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THE IRISH ACADEMY OF ENGINEERING

A VISION OF

TRANSPORT IN IRELAND IN 2050

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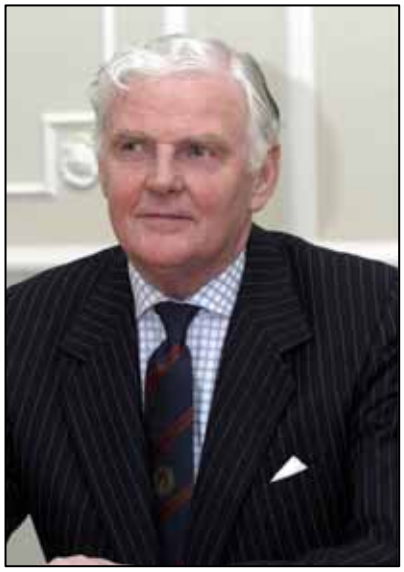

The overall objective of the Irish Academy of Engineering, which was founded in 1997, is to advance the science and practice of engineering in Ireland as an essential element in the development and enhancement of living standards. It produces reports on medium to long-term issues whose purpose is to inform and stimulate discussion in advance of policy decisions.

This report is a contribution to the development of a long-term vision for the transport of people and goods on the island in 2050. It is a vision of what might be, and is firmly rooted in engineering developments, which are evident today. It is not a forecast. However by presenting the document in a setting of the year 2050 the Academy aims to stimulate debate, discussion, and analysis leading to policy developments. It has been developed in the context of changes in climatic conditions, the importance of Asia in global trade, energy supply, technology advances and a much higher population on the island.

While a perspective of almost half a century may seem long it is well within the lifetime of most of today's students. It is worth remembering that decisions, which are taken now, are forming the framework for developments in the approaching decades. Without a forward vision there is a risk of falling victim to short term incrementalism, which offers less than optimum solutions. A long-term vision can provide a basis for more rigorous analysis and planning. To quote George Bernard Shaw "Some men see things as they are and ask why. Others dream of things that never were and ask why not."

This report is presented to public and private policy makers on the island, and to the public at large. The Academy will be pleased to discuss the basis for its vision of Transport 2050 with interested groups throughout the island.

The Academy would like to express its appreciation to its members and colleagues listed below who have prepared this report:

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Liam Connellan
President

INTRODUCTION

This is not a projection of current trends. It is a vision. It is a vision of transport in Ireland in 2050, based around a set of assumptions that the authors have reason to believe is soundly based. To help relate to the more familiar world of today, the story is written in retrospect. The reader is invited to imagine what it would be like living in the middle of the twenty-first century, thinking about how transport in Ireland has evolved since the turn of the twentieth century.

Fifty years is a long time. It seems less perhaps to those who have exceeded this time period in adult life. In the last fifty years there have been some staggering changes, particularly in the world of communication and information management. There have been changes to the appearance of our rural landscape and urban settlements, but in many respects such changes have not been dramatic.

Lifestyle has improved significantly and our more affluent society is more aware of what is going on and how decisions are taken in regulating the physical environment. Incomes are likely to continue to rise over the next fifty years, but our belief is that change will be felt in the institutions of governance and the pressures of meeting competition in a global economy more than in the physical appearance of our cities, towns and villages.

The object of this exercise was not to predict, plan or project forward the trends that are evident in society today. It was to cast a vision, essentially an optimistic vision, of transport in Ireland in the middle of this century. Such visionary thinking has parallels in the sixties vision of walking on the moon.

We have set 2050 as a date, which is convenient for the assumptions upon which the vision is based, but the changes in society, technology and the projects visualised could emerge anytime during the century. Welcome to the future…

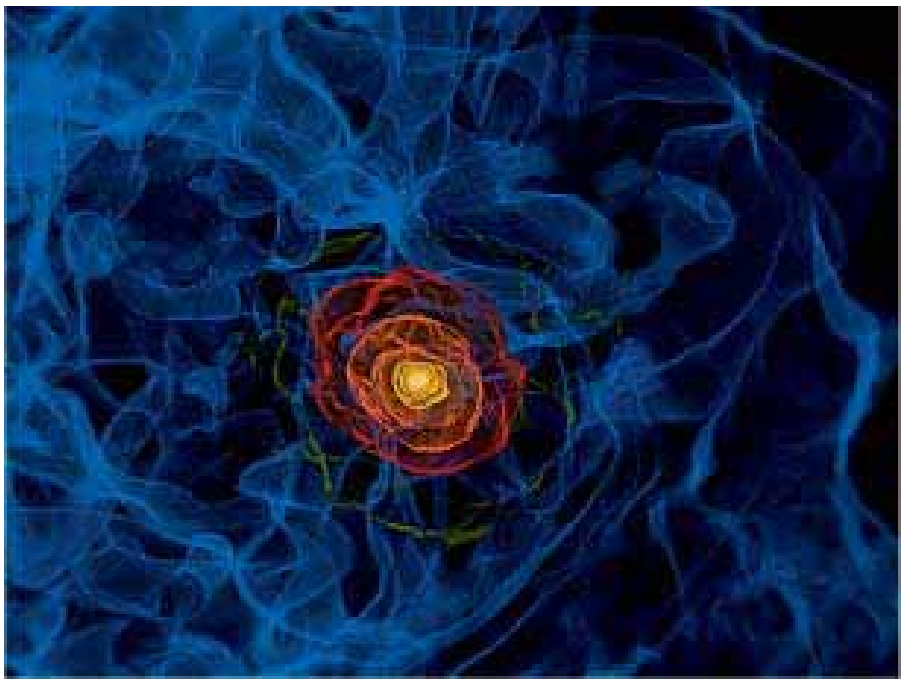

Fig 1 – The Birth of a Star

1 THE VISION

1.1 Ireland 2050

It is the middle of the twenty-first century. The population of the island of Ireland is approaching 8 million. There are almost 4 million dwellings on the island, and the same number of private cars.

Two and a half million dwellings are less than 50 years old. Of these, some 600,000 new houses have been built on land that had already been developed before the end of the twentieth century – land that was then known as 'brownfield'.

There has been a consistent level, year-on-year, of new houses erected in open countryside – totalling 750,000 new dwellings over the last 50 years – despite repeated attempts to tighten planning policy and halt what many at the turn of the century believed was a form of development that would alter forever the character of the Irish rural landscape. Planning policy has been successful in protecting precious landscape.

The residual 1.15 million dwellings have been built in extension of existing built up areas and, in some cases, in what amounts to new settlements. A total of 50,000 hectares of land that in the twentieth century comprised green fields has now been built upon. What was once regarded as the antithesis of sustainable development has added just 0.6 % to the urbanised land area of the island.

Almost three-quarters of all urbanisation since the turn of the century has taken place – not altogether according to plan – near to or in extension of the towns and cities that comprise the eastern seaboard of Ireland, extending from Larne to Wicklow.

Planning policy successfully directed most of this development to selected localities and prevented development from being scattered amongst less well-suited locations. Each urban extension was carefully planned to reflect local characteristics and build upon its unique features. Open space and wildlife corridors were retained. Within areas of socially balanced residential development, a wider range of house-types at somewhat higher densities has been achieved than would ever have been envisaged in a suburban development typical of the previous century. Each new urban extension provided a degree of self-containment and its own distinctive nucleus. The planned urban extension in the twenty-first century linked homes to employment opportunity and made environment-friendly transport a reality.

Sixty percent of the population of Ireland, 4.8 million people, now live in the multi-centred metropolis that spans the eastern seaboard of Ireland.

Substantial development, however, has also taken place in and around Limerick/Shannon, and at Waterford, Cork and Galway. Parallel investment in a western transport corridor linking Letterkenny/Derry through Sligo, Galway, Limerick/Shannon to Cork has led to significant development and has ensured that prosperity has not been confined to the east of the island.

Newry and Dundalk now represent a twin-centred city with a regional catchment of a quarter of a million people, and the development of

strategic linking corridors from here into the heart of Ireland has supported the planned growth and development of Mullingar, Tullamore and Athlone.

In Dublin and Cork the climate change imperative has led to the installation of critical flood protection measures to guard low-lying areas against rising sea level and storm surges.

The success of the eastern seaboard growth corridor has been the key to overcoming peripherality in all regions of Ireland.

1.2 How We Get About

The transportation network in Ireland has changed from a radial pattern – the historic arteries that like spokes of a wheel reached out from Dublin and Belfast to the west – to that of a lattice or grid pattern linking all the centres of accelerated growth north to south and east to west. This inter-connection has been a significant factor in the equitable distribution of economic opportunity inland.

Motorway travel between Belfast and Dublin, part of the Trans European Transport Network, now offers a journey time of less than one hour and 45 minutes. In Dublin the motorway box connecting the M50 with the N11 has been completed.

A new track bed has been laid from Belfast through Dublin to Cork, and rail passengers can now complete the inter-city journey between Belfast and Dublin in one hour 10 minutes, and from Dublin to Cork in two hrs 15 minutes, using the high-speed trains. Dublin has a new central station linking the high-speed rail connections.

Apart from the completion of the high-speed rail and the motorway connection to Dublin, the important strategic investment in infrastructure in the North of Ireland, unforeseen before the twenty-first century, was the motorway up the east side of Lough Neagh, linking the North's M1 and M2 motorways to Belfast International Airport. Significant inward investment was attracted to the resulting major interchange, where the motorway from Dublin crosses the M1 east of Moira, while the connection northwards past the airport to Larne contributed significantly to the successful regeneration of the Port of Larne. Also from this intersection, a highway now reaches northeast through Carryduff, Comber and Newtownards to Bangor, completing Belfast's peripheral 'C' route.

Also unforeseen in the twentieth century was the importance of the Diagonal in shaping the future of Dublin. The Diagonal, a direct road connection between Dundalk/Newry (and all points north), through Navan and Portlaoise to Cork, has been hugely important in easing city congestion and distributing development opportunities in and around the Greater Dublin Area.

High-speed rail connections to Dublin and Belfast International Airports became a priority early in the century. Air travel has continued to grow at a steady pace with the number of air transport movements increasing through Dublin, for example, from 200,000 to 500,000 over the last 50 years, and passenger throughput rising from 15 million to 51 million over the same period. Dublin Airport and Belfast International Airport have expanded comfortably to meet the rising demand.

Belfast now has a 12-minute interval light rail service connecting the International Airport through Belfast City Centre to Newtownards, and there

are plans to complete a figure of eight, bringing Bangor and Lisburn into the loop.

1.3 Final Part of the European Jigsaw – The Tuskar Tunnel

Without doubt the dominant transport development in Ireland in the twenty-first century has been the 60km Tuskar tunnel connecting County Wexford to North Pembrokeshire across St George's Channel.

Rail passengers travelling between Dublin and London can now complete the journey in less than three hours and link into the well-developed mainland Europe High Speed Rail Network.

The track, linking the Shannon Estuary as a freight entrepôt to mainland Europe on European gauge track via Bristol and the new English Channel tunnel, met the twenty-first century needs of inter-continental freight movements to and from the heart of Europe. This provided a solution for the shipping industry wanting to use increasingly large post-Panamax ships and challenged by a crowded English Channel, shallow waters and the limited development opportunities at the major North Sea hub ports.

The success of the Tuskar tunnel has given impetus to a fixed link connection from County Antrim to the Mull of Galloway in Scotland. This is now being named the Beaufort link, and is presently in an advanced stage of planning with enabling works already being carried out.

Ireland is at last changing from a peripheral island to a connected part of Europe.

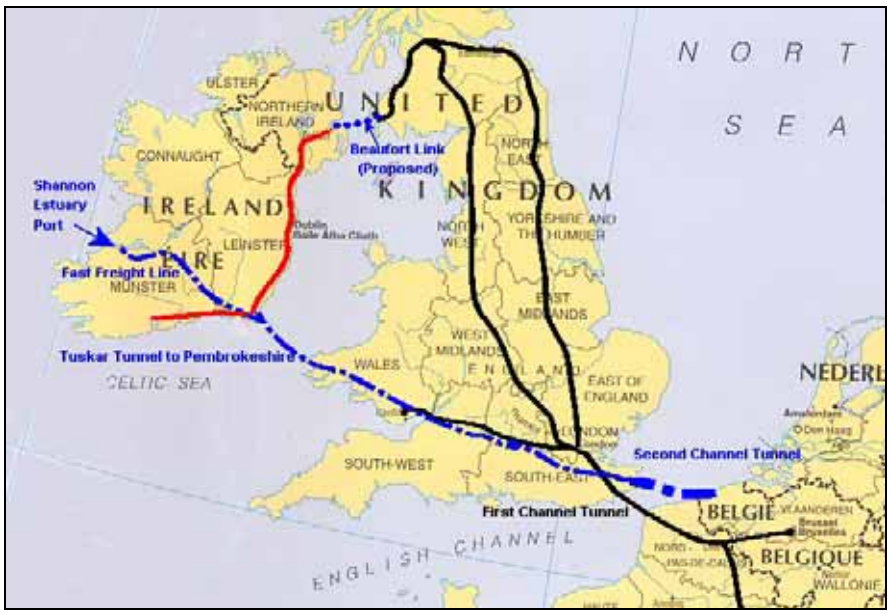

Fig 2 – Fast Freight and Tuskar Tunnel Alignment

The success of the new Shannon Super-Port, with its high capacity, deep draught port and its rail connection across Ireland and Great Britain via sea tunnels has emulated Halifax, Nova Scotia. It has proven capable of servicing the biggest container ships in the world, and has afforded opportunity for Limerick/Shannon to play a lead role in the development of the west of Ireland.

Maritime transport and ports continue to handle over 90 % by volume of all goods entering and leaving Ireland. Irish Ports now put through 125 million tonnes (rising from 70 million tonnes at the turn of the century).

The expansion of Dublin Port, from 20 million tonnes to 65 million tonnes over the last 50 years, was made possible by relocating Dublin's 28 hectares oil zone and bulk traffic to Loughshinney. This environmentally sensitive relocation was achieved after a hard fought deal. The Port, however, was consequently able to expand and develop to provide longer, deeper berths, necessarily catering for the myriad of differing vessel configurations now operating, with adjacent serviced land and increased storage space for containers.

The last 50 years has seen the advent of the Fastship (where a rail system reaches right into the ship), and the Big Container vessels, which have presented a challenge for the North European Ports. Rotterdam Port, at the turn of the century extending for 40km and putting through 15 times the tonnage of Dublin, had serious problems adapting to the new shipping requirements, and this opened the way for what became known as The Shannon Project.

Only Rotterdam and the Shannon Estuary were capable of handling the huge Malacca Max vessels – huge ships, three times larger than conventional container ships, that had emerged as the most efficient way to handle the massive trade generated in the South China Sea.

Smaller ports throughout Ireland expanded through specialisation and handling break bulk trades.

1.4 Continuing Concern for the Environment

Plans were wisely drawn up in the early part of the century to cope with sea-level variations – an anticipation of the climate getting warmer and wetter, as it has done over the last 50 years. Sea defences have protected the low-lying areas of coastal cities from the effects of rising sea level, and storm surge defence works were carried out in Cork and Dublin.

The case against CO_2 was proven early in the century, but fuel emissions from road transport as the main contributory factor significantly diminished through legislation and technology improvements to the point where air quality was no longer a constraint on road transport policy.

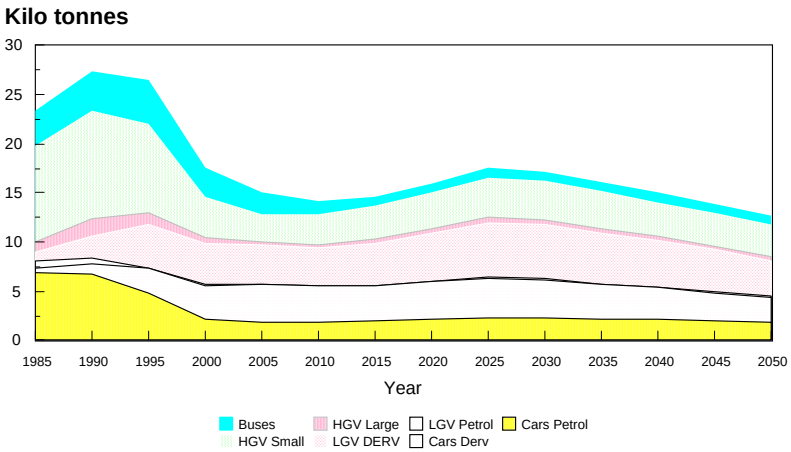

Fig 3 – UK Urban Road Transport Emissions of PM_{10}

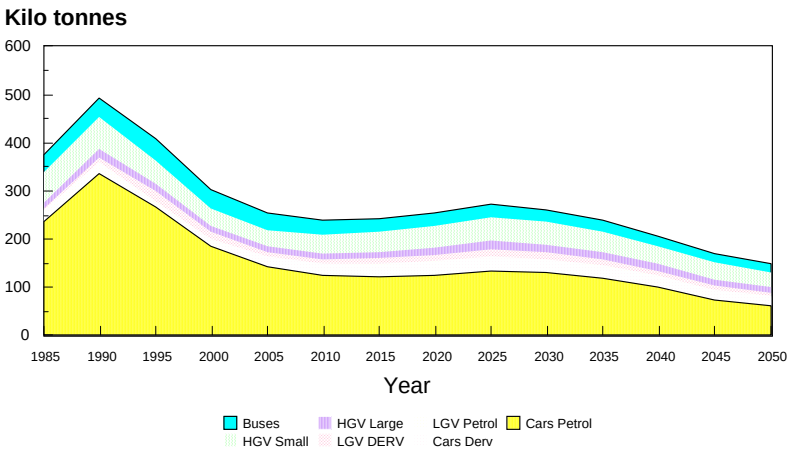

Fig 4 – UK Urban Road Transport Emissions of NOx

The charts show the Road Transport Emissions for the UK. Similar trends were experienced in Ireland.

Consequently the objective of reducing demand for travel became less significant in pursuit of what is understood by sustainable development.

The fuel-cell engine – and the removal of the link between cars and CO_2 – altered the sustainability equation, factoring in the human, psychological and spiritual ingredients, as well as local food production and renewable energy, composting, recycling vegetable gardening made possible by retaining green space within cities. The new approach set aside the obsession with filling in the holes in the city fabric, which was the turn of the century view of sustainable development (compact cities and brownfield sites).

The interactive relationship between land use and transport was acknowledged and increased public transport use was a direct consequence of development carried out around existing and new transport nodes.

With hydrogen emerging as the favoured energy fuel, the hydrogen fuel cell-propelled vehicles now provide a quiet, safe, green, easy-to-drive, cheap occasionally auto-piloted car, with automated road network charging.

The physical appearance of the urban/suburban environment has not been subjected to anything like such fundamental change as the means of travel – heritage protection continues to be a burning issue.

1.5 Inter-Connected Cities: The Key to Economic Growth

The people of Ireland are more affluent than they were at the turn of the century, with incomes continuing to rise. Expectations about lifestyle have risen accordingly. But the world is acknowledged to be a more competitive place. Economic prospects of nation states and autonomous regions have become more reliant on the fortunes of cities.

As a result of local government reorganisation, inter-dependent urban and rural authorities came under a single authority. The city regions of Dublin and Belfast are now the most powerful units of governance in Ireland. But city regional administrations in Cork, Galway, Waterford,

Limerick/Shannon, Letterkenny/Derry, Newry/Dundalk and Mullingar/Tullamore/Athlone have been equally successful. They are strong because they represent self-contained labour and housing markets. They are strong because there is an objective and focused community of interest reflected in the concentration of transport links and communication networks on their respective centres.

All parts of Ireland are now better off, and politicians, seeking to distribute wealth equitably, have increasingly realised that the only way to avoid falling behind in an ever-more competitive world is to pursue a strategy of substantial investment in infrastructure. Personal mobility and a vigorous local economy have become the twin objectives of regional transport policy.

The last 15 years has also seen a significant shift towards more sustainable modes of transport as a result of visionary investment in transport infrastructure. The harnessing of geo-positioning systems and electronic vehicle identification through smart tax discs enabled network charging, variable speed limits and road trains on the main highways to be progressively introduced, reducing congestion and raising cash for infrastructure. Road-building technology is now highly automated, with pre-fabricated highway sections and carpet-laid wearing courses incorporating catalytic agents to deal chemically with the residual pollutant of nitrogen oxide.

The pulling power of the city region has required many new homes. In-migrants have continued to push up population and new hubs of commercial activity have evolved around popular edge-of-city locations. Cities have become polycentric. New workplaces in the hubs have been established to meet the demand for businessmen and women to meet face-to-face, and young people have populated the hearts of cities and larger towns.

Settlements that had been throttled by green belts in the early part of the century, were later encouraged to expand along public transport corridors, separated by 'green lungs' and 'green wedges' of open countryside protected from development. Quality of life imperatives ensured that green space nature in the city became protected with zeal equal to that applied to the built heritage.

Little physical change has taken place in the rural areas, other than as a consequence of sound agricultural diversification. A new rural settlement pattern of farmstead-hamlets has emerged with the culture of tele-working. The long-distance nature of commuting, boosted by uptake of tele-commuting and part-time home working has fuelled demand for weekday loft-style city apartments coupled with large distant greenfield houses.

People are now living where they want to live and – critically – where they continue to want to live.

2 DRIVING FORCES FOR CHANGE

2.1 Spatial Strategy and Population Distribution

In the decade up to the end of the last century considerable concentration of the population of Ireland occurred along the east coast. This was particularly pronounced between Belfast and Dublin and was encouraged by a group of business people from Belfast and Dublin who had a vision of a Belfast Dublin Economic Corridor. This was partly in contrast to the policies of the governments, who declared support for greater development outside this area and put funding into that strategy.

The corridor has been a success and has grown to stretch from Larne through Belfast to Dublin and on to Carlow. This continues to be the main industrial and commercial area of activity on the island, resulting in increasing desire by people to live in the corridor.

With the population now approaching 8 million people, it is fascinating to remember that it was well above that figure 200 years ago. The big difference is the spread and distribution. Two hundred years ago the population was spread all over the island with few living in the big towns. The population density now is 92 people per sq km, up from 68 people per sq km 50 years ago. This is still a sparse density island compared to other European countries, such as Germany at 250, Netherlands at 450, Belgium at 312, UK at 250, although it is near Denmark at 150 people per sq km.

However, the vast majority live in the big cities. Belfast, Cork, Dublin, Galway, Limerick, Londonderry and Waterford have a total population in their commuting areas of 5.5 million or over 70% of the people. Nearly 50% live in the two largest cities. The low density has made the island attractive to live in and retained its green image.

The low overall density and high concentration in the Larne - Carlow corridor leaves the other areas of the island very difficult to provide with viable public transport and underlines the importance of the continuing attempts to concentrate growth along transport corridors connecting the main urban areas.

The mix of population densities is the reason that the policy of developing excellent park and ride facilities around and in the urban areas has made a contribution to improving the use and quality of public transport, while also reducing congestion in the urban areas. It is also the reason why transport has developed along somewhat different lines to much of Europe.

The trend of apartment living that became very popular at the start of this century faded out in the 2020s, but in recent years has again become a growing trend. This is the one of the impacts of network charging. It has become effective as a means of reducing congestion and encouraging the use of public transport. It is encouraging people to live within walking distance of their work.

2.2 Quality of Life Expectations

In the year 2050 lifestyles in Ireland have changed dramatically. These changes were driven by a number of factors, including economic growth, care for the environment, population growth, technology and so forth.

The population is now more evenly distributed throughout the country, due in no small way to how the implementation of the National Spatial Strategies progressed over the years and the development of the infrastructure. Despite this, the major cities on the east coast, Dublin and Belfast, have populations of 2.5 million and 1 million respectively. City boundaries in both locations have been extended, and Dublin city now encompasses what was previously known as the Greater Dublin Region, including parts of Meath, Kildare and Wicklow.

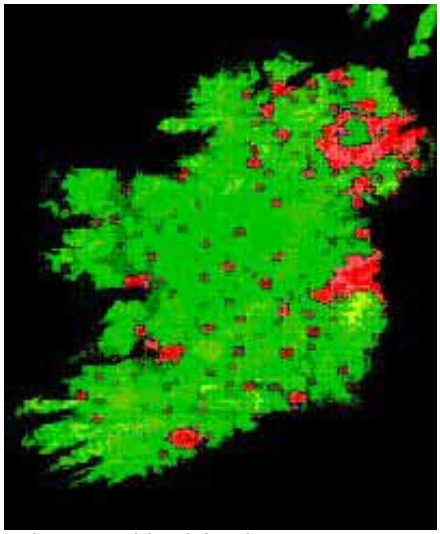

Fig 5 – Stable Lights from Space 2000

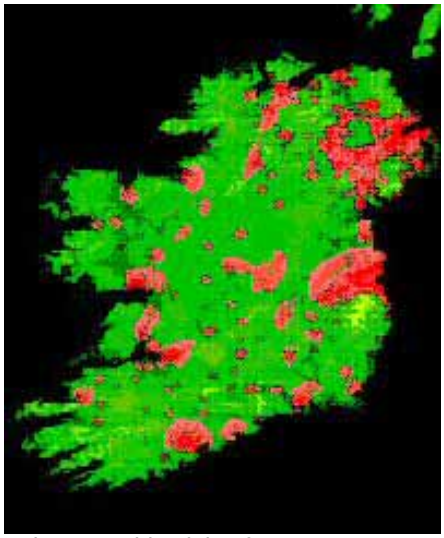

Fig 6 – Stable Lights from Space 2050

The concept of co-housing, as developed in Israel, has proved popular in certain areas. A community of homes with shared facilities such as kitchen, dining rooms and communal areas. These have proved to be particularly popular with the elderly.

The introduction of new personal retirement plans for workers at the beginning of the century has given the individual the choice in relation to pension planning. This has allowed individuals to plan for early retirement if that is their choice.

Over the last 50 years there has been an ever-increasing interest in physical fitness. The demand has been met by the main sporting organisations, which have invested heavily in meeting the demands of younger people particularly. The number of gyms has increased enormously, which has resulted in a much fitter and longer living population than 50 years ago.

The concept of people working from home continues to be very popular. There has been spectacular and continuous improvement in the development of computers. It is now as easy to carry out one's work from an office at home as to make the journey to a centralised location. The developments in tele-conferencing have assisted in bringing eye-to-eye contact with colleagues.

The community office located in villages and towns has proved popular. These allow people to have access to the most advanced technology services, which in turn allows the locals to work remotely from their main centre of employment. The use of low-cost accommodation and services has helped a number of companies to become more competitive, and in a limited way can be described as a success.

Mains electricity has been replaced in many developments by hydrogen technology. Electrical power is locally generated using stationary reformer/fuel-cell units.

Technological developments allowed the role of some schools to change. The introduction of tele-conference techniques has allowed education to come to the home of the student. This has proved particularly beneficial to those living in remote regions of the country.

The introduction of smart cards has proved a major success. While smart cards were introduced initially for payment of public transport journeys, their use has been extended to a variety of public payment uses. When entering a network-charging zone, the payment is automatically deducted from the value of the card.

The change over from vehicles powered by oil to hydrogen fuels is complete and all service stations have now been converted and extended to cater for the hydrogen fuel driven vehicles. Countries in the Middle East who were the main suppliers of fuel in the past now struggle to come to terms with the new environment.

The development of the Traffic Information Manager (TIM) has been of great assistance to motorists. It is now possible for the car computer to choose the route with the least congestion and give an estimate of the time taken to complete your chosen journey.

Technology has played a vital part in enhancing road safety, which has resulted in a dramatic reduction in road fatalities. The introduction of automatic speed loops in speed-restricted locations automatically reduces the speed of the vehicle. This technology has been used as a control device on railways since the last century. The automatic capping of the maximum speed a vehicle can travel at has also helped.

The completion and the further development of the Galileo System (European satellite navigation system) some years ago has allowed for the tracking of vehicles and people. From a commercial point of view, it has resulted in major transport efficiencies when coupled with the advanced telecommunications systems in place.

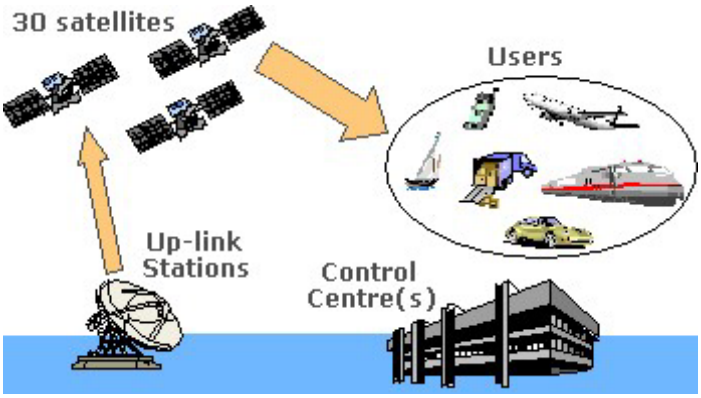

Fig 7 – Galileo – European Satellite Navigation System

The Galileo system has been developed by the European Union, and is based on a constellation of 30 satellites and ground stations providing information concerning the positioning of users in many sectors of transport.

Technology does not come without its downside, and systems such as the Galileo system have invaded personal privacy. The imbedding of

microchips with all personal details encoded has resulted in controversy, but has resulted in monitoring of the movement of some people.

The introduction of the new fuels has greatly assisted the protection of the environment and has ameliorated the disastrous consequences of global warming.

2.3 Changing Perspectives on Energy

The development of energy policy at the beginning of the twenty-first century was characterised by scenario planning by a wide range of agencies and organisations. They included the EU Directorate of Energy, individual national Departments of Energy and private sector companies in the energy business, such as Shell International Petroleum Company Ltd.

While the scenarios themselves did not pretend to be able to forecast the future, the eventual outturn is an amalgam of elements of a number of them. The overarching question that was posed at the start of the century was 'what energy needs, choices and possibilities will shape a global energy system which halts the rise in human induced carbon dioxide emissions within the next 50 years – leading to a stabilising of atmospheric carbon levels without jeopardising economic development.'

Three fundamental drivers brought about changes in the energy system. The first was energy resource scarcity. Coal has not become scarce but is now concentrated in a few countries only, and because of remoteness from markets and costs of exploitation, competitiveness will eventually be affected. Oil production had long been expected to peak, but did not happen until around 2025, resulting in a scarcity of supply. The rate of decline has been slowed by increased vehicle efficiencies, and the focussing of oil demand on the transportation sector. The decreasing costs of biofuels and gas to liquids have constrained oil price increases. There is still uncertainty regarding gas resources, as estimates of recoverable gas have varied since 2025. The challenge remains as the timely development of the infrastructure to transport remote gas economically.

In the earlier part of the century, conventional nuclear development ceased, not only because of safety concerns but because new nuclear developments were uncompetitive. With new technology advances, nuclear power is again approaching competitiveness.

The second driving force in the evolution of energy patterns has been new technology. The combined cycle gas turbine had become the technology of choice for power generation – greatly increasing the demand for gas, which is already the preferred heating fuel. Two technologies that have benefited from manufacturing economies are solar voltaics and hydrogen fuel cells. Fuel cells require new fuelling infrastructure, while photovoltaics need new forms of storage and significant cost reductions.

Fig 8 – Wind Power System

Fig 9 – Photovoltaic Cells

Fig 10 – Wave Station

Fig 11 – Undersea Tidal Turbines

The third key influence that has shaped the energy system of 2050 is social and personal priorities. Government and public attitudes toward energy security and self-sufficiency have, for example, influenced the penetration of natural gas into Europe and Asia. They were also the driving force for government support for renewable energy.

Demographics, urbanisation, incomes, market liberalisation and energy demand have all been important factors in shaping the system, but were not central to its evolution. By contrast, the availability of energy resources and, in particular, the scarcity of oil in the period 2025-2050, followed by gas sometime later, have transformed the system. What has taken the place of oil is an orderly transition to bio-fuels in advanced internal combustion engines, together with a gradual change to new technologies and new fuels, a number of which are hydrogen based. The most important application is the hydrogen fuel cell, which uses hydrogen reacting with an electrolyte to produce electricity to power vehicles, and water as a harmless residue.

Concerns about supply security have complemented the focus on health and environment in stimulating greater energy efficiency. This has prolonged the life of existing technologies, particularly the internal combustion engine. Developments have brought a range of advanced internal combustion and hybrid engines, using as little as one third of the traditional fuel usage to deliver the same performance. Fuel cell vehicles were first introduced more generally in 2005, but fuelling inconvenience and consumer indifference confined their use to fleets. A similar indifference met stationary fuel cell applications.

Natural gas expanded rapidly early in the century, when all new power generation was predominantly gas fuelled. Pan Asian and Latin American gas grids emerged after 2010. Significant LNG trade increased supply and enhanced gas competitiveness. Traditional oil exporters have developed gas exports to reduce deficits and this was increasingly seen as an alternative source of revenue, rather than as competition with oil. After 2020, when gas had become the dominant source of primary energy, growing unease developed about supply security. Uncertainty about the availability of long-term resources and fear of political disruption in supplying countries has already started to constrain expansion.

In the first two decades of the century renewable energy grew rapidly in OECD countries, within the framework of established electricity grids and with strong government support. By 2020 a wide variety of renewable sources, including photosynthesis, wind and photovoltaic solar, was supplying upwards of 20% of electricity in many OECD countries and nearly 10% of global primary energy. Growth stalled as rural communities who were willing to support a few wind turbines rejected thousands, and it became difficult to gain approval for major renewable energy projects.

As oil became scarce around 2040, advances in biotechnology and vastly improved vehicle efficiency brought a relatively smooth transition to liquid bio-fuels and low-cost modifications to existing transport infrastructure. Biomass plantations, originally developed for power supply, have been converted to transport fuel supply.

Since 2025, when the first wave of renewable energy began to stagnate, biotechnology, photosynthesis techniques, materials advances and sophisticated electrical network controls have enabled a new generation of renewable technologies to emerge. The most important of these have been photosynthetic and thin film embedded solar systems. A range of commercial solutions has emerged to store and utilise distributed solar energy. By 2050 renewables have reached a third of world primary energy and are supplying most incremental energy.

In recent years, superior ways of meeting energy needs are being developed to meet customer preferences. It is a world of experimentation and many failures. Automobile manufacturers know that fuel cell vehicles fit the mood of the day because they are cleaner, quieter and offer high performance. The constraint has been fuel infrastructure. The auto industry has solved this problem by producing a 'fuel in a box' for fuel cell vehicles. The fuel itself is made from oil, natural gas or biomass. The boxed fuel is sold through normal distribution channels.

After 2025, the growing use of fuel cells as a heat and power source created a rapidly expanding demand for hydrogen. Large-scale nuclear and renewable energy schemes to produce hydrogen have become attractive since 2030.

The production of hydrogen using wind, tide, wave and solar energy solved the major disadvantage of those sources of power, that the power generation is dictated by weather conditions rather than by when it is needed. This also overcame the problems of introducing this unreliable power directly into the national grid. Using the power to make hydrogen means the energy can be stored as a liquid and used when needed.

Hydrogen was transported in gas grids until the need for dedicated hydrogen pipelines emerged, and a process of development of hydrogen infrastructure has begun. Hydrogen has become the preferred energy carrier and storage medium.

The energy system of 2050 is now heading toward being affordable, sustainable and one that has found solutions to environmental concerns. It has been through its toughest test in meeting the huge energy needs of the vast majority of the world's population as they passed through industrialisation and sought to improve the quality of their lives.

2.4 Predictions of Climate Change

The more pessimistic predictions of climate change implications early in the twenty-first century were proven correct by 2050. Dramatic changes in rainfall patterns in the Northern Hemisphere were mirrored in Ireland with winter rainfall increasing in intensity/runoff by an average of 20% (over the design intensity standards of the twentieth century). Coupled with this run-off phenomenon was the average increase in sea level in the Irish Sea area of approximately 0.4m sea-level rise (SLR). The main driver of this SLR was the lagged response of CO_2 emissions. Despite the eventual implementation of the Kyoto protocols by the world's industrial powers (and main polluters/generators of anthropogenic CO_2) the earth's climate and

meteorological systems continue to suffer from the historic carbon dioxide levels released to the earth's atmosphere.

Engineering drainage design codes have been up-graded to deal with increased run-off to arterial drainage systems and the problem of dealing with flood-plain inundations driven by extreme high spring tides/rising sea-level. The occasional serious storm surge flooding problems of the twentieth century became more frequent and widespread during the first half of the twenty-first century, making it necessary for governments of coastal states to prepare schemes for optimum protection of low-lying urban coastal floodplains critical to the economic well being of nation-states.

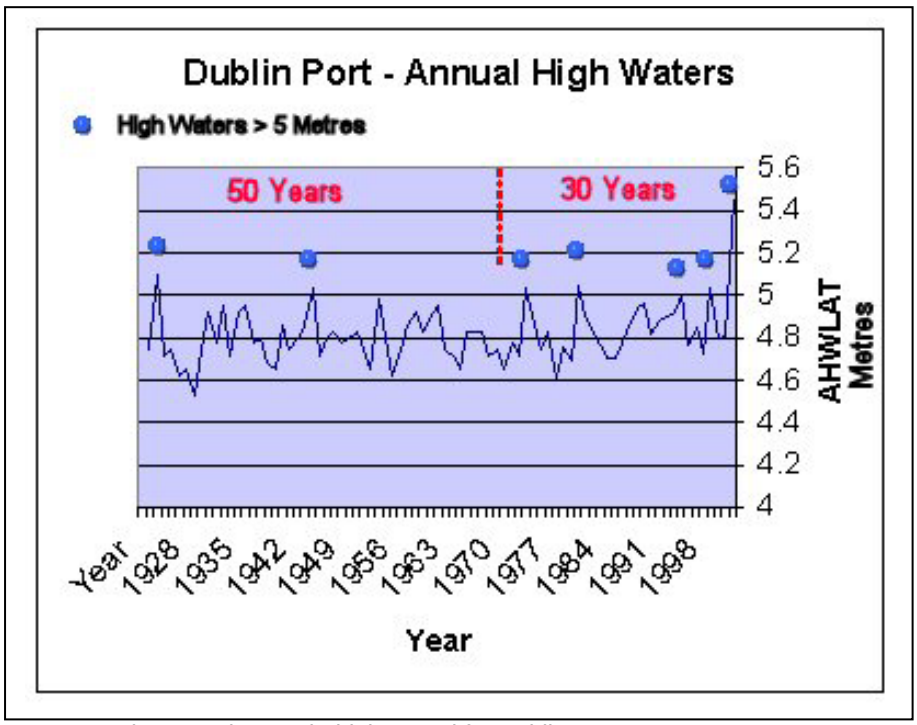

Fig 12 – Observed Tidal Record for Dublin Port – 1923 to 2002

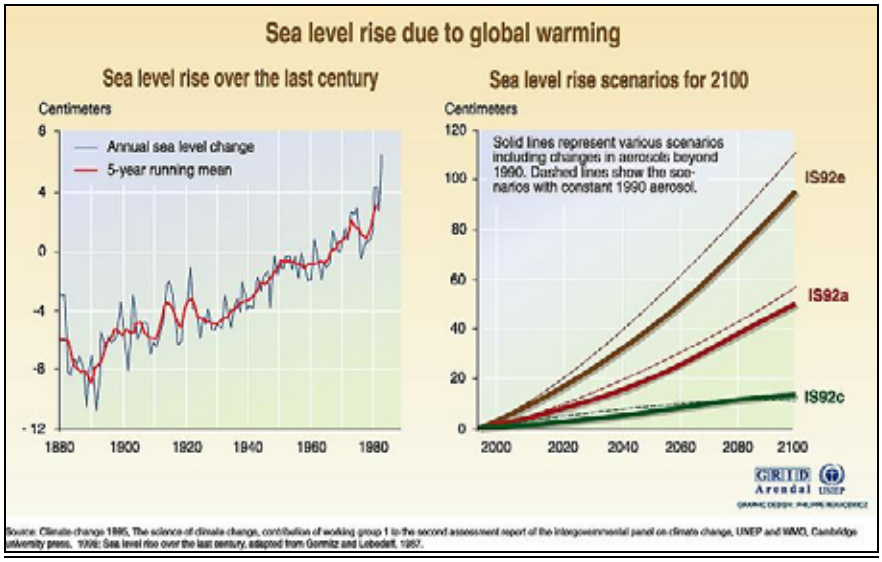

Fig 13 – Sea Level Rise due to Global Warming

Structures similar to the Thames and Lagan Barriers have been constructed in threatened river/port estuaries with dyke type embankments

to protect low-lying urban areas from inundations. Despite the high cost of these essentially civil engineering protection measures, they amount to only a fraction of the economic costs incurred if such areas were allowed to be flooded in storm surge events.

Cities such as Belfast, Dublin and Cork have had major hydrological, runoff and SLR studies completed, protection measures designed and constructed to cater for storm surge events. The Dublin Bay area, for instance, has been protected by the construction of a dyke in vulnerable areas, such as Baldoyle, Sutton, Clontarf and Sandymount, with tidal barriers at appropriate locations.

Fig 14 – M50 Eastern Ring and Tidal Protection Dykes

There was growing evidence at the beginning of the century that weather patterns were changing and that engineers, in designing elements of infrastructure, had to take account of a greater severity of:

- Rainfall – intensity and duration (increased runoff).
- Wind – higher velocities, longer duration of gusts.
- Tides/Wave Heights – abnormal tidal surges have been increasing over the past 20 years; increasing severity of storms and greater wave heights are anticipated with the rising sea level phenomenon.

Design codes and standards have been upgraded to take account of the above scenarios, as weather developments dictated.

It was already foreseen that ports and flood plain areas of adjacent cities/urban areas needed to have their surface levels raised and/or tidal/surge barriers constructed to protect low-lying areas from the effects of rising sea level. These works have been completed.

The construction of the protection dyke around Dublin Bay has provided a ready-made alignment/support for the extension eastwards of the M50 Ring Motorway around the city (Eastern Bypass), with necessary connections to Dublin Port and Dun Laoghaire Harbour as indicated in Fig 14.

2.5 Technology Influences

Looking back over the last 50 years or so, it is clear that our use of technology has greatly increased. It is all-pervasive, and for good reasons, affecting virtually everything that we use and do, particularly in the transportation field.

An example of this is TIM (Traffic Information Manager) which greets us each morning with today's personalised weather forecast, for the region as well as locally (to enable us to choose the best clothes for the day), and gives the best options for the day's travel to work together with the most appropriate timings. TIM has a pre-loaded debit card facility that covers all modes of transport (fares for bus/coach or trains, and network charges if a particular car is to be used). TIM is used for pre-booking a travel slot on the automated highway, for the actual access to and use of the automated highway. It is also available to access the World Wide Web for latest tickets, offers and shopping.

The wrist watch and mobile phone of the early twenty-first century have been replaced by the wristband communicator, which goes far beyond telling the time (it even speaks!) but provides and displays video messages just like the home communicator (which replaced the analogue/digital telephone).

All vehicles now have a registration chip embedded in the number plate (EVI or Electronic Vehicle Identification), to the European standard, containing all relevant information about both the vehicle and the registered owner, which enables its use on the highway. 'No chip no travel', transmits the vehicles identity to the global positioning system and energises the control circuits for the on-board front, side and rear radars and GPS for vehicle position on the carriageway and platooning (road train) position.

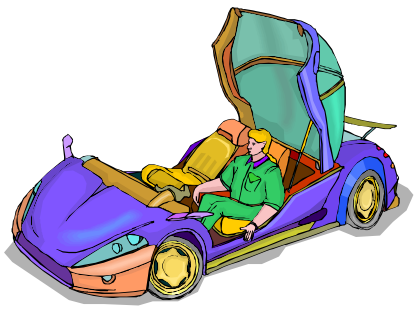

Fig 15 – Sports Coupe

Fig 16 – Town Runabout

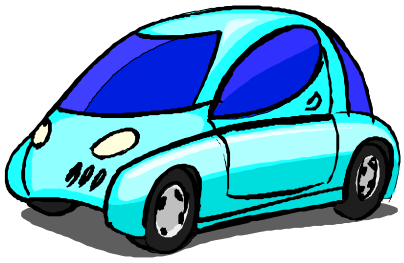

Fig 17 – Single User Urban Fuel Cell Vehicle

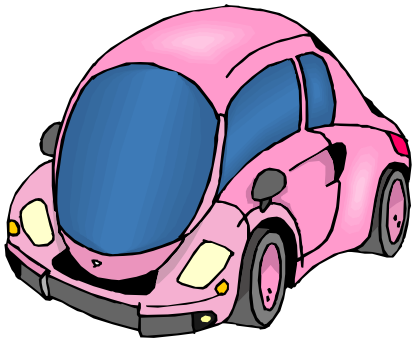

Fig 18 – Full Transparent Front Vehicle

Automated highways took a very long time to be accepted by the general public due to fears of possible breakdowns in the computerised control systems and the potential for major crashes. As their reliability was shown to be high with their continuous scanning techniques, and the carnage on the road was reduced, they have become widely accepted and greatly in demand. This is not just because they are a more convenient way to travel long distances (the driver can relax, rest or read papers as the vehicle is fully controlled by the systems) but their safety record is excellent, having removed the major factor in twentieth century accidents (the driver was cited as a major factor in crashes in 94% of cases) from the control equation.

Automated highways have been constructed in parallel with the 'ordinary' road, as initially there was insufficient take-up to justify the conversion of one of the dual carriageways that were on the route. They are only available, so far, on the major inter-urban routes between Dublin and Belfast, Belfast to Londonderry, Dublin to Cork, Dublin to Waterford, Dublin to Galway and Dublin to Limerick/Shannon, though there is considerable demand for their expansion on to the heavily trafficked urban ring roads, particularly around Dublin and Belfast.

At the start of the twenty-first century, roads were the only transportation infrastructure where the user did not have to pay a charge for its usage. Around 30 years ago, after many attempts to introduce various forms of congestion charging, parking levies, charges for use of new ring roads and estuarial crossings (by toll plazas), the technology improved (GPS and roadside monitors) to enable network charging to be introduced nationwide. This system was considered to be more equitable, as it involved all members of the public. All users had to pay for their usage of the network, though at variable rates, depending upon the traffic importance of their part of the network. The key acceptance factor was the use of all of the funds raised from this charge system for improvements to the overall transportation infrastructures.

All vehicles carry onboard displays, which show continually the rate at which the debit, which you must have before entering the network, is being drawn down. This alerts users to the fact that their journey is costing them money and shows how variations of routes can affect this draw down rate. These onboard displays also show the route planned and progress along it and are linked to the vehicles' monitoring systems to, for example, indicate whether there is enough fuel on board to complete the journey or display the location of the nearest refuelling point.

The majority of drivers now gain access to their vehicles through recognition by the vehicles' sensors of their personally embedded 'life' chips. These "life" chips were originally intended to provide a health safety net for at-risk patients whereby their movements were continually

monitored by GPS systems and if immobile in risk areas (middle of the street, footpath, stairway) for too long the medical people were alerted to respond. A number of patients were identified by this system in time to save their lives and the publicity from these cases made the more general introduction of the embedded chips much more acceptable (in spite of the major objection to personal identification cards earlier in the century).

Due to the security protocols built in (everyone has a unique identity, no two are alike anywhere in the world) the "life" chips are increasingly used for personal identification when making credit card type purchases, as well as providing easier access to many shops, bars and restaurants that have installed the recognition hardware at their point of sale outlets.

Security is a major continuing feature of present day living, with the access points to all modes of transport having basic screening devices to identify any dangerous or illegal materials such as explosives, drugs and radioactive material. Criminals and those recorded for offences (through their 'life' chips) are granted only centrally approved access/journeys.

The evolution from fossil fuels for motive power to fuel cells based on liquid hydrogen and ethanol was completed some 20 years ago, and fossil fuels have now been banned from public use (even coal fires in domestic appliances). This has greatly enhanced the environment through reduction of CO_2 and NOx gases. The ban was necessary, due to the escalation that occurred after 2010 when the reductions from technological improvements to vehicle engines based on fossil fuel derived energy were overtaken by the sheer increase in numbers of vehicles.

Take-up in the new fuel technologies was slow, though the first filling stations for liquid hydrogen were introduced in the UK and Iceland as long ago as 2003 and followed on in Dublin and Belfast shortly thereafter.

Most of the liquid hydrogen needed for transport is derived from solar, wind and tidal power generation stations, where the intermittent nature of these stations requires energy to be stored. This storage is too inefficient for battery or similar storage devices, thus the energy created is used to refine water into its constituents of oxygen and hydrogen, which are then stored under pressure as a liquid for subsequent re-use. The whole energy cycle is self-sustaining and in line with the current government requirement for all energy sources to be sustainable in the longer term.

One of the catalysts for the conversion to fuel cell technology was the introduction in 2015 of the PPQ (Personal Pollution Quota), which detailed the maximum pollution an individual could cause each week when using transportation modes, and left the choice of mode to the individual on a daily basis. This was based on the model introduced in Scandinavia in 2012, which was contentious initially but quickly adopted by the environmentally sensitive population there. The quotients for each modal type were based on the train/tram being 0, walking and cycling -1, buses 1, lorries (with fuel cell power units only) 4. Fossil fuelled cars were 10, hybrid-engine cars 3 and fuel cell only cars 2. The length of journey in each mode acted as a multiplier of these figures.

The transport control systems identified the person and the vehicle used and calculated the pollution quotient, notifying this to the individual through their TIM. This meant that people gradually moved from the "gas guzzlers" to Smart Cars and used public transport more readily.

Smart cars are made to be safe, more comfortable and reliable, with a fuel range around 400 Kms. They are constructed with a 'one-box' body,

providing a high-strength cage to seat either four occupants (as in the family car) or maximum of two occupants (the daily run about or city car). The body cage is covered with a minimum weight skin, which can be replaced easily when repairing surface marks.

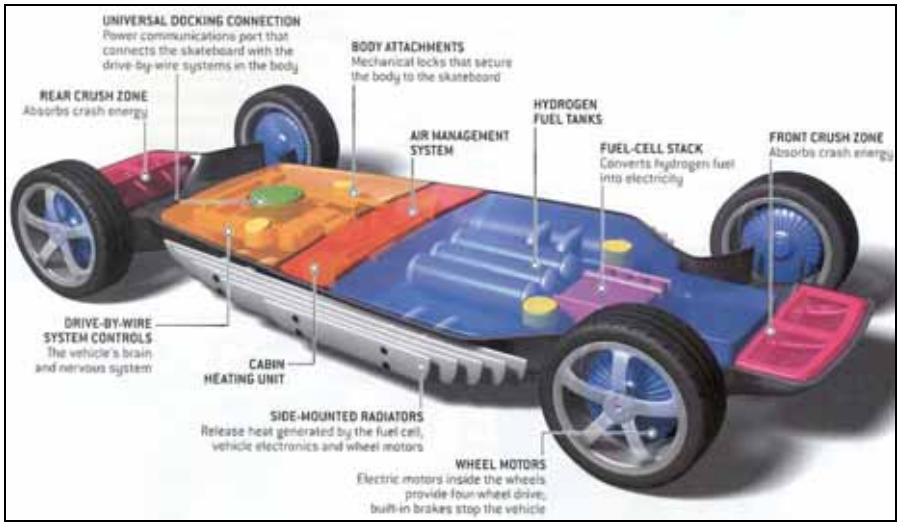

Fig 19 – Skateboard Chassis

The finish no longer requires paint, but is an easily applied foil, which can be equally easily replaced if the owner wishes to change the appearance of the vehicle. Of materials used in the construction of the cars 80% are recyclable. They are constructed to be quiet, safe, reliable, green (environmentally sensitive) and easy to drive.

The power train (engine and transmission) is now based around the hydrogen fuel cell. The internal combustion (IC) engine has largely disappeared, other than in some of the older cars, which are kept by many as antique and classic cars from a bygone era. Even these have mainly been converted to run on liquid hydrogen as the IC fuel, or increasingly to ethanol. Hybrid engines (IC and electric) were the interim stage of development to the zero emissions vehicle, but were superceded by diesel hybrids and the fuel cell.

The design of the modern vehicle has integrated the fuel cell with drive-by-wire technology, replacing previous, predominantly mechanical systems for steering, braking, throttling and other functions with electronic controlled units. This has freed up space as electronic systems are generally less bulky than mechanical ones. Drive-by-wire technology has eliminated the need for the previous conventional instrument panel, foot pedals and steering column, and replaced these with a single steering guide control. This contains a video display panel, performing all the functions of steering, braking and accelerating, which can be swung into position for use from either side of the vehicle, freeing up the driver and any passengers to have more toe space and better frontal visibility, as there are no engine compartments or dashboards to obscure the view.

Transmissions were also revolutionised by mounting two or more motors directly on the wheels, thus eliminating the previous gearbox, clutch and transmission system.

Fig 20 – Interior of Drive-by-Wire Vehicle showing Increased Driver Space

The overall ride quality is much smoother, as the power is applied directly to each wheel without gear change snatches.

With light carbon bodies and electric motors installed at wheel level, the centre of gravity of the modern car is kept low. This improves road holding to a marked degree for the smaller vehicles with aerodynamic styling to ensure that vehicles are not blown off the carriageway.

Speed control is a standard feature built into each vehicle, as required by legislation, incorporating the GPS system to identify location and a roadside database (communicating with the vehicle's monitors) to identify the speed restriction. This control system is normally set to fully automatic, wherein the vehicle sensors identify a move into a speed restricted area (30 mph zone for example), alerts the driver audibly and reduces speed to the specified limit, with the driver retaining steering and braking control. The driver can, however, override this by pressing a button and reducing the speed manually. This facility is deemed necessary in emergencies and heavy/congested driving conditions. When activated, the vehicle gives audible warnings to the driver until the speed of the vehicle is reduced to the particular limit in force.

Today's car is designed to provide 'living room' style comfort, with a full range of audio and video displays (including TV news reports, though they are now received via the Web satellites), which are only available when the vehicle is in motion and under transport system control. Where the driver is actually in control of the movement of the vehicle, these displays are limited to the traffic information and navigation displays (even mobile telephony is switched off) with alerts for accidents and congestion that may lie ahead. The full multimedia package is available when the engine is switched off.

The vehicle's built-in sensors and diagnostic systems carry out an analysis of its fitness at a pre-arranged time each day (or whenever a fault develops) and if maintenance is required communicates with the garage (to which it has been previously registered) to book the necessary service. The results of the booking are communicated to the owner for confirmation. The vehicle is then collected by the garage staff, coupled up using a virtual tow bar arrangement (one driver, many vehicles) and driven off for maintenance. When repairs/maintenance are completed, usually during the same evening, the garage returns the vehicle to the owner. Sometimes

in the early hours of the morning a convoy of three or four vehicles, being returned to their owners, can be seen winding their way through the streets.

Cars come in three basic sizes, the four up plus luggage family car, the city runabout which carries a maximum of two people and a smaller, narrower version, which is for a single occupant only but needs less kerb space when parked.

Some illustrations of these car types are shown in the figure below.

Fig 21 – Merlin Electric Vehicle – Single User

Fig 22 – Four User Family Car

Congestion does not apply to the automated highways, where access is not permitted until there is sufficient space available to complete the journey. Queuing is done off-highway. During the journey the navigation display shows the continually updated estimated journey time to keep the passenger aware of how the system is operating and so they can make appropriate plans to accommodate the journey time. Whilst in the holding area waiting to access the automated highway, the same display shows a countdown of the queue time until the vehicle joins the highway. The holding area facilitates use of toilets, shops and so on, at the interchange and when stationary the full range of audio and video facilities are also available to make best use of the waiting time.

Wideband access to the Internet is available to every home in the land and built in to all new builds. This supplies access to most of the information needs of the average family. However, it also gives people the choice of working from either home or communal office facilities. A large proportion of the current working population, particularly those in the service industries, do in fact work from home, which has greatly reduced the daily journeys to work. This has been most successful where a dedicated 'office area' has been set aside in the home. Some of the work journeys have been replaced with extra leisure time journeys, arising from the ability to replace regimented office hours with the greater flexibility of home working. Productivity analyses have shown that for most people there have been considerable increases in productivity from home working, to the extent that improvement in lifestyles (greater free and leisure time) has ensued.

Communal offices are sited close to schools and shopping areas and are largely accessed on foot/cycle from a travel interchange. This facilitates one of the parents being able to get their children to school whilst going to work, without having to use their car for that specific purpose. It also permits the human interaction that a lot of business activity requires and provides access to all of the wideband office facilities that modern commercial and industrial business demands (downloading work requirements from head office by e-mail, accessing on a worldwide basis

the best and most up to date knowledge, uploading completed work to where it is required and arranging face to face meetings).

In the last 20 years there has been a revolution in the construction of the new and the maintenance of the old infrastructure. The network charging system and the associated reinvestment in transportation has funded much of this. Downtime and out of use time has been sharply reduced with considerable benefits to the travelling public.

This has been achieved through innovative plant design and modular construction of running surfaces. The top renewable pavement surfaces are prefabricated in off-site production units under factory conditions (that is to tailor made solutions with high-quality assurance). Pavement materials are transported to site, 'unrolled' and installed, at a rate of almost 5kms per working day, for almost immediate use. Compaction is minimal, as the materials are compacted in the factory initially and the units are simply stitched together by means of microwave heating of the factory prepared bonding surfaces. After one passage of the microwave equipment and roller, the road surface is immediately ready to be driven on.

The innovative plant used for repaving, and new construction paving also, has been based around the one-pass Goliath Rolopaver, introduced to Ireland in the early 2030s. This has been instrumental in reducing new construction and maintenance times to an absolute minimum. Pavement materials are delivered to the site in large rolls, and then heated by microwave equipment to allow them to be unrolled without cracking the layers. The microwaves also activate the bonding agent, a geosystatic fabric layer, ensuring good adhesion when unrolled and in place. The same process, microwaving, is used to unstitch worn surfacing prior to its replacement with new pavement material. This ensures large areas are removed and replaced (up to 5kms per day) with the minimum of disruption to traffic.

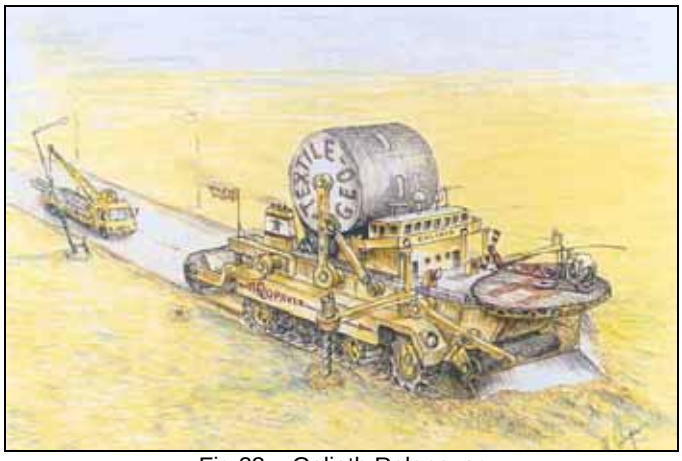

Fig 23 – Goliath Rolopaver

The modular construction also incorporates materials which give 10 dB(A) noise reduction and smart lines, which can be changed to enable variable lane flows as required. The smart lined road also enables "zipping" through its electronic guides. Further sensors are built in to the surfacing to measure strains, volume and type of traffic, temperature of surfacing (for icing action for example) and a system to recover energy from the blacktop through heating from the sun and reuse when ice formation is imminent.

Concrete products used on the highway were impregnated with a catalyst, titanium dioxide, to absorb the nitrogen oxide (NOx) pollutant gases

produced by vehicle power sources. These, in sunlight, help to convert the nitrogen oxide to nitric acid, which in turn is neutralised by the high alkalinity of the concrete product. Around 80-90% of NOx, which comes into contact with these products, is consumed. Products include bridge superstructures, safety barriers, retaining walls, concrete pavements and kerbing. These products remain in use even though most of the NOx gases from transport have long since almost disappeared.

The introduction of network charging for road usage has allowed successive governments to continue the work in upgrading the infrastructure, and the country can boast a good road and rail network.

The development of the Western Economic Corridor with its rail and road links between Derry, Limerick and Cork has had a huge impact in this area. The development of state of the art hospitals and universities has resulted in a pattern of movement hardly envisaged 50 years ago. Now the main movement is along this corridor, and instead of the major facilities being placed in Dublin, it is now possible for the population to receive medical treatments in their own areas without the need to attend at hospitals on the east coast.

The development of the Diagonal corridor linking Newry/Dundalk with the midland town of Portlaoise and with Cork has greatly enhanced this area. The completion of this corridor finishes the commitment to provide three economic corridors in the country with inter-linking connections.

3 TRANSPORT

3.1 Strategic Links

Trade volumes to and from Ireland in relation to the island's population density have always been considered too low to justify the enormous cost of constructing a fixed link such as a tunnel or bridge to the UK and onward to the Continent. The construction industry has over the last 50 years developed improved tunnelling methods, resulting in more certainty as to the final cost, and developed the techniques of building the major infrastructure projects. Both these improvements resulted in lower costs. The major enterprise of a fixed link between Ireland and Wales thus became viable in the larger scenario. Hugely increased intercontinental trade movements developed between the European Union, the United States and Asia, which have been the result of the drift of manufacturing to the Far East over the last 60 years or so.

Fig 24 – Hub Port Facilities

This quantum increase in trade was facilitated by the construction of giant container ships of 250,000 DWT at 21m draught with a capacity of around 18,000 TEU^{S} (20ft. container units) with necessary huge hub ports equipped with appropriate handling equipment for servicing such ships.

Coupled with this inexorable trade growth to and from the western EU ports (such as Rotterdam, Hamburg, Antwerp and Le Havre) was the growth of resistance by the environmental lobby, successfully preventing the extension and development of such ports to handle/service these giant container ships. Another contributory factor was the increasing number of accidents of ships in the English Channel, which was the result of congestion and shallow waters. This brought about large increases in insurance rates for large ships to use those waters, resulting in the shipping companies looking for alternatives.

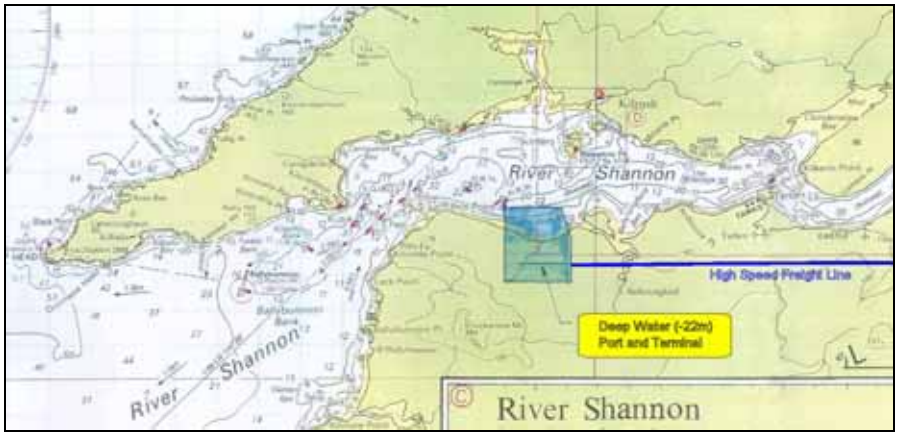

Fig 25 – Shannon Estuary Freight Entrepôt Location

The Shannon Estuary had long been identified as an ideal location for the construction of a high capacity/deep draught container port. Its

development and eventual connection - with a dedicated high-speed rail connection across Ireland, via the 'Tuskar' Sub Sea Tunnel across the UK and via Channel Tunnels to the Continental High Speed Rail Network - allowed double-stack container trains to distribute the trade onward to Europe.

Fig 26 – Shannon Estuary Freight Entrepôt to Tuskar Tunnel Alignment

The opening of the Shannon Estuary Freight Entrepôt, with the land link to Ireland (North and South), has provided a fast and efficient artery for both intercontinental freight transfer and fast passenger trains connecting to British and Continental conurbations on the International Standard Gauge (1.43m.) track. Where required, dual gauge and re-aligned and upgraded tracks have been laid in Ireland to provide necessary access to Eurostar, Shuttle and double-stack container trains.

The development of the Shannon Estuary Freight Entrepôt and concomitant support services have given further impetus to the economic enhancement of the western corridor (Cork, Galway, Sligo, Enniskillen and Derry) concept of counter development to balance the Belfast-Dublin-Wicklow/Carlow economic corridor along the east coast of the island.

The success of the Tuskar tunnel has given added impetus to the proposal for a fixed link connection from County Antrim to the Mull of Galloway in Scotland under the Beaufort Dyke. The Beaufort Link is now anticipated as a road tunnel. The debate still continues about usage by trains. The difference in gauge between Ireland and GB raises many difficult questions that have not been resolved. Present planning will allow dual use in the future, should a rail connection prove to be an appropriate solution.

The construction of the Beaufort Link has only proved possible following the engineering developments in the past decades in the methods of constructing links over very deep waters such as the Beaufort Dyke, which separates Scotland from Ireland. Early attempts to construct this tunnel in the late 1800s by a railway company never got beyond a few exploratory shafts sunk in Co Antrim.

3.2 Ports and Shipping

At the turn of the century it was accurately predicted that:

- Ports will be subjected to controls in relation to type and volume of trade permitted in specific categories; some relocation of port modal facilities from congested cities is considered likely.

- Ports will be encouraged to specialise in specific trades or modes and ship types/configurations.

- Both ship design and port equipment will likely develop to enable higher capacity/faster loading and unloading to be achieved for the ever-increasing J.I.T. requirements of industry and trade.

- Concepts such as ship-to-shore cranes capable of multiple container lifts and/or docking arrangements, enabling a container ship to be serviced along both sides (thus shortening time in port), are also envisaged. It is likely that with advances in technology (and reliability of equipment), increased automation will be applied to port terminal operations.

- Ship hull design is likely to develop along the lines currently indicated, that is multi-hull designs in strong/light weight materials, for fast premium services. Conventional ships for container and bulk trades are likely to increase in length, beam, draught, tonnage, speed and increased energy efficiency – all leading to the need for ever improved port facilities and necessary intermittent upgrading as technology advances.

- The construction of a fixed link (sub-sea tunnel) between Ireland and the UK should not have a major effect on trade throughput of the main commercial ports. For example, the Channel Tunnel between England and France has not significantly affected traffic through the Dover/Calais ports. It is likely that premium trades/perishables and passenger-car shuttle traffic would be the main users of such a physical link, apart from the intercontinental container traffic alluded to already.

The maritime transport scenario for the island of Ireland at the middle of the twenty-first century has not changed significantly from its historical importance in handling over 95% by volume and approximately 90% by value of the island's trade.

The technological developments in fast ship design, apparent at the start of the twenty-first century, have continued apace with the construction of high-speed (40 knots) container and Ro/Ro ships, providing increased frequency and speed of service.

Fig 27 – High Speed SWATH Vessel

These large, relatively shallow draught (SWATH-small water plane, twin hull) vessel designs require new configurations of port facilities to handle their specialist loading/unloading requirements and provision for manoeuvrability of these large vessels. For the Lo/Lo mode, long outreach/high capacity (multi-lift) and high reliability cranes are required. For the Ro/Ro mode, high capacity/multi-deck bridge ramps are required for fast loading operations.

The main commercial ports now have efficient (motorway standard) connections to the upgraded road network and, where appropriate, upgraded rail connections have been provided for specific trades.

Fig 28 – Loughshinney Port

The introduction of more stringent government and EU planning and operational controls on ports has led to the relocation of certain trades and facilities from the larger ports to smaller (upgraded and new-build) port locations (such as Loughshinny, North County Dublin to handle bulk and also oil trades previously handled in Dublin Port) to alleviate unnecessary congestion at the larger ports handling containerised trades.

The trade of the two main domestic ports on the island has grown (in million tonnes) as follows over the past 50 years:

Year	2000	2050
Rep. of Ireland	45.3	100.0
Northern Ireland	21.5	50.0
Dublin	20.0	40.0
Belfast	12.5	28.0

Fig 29 – Total Trade – Ireland (Mt)

The GDP growth rate has averaged at approximately 2% per annum over the 50-year period, permitting more rational and coherent budgetary planning in the all-important areas of investment in planning of necessary infrastructural developments and facilities.

3.3 Civil Aviation

3.3.1 Features of the Last Twenty Years

The main features of the last twenty years that have influenced the aviation sector have been the following:

- The huge development of efficient, high-speed rail and road services throughout the island. Access has been further improved by the imminent start-up of the Rosslare/Pembroke (Tuskar) tunnel.
- The continuing depletion and increasing cost of hydrocarbon fuels and the sluggishness of the aviation industry in accelerating research into alternative energy propulsion.

The industry has so far successfully deferred the inevitable change to alternative energy-sourced propulsion systems by using highly innovative

improvements on the existing technology. These have included improved engine technology, improved lightweight composite materials in the airframes, wider use of large-capacity double-deck aircraft, high altitude mesospheric flight tracks, fuel-cell technology and so forth. Extensive trials of aircraft powered by hydrogen-gas combustion have been ongoing over the last five years in the US and France, and it is expected that the first commercial flight will operate in 2060. The final phasing out of hydrocarbon-powered aircraft is expected to occur by the end of the twenty-first century.

Public acceptance of the use of hydrogen for ground transport has now been achieved, but it will take another ten to twenty years before people will accept it for aviation travel. The legacy of the Hindenberg disaster in 1937 still lingers, and while lightning rather than hydrogen was the direct cause, it will take a few more years before hydrogen will become accepted as a safe power source. Work to overcome the large-scale technical problems of hydrogen storage both on the ground and on board the aircraft is ongoing, and is expected to be resolved in the next five to ten years.

3.3.2 Airports: Dublin Area

It is well over 60 years since the first of the twin parallel runways – RW 28L – opened for traffic on mid-summer's day in 1989. The second of the twins – RW 28R – eventually entered service in 2015 after lengthy planning problems, and the system is now working well.

Fig 30 – Second Runway at Dublin Airport

It is estimated that 51 million passengers will pass through the airport this year. Since the lengthening and strengthening of 28L in 2025 to cater for maintenance and provide for heavier long-haul traffic, it is anticipated that the system will cater for traffic for the foreseeable future.

The addition of two passenger terminals and four aircraft passenger parking piers is working well, and caters adequately for economy class airlines with rapid turnaround aircraft times. Vastly improved all-weather air navigation procedures, particularly in the approach areas, based on the Galileo European satellite navigation network have virtually ensured 90% integrity of the traffic timetables. The metro connection to mainline rail systems, and Dublin, is operating satisfactorily every 15 minutes. Taxi and bus operations, along with the new automated highway to the city and along the six-lane Eastern Bypass, are working well.

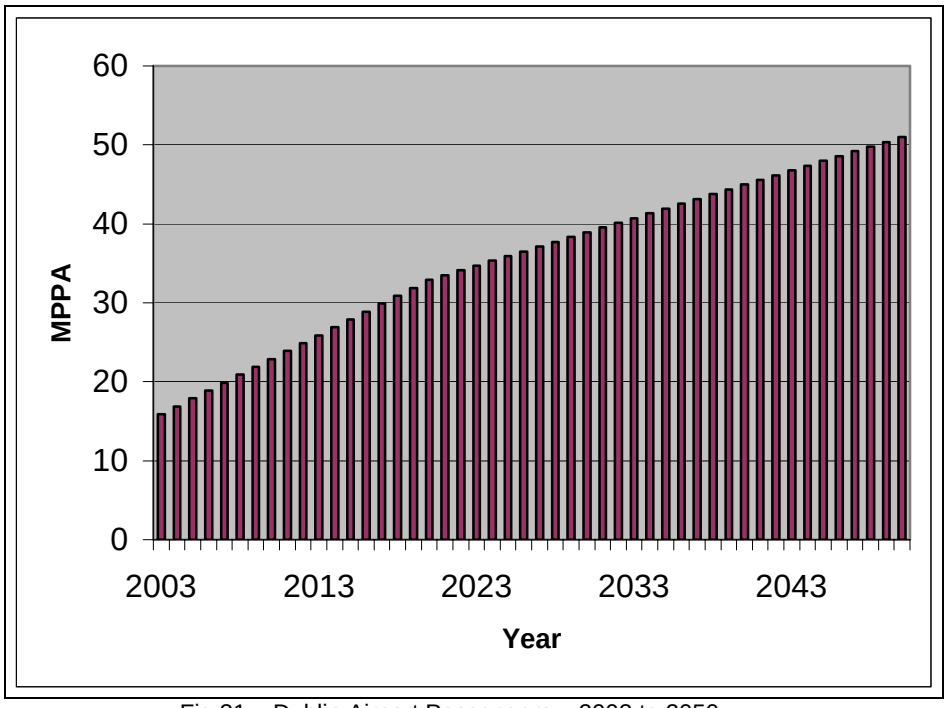

Fig 31 – Dublin Airport Passengers – 2003 to 2050

Virtually all general aviation traffic is now operating from Casement (Baldonnel), thus freeing up Dublin Airport for large commercial jet operations. Since the main terminal was upgraded ten years ago for the larger double-decker aircraft, the frequency of these aircraft is increasing, after a slow initial usage.

3.3.3 Airports: Belfast Area

The commercial case for an extra runway at Belfast International Airport has yet to be proven. Annual traffic, at 15 m.p.a., is still well short of that of Gatwick at the beginning of the century. The continuing development of manufacturing industries, the stable political situation and vastly improved surface road and rail links with the Republic means that Dublin will remain the major aviation hub for the island of Ireland. 'Leakage' to Dublin, particularly for low-cost, short and medium haul operations will probably continue, and Aer Lingus, which has survived many vicissitudes, is now a very successful operator, with Dublin Airport as its main base of operations. Belfast City Airport continues to operate as an excellent reliever for Belfast International. All major carriers now operate through Belfast International Airport, but there is sufficient peripheral traffic to ensure that Belfast City Airport remains a viable entity, particularly due to its convenient downtown location.

3.3.4 Shannon Airport

Since the break-up of Aer Rianta in 2005 and the subsequent elimination of the compulsory North American stopover, the airport has slowly recovered from the slump that consequently followed. The airport has developed as a major European airfreight hub, mirroring the role of the Tuskar Tunnel System for surface rail freight traffic.

The new transatlantic shipping terminal in the Shannon estuary has already generated significant extra air traffic through the airport. The Shannon Estuary Freight Entrepôt is ensuring the viability of the airport for the foreseeable future.

3.3.5 Cork Airport

The airport in Cork continues to evolve at a steady pace, reflecting the increasing development of the region. A significant factor has been the rapid expansion of peripheral satellite towns, such as Ballincollig, Watergrass Hill and Bandon, in line with the development of the pharmaceutical industries around the harbour areas. Cork is now the fifth largest pharmaceutical centre in the world.

3.3.6 Regional Airports

The island network of regional airports is a valuable backup for the international services through the main airports. Improvements in hydrogen propulsion technology have particularly improved the economics of the operation of small commuter aircraft. The regional airports that have survived the recession of the 2020s and 30s (Derry, Farranfore, Knock and Galway) are doing well and their future looks bright.

3.4 Inter Urban Road Development

3.4.1 The Past

Roads have always been the dominant mode of internal transport in Ireland, accounting for 90% of freight traffic and 96% of passenger traffic.

While Ireland had reasonably good road coverage in terms of road density, the quality of the road infrastructure was poor by EU standards. For example, in 2000, about 0.1% of the total road network in the Republic of Ireland was of motorway standard compared with an EU average of 1.3%.

Road travel has grown significantly in Ireland in recent years. The number of private cars had risen by 44% since 1992 and stood, in 1999, at 1.3 million. However, car ownership levels were still low by European standards; in 1997 there were 442 cars per 1,000 population in the EU as a whole, and the 1998 figure for Republic of Ireland was 309 per 1,000 population (358 per 1,000 population in Northern Ireland). The number of goods vehicles had risen by over 34,000 since 1994 and stood at 170,000 in 1998.

Traditionally, the level of investment in roads had been low, by any standard. The first major increase in road investment in the Republic of Ireland came with the Operational Programme for Transport (OPT 1994-1999) that had, as an objective, to complete the development of the National Primary Road network by the year 2005. This investment aimed to achieve a level of service equivalent to 80 kph inter-urban journey average operating speed on the network.

The Programme recognised Ireland's peripheral location, without a land link to the rest of the EU, and requiring efficient access to ports and airports in order to minimise the economic disadvantage of the absence of such links. It also recognised Ireland's dispersed patterns of development and human settlement, and the increasing concentration of economic activity in the major coastal cities of Dublin, Cork, Limerick, Galway and Waterford, in addition to Belfast and Londonderry in Northern Ireland. The total cost of implementing the proposed road improvement works to upgrade these roads by 2019 was estimated at €7.3 billion (in 1998 terms).

Taking account of the unprecedented economic growth of the late 90s, and of the consequent growth in traffic, it was apparent that there were significant deficiencies in the road network, particularly in the national roads. This issue was addressed in the Roads Provisions in the National Development Plan 2000-2006 (NDP). In the NDP, a route development approach was taken, together with a higher Level of Service objective of achieving an average inter-urban speed of 94kph on dual carriageways and 105kph on motorways.

The primary road transport objectives for national roads included the improvement of the reliability of the road transport system, and the improvement of internal road connectivity between and within the regions to foster balanced regional development, to better facilitate access to and from the main ports and airports, to facilitate continued economic growth while ensuring a high level of environmental protection and to achieve the objectives of the Government Road Safety Strategy. The amount provided in the NDP for national road improvement was €6 billion. This programme has continued apace and largely been met, but with some slippage in output objectives due mainly to delays in project start-ups and to unusually high levels of inflation in the construction sector of the economy.

In Northern Ireland the strategic direction was set out in the 'Shaping our Future' Regional Development Strategy for Northern Ireland 2025. The Regional Transportation Strategy for Northern Ireland provided the detailed impetus for increased funding for the roads infrastructure therein, as voted by The NI Assembly. The vision was to have a modern, sustainable, safe transportation system, which benefits society, the economy and the environment and which actively contributes to social inclusion and everyone's quality of life.

The work included the widening of the western approach to Belfast, M1 to Westlink; completion of the A6 Toome and A21 Comber Bypasses; improvements to the A1 from Dromore to Newry and A8 Belfast to Larne; together with Bypasses on the A5 at Newtownstewart, Strabane and the A2 at Limavady.

3.4.2 Drivers of Change

There are a number of factors in Ireland's ongoing development and growth, which have acted as drivers of change and determined the nature of the society and the levels of economic activity that needed to be served by the road transportation system.

The population of the island of Ireland has grown to nearly 8 million by 2050. Dublin contains 2.0 to 2.5 million and Belfast has 0.75 to 1.0 million people. The rest of the population is largely located in the growth centres, in those gateway and hub towns and cities identified in the National Spatial Strategy, (2002-2020) for the Republic of Ireland and also in the Regional Development Strategy for Northern Ireland 2025. As a policy, growth has been confined to these areas and the tendency, widespread in the early part of the century, to develop isolated housing units in rural areas has been arrested through a structured approach to planning and development.

The level of car ownership has increased significantly and the number of cars is now approaching 4 million on the island in 2050. The car is the dominant modal choice for personal travel and reliance on congestion to reduce traffic growth caused damage to the economy.

Advances in telecommunications have provided opportunities to reduce traffic growth by encouraging tele-shopping, tele-working and tele-conferencing. Better information flow on road conditions and on alternative modes of transport have abated traffic growth somewhat and were more successful having been applied in a voluntary manner rather than imposed.

Road transport has traditionally been one of the largest contributors of greenhouse gasses and other pollutants. Developments in technology have considerably reduced this damage, as car construction and engine technology have developed substantially. The body and engine of the car are much lighter and the efficiency has improved by a factor of four or five over 2000 levels. The hybrid car (diesel/electric; petrol/electric) has reduced emissions significantly. With reducing carbon-based fuel availability the fuel cell, using compressed hydrogen gas, has now become the main form of propulsion.

Information technology has enabled much better system management to be achieved. Satellite GPS has facilitated vehicle identification for tolling, traffic law enforcement and vehicle location. It facilitated the introduction of automatic speed controls both in vehicles and on sections of the network. Road pricing at various points and at varying times has been introduced using smart card technology.

These developments have increased network capacity, helped the environment and managed congestion. The growth in truck numbers in the vehicle pool has continued and trucks remain the dominant means of moving goods because of their flexibility and cost effectiveness. Improvements in vehicle technology have made trucks quieter, safer and more fuel-efficient.

3.4.3 The Present: 2050

In this year, 2050, the National Spatial Strategy (in the Republic of Ireland), and the Shaping the Future Strategy (in Northern Ireland) have been fully implemented and have matured. The Dublin conurbation now exceeds 2.0 million people, and is part of a multi-centred metropolis that spans the eastern seaboard of Ireland, from Carlow to Larne. This entire area contains as many as 4.5 million people.

Substantial development has also taken place in the regional centres, located around the gateways/hubs identified in the National Spatial Strategy and in the Regional Development Strategy. This approach has ensured that more balanced economic development has taken place throughout the island than was emerging before these strategies were put in place and implemented.

Such a distribution of both population and economic activity has brought about a radical change in the shape and configuration of the National Road Network, required to serve the entire population equally.

The Euroroute, E01, (Rosslare-Larne) has been fully developed, comprising dual carriageway from Rosslare to North Wicklow and motorway around Dublin and northwards to Newry with a new motorway from there, linking with the M1 approach to Belfast at an enhanced interchange near Sprucefield. From there, the Westlink (to motorway standards) and M2 connect to Larne by a new dual carriageway. A significant development in the North of Ireland, unforeseen before the twenty-first century, has been the motorway up the east side of Lough Neagh, linking the M1 and the M2 motorways and Belfast International Airport. The ‘Junction 8’ intersection east of Moira between this, the M1

and the motorway to Dublin, attracted unprecedented inward investment at this location, while the connection northwards to Larne contributed significantly to the successful regeneration of the Port of Larne.

Motorways have been constructed linking Dublin with Cork, Limerick and Galway. A dual carriageway has been provided from Kilcullen to Waterford via Carlow and Kilkenny. The north west is served by a dual carriageway from Kinnegad through Mullingar and Longford to Sligo, and major improvements have been made to the road from Sligo to Donegal, Lifford, Letterkenny and Derry. The north east is served by a high standard single carriageway from Dundalk to Cavan, through Edgeworthstown to Athlone.

A dual carriageway link has been provided between Limerick and Tarbert to provide access to the new Shannon Estuary Port.

The Western Corridor has been built, linking Derry, Sligo, Castlebar, Galway, Limerick and Cork, with the strategic connection from Limerick to Waterford and Rosslare. The network has been further developed by a dual carriageway having been provided between Cork, Limerick, Ennis and Galway and the south west, served by a substantially improved Cork through Killarney and Tralee to Limerick road. The south east is further served by a substantially improved Cork to Waterford road.

A good quality dual carriageway has been provided between the end of the M22 at Artresnahan and Londonderry with bypasses to all major intervening towns. The A26 has been extended through the Frocess to Coleraine and on to Londonderry. The road from the end of the M1 at Dungannon has been upgraded to dual carriageway to Ballygawley. The routes from Ballygawley through Enniskillen to Sligo, Ballygawley through Monaghan and Ardee to Dublin, Ballygawley through Omagh and Strabane to Londonderry, Enniskillen to Omagh, Coleraine through Cookstown, Dungannon and Armagh to Newry have all been upgraded to high standard single carriageways to 80 kph average operating speed design.

The M3 Motorway has been extended through the Sydenham Bypass to Bangor along a completely new alignment with a major intersection, which serves Belfast City Airport and the D5 Developments.

This comprehensive network has provided a high level of access and linkage between all the major development nodes on the island of Ireland.

A number of new routes are in place, which were not previously identified. In the Greater Dublin Area two significant developments have taken place. The first is the full completion of the M50 to a full motorway box configuration, through the extension of the Port Tunnel across Sandymount Strand, built on the flood protection barrier, to link with the M11 south of Dun Laoghaire. This provides essential circulation and distribution capability right round Dublin City, as well as providing direct access to the National Primary Network for the large volumes of ferry originating traffic from the ports of Dublin and Dun Laoghaire.

A new Orbital Ring Route, to motorway standard, for the Dublin conurbation has been developed linking the 30km necklace of towns Balbriggan – Dunshaughlin – Enfield – Kildare. This provides a better level of service for North/South traffic and avoids the congestion of the outskirts of Dublin for through traffic.

A new dual carriageway route, called the Diagonal, has also been provided linking Dundalk/Newry, Kells, Mullingar, Tullamore, and Portlaoise, linking the north eastern developed area with the midlands hubs/gateways,

providing through access to the south east, south and south west. This route has been extended, also to dual carriageway standard, from Portlaoise through Carlow to Enniscorthy to link with the E01.

Fig 32 – All Ireland Inter Urban Routes with Development Nodes

In more recent times automated highways have been constructed parallel to the 'ordinary' road, as initially there was insufficient take-up to justify the conversion of one of the dual carriageways that were on the route. They are only available, so far, on the major inter-urban routes between Dublin and Belfast, Belfast to Londonderry, Dublin to Cork, Dublin to Waterford and Dublin to Limerick/Shannon, though there is considerable demand for their expansion on to the heavily trafficked urban ring roads, particularly around Dublin and Belfast.

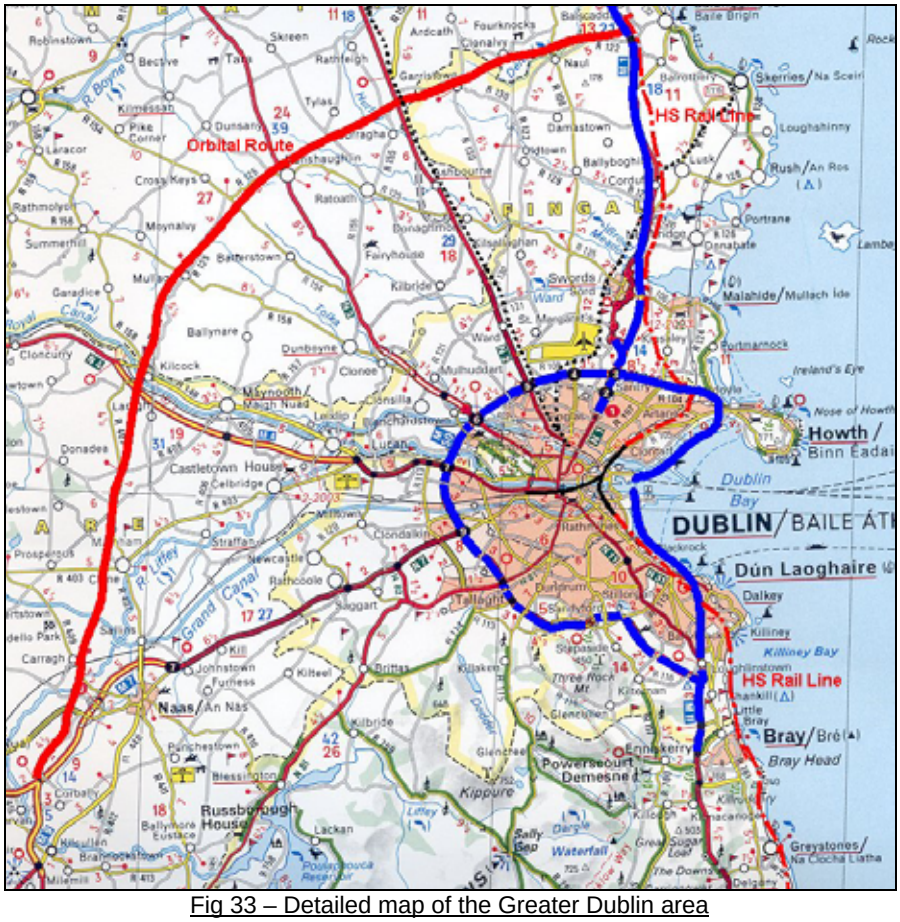

Fig 33 – Detailed map of the Greater Dublin area

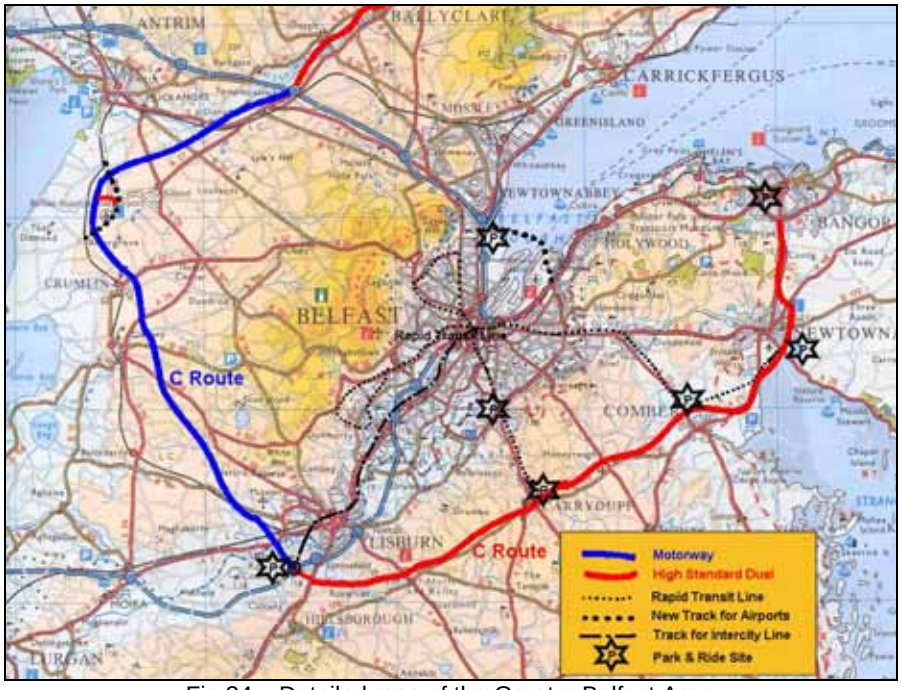

Fig 34 – Detailed map of the Greater Belfast Area

3.5 Railways

3.5.1 1950-2000

There were no railways in Ireland 250 years ago. This was the same as the rest of Europe; the rail system in Ireland developed in parallel with Europe.
Construction started in the 1830s, reaching fever pitch in the 1840s, and by 1870 most of the natural route ways facilitating railway engineering had lines in place. In 1840 Ireland had a population approaching 8 million with few large urban areas. The rail system grew to its zenith in about 1911, by which time the population had dropped to around 5 million and there had been a big shift to urban areas.

Following the Second World War the development of road transport and the improving wealth of people led to an increase of car ownership and an increase in the carriage of freight by road. Traffic by rail decreased, but traffic levels on roads was still not causing congestion.

Investment in an improved road infrastructure for Northern Ireland went hand in hand with the closure of many railway routes. Rail closure in the Republic was a lot less severe but the rate of investment in roads was lower.

By the 1980s congestion on the road system was beginning to become a problem, particularly in the urban areas of Belfast, Cork and Dublin and in other cities. It was in Dublin and Belfast that a sufficiently large population and large physical area existed for the rail network to be an attractive proposition for alleviation of urban road congestion.

Belfast rearranged its rail system to allow through running of commuter passenger trains and Dublin developed the electrified DART system. High-quality trains were introduced on the Belfast to Dublin route and on the Dublin to Cork route.

Lack of the necessary funding meant that the full potential of the rail system could not be developed. However, the investments that were made were sufficient to show that there was potential in rail travel in Ireland when a quality service with good frequency was established.

3.5.2 Drivers of Change

Railways, as distinct from road or air transport, have taken the greatest advantage out of developing technology because of one simple fact. Trains being restricted to running on track do not have the freedom of aircraft, ships or to a lesser extent road traffic to depart from the selected route. Thus it was much easier to control the movement of trains and provide a quality service. As travel and freight traffic increased, even areas of sea and air space were becoming congested and suffering greater control and lack of journey reliability.

All the technology was available at the turn of the century to control trains from the satellite and central signal cabins and change the duties of the driver or not have one. There were freight trains running in Australia under computer control, which were showing improved timing and 25% fuel use reduction.

We also had the ability to create near total reliability, as had been done for aircraft. This was applied to trains.

With technology and a human desire to make rail travel a customer friendly experience, the railways have become the preferred means of travel for the commuter and for medium distance travel. Because of the size of the island this means a major portion of the travel in Ireland. It is important to realise that this has meant concentrating on the conditions and service experienced by the traveller to ensure a very high level of expectation and to satisfy that.

3.5.3 2000-2050

Belfast and Dublin have developed their commuter travel with Metro type systems of various types such as DART, LUAS and Eway. These, however, used to share track with intercity services, putting an increasing restraint on the frequency of service of commuter services and the speed of intercity services. To overcome this, additional tracks have been laid on the main intercity routes into Belfast, Cork and Dublin. Both the track and the rolling stock have changed significantly, the concentration being on giving a better experience to the traveller.

Ireland has ceased to have two different rail inclinations. The same specification for track over the whole island has concentrated the provision of a better ride quality.

Prompted by EU legislation, a Rail Safety Authority covering the whole Island resulted in common signalling and communication standards, but except for the new line from Shannon to connect up to the Irish Sea tunnel (see Tuskar Tunnel later), the track gauge peculiar to the island of Ireland remains.

Fig 35 – High-speed Trains

The development of new signalling systems operated from satellites has greatly reduced the capital costs and now controls most of the train operations in the country.

The introduction of high-speed express trains on the Dublin to Belfast and Dublin to Cork lines have been a huge success with journey times greatly reduced to one hour 10 minutes and two hours 15 minutes respectively. Consideration is now being given to a Dublin to Galway high-speed service and a high-speed connection to the Tuskar Tunnel.

A new tilting train service has been completed between Dublin and Wexford to interchange with a new passenger service to the continent via the Irish Sea tunnel.

Many new lines have been opened, most on the bed of lines that were closed in the past. These new lines are radiating from our major cities. The rail tracks to Galway have been doubled, while the rail connections to Heuston and Connolly Stations in Dublin have been quadrupled in order to meet customer demands. The rail connection to the airport and the new city centre loop connecting Connolly and Heuston has proved a major

success and this has allowed through trains to operate from Belfast to Cork.

Fig 36 – Inter-urban Train

The restricted capacity caused by the single line crossing of the Lagan in Belfast, built in the 1990s with the cross-harbour road bridge, has been relieved by widening this section of the railway to double line track.

The new western rail corridor connecting Derry, Sligo, Galway, Limerick and Cork has been one of the major driving forces in the economic development of the western corridor. This corridor now boasts three international airports, six universities and four major hospitals with multi-disciplinary teams of medics – truly centres of medical excellence.

The route developed from the Shannon estuary to north of Wexford then under the Irish Sea to south Wales and into the British freight network via Bristol, has been the biggest infrastructure project ever undertaken in the country. The old Great Western track from Bristol to London has for a large part greater clearance to standards set by Brunel for his broad gauge. This line is dual gauge from the Shannon to Wexford, enabling it to carry wagons of European and Irish track gauge and with clearances equal to or greater than Eurotunnel trains. This project has been developed in order to cater for the large ships serving Europe through the Shannon Estuary.

Intelligent train operation control based on radio communication has led to moving block systems for controlling the speed of trains on the same track to support denser train operation. This includes onboard forward monitoring to detect obstacles at crossings and stations by image processing.

The most dramatic change to the control of trains has been the use of new signalling systems. These have been developed following the introduction of a European controlled satellite navigation system (Galileo). Combining the highly accurate knowledge of the location of trains from GPS with radio communications and track side safety systems allows the railways to have much more frequent services with clockwork timing.

This has resulted also in detailed timing information being available at all stations and aboard all trains. The television sets at home are able to display all this information at the flick of a switch, with all the routes applicable to your family being the first to be displayed. All these developments are part of the TIM (Traffic Information Manager) system.

3.5.4 Trains – Fuel Cells

The increasing use of the train as a means of transport put pressure on the emissions from engines, or in the case of electric trains from the generation of electricity. The development of the fuel cell using hydrogen as its source of energy has had a particular attraction for railways. The system required considerably less capital to install than electrification. The storage of the

hydrogen, which takes up much more space than diesel fuel, is not a problem on a train, unlike cars. It was also attractive in that there is greater control of both development and running of the railway system. This gave greater confidence in the development of railways as the first major transport system to use a new form of motive power on a large scale.

Fig 37 – Tilting Train on Tight Curve

Tilting trains with coaches that have a moving centre of gravity have been further developed to cope successfully with tight curves.

Developments in noise reduction have made their way into track and coach technology, driven by legislation to reduce noise pollution.

Power recovery systems to use the energy from braking have become more common on electrified railways and also on internally powered trains as electricity storage systems are refined from the automobile industry.

Information technology has improved passenger information, as well as the reliability of the railways.

Payment for travel by way of pre-paid smart cards and the Internet are now the most common systems in use.

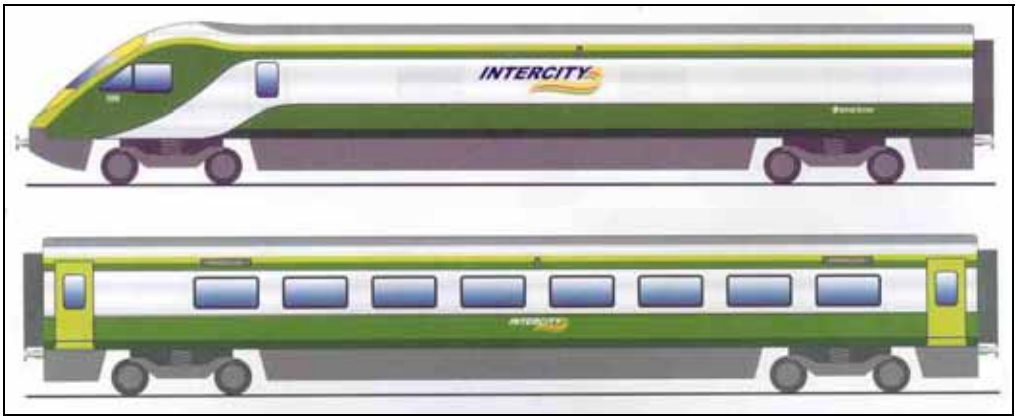

Fig 38 – Intercity Train Livery

Fig 39 – Ireland Rail Map of the System

3.6 Urban Transport

3.6.1 Urban Vision

In considering the position of urban transport, the situation in Dublin and Belfast will be dealt with in this report.

3.6.2 1940-2000

The first 60 years have seen the car become the prominent means of transport, as increasing wealth has enabled ownership to quadruple. In that time public transport has seen the demise of the railways and their resurgence during the last 20 years of the twentieth century. Trams disappeared in the 1940's to be replaced by trolley buses. Electrification

was introduced as the prime mover power source, to be followed by diesel as double-decker buses took over. These were then replaced by single deckers, and recently the resurgence of the double-decker bus. What did not happen in that period, with a few exceptions, was the development of an integrated system in the city or a big improvement in the quality of the public transport customers' experience. This is not very surprising because ridership fell as car ownership increased and roads improved.

3.6.3 Traffic Congestion

The increasing congestion caused by more cars caused a rethink. Firstly, to improve the role of public transport, and secondly in the beginning of the century culminating in planning policies to curb the need for movement by people for their everyday life.

Congestion in Dublin, for instance, resulted in average journey times in the city increasing substantially, with average speeds reduced from 8mph in 1994 to 5.6mph in 2002.

Route	Speed (mph) in 1999	Speed (mph) in 2002
Tallaght – Rathmines - Centre	10.6	5.6
Ballyroan - Harold X - Centre	7.5	6.25
Sandyford - Ranelagh - Centre	8.75	5.0
Monkstown - Centre	8.1	5.6
Finglas - City Centre	12.5	8.1

Fig 40 – Average Journey Times in Dublin

3.6.4 RAC Study

A study (Motoring towards 2050) carried out in the year 2000 under the auspices of RAC Foundation in England included the following conclusions:

- Travel has grown three-fold between 1950 and 2000.
- Traffic has grown much faster than road capacity.
- The prime driver of car traffic growth has been car ownership growth.
- Limiting car ownership is unlikely to be an effective way to check traffic growth.
- In the year 2000 road transport accounted for half of most pollutants and a fifth of all CO2 emissions.

These conclusions applied equally in the island of Ireland.

3.6.5 Dublin - The Present: 2050

In the year 2050, the population of the island has grown to 8 million. In the same period average GDP growth has been 2.0% per annum. The population of Dublin has increased to 2.5 million during the same period.

Car ownership in the greater Dublin region has now increased to one car for every two persons. Luckily, car usage at peak times into the city has decreased as public transport systems have improved.

There have been substantial road improvements in the past 50 years. These improvements included the completion of the Port Tunnel, the Eastern Bypass, a new ring road to ease traffic on the M50 and a new orbital road linking Balbriggan, Dunshaughlin, Enfield and Kildare. See Fig 32.

The bus system continues to play a very important role in dealing with peak hour passenger traffic in Dublin. The introduction of quality bus corridors has caused a dramatic improvement in the quality of public transport.

The introduction of exclusive rights of way for public transport and of quality bus corridors at the beginning of the century has impacted in a very positive way, with ridership increasing enormously on their introduction as shown in the table below for 2001.

Route	Increase year 2001
Stillorgan	240%
Lucan	37%
Malahide	44%
Blanchardstown	27%

Fig 41 – Route Ridership

3.6.6 Platform for Change

The Dublin Transportation Office, in its 2000 report 'Platform for Change', set out a vision for public transport for Dublin up to the year 2016. While the plans set out took longer to implement in some cases, there is no doubt that the vision outlined in the document, and highlighted below, has been achieved:

- A city and region, which embraces the principles of sustainability.
- Encompassing a leading European City, proud of its heritage and looking to the future.
- Having at its heart the national capital, seat of government and national centres of excellence.
- A strong, competitive, dynamic and sustainable region.
- A living city and region, on a human scale, accessible to all and providing a good quality of life for its citizens.

The Dublin Transportation Office strategy to get a major transfer from the private car to public transport has been achieved. The modal split of traffic coming into the city centre at peak hour is shown in the table below.

Each year, a survey is carried out to determine the modal split of traffic entering and leaving the inner canal ring of the city. The results over a number of years are shown below.

	1991	1997	2002	2016*	2050
Population	1,249	1,430	1,536	1,750	2,500
Cars	319	439	559	840	1,250
Employment	470	582	741	878	1,300
Peak traffic by Car	110 (63%)	181 (72%)	232 (72%)	180 (37%)	245 (34%)
Bus	44 (26%)	47 (19%)	60 (19%)	69 (14%)	115 (16%)
Rail	18 (11%)	22 (9%)	28 (9%)	239 (49%)	360 (50%)
Total	172	250	320	488	720

* 2016 with METRO/DART in operation

Fig 42 – Dublin Region 1991-2050 ('000s)

The proposals for the development of transport corridors for Dublin set out in the 'Platform for Change' have now been developed with both road and rail links to the capital.

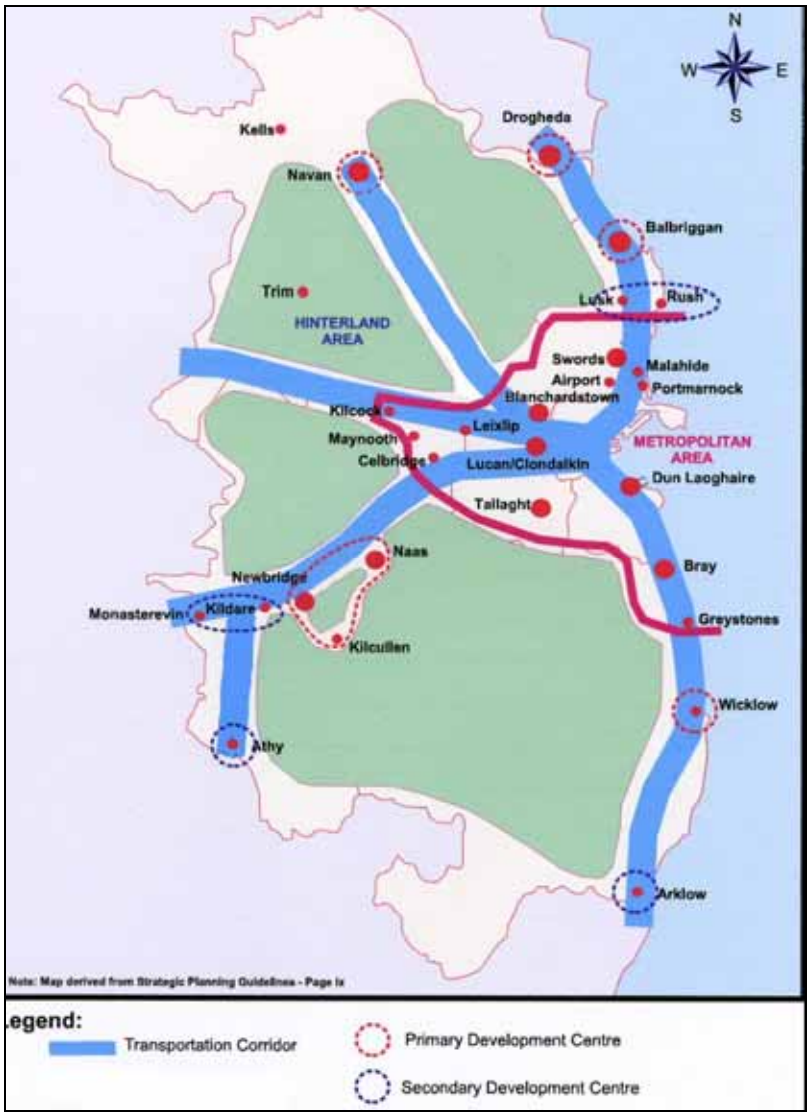

Fig 43 – Dublin Transportation Corridors

With the increase of the Dublin population to 2.5 million, the city boundaries have been extended, particularly to the north and west of the city, necessitating the extension of rail based public transport systems.

At the beginning of this century it was agreed to use the DART system as the backbone of the now well established METRO-DART system. This meant that the chosen rail gauge for the METRO was the same as that on the Iarnrod Eireann main line. This was in line with proposals put forward by the Voorhees Report in the last century, which envisaged the DART as the METRO for Dublin.

The decision to combine the DART and METRO proposals was taken at the time mainly on technical compatibility (both systems had similar signalling and rolling stock characteristics) and now the system offers train headways of less than one minute in busy areas. This decision also allowed both Iarnrod Eireann rolling stock and METRO-DART trains the use of the tunnel connecting Connolly Station, Spencer Dock, Stephens Green and Heuston Station.

The rail-based system developed for Dublin was generally configured in accordance with the Dublin Transportation Office visionary 'Platform for Change' document, which was published at the beginning of the century.

The shape of the present public transport systems in the Dublin area are shown below:

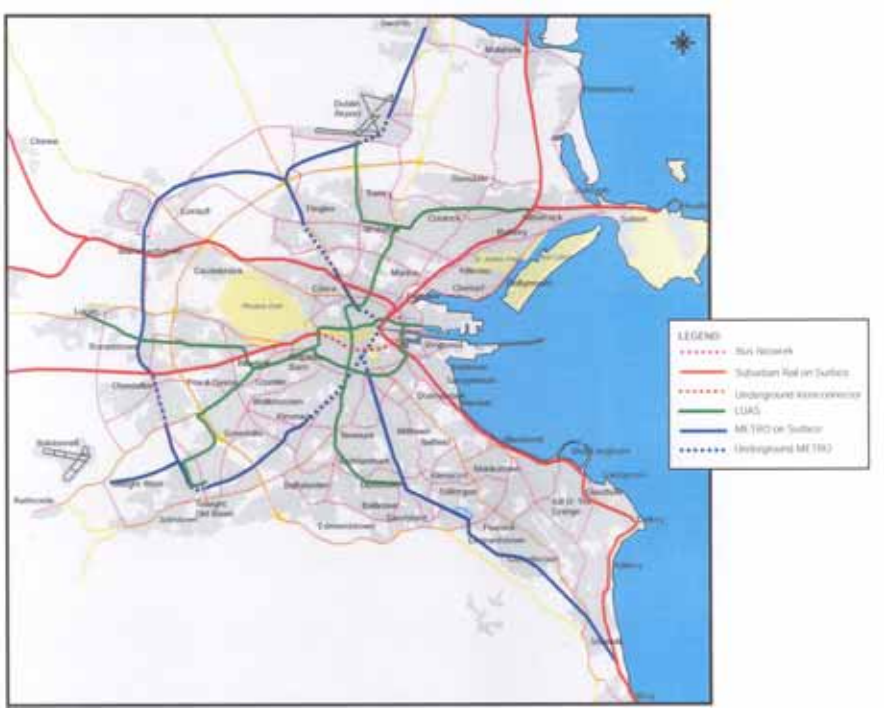

Fig 44 – Integrated Transport System for Dublin

Fig 45 – Integrated Rail Transport System for Dublin

3.6.7 Belfast

The Belfast Metropolitan Transport Plan (BMTP) published in 2003 covered the period up to 2025. The implementation of the plan saw a major swing towards public transport, as outlined below.

Five new stations on the existing rail network, two of them being major park and ride sites, West Lisburn, and at the Carrickfergus/Trooperslane area. The other stations are at City Airport, Gamble Street (Cathedral Quarter), and at Great Victoria Street, which is a redevelopment. The last two are now the city's two major public transport interchanges. Major redevelopments have taken place in these areas.

The introduction of a Rapid Transit System for Belfast has been an outstanding success. Four routes, West Belfast, Tillysburn/Harbour Estate, Dundonald and Cairnshill, serve the city centre. All except West Belfast end at major park and ride sites and serve the routes not covered by existing railway lines.

The development of park and ride facilities at the following places has greatly assisted the development of public transport in the greater Belfast area:

- On the Railway System -
  West Lisburn
  Carrickfergus

- On the Rapid Transit System -
  Dundonald
  Cairns Hill
  City Airport

- On the Motorways -
  Kennedy Way (West Belfast)
  Fortwilliam (North Belfast)

The provision of fully integrated facilities for taxis at major bus, rail stations and some park and ride sites and the use of bus lanes, have assisted in reducing the use of cars in the city centre.

Major road improvements have been carried out during the early part of the century. These included:

- Widening of the M1 and junctions of the Westlink.
- Improving capacity at the Sandyknowes junction on the M2 and the length to the Greencastle junction.
- Widening the A2 at Greenisland.
- Widening the A2 Sydenham bypass from the M3 to Tillysburn.
- Mentioned for consideration at four other routes:
  - The Outer Orbital (A55).
  - The A24, Downpatrick road outside the Outer Orbital.
  - The A20, Newtownards road outside the Outer Orbital.
  - The M1, from Blacks Road to Lisburn.

3.6.8 Intelligent Transport Systems

Extensive traffic management schemes to reduce some routes' attractiveness to vehicles and to provide greater priority to public transport and local movement were introduced.

Implementation of Real Time Passenger Information systems and the roll-out of an integrated ticketing scheme from the electronic system were introduced.

Other innovations included:

- Variable messaging signing and parking information.
- Bus priority at traffic junctions.

The introduction of network charging, originally to help finance road improvements, has now been successfully used to help reduce congestion in the city centre, with the funds raised being applied to improve public transport and the road network. Charges are variable in time and in place. Rural areas are free, while main corridors are charged at different rates according to the level of usage at the particular time, much as had been introduced previously in Singapore.

3.6.9 50 Year Review (Belfast)

In this year of 2050, we are still complaining about traffic but it is a different sort of complaint about a different transport system.

More of us have our individual 'cars'. We are able to use them for journeys between our houses in the suburbs, to travel to park and ride stops for rail and bus, for journeys to adjacent towns and for our trips to the country and seaside. We are still using them to do our shopping at the large regional shopping centres, which have grown to the extent that they have developed their own internal bus friendly systems.

Our cars have become more suitable for local traffic in the metropolitan areas. There is less private commuter traffic, allowing greater frequency of commuter public transport.

The biggest change has been the development of busways. The lack of railways to serve the south eastern approaches to the city caused increased congestion and this produced an opportunity for the introduction of busways, which have proved successful.

The other rapid transit bus-based systems have been changed to light rail or tram systems where increased capacity was required. The city centre of Belfast 50, years ago, was already an area into which cars were not normally allowed. This area has been extended. Large numbers of the streets in the centre of the city have in consequence been roofed over, including Westlink for much of its length.

The central area has become a better integration of work, shopping and leisure, and in contrast to regional shopping centres has a large residential population. Better boarding facilities for suburban buses have been developed in the centre of the city so as to allow it to become friendlier to shoppers. Major transport interchanges have become established, defining the boundaries of the central area of the city serving the suburban areas and the outlying park and ride sites.

The control of all rail-based transport systems has been taken over by computers with infrequent intervention by humans.

The private car can now be controlled by a traffic management system and this is now obligatory on most metropolitan transport corridors.

The track from Belfast to Lisburn has been increased to fast and slow tracks in each direction to serve the needs of intercity and commuter trains.

The line from the city centre to Bleach Green has one additional track to allow more flexibility for stopping, and limited stop trains to be interwoven in the timetable.

Travel times on intercity trains have been reduced by 30%. Commuter trains are no faster, but the quality of the service is such as to make it a pleasure to travel even during the rush hours.

The new forms of motive power (i.e. the emissions are safe) that have been developed allow all stations to be fully covered from wet weather.

All the main travel corridors out of the city that are not provided with a rail system have had their rapid transit bus systems changed to tram or rail-based systems.

A new system has been built following an orbital route with interchanges at intersections with each of the radial systems. These interchanges form in most parts the centre of local shopping and service areas. Local buses use them as feed points for their services. These are also the centre point for some of the park and ride schemes.

The impossibility of providing good public transport in rural areas and the increased numbers of car owners has led to a great increase in private road traffic in rural areas. The increasing unattractiveness of driving into and through the Belfast urban area resulted in much greater flows of cars and lorries in the rural areas surrounding the city. The answer to this has been the construction of the Cordon like C route. This joins Larne, Ballyclare, Antrim, Lisburn, Comber, Newtownards and Bangor to form a cut off and by-pass route, leaving the enclosed ring to be served by a frequent public transport system.

The intelligent transport system is still the main information service source for all travellers. We can key in our destination and be directed on the best route to use our cars. We may be given no option but to use the defined route or face a heavy charge. It may from time to time come up with a combined car/public transport route as the best solution.

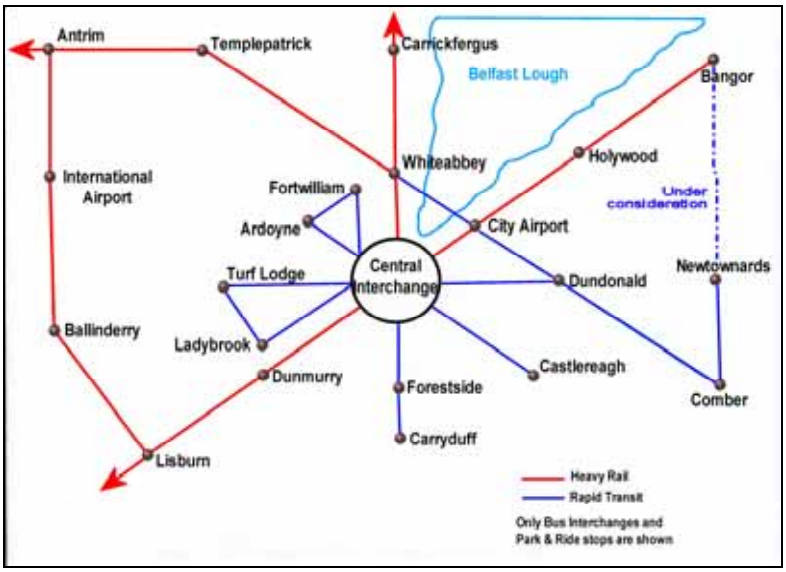

Fig 46 – Belfast Transport System Schematic

Other Cities

In addition to the cities of Dublin and Belfast five other cities – Cork, Limerick, Galway, Waterford and Derry – have major growths in population, as shown in the table below.

City	Population 1996	Population 2002	Population 2020	Population 2050
Cork	325,000	350,000	454,000	516,000
Limerick	214,000	236,000	284,000	320,000
Galway	127,000	146,000	192,000-	217,000
Waterford	111,000	119,000	138,000	200,000
Derry	103,000	107,000	126,000	160,000

Fig 47 – Other Cities Population Growth

With car ownership at about 4 million throughout the island, cities have tackled the car congestion problem by developing good public transport systems using existing railway infrastructures, light rail systems and enhanced quality bus systems.

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