The Potential for Cooperative Intelligent Transport Systems in Dublin City Centre: An Exploratory Study.

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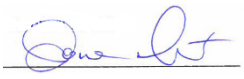
A dissertation submitted to the University of Dublin
in partial fulfilment of the requirements for the degree of
MSc in Management of Information Systems

August 2018

Declaration

I declare that the work described in this dissertation is, except where otherwise stated, entirely my own work, and has not been submitted as an exercise for a degree at this or any other university. I further declare that this research has been carried out in full compliance with the ethical research requirements of the School of Computer Science and Statistics.

Signed: 

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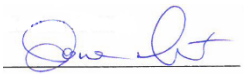
Signed: 

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Contents

List of Figures

List of Tables

List of Acronyms

C-ITS: Cooperative Intelligent Transport Systems

ITS: Intelligent Transport Systems

ICT: Information Communication Technology

ATMS: Advanced Traffic Management Systems

ATIS: Advanced Traffic Information Systems

APTS: Advanced Public Transportations Systems

V2X: Vehicle to Anything

V2V: Vehicle to Vehicle

I2V: Infrastructure to Vehicle

IVS: In-Vehicle-Signage

RSU: Road Side Unit

IVI: In Vehicle Information

WW: Weather Warning

RWW: Road Works Warning

TJAW: Traffic Jam Ahead Warning

EBLW: Emergency Brake Light Warning

VICS: Vehicle Information and Communication System

ETC: Electronic Toll Collection

OBU: On Board Unit

FOT: Field Operational Trial

PVD: Probe Vehicle Data

TCC: Traffic Control Centre

V-ITS: Vehicle ITS Station

C-ITS-S: C-ITS Station

R-ITS: Roadside ITS Station

V-ITS: Vehicle ITS Station

Abstract

Daily, the current modes of transport are causing worldwide traffic congestion and disruption problems. The steady and encouraging trend in road safety that Europe has witnessed over the last decade has subsided. Furthermore, road transport remains responsible for most transport emissions, in terms of greenhouse gases and air pollutants. The area of Cooperative ITS has accelerated in Europe after more than a decade of research and development. The EU Commission have adopted a C-ITS strategy to ensure consistent and interoperable deployment of services. The strategy instructs city authorities in EU member states to deploy C-ITS services by 2019, car manufactures have committed to the production of vehicles equipped with C-ITS technology by 2019 also. EU are confident that C-ITS has the potential to have a significant impact in counteracting the increasing problems of congestion, transport energy consumption and emissions as pilot projects are showing promising results. A dearth of research and activities has been identified in Ireland in relation to C-ITS. The objective of this research paper is to identify if the potential benefits of C-ITS services can support Dublin City Centre's current and imminent transportation objectives and challenges encompassing all modes of travel. In pursuit to address the objectives, this study carries out unobtrusive research using secondary sources, employing a qualitative content analysis and develops a framework for data analysis using a deductive approach. The findings and conclusions of this study formulate recommendations on how city authorities in Dublin can progress with C-ITS deployment. A key empirical finding of this study concluded that C-ITS has strong potential to provide solutions to several transportation challenges and objectives in Dublin City Centre. The benefitting areas were also identified This document provides precursor to future C-ITS deployments in Dublin City Centre.

Chapter 1 Introduction

This dissertation embarks on an exploratory study in the emerging field of Cooperative Intelligent Transport Systems (C-ITS) a subset of Intelligent Transport Systems (ITS). This topic central to this study is broadly consistent with and draws from the themes that are covered on the M.Sc. in Management of Information Systems programme in the School of Computers Science and Statistics, Trinity College Dublin.

ITS is a vast field comprised of numerous associated components which interacts with innovative technology in transport infrastructure and traffic management. ERTICO is an organization that represents the interests and expertise of organisations all over Europe that are involved in the provision of ITS. ERTICO define ITS as;

> "*…the integration of information and communications technology with transport infrastructure, vehicles and users. By sharing vital information, ITS allows people to get more from transport networks, in greater safety and with less impact on the environment.*" (ERTICO, 2009)

The broad scope of ITS is introduced in the following chapter so readers may appreciate the foundations of C-ITS.

Cooperative ITS is defined as a

> *"subset of overall ITS that communicates and shares information between ITS stations to give advice or facilitate actions with the objective of improving safety, sustainability, efficiency and comfort beyond the scope of stand-alone systems"* (ISO/TR 17465-1, 2014).

1.1 Background

A report published by the European Commission (2017) indicates that in 2010 seventy-three percent of European citizens lived in urban areas. It is predicted that the concentration of people living in urban areas in Europe will go beyond eighty percent by 2050 (United Nations World Urbanisation Prospects, 2018). The pursuit to balance public and private demand for mobility against limited spatial, infrastructural and financial resources, whilst achieving safety and

environmental targets is a challenge for city authorities in all parts of the world (Edwards et al., 2017).

Sitavancova and Golombek (2009) found poor air quality generated from traffic exhaust fumes is causing the premature death of almost 300,000 citizens per year in the European Union (EU). Despite the adverse effects of transportation, it is a necessity to everyday life. Furthermore, one key factor for healthy and functioning internal markets in the EU is efficient transport systems. Five percent of all EU member state jobs are related to the transport sector and it is responsible for approximately seven percent of the EU's GDP. It has also been argued that a functioning transport sector is a key contributor to one of the EU's primary objectives "the free movement of persons and goods between member states" (Sitavancova and Golombek, 2009). Since this study in 2009 there has been no improvement in these statistics and the latest figure has increased to 400,000 (European Environmental Agency, 2017)

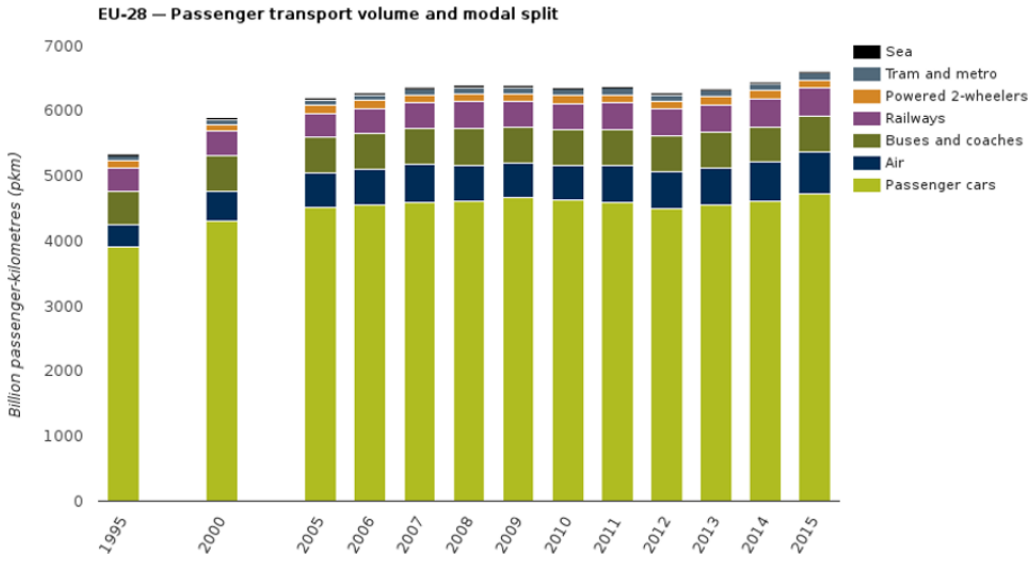

Figure 1: Passenger Transport Modal Split (European Environmental Agency, 2018)

Passenger transport demand (passenger km) in the EU-28 grew by almost three percent between 2014 and 2015, the largest annual increase since 1999 (European Environmental Agency, ibid.). Private car passenger travel remains the dominant transport mode accounting for over seventy percent of total transport. Globally there is an increasing awareness that private cars reduce the speed of traffic, create congestion and cause damage to both the

environment and human health. transport usage across the main modes of transport in EU countries. This graph in figure 1 shows the dominance of private cars as the primary form of transport and it highlights the need for a modal shift towards more sustainable transport if EU environmental targets are to be achieved. There is a growing policy shift, particularly in Europe, towards the development of more effective modes of transport, primarily, public transport.

Road Safety is a major societal problem, in 2011 over thirty thousand people were killed on EU roads. Every road fatality account for an estimated four permanently disabling injuries such as damage to the brain or spinal cord, eight severe injuries and fifty minor injuries (EC.Europa.eu, 2018a). The EU Commission adopted a large- scale Road Safety Programme in 2010 which aims to significantly reduce road deaths in Europe between 2011 and 2020. The programme sets out an assortment of initiatives, at European and national level, concentrating on improving vehicle safety, the safety of road infrastructure and the behaviour all road users'. Road fatalities statistics are declining as shown in figure 2 but not at the rate anticipate, and the objective of a further fifty percent decrease in fatalities from 2009 levels by 2020 (EC.Europa.com, ibid.) may not be achievable based current conditions.

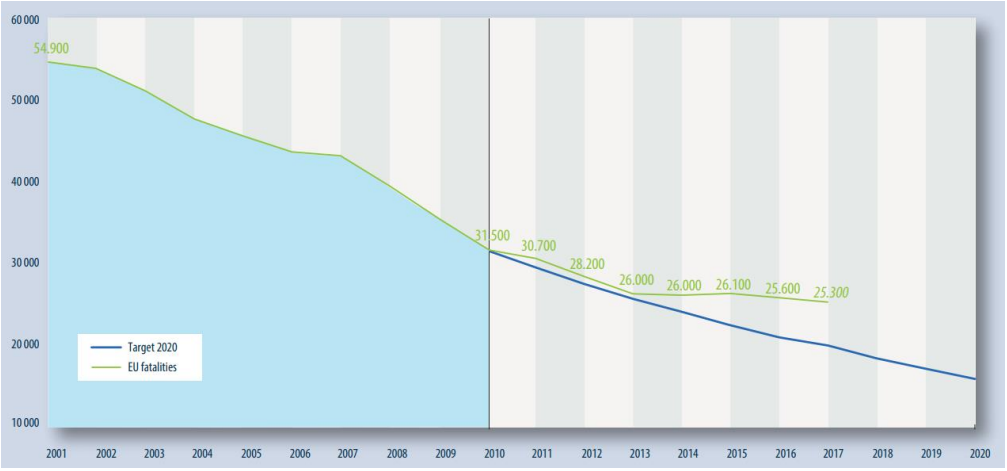

Figure 2: Road fatalities in the EU since 2001 (EC.Europa.eu, ibid).

Similarly, latest datasets demonstrate that overall CO_2 emissions are declining as illustrated in figure 3, however this is not the case for transport related emissions.

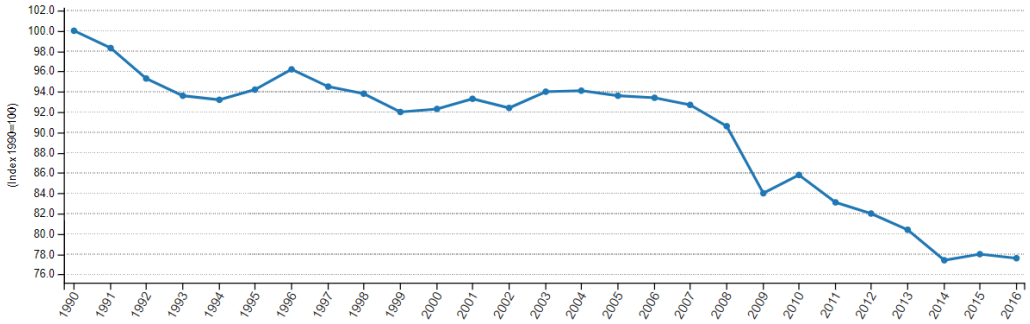

Figure 3: Greenhouse Gas emission trend, EU 28, 1990 -2016 (EC.Europa.eu, 2018b)

On further review it transpires that transport related emissions have significantly increased shown in figure 4 and the European Commission's aim of sixty percent reduction in transport greenhouse gas emissions by 2050 (European Commission, 2011) is ambitious. In 2016 emissions relating road transportation accounted for over seventy percent of total transport related emissions.

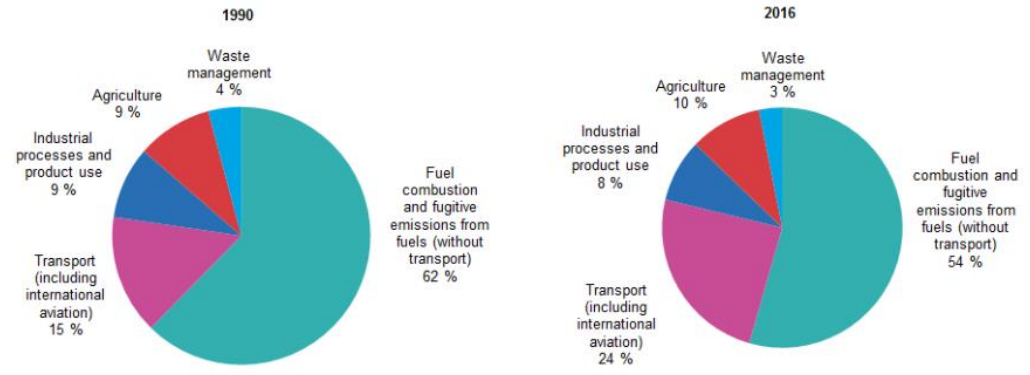

Figure 4: Greenhouse gas emissions, analysis by source sector, EU-28,1990 and 2016 (EC.Europa.eu, 2018c)

Health issues relating to the prolonged exposure to air and noise pollution have also been highlighted, with nitrogen dioxide (NO_2) levels in urban zones

particularly concerning (Moldanova et al., 2011; Reis et al., 2016). The main sources of NO_2 are internal combustion engines that burn fossil fuels.

Improving safety and environmental issues in road transport while increasing capacity can be to some extent accomplished through delivery of new, or expansion of existing, infrastructure. However, these solutions generally require a high level of investment and can often be long-term disruptive projects (Edwards et al.,2017). There is growing support that C-ITS has the potential to increase the efficiency of existing urban infrastructure by improving network capacity, whilst simultaneously providing safety and environmental benefits, and reducing fuel and energy demand (Jandrisits et al., 2015; Edwards et al.,2017; European Commission 2016) without requiring the level of investment generally required for intrusive upgrade schemes.

Edwards et al. (2017) suggest that it is likely that cities can achieve policy objectives that add value to the road network by means of 'targeted C-ITS measures' geared towards particular users or vehicles. Furthermore, the authors posit that smarter delivery of mobility services citywide can be achieved through 'Packages' of measures. These views are supported by the views of the EU Commission, the 2008 'Action Plan for the Deployment of Intelligent Transport Systems in Europe' (European Commission, 2008), the Directive on ITS deployment (European Commission, 2010) and subsequent Strategy for C-ITS in Europe (European Commission, 2016) are major milestones for the field of ITS in Europe. These communications from recognise the anticipated role C-ITS has to play in coping with the restrictions of traditional infrastructure and standalone ITS systems.

1.2 Research Focus

Daily, the current modes of transport are causing worldwide traffic congestion and disruption problems. This overload in vehicle capacity has propelled an approach called ITS to the forefront of transport thinking in the hope that it can relieve the worldwide transport congestion problems. It has been primarily driven by the negative effects which the increase in private vehicle ownership has brought upon worldwide transport systems. Vandezande & Janssen (2012) argue that ITS are often publicised as a possible solution to this problem yet fall short when it comes to fully achieving the desired results. The

statistics reported by the European Commission demonstrate that the steady and encouraging trend in road safety that Europe has witnessed over the last decade has subsided. Road transport is still responsible for most transport emissions, in terms of greenhouse gases and air pollutants. The EU are confident that C-ITS has the potential to have a significant impact in counteracting the increasing problems of congestion, transport energy consumption and emissions (Ricardo Energy & Environment, 2016)

C-ITS is receiving significant attention around the world from academics, industry and governments which has cultivated intense research activities and standardisation endeavours in recent years. In Europe there has been a commitment by the automotive industry to deploy C-ITS enabled vehicles from 2019 fully supported by EU Commission, with millions of euro already invested by both industry and government (European, Commission 2016)

EU Commission have launched a C-ITS Strategy and have requested local authorities and road authorities in member states to deploy C-ITS Services by 2019.After a successful testing and pilot projects several countries in the EU moving rapidly towards deploying C-ITS services. Ireland so far have been a spectator in relation to activities in Europe and have not progressed any C-ITS testing on Irish roads. Recent developments in Europe indicate that there is a call for research in the area of C-ITS in Ireland. C-ITS can be deployed on a wide range of roads, however this study investigates urban roads specifically Dublin city centre.

1.3 Research Questions

The overall aim of this research is to advance an understanding of C-ITS in an urban setting, particularly in relation to future C-ITS deployments in Dublin City Centre. Within the context of the European guidelines for the deployment of C-ITS services.

The research questions central to this study are:

> *To what degree could C-ITS assist with Dublin's City Centre current and imminent transportation challenges and objectives?*
>
> *How should city authorities progress with C-ITS?*

1.4 Research Objectives

The objectives specific to this study are:

1. Identify the current and imminent transportation objective and challenges in Dublin City Centre encompassing all modes of travel.
2. Identify what type of work or project would be involved to achieve the defined the objectives and challenges and Identify the resulting area that would benefit, from that particular type of project.
3. Formulate recommendations on how city authorities can progress with C-ITS deployment.

1.5 Dissertation Structure

The contents of table 1 provides a roadmap, which is broken down by chapter number. The intention of the roadmap is to highlight the academic constructs applied and drawn from throughout this body of work.

Chapter 1	Provides the high-level composition of this dissertation. Introduces the research topic, the rationale for project selection, the research focus and objectives central to this study. In addition, it provides a brief overview of research undertaken and methodology.
Chapter 2	Literature review discusses the existing body of knowledge relevant to the study of C-ITS and situates it within the broader field of ITS. This chapter presents the current political and technological developments in Europe within the backdrop of the wider issues that may be impacted through the deployment of C-ITS Services.
Chapter 3	Discussion of the research design, selected methodology, data sources and data analysis techniques employed in this study. The validity and reliability of the study are also considered.
Chapter 4	Provides a description of the data analysis techniques and process used in the study. Reports the findings and results of the content analysis. In additional difficulties encountered are discussed.
Chapter 5	Discussion of the results reported in chapter four. Conclusions reached from the research are summarized and suggestions put

	forward for possible future research. Limitations of the strategy are addressed.

Table 1: Roadmap of Dissertation Chapters Research Question

1.6 Research Strategy

This study carries out unobtrusive research using secondary sources, employing a qualitative content analysis and develops a framework for data analysis using a deductive approach. Full details of the methodology employed and the procedures that were followed while conducting the content analysis are provided in chapter three.

1.7 Value of this Research

There is currently no research concerning C-ITS in Ireland or Dublin, furthermore C-ITS has not been addressed by national or regional transportation plans. Findings from this study call for action from city authorities responsible for transportation in Dublin City Centre. This study could assist strategy formulation, the recommendations of this study could form the basis or the ground work of future C-ITS deployments in Dublin City Centre.

C-ITS is discussed in greater detail in chapter two under three headings; a background to C-ITS, the wider issues affected by the deployment of C-ITS and the EU Commissions activities in recent years in this area.

Chapter 2 Literature Review

2.1 Introduction

The primary aim of this literature review is to analytically explore the growing body of knowledge in the rapidly emerging field of C-ITS. A secondary aim is to interpret C-ITS related publications from the EU commission including the EU C-ITS Strategy and what this entails for a local authority such as Dublin City Council (DCC). A third aim of the literature review is to provide guidance on the final selection and definition of a research question for this dissertation. As C-ITS is an emerging field this study endeavours to present some of the fundamental concepts in a digestible style, so readers and decision makers may fully grasp the overarching purpose, considerations and use cases of C-ITS.

2.2 Setting the scene: The broad scope of ITS

Daily, the current modes of transport are causing worldwide traffic congestion and disruption problems. This overload in vehicle capacity has propelled an approach called ITS to the forefront of transport thinking in the hope that it can relieve the worldwide transport congestion problems. It has been primarily driven by the negative effects which the increase in private vehicle ownership has brought upon worldwide transport systems.

Considered to be a scientific and engineering discipline the scope of ITS is vast and evolving, Figueiredo et al., (2001) report the concept of ITS first emerged in the nineteen-thirties refined over the decades to present day acceptance. Ghosh & Lee, (2010) claim the main purpose of ITS is to minimise the time in transit of all passengers and goods within the confines of safety and fair distribution of available resources, specifically under the conditions of increases in travel speeds, increasing passenger numbers, and demand for accurate real-time information.

Figueiredo et al., (2001) view ITS as the solution of transport problems such as safety, congestion, transport efficiency and environmental conservation. This involves the application of advanced communication, information and electronics technologies. The main purpose of ITS is the deployment of these technologies to create “more intelligent” roads and vehicles. Furthermore, ITS

technologies can be used as a source of information for transport users to enable more effective movement of people and goods. Another key driver of ITS has been the increasing interest from the automotive industry, transportation professionals and political decision makers. Figure 5 represents the interactions of all the key components involved in delivering efficiency, comfort, safety and environmental conservation in transport systems.

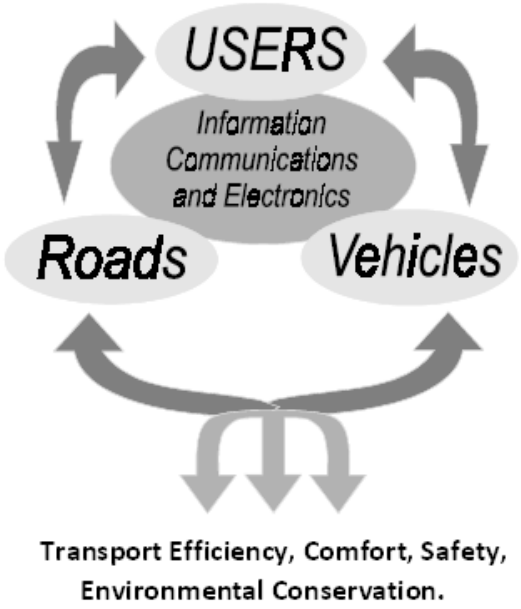

Figure 5: ITS Conceptual Model (Figueiredo et al., 2001, p. 1)

Figueiredo et al., (2001) highlight that there has been a realisation in the last twenty-five years by providers of transport services that society required alternative approaches in the delivery of transport services. This perception is substantiated by Ghosh & Lee (2010) who advocate that since the mid nineteen nineties it has become evident that the issue involving the efficient movement of people and goods is more complex than had earlier been envisaged. The problem affects all presently used modes of transport, including vehicles, roads, trains, passenger and cargo aircrafts, ships and ferries. Ghosh & Lee (ibid.) argue that creating a real solution to this problem requires the adoption of a holistic approach, that must consider the asynchronous and intricate interdependencies between the variety of transport modes. In addition, this approach should be guided by the central aim of

minimising the journey time for all passengers and goods in transit based on the even distribution of available resources.

Figueiredo et al., (2001) notes there are six major categories of developed ITS systems. This report briefly outlines the three categories most closely associated with mass transport systems.

A. Advanced Traffic Management Systems (ATMS)
B. Advanced Travellers Information Systems (ATIS)
C. Advanced Public Transportations Systems (APTS)

A. Advanced Traffic Management Systems (ATMS)

ATMS use a series of surveillance cameras, roadway loop detectors, variable message signs and network signals to improve traffic flow with which is intended to reduced traffic delays. Information is fed back from devices and detectors to one central traffic management station which can monitor and control parameters that can affect traffic flow in real time. Information collected from ATMS is also relayed to ATIS.

B. Advanced Travellers Information Systems (ATIS)

ATIS supplies real time travel information to commuters which enables the determination of the most favourable route and transport service to adopt for a specific journey. This information is relayed to commuters through electronic signs, portable devices connected to the internet and radio systems.

C. Advanced Public Transportations Systems (APTS)

APTS uses technologies from ATMS and ATIS to monitor, plan and improve the operation and quality of mass transport services such as trains and buses. APTS can provide route information, travel schedules, costs and unexpected changes in the transport service. Communication with traffic management systems enables the actuation of traffic lights to give priority to public transportation. Internal and external cameras on buses and trains provide critical information in the prevention, detection and prosecution of criminal activity which ensures the safety of passengers and drivers alike. Furthermore, APTS can improve efficiency, lower transport costs and increase customer satisfaction.

C-ITS builds on existing ITS infrastructure the purpose of both is to deliver dedicated sets of tools. However, the main difference is that ITS provides digital tools which produces intelligence at the roadside or in vehicles, whereas C-ITS builds on that existing technology by enhancing the communications between the different actors in the systems. The following sections of this chapter discusses C-ITS in greater detail.

2.3 C-ITS Background

The premise of C-ITS is to facilitate direct two-way communication between a variety of actors in a transport system such as traffic control centres, roadside infrastructure and vehicles. According to Ndashimye et al., (2017) the underpinning technology can transfer messages wirelessly from vehicle to vehicle (V2V) or infrastructure to vehicle (I2V) collectively labelled as vehicle to anything (V2X) using a variety of communication protocols which will be discussed in greater detail further on in this chapter. Additionally, in the literature to date C-ITS, V2X and I2V are terms used interchangeably with the term connected vehicles (Uhlemann, 2015). The potential benefits of C-ITS are improved safety, smarter use of the road network, increased energy efficiency, operational efficiency and lower CO_2 emissions (Sjoberg et al., 2017), (Jandrisits et al., 2015).

A typical V2V and I2V communications scenario is illustrated in figure 6, observe how the vehicles out of reach of the road side unit (RSU) act as nodes in the network extending the range through V2V communications.

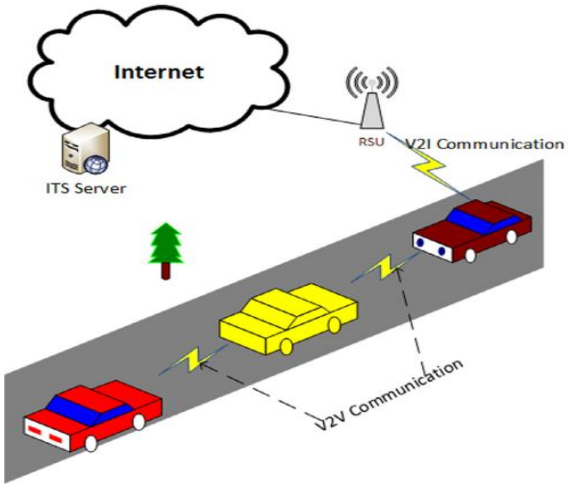

Figure 6: V2V and I2V Communications, (Ndashimye et al. 2017)

Cooperative systems have the potential to allow traffic control centres to collect accurate and comprehensive information from vehicles regarding traffic conditions in real time. The data collected can provide a clearer picture of conditions in the network than the ATMS, as V2V and I2V are essentially crowd sourcing information about traffic conditions. This information is then sent back to the traffic control centre which can then be used to manage the flow of traffic more intensively, and efficiently thus improving the flow through the network (Jandrisits et al., 2015). Furthermore, C-ITS can inform drivers about traffic incidents, such as hazards, traffic signal phases and the latest traffic conditions (Jandrisits et al., 2015); (Katsaros et al., 2011). The basis for providing in vehicle information (IVI) is to allow drivers to make informed decisions on route selection and elicit more efficient or safer driving actions (Edwards et al., 2017).

Seminal C-ITS research was carried out in laboratory settings using traffic micro-simulation programs that focused on the development of algorithms. While much micro-simulation studies were carried out autonomously, they helped determine the probable impacts of C-ITS systems and the network-wide effects of the technology (Edwards et al., ibid.). Research carried out by Edwards et al., (ibid.) examined findings of what is agreed to be the breakthrough C-ITS projects from Europe, Japan and the United States that paved the way for future works. The projects listed in table 2 investigated the impacts of C-ITS through field trials or simulation studies.

CVIS	Design, Development and testing of V2X technologies and architectures (Ernst, 2006).
Coopers	Demonstrated the dissemination of infrastructure status and road hazard warning (RHW) information via dedicated V2I communication. The system was acceptable to drivers, did not cause undue distraction, enhanced compliance with traffic rules and had a positive impact on safety.
Safespot	Examined cooperative vehicle highways to improve road safety (Andreone et al.,2010).
Drive C2X	Complete penetration rates of In-Vehicle-Signage (IVS) systems providing speed limit information could decrease fatalities by 23% and injuries by 13%.

	Further provision of adverse Weather Warning (WW), Road Works Warning (RWW), Emergency Brake Light Warning (EBLW) and Traffic Jam Ahead Warning (TJAW) could reduce fatalities by 6%, 3%, 2%, and 2% respectively. However, complete penetration was not assumed possible until beyond 2030 (Drive C2X, 2014).
Freilot	Sought to improve the efficiency of freight movements in urban areas, with focus on energy efficiency at intersections, behavior of accelerating vehicles, adaptive speed limitation, 'eco-driving' support and fleet-management, real-time loading and delivery space booking (Gonzalez-Feliu et al.,2013) Field operational trials at the Dutch Integrated Test site for Cooperative Mobility (DITCM) in Helmond-Eindhoven yielded a 13% reduction in fuel consumption and CO_2 emissions with intersection priority and speed advice alone (Blanco et al., 2012).
Cosmo	Reported a 13% fuel consumption reduction as well as a 6.4% increase in average speed for seven equipped buses in Gothenburg following time-to green speed advice at intersections, bay-entry, and queue-avoidance advice stops.
SmartWay (Japan)	A next generation road system that incorporated existing services such as Vehicle Information and Communication System (VICS) and Electronic Toll Collection (ETC) as well as other services using advanced ITS technology (Kanazawa and Suzuki, 2016). Set standards and specifications for OBU's and RSU's and performed system functions through on-road trials. Deployed nationwide services to provide dynamic route guidance and assisted safe driving through provision of road hazard alerts, including congestion, to drivers.

Table 2: Key Seminal Projects (Cited in: Edwards et al., 2017)

The studies listed in table 2 concentrated on a specific category of vehicle or operations using those vehicles on sections of road. The focus of the studies was driven by either technological validations of V2X or use cases related to individual policy targets for example lowering CO_2 emissions although not necessarily both. According to Tielert et al., (2010); Schricht et al., (2011); Xia et al., (2013) estimated benefits from simulations studies that are confined to a low number of vehicles or a specific section of road such as highways, may imply exaggerated results than those feasible throughout an actual urban network.

2.4 C-ITS Activities in Europe

Europe received a frequency allocation of 5.9 GHZ in 2008 which has a designated purpose of increasing road traffic safety and efficiency. According to Sjoberg et al., (2017) this milestone gave rise to intensive V2X activities throughout Europe supported by the EU commission and industry. Standardisation has an important role to play when it comes to communication interoperability. Most of the technology underpinning C-ITS services has been standardised in Europe by ETSI TC ITS (vehicle), CEN TC 278 WG16 (roadside infrastructure), and IEEE 802.11 p/ITS G5 (communications) (Sjoberg et al., 2017). With the standards in place vehicle field operational tests (FOTs) can be carried out to test C-ITS in real-world settings (Barnard et al., 2015). A FOT is defined as "a study undertaken to evaluate a function, or functions, under normal operating conditions in road traffic environments typically encountered by the participants using study design so as to identify real world effect and benefits" (FOT-NET, 2014). Therefore, vehicles are monitored under normal driving conditions, data can then be collected relating to the performance of the system, the vehicles and drivers capturing the changing synergy of the overall transport system.

A significant development in Europe is the C-ITS Corridor project, where authorities from the Netherlands, Germany and Austria are working with the automotive industry on the deployment of seamless interoperable, harmonised V2X technologies and services. The corridor shown in figure 7 runs from Frankfurt, Via Rotterdam to Vienna, this is a major freight and transport corridor and the largest cross-border application of V2X technology to date (ITS International, 2016).

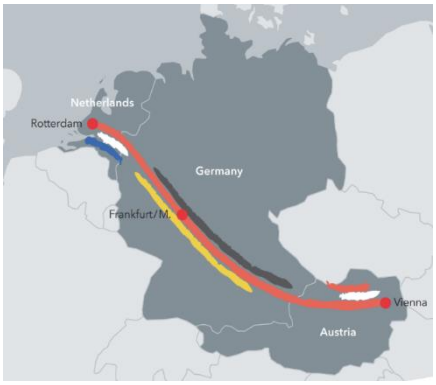

Figure 7: C-ITS Corridor (ITS International, 2016)

The participating countries agreed upon the introduction of two cooperative services to be provided along the entire C-ITS Corridor. These services are Road Works Warning (RWW) illustrated in figure 8 and Improved Traffic Management using Probe Vehicle Data (PVD) in figure 9 and 10 (CODECS, 2016)

Figure 8: RWW Drivers are alerted of upcoming construction sites and their relevant data as well as any obstacles (e.g. Closed lanes) (BMVIT, 2016)

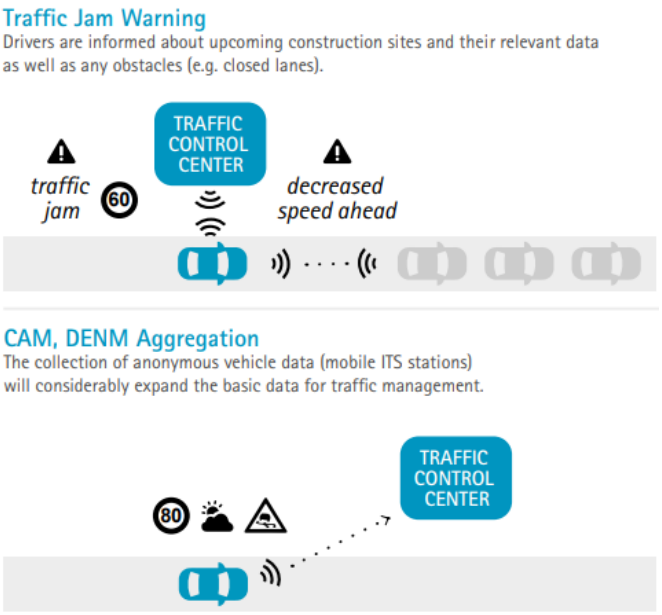

Figure 9: PVD example, sensor data from passing traffic is collected for use by traffic management (BMVIT, 2016)

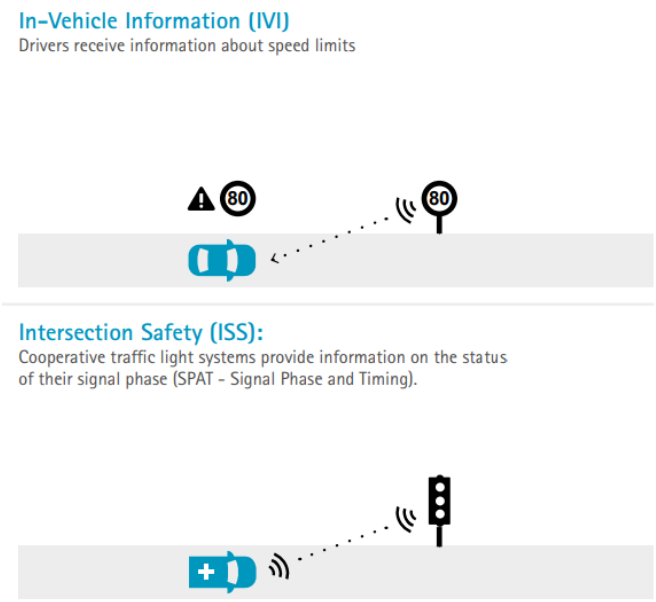

Figure 10: PVD example, sensor data from passing traffic is collected for use by traffic management (BMVIT, 2016)

The Netherlands, Germany and Austria have made significant advancements since 2013, FOT's and pilots have been evaluated. Currently stakeholders are preparing towards the final preparatory phase of the project, car manufacturers such as Volvo and Volkswagen have confirmed new vehicles will be equipped with the enabling technology from 2019. The Netherlands have moved to the 'Roll Out Preparation Phase', which will focus on investigating some unresolved questions in relation to privacy, security and scalability. Germany has commenced roll out to the entire country and Austria are following in their footsteps with the adoption of a national C-ITS Strategy (Rijkswaterstaat, Ministry of Infrastructure and Water Management Netherlands, 2017)

Jandrisits et al (2015), present the communication scenario and convergence strategy considered and selected for *ECo-AT (European Corridor – Austrian Testbed for Cooperative Systems)* the Austrian component of the European Corridor project. The convergence strategy makes use of both ETSI ITS G5 and mobile cellular communication systems categorised as access technologies. The underpinning ECo-AT System architecture is shown in figure 11 and each component of the system is clearly defined.

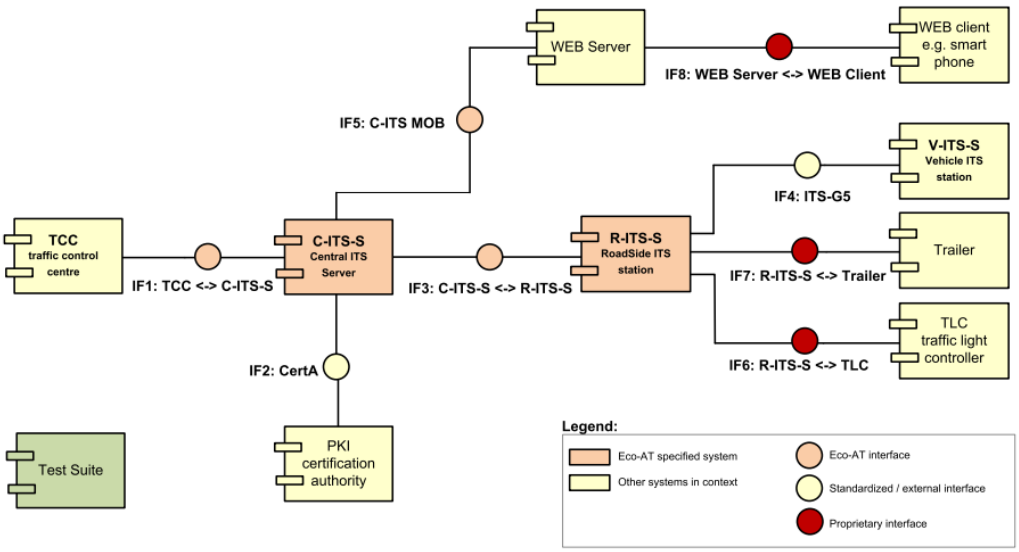

Figure 11: Eco-AT high level system architecture (Jandrisits et al., ibid.)

The convergence strategy presented by Jandrisits et al (ibid.) provides for a comprehensive representation of how cooperative systems exchange information between the various actors in a transport system. In addition, the strategy conveys the necessary consideration given to the strengths and limitations of the two available access technologies. These considerations can be summarised as follows:

- ETSI ITS G5 is intended to increase the driver's awareness to their surroundings and to support time critical applications the disadvantages are short-range coverage which can make for difficult communication conditions (e.g. obstruction caused by other vehicles).
- On the other hand, mobile cellular 3G and 4G provide a relatively comprehensive and reliable communication but with the disadvantage of increased latency.
- Neither of the two access technologies fulfil all requirements, however this weakness can be addressed by ensuring that the most suitable access technology is selected based on the application.

- The limitation with wireless applications is that they can never be error free, therefore applications must be developed to handle transient errors.
  (Jandrisits et al., ibid.)

The two communication paths between the TCC and the V-ITS-s are illustrated in figure 12, one path use ETSI ITS G5 and the other uses mobile cellular networks. The aim of the convergence strategy is to deliver information between the TCC and V-ITS-S end to end on both paths illustrated in figure 13.

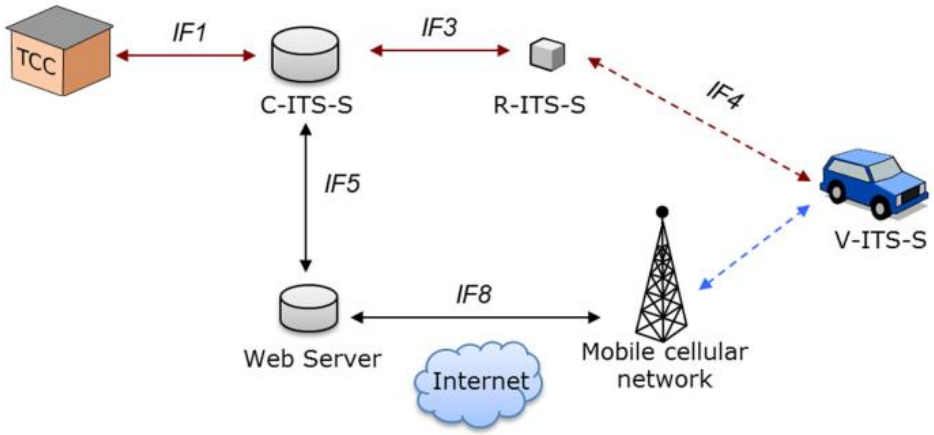

Figure 12: Communication paths from the TCC and the C-ITS towards the V-ITS-S (Jandritis et al., ibid.)

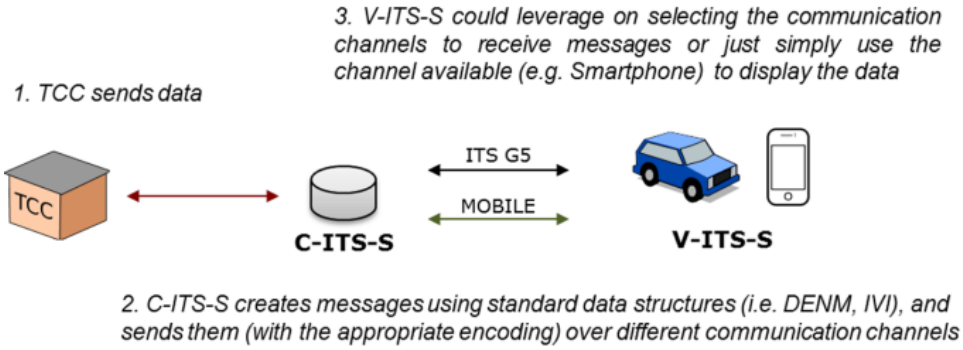

Figure 13: Convergence approach used in ECo-AT (Jandrisits et al., ibid.)

The convergence approach illustrated in figure 13 permits users to have the option of exploiting information according to their requirements. This means that if there is no ETSI ITS-G5 installed then a Smartphone can be used to receive the data smartphone can receive the data. This provides continuity as

the same information will be communicated and displayed in the vehicle to the driver regardless of the communication channel used to receive the data.

The Car 2 Car Communication Consortium (C2C-CC) is an industry-controlled organisation of European vehicle manufacturers, equipment suppliers, researchers and other partners. In 2015 members of C2C-CC committed to the production of vehicles equipped with V2X technology by 2019 with the intention of improving traffic safety and efficiency. Whilst demonstrating measures to ensure interoperability and consistency for supporting deployment of C-ITS throughout Europe (Car-2-car.org, 2018).

2.4.1 The EU Commission's Perspective on C-ITS

Preceding considerations of C-ITS services in Dublin City, a thorough understanding of the expectations and deliverables imposed by EU directives is a fundamental requirement of this study. This section interprets the EU C-ITS Strategy and investigates the various developments and activities undertaken by the EU Commission in recent years that support the deployment of cooperatives, connected and automated mobility. The market potential of which is estimated to be worth 'dozens of billions of euro annually' which the EU commission are confident will generate many new employment opportunities (Europa.eu, 2016).

The EU commission advocate the transformative potential of C-ITS and adopt the vision that cooperation, connectivity, and automation are interrelated technologies that support each other that in due course will become one and the same (EU Commission, 2016).

Europe have recognised that countries around the world namely United States, Australia, Japan, Korea and China are rapidly progressing with the deployment of C-ITS services and in some countries equipped vehicles and C-ITS services have already emerged on the market (European Commission, ibid.). The EU emphasise the potential and in their view the underutilisation of developments in telecommunication technologies in transportation, and sought to harness the following benefits of C-ITS:

- Improving road safety.
- Reducing congestion.

- Optimising the performance and available capacity of existing transport infrastructure.
- Enhancing mobility in a multi-modal transport chain.
- Increasing travel time reliability.
- Improving the efficiency of logistic operations thus reducing energy use as well as diminishing the environmental impact of road transport.

(European Commission, ibid.)

2.4.2 ITS Directive Delegated Act – Legal Certainty

The EU commission has been working for over a decade to advance ITS and develop C-ITS services. ITS implementation has accelerated in Europe since the 2008 Action Plan for the Deployment of ITS in Europe and the subsequent adoption of a legal framework packaged in the ITS directive in 2010. These publications recognise the function C-ITS can have in overcoming the limitations of what would be considered traditional infrastructure while seeking to assure its harmonised and consistent deployment in Europe. Action 4.2 of the ITS 2008 Action Plan aims specifically at the

> *"Development and evaluation of cooperative systems in view of the definition of a harmonised approach; assessment of deployment strategies, including investments in intelligent infrastructure"* (European Commission, 2008).

The aim of the ITS Directive 2010/40/EU (European Commission, 2010) is to accelerate the coordinated deployment of ITS across Europe Member states are free to decide which systems to implement Specifications are adopted for compatibility, interoperability and continuity

The EU Commission commenced a review process of the ITS Directive to evaluate to what degree the ITS Directive contributed to faster, coordinated deployment (EC.Europa.eu, 2017) this has not yet concluded.

2.4.3 C-Roads – Large Scale Deployment Projects

The C-Roads entity was established as a collaborative endeavour between road operators and member states for testing, piloting and deploying C-ITS services spanning borders in view of interoperability and harmonisation and is

co-funded by the EU. Core members of the platform are denoted in in figure 14 using the letter C these are member states that have subscribed to collaborate to accomplish deployments that enable interoperable and seamless cross-border C-ITS services for European commuters. Currently Ireland is not a core member, however the National Transport Authority (NTA) has signed up to be an associated member of the platform. Associated members are representatives of states that monitor pilot projects closely (C-roads.eu, 2018.)

Figure 14: C-Roads core members (C-roads.eu, ibid.)

The main goals of the C-Roads platform are to connect C-ITS pilot projects to:

- Ensure the development and dissemination of common technical specifications.
- Ensure interoperability by fostering conditions that enables cross-site testing.
- Develop system tests based on the common communication scenarios by focusing on a hybrid communication combination of ETSI ITS-G5 and 3G/4G cellular networks.

2.4.4 C-ITS Platform – Common Vision

In 2014 DG MOVE the Directorate-General of the European Commission responsible for transport and mobility within the EU took a prominent role in

the deployment of C-ITS through the establishment of the C-ITS Platform. The core objectives of the platform are twofold, firstly to concentrate on the main barriers and enablers that were identified to the deployment of C-ITS. Secondly to assist the Commission in the development of a shared vison and a roadmap for the deployment of C-ITS in the Europe (EC.Europa.eu, 2016). The scope of phase one concentrated on the main technical considerations, legal issues, security concerns in relation to in vehicle data and other resources. The task of the platform during phase one was to provide policy recommendations for the development of a roadmap and a deployment strategy for C-ITS in the EU. Identify a mechanism for ensuring interoperability across borders and throughout the entire value chain. The recommendations made in the report formed the basis of the European Strategy for C-ITS which is discussed in greater detail in the following section. The work of the platform is ongoing, figure 15 shows the composition of the platform members by grouping.

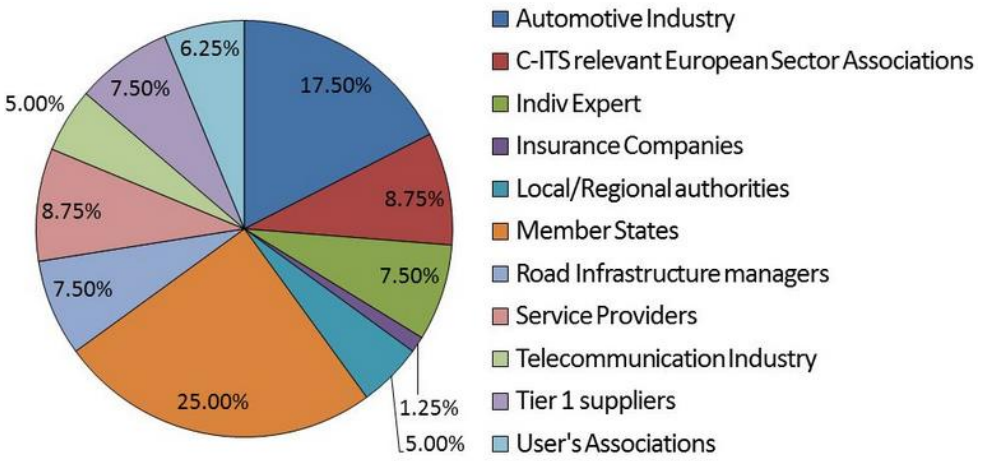

Figure 15: Platform Members (Traffictechnologytoday.com, 2018)

2.4.5 European C-CITS Strategy – Deployment Framework

Industry announced that C-ITS enabled vehicles will be deployed by 2019 the EU have stated for this to happen that coordination is urgently required at European level (European Commission, 2016). Therefore, on the 30th of November 2016 the European commission adopted *A European strategy on Cooperative Intelligent Transport Systems, a milestone towards cooperative,*

connected and automated mobility. The main objective of this strategy is to enable wide-scale commercial deployment of connected vehicles on EU roads from 2019. The EU Commission's perspective is that the transportation sector is on the cusp of enormous change and that the surge in ICT innovation and disruptive business models has increased the demand for new mobility services, simultaneously the sector is also required to make transport safer more efficient and sustainable. The commission identifies the transformative social and economic opportunities for citizens and business and insist that now is the time to focus on these opportunities to realise the benefits. The strategy advocates that digital technologies are the strongest driver and enabler of this transformation process (ibid., p3).

Principals of the Strategy

The strategy focuses on six key components:

1. **Avoid a fragmented internal market**

   There are currently numerous C-ITS deployment activities happening in Europe many of which are funded by the EU. In parallel with these activities the automotive industry has confirmed its objective to commence delivery of C-ITS enabled vehicles by 2019. Therefore, the first objective of the strategy is to discourage a fragmented internal market in the sphere of C-ITS and to foster collaboration amongst various project teams internationally, to ensure interoperability and continuity of C-ITS services across Europe (ibid., p3)

2. **Define and support common priorities**

   The strategy advises that to achieve continuity, the availability of C-ITS services across Europe for end-users must be guaranteed. The strategy proposes a catalogue of what is considered technologically mature C-ITS services that the EU Commission believe will offer distinct advantages for transportation and society in general. These services are detailed below under the heading Day 1and Day 1.5 C-ITS Services. The EU recommend a swift and timely deployment of mature C-ITS services across Europe by Member States, local authorities, road operators, ITS industry and the automotive industry. The Strategy sets out the EU's commitment to

supporting the deployment of services offering financial assistance to Member States and industry (ibid., p 6).

- **Day 1 C-ITS Services**

  Are categorized as services that are required to be available in the short-term i.e. before or during 2019. These services were favoured by the C-ITS Platform due to the expected benefits for society and the maturity of the supporting technologies. The strategy highlights that the selection and approval process of these services did not factor in personal benefits, users' willingness to pay for services, business cases or market driven deployment (ibid., p 6).

- **Day 1.5 C-ITS services**

  C-ITS platform also approved these services which are categorized as mature and highly sought-after by the market. However, their exact specifications or standards were not finalized as of publication of the strategy (ibid., p6).

List of Day 1 Services	List of Day 1.5 Services
Hazardous location notifications: • Slow or stationary vehicle(s) and traffic ahead warning • Road works warning • Weather conditions • Emergency brake light • Emergency services vehicle approaching • Other hazards **Signage applications:** • In-vehicle signage • In-vehicle speed limits	• Information on fueling and charging stations for alternative fuel vehicles • Vulnerable road user protection • On street parking management and information • Off street parking information • Park and ride information • Connected and cooperative navigation into and out of the city (first and last mile, parking, route advice, coordinated traffic lights)

• Signage violation/intersection safety • Traffic signal priority request by designated vehicles • Green light optimal speed advisory • Probe vehicle data • Shockwave damping	• Traffic information & smart routing

Table 3: C-ITS services EU Commission (ibid., p7).

An objective of the C-ITS platform was to carry out a cost benefit analysis for the deployment of C-ITS services based on road transportation in the EU. The findings of this analysis were that the deployment of interoperable Day 1 C-ITS services throughout Europe would yield a benefit cost ratio of up to three to one, based on cumulative costs and benefits from 2018 to 2030. To achieve this the platform deliberated on what types of deployments demonstrated the most potential regarding fast widespread acceptance. Thus, asserting that swift deployment of the maximum amount of services as possible would lead to faster recovery of costs and greater benefits in general (ibid., p10).

The strategy highlights the following specific actions:

- *"Member States and local authorities alongside road operators, vehicle manufacturers and the ITS industry should deploy C-ITS ensuring that at minimum Day 1 C-ITS services are fully supported."* (ibid., p11)
- *"The Commission will support Member States and industry in deploying Day 1 C-ITS services."* (ibid., p11)
- *"The Commission will encourage the update of Day 1.5 service list and future C-ITS service lists, through the continuation of the C-ITS Platform process."* (ibid., p11)

3. **Use a mix of communication technologies**

   V2X messages will be transmitted for a variety of services, between different components in a range of transport scenarios. The assumption

of the EU is that in general road users are not unconcerned with the communication technology used for the transmission of V2X messages. Yet the strategy foresees there will be a growing expectation from road users to seamlessly receive all information on traffic and road safety across Europe. Therefore, the approach proposed by the strategy is a hybrid communication one, using a combination of complementary and available technologies. The strategy further determines that currently the most suitable hybrid communication approach is a mix of Wi-Fi based short range communication and cellular networks (ibid., p14).

4. **Address security and data protection issues**

   The strategy recognizes that security and data protection are paramount when addressing connectivity issues. The strategy asserts that secure communications must be guaranteed, and citizens must be assured that their data only be used for its intended purpose. Addressing the above concerns, the strategy incorporates the formulation of a common EU security policy for C-ITS and unambiguous procedures for citizens to protect their confidential data (ibid., p14).

5. **Develop the right legal framework**

   The strategy recognizes that a respective framework is required to deliver *legal certainty* to public and private investors. This framework must also ensure that the underpinning technical protocols (services, communication technologies, standards, frequencies, security, data protection etc.) are comprehensively adopted throughout Europe creating interoperability and continuity of C-ITS services. The development of the framework will also collaborate with stakeholders to incorporate learning outcomes of C-ITS projects and initiatives. To this end the strategy incorporates a commitment to establish a legal framework which incorporating lessons learned from pilot projects and FOT's (ibid., p18).

6. **Cooperate at international level**

> Globally the C-ITS market is continuing to grow. Currently the EU are working in partnership at an international level in the areas of security, research and establishing harmonization of standards. Therefore, the strategy includes steps for the continued commitment of collaboration with international partners and C-ITS deployments to foster innovation and knowledge exchange (ibid., p23).

The C-ITS strategy does not directly mention urban roads however EU funded research has produced a Roadmap for C-ITS in European Cities. This document reports that many research and development projects have addressed the technical issues of C-ITS and have proven that the technology works. However, the contribution from these technical solutions to the planning of urban transport policies, and the implementation of these policies, is not as well understood (Centaur Consulting LTD, 2017 p39)

Smart Cities lies outside the scope of this paper still it is worth highlighting that Kallas (2013) acknowledged the roll-out of ITS as a key component in the delivery of smart cities. However Smart Cities require people, businesses and organisations working together on the development of innovative technologies in the transport, energy and ICT sectors. The combination of diverse sectors working in partnership can vastly improve the urban environment and functionality of modern cities (Caragliu et al., 2009). This is of interest as essentially C-ITS enables “smarter” ITS infrastructure and a “smarter” transport system. This is a potential area for future research.

2.5 Private Car Ownership in Ireland

In Ireland there were 92,000 new private cars licenced for the first time in 2014 the total number of private cars licenced for that same year were 1,933,868 with just over a quarter of vehicles registered in Dublin (Dttas.ie, 2017).

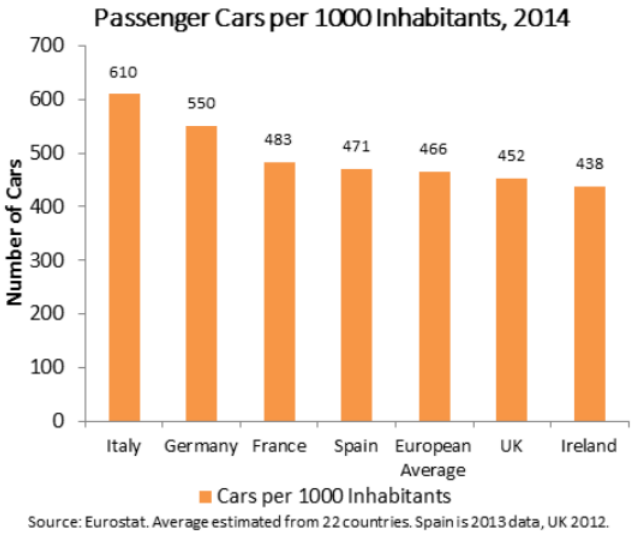

Figure 16: (Passenger Car Statistics, ibid.)

The most recent Eurostat data available (2014) indicates that private car ownership numbers are lower in Ireland compared with other European countries. The estimated level of 466 private cars per 1000 inhabitants is the average figure of the twenty-two EU countries for which data was collected. Ireland falls below this average with a figure of 438. The comparison to other countries shows they all have a higher density of private car ownership. Ireland ranks the eight lowest of the countries. Nineteen countries recorded increases in this measure between 2013 and 2014 while Ireland increased by 1.39 percent from 432 to 438 (Department of Transport, Tourism and Sport's Economic and Financial Evaluation Unit, ibid.)

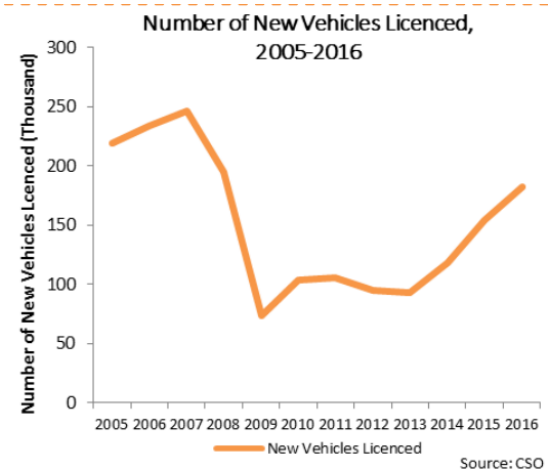

Figure 17: (Number of New Vehicles Licenced, ibid.)

This insight raises the question of how beneficial C-ITS enabled roads will be in Dublin and the rest of Ireland? As only new cars from 2019 will be compatible with C-ITS roadside devices if approximately a quarter of drivers can use the services. In contrast Preuk et al (2016) argue that vehicles not equipped with on board C-ITS devices may potentially benefit from the effects of C-ITS by experiencing fewer changes in speed or a reduction in start-up delays at junctions. Equally drivers of non-equipped vehicles may also become impacted by 'out of the ordinary behaviour' of equipped vehicles in certain situations for example long, slow coasting to traffic signals (Rittger et al., 2015).

2.6 Geometry of a City

In a recent interview with ITS International Jarrett Walker a leading international consultant in public transit planning and policy, argues that there are three separate and distinct urban mobility problems that are wrongly interchanged with each other. Furthermore, Walker warns that the solution to one problem is not the solution to the other. The vision that Walker offers on these problems are summarised as follows:

- The problem of air pollution and energy use can only be solved with electric vehicles.
- Electric powered vehicles are the solution to energy use/air pollution problem.
- Automation is the solution to road safety and the human time in transit,
- Public transport and cycling are the solutions to city congestion and the more efficient use of space.

  (ITS International, 2018)

Walker further argues that cars in cities are a hindrance to mass transport and he is adamant that cars will never be the answer whether electrified or automated. Walker uses the analogy of trying to fit an elephant in a wine glass to make his point. These views are well documented in a book Walker published several years ago titled *Human Transit*, the contents of which are based on the authors twenty years of practice and experience. Walker holds the view that since private car ownership became ubiquitous this mode of transport was the obvious choice for independent and unrestricted travel and

in rural areas this will continue to be the case. In contrast with the rise of urbanisation, cities have a finite amount of space and simply put can no longer cater for the volume of private cars. (Walker, 2012 p2).

According to Walker, (ibid.) the dual threat of climate change and the demand for oil outweighing supply is driving a new evaluation of how cities function. Walker argues that a vital component of that endeavour is public transport because it is the most efficient means for moving large numbers of people throughout a city. Walker posits that the choice of technology does matter whether bus, train or ferry however the 'geometry' of transport is the same. Walker explains that this is based on the understanding that both buses and trams can offer fast and reliable services if they have a designated lane free from obstruction. However, the same buses and trams can also be slow and unreliable if the only option they have is to use a congested lane with other traffic. Walker cautions that if the move to technology choices is rushed and less consideration is given to geometry that it will result in an ineffective service, unfit for purpose regardless of how appealing the technology may be. Furthermore, that the fundamental points which determine whether transport can serve a city well are not based on the technology choices (Walker, 2012 p7).

Walker's views on public transport resonates in the Transportation Study for Dublin City Centre. This study highlights the requirement that Dublin caters for future economic growth. The study reports that there were approximately 200,000 journeys into the city centre each week during the peak morning period (7am -10am) in 2015. This is estimated to grow and by 2023 Dublin city centre will have to cater for 40,000 additional journeys in the morning peak an increase of over twenty percent. Dublin City Council and the NTA have stated that it is not realistic or advantageous to cater for this increase in demand by private car. As an alternative, this growth must be catered for through sustainable transport modes. To this end Dublin City Council sought a modal shift of fifty-five percent for public transport, fifteen percent for cycling, ten percent for walking and twenty percent for private car use in the annual cordon count by 2017 (Dublin City Council & National Transport Authority, 2015). This target was partially achieved (Dublin City Council & National Transport Authority, 2018).

2.7 Socio Technical Systems

The EU have stated that to ensure wide acceptance of C-ITS technologies and to maximise their economic and social impact, citizen involvement is key and C-ITS deployment should focus on the (European Commission, 2016). Considering this commitment from the EU Commission to focus C-ITS deployment on the user there is a dearth of evidence supporting this claim. As illustrated in Figueiredo's Conceptual Model at the beginning of this chapter, humans, vehicles, ICT and systems are what is encapsulated by ITS and therefore C-ITS.

The main role of a local authority is to provide essential services to citizens. Citizens are at the heart of local governance this is evident in DCC's mission and vision statements which are detailed below.

Mission statement: "*Dublin City Council will provide quality services for its citizens and visitors and act to protect and promote Dublin's distinct identity in a way that acknowledges our past and secures our future."* (Dublin City Council, 2015, p.6)

Vision Statement for Dublin: "*The best place in which to be, to live, to work, to do business and to enjoy. A city that has everything by being friendly, progressive, different and brilliant."* (ibid.,)

Vision statement for DCC: "*A Council that is open, innovative, progressive and which provides leadership by engaging fully with its citizens and stakeholders."* (ibid.,)

Enid Mumford, the British social scientist and computer scientist advocated an 'ethical, socio-technical and participatory' methodology as a blueprint for ICT systems. Mumford describes this as more of a philosophy than a methodology and she held a firm belief that computers should be used ubiquitously to enhance the quality of human life.

Socio-technical systems theory draws on several concepts relating to open systems theory, however it first emerged following the seminal action-research carried out by the Tavistock Institute of Human Relations in the 1940s, more specifically to a coal mining study in the United Kingdom. The research highlighted the mutual dependency between work systems (categorised as

organisational and social) and technical systems. The Tavistock Institute considered their research should not only be efforts to improve knowledge, but that they should also support the improvement of work environments that were insufficient in human terms. The result of which steered the development of a methodology they named ‘socio-technical’. This meant that technology, which, in their classification, encompassed both machines and the related work organisation, must not be allowed to be the dominant factor when new work systems were implemented. Signifying that equal consideration must be given to providing a high quality and satisfying work environment for employees. At that time, a common example of a deterministic technology was the assembly line factories associated with Taylorism. Where the employee performed the same repetitive actions all day, thus being forced to maintain the pace of labour dictated by the conveyor belt. The primary objective of socio-technical developments was to ensure that both technical and human parts of the work system ought to be given equal importance in the design process.

Socio-technical design also had an important participatory aspect which is discussed in greater detail in the following section. The socio- technical approach recognises that if one part of a system is altered it will impact the entire system, causing unforeseen behaviours and unpredictable results. During the progress of computerisation in the organisations of the 1970s and 1980s, Mumford witnessed that computer-based information systems design had become a process solely focused on the technological aspects and were defined only to address technical problems illustrated in figure 18. Mumford identified that the interdependencies between human and machine were not acknowledged, and when only the machine component of the system is considerately designed, the effects on the human are unfavourable and uncertain. Mumford presented numerous cases of a technical approach to systems design and her findings have been substantiated by further academic research, that when focus is directed only to the technical aspects of computer-based systems, it results in expensive failures and ineffective systems. (Mumford, 2003, Mumford, 2006).

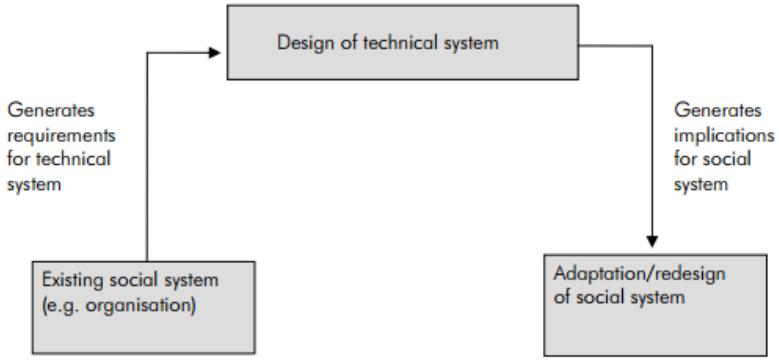

Figure 18:The Engineering Paradigm: A Technical Approach to IS Design (Olphert and Damodoran, 2007, p493)

Mumford's Effective Technical and Human Implementation of Computer-based Systems (ETHICS) is one of several socio-technical approaches to computer systems design illustrated in figure 19, developed to highlight the interdependencies of technical components and the human agents within a system, recognising the requirement for both parts to be designed together.

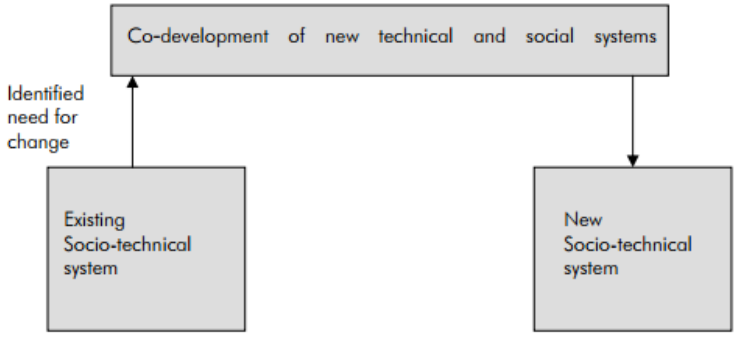

Figure 19: A Socio-technical Approach to IS Design (Olphert and Damodoran, 2007, p493)

Socio-technical theory has been continually developed and tested since the methodology first emerged. Long after Mumford's and the Tavistock's initial works an international organisation for standardization was for Human-centred design process for interactive systems was first released in 1999 ISO 13407:1999. The standard was revised in (2010 ISO 9241-210:2010) and details set of fundamental specifications and recommendations for human-centred design principles and activities for the entire life-cycle of ICT interactive systems. (ISO, 2017)

2.7.1 Participatory approach

Mumford asserts that the most important contribution that a socio technical approach can contribute is its value system and emphasises two features. Firstly, that the users of the system must have as equal a priority in the design phase as the technical components of the system. Secondly, the principal of democracy. This means that democratic and participative communication and decision-making must be available to give these people a voice. The Norwegian Computer Centre in the 1970s began to implement this approach to design and development of computer systems and a discipline of participatory design began to emerge. Mumford recognised that design cannot be detached from the decision making that occurs at various phases in systems development. She argues that participation must take place throughout the entire process not just at specific phases. She proposes that all-inclusive participation in the total design process for a new system would involve the following steps.

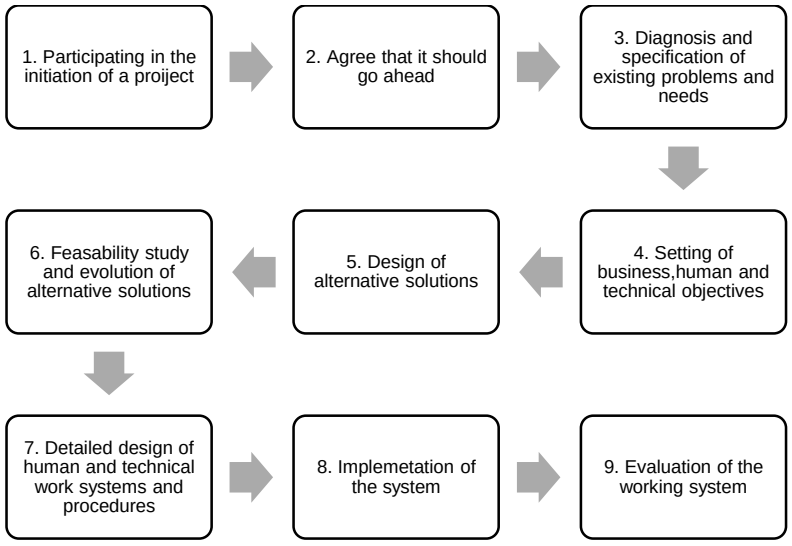

Figure 20: Participatory Design Process for New Systems (Mumford, 2003)

Olphert and Damodoran (2007) build on Mumford's Socio-Techno and Participatory approach. Their research focuses on the benefits that could be achieved in e-government information systems, when using socio-techno methodology combined with a participatory approach to designing computer-based systems. The study examined twenty diverse case studies of citizen

engagement initiatives from countries all over the world. It focused on two types of citizen engagement -

> **Type A**: Predominantly focused on case studies engaging with citizens for decision and policy making
>
> **Type B**: Predominantly focused on case studies engaging with citizens in ICT development

Their investigation identifies the characteristics of effective citizen engagement validating Mumford's theory regarding the participation process. The authors found that during development of ICT initiatives, engagement was most effective when citizens participated from the beginning and throughout the entire process. Furthermore, when it came to policy making, citizen engagement was most effective when they felt inspired and empowered to contribute to pertinent decision making.

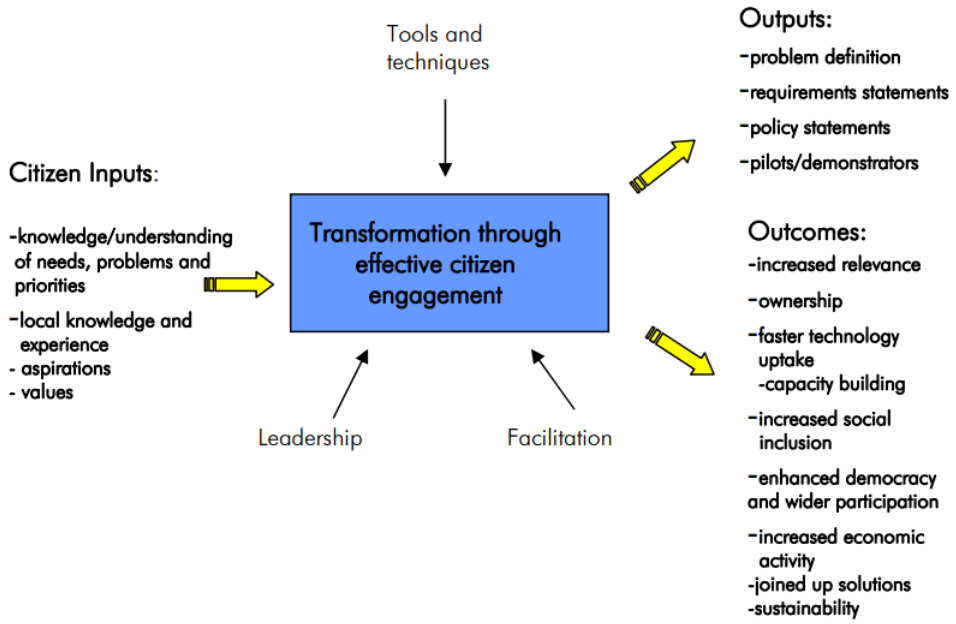

Figure 21: A Benefits Model of Citizen Engagement Process (Olphert and Damodoran, 2007, p495)

The key findings from the study included that there was evidence of wide-ranging efforts to attain citizen participation in many aspects of planning and policy deliberation. Though, there was scarce evidence of any significant citizen participation in systems design for government ICT initiatives. Furthermore, that e-government systems are failing to meet their goals for effectiveness, operation and public adoption. The review of case studies by the

authors revealed that reaching the targets of increased citizen participation in democracy, increased social inclusion and faster adoption of ICT remain unattainable for governments around the world.

2.8 Conclusions

The steady and encouraging trend in road safety that Europe has experienced over the last decade has reduced. Road transport continues to be responsible for most transport emissions, in terms of greenhouse gases and air pollutants. At an EU level, a major question which could be posed is whether the implementation of C-ITS could lead to improved air quality, road safety and a reduction in the premature death of thousands of EU citizens each year. This remains to be seen, however the potential societal benefits that C-ITS promises cannot be ignored.

Many FOT's and pilot projects have provided compelling results that demonstrates the potential of C-ITS. A review of the literature has demonstrated that the technology enabling I2V, V2V and V2X has reached maturity with capacity to support at the very minimum. After investing more than a decade of research and development in C-ITS the EU Commission are now accelerating efforts with the introduction of C-ITS Strategy some countries are currently rolling out nationwide or at the brink of nationwide deployment for Day 1 C-ITS services.

Ireland so far has been a spectator of collaborative C-ITS trials and initiatives carried out by EU member states. As it stands there is no policy or strategy in Ireland nationally or regionally for C-ITS, despite the EU Commissions instructions for all member states to deploy C-ITS services by 2019. Ireland can no longer afford to take a passive stance. Which raises the question why has Ireland taken a passive stance? One explanation for this could be that many of the significant European developments focus on interoperable cross-border C-ITS services. Ireland is unique in a fundamental way from most of the European countries that are excelling in the C-ITS field. First and foremost, Ireland is an island on the periphery of Europe, are cross-border C-ITS services of major benefit to Irish drivers? The EU C-ITS strategy and associated activities heavily focuses on seamless interoperable cross border

European services. Cross border services are not aligned with Ireland's needs, unique country in EU size Island is the EU Strategy targeted more towards mainland European countries? One size fits all approach?

A preliminary question that emerged from the findings of this literature review considered the transportation challenges in Dublin City Centre and how the perceived benefits of C-ITS could address those challenges. This question was refined further.

A fundamental aim of this literature review was to determine relevant information on the status of C-ITS in Europe from the perspective of Dublin City Council (city authority). A review of the most relevant literature was the catalyst that facilitated the definition of the research questions central to this study. The methodological process and considerations for resolving the research question are detailed in the following chapter.

Chapter 3 Methodology

3.1 Introduction

This paper provides a qualitative analysis of secondary data to evaluate the potential for C-ITS in the urban setting of Dublin City Centre. This chapter presents the research design that guided this study. It also describes the research strategy employed and the data sources that underpin this body of work. It discusses in detail the rationale that instigated methodology selection, and adoption of a deductive approach, the application of the methodology, how the data was collected and how the data was used. Several key findings are brought forward from the literature review which resulted in the formulation of a research question, the selection of qualitative content analysis strategy, thus providing a trajectory for the remaining chapters of this dissertation.

3.2 A Model for Qualitative Research Design

The Interactive Model for Qualitative Research developed by Joseph Maxwell (Maxwell,1996) illustrated in figure 22 was used as the overarching plan for structuring this dissertation. Maxwell (2005) argues that qualitative research design should not be limited to the traditional nor sequential models of quantitative research design. Maxwell's reasoning for this argument is that neither of these models sufficiently represent the rationale and process of qualitative research (Maxwell, ibid.). In a qualitative study "research design should be a reflexive process operating through every stage of a project" (Hammersley & Atkinson, 1983 Cited in: Maxwell, 2005). Maxwell's model contains five interconnected components as part of an interacting structure, fostering a recursive and circular process as opposed to sequential and linear. It involves cycles of reflection and refinement where components interact with one another allowing cross-pollination between components of the model. A defining characteristic of Maxwell's model is that it treats research design as a real entity, and not simply a planning exercise.

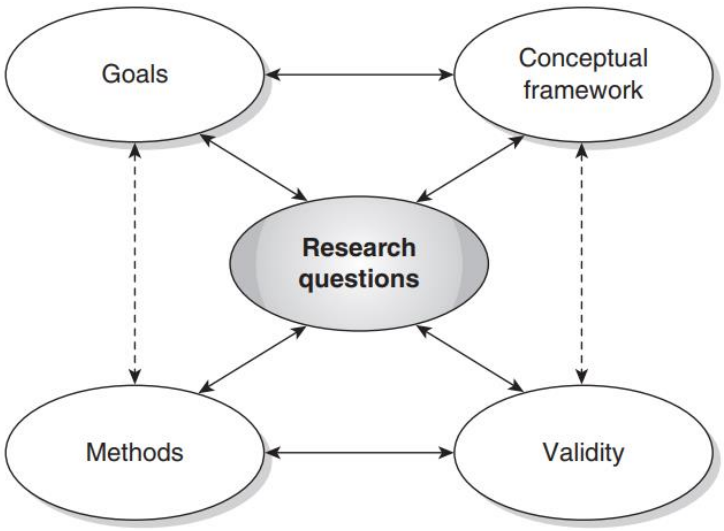

Figure 22: Interactive Model for Qualitative Research (Maxwell, 1996)

The model is highly appropriate for use with this body of work, as it provides the flexibility which is essential for an exploratory study. Adams & Schvaneveldt (Cited in: Saunders, 2007) support this point by maintaining that the flexibility inherent in exploratory research does not mean lack of direction to the enquiry. Instead it should be understood that the focus is initially broad and becomes gradually narrower as the research progresses.

Maxwell (1996) highlights the significance of connecting with a research paradigm or paradigms when designing a study. According to Goldkuhl (2012) qualitative research is commonly associated with interpretivism but not confined to this paradigm, alternatives include critical research and sometimes positivism. Qualitative research in information systems can be performed following a paradigm of pragmatism (Goldkuhl, 2012) and it is associated with action, intervention and constructive knowledge. The pragmatic approach to science is adopted throughout this study on C-ITS. The rationale being that pragmatism permits the researcher to take a practical approach, assimilating different perspectives to support the gathering and interpretation of data allowing researchers to implement the method most suitable in addressing the research question (Saunders, 2007). Therefore, pragmatic researchers are less caught up in philosophical debates of which paradigm is better and the focus remains firmly on resolving the research question.

According to Goldkuhl (2004) one of the underpinning ideas within pragmatism is that the meaning of a concept is based on the practical outcomes of the concept. A fundamental concept of pragmatism is that knowledge should make a difference in action (Dewey 1931, Cited in: Goldkuhl 2004). Goldkuhl (2012) states that pragmatism has a curiosity not only for what 'is', but also for what 'might be'. This thinking, that knowledge generates new understandings and that the belief in that knowledge provokes action is at the core of this study.

3.3 Research Questions

The purpose of this dissertation was initially to explore the topic of C-ITS in greater detail with a view to it's potential in Dublin City Centre, to gain new insights and an understanding of the topic. Following an extensive review of the literature on the topic of C-IT'S the following items were clarified:

- The technology underpinning C-ITS services has reached maturity.
- Pilot projects and FOT's are proving successful
- There is a dearth of literature on the topic a C-ITS that relates to Dublin or Ireland. There is currently no national strategy.
- The wider societal issues that may be impacted by C-ITS and the potential it has for alleviating these issues
- Precautions for consideration regarding new technologies and transport.
- Policy developments at a European level.
- Specific actions for local authorities in EU member states.
- The potential benefits were highlighted by academic's industry and governments, however they also recognized that no two cities are the same.
- Several research and development projects have focussed on the technical issues of C-ITS and have proven that the technology can be made to work. However, the EU Commission have recognised that the contribution from these technical solutions to the planning of urban transportation strategy, their implementation is not as clear cut.

These findings were a key component in formulating the research question, equipped with a new intelligence about the research topic the following research questions were formulated:

> *To what degree could C-ITS assist with Dublin's City Centre current and imminent transportation challenges and objectives?*
>
> *How should city authorities progress with C-ITS?*

In pursuit of an answer to these questions this study carries out unobtrusive research using secondary sources, employing a qualitative content analysis and develops a framework for data analysis using a deductive approach based on a priori coding scheme inferred from the literature review.

3.4 Data Sources

Following the formulation of the research question deliberations commenced on what the most suitable be data source would be for this study. It was crucial to this study to obtain a factual and accurate account of the current and imminent transportation challenges and objectives in Dublin City Centre.

Initially conducting a survey was deliberating, that asked members of the public who travel into the city what they considered to be the challenges and objectives. This was ruled out due to the risk of being unable to capture all travel modes.

The following three government publications are to be the most suitable sources of data for this study. The reason that they are considered suitable is that are compiled by city and national authorities in consultation with the public and in consideration of other national and region plans. Therefore, the publications outlined below are deemed a legitimate source of data for this study.

- **Dublin City Centre Transport Study (NTA and DCC) 2015 -2023**
  The study seeks to address the imminent transport issues facing the core city centre area to facilitate the implementation of the Dublin City Development Plan 2016 – 2022 and to safeguard the future growth of the city in terms of general economic development and new transport infrastructure (Dublin City Council & National Transport Authority, 2015).

- **Dublin City Development Plan 2016-2022**

  The Dublin City Development Plan is one of the most important policy documents for DCC. The plan recognises that Transport has an important contribution to make towards achieving a sustainable city. The continued delivery of an efficient, integrated and coherent transport network is a critical component of the Development Plan's core strategy. DCC works with the NTA and other transport agencies to deliver key projects set out in the plan (Dublin City Council, 2016).

- **Dublin City Council Corporate Plan 2015 – 2019**

  This Corporate Plan serves as Dublin City Council's strategic framework for action for a period of five years. It is prepared in compliance with the Local Government Act 2001 and the Local Government Reform Act 2014. The Plan also recognises and considers a range of existing National and European policies, strategies and plans in relation to programmes and activities which are central to the goals and objectives in Dublin City Council's Corporate Plan (Dublin City Council, 2015).

3.5 Research Strategy

The research strategy selected as most appropriate for answering the research questions is a qualitative content analysis. The rationale for employing a content analysis strategy is to systematically convert a large quantity of text into a highly organised and concise summary of key results. In this study each text will be analysed for challenges and objectives. Content analysis has been *described as*:

> *"a systematic, replicable technique for compressing many words of text into fewer content categories based on explicit rules of coding*" (Berelson, 1952; GAO, 1996; Krippendorff, 1980; and Weber, 1990; Cited in: Krippendorff, 2004).

Content analysis is applicable in many areas of research, the methodology of this strategy has been increasing in usage and variety. It has become a prevalent method for qualitative and quantitative analyses in business and

management research, nonetheless it is often wrongly understood and mistakenly applied (Guar & Kumar, 2017). Krippendorff (2004) claims that ultimately all reading of texts is qualitative even when specific characteristics of a text are later converted into numbers. Thus, questioning the legitimacy and worth of the distinction between quantitative and qualitative content analyses.

According to Krippendorff (2004) six questions must be addressed in every content analysis. The answers for this study are in bullet points below.

1. Which data are analysed?
    - Text.
2. How are they defined?
    - Data defined by categories and their indicators.
3. What is the population from which they are drawn?
    - Census (body of texts that includes all of its kind, also referred to as a complete collection).
4. What is the context relative to which the data are analysed?
    - Identify what areas C-ITS may or may not have potential in Dublin City Centre
5. What are the boundaries of the analysis?
    - Sourced from government agency publications
6. What is the target of the inferences?
    - The transportation challenges and objectives described within each body of text.

3.5.1 Qualitative Content Analysis

The most common perception in qualitative research is that content analysis involves word frequency count. This may be the case in some studies where researchers use word frequency counts to make inferences about the data being analysed. However, this is just one way of implementing the content analysis strategy, as it extends far beyond simple word counts. What fortifies the technique is its dependence on coding and categorization of that data. Webber, (1990) defines a category as a collection of words that have the same meaning or connotations.

Krippendorff (2004) acknowledges that content analysts can adopt multiple contexts and pursue multiple research questions in the same study. The model in figure 23 encapsulates the qualitative process capturing the reflexive and recursive process of researchers. This model also demonstrates how researchers recognise the domains of other academics, in pursuit of their own research questions and the application of 'analytical constructs' based on relevant literature (Krippendorff, 2004).

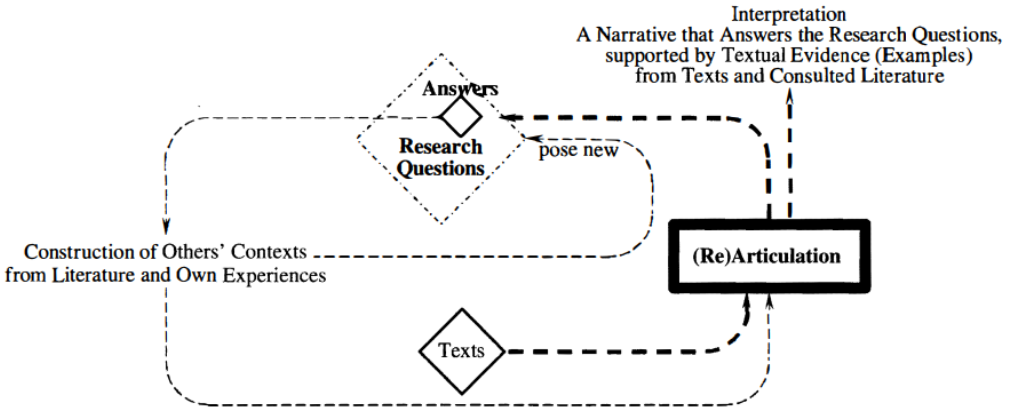

Figure 23: Qualitative Content Analysis (Krippendorff, 2004, p91)

3.5.2 Framework for Data Analysis - Deductive Approach

Content analysis can be abductive, inductive or deductive, the latter being the approach used in this study. Deductive content analysis can be employed in situations where the researcher is required to test data in a different context to the one that it was originally collected. It is possible that this could also involve testing categories, concepts, models or hypotheses. When implementing a deductive content analysis, a categorization matrix is firstly developed to code the data corresponding to the categories and indicators. Depending on the purpose of the study, either a structured or unrestricted matrix of analysis can be implemented (Elo & Kyngas, 2007). The matrix is based on some previous work such a literature review, theory or model. Deductive inferences according to Krippendorff (2004) are logically conclusive, implied in their premises and proceed from generalisations to specifics.

In this study findings from the literature review are brought forward to formulate a structured categorisation matrix. These findings are based on the research of

the EU Commission, industry experts and academics in the domain of ITS and C-ITS.

C-ITS can offer solutions and assist with cities transportation:

- objectives
- challenges

Transportation projects may be categorised as follow:

- Specifically states dependence on physical infrastructure projects
- Does not depend on physical infrastructure projects
- Specifically states dependence on ICT or ITS

The wider impacts and potential benefits of C-ITS may be categorised as follows:

- Improving road safety **(Safety)**
- Reducing congestion **(Road Network Efficiency) (Environmental)**
- Optimising the performance and available capacity of existing transport infrastructure **(Road Network Efficiency)**
- Enhancing mobility in a multi-modal transport chain **(Multi-Modal)**
- Increasing travel time reliability (**Road Network Efficiency)**
- Improving the efficiency of logistic operations thus reducing energy use as well as diminishing the environmental impact of road transport **(Environmental)**
- **Operational Efficiency**

The findings are used to formulate a structured categorization matrix specifically designed for this study, documented in chapter 4 (figure 24).

3.6 Validity and Reliability

Weber (1990 p.12) emphasises that "*to make valid inferences from the text, it is important that the classification procedure be reliable in the sense of being consistent"*. Therefore, if the classification procedure is reliable different

analysts should be able to code the same text in the same way. Weber further notes, that "reliability problems usually grow out of the ambiguity of word meanings, category definitions, or other coding rules" Weber (1990 p.15).

Krippendorff, (2004 p.45) advises that to preserve the reliability of a content analysis involves developing a set of explicit recording instructions. These instructions then enable the reproducibility of the results by external coders.

3.7 Research Strategy Justification

The rationale for that led to the selection of a content analysis as the most suitable research strategy was ultimately based upon practicalities relating to what data sources could be collected and used to answer the research questions. This decision hinged on the identification of what the most reliable sources of the data were to determine the current and imminent transportation objectives and challenges in Dublin City Centre.

A preliminary consideration for obtaining data explored the use of an online survey. The target audience for the survey would have been city dwellers and commuters that travelled into the city using a variety of transport modes. However, it was deemed that a survey would not provide the data required to guarantee a true reflection of the complexities of the transport system in Dublin City Centre. Furthermore, there was no guarantee that the data collected would evenly reflect all transport modes for example; if one hundred people completed the survey and out of that ninety percent were cyclists. Another limitation to data obtained through a survey was the concerns about subjectivity depending on the mode of travel used and the time of day or day of the week. The focus then shifted on how to eliminate bias and subjectivity from the study, this thought process generated the idea of using existing publications.

There are three significant government publications that guide transportation strategy in Dublin City Centre. Additionally, they capture all modes of transport, and address the issues relating to these modes. These publications are regarded and a reliable data source for this study, as they are compiled after a period of public consultation and the consider the transport challenges and objectives within the city bounds.

Once the decision was made that the above publications are the most suitable data source, the obvious and most effective research strategy to use was a content analysis strategy. Content analysis has several methodological advantages over other research strategies; it is unobtrusive and reasonably free of researcher demand bias and informant recall bias (Krippendorff, 2004 p87).

The following chapter captures the data analysis techniques and the findings of the qualitative methods employed in this study, the reliability and validity concerns are also discussed.

Chapter 4 Content Analysis Findings: Description and Analysis

4.1 Introduction

This research is focused on a content analysis of three specific government publications. A primary concern of this study is to accurately identify what the current and imminent transportation challenges are in Dublin City Centre. This is a fundamental requirement of this study as the research questions posed cannot be answered without this determining this data. This chapter describes the data analysis process, the implementation of the deductive data analysis techniques that were developed for this study and finally presents the results of the analysis.

4.2 Data Analysis Process

The process involved several iterations of categorisation and coding on each document to make inferences from the texts. The documentation supporting the process of analysis described herein can be found in appendices 1 to 5.

4.2.1 Step1: Categorization matrix

When implementing a deductive content analysis, a categorization matrix is firstly developed to code the data corresponding to the categories. This matrix is based on the literature review findings as discussed in chapter 3.

Category	Dependence	Area of Potential
Challenge	Specifically states dependence on physical infrastructure projects	Environmental
	Specifically states dependence on ICT or ITS (Potential for C-ITS)	Safety
	Does not depend on physical infrastructure projects (Potential for C-ITS)	Operational Efficiency
		Road Network Efficiency
		Multi Modal
Category	**Dependence**	**Area of Potential**
Objective	Specifically states dependence on physical infrastructure projects	Environmental
	Specifically states dependence on ICT or ITS (Potential for C-ITS)	Safety
	Does not depend on physical infrastructure projects (Potential for C-ITS)	Operational Efficiency
		Road Network Efficiency
		Multi Modal

Figure 24: Structured Categorization Matrix

4.2.2 Step 2: Determine Categories Within Each Publication

Online versions (PDF) of each government publication were available permitting the use of Microsoft Excel for application of the deductive analysis techniques. A separate worksheet was created for each publication to capture the target of inferences as each document was read. The process commenced by conducting two iterations of analysis to each document. The first iteration determined the transportation challenges the second determined the transportation objectives. Upon determining this information, one final iteration of analysis was carried out on each document to ensure that no errors had been made or details overlooked. As each document was being analysed when text was classified to correspond with either a challenge or objective corresponding text was copied to the relative worksheet. This resulted in the isolation of the challenges and objectives from each publication. (Covered in appendices 1 to 3).

4.2.3 Step 3: Code Categories Using Indicators

Once the challenges and objectives were clearly identified within the texts the indicators were used to code the data. The first iteration of coding determined if the challenge or objective was dependent on either physical infrastructure projects, ICT/ITS, or had no dependence on physical infrastructure projects. The second iteration of coding determined if the challenge or objective related to the area of environment, safety, operational efficiency, road network efficiency or multi modal. Upon determining this information, one final iteration of analysis was carried out on each worksheet to ensure that no errors had been made or details overlooked. (Covered in appendices 1 to 3)

4.2.4 Step 4: Compile Overall Results of Study

Create new worksheet for reporting overall results. Extract all challenges and all objectives from the worksheets corresponding to each publication. Copy them to the new worksheet. Perform check ensuring that all formatting relating to coding was copied across. Create tables and structures for reporting summary of results in the dissertation document. (Covered in appendices 3 to 5)

4.3 Reporting of Findings

4.3.1 Reporting on Challenges

The total number of valid challenges identified from all publications was nineteen, shown in table 4 below.

1	The overall transport network will make Dublin City Centre a more environmentally friendly place	C
2	Increasing significantly the existing mode share for active modes, i.e. walking and cycling, and supporting the forthcoming National Policy Framework for Alternative Fuels Infrastructure.	C
3	contribute to climate change mitigation and a more sustainable city	C
4	A crucial factor in the discussion of movement and transport is the challenge of tackling climate change	C
5	The Council shall use its powers to manage transport related spaces in the city so as to reduce transport-related emissions in the city area by at least 3% per year over the lifetime of the plan.	C
6	Despite this there are still a significant amount of traffic related accidents in the city centre, with a number of identifiable accident 'Black Spots'. Information from the Road Safety Authority (RSA) sets out the location of accidents within the city centre. The general pattern is similar for pedestrian, cyclists and private vehicles. It is clear that the central area of the City, particularly around the City Quays, O'Connell Street and Dame Street are areas where road safety for all users could to be improved.	C
7	The need to improve the journey time and reliability of bus services in the City Centre area;	C
8	The need to continue to invest in the Real Time Passenger Information and ITS Bus priority system;	B
9	To provide journey time information and route guidance via web and mobile devices, and to make this data freely available for all navigation systems.	B
10	The current movement of traffic within the City Centre is dependent on a number of gyratory systems – e.g. St Stephen's Green, Westmoreland Street / D'Olier Street and Beresford Place. The gyratories are prone to congestion and blocking back of traffic at peak hours, with heavy flows of relatively fast-moving and weaving traffic in the off-peak periods. Such arrangements do not give priority to pedestrians, cyclists or buses, and often force them to deviate significantly from the most direct route	C
11	To increase the capacity for the movement of people and goods into and within the City Centre, and facilitate efficient and effective goods delivery.	C
12	Managing city centre road-space to best address the competing needs of public transport, pedestrians, cyclists, and the private car.	C
13	Effective integration of land-use and transportation, and the management of access and mobility.	C
14	The continued delivery of an efficient, integrated and coherent transport network is a critical component of the development plan core strategy	C
15	Ensuring maximum benefits are achieved from public transport improvements including Luas cross-city and the anticipated Bus Rapid Transit network.	C
16	Improving the city centre environment for pedestrians through public realm enhancements and through improvement of the strategic pedestrian network.	A
17	The expansion of the strategic cycle network along all major water bodies including the River Liffey and the canals.	A

18	To ensure that the number of cyclists travelling within, to and from the city centre continues to rise, it is essential that this study addresses the need to expand and improve the infrastructural requirements of an increased cycling community within Dublin City Centre.	A
19	The potential to facilitate the ongoing expansion of the dublinbikes scheme;	B

Table 4:: Challenges coded by potential and dependence

4.3.2 Results of Challenges

All Challenges	**19**
Specifically states dependence on physical infrastructure projects (A)	3
Specifically states dependence on ICT or ITS (potential for C-ITS) (B)	3
Does not depend on physical infrastructure projects (C)	13

Table 5: All Challenges from All Publications

The tables 6 to 8 below show the number of challenges per dependence and the area of potential benefit.

Challenges	**Specifically states dependence on physical infrastructure projects (No Potential for C-ITS)**	**Area of Potential Benefit**	**Number**
		Environment	0
		Safety	0
		Operational Efficiency	0
		Road Network Efficiency	0
		Multi-Modal	3

Table 6: Challenges with Dependence of Physical Infrastructure Projects

Challenges	**Specifically states dependence on ICT or ITS (Potential for C-ITS)**	**Area of Potential Benefit**	**Number**
		Environment	0
		Safety	0
		Operational Efficiency	0
		Road Network Efficiency	2
		Multi-Modal	1

Table 7: Challenges with Dependence of ICT or ITS

Challenges	Does not depend on physical infrastructure projects (Potential for C-ITS)	Area of Potential benefit	Number
		Environment	5
		Safety	1
		Operational Efficiency	0
		Road Network Efficiency	7
		Multi-Modal	0

Table 8: Challenges with no Dependence on Physical Infrastructure Projects

4.3.3 Reporting of Objectives

The total number of transportation objectives from all three publications was twenty-nine shown in table 9 below.

0	To improve the city's environment for walking and cycling through the implementation of improvements to thoroughfares and junctions and also through the development of new and safe routes, including the provision of foot and cycle bridges. Routes within the network will be planned in conjunction with green infrastructure objectives and on foot of (inter alia) the NTA's Cycle Network Plan for the Greater Dublin Area, and the National Cycle Manual, having regard to policy GI5 and objective GIO18.	A
2	To promote Bike and Ride at public transport hubs by providing secure, dry, bike parking facilities.	A
4	To support the growth of Electric Vehicles and e-bikes, with support facilities as an alternative to the use of fossil-fuel-burning vehicles, through a roll-out of additional electric charging points in collaboration with relevant agencies at appropriate locations.	A
5	To support and collaborate on initiatives aimed at achieving more sustainable energy use, particularly in relation to the residential, commercial and transport sectors.	C
6	to minimise the adverse environmental impacts of the transport system.	C
7	To provide 30kph speed limits and traffic calmed areas at appropriate locations throughout the city and subject to stakeholder consultation.	C
8	To develop lorry parks, bus parks and taxi holding areas in selected areas where deemed necessary and in co-operation with private enterprise, so as to eliminate the hazards of unsuitable lorry, bus and taxi parking in residential and other areas.	A
9	To develop a city centre pedestrian network which includes facilities for people with disabilities and/or mobility impairments based on the principles of universal design.	A
10	halve road casualties by 2022	C
11	To develop a safer City Centre for all transport modes and users	C
12	To provide for the safe, sustainable and efficient movement of people, and manage the efficient movement of goods and transport in the city, in a sustainable manner.	C
13	Prioritise works to ensure best value maintenance for the city's • infrastructure and to ensure the city's road, footpath and cycling network is maintained to the highest safety standard	A
14	Significantly improve pedestrian and walking facilities in the city	A
15	Within 30 years we will move close to zero fatalities in road transport	C
16	to improve road safety	C
17	To continue investment in the city's computer-based area traffic signal control system and in other Information Technology (IT) systems to increase the capacity of Dublin City Council's Traffic Control Centre to manage traffic in the city and to improve the priority given to pedestrians, cyclists and public transport in the city.	B
18	Optimise our investment in Intelligent Transport Systems (ITS) to • ensure traffic movement is optimised	B

19	Introduce a Transportation Asset Management System (TAMS)	B
20	To improve the management and control of traffic in the city, to increase internal and external sustainable accessibility,	C
21	To increase the capacity for the movement of people and goods into and within the City Centre, and facilitate efficient and effective goods delivery	C
22	To support and facilitate the development of an integrated public transport network with efficient interchange between transport modes, serving the existing and future needs of the city in association with relevant transport providers, agencies and stakeholders.	C
23	To work with the relevant transport providers, agencies and stakeholders to facilitate the integration of active travel (walking, cycling etc.) with public transport, thereby making it easier for people to access and use the public transport system	C
24	To work with Iarnród Eireann, the NTA, Transport Infrastructure Ireland (TII) and other operators to progress a coordinated approach to improving the rail network, integrated with other public transport modes to ensure maximum public benefit and promoting sustainable transport and improved connectivity.	A
25	To support the development and implementation of integrated ticketing and real time passenger information systems across the public transport network in association with relevant transport providers and agencies. Progress on the integration of Dublin shared bike scheme and Leap Card schemes will be monitored.	C
26	To promote 'Park and Ride' services at suitable locations in co-operation with neighbouring local authorities.	A
27	To make it easier for people to use the transport networks.	C
28	Manage necessary road openings in a manner that minimises • disruption to the city	C
29	To maximise the use of public transport infrastructure and minimise car dependence, higher densities and interactive mixed uses will be encouraged within walking distance of public transport corridors and nodes (rail stations and interchanges) and at other key locations such as key district centres.	C

Table 9: Objectives Coded by Dependence and Potential

4.3.4 Results of Objectives

All Objectives	**29**
Specifically states dependence on physical infrastructure projects (A)	9
Specifically states dependence on ICT or ITS (potential for C-ITS) (B)	3
Does not depend on physical infrastructure projects (potential for C-ITS (C)	18

Table 10:All Objectives from All Publications

The tables 11 to 13 below show the number of challenges per dependence and the area of potential benefit.

Objectives	Specifically states dependence on physical infrastructure projects	Potential benefit	Number
		Environment	3
		Safety	4
		Operational Efficiency	0
		Road Network Efficiency	0
		Multi-Modal	2

Table 11: Objectives with Dependence of Physical Infrastructure Projects

Objectives	Specifically states dependence on ICT or ITS (Potential for C-ITS)	Potential benefit	Number
		Environment	0
		Safety	0
		Operational Efficiency	3
		Road Network Efficiency	0
		Multi-Modal	0

Table 12: Objectives with Dependence ICT or ITS

Objectives	Does not require large intrusive infrastructural (Potential for C-ITS)	Potential benefit	Number
		Environment	2
		Safety	6
		Operational Efficiency	1
		Road Network Efficiency	1
		Multi-Modal	6

Table 13: Objectives with no Dependence on Physical Infrastructure Projects

4.4 Difficulties Encountered

To ensure the validity and reliability of this study one of the most critical steps involved was developing a set of explicit recording instructions so data can be analysed consistently and according to uniform standards. This ensures that the study is reproducible by other researchers. For a solo novice content analyst developing these standards was challenging, learning how to design and implement explicit rules of coding took much consideration, practice, trial and error. To this end the time spent reading and assimilating information on how to carry out these standards was not envisaged and indeed the application of those standards within the study. However, validly and reliability concerns have been addressed in this study to standards that satisfy the

academics. Therefore, the time spent learning to understand the process of the research strategy was a worthwhile endeavour. The works cited in the previous chapter from Krippendorff and Weber were not by any means easy reading, but they were an invaluable research aid.

The following chapters presents a synthesis of the findings and the overall conclusions of this study.

Chapter 5 Conclusions and Future Work

5.1 Introduction

The overall aim of this research was to advance an understanding of C-ITS in an urban setting, particularly in relation to future C-ITS deployment in Dublin City Centre. In the context of European guidelines for the deployment of Day 1 C-ITS services by 2019.

5.2 Research Objectives: Summary of Findings and Conclusions

The specific research objectives were

1. Identify the current and imminent transportation objective and challenges in Dublin City Centre encompassing all modes of travel.

2. Identify what type of work or project would be involved to achieve the defined objectives and challenges and identify the resulting area that would benefit, from that project.

3. Identify how city authorities should progress with C-ITS deployment.

This section will revisit the objectives above, summarise the findings of this study and offer conclusions based on these findings. The previous chapter ‘Content Analysis’ results requires to be summarised and will be addressed within this chapter. Recommendations for future research will be discussed in terms of possibilities to progress C-ITS deployment outside of the city boundaries. Importunately, the contribution of this research to the development of C-ITS services in Dublin City Centre will be clarified.

5.2.1 Research Objective 1: Dublin City Centre Transportation Objectives and Challenges

Findings from the literature review discovered C-ITS has the potential to assist city authorities address transportation issues while achieving policy targets. The literature review reports that many research and development projects have addressed the technical issues of C-ITS and have proven that the technology works. However, the contribution from these technical solutions to the planning of urban transport policies, and the implementation of these policies, is not as well understood. To evaluate the potential of C-ITS in Dublin the city objectives and challenges first needed to be defined.

Summary of Findings

a. An objective of this study was to accurately identify what the current and imminent transportation challenges are in Dublin City Centre. This was a fundamental requirement of this study as the research questions posed cannot be answered without determining this data. Following a data collection assessment, valid and reliable data sources were determined. Following a content analysis on three publications nineteen challenges and twenty-nine objectives were determined valid for this study.

Conclusion

a. Seventy-two objectives in total were identified in the publications, forty-three of those objectives were not included in this study as they depended on other criteria that was outside the scope of this study. For example, dependence solely on national frameworks or national strategies. Therefore, a conclusion that can be drawn from this is that twenty-nine objectives met the criteria for analysis used in this study.

   Thirty-nine challenges in total were identified ten of those challenges were not included in this study as they depended on other criteria that was outside the scope of this study. For example, dependence solely on ongoing physical infrastructure projects or DCC strategies. Therefore, a conclusion that can be drawn from this is that nineteen challenges met the criteria for analysis used in this study.

5.2.2 Research Objective 2: The Challenge or Objective Depended on

The literature review found that improving safety and environmental issues in road transport while increasing capacity can be to some extent accomplished

through delivery of new, or expansion of existing, physical infrastructure. However, these solutions generally require a high level of investment and can often be long-term disruptive projects. There is growing support amongst academics, governments and industry that C-ITS has the potential to increase the efficiency of existing urban infrastructure by improving network capacity, whilst simultaneously providing safety and environmental benefits, and reducing fuel and energy demand without requiring the level of investment generally required for intrusive upgrade schemes.

Summary of Findings

a. Out of a total of nineteen challenges that met the criteria of the literature review findings, three challenges depended on physical infrastructure, three did not have a dependence on physical infrastructure and three depended on ITS or ICT. The projects that did not depend on physical infrastructure or depended on ICT or ITS were identified as having potential for C-ITS deployments.

b. Out of a total of twenty- nine objectives that met the criteria of the literature review findings, nine objectives depended on physical infrastructure, eighteen did not have a dependence on physical infrastructure and three depended on ITS or ICT. The projects that did not depend on physical infrastructure or depended on ICT or ITS were identified as having potential for C-ITS deployments.

Conclusions

a. Out of a total of nineteen challenges C-ITS has potential to assist with sixteen challenges out of the nineteen identified. The resulting benefits of these sixteen were in the areas of four of the five identified areas of potential benefit. However, the areas of Environment and Road Network Efficiency were identified as having the most potential. Operational Efficiency as identified as having the least potential as there were no challenges identified in the area. Therefore, the conclusion that can be drawn from this research is that C-ITS is compatible with seventy-two percent of the transportation challenges in Dublin City Centre.

b. Out of a total of twenty- nine objectives, C-ITS has potential to assist with twenty-one objectives out of the twenty-nine identified, the resulting benefits of these twenty-one were spread across all the five identified areas of potential benefit. However, the areas of Safety and Multi Modal were identified as having the most potential. Road Network Efficiency was identified as having the least potential as it was compatible with just one challenge identified in the area. Therefore, the conclusion that can be drawn from this research is that C-ITS is compatible with eighty-four percent of the transportation challenges in Dublin City Centre.

5.2.3 Research Objective 3: Identify How City Authorities Should Progress With C-ITS Deployment

The literature review identified that the EU commission have been heavily invested in C-ITS over the last decade and greatly want to harness the transportation and societal benefits that C-ITS promises. An EU wide strategy for C-ITS has been adopted by the Commission. FOT's and pilot projects have proved that the underpinning technology of C-ITS has reached maturity. Standardisation has an important role to play when it comes to communication interoperability. Most of the technology underpinning C-ITS services has been standardised in Europe. The C-TS platform recommended a catalogue of Day 1 and Day 1.5 Services. These services are favoured due to the expected return on investment when rapidly deployed, societal benefits and the maturity of the supporting technology. Local authorities have been instructed to deploy at minimum Day 1 C-ITS Services by or during 2019. Automobile industry in Europe have committed to producing vehicles equipped with C-ITS technology by 2019. As it stands there has been no effort to deploy C-ITS service on Irish roads. The EU commission have committed to supporting member states and offering financial assistance for C-ITS related projects. C-Roads is a platform established for collaboration in member states for C-ITS pilot projects. Private car ownership numbers are lower in Ireland compared with other European countries only one quarter of cars on Irish roads will be equipped with on-board units from 2019.

The EU have stated that to ensure wide acceptance of C-ITS technologies and to maximise their economic and social impact, citizen involvement is key and C-ITS deployment should focus on the user. Citizens are at the heart of local governance this is evident in DCC's mission and vision statements.

Mumford's, 'ethical, socio-technical and participatory' methodology provides a detailed blueprint to ensure citizens involvement in system design.

Therefore, out of a total of nineteen challenges C-ITS has potential to assist with sixteen challenges out of the nineteen identified. The resulting benefits of these sixteen were in the areas of four of the five identified areas of potential benefit. With Environment and Road Network Efficiency identified as having the areas for most potential. Operational Efficiency was identified as having the least potential as there were no challenges identified in the area. Therefore, the conclusion that can be drawn from this research is that C-ITS is compatible with seventy-two percent of the transportation challenges in Dublin City Centre.

Therefore, out of a total of twenty- nine objectives, C-ITS has potential to assist with twenty-one objectives out of the twenty-nine identified, the resulting benefits of these twenty-one were spread across all the five identified areas of potential benefit. However, the areas of Safety and Multi Modal were identified as having the most potential. Road Network Efficiency was identified as having the least potential as it was compatible with just one challenge identified in the area.

Summary of findings

a. Transport authorities have given specific instructions to deploy C-ITS services as soon as possible EU. These services should support a hybrid approach to a hybrid communications approach using ETSI G5-ITS and 3G/4G. C-ITS equipped vehicles will be available in Ireland from 2019. C-ITS services will achieve greater benefits that quicker they are deployed citywide. Ireland will progress from an associate member to a core member within the C-Roads platform, the lessons learned from previous pilot projects in Europe will be of great assistance.

b. Recommendations of the EU commission is that C-ITS deployment should focus on the user. The nature of local governance places the citizen at the centre of all the services provide by local government. Citizen engagement is vital to the successful adoption and therefore impact of C-ITS. Therefore, future deployments in Dublin should be focused on the citizen.

c. There is a growing policy shift, in Europe, towards the development of more effective modes of transport, primarily, public transport. The private car is an impediment to mass transport in cities. DCC are seeking a modal shift towards more sustainable modes of transport. The geometry of Dublin City Centre can Geometry of city and mass transit.

d. This empirical finding of this study concluded that C-ITS has strong potential to provide solutions to several transportation challenges and objectives in Dublin City Centre. The benefitting areas were also identified. These findings provide a strong foundation for preliminary considerations to deployment in the city.

Recommendations

a. Therefore, a recommendation that can be made from this research is that DCC in collaboration with the NTA must create a strategy for the deployment of Day 1 C-ITS services without delay, action is required. DCC should seek guidance from the C-roads platform and commence the application process for EU funding where applicable. C-ITS deployments must be designed to support the communication scenario and therefore must use a hybrid approach using ETSI G5-ITS and 3G/4G. Deployments should also take into consideration new car numbers in Dublin.

b. Therefore, a recommendation that can be made from this research is that C-ITS services should be deployed in Dublin City Centre as soon as possible. The faster that C-ITS is rolled out citywide the quicker the return of investment will be; this will also ensure overall benefits to citizens.

c. Therefore, a recommendation that can be made from this research is that DCC and the NTA must ensure the development of systems and services that focus on the citizen. A socio technical and participatory approach to system design should be adopted to ensure that citizens remain the focus of C-ITS deployments. Participatory design process for new systems will ensure citizen are involved even during the preliminary project phase.

c. Therefore, a recommendation that can be made based on this research is that a priority for DCC is to collaborate and work with public transport providers and stakeholders to target C-ITS where it can have the maximum impact, value and societal benefits, taking into consideration the unique geometry of transport in the city. This finding warrant action from city authorities in relation to C-ITS

d. Therefore, a recommendation that can be made based on this finding is that progress of C-ITS can be made by city authorities by pinpointing C-ITS projects based on comparing the objectives and challenges identified by this study of having (table 4 and 9 chapter 4) with the list of Day 1 services. This exercise will permit the identification of specific requirements (Table 4 and 9) and what use cases (catalogue of Day 1 services) meet these requirements. Deployments can be grouped in to 'packages' to target particular user group or to address a societal problem.

The findings conclusions and recommendations detailed in this concluding chapter above have satisfactorily answered the following research questions:

To what degree could C-ITS assist with Dublin's City Centre current and imminent transportation challenges and objectives?

How should city authorities progress with C-ITS?

5.3 Limitations

As with all research limitations exist and should be identified. The limitation identified within this study is that the content analysis was performed by a solo coder. Efforts were made to preserve the reliability and validity of this study by following explicit recording instructions. However, to fully confirm this claim it requires the same results to be reproduced by a second coder. Therefore, the reproducibility of the study has yet to be confirmed.

5.4 Future Research

Due to time constraints, this study investigated challenges and objectives in Dublin City Centre, however the literature review identified that C-ITS can be used across all categories of roads. Using similar techniques conducted as part of this body of work, future research could examine where C-ITS services

could have the most impact on regional roads in the Greater Dublin Area or in a rural setting in Ireland.

An area of interest highlighted in the literature review was the link between C-ITS and Smart Cities. This is an area that requires further exploration and research. Future research could be carried out using Dublin City Centre as a case study.

There was a dearth of literature relating to citizen involvement or citizen opinion on C-ITS. What do citizens in Dublin think of C-ITS services? Will they see the transformational potential that the EU Commission advocates? Will the three quarters of Dubliners without the equipped vehicles use smartphones to access the services? What aspects of C-ITS would citizens find useful in their everyday lives? These questions could be investigated in further studies.

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Appendix 1: Transportation Study Part 1

Transportation Study					
Environmental	**Safety**	**Operational Efficiency**	**Road Network Efficiency**	**Multi-Modal**	**Other**
Challenges					
The overall transport network will make Dublin City Centre a more environmentally friendly place	Any new transport proposals will reduce conflict between modes, making the streets safer for all users;		A critical aspect of this Study is to ensure that Dublin City is 'future proofed' for anticipated growth. The Dublin City Council Development plan provides for the expansion of Dublin City Centre as an employment hub and principal destination, as well as a location for new residential development. There are also significant residential developments planned outside Dublin City, and linkages to the city centre employment areas from these new residential locations will be vital for Dublin to continue to expand as Ireland's primary economic centre.		The need for a defined 'strategic' pedestrian network that provides a consistently high quality of service for pedestrian movement within the city;
	Despite this there are still a significant amount of traffic related accidents in the city centre, with a number of identifiable accident 'Black Spots'. Information from the Road Safety Authority (RSA) sets out the location of accidents within the city centre. The general pattern is similar for pedestrian, cyclists and private vehicles. It is clear that the central area of the City, particularly around the City Quays, O'Connell Street and Dame Street are areas where road safety for all users could to be improved.		The key challenge of this Study is to ensure that the changes in the transport environment required to achieve this modal shift will result in an increase in the overall transport capacity within the city centre.		The accumulation of unnecessary street clutter (such as redundant signposts) in parts of the city centre impeding pedestrian movement; and
	To develop a safer City Centre for all transport modes and users.		The need to protect the investments made, and being made, in public transport and ensure their benefits continue to be delivered;		The relative lack of pedestrian friendly areas of public open space (as highlighted in the Council's Public Realm Strategy.
			The need to improve the journey time and reliability of bus services in the City Centre area;		To ensure that the number of cyclists travelling within, to and from the city centre continues to rise, it is essential that this study addresses the need to expand and improve the infrastructural requirements of an increased cycling community within Dublin City Centre.
			The requirement for the introduction of additional bus transport services to increase public transport capacity;		The key requirement to provide a quantum improvement in the provision and quality of facilities for cyclists in Dublin City;
			The need to continue to invest in the Real Time Passenger Information and ITS Bus priority system;		The ability of the cycle network to attract more cyclists, especially those more risk adverse and leisure cyclists;

Appendix 1: Transportation Study Part 2

Transportation Study					
Environmental	**Safety**	**Operational Efficiency**	**Road Network Efficiency**	**Multi-Modal**	**Other**
Challenges					
			Bus stop congestion at some key areas of the city centre – both for pedestrians and buses		Potential for improvement of the permeability for cycle movement within and through the city centre, with a number of one-way streets and long gyratory traffic movements not suitable for the efficient and safe movement of cyclists; and
			Bus and bicycle conflicts at various locations		To provide opportunities to enhance the Public Realm through transport interventions in the City Centre.
			The large number of taxis serving the City Centre, and how they interact / impact on other public transport services and road users		The new Luas Cross City will require the alteration of junction signal timings, considerably decreasing the amount of green time available for other modes, which in turn will seriously reduce road capacity in the core city centre.
			That there are many vehicles using the city centre as a through route, and which do not have a destination in the City Centre. Such vehicles could be accommodated on alternative routes, circumnavigating the central area;		Other specific challenges in relation to the public transport environment which must be addressed as part of this study include the construction and future operation of Luas Cross City and the introduction of Bus Rapid Transit (BRT) to serve Dublin City Centre.
			To provide journey time information and route guidance via web and mobile devices, and to make this data freely available for all navigation systems.		The introduction of BRT routes to service high demand bus corridors is currently being considered by the NTA. Specific changes to the transport arrangements currently operating in the city centre will be needed to facilitate the introduction of these BRT routes in the short to medium term.
			The current movement of traffic within the City Centre is dependent on a number of gyratory systems – e.g. St Stephen's Green, Westmoreland Street / D'Olier Street and Beresford Place. The gyratories are prone to congestion and blocking back of traffic at peak hours, with heavy flows of relatively fast-moving and weaving traffic in the off-peak periods. Such arrangements do not give priority to pedestrians, cyclists or buses, and often force them to deviate significantly from the most direct route		The introduction of new transport options into the city centre will significantly alter the current configuration and capacity of the modes currently using the streets of the city centre. Accordingly, it is important that the bus and private car networks within the core city centre are reconfigured to ensure that the impacts of Luas Cross City /BRT are addressed.
			That an appropriate level of private car vehicular access to the City Centre will be retained for retail and commercial purposes		: to produce a transport system capable of catering for the existing and future travel needs of Dublin City Centre

Appendix 1: Transportation Study Part 3

Transportation Study					
Environmental	**Safety**	**Operational Efficiency**	**Road Network Efficiency**	**Multi-Modal**	**Other**
Challenges					
			The potential to develop a managed delivery system in the city centre to reduce the size of goods vehicles operating the core central areas during daytime hours; a		how the existing transport networks operate within the city centre, a situation which will be made substantially more challenging when Luas Cross City further reduces the capacity of the road network. In fact, given the road network changes over recent years, even accommodating previous vehicle levels is not a feasible option
			The key challenge of this Study is to ensure that the changes in the transport environment required to achieve the desired modal shift will result in an increase in the overall transport capacity within the city centre. These changes must guarantee that future growth within the city can be facilitated by the revised transport system		To protect the investment that already has been, and continues to be, made in public transport in the city
			is the critical need to ensure that Dublin City can cater for an anticipated growth of approximately 20% in the number of trips coming into the City Centre each morning by 2023, compared to the number observed in Census 2011		It is evident that, in general, the individual transport networks within Dublin City have benefited significantly from the ongoing work and investment of Dublin City Council and the NTA. Despite this, it is clear that the current provision for each mode is inadequate in some way, and does not fully match the functional requirements of the mode either
			The potential for changed freight delivery practices, including: o An operational strategy for a range of freight trip generating sectors within the city; o The development of delivery and servicing plans in areas subject to HGV management; o The use of different vehicle types for a range of distribution purposes; o The greater use of Intelligent Transport Systems in the management of freight movement; o The potential for the use of rail and tram for the distribution of freight; and o The location of a Freight Consolidation Centre for distribution within the City Centre and beyond.		The NTA Cycle Network Plan for the GDA which includes specific network proposals for Dublin City Centre;
					The NTA Cycle Network Plan for the GDA which includes specific network proposals for Dublin City Centre;
					Despite the increase in cycle parking, the ad hoc nature of the cycle parking in some parts of the City Centre is having a negative impact on pedestrian movement (e.g. South William Street).
			To increase the capacity for the movement of people and goods into and within the City Centre, and facilitate efficient and effective goods delivery.		Despite the increase in cycle parking, the ad hoc nature of the cycle parking in some parts of the City Centre is having a negative impact on pedestrian movement (e.g. South William Street).

Appendix 1: Transportation Study Part 4

Transportation Study

Environmental	Safety	Operational Efficiency	Road Network Efficiency	Multi-Modal	Other
Objectives					
	To develop a safer City Centre for all transport modes and users		To protect the investment that already has been, and continues to be, made in public transport in the city.	To make it easier for people to use the transport networks.	To provide opportunities to enhance the Public Realm through transport interventions in the City Centre.
			To increase the capacity for the movement of people and goods into and within the City Centre, and facilitate efficient and effective goods delivery		
			To improve accessibility and permeability to, and within, the City Centre for pedestrians, cyclists and public transport users, while also maintaining an appropriate level of access for vehicular traffic for commercial and retail purposes.		

Appendix 2: Development Plan Part 1

Dublin City Development Plan					
Environmental	**Safety**	**Operational Efficiency**	**Road Network Efficiency**	**Multi-Modal**	**Other**
Challenges					
Increasing significantly the existing mode share for active modes, i.e. walking and cycling, and supporting the forthcoming National Policy Framework for Alternative Fuels Infrastructure.			Managing city centre road-space to best address the competing needs of public transport, pedestrians, cyclists, and the private car.		Pro-active engagement and collaboration with communities to bring about further modal shift and effective mobility management.
contribute to climate change mitigation and a more sustainable city.			Effective integration of land-use and transportation, and the management of access and mobility.		The expansion of the strategic cycle network along all major water bodies including the River Liffey and the canals.
A crucial factor in the discussion of movement and transport is the challenge of tackling climate change					Improving the city centre environment for pedestrians through public realm enhancements and through improvement of the strategic pedestrian network.
The Council shall use its powers to manage transport related spaces in the city so as to reduce transport-related emissions in the city area by at least 3% per year over the lifetime of the plan.					Ensuring maximum benefits are achieved from public transport improvements including Luas cross-city and the anticipated Bus Rapid Transit network.
					The continued delivery of an efficient, integrated and coherent transport network is a critical component of the development plan core strategy

Appendix 2: Development Plan Part 2

Dublin City Development Plan					
Environmental	**Safety**	**Operational Efficiency**	**Road Network Efficiency**	**Multi-Modal**	**Other**
Objectives					
To support the sustainability	To provide 30kph speed limits and traffic calmed areas at appropriate locations throughout the city and subject to stakeholder consultation.	To continue investment in the city's computer-based area traffic signal control system and in other Information Technology (IT) systems to increase the	A wide range of public realm, traffic management and public transport projects will occur in the city centre during the life of the Dublin City development plan. The city's road network must be effectively managed during this period in order to keep all road users interacting safely and efficiently while ensuring full accessibility and maintaining the economic competitiveness of the city.	To support and facilitate the development of an integrated public transport network with efficient interchange between transport modes, serving the existing and future	to ensure that land-uses and zoning are fully integrated with the provision of a high-quality transportation network that accommodates the movement needs of Dublin city and the region.
To maximise the use of public transport infrastructure and minimise car dependence, higher densities and interactive mixed uses will be encouraged within walking distance of public transport corridors and nodes (rail stations and interchanges) and at other key locations such as key district centres.	To develop lorry parks, bus parks and taxi holding areas in selected areas where deemed necessary and in co-operation			To work with the relevant transport providers, agencies and stakeholders to facilitate the integration of active travel (walking,	To promote and facilitate the provision of Metro, all heavy elements of the DART Expansion Programme including DART Underground (rail interconnector), the electrification of existing lines, the expansion of Luas, and improvements to the bus network in order to achieve strategic
Increasing capacity on public transport including bus corridors, DART, suburban railway lines and Luas will continue to reduce the reliance on private car usage and provide opportunities for people to alter their travel behaviour and increase modal shift to more sustainable modes. Promoting modal change also encourages active travel (i.e. walking and cycling) in general and as a means to access public transport routes. Car clubs, whereby cars are rented for short periods, facilitate people who have limited need for a car and these clubs can help reduce car ownership levels and free up road space for more sustainable travel modes Whilst having regard to the necessity for private car usage and the economic benefit to the city centre retail core as well as the city and national economy, to continue to promote modal shift from private car use towards increased use of more sustainable forms of transport such as cycling, walking	To review the existing traffic layout of the junction at Doyle's Corner, Phibsborough, during the lifetime of the plan with a view to providing for the needs of vulnerable road users, including pedestrians and cyclists as well as public transport and improving traffic safety			To work with Iarnród Eireann, the NTA, Transport Infrastructure Ireland (TII) and other operators to progress a coordinated approach to improving the rail network, integrated with other public transport modes to ensure maximum public benefit and promoting sustainable transport and improved connectivity.	To facilitate the needs of freight transport in accordance with the National Transport Authority's Transport Strategy for the Greater Dublin Area 2016–2035.

Appendix 2: Development Plan Part 3

Dublin City Development Plan					
Environmental	**Safety**	**Operational Efficiency**	**Road Network**	**Multi-Modal**	**Other**
Objectives					
Increased levels of cycling and walking are encouraged, as they are both more sustainable modes than private car use and can form part of sustainable journeys in conjunction with public transport use. Active travel can also contribute to healthy lifestyles	To improve the management and control of traffic in the city, to increase internal and external sustainable accessibility, to improve road safety, to safeguard commercial servicing requirements, to mitigate the impact of construction works and to minimise the adverse environmental impacts of the transport system.			To support the development and implementation of integrated ticketing and real time passenger information systems across the public transport network in association with relevant transport providers and agencies. Progress on the integration of Dublin shared bike scheme and Leap Card schemes will be monitored.	To support improvements to the city's bus network and related services to encourage greater usage of public transport in accordance with the objectives of the NTA's strategy and the government's 'Smarter Travel' document
To improve the city's environment for walking and cycling through the implementation of improvements to thoroughfares and junctions and also through the development of new and safe routes, including the provision of foot and cycle bridges. Routes within the network will be planned in conjunction with green infrastructure objectives and on foot of (inter alia) the NTA's Cycle Network Plan for the Greater Dublin Area, and the National Cycle Manual, having regard to policy GI5 and objective GIO18.	To work with the relevant agencies to ensure that safety issues are addressed at the entrance and exit of Ashtown gates at the Phoenix Park.			To promote 'Park and Ride' services at suitable locations in co-operation with neighbouring local authorities.	(i) To facilitate and support measures proposed by transport agencies to enhance capacity on existing public transport lines and services, to provide/ improve interchange facilities and provide new infrastructure
To promote Bike and Ride at public transport hubs by providing secure, dry, bike parking facilities.	To develop a city centre pedestrian network which includes facilities for people with disabilities and/or mobility impairments based on the principles of universal design.			To promote best practice mobility management and travel planning to balance car use to capacity and provide for necessary mobility via sustainable transport modes.	Subject to a station layout assessment, to promote the re-instatement of station entrance at Amiens Street/Buckingham Street Junction

Appendix 2: Development Plan Part 4

Dublin City Development Plan					
Environmental	**Safety**	**Operational Efficiency**	**Road Network**	**Multi-Modal**	**Other**
Objectives					
To support the growth of Electric Vehicles and e-bikes, with support facilities as an alternative to the use of fossil-fuel-burning vehicles, through a roll-out of additional electric charging points in collaboration with relevant agencies at appropriate locations.	halve road casualties by 2022			To review and monitor Travel Plans through the Dublin City Council Mobility Management Section.	To review future strategic provision of bus depots/garages in the city in consultation with Dublin Bus and the NTA.
To increase capacity of public transport, cycling and walking, where required, in order to achieve sustainable transportation policy objectives. Any works undertaken will include as an objective, enhanced provision for safety, public transportation, cyclists and pedestrians, and will be subject to environmental and conservation considerations.					To promote and seek the development of a new commuter rail station at Cross Guns serving the existing rail line infrastructure. Such a provision may be a stand-alone facility or form part of a larger mixed use development.
To tackle the adverse environmental and road safety impacts of traffic in the city through measures such as: • The implementation of traffic calming measures including the restriction of ratruns in appropriate areas in accordance with best practice and following advice contained in the Design Manual for Urban Roads and Streets. • The ongoing monitoring of traffic noise and emissions, and the assessment and evaluation of the air quality and traffic noise impacts of transport policy and traffic management measures being implemented by Dublin City Council. • The support of the government's Electric Transport Programme by examining measures that would facilitate the roll-out of charging infrastructure for electric vehicles. • To support programmes of action which tackle the issue of road safety in the city. • To promote traffic calming in existing residential neighbourhoods through innovative street design and layout such as homezones					To continue to promote improved permeability for both cyclists and pedestrians in existing urban areas in line with the National Transport Authority's document 'Permeability – a best practice guide'. Also, to carry out a permeability and accessibility study of appropriate areas in the vicinity of all Luas, rail and BRT routes and stations, in co-operation with Transport Infrastructure Ireland and the National Transport Authority

Appendix 2: Development Plan Part 5

Dublin City Development Plan					
Environmental	**Safety**	**Operational Efficiency**	**Road Network**	**Multi-Modal**	**Other**
Objectives					
To promote the greater use of low carbon fuels.					To require Travel Plans and Transport Assessments for all relevant new developments and/or extensions or alterations to existing developments
We will halve the use of 'conventionally-fuelled' cars in urban transport by 2030 and phase them out by 2050; achieve essential CO2-free city logistics in Dublin by 2030. Within 30 years we will move close to zero fatalities in road transport					To minimise loss of on-street car parking, whilst recognizing that some loss of spaces is required for, or in relation to, sustainable transport provision, access to new developments, or public realm improvements.
to achieve a doubling of all active travel and public transport trips and to halve private vehicular trips to Dublin by 2030					To discourage commuter parking and to ensure adequate but not excessive parking provision for short-term shopping, business and leisure uses.
Reduced carbon usage and encouragement of more sustainable transport modes and active travel.					To control the supply and price of all parking in the city in order to achieve sustainable transportation policy objectives.
Assists in increasing the role of sustainable transport and active travel.					To provide for sustainable levels of car parking and car storage in residential schemes in accordance with development plan car parking standards (section 16.38) so
To support and collaborate on initiatives aimed at achieving more sustainable energy use, particularly in relation to the residential, commercial and transport sectors.					To encourage new ways of addressing the parking needs of residents (such as car clubs) to reduce the requirement for car parking.
					: To consider providing additional on-street motorcycle parking at various locations throughout the city where considered
					To identify suitable and appropriate new locations (including off-street) in the city centre for the parking of private or tour-operated coaches with a view to discontinuing the practice of allowing

Appendix 2: Development Plan Part 6

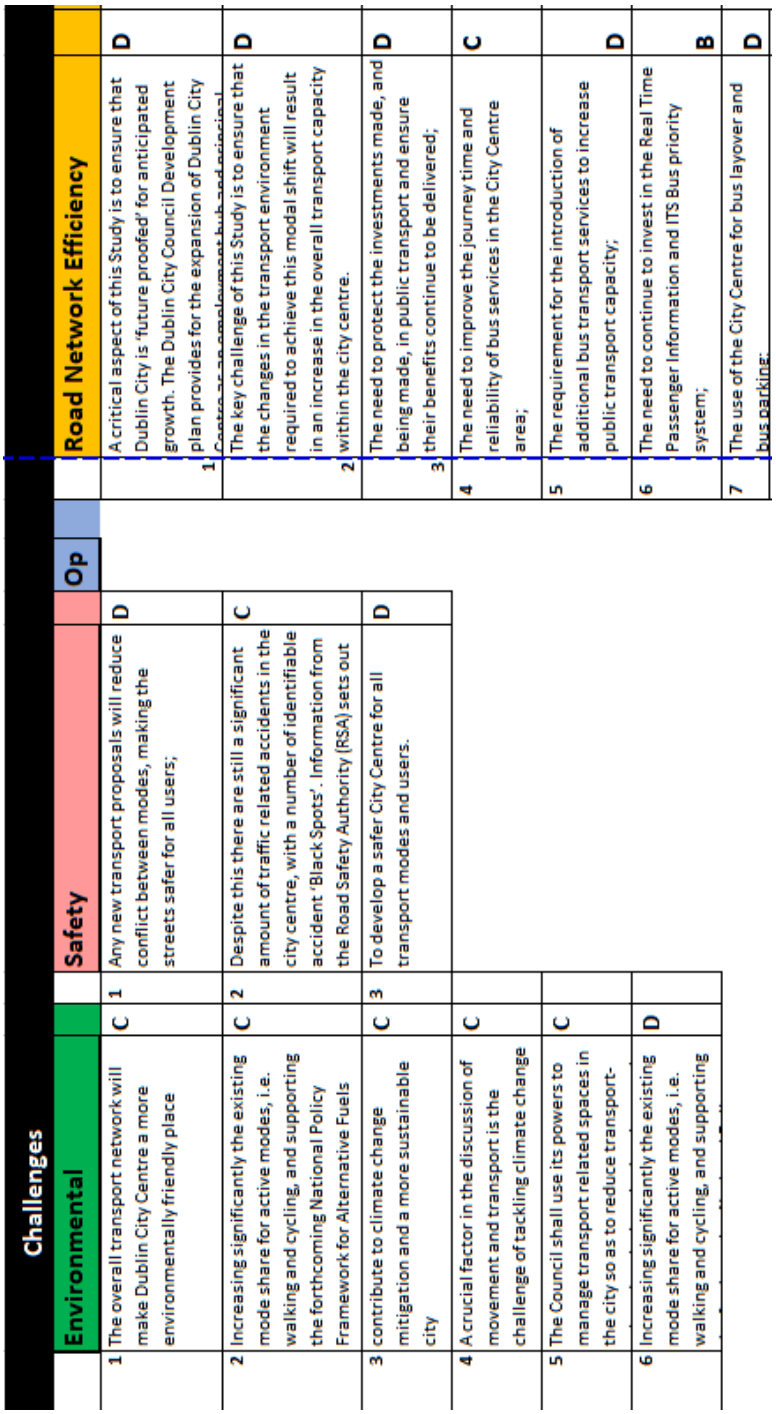
Dublin City Development Plan
Other
Objectives
To initiate and/or implement the following road improvement schemes and bridges within the six year period of the development plan, subject to the availability of funding and environmental requirements and compliance with the 'Principles of Road Development' set out in the NTA Transport Strategy. Roads • River Road • Richmond Road • Malahide Road/R107 (including North Fringe Improvements) • Blackhorse Avenue (commenced) • Clonshaugh Road Industrial Estate • Ballymun (improved town centre linkage) • Kilmainham/South Circular Road • Link from Military Road to Conyngham Road • East Wall Road/Sheriff Street to North Quays • Cappagh Road. Bridges • Dodder Bridge • Liffey Valley Park pedestrian/cycle bridge • Cycle/pedestrian bridges that emerge as part of the evolving Strategic •
To protect the routes of the proposed eastern by-pass from existing Dublin Port tunnel to Poolbeg, also referred to as the Southern Port Access Route, and in the longer term to provide a route corridor between Poolbeg and the Southern Cross/ South Eastern Motorway (in accordance with the NTA Strategy for the Greater Dublin Area 2016–2035). The preferred route for DCC is by means of a bored tunnel, under Sandymount Strand and Merrion Strand and will be subject to full statutory Environmental Assessment, together with an Appropriate Assessment for the entire proposed routes,
To manage restrictions on the use of road space for road works or general construction in accordance with Dublin City Council's 'Directions for the Control and Management of Road Works'.
To review traffic management and calming plans for local areas throughout the city in consultation with local communities and subject to availability of resources.
To assist the NTA in the development of a Regional Traffic Management Strategy in co-operation with neighbouring
To develop a traffic management and environmental protection plan for sports stadia and significant cultural events in consultation with relevant transport, sporting, community and cultural bodies.
To engage with public transport providers/ agencies and event organisers regarding the feasibility of developing a 'Free Travel' scheme for ticket holders attending major events, concerts, conferences and sporting fixtures in the city
To review the implementation of the HGV management strategy with a view to developing an improved approach to managing such vehicles in the city
To support the implementation of appropriate speed limits throughout the city in accordance with guidelines published by the Department of Transport, Tourism & Sport.
To implement best practice in road design as contained in statutory guidance and in the DMURS (the use of which is mandatory) with a focus on place-making and permeability (for example, by avoiding long walls alongside roads) in order to create street layouts that are suited to all users, including pedestrians and cyclists.
To provide on- and off-street disabled driver parking bays in excess of minimum requirements where appropriate (see
Movement – Helping to build an integrated transport network and encouraging the provision of greater choice of public
Support the continued development of a quality, affordable and accessible movement system within the city prioritising walking, cycling and quality public transport which serves both the needs of local neighbourhoods and the
To prioritise the introduction of tactile paving, ramps and kerb dishing at appropriate locations, including pedestrian crossings, taxi ranks, bus stops and rail platforms
To introduce traffic-free areas on sections on Drury Street, South William Street, Exchequer Court, Dame Court and Dame Lane while ensuring that access to car parks and deliveries is still provided for.

The integration of strategic transportation programmes into the urban form and structure of the city, thereby achieving maximum benefit from investment in public transport infrastructure
The National Spatial Strategy 2002–2022 recognises that the physical consolidation of Dublin, supported by effective landuse policies for the urban area itself, is an essential requirement for a competitive Dublin, and that consolidation is also required for the public transport system to function effectively

Appendix 3: Corporate Plan

Dublin City Council Corporate Plan					
Environmental	Safety	Operational Efficiency	Road Network	Multi-	Other
Objectives					
Co-operate with adjoining Local Authorities to mitigate against • climate change, in a co-ordinated manner, with particular regard to energy, settlement patterns, transport, waste management, and green corridors	To provide for the safe, sustainable and efficient movement of people, and manage the efficient movement of goods and transport in the city, in a sustainable manner.	Optimise our investment in Intelligent Transport Systems (ITS) to • ensure traffic movement is optimised	Manage necessary road openings in a manner that minimises • disruption to the city		Ensure transportation planning is adequately resourced to represent • Dublin's best interests in forming a central input into local and national development plans
To promote healthy living and the rec	Ensure national and local road safety initiatives are implemented to • maintain Dublin as one of the safest cities in Europe for pedestrians	Introduce a Transportation Asset Management System (TAMS)			Implement the traffic management plan recommendations in the • strategic study for Dublin city
	Place the pedestrian at the highest level of priority in transportation • planning followed by cycling, public transport, goods and other vehicles				Ensure transportation planning follows the Design Manual for Urban • Streets and Roads and is in line with the Government Policy 'Smarter Travel – A Sustainable Transport Future'
	Ensure local safety issues are addressed through the efficient use of • the TAG (Traffic Advisory Group) system				Provide the most efficient parking service to citizens and users of • Dublin city and neighbourhood roads and streets
	Prioritise works to ensure best value maintenance for the city's • infrastructure and to ensure the city's road, footpath and cycling network is maintained to the highest safety standard				Implement the Dublin city recommendations from the Greater Dublin • Cycle network
	Significantly improve pedestrian and walking facilities in the city				Pursue appropriate Smart City projects with leading international I.T. • companies
					To deliver improved quality of life and social inclusion throughout the city by providing sustainable neighbourhoods, supported by a range of services and connected by good public transport and green infrastructure.
					To develop and maintain the road, street and public domain network to the highest international standards whilst maintaining the integrity of the city's unique heritage.

Appendix 4: Challenges Combined Part 1



Challenges										
	Environmental			Safety		Op		Road Network Efficiency	
1	The overall transport network will make Dublin City Centre a more environmentally friendly place	C	1	Any new transport proposals will reduce conflict between modes, making the streets safer for all users;	D		1	A critical aspect of this Study is to ensure that Dublin City is 'future proofed' for anticipated growth. The Dublin City Council Development plan provides for the expansion of Dublin City Centre as an employment hub and precinct	D
2	Increasing significantly the existing mode share for active modes, i.e. walking and cycling, and supporting the forthcoming National Policy Framework for Alternative Fuels	C	2	Despite this there are still a significant amount of traffic related accidents in the city centre, with a number of identifiable accident 'Black Spots'. Information from the Road Safety Authority (RSA) sets out	C		2	The key challenge of this Study is to ensure that the changes in the transport environment required to achieve this modal shift will result in an increase in the overall transport capacity within the city centre.	D
3	contribute to climate change mitigation and a more sustainable city	C	3	To develop a safer City Centre for all transport modes and users.	D		3	The need to protect the investments made, and being made, in public transport and ensure their benefits continue to be delivered;	D
4	A crucial factor in the discussion of movement and transport is the challenge of tackling climate change	C					4	The need to improve the journey time and reliability of bus services in the City Centre area;	C
5	The Council shall use its powers to manage transport related spaces in the city so as to reduce transport-	C					5	The requirement for the introduction of additional bus transport services to increase public transport capacity;	D
6	Increasing significantly the existing mode share for active modes, i.e. walking and cycling, and supporting	D					6	The need to continue to invest in the Real Time Passenger Information and ITS Bus priority system;	B
							7	The use of the City Centre for bus layover and bus parking;	D

Appendix 4: Challenges Combined Part 2

Multi-Modal	
Improving the city centre environment for pedestrians through public realm enhancements and through improvement of the strategic pedestrian network	A
The expansion of the strategic cycle network along all major water bodies including the River Liffey and the canals.	A
Pro-active engagement and collaboration with communities to bring about further modal shift and	D
It is evident that, in general, the individual transport networks within Dublin City have benefited	D
To ensure that the number of cyclists travelling within, to and from the city centre continues to	A
The potential to facilitate the ongoing expansion of the dublinbikes scheme;	B

	Other	
1	The need for a defined 'strategic' pedestrian network that provides a consistently high quality of service for pedestrian movement within the city;	D
2	The accumulation of unnecessary street clutter (such as redundant signposts) in parts of the city centre impeding pedestrian movement; and	D
3	The relative lack of pedestrian friendly areas of public open space (as highlighted in the	D
4	The key requirement to provide a quantum improvement in the provision and quality of facilities	A
5	The ability of the cycle network to attract more cyclists, especially those more risk	D
6	To provide opportunities to enhance the Public Realm through transport interventions	D
7	Other specific challenges in relation to the public transport	D
8	The introduction of BRT routes to service high demand bus	A
9	To protect the investment that already has been, and continues	D
10	Despite the increase in cycle parking, the ad hoc nature of the	D

7	The use of the City Centre for bus layover and bus parking;	D
8	Bus stop congestion at some key areas of the city centre – both for pedestrians and buses	D
9	Bus and bicycle conflicts at various locations	D
10	The large number of taxis serving the City Centre, and how they interact / impact on other	D
11	That there are many vehicles using the city centre as a through route, and which do not	D
12	To provide journey time information and route guidance via web and mobile devices, and to	B
13	The current movement of traffic within the City Centre is dependent on a number of gyratory	C
14	That an appropriate level of private car vehicular access to the City Centre will be	D
15	The potential to develop a managed delivery system in the city centre to reduce the size of	D
16	The key challenge of this Study is to ensure that the changes in the transport environment	D
17	is the critical need to ensure that Dublin City can cater for an anticipated growth of	D
18	The potential for changed freight delivery practices, including: o An operational strategy	D
19	To increase the capacity for the movement of people and goods into and within the City	C
20	Managing city centre road-space to best address the competing needs of public	C
21	Effective integration of land-use and transportation, and the management of access	C
22	The continued delivery of an efficient, integrated and coherent transport network is a	C
23	Ensuring maximum benefits are achieved from public transport improvements including Luas	C
24	The NTA Cycle Network Plan for the GDA which includes specific network proposals for Dublin	D
25	how the existing transport networks operate within the city centre, a situation which will be	D
26	: to produce a transport system capable of catering for the existing and future travel needs	D
27	The new Luas Cross City will require the alteration of junction signal timings.	D
28	Potential for improvement of the permeability for cycle movement within and through the city	D
29	The introduction of new transport options into the city centre will significantly alter the	D

Appendix 5: Objectives Combined Part 1

	Objectives															
	Environmental			Safety			Operational			Road Network			Multi-Modal		Other	
1	To maximise the use of public transport infrastructure and minimise car dependence, higher densities and interactive mixed uses will be encouraged within walking distance of public transport corridors and nodes (rail stations and interchanges) and at other key locations such as key district centres. It is the Policy of Dublin City Council: MT1: To support the sustainability principles set	D	1	To provide 30kph speed limits and traffic calmed areas at appropriate locations throughout the city and subject to stakeholder consultation.	C	1	To continue investment in the city's computer-based area traffic signal control system and in other Information Technology	B	1	A wide range of public realm, traffic management and public transport projects will occur in the city centre during the life of the Dublin City	D	1	To support and facilitate the development of an integrated public transport network with efficient interchange between transport modes, serving the existing and future needs of the city in	C	to ensure that land-uses and zoning are fully integrated with the provision of a high-quality transportation network that accommodates the movement needs of Dublin	A
2	Increasing capacity on public transport including bus corridors, DART, suburban railway lines and Luas will continue to reduce the reliance on private car usage and provide opportunities for people to alter their travel behaviour and increase modal shift to more sustainable modes. Promoting modal change also encourages active travel (i.e. walking and cycling) in general and as a means to access public transport routes. Car clubs, whereby cars are rented for short periods, facilitate people who have limited need for a car and these clubs can help reduce car ownership levels and free up	D	2	To develop lorry parks, bus parks and taxi holding areas in selected areas where deemed necessary and in co-operation with private enterprise, so as to eliminate the hazards of unsuitable lorry, bus and taxi parking in residential and other areas.	A	2	Optimise our investment in Intelligent Transport Systems (ITS) to • ensure traffic movement is optimised	B	2	To protect the investment that already has been, and continues to be, made in public transport in the city.	D	2	To work with the relevant transport providers, agencies and stakeholders to facilitate the integration of active travel (walking, cycling etc.) with public transport, thereby making it easier for people to access and use the public transport system	C	To promote and facilitate the provision of Metro, all heavy elements of the DART Expansion Programme including DART Underground (rail interconnector), the electrification of existing lines, the expansion of Luas, and	A
3	Increased levels of cycling and walking are encouraged, as they are both more sustainable modes than private car use and can form part of sustainable journeys in conjunction with public transport use. Active travel can also contribute to healthy lifestyles	D	3	To review the existing traffic layout of the junction at Doyle's Corner, Phibsborough, during the lifetime of the plan with a view to providing for the needs of vulnerable road users, including pedestrians and cyclists as well as public transport and improving traffic safety	D	3	Introduce a Transportation Asset Management System (TAMS)	B	3	To increase the capacity for the movement of people and goods into and within the City Centre, and facilitate efficient and effective goods delivery	C	3	To work with Iarnród Eireann, the NTA, Transport Infrastructure Ireland (TII) and other operators to progress a coordinated approach to improving the rail network, integrated with other public transport modes to ensure maximum public benefit and promoting sustainable transport and improved	A	To facilitate the needs of freight transport in accordance with the National Transport Authority's Transport Strategy for the Greater Dublin Area 2016-2035.	D

Appendix 5: Objectives Combined Part 2

2	Objectives															
3		Environmental			Safety			Operational			Road Network			Multi-Modal		
7	4	To improve the city's environment for walking and cycling through the implementation of improvements to thoroughfares and junctions and also through the development of new and safe routes, including the provision of foot and cycle bridges. Routes within the network will be planned in conjunction with green infrastructure objectives and on foot of (inter alia) the NTA's Cycle Network Plan for the Greater Dublin Area, and the National Cycle Manual, having regard to policy GI5 and objective GIO18.	A	4	To work with the relevant agencies to ensure that safety issues are addressed at the entrance and exit of Ashtown gates at the Phoenix Park.	D	4	To improve the management and control of traffic in the city, to increase internal and external sustainable accessibility,	C	4	To improve accessibility and permeability to, and within, the City Centre for pedestrians, cyclists and public transport users, while also maintaining an appropriate level of access for vehicular traffic for commercial and retail purposes.	D	4	To support the development and implementation of integrated ticketing and real time passenger information systems across the public transport network in association with relevant transport providers and agencies. Progress on the integration of Dublin shared bike scheme and Leap Card schemes will be monitored.	C
8	5	To promote Bike and Ride at public transport hubs by providing secure, dry, bike parking facilities.	A	5	To develop a city centre pedestrian network which includes facilities for people with disabilities and/or mobility impairments based on the principles of universal design.	A							5	To promote 'Park and Ride' services at suitable locations in co-operation with neighbouring local authorities.	A
9	6	To support the growth of Electric Vehicles and e-bikes, with support facilities as an alternative to the use of fossil-fuel-burning vehicles, through a roll-out of additional electric charging points in collaboration with relevant agencies at appropriate locations.	A	6	halve road casualties by 2022	C							6	To promote best practice mobility management and travel planning to balance car use to	D
10	7	To increase capacity of public transport, cycling and walking, where required, in order to achieve sustainable transportation policy objectives. Any works undertaken will include as an objective, enhanced provision for safety, public transportation, cyclists and pedestrians, and will be subject to	D	7	To develop a safer City Centre for all transport modes and users	C							7	To review and monitor Travel Plans through the Dublin City Council Mobility	D

Appendix 5: Objectives Combined Part 3

2	Objectives														
3		Environmental			Safety			Operational			Road Network			Multi-Modal	
11	8	To tackle the adverse environmental and road safety impacts of traffic in the city through measures such as: • The implementation of traffic calming measures including the restriction of ratruns in appropriate areas in accordance with best practice and following advice contained in the Design Manual for Urban Roads and Streets. • The ongoing monitoring of traffic noise and emissions, and the assessment and evaluation of the air quality and traffic noise impacts of transport policy and traffic management measures being implemented by Dublin	D	8	To provide for the safe, sustainable and efficient movement of people, and manage the efficient movement of goods and transport in the city, in a sustainable manner.	C							8	To make it easier for people to use the transport networks.	C
12	9	To promote the greater use of low carbon fuels.	D	9	Ensure national and local road safety initiatives are implemented to • maintain Dublin as one of the safest cities in Europe for pedestrians	D							9	Manage necessary road openings in a manner that minimises • disruption to the city	C
13	10	We will halve the use of 'conventionally-fuelled' cars in urban transport by 2030 and phase them out by 2050; achieve essential CO2-free city logistics in Dublin by 2030.	D	10	Place the pedestrian at the highest level of priority in transportation • planning followed by cycling, public transport, goods and other vehicles	D							10	To maximise the use of public transport infrastructure and minimise car dependence, higher densities and interactive mixed uses will be encouraged within walking distance of public transport corridors and nodes (rail stations and interchanges) and at other key locations such as key district centres.	C

Appendix 5: Objectives Combined Part 4

Objectives													
	Environmental			Safety			Operational			Road Network		Multi-Modal	
11	to achieve a doubling of all active travel and public transport trips and to halve private vehicular trips to Dublin by 2030	D	11	Ensure local safety issues are addressed through the efficient use of • the TAG (Traffic Advisory Group) system	D						11	Movement – Helping to build an integrated transport network and 6	D
12	Reduced carbon usage and encouragement of more sustainable transport modes and active travel.	D	12	Prioritise works to ensure best value maintenance for the city's • infrastructure and to ensure the city's road, footpath and cycling network is maintained to the highest safety standard	A								
13	Assists in increasing the role of sustainable transport and active travel.	D	13	Significantly improve pedestrian and walking facilities in the city	A								
14	To support and collaborate on initiatives aimed at achieving more sustainable energy use, particularly in relation to the residential, commercial and transport sectors.	D	14	Within 30 years we will move close to zero fatalities in road transport	C								
15	Co-operate with adjoining Local Authorities to mitigate against • climate change, in a co-ordinated manner, with particular regard to energy, settlement patterns, transport, waste management, and green corridors	D	15	to improve road safety	C								
16	To promote healthy living and the recreational use of Dublin's unique natural amenities while protecting the environment and building resilience to cope with climate change.	D											

Appendix 5: Objectives Combined Part 4

Objectives														
	Environmental			**Safety**			**Operational**			**Road Network**			**Multi-Modal**	
11	to achieve a doubling of all active travel and public transport trips and to halve private vehicular trips to Dublin by 2030	D	11	Ensure local safety issues are addressed through the efficient use of • the TAG (Traffic Advisory Group) system	D							11	Movement – Helping to build an integrated transport network and	D
12	Reduced carbon usage and encouragement of more sustainable transport modes and active travel.	D	12	Prioritise works to ensure best value maintenance for the city's • infrastructure and to ensure the city's road, footpath and cycling network is maintained to the highest safety standard	A								6	
13	Assists in increasing the role of sustainable transport and active travel.	D	13	Significantly improve pedestrian and walking facilities in the city	A									
14	To support and collaborate on initiatives aimed at achieving more sustainable energy use, particularly in relation to the residential, commercial and transport sectors.	D	14	Within 30 years we will move close to zero fatalities in road transport	C									
15	Co-operate with adjoining Local Authorities to mitigate against • climate change, in a co-ordinated manner, with particular regard to energy, settlement patterns, transport, waste management, and green corridors	D	15	to improve road safety	C									
16	To promote healthy living and the recreational use of Dublin's unique natural amenities while protecting the environment and building resilience to cope with climate change.	D												