINDINGS AND RESULTS

5.1 Introduction

The previous chapter discussed the research methodology and design, the sampling methods used to select the participants and the data collection instruments used to collect both the quantitative and the qualitative research data. The use of these research methodologies was in line with the Theory of Planned Behaviour as the theory underpinning the study, as presented in Chapter Three. The purpose of this chapter is to present the analysis and interpretation of data collected and it is presented as per data collection instruments used.

5.2 Overview of the Participating Company

The company that agreed to participate in this study is a major operator in the auto logistics field and is operating in South Africa and the Southern African Development Community (SADC) region. The company has a fleet of more than 200 heavy vehicles, this includes both truck tractors and trailers, specialising in the car carrying market. This company has employed more than 300 drivers as recorded on the DriveCam data. DriveCam is a technology that the company has implemented to assist them with monitoring their drivers, as well as initiating training to drivers for improving their driving skills (see Chapter Two).

5.3 Results from the Questionnaires

From the total of 19 questionnaires returned, three were completed by management and NDS coordinators and 16 were from the drivers of the participating organisation. The participating organisation has implemented the NDS for more than 5 years, as shown in Question 15 of the questionnaire. The questionnaire was divided into three sections, with Section 1 and Section 2 focusing on drivers and Section 3 focusing on management and coordinators of the NDS technology, referred to in some chapters as MIS specialists. The results will be presented per section, starting with Section 1.

5.3.1 Section 1: Demographic information

This section consisted of several demographic questions, and the questions were for descriptive purposes and were included to provide the study with an indication of the types of drivers who participated in the study. The demographic results indicate that the drivers who participated in this study are all males and older than 30 years of age, as shown in Figure 5.1.

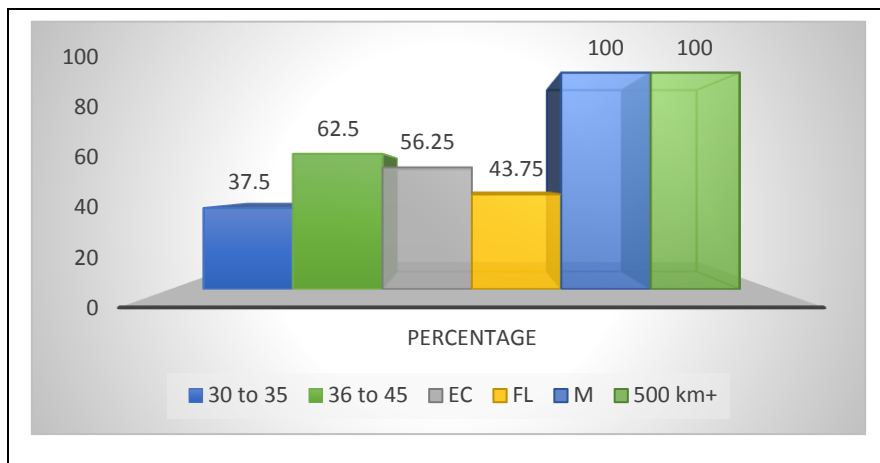


Figure 5.1: Driver's demographic information

It is evident that the participating drivers are between the ages of 30 and 45, with 56.25% holding EC driving licenses and 43.75% holding foreign licenses.

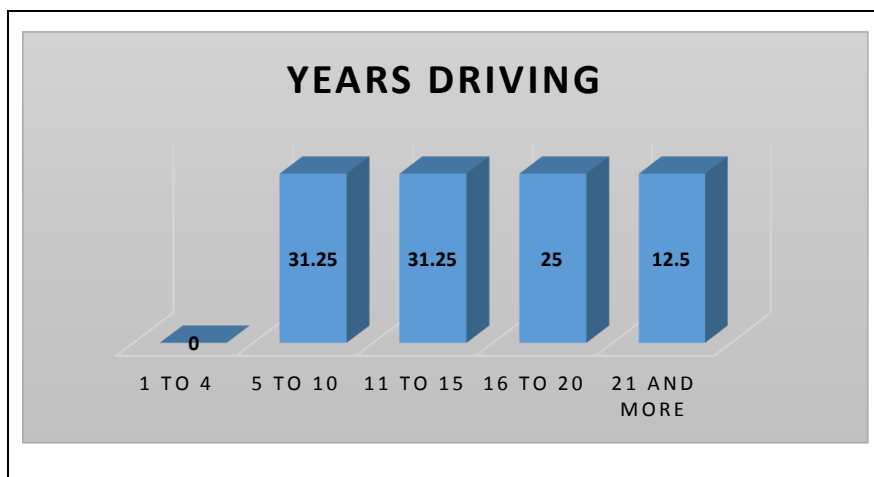


Figure 5.2: Number of years of driving

The majority of the drivers, about 68.75%, are well experienced drivers with more than 10 years driving experience, with just about 31.25% with 10 years or less of experience (see Figure 5.1 and 5.2), and all of them drive more than 500 kilometres a week as per Figure 5.1. The

experience of the drivers is evident in their response to Question 12 of Section 2, where more than 96% of the drivers rated themselves very good in terms of safe driving practices.

5.3.2 Section 2: Drivers opinion of Naturalistic Driving Studies

This section deals with how drivers feel about NDS and the idea of being monitored as well as their opinion about how other people feel about them being monitored. The results in this section are very important for the study as they address some of the research objectives and questions. This section focuses on driver’s opinions and feelings about the NDS that is monitoring them, in terms of what they think it is used for. A graphical indication of the results is shown in Figure 5.3 and 5.4. The description of the naming codes used in the graphical representation are explained in Table 5.1:

Graphical Code	Description	Results in %
Fir-Mach	To gather information so your boss can fire you, if you don’t drive safe (Firing Mechanism)	63.75
D-Imp	To monitor you so the information collected can help improve your driving ability (Driver Improvement)	83.75
Trip-Mon	To monitor you so you don’t go where you are not supposed to go (Trip Monitoring)	50
Traffic-Jam	To monitor where you are so it can advise you about traffic jams or traffic congestions (Traffic Jams)	47.5
Crime-Prev	To monitor the vehicle so it can assist if the vehicle is hijacked or transported goods are stolen (Crime Prevention)	77.5

Table 5.1: Results of driver’s opinions about the use of NDS in their organisation

The results show that most of the drivers (more than 63%) think that they are being monitored so that management can take corrective steps if they do not drive safely, such as being reprimanded or fired. But the good thing is that about 83% of the drivers are happy that they are being monitored, as they think the monitoring can assist them in improving their driving behaviour. About 50% of the drivers are of the opinion the monitoring has to do with management wanting to police them and make sure they don’t go to places they are not supposed to go, and only about 47.5% agree that the systems also assist them in avoiding traffic jams or traffic congestion (see Figure 5.3 for the graphical representation).

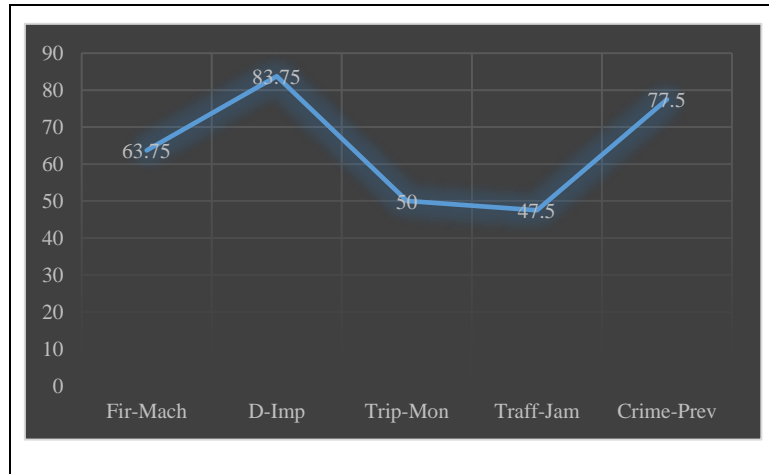


Figure 5.3: Results about what NDS is used for

Another important response was in relation to crime prevention; the objective as stated by management is that they would like to be able to warn their drivers about crime related issues such as high jacking, and 77.5% of drivers agree that the system is assisting in that matter. Figure 5.4 below shows that the confidence of the drivers in terms of their ability to always follow all road rules and maintain safe driving practices is impressive, at 96.25%.

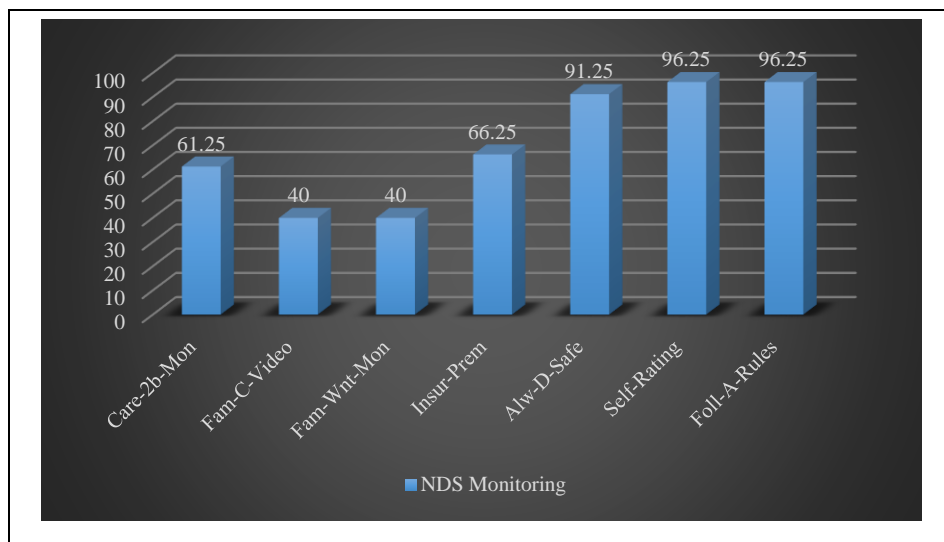


Figure 5.4: Results from perception about NDS monitoring

In Section 2 of the questionnaire some of the questions focused on the drivers' opinion in relation to the subject of being monitored. This was to determine a very major concern in NDS research, as other researchers are worried that the participants are not happy with being monitored (de Croon, Kuijer, Broersen et al., 2004). Table 4.2 shows how the drivers of the participating organisation responded to these questions.

Graphical Code	Description	Results in %
Care-2b-Mon	Do you care if you are being monitored or not?	61.25
Fam-C-Video	Do you care if your significant others, see your driver behaviour video?	40
Fam-Wnt-Mon	Do your family members think you should be monitored?	40
Insur-Prem	Is your insurance company asking you to be monitored for insurance premium calculations?	66.25
Alw-D-Safe	Do you always drive safely and follow road rules?	91.25
Self-Rating	How do you rate yourself in terms of safe driving practices?	96.25
Foll-A-Rules	Do you always follow all road traffic rules in a normal driving day?	96.25

Table 4.2: Results of drivers' opinions about the use of NDS monitoring

The table shows the percentages of how drivers rated these questions, the list below is the results thereof. The results show that 40% of the drivers did not worry about family members or significant others watching a video of them driving and this could be because most of the drivers are very confident with their driving skills as about 96% rated themselves as good drivers who practice safe driving on a daily basis. Even with drivers rating themselves very high in terms of good driving practices, it is of concern that about 61% were concerned with the fact that they are being monitored.

The results in this section show that drivers have mixed feelings and/or opinions about the NDS technology. In Table 5.2 drivers are very happy with being monitored, as they indicated that it improves their driving ability and also good for security purposes, such as in high jacking situations. But Table 5.1 is also showing concern about being monitored. Something to note as well is the fact that more than 66% are happy with being monitored because it assists with insurance premium calculations. But in terms of addressing some of the research objectives, the following paragraph shows how the results achieved this.

5.3.2.1 Research objectives addressed by Section 2 of the questionnaire

The research objective that is addressed by this section is **Objective 4: To determine the driver's perceptions and experience about NDS and its role in improving road safety.** This objective was met but responses illustrated in Table 5.1 and Table 5.2 show the drivers' perception that the system is offering them an opportunity to learn more about their driving behaviour and also giving them the chance to improve when it comes to safe driving behaviour.

They also noted that the system is assisting them in terms of risky situations, such as high jacking and cargo theft. Despite these benefits, about 63% are also worried that the data could be used to reprimand or fire them, if they don't comply with the set driving safety standards (see Table 5.1).

5.3.2.2 Research questions addressed by Section 2 of the questionnaire

Research Question 1 and Question 4 are addressed by this section as well.

1 – What is the effect of NDS on driver behaviour in terms of safe driving practices?

More than 96% of the drivers rated themselves as very good drivers, and this could be interpreted as a positive outcome. The positive attitude is also visible in drivers agreeing that the system has improved their driving behaviour; about 84% noted that it can be used to improve their driving ability (see Table 5.1).

2 – What are the drivers' perceptions and experience about NDS and its role in improving road safety? The answer to this question is the same as the one discussed above, where the overall perception is positive, with just a slight worry about the perception that the information is being used to reprimand drivers.

5.3.3 Summary of Section 1 and Section 2 of the questionnaire

Section 1 and 2 of the questionnaire focused on the demographic information and driver opinions about NDS use and monitoring objectives. All the drivers who responded were male drivers between the ages of 30-45, who are holding either a driver license, EC or foreign licences, with five years of driving experience (the majority having more than 10 years' experience). All the drivers do more than 500km of driving per week; in road safety terms, these drivers are spending a lot of time on the road and their safe driving ability is of importance.

On the drivers' opinions and perceptions, it is encouraging to note that most of the drivers are happy to be monitored and they think it improves their driver safety skills. The fact that the NDS technology can also be used for crime related issues such as issuing warning during high jacking or theft was a positive motivator to the drivers and shows them that the management cares about their safety as well.

5.3.4 Section 3: Answers from NDS management and co-ordinators

Question 19 required the officials (NDS management and coordinators) to give a summary of the major objectives of the NDS programme in their organisations. Figure 5.5 shows an abstract from one of the responses and more information is provided in Appendix B. The following is a collective overview of their answers:

- To successfully identify risky driver behaviour.
- To reduce risky driver behaviour, through driver training and coaching.
- To maintain a high level of road safety awareness.
- To reduce risk exposure to drivers, including high jacking and road accidents.
- Use the NDS programme as a tool for continuous improvement of driver behaviour on the road.
- To utilize the data for root cause analysis for accident investigations, high jacking situations and continuous improvement to minimise risks.

19. In summary what are the major objectives for implementing NDS programme in your organisation.

1. TO UTILIZE PROGRAM TO :

a. SUCCESSFULLY IDENTIFY RISKY DRIVER BEHAVIOURS .

b. REDUCE RISKY BEHAVIOR

c. USE AS A TRAINING TOOL TO CHANGE ATTITUDE of INCORRECT BEHAVIOR

d. MAINTAINS HIGH LEVEL OF AWARENESS.

e. REDUCE RISK EXPOSURE .

Figure 5.5: Abstraction from questionnaire

Based on these objectives, **Question 14**, which was the first question asked to the NDS management and co-ordinators to answer, required them to state if the objectives set by the organisation in relation to the NDS programme were achieved. All the officials said yes, indicating that the management is in agreement that the objectives set when the programme was initiated were achieved to the satisfaction of the organisation, as shown in Figure 5.6. The

NDS programme has been running for more than 5 years as indicated by responses to Question 15.



Figure 5.6: Response to Section 3 of the questionnaire

Question 16 asked the NDS management and coordinators to rate the programme's performance since its implementation, by giving it a score from 1 to 5, with 1 being not successful and 5 being very successful. The results show that 80% of the managers indicated that the programme was very successful.

Question 17 asked the management if they communicate to the drivers about safe driving behaviour at all times, based on the results of each driver's allocated score. About 93.3% indicated that they do communicate to the drivers, and this is also evident in the driver coaching programmes that the organisation has implemented.

In **Question 18** management were asked if they offer any incentives to the drivers for practising safe driving behaviour. Again on scale of 1 to 5, the management were to indicate what most describes their action, and only 33.3% was allocated to this question - which shows that the this organisation does not have incentive schemes to encourage safe driving.

5.3.4.1 Research objectives addressed by Section 3 of the questionnaire

The research objective that is addressed by this section is the third objective, which is to determine if the set objectives of the companies that have installed the NDS technology were

achieved. This objective was met by the responses received from the questionnaires, as 100% of the officials indicated that the objectives were met, see Figure 5.6.

5.3.4.2 Research questions addressed by section 3 of the questionnaire

Question 2 was addressed by Section 3 of the questionnaire. The question asked was: *What are the important factors that determine the success of the NDS to companies that have installed NDS to monitor driver behaviour?* This question was addressed by the responses to **Question 19**, which are listed and explained in detail at the beginning of this section. In summary, the management indicated that the factors included their ability to identify risky driver behaviour, the potential to implement training and coaching programmes to encourage safe driving and the ability of the system to offer security warnings regarding high jacking or theft of goods.

5.3.4.3 Summary of Section 3 of the questionnaire

Section 3 of the questionnaire focused on the NDS management and coordinators. It is evident that all the management officials agree that the NDS was implemented more than five years ago and since then they have seen the success of the system in terms of the set objectives. Management has also shown strong willingness to give feedback to the drivers in terms of driver training and coaching, so they can improve their driving behaviour. The results also indicated that incentives for good driving behaviour is not a strategy that the management uses.

5.3.5 Analysis of the questionnaires in relation to the TPB framework

The questionnaires had three sections, with Section 1 and 2 addressing the demographics, the opinions about NDS use and the perceptions about the NDS monitoring practices. Section 3 talked to the management and coordinators to address issues of the objectives of the technology as well as the performance indicators, in terms of what the management intended to achieve with the NDS technology. A short summary was discussed when each section's results were reported; in this section the researcher will address the results of the sections in relation to the research framework that was used in this research. The Theory of Planned Behaviour (TPB) was preferred for this study. The questionnaire addressed the constructs of the TPB as discussed below.

To get to the TPB analysis, all the attributes of the questionnaire were arranged to address a specific TPB construct, and the combination of the responses grouped by constructs and percentage score calculated; average score was determined using the following equation:

- $TPB\ Constructs = (D\ Ave. + O\ Ave.)/2$
- $D\ Ave. = \text{Average percentage of all Driver Attributes from the results}$
- $O\ Ave. = \text{Average percentage of all Officials Attributes from the results}$

A summary of the percentage results is given in Table 5.3 and Table 5.4, and the results are an indication of the following in terms of the TPB attributes:

5.3.5.1 Results of attitudes towards the behaviour

This construct, as explained in detail in Chapter Three, looks at the individual's overall assessment of a particular behaviour, looking at the consequences or benefits of a particular behaviour. Five attributes were found to address this construct, namely: care to be monitored (Care-2b-Mon); firing mechanism (Fir-Mach); driver improvement (D-Imp) and crime prevention (Crime-Prev). These attributes can either offer an incentive or bare a negative consequence. Drivers might develop a favourable attitude if they know the system might help prevent criminal acts towards them or develop a negative attitude if being monitored means they could be fired if they do not adhere to the rules. The results in Table 5.3 show a slight positive indicator of just 52.5% after making use of the equation. This means that the overall attitude was favourable.

5.3.5.2 Results of subjective norms

This construct deals with own evaluation of social pressure to perform the expected behaviour. This is influenced by beliefs about how other people who may be of importance would like them to behave. For this study, the research wanted to find out if people of importance such as management, clients, family members, etc. have participated in the development of the driver's normative beliefs. Four attributes were identified to address this construct, namely: firing mechanism (Fir-Mach); family influence if they see the video (Fam-C-Video); crime prevention (Crime-Prev) and family members encouraging the driver to be monitored (Fam-Wnt-Mon). These attributes are mostly influenced through communication from either family

members or management. The results show that the subjective norms play an important part in influencing the intention of the drivers to perform a behaviour, with a score of 74.3%.

TPB-Constructs	Attributes from study		Results		
	Drivers (D)	Officials (O)	D Ave.	O Ave.	Final
Attitude towards the behaviour	<ul style="list-style-type: none"> • Care-2b-Mon • Fir-Mach • D-Imp • Crime-Prev 	<ul style="list-style-type: none"> • Incentives 	71.7	33.3	52.5%
Subjective Norms	<ul style="list-style-type: none"> • Fir-Mach • Fam-C-Video • Crime-Prev • Fam-Wnt-Mon 	<ul style="list-style-type: none"> • Communication 	55.3	93.3	74.3%
Perceived control	<ul style="list-style-type: none"> • Self-Rating • Foll-A-Rules • Alw-D-Safe • Trip-Mon • Traff-Jam 	<ul style="list-style-type: none"> • Success 	66.3	80	73.15%

Table 5.3: TPB results analysis table

5.3.5.3 Results of perceived behavioural control

With drivers rating themselves very high in Section 2 of the questionnaire in terms of confidence in driving ability, one would have expected these attributes to contribute higher than all the other constructs when it comes to influencing intention to perform a behaviour. With a score rating of about 73%, this places them in second place. Perceived behavioural control is how the individual feels able to enact the behaviour, but with the other part being about a person's measure of control over the behaviour; this could explain the score rating being less. The results of this construct also have a clear indication that management with a rating of 93.3% can play an important role in improve or building the drivers' normative beliefs.

5.3.5.4 Conclusion analysis of the questionnaire analysis using TPB framework

The final results applying the equation $TPB\ Constructs = (D\ Ave. + O\ Ave.)/2$, making use of values from the analysis in Table 5.3, shows that attitudes towards behaviour contributed about

52.5 percentage points, subjective norms contributed 74.3 and perceived behavioural control 73.2.

Attitude towards behaviour	Subjective norms	Perceived control	Behavioural intention
52.5	74.3	73.15	66.65

Table 5.4: Behavioural intention percentage

By analysing various attributes and their chances of making the NDS a success or failure, the results showed that there is about 66.7% chance of the NDS being effective in improving driver behaviour. The results have taken all the attributes including negative ones, but the overall outcome is a positive one. This results only represent the questionnaire based on the opinion of both management and drivers. The results of the actual real life performance of the NDS are discussed in the following sections.

5.4 Results from the DriveCam Technology

5.4.1 Introduction

The main research question of the study is: **How effective is NDS in improving driver behaviour and adherence to road rules?** The DriveCam technology produces a lot of data in relation to driver behaviour. Most of the triggers in the system are programmed to deal with driving practices, such as eating while driving, talking to a colleague while driving and not focusing on the road way, etc. Most of these triggers are very good in collecting information useful for use during driver coaching and training. For the purpose of this study the analysis focused on issues that have to do with road rules and/or traffic violations. Table 5.5 gives a full description of the attributes used to measure driver performance.

Attribute	Points	Description
Distractions: Distractions are common while driving. A driver's attention may be divided between driving, navigating, talking to passengers and other activities. Distractions that cause an event to be activated or lead to a risky situation are scored as distraction.		
Cell phone	3	This is selected if the driver is using a handheld cell phone.
Food and Drink	3	This is selected if attention to food and drink put the driver in a risky situation.
Passenger (s)	3	This is selected if the driver dedicates too much attention to a passenger and it contributes to a risky driving situation.
Fundamentals: These categories involve the fundamentals of safe driving and go to the very root of most crashes.		
Failed to keep an Out	3	Space is the key to avoiding mistakes by other drivers. This behaviour is marked if a risky situation is clearly visible, yet the driver ignores it and positions the vehicle in a space that reduces outs available.
Too fast for Conditions	5	This will be triggered if the driver is driving at a speed that puts the vehicle in a tight spot or if the driver does not slow down for pedestrians looming around.
Unsafe lane change	5	This will be selected if the driver makes a lane change that leads to a risky situation.
Traffic Violations: these refer to traffic violations regulated by the relevant traffic authority and the driver is aware of them.		
Rolling stop	3	(<i>Yielding at a stop sign</i>) an instance when a vehicle driver slows down but does not stop at a stop sign.
Stop sign	5	Not stopping at a stop sign and/or not following stop sign rules.
Red light	5	Driving through a red light and/or flashing red light without following the rules.
Speeding	5	Not following set speed limit. Either roadway speed limit or type of vehicle set speed.
Designated roadway	3	Driving in a wrong lane, without any distractions on the correct lane.

Table 5.5: DriveCam Trigger Attributes

The accumulated points are used to rate each driver, as well as a group of drivers, e.g. drivers specialising in cross border transportation. In this study, two case studies from the same organisation were analysed. The first one focused on drivers that travel locally and the second one focused on drivers that go beyond the South African borders. The collected data had a total of number of 137 drivers: 82 from Cross Border Transportation and 55 from Local Distribution, with recorded driving behaviour for the year 2015. The study plan had aimed for a total of at least 100 drivers, so the collected data was more than adequate for the analysis to address the research objectives.

5.4.2 Local Distribution Driver’s Annual Monitoring

The technology managed to capture about **1 488** behaviours from the 55 local distribution drivers, and of this a total of **291** behaviour score was allocated to the group, giving it a risk identification of **12.16%**; this is based on all triggers. Table 5.6 shows seven violations that were triggered in terms of the attributes that the study focused on. Out of the seven violations, four were related to Traffic Violations, two related to Fundamentals and the last related to Destructions.

Cell phone	Failed to keep an out	Too fast for conditions	Red Light	Rolling stop	Speeding	Stop sign
1	16	1	15	7	115	7
Total: 162						

Table 5.6: Results from local distribution drivers

It is evident that speeding was found to be most problematic for drivers, followed by failing to keep an Out, the third one being failing to stop at a red robot. The violation order is in a sequence that can be interlinked, meaning if the driver is speeding, it will be difficult for the driver to stop the vehicle in time and therefore he will also fail to keep an Out as the vehicle will stop too close to the next vehicle. It is also not easy to stop at traffic lights, so skipping of red traffic lights will also be related to risky behaviour such as speeding. This raised the researcher’s curiosity on whether the drivers are practising risky driving, and Figure 5.7 shows the top 10 violators in terms of total score allocated by the DriveCam technology.

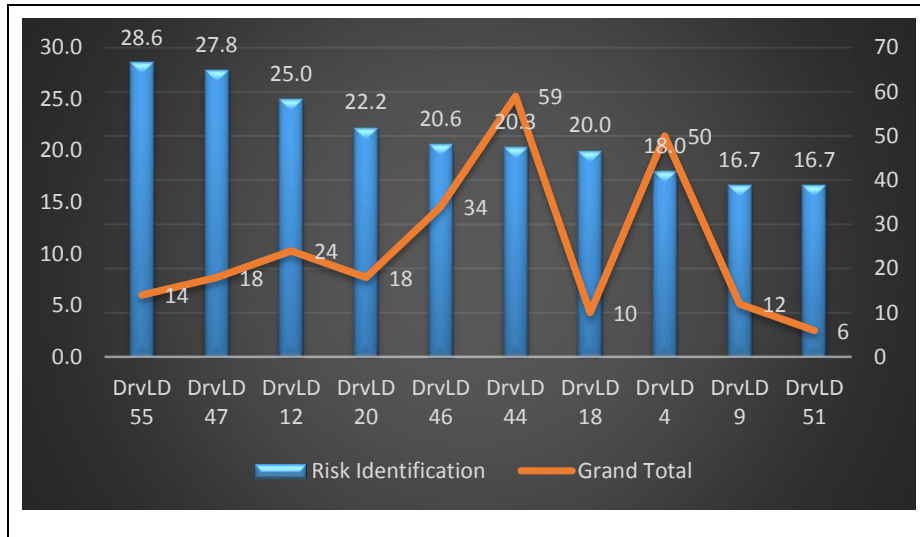


Figure 5.7: Top 10 violators (Risky Behaviour)

The illustration from the figure indicates that having more behaviour triggers does not necessarily mean one is a risky driver. DrvLD 55, has only 14 driver behaviour triggers, but is the riskiest driver identified for the year 2015 with 28.6% of risky behaviour as compared to DrvLD 44 who triggered the system 59 times, but has only about 20.3% of recorded risky behaviour.

5.4.3 Local Distribution Drivers' Monthly Monitoring

On monthly monitoring the study focused on two categories. The first one was the monitoring of driver's performance in terms of the number of points they collected on a monthly basis, and it only paid attention to the same drivers that made it to the top 10 on the annual analysis. Figure 5.8 showcases the results on both the graph and table.

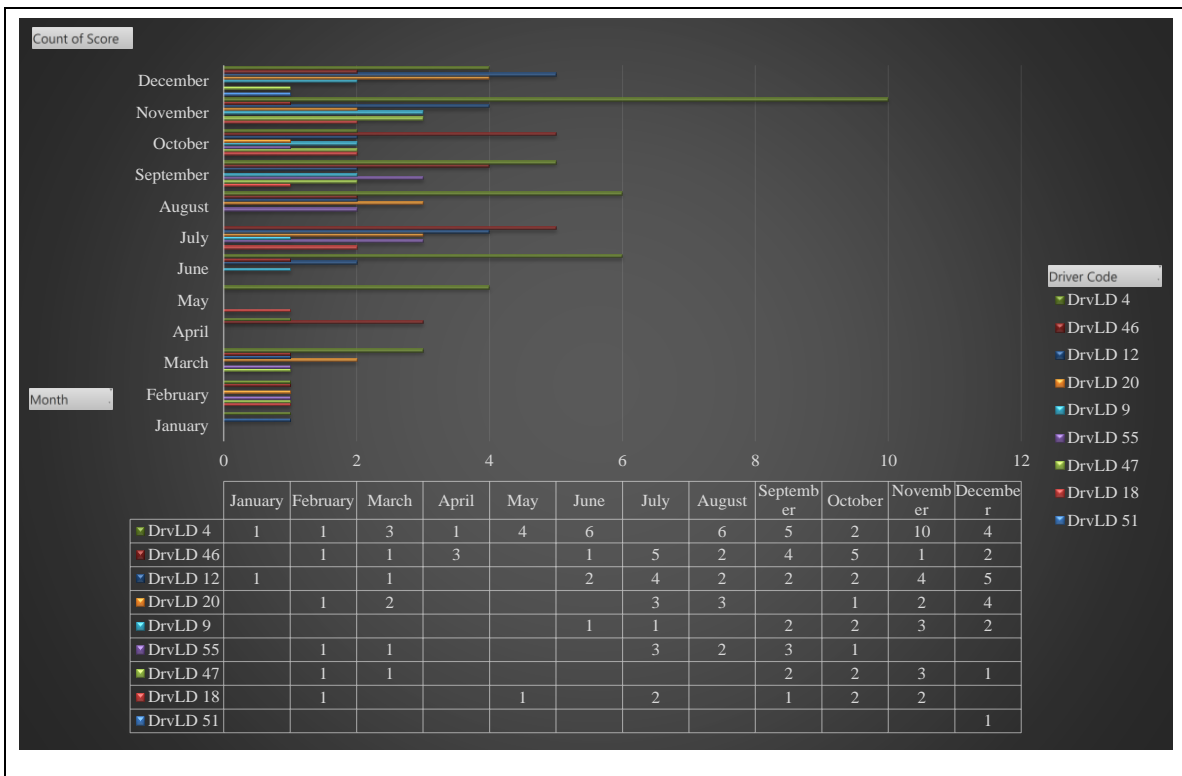


Figure 5.8: Monthly performance of LD drivers

When the scores are looked at on the basis of who collected most violations on a monthly basis, DrvLD 4 is the highest violator as he collected about 43 violations; also to note DrvLD 51 who was the least risky driver, he did not even appear on the violations. The type of violations that were triggered are shown in Figure 5.8. These results are an indication that if a driver keeps on violating road rules, the driver is likely going to be involved in a crash. The outcome field are shown in Figure 5.9. All events are assigned an outcome, these outcomes are based on 6 indicators:

1. No collision – this is a default indicator, which most events will be left at.
2. Near collision (0) – Unavoidable, this is used if the driver was involved in a near collision and this circumstance could not have been avoided.
3. Near collision (5) – Avoidable, this is selected if the driver was involved in a near collision and the circumstance could have been reasonably avoided through prudent safe driving activities.
4. Collision (0) – this is used if the analyst believes the vehicle has had an impact with another object that may have resulted in injury or property damage, or has possibility or resulting in a claim against the organisation. This event is scored manually by the analyst.

5. Possible collision (0) – this is selected if the analyst believes (but is not sure) that the vehicle was involved in an impact.
6. Positive recognition (0) – this is selected if the driver recognised a dangerous situation early and exercised exceptional safe driving practices.

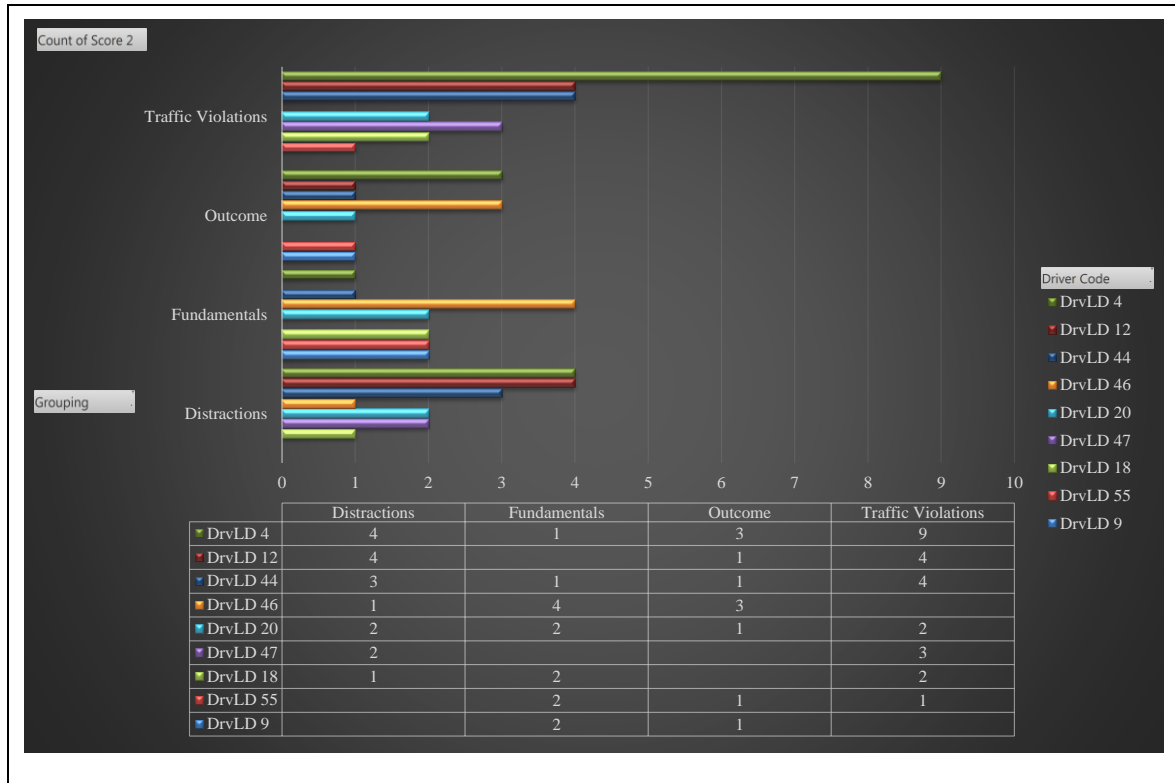


Figure 5.9: Violations by top 10 drivers

Out of the 6 indicators, only one earns the driver a point (points mean, risky driving) and with regards to the results it shows that DrvLD 4 has had more near collisions than most drivers and has also violated a number of traffic violations. DrvLD 55, who has been found to be the one with the most risky driver behaviour during the year 2015, has violated fundamentals and also earned a point for Outcome and this is consistent with the understanding that if you violate fundamentals you are bound to have a collision or near collision that could have been avoided, by for example not driving too fast.

5.4.4 Cross Border Drivers' Annual Monitoring

The technology managed to capture about **1 743** behaviours from the 82 cross border drivers, and of this a total of **164** behaviour score was allocated to the group, giving it a risk identification of **9.24%**; this is based on all triggers. Table 5.7 shows five violations that were

triggered in terms of the attributes that the study focused on. Out of the five violations, three were related to Traffic Violations, and Fundamentals and Destructions had one violation each.

Cell phone	Failed to keep an out	Red Light	Speeding	Stop sign
11	8	5	7	2
Total: 33				

Table 5.7: Results from Cross-Border drivers

It is surprising that cross border drivers, who are expected to do longer distances, seem to follow the speed regulations. The highest number of violations appear to be those of using a cell phone while driving, followed by failing to keep an Out, with speed being the third one. In terms of who the risky driver is, the driver with about 50% risky behaviour identified comes from this group, as shown in Figure 5.9, and further studies will be required in the future to research this field topic.



Figure 5.10: Top 10 violators (Risky Behaviour)

The illustration from the figure is not very different from that of local distribution drivers, in terms of the fact that having more triggers recorded does not necessarily mean the driver has a risky behavioural problem. The highest risky driver, DrvCB 16 with 50% risky behaviour indicator, only has about 2 triggers recorded for the year 2015 and DrvCB 70, with 81 triggers, has only 28.4% risky behaviour indicator recorded.

5.4.5 Cross Border Driver's Monthly Monitoring

The results from the cross border drivers also show a similar situation as that of local drivers; the fundamentals are still the most violated, and hence the outcome points are also higher.

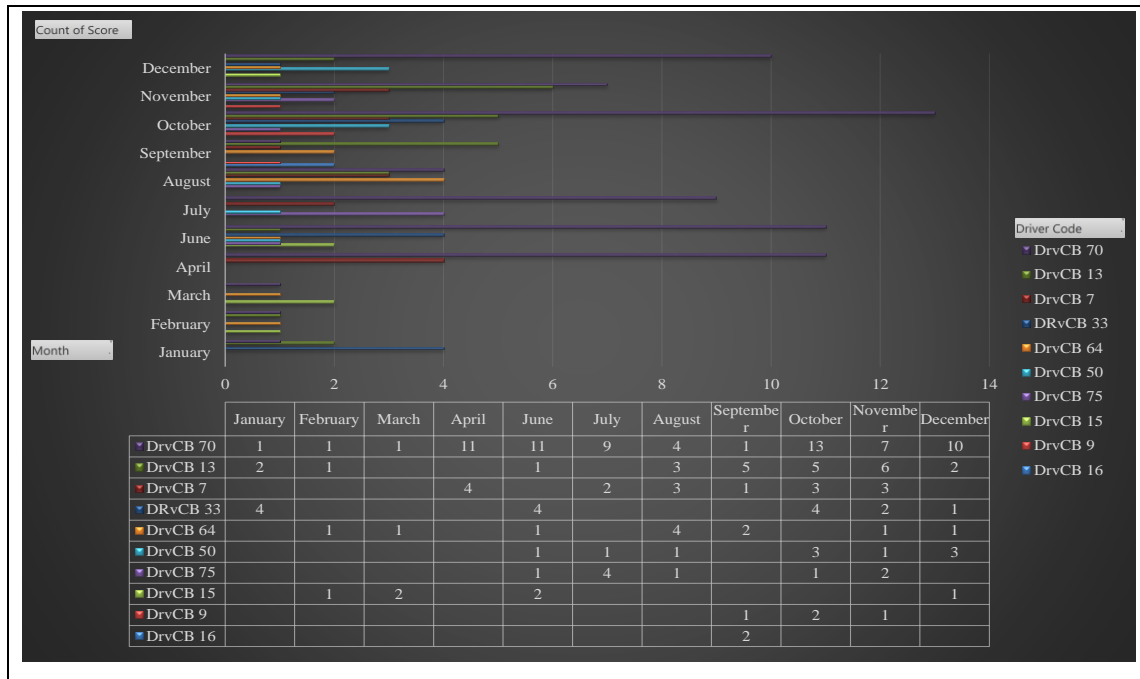


Figure 5.11: Monthly performance of CB drivers

DrvCB 16, who was found to be the top risky driver during the year 2015, was awarded one point for outcome, gained by committing two violations in September. DrvCB 70, who had the highest number of risky behaviour indicators - with 81 counted triggers - was violating all the attributes, see Figure 5.10 and Figure 5.11. DrvCB 70 committed a total of 69 violations, which occur almost on a monthly basis. This is the driver that management need to pay more attention to in terms of driver coaching and training. In terms of traffic violations, most cross border drivers are performing well, but management still needs to pay attention to these drivers as they might not get traffic fines and, therefore, it won't be easy to see an alert of risky driver behaviour.

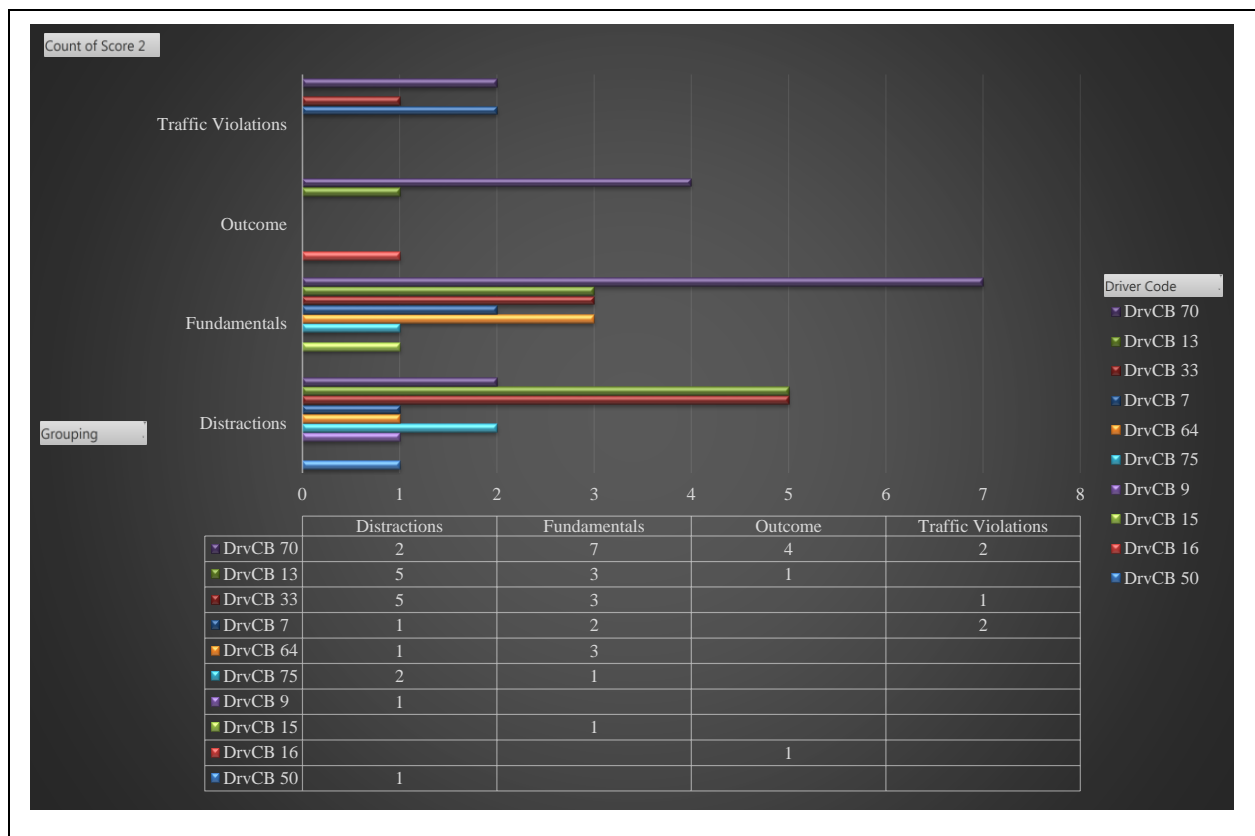


Figure 5.12: Violations by top 10 drivers

Most of them are committed violations in terms of fundamentals and this are directly linked to collisions or near collisions.

5.5 Analysis of Results from the DriveCam Using TPB

As already discussed, the TPB was developed as a model to measure how human actions are guided. It assumes that a person’s intention to perform a certain behaviour is determined by three motivational influences: attitude, subjective norms and perceived behavioural control; and in simple terms people engage in behaviours if the expected outcome of the behaviour is understood to be of benefit to the individual.

The NDS technology used by the DriveCam programme has a list of attributes that can be used to measure driver behaviour and/or performance. For the purpose of this study, only three were applied and analysed. The descriptions of these attributes are discussed in Table 5.5. These attributes can be directly linked to the constructs of the TPB as illustrated in Figure 5.12. The DriveCam system allocates points for every attribute that is triggered as an event by the system. These points count towards calculating if the driver has a risky driving behaviour or not.

This study had aimed to evaluate the effectiveness of the NDS in improving driver behaviour and adherence to road rules. To evaluate, this theory was used by inserting the focal attributes into the TPB constructs, which assisted in checking if the attributes can lead to a result that can help identify risky behaviour. Two examples will be used in this section to show how the TPB work with the NDS attributes.

DrvCB 70 had 2 violations for distractions, which is linked to subjective norms in the sense that cell phone use, eating while driving and focusing on passengers instead of roadway for example, are behaviours that can be influenced by pressure from people of importance or pressure from a need. For example, if the driver receives a cell phone call from the manager while he is driving, he might be pressured to answer the call.

DrvCB 70 also received 7 violations for fundamental attributes, and these are linked to perceived control, in a sense that the driver might drive too fast for conditions that a reasonable person might consider risky. But if the driver's self-confidence on his/her driving skills is too high, the driver might violate a fundamental attribute.

DrvCB 70 received 2 traffic violations, traffic violations are related to attitude towards a behaviour, in the sense that the consequences of violating the attributes could motivate or demotivate the driver. For example, if the driver is scared of receiving a traffic fine, the driver might be motivated to obey and not violate traffic rules.

Both DrvCB 70 and DrvLD 4, who were found to be top violators, had violated these attributes. DrvCB 70 got a total of 69 violations in the year 2015, and DrvLD 4 got a total of 43 violations; the total was motivated by 4 violations for Distractions, 1 for Fundamentals and 9 for Traffic Violations. In general, all the top 10 violators and top 10 drivers with risky behaviour have violated this attributes. Therefore, in conclusion, the TPB was able to analyse driver behaviour data, and provide results that can be used by management to coach or train drivers for an improvement in driving behaviour.

5.6 Quick comparison of results in relation to other NDS research

In comparison the other studies as discussed in the literature review, this study reached similar results as indicated in the paragraphs below, only those deemed relevant to this study are discussed:

- ***The 100 car NDS*** – the results of provided 82 crashes, 761 near crashes 8 295 incidents, whereas, this study provided more than 3 000 behaviour triggers with a total of 455 risky behaviour score from 219 drivers, with 137 drivers analysed in detail. The problems of technology failures such as those of near crashes incidents occurring when the system was initialising experienced during the 100 car NDS were not recorded for this study.
- ***FMT study*** – during this study the results showed that drivers were not in-favour of the technology as they would prefer to be trained on how to deal with fatigue than to be controlled by a technology. From this study the results show that drivers where in-favour of being informed by the technology of the dangers whilst driving, and the management also provided drivers with training on safety driving behaviour, which corrected the lack of training on the FMT study.
- ***IT and Lorry Driver study*** – the final results of the study indicated that the application of the on-board computer system affected the truck drivers negatively in terms of their job control and commitment to the organisation. From this study, drivers had conflicting feelings in terms of how the view the on board monitoring system. The results show that most of the drivers were concerned that the recordings could lead to them being reprimanded or fired, but on the same note they are happy to be monitored, as they think the monitoring can assist them in improving their driving behaviour and also keep them safe from criminal activities against them.

5.7 Chapter Summary

To conclude this study properly, it was necessary to analyse the data collected in order to answer the research questions as well as to address the objectives of the study. This chapter presented the analysis and interpretations of the research findings.

Data was collected from a company that specialises in logistics services, operating in the vehicle delivery market. The company's operations cover the SADC region, with the head

office in South Africa. The company has more than 5 years of experience making use of the NDS to monitor drivers. This study made use of three data collection methods including a questionnaire to address the opinions and feelings of both drivers and the management responsible for NDS. Informal interviews were also conducted to assist management with answering **Question 19**, the results of which were recorded in Section 3 of the questionnaire. The last one was content data collected by the DriveCam technology.

The results from the questionnaire showed that the drivers were all male of ages between 30 and 45, holding either an EC driving licence or a foreign driving licence. The majority of the drivers had more than 10 years of driving experience and have been driving more than 500km per week, which means that they spend a lot of time on the road. These drivers indicated that they are very confident with their driving ability and their self-rating score came at more than 96%. The drivers also indicated that they are concerned with the fact that they are being monitored, but the benefits of the system in providing knowledge that can improve their driving and its ability to report on crime-related activities against them were major motivating factors, and this makes them happy to be monitored.

The main worry of the drivers about being monitored was that they think the information collected from the NDS might be a way for managers to get them fired if they don't adhere to the rules. However, results from Section 3 of the questionnaire, which was aimed at eliciting responses from management, indicated that the fears of the drivers were not necessary. The management showed that they make use of the information from NDS to plan driver improvement interventions, such as driver training programmes. When correlating this with the responses to Question 6 of Section 2, the management seems to be correct as more than 83% responses from drivers indicate that they are aware that the information is collected so it can be used to help improve their driving ability.

Results of the TPB constructs making use of the equation $Constructs = (D Ave + O Ave)/2$ showed that the NDS has a rating of 66.7% in terms of its effectiveness to improve driver behaviour. The main research question for this study was: *How effective is NDS in improving driver behaviour and adherence to road rules?* The results from the questionnaires have indicated that the NDS is 66.7% effective when it comes to improving driver behaviour and adherence to road rules. More information on the 'how' part of the question was address by

results for the NDS technology (DriveCam), a summary of these results is given in the next paragraphs.

The DriveCam technology collected a lot of data, and for the purpose of achieving the objectives of this study, data was analysed from two types of drivers, namely those doing local trips and those doing cross border trips. From the analysed data, a total of 219 drivers were recorded, the technology captured more than 3 000 behaviour triggers and a total of 455 risky behaviour score was captured. Only three attributes triggered by the system were considered and grouped as follows: attributes relating to **driver distractions** (cell phone use, food and drink, passengers); attributes relating to **fundamentals** (failed to keep an Out, too fast for conditions, unsafe lane change); the third one was **traffic violations** (rolling stop, stop sign, red light, speeding, designated roadway). Based on the attributes, local drivers were found to have a 12.6% rating in terms of risky driving behaviour and cross border with 9.24%, indicating that local drivers violated more of the road rules and have more risky driving tendencies than the cross border drivers.

Allocating the attributes of the triggers and allocating them to a TPB construct allowed the researcher to identify risky behaviour, as well as to identify top violators. All the top violators were found to have violated mainly the traffic rules and driver distractions. The overall results provided a clear indication that from making use of the data from the technology it is possible to identify risky driver behaviour, which can inform management for the implementation of driver improvement projects.

In summary, the results were in favour of the NDS and showed that the technology is effective in improving driver behaviour; but care must be given to getting consent from drivers when implementing the technology. For NDS to be successful, communication between the management and the drivers is important and drivers must be informed about what the technology is used for and how the information will be shared and what it will be used for. The results of this also showed that most drivers are not concerned about how significant others think about their driving, this could be friends and family members. As a recommendation, the organisation can try and involve these significant others in the safe driving awareness campaigns. The results showed that driver distractions were also at the top of violations as well and, from literature, it is evident that distractions could also come from passengers - some

of the heavy vehicle drivers involved in the RTMS programme drive with their partners. More recommendations are discussed in Chapter 6.

CHAPTER 6

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The previous chapter discussed the results and findings of this study using the Theory of Planned Behaviour to analyse both the questionnaires and the DriveCam data as a framework.

This chapter concludes the report by providing a summary of the study findings, providing recommendations and suggesting future research. Research limitations and difficulties that were experienced during this study are also outlined in the chapter.

6.2 Summary of the Study

The study followed a qualitative research methodology and also applied a mix method for data collection, where questionnaires were used to collect data about driver and management opinions and feelings about the Naturalistic Driving Studies. The Theory of Planned Behaviour was found suitable for this study, because of its potential to address behaviour attributes that are relevant for the study.

The main objective of this study was to evaluate the effectiveness of NDS in improving driver behaviour and adherence to road rules, with the aim of recommending means that can improve the success and effective use of NDS in South Africa. Specific objectives included:

1. To establish the sequence of incidents recording by the NDS technology on vehicles that already have the in-vehicle device installed.
2. To compare the sequence of decision making of drivers for a period of time after the technology had been installed in the vehicles.
3. To determine if the intended objectives of the companies that have installed the technology were achieved.
4. To determine the driver's perceptions and experience of NDS and its role in improving road safety.

In order to achieve the objectives, the study had to make use of a mix method for data collection, with questionnaires being the main data collection tool for addressing Objective 3 and 4, and the analysis of the NDS data collected by making use of DriveCam technology to address the objectives 1 and 2.

From the questionnaire results it was determined that by analysing various attributes and their chances of making the NDS a success or failure, there is about 66.6% chance of the NDS being effective in improving driver behaviour. The results have taken into account all the attributes, including negative ones, but the overall outcome was a positive one. The DriveCam technology was able to capture a combination of 3 231 triggered attributes events and a 455 risky behaviour score.

In Chapter One, the research problem was identified, which then led to the development of the main research question, and sub-questions where developed to address the main question which is: **How effective is the Naturalistic Driving Study in improving driver behaviour and adherence to road rules?**

Sub-sections of Chapter Five have indicated how the sub-questions were answered. The drivers' opinions and perceptions were encouraging; most of the drivers are happy to be monitored and they believe being monitored will improve their driver safety skills. The fact that the NDS technology can also be used for crime related issues such as issuing a warning during high jacking or theft was a positive motivator to the drivers; it shows them that the management cares about their safety as well.

The results of the DriveCam technology itself also indicated the sequence of how the technology allocates points and violations in order to decide if a drive has a risky behaviour problem, and if the driver is likely to be involved in a vehicle crash. It is also of importance to note that the NDS technology has various attributes that can be used to analyse driver behaviour and performance. For the purpose of this study, only three were applied and analysed; these were found to be important to the study in terms of addressing questions about the ability of the technology to evaluate adherence to road rules.

6.3 Delineations, Limitations and Challenges

The scope of the study was limited to vehicles that are already fitted with NDS technology, such as DriveCam and other Data Acquisition Systems. The vehicles were also limited to those that are owned by organisations that are participating on the RTMS for road safety programme. The aim was for two different organisations' data to be used, but in the end data received from just one organisation was adequate for the study, as the organisation had two different sets of vehicles and drivers that participated in the study.

Challenges encountered during the study were not that many, but the few that were found were very crucial to the success of the study. The first one had to do with data collection: not all organisations that promised to provide data fulfilled their promise. The second one had to do with the data received: the data was of good quality, but some fields had data that could not be analysed using excel and the researcher was forced to first spend days fixing the errors before analysis could begin.

6.4 Recommendations for Future Study

It is recommended that more logistics organisations make use of naturalistic studies to collect data and further analyse it to create more knowledge for the organisation. This study identified that knowledge gained during NDS study should be used to benefit the organisations, and one of the benefits that can be gained by implementing NDS is to identify training needs for drivers and initiate driver training programmes to address the issues. Technologies like the DriveCam can identify these needs automatically, if the organisation subscribes to the full programme and this can limit cost for training development and improve organisation performance.

There is also potential for researchers to learn more about driving behaviour and, therefore, a further study is recommended that will also focus on factors that could have affected cross border drivers' adherence to speed limits, and to address the question why local distribution drivers violated the red light and stop sign indicators. The research also recommends that a study making use of a longer period of data is needed so as to be able to track the driver's performance over a longer period. This study was limited to a single organisation operating in the SADC region. Further studies should also focus on the rest of the African continent, as well as public transport drivers, as this can add value in fighting against road accidents.

6.5 Conclusion

Road safety is a serious problem in South Africa and it is a fact that lives are lost and families lose breadwinners. Therefore, road safety initiatives and programmes are of importance to address this problem. This study gave an indication that the use of ICT in road transport safety initiative is a positive step in the fight against fatal crashes. The technology used to study driver behaviour clearly shows triggers that are of concern in relations to road safety and the ability of drivers to follow road rules. Organisations that implement this technology are also able to input/code their own triggers and indicators that the system should trace. This gives users the ability to customise the system and add more triggers that traffic regulations are not yet regarding as of concern, these customisation can include triggers such as issues concerning driver distraction by eating or conversing with passengers whilst driving.

Information and communication technology is being used by other authorities to assist in reducing road crashes. South Africa should also start investing more into this field, especially the naturalistic driving studies, which have already proven to be a good tool to collect valuable data and also provide information that can be used in planning road safety strategies. Organisations that have installed the NDS technology are already enjoying return on investment. The technology can be used as a way to document information that can be used for driver coaching and training, which will lead to improved driving ability and interest in practising safe driving.

7. REFERENCES

Discovery DQ-Track, [Homepage of Discovery Insurance], [Online], 2016, Available: <https://www.discovery.co.za/portal/individual/insure-dq-tracking> [2016] .

HOLLARD: Pay As You Drive, [Homepage of Hollard Insurance], [Online], 2016, Available: http://www.payasyoudrive.co.za/?utm_source=PAYD&utm_medium=PPC [2014] 05 October 2014].

South African Government, [Homepage of South African Government], [Online], 2013, Available: <http://www.gov.za/about-government/road-safety-arrive-alive-0> [2016] 4/4/2016].

South African History Online, [Homepage of SA History Online], [Online], 11 February 2016, Available: <http://www.sahistory.org.za/topic/defining-culture-heritage-and-identity> [2016] 6/14/2016].

A Decade of Action for Road Safety 2011-2020, [Homepage of WHO], [Online] Available: http://www.who.int/roadsafety/publications/decade_launch/en/ [2016] 4/4/2016].

Global status report on road safety 2013, WHO.

The Safe System, [Homepage of Road-Safe], [Online] Available: <http://www.roadsafe.com/safesystem> [2016] 6/11/2016].

The Safe System Approach: Road Safety Manual - World Road Association (PIARC), [Homepage of World Road Association], [Online] Available: <http://roadsafety.piarc.org/en/road-safety-management/safe-system-approach> [2016] 6/11/2016].

Southern African Development Community, [Homepage of SADC], [Online] Available: <http://www.sadc.int/about-sadc/> [2016] 9/12/2016].

What is gross domestic product (GDP)?, [Homepage of Business Dictionary], [Online] Available: <http://www.businessdictionary.com/definition/gross-domestic-product-GDP.html> [2016] 9/12/2016].

Adams, J.A. 1987, "Historical review and appraisal of research on the learning, retention, and transfer of human motor skills.", *Psychological bulletin*, vol. 101, no. 1, pp. 41.

Aeron-Thomas, A. & Jacobs, G. 2011, "14 Road crashes and low-income cities: impacts and options", *Urban Transport in the Developing World: A Handbook of Policy and Practice*, , pp. 386.

- Ajzen, I. 2015, "The theory of planned behaviour is alive and well, and not ready to retire: a commentary on Sniehotka, Pesseau, and Araújo-Soares", *Health Psychology Review*, vol. 9, no. 2, pp. 131-137.
- Ajzen, I. 1991, "The theory of planned behavior", *Organizational behavior and human decision processes*, vol. 50, no. 2, pp. 179-211.
- Ajzen, I. 1985, *From intentions to actions: A theory of planned behavior*, Springer.
- Akers, R.L., Krohn, M.D., Lanza-Kaduce, L. & Radosevich, M. 1979, "Social learning and deviant behavior: A specific test of a general theory", *American Sociological Review*, , pp. 636-655.
- Ameratunga, S., Hajar, M. & Norton, R. 2006, "Road-traffic injuries: confronting disparities to address a global-health problem", *The Lancet*, vol. 367, no. 9521, pp. 1533-1540.
- Babbie, E. 2005, "The basics of research", *Belmont, CA: Thomson Wadsworth*, .
- Babbie, E. & Mouton, J. 2001, "The practice of social science research", *Belmont, CA: Wadsworth*, .
- Bagchi, M. & White, P. 2005, "The potential of public transport smart card data", *Transport Policy*, vol. 12, no. 5, pp. 464-474.
- Bandura, A. & McClelland, D.C. 1977, "Social learning theory", .
- Bazeley, P. 2013, *Qualitative data analysis: Practical strategies*, Sage.
- Bliss, T. & Breen, J. 2012, "Meeting the management challenges of the Decade of Action for Road Safety", *IATSS research*, vol. 35, no. 2, pp. 48-55.
- Blythe, P.T. 2004, "Improving public transport ticketing through smart cards", *Proceedings of the Institution of Civil Engineers, Municipal Engineer*Citeseer, , pp. 47.
- Botha, G.J. & Van der Walt, H. 2006, "Fatal road crashes, contributory factors and the level of lawlessness", *SATC 2006*, .
- Cassim, L. 2011, *Postgraduate Toolkit*, ERS Consultants.
- Castells, M. 2011, *The rise of the network society: The information age: Economy, society, and culture*, John Wiley & Sons.
- Champion, V.L. & Skinner, C.S. 2008, "The health belief model", *Health behaviour and health education; theory, research, and practice*, , pp. 45-65.
- Chan, E., Pradhan, A.K., Pollatsek, A., Knodler, M.A. & Fisher, D.L. 2010, "Are driving simulators effective tools for evaluating novice drivers' hazard anticipation, speed

management, and attention maintenance skills?", *Transportation research part F: traffic psychology and behaviour*, vol. 13, no. 5, pp. 343-353.

Churchill, B. & Walter, M. 2013, "Content analysis", *Social research methods*, , pp. 254-269.

Cohen-Blankshtain, G. & Rotem-Mindali, O. 2016, "Key research themes on ICT and sustainable urban mobility", *International Journal of Sustainable Transportation*, vol. 10, no. 1, pp. 9-17.

Cooper, D.R., Schindler, P.S. & Sun, J. 2006, "Business research methods", .

Corbin, J. & Strauss, A. 2014, *Basics of qualitative research: Techniques and procedures for developing grounded theory*, Sage publications.

Crainic, T.G., Gendreau, M. & Potvin, J. 2009, "Intelligent freight-transportation systems: Assessment and the contribution of operations research", *Transportation Research Part C: Emerging Technologies*, vol. 17, no. 6, pp. 541-557.

Creswell, J.W. 2013, *Research design: Qualitative, quantitative, and mixed methods approaches*, Sage publications.

Creswell, J.W., Klassen, A.C., Plano Clark, V.L. & Smith, K.C. 2011, "Best practices for mixed methods research in the health sciences", *Bethesda (Maryland): National Institutes of Health*, , pp. 2094-2103.

Creswell, J. 2009, *Research design: Qualitative, quantitative, and mixed methods approaches*, SAGE Publications, Incorporated.

Cuenen, A., Brijs, K., Brijs, T., Van Vlierden, K., Daniels, S. & Wets, G. 2016, "Effect evaluation of a road safety education program based on victim testimonials in high schools in Belgium", *Accident Analysis & Prevention*, vol. 94, pp. 18-27.

Dalal, S., Khodyakov, D., Srinivasan, R., Straus, S. & Adams, J. 2011, "ExpertLens: A system for eliciting opinions from a large pool of non-located experts with diverse knowledge", *Technological Forecasting and Social Change*, vol. 78, no. 8, pp. 1426-1444.

Davis Jr, F.D. 1986, *A technology acceptance model for empirically testing new end-user information systems: Theory and results*, .

Davis, F.D. 1989, "Perceived usefulness, perceived ease of use, and user acceptance of information technology", *MIS quarterly*, , pp. 319-340.

Davis, F.D. 1985, *A technology acceptance model for empirically testing new end-user information systems: Theory and results*, .

- de Croon, E.M., Kuijper, P.P.F., Broersen, J.P. & Frings-Dresen, M.H. 2004, "Information technology and road transport industry: how does IT affect the lorry driver?", *Applied Ergonomics*, vol. 35, no. 4, pp. 313-320.
- Delhomme, P., De Dobbeleer, W., Forward, S., Simões, A., Adamos, G., Areal, A., Chappé, J., Eyssartier, C., Loukopoulos, P. & Nathanail, T. 2009, "Manual for designing, implementing and evaluating road safety communication campaigns", .
- Dinges, D., Maislin, G., Brewster, R., Krueger, G. & Carroll, R. 2005, "Pilot test of fatigue management technologies", *Transportation Research Record: Journal of the Transportation Research Board*, , no. 1922, pp. 175-182.
- Dingus, T.A., Klauer, S., Neale, V., Petersen, A., Lee, S., Sudweeks, J., Perez, M., Hankey, J., Ramsey, D. & Gupta, S. 2006, "The 100-car naturalistic driving study, Phase II results", *The 100-car naturalistic driving study, Phase II-results of the 100-car field experiment*, .
- Doerzaph, Z.R. 2004, "Intersection stopping behavior as influenced by driver state: Implications for intersection decision support systems", .
- Downe-Wamboldt, B. 1992, "Content analysis: method, applications, and issues", *Health care for women international*, vol. 13, no. 3, pp. 313-321.
- Dozza, M. & González, N.P. 2013, "Recognising safety critical events: Can automatic video processing improve naturalistic data analyses?", *Accident Analysis & Prevention*, vol. 60, pp. 298-304.
- Elliott, M. 2004, "The attitudes and behaviour of adolescent road users: an application of the theory of planned behaviour", .
- Elo, S. & Kyngäs, H. 2008, "The qualitative content analysis process", *Journal of advanced nursing*, vol. 62, no. 1, pp. 107-115.
- Espié, S., Boubezoul, A., Aupetit, S. & Bouaziz, S. 2013, "Data collection and processing tools for naturalistic study of powered two-wheelers users' behaviours", *Accident Analysis & Prevention*, vol. 58, pp. 330-339.
- Feng, L. 2006, *Intelligent traffic system*, .
- Fishbein, M. 1979, "A theory of reasoned action: some applications and implications.", .
- Forward, S.E. 2009, "The theory of planned behaviour: The role of descriptive norms and past behaviour in the prediction of drivers' intentions to violate", *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 12, no. 3, pp. 198-207.
- Gainewe, M. & Masangu, N. 2010, "Factors leading to fatal crashes and fatalities on the South African roads: 2005-2009", *SATC 2010*, .

- Garcia-Ortiz, A., Amin, S. & Wootton, J. 1995, "Intelligent transportation systems—Enabling technologies", *Mathematical and Computer Modelling*, vol. 22, no. 4, pp. 11-81.
- Garmer, K., Ylven, J. & Karlsson, I.M. 2004, "User participation in requirements elicitation comparing focus group interviews and usability tests for eliciting usability requirements for medical equipment: a case study", *International Journal of Industrial Ergonomics*, vol. 33, no. 2, pp. 85-98.
- Geels, F.W. & Smit, W.A. 2000, "Failed technology futures: pitfalls and lessons from a historical survey", *Futures*, vol. 32, no. 9, pp. 867-885.
- Giannopoulos, G.A. 2004, "The application of information and communication technologies in transport", *European Journal of Operational Research*, vol. 152, no. 2, pp. 302-320.
- Gichoya, D. 2005, "Factors affecting the successful implementation of ICT projects in government", *the Electronic Journal of e-government*, vol. 3, no. 4, pp. 175-184.
- Gifford, J.L. 2010, "ICT and road transportation safety in the United States: a case of “American exceptionalism”", *IATSS research*, vol. 34, no. 1, pp. 1-8.
- Glaser, B.G. & Strauss, A.L. 2009, *The discovery of grounded theory: Strategies for qualitative research*, Transaction publishers.
- Goddard, W. & Melville, S. 2004, *Research methodology: An introduction*, Juta and Company Ltd.
- Golob, T.F. & Regan, A.C. 2001, "Impacts of information technology on personal travel and commercial vehicle operations: research challenges and opportunities", *Transportation Research Part C: Emerging Technologies*, vol. 9, no. 2, pp. 87-121.
- Gordon, T., Kostyniuk, L., Green, P., Barnes, M., Blower, D., Bogard, S., Blankespoor, A., LeBlanc, D., Cannon, B. & McLaughlin, S. 2013, "A multivariate analysis of crash and naturalistic driving data in relation to highway factors", .
- Graham, S. & Marvin, S. 2001, *Splintering urbanism: networked infrastructures, technological mobilities and the urban condition*, Psychology Press.
- Guillemin, M. & Gillam, L. 2004, "Ethics, reflexivity, and “ethically important moments” in research", *Qualitative inquiry*, vol. 10, no. 2, pp. 261-280.
- Guttman, N. & Lotan, T. 2011, "Spying or steering? Views of parents of young novice drivers on the use and ethics of driver-monitoring technologies", *Accident Analysis & Prevention*, vol. 43, no. 1, pp. 412-420.
- Healey, J.A. & Picard, R.W. 2005, "Detecting stress during real-world driving tasks using physiological sensors", *Intelligent Transportation Systems, IEEE Transactions on*, vol. 6, no. 2, pp. 156-166.

- Heeks, R. 2010, "Do information and communication technologies (ICTs) contribute to development?", *Journal of International Development*, vol. 22, no. 5, pp. 625-640.
- Hochbaum, G., Rosenstock, I. & Kegels, S. 1952, "Health belief model", *United States Public Health Service*, .
- Holden, M.T. & Lynch, P. 2004, "Choosing the appropriate methodology: understanding research philosophy", *The marketing review*, vol. 4, no. 4, pp. 397-409.
- Holloway, I. & Wheeler, S. 2013, *Qualitative research in nursing and healthcare*, John Wiley & Sons.
- Howe, D. , 2010, 2010-last update *Information and communication technology / Define Information and communication technology at Dictionary.com* Available: <http://www.dictionary.com/browse/information-and-communication-technology> [2016] 9/12/2016].
- Hsieh, H.F. & Shannon, S.E. 2005, "Three approaches to qualitative content analysis", *Qualitative health research*, vol. 15, no. 9, pp. 1277-1288.
- Israel, M. & Hay, I. 2006, *Research ethics for social scientists*, Sage.
- Jitsuzumi, T., Mitomo, H. & Oniki, H. 2000, "Contributions of ICT to sustainable information society: Managerial, macroeconomic, and environmental impacts in Japan", .
- Johnson, R.B. & Onwuegbuzie, A.J. 2004, "Mixed methods research: A research paradigm whose time has come", *Educational researcher*, vol. 33, no. 7, pp. 14-26.
- Jovanis, P., Agüero-Valverde, J., Wu, K. & Shankar, V. 2011, "Analysis of naturalistic driving event data: Omitted-variable bias and multilevel modeling approaches", *Transportation Research Record: Journal of the Transportation Research Board*, , no. 2236, pp. 49-57.
- Kautonen, T., Van Gelderen, M. & Tornikoski, E.T. 2013, "Predicting entrepreneurial behaviour: a test of the theory of planned behaviour", *Applied Economics*, vol. 45, no. 6, pp. 697-707.
- Klapwijk, J. 1989, "On worldviews and philosophy", *Bringing into Captivity Every Thought: Capita Selecta in the History of Christian Evaluations of Non-Christian Philosophy*, .
- Klapwijk, J. 1989, "On worldviews and philosophy", *Bringing into Captivity Every Thought: Capita Selecta in the History of Christian Evaluations of Non-Christian Philosophy*, .
- Klauer, S.G., Neale, V.L., Dingus, T.A., Ramsey, D. & Sudweeks, J. 2005, "Driver inattention: A contributing factor to crashes and near-crashes", *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* SAGE Publications, , pp. 1922.

- Kohlbacher, F. 2006, "The use of qualitative content analysis in case study research", *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research*.
- Kothari, C.R. 2004, *Research methodology: Methods and techniques*, New Age International.
- Krohn, M.D., Skinner, W.F., Massey, J.L. & Akers, R.L. 1985, "Social learning theory and adolescent cigarette smoking: A longitudinal study", *Social problems*, , pp. 455-473.
- Kumar, S. & Phrommathed, P. 2005, *Research methodology*, Springer.
- Labuschagne, F.J.J. & Pallet, K. 2010, "Intelligent vehicle based traffic monitoring - exploring application in South Africa", *29th Annual Southern African Transport Conference 16 - 19 August 2010 "Walk Together"*, CSIR International Convention Centre, Pretoria, South Africa., 16-19 August 2010.
- Lagarde, E. 2007, "Road traffic injury is an escalating burden in Africa and deserves proportionate research efforts", *PLoS Med*, vol. 4, no. 6, pp. 170.
- Lajunen, T. & Räsänen, M. 2004, "Can social psychological models be used to promote bicycle helmet use among teenagers? A comparison of the Health Belief Model, Theory of Planned Behavior and the Locus of Control", *Journal of Safety Research*, vol. 35, no. 1, pp. 115-123.
- Laporte, S. 2010, *Literature review of naturalistic driving studies*, .
- Lasota, D., Staniszewska, A., Tarchalska-Kryńska, B., Mirowska-Guzel, D. & Krajewski, P. 2015, "Nietrzeźwość a ryzyko zgonu w wypadku komunikacyjnym= Insobriety and the risk of death in traffic accident", *Journal of Education, Health and Sport*, vol. 5, no. 6.
- Leedy, P. & Ormrod, J.E. 2005, *Practical research*, publisher not identified.
- Leedy, P. & Ormrod, J.E. 2005, *Practical research*, publisher not identified.
- Legris, P., Ingham, J. & Collerette, P. 2003, "Why do people use information technology? A critical review of the technology acceptance model", *Information & Management*, vol. 40, no. 3, pp. 191-204.
- Levick, N.R. & Swanson, J. 2005, "An optimal solution for enhancing ambulance safety: implementing a driver performance feedback and monitoring device in ground emergency medical service vehicles", *Annu Proc Assoc Adv Automot Med*, pp. 35.
- Lindsay, B.G. 1995, "Mixture models: theory, geometry and applications", *NSF-CBMS regional conference series in probability and statistics*JSTOR, , pp. i.
- Luarn, P. & Lin, H. 2005, "Toward an understanding of the behavioral intention to use mobile banking", *Computers in Human Behavior*, vol. 21, no. 6, pp. 873-891.

- Ludin, Z. 2011, "On ethical problem solving in user-centered research: an analysis", *CHI'11 Extended Abstracts on Human Factors in Computing Systems* ACM, , pp. 791.
- Madden, T.J., Ellen, P.S. & Ajzen, I. 1992, "A comparison of the theory of planned behavior and the theory of reasoned action", *Personality and Social Psychology Bulletin*, vol. 18, no. 1, pp. 3-9.
- Markl, M. 2016, "Effectiveness of road safety educational program for pre-drivers about DUI: practical implication of the TPB in developing new preventive program in Slovenia", *Transportation Research Procedia*, vol. 14, pp. 3829-3838.
- Mason, M. 2010, "Sample size and saturation in PhD studies using qualitative interviews", *Forum qualitative Sozialforschung/Forum: qualitative social research*.
- Masuri, M.G., Isa, K.A.M. & Tahir, M.P.M. 2012, "Children, youth and road environment: road traffic accident", *Procedia-Social and Behavioral Sciences*, vol. 38, pp. 213-218.
- McKnight, A. & Adams, B. 1970, "Driver Education Task Analysis: Volume II: Task Analysis Methods", *NHTSA, Washington*, .
- McLaughlin, S.B., Hankey, J.M. & Dingus, T.A. 2008, "A method for evaluating collision avoidance systems using naturalistic driving data", *Accident Analysis & Prevention*, vol. 40, no. 1, pp. 8-16.
- Meyer, D.Z. & Avery, L.M. 2009, "Excel as a qualitative data analysis tool", *Field methods*, vol. 21, no. 1, pp. 91-112.
- Michon, J.A. 1985, "A critical view of driver behavior models: what do we know, what should we do?" in *Human behavior and traffic safety* Springer, , pp. 485-524.
- Miller, D.R. 1962, "The study of social relationships: situation, identity, and social interaction.", .
- Mischel, W. 1973, "Toward a cognitive social learning reconceptualization of personality.", *Psychological review*, vol. 80, no. 4, pp. 252.
- Mitton, N. & Simplot-Ryl, D. 2011, "From the Internet of things to the Internet of the physical world", *Comptes Rendus Physique*, vol. 12, no. 7, pp. 669-674.
- Miyatake, N., Tanaka, N., Sakano, N. & Kinoshita, H. 2013, "Relationship between road traffic accidents and drinking habits in all 47 prefectures of Japan", *Journal of transportation Technologies*, vol. 3, no. 03, pp. 190.
- Mkansi, M. & Acheampong, E.A. 2012, "Research philosophy debates and classifications: students' dilemma", *Electronic Journal of Business Research Methods*, vol. 10, no. 2, pp. 132-140.

- Montano, D.E. & Kasprzyk, D. 2015, "Theory of reasoned action, theory of planned behavior, and the integrated behavioral model", *Health behavior: Theory, research and practice* (, .
- Mouton, J. 2011, *How to succeed in your master's and doctoral studies: A South African*, Van Schaik Publishers.
- Mugenda, O. & Mugenda, A. 2003, "Quantitative and qualitative research methods", .
- Muronga, K. & Venter, K. 2014, "Naturalistic driving data : managing and working with large databases for road and traffic management research", *33rd Annual Southern African Transport conference*, 8 July 2014.
- Myers, M.D. & Newman, M. 2007, "The qualitative interview in IS research: Examining the craft", *Information and organization*, vol. 17, no. 1, pp. 2-26.
- Naci, H., Chisholm, D. & Baker, T.D. 2009, "Distribution of road traffic deaths by road user group: a global comparison", *Injury prevention : journal of the International Society for Child and Adolescent Injury Prevention*, vol. 15, no. 1, pp. 55-59.
- Nawi, H.S.A., Rahman, A.A. & Ibrahim, O. 2011, "Government's ICT project failure factors: A revisit", *Research and Innovation in Information Systems (ICRIIS), 2011 International Conference on IEEE*, , pp. 1.
- Neale, V.L., Perez, M.A., Doerzaph, Z.R., Lee, S.E., Stone, S. & Dingus, T.A. 2006, "Intersection decision support: evaluation of a violation Warning system to mitigate straight crossing path collisions", .
- Neale, V., Klauer, S., Knipling, R., Dingus, T., Holbrook, G. & Petersen, A. 2002, *The 100 car naturalistic driving study, Phase I-experimental design*, .
- Nejad, L.M., Wertheim, E.H. & Greenwood, K. 2005, "Comparison of the health belief model and the theory of planned behavior in the prediction of dieting and fasting behavior", *Sensoria: A Journal of Mind, Brain & Culture*, vol. 1, no. 1, pp. 63-74.
- Nordengen, P., Prem, H. & Mai, L. 2008, "Initiative to introduce a performance-based standards (PBS) approach for heavy vehicle design and operations in South Africa", .
- Oneyear, N., Hallmark, S., Carney, C. & McGehee, D. 2016, "PREDICTION OF LANE ENCROACHMENT ON RURAL TWO LANE CURVES USING THE SHRP 2 NATURALISTIC DRIVING STUDY DATA", *Development of rural curve driving models using lateral placement and prediction of lane departures using the SHRP 2 naturalistic driving data*, , pp. 80.
- Paone, J., Bolme, D., Ferrell, R., Aykac, D. & Karnowski, T. 2015, "Baseline face detection, head pose estimation, and coarse direction detection for facial data in the SHRP2 naturalistic driving study", *2015 IEEE Intelligent Vehicles Symposium (IV)IEEE*, , pp. 174.

Parkinson, F., Kent, S., Aldous, C., Oosthuizen, G. & Clarke, D. 2013, "Road traffic crashes in South Africa: The burden of injury to a regional trauma centre", *SAMJ: South African Medical Journal*, vol. 103, no. 11, pp. 850-852.

Patton, M.Q. 2005, *Qualitative research*, Wiley Online Library.

Peters, E.D. 2014, *3rd Africa Road Safety Seminar*,
[http://www.transport.gov.za/Portals/0/Speeches/2014/SPEECH MINISTER 3 GRSP AFRICA SEMINAR.pdf](http://www.transport.gov.za/Portals/0/Speeches/2014/SPEECH%20MINISTER%203%20GRSP%20AFRICA%20SEMINAR.pdf) edn.

Petty, N.J., Thomson, O.P. & Stew, G. 2012, "Ready for a paradigm shift? Part 2: Introducing qualitative research methodologies and methods", *Manual therapy*, vol. 17, no. 5, pp. 378-384.

Plaatjies, P. 2010, "National training framework for road traffic management", *SATC 2010*, .

Regan, M., Williamson, A., Grzebieta, R., Charlton, J., Lenneb, M., Watson, B., Haworth, N., Rakotonirainy, A., Woolley, J. & Anderson, R. 2013, "The Australian 400-car naturalistic driving study: innovation in road safety research and policy", *Proceedings of the 2013 Australasian road safety research, policing & education conference, Brisbane, Queensland*.

Renzi, S. & Klobas, J. 2008, "Using the theory of planned behavior with qualitative research", .

Ritchie, J., Lewis, J. & Elam, G. 2003, "Designing and selecting samples", *Qualitative research practice: A guide for social science students and researchers*, vol. 2, pp. 111-145.

Ross, A. & Israel, D. 2002, "Quantitative and qualitative research methods", *London: Dudley-Hall Inc*, .

Rubin, H.J. & Rubin, I.S. 2011, *Qualitative interviewing: The art of hearing data*, Sage.

Sayer, J., Devonshire, J. & Flanagan, C. 2007, "Naturalistic driving performance during secondary tasks", *Proceedings of the Fourth International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design*, pp. 224.

Schüklenk, U. 2005, "Module one: introduction to research ethics", *Developing World Bioethics*, vol. 5, no. 1, pp. 1-13.

Scott-Parker, B., Goode, N., Salmon, P. & Senserrick, T. 2016, "Knowing me knowing you: Key players and their interactions within the young driver road safety system", *Safety Science*, vol. 88, pp. 88-96.

Scott-Parker, B., Watson, B., King, M.J. & Hyde, M.K. 2012, "'They're lunatics on the road': Exploring the normative influences of parents, friends, and police on young novices' risky driving decisions", *Safety Science*, vol. 50, no. 9, pp. 1917-1928.

Seaman, S., Lee, J., Angell, L., Mehler, B., Seppelt, B. & Reimer, B. 2016, "Exploring Generalizability of Field Experiment Radio Tasks with Naturalistic Driving Data: A Comparison with SHRP2 NEST", *Proceedings of the 8th International Conference on Automotive User Interfaces and Interactive Vehicular Applications Adjunct* ACM, , pp. 111.

Seshadri, K., Juefei-Xu, F., Pal, D.K., Savvides, M. & Thor, C.P. 2015, "Driver cell phone usage detection on strategic highway research program (SHRP2) face view videos", *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition Workshops*, pp. 35.

Shankar, V., Jovanis, P., Aguero-Valverde, J. & Gross, F. 2008, "Analysis of naturalistic driving data: prospective view on methodological paradigms", *Transportation Research Record: Journal of the Transportation Research Board*, , no. 2061, pp. 1-8.

Şimşekoğlu, Ö & Lajunen, T. 2008, "Social psychology of seat belt use: A comparison of theory of planned behavior and health belief model", *Transportation research part F: traffic psychology and behaviour*, vol. 11, no. 3, pp. 181-191.

Sleet, D.A., Baldwin, G., Dellinger, A. & Dinh-Zarr, B. 2011, "The decade of action for global road safety", *Journal of Safety Research*, vol. 42, no. 2, pp. 147-148.

Tashakkori, A. & Teddlie, C. 2010, *Sage handbook of mixed methods in social & behavioral research*, Sage.

Tavafian, S.S., Aghamolaei, T., Gregory, D. & Madani, A. 2011, "Prediction of Seat Belt Use Among Iranian Car Drivers: Application of the Theory of Planned Behavior and the Health Belief Model", *The First International & 4th National Congress on health Education & Promotion, 2011* Tabriz university of medical sciences, .

Taylor, T., Pradhan, A., Divekar, G., Romoser, M., Muttart, J., Gomez, R., Pollatsek, A. & Fisher, D. 2013, "The view from the road: The contribution of on-road glance-monitoring technologies to understanding driver behavior", *Accident Analysis & Prevention*, vol. 58, pp. 175-186.

Toroyan, T., Laych, K., Peden, M. & Krug, E. , 2015, *Global status report on road safety* Available: http://www.who.int/violence_injury_prevention/road_safety_status/2015/en/ [2016] 6/10/2016].

Valero-Mora, P., Tontsch, A., Pareja-Montoro, I. & Sánchez-García, M. 2010, "Using a highly instrumented car for naturalistic driving research: a small-scale study in Spain", *Prologue Deliverable D*, vol. 3.

Vallerand, R.J., Deshaies, P., Cuerrier, J., Pelletier, L.G. & Mongeau, C. 1992, "Ajzen and Fishbein's theory of reasoned action as applied to moral behavior: A confirmatory analysis.", *Journal of personality and social psychology*, vol. 62, no. 1, pp. 98.

van Schagen, I., Welsh, R., Backer-Grondahl, A., Hoedemaeker, M., Lotan, T., Morris, A., Sagberg, F. & Winkelbauer, M. 2011, "Towards a large scale European Naturalistic Driving study: final report of PROLOGUE: deliverable D4. 2", .

- Venter, K. 2014, "An Exploratory Study into South African Novice Driver Behaviour", .
- Walker, G.H., Stanton, N.A. & Young, M.S. 2001, "Where is computing driving cars?", *International Journal of Human-Computer Interaction*, vol. 13, no. 2, pp. 203-229.
- Wallace, J. 2005, "Overview of the DriveCam Program", *Dec*, vol. 15, pp. 13.
- Wang, E.H. 1999, "ICT and economic development in Taiwan: analysis of the evidence", *Telecommunications Policy*, vol. 23, no. 3, pp. 235-243.
- Weber, R.P. 1990, *Basic content analysis*, Sage.
- WHO 2015, *Global status report on road safety 2015*.
- Williams, C. 2011, "Research methods", *Journal of Business & Economics Research (JBER)*, vol. 5, no. 3.
- Winkelbauer, M., Eichhorn, A., Sagberg, F. & Backer-Grøndahl, A. 2010, "Naturalistic Driving" in *Data and Mobility* Springer, , pp. 163-176.
- Wolters, A.M., Marshall, P., Griffioen, S. & Mouw, R. 1989, "On the idea of worldview and its relation to philosophy", *Stained glass: Worldviews and social science*, , pp. 14-25.
- Woodyard, C. 2003, "Shuttles save with DriveCam", *Dec*, vol. 9, pp. 1.
- Wouters, P.I. & Bos, J.M. 2000, "Traffic accident reduction by monitoring driver behaviour with in-car data recorders", *Accident Analysis & Prevention*, vol. 32, no. 5, pp. 643-650.
- Wundersitz, L., Hutchinson, T. & Woolley, J. 2010, "Best practice in road safety mass media campaigns: A literature review", *Social psychology*, vol. 5, pp. 119-186.
- Yin, R.K. 2013, *Case study research: Design and methods*, Sage publications.
- Young, M.S., Birrell, S.A. & Stanton, N.A. 2011, "Safe driving in a green world: A review of driver performance benchmarks and technologies to support 'smart' driving", *Applied Ergonomics*, vol. 42, no. 4, pp. 533-539.
- Yousafzai, S.Y., Foxall, G.R. & Pallister, J.G. 2010, "Explaining internet banking behavior: theory of reasoned action, theory of planned behavior, or technology acceptance model?", *Journal of Applied Social Psychology*, vol. 40, no. 5, pp. 1172-1202.
- Zwass, V. 2016, *Information System*, Encyclopedia Britannica.

8. Appendix A: Study Questionnaires

Brief summary of the research study

The study is part of a Master's program of work for Khangwelo Muronga. Khangwelo Muronga is currently holding a BTech degree in Business Information Systems and registered student at the Tshwane University of Technology. The purpose of the project is to examine general beliefs associated with Naturalistic Driving Studies (NDS) in regard to the opinions and views of drivers of vehicles fitted with driver monitoring devices and management of companies that have installed these devices. **The main objective of the study is to evaluate the effectiveness of Naturalistic Driving Studies in improving driver's behaviour and adherence to road rules.**

Study Title: The effectiveness of Naturalistic Driving Studies in improving driver behaviour.

Most of the information required to address the research questions will come from analysing the data that was collected by participating organisations. This questionnaire is focused on understanding opinion of managers and drivers involved in NDS programmes.

To achieve the objectives of the study the following will be evaluated:

Attitude	<ul style="list-style-type: none">• Whether drivers are in favour of being monitored• Whether drivers believe that the technology can encourage safe driving
Subjective norms	<ul style="list-style-type: none">• How much the driver feels social pressure to allow being monitored• How much motivation do driver's need to allow being monitored
Perceived behavioural control	<ul style="list-style-type: none">• Whether the drivers understand how the device works• Whether the driver feels in control of the data being collected• Whether the drivers are confident of their driving ability and therefore don't mind being monitored.

The research aims to investigate organisations that have already implemented the NDS and the data required to address the above variables have already been collected by this organisations. The researcher will request the data from the organisations concerned and analyse this data to achieve the objectives of the research.

Notes:

- **If you are a manager and/or responsible for the drive cam initiative, please complete only Section 1 and 3**
- **If you are a driver please complete Section 1 and 2**
- **If all Sections apply to you, please complete all**

Section 1: Demographic Information

This section consists of several demographic questions. These questions are for descriptive purposes and will give us an indication of the types of drivers who participated in the study. Please answer all questions.

1. What is your Age (in years)?

18 - 21	22 - 29	30 - 35	36 - 45	46 +

2. What is your Gender? (please tick the correct one)

Male	<input type="checkbox"/>	Female	<input type="checkbox"/>
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3. What types of driving license do you have? (tick all that apply)

A	A1	B	C	C1	EB	EC	EC1	Foreign Licence

4. How many years have you been actively driving?

1 - 4	5 - 10	11 - 15	16 - 20	21 +

5. How many work kilometres in a week (average) do you drive?

Less than 100 km	
100 – 300 km	
300 – 400 km	
400 – 500 km	
More than 500 km	

Section 2: Driver's Opinion of Naturalistic Driving Studies

The following section is about how you feel about the subject as well as your opinion about how other people feel about the subject. Please answer each question by selecting one option that best describes your opinion.

6. In your own opinion what do you think the information gathered during NDS is used for?	Extremely unlikely	Slightly unlikely	Don't know	Slightly likely	Extremely likely
<i>Note: NDS refers to the use of in-vehicle monitoring devices to monitor you while driving.</i>					
To gather information so your boss can fire you, if you don't drive safely.	1	2	3	4	5
To monitor you so the information collected can help improve your driving ability.	1	2	3	4	5
To monitor you so you don't go where you are not supposed to go.	1	2	3	4	5
To monitor where you are so it can advise you about traffic jams	1	2	3	4	5
To monitor the vehicle so it can assist if the vehicle is hijacked or transported goods are stolen	1	2	3	4	5

7. Generally speaking, how much do you care whether you are being monitored or not?

Not at all	1	2	3	4	5	Very Much
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8. Generally speaking, how much do you care if your wife, kids, parents, friends etc. can see your driving behaviour on a video?

Not at all	1	2	3	4	5	Very Much
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9. My family members think that I should be monitored while driving as it is good practice

Not at all	1	2	3	4	5	Very Much
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10. My insurance company says I should be monitored to determine my premiums

Not at all	1	2	3	4	5	Very Much
------------	---	---	---	---	---	-----------

11. Whether or not am being monitored, I always drive safe and follow the rules

Not True	1	2	3	4	5	Very True
----------	---	---	---	---	---	-----------

12. How would you rate yourself in terms of safe driving practices?				
Very bad	Slightly bad	middle	Slightly good	Very good
1	2	3	4	5

13. How likely is it that you would follow all road/traffic rules on a normal driving day						
Very unlikely	1	2	3	4	5	Very likely

Section 3: Management/Coordinators responsible for NDS

The following section relates to you as a manager and/or the person responsible for the NDS programme in your organisation and its purpose is to collect facts in relation to the programme.

14. Are the organisational objectives being achieved by the programme?
(Please tick the correct one)

YES	<input type="checkbox"/>	NO	<input type="checkbox"/>
-----	--------------------------	----	--------------------------

15. For how many years has the programme being running?

1 - 4	5 - 10	11 - 15	16 - 20	21 +
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16. Since the implementation for the programme how would you rate it's success.						
Not successful	1	2	3	4	5	Very successful

17. Do you always communicate or advice the drivers about safe driving behaviour based on the results of the programme?

Strongly disagree	1	2	3	4	5	Strongly agree
-------------------	---	---	---	---	---	----------------

18. Do you offer any incentives to your drivers for practicing safe driving behaviour?

Strongly disagree	1	2	3	4	5	Strongly agree
-------------------	---	---	---	---	---	----------------

19. In summary what are the major objectives for implementing NDS programme in your organisation.

9. Appendix B: Sample of results from management

Section 3: Management/Coordinators responsible for NDS

The following section relates to you as a manager and/or the person responsible for the NDS programme in your organisation and its purpose is to collect facts in relation to the programme.

14. Are the organisational objectives being achieved by the programme?
(Please tick the correct one)

YES	<input checked="" type="checkbox"/>	NO	<input type="checkbox"/>
-----	-------------------------------------	----	--------------------------

15. For how many years has the programme being running?

1 - 4	5 - 10	11 - 15	16 - 20	21 +
	<input checked="" type="checkbox"/>			

16. Since the implementation for the programme how would you rate it's success.

Not successful	1	2	3	<input checked="" type="checkbox"/>	5	Very successful
----------------	---	---	---	-------------------------------------	---	-----------------

17. Do you always communicate or advise the drivers about safe driving behaviour based on the results of the programme?

Strongly disagree	1	2	3	<input checked="" type="checkbox"/>	5	Strongly agree
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18. Do you offer any incentives to your drivers for practicing safe driving behaviour?

Strongly disagree	<input checked="" type="checkbox"/>	2	3	4	5	Strongly agree
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19. In summary what are the major objectives for implementing NDS programme in your organisation.

1. To utilize program to:
 - a. Successfully identify risky driver behaviour.
 - b. Reduce risky behaviour
 - c. Use as a training tool to change attitude of incorrect behaviour
 - d. Maintain high level of awareness.
 - e. Reduce risk exposure.

Section 3: Management/Coordinators responsible for NDS

The following section relates to you as a manager and/or the person responsible for the NDS programme in your organisation and its purpose is to collect facts in relation to the programme.

14. Are the organisational objectives being achieved by the programme?
(Please tick the correct one)

YES	<input checked="" type="checkbox"/>	NO	<input type="checkbox"/>
-----	-------------------------------------	----	--------------------------

15. For how many years has the programme being running?

1 - 4	5 - 10	11 - 15	16 - 20	21 +
	<input checked="" type="checkbox"/>			
1	2	3	4	5

16. Since the implementation for the programme how would you rate it's success.						
Not successful	1	2	3	4	<input checked="" type="checkbox"/> 5	Very successful

17. Do you always communicate or advice the drivers about safe driving behaviour based on the results of the programme?						
Strongly disagree	1	2	3	4	<input checked="" type="checkbox"/> 5	Strongly agree

18. Do you offer any incentives to your drivers for practicing safe driving behaviour?						
Strongly disagree	1	<input checked="" type="checkbox"/> 2	3	4	5	Strongly agree

19. In summary what are the major objectives for implementing NDS programme in your organisation.

To reduce the high risk of hijacking, accidents and a very good tool for training as you easily can identify certain behaviours. Definitely a continuous improvement for driver behaviour on route.

10. Appendix C: Information Leaflet and Informed Consent



Faculty of Information and Communication Technology
Faculty Committee of Research Ethics

12 April 2016

Ref #: FCRE/ICT/2015/08/003(2)
Name: Muronga K
Student # 209303611

Mr K Muronga
C/o Prof N Ruxwana
Department of Informatics
Faculty of Information and Communication Technology

Dear Mr K Muronga,

Decision: Final Approval

Name: K Muronga

Proposal: The effectiveness of the naturalistic driving studies in improving driver behaviour

Qualification: Magister Technologiae: Business Information Systems

Supervisor: Prof N Ruxwana

Thank you for submitting the revised project documents for ethics clearance. The updates and clarification are duly noted.

Final approval is granted.

The proposed research project may now continue with the proviso that:

1) The researcher/s will conduct the study according to the procedures and methods indicated in the approved proposal, particularly in terms of any undertakings and/or assurances made regarding informed consent and the confidentiality of the collected data.

2) The proposal (inclusive of the applicable information leaflet/s, informed consent document/s, interview guide/s and/or questionnaire/s) will again be submitted to the Committee for prospective ethical clearance if there are any substantial changes from the



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existing proposal, particularly if those changes affect any of the study-related risks for the research participants.

3) The researcher will act within the parameters of any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study.

Note:

The reference number [top right corner of this communiqué] should be clearly indicated on all forms of communication [e.g. Webmail, E-mail messages, letters] with the intended research participants.

Annual review:

1. The formal ethics approval of all research projects need to be renewed on an annual basis.
2. The current ethics approval expiry date for this project is 31 December 2017.
3. No research activities may continue after the ethics approval expiry date indicated on the formal Research Ethics Committee approval letter.
4. The Research Ethics Progress Report (electronic copy available at the following website: <http://www.tut.ac.za/Other/rminew/ResearchEthicsCommittees/Pages/default.aspx>) constitutes an application for such ethics approval renewal and must be submitted to the FCRE by 1 November 2017.

Yours sincerely,



GE Ditsa (Prof)
Chairperson: Faculty Committee of Research Ethics
[Ref#2015=08=003(2) =MurongaK]



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Tshwane University
of Technology

We empower people

FACULTY OF INFORMATION AND
COMMUNICATION TECHNOLOGY

DEPARTMENT OF INFORMATICS

INFORMATION LEAFLET AND INFORMED CONSENT

PROJECT TITLE: THE EFFECTIVENESS OF THE NATURALISTIC DRIVING STUDIES IN IMPROVING DRIVER BEHAVIOUR

Primary investigator: Mr Khangwelo Muronga, BTech (Business Information Systems)

Study leader: Prof. N. Ruxwana, PhD, Department of Informatics, Tshwane University of
Technology

Dear Potential research participant

You are invited to participate in a research study that forms part of my formal Master's Degree research at Tshwane University of Technology. This information leaflet will help you to decide if you would like to participate. Before you agree to take part, you should fully understand what is involved. You should not agree to take part unless you are completely satisfied with all aspects of the study.

WHAT IS THE STUDY ALL ABOUT?

The main objective of this study is to evaluate the effectiveness of Naturalistic Driving Studies (NDS) in improving driver's behaviour and adherence to road rules, with the aim of recommending means that can improve the success and effective use of NDS in South Africa. NDS, also known as naturalistic observations, is a new approach among already applied traffic research methods and provides information that was difficult or even impossible to obtain through current or normal research methods.

Under this naturalistic observation approach, the behaviour of road users is observed unobtrusively in a natural setting for a period of time. With the aim of allowing researchers to observe and analyse the interrelationship between the driver, vehicle; road and other traffic in normal situations, in conflict situations and in actual crashes. This information can further assist authorities in planning strategies based on scientific information to reduce road fatalities and improve road safety.

The study aims to explore the implemented NDS research by organisations such as insurance companies and logistics companies and you have been selected because you are associated with one or more of the companies being studied.

WHAT WILL YOU BE REQUIRED TO DO IN THE STUDY?

If you decide to take part in the study, you are required to do the following:

- To sign this informed consent form
- To complete the questionnaires
- After completing questionnaires you might be asked to attend contact sessions (informal interviews) with the researcher to clarify some questions.

ARE THERE ANY CONDITIONS THAT MAY EXCLUDE YOU FROM THE STUDY?

You will not be eligible to take part in the study if you did not sign the Consent Form or don't agree with the terms and conditions specified in it.

CAN ANY OF THE STUDY PROCEDURES RESULT IN PERSONAL RISK, DISCOMFORT OR INCONVENIENCE?

The interview involves no foreseeable emotional discomfort or inconvenience to you. There is no risk to you in participating in this study. If, however, you become uncomfortable or stressed by answering any of the interview questions, you can skip the question or stop the interview.

WHAT ARE THE POTENTIAL BENEFITS THAT MAY COME FROM THE STUDY?

The results of the study will have no direct personal benefits to you, but you will make a contribution by expanding the understanding of NDS research and assist in making our roads safer.

WILL YOU RECEIVE ANY FINANCIAL COMPENSATION OR INCENTIVE FOR PARTICIPATING IN THE STUDY?

Please note that you will not be paid to participate in the study.

WHAT ARE YOUR RIGHTS AS A PARTICIPANT IN THIS STUDY?

Your participation in this study is entirely voluntary and anonymous. You can choose freely to participate or not to participate. In addition, at any point during this study, you have the right to withdraw without any penalty or future disadvantage whatsoever. You don't even have to provide the reason/s for your decision. Your withdrawal will in no way influence your continued relationship with the research team.

HOW WILL CONFIDENTIALITY AND ANONYMITY BE ENSURED IN THE STUDY?

Only the researcher and the supervisors will have access to the completed questionnaires. Your answers will be totally anonymous and your identity will not be revealed under any circumstance. Also, nobody outside the study panel and/or research ethics committee will be able to connect any answer to you in any recognisable way. The results of this study might be published in a scientific journal and/or presented at scientific meetings, but again without revealing the identity of any research participant. The original interview answers will be stored in a safe place for three years, after which they will be destroyed.

IS THE RESEARCHER QUALIFIED TO CARRY OUT THE STUDY?

The researcher is an adequately trained and qualified researcher in the study fields covered by this research project, specifically in Business Information Systems.

HAS THE STUDY RECEIVED ETHICAL APPROVAL?

Yes. The Faculty Higher Degrees Committee and the Research Ethics Committee of the Tshwane University of Technology have approved the formal study proposal. All parts of the study will be conducted according to internationally accepted ethical principles.

WHO CAN YOU CONTACT FOR ADDITIONAL INFORMATION REGARDING THE STUDY?

The primary investigator, Mr K Muronga, can be contacted during office hours at Tel (012) 841 2337, or on his cellular phone at 076 765 8104. The study leader, Prof N.L Ruxwana, can be contacted on 012 382 9626. Should you have any questions regarding the ethical aspects of the study, you can contact the chairperson of the TUT Faculty of ICT Research Ethics committee, Dr AB Pretorius, during office hours at Tel (013) 653 3136, Email PretoriusAB1@tut.ac.za. Alternatively, you can report any serious unethical behaviour at the University's Toll Free Hotline 0800 21 2341.

DECLARATION: CONFLICT OF INTEREST

None.

A FINAL WORD

Your co-operation and participation in the study will be greatly appreciated. Please sign the informed consent below if you agree to participate in the study. In such a case, you will receive a copy of the signed informed consent from the researcher.

CONSENT

I hereby confirm that I have been adequately informed by the researcher about the nature, conduct, benefits and risks of the study. I have also received, read and understood the above written information. I am aware that the results of the study will be anonymously processed into a research report. I understand that my participation is voluntary and that I may, at any stage, without prejudice, withdraw my consent and participation in the study. I had sufficient opportunity to ask questions and of my own free will declare myself prepared to participate in the study.

Research participant's name: _____ (Please print)

Research participant's signature: _____

Thanking you in advance



MR K Muronga (Primary Investigator)
E-mail: kmuronga@gmail.com
Cell: 076 765 8104



Prof NL Ruxwana (Study leader)
E-mail: ruxwananl@tuf.ac.za
Cell: 012 382 9626

LETTER REQUESTING PERMISSION TO CONDUCT RESEARCH

Khangwelo (Khay) Muronga
kmuronga@gmail.com
kmuronga@csir.co.za
Mobile: 076 765 8104
Tel: 012 841 2337

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

My name is Khangwelo (Khay) Muronga and I need assistance in regards to RTMS registered vehicles. I need you with my research study which involves analyzing Driver Behaviour data, this is the data collected by on-board computers (DriveCam as you call it).

I am a registered Master's student in the Department of informatics at the Tshwane University of Technology. My supervisor is Prof. Nkqubela L Ruxwana. The approved topic of my research is: **The effectiveness of the Naturalistic Driving Studies (NDS) in improving driver behaviour.** The objectives of the study are:

- (a) To evaluate the effectiveness of NDS in improving driver's behaviour and adherence to road rules;
- (b) To recommend means that can improve the success and effective use of NDS in South Africa

I am hereby seeking your consent to interview and also issue questionnaires to your staff members as well as clients, who are involved in the driver monitoring program. To assist you in reaching a decision, I have attached to this letter:

- (a) A copy of an ethical clearance certificate issued by the University
- (b) A copy of a summary of the approved research proposal by the University
- (c) A copy the research instruments which I intend using in my research

Should you require any further information, please do not hesitate to contact me or my supervisor. Our contact details are as follows:

(kmuronga@gmail.com, 0767658104 and ruxwanaNL@tut.ac.za, 0829302550)

Upon completion of the study, I undertake to provide you with a bound copy of the dissertation.

Your permission to conduct this study will be greatly appreciated. For further information, so you can have an informed consent, please see specific objectives below:

The objectives of the research study

The main objective of this study is to evaluate the effectiveness of NDS in improving driver's behaviour and adherence to road rules, with the aim of recommending means that can improve the success and effective use of NDS in South Africa.

Specific objectives will include:

- To establish the sequence of incidents recording by the technology on vehicles that already has the in-vehicle device installed
- To compare the sequence of decision making of drivers after a period of time with the technology being installed in the vehicles
- To determine if the intended objectives by companies that has installed the technology were achieved
- To determine the driver's perceptions and experience about NDS and its role in improving road safety

Based on the objectives the required data will be the driver statistics produced by DriveCam system for at least a period of one year (12 Month), and anonymity of the organization and/or participant will be adhered to as the research ethics commands it.

If you accept to allow me to conduct research using your data as well as handing a questionnaire to some of your drivers, please complete the below

Name of approver: HOSHANG LALEKI Designation: COMPLIANCE MANAGER

Signature:  Date: 15/05/2016

Yours sincerely,



Khangwelo Muronga