IN-DEPTH ACCIDENT ANALYSIS AND CASE STUDY IN NIGERIAN ROAD AND TRAFFIC CONDITION

A THESIS SUBMITTED TO

THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCE

OF

ATILIM UNIVERSITY

BY

ABUBAKAR DAYYABU

IN PARTIAL FULFILLIMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS

IN THE DEPARTMENT CIVIL ENGINEERING

MARCH 2014

Approval of the Graduate School of Natural and Applied Science, Atilim University

Prof. Dr. İbrahim Akman

Director

I certify that this thesis satisfies the entire requirement as a thesis for the degree of Masters of Science.

Assoc. Prof. Dr. Tolga AKIŞ

Head of Department

This is to certify that we have read the thesis, "Thesis Name" submitted by "candidate name" and that in our opinion, it is fully adequate, in scope and quality, as a thesis for the degree of Masters of Science.

Asst. Prof. Dr. Cumhur AYDIN

Supervisor

Examination Committee Members

Asst. Prof. Dr. Cumhur AYDIN

I declare and guarantee that the entire data, knowledge and information in this document has been obtained, processed and presented in accordance with academic rules and ethical conduct. Based on these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Abubakar Dayyabu

ABSTRACT

IN-DEPTH ACCIDENT ANALYSIS AND CASE STUDY IN NIGERIAN ROAD AND TRAFFIC CONDITION

Abubakar Dayyabu

M.Sc. Civil Engineering Department

Supervisor: Ass.Prof.Dr. Cumhur Aydin

March 2014

The in-depth accident investigation is the process of detail data gathering related to the involved persons, the road/environment, involved vehicles for the purpose of detail analysis and the reconstruction of the accident. It can be used to conclude on the main causes of accidents and proposing an appropriate and effective countermeasure, to prevent re-occurrence of similar accident type.

The thesis has reviewed and modified European Truck Accident Causation Study methodology. The modified methodology was applied on Nigerian Highways. In the modified methodology 100 parameters comprising of detail information of involved persons, vehicles, road and environment were collected and analyzed to come up with the accident causes and proposed an effective countermeasure.

The use of the Nigerian National Accident Investigation Manual, the comprehensive Truck database can help in better understanding the main causes of truck involved accidents, and hence providing effective countermeasures.

Keywords: Traffic accidents, In-Depth Accident Analysis

ÖZ

DERİNLEMESİNE KAZA ANALİZLERİ VE NİJERYA KARAYOLU VE TRAFİK ORTAMINDA BİR ÖRNEK ÇALIŞMA

Abubakar Dayyabu

Yüksek Lisans, İnşaat Mühendisliği Bölümü

Tez Yonetcisi: Yrd. Doç. Dr. Cumhur Aydın

Mart 2014

Derinlemesine kaza analizi; trafik kazasının yeniden canlandırılması ve detaylı incelenmesi amaçlarına yönelik belirtilen bu aşamaları da içine alan kazaya karışan yol kullanıcıları, yol/çevre ve araçlar başlıklarında detaylı bilgiler toplama sürecidir. Analizler trafik kazalarının nedenlerini ortaya koyma, uygun ve etkin iyileştirme tedbirinin önerilmesi ve benzer kazaların önlenmesi amacıyla kullanılabilmektedir.

Bu tez, Avrupa Kamyon Kazaları Nedenleri Çalışma metodolojisini incelemiş ve bir modifikasyonunu yapmıştır. Revize yöntem Nijerya Karayollarında bir örnek çalışma içinde uygulanmıştır. Kazaya karışan yol kullanıcıları, araçlar ve yol ile çevreye yönelik 100 parametreye ilişkin detaylı bilgi toplanmış ve bunlar kaza nedenlerinin bulunması ile etkili iyileştirme tedbirleri önerilmesi amacıyla incelenmiştir.

Nijerya Ulusal Trafik Kazası Araştırma El Kitabı ve detaylı kamyon veri bankası, kamyonların karıştığı kazaların temel nedenlerinin daha iyi anlaşılması ile etkili iyileştirme tedbirlerinin önerilmesinde yardımcı olabilecektir.

Anahtar kelimeler: Trafik kazaları, Derinlemesine Kaza Analizleri

I dedicated this work to my beloved family members.

ACKNOWLEDGEMENT

I express sincere appreciation to my supervisor Ass.Prof.Dr. Cumhur Aydin and entire staffs of Civil Engineering Department, Atilim University for their guidance throughout the research.

I also want to express my special appreciation to the Executive Governor of Kano State for giving me a scholarship grant for two years.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

1 INTRODUCTION OF CASE STUDY

1.0 Introduction

A major problem in the world today is the high rate of accidents and deaths on our roads. According to the World Health Organization (WHO), traffic accident deaths are a global epidemic sweeping people through the world gradually (1). This scourge, if not addressed properly will be the second most common cause of disability and adjusted life year loss in developing countries by the year 2030. Each year, an estimated 1.2 million people are killed in road crashes and up to 50 million injured worldwide (2).

Developing countries endure the most of the fatalities and disabilities from road traffic accidents, accounting for more than 85% of the world's road fatalities and nearly 90% of the total daily cost due to road injuries. The problem is increasing in these countries at a fast rate, while it is declining in all industrialized nations such as Western Europe, North America, Japan, Australia and New Zealand. For instance, about 10 per cent of global road deaths in 1999 took place in Sub-Saharan Africa, where only 4 per cent of global vehicles are registered (3). Conversely, in the entire developed world, with 60 per cent of all globally registered vehicles, only 14 per cent of road deaths occurred. Two countries, South Africa and Nigeria accounted for most of the reported deaths in Sub-Sahara Africa. Other countries that experience high number of road deaths are Ethiopia, Kenya, Uganda, Tanzania and Ghana. (4)

Statistics have shown that mortality in road traffic accidents are very higher among younger than adults in their prime and who also constitute the workforce (5). These are usually the bread winners in many cultures. Over 75 per cent of road traffic casualties in Africa are in the economic productive age bracket of between 16 and 65 years. Those aged over 65 years account for a small proportion of road casualties partly due to their small numbers in the general population. Children often get injured as pedestrians and many become orphaned from these accidents. This imposes harsh social conditions made much worse in countries without social security services (6).

1.1 Independent Accident Investigation in Europe

In the year 2001, The European Commission releases a White Paper, title "European transport policy for 2010: time to decide", the paper was released after the commission had acknowledged the fact that the bulk of current road accident investigation practices remain focused on the issues of liability and compensation for damages. The Commission further states that such investigations are unable to stem the growing need felt in Europe and the United States for independent technical investigations geared towards revealing the causes of accidents and proposing of countermeasures. (7)

The European Commission 2003 paper, title saving 20 000 lives on our roads, recognizes that investigations aiming at the causes and consequences of road accidents, should be independent from investigations conducted by the judicial authorities or insurance companies, data must be gathered in an independent and transparent manner. (7)

Finally European Commission initiated an independent accident investigation, referred to as the European safety oriented road accident investigation program (or simply European Program). A safety oriented road accident investigation aims to identify accident causes, contributing factors, injuries, injury mechanisms an injury outcomes, and how the accident and injuries could have been prevented. It pays attention to aspects that a judicial inquiry might not consider, such as physical, psychological, social, political, economic and technical issues. (7)

1.2 Research Area

a) **Federal Republic of Nigeria:** Nigeria is a West African country form from an amalgam of ancient Kingdoms, Caliphates, Empires and City-states with a long history of organized societies. The name Nigeria was adopted in 1898 to designate the British Protectorates on the River Niger. Nigeria has an area of 923,768.00 sq kilometers and lies between latitude 40 and 140 north of the equator and longitudes 30 and 140 east of the Greenwich meridian. It is entirely within the tropical zone.

It is bounded on the West by the Republic of Benin on the North by the Republic of Niger and on the East by the Federal Republic of Cameroun. On the North-East border is Lake Chad while also extends into the Republic of Niger and Chad and touches the northernmost part of the Republic of Cameroun. In the South, the Nigerian coast- line is bathed by the Atlantic Ocean. (8&9)

b) The Road Network

The Case Study has been carried out on the Kano-Maiduguri Road**,** Kano-Maiduguri Road is one of the oldest road in northern Nigeria, constructed around 1920 under the colonial rule, linking the northwestern region of old Kaduna, Sokoto and Kano with northeastern region of old Borno, Bauchi and Gwangola.

The road was initially constructed as surface dressed road with two lanes, upgraded to an asphalt concrete road and finally was awarded for major expansion of four lane divided highway in 2007 on which the work is still in progress.

ROAD GEOMETRY	
Description	Remark
Length	543km
Terrain	Level
Carriage way width	7.6m
Shoulder width	2.3m
Median width	
Median height	

LEGEND

STUDY ROAD

OTHER LINKS

Figure 1 Showing the Nigerian map together with the case study area

1.3 Actions for Improving Accident Investigation

The major action taken by Nigeria since becoming a country in 1960 in the area of road traffic accident reduction was the establishment of the Nigerian Road Safety Commission, in the year 1988 which was charged with following responsibilities as summarized below and to work in close cooperation with Nigerian police force and Nigerian fire brigades.

The responsibilities of the Commission can be summarized as follows:

a) To make the highway safe for motorists and other road users.

b) To recommend works and devices designed to eliminate or minimize accidents on the highways.

c) To give prompt attention and care to victims of accidents.

d) To conduct researches about the causes of motor accidents and to propose methods of preventing them together with making research results available to the different parties.(FRSC)

1.4 Problem Statement

a) According to the world health organization prediction of the world causes of death, it was found that in year 2004 road traffic accidents was the ninth death leading, however, predicted to be the fifth death leading by the year 2030 if less effort is taken in the areas of road safety, accident investigation, and countermeasures implementations.(1)

b) Research by Transport Research Laboratory (TRL) has estimated about 750,000 people were killed in road accidents globally, of most concern was that about 640,000 of these, that is, 85 percent occur in developing countries or emerging nations. Hence, there is a great need to focus much more effort in the Third World countries.(10)

c) According to statistical comparison tools of death per 10,000 registered vehicles as used by most countries of the world, Nigeria has the highest accident per 10,000 registered vehicles having accidents rate up to a hundred times greater than developed countries like the United Kindom, Sweden or Japan. (11)

d) Finally from the accident record of Kano-Maiduguri road as presented in table 1 above it indicates there are a higher percentage of truck accidents and fatality from truck involved accidents the road, having 137, 115, 124 and 91 total accidents in 2010, 2011, 2012, and 2013 having 19%, 20%, 15% and 18% truck accidents out of the total in years respectively and resulted in 41%, 40%, 38% and 36% fatality out of the total fatalities on the road.

1.5 Scope of the Research

The scope of the thesis may involve the detail data collection of all truck accidents of the road network, a detail data collection of the participants, the vehicles and the road using European Truck Accident Causation study (ETAC) questionnaire and manual, collecting all other relevant information from hospitals, road transport authorities, road transport union and eye witnesses. Finally, analyzing the collected information to determine the main causes of the accident and propose appropriate countermeasures through reconstruction of the accident.

1.6 Aim of the Research

The aim of the research is mainly to test a modified European truck accidents causation study methodology (ETAC), on a Nigerian Road network, through an in-depth accident analysis, for its technical and operational feasibility in determining accident causes and contributing factors, using its experiences gathered in European Truck Accident Causation Study project conducted in seven member states of European commission for the period between 1st April 2004 and 30th September of data collection by teams of multidisplanary members.

1.7 Objective of the Research

Currently, only limited statistics are available regarding accidents involving trucks and even less is known about the cause of these accidents. To fill in this lack of knowledge, the European Commission (EC) and the International Road Transport Union (IRU) launched a unique scientific study, the European Truck Accident Causation study (ETAC). A modified European Truck Accident Causation Study (ETAC) methodology would be used in the case study with objectives as follows

a) To test the modified European Truck Accident Causation Study (ETAC) methodology on Kano – Maiduguri road, Nigeria

b) To identify the main cause and the causal sequence of accidents involving trucks,

c) To make the results available to the research community and other relevant parties,

d) To recommend actions that could reduce truck accidents and/or their seriousness

CHAPTER TWO

2 ACCIDENT INVESTIGATION METHODOLOGIES

2.0 Introduction

As in many developing countries also in Nigeria, accident trends are presented annually based on the official national accident statistics. These accident statistics use the data from police accident reports, and Nigerian road safety commission. Although these statistics are useful, a limitation is that very little information about how accidents occur, the cause of the accident and the injury mechanisms is available. This limitation can be overcome by carrying out specialist in-depth accident investigations, collecting more detailed information than available in the police records. According to many safety organizations and standards the investigation should be carried out by an independent organization aiming at finding the sequence of events before and after the accident, in un-bias method so as to prevent the re-occurrence of similar accident type by proposing a countermeasure.

2.1 Independent Accident Investigation

The concept of independent accident investigations into the causes of accidents and the issuing of recommendations to improve the safety of transportation was established in the USA, where in 1967 the National Transportation Safety Board (NTSB) was founded. The NTSB was the first independent investigation agency in the world to cover all modes of transportation; aviation, maritime, railways, roads and pipelines. (12)

In Europe after an Amsterdam conference in 1987, the positive experiences regarding joining efforts of all modes of transportation convinced other countries of the usefulness and need to promote this philosophy of independent investigations. In 1990, the concept also became reality in Sweden with the foundation of the Staten Haveri commission and in Canada with the Transport Safety Board of Canada.

During the First World Congress on safety of Transportation on the initiative of Delft University of Technology in November 1992, the chairmen of the transportation safety board's of the USA, Canada, Sweden and the Netherlands agreed to start working together on the establishment of an international association. (13)

The objectives of the association were formulated as:

- **i.** To improve transport safety by learning from each other
- **ii.** To make information available into the causes of transportation accidents, to exchange information on causes, safety studies, recommendations, accident data, investigation methods and techniques
- **iii.** To share information on implementation of important safety recommendations
- **iv.** To conduct periodic conferences, to discuss investigation methodologies and techniques, open to all segments of the transportation community. (13)

a) United Kingdom

In-depth accident investigations have a long tradition in the UK. The Co-operative Crash Injury Study (CCIS) was now in its seventh-phase and has been running for 30 years been an independent accident investigation. Its funding is mixed: public (Department for Transport) and private (Ford, Toyota, Nissan, Visteon, Renault and Citroen). It involves in retrospective crash examinations, completed with hospital and coroners re-port. CCIS assesses vehicle crash worthiness and injury causation and the results are used for new product specifications and consumer crash testing. CCIS crash investigation teams are based at Loughborough and Birmingham Universities, as well as in the Vehicle Inspectorate Executive Agency. The On-The- Spot (OTS) study is funded by the Department of Transport and investigates vehicle, road and human factors in accident causation in direct support of the UK casualty reduction target. OTS covers all road user types. (14)

b) Sweden

The Swedish Accident Investigation Authority (Statens haverikommission - SHK) is a state authority with the task of investigating accidents and incidents with the aim of improving safety (15). The Swedish Accident Investigation Board is a true independent organization, with a budget of its own and the possibility to ask for special grants in certain situations. It consists of a group of law-schooled experts for all the transport modes, who takes the lead in the investigation team set up for each occasion. Technical expertises are selected from a group of independent experts, some of which are closer (or permanently) connected to SAIB. Recommendations are issued in each case and are followed-up by SAIB as well as the Swedish Road Traffic Inspectorate (SRTI).

Besides the basic statistical level registration of data about all police reported accidents. There are three levels of in-depth studies in Sweden:

i. Independent investigations initiated and performed by the Swedish Accident Investigation Board (SAIB), carried out on fatal accidents with more than 5 fatalities.
ii. OLA-studies of facts, solutions and intentions for preventive measures. These cases are selected among fatal accidents by staff members of the Swedish National Road Administration (SNRA) together with the Regional Road Administration (RRA) offices, and the studies are decided by the Director General of SNRA together with the Director of the region in question.
iii. In-depth studies of all fatal accidents initiated and performed by staff members of the Regional Road Administration offices, according to the ordinance with instructions to SNRA.

c) German

In Germany the first so-called ‘’In-Depth Investigation Teams “were initiated in the 1970s by German automakers. In 1973, the Federal Road Research Institute established an independent team at the Medical University of Hanover (in cooperation with the Technical University of Berlin). By 1984, this developed into a long term on-scene accident research study (16), based in a defined geographical area surrounding and including Hanover, which collected representative.

The German In-Depth Accident Study “GIDAS” project is jointly financed by the German Government and Automotive industry. The budget is approx, One million Euros per year for the total cost of each of the two projects-areas. The investigated regions are the Hanover area as well as the Dresden area.

Over the years, the German In-Depth Accident Study (GIDAS) project has seen several improvements in various fields of the accident data acquisition process. This includes: (17)

i. Inclusion of primary safety systems.
ii. Analysis of accident causation.
iii. Improved data management and distribution.
iv. Generation and maintenance of multilingual documentation closely tied to the database structure.
v. On spot digital recording and leveraging of a variety of technical third-party data sources.
vi. Introduction of AIS 2005 and a corresponding diagnostic dictionary.
vii. Program for classification of fractures.

d) Turkey

In Turkey traffic accidents investigation is lake in many developing countries, is carried out by police department mainly for litigation purposes, statistical analysis and insurances.

According to the traffic acts/Laws, crash investigation is carried in order to provide detection of violation and violator with evidences and to detect a causal link between behavior and result. Then the accident report is issued. The investigation is carried out by traffic police with traffic expertise after receiving 70 hours accident investigation training in accident investigation department. Finally the acquired information is processed on POLNET accident database, and is used to eliminate the causes affecting the occurrence of the crashes. Accident report, issued after the completion of crash investigation, is submitted to judicial authorities for judgments and penalties. However, in some instances, courts appoint other expertise to help in finding the violator such as (18);

i. Forensic Medicine Specialized Boards of Traffic
ii. Technical Universities
iii. General Directorate of Highways
iv. Mechanical engineers are assigned as expertise regarding the detection of technical defects of vehicles, whereas civil engineers for defects of the road.

2.2 Definitions of Accident Investigation

Road accident investigations are currently conducted by a number of different organizations and take a number of different forms. In this thesis the following definition should be applied:

Accident: There are many definitions of accident. Most books agree that an accident is an undesired event that causes injury or property damage. (Bird and Germain 1985) "That occurrence in a sequence of events that produces unintended injury, death, or property damage" (National Safety Council 2001, viii)

Accident Investigation: An accident investigation is a structured process that attempts to uncover the sequence of events that produced or had the potential to produce injury, death, or property damage to determine the causal factors and corrective actions. (Sorrell 1998). The standard definition is the analysis and evaluation of an accident to determine the specific root cause or causes of the accident. (Clifton A.2000)

In-depth Investigations: (independent as well as non independent) Detailed multidisciplinary investigations with a high number of variables (the number of variables usually varies from a few hundreds of more than a thousand). The aim is to prevent the re-occurrence of serious accidents by discovering structural failures and proposing corrective measures.

Independence: when applied to in-depth road accident investigations, as "the structural (this is to say, separated from authorities and with a clear legal status) and financial (yearly stability of funds) ability to decide WHAT and HOW to investigate, and also to PUBLISH the results of the investigations".

Causal Factors: Causal factors are events and circumstances that lead to an accident. Causal factors incorporate "root causes", "immediate causes", lower level courses, and upper level courses. When discovering causal factors, it is important to analyze all cases at all levels. (Clifton A.2000). Factor has been defined as 'any circumstance connected with a traffic accident without which the accident could not have occurred'. However, this factor alone 'is not sufficient itself to cause an accident' (Baker and Ross, 1961).

Emergency Services: The services which can be accessed by dialing the Member States' emergency number (e.g. 112), including Police, Fire and Rescue, Ambulance service. (19)

Stakeholder: the groups and individuals, who are in a position to take action, through policy or practice, to improve road safety or who gather, manage or hold accident related information, useful to road safety. (19)

2.3 Theories of Accident Causations

Every study needs a theory as a frame to interpret data and lead them to 'results'. Without a clearly defined theory, every analysis is subject to biases by implicitly referring to naïve theories. In the absence of a well defined model of reference, analyses of accidents indeed tend to produce typologies which mix up very disjoined phenomena, putting, for example on the same level: maneuvers, processes, factors, consequences, types of collision, etc. Thus, to understand accident data we need to rely on an accident production theory, even more when thinking to integrate the complex human component in this analysis. (20)

Most of these theories have been used in road safety, still today, focusing on one specific point. But the road accident remains more complex than in other domains, because the human is at the center of the regulation. He has to interact with the machine (drive his car: hold the steering wheel, change direction, brake, change gear, accelerate, look at mirrors, etc.), to interact with an unsettled environment (lighting conditions, weather conditions, road surface, road geometry, road signs, etc.), to interact with the other users (pedestrian, 2 wheeler users, etc.). All these factors and interactions make that the accident causes are multiple, not unique, can be independent of each others, not having the same end, with different degree of implication. (21).

To understand the causes of accidents in order to be able to identify effective means for their prevention, several theories of accident causation have been proposed coming most of them from accident prevention in enterprise the following are some of the theories used:

a) **The Domino Theory**: developed in 1931 by H. W. Heinrich; it states that an accident is only one of a series of factors, each of which depends on a previous factor in the following manner (Heinrich 1980): (21)

i. Accident causes an injury.
ii. Individual's negligent act or omission, or a faulty machine, causes an accident.
iii. Personal shortcomings cause negligent acts or omissions.
iv. Heredity and environment causes personal shortcomings.

The model relies on the facts that 88% of accidents caused by unsafe acts, 10% by unsafe conditions and 2% are unavoidable. The more remote causes of accident consisted of the environmental and social conditions, controlled by the management, within which the accident occurred. On this basis an accident investigation model can be developed.(21)

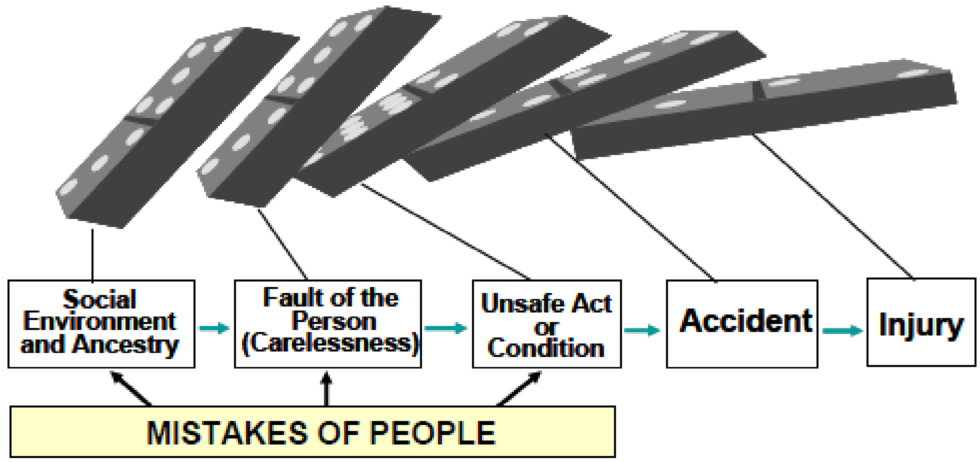


Figure 2 Showing the Domino theory of Accident Causation

b) **The "Human Factors" Theory:** The accident causation can be attributed to a chain of events ultimately caused by human error, driven by overload (due to environmental factors such as noise, distraction, or internal factors - personal problems, emotional stress or situational factors unclear instructions, risk level), inappropriate response/compatibility (like identifying hazard but not correcting it, remove safeguards, ignoring safety , etc.) or inappropriate activities (performing tasks without the requisite training, misjudging the degree of risk involved with a given task, etc.). (21)

c) **The "Accident/Incident" Model:** Petersen developed this model (1975). It is an extension of Human Error Theory by adding ergonomic traps and decision to err. This theory also includes system failure as a cause of accident. (21)

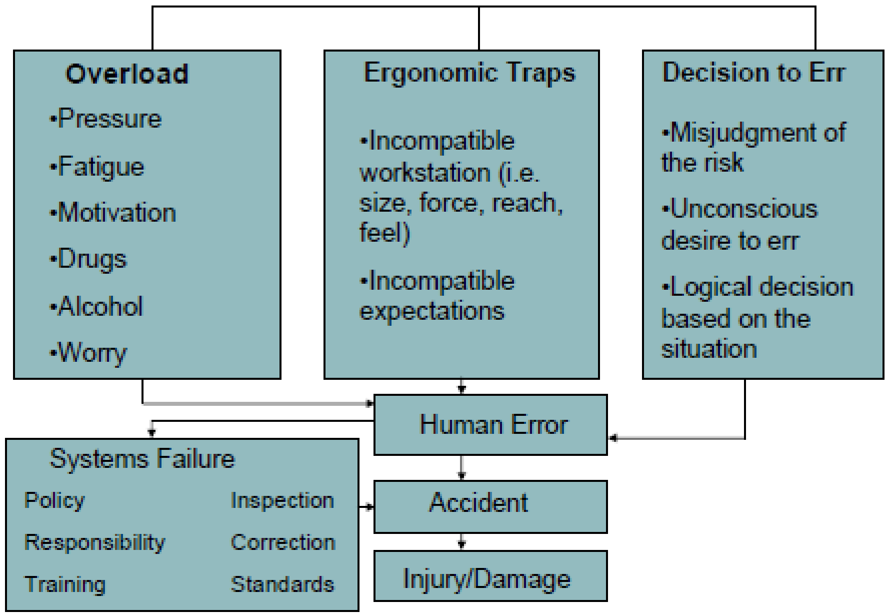


Figure 3 showing The "Accident/Incident" model

d) **The Epidemiological Theory:** Traditionally, safety theories and programs focused on accidents and injuries. Industrial hygiene may lead environmental factors that can lead to sickness, disease, or other forms of impaired health. Epidemiological theory studies the relationship between environmental factors and accidents or diseases. The model is based on the identification on two characteristics : (21)

i. Predisposition characteristics related to susceptibility of people, perceptions or environmental factors;

ii. Situational characteristics such as risk assessment by individuals, peer pressure, priorities of the supervisor, or attitude, etc.

The two characteristics, taken together, can result in conditions that might result in accident or illness. For example, a worker who is susceptible to fair pressure is more likely to have an occupational accident or illness.

e) **The “Systems” Theory:** The notion consist to consider accident causation as a system, a system being a group of regularly interacting and interrelated components that together form a unified whole. System theory views a situation in which an accident might occur as a system comprised of three components: the person (host), the machine (agency) and the environment. The likelihood of an accident is determined by how the three components interact. In industrial environment, five factors have to be considered: job requirements, the worker’ abilities and limitations, the gain if the task is successfully accomplished, the loss if the task is attempted but fails, and the loss if the task is not attempted. (22) the most fruitful -and shared among the community of safety researchers approach appears to be the so-called 'systemic approach'. This approach assumes that the components that comprise the transport system include: the users, the transport tools and the infrastructures used. (20)

Systems Theory Applied to Transportation Engineering

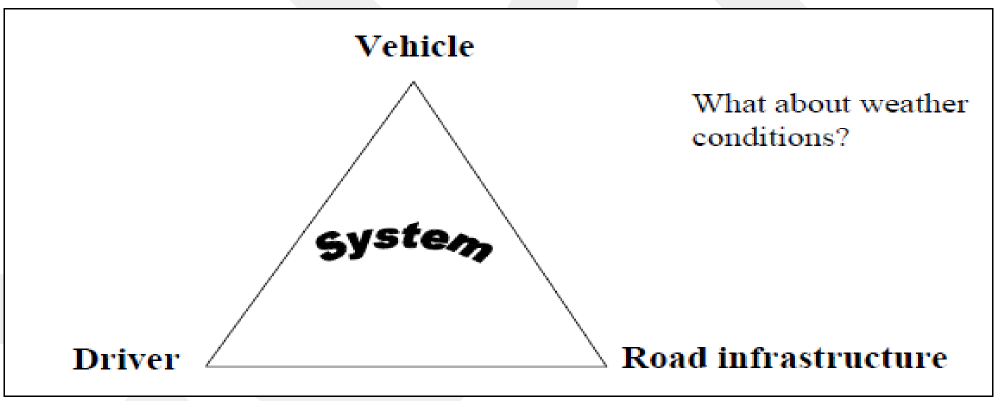


Figure 4 Showing Systems Theory Applied to Transportation Engineering

Road accidents are seen as failures of the whole traffic system (interaction between the three elements) rather than a failure of the driver alone.

f) **The “Combination” Theory:** This theory starts from the fact that for some accidents, a given model can explain why accident happened and for others, the model cannot explain. According to the combination theory, the actual cause may combine parts of several different models. This theory is suitable for accident prevention and investigation.(21)

g) **The "Behavioral" Theory:** Often referred to as behavior-based safety (BBS). It is based on the 7 following principles: (21)

i. Intervention
ii. Identification of internal factors
iii. Motivation to behave in the desired manner
iv. Focus on the positive consequences of appropriate behavior
v. Application of the scientific method
vi. Integration of information
vii. Planned interventions

2.4 Theories of Accident Analysis/Reconstruction

Accident analysis is a process of facts gathering, comparison of facts to find out the causes of accidents, while accident reconstruction is the process of obtaining pre/impact/post crash activities by the drivers, on the vehicle and on the road. An accident reconstruction is based on the three laws of physics, which have to be used by the investigator in order to define parameters such as initial speeds and post crash speeds. These laws can be used separately (if only one variable is unknown) or combined (if more variables are unknown).

These three laws are:

i. Conservation of energy
ii. Conservation of linear momentum
iii. Newton's second law

2.3.1 Impact Theory of Galilei, Huygens and Newton

The goal of this theory was to predict the behavior of colliding objects. The theory focus on the velocity at the end of the impact calculated from the velocity at the beginning than the determination of the force of impact and the chronological process.

The following assumptions are made:

i. Duration of the impact is short and the forces are huge
ii. All external forces are small comparing to the momentum and negligible
iii. The time integral of momentum is finite
iv. Conservation of kinematics configuration during impact
v. Deformation of the bodies during the impact are not counted in the calculation

2.3.2 The Three Fundamental Newton's Classical Laws

Isaac Newton, born in Woolsthorpe, England (A.D. 1642-1727), was a mathematician and physicist. Newton first stated these laws in his Principia published in 1687.

Newton's First Law of Motion: Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it.

Newton's Second Law of Motion: The relationship between an object's mass m, its acceleration a, and the applied force F is F = ma. Acceleration and force are vectors (as indicated by their symbols being displayed in slant bold font); in this law the direction of the force vector is the same as the direction of the acceleration vector. F is the acting force, m the mass of the body and an acceleration of the body due to the acting force.

Newton's Third Law of Motion: Action and reaction are equal and opposite, i.e. when two bodies interact, the force exerted by the first body to the second body is equal and opposite to the force exerted by the second body on the first.

Newton defined the collision into two phases: the compression and the restitution phase. In case of a full impact, at the end of the compression phase the velocities of both vehicles at the impulse point are identical. Due to elasticity of the vehicle structures, the two vehicles will separate again.

Conservation of energy

The principle states that the amount of energy in a closed system is constant, regardless of the changes in the form of that energy. Energy can neither be created nor destroyed.

Therefore the kinetic energy before the impact equals the kinetic energy after the impact plus the energy loss:

Energy can be lost during the impact due to:

i. Deformation of vehicles
ii. Rotation of vehicle
iii. Friction between tires and pavement
iv. Sound due to impact

The energy loss due to deformation is the most important value, because its amount is much greater than the other losses. The other losses are difficult to be defined, because of the unknown parameters that are depending on (e.g. duration of impact, moments of inertia of vehicle, centre of gravity of vehicle). Since they are typically one order of magnitude smaller, they are most often neglected. A parameter, which is commonly used to define the deformation energy loss, is the Energy Equivalent Speed (EES).

Principle of linear momentum:

Momentum is the product of inertia and velocity. During any collision, momentum is conserved as a consequence of Newton's 3rd Law - the Law of Action-Reaction. So momentum means the tendency of an object in motion not to slow down. What this means is that the total momentum before a collision is always equal to the total momentum after a collision.

2.4 Accident Causations

Accidents are generally cause by many factors links with many events. However, these factors are grouped into three main groups which include; human factors, infrastructure/road factors and vehicle factors. According to a report by the World road association (PIARC), road traffic accidents are caused by three main factors with each contributing human behavior factor 93%, road factor 34%, and vehicle factor 13% (23). Another study by European Truck Accident Causation study (ETAC), the results of the study showed that 85.2% of the collisions were linked to human error on the part of one of the road participants (truck driver, car driver, pedestrians) as opposed to technical or infrastructure related problems. However, the study found that out of the collisions linked to human error, only 25% are caused by the truck drivers (24). The main errors for collisions between a truck and other road user were: non-adapted speed, failure to observe intersection rules and improper maneuver when changing lanes. (24).

A review of the literature and current accident studies confirmed that the problem with many accident causation coding systems currently used across Europe is that they do not separate the 'errors' (or human failures) from the 'factors' which lead to these failures. As it is shown in the fig.2.4 below the system always comprises three components that is the driver, the environment and the vehicle, the problem in their interaction resulted in failure or accident.

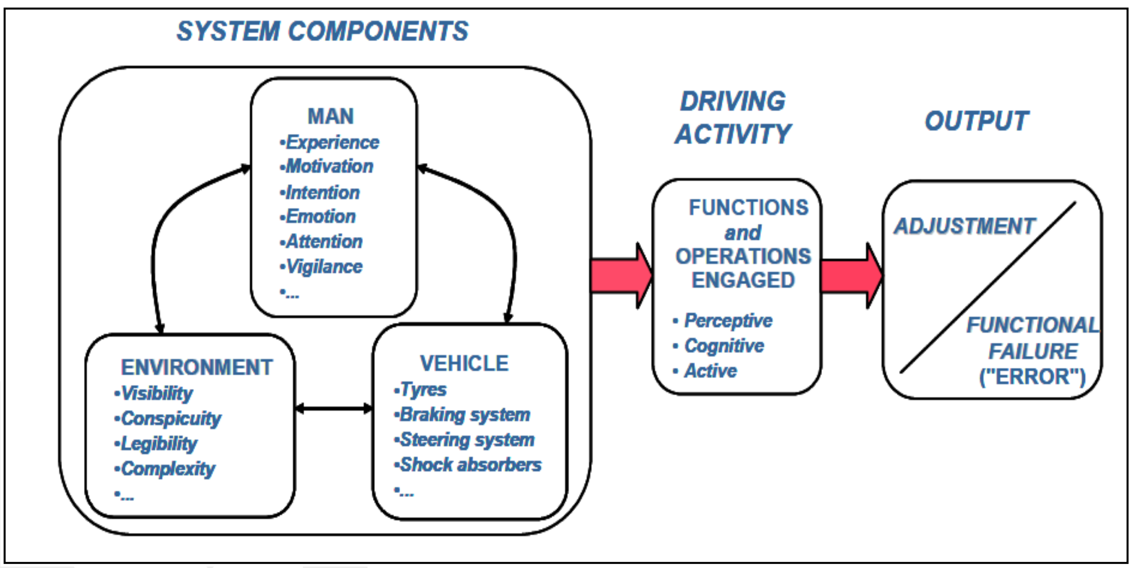


Figure 5 Showing How Road Traffic Accidents are Caused

2.5 Review of Existing Practices Regarding Accident Investigation in Nigeria

Nigeria is like other undeveloped countries, with some accident investigation practice mainly conducted by traffic police and road safety officers, focusing higher attention on litigation purposes, below will be a detailed explanation on how the accident is investigated, agencies involve and basic procedure.

2.5.1 Accident Emergency Organizations in Nigeria

The main organizations involved in emergency response in Nigeria include Nigerian police force, the Road Safety Commission and fire brigades. For the purpose of handling crisis and emergency related incidents, the three different Organizations receive reports or alarm from the general public and respond, in accordance with emergency response procedures;

i. The fire department provides firefighters to deal with fire related rescue operations.
ii. The police force is responsible for providing community safety and acting to reduce crime against persons and property.
iii. The Nigerian Road Safety Commission ensures the safety of road users by responding to road traffic crashes. (25)

2.5.2 Accident Investigation Agency in Nigeria

a) **Police Authorities**; Police authorities have specific duties and functions in the context of accident occurrence, which are regularly defined by law. Because of their position and their mandate in society. This leads to a strictly formalized process without any adaptation to the specific situation. The standards are in common useful and sufficient, but in specific situations, some important facts may get lost. The duties to be fulfilled by Police forces are:

i. Providing safety at the accident site for the road user and the traffic situation, assistance to injured persons
ii. Juridical examination with first decision who is to blame, and documentation of proofs and witness testimonies
iii. Protecting the rights of the victims involved in the accident
iv. Recording of data for prevention purposes
v. Recording of statistical data regarding the statistic regulations by law (26)

b) **Nigerian Road Safety Commission;** As mended by law Nigerian Road Safety Commission has been assigned to investigate all road traffic accidents in Nigeria. The

Commission assigns road collision investigators who work in close cooperation with police authority and other stakeholders. The responsibilities of the Commission can be summarized as follows:

i. To make the highways safe for motorists and other road users.
ii. To recommend works and devices designed to eliminate or minimize accidents on the highways.
iii. To give prompt attention and care to victims of accidents.
iv. To conduct researches about the causes of motor accidents and to propose methods of preventing them together with making research results available to the different parties.(27)

2.5.3 Emergency Call System in Nigeria

i. The primary mode of receiving emergency reports is via telephone calls by civilians or officers on patrol to the Rescue Officer who is responsible for deploying team members to the scene of the accident.
ii. The location information required when an incident is reported includes; the location of the accident i.e. the specific route the accident had taken place and the location of the accident.
iii. The rescue officer usually assigns rescue team, the typical rescue team consists of four members, a driver, rescue team leader as well as two other team members. The officers communicate with each other via the use of standard issued cell phones.
iv. The team leader is the point of contact between his team members and the unit command. He is in charge of keeping the unit command updated on the status of each incident. (26)

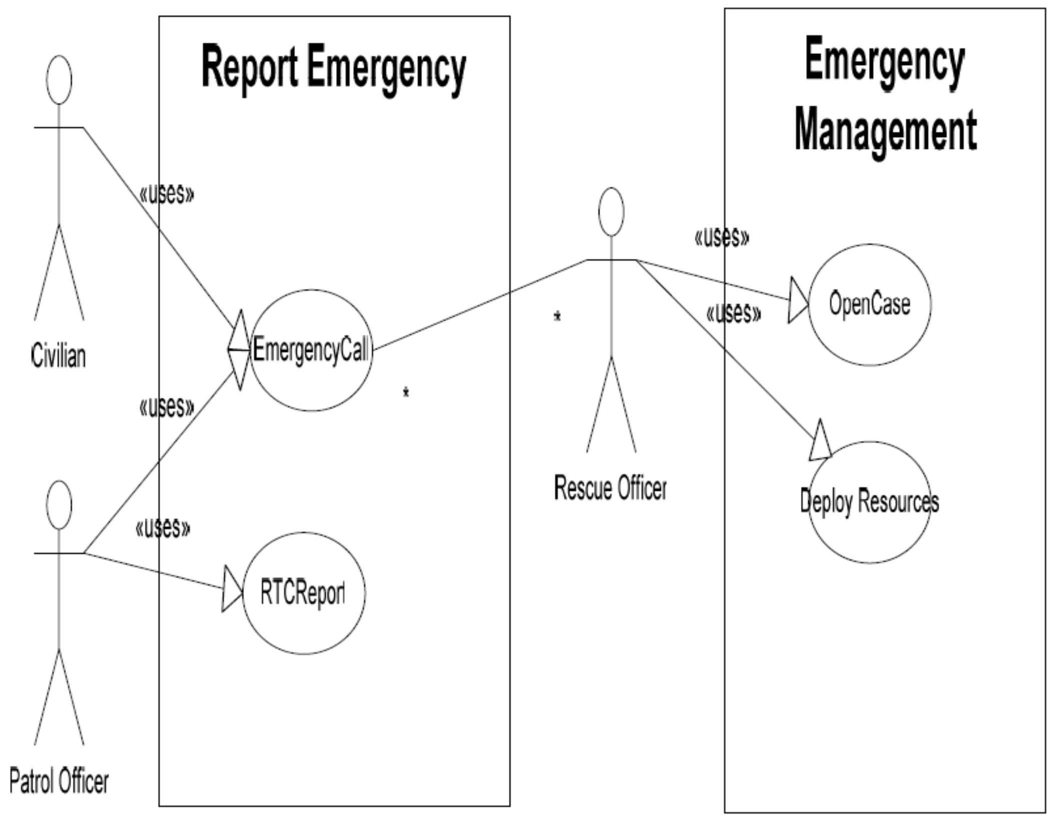


Figure 6 Use case diagrams for emergency operations of the Road Safety Commission

2.5.4 Nigeria Road Safety Accident Reporting System

Two Accident reporting system are practiced in Nigerian, for accidents involving less than six persons fatalities and accidents involving greater than six persons fatalities. The procedure for the two accidents reporting and investigating system are presented as follows;

a) Accident With Less than Six Persons Fatality

For accidents involving fewer than six person's fatalities, that is properties damage accidents, injured only accidents and accident with one, two or three persons fatality only on scene investigation is carried out, using crash information form. The investigation process in summarized as follows;

i. After receiving accident notification by either public or officer on patrol, rescue team are organized and send to rescue victims, admit first aid to the victims, transport the victims to the nearest hospital.

ii. After successfully managing an incident, the team leader of the rescue operation would be responsible for the filing of Road Traffic Crash reports via email to the Nigerian federal road safety Headquarter.

iii. The contents of the report includes; the command code, time of accident, route, location, number of people involved, number of injured which includes the number of females, males and children involved, the number of people killed and the cause of the accident. He is also expected to submit a hard copy of road traffic crash report form to the unit command. (26)

b) **Accident with More than Six Persons Fatality**

With accidents involving higher fatality of six and above, Nigerian road safety commission apart from the three aspects of reporting and recording of accidents, the unit command responsible for that accident investigate the accident through its accidents investigation unit. The investigation procedure is as follows;

i. After receiving accident report from rescue team, by the command with six or more fatalities, the command director writes a memo attached with the accident report to research and statistic department to investigate the accident.

ii. Upon receiving the department appoint a team of five persons to go and take measurement on the road and vehicles evidences including dimension of the road, the rest position, dimension of the vehicle damage on the vehicles.

iii. The team analyzed the collected data by experience to conclude about the causes of the accidents.

iv. Finally, presented a report to the unit command with respect to the accident

2.5.5 Limitations with the Available 'Accident Reporting and Analysis System' in Nigeria

At present with the available system in Nigeria, road safety investigation and statistical information provide quite a limited insight into the causes and preventive measures of road accidents. Because;

a) Statistical data are very weak when it comes to analyzing the causes of accidents in a technical way. Similarly, it is also limited when the focus is on prevention of accidents as well as developing improvement measures.

b) Evidence information collected by the Police have usually been used to blame the parties or for the liability allocation. This reduces the possibilities for understanding the accident contributing factors that are needed to understand the complex causal processes from the Police report.

CHAPTER THREE

3 EUROPEAN TRUCK ACCIDENT CAUSATION STUDY METHODOLOGY

3.0 Introduction

Road safety is a major pre-occupation of the European Commission and the road transport industry and it depends on numerous significant factors. In order to improve road safety and to plan effective safety improvement actions for truck transport, we must first identify the problems to be addressed, i.e. what are the main causes of truck accidents. (27)

The European Truck Accident Causation Study ETAC project, initiated by the European Commission and the International Road Transport Union (IRU), was launched in order to set up a heavy goods vehicle accident causation study across European countries to identify all accidents contributing factors and future actions which could contribute to the improvement of road safety. (27)

The results are based on a detailed analysis of truck accident data collected in seven European countries, according to a common methodology which has been elaborated through numerous national and European projects.(27)

3. 1 Review of ETAC Methodology

3.1.1 Accident Investigation Procedure

In accordance with European Truck Accident Causation Sturdy (ETAC), accident investigation is carried out in four stages, including First on-scene data collection of (Driver, Vehicle and Road), a detail data collection of (Driver, Vehicle and Road), Case analysis and accident reconstruction as presented in figure 7

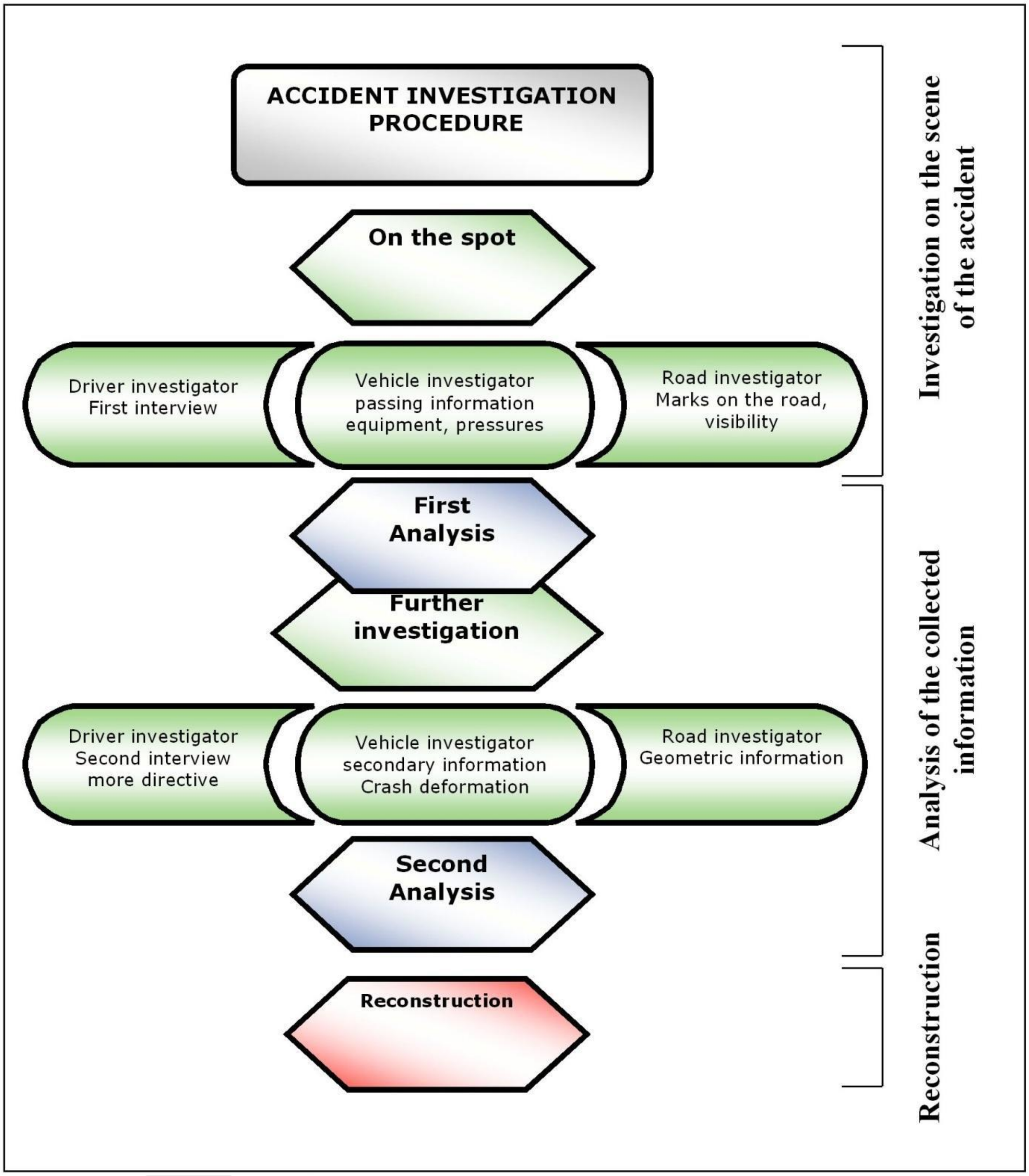


Figure 7 In-depth Investigation Method from the ETAC Main Report

3.1.2 On-Spot Investigation

It has been proven that the best way to understand the causation process is to go to the scene of the accident as soon as the accident occurs. The team is expected to collect all data that vanish with time related to the driver, the vehicle and the road during the first visit to the accident scene.

i. **Driver investigation;** the team leader interviews drivers on the scene of the accident, collect basic information and establish contact with the driver or witness.

ii. **Road Investigation;** the team member obtains transient data, including final position, skid marks, point of impact from the road.

iii. **Vehicle Investigation;** the team members take photographs of the vehicles in their final position, the deformations, the state and use of vehicle equipment, load, and examine the use and the state of the various equipment (lighting, radio/telephone, seat position and belt use, gear level position, tire pressure). (27)

3.1.3 Detail Investigation

The team members during the subsequent visit to accident Participants, the accident site and the involved vehicles, undertakes a detail data gathering with questionnaires or checklists

i. The "driver investigator" meets the driver once again, at hospital or at home, to discuss personal and medical details, general driving habits, training, previous accidents and sanctions, before coming back to the accident situation.

ii. The Road, further detail about the road geometry, and traffic conditions (density and speed) and filling all other parameters in the questionnaire that are related to road, during the subsequent investigation.

iii. The Vehicle, the team carries out a more in-depth data gathering on the vehicle, including engine, braking, steering systems, other equipment and its condition and detail measurement of deformation which would be used during reconstruction. (27)

3.1.4 Accident Analysis

The methodology recommends analysis of all collected data during the first and subsequent visits based on;

- **i.** Accident types
- **ii.** Failure types
- **iii.** Failure mechanism
- **iv.** Sequence of events (27)

3.1.6 Accident Reconstruction

The methodology recommends reconstructing the accident from the detailed information collected and analysis results using empirical hand calculation or PC-crash software depending on expertise, availability and experience of the team.(1)

3.2 Accident Analysis

Case analysis includes identifying and coding how and why events such as collisions between road users or injuries to road users occurred, and more specific analyses such as vehicle speed, Deformation energy, change in velocity. (28)

The accident analysis is carried out based on;

3.2.1 Analysis Based on Accident types

Accident analysis based on accident types is aiming at grouping accidents based on types as to understand the occurrence level of each type of accident.

The following list represents the accident types used in the Czech Road Accident Typology, which is based on the Austrian version. Accidents are divided into the following 10 types;

- i. Single vehicle accidents.
- ii. Road accidents of vehicles driving in the same direction on the road section.
- iii. Road accidents of oncoming vehicles on the road section.

iv. Road accidents of vehicles entering a junction from the same direction.
v. Road accidents of vehicles entering a junction from opposite directions.
vi. Road accidents of vehicles entering a junction from neighboring lanes.
vii. Road accidents of vehicles and pedestrians.
viii. Road accidents with standing or parked vehicles.
ix. Road accidents with animals and rail vehicles.
x. Other road accidents. (28)

3.2.2 Analysis Based on Failure Mechanism

This type of accident analysis is aimed at understanding the process through which the accident happened;

i. Understanding how the driver acts, what influence his action and the consequence of his action.
ii. Understanding how the environment and the road are, how they contribute to the accident occurrence.
iii. Understanding how the vehicle was and the vehicle contributes to the occurrence of the accident. (30)

3.2.3 Analysis Based Sequence of Events

This type of analysis is aimed at understanding sequences of what go wrong and how it link to the occurrence of the accident;

i. What was the critical event that has happened.
ii. What links to the critical event.
iii. How it was linked. (31)

3.3 Accidents Reconstruction

Is a process through which an accident is normally reconstructed either from the final rest position of the vehicles to the normal driving states or from the normal driving state to the final rest position of the vehicle, in order to find pre/impact/post impact conditions regarding speed, energy. (29)

3.3.1 Reconstruction Parameters

a) Kinetic Energy

The pre-impact motion of a vehicle is characterized by what is called “kinetic energy” or motion energy, which is a mathematical description involving the vehicle’s speed and weight. As a collision commences, the vehicle’s kinetic energy and speed are reduced by

i. The energy lost to the road surface.
ii. Energy lost during erratic motion and/or side-slipping.
iii. Energy lost, resulting from the vehicle damage.
iv. The energy transferred to property such as utility poles, fences, walls.

When the vehicle reaches its Final rest position (FRP), it has zero kinetic energy. The energy method of reconstructing the pre-impact speed of a vehicle includes isolating each event and identifying its energy loss, quantifying the energy loss by the equivalent speed needed to produce each loss, and then adding the equivalent speeds of all the events together using what is called “the combined speed equation” to find the pre-impact vehicle speed. This is usually a minimum speed since some of the energy cannot be quantified. (32)

b) **Energy Equivalent Speed (EES)**

The term Equivalent Energy Speed (EES) has been defined by Burg, Martin and Zeidler in the year 1980 and was suggested for a common use. Equivalent Energy Speed (EES) is a speed measure which will be transformed into deformation energy during the collision.

The plastic deformation energy of the damaged car is expressed as a kinetic energy of the car with the virtual velocity value Equivalent Energy Speed (EES). (29)

c) Speed from Friction Marks Made by Tires

A common crash event involves losing energy (and speed) by transferring it to the road and causing a visible tire mark, skid mark. The equivalent speed of such an event depends on road friction (drag factor), the distance over which deceleration occurred, and the degree of braking, called braking efficiency (BE). These measured quantities can be used to calculate a minimum speed needed to make the tire marks by using the speed from skid marks equation: (32)

S (mph) =√ ((30 (f) * (d) * (BE))…………………………………… (3.1)

Table 1 Drag coefficient Values

Dry asphalt, cement	0.60 -0 .80
Wet asphalt, cement	0.45-0.70
Ice, loose snow	0.10-0.25
Packed snow	0.30-0.55

d) DELTA-V - Δv

The Greek capital letter Δ, pronounced "delta", is used to denote "change of": the letter v denotes velocity. So Δv or "delta-v" means a change of velocity (i.e. from the moment of initial contact between vehicles until the moment of their separation).

Vehicle crush deformation and energy equivalence relationships are technical accident reconstruction tools for estimating the change in velocity during an impact.

Delta-v is a basis for evaluation damage severity and potential injury severity. If the Delta-v occurs over several seconds and is relatively small, it usually causes little or no injury. If the deceleration is high over in a small time, injury or death is usually the result. Remember, it is not the fall that kills, it is the sudden stop. (29)

3.4 Training

Training of team members was carried out with the help of Road Safety Data Collection and Analysis, Road Accident Investigation Guidelines for Road Engineers (PIARC), and European Truck Accident Causation study, manual and questionnaire. The various items discussed during the training are as follows ;(28)

3.4.1 On Scene Team Safety

Accident scene, most of the time is dangerous and hazardous depending on the location and severity of the accident. Drivers' behavior change when they see a serious fatal accident. The purpose of this section is to provide the investigation team with information on how to perform investigations in the safest possible way at an accident site.

The team safety is considered in three stages which includes; (28)

a) **Travelling to the Scene of an Accident**

i. Travelling to the accident scene should always be at allowable legal speed,
ii. The driver must have a valid driving license
iii. When team members do not feel comfortable travelling, the driver should either slow down to an appropriate speed or the job should be abandoned.
iv. If the driver feels over tired, ill or unfit in any other way they must not drive.
v. The vehicle shall not be overloaded to its design carrying weight and tire pressures must conform to the vehicle loading.
vi. The driver and passengers must wear their seatbelts at all times while in the vehicle. (28)

b) **Arrival On-Scene safety**

i. The vehicle shall be parked in a safe place that do not block the emergency services from entering and leaving the accident scene, the Police, and the normal traffic flow on the road if the road is not closed by either police or rescue service.

ii. On arriving at the accident scene, the team leader shall observe within the first minute if the accident site is regarded as safe.

iii. The team leader shall make contact with the rescue services commander or police, introduce themselves, ask for a permission where they are allowed to work, ask about any restrictions.

iv. If at any time any team member feels unsafe or threatened (and this cannot be resolved immediately) then the team should stop the investigation and leave the scene. (28)

c) **Making the Site Safe**

i. All team members should wear suitable protective clothing thick protective gloves, reflection jacket, and safety boot to avoid contamination by oils, fuel, greases glass and jagged metal edges.

ii. Team members should always be aware of the risk of moving traffic, and the possibility of further vehicles intruding into the accident scene.

iii. Emergency lights should be set up if required. If necessary, have someone alerting oncoming traffic ahead of the potential danger of the team working on the road.

iv. The team should place cones and signs where appropriate.

v. The cones should be placed out from the "front" of the crash scene rearwards, to protect the person coning out, as they are placed within the coned-off area heading forwards.

vi. When retrieving the cones, the person collecting them should start at the rear of the scene and walk forwards, to protect them from walking in live traffic. (28)

3.4.2 Interview Guidelines

The interview guidelines are introduced to the team members for understanding how to establish a good interview relationship, how to engage the person in the interview, which questions are to be asked, and how to manage interventions from other people in the case where others are present. (29)

a) Depending on accident circumstances First interview on-scene or at hospital emergency room shall be relatively brief.

b) Follow-up interview a complementary data collection interview shall be conducted within 48 hours of the accident. The investigators should direct their questions based on their initial understanding of the accident, resulting from the initial interview and an examination of the first data collected by the team at the accident scene.

c) Introduce oneself by name and role, do not hesitate to give your name

d) Brief introduction of the project and its purpose

e) Present the frame and the purpose of the work. Keep explanations concise

f) Reassure the interviewee by stating the ethical guarantees of non disclosure of the contents of the interview to the police or judges.

g) Request from the interviewee to explain "How did this accident occur? And remind him/her that this study can allow the prevention of other accidents.

h) Three distinct phases in the interview are recommended which are; a first phase (Open Phase) of listening centered on the progress of the accident, a second phase (Deepening Phase) of gaining a deeper understanding and questioning on this progress and a third phase (Filling-in Phase) centered on the contents of the information in the questionnaire.(29)

3.4.3 Participants, Interview

The team members were trained on how, when and what to obtain from the accident victims including drivers, eye witness about the accident to enable the team in understanding what how and why the accident occurred.

Depending on the condition of the interviewer the interview is carried out either at the accident scene or at a subsequent time at hospital or victim's residence.

a) On-scene; contact the crash participant on-scene, to ask basic questions and obtain basic information such as;

i. Permission to participate in the program

ii. Personal status; (name, sex, address, phone, mail)
iii. State of the driver or rider (Long and short-term illness, Intoxication level, Use of other drugs)
iv. Accident and emergency situations (perception, understanding, actions)

b) Subsequent Interview is to be conducted within 48hrs of the accident occurrence, with much more details of driver information using a questionnaire, information to be collected are detail in Appendix E with summary as follows;

i. Driving license for this vehicle (available or not, training, date)
ii. Driving experience with this sort of vehicle
iii. Previous accidents
iv. Trip in progress (type, purpose, destination, the choice of the itinerary, the start of the trip, the frequency). (27)

3.4.4 Vehicle Inspection

The team members are trained on vehicle data collection that describes the involved vehicles, including general vehicle information, its condition, and damage, safety equipment, to a level that will enable a detailed case analysis and accident reconstruction. The detail information is given in questionnaire includes; (27)

i. Photographs of the vehicle exterior, interior and accident traces
ii. General information about the vehicle (e.g. Make, model, engine, gearbox type, cargo)
iii. Deformations of the vehicle due to the accident
iv. Exterior observations (e.g. Functionality of doors, deformation of door hatches, damage to windows)
v. Interior observations (e.g. Intrusions, information on airbags and seat belts, seat positions, marks from passengers due to a collision)
vi. Vehicular Event Data Recorder information (if applicable)

vii. Identification of vehicular safety systems from inside and outside the vehicle (including ABS, electronic stability program, lane departure warning, Antilock system, cruise control, etc.) (27)

3.4.5 Infrastructure Inspection

The team members were trained on the importance and necessity of the Road related data that would help in analyzing and reconstruction of the accidents. The Information is categorized into transient and permanent. (29)

The transient information is the information on the road which could not be permanent on the accident scene, which to be collected by the team during the On-scene first visit including;

i. Weather conditions; (dry, fog, rain, snow)
ii. Position of accident; (travel direction of involved participants, location - traffic lane, shoulder, roadside)
iii. Temporary obstacles; (Parked vehicles)
iv. Accidents produce marks; (Skid marks, yaw mark)
v. Material left; (Glass debris)

Permanent information, are the information that do not vanish with time which the team could delay during on-scene visit to later time including;

vi. Road description (tangential section, type of intersection, road number, road category, cross section)
vii. Specific places/objects; (pedestrian crossing, rail crossing, bridge, tunnel, bus/tram stop, parking place, petrol station)
viii. Road alignment; (evident deficiency or not, slope, narrowing)
ix. Road surface; (type, permanent state, actual conditions e.g. snow, wet surface)
x. Road signs and marking; (availability, condition, location)
xi. Roadside obstacles; (tree, column, bridge)
xii. Visibility conditions; (clear, limited by alignment, vegetation, obstacles) (27)

CHAPTER FOUR

4 RESEARCH METHODOLOGY

4.0 Introduction

This chapter describes the methodology that has been used in Nigeria in the thesis case study, which was prepared after reviewed of the original European Truck Accident Causation methodology study (ETAC). The European Truck Accident Causation methodology study (ETAC), was initially prepared by (Centre Européen d'Etude de Sécurité et d'Analyse des Risques), (CEESAR), using its experience gained from over 10 years of accident data collection and it was used for European Truck Accident Causation study (ETAC). (27)

Simplification of the original European Truck Accident Causation study methodology (ETAC) became necessary due to the large coverage of the original methodology. It involves thousand of accident investigation experts from seven different countries investigating about 3000 parameters in every accident.

4.1 Investigation Procedure

In accordance with the applied methodology, the investigation would be carried out in six different stages, covering team organization, data collection, analysis, reconstruction and conclusion. The procedure stages for the case study were presented in figure 8 as follows:

a) Organization of team members; The team leader always organized and informed the team member through phone calls about an accident and time to visit the accident scene.

b) First Scene Visit; mainly information related to the general information, road, vehicle and making contact with the driver were carried out during the first visit of accident scene using modified European Truck Accident Causation study (ETAC) questionnaire.

c) Second Visit; this visit were carried out within 48hrs of the accident occurrence, mainly to the driver to obtain detailed information about the driver, driving situation accident narration from the driver using a driver modified questionnaire.

d) Third Visit; the team re-visited the accident scene for the second time to obtain all other information which was not filled during the first visit.

e) Analysis; the team members study the filled questionnaire for the presence of mistakes and omissions, analyzed the accident based on accident mechanism, the sequence of events, and system analysis to understand the causes of the accident.

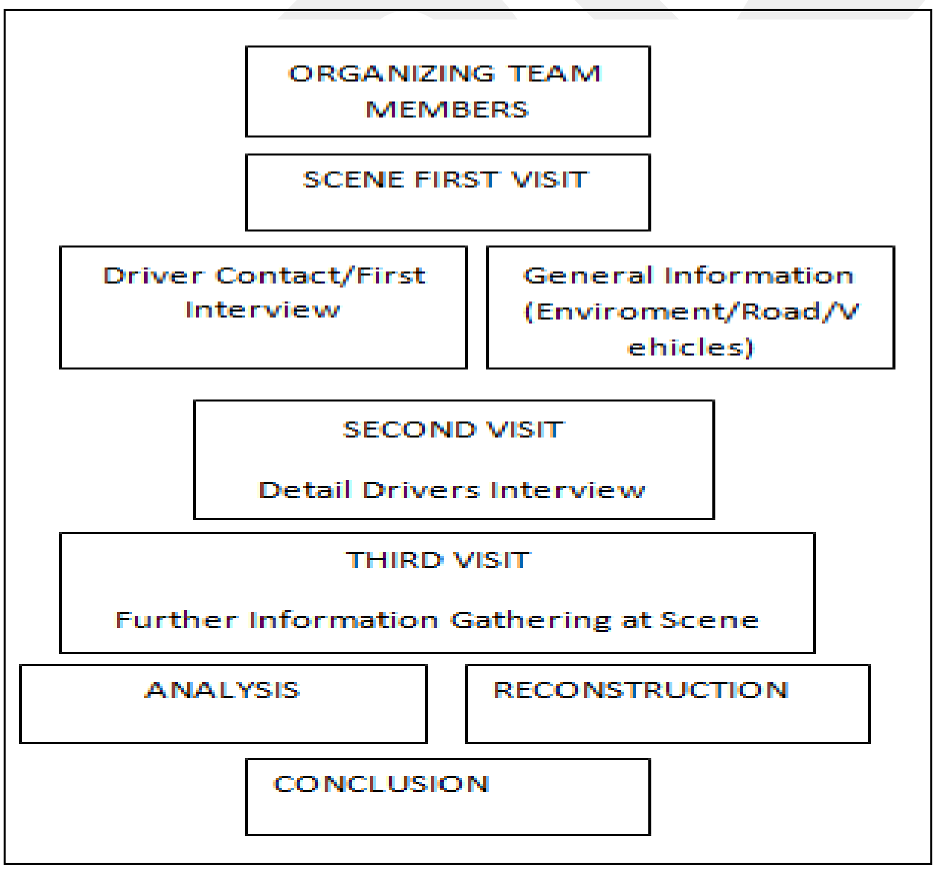


Figure 8 Applied Investigation Procedures

4.3 Accident Selection Criteria

Accident selection is based on notification from the Nigerian Road Safety Commission rescue officer, who received accident notification from the public or patrol officers. Due to Financial constrain been a first application trail, the outcomes of the team meetings, the team members adopted an accident selection criteria which were as follows:

a) Only fatal accident shall be investigated.

b) The investigation areas should be limited to approximately a 30-45 minutes drive from Kano City Centre.

c) Each accident must involve at least one truck (commercial vehicle of gross weight >3.5t).

4.4 Data Collection

The thesis, simplified the data collection method, the number of parameters to be collected and the data collection tools to be used.

a) 100 parameters were considered out 3,000 parameters in the European Truck Accident Causation Study (ETAC) methodology. This is because they are the only data that can be accessed due to limited expertise in the case study for data collection. The 100 parameters selected can help to reconstruct the accident to obtain the accident causes.

b) Data were collected directly using a modified questionnaire as a main data collection tool, supported with additional information, which seem relavant and important.

c) The team adopted a simple data collection method, where the questionnaire was filled by the team leader and measurements were supervised by the team leader.

d) Data covering general information, infrastructure and environment information, vehicle information, road user information and reconstruction information that could enable finding of accident causes were collected with help of modified questionnaire. The information considered during the case study are given in table 2.

e) The team only works during 8hrs on Monday through Friday and no part of the gathered data was shared with judiciaries or Police. Only one single road truck accident data were collected and investigated.

Table 2 Summary Of The Information Collected During Study

GENERAL		
Date of the accident	Time of the accident	Weather condition at time of accident
Day of the accident	Location of the accident	Accident severity
PARTICIPANT		
Sex	Profession	Rider State At The Accident Day
Age	Driving Work Type	Training
Height	Vehicle Owner Ship Type	License
Weight	Current Professional Status	Driving Experience
Nationality	Long Term Illiness History	Previous Accident History
Familiarity Of The Road	Short Term Illiness History	Trip In Progress
Educational Background	Rider State Day To The Accident	Presence Of Pressure
ROAD		
Road Type	Presence Of Road Markings	Traffic Type
Road Access Regulation	Condition Of Road Markings	Traffic Detour
Road Geometry	Presence Of Vertical Signs	Permanent Visibility Limitations
Road Condition	Condition Of Vertical Signs	Temporary Visibility Limitations
Road Profile	Speed Limit At Accident Scene	Number Of Lanes
Drainage Condition	Speed Limit At Approaches	Changes In The Infrastructure
Surface Condition	Road Side Obstacles	
VEHICLES		
Vehicle Reg. Number	Presence f Bumper/Underrun	Mirror Type
Manufacturer	Condition f Bumper/Underrun	Mirror Condition
Model	Cab Design/Material	Light Type
Body Type	Seat Typy/Condition	Light Condition
Body Color	Presence of Internal Equipments	Load Type
Vehicle Dimension	Usage of Internal Equipment	Load Condition
Braking Type	Gearbox Type	Presence of Safety Devices
Gross Weight	Power Source	Usage of Safety Devices
Number of Axles	Type of Windscreen	Presence of Tachometer
Number Twin Tires	Cleanliness of Windscreen	Usage of Tachometer
Vehicle Capacity		
RECONSTRUCTION		
Precipitating event	Collision avoidance action	Principle direction of force
Pre-crash motion	Pre-collision marks	Rest position
Pre-crash speed	Collision point	Deformation
Travelling direction	Number of impact	Hours on Wheel

4.5 Accident Analysis

Though in the European Truck Accident Causation study (ETAC), 600 accidents were investigated, that has enabled accidents analysis based on accident types and failure types. However, due to first trial and time limitation for the research, only two accidents were investigated, which could not be grouped into accident types and failure types. The thesis simplified the analysis as follows;

a) Analysis based on failure mechanism; in this analysis the thesis tried to understand the process that leads to the occurrence of the accident, through the available data gathered during the data collection process.

b) Sequence of event; in this analysis the thesis tried to understand how the accident occurred, through linking all events that take place in the accident occurrence.

c) System failure; in this type of analysis the thesis tried to understand what are the contribution of system components, that are, the road, the vehicles and the drivers to the accident occurrence.

4.6 The Possible Contributions about the Proposed System

The proposed modified European Truck Accident Causation study (ETAC) methodology application in Nigeria will bring several contributions to the Road Safety System. These are:

a) It might improve the road safety and to develop effective national road safety legislation.

b) It helps accident investigators in providing unbiased report.

c) It helps public and policy makers to initiate in-depth accident causation studies in the country.

d) It could help policy makers in marking easier policies.

e) The modified European Truck Accident Causation study (ETAC) methodology will help Nigerian road safety agencies to identify the main accidents contributing factors as well as the accident contributing factors.

f) The applied study methodology will help Nigerian road safety agencies to identify actions to be taken for the reduction of truck accidents and/or their seriousness.

CHAPTER FIVE

5 APPLICATION AND ANALYSIS OF THE CASE STUDY

5.1 The Case Study

The thesis' case study was aimed to propose a new accident investigation procedure for the investigation and analysis of the truck involved traffic accidents in Nigeria. The need for introducing such a new procedure has principally come from the need of implementing in-depth analysis on traffic accidents in order to clearly define the accident contributing factors that lead to the accidents.

The methodology takes into account all aspects of the accident, following a sequential study, including the reconstruction of the accident and the analysis of the data together with the identification of accident causes. It is very important to improve the contents and the quality of the collected data. This quality target will allow Nigerian road safety improvements through the understanding of the different travelling and risk exposures of the different countries.

The study would be conducted in accordance with guidelines, including manual and questionnaires set by European Truck Accident Causation study (ETAC), which was a project, initiated by the European Commission and the International Road Transport Union (IRU).

European Truck Accident Causation study (ETAC) was implemented to set up the truck accident causation study across European countries to identify future actions which could contribute to the improvement of road safety in the European Union 27 member states.

A modified form of the European Truck Accident Causation study (ETAC), was defined in Chapter Four has been applied in the Nigerian Case Study. This chapter first describes the preparation stages of the case study. Then the detail information about the two case study accidents under investigation together with the road and its environment has been given. Finally the chapter concludes the results and the analysis of the case study traffic accidents.

5.2 Pre-Preparation for the Case Study

5.2.1 Team Formation

Pre-preparation of an in-depth accident analysis in Nigeria began with the submission of the introductory letter together with a proposal of intended research to the various involved organizations in the country.

In order to execute the case study, an investigation team has been formed in Nigeria. This team composed of six members, five from the Nigerian Road Safety Commission, which were One Assistant Route Commander (ARC), One Deputy Route Commander (DRC), One Superintendent Route Commander (SRC), One Chief Road Marshal Assistant (CRMA), One Road Marshal Assistant I (RMAI), and one road traffic engineer from the Ministry of Transport on which they all have some road and accident investigation Knowledge. The duties of members are explained as follows;

i. Assistant Route Commander (ARC); to lead the team and help in admitting questionnaire.
ii. Deputy Route Commander (DRC); to assist the team leader and also act as team leader in the absence of the team leader.
iii. Superintendent Route Commander (SRC); to take pictures, sketches and measurements.
iv. Chief Road Marshal Assistant (CRMA); to assist in taking measurements.
v. Road Marshal Assistant I (RMAI)
vi. Highway traffic engineer;

5.2.2 Training

Team training was carried out in accordance with the revised European Truck Accident Causation study (ETAC) methodology, with the help of the manual, European Truck Accident Causation study (ETAC) questionnaire and Road safety Data Collection, Transfer and Analysis Training Package (DaCoTA) have been used to facilitate the training of the investigation team members. The following topics were evaluated throughout the training;

i. Preparing an Investigation Team
ii. Scene Examination and recording visual evidence about the crash scene
iii. Vehicle Examination
iv. Collecting Road User Data
v. Medical information
vi. Case Analysis
vii. Investigation Safety

5.2.3 Working Principles

After training of the team members, the team agreed upon responsibilities on how and who to gather all relevant information. The following decisions were made;

i. Interview and filling of questionnaire to be carried out by the team leader.
ii. Medical records of the involved persons to be collected from participants admitted hospitals through interview of participant medical personnel.
iii. Alarms of accident notification to be received by the team leader from the rescue officer of Nigerian road safety commission via telephone call and mail.
iv. The team leader to notify team members through phone contacts and mail.
v. Investigations to be carried out Monday through Friday during normal working hours (08.00-16.00).
vi. Drivers and witnesses remaining at the scene to be interviewed about their experience of the accident, an in-depth follow-up interview to be made as soon as possible.
vii. Retrospective investigations to be made to retrieve data for those days and hours of the week when the investigation team are not operating.

5.2.4 Accident Notifications

Due to the importance of accident notification, being the beginning of every accident investigation. The following issues have been identified;

i. The purpose of the Accident Notifications section is to ensure that investigation teams are aware of the accidents as they occurred. Furthermore, it is valuable to ensure that the teams are meeting their accident scene in a timely manner and are able to monitor and report accident basic information.
ii. Experience has shown that real-time accident notification information might not include some important details. Some teams have always reached the accident scene immediately to determine if accidents are to be investigated without knowing beforehand whether they fit within the Sampling Plan requirements (i.e. If the accident on a public road, road user hospitalization status, if vehicles or road users are on-scene, etc.).
iii. The team ensures that the accident notification information adequately identifies all accidents that meet the accident selection criteria.
iv. The team ensures the alarms provide detailed information on the location of the accident. Team record notifications about all accidents occurring in the study area during the pilot study, and note which accidents were accepted and rejected, and the reasons why.
v. The accident notification data are used in producing a brief report at the end of the pilot study about all accidents within the study area.
vi. The team ensures that Accident notification is received within 24 hours of the accident occurrence to allow the team adequate time to collect as much of the remaining information from the scene of the accident as possible. For on-scene investigations, instant notification (e.g. By e-mail, two-way radio, SMS, etc.) from the Police or emergency services of the Nigerian Road Safety Commission when an accident occurs are required to enable the team to reach the scene of the collision before it is cleared.

The summary of Accident notifications received during the period of the case study between July and September 2013 are shown in Table 3

Table 3 Summaries of Accidents Notifications Received During Case Study Period

S/N	DATE	TIME	VEH. INVOL	NO.KILL	NO.INJURE	NO.INVLV
1	05/08/13	1310	DAF TRUCK & TOYOTA BUS	6	4	17
2	12/08/13	0730HRS	TOYOTA BUS & DAF TRUCK	12	2	16
3	13/08/13	1315HRS	CANTER & BIKE	0	1	2
4	16/08/13	2115HRS	IVECO TRUCK & TOYOTA BUS	0	5	5
5	19/08/13	1940HRS	V/WAGEN, TYT BUS & CANTER	0	3	9
6	24/08/13	1815	TIPPER & BIKE	0	1	6

5.2.5 Accidents selection criteria

Based on the accidents selection criteria of European Truck Accident Causation study (ETAC) methodology and the outcomes of the team meetings two criteria's have been added into the case study which are as follow:

i. Only fatal accident shall be investigated.
ii. The investigation areas should be limited to approximately a 30-45 minutes drive from Kano City Centre.

Only two accidents out of the six accidents notifications received were found to be suitable. These accidents occurred on the 5th of August 2013 and 12th of August 2013.

5.3 Evaluation Mechanism

The evaluation mechanism has been started with the process of gathering information. In order to gather the relevant data, initial and subsequent visits to the accident scene have been made. This step was followed by the second step which is the analysis of the accidents.

5.3.1 On-the-scene: The information was gathered by the team when the involved vehicles were kept in their final positions after the accidents. The following steps/issues were carried out;

i. Filling the Forms: A specific form reporting all the general information (location, time, weather, description) was filled in on the accident scene.
ii. Taking Pictures: Several pictures were taken in order to have a description of the accident location (e.g. brake signs) and involved vehicles;
iii. Making Contacts: The first contacts were established with the vehicle occupants, in order to carry out a detailed interview for injured driver who cannot be interviewed at the accident scene.

5.3.2 Retrospective: The further information was also gathered during the subsequent visit by the team members. This information can assist the team during the analysis or they are needed, but not recorded during the first visit to the accident scene.

i. Interviews: Detailed interview was carried out on the vehicle occupants that gave their availability during the first visit to the accident scene.
ii. Vehicles analyses: The involved vehicles were deeply analyzed in order to highlight outside and inside deformations.
iii. Back on the scene: The team re-visited the accident scene within a very short time period after the accident, in order to carry detailed analysis, aimed at identifying all the parameters that will be used to perform the accident reconstruction**.**

5.3.3 Case Analysis

The accidents were analyzed according to a sequential model based on:

i. Failure mechanism
ii. Sequence of events (driving/conflict/emergency/crash/post crash)
iii. System Failure

The results of these analyses and cognitive reconstructions would be used to determinate the main causes and contributing factors and allow active safety improvements throughout regulation, active safety countermeasures (determination, evaluation), driver formation, and road improvements.

From a passive safety point of view, the participant's medical report, which was supplied by the local hospital, was used to correlate the injuries sustained with the accident injury mechanisms and the zones impacted inside or outside the vehicle. This correlation was the basis of passive safety improvements through passive safety equipments.

5.3.4 Reconstruction

An accident reconstruction is based on the three laws of physics, which are used by the team in order to define parameters, such as initial speeds and post crash speeds. These laws were used separately (when only one variable is unknown) or combined (when more variables were unknown). The reconstruction is considered in three phases which are;

a) Pre-CollisionPhase: The details of Phase just before the accident precipitating events, including the original speed, acceleration.

b) Collision Phase: The details of Phase from the beginning of precipitating events in the period immediately after separation for elastic collision and to the point of impact for non elastic collision. It includes the impact Velocity, change in velocity, the energy dissipated by the involved vehicles and skidding marks.

c) Post-Collision Phase: The Phase is related to the information at the final position of the vehicle and the Road. It includes distance from point of impact to the rest position, deformation and its magnitude and speed.

5.4 Accidents under Investigation

During the case study period the team received six accident notifications out of which two accidents satisfied the research methodology and were investigated through an in-depth accident analysis covering data collection, analysis, reconstruction and countermeasures. The following sub-chapters describe these accidents and include their analysis.

5.5 Accident One

The first accident that satisfies the methodology requirement occurred on the 5th of August 2013 with the information, description and narration in the subcequent paragphs.

For the execution of the case study the team carried various operations at in order to collect as much information as possible that could enable better understanding of the accident. The date of various operations was given in the table below;

Table 4 Data Collection Schedules

Date	Description of the Study Steps	Participant
5^{th} August 2013	Accident occurrence date, First visit involving Driver contact,General information regarding Enviroment/Road/Vehicle	Six team members
6^{th} August 2013	Driver detail interview	Six team members
7^{th} August 2013	Collection of Raod and Vehicles detail information	Six team members

The accident locations from a google earth map of the case study road network were indicated in figure.

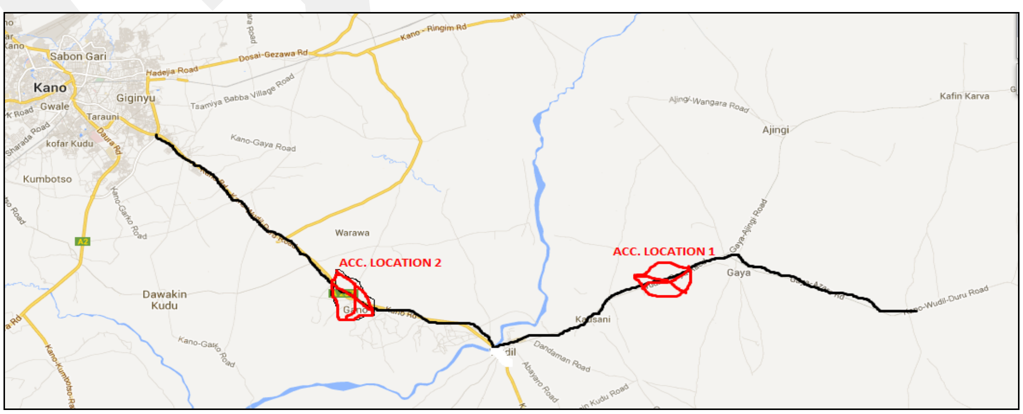


Figure 9 Accident Locations Along the Case Study Road

5.5.1 Accident Information

a) Accident General Information

The accident occurred on a two Lane un-divided highway, on Monday the 5^{th} August 2013 at 1310hrs, was selected as the first accident in the case study. The road layout was relatively straight from both directions with little upgrade in the northbound direction. There were no junctions in the vicinity. The accident involved a truck trailer and an eighteen setter Toyota commercial bus, no other vehicles were involved. The accident resulted in six fatalities and four serious injuries. The further detail information about Accident has been given in Appendix (C).

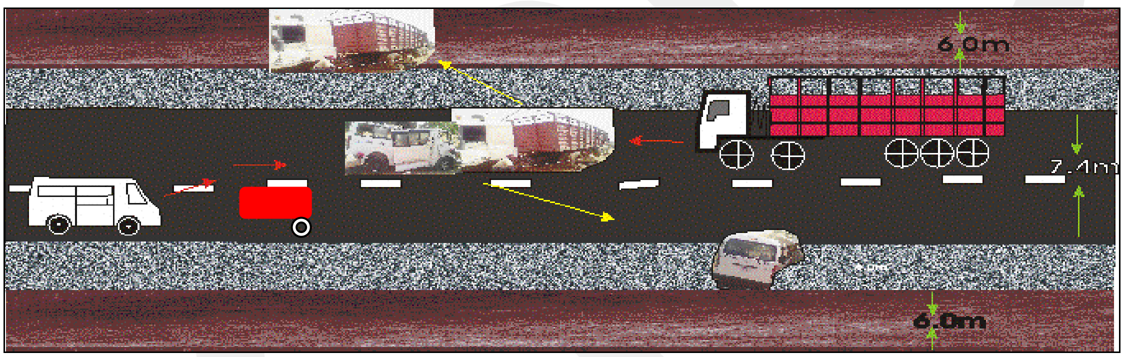


Figure 10 Accident Sketch

b) Accident Scenario: The Toyota bus driver moving at higher speed overtook a slower moving vehicle in its front, with no enough passing distance, resulted in head on collision with the truck coming from the opposite direction.

c) Infrastructure Information

The information about the Road collected at first and subsequent visits are presented in detail in Appendix (C), and summarized as follows;

- The accident occurred on a two lane undivided highway.
- The road was relatively flat in a flat trend, in which both approaches were relatively straight.

- The road markings were not visible.
- The road was free from any restriction regarding height and weight.
- The speed limit for this road is 60mph (97kmh) as posted speed limit.
- The weather condition at the time of the accident was fine and dry; it was daylight.

d) Participants Information

The participants interviewed were the Truck driver and the Bus driver assistant, the details of the participants' information were provided in an Appendix (C), and summarized as follows;

i) Truck driver; The Truck driver information was gathered from the driver at his residence a day after the accident and was summarized as follows;

- The Truck driver was a 51 year old male. He was a resident of the country and familiar with the road.
- The driver had a family of 13 members, including two wives and eleven children.
- The driver, had droves this category of truck for almost nineteen years.
- The driver was not wearing the seat belt and the steering wheel hub airbag was not deployed, neither the struck-side seat back air bag was deployed.
- There was no any physical injury to the driver, but only stayed in the hospital for 6hr from a headache.
- The driver slept badly in Maiduguri a day prior to the accident, a non residence place.

ii) Bus driver; The Bus driver died at the scene of the accident, and the driver information was collected from the driver assistant. The information was summarized as follows;

- The Toyota bus driver was a 38 year old male.
- He was a resident of the country and familiar with the road.
- The driver had a family of five, including one wife and four children.

- The driver was driving this category of vehicle, for eleven years.
- The driver was not wearing a seat belt and the steering wheel hub airbag was not deployed, neither the struck-side seat back air bag was deployed.
- The driver died on the spot with most damages on offer body part including head and chest.

e) Vehicles Information

The information about the involved vehicles was collected during the first and subsequent visits to the accident site, and were presented in detail in Appendix (C), and summarized in table 5 as follow;

Table 5 Summary of the involved vehicles information's

Truck	**Bus**
Daf truck XF95 model	Toyota litehiace DLX model
First Reg. 2005	First Reg. 2011
Diesel, Manual	Petrol, Manual
Dimension (18400*2500*2900)	Dimension (4695*1695*1980)
GCWR 44000kg	GCWR 2800kg
Cargo 24000kg	Cargo 150kg
Occupants 150kg	Occupant weight 1320kg
	Engine Capacity (cc)-2500
	Deformation of 3190mm

5.5.2 Analysis based on failure mechanism

Accidents occur due to failure of one or more of the system components, which include the human, the vehicle and the infrastructure; in the analysis each component failure is studied in reference to the failure of the whole system to understand the process through which failure occurred.

a) **Driver**: According to study conducted by PIARC and ETAC, Driver behaviors contribute about 90% of accidents in the world. Some of the most common driver behaviors which lead to accidents include: (a) Over speeding, (b) tailgating, (c) inattentiveness, (d) poor visual scanning, (e) making poor decisions, (f) improper lane changes, (g) unsafe passing, (h) failing to yield the right-of-way, (i) failure to keep right, and (j) being unable to handle a vehicle in emergency situations.

The problem started with the driver going too far to a distance of 544km long, “Prolonged distance”, under time constrained due to the presence of curfew in Maiduguri city from 6:00pm to 6:00am.

The bus driver, was at higher speed and in a hurry to cover a distance of 544km, within time constraints of 5hrs on road network with a maximum speed limit between 50km/h to 100km/h. Drivers in a hurry, or otherwise emotionally distressed by upstream curfew, overtook the vehicle in its front and demand the right-of-way from opposing Truck driver. This sort of unhealthy driving leads to serious head on collision accident.

The bus driver overtook the vehicle in its front, drives on the wrong side of the road and demanded the truck right of way coming on the opposite side of two lane highway. When driver pass another vehicle on a two-lane road, he must drive in the lane of oncoming traffic. This sort of driving resulted in head-on collision, which is the most dangerous type of all accidents. As the force of both vehicles must be dissipated instantly, and results in serious fatality and damage to the involved vehicle.

The truck driver who was away from his family and sleeps badly in the city of Maiduguri due to curfew, the driver started a journey at early morning 6:00am and driven for 7hrs against the recommended truck driving for four hours, the driver was under fatigue, and failed to yield the right of way to the other driver. Drivers under fatigue are more risky to accidents, as Fatigue manifests itself in slower reaction time, diminished steering performance, reduced ability to keep distance to the car in front, and increased tendency to mentally withdraw from the driving task.

Truck Driver had experienced stress for long working hours, poor road condition, sudden change in the road number of lanes and spending long periods away from home.

Stress manifest it's self by changing the attitude and behavior of the drivers to behave in an abnormal ways.

The truck driver under stress and fatigue, failed to yield right of way to bus driver coming from the opposite direction. Failure to yield the right-of-way to another vehicle or pedestrian is the primary collision factor in about 20% of fatal and injury collisions in California.

The drivers' related failures that influence the accidents as analyzed in the above paragraphs are summarized in table 6 as follows;

Table 6 Summary of Accident Analysis Based On Human Failure

Bus Driver Contributing Factors		**Truck Driver Contributing Factors**
Bus Driver In Hurry		Truck Driver, Drive For 7hrs
To Cover 543km In Less Than 5hrs		Greater Than Allowable of 4hrs
Travelled At Higher Speed		Under Fatigue
Driver Overtook Vehicle in its Front		Drive With Less Care
Drives on the Wrong Side of the Road		Failed To Yield The Right-Of-Way
Demand the Right of Way of Opposing Truck		
	Resulted in collision	

The team concluded that the serious head on-collision was caused as a result of overtaking and driving on the wrong side of the road by the bus driver.

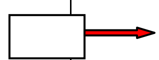
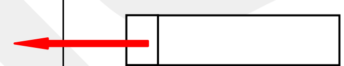
The team concluded that the truck driver having a family of thirteen was unhappy for not sleeping within his family for almost three days, put the driver under stress.

Finally the team concluded that fatigue, which the truck driver was on for working from 6:00am to 14:00pm with the only 25minute rest.Fatigue manifests itself in slower reaction time, diminished steering performance, reduced ability to keep distance to the car in front, and increased tendency to mentally withdraw from the driving task.

b) Vehicles: Vehicles were amongst the three system components that interacts together on a road, in which their failure could contribute or results in an accident, the vehicle's failure might include; Engine failure, engine transmission body damages, tire failure, vehicle color, and vehicle geometry.

The failure on the vehicles was of deformation, as the result of instant dissipation of forces on the colliding vehicles as summarized in table 7

Table 7 Summary of Vehicles Analysis Based On Vehicle Failure

Bus with force of 2.76KN Kinetic energy of 74.37MJ 	At collision the truck force neutralized the force and kinetic energy of the Bus	Truck with force of 44.87KN Kinetic energy of 246.19MJ 
	The Bus material can no longer absorb the excess force and kinetic energy	
	Resulted in deformation of the bus	

Stiffness is a vehicle property that affects the nature and severity of the accident, at a collision there was a resultant kinetic energy of 171MJ dissipated which the bus material could not resist, resulted to the bus deformation.

The accident resulted in four fatalities and a 3.19m serious deformation on the Toyota mini bus caused by the dissipated energy by the involved vehicles at the impact.

d) **Road:** The road geometry at the accident scene was standard two lane highways of about 10km located in between 45km and 400km four lane divided highway, on a flat terrain.

Table 8 Road Geometrical Data

Number of lanes	2
Lane width	7.4m
Shoulder width	2.8m, 2.7m
Median width	No media
Median height	No media

The truck driver who drives for 400km, on a four lane divided highway driving at a speed of 70km/h for 7hrs comes into two lane highway without proper speed reduction measure prior to the two lane un-divided highway. Narrow, undivided 2-lane rural highways with 50km/h speed limits are particularly hazardous. Because vehicles are traveling in opposite directions at high speeds without a barrier or median, dangerous head-on collisions are more likely to occur.

The bus driver who drives for 40km on four lane divided highways at a speed limit 100km/h, faced with lane changes to two lane un-divided highway without proper speed calming measure prior to the two lane un-divided highway.

5.5.3 Analysis Based on Sequence of Events

These analyses consider the system as a whole, it considers what, and how the failures occur and what leads to these failures. The analysis is presented in Table 7 as follows;

Table 9 Accident Analysis Based On Sequence of Event

Critical Events	Specific Critical Events	More Specific Critical Event	Links
Distance (A4)	**Prolonged distance (A4.1)**	(B1), (C1), (C2), (C3), **(D1),** (E6), (I1), (J1), (J2)	
	Shortened distance (A4.2)		
Planning (D)	**Inadequate plan (D1)**	Error in mental model (D1.1)	(C1), (E1), (E3), (E4), (E7), (E9), (L2), (M1), (M2), (M3)
		Overlooked side effects (D1.2)	
		Other (D1.3)	
	Priority error (D2)	Legitimate higher priority (D2.1)	(C1), (E9), (F2), (J1), (J2
		Conflicting criteria (D2.2)	
		Other (D2.3)	
Organization (M)	Deficient instructions/procedures (M1)	Other (M1.1)	None defined
	Overload/ Too high demands (M2)	Other (M2.1)	None defined
	Management failure (M3)	**Other (M3.1)**	**Accident**
	Inadequate training (M4)	Other (M4.1)	None defined

From the sequence of events analysis, the team concluded that, lack of organized commercial transportation system in the country to manage and regulate the operation of commercial vehicles is among the challenges faced by the Nigerian transport system. Commercial vehicles are operated by individuals, the selection of travel speed, duration of travel are selected by the driver.

From the sequence of events analysis, the team concluded that the presence of curfew in the city of Maiduguri where the bus driver was heading to, which allowed to be entered before 6:00pm as a result of insecurity in the area, had made the driver to drive from Kano to Maiduguri 544km in at most five hours crossing many big cities where his speed limit most drop drastically, resulted in higher speed by the bus driver and driving in hurry with less care.

5.5.4 System Analysis

According to the System theory of accident causation, accidents are caused as the result of failure of the system or system components including the participants, the vehicles and the infrastructure. The system analysis of the accident is presented in figure 4.3 as follows;

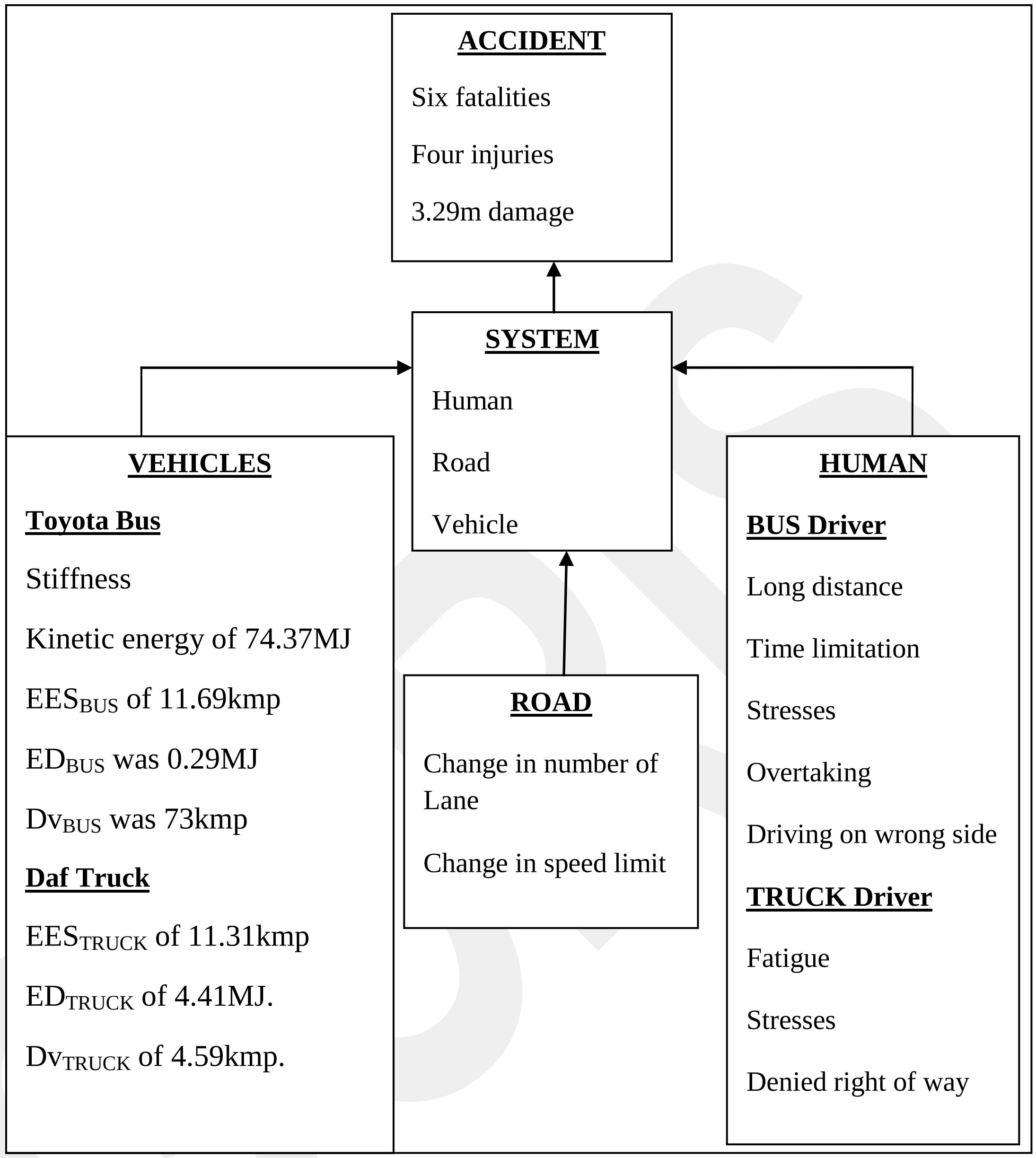


Figure 11 Summary of Accident Contribution Factors Analysis Using Fault Tree Analysis Method

5.5.5 Reconstruction Information

The detailed reconstruction information was presented in Appendix (C), with its summary of pre-crash/crash/post-crash as follows;

i. Pre-crash phase

- Skidding of 1.8m on the truck side
- Bus driver accelerates to return to his original lane

- The two vehicles posses the following data's as summarized in pre collision table 8 as follow;

Table 10 Summary of Pre-crash Information of Involved Vehicles

Description	TRUCK	BUS
Speed (km/h)	75	130
Acceleration (km/h/s)	2.37	2.41
Combined weight (kg)	68150	4120
Force (KN)	44.87	2.76
Kinetic Energy	246.19MJ	74.37

From the pre-crash data the team concluded that both the two driver action were not adequate to avoid the collision and its seriousness. The truck driver applied brake for little second that produce skid of only 1.8m length and the bus driver acceleration was not enough or properly executed as indicated in the location of deformation.

ii. Collision-phase

- The vehicles collided on the road, in the truck lane
- The distance from the skidding mark to the impact point was 12m
- Energy equivalent speed, EES_{BUS} was 11.69kmph, and EES_{TRUCK} was 11.31kmph
- Deformation energy, ED_{BUS} was 0.29MJ and ED_{TRUCK} was 4.41MJ.
- Change in velocity Dv_{BUS} was 73kmp and Dv_{TRUCK} was 4.59kmph.

At collision the bus possessing 74MJ of kinetic energy against 246MJ of the truck, resulted in a serious deformation of the bus. Sudden change in velocity of 73KMPH and 4MJ deformation energy indicate a higher severity of the accident.

iii. Post-collision phase

- The truck resting position was at 7.8m on its right safety zone
- The distance from the impact point to the rest position of the truck was 16.8m
- Damaged of the driver side mirror, left front wheel, and left side of front bumper
- The bus resting position was at 13.4m from the point of impact on the on its safety zone
- Maximum damage depth on the bus at rest position was 3.19m.

13.4m travel by the bus after collision that resulted in 3.19m deformation indicates that the bus driver possessed higher amount of kinetic energy that despite the lost of higher amount during collision the bus travel a distance of 13.4m.

5.5.6 Conclusion Of Case Study One

a) The major achievement of the new methodology was it collect much more information than the existing Nigerian accident investigation methodology. The method emphasis on early data gathering, which prevent lost of important data that can vanish with time.

b) From the case analysis, it can be concluded that the main accident cause is related to human failure/factor. The analysis result shows that, the main accident contributing factors in case one accident were fatique on the truck driver and a higher speed by the Toyota bus driver.

c) The result indicates a great need for the Nigerian road safety agencies and the Government of Nigeria to intensify more effort toward promoting road safety, proper enforcement, regulating commercial vehicle road users working conditions.

5.6 Accident Two

The second accident that satisfies the methodology requirement occurred on 12th of August 2013 with the information, description and narration as follow;

For the execution of the case study the team carried various operations at in order to collect as much information as possible that could enable better understanding of the accident. The date of various operation were given in table below

Table 11 Data Collection Schedules.

Date	Description of the Study Steps	Participant
12th August 2013	Accident occurrence date	
13th August 2013	First visit involving Driver contact,General information regarding Enviroment/Road/Vehicle	Six team members
13th August 2013	Driver detail interview	Six team members
14th August 2013	Collection of Raod and Vehicles detail information	Six team members

5.6.1 Accident General Information

a) **Accident Information:** The accident occurred on Monday the 12th August 2013 at 0730hrs, which was selected as the second case study. The accident occurred on a four lane divided highway, along a gentle curve; there were no junctions in the vicinity. The accident involved a truck and a seven setter Toyota commercial bus, no other vehicles were involved. The accident resulted in twelve fatalities and two serious injuries. The further detail information about the accident, general information has been presented in Appendix (C).

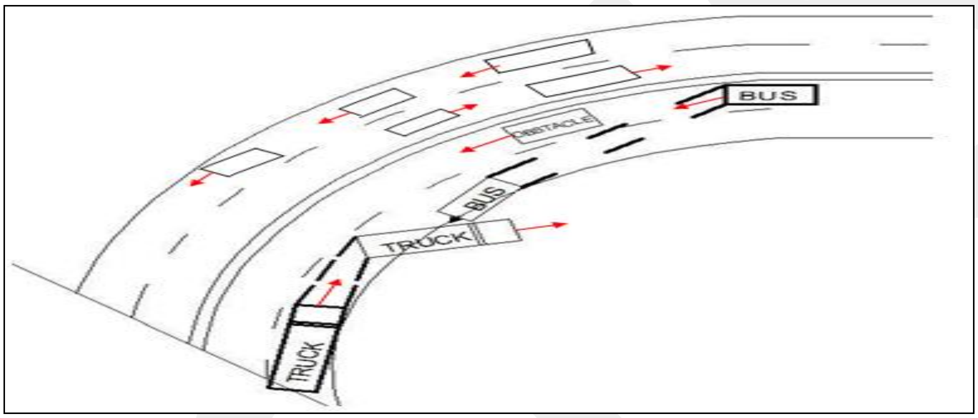


Figure 12 Accident Two Sketch

d) **Accident scenario:** The Toyota bus driver moving at wrong travel lane at higher speed overtook a slower moving vehicle in its front, with no enough passing distance, resulted in head on collision with the truck coming from the opposite direction.

c) Infrastructure Information

The information collected from the accident scene related to the infrastructure is presented in detail in Appendix (C), with its summary as follows;

- The accident occurred on a four lane divided rural highway.
- The road was relatively flat in a flat trend, with a gentle curve at point of accident.
- There were no road markings at point of accident.

- The road was free from any restriction regarding height and weight.
- The speed limit for this road was 110kmh as posted speed limit.
- Weather conditions at the time of the accident were raining and a little darker; beginning of the night hours.

d) Participant Information

The detail information related to the involved persons collected through interview are presented in Appendix (C), and are summarized as follows;

i) Truck driver

- The Truck driver was a 42 year old man. He was a resident of the country and familiar with the road.
- The driver has a family of 8 including one wife and seven children.
- The driver, had drives this category of truck for almost eleven years.
- The driver was not wearing a seat belt and the steering wheel hub airbag was not deployed, neither the struck-side seat back air bag was deployed.
- There was no any physical injury on the driver, but only stayed in the hospital for 6hr from a headache.

ii) Bus driver

- The Toyota bus driver was a 29 year old male.
- He was a resident of the country and familiar with the road.
- The driver is single, not married.
- The driver was driving this category of vehicle, for three years.
- The driver was not wearing a seat belt and the steering wheel hub airbag was not deployed, neither the struck-side seat back air bag was deployed.
- The driver died on the spot with too many damages/crushed.

e) Vehicles Information

The detail information related to the involved vehicles is presented in Appendix (C) and is summarized in table 9 as follow;

Table 12 Summary of Involved Vehicles Information

Truck	**Bus**
Daf truck 3300 model	Toyota Litehiace (Bus) 1997 Model
First Reg. 2005	First Reg. 2000
Diesel, Manual	Petrol, Manual
Dimension (15500*2490*3200)	Dimension (3800*1575*1600)
GCWR 31600kg	GCWR 1950kg
Cargo 0kg	Cargo 70kg
Occupants 140kg	Occupant weight 910kg
	Engine Capacity (cc)-2500
	Deformation of 2100mm

5.6.2 Analysis based on failure mechanism

The analysis of the accident based on failure mechanism, the sequence of events and system failure are to be carried out in order to make a conclusion about the accident resulting causes.

Accident occur due to failure of one or more of the system components, that includes the human, the vehicle and the infrastructure, on this analysis each component failure is study in reference to system failure.

a) Driver; The driver failures that resulted in case two accidents began with the driver under fatigue for working from 6:00 to driving on the wrong side of the road overtook vehicle in its front and demanded the right way of opposing Truck.

The Bus driver who was on the wheel for 14hrs was under fatigue. Drivers under fatigue are more risky to accidents, as Fatigue manifests itself in slower reaction time, diminished steering performance, reduced ability to keep distance to the car in front, and increased tendency to mentally withdraw from the driving task.

The Bus driver driving on the wrong side of the carriageway, overtook the vehicle in its front, drives on the wrong side of the road and demanded the truck right of way coming on the opposite side of one way carriage way. When driver pass another vehicle on a two-lane road, he must drive in the lane of oncoming traffic. This sort of driving resulted in head-on collision, which is the most dangerous type of all accidents. As the force of both vehicles must be dissipated instantly, and results in serious fatality and damage to the involved vehicle.
The drivers' related failure that resulted in case two accidents based on failure mechanism are summarized in the table as follows;

Table 13 Summary of Drivers Related Failure that Resulted in Accident

Bus Driver		**Truck Driver**
Driver under fatigue		The driver failed to yield right of way
Working from 6:00am-20:00pm		
Drive on the wrong side of the carriageway		
Overtook vehicle in its front		
Demand the right of way of opposing Truck		
	Resulted in collision	

From the analysis, the team concluded that the bus driver was under fatigue as he has been on the whole working from 6:00 to 20:00pm resulted in driven with less attention to the driving task as proved by many scholars, Fatigue manifests itself in slower reaction time, diminished steering performance, reduced ability to keep distance to the car in front, and increased tendency to mentally withdraw from the driving task.

From the analysis, the team concluded that the bus driver driving on the wrong carriageway due to lack of proper enforcement and penalties for violating traffic rules, yield to the beginning of the problem which subsequently resulted in serious fatal accidents.

b) Vehicles; Vehicles were amongst the three system components that interacts together on a road, in which their failure could contribute or results in an accident, the vehicle's failure might includes; Engine failure, engine transmission body damages, tire failure, vehicle color, and vehicle geometry.

The failure on the vehicles was of deformation, as the result of instant dissipation of forces on the colliding vehicles as summarized in table 7

Table 14 Showing Summary of Vehicle Analysis Based on Failure Mechanism

Bus with force of 1.96KN Kinetic energy of 14.65MJ	At collision the truck force neutralized the force and kinetic energy of the Bus	Truck with force of 20.81KN Kinetic energy of 127.98MJ
	The Bus material can no longer absorb the excess force and kinetic energy	
	Resulted in deformation of the bus	

Stiffness is a vehicle property that affects the nature and severity of the accident. In a collision, there was a resultant kinetic energy of 113MJ dissipated which the bus material could not resist, resulted on deforming the mini bus.

The accident resulted in four fatalities with 2.1m serious deformation on the Toyota mini bus caused by the dissipated energy by the involved vehicles at the impact.

c) Road: The road geometry at the accident scene was standard four lane divided highways along a gentle curve on a flat terrain. The visibility at the accident scene was clear and no junction at vicinity of the accident scene

Table 15 Road Geometrical Data

Number of lanes	4
Lane width	3.6m
Shoulder width	3.1m
Median width	4m
Median height	0.25m

From road infrastructure the team concluded that the road has little or no contribution to the occurrence of the accident.

5.6.3 Analysis Based on Sequence of Events

This analysis considers system as a whole; it considers the what, how the failures occur and what links to these failures. The analysis is presented in Table 4.9 below.

From the sequence of events analysis the team concluded that lack of organized commercial transportation system in the country to manage and regulate the operation of commercial vehicles in the country, which are operated by individuals resulting in drivers working for too many hours continuously without having a proper rest.

From the analysis, the team concluded that the bus driver driving on the wrong carriage way due to lack of proper enforcement and penalties for violating traffic rules, yield to the beginning of the problem which subsequently resulted in serious fatal accidents.

Table 16 Showing Accident Analysis Based on Sequence of Events

Direction (A6)		Incorrect direction (A6.1)	(B1), (C1), (D1), (D2), (E2), (E6),
Planning (D)	Inadequate planning (D1)	Error in mental model (D1.1)	(C1), (E1), (E3), (E4), (E7), (E9), (L2), (M1), (M2)
		Overlooked side effects (D1.2)	
		Other (D1.3)	
	Priority error (D2)	Legitimate higher priority (D2.1)	(C1), (E9), (F2), (J1), (J2), (M1)
		Conflicting criteria (D2.2)	
		Other (D2.3)	
Temporary person related functions (E)	Memory failure (E1)	Lenin long ago (E1.1)	(M2)
		Temporary inability (E1.2)	
		Other (E1.3)	
	Fear (E2)	Previous mistakes (E2.1)	None defined
		Insecurity (E2.2)	
		Conceivable consequences (E2.3)	
		Other (E2.4)	
	Distraction (E3)	Passengers (E3.1)	(I1)
		External competing activity (E3.2)	
		Internal competing activity (E3.3)	
		Other (E3.4)	
	Fatigue (E4)	Circadian rhythm (E4.1)	(M2), (M3)
		Extensive driving spell (E4.2)	
		Other (E4.3)	
Organization (M)	Deficient instructions/procedures (M1)	Other (M1.1)	None defined
	Overload/ Too high demands (M2)	Other (M2.1)	None defined
	Management failure (M3)	Other (M3.1)	Accident

5.6.4 System Analysis

According to the System theory of accident causation, accidents are caused as the result of failure of the system or system components including the participants, the vehicles and the infrastructure. The system analysis of the accident is presented in figure 4.4 as follows;

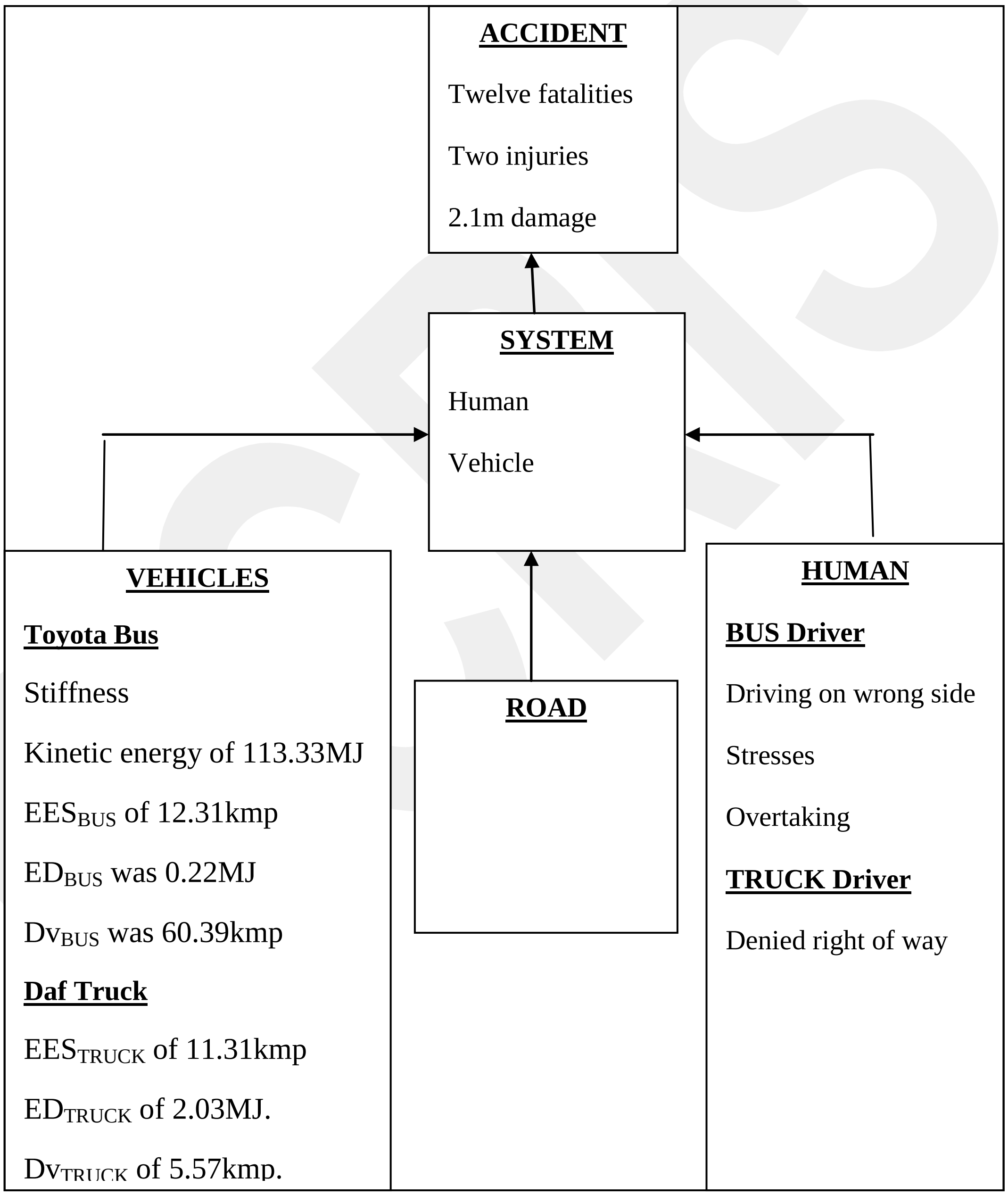


Figure 13 Analysis of Accident Based on System Analysis

5.6.5 Reconstruction Information

a) Pre-crash phase

- Skidding of 2.7m on the bus side
- Bus driver brakes and swerve toward safety zone.
- The truck driver swerves toward safety zone.
- The two vehicles posses the following data's as summarized in the pre - collision table below

Table 17 Summary of Pre-Crash Information for the Involved Vehicles

Description	TRUCK	BUS
Speed (km/h)	90	100
Acceleration (km/h/s)	2.37	2.41
Combined weight (kg)	31600	2930
Force (KN)	20.81KN	1.96
Kinetic Energy	127.98MJ	14.65

A skid length of 5.7m produced by the bus from the normal traveling lane to the point of impact indicates late brake and swerving action by the bus driver.

From the speed of 100-110km/h at which the bus was moving prior to precipitating event, the team concluded that, the produce skid could not avoid the occurrence and seriousness of the accident.

From the team observation, absence of skid mark on Truck side indicates less or no action was made by truck driver to avoid the occurrence or seriousness of the accident.

b) Collision-phase

- The vehicles collide on the outer lane to the safety zone, in the truck lane
- The distance from the skidding mark to the impact point was 6.8m
- The accident resulted in deformation of 2.1m on the bus.
- Energy equivalent speed, EES_{BUS} was 12.31kmph, and EES_{TRUCK} was 11.31kmph
- Deformation energy, ED_{BUS} was 0.22MJ and ED_{TRUCK} was 2.03MJ.
- Change in velocity Dv_{BUS} was 60.39kmph and Dv_{TRUCK} was 5.57kmph.

From the value of change of velocity on the bus of 60.39kmph indicate the accident was serious and fatal as a result of higher change in speed within a little time. The team concludes that the serious crash of the bus occupants was as a result of serious deformation of the bus.

c) Post-collision phase

- The truck and bus final position were at 3.2m on right safety zone from the point of impact.
- The bus was completely damaged from the front including driver seat, engine to almost half of its body.
- The truck had only minor damage in its front middle.

The bus was pushed backward of 3.2m from point of impact, which indicates that a higher percentage of the resultant energy of 133MJ was stocked and finally resulted in deforming the bus by 2.1m. Absence of deformation on the bus was due to higher stiffness of the bus materials.

5.6.6 Conclusion Of Case Study Two

a) The major achievement of the new methodology was it collected much more information than the existing Nigerian accident investigation methodology. The method emphasis on early data gathering, which prevent lost of important data that can vanish with time.

b) From the case study, it can be concluded that a detail European Truck Accident Causation (ETACs) can be applied to Nigerian Road networks by well trained experts. A modified ETAC methodology was successfully tried for the first time in Nigeria.

c) From the study result it can be concluded that the main causes of the accident, in accident two of the case study were fatigue on the Toyota bus driver which is linked to careless driving and overlooking side effect and lack of proper enforcements of traffic rules.

d) The analysis concluded that, lack of good Road transport management, as drivers drive in all direction on a four lane divided highway, as among the main accident cause.

CHAPTER SIX

6 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

After testing of modified European Truck Accident Causation study (ETAC) manual on Nigeria highway, the following conclusions were drawn from the study;

a) In-depth accident investigation is a detailed multidisciplinary investigation with a higher number of variable varying from a few hundreds to more than a thousand, aiming at preventing re-occurrence of similar accident type through detailed analysis and reconstruction.

b) In-depth accident investigation has many advantages as it involves the collection of much more detailed data related to the accidents, it involved knowledge sharing as many experts that are related with safety issues were involved and conclusions are more realistic than in normal investigation.

c) The in-depth investigation required collection of much more detail data that could enable better understanding of the causes of road traffic accident, better proposing of countermeasures and more effective accident reduction.

d) The understanding of an accident needs a theoretical analytic model. A simple way to present this model is to divide the accident into three phases:

i. Pre-crash phase,
ii. Crash phase
iii. Post-crash phase.

The principle of reconstruction is used to allow the accident investigation team to estimate relevant parameters that characterize the above mention phases.

e) In the case study accident one, in which the accident was head on-collision on two lane section of the highway, violation of the speed limit was observed. The drivers are traveling at higher speed due to the lack of proper transport management system to look after the driving situation at the very point, through a proper tracking system. The team concluded that there is a need for grouping commercial transport in Nigeria in order to be well co-ordinate and managed.

f) As in the case study accident two, in which the accident was head on-collision on four lane divided highway, fatal violation of traffic rules has been observed. The drivers can select the wrong driving direction mostly because of the lack of adequate enforcement. The team concluded that there is a greater need of more and appropriate enforcement on Nigerian highways such as providing patrol officers in locations where collision frequently occurred.

g) The analysis concluded that, lack of good Road transport management, as drivers drive in all direction on a four lane divided highway, as among the main accident cause in accident two of the case study.

6.2 Recommendation

After three months testing of modified European Truck Accident Causation study (ETAC) methodology for in-depth accident investigation, on Nigerian road network conducted in collaboration with Nigeria, Federal Road Safety Corps (FRSC), and Ministry of work and transport. The following recommendations were drawn:

a) In-depth road accident investigation program should be established throughout the country whereby States members will conduct in-depth accident investigations and contribute data to a National road accident database.
b) The accident investigation program should be independent. Accident investigations could be conducted in cooperation with stakeholders, but should not be influenced by them.
c) The accident investigation program should have sufficient financial resources and should not rely on external funding to conduct any individual accident investigation.
d) The accident investigations should be carried out by a more dedicated multidisciplinary team. Each team should have a core group of permanent members with specialist knowledge across the relevant areas of accident investigation and sufficient road safety experience.

e) In-depth accident co-leaders should be trained by existing independent accident investigation agencies such as European Truck Accident Causation study (ETAC), National Transport Safety Board (NTSB), International Road Transport Union (IRU). Investigators should be given comprehensive training in accident investigation to ensure uniform standards of investigation across the country.
f) A National investigation manual should be developed to provide common investigation methodologies and the data to be collected, to conduct in-depth accident investigations in a harmonized manner. A National road accident database should be developed to record the accident investigation data collected from all Member States.
g) No data containing information that would lead directly to the identification of persons involved in the accident should be released to a third party. Data may be made available for research or analysis purposes.
h) Countermeasures, developed from aggregate accident data, should be addressed to the stakeholders, who shall take the necessary measures to ensure that these recommendations are duly taken into consideration.

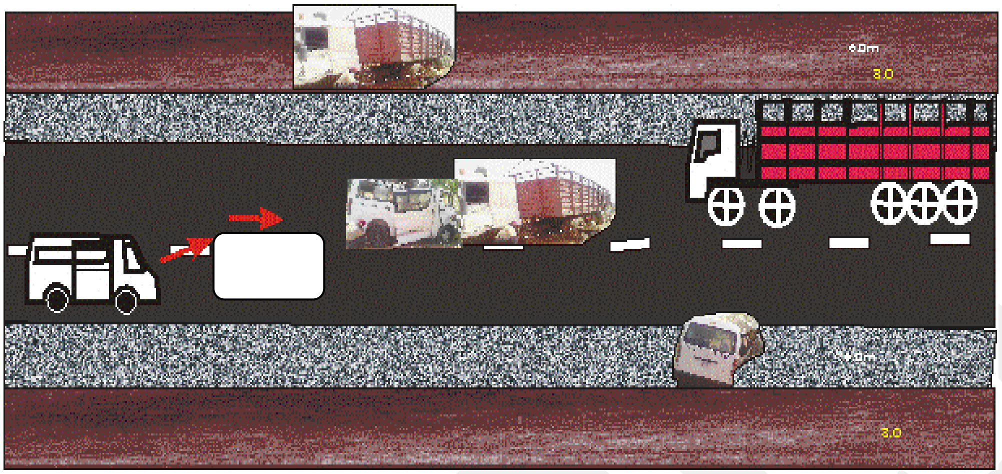
REFERENCES

1) World Health Organization 2002. 5-years WHO Strategy for Road Traffic Injury prevention.
2) World Health Organization 2004. World Report on Road Traffic Injury Prevention.
3) Oderoet al. 2003. Road traffic injuries in Kenya: Magnitude, causes and status of intervention.
4) Chris B. 2001. The importance of a road accident data system and its utilization.
5) Balogun JA. 1992. Pattern of road traffic accident cases in a Nigerian University teaching hospital between 1987 and 1990.
6) Eke N. 2001. Road Traffic Accidents in the Developing World: Who are Liable.
7) Safety Net. 2008. Deliverable D4.5 Recommendations for Transparent and Independent Road Accident Investigation
8) http://www.ng.total.com/01_about_nigeria/0103_history.htm (Retrieved 15 May 2013)
9) http://www.google.com.ng/search?q=nigeria+geography&tbm (Retrieved 15 May 2013)
10) TRL (2001) the importance of a road accident data system and its utilization.
11) Jacobs G D. 1996. Further research on accident rates in developing countries. Accident Analysis and Prevention.
12) http://www.ntsb.gov/ retrieve on 11/12/2013
13) Pieter V. "Independent Accident Investigation: Every Citizen's Right, Society's Duty"
14) Elliman R. Proposing a Framework for Pan-European Transparent and Independent Road Accident Investigation.
15) http://www.havkom.se/default.asp retrieve on 11/12/2013
16) Otte, D. Scientific Approach and Methodology of a New In-Depth- Investigation Study in Germany.
17) Andre S. Development Of The Accident Investigation And Data Handling Methodology In The Gidas Project
18) http://www.unece.org/fileadmin/DAM/trans retrieve on 11/12/2013

19) Safety Net (2008) Deliverable D4.5 Recommendations for Transparent and Independent Road Accident Investigation.
20) TRACE D.5.5 2008 'Analyzing Human Factors in road accidents'
21) Gibson J. 1983 Theoretical Field Analysis of Automobile Driving
22) TRACE Deliverable D 2.3 Accident causation and pre-accidental driving situations.
23) PIARC 2007. Road Accident Investigation Guidelines For Road Engineers
24) ETAC 2006 Final Report
25) http://frsc.gov.ng/ Retrieved 12/3/2013
26) Boukari S. A Tactical Emergency Response Management System (Terms) Framework
27) M. C. Simon A Common Methodology for Truck Accident In-depth Study
28) Road Safety Data, Collection, Transfer and Analysis DaCoTA D2.3 Training Package including training manual and draft protocols 2012
29) Pan-European Co-ordinate Accident and Injury Database PENDANT (Accident Reconstruction Guidelines) 2002
30) Thierry Hermitte Real-World Car Accident Reconstruction Methods For Crash Avoidance System Research 2000
31) Safety Net. Deliverable 5.2: In-depth Accident Causation Data Study Methodology Development Report 2006
32) American Prosecutors Research Institute APRI Accident Reconstruction Basic for Prosecutors 2003

APPENDICES

Appendix A: Picture of accident one of the case study including the sketch, the vehicles



Accident Sketches Showing the Two Vehicles from Opposite Direction and Point of Impact

Side View of the Involved Bus

Front View of the Involved Bus

Rear View of the Involved Bus

Front View of the Involved Truck in the Rest Position

Side View of the Involved Truck in Its Rest Position

Appendix B: Pictures of accident two of the case study including the sketch, the vehicles

Road Cross-Section Showing Various Road Elements

PICTURE SHOWING SKID MARKING PRODUCE BY THE INVOLVED BUS

Front View of the Involved Bus

Rear View of the Involved Bus

FRONT VIEW OF THE INVOLVED TRUCK

REAR VIEW OF THE INVOLVED TRUCK

SIDE VIEW OF THE INVOLVED TRUCK

SIDE VIEW OF THE INVOLVED TRUCK

Appendix C : Summary of the applied questionnaire

Appendix C1 General Information

a.	**Identification**			
1	ACCNUM	Accident Number	1	2
2	GINPUT	Input by	ABUBAKAR DAYYABU	ABUBAKAR DAYYABU
3	GACCLO	Accident location (road number or name / town / department)	A273/KANO-MAID/FEDERAL	A273/KANO-MAID/FEDERAL
4	GROADF	Number of Forms : Roads	1	1
5	GVEHIF	Number of Forms : Vehicles	2	2
6	GPEDEF	Number of Forms : Pedestrians	0	0
7	GPHOTN	Number of photos available	6	8
8	GSKETN	Number of sketches available	2	1
b.	**Vehicles**			
9	GTRUCK	Number of trucks involved in this accident	1	1
10	GBUSES	Number of buses, coaches involved in this accident	1	1
11	GVEHIN	Are there any other vehicles involved (but not damaged) in The accident?	NO	NO
12	GPEDIN	Are there any other pedestrians involved (but not injured) in the Accident?	NO	NO
c.	**Date**			
13	GDATAC	Date of the accident (yyyymmdd)	2013/08/05	2013/08/13
14	GTIMAC	Time of the accident (hhmm)	1310hrs	2000hrs
15	GDAYAC	Day of the accident	1 MONDAY	1 MONDAY
d.	**Location**			
16	GLOCAT	Location type	1. Outside urban area	1. Outside urban area
17	GARTY1	Type of Area (choice #1)	7. Named locality / Hamlet	7. Named locality / Hamlet
18	GARTY2	Type of Area (choice #2)	7. Named locality / Hamlet	7. Named locality / Hamlet

Appendix C1: General Information (continuation)

e.	**Weather Conditions**			
19	GPRECI	Precipitation	1. None	2. Rain
20	GPRERA	Level of precipitation	1. No precipitation	3. Medium
21	GWINDT	Wind	1. No wind	1. No wind
23	GLIGTH	Lighting Conditions	1. Light (Day)	5 Darkness (night) without public lighting
24	GWEAEF	Did weather have a possible effect on the accident Occurrence?	1. No	1. No
f.	**Accident Type**			
25	GFIRIM	Scene of first impact	1. On Road	1. On Road
26		Rest Position	3. On safety zone	2. On shoulder
g.	**Accident Severity**			
27	GFATNU	Number of fatalities within 30 days	6	12
28	GINJNU	Number of injured occupants or pedestrians within 30 days	4	1
29	GUNIJN	Number of uninjured occupants and pedestrians	6	4

Appendix C2 Infrastructure Information

a.	**Identification**			
1	ACCNUM	Accident Number		
2	IROATY	Road Type (Country specific)	1. Motorway/highway	1. Motorway/highwa y
3	IREGRO	Road access regulation	1. Free	1. Free
4	IINST1	Specific installations (Choice#1)	1. No specific installations	1. No specific installations
5	IENGIN	Specific type of engineering work and location	0. None	0. None
6	IENGEF	Influence of the engineering work on the accident	1. No	1. No
b.	**Road Restrictions**			
7	IAUTHO	Road-user authorized to use this Road?	1. No	1. No
8	IWERES	Weight Restriction (in tons : ##.#)	1. No	1. No
9	IHERES	Height Restriction (in meters : #.#)	1. No	1. No
10	IWIRES	Width restriction (in meters : #.#)	1. No	1. No

Appendix C2 Infrastructure Information (continuation)

11	ISPESC	Legal speed limit at accident scene (km/h)	70	100
12	ISPEAP	Legal speed limit for the approach route (km/h)	100	100
13	ISPESP	Legal speed limit for trucks or buses (km/h) according to the type of road, type of load, type of truck	60	60
c.	**Road Geometry**			
14	IAPPRO	What is the approach route like?	1. Generally straight	1. Generally straight
15	IGEOM1	Type of geometry at accident scene	1. Generally straight	3. Wide curve (mean radius more than 1 000 meters on roads and more than 2 000 meters for highways and motorways)
16	ILADI1	Total number of lanes on the direction 1 (straight, turn left, turn right)	1	3. Wide curve (mean radius more than 1 000 meters on roads and more than 2 000 meters for highways and motorways)
17	ILADI1	Total number of lanes on the direction 1 (straight, turn left, turn right)	1	2
17	ITURL1	Turn left lane	1 no	1 no
18	ITURR1	Turn right lane	1 no	1 no
19	ISEPAR	Directions separated by	3. Discontinuous painted lines	4. Divider Central dividing island
d.	**Road Alignment for Straight Alignment**			
20	ILENPR	Length of straight stretch preceding scene of accident (in meters)	2000mm	432m
21	ILENTO	Total length of straight stretch before and after the scene of accident (in meters)	1800mm	690m

Appendix C2 Infrastructure Information (continuation)

e.	**Road Geometric Measurement**			
22	IPROFI	Profile	1. Flat	1. Flat
23	IDESL1	Description of the left edge limits and divider boundaries (including separator or dividing island)	3. Discontinuous painted lines	3. Concrete barrier
24	IDESR1	Description of the right edge limits and divider boundaries (including separator or dividing island)	7. Slope, Embankment	7. Slope, Embankment
24	ISURL1	Surface material roadside	9. Bituminous pavement	9. Bituminous pavement
25	IOBSL1	Roadside Obstacle	1. None	1. None
26	IWIDL1	Width (meters)	7.6	7.2
27	IDANGR	Possible danger when using the escape area on the right side	1 No obstruction	1 No obstruction
f.	**Road Surface State**			
28	IROAST	Road state	1. Flat	1. Flat
29	IROACO	Road Condition	1. Good condition	1. Good condition
30	ISURCO	Condition of surface	2. Dry,	4. Wet (splashing)
31	IPOLLU	Surface pollution	NO	0. No need
32	IWATER	Drainage or water accumulation problems	NO	NO
g.	**Horizontal Road Markings**			
33	IMARKC	Central markings	3. None	3. None
34	IMARKS	Were the shoulders marked?	3. None	3. None
35	IMARKV	Visibility of the road markings	2. Partially worn	1. No carriageway marking
h.	**Other Equipment**			
36	IEQUI1	Was there any specific equipment on the road (Choice #1)	1. No	1. No
37	IVERT1	List of the vertical road signs	1. No	no
38	IWORKS	Were there road works or a road Construction site?	2. Yes	1. No
39	IWORSI	Road signs before road works	NO	2. Yes

Appendix C2 Infrastructure Information (continuation)

i.	**Traffic**			
42	ITRADE	Was there a traffic detour?	1. No	1. No
43	ITRAHI	Was there a hindrance to traffic Flow? (Road work, detour, road narrowed)	2. Yes	2. Yes
44	TRAVA	Most significant variation in the traffic density (at the time of the accident)	1. Normal traffic volume outside rush hours	1. Normal traffic volume outside rush hours
45	ISUACC	Did the accident follow another Accident?	1. No	1. No
j.	**Change in the Infrastructure**			
47	IINFCH	Was there an abrupt change in infrastructure or environmental conditions between the approaching zone and the Accident zone?	2. Yes From 4 lane to 2 Lane	1. No
k.	**Change within the Accident Zone**			
48	IPROBK	Change in the road incline profile	1. No change	1. No change
49	IWIDBK	Change in the carriage way width	1. No change	1. No change
50	IDIRBK	Change in the number of directions	1. No change	1. No change
51	ILANBK	Change in the number of lanes in the direction of the vehicle	1. No change	1. No change
52	ILADBK	Change in the lanes directions	1. No change	1. No change
53	IHORBK	Change in the road central markings	1. No change	1. No change
54	IEDRBK	Change in the type of right road shoulder	1. No change	1. No change
55	IEDLBK	Change in the type of left road shoulder	1. No change	1. No change
56	IWIRBK	Change in the width of the right road shoulder	1. No change	1. No change
57	IWILBK	Change in the width of the left road shoulder	1. No change	1. No change

Appendix C2 Infrastructure Information (continuation)

58	ILERBK	Change in the level between road and right shoulder	2. Yes	2. Yes
59	ILELBK	Change in the level between road and left shoulder	2. Yes	2. Yes
60	ISHRBK	Change in the road edges of the right shoulder	2. Yes	2. Yes
61	ISHLBK	Change in the road edges of the left shoulder	2. Yes	2. Yes
62	ISURBK	Change in the road surfacing quality	1. No change	1. No change
63	ISUTBK	Change in the type of surfacing	1. No change	1. No change
64	IDIVBK	Change in the directions separator	1. No change	1. No change
65	ISTABK	Change in the road state	1. No change	1. No change
66	ILIGBK	Change in road lighting	1. No change	1. No change
67	IBANBK	Change in the banking of the curve	1. No change	1. No change
l. Permanent Longitudinal Visibility				
68	ILOVIS	Minimum length of longitudinal visibility (in meters) (if >300, code SSS)	SSS	SSS
69	ILIMVI	Limited visibility	1 None	2. Due to alignment and road edge
m. Temporary Cause / Limitation to Visibility				
70	ITEMVI	Temporary limitation to visibility	1 None	5. Weather conditions
71	IWEAVI	Weather conditions / atmospheric conditions	1 None	4 Precipitation

Appendix C3 Participant Information

a. Identification				
1	ACCNUM	Accident number	1	2
2	OCCNUM	Participant number	1	1
b. Location				
3	OLOOCP	Type of road user	1. Driver or rider	1. Driver
4	OLOOCP	Participant position in the row (for motorcycle, rider = 0 ; for pedestrian OLOOCP=0)	1	1
5	OLOOCS	Side seated	1. Left	1. Left

Appendix C3 Participant Information (continuation)

6	OLODIR	Facing direction of the seat	1. Forward	1. Forward
c.	**Personal Status**			
7	OPSSEX	Sex / Pregnancy	1. Male	1. Male
8	OPSAGY	Age : Number of years	51	42
9	OPSAGM	Age : Number of months	612	504
10	OPSTAL	Height of participant [cm]	1.6	1.6
11	OPSWEI	Weight of participant [kg]	80	75
d.	**Injury Report for Participants**			
12	OIRSTA	Trauma status	4. Hospitalized for less than 24 hours	4. Hospitalized for less than 24 hours
13	OIRHOS	Number of days in hospital	0	0
14	OIRIN_1	Injury information source	1. Treating physician or other hospital personnel and medical records	1. Treating physician or other hospital personnel and medical records
e.	**Personal Status**			
z	DPSNAT	Nationality	Nigerian	Nigerian
16	DPSFAM	Current family status	13	8
17	DRESPO	Responsibility in the accident	5. Partially no responsible	5. Partially no responsible
18	DPSPRO	Profession	61. Skilled worker	61. Skilled worker
19	DPSPRF	Is the driver or the rider a Professional driver?	2. Yes, professional driver and he was involved in the accident with his professional vehicle	2. Yes, professional driver and he was involved in the accident with his professional vehicle
20	DPSCPS	Current Professional status	1. Working	1. Working
f.	**Long Term and Short Term Illness**			
21	DLTIL_1	Long term illnesses, injuries or inadequacies	0. Inapplicable	0. Inapplicable
22	DLTEFF	Did the long term illness play any role in the accident Occurrence?	1. No	1. No

Appendix C3 Participant Information (continuation)

g.	**Short Term Illnesses, Injuries or Inadequacies**			
23	DSTILL	Short Term illness	3. Headache	1. Normal
24	DSTEFF	Did the short term illness play any role in the accident Occurrence?	1. No	1. No
25	DSTMED	Had the driver or the rider been taking medication within the Last three days?	1. No	1. No
26	DSTOPH	Did the driver or the rider have special sight problems related to Driving?	0. None	0. None
27	DSTSPN	Spectacles need	1. No glasses	1. No glasses
28	DSTSPU	Use of spectacles during the accident	1. Not used	1. Not used
29	DSTOPP	Is it believed that a sight problem played a role in the Accident?	1. No	2. partially Due to rain
30	DSTHEP	Is it believed that a hearing problem played a role in the Accident?	1. No	1. No
h.	**State of the Driver or Rider**			
31	DSTACT	Activity of the driver or the rider on the day of accident	1. Usual activities	2. Resting with family
32	DSTSTA	State of the driver or the rider just before the impact	1. Usual activities	1. Usual activities
i.	**Driving Licence**			
33	E42-37	Driver's license status	1. Valid	1. Valid
34	DDLLI_1	Driver’s license qualification	C. Truck > 3,5 tons	C. Truck > 3,5 tons
35	DDLLD_1	Driver’s license date of issue (yyyy/mm/dd)	2012/02/16	2010/05/12
36	DDLCOD	Complementary driver training during the last two years	1. No	1. No
37	DDLINJ	Special conditions for driving license	1. None	1. None

Appendix C3 Participant Information (continuation)

j.	**Driving Experience**			
38	DDEKIL	Number of kilometers driven for the last year with this category of vehicle (in thousand kms)		
39	DDECAT	How often is this category of Vehicle used?	1. Daily (usually)	1. Daily (usually)
40	DDECON	Ownership of the involved vehicle	6. An individual vehicle	6. An individual vehicle
41	DDEPUY	Number of years since purchase	5	3
42	DDEPUM	Complementary number of Months since purchase	60	38
k.	**Number of Previous Accidents**			
43	DDEGUD	At fault, property-damage accidents	2. Yes	2. Yes
44	DDELAY	Years since last accident	2	7
45	DDELAM	Complementary months since last accident	27	82
46	DDEDAM	Was the driver or the rider aware of any known Defect/damage to the vehicle?	2. No + defect detected during the evaluation	2. No + defect detected during the evaluation
l.	**Truck or Bus Driver Only**			
	DTDNYA	Number of years since beginning of truck driving activity	19	12
48	DTDNYS	Number of years since beginning of truck driving activity in this company	12	4
49	DTDPST	Professional status of the driver	2. Employed	2. Employed
50	DTDTAD	Vehicle driving experience	1 Truck	1 Truck
51	DTDHAB	Is it the usual truck?	2. Yes	2. Yes

Appendix C3 Participant Information (continuation)

52	DTDACT	Activity the day before the accident (truck drivers only)	On a trip	With family
53	DTDACC	Convoy trip	1. No	1. No
m.	**Trip in Progress**			
54	DTPPUR	Purpose of trip in progress	2. Work, Business	1. Home-Work place
55	DTPORI	Origin of trip	2. Work, Business	1. Home
56	DTPDES	Destination of trip	2. Work, Business	2. Work, Business
57	DTPOFT	How often is the site of the accident passed in the same Direction?	4. Several times a year (trip felt to be familiar)	4. Several times a year (trip felt to be familiar)
58	DTPDIP	Trip planned by the driver or the rider : Distance (km)	40-50km	700-800km
59	DTPTIP	Trip planned by the driver or the rider : Time (--.-- : hours and minutes)	1-2hr	11-12hrs
60	DTPREA	Main reason for choosing this route	2. Only route available	2. Only route available
61	DTPATM	Atmosphere in the vehicle	2. Calm conversation in progress	2. Calm conversation in progress
62	DTPTIR	Did the driver or the rider feel Tired at the accident time?	2. Yes	1. No
63	DTPITC	Was there an imposed time constraint on the driver or the Rider?	1. No, not in a hurry	1. No
n.	**Accident & Emergency Situations**			
64	DESAC_1 DESAC_2	What was the driver or the rider doing immediately before the Precipitating event?	8. Just driving or moving	8. Just driving or moving
65	DESATT	Where was the driver or the rider attention focused just Before the precipitating event?	6. On his (her) own moving or activity	6. On his (her) own moving or activity
66	DESMAN	Individual maneuver after precipitating event	20. Maneuver for parking	20. Maneuver for parking

Appendix C3 Participant Information (continuation)

67	DES1CO	Driver or rider involved in first collision with :	7. A vehicle coming towards, in the opposite direction	7. A vehicle coming towards, in the opposite direction
68	DESSPE	Stated speed in situation prior to accident (in the driver's or rider's opinion) (km/h)	75km/h	90km/h
69	DESDAN	Was the danger perceived before the first impact as stated By the driver or the rider?	2. Yes	2. Yes
70	DESWA_1 DESWA_2	Use of vehicle warning signal before the first impact as stated by the driver or the rider (Possible combination)	2. Horn used	2. Horn used
71	DES1EV	Most important evasive action as stated by the driver or the rider	2. Turned to the right	2. Turned to the right
72	DES2EV	Second most important evasive action as stated by the driver or the rider same values as DES1EV	2. Turned to the right	2. Turned to the right
73	DES1CA	First cause of accident as stated by the driver or the rider	2. Another person (maneuvers, intentions)	3. Driving on wrong side of the road.

\Appendix C4 Vehicle Information

Truck Information				
a. Identification				
1	ACCNUM	Accident Number	1	2
2	VEHNUM	vehicle Number	LSR367XA	GYA42XA
b. General Technical Information				
3	TMANUF	Manufacturer	6. Daf	6. Daf
4	TMODEL	Model	95 MOD	3300
5	T1REGM	First registration Month	JAN	July
6	T1REGY	First registration Year	2005	2010
7	TVINNU	Vehicle Identification Number (V.I.N)	K410623701AF24	LM002163712401
8	TBODYT	Body type (straight truck)	3. Flatbed with sides	3. Flatbed with sides
9	TCOLOR	Main color of the truck	11. Bright red	1. White
10	TSEADR	Driver's seat side	1. Left	1. Left
11	TTRAIL	The number of trailers or semi trailers, coupled to the vehicle	1	1
c. Design Specification **Brakes**				
12	TBRASY	Braking system type	1. Pneumatic	2. Pneumatic
d. Mandatory Technical Control				
13	TMANIN	Was the mandatory inspection Done?	2. Yes	2. Yes
14	TMANMO	Number of months since the last Inspection	1	10 days
e. Inspection Carried Out By the Crash Investigator				
15	TINSTY	Type of inspection	2. A brief visual inspection	2. Brief visual inspection
f. Apparent Condition before the Accident				
16	TDEFOR	Were there any important deformations from previous Impacts?	1. No	1. No

Appendix C4 Vehicle Information (continuation)

17	TMODI1	Most important modification to the vehicle (not standard equipment or manufacturers' option)	1. No modification	1. No modification
g. Vehicle Parameters General Information				
18	TLENTO	Vehicle length (mm)	2200	2200
19	TWIDTH	Vehicle width (mm)	2500	2490
20	THEIGH	Vehicle height (mm)	2900	3200
21	TTLONG	Vehicle combined length (truck and trailer) (mm)	18400	15500
22	TLEGWT	Gross Combined Weight Rating (GCWR) (kg)	39500	31600
h. Axle Description				
23	VNAXLE	Number of axles	5	4
24	VOVHAN	Front overhang (mm)	600	1270
25	VTRACK	Track (mm)	2500	2220
26	TTWINT	Twin tires	2. Yes	**2.Yes**
27	TAXLTY	Type of axle	1 Non lift	1.Non lift
28	VLEAXLE	Wheelbase to next axle (mm)	8600	8600
29	TSUSPE	Type of suspension	2 Pneumatic suspension	2 Pneumatic suspension
i. Brakes and Suspension: Defects				
33	VSUSDE	Suspension defects	1. No defect	1. No defect
34	VSUSDT	Effect of suspension and shock absorption defects	0. No defects	0. No defects
35	VBRADE	Brake defects	1. No defect	1. No defect
36	VBRADT	Influence of the brake defect on the accident	0. No defects	0. No defects

Appendix C4 Vehicle Information (continuation)

j. Bumpers and under run Protection				
37	TBUMIN	Is it believed that bumper had (or could have) an influence on the accident issue	1 No	1 No
38	TFUNIN	Is it believed that front under run protection had (or could have) an influence on the accident issue	1 No	1 No
39	TRUNIN	Is it believed that rear under run protection had (or could have) an influence on the accident issue	1 No	1 No
40	TSUNIN	Is it believed that side under run protection had (or could have) an influence on the accident issue	1 No	1 No
k. Front Bumper (Only If TBUMIN is yes)				
41	TBUFRS	Front bumper : shape	2. tubular	
42	TBUFRW	Front bumper : width (mm)	350	
43	TBUFHE	Front bumper : height (mm)	350	
44	TBUFRL	Front bumper : length (mm)	2490	
45	TBUFRH	Front bumper Height from the ground (mm)	405	
l. Front Under run Protection FUP (Only If TFUNIN Is Yes)				
46	TUNDIN	Is it believed that under run protection had (or could have) an influence on the accident issue	1 No	1 No
47	TFUPIN	Front Under run Protection : presence and influence	1. Not fitted and not needed in this crash type	1. Not fitted and not needed in this crash type
m. Rear End Protection (Only If TRUNIN is yes)				
48	TREABU	Rear end protection : presence and influence	1. Not fitted and not needed in this crash type	1. Not fitted and not needed in this crash type

Appendix C4 Vehicle Information (continuation)

n. Side Under run Protection (Only If TSUNIN is yes)				
49	TSUPIN	Side Underrun Protection: presence and influence	1. Not fitted and not needed in this crash type	1. Not fitted and not needed in this crash type
o. Cab Design				
50	TCABTY	Type of Cab	1. Conventional Cab	1. Conventional Cab
51	TCABSY	Cab size	3. Long cab (L ≥ 1.9 m	3. Long cab (L ≥ 1.9 m
52	TCABMA	Cab Material	1. Steel	1. Steel
p. Seat				
53	TSEATF	Type of front seat driver and passenger	3 Fixed seat	3 Fixed seat
54	TSEATR	Type of rear seat	3 Fixed seat	3 Fixed seat
q. Steering				
55	TSTEPO	Power steering	2. Yes	2. Yes
56	TSTEDE	Steering equipment defect	1. No defect	1. No defect
57	TSTEEF	Effect on steering	1. No effect	1. No effect
r. Internal Equipment				
58	TINECD	Radio / cassette / CD player	3. There is a player and it was in use	3. There is a player and it was in use
59	TINETE	Telephone	1. No vehicle telephone	1. No vehicle telephone
60	TINECB	CB	1. None	1. None
61	TINETV	Television	1. None	1. None
62	TINEAC	Air conditioning	1. No air conditioning	1. No air conditioning
63	TINEOT	Other equipment : comments	MP3	
s. Engine & Transmission				
64	TGEARB	Kind of gearbox	1. Manual	1. Manual
65	TTANKM	Fuel Tank material	1. Metal	1. Metal
66	TPOWER	Power source in use at time of the accident	2. Diesel	2. Diesel
67	TOILLE	Fuel leak	1. No	1. No
68	TLEAKS	Pre-crash leaks on vehicle	0. No leaks, not applicable	0. No leaks, not applicable
t. Windows and Vision				
69	TWINDS	Type of windscreen	1. Laminated with seal	1. Laminated with seal
70	TWINPO	Position of windscreen after crash	1. In place	1. In place
71	TWINCL	Cleanliness of windscreen before the crash	1. Clean	1. Clean

Appendix C4 Vehicle Information (continuation)

72	TWINEF	Effect of the cleanliness of windscreen on vision	1. No effect	1. No effect
73	TSUNLE	Position of left sun visor	1. Closed	1. Closed
74	TSUNRI	Position of right sun visor	1. Closed	1. Closed
u. Mirrors and Detection				
74	TMIRES	Driver side mirrors	01. Main mirror left	01. Main mirror left
75	TMIREC	Passenger side mirrors	2. Wide angle mirror	2. Wide angle mirror
76	TMIEQU	Mirror system driver and passenger side	1. Manual adjustment	1. Manual adjustment
78	TMIRST	State of the mirrors before the crash driver and passenger side	1. Good condition (clean)	1. Good condition (clean)
v. Lights				
79	THEADL	Type of headlights	1. Standard 2. Halogen	1. Standard 2. Halogen
80	THEAAD	Height adjustable headlights	2. Yes	2. Yes
81	VLIGUS	Use of lights at the beginning of the danger situation	2. Dipped head lights	2. Dipped head lights
82	VLIGCO	Condition of lights before the crash	1. Good state	1. Good state
83	VLICLL	Cleanliness of the lamps	1. Clean	1. Clean
84	VLIGEF	Effect of lamps cleanliness or state for the driver	1. No effect	1. No effect
85	VVISEF	Effect of lamps cleanliness or state for the opposite driver	1. No effect	1. No effect
86	TVISCO	Visibility of the vehicle. Was there a noticeable contrast between the vehicle and the Environment? (for the other driver)	2. Yes due to color	2. Yes due to color
w. Load				
87	TOCNUM	Number of occupants	**2**	2
88	TLOAOC	Total weight of occupants (kg)	150	140
89	TLOATO	Gross Vehicle Weight		

		(GVW) (kg)		
90	TLOAVE	Total cargo weight (for this vehicle) (kg)		
91	TLOAHE	Load height (from the platform to the top of the load) (cm)		**0**
92	TLOACG	Height of the centre of gravity of the load from the platform (cm)		**0**
93	TLOADA	Hazardous load	1. No danger	1. No danger
x. ITS Safety Systems				
94	TSSABS	Anti lock braking system	3. Not fitted (ITS use would reduce injuries)	3. Not fitted (ITS use would reduce injuries)
95	TSSBRA	Brake Assistance	3. Not fitted (ITS use would reduce injuries)	3. Not fitted (ITS use would reduce injuries)
96	TCSESP	Stability control system (ESP…)	1 Not fitted (not needed in this crash type)	1 Not fitted (not needed in this crash type)
97	TSSASS	Traction and stability control system	1. Not fitted (not needed in this crash type)	1. Not fitted (not needed in this crash type)
98	TSSSPL	Speed Limiter	1. Not fitted (not needed in this crash type)	1. Not fitted (not needed in this crash type)
99	TSSACC	Inter-vehicle distance regulation	1. Not fitted (not needed in this crash type)	1. Not fitted (not needed in this crash type)
100	TSSACR	Data recorder	3. Not fitted (ITS use would reduce injuries)	3. Not fitted (ITS use would reduce injuries)

Bus and coach information				
a. Identification				
1	ACCNUM	Accident Number	1	2
b. General Administrative & Technical Information				
3	BMANUF	Manufacturer	99. Unknown TOYOTA	99. Unknown Toyota
4	BMODEL	Model type (commercial name)	TOYOTA LITEHIACE (BUS) DLX MODEL	Toyota Litehiace 1997 Model
5	BVEIDN	Vehicle Identification Number (V.I.N)	JTFJX02P403001507	4T305100931020
7	BREGMO	Month of first registration of the vehicle	JULY	Dec.
8	BREGYE	Year of first registration of vehicle	2001	2000

Appendix C4 Vehicle Information (continuation)

9	BNBLEV	Type of coach	1 Single floor	1 Single floor
10	BDRISE	Driver's seat side	1. Left	1. Left
11	BCOLOR	Predominating Color of the motor vehicle	1. White	1. White
12	BPOWSO	Power source in use at time of the accident	1. Petrol	1. Petrol
13	BLENTO	Vehicle length (mm)	4695	
14	BWIDTH	Vehicle width (mm)	1695	1575
15	BHEIGH	Vehicle height (mm)	1980	1600
16	BLEGWT	Gross Combined Weight Rating (GCWR) (kg)	2800kg	1950
17	BHEICG	Centre of gravity height for empty vehicle (from the ground) (mm)	1050	1050
Vehicle Parameters **d. Axle Description**				
18	BNAXLE	Total number of axles	2	2
19	BOVHAN	Front Overhang (mm)	75	90
Vehicle General Technical State **e. Mandatory Technical Inspection**				
20	BTECIN	Was the mandatory inspection Done?	2. Yes	2. Yes
21	BMANMO	Number of months since last inspection	2	3
f. Inspection Carried Out By the Crash Investigator				
22	BTINTY	Type of inspection	2. A Brief visual inspection	2. A brief visual inspection
g. Apparent Condition Before The Accident				
23	BDEFPI	Were there any important deformations from previous Impact?	1. No	1. No
h. Load during Trip **Authorized Capacity**				
24	BCAPAC	Authorized capacity	11	8
25	BCAPST	Authorized stand up occupant capacity	0	0

Appendix C4 Vehicle Information (continuation)

	i. Real Capacity			
26	BCAPL1L	Number of seats 1st floor	11	8
27	BNBOC1	Number of occupants 1st floor	14	14
28	BOCNUM	Number of occupants	14	14
	j. Load			
29	BOCWEI	Total weight of occupants (kg)	1120kg	
30	BLOAVE	Total cargo weight (for this vehicle) (kg)	200kg	
31	BLOATO	Gross Vehicle Weight (GVW) (kg)		
	k. Tachograph Information			
32	BTACTY	Type of Tachograph		Not in used

Appendix C5 Reconstruction Information

	a. Identification			
1	ACCNUM	Accident Number	1	2
Pre-Collision Phase				
2	RDPPEV	Precipitating event	D12. Incorrect maneuver	Driving on wrong side
	b. Pre-Crash Motion, Just Prior to Precipitating Event			
3	RDPPRE	Description	30. Passing maneuver, passing on left	30. Passing maneuver, passing on left
4	RDPTSP	Travelling speed (km/h)	60-70km/h Truck 110-120Km/h Bus	70-80km/h 90-100km/h
6	RDPLSI	Line-sight to other vehicle	12	12
	c. Pre-Crash Motion, After Precipitating Event			
7	RDPPRE	Description	30. Passing maneuver, passing on left	30. Passing maneuver, passing on left
Pre-crash Description				
8	RDPCAN	Collision avoidance number	2	2
9	RDPCAV	Collision avoidance action (see manual)	2. Swerve 3. Braking and Sliding 4. Speeding by the bus driver	2. Swerve 3. Braking and Sliding
10	RDPMAR	Presence of pre-collision marks made by the current vehicle	6. Braking and Sliding	6. Braking and Sliding And speeding by bus driver

Appendix C5 Reconstruction Information (continuation)

11	RDPBRO	Did the vehicle slide broadside Before the first impact?	1. No	1. No
12	RDPBRD	Direction of slide broadside Before the first impact?	2. Anti-clockwise by the bus 3. Clockwise by the truck	2. Clockwise
13	RDPBRS	Slide broadside location before The first impact?		3. On the right edge
14	RDPDIS	Real developed distance from the first mark to first impact Chronologically (##. #. Meters)	12m	6.8m
d. Collision Phase				
15	RCOTIM	Calculated time from precipitating event to 1st impact (##.# s)		
16	RCONBI	Total number of impacts	1	1
17	RCOMIN	Main impact number	1	1
20	RCOTIV	Type of impact for the vehicle under study	1. Frontal	1. Frontal
21	RCOTIO	Type of impact for the opposite vehicle	1. Frontal	1. Frontal
22	RCOTOB	Corresponding Obstacle	5. Small bus ≤2,8 t	5. Small bus ≤2,8 t
23	RCOFIR	Fire?	1. No fire	1. No fire
e. Collision Deformation Code CDC or Truck Deformation Code TDC				
24	RCODIF	Direction of Force	12 O clock	12 O clock
25	RCODEL	Deformation Location	FRONT	FRONT
26	RCOLLO	Lateral Location	YO 2/3 Left Width	YO 1/2 Left Width
27	RCOVLO	Vertical Location	Middle	Middle
28	RCODDI	Type of damage distribution	Narrow Impact Area	Narrow Impact Area
29	RCODEX	Deformation extent	1	1
For Trucks Only **Cab Deformation** **f. Inside Deformation Cab**				
30	TINTRU	Intrusion of external object into cab	1: No	1: No
31	TCABSU	Status of Cab suspension after the crash	1. Intact	1. Intact

Appendix C5 Reconstruction Information (continuation)

32	TCABFI	Status of Cab fixation after crash	1. Intact	1. Intact
33	TPEACA	Amount of penetration of cab from the rear panel into interior	NO	NO
g. Under-run Penetration of Adverse Vehicle				
34	TUNDER	Under towing vehicle	1. No, no penetration	1. No, no penetration
Post-Collision Phase				
35	RPOMA_1	Presence of post-collision marks	5. Sliding	5. Sliding
36	RPODIS	Real developed distance from the first impact point to the vehicle at rest	7.8m	3.2m
37	RPOFPV	Final position for the vehicle	4. On the road wheels	4. On the road wheels
	RPOFPT	Final position of the towed vehicle	4. On the road wheels	4. On the road wheels