

Design-Driven Innovation: Sustainable Transport Opportunities for the Inland Waterways of Ireland

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Abstract

The inland waterways of Ireland have over 1000km of lakes, rivers and canals linked into a network of seven navigations, managed by Waterways Ireland. They have responsibility for the management, maintenance, development and restoration of inland navigable waterways principally for recreational purposes. In contrast to Ireland, mainland Europe uses Inland Waterways Transport (IWT) mainly for freight transport. Approximately 88% of all the transport services performed by IWT in the EU are accounted for by The Netherlands, Germany, Belgium and France. The modal split share of inland shipping in Germany (11.2%) and in the Netherlands (36.7%) are significantly higher than the EU average of 6.2 % in 2011. The figures for newly built river cruise ships have grown since 2007 to 23 ships in 2012, when 900 cabin ships passed through the Main-Danube Canal. The total labour force of the IWT in Europe is estimated to be 43,860. The share of the total employment in the freight and passenger IWT sectors are 60% and 40% respectively.

This paper presents a new scenario for the use of the inland waterways of Ireland for both freight and passengers, developed using a Design-Driven Innovation methodology. Statistical analysis of national annual road freight transport was carried out using the EU Eurostat database to determine potential freight volumes that this integrated transport proposal will support. The key objectives of the scenario are to support the EU CO₂ targets for transport and to reduce congestion, by transferring road transport logistics and public transport to the inland waterway. Several vessel concepts are developed including a canal catamaran freight vessel, a catamaran water bus platform for public transport and tourism, and a new vessel sector the Cruise-Logistics-Ferry (CLF). The key driver for the CLF is sustainable luxury, as the tourism role of the vessel facilitates the transports and logistics needs of rural communities on the Shannon-Erne Waterway.

A key aspect of the scenario is the implementation of an e-maritime support platform to develop smart shipping corridors based on volumetric navigation concept (VNC) and fleet management operation (FMO). VNC will provide a navigation support tool to increase infrastructure use and passage density capability by 20% on regulated areas. FMO is focused on emissions reduction which can be obtained through an optimization of waste times of shipping stakeholders. Truck fleet management concepts will be applied to fleet vessels in order to monitor and optimize times of voyage of vessels. The slow steaming concept will be applied taking into account the status of truck fleet expected to pick up the cargo of the vessels. ETA and ETD times of vessels and trucks will be optimized as a consequence of sharing information between stakeholders involved.

1 Introduction

Ireland's canal system (the Grand and Royal Canals, and feeders) was built or improved in the 18th and 19th centuries to provide an effective commercial transport infrastructure. The canal system provided an artery for both passenger and goods transport. The building of the Grand Canal from Dublin to the river Shannon (144 km) commenced in 1756 and was completed in 1804 [1]. Work on the Royal Canal, running 146 km from the river Liffey in

Dublin to Co. Longford, began in 1790 and was completed in 1817 [2]. The canals soon faced competition from horse drawn coach services and then from the railways which followed the canal routes in places. In turn the advent of fast cost effective motorised road transport for passengers and freight made the canal system obsolete. Trade via the canal system ended in 1960 when the last Guinness boat arrived in Limerick from St. James Gate, Dublin, and most of the canal network was closed to commercial navigation [1]. During the 1970s navigable sections of the canals were used by pleasure cruisers and the volunteer group, The Inland Waterways Association of Ireland (IWA) [3], were instrumental in promoting the canal system. Redevelopment of the canal system as a public amenity took place from the late 1980s through to the 1990s under the direction of *Dúchas* The Heritage Service (the national body at the time responsible for natural and built heritage). Today the restored canals and towpaths provide a means of recreation for boating enthusiasts, fishermen, walkers, joggers and cyclists. The inland waterways are now maintained by Waterways Ireland (WI) [4].

Increased awareness of an over reliance on fossil fuels and the need to reduce transport CO₂ emissions (formalised in EU and national directives) has brought into sharp focus the need for energy efficient transport modes for passengers and freight. An IEA report [5] states that: "Shifting freight from energy intensive modes such as road and air to rail and shipping should be a priority for many countries. Freight road transport has significant external costs..." The IEA recommends that governments focus on improving the sustainability of freight transport and notes that this requires the provision of infrastructure to assist with improved freight logistics and to encourage modal shift. Comparing energy use by sector for EU-28, Ireland has the highest percentage energy consumption for transport at 40% compared to an EU-28 average of 33%.[6]

In an analysis of the modal split for freight transport between road, rail and inland waterways, for EU-28 in 2012, Ireland has the highest reliance on road infrastructure for freight transport at 99.1% compared to the EU-28 average of 75.5%. Ireland does not use the inland waterways for freight transport compared to an EU-28 average of 6.7% [6]. A recent Environmental Protection Agency report on sustainable transport in Ireland concludes: "There is a policy gap in the area of freight and policy makers should develop a separate national freight strategy with input from stakeholders and industry representatives in order to evaluate the potential for more efficient road freight and freight modal shift from road to rail and/or inland waterways." [7] The present paper provides a preliminary investigation into the potential of the inland waterways of Ireland for carrying commercial transport – freight and passengers.

2 Inland Waterways of Ireland

The navigable inland waterways of Ireland comprise over 1000km of lakes, rivers and canals linked into a network of seven navigations, managed by Waterways Ireland (WI) [5]. WI have responsibility for the management, maintenance, development and restoration of inland navigable waterways principally for recreational purposes. The maximum dimensions of craft permitted are length 18.50 m, beam 3.90 m, draft 1.20 m and height over water 2.75 m [8]. The navigable inland waterways of Ireland are not currently used to carry commercial freight. Waterways Ireland's figure for Ireland of over 1,000km of navigable inland waterway is similar to the UK's figure of 1,050km where 3,704,000 tonnes of freight were carried in 2013 [6]. This suggests a preliminary indication of the freight carrying capacity of the inland waterways of Ireland. This tonnage amounts to approximately 3% of the Irish road freight tonnage for 2012.

3 Design-Driven Innovation

To facilitate design innovation marine designers should consider implementing a Design-Driven Innovation strategy as is often employed within product design. People do not buy products but buy design meanings. People use things for profound emotional, psychological, and socio-cultural reasons as well as utilitarian ones. Analysts have shown that every product and service in consumer as well as industrial markets has a design meaning. Marine designers should therefore look beyond features, functions and performance, and understand the real design meanings users give to vessels.

The process of Design-Driven Innovation is an exploratory research project, which aims to create an entirely new market sector for a given product through changing the design meaning the user has for the product. It occurs before product development, as shown in Figure 1, and is not the fast creative brainstorming sessions that are typical of concept generation but a design investigation similar to technological research.[9] In essence, it is the development of a design scenario through engaging with a range of interpreters in technology and cultural production. Knowledge is generated from immersion with the design discourse of the interpreter's groups. The process can be structured or unstructured and is dependent upon the nature of the relationship of the client with the interpreters. The interaction between innovation of design meaning and technology innovation can transform the market within an industry and even create new market sectors. The two strategies are complimentary as technological and socio-cultural models are inextricably linked, evolving together in innovation cycles. The successful interaction between design-driven and technology-push innovation is called a technology epiphany, shown in Figure 2, it creates a market leader and in some cases a completely new market sector. It is the basis for successful products such as the Apple iPod. [10]

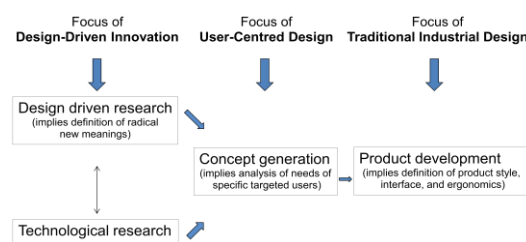


Fig.1: DDI as research [1]

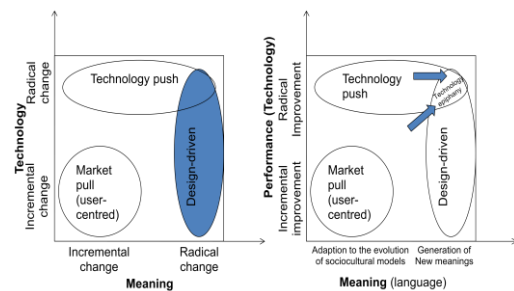


Fig.2: The strategy of DDI [13]

McCartan et al [11] presented a design concept based on this high speed platform to compete with road transport and air transport, supported by specialised infrastructure to optimise the vessel loading and unloading process for cars and HGVs. The vessel design combined the following functions: high speed ferry as an alternative to HGV road transport; passenger ferry as a alternative to flights; luxury cruising cabins. It is based on a 120m trimaran platform designed to operate at 40 knots as a coastal cruiser in the Mediterranean, connecting the coast of Spain, France and Italy. The project was an engagement in Design-Driven Innovation (DDI), with the objective of changing the design meaning of what a multi-purpose commercial vessel can be. Proposing the CLF (Cruise Logistics Ferry) as a new market sector for the commercial marine industry, Figure 3. The key driver was sustainable luxury, as the vessel is multifunctional, providing a high speed alternative to less sustainable modes of transport. Thus addressing the growing European definition of green luxury with the potential to create a new market sector between cruise ships and high end passenger ferries, while also reducing motorway traffic and hence logistics carbon footprint.



Figure 3: CLF



Figure 4: The Ultra-luxury CLF

The ultra-luxury small cruise ship sector has experienced significant growth in recent years. McCartan and Kvilums [12] presented a design proposal for a catamaran eco-luxury cruise ship, which integrates a Passive Design methodology within the marine design process, Figure 4, with the objective of reducing the energy consumption of the vessel as an ecological statement enhancing the sense of luxury within the design. The design is an engagement in luxification, an evolution of luxury in cruising, creating a new market through Design-Driven Innovation, with the objective of offering green luxury user experience with a sense of intimacy similar to that of a superyacht. The concept design shows the potential of

Passive Design as a means of reducing emissions in line with EEDI legislation, by reducing hotel loads such as HVAC systems and lighting. While this proposal was designed for the Mediterranean where the HVAC requirements are a considerable energy consideration. The use of the catamaran hull compared to a monohull design reduces the power requirement and hence CO₂ by 56% at 13knots and by 68% at 22 Knots, based on a target displacement of 650 tonnes.

4 EU Targets for Transport

The EU economy is one of the most open in the world. The future prosperity of the continent will depend on the ability of all of its regions to remain part of a fully integrated world economy. The transport industry is an important part of the economy: in the EU it directly employs around 10 million people and accounts for about 5% of GDP. Growing congestion and poorer accessibility are significant issues, given that fuel costs and congestion levels are expected to rise significantly by 2030, leading to further divergences in accessibility. In October 2009, the European Council showed support for the objective of reducing GHG emissions in the EU by 80 to 95% by 2050 compared to 1990 levels, resulting in a tight carbon budget for the transport sector. Transport accounts for about one fourth of GHG emissions: 60% comes from passenger transport, one quarter is urban, less than one quarter is inter-continental over half of which is medium-distance [13]. To meet these challenges transport has to: use less energy; use cleaner energy; exploit efficiently a multimodal, integrated and 'intelligent' network. This has resulted in Ten Goals for competitive and resource efficient transport. The key Goals for water transport being:

1. Halve the use of 'conventionally-fuelled' cars in urban transport by 2030; phase them out in cities by 2050; achieve essentially CO₂-free city logistics by 2030.
2. 30% of road freight over 300 km should shift to other modes by 2030, and more than 50% by 2050
3. By 2050, connect all core network airports to the rail network; all seaports to the rail freight and, where possible, inland waterway system
Increasing the efficiency of transport and of infrastructure use with information systems and market-based incentives
4. Deployment of SESAR by 2020 and completion of the European Common Aviation Area. Deployment of ERTMS, VTS, ITS, SSN, LRI, RIS and Galileo
5. By 2020, establish the framework for a European multimodal transport information, management and payment system

The EU White Paper on transport [13] proposes that these goals will be achieved through: Internal market; innovation; infrastructure; International. The internal market will create a genuine single European transport area by eliminating all residual barriers between modes and national systems. MoS example: E-Maritime initiative for paperless and intelligent shipping. EU research needs to address the full cycle of research, innovation and deployment in an integrated way. In terms of infrastructure the revision of TEN-T (2011) based on the creation of a 'core network' and on a corridors' approach, will result in over € 1.5 trillion investments for 2010-2030. The Motorways of the Sea (Mos) is the building block for the Maritime Dimension of TEN-T, covering the whole European maritime space, the financing framework for maritime (ports and shipping). Providing a platform for the development of key activities: ships and ship operations; ports and access to hinterland; human element (training for MoS); organisational systems and procedures. Leading to Safe, Secure and Sustainable Maritime Operations, instrumental to European Competitiveness. Examples of which are: safety of navigation, environmental performance of ships and ports (e.g. LNG), traffic management and navigation services (e.g. e-maritime), optimised ship operations, ICT for ports and logistics. International involves opening up third country markets in transport services, products and investments.

5 Transport Analysis and DDI Scenario

In 2012 the modal split of passenger transport in Ireland, in terms of total inland passenger-km was: 82.8% cars; 14.4% buses and coaches; 2.8% train. All data is based on movements on national territory, regardless of the nationality of the vehicle. [6] The rail network links all regions to Dublin, but has limited connectivity within the west coast regions, as shown in

Figure 5. The high percentage of car use is indicative of limited integration of the multi-modal public transport system or limited service provision. Probably due to low population densities limiting the economic viability of services. The use of 0.9% rail transport compared to 99.1% road transport, for the modal split of freight transport for 2012 is an underutilisation of potential multi-modal logistics solutions. As the ports of Cork, Rosslare Europort, Dun Laoghaire, Dublin and Drogheda are in close proximity to the rail network. These could be integrated using road transport nodes in each region.

A significant consideration of both road and rail transport is the cost of infrastructure construction and maintenance, in addition to the cost of modal nodes. Waterway transport on the other hand can use existing coastal ports and canals. Once the required infrastructure (bridges, automated lock gates) is developed, the annual maintenance would be a fractional percentage of road or rail infrastructure. The key opportunity building on the DDI development of the CLF is to combine tourism with logistics needs. A coastal cruiser service would connect the major ports to rural communities on the west coast reducing road transport through the cost effective implementation of logistic chains. The design meaning to tourists would be carbon neutral travel as all the CO₂ could be assigned to the freight. The use of water transport as part of an integrated transport system would help to meet the 50% modal shift 2050 target. The use of existing ports would enable the west coast towns to be connected to cork and Rosslare. The use of both low speed and high speed craft would allow a minimum CO₂ foot print to be assigned to time critical and non-time critical goods. A west coast potential route would be: Donegal; Sligo; Ballina; Westport; Galway; Foynes; Tralee; Cork; Youghal; Rosslare. An East coast potential route would be: Rosslare; Arklow; Wicklow; Dun Laoghaire; Drogheda; Dundalk. These would be supported by road transport integration to service the hinterland of each port.



Figure 5: Rail system map indicating port



Figure 6: Inland Waterways

The map of the inland waterways in shown in Figure 6. The Shannon River Navigation, Shannon Erne Waterway and Erne Navigation, connect Belleek in Lower Lough Erne to Tralee. A distance in the region of 390km which on a catamaran CLF at 22knots (41km/h) would be a 10 hour journey, ignoring lock gate transit times. This could be developed as a river cruise route. At 11 knots the CO₂ would be considerably less but the journey twice as long. A catamaran CLF has 25m beam and 81m Loa, and would be capable of carrying up to 20 TEUs. The River Barrow Navigation (23 locks) could provide TEU transport using a canal catamaran to move non-time critical goods as far as Dublin or onto the Shannon waterway using the Grand Canal system (46 locks). At low speed the power requirement and hence CO₂ are significantly low and a battery electric or hydrogen fuel cell metal hydride system

would be sufficient to provide propulsion. Resulting in a ZEV powered by the growing wind farm network in Ireland. Rail transport would be used to move the TEUs onto the Barrow Navigation from Rosslare Europort. In a similar manner TEUs from Dublin Port could be transported along the Grand Canal and Royal Canal (when complete) to the Shannon river system. A network of transport nodes along the inland waterway system would enable the TEUs to be transferred to electric vehicle HGVs for local delivery. Again these vehicles could be powered by wind farms through the grid resulting in ZEV.

The significant undertaking in the implementation of a canal catamaran system would be the modification of bridges and the development of autonomous control systems for the vessel, as crew costs would not be economically sustainable. The canal catamaran is shown in Figure 8, it has a canoe type hull to avoid the need for turning the vessel within the canal network. It is a modular platform enabling it to be converted into a canal boat for tourist cruising to meet the flexible demand of seasonal variation, shown in figure 9. The canal cruising platform has a solar panel roof to further reduce CO₂ in use.



Figure 8: Canal catamaran logistics platform



Figure 9: Canal catamaran cruising platform

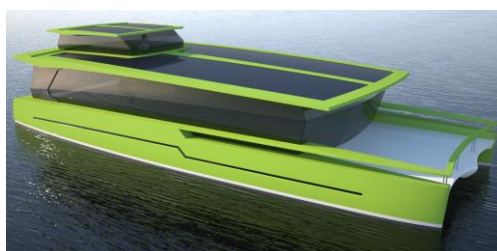


Figure 10: Studio Starkel 16.5m solar powered Eco-cat

To support sustainable tourism and public transport on the Shannon-Erne waterway the Studio Starkel Eco-cat is a ZEV, shown in Figure 10. It can achieve 8knots at 24kw engine power, with a maximum speed of 12knots, and had an all electric powertrain with batteries charged by 75m² of solar cells on the roof. It has a capacity of 64 passengers and 2 crew at a displacement of 17 tonnes.

Region/Year	2008	2009	2010	2011	2012	TEU/ day
Border	24,006	12,750	11,577	10,926	11,347	1413
Midland	23,689	10,975	8,217	6,649	6,266	780
West	22,846	13,570	9,640	7,949	8,385	1044
Dublin	43,981	24,041	22,617	20,555	20,884	2601
Mid-East	35,107	21,260	13,456	11,261	10,566	1316
Mid-West	25,250	12,668	12,305	11,296	8,641	1076
South-East	28,883	18,568	15,606	14,921	14,011	1745
South-West	37,691	20,320	22,221	18,452	19,418	2418

Table 1: National annual road freight transport of total transported goods by regions of unloading (NUTS 3) (1 000 t) [6]

In order to identify the number of vessels required an analysis of the National annual road freight transport of total transported goods by region of unloading is shown in Table 1[6]. Since the financial crisis the volumes appear to be stabilising, with expected long term economic recovery these volumes would be expected to rise. Using the 2012 volumes as a

base case scenario, the average number of TEUs unloaded in each region per day is shown in the right column, based fully loaded TEUs of 22 tonne capacity. Developing the canal catamarans to transport two TEUs and considering the freight movements to require 5% by high speed CLF, 45% by catamaran CLF and 50% by canal catamaran. The potential number of vessels for each region are determined based on the number of TEUs per day and these relative percentages, shown in Table 2. The total number of vessels required are: 26 high speed CLF; 139 catamaran CLF; 1549 canal catamaran.

Region	50% RT TEU	High Speed	Catamaran	Canal
		CLF	CLF	Catamaran
Border	707	3	16	177
Midland	390	2	9	98
West	522	2	12	131
Dublin	1300	5	29	325
Mid-East	658	3	15	164
Mid-West	538	2	12	135
South-East	872	4	20	218
South-West	1209	5	27	302
Total Vessels		26	139	1549

Table 2: Number of vessel based on 50% replacement of Road Transport

6 E-maritime support platform for smart shipping corridors

The e-maritime support platform for smart shipping corridors has two main pillars: volumetric navigation concept (VNC) and fleet management operation (FMO). Monitoring information is given to maritime administrations to control operations and master through enhanced onboard systems. New platform providing volumetric navigation support the smart decision of masters and allows increasing waterways traffic efficiency in a safe manner. Each vessel is surrounded by an envelope of safety ensuring the proper navigation. High accuracy precision based on expected new Galileo services, oceanographic and weather conditions (sea currents speed and direction, wind speed and direction), manoeuvrability of vessels, are some of the key inputs for performing those envelopes. All of them are interchanged using VHF communications based on AIS binary messages. New ongoing protocol VDE as future of AIS will be integrated with inland ports. This key pillar will provide a navigation support tool to increase infrastructures use and passage density capability by 20% on regulated areas based on a realistic risk assessment on infrastructure constraints and navigation conditions. A reduction of waiting times and bottle necks will be achieved mainly in the load/unload berths where the freight change of mode of transport (vessel / truck). The other pillar is focused in emissions reduction which can be obtained through an optimisation of waste times of shipping stakeholders. Truck fleet management concepts will be applied to fleet vessels in order to monitor and optimize times of voyage of vessels. Slow steaming concept will be applied taking into account waters levels information in the river and locks, and status of truck fleet expected to pick up the cargo of the vessels when ended their trip. ETA and ETD times of vessels and trucks will be optimised as a consequence of sharing information between stakeholders involved. There will be an umbrella over those two pillars called Smart corridors. Waypoints on route will be provided dynamically during voyage integrating both concepts VNC and FMO.

Discussion

The scenario developed through Design-Driven Innovation is a proposition based on the experts engaged in the design discourse. As such it is the starting point of a proposal, which required engagement with stakeholders to validate the potential benefit and impact. It also requires a detailed analysis of the vessel platforms proposed in terms of construction, infrastructure and energy consumption as an integral part of a business model, to stress test operational costs and market demand variations. The estimation of vessel numbers based on assumed percentages of vessel type and the volume of TEUs and their weight needs a

detailed assessment. This should be based on actual journeys and vessel requirements, rather than the statistics on region of unloading. The catamaran CLF is a flexible speed platform that can operate at 22knts or 11knots depending on requirements. The high speed CLF is designed to operate at 40knots, transporting 12 TEUs from Cork to Dublin would take 3hrs 45mins compared to a road journey of 2.5-3 hrs depending on traffic.

The EU Regional Aid Guidelines (RAGS) [14] allow the provision of enhanced rates of State Aid in the least economically developed areas. The 2014-2020 RAGS were implemented on 1st July 2014. Under the terms of the RAGS, regions covering 51.28% of Ireland's population were designated as 'assisted areas', which represents the majority of the inland and coastal areas for the proposed integrated water transport system. This enables Ireland's enterprise development agencies to grant State aid, at enhanced rates, to businesses in order to support new investment and new employment in these most disadvantaged regions. Regional aid is also provided under schemes for tourism grants, marine tourism, urban and rural renewal and other tax-based development schemes. This State financial instrument would be the key mechanism to realise this DDI integrated logistics proposal.

Conclusion

This paper presents a DDI scenario for the use of coastal and inland waterways of Ireland as an integrated logistics solution for both freight and passengers. The key objectives of the scenario was to support the EU CO₂ targets for transport and to reduce congestion, by transferring road transport logistics and public transport to the coastal inland waterway. Several vessel concepts were proposed including two CLF concepts. The key driver for the CLF is sustainable luxury, as the tourism role of the vessel facilitates a sustainable economic model for the transport and logistics needs of rural communities on the Shannon-erne Waterway. A critical aspect of the scenario is the implementation of an e-maritime support platform to develop smart shipping corridors based on volumetric navigation concept (VNC) and fleet management operation (FMO). This is a first step in the analysis of the potential of the coastal and inland waterways of Ireland, to meet the EU targets for transport. State aid has been identified as a potential funding mechanism to support the realisation of these proposals.

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Acknowledgements: The authors wish to thank Charlie Kitchenham, who developed the canal catamaran concept reported in this paper as a minor project in his final year as a Coventry University Boat Design student.