SCHOOL OF CIVIL ENGINEERING & GEOSCIENCES

OPTIONS TO IMPROVE THE MOVEMENT OF CAR TRANSPORTERS FROM NISSAN MOTOR MANUFACTURING UK TO THE PORT OF TYNE

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Submitted in partial fulfilment of the requirements for the degree of Master of Science in Transport Planning and Engineering in the Faculty of Science Agriculture and Engineering.

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DECLARATION

“I hereby certify that this work is my own, except where otherwise acknowledged, and that it has not been submitted previously for a degree at this, or any other university”.

Daniel Esteban Merchan Urquiza

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ABSTRACT

Nissan Motor Manufacturing UK (NMUK) constitutes a very important spot in the manufacturing activity in the UK. Hence, it has great influence in the North East economy by creating jobs and generating derived industry. Exporting 80% of the output, the movement of car transporters carrying new vehicles to the Port of Tyne (PoT) is of vital importance for the company.

The present dissertation suggests options to improve the transport of NMUK lorries by examining the feasibility of different infrastructure and ITS solutions for their implementation in the most congested areas.

Congestion is mainly influenced by the growing number of vehicles due to the recovery of the economic recession in 2008 and the numerous junctions that affect free flow in the A19 trunk road. Moreover, the Tyne Tunnel creates a bottleneck in the road which affects also vehicles taking the A19/A185 interchange in route to PoT.

DfT plans to improve Downhill Lane and Testos interchanges upgrading the A19 to expressway from York to Newcastle will take considerable time to be constructed. Equally, infrastructure proposals for the rest of the route are not ideal due to the high cost, slow implementation and generation of new traffic.

Having around 20% reduction in travel times and a 72% return of the investment in the first year; coordinated traffic lights and prioritisation of NMUK lorries were found to be most suitable solution. Fast execution and low cost compared to infrastructure developments are a big advantage too. However, partnerships with local authorities are necessary to implement such schemes.
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CHAPTER 1: INTRODUCTION

1.1 Introduction

The transport of goods is a necessary condition for economic growth, wealth and welfare in any society (Meersman, et al., 2001). It is directly related to industry and commerce which depend on logistic chains to achieve more efficient processes and to meet demands of different types of clients to generate revenues.

Environmental impact is becoming increasingly important specially in the transport sector which accounted for 19.5% of the total greenhouse gas emissions and more than a quarter of all carbon dioxide emissions in the EU27 for 2008 (EEA, 2009), with 95% contribution by road transport.

To enhance competitiveness, different Governments around the world are looking for partnerships with operators, manufacturers, research centres, local authorities and more stakeholders to achieve specific goals such as: support the development of the freight industry, maintain and improve the accessibility to rural and remote areas, minimise impact of the freight movements on the environment and ensure freight policy integration (Scottish Government, 2009), such is the case of the White Paper in Great Britain which establishes the guidelines for sustainable transport.

It is a very hard task to reduce the negative effects of freight transport without impeding economic welfare. In previous years the tendency was to build
new roads or to widen the existing ones but the new approach is to manage more efficiently the current transport network.

Many solutions have been extensively studied and tested in recent years in different countries of the world with and without success depending on economic, political, geographic and infrastructure factors.

The use of different modes of transport such as rail seems to be an ideal solution. But the growing and overwhelming dominance of road as a mode for freight transport makes improbable that other modes will make a serious impression on reducing road freight tonnes. Although water and rail help to reduce the modal share of road, they only serve to slow not halt the increase in road freight in total tonnage terms.

The use of ITS (Intelligent Transport Systems) makes possible to improve the network efficiency without the need for major infrastructure enhancements (Davol, 2001).

These technologies are focused on the development of more efficient vehicles and the creation of smarter roads.

While the introduction of reliable electric vehicles as a response to air pollution and autonomous prototypes are proofs of the great advances in the automotive industry in recent years. Smart traffic lights and interconnected networks have contributed to reduce the impact of the increasing number of vehicles on the roads.
There has been much research and many trials regarding intelligent networks and smart vehicles. Smart traffic lights, automated vehicles, vehicle to vehicle communication and communication between the road and the vehicle are examples of how the technology is continuously improving the transport efficiency.

However, most of the ITS studies are mainly focused on the priority and interaction of public transport and emergency vehicles without considering the freight sector. A common approach is the communication between the public transport and emergency vehicles to the traffic lights controller to give a green light when the vehicles are close to the crossroad.

This project is concentrated in the study of the best ways to improve freight using concepts of ITS used for Public Transport supported by the good logistics practice in the manufacturing industry. More specifically, how to enhance the movement of car transporters from NMUK located in South Shields to the Port of Tyne making use ITS solutions.

The main route that links these two points is the A19 trunk road which presents congestions areas especially in the junctions close to the Tyne Tunnel, causing delays in the delivery of new vehicles to be exported. This problem could increase with the growth in the number of vehicles on the A19 and the raise in the car production volumes.

The site where NMUK is located was specifically designated as a key cluster for the manufacturing industry. Having the car plant as the main industrial spot, the area is occupied by many other companies, most of them automotive
suppliers. The authorities expect a higher number of companies in the forthcoming years. Having this type of industrial clusters benefits not only the creation of jobs but also facilitates the movement of goods in the supply chain by avoiding long distances and several number of different routes.

The Port of Tyne is the most important trading hub for automotive import and export of vehicles in the North East of the UK.

1.2 Objective

The general objective of this project is to identify and minimise the reasons for congestion that cause delays to the transport of new vehicles from the NMUK plant to the Port of Tyne. The understanding of the application of diverse methods of traffic control and prioritisation is essential for this purpose. The specific objectives of the present dissertation are:

- Review of literature regarding the efficiency in the transport of goods and how is affected by the manufacturing industry and legislation.
- Revision of previous research carried out related to Intelligent Transport Systems, more specifically concerning to traffic lights control and vehicle prioritisation.
- Analysis of the different sections of the route from NMUK to PoT and identification of congested areas.
- Determine the key factors that have caused congestion in the route in the last ten years.
- Review of forthcoming transport schemes in the area and their influence on traffic flow.
- Ascertain possible solutions for the movement of car transporters from NMUK to PoT based on ITS technologies.
- Summarize and conclude the findings and limitations of the study.

1.3 Outline

The introduction gives an overview of the research and the inclusion of ITS technologies in the freight sector.

Chapter 2 presents the literature review with respect to the transport of goods and its implications on the supply chain as part of the manufacturing process. This chapter also mentions different approaches to improve the efficiency of freight such as different sizes of lorries and the size limits in the UK, driver behaviour and multi-modal travel. It is also included a revision of previous ITS research for prioritisation of vehicles in junctions and automated vehicles.

Chapter 3 describes the procedure used to carry out this research. It starts describing the study area followed by the data gathering from sources as DfT and Gateshead City Council. The use of mapping tools for traffic levels and the mechanism for the analysis of the route are also described in this chapter.

Chapter 4 reports the findings of the data analysis, it determines the relationship between road dimensions and the AADT levels. In the same way, this part of the study shows the degree of congestion at peak hours along the route.

Chapter 5 interprets and discusses the possible causes of congestion in specific areas of the route based on the results obtained. That is to say, the
effects that junctions and other infrastructure developments have in the traffic
growth in this area. This chapter also suggests feasible solutions that can be
implemented to enhance the movement of car transporters from NMUK to PoT.

Chapter 6 presents a synthesis of the main points and key findings of the
research. It makes recommendations for the use of ITS in the freight sector and
provides comments about the affection of new infrastructure in congestion. It also
states limitations and gives advice for future research.
CHAPTER 2: LITERATURE REVIEW

2.1 Importance of the transport of goods

From an economic point of view, transport 'adds value to a company by creating time and place utility; the added value is the physical movement of goods to the place desired and at the time desired' (Coyle et al., 1996 p.318).

Furthermore, transport and logistics excellence has become a prerequisite to achieving a world-class supply chain (Zeng and Rossetti, 2003).

On the one hand, mobility of goods as well as of persons is a necessary condition for economic growth, wealth and welfare. On the other hand it generates negative external effects which might hamper economic activity and harm wellbeing. This duality makes the design of policies, which reduce the external effects of freight transport without impeding economic welfare and economic growth, a hard task. It can only be successful if one has a clear insight in all the factors and mechanisms which have an impact on freight transport, on the negative external effects resulting from freight transport and on the complex network of relations between freight transport, passenger transport and economic activity. (Meersman, et al., 2001)

It should be noticed that road based freight traffic affects the environment by increment of emissions, increased noise, pollution and deteriorating air quality. It also results in freight vehicles using inappropriate roads in sensitive rural areas or along residential roads. However, vehicle/engine efficiency has undoubtedly improved over recent years. It is clear there is the need to balance,
where possible, the efficient distribution of goods and services whilst limiting the effect that this level of distribution has on the society it serves. There is a need to maintain economic vibrancy and growth with the realisation that we have to transport our goods and services in the most sustainable way. (Wiltshire Council, 2011)

2.2 Automotive manufacturing industry and logistics

Zahurul Islam (2005) states that it is important to notice how the advancement in transport, logistics and communication technologies has revolutionised total manufacturing, value adding and distribution.

The industry is characterized by multi-tier value chains starting. Meyr (2004) describes the converging character of the value chain, where multiple parts are manufactured or assembled subsequently to fewer numbers of components or one final car.

![Figure 2.1 Supply chain overview (Bauer, 2011)](image)

More specifically, raw material suppliers deliver basic raw materials such as steel, plastics and other chemicals in a first step. Then, multi-tier suppliers manufacture single parts and components or integrated modules that are assembled by the manufacturer to a final vehicle. Finally, vehicles are distributed via a dealer network serving a primary market to private or business customers. (Bauer, et al., 2011)
The automotive industry trend is to deliver vehicles with zero CO2 emissions in the long term. In this context, CO2 emissions are related to the supply chain steps and the vehicle usage phase. Hence the trend towards greening the automotive industry covers not only the car as end-product and the emissions in its lifecycle, but also the steps along the supply chain including suppliers for car production (Beske et al., 2008).

The labour costs differences and maturing automotive industries in emerging countries further drive globalization of the industry. Offshore and nearshore locations for different suppliers have forced to logistics and transportation optimization such as using intermodal transport, collaboration and consolidation and transport bundling & route planning which now are important tasks in the industry.

In the case of NMUK, the development of parts suppliers in the area reduces economic and environmental costs derived from transport. Moreover, in their aim for expansion, they look to supply not only domestic, but also overseas demand. As a result, the alliance with the Port of Tyne plays a key role to achieve successful outcomes.

2.3 Traffic lights control

Basically there are two methods to set traffic lights timing. Fixed-time signals assign the green light for a predetermined period. Some of them can be set to change the amount of time the light is green during peak traffic hours. These are usually in urban areas, where traffic movement is fairly predictable.
Traffic-responsive signals vary the timing of the lights according to the amount of traffic. They use sensors to detect the number of vehicles on an approach. The time the light stays green adjusts to let as many drivers as possible through before the signal changes to respond to traffic coming from another direction. (Virginia Department of Transportation, 2005)

Apart from this classification, traffic light strategies also can be classified as *Isolated strategies* that are applicable to single intersections and *coordinated strategies* which consider networks comprising many intersections. (Papageorgiou, et al., 2003)

Several studies to optimize traffic signal plans have considered queuing and fixed-time strategy. Osorio & Bierlaire (2008) developed a model which was tested and compared with other signal setting methods, such as Webster and HCM, in sub network in the city of Lausanne, Switzerland and demonstrate its ability to cope with congested scenarios by using a micro simulation tool.

In a further study (Osorio & Chong, 2012), an algorithm simulation was used to deal with large-scale signal control problems for the same city using a metamodel approach. The simulations were made with traffic at evening peak hours, showing favourable results compared with other signalisation plans. According to MIT news (Chandler, 2014), this approach reduced the average travel time for commuters by 22 percent and will be tested in areas of Manhattan with collaboration of the New York Department of Transportation.

Intelligent communication between vehicles has also been treated as a solution to manage road intersections efficiently. Ghaffarian, *et al.* (2012) used a
linear programming traffic controller to manage vehicles in intersections by avoiding the use of traffic lights. This controller gathers vehicles information and schedules them based on safety, priority and time constraints similar to the TRACS II surveys used in the UK for public transport and specially for bus scheduling. Their model is limited to isolated junctions and analyse vehicles on the head of the queues only. They also depend on that all the vehicles are well equipped with GPS and the VANET system to communicate with the controller, the drivers also need to know where they are going and setting up in the system because changing their decision in the middle of the intersection could lead to collisions.

Similarly, Viriyasitavat & Tonguz (2012) propose a method to avoid physical traffic lights by using Virtual Traffic Lights-Priority Intersection Control (VTL-PIC) for communication between vehicles. For this purpose, the vehicles which are approaching to the intersection elect a leader to be the responsible to manage the vehicles crossing and the different virtual green times. The leadership is passed to a new vehicle and so on. When an Emergency vehicle is detected, the leader communicates with it to give priority in that direction. Simulations demonstrated 45 second savings in travel time of all the vehicles compared to conventional physical traffic lights schemes using VTL only and up to 120 second savings for emergency vehicles when using VTL-PIC. Reductions in crashes were also estimated due to the inexistence of Emergency vehicles crossing in red lights. This scheme also depends on the technology which must be equipped in all the vehicles of the network.
Another method to manage crossroads in crowded environments is the use of photoelectric sensors on the side of the road distributed at certain distances to estimate the amount of vehicles prior to the crossroad. The traffic lights are controlled by a Central Control System which receives information from the sensors and is set by the Traffic Administration Department to weight the importance of each road approaching to the crossroads in order to establish priorities for green light. This study deals with emergency vehicles such as fire trucks, police cars and ambulances. These vehicles must have RFID (Radio frequency identification) installed previously so that when they are approaching to the intersection, the Central Control System opens the road based on the information sent by the sensors. The priority order is: Emergency vehicles first, road weighing second and third the amount of cars in each road. (Salama, et al., 2010)

Public transport has been one of the main concerns when analysing traffic management. This is still being the most efficient way to transport people, and many efforts have been made to prioritize them in intersections.

The UK has been in the forefront of ITS applications. One example is the SKELENT scheme (Hounsell, 1988) in the mid-1980s which took place in South East London and Kent. This project dealt with Bus Priority at Traffic Signals using the called Selective Vehicle Detection which uses transponder on board and an inductive loop detector to interact with the traffic controller in order to give priority by extending green times and reducing red times without forgetting compensation for the rest of vehicles in non-prioritised stages without buses.
Bowen, *et al.* (1994) point out a further analysis on bus priority specifically of the SELKENT scheme by using not only Selective Vehicle Detection in London but also Automatic Vehicle Detection in Southampton and manage the priority management controlled by SCOOT which makes the balance between buses and the rest of the vehicles.

Hounsell, *et al.* (1998) mention the results of the field trials for the SELKENT scheme in Camden Town and Edgware Road areas: average delay savings of 4 sec/bus/junction with an average of 8 seconds (70%) at lightly trafficked junctions with no significant disbenefits to general traffic. An economic return of 72% of system costs in the first year. This paper also mentions the INCOME project similar to Compass4D for public transport, launched by the European Commission in London, Brussels, Gothenburg, Piraeus and Turin.

In a more recent study, the communication and cooperation between buses showed important improvements in punctuality and consequently in reductions in passenger waiting times at bus stops. In this study, the priority for a bus is based not only on its own headway but also the headway of the following bus taking into consideration the scheduled headway time of each vehicle. (Hounsell & Shrestha, 2012)

Bhouri, *et al.* (2010) state a method to regulate the urban traffic, giving priority to buses, based on dividing the traffic network in four agents. The first agent is called Bus Agent, which is the bus itself with the objective to minimize the time spent at traffic lights. The second agent is the Bus Route Agent which supervises all the bus agents to prevent the creation of bus queues and maintain a proper distance between them. The third agent is the Stage Agent which is in
charge to clear the vehicles waiting on each lane or approaching to it by controlling the duration of the green light. The fourth agent is the Junction Agent which controls the whole junction traffic lights and develops a traffic light plan by supervising and collaborating with all the Stage Agents in the junction. The simulation showed an improvement of 38% on time spent by buses on traffic lights and about 51% of the vehicles lost time.

The advantage of this method is the improvement of public and private transport by taking into consideration the whole network. The authors state that this model copes with the limitations of microscopic models being time consuming and inaccurate for real time control strategies, they also states that their proposal surpass macroscopic models which consider continuous flow without making distinction of buses.

One of the main projects in Europe for traffic light management and vehicle priority is Compass4D. Compass4D is a 10 million Euro project launched in January 2013 until 2016 by ERTICO, it involves seven European cities such as Bordeaux, Copenhagen, Eindhoven-Helmond, Thessaloniki, Verona, Vigo and Newcastle. Key funding partners include Siemens and Volvo. (ERTICO - ITS Europe, n.d.)

The aim is to improve safety, reduce congestion and pollution by helping motorists to drive more efficiently mainly during frustrating rush-hour commute.

The project links an in-vehicle communication system, similar to a Sat-Nav device, directly with the city’s Urban Traffic Management Control centre. The system advises to the motorist to avoid areas which are becoming congested
and gives warn of approaching danger and obstacles on the road. It also displays the ideal speed the motorists should drive in order to pass through a series of green traffic lights and avoid the red ones, reducing the need for stopping, starting and accelerating. In red lights, the time remaining for light to turn green is given and advice on turning the engine off to reduce fuel use and emissions while idling. (Siemens UK, 2015)

In the case of emergency vehicles such as ambulances, the system gives priority at junctions, allowing free passage.

The trials in the seven different cities in Europe have with passenger vehicles, hydrogen vehicles, electric vehicles, HGVs, buses and emergency vehicles. Moreover, the system is placed in different scenarios to analyse how well it will perform in all driving situations such as urban and motorways. (Compass 4D, n.d.)

Figure 2.2 Compass 4D illustration (Source: www.siemens.co.uk, 2015)

Figure 2.3 Compass 4D in-vehicle display (Source: www.mirror.co.uk, 2015)
Gorobetz, et al. (2006) propose the use of Artificial Intelligence to coordinate public transport electric vehicles (Trams) and traffic lights. The aim was to have a no stop electric transport, except for the passengers taking; but it also will lead to reduce the number of electric energy charges caused by acceleration and braking cycles.

Each vehicle and each crossroad traffic lights set is independently governed by an artificial agent called tram agent and crossroad agent which are incorporated in the electric transport control system. The whole system is controlled by a superagent which is responsible for the negotiation and cooperation between the two types of intelligent agents. The computer modelling showed a 20% energy saving and between 40-50% in time saving.

Priority to public transport units are a key role to reduce CO2 emissions as stated by Copenhagen in its plan to be the first CO2 neutral capital in the world by 2025. The difference is that they treat the public transport units as a fleet and they make use of the existing GPS units in every vehicle to detect their position.

Using GPS and a traffic light controller, they give priority or not depending on the control strategy and the current policies.

To control the network they use the policy based adaptive signal control system called Imflow. The first field tests carried out in one intersection showed promising results. (Van den Bosch & Torp Madsen, 2014)

Additionally to the last study mentioned, ITS Action Plan 2015-2016 in Copenhagen (Technical and Environmental Administration, 2014) mentions a test in an area in the south west part of the city which has 10 traffic signals and
66 cameras to give priority to buses. The first results have shown that individual bus lines are saving up to two minutes during rush hour over the relatively short distance. Motorists and cyclists are expected to decrease their travel time by 20% in the area.

The Tyne and Wear Integrated Transport Authority (2011) suggests that should be considered the possibility of more radical interventions over the longer term. The construction of Bus Rapid Transit (BRT) schemes in the Cambridge and Dunstable areas raises the question as to whether one or more of the former rail or waggon way alignments across the conurbation could lend to a similar function.

With capital expenditure opportunities expected to be restricted for the foreseeable future, the lower overall costs of BRT relative to rail-based interventions suggest potential for further study.

2.4 Multimodal freight transport

The overwhelming majority of freight distribution within the county is made by road, and that this is likely to remain so in the foreseeable future. The transfer of road freight to rail would benefit particularly climate change. (Wiltshire Council, 2011)

Road is the dominant transport mode in Europe, claiming 73.4% of passenger transport, and 71.8% of the hinterland freight transport, excluding sea transport. Speed of movement is, of course, not the only issue with regards to freight movement. The effects on congestion, road safety and air quality must
also be taken into account, as must national government guidance, which encourages modal shift to rail, sea and, in some cases, inland waterway. It should also be noted that much freight movement is trans-national. (The Tyne and Wear Integrated Transport Authority, 2011)

Rail freight has grown rapidly in the past ten years and further growth (30% in freight tonnes lifted nationally) is forecast to 2014/15. Depending on variables such as payload and train length, this could be equivalent of 240 additional freight trains nationally per day on week days (Network Rail, 2007).

A national HSR (high speed rail) network will help to opening up economic potential across the UK, support regional competitiveness and inward investment opportunities and, by creating additional capacity on the existing classic main lines for passenger and freight traffic, will improve the regional economy. (The Tyne and Wear Integrated Transport Authority, 2011)

Multimodal transport has been studied by different Governmental Organizations and ONGs as a way to improve the movements of freight.

It can be defined as the most cost- and time-effective way of moving goods from shipper to consignee by at least two different modes of transport by a single operator under a single contract. (Zahurul Islam, 2005)

The Scottish Government (2009) stated that for a competitive multimodal transport it should be enhanced and expanded railway and motorway networks, improve links and implement environmental schemes. They also noticed that the causes and barriers regarding to multi modal freight are the limited degree of interconnectivity, the lack of regional and jurisdictional coordination among
stakeholders and regions and high investment costs and the efficiency in long journeys only.

Moreover, freight companies base their choice on transit time, logistics cost and reliability rather than being biased by the mode itself. However, policy makers can take steps to internalize external costs of transportation including emissions, road wear and tear, and the like, and, in doing so, promote modal switch in line with the incentives of shippers. It is important to note that the modal shift must provide added value to shippers for the change to be done. (Transportation Research Board, 2012)

2.5 Reduction of fuel consumption and emissions

In the EU, the fuel of a 40-tonne tractor–semi-trailer combination accounts for about 30% of its total operating costs. (European Commission, 2012)

The ECOSTARS program (Fell, et al., 2014) achieved reduction in energy and improvement in air quality. The project began in South Yorkshire and was applied in other countries such as Italy, Spain, Sweden, Netherlands and Czech Republic. To achieve operational efficiency, the foundation of the ECOSTARS project was based on adoption of cleaner vehicles, fuel management, driver skills, vehicle specification and correct maintenance, use of IT systems and performance monitoring. ECOSTARS also helped to encourage the faster introduction of vehicles using clean fuel technologies, as well as the take up of fuel efficient driving schemes.
ECOWILL was a similar project which encouraged ecodriving to reduce emissions and save fuel. (Intelligent Energy Europe, 2013)

The FLEAT project funded by the EU (Jellinek & Krutak, 2010) showed a total saving of 4.300 tons of CO2 in a pilot made using 21872 vehicles from public and private fleets, having the largest contribution from ecodriving actions. Other factors to contribute to CO2 reduction are: vehicle technology and mobility management.

Similarly, in the SAFED program, the Department for Transport (2004) showed the effectiveness of drive training, achieving 36.9% reduction in gear changes, without adding time to journeys, substantial fuel savings recorded in litres and pounds and an average improvement in MPG of 10.01%.

Alternative fuels can also be a way to improve the effect on the environment. According to a study made by the European Commission (2009) called BEST, the use of bio-ethanol as an alternative fuel is also viable and reliable in both, low and high blends.

In more recent studies carried out by the EU, such as the CONVENIENT project (European Commission, 2012) in partnership with IVECO, DAF, VOLVO, research centres and Universities. The still ongoing project aims to achieve a 30% of fuel savings by implementing new technologies in both, the truck and semi-trailer. The detailed saving percentages are shown in the figure below.
Similarly, the Transformers project (European Commission, 2013) aims to make HGVs more efficient and reduce fuel consumption in 25% by making trucks-trailers automatically adaptable to the actual driving environment (i.e. traffic situation, topology, and payload).

They plan to achieve the objective by using an adaptable Hybrid-on-Demand (HoD) driveline concept applicable to existing and future trucks, a pre-standard electric Hybrid-on-Demand Framework and the implementation of a mission-based configurable aerodynamic overall truck-trailer design.

The coordinator of the project is VOLVO, with the participation of BOSCH, DAF, DAIMLER, Procter & Gamble, among others. The project is ongoing and is expected to be delivered by February 2017.
2.6 Partnerships

Many countries recommend partnerships to achieve successful outcomes in the transport sector, especially regarding to freight.

In an European context, the WINN project (European Commission, 2012) is a step forward to increase collaboration and consensus between different stakeholders dealing with freight transport and logistics to define and implement research and innovation measures including policy that may be implemented in the medium-long term. The stakeholder network includes research centres, public bodies, and private industry at national and European level. Manufacturing companies, retail, logistics services providers, transportation companies and logistics hubs and platforms (airports, ports, dry ports, etc.) are all represented in these networks.

The UK launched a project called FQPs Freight Quality Partnerships (Department for Transport, 2003) which encourages partnerships between the industry, local governments and the wider community. Working together, the aim is to promote a distribution system that looks for economic growth, whilst minimising the social and environmental impact. Particular examples of what FQPs can achieve include agreements on routing, load sharing and town centre access without mentioning benefits such as congestion and emissions reduction and improve the efficiency of freight distribution in rural areas.

Aligned with this vision, in their Multi-Modal Freight Locations Study, the Scottish Government (2009) mentions the necessity for partnerships between the private and the public sector to find the best financially viable solutions for
transport problems. This Government encourages and helps all the private investments in freight infrastructure by assisting in planning permissions, improving transport accessibility links, etc.

Locally, the Tyne and Wear Region established a Freight Partnership in 2005 which includes operators, local authorities and other stakeholders and considers problems and opportunities in order to identify a sustainable distribution strategy that meets the needs of operators and their clients, whilst being mindful of wider public policy goals. All the information about the meetings could be found on the Partnership's website: http://www.tyneandwearfreight.info (The Tyne and Wear Integrated Transport Authority, 2011)

2.7 Weight and dimensions of lorries in the UK

The current UK limits, set out in full in the Road Vehicles (Construction and Use) Regulations 1986 (SI 1986/1078), as amended, are as follows:

- Weight: 44 tonnes for 6 axles lorries; 40 tonnes for lorries with 5 axles.
- Length: 12 metres for a rigid vehicle and 16.5 metres for an articulated vehicle.
- Width: 2.55 metres excluding driving mirrors. 2.6 metres for refrigerated vehicles.
- Height: No limit, but 4.95 metres should be achieved in order to use the motorway and trunk road network. (Butcher, 2009)

Although there have been suggestions by the press, trials made in Germany and the Netherlands and studies made by the European Union
regarding the possibility of the permission of longer and heavier lorries in the UK increasing the weight limit to 60 tonnes even 100-tonne lorries. The response of the UK Government has not been positive, it does not see a clear evidence that these could deliver economic benefits. On the contrary, the Government concerns more about the impact on pavements, bridges and other infrastructure. They consider that LHVs will encourage the shift from rail to road freight causing an increase in CO2 emissions, affecting the rail industry and increasing the road traffic.

The unsuitability for vehicles to be driven in some road and junctions, new safety risks and the efficient use of such vehicles, particularly when sourcing loads of sufficient size to make return journeys sustainable make unlikely a positive response of the Government. (Butcher, 2009)

2.8 Road trains

A road train consists of a conventional tractor unit towing two or more trailers or semi-trailers. Is a method for the transport of goods used in remote areas of Argentina, Australia, Mexico, the United States, and Canada to move freight efficiently. (Gary’s Job Board, 2015)

In contrast to current heavy good vehicles (HGV) of length 16.50m/18.75m that are used in most European countries, long heavy vehicles (LHVs) could carry 50% more volume considering their lengths of 25.25m. The range of weight limits is between 40t (German trials) and 60t (Sweden). Compared to existing weight limits of 40/44t, this implies an increase of up to 50% in tonnage. (Steer, et al., 2013)
The concept of LHV is simple in the sense that in addition to more powerful motors a trailer is attached to a standard HGV. This allows flexibility in trailer combinations and avoids the necessity of large investments into vehicle fleets leading to a CO2 emission decrease.

Opponents to LHVs claim a potential shift from alternative freight sectors (e.g. rail, ship, air) to road leading to an increase in the number of trucks causing an opposite effect on the environment.

Difficult handling in different situations, interaction with other motorists, the necessary investment in the reconstruction of infrastructure (e.g. bridges, tunnels, dedicated lanes, parking facilities, etc.) and road traffic management (e.g. traffic light phasing) are also disadvantages for LHVs introduction.
With the above mentioned, the additional costs such as maintenance service, driver education, training and externalities could be justified only if the load of LHV exceeds HGV significantly. (Kritzinger, et al., 2010)

2.9 Autonomous vehicles

The Cargo-Ants project aims to create smart Automated Guided Vehicles (AGVs) and Automated Trucks (ATs) that can co-operate in shared workspaces for efficient and safe freight transportation in main ports and freight terminals. The project, funded by the EU, is being carried out from Sept 2013 with the cooperation of VOLVO and other research scientific centres.

The project objectives are to develop and demonstrate a reliable positioning system and environmental perception and safe interaction in smart AGVs and ATs (Cargo-Ants, 2013).

Figure 2.6 Cargo-ANTS concept (Source: www.cargo-ants.eu, 2013)
One of the most important programs was the SARTRE project. The main objective was the development of safe environmental road trains (platoons). The project brought together the skills and expertise of 7 partners from 4 countries: Applus+ IDIADA, Institut für Kraftfahrzeuge Aachen (ika), Ricardo, SP Technical Research Institute of Sweden, Tecnalia, Volvo Cars and Volvo Technology.

The overall concept of SARTRE is to have a group of vehicles driving together with a lead vehicle, driven normally by a trained professional driver, and several following vehicles driven fully automatically by the system with small longitudinal gaps between them. Driving in this way in a platoon brings benefits in fuel consumption, 20% emissions reduction, less congestion, safety and driver convenience. A truck can save up to 2.8 tons of CO₂ in a single year and a car up to 0.1 tons simply by platooning. At a gap of 8m all of the vehicles achieve fuel savings from 7 to 15%. (SARTRE Project, 2012)

In addition to investigating the concept, a demonstrator system has been developed consisting of 5 vehicles: a lead truck, a following truck, and 3 following
cars. Demonstrations were carried out in closed test tracks and public motorways near Gothenburg and Barcelona.

The consideration of how platoons interact with other non-platoon users is a critical facet of the programme. All makes perfect sense when every vehicle on the road is automated and able to communicate with each other, but different issues arise when robots are sharing space with humans. (Motherboard, 2014)

![Platoon under test at IDIADA](Source: www.sartre-project.eu, 2012)

Figure 2.8 Platoon under test at IDIADA (Source: www.sartre-project.eu, 2012)

In another strategy to introduce automated road vehicles in the market. Mercedes Benz developed in 2014 a 40 tonne automated Heavy Good Vehicle called Future Truck 2025. As the vehicle’s name suggests, the intention is to launch a roadworthy version by 2025. The benefits are clear regarding to security and fuel economy due to an efficient drive. But problems with the reduction of jobs and drivers unions. (DailyMail, 2014)
The lorry is controlled by an interface called Highway Pilot which is a combination of radar sensors at the front and sides, a stereo camera behind the windscreen, precise three-dimensional maps and V2V/V2I communication – which stands for Vehicle to Vehicle and Vehicle to Infrastructure – the exchange of information between the truck and other vehicles, and with the world outside the motorway. A tablet is used to control the system, and drivers can also see routes and information about the truck.

The system also recognizes Emergency vehicles or broken cars on the road which by the way should have a V2V communication. Nonetheless, overtaking is manual. In autonomous mode the Future Truck 2025 would patiently follow the slow-mover, as it never leaves its lane. But in this case overtaking is worthwhile the driver pivots the seat into the driving position, takes over manual control, indicates and changes lane to overtake. Returning to his lane, he can then hand control back to the “Highway Pilot”. Important note: The driver of the autonomous truck is always in full control, and can always override the technology by steering, braking or accelerating as required. (Daimler, 2014)

Figure 2.9 Truck scan of vehicles and incidents
(Source: www.dailymail.co.uk, 2014)
Daimler Group released in May 2015 another automated heavy vehicle called Freightliner Inspiration which is based on the Mercedes Benz Future truck 2025 mentioned above. It uses the same technology and the same Highway Pilot interface with the difference that everything was done with a closer approach to series production. (Daimler, 2015)

The Freightliner Inspiration Truck is the first licensed autonomous commercial truck to operate on an open public highway in the United States. Developed by engineers at DTNA, it promises to unlock autonomous vehicle advancements that reduce accidents, improve fuel consumption, cut highway congestion, and safeguard the environment. (Freightliner, 2015)

Behind the grille is a short-range radar scanning out to 230 ft. (70 m) in a 130-degree arc, while a long-range unit scans out to 820 ft. (250 m) in an 18-degree arc. These hook into the Active Cruise Control and Active Brake Assist. Behind the front windscreen is a stereo camera that can recognize road markings and operate the steering mechanism. (Gizmag, 2015)

Figure 2.10 Freightliner Inspiration radars (Source: www.gizmag.com, 2015)
2.10 Route Management

To mitigate the impact of the movement of goods, improving capacity in key roads and junctions would be desirable, but there has increasingly been a move away from continually increasing the road capacity, towards managing and maximising the existing network and managing transport demand upon it.

The following road hierarchy has been useful to facilitate the movement of freight traffic with the minimum social, environmental and economic costs.

- Strategic: Roads for long-distance journeys.
- Local: Roads for local journeys (long-distance movements not encouraged)
- Access: Roads for access only (through traffic not advised or encouraged)

HGV mitigation from the public typically may include speed, signing, traffic calming, noise abatement or infrastructure. Where it is considered appropriate, certain roads may be subject to the imposition of weight restrictions, if lorry movements on these routes are deemed as unacceptable.

It is important to mention that GPS systems sometimes route lorries along unsuitable roads due to the fact that the vast majority of these devices show only ‘car specific’ information. To solve these issues there has to be a joint work between the Council and the satellite navigation and mapping companies. (Wiltshire Council, 2011)

An example of reliable routing is the interactive map in the Tyne and Wear Freight Partnership website (http://www.tyneandwearfreight.info) which displays
a suggested route from the origin point of the shipment to a tenant's location, taking into account height and weight restrictions.

Planning routes is mentioned as Best Practice by the Department for Transport (2005) to achieve a more efficient freight movement. Computerised Vehicle Routing and Scheduling (CVRS) is a software developed along with a contractor that deals with the goods delivery in a much better way.

CVRS systems can take large numbers of customer orders and calculate the most effective way of meeting them. They calculate the time and resources required to complete the work, using collection and delivery information and observing the pre-determined parameter settings that control the way in which the transport operation is run. Parameters can include road speeds, load size, customer opening times and driver hours. However, this approach is useful for large fleets, more than 25 3.5 tonne vehicles, multi drop delivery, multi customer with individual requirements. Therefore, it could be concluded that it is not suitable for the present project.
CHAPTER 3: METHODOLOGY

3.1 Overview

This chapter presents the procedure used to find the most adequate solutions to improve the efficiency of freight movement from NMUK to PoT.

To have a better understanding of the current situation, it was established contact with NMUK through many phone calls and e-mails, in order to obtain information regarding to the route used by the car transporters, the number of daily trips, problems encountered in route and other aspects related to their logistical operation logistical. The response is attached in Appendix A.

These knowledge is required to determine the most suitable solutions taking into account factors such as economic investment, existing technology and time for implementation.

The next step was to divide the route in different sections and analyse the capacity and the level of traffic at peak hours in each of those sections.

If the capacity of the road is not enough for the actual traffic, it is very likely the necessity of infrastructure enhancement widening the road. But in the cases when the road is congested at peak hours but the dimension and/or number of lanes on the road is enough theoretically, the delays could be caused by junctions, traffic lights or any other feature. Therefore, the identification of the causes of delays was done by observing infrastructure factors such as the layout of each site and external contributors like the trend in number of vehicles.
The last point of the analysis was to suggest short term and viable methods to improve the free flow of lorries from NMUK to PoT.

3.2 Study Area

This project is focused on the route between NMUK and the Port of Tyne. The NMUK plant is located in Sunderland, specifically in Washington Rd, Sunderland, Tyne and Wear SR5 3NS. The Port of Tyne is located in Maritime House, Tyne Dock, South Shields, Tyne and Wear NE34 9PT. Both places are separated 4.6 miles approximately following the A19 road.

3.2.1 Nissan UK

Nissan Motor Manufacturing UK is located in Washington boundaries, Tyne & Wear, in North East England. It's built on the former Usworth Aerodrome. A19 and A1231 Sunderland Highway trunk roads. The factory is adjacent to the UK Nissan Distribution Centre (NDS) and has a number of on-site suppliers. The plant currently has 10 onsite wind turbines, producing up to 10% of the energy required. (Wikipedia, 2015)

Nissan employs more than 6,000 workers and last year produced 510,000 vehicles at its plant in Sunderland, home of the Nissan Qashqai, Juke and Note vehicles. (Alliance Renault Nissan, 2013). The company exports 80% of its production to more than 130 markets. (NISSAN, 2015)
3.2.2 Port of Tyne

Located in the North East of England the Port of Tyne is a deep water, lock-free port that benefits from an excellent location and transport infrastructure. Is the UK’s number one car handling facility for exports, number three overall in the UK, and Europe’s seventh largest car handling facility. In 2014, the Port of Tyne handled almost 650,000 units of which imports accounted for 203,000 and exports 441,000. The port’s top two manufacturers were Nissan and VW Group. It also handles Renault, Dacia, Audi, International Motors, General Motors and heavy equipment for Komatsu. (Automotive Supply Chain, 2015)

With high security reception, storage facilities, a rail distribution terminal and considered to be one of the most versatile and efficient handling terminals in the UK, the Port of Tyne is recognised as a major European vehicle handler. (Port of Tyne, 2015)

As mentioned in Automotive Supply Chain (2015), the awaited improvements to the A1 Western Bypass and upgrades to the A19 could help the Port expansion.

3.2.3 International Advanced Manufacturing Park

The International Advanced manufacturing Park (IAMP) is a joint venture between Sunderland and South Tyneside Councils working closely together with the North East Local Enterprise Partnership. The IAMP development is expected to be located in the area north of Sunderland’s Nissan car plant close to the A19 (T).
The project looks to provide companies with the facilities to set-up and expand in the North east Region by developing a high quality strategic employment site for advanced manufacturing to attract national and international business investment and job creation.

Detailed analysis show real need for a large area of business space within the North East Region. There are particular demands for supply chain companies close to Nissan Motor Manufacturing. Over recent years a number of large investment projects have regretfully had to be turned away due to a shortage of suitable sites in the area. (South Tyneside, 2014)

3.2.4 Port of Tyne and Nissan Relationship

NMUK is located 5 miles from Port of Tyne where international distribution is based. (Wikipedia, 2015)

The Port of Tyne has been used by Nissan since 1995 as its main entry port into the UK for vehicles manufactured overseas. The Nissan-Renault Group decided in 2012 to use Port of Tyne for Renault and Dacia vehicles replacing the former deal with the Port of Teesside. “Moving to a single, consolidated port is the latest step in the deepening collaboration between Renault and Nissan. Using the same port in this critical region reduces overall costs and complexity,” said Christian Mardrus, Renault-Nissan Alliance Managing Director for Logistics. (Alliance Renault Nissan, 2013)
3.3 Mapping systems

For the analysis of the route and the collection of necessary data, there were used desktop web mapping services in order to have the latest information.

Google Maps: is a web mapping service developed by Google. It offers satellite imagery, street maps, 360° panoramic views of streets (Street View), real-time traffic conditions (Google Traffic), and route planning for traveling by foot, car, bicycle (in beta), or public transportation. (Wikipedia, 2015)

Google Traffic: is a feature on Google Maps which displays traffic conditions in real-time on major roads and highways in over 50 countries [1]. When a threshold of users in a particular area is noted, the overlay along roads and highways on the Google map changes colour. (Wikipedia, 2015)

Digimaps: Is a collection of services that deliver maps and map data of Great Britain to UK tertiary education. (University of Edinburgh, 2015)

It was used for to obtain layouts of different areas and to measure distances in sections of the road.

3.4 Route from NMUK to PoT

This route was given by Jessica Price from Renault-Nissan Alliance Logistics Europe. (Price, 2015)

Nevertheless, as it could be seen in Appendix A, the route is not clear. Therefore it was necessary to identify the entrances and exits that are used by NMUK car transporters in order to set start and end points.
The gate used for transports of goods at NMUK is located in the south west part of the plant as could be seen in Figure 3.1.

Figure 3.1 NMUK map (Source: www.google.co.uk/maps, 2015)

In the case of the PoT, the gate used by NMUK lorries is Jarrow Rd located in the South Estate of the port as shown in Figure 3.2.

Figure 3.2 PoT South Estate Site plan (Source: www.steve-ellwood.org.uk)
As a result, the route of car transporters is the one shown in Figure 3.3

Figure 3.3 NMUK - PoT route (Source: www.google.co.uk/maps, 2015)
Additionally, according to Google (2015), the driving instructions of the trip are:

![Driving Instructions](https://www.google.co.uk/maps/directions?source=api&destination=NMUK&output=xml&Lat1=54.949895&Long1=-1.357833&Lat2=54.949895&Long2=-1.357833&VehMode=driving&key=AIzaSyA7YtzUf8cJ4Qkz8yYJN_zsK45NFo2fYtQ)

3.5 Capacity of the road

The first step of this analysis is to check if the capacity of the road is enough for the current and future traffic. The Congestion Reference Flow (CRF) is the indicator used to determine the level of congestion in a road.

The CRF of a link is a standard measure and is an estimate of the Annual Average Daily Traffic (AADT) flow at which the carriageway is likely to be ‘congested’ in the peak periods on an average day. Congestion is defined as the situation when the hourly traffic demand exceeds the maximum sustainable hourly throughput of the link.

The link ‘Stress’ is the ratio of the AADT to the CRF. When this ratio exceeds unity (1.0), it indicates that the section of road is likely to suffer from link
congestion at certain times of the day due to lack of link capacity. Note that it is possible for a road to suffer from link congestion at less than the theoretical link capacity for factors other than the number of lanes and percentage HGVs.

If there are link congestion issues and the stress levels are in excess of 1.0, it would suggest that the only practical solution would be some increase in capacity, such as widening. It is also worth noting that a link stress of between 0.85 and 1.0 will usually lead to turbulent traffic conditions during peak periods (Atkins, 2012).

To carry out the analysis, this document divides the route in segments delimited by the junctions in the road as could be seen in Figure 3.5 and Table 3.1. These segments also correspond to traffic data available in DfT and TADU from Gateshead City Council.
Figure 3.5 Division points in the route
Table 3.1 Sections of the route

<table>
<thead>
<tr>
<th>Section</th>
<th>Road</th>
<th>Type of Road</th>
<th>Carriageway</th>
<th>Start</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td>SECTION 1</td>
<td>A1290</td>
<td>PR: Class A Principal road in Rural area</td>
<td>S2: Single</td>
<td>Point A: Nissan Plant</td>
<td>Point B: Downhill Lane interchange (A19/A1290)</td>
</tr>
<tr>
<td>SECTION 2</td>
<td>A19</td>
<td>TR: Class A Trunk road in Rural area</td>
<td>D2AP: Dual lane all purpose</td>
<td>Point B: Downhill Lane interchange (A19/A1290)</td>
<td>Point C: Testos roundabout (A19/A184)</td>
</tr>
<tr>
<td>SECTION 3</td>
<td>A19</td>
<td>TR: Class A Trunk road in Rural area</td>
<td>D2AP: Dual lane all purpose</td>
<td>Point C: Testos roundabout (A19/A184)</td>
<td>Point D: A19/Hedworth Ln interchange</td>
</tr>
<tr>
<td>SECTION 4</td>
<td>A19</td>
<td>TR: Class A Trunk road in Rural area</td>
<td>D2AP: Dual lane all purpose</td>
<td>Point D: A19/Hedworth Ln interchange</td>
<td>Point E: Lindisfarne junction (A19/A194)</td>
</tr>
<tr>
<td>SECTION 5</td>
<td>A19</td>
<td>TU: Class A Trunk road in Urban area</td>
<td>D2AP: Dual lane all purpose</td>
<td>Point E: Lindisfarne junction (A19/A194)</td>
<td>Point F: Jarrow interchange (A19/A185)</td>
</tr>
<tr>
<td>SECTION 6</td>
<td>A185</td>
<td>PU: Class A Principal road in Urban area</td>
<td>D2AP: Dual lane all purpose</td>
<td>Point F: Jarrow interchange (A19/A185)</td>
<td>Point G: A185/National Cycle Rte 14 junction</td>
</tr>
<tr>
<td>SECTION 7</td>
<td>A185</td>
<td>PU: Class A Principal road in Urban area</td>
<td>S2: Single</td>
<td>Point G: A185/National Cycle Rte 14 junction</td>
<td>Point H: Jarrow Rd (Port of Tyne entrance)</td>
</tr>
</tbody>
</table>

The method of calculation depends on the type of road. That it so say, for sections 1 to 4, it is used DMRB, Volume 5, Section 1, Part 3, TA 46/97 correspondent to rural roads (Highways England, 1997). And for urban roads is used DMRB, Volume 5, Section 1, Part 3, TA 79/99 for urban roads (Highways England, 1999).

For rural roads, the method of calculation is as follows:

\[
CRF = \frac{\text{CAPACITY} \times NL \times Wf \times 100}{P_{kF} \times 100 \times P_{kD} \times \text{AADT} \times \text{AAWT}}
\]

Capacity = A – (B x Pk%H)

Link Stress = AADT/CRF

Where:

- CAPACITY is the maximum hourly lane throughput vehicles.
- A and B are lane capacity factors.
- Pk%H is the percentage of HGVs.
- NL is the number of lanes per direction.
- Wf is a width factor.
- PkF is the proportion of total daily flow (2-way) in peak hours.
- PkD is the directional split of the peak hour flow.
- AADT is the annual average daily traffic flow on the link, and
- AAWT is the annual average weekday traffic flow on the link.

Wf, PkF and PkD are obtained from DMRB Volume 5, Section 1, Part 3 TA 46/97

%HGVs are obtained from traffic counts DfT website (Appendix B)

AADT/AAWT is obtained from Gateshead City Council (Appendix C)

For urban roads, the analysis consists in the comparing the values in the table of capacities for urban roads (Appendix E) multiplied by 24 hours, and the AADT value obtained from the tables in Appendix B. The link stress formula is the same as for rural roads.

### 3.6 Traffic level on the route

To identify the levels of congestion in the different sections of the route, it was used a mapping tool. Tyne and Wear UTMC mapping system does not have detailed data for each part of the route analysed, instead they collect information from A1/A19 junction to A19/A184 (Testos) roundabout in the north as one segment and from A19/A184 to A19/B1285 in the south as another segment.
which being too long, are not representative for this study. Moreover, sections 1 and 7 are not considered in UTMC data yet. As a result, Google Traffic was used.

Figure 3.6 indicates the congestion in each link of the network by giving a different colour to each of them.
CHAPTER 4: RESULTS

This chapter presents quantitative and qualitative findings as a result of the analysis of each section of the route.

The first aspect examined was the capacity of the road to verify if the design dimensions are enough to manage the traffic volumes. The values presented are a result of the calculation method explained in Section 3.5.

Next, this section shows a table with the traffic levels along different sections of the route in order to identify the most congested points at peak hours.

Finally, this chapter describes the layouts of these points and possible causes of congestion which are analysed in Chapter 5.

4.1 Capacity of the road

4.1.1 Section 1

\[
\begin{align*}
A &= 1380 \\
B &= 15 \\
PK\%H &= 2.73 \\
\text{Capacity} &= 1339.05 \text{ vehicles per hour per lane} \\
NL &= 1 \text{ lane per direction} \\
Wf &= 1.46 \\
PkF &= 9.6 \\
PkD &= 58.4 \\
\text{AADT/AAWT} &= 0.86
\end{align*}
\]
CRF = 29989.14 vehicles per day
Link stress = 0.199. Therefore there is no risk of congestion.

4.1.2 Section 2

A = 2100
B = 20
PK%H = 5.82
Capacity = 1984 vehicles per hour per lane
NL = 2 lanes per direction
Wf = 1
PkF = 9.4
PkD = 57.4
AADT/AAWT = 0.88
CRF = 62284 vehicles per day
Link Stress = 0.9121. Therefore, it is likely to be congested at peak hours.

4.1.3 Section 3

A = 2100
B = 20
PK%H = 7.28
Capacity = 1955 vehicles per hour per lane
NL = 2 lanes per direction
Wf = 1
PkF = 9.4
PkD = 57.4
AADT/AAWT = 0.88

CRF = 63770 vehicles per day

Link Stress = 0.567. Therefore there is no risk of congestion.

### 4.1.4 Section 4

A = 2100

B = 20

PK%H = 5.83

Capacity = 1984 vehicles per hour per lane

NL = 2 lanes per direction

Wf = 1

PkF = 9.4

PkD = 57.4

Having no data from TADU, the value of 0.97 for AADT/AAWT was obtained by using table in Appendix D as suggested by DMRB (Highways England, 1997).

CRF = 71335 vehicles per day

Link Stress = 0.512. Therefore, no risk of congestion.

### 4.1.5 Section 5

%HGVs = 7.16

AADT = 29815 vehicles per day.

Capacity = 86400 vehicles per day

Link Stress = 0.345. Therefore there is no risk of congestion.
4.1.6 Sections 6 and 7

In this part, the present study analyses the sections 6 and 7 as one section. This is because the traffic count data is available for the two different parts as one section from Point F to Point H.

\[
\% \text{HGVs} = 4.85 \\
\text{AADT} = 18247 \text{ vehicles per day.} \\
\text{Capacity} = 86400 \text{ vehicles per day.} \\
\text{Link Stress} = 0.21. \text{ Therefore there is no risk of congestion.}
\]

4.2 Traffic level

Although in the NMUK email (Appendix A), the peak hours are 07h00 to 09h00 and 17h00 to 19h00. The present study took typical congestion levels from 07h00 am to 10h00 am and from 16h00 pm to 19h00 pm every 15 minutes based on the journey time chart from Tyne and Wear UTMC (Appendix F). The data obtained are in the Table 4.1.
### Table 4.1 Traffic levels

<table>
<thead>
<tr>
<th>Section 1: A1290 between NMUK and Downhill Ln Interchange</th>
<th>Google Maps Typical Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Morning Peak Hour</strong></td>
<td></td>
</tr>
<tr>
<td>7:00</td>
<td>7:15</td>
</tr>
<tr>
<td>Northbound</td>
<td></td>
</tr>
<tr>
<td>Southbound</td>
<td></td>
</tr>
<tr>
<td><strong>Afternoon Peak Hour</strong></td>
<td></td>
</tr>
<tr>
<td>16:00</td>
<td>16:15</td>
</tr>
<tr>
<td>Northbound</td>
<td></td>
</tr>
<tr>
<td>Southbound</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 2: A19 between Downhill Ln interchange and Testos roundabout</th>
<th>Google Maps Typical Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Morning Peak Hour</strong></td>
<td></td>
</tr>
<tr>
<td>7:00</td>
<td>7:15</td>
</tr>
<tr>
<td>Northbound</td>
<td></td>
</tr>
<tr>
<td>Southbound</td>
<td></td>
</tr>
<tr>
<td><strong>Afternoon Peak Hour</strong></td>
<td></td>
</tr>
<tr>
<td>16:00</td>
<td>16:15</td>
</tr>
<tr>
<td>Northbound</td>
<td></td>
</tr>
<tr>
<td>Southbound</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 3: A19 between Testos roundabout and A19/Hedworth Ln interchange</th>
<th>Google Maps Typical Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Morning Peak Hour</strong></td>
<td></td>
</tr>
<tr>
<td>7:00</td>
<td>7:15</td>
</tr>
<tr>
<td>Northbound</td>
<td></td>
</tr>
<tr>
<td>Southbound</td>
<td></td>
</tr>
<tr>
<td><strong>Afternoon Peak Hour</strong></td>
<td></td>
</tr>
<tr>
<td>16:00</td>
<td>16:15</td>
</tr>
<tr>
<td>Northbound</td>
<td></td>
</tr>
<tr>
<td>Southbound</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 4: A19 between A19/Hedworth Ln interchange and Lindisfarne junction</th>
<th>Google Maps Typical Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Morning Peak Hour</strong></td>
<td></td>
</tr>
<tr>
<td>7:00</td>
<td>7:15</td>
</tr>
<tr>
<td>Northbound</td>
<td></td>
</tr>
<tr>
<td>Southbound</td>
<td></td>
</tr>
<tr>
<td><strong>Afternoon Peak Hour</strong></td>
<td></td>
</tr>
<tr>
<td>16:00</td>
<td>16:15</td>
</tr>
<tr>
<td>Northbound</td>
<td></td>
</tr>
<tr>
<td>Southbound</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 5: A19 between Lindisfarne Junction and Jarrow interchange</th>
<th>Google Maps Typical Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Morning Peak Hour</strong></td>
<td></td>
</tr>
<tr>
<td>7:00</td>
<td>7:15</td>
</tr>
<tr>
<td>Northbound</td>
<td></td>
</tr>
<tr>
<td>Southbound</td>
<td></td>
</tr>
<tr>
<td><strong>Afternoon Peak Hour</strong></td>
<td></td>
</tr>
<tr>
<td>16:00</td>
<td>16:15</td>
</tr>
<tr>
<td>Northbound</td>
<td></td>
</tr>
<tr>
<td>Southbound</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 6: A185 between Jarrow Interchange and A185/National Cycle Rte 14 junction</th>
<th>Google Maps Typical Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Morning Peak Hour</strong></td>
<td></td>
</tr>
<tr>
<td>7:00</td>
<td>7:15</td>
</tr>
<tr>
<td>Northbound</td>
<td></td>
</tr>
<tr>
<td>Southbound</td>
<td></td>
</tr>
<tr>
<td><strong>Afternoon Peak Hour</strong></td>
<td></td>
</tr>
<tr>
<td>16:00</td>
<td>16:15</td>
</tr>
<tr>
<td>Northbound</td>
<td></td>
</tr>
<tr>
<td>Southbound</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 7: A185 between A185/National Cycle Rte 14 junction and Jarrow Rd (Port of Tyne entrance)</th>
<th>Google Maps Typical Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Morning Peak Hour</strong></td>
<td></td>
</tr>
<tr>
<td>7:00</td>
<td>7:15</td>
</tr>
<tr>
<td>Northbound</td>
<td></td>
</tr>
<tr>
<td>Southbound</td>
<td></td>
</tr>
<tr>
<td><strong>Afternoon Peak Hour</strong></td>
<td></td>
</tr>
<tr>
<td>16:00</td>
<td>16:15</td>
</tr>
<tr>
<td>Northbound</td>
<td></td>
</tr>
<tr>
<td>Southbound</td>
<td></td>
</tr>
</tbody>
</table>

### TRAFFIC SPEED

<table>
<thead>
<tr>
<th>Colour</th>
<th>Qualitative speed value</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>Normal</td>
<td>&gt; 50 mph</td>
</tr>
<tr>
<td>Yellow</td>
<td>Slower</td>
<td>25 – 50 mph</td>
</tr>
<tr>
<td>Red</td>
<td>Lowest</td>
<td>&lt; 25 mph</td>
</tr>
<tr>
<td>Red</td>
<td>Stop and Go</td>
<td></td>
</tr>
</tbody>
</table>

*Speeds apply for trunk roads. For small and urban roads, qualitative interpretation applies.*
For the analysis, this document will focus on the congested areas represented red colour in Table 4.1. Their characteristics are summarised in Table 4.2.

### Table 4.2 Summary of congested areas

<table>
<thead>
<tr>
<th>SECTION/POINT</th>
<th>DIRECTION</th>
<th>HOURS</th>
<th>POSSIBLE CAUSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 1 approaching to point B</td>
<td>Northbound</td>
<td>16h00 – 16h30</td>
<td>Delays in Point B</td>
</tr>
<tr>
<td>Section 2 approaching to point C</td>
<td>Northbound</td>
<td>17h00 – 18h00</td>
<td>Delays in Point C</td>
</tr>
<tr>
<td>Section 4 congestion continues in section 5</td>
<td>Northbound</td>
<td>07h30 – 08h30</td>
<td>Delays in Tyne Tunnel entrance</td>
</tr>
<tr>
<td>Section 5 approaching to point F</td>
<td>Northbound</td>
<td>07h00 – 09h00</td>
<td>Delays in Tyne Tunnel entrance</td>
</tr>
<tr>
<td>Section 7 and point G</td>
<td>Northbound</td>
<td>17h00 – 18h00</td>
<td>Delays in Junction (point G)</td>
</tr>
</tbody>
</table>

### 4.3 Layout of congested areas

#### 4.3.1 Section 1

**Location:** A1290 between NMUK and A19/A1290 Interchange.

**Type of road:** PR, class A principal road in rural area.

**Carriageway:** Single carriageway, 2 lanes. 7.3 metres width.

**Description:** The A1290 road is joined with A19 road by a grade separated junction. The upper level of this junction consists of signalised roundabouts to join A1290 from west to east.
**Problem:** Congestion at afternoon peak hours. Delays and queues in the junction are caused by the merge of vehicles on the A1290 coming from the west and vehicles on Downhill Lane coming from the east. Figures 4.1 and 4.2 show the layout of the junction. Figure 4.3 shows the congestion in the area.

![Figure 4.1 Downhill Ln interchange layout](Source: digimap.edina.ac.uk, 2015)

![Figure 4.2 Downhill Ln interchange eastbound approach](Source: www.google.co.uk/maps, 2015)
4.3.2 Section 2

**Location:** A19 between Downhill Ln Interchange and Testos roundabout.

**Type of road:** TR, class A trunk road in rural area

**Carriageway:** Dual carriageway: three lanes northbound, two lanes southbound. 3.65 metres width per lane

**Description:** Being between two congested junctions. This section presents high traffic level. Downhill Ln Interchange was described in Section 4.3.1, Testos roundabout is a simple signalised roundabout.

**Problem:** Congestion at afternoon peak hours caused by Testos roundabout. Delays and queues are caused by the merge of vehicles on the A1290 and vehicles in Downhill Lane. In figure 4.4 could be observed the congestion in red colour in approaching to Testos roundabout. Figures 4.5 and 4.6 show different views of the A19 road towards the roundabout.
Figure 4.4 Traffic in Section 2
(Source: www.google.co.uk/maps, 2015)

Figure 4.5 View from the eastbound approach to Testos roundabout
(Source: www.google.co.uk/maps, 2015)
4.3.3 Section 4

**Location:** A19 between A19/Hedworth Ln Interchange and Lindisfarne junction.

**Type of road:** TR, class A trunk road in rural area

**Carriageway:** Dual carriageway, two lanes each direction. 3.65 metres each lane.

**Description:** A19/Hedworth Ln is a grade separated interchange. Therefore, both roads do not cross, but they merge ahead. This is the beginning of the congestion in section 5 starting at the Tyne tunnel approach.

**Problem:** Congestion at morning peak hours caused by Tyne Tunnel entrance which is close Jarrow interchange. The merge of vehicles from Hedworth Lane is also a contributor to congestion. Figure 4.7 shows in red colour the northbound congestion before and after the interchange. Figure 4.8 presents the beginning of the queue while figure 4.9 shows the merging after the roundabout.
Figure 4.7 Congestion level before and after Lindisfarne Junction
(Source: www.google.co.uk/maps, 2015)

Figure 4.8 Congestion start point
(Source: www.google.co.uk/maps)
4.3.4 Section 5

**Location:** A19 between Lindisfarne Junction and Jarrow Interchange

**Direction:** Northbound

**Type of road:** TU, class A trunk road in urban area

**Carriageway:** Dual carriageway, two lanes each direction. 3.65 metres per lane.

**Description:** Section between two junctions and approaching to the Tyne Tunnel entrance.

**Problem:** Bottleneck at morning peak hours caused by vehicles going northbound to the Tyne Tunnel which is 230 metres approx. (Figure 4.11) to the exit from A19 to A185. UTMC Figure 4.10 shows the abruptly raise in journey times at morning peak hours. The congestion begins in Section 4 as could be seen in figure 4.7. As figures 4.12 and 4.13 show, in the Jarrow interchange entrance the congestion levels are low.
Figure 4.10 Journey time for Tyne Tunnel northbound approach  
(Source: Tyne and Wear UTMC, 2015)

Figure 4.11 Distance from the Jarrow int. exit to the Tyne Tunnel entrance  
(Source: digimap.edina.ac.uk, 2015)
Figure 4.12 Congestion levels in Jarrow interchange
(Source: www.google.co.uk/maps, 2015)

Figure 4.13 Congestion in Tyne Tunnel approach.
(Source: www.google.co.uk/maps)
4.3.5 Section 7- Point G

Location: A185/National Cycle Rte 14 junction

Direction: Northbound

Type of road: PU, Class A principal road in urban area

Carriageway: Single carriageway, two lanes. 3.65 metres each lane.

Description: A185 road is a dual carriageway road with two lanes in each direction in Section 6. From the non-signalised National Cycle Rte 14 junction, the road narrow to a single carriageway road until the PoT entrance. In the middle of section 7 there is a Nursery in the north side of the road Figure 4.14.

Problem: Firstly, the cause of congestion at afternoon peak hours is the T junction in point 7 where vehicles going from north to west and from east to north block the flow of vehicles going from east to west. The east view of the junction could be seen in figure 4.15.

Secondly, cause of congestion is also the reduction from a two carriageway four lane road to a single carriageway two lane road (figure 4.16). This reduction, added to the merge of vehicles in the junction mentioned going from north to east, worsen the situation. Traffic levels are shown in figure 4.17.
Figure 4.14 Section 7 layout
(Source: digimap.edina.ac.uk, 2015)

Figure 4.15 Eastbound approach to A185/National cycle Rte. 14 junction
(Source: www.google.co.uk/maps, 2015)
Figure 4.16 Reduction to one lane northbound
(Source: www.google.co.uk/maps, 2015)

Figure 4.17 Congestion levels Section 7
(Source: www.google.co.uk/maps, 2015)
CHAPTER 5: INTERPRETATION

This chapter will focus on the interpretation of results and information for the congested parts of the route only.

5.1 Dimensions of the links

Table 5.1 Summary of road capacities

<table>
<thead>
<tr>
<th>Sections</th>
<th>AADT</th>
<th>Capacity</th>
<th>CRF (vehicles per day)</th>
<th>Link stress</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5995</td>
<td>1339.05 veh/hr/lane</td>
<td>29989.14</td>
<td>0.199</td>
<td>Link stress much lower than 1. Therefore there is no risk of congestion</td>
</tr>
<tr>
<td>2</td>
<td>56815</td>
<td>1984 veh/hr/lane</td>
<td>62284</td>
<td>0.912</td>
<td>Link stress value between 0.9 and 1, therefore, it is very likely to have congestion at peak hours.</td>
</tr>
<tr>
<td>3</td>
<td>36146</td>
<td>1955 veh/hr/lane</td>
<td>63770</td>
<td>0.567</td>
<td>Link stress below 1. No risk of congestion. A19/A184 roundabout has an effect splitting traffic</td>
</tr>
<tr>
<td>4</td>
<td>36537</td>
<td>1984 veh/hr/lane</td>
<td>71335</td>
<td>0.512</td>
<td>Value below 1, therefore, in this section of the road, the number of lanes are not a cause for congestion in the forthcoming years.</td>
</tr>
<tr>
<td>5</td>
<td>29815</td>
<td>86400 veh/day</td>
<td>0.345</td>
<td></td>
<td>This value shows that the dimension of the road is enough to cope with the actual traffic and future growth.</td>
</tr>
<tr>
<td>6-7</td>
<td>18247</td>
<td>86400 veh/day</td>
<td>0.21</td>
<td></td>
<td>This value shows that the dimension of the road is enough to cope with the actual traffic and future growth.</td>
</tr>
</tbody>
</table>

According to table 5.1, in all sections of the route, except section 2, the road dimensions are enough to cope with the present and growing traffic. It is important to note that the link stress value dropped drastically from Section 2 to Section 3, showing the effect that Testos roundabout has in the traffic split.
Hence, it can be deduced that the congestion problems are caused by the junctions along the A19 road.
5.2 Traffic growth

Figure 5.1 Licensed cars in GB

Figure 5.2 Licensed cars in the North East

Figure 5.3 Licensed HGVs in GB

Figure 5.4 Licensed HGVs in the North East

Figure 5.5 New cars registered in GB

Figure 5.6 New cars registered in the North East

Figure 5.7 New HGVs registered in GB

Figure 5.8 New HGVs registered in the North East
Figures 5.1 – 5.8 show that the North East vehicle growth volumes in both, total vehicles and HGVs is in the same as the Great Britain trend. The total number of licensed cars has been growing slightly since 2001, but the new cars registration presents a decrease period from 2007 to 2012 when it began to grow again. Values for the figures were taken from the Statistical data set from DfT. (Gov.uk, 2015)

The economic downturn from late 2008 affected the new registration figures from then onwards, but a downward trend was already apparent before that (DfT, 2015).

Figure 5.9 shows the production of manufactured vehicles in the UK. The effect of the economic crisis is noticeable, reaching the lowest point between 2009 and 2010. From 2010, there is a steadily growth in vehicles production, being forecasted above 2 million of vehicles by 2020.

Figure 5.9 UK vehicle output in units - actual forecast volumes until 2020
(Davies, et al., 2015)
5.2.1 Section 1

In figures 5.10 and 5.11 it is possible to see how the traffic has changed from 2000 to 2014, having a sudden rise in 2006 and decreasing slightly in the following years.

![Figure 5.10 AADT Section 1](image1)

![Figure 5.11 AADT HGVs Section 1](image2)

The graphs show that AADT and the number of HGVs have a similar trend. There was a sudden rise in vehicles in 2006, followed by a decrease possibly because of the economic crisis in 2008 and a steadily increase similar to the national trend.

5.2.2 Section 2

![Figure 5.12 AADT Section 2](image3)

![Figure 5.13 AADT HGVs Section 2](image4)
In this point it is very important to note that although the general number of vehicles has increased from around 50000 in 2000 to around 60000 in 2014 leading to a congested road at peak hours, the number of HGVs in this part of the road has decreased apart from the outlier in 2012 that shows an abrupt rise in the amount of HGVs.

The outlier in number of HGVs could be explained due to the increase of the manufacture automotive industry in that year, being NMUK and the auto parts industry very important in the area and in the number of HGVs.

5.2.3 Section 4

Overall, the Figure 5.14 shows an increase of more than 4000 vehicles per day in this section. From 2000 to 2006 there was a high increase in the figures reaching more than 38000 vehicles per day, but from this point the amount of vehicles were reduced by around 1000 compared to 2006.

Figures 5.14 and 5.15 show that the number of HGVs and the general traffic are in synchrony since 2005. Overall the total trend of the traffic does not seem a problem for the capacity of the road.
5.2.4 Section 5

Strong fluctuations in the volume of vehicles are presented in figure 5.16, but it is clearly noticeable an increment of the number of vehicles in 2010 as well as in the number of HGVs.

The lowest point in 2009 could be a result of two causes: the economic crisis in 2008 and the start of the expansion of the Tyne Tunnel.

Contrarily, in 2010 there are sudden rises in the number of total vehicles and HGVs presumably due to a recovery of the economy and the opening of the Jarrow junction (A19/A185) in the south approach to the Tunnel.

The construction began in 2008. The south junction was opened to the public in June 2010. Completed and opened 21 November 2011 tunnel, both tunnels. February 2011 new tunnel operational but refurbishment of old tunnel. (TT2 Limited, 2015)
5.2.5 Sections 6-7

The traffic level has not varied significantly from 2000 to 2014. Figure 5.18 shows a slight fluctuation with the highest value of above 25000 vehicles/day in 2006 and the lowest point at around 22500 vehicles/day in 2000. These values, added to the link stress, does not represent a risk for the road capacity.

HGVs volumes in figure 5.19 present irregularities through the time, although from 2006 it seems to follow the national trend.

Figure 5.18 AADT Sections 6-7

Figure 5.19 AADT HGVs Sections 6-7
5.3 Possible Solutions for congested areas

This part analyses the possible solutions for the movement of lorries for sections 1, 2, 4, 5, and 7. The solutions are divided in infrastructure and ITS. In some sections of the route, Highways England has already planned improvements for junctions which will also be mentioned.

5.3.1 Section 1

a. Infrastructure solutions

i. A19/A1290 (Downhill Lane) junction improvement

It is already planned by DfT to upgrade this junction. Highways England will provide significantly enhanced capacity on the junction between the A19 and the A1290 in Sunderland, supporting local plans for an International Advanced Manufacturing Park to the north of the existing Nissan Plant. (DfT, 2015).

This project is part of a larger project that consists in the improvement of the A19/A184 Testos roundabout which is stated below in Section 2.

The plans are still at the design stage. Hence, there are not details of this junction.

Advantages

This solution will improve the traffic flow not only for lorries, but for the traffic in general, giving more capacity for all type of vehicles.
Disadvantages

- Unsustainable: Infrastructure improvements usually create new traffic which would not arise without the enhancement of the transport supply. Therefore, in a certain period of time, the congestion will be the same or even worse.

- Expensive: Infrastructure improvements demand a high economic cost.

- Slow: This improvement will take until 2021 to be completed according to Highways England (2015). And, during construction will create more congestion.

b. ITS solutions

i. RFID based priority

In this scheme, each car transporter should have a RFID device on board and an inductive loop detector must be located on the road at a certain distance before reaching the Downhill Lane junction. Consequently, the detector interacts with the traffic controller to give green light to the car transporter when it arrives to the junction.

Advantages

- Prior tests have shown reductions of 4 sec in each junction and 8 seconds (70%) at lightly trafficked junctions with no significant disbenefits to general traffic.

- It was determined an economic return of 72% of system costs in the first year. (Hounsell, et al., 1998)
- Low cost compared to infrastructure developments.

**Disadvantages**

- Putting induction loops into the ground takes time.
- It is necessary the permission and coordination with the local authorities to permit the implementation of the scheme to benefit the movement of car transporters.

**ii. Self-optimised signal control**

These systems optimise and prioritise the signal timing calculating the minimum impact on the road given by different weights of factors such as number of vehicles, main road, emergency vehicles, etc. In the present case, the vehicles on the A1290 approaching to the junction westbound will be given more weight than the vehicles approaching to the junction eastbound. Besides, the car transporters will be given additional weight (e.g. Equivalent to 20-50 cars), resulting in more rapid movement of the lorry.

**Advantages**

- Reductions of travel time for prioritised vehicles between 20% and 30% according to implementations in some European cities. (Civitas Initiative, 2013)
- Reduction of travel time around 10% for cars. (Wahlstedt, 2013)
- Low cost compared to infrastructure developments.
Disadvantages

- Local Authorities are more likely to implement these systems for Public Transport, therefore, it will be necessary to convince them to obtain permission and coordination to prioritise car transporters.
- Tests have not been done in freight operators.
- Prior implementations have been carried out in urban roads only.
- In bottlenecks there is not much advantage compared to fixed time signals. (Gardner, et al., 2009)

iii. Compass 4D

Mobility ITS scheme that gives priority at traffic lights, speed advice and idling support for drivers (ERTICO - ITS Europe, n.d.). In the present case, the car transporters and the junction will have Compass 4D implemented. As a result, the lorry drivers coming from the A1290 will be able to control the traffic lights and avoid the red light waiting.

Advantages

- Low cost compared to infrastructure developments.
- Reduction of travel time between 6 and 22% in early tests.
- Reduction in energy consumption between 5 and 16% in early tests in an electric vehicle. (Blythe, 2015)

Disadvantages

- At the date of this project, there are not official results of the implementation in lorries.
- The system present limited advantage when the road is totally congested and presents long queues.
- Coordination and permission from local authorities for the scheme to be implemented.

5.3.2 Section 2

a. Infrastructure solutions

i. A19/A184 (Testos) roundabout improvement

The junction upgrade is planned by DfT. Highways England will provide a grade separation of the junction between the A19 and A184, providing free-flowing access to the southern end of the Tyne Tunnel. Together with the A19 Coast Road, this scheme raises the A19 to expressway standard from Yorkshire to north Newcastle. (DfT, 2015)

This project includes the A19/A1290 junction improvement mentioned in the previous section. The original plans before including the upgrade of the A19/A1290 junction were to construct a flyover to take the A19 over the roundabout. Entry and exit slip roads to connect the A19 to the new slightly larger roundabout.

The A19 carriageway will be moved slightly to the west and will be raised above ground on an embankment. This will carry it over the roundabout via two bridges. Traffic to and from the north at Downhill Lane Junction will be linked via new parallel connector roads to the new south facing slip roads at Testos Junction. (Highways England, 2015). The proposed scheme is shown in figure 5.20.
The initial periods of start and completion were autumn/winter 2016/2017 and autumn/winter 2017/2018, but now will be open to the public in spring 2021.

Figure 5.20 Testos roundabout improvement (Highways Agency, 2014)
The results of the TAG appraisal study shown in Table 5.2 table show the qualitative assessment of this schemes comparing Do Min and Do Some scenarios.

Table 5.2 Testos roundabout TAG results (Highways England, 2014)

<table>
<thead>
<tr>
<th>Scheme</th>
<th>N of Testos</th>
<th>S of Testos</th>
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<td>92.22%</td>
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<td>Overall Assessment</td>
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</table>

Advantages

- This solution will improve the traffic flow not only for lorries, but for the traffic in general, giving more capacity for all type of vehicles.
- Together with the A19 Coast Road, this scheme raises the A19 to expressway standard from Yorkshire to north Newcastle.

Disadvantages

- Unsustainable: Infrastructure improvements usually create new traffic which would not arise without the enhancement of the transport supply. Therefore, in a certain period of time, the congestion will be the same or even worse.
- Expensive: Infrastructure improvements demand a high economic cost.
- Slow: This improvement will take until 2021 to be completed according to Highways England (2015).
b. ITS solutions

i. RFID based priority

In this scheme, each car transporter should have a RFID device on board and an inductive loop detector must be located on the road at a certain distance before reaching the Testos roundabout. Consequently, the detector interacts with the traffic controller to give green light to the car transporter when it entries and exits from the junction.

Advantages

- Prior tests have shown reductions of 4 sec in each junction and 8 seconds (70%) in lightly trafficked junctions with no significant disbenefits to general traffic.
- It was also determined an economic return of 72% of system costs in the first year. (Hounsell, et al., 1998)
- Low cost compared to infrastructure developments.

Disadvantages

- Putting the induction loops into the ground takes time.
- It is necessary the permission and coordination with the local authorities to permit the implementation of the scheme to benefit the movement of car transporters.
ii. **Self-optimised signal control**

These systems optimise and prioritise the signal timing calculating the minimum impact on the road given by different weights of factors such as number of vehicles, main road, emergency vehicles, etc. In the present case, the vehicles on the A19 approaching to the roundabout north and southbound will be given more weight than the vehicles approaching east or westbound. Besides, the car transporters will be given additional weight (e.g. Equivalent to 20-50 cars), resulting in more rapid movement of the lorries.

**Advantages**

- Reductions of travel time for prioritised vehicles between 20% and 30% according to implementations in some European cities. (Civitas Initiative, 2013)
- Reduction of travel time around 10% for cars. (Wahlstedt, 2013)
- Low cost compared to infrastructure developments.

**Disadvantages**

- Local Authorities are more likely to implement these systems for Public Transport, therefore, it will be necessary to convince them to obtain permission and coordination to prioritise car transporters.
- Tests have not been done for freight cases.
- Prior implementations have been done in urban roads only.
- In bottlenecks there is not much advantage compared to fixed time signals. (Gardner, et al., 2009)
iii. **Compass 4D**

Mobility ITS scheme that gives priority at lights, speed advice and idling support for drivers. In the present case, the car transporters and the junction will have Compass 4D implemented. As a result, the NMUK lorry drivers coming from the A19 north and southbound will be able to control the traffic lights and avoid the red light waiting.

**Advantages**

- Low cost compared to infrastructure developments.
- Reduction of travel time between 6 and 22% in early tests.
- Reduction in energy consumption between 5 and 16% in early tests in an electric vehicle. (Blythe, 2015)

**Disadvantages**

- At the date of this project, there are not official results of the implementation in lorries.
- The system present limited advantage when the road is totally congested and presents long queues.
- Coordination and permission from local authorities for the scheme to be implemented.
5.3.3 Section 4

a. Infrastructure solutions

i. A19/A194 (Lindisfarne) junction improvement

It is intended by South Tyneside Council (2013) to improve this junction by making the following alterations:

- An additional lane on A194 East and Westbound approaches to Lindisfarne Junction.
- Widen A19 Northbound on-slip exit to two lanes and designate circulatory lanes accordingly to provide additional stacking storage.
- Relocates bus stops on A194 Eastbound approaching to John Reid Road.
- Turns improvements in John Reid Road.

Figure 5.21 Lindisfrane junction plan
(Source: digimap.edina.ac.uk)
Advantages

- Reduction of traffic in the site of around 40% by 2030.
- Time savings around 5 minutes.
- This solution will improve traffic flow in A194 Road which creates an alternate toward the Port of Tyne. Currently, this route presents many roundabouts and junctions which even being 0.1 miles shorter, takes 5 minutes more. Therefore is not currently considered as an option. Figure 5.22 shows a comparison between the two routes.

Figure 5.22 Routes to PoT
(Source: www.google.co.uk/maps, 2015)
Disadvantages

- Unsustainable: Infrastructure improvements usually create new traffic which would not arise without the enhancement of the transport supply. Therefore, in a certain period of time, the congestion will be the same or even worse.

- Expensive: Infrastructure improvements demand a high economic cost.

- Uncertainty: This improvement is not in the DfT plans for enhancement in the region.

- Slow: If this scheme is approved will take some years to be completed as most infrastructure developments.

b. ITS Solutions

ITS solutions such as priority on traffic lights could be applied for the alternate route stated above. That analysis is not part of the present document.

5.3.4 Section 5

a. Infrastructure solutions

i. Extension of the A19 exit slip road towards A19/A185 (Jarrow) interchange

The slip road that connects the A19 with the Jarrow Interchange is around 135 metres long (figure 5.23). An infrastructure solution is to extend the slip road to 810 metres, so that it will form together with the slip road from the A19/A194
junction a third lane in the northbound carriageway which will be exclusive for vehicles merging from the A194 eastbound to the A19 northbound and from the A19 northbound to the A185 eastbound. Similar to have a hard shoulder along the entire road, but open only for vehicles going to the A185.

![A19/Jarrow interchange slip road](Source: digimap.edina.ac.uk)

**Advantages**

- Free flow for lorries and vehicles in general from Lindisfarne junction to Jarrow interchange which does not present congestion that currently suffer heavy traffic due to the Tyne Tunnel approach queues.
- Reduction in energy consumption, travel time and pollution produced by vehicles queueing.
Disadvantages

- Unsustainable: This improvement could lead to social pressure to open the proposed lane for all motorists removing the exclusivity for vehicles going to the A185. This will result in the creation of new traffic, similar to hard shoulder running applied in other roads.

- Expensive: Infrastructure improvements demand a high economic cost, this proposal will also have to widen the bridge which is located just before the existing slip road which would increase the cost.

- Slow: The scheme would take a long time from the proposal to be approved, built and opened to the public.
b. ITS solutions

ITS solutions to control traffic are not likely to happen due to the inexistence of traffic lights or any other devices which can be controlled.

i. **Open road tolling in Tyne Tunnel Toll payment plazas**

Although there is no high congestion, in the future it would be useful to replace the toll payment machines after crossing the Tyne Tunnel northbound (Figure 5.26) by open road tolling (Figure 5.27) for a free flow without interruptions or queues. An alternate solution is to replace at least the prepaid toll detectors by open road tolling.
Advantages

- Lower cost compared to the infrastructure solution.
- Reduction of congestion in the A19 northbound approaching to the south entrance of the tunnel due to stop and pay or stop and card recognition in the toll plaza.
- Flow of vehicles going from the A19 to the A185, such as NMUK car transporters, will be less affected by traffic going through the Tunnel.
- Reduction of accidents around 62% according to similar schemes (Davis, 2010).

Disadvantages

- Additional costs to replace existing toll machines by long distance RFID detectors, automatic number plate recognition cameras or GPS technologies to collect payment.
- Additional costs to install enforcement devices for unpaid tolls.
- This implementation does not depend on NMUK.

5.3.5 Section 7, Point G

a. Infrastructure solutions

i. A185 widening

Build a 330 metres long additional lane in the A185 eastbound from the end of Straker St after the junction with National Cycle Rte 14 to the entrance to the
Port of Tyne. Additionally, it is necessary to relocate the Nursery. Layout could be seen in Figures 4.14 and 5.28.

![Figure 5.28 Layout of the site (Tyne and Wear UTMC, 2015)](image)

**Advantages**

- Reduce of congestion due to the merging of vehicles.
- Reduce in travel time for NMUK car transporters.
- Reduction of pollution for traffic jams.

**Disadvantages**

- Relocation of the nursery.
- Infrastructure schemes are expensive.
- The implementation will take a long time after being proposed, approved, constructed and opened.
- The implementation depend on the coordination between NMUK and local authorities.
b. ITS solutions

i. Traffic signal control in A185/National Cycle Rte. 14 junction

Placement of coordinated traffic lights in the currently uncontrolled junction.

Advantages

- Reduction of travel time.
- Reduction of crashes by avoiding confusion between priorities.
- This traffic light could be prioritised for NMUK lorries.

Disadvantages

- The implementation depends on the coordination between NMUK and local authorities.

5.4 Analysis and discussion

This section analyses the possible solutions presented above for each section of the route and the likeliness of them to happen being an advantage for the movement of car transporters from NMUK to the Port of Tyne.

Being infrastructure developments the traditional answer for the growing traffic, ITS solutions presented here, are in most cases viable solutions for the particular case of this study.

As could be seen in the previous chapter, to enhance A19/A129 (Downhill Lane) junction and A19/A184 (Testos) roundabout in Section 1 and Section 2
respectively, is part of one improvement to be completed on spring 2021 according to Highways England (2015).

Although these improvements will relieve traffic in the area, it is expected they will also represent a problem during the years they are under construction, causing even more delays and congestion which will impact NMUK logistics.

Besides, if the growing trend in number of HGVs and vehicles continues, there will be more vehicles in the upcoming years. This, added to the likeliness of the creation of new traffic attracted to the improvement, results in an unsustainable solution.

On the other hand, ITS based solutions are viable answers in both cases, being the junction and the roundabout signalised by traffic lights, it is possible to prioritise the movement of NMUK car transporters to and from PoT using either way, RFID, self-optimised signal control or Compass 4D schemes.

The problem of these schemes is the necessity of not only extra investment, but also the coordination with authorities to give priority and more weight to a company like Nissan which makes 238 trips per day (Price, 2015), representing most of the total trips in Section 1 and almost 10% of HGV trips in Section 2.

In the same way as Sections 1 and 2. Sections 4 and 5 can be analysed together for having the same cause of traffic at the same hours which is perfectly seen in Table 4.1.

The traffic at peak morning hours in the northbound approach to the Tyne Tunnel in section 5 causes a long queue which extends to Section 4.
The trend in the number of vehicles in Section 5 was influenced by the opening of the new Tyne Tunnel and the Jarrow interchange improvement. Figure 5-16 specially shows that after the Tunnel opening, the AADT was even greater than before the new Tunnel was constructed, which reinforces the statement that the creation of new traffic besides the natural growing trend.

Despite being presented in 2013, it is not surprising that South Tyneside Council application to improve A19/A194 (Lindisfarne) junction has not received a response from DfT. Weaknesses of this junction to be enhanced are that it is currently a grade separated junction; the main cause of congestion in the A19 is not the junction itself, but the Tyne Tunnel approach; and the number of vehicles is not as high as in Section 2 analysed in paragraphs above, which will be attended by DfT.

For section 4, apart from the unlikely infrastructure improvement. The use of ITS could be applied to enhance a different route to PoT, not suitable for car transporters at the moment. Coordinated traffic lights and priority for NMUK transporters as described before are the most suitable ITS solutions although they will require extra investment and coordination between NMUK and local authorities for the alternate route.

Being re-opened in 2011, a new widening of Tyne Tunnel is practically impossible and an unsustainable solution. One measure to enhance the movement of the traffic caused by the tunnel approach it is to replace the toll payment plazas by open road payment tolls. The effect of them will not be immediate because the real problem is the bottleneck generated at the approach rather than the relief at the end of the tunnel. However, this could be a solution
for the forthcoming years when the traffic reaches a higher level that congests the toll payment plaza.

The proposed infrastructure solution of joining the slip roads from Lindisfarne junction to the A19 and from A19 to Jarrow interchange in order to have an 810 metres hard shoulder could result in an ideal solution for NMUK car transporters. Even more taking into account that this lane would be exclusive for the few number of vehicles that take that route.

On the contrary, if the extra lane converts this part of the A19 to a smart motorway for every motorist to use it at congested hours, there will not be a big difference in congestion relief because the Tunnel will still be two lanes wide. Therefore, there will not be a great advantage for NMUK lorries.

Apart from the stated above, the high costs of infrastructure development makes this scheme very unlikely to happen.

Similarly, for section 7 a road widening is proposed with the difference that the extra lane will not only benefit NMUK lorries but to all the motorists. This scheme is simpler to build but it is necessary to relocate the existing nursery and convince the local authorities of the vital importance of this road for the activity of the PoT and the local industry.

Moreover, to put traffic lights in the A185/National Cycle Rte 14 junction would improve the traffic management in the area, and could lead to prioritisation for NMUK and other lorries going to PoT. It seems that this alternative is simpler to adopt and more likely to happen in a future considering the current levels of freight in the area.
Ultimately, as an overall solution for the entire route the use of coordinated traffic lights along the whole route could have favourable results as they could result in green waves and better flow of traffic as have been stated in some studies.

The use of in-vehicle technology could be a great advantage for the movement of lorries. Cruise control especially in off peak hours together with coordinated traffic lights could lead to improvements not only in journey times, but also in fuel consumption.

Depending on the technological advance and the policies for HGVs dimensions, platoons of lorries and autonomous vehicles could be a viable alternative to improve the movement of new cars. Their use will not only make inessential the use of human drivers, but will also shorten the gaps between vehicles, leading to larger and safer fleets beneficial for the forecasted growth in the production of vehicles.

The aim is to integrate various ITS solutions placed in the infrastructure and in-vehicle to make the most of them.

As has been noted, many solutions have been proposed and analysed to enhance the movement of car transporters. Planned infrastructure solutions will not benefit movement of NMUK lorries in the short term while proposed infrastructure solutions in Sections 4, 5 and 7 are unlikely to happen in a short term.
Nevertheless, ITS solutions are more approachable not needing high investment and with the possibility to be adopted by NMUK lorries after making a Cost-benefit analysis.

As mentioned before, it is indispensable to coordinate with local authorities to agree in giving NMUK vehicles priority for movement. In this point is important to realize the economic importance that NMUK has in the area by generating jobs and creating industry not only directly, but also indirectly, encouraging world class auto parts suppliers to open factories in the area to provide NMUK and other car manufacturers inside of the country and abroad.

### 5.5 Limitations

Limitations of this study are concerns about the use of Google Maps as a tool to identify areas and times of high congestion in the route analysed. The use of more reliable sources such as local authorities and authorized governmental organizations for surveys would have given more trustable results.

However, Tyne and Wear UTMC does not have detailed data for congestion in each part of the route as this study needed. Instead, they divide the route from in the A19 from A1/A19 junction to A19/A184 (Testos) roundabout in the north as one segment and from A19/A184 to A19/B1285 in the south as another segment. Sections 2 to 5 are just tiny parts in the later segments mentioned. Additionally, UTMC does not have any congestion data regarding to sections 1 and 7. According to them, the next year areas 6 and 7 will be equipped with counting cameras in order to determine congestion levels.
Therefore, these data are not representative for this study as there was the need for more accuracy which forced to the use of Google Traffic.

Equally important was the difficulty to get data from NMUK to carry out a precise analysis. Few information (less than requested) about the route used, the number of trips and issues regarding to the movement of lorries from the manufacturing plant to PoT and vice versa was obtained after many attempts, various emails and phone calls to different persons in the company.
CHAPTER 6: CONCLUSIONS

This chapter presents the main findings of this study, the implications of these findings and the limitations of the research carried out.

Due to the big economic impact and influence of NMUK in the North East Economy, the analysis of options to enhance the movement of car transporters to PoT is of big importance to minimise the effects of congestion in the delivery of new vehicles to be exported.

The level of traffic in the general vehicles as well as HGVs were affected by the economic recession in 2008. The effects of this recession were felt until 2012 when the number of vehicles start to grow again.

The growth in the level of traffic in the area of study in both, total number of vehicles and number of HGVs is not different from the trends shown in the national figures in GB, except for Section 5.

The low link stress values obtained in each section demonstrated that the design dimensions for the A19 and A185 roads can easily manage not only the actual traffic volumes, but also increasing volumes for future years. Therefore, the main causes of congestion are the junctions and slip roads for the merging of vehicles.

The Tyne Tunnel is the major cause of congestion in Section 5, creating a bottleneck in the northbound approach that results in queues which extend until the prior roundabout in Section 4.
The opening of the new Tyne Tunnel led to the creation of new traffic which was inexistent before its construction. This finding denotes the theory that new infrastructure developments are unsustainable solutions.

As mentioned before, being unsustainable, high cost and slow construction. Infrastructure solutions are not the best options to enhance the movement of NMUK lorries in the short term. Planned infrastructure developments for A19/A184 and A19/A1290 will enhance traffic flow but definitely not in the short time.

Traffic lights prioritisation is the most viable solution taking into account the costs of new traffic lights and in-vehicle devices compared to infrastructure costs. Furthermore, prior studies have determined a return of 72% of the costs in the first year of operation and around 20% of reduction in travel time.

In that case, the use of self-optimised and coordinated traffic lights in conjunction with priority for NMUK lorries could impact positively in the logistic operation of the company. This topic is worth to analyses in more detail in future research.

For Section 5, the use of ITS would be possible with the creation of an extra lane to turn the A19 to a smart motorway keeping the priority for NMUK lorries.

Replacing the current toll payment plazas by open road tolling will help to avoid future congestion problems at the north exit of the Tyne Tunnel.

Partnerships and alliances between the public and private sector are vital the implementation of traffic management schemes. In this case, to implement
traffic lights prioritisation or even to consider development of new infrastructure, NMUK and the local authorities should agree in giving special treatment to NMUK car transporters as a vital part of the North East economy.

The use of autonomous vehicles and platoons for commercial purposes is not a reality yet and their use will be conditioned by national regulations.

Although the use of mapping and traffic systems of authorized institutions such as UTMC and Traffic Counts gives more reliability to any traffic analysis. Their lack of information regarding to congestion levels makes Google Traffic a useful tool to determine congested areas showing live and typical traffic levels in every single section of the route analysed.
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APPENDICES

Appendix A

Nissan email

RE: Nissan request

pj Price, Jessica <Jessica.Price@nissan-nmuk.co.uk>

To: Daniel Merchan Urquiza (PoT) [..] 

Tue 13/12/2015 13:33

You forwarded this message on 13/12/2015 06:41

| Action Items |

Hi Daniel,

Please find answers as follows:

- Which route is used for freight movement from Nissan to Port of Tyne? 12kms each way as follows:

![Map of Nissan to Port of Tyne route](image)

- What is the timetable of lorry movements between Nissan and PoT? 14 trucks operating on a shift pattern of 5-7-5
- What is the number of daily trips from Nissan to PoT? 228 trips per day on a load factor of 9 vehicles per load
- Do the lorries take advantage of the trips from Nissan to PoT, to return loaded with imported vehicles from the port to the plant? Yes
- How many vehicles can a lorry carry? This depends on which vehicles are loaded but the standard load factor is 9. Example loaded: 9 Qashqai (see below)
- What is the number of imported and exported vehicles per year and the expected growth? Please find Nissan’s official figures online. I cannot give you our mid-term plan volumes for confidentiality reasons.

- What difficulties do the drivers find with the route? No difficulties per se, but traffic lights and traffic slow down the optimum cycle time on occasion. As do any roadworks (an example being the development of the bridge and road markings at the junction to the A15 road).

- What is the average time of the trips at peak hours and off peak hours to and from PoT?
  Round trip average is 1hr 20 mins. Peak times are 9:00 - 9:30 & 17:00 - 18:00.

- Have any technology solutions been applied in order to improve the freight movement on the route? We have looked into developing the route into an intelligent freight corridor (sensors on vehicles to advise on optimum speeds and ensuring lights are green when the trucks are passing) with the help of a local university. Nothing has as yet been implemented.

Good luck with your research.

Kind regards,

Jessica Price
Phone: +61-1300162235
Mobile: +61-797641232

From: Daniel Merchan Urquiza (PST) [mailto:D.E.Merchan-Urquiza1@newcastle.ac.uk]
Sent: 13 October 2015 11:09
To: Price, Jessica
Subject: Re: Nissan request

Hello Jessica,

Thank you very much for replying, the email that my supervisor sent to Stuart Boyd and that Glen offered to help us is the following:

Dear Stuart,

I am Senior Researcher at the Transport Operations Research Group at Newcastle University. I am currently supervising one of our Masters’ students, Daniel Merchan Urquiza, towards submission of his thesis. Daniel is investigating the impact of intelligent transport systems on
operational efficiency and environmental impacts, with a case study on the route between Nissan and the Port of Tyne. The student project is based on a major project called COMPASS4D which deploys cooperative systems to create an ‘Energy Efficient Intersection Service’ giving green light priority to selected vehicles at certain junctions, and an optimal speed advisor in the vehicle to advise drivers about upcoming traffic light phases (http://www.compass4d.eu/).

For his project, Daniel has some information that he requires:
- Which route is used for freight movement from Nissan to Port of Tyne?
- What is the timetable of lorry movements between Nissan and PoT?
- What is the number of daily trips from Nissan to PoT?
- Do the lorries take advantage of the trips from Nissan to PoT, to return loaded with imported vehicles from the port to the plant?
- How many vehicles can a lorry carry?
- What is the number of imported and exported vehicles per year and the expected growth?
- What difficulties do the drivers find with the route?
- What is the average time of the trips at peak hours and off-peak hours to and from PoT?
- Have any technology solutions been applied in order to improve the freight movement on the route?

It would be very helpful if you were able to provide some information relating to the above questions to Daniel.

I believe he would also find it extremely interesting and informative to take a cab ride on the route. Is this something that could be arranged?

On Daniel’s behalf I would like to thank you in advance for any help you can provide. He can be contacted direct on 07956 215756.

Kind Regards,
Simon Edwards
Senior Research Associate in ITS
0191 2088117
From: Jessica Price@nissan-nmuk.co.uk
Sent: 13 October 2016 08:36
To: Daniel Merchan Urquiza (PQT)
Subject: Nissan request

Hallo Daniel,

I work for Glen Walker in Outbound Logistics, responsible for UK flows.

Can you please list your questions/information required and I will do my best to answer them?

Kind regards,

Nissan in Europe: Find your local
Official Nissan website

Direct links to all the official Nissan websites in Europe. Find a local dealer and get details on the latest Nissan models in your country.

Read more.

Jessica Price
Controller
AIE

Nissan Motor Manufacturing UK
Washington Road
SR5 3NS Sunderland, UK

Phone: 44-1914313237
Mobile: 44-7976481233
Email: Jessica.Price@nissan-nmuk.co.uk
Http://www.nissan-europe.com

*****************************************************************************
*****************************************************************************
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This message including any attachments to it (Message) is private and confidential and may contain proprietary or legally privileged information. If you have received this Message in
Appendix B

Tables used for the percentage of HGVs. Values were obtained from South Tyneside Traffic Counts (Department for Transport, 2015)

Section 1

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<td>2498</td>
<td>34007</td>
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<td>2523</td>
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<td>2013</td>
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<td>39322</td>
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</tr>
<tr>
<td>2014</td>
<td>2821</td>
<td>40424</td>
<td>6.98</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>2625</strong></td>
<td><strong>36143</strong></td>
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</tbody>
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### Section 4

<table>
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<th>Year</th>
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<th>AADT</th>
<th>% HGVs</th>
</tr>
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<tbody>
<tr>
<td>2010</td>
<td>2145</td>
<td>36032</td>
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<tr>
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<td>2141</td>
<td>36899</td>
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<td>2034</td>
<td>36453</td>
<td>5.58</td>
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<tr>
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<td>2062</td>
<td>36363</td>
<td>5.67</td>
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<td>2014</td>
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<td>36936</td>
<td>6.16</td>
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<td><strong>2132</strong></td>
<td><strong>36537</strong></td>
<td><strong>5.83</strong></td>
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### Section 5

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<tbody>
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<td>2010</td>
<td>2166</td>
<td>29954</td>
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<td>30026</td>
<td>7.33</td>
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<td>2012</td>
<td>2053</td>
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<tr>
<td>2013</td>
<td>2054</td>
<td>29493</td>
<td>6.96</td>
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<td>2014</td>
<td>2202</td>
<td>30024</td>
<td>7.33</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>2136</strong></td>
<td><strong>29815</strong></td>
<td><strong>7.16</strong></td>
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</table>
Sections 6 and 7

<table>
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<th>HGVs</th>
<th>AADT</th>
<th>% HGVs</th>
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<tbody>
<tr>
<td>2010</td>
<td>833</td>
<td>17970</td>
<td>4.63</td>
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<tr>
<td>2011</td>
<td>877</td>
<td>18267</td>
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<td>2012</td>
<td>883</td>
<td>18099</td>
<td>4.88</td>
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<tr>
<td>2013</td>
<td>909</td>
<td>18149</td>
<td>5.00</td>
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<tr>
<td>2014</td>
<td>921</td>
<td>18747</td>
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<tr>
<td>Average</td>
<td>885</td>
<td>18247</td>
<td>4.85</td>
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Appendix C

Tables used to obtain AADT/AAWT. Values are from Gateshead City Council Traffic and Accident Data Unit TADU. (Gateshead City Council, 2015)

Section 1

<table>
<thead>
<tr>
<th>Year</th>
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<th>AADT</th>
</tr>
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<tbody>
<tr>
<td>2010</td>
<td>8672</td>
<td>7536</td>
</tr>
<tr>
<td>2011</td>
<td>10005</td>
<td>8621</td>
</tr>
<tr>
<td>2012</td>
<td>9302</td>
<td>7908</td>
</tr>
<tr>
<td>2013</td>
<td>8599</td>
<td>7513</td>
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<td>2014</td>
<td>3611</td>
<td>3002</td>
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<tr>
<td><strong>Average</strong></td>
<td><strong>8038</strong></td>
<td><strong>6916</strong></td>
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</table>

Section 2

<table>
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<th>AADT</th>
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<tr>
<td>2010</td>
<td>54533</td>
<td>48545</td>
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<tr>
<td>2011</td>
<td>57132</td>
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<tr>
<td>2012</td>
<td>56457</td>
<td>50369</td>
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<tr>
<td>2013</td>
<td>59642</td>
<td>52758</td>
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<tr>
<td>2014</td>
<td>63253</td>
<td>56084</td>
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<td><strong>Average</strong></td>
<td><strong>58204</strong></td>
<td><strong>51676</strong></td>
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### Section 3

<table>
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<th>AAWT</th>
<th>AADT</th>
</tr>
</thead>
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<tr>
<td>2010</td>
<td>33913</td>
<td>30090</td>
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<tr>
<td>2011</td>
<td>35232</td>
<td>31441</td>
</tr>
<tr>
<td>2012</td>
<td>38333</td>
<td>33809</td>
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<tr>
<td>2013</td>
<td>40091</td>
<td>35224</td>
</tr>
<tr>
<td>2014</td>
<td>42656</td>
<td>37532</td>
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<tr>
<td>Average</td>
<td>38045</td>
<td>33620</td>
</tr>
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</table>
Appendix D

Traffic characteristics table (Highways England, 1999)

<table>
<thead>
<tr>
<th>Traffic Characteristic</th>
<th>Motorway</th>
<th>Trunk Road</th>
<th>Principal Road</th>
</tr>
</thead>
<tbody>
<tr>
<td>AADT % Heavy Vehicles (Typical Range)</td>
<td>15.5 (6-26)</td>
<td>12.1 (4-26)</td>
<td>7.5 (2-20)</td>
</tr>
<tr>
<td>Peak Hour Flow / AADT % (Typical Range)</td>
<td>10.0 (7-12)</td>
<td>9.4 (7-12)</td>
<td>9.6 (7-12)</td>
</tr>
<tr>
<td>Peak Hour Directional Split % (Typical Range)</td>
<td>56.3 (50-70)</td>
<td>57.4 (50-70)</td>
<td>58.4 (50-70)</td>
</tr>
<tr>
<td>Peak Hour % Heavy (Typical Range)</td>
<td>13.5 (5-25)</td>
<td>10.4 (3-20)</td>
<td>5.6 (2-12)</td>
</tr>
<tr>
<td>Peak Hour % Heavy / AADT % Heavy (Typical Range)</td>
<td>0.87 (0.50-1.00)</td>
<td>0.86 (0.50-1.00)</td>
<td>0.75 (0.50-1.00)</td>
</tr>
<tr>
<td>AADT / AAWT (Typical Range)</td>
<td>0.93 (0.89-1.00)</td>
<td>0.97 (0.90-1.00)</td>
<td>0.98 (0.90-1.02)</td>
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</tbody>
</table>
## Appendix E

Table of capacities of Urban Roads (Highways England, 1997)

One-way hourly flows in each direction

<table>
<thead>
<tr>
<th>Carriageway width</th>
<th>Two-way Single Carriageway - Busiest direction flow</th>
<th>Dual Carriageway</th>
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<tbody>
<tr>
<td></td>
<td>(Assumes a 60/40 directional split)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total number of Lanes</td>
<td>Number of Lanes in each direction</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2-3</td>
</tr>
<tr>
<td>6.1m</td>
<td>6.75m</td>
<td>7.3m</td>
</tr>
<tr>
<td>UM</td>
<td>Not applicable</td>
<td>4000</td>
</tr>
<tr>
<td>UAP1</td>
<td>1020</td>
<td>1320</td>
</tr>
<tr>
<td>UAP2</td>
<td>1020</td>
<td>1260</td>
</tr>
<tr>
<td>UAP3</td>
<td>900</td>
<td>1110</td>
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<tr>
<td>UAP4</td>
<td>750</td>
<td>900</td>
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