National Transport Authority

GDA Transport Strategy – Background Paper)

Integration of People, Technology, and Mobility

REP/12345/S001

V2 | 8 June 2021

Job number 281983-00

Ove Arup & Partners Ireland Ltd

Arup
50 Ringsend Road
Dublin 4
D04 T6X0
Ireland
www.arup.com

ARUP

Document Verification

ARUP

Job title		GDA Transport Strategy – Background Paper)		Job number 281983-00
Document title		Integration of People, Technology, and Mobility		**File reference**
Document ref		REP/12345/S001		
Revision	**Date**	**Filename**	Integration of People, Technology, and Mobility_v1.docx	
Working Draft 1	28 May 2021	**Description**	Working draft.	
			Prepared by	Checked by	Approved by
		Name	Terry Lee-Williams Pooky Mitchell Larissa Miller	Larissa Miller	David O'Keeffe
		Signature			
V2	8 June 2021	**Filename**	GDA Background Paper_Integration of People, Technology, and Mobility_08.06.2021.docx	
		Description	Revised following NTA and Arup peer review.	
			Prepared by	Checked by	Approved by
		Name	Pooky Mitchell Larissa Miller	Larissa Miller Renata Lajas	
		Signature			
		Filename		
		Description		
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename		
		Description		
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Issue Document Verification with Document ✓

Contents

Page

1 Introduction

This Background Paper to the Greater Dublin Area Transport Strategy summarises the emerging mobility technology and trends on a global basis that can influence how we travel. It addresses the integration of people's needs, emerging technology, and the mobility system, emphasising the core principle that mobility is about people, and how they access opportunities across their life stages. How and where those opportunities are delivered significantly alters mobility needs, and the intensity and distribution of mobility changes how those needs can be fulfilled. Arup was commissioned by the National Transport Authority (NTA) to produce this Background Paper.

Mobility markets are regulated by governments, in areas like entry, pricing, and operating standards. Through this regulation, governments demonstrate how they value and enable different forms of mobility, influencing how people move, and in what volumes.

Mobility technology continues to evolve, but it isn't fundamentally changing. The progress of technology has made a range of mobility-related devices and supports easier, cheaper, quicker, and more attractive to access. These technology shifts have changed, and will further change:

- How people can consider and choose their mobility options;
- How those options can be regulated, positioned and priced to achieve public value outcomes; and
- The capacity of stakeholders to participate in what is a competitive mobility market.

1.1 Advancing Technologies and New Mobility Modes

Emerging mobility technology

Emerging mobility technology is a broad subject, but can be understood when broken into three categories with differential functions: information technology, vehicle technology, and vehicle and infrastructure technology:

Information technology	Vehicle technology	Infrastructure technology
• Improves how people can make better mobility choices, with each person defining their own "better", often called digital personalisation. This can occur prior to or within a journey. • Improves how transport systems owners and managers can nudge people towards decisions that enhance system benefits – usually grouped under Mobility as a Service and mobility pricing. • Enables data sharing between vehicles (V2V), between vehicles and infrastructure (V2I) and between infrastructures that carry vehicles (V2X).	• Improves the functional benefit and safety to the user. • Improves energy efficiency and reduces carbon emissions. • Improves the financial and economic performance of a vehicle or network.	• Improves safety as a primary objective. • Improves network, signal, and operations management. • Provides charging technology.

New mobility modes

Until the early 1900s our main mobility systems in cities included walking, cycling, trains, horses, and horse-drawn vehicles. The arrival of the disruptor, the motor car (electric at first, then with internal combustion engine) rapidly changed what a city was, how it could be shaped, and how it could operate. The car gave people more options and allowed them to escape over-crowding and poor sanitation in city centres; by mid-century, distance was not a barrier to accessing opportunity.

The private motor vehicle has changed the urban form of cities worldwide, leading to large geographic feeders surrounding more compact cities, and Dublin remains no exception.

Now, newer forms of mobility are challenging our perceptions of:

- The concept of the motor vehicle;
- What constitutes a vehicle; and

- Why it is necessary to define them in this way.

Making space for the new modes

The roles of different forms of mobility are typically considered in terms of the infrastructure required to support them. A pedestrian had the footpath, a motor vehicle had the roadway, though it had previously been dedicated to bicycles and horses. Though the roadway was shared between multiple modes in the beginning, over time and with its increasing speed of travel, the motor vehicle predominated to the detriment of other modes, leading to segregation of space.

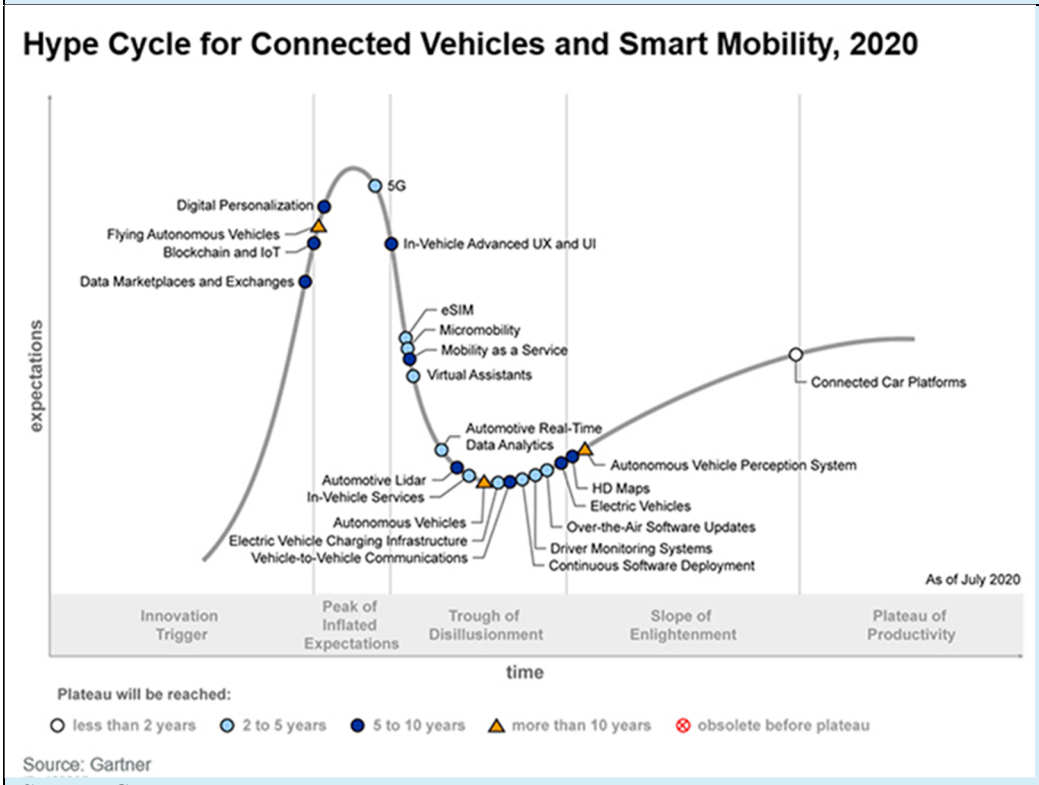
Allotting dedicated space for different modes is not a simple task and even today determining whether a new mode, such as e-scooters, belongs on a footpath, a cycle track, or a road, can be a matter of contention. If the infrastructure is considered too deterministic (i.e. bikes belong on a cycle track) it follows that new dedicated space should be required for each new form of transport that emerges. As this is not feasible, a method for determining how to distribute and share the space is necessary. For this, the primary drivers should be:

- The speed of travel of the mode;
- The probability of conflict between modes sharing space; and
- Achieving this without compromising the evolving needs of the travelling public.

Micro-mobility, which is travel using lightweight vehicles (both personal and shared), can help make cities available to everyone, but the streets need to be designed to facilitate these modes. Good cycling infrastructure can support many different transport modes, providing access to the city for many different people. Currently, in most cities there is no dedicated space for the less popular micro-mobility devices; they are used on footpaths, cycle lanes and roads. This results in conflicts as pedestrians don’t feel safe with electric devices on footpaths, but micro-mobility users don’t feel safe on roads.

The Gartner Hype Cycle

The Gartner Hype Cycle is a useful analytical tool for considering the maturity of emerging mobility technologies. Updated annually, it shows the progress of new technologies through from their innovation phase, with an emphasis on the fluctuating hype and expectations that accompany each new innovation.



Source: Gartner

1.2 From Owning to Sharing

Shared mobility is not new, it has been around for three centuries. A horse-drawn carriage selling seats is an example of shared mobility, as is a train or a bus. Digitalisation enabled the emergence of digital commerce and strengthened the "sharing economy" movement. In the transport sector this meant opening up further mobility options and using powerful communication business channels like apps to drive growth. Examples of the sharing economy for individual mobility include ride-hailing, car-sharing, and electric scooter and bike share schemes.

Growing markets

In an app-based marketplace, change in consumption behaviour rapidly formed new patterns. In Europe, the sharing economy was responsible solely in one year for €28.1bn worth of transactions (May'15- May'16), with an estimated 191 million citizens engaging in at least one transaction involving payment.[1] There is a growing demand for the sharing economy; the carsharing market is predicted to have a compound annual growth rate of 23% between 2013 and 2025, with already roughly seven million car sharing users worldwide in 2015.[2]

Choice or circumstance

Significant venture capital is invested in the concept that a growing proportion of young people won't own a vehicle, but it is hard to determine if this is a choice or a product of circumstance. As global economic conditions have resulted in stagnant wages, but not constrained the rising cost of housing, countries have seen a decline in the relative purchasing power of younger people compared to previous generations.[3] This is often conflated with lack of interest in owning the vehicles we move around in.[4] With conflicting research on the topic, it is hard to demonstrate what the impact of restored purchasing power would be on rates of mobility ownership. If cars were more affordable relative to income, would people prefer the convenience of their own car over shared vehicles? Even without concrete evidence, it is generally accepted that the realities of ownership vs usership are complex. In cities with many mobility options, even people who choose to own vehicles also make wider, context-specific mobility choices and may opt for shared modes.

Examining the benefits

There is also a lack of reliable evidence to demonstrate that all shifts to shared travel are beneficial. For example, a taxi or hire car service typically drives 1.7km per 1km of passenger service. That same passenger if driving themselves would only drive 1km for the same journey. In this case, shared mobility is far less network efficient and produces additional carbon emissions. Studies from the US have also found that ride-hailing has a stronger substitution effect on public transport than a complementary effect.[5]

Speculation and regulation

Is the rise of the sharing economy in mobility based purely on speculation? Billions of dollars of investment capital have been lost across shared mobility platforms; to date there appears to be no service operator making a profit,[6] but the market is sustained through inflated projections and public benefit claims that generally remain unsupported by evidence.

There is little doubt that there will continue to be market testing of shared mobility models and new operators joining the market. Referring to the Gartner Hype Cycle, most investors, operators and owners are still sliding to the 'trough of disillusionment' as the market has yet to mature. This does not mean that the mobility models will not mature, and it doesn't preclude success. Rather, the trough of disillusionment indicates that heightened expectations won't be realised early; consumers, markets, regulators and suppliers will mature the service offering to fill an actual gap in mobility access.

On an international basis, what is the role for Government regulation in a shared mobility ecosystem? Taxis are also "shared mobility" services and while not directly subsidised, this industry has survived globally through a combination of Government regulation and limiting entry; in return for guaranteed coverage and level of service.

When governments started removing these controls in various parts of the world, and allowed the market to prevail, mobility deserts returned. Areas where very

few sharing services are available (due to wide ranging issues from low density, low demand, and safety, through to poverty restricting use), are the areas with soaring demand for public transport and "on demand" public transport (i.e. subsidised shared taxis). A good example of this is Sydney, where an unconstrained market approach was adopted to accommodate ride-hailing companies, and conditions of licences were removed other than those related to public safety. State Government was tasked with resolving the loss of supply to outer suburban areas as minimum service standards were removed. A stark social inequity resulted, a classic market failure, and why the regulations existed in the first place. The cost of filling the service gaps continues to rise.

The potential

The technology development accompanying these shared mobility services is highly valuable to both operators and customers. Platforms like City Mapper, Moovit and Google can give transport customers instant information on the fastest route, passenger loads on different services, and help reduce waiting times. This information sharing is very desirable and can improve the productivity of network public transport services by directing customers to the closest available mode of public transport to effect their journey. This equips passengers with the information necessary to make sustainable transport choices and allows network operators to increase ridership.

Network managers can use the data arising from the wide use of applications to see the choices customers make, and with analysis, what drives those choices. This enables service procurement and service design to respond to expressed consumer choice, rather than simple, theoretical models.

And the challenge

It is, however, challenging to achieve this on an equitable, national basis without direct or indirect subsidies. This is especially true when most shared mobility service providers are operating at a loss while chasing profits. Such service providers have less financial capacity to be good corporate citizens and are more resistant to data sharing that exposes their true financial position.

The challenge for Governments is to set terms and conditions of operating that are fair and equitable for operators and encourage risk taking and innovation to fill gaps in mobility markets, while avoiding public nuisance, safety issues and negative network effects.

The overlap between physical and digital realms requires an integrative operations policy to define and protect the public interest with the lightest possible impediments to success of arising technologies. As always, this is not a binary situation, but requires balance between competing interests.

1.3 Evolving Customer Expectations and Demands

Mobility is a problem to be solved for anyone looking to experience a fulfilling life and engage with society. Every day, people across the Greater Dublin Area (GDA) need to meet their mobility needs to access education, work, sport, retail, various essential services, and social and leisure opportunities. Attitudes,

preferences, and expectations towards mobility are evolving more quickly now than ever. The predominant changes in citizen expectation around mobility markets are that:

- Everything should be convenient;
- There should be no asymmetry of information; and
- There should be no surprises.

Meeting these needs is the core marketing mantra of the on-line world and has pervaded market strategies across multiple sectors.

Convenience

For transport, removing the anxiety that arises from not knowing how to access transport networks is key:

- How does a new user know what bus service (or services) to take to their destination?
- How does a new user of a bus network know where the bus stop is, which direction they need to head in, and which side of the road to wait on?
- How do they pay, and how do they know how far they are going?
- How do they put value on a Leap Card, and how do they even know they need a Leap Card?
- How do they know when they reach their destination? Is there another stop that is closer?

It is easy to understand from a user perspective that initial engagement with public transport can cause hassle, and be inconvenient compared to making the same journey by car, where a navigation system might provide directions, and a parking space might be sourced and paid for using an existing payment method such as a toll tag. This expectation that everything is between one and three clicks away should drive a user experience design commitment across the entire mobility system.

Full transparency

Another aspect of the information age is that there can be no information that is withheld from customers that is known to the transport operator. It will inevitably be discovered and shared. If operators use a nudge technique to influence behaviour, it is likely that someone will use social media to make this public. It can be of mutual benefit to users and operators for accurate and complete information to be widely available.

No surprises

Unlike the private realm of marketing where often the technique is to acquire the customers with a service or pricing promise, then rely on a different interpretation to upsell or not deliver, Government must deliver on its promises with no catches or surprises to maintain trust. This is critical when dealing with third party providers of user interface applications, such as Mobility as a Service or ticketing products. What passes as legitimate customer acquisition techniques in the

vendor’s usual fields of endeavour must be softened when acting on behalf of the Government. Customers will continue to expect greater transparency and accuracy i.e., more and better information, from Government.

Implications for public transport

Mobility is now a product in market. Public transport is in competition with private mobility providers like FreeNow and Bolt, Dublin Bikes is in competition with multiple competitors, and various forms of car access are in competition with all of these. This commoditisation of mobility, with clever marketing through direct social channels to consumers, means that public transport needs to invest directly in multiple information channels if it is to remain relevant.

This may seem counterintuitive. As a public service that operates at a loss for every passenger carried, and often as a service of last resort, there can be an idea that public transport requires the least marketing, as it has “sticky” clients. But this is a misnomer.

Not only must public transport succeed for the GDA to avoid congestion paralysis, it must also be more attractive to more people where it makes most sense, and sometimes potential riders should be encouraged to shift to other options where that is most useful.

The hierarchy of active, public, and private transport requires maintenance of consumer preferences, active engagement to understand changes in behaviour or expectations, and predicting where demand might shift; all to enable course correction before problems occur.

Going cashless

Another significant shift that has been building for some time but accelerated in 2020, has been away from cash. While the Next Generation Ticketing (NGT) project is underway, incorporating pay by phone options, customers are seeking to dispense with cards.[7] Pay by phone apps can reduce customer anxiety because:

- Phones are essential items they never leave home without;
- They can manage the account value on their phone; and
- If the system is configured for it, they can use existing funds or credit as their circumstances require.

There are however some people in the GDA who will continue to rely on other forms of payment.

Changing travel patterns

In the aftermath of COVID-19, there are expected to be significant shifts in patterns of travel, evidenced by the direction to the public sector about office vs home working attendance. The property markets are already signalling a change in value for rents further from centres. While the implications of this over a 10-year period cannot be accurately predicted, the impacts on demand as the economy reopens should be monitored consistently across multiple data sets to understand:

- What is driving changes in demand?
- For how long will those changes apply?
- What might be the required response by Government, transport authorities and operators?
- What Government support is needed for the resulting adjustments?

1.4 This Background Paper

Thoughtful integration of people, technology and mobility will be the foundation to shaping policies and regulations and promoting the sustainable management of cities like Dublin. This paper takes a holistic approach to the shifts in technology, and what they mean to people and their relationship to mobility, addressing the opportunities and challenges brought about by the emerging mobility ecosystem.

It concludes with a view on how Government can create the greatest public value from those advances and what it could do to facilitate good outcomes. The aim is to focus on what meaningful change – i.e. a change in access to opportunity that is beneficial – looks like and avoid the trap of relying on immature technologies before they are proven both useful and market ready.

Developing robust, standardised and collaborative mobility models which consider user privacy, the public good, and city sustainability goals is key to unlocking the new age of mobility.

This report was commissioned by the National Transport Authority in order to inform the Transport Strategy for the Greater Dublin Area. The views expressed, and the recommendations are those of Arup.

2 Mobility Data

2.1 Mobility data

2.1.1 Overview and application

Transport data and how it is used

In the transport sector, data can be collected for:

- Active transport trips: volume, origins and destinations, travel routes, distances and time spent travelling, modes;
- Public transport passenger trips: volume, origins and destinations, travel routes, distances and time spent travelling, modes, and interchange;
- Private vehicle trips: volume, origins and destinations, delays, vehicle speeds, idle time, travel routes, distances and time spent travelling, modes, and real time geolocation;
- Car parking: occupation; capacity; and turn-over;
- Infrastructure (national roads, bridges, tolls, intersections, bicycle lanes, footpaths, car parking, shared micro-mobility parking, charging stations): locations, characteristics, condition, capacity, and use;
- Public transport services: schedules, on time running, patronage, capacity, fares and revenue, and accessibility;
- Accidents: for all modes; location and time, type, conditions, factors, severity, modes involved;
- Urban congestion: traffic counts/flow, peak hours, emissions, air pollution, and fuel usage;
- Transport customer attitudes towards their mobility options and the value of time; and
- Use of space: public and private spaces including road networks, green spaces, pedestrian spaces, parking, and depots.

Some of the above data is not easily available to collect in Ireland.

Transport system planners, designers, and operators can use anonymised mobility data to:

- Enhance network accuracy, efficiency, connectivity, and accessibility;
- Improve safety;
- Right-size infrastructure investments in access, volume and timing;
- Predict optimum maintenance and upgrades of infrastructure assets (instead of scheduled maintenance);
- Measure and respond better to changes in travel behaviour and trend tracking;

- Influence the adoption and use of sustainable modes of transport;
- Manage emissions by influencing travel patterns and modes;
- Improve journey planning for public and private mobility;
- Integrate and bundle different transport modes and enable on-demand services where warranted; and
- Reduce reliance on cars and maximise mobility resource utilisation.

'Big Data' sets the foundations for information and vehicle technology

The concept of 'Big Data' acknowledges that the data sets available now are too large or complex to be dealt with by traditional data-processing application software. The rapid growth in data generating and collecting devices such as mobile devices, cameras, microphones, radio-frequency identification (RFID) readers, wireless sensor networks, and Internet of Things (IoT) devices, has fuelled predictions that the global datasphere will increase to 175 zettabytes of data by 2025.[8] 'Big Data' is the foundation upon which all emerging information technologies and vehicle technologies are made feasible, accessible and operational. It will also play a key role in the governance and management of these mobility systems and assets for transport authorities.

Mobility data ownership and regulation

The collection and use of data can be controversial, and it is a highly sought-after business asset. When collected privately for commercial purposes, mobility data will be used to service only the businesses that own and operate the data value chain, and valuable insights are lost to other players in the ecosystem. Private mobility providers in many cities have used data to identify and withdraw from servicing low density areas, which can exacerbate existing mobility problems for those in less accessible or disadvantaged areas. There are also problems surrounding the potential risks of personal data allowing individuals to be identified.

For Governments, there is a high expectation from citizens that the GDPR will be a minimum requirement, and that data shared with the Government is fully anonymised and unable to be used for any secondary purpose. Where Governments enter into data-based applications, such as Mobility as a Service, they must satisfy themselves that the third-party private transport service suppliers are not in a position to undermine public trust in Government, even by inference or association.

In cities worldwide, shared mobility providers collect passenger and driver trip data through vehicle sensors and user mobile phones[9], to:

- Develop new business models and products;
- Provide better value to their customers; and
- Create new revenue streams for themselves.[10]

To ensure that transport authorities and city planners play a more central and responsible role in the data value chain, many cities have started gathering and integrating different types of mobility data from both primary and secondary sources, based on existing and emerging data standards.

Case study: Mobility Data Specifications (MDS)

Mobility Data Specifications (MDS) is an open data protocol that standardises and manages micro-mobility data. After facing down legal challenges by ridesharing companies, it now mandates that all micro-mobility providers share their raw trip and fleet data with the cities they wish to operate in. Cities who adopt MDS can query current and historical data and also trigger alerts to the companies if their micro-mobility vehicles are in violation of Government regulations (parking zones, speed limits, etc.)[11]. Similar to existing mobility standards such as the General Transit Feed Specification (GTFS) and General Bikeshare Feed Specification (GBFS)[9], MDS can help pave the way for more granular insights of streets, public spaces and busy urban areas, supporting all the functions envisioned for emerging information and vehicle technologies.

Where there is value and customer insight to be gained from sharing real-time data analytics, there will always be resistance from data collectors who would prefer to keep the raw data assets in-house. Some mobility providers, including Uber, have argued that collecting and sharing individual trip data with authorities and city planners could breach the cyber-security and privacy rights of their customers, opting instead to aggregate the data before sharing.[12] The sharing of this aggregated data has historically been slow and limited.

In the Greater Dublin Area

- Mobility data are collected using installed information and vehicle technologies such as radio frequency ID tags, cameras, traffic counters and roadside and underground sensors. This data, showing the movement of people, goods, and services to, from and within the GDA, is used by transport authorities in the planning of infrastructure and services, demand management, and incident response.
- Dublin Bikes produces near real-time trip data that is aggregated and accessible to everyone through their 'Dublinked Open Data Store'. Data.gov provide 'City Cycle Counts' for Dublin city's busiest corridors. The availability and analysis of these data sets yields insights into the usage of cycling infrastructure, Dublin Bikes assets, and the movement of people.
- An example of the type of insight and value harnessed through mobility data can be found in analysis of Dublin City as part of Here's 'Urban Mobility Index'. Of the 38 major global cities examined, Ireland ranked 24th overall amongst the four key criteria of connectivity, sustainability, affordability, and innovation. Dublin performs well in categories like 'Public Transport Coverage' (9th), 'Public Transport Density' (7th), 'Official Docked Bikes' (5th), but the city performs poorly in 'Traffic Congestion Index' (32nd), 'Public Transport Frequency' (25th) and 'Public Transport Expense" (35th).[13]
- As e-scooter companies seek to enter Dublin's mobility market, transport authorities will need to consider the data sharing standards they are held to.

2.1.2 Opportunities and challenges

Opportunities

- Data can be used to capture the continuous loop of shifts in mobility patterns, land use and the effects on the GDA's mobility system.
- The transport customer is amenable to data sharing in return for better travel and improved user experience. A recent Transport Systems Catapult study showed that 57% of respondents claimed to not mind sharing their personal data if this was used to develop a better transport service.[14]
- There are already many existing mobility data sources, both open and proprietary, which can be integrated for the benefit of all mobility stakeholders in the Irish market (i.e. transport authorities have data that is useful to mobility providers and vice versa).

Challenges

- A lack of agreement on data-sharing protocols. This will be difficult to establish, as competitors in the market and Government itself may have opposing views on the value of sharing the data and subsequent insights. The challenge will be to align private business goals and public mobility needs, avoiding monetisation.
- Private mobility providers may seek to withdraw service from unprofitable areas if Government doesn't provide subsidies or incentives for them to operate in those areas.
- Locally there are regular and continual challenges to the concept of Government collecting and sharing data, for legitimate purposes, that complainants typically would share on private networks. Privacy protection above and beyond, that is demonstrable, will be required to maintain public confidence.
- The foundations of the data value chain are complex and require a robust data policy to ensure its governance. Existing regulations will need to be updated and liberalised to account for large-scale data sharing, whilst protecting people's right to privacy.
- Current traffic models and data analysis can be limited in scope and application. They may overestimate the negative effects of changes to supply of road space dedicated to cars, underestimate the redistribution and elimination of trips, and may not adequately address the role of walking.

2.1.3 Recommended measures

The following measures are recommended for mobility data collection and use:

- **Develop a robust data policy:** Cognisant of the high trust requirement for Government, articulate a transport data policy that reflects other Government data policies, but uses very plain language and focuses on the protections afforded to people and how data must always be used responsibly and shared in an anonymised way. It should require that the benefits are made apparent

before data is shared, and could form a charter for the development of a model, standards and tools. As the majority of data activism and the majority of data-driven mobility is centred in Dublin, the policy could initially focus on the GDA.

- **Develop a Common Information Model:** The NTA and city regulators should collaborate with mobility providers and independent data experts to develop a Common Information Model (CIM) for the GDA. This will improve the interoperability management of information technologies which can be used for better planning and operation across the transport system. Agreement from all stakeholders should be sought around data interoperability across the diverse set of resources and vendors; how data should be described and accessed, and through what channels.
- **Establish open standards:** To ensure a flexible system architecture and unification of various modelling projects across the mobility landscape, the CIM for mobility data should be modularized and based on open standards. This will form the basis for the next generation of mobility and urban planning, which may likely involve large scale, digital mobility hubs with vast, integrated data repositories connected through the cloud via Application Programming Interfaces (APIs), Blockchain and other emerging information technologies.
- **Enhance open source tools:** Developers of open source tools and APIs should look to already mature and well-developed CIM standards (e.g. Distributed Management Task Force's CIM[15]), as well as extending the Gemini Principles[16] for data sharing frameworks to help inform the development process. Mature tools are more likely to be trusted and robust.
- **Create a customer information test bed:** Pilot customer-centric approaches for improving customer information and interaction, using Dublin as a test bed. The outcomes will provide a better understanding of what is driving the changes in customer attitudes that directly affect the NTA's service networks, and identify areas for positive behaviour change. Using real citizen feedback can be powerful in influencing sceptics, rather than theoretical models. This would support an innovation agenda and would likely attract significant academic partnership support. Open data access for app developers who have ideas to create customer value could also be included. (Examples: Transport for London's open data hub https://tfl.gov.uk/info-for/open-data-users/our-open-data and Transport for NSW's open data hub and developer portal https://opendata.transport.nsw.gov.au/).
- **Develop, implement, and monitor a GDA data mapping tool and dashboard:** These tools will facilitate insights from the large network data sets, and track multiple changes in customer behaviour, enabling the NTA and city managers to focus on the most important issues. Narrowing the focus of network managers to the most important customer outcomes, and the performance needed to achieve those, means that identifying the interventions required becomes easier. Linking live changes to the mobility corridors and the available space to the transport models, and calibrating the models with live data, will allow for comparing the model predictions with actual movements in a continuous loop.

- **Shape the Next Generation Ticketing:** Focus early on user experience in system and service design so that it improves convenience, reduces friction, and includes incentives that respond to changed customer attitudes and behaviours. The NGT can be an enabler of passenger growth and satisfaction, moving away from the barrier that the current ticketing system represents. Integrating customer service experts from private sector commercial businesses can provide insight into where customer value is represented, and how to put typical transport systems and operations management concerns into the background.
- **Carry-out continuous effectiveness assessments:** Monitor and review transport system conditions against achievement of the desirable outcomes in behaviour change, and drive continuous improvement in network performance from a customer point of view.

3 Connected, Autonomous, Shared and Electric Vehicles

3.1 Electric Bikes, Scooters & Other Personal Mobility Modes

3.1.1 Electric bikes - Overview and application

Electric bicycles or e-bikes are bicycles with an integrated electric motor used to assist propulsion. This means that they can extend the travel distance, or gradients traversed, well beyond the typical limits of a standard bicycle. They use rechargeable batteries and typically reach top speeds of 25km/h, with some high-powered varieties able to travel more than 45km/h. E-bikes can be broken down into two broad categories, Pedelecs and S-Pedelecs.[17]

Pedelecs are:

- E-bikes that assist the rider's pedal power.
- Electric motor output of 250W with top speed of 25km/h.
- Treated legally like bikes; no license, insurance, helmet required.
- Cycle paths may/must be used.
- No age limit in EU.

S-Pedelecs are:

- Classified under mechanically propelled vehicles (MPV) in Irish law, they are electrically powered and do not require pedalling power from the rider.[18]
- Electric motor output of 4,000W with top speed of 45km/h.
- Treated legally like mopeds; roadworthiness, crash helmet, license, insurance and tax are required.
- Riding lane allocation differs from country to country, with some opting to develop dedicated lanes specifically for S-Pedelecs. In Ireland, MPVs are only allowed to operate on the road.
- Age limit from 16 years.

The market, while technically restricted, has not stopped the sale of the more powerful S-Pedelec models that do not require pedalling and are effectively motorcycles with pedals. A lot of the power modulation is via a software control that is easily modified by users, and top speeds of more than 80km/h are commonly achieved and shared on social media. While there is no question that extending the average comfortable cycling distance with battery assist constitutes a public benefit, there is a question of whether a bicycle capable of easily travelling at trafficable speeds should be in a bicycle lane.

Bike sharing schemes

Bike sharing schemes or Public-use Bicycles (PUBs) are short term urban bicycle rental schemes that enable bicycles to be accessed at, and returned to, any self-serve bicycle station around the city. The success of these schemes depends on the quality of the bicycle, their ease of use, and availability.

Bike sharing schemes all require either direct or indirect subsidy to meet desirable standards of performance. If a city or state requires a minimum standard of service, including ensuring that bikes are distributed, maintained, and removed when vandalised, there must be an accompanying incentive for operators to enter the market. This can be achieved through limiting the number of providers that are licensed to operate in a market; reducing competition, and allowing for some level of protection from market forces.

As a dense core, Dublin’ s city centre can support a bike share market relatively well, but the lower density periphery and smaller urban centres across the broader GDA likely cannot.

In the Greater Dublin Area

- **There are 3 bikeshare providers in Dublin: Dublin Bikes, BleeperBike and Moby; the latter two operating with the dockless model.**
- **The Dublin Bikes scheme, subsidised through advertising, sponsorship and Government funding, has internationally proved to be a great service.[19] The data it produces shows that the bikes follow the same general patterns of commutes – into the city centre in the morning and outbound during the day. To allow unplanned trips more generally, the bikes are redistributed between peak hours.**
- **Dublin Bikes is upgrading around 800 bikes in the fleet to ‘hybrid electrics’ with 117 charging/docking stations to be made available.[20] This follows the trend from BleeperBike and Moby who have already been licensed to deploy up to 1,000 Pedelecs since January 2020.[21]**
- **Dublin Cycle Buddy integrates data from all three bike share providers into a single platform which allows riders to see their closest available bikeshare.[22]**
- **95,000 cyclists in Dublin use bikes every day[23] and Irish bikes sales surged in 2020 by as much as 70% from 2019.[24] Across Europe, electric bikes account for 17% of sales.**
- **Food delivery services rely heavily on electric bikes in the GDA.**

3.1.2 Electric bikes - Opportunities and challenges

Opportunities

- Grow cycle use for trips of less than 10 kilometres, whether by shared or owned bicycles.
- Current bike schemes globally, including Dublin Bikes, are banking on electric assist to make cycling more attractive. It is likely that this will succeed in principle.

Challenges

- The maintenance cost of electric bikes, and the charging complexity, may make them unaffordable.

- Bike hire will be less competitive if full articulation of protected bike routes and safe cycle parking are provided in both residential and commercial districts.
- The mixing of electric bikes, with faster acceleration and pace, with standard bicycles can create challenges where narrow bike lanes exist, as riders seek to overtake.
- The growing popularity of electric assist family bikes, with child seating in a cargo hold, is widening the physical profile of bikes and creating an infrastructure design challenge.
- The difficulties in predicting bike speed and in bike visibility on roads will present a safety challenge between motor vehicles and cyclists.
- As riders of e-bikes become more confident, numerous, and proficient, the relatively small footprint of bike lanes will become more challenging.
- The broad catchment enabled by e-bikes, associated with low-density development outside city centres, may pose obstacles to the viability of some schemes, as it increases the cost of re-deployment and management.

3.1.3 Electric scooters - Overview and application

An electric scooter, or an e-scooter is similar to a two-wheeled manual scooter except it does not require any physical effort. It is propelled forward by an electric motor and is equipped with brakes. The e-scooter is rechargeable, and the electricity is stored on a battery within the scooter.[25] E-scooters come in different models; two, three or even four wheeled, and different sizes. The average size is slightly higher than the waistline; with some smaller, foldable and more practical, and others bigger and designed for unstable terrains. Geofencing (which limits where an e-scooter can be operated) and smart sensors can be used to regulate speed and street clutter.

There are more than 150,000 scooters in 177 cities cumulatively in the US and Europe available for sharing. The market size value for this industry is estimated at USD 18.6 billion from the data collected in 2019[26]. These devices can have travel speeds at or above the posted inner-city limits of 30, 40, 50 and 60km/h[27]. This technology will be followed by more electric mobility, with longer ranges, shorter charging times, and lower costs.

There are over 20 electric scooter renting companies operating worldwide; the main ones being Lime, Bird and Wind. Each country and city has reacted differently, establishing their own set of rules for the arrival of electric scooters. The main concern regarding electric scooters is around safety and enforcement of regulation. A recent German study showed that the two most common causes of electric scooter accidents involved inebriation and the incorrect use of cycle lanes and footpaths.[28] A current Arup study for another global client notes that scooters are seen as a “non-driving” solution for people returning from socialising, with low prices that incentivise this use.

In context, this is another market maturity issue. Until regulated, and after safety campaigns began to work, people drove cars while under the influence of alcohol as a matter of course.

European case studies	
France	In 2019 the French Minister of Transport established a nationwide baseline of laws concerning a new group of emerging mobility vehicles which includes e-scooters. Users are banned from riding e-scooters on pavements, receiving a €135 fine if they do. Their set speed limit is 8km/h in pedestrian streets and high-density areas. Riders who contribute to street clutter also pay a €35 penalty. This is to adapt e-scooters to the city's layout, and the approach can be constantly improved and changed if needed.
Spain	Spain qualified individual mobility systems, such as e-scooters, as vehicles, meaning that the common traffic rules are applicable to the users and e-scooters can no longer be used on sidewalks. In early 2021, Speed limits of 20, 30 and 50km/h have also been introduced depending on the road type.
Germany	Germany officially allowed e-scooters on their streets on the 15th of June 2019. There is no need for any type of licence to use them, but users must be at least 14. Wearing a helmet is not mandatory. The e-scooters are to be used on the cycle paths when they are available, otherwise they are allowed to use the roads but not the footpaths.[29]
Belgium	Belgium introduced a new speed limit for e-scooters in 2019, raising it from 18 to 25km/h. E-scooters can be ridden by anyone aged 18 or over under the same laws as bicycles. This means that they are not allowed to be used on paths and must be used on cycle lanes when available.[30]

In the Greater Dublin Area

- **E-scooters are not currently legislated for in Ireland, but upcoming legislation will seek to introduce a balance between encouraging uptake of scooters and other personal mobility devices while addressing rider and public safety issues.**
- **Individually owned devices are already in use on Dublin streets, on both footpaths and road lanes, and without specific speed limits.**
- **In a recent study of 40 patients who went to Connolly Hospital for e-scooter related injuries: 60% were not wearing helmets, 68% sustained fractures, over one third needed serious surgery, over half did not have a full driving license and the majority were in their late 30 to early 40s.[31] As this study is limited only to people who required hospitalisation, it has a bias towards serious injury presentation.**
- **A pilot project from DCU, TIER and Luna was announced in April 2021 to deploy 30 AI e-scooters to collect micro-mobility data. This project will potentially identify improvements to the safety and standards of micro-mobility devices, and explore some of the smart city possibilities associated with mobility data.[32]**
- **Dublin Bus has proposed a pilot scheme to explore the integration of shared e-scooters with the bus network. It is envisaged that thousands of e-scooters may be made available to the public for free around Dublin. The proposal anticipates that the pilot scheme would be at "minimal net cost to the supporting agencies as costs incurred could be borne by participant suppliers and research grants".[33]**

3.1.4 Electric scooters - Opportunities and challenges

Opportunities

- Potential to moderate bus and car demand in denser inner-city areas, and reduce pressure on city bus, light rail and suburban rail services.
- Lower cost to supply, redistribute and maintain due to their smaller size, compared with bikes.
- Potential to work with e-scooter companies in the collection, analysis and sharing of mobility data to inform city infrastructure, transport planning, safety enforcement and fleet management.
- Highly transportable for the customer; various designs enable rapid folding and easy carriage, making their integration with public transport easier.
- Parking infrastructure can be relatively cheap to build and maintain. The small footprint means otherwise unused space (away from pedestrian flows) can be used.
- Intense market competition can be harnessed to achieve city transport goals.

Challenges

- A growing reluctance for suppliers to enter uncontrolled markets unless cities are large and have lax regulation.
- Uncertainty on whether hire scooters are viable in the long-term vs private ownership.
- Public transport operator tie ups with a single provider will prevent the competition that creates lower costs and fuels greater innovation.
- Enforcement of safety regulations.
- Limiting use for children (many of whom use the non-motorised versions already) could create a skills and confidence gap.
- Concern about scooters as a “new” mobility could trigger overly restrictive regulatory controls.
- Potential to create footpath clutter as e-scooters are dockless, creating safety and accessibility issues for pedestrians, and requiring management and enforcement.
- The design of scooters to manage uneven road surfaces, braking force vs speed capability, the integration of lighting and similar safety concerns are complicated by the speed potential.
- Scooters are capable of navigating small gaps at speed in the public realm, and the mixing of speed, pedestrians, and inexperienced riders, will be complex to manage.
- E-scooters trips may replace some walking and cycling trips.

3.1.5 Other personal mobility modes – overview

Beyond e-scooters and e-bikes, there is a plethora of emerging personal mobility devices coming to market. Improved overall safety and footfall in newly pedestrianised areas have encouraged the uptake of micro-mobility devices such as:

- Segways (standing and sitting versions): A self-balancing two-wheeled "personal transporter". It is powered by an electric motor and is equipped with a rechargeable battery. It has a handle, a platform to stand on, and is propelled and steered by leaning in the direction desired.
- Scooter hybrids: A scooter that is designed to be propelled by both the user and an electric motor within the scooter. It is very similar to an e-scooter but it allows for physical assistance.
- Folding scooters: A lightweight, non-motor powered, scooter that can be folded or dismantled, making it easier to carry or store.
- Mobility scooters: A two, three or four wheeled electric scooter with a seat for better comfort, with the aim to assist the mobility of people with diminished physical capacities.
- Electric/non-electric skateboards: A four wheeled device made of a board and wheels, it is used by physically pushing with your foot while on the board and steered by leaning either side. An electric skateboard would replace the physical aspect with an electric propulsion managed by a small controller that the user has in their hand.
- Quadricycles: Similar to cars in some ways, but electric and designed with a limited weight capacity, engine power, and speed.
- Adaptive bikes and tricycles.
- Advanced electric wheelchairs with greater range and speed.

Quadricycles are already proving very popular where allowed in Europe (in particular in Amsterdam), and would contribute to emissions reductions. But they pose questions around the type of vehicle they are and where they should operate.

The extent at which some micro-mobility devices are being used surpasses the initial purpose of them. For example, some are used as disability aids when they were not designed for it, but it is a positive aspect. As people continue to find new ways of using micro-mobility devices, adapting them to their own needs, the available infrastructure also needs to evolve to support these new mobility modes and how they are used.

3.1.6 Recommended measures

The following measures are recommended when regulating, planning for, procuring, and managing electric bikes, electric scooters, and other personal mobility modes:

- **Provide legal status:** Ireland might consider that the generalised benefits of encouraging all sorts of mobility devices as they come to market, and

convincing people to shift to them, is worthy of affording legal status to their operation as a principle.

- **Take an integrated planning approach**: The NTA could evolve its standard data models, to better understand the implications of shifts in price, opportunity and service type, to identify where the greatest opportunities for change exist, and how influence can be applied in a way that will support public benefit. An agent-based model with a developed equity tool would assist.
- **Investigate implications of reliance on unproven mobility services**: Before recommending that changes in mobility be promoted, investigate the commercial and cost implications of reliance on mobility services that have yet to prove profitable. Creating modal shift is difficult, and losing momentum because of market failures can be difficult to recover from.
- **Consider optimal market structure:** A limited market for each urban area might yield greater results than an open market. Work with the local authorities in the GDA to determine what an optimal, balanced, supply chain might look like, based on international experiences.
- **Identify the short public transport trips that could convert to micro mobility:** Public transport service demand could be analysed to determine what proportion of peak inner-city bus demand is attributable to short trips which lead to overloading, and congestion due to high vehicle frequency. Short trips by able people could be encouraged to shift to electric bikes and scooters.
- **Consider policy and regulations based on speed profiles:** The RSA, with wider transport input, might consider a policy, standards and legislative framework for vehicles based on speed potential that separates any vehicle type into footpaths/bike paths/roadways/motorways and creates safety, licensing, registration and taxation bands. Using a safe-systems approach; not starting from the point of cars, but performance, and align the spatial distribution of people using different devices. This might also incentivise people to buy the sort of device that is right for their level of comfort around speed and safety.
- **Create vehicle standards:** Around speed management, braking capacity and minimum safety features per speed range. This will inform the supply chain and vehicle importers about minimum requirements for vehicles to be sold legally.
- **Integrate with public transport:** Investigate the infrastructure integration required, both at stations and stops and on vehicles, to better integrate mobility devices with the public transport network. There are many global examples of well-designed bike and device integration on buses and trains, as well as integrating safe storage at stations and stops.
- **Investigate optimal funding model for public transport integration:** To understand the types of shared mobility that would benefit the NTA's service remit and reduce costs to the operating model, before committing to integration costs.

- **Design inclusive infrastructure:** Design infrastructure that can safely accommodate different types of micro-mobility, keeping the transport customer and their different needs and uses, at the forefront.

3.2 Connected and Autonomous Vehicles

3.2.1 Overview and application

Connected Vehicles (CVs) and Autonomous Vehicles (AVs)

The term connected vehicles (CV) is part of the EU's Cooperative-Intelligent Transport Systems (C-ITS) commitment and refers to vehicles that can communicate with each other (vehicle-to-vehicle; V2V), with infrastructure (V2I), and with the wider ecosystem of other road users and cellular networks (V2X), through extensive data sharing. The EU's 2016 strategy on Cooperative, Connected and Automated Mobility (CCAM), details how information, vehicle and infrastructure technologies are required for CVs to achieve two levels of specified C-ITS priority services: 'Day 1' and 'Day 1.5'[34]. These services include vehicle speed limits, intersection safety/signal violation, and vulnerable road user protection. Dependent on this network of connectivity and the technologies that enable it, are autonomous vehicles.

Autonomous vehicles (AVs) use automated driver-assistance systems (ADAS) such as Radar/LiDAR, ultrasound, and in-vehicle cameras, along with other on-board and roadside IoT sensors, AI, computer vision, human-machine interfaces, edge-computing, and a whole set of start-of-the-art technologies to deliver self-driving vehicles capable of operating without any driver input.

There are six levels of vehicle autonomy:

(0) no automation

(1) driver assistance

(2) partial automation

(3) conditional automation

(4) high automation

(5) full automation.

The current commercial deployments of AVs reach Level 2 autonomy, while pilots and trials are common for Level 4. At Level 4, vehicles can operate independently in very well defined and controlled environments and are remotely monitored at central operation centres. Small fleets of Level 4 AVs are already being deployed in several cities around the world. These vehicles still require back up drivers on standby to intervene in special circumstances; defeating the business case for cost savings through autonomy for now.

The hype vs reality

The ambition of the motor industry to have fully connected and autonomous vehicles (CAVs) in mass operation has, to date, been difficult to achieve. Of all

the hyped mobility technologies, Level 5 fully autonomous vehicles have experienced the most freefall, as the relative immaturity of the technology has proved to be expensive, unreliable and ultimately fallible in its current development state. The promise of greatly reduced operating costs is still at least a decade away. For the people of Dublin that doesn't mean the investment in research and development will not pay dividends through:

- Safety benefits from active sensor use;
- An understanding of how vehicles and people can interact;
- Insights into the types of data that will be generated; and
- Upgrades to data networks that will enhance understanding of place and the spatial interactions with vehicle movements.

Global case studies: Autonomous Vehicles	
France	Since June 2020, Navya has launched several Level 4 highly automated shuttle services named 'Autonom Shuttle Evo'. The shuttles can transport up to 15 passengers at speeds of 25km/h in dedicated zones or 'geofenced' areas with connected sensors and smart infrastructure.[35]
Germany	Germany has adopted legislation that will allow Level 4 autonomous vehicles on public roads by 2022 in anticipation of the scaled deployment of robotaxis and delivery services in chosen locations.[36]
US	Waymo deployed Level 4 driverless taxi services in Phoenix, Arizona in October 2020. Nuro, who have run delivery services of goods with their 'R2' Level 4 vehicle, were granted a permit to commercially operate on public roads in California.
China	AutoX announced in January 2020 that Level 4 Robotaxi services will be available in a designated area of the Pingshan District, Shenzhen. They will be using Waymo vehicles.[37]
Global case studies: C-ITS and Connected Vehicles	
Germany	There has been a longstanding contribution to the testing of C-ITS services in traffic environments in Germany. Many of the testing sites have entered Phase 2, allowing the support and extension of Day 1 and Day 1.5 C-ITS services in Hessen and Niedersachsen.[38]
UK	Pilot C-ITS services were carried out in phases commencing in February 2020. The "A2M2 Connected Corridor" spans 110km across various operational environments, with the learnings expected to inform future policy development for CAVs.[38]
France	There are two pilots for C-Roads in France, operating across four sites. In both cases, C-ITS services are advancing in their implementation across urban environments. Smartphone integration is also being enabled across both pilots.[38]
Spain	The DGT 3.0 pilot spans 12,270km across five sites in Spain, including urban and interurban areas, each with unique C-ITS services under assessment. These pilots are a bid to verify interoperability on a national and EU scale.[38]
Netherlands	The Dutch Corridor Area has seen testing of Day 1 services with an emphasis on road freight. Utilisation of traffic management services has facilitated a reduction in buffering at nodes, and thus reduced congestion, emissions and costs.[38]

In Ireland

- Transport Infrastructure Ireland is running a C-ITS pilot to deploy, trial and assess CVs along with Day 1 and Day 1.5 C-ITS services across the Irish TEN-T network (N1, M1, M50, N7, M7, N18 and M8), as well as on urban corridors within Dublin. Prospective plans include exploring scalable cross-border testing with Northern Ireland.[39]
- Although testing of AVs in Ireland has been limited to private land or via simulators to date, the Department of Transport and the Department of Taoiseach have been working to develop guidelines and legislation to allow testing of AVs on Irish roads.[40]
- Jaguar Land Rover and five tech companies have teamed up to run a research hub called The Future Mobility Campus Ireland (FCMI) in Shannon, as announced in November 2020. The site will act as a testbed for CAVs and infrastructure technologies that enable autonomous parking and charging, smart junctions, and connected and instrumented roadways.[41]

3.2.2 Opportunities and challenges

Opportunities

- C-ITS and connected vehicles have the potential to improve the overall customer experience, allow for delivery of different services, and enhance fleet efficiencies and operations such as license awarding, tracking, performance and adherence to road rules.
- The core promise is that the driver assist technologies will significantly improve both safety and ride quality.
- There are many autonomous vehicles in development and in trial, but they require specific operating conditions, including a lack of snow, mud or heavy rain, which can disable systems rapidly.
- AVs can be very effective for rail systems, particularly where the vehicles are in a completely separated right of way.
- The city centre is the most contested environment for public transport operations. Modes compete with each other, and buses in particular are large, difficult to operate in the restricted spaces, and require multiple routes to penetrate the various city districts. Smaller autonomous pods servicing the centre as an extension of NTA services, enabling only a few key routes to be used to through route buses, could improve services by simplifying the network, increasing reliability, and reducing operating costs.
- Within the GDA, there are numerous business parks and residential estates that are challenging for standard bus services. The future ability to use smaller, autonomous vehicles to connect people to trunk routes, then running those trunks more intensively, could greatly improve accessibility.

Challenges

- CAVs perform best in trials in low speed environments and need very high quality, highly consistent maintenance of the built environment, so that the

vehicles can navigate reliably. This will most often be achieved in city centres. Those constraints, assuming a business case was made to improve line marking, signage and consistency of intersection design, have a particular application for the NTA.

- Security for passengers, where no driver is on board to moderate behaviours, is something that requires further understanding from a customer confidence point of view.
- Security of unattended vehicles, particularly given the vulnerability of operating capacity due to sensor reliance, is still to be resolved commercially.
- Cost is currently significant for the volume of data to be shared and computed to enable autonomous operation, although the cost of data tends to reduce rapidly over time. This will need commercial resolution by suppliers before the total cost of ownership can compete with today's driver operated vehicles.
- The distribution of costs incurred for the benefit received can challenge business cases. The costs of maintaining road markings, signage, reconfiguration of signals and junctions and updating map data where disruptions are planned, all sit with Local Authorities. The benefits to the customers, and the lower operating costs that arise would benefit the NTA's contracted service providers. A whole of Government approach is required to balance the costs borne and benefits received.
- The reliability of communications networks requires resolution, not only in mobile data networks, but also GNSS. This will be driven by the market, but it should not be underestimated as a challenge in older cities like Dublin with narrow street networks and highly variable operating conditions.
- The legal and regulatory conditions to enable autonomous vehicles requires significant commitment by Government before liability is established and costed into autonomous vehicle pricing. The NTA must avoid establishing liability for technical failures of autonomous vehicles leading to unfortunate outcomes.
- Where the lowest-cost optical systems are used, benign environmental conditions are critical to reliability. Where CAVs rely on LIDAR and/or GNSS, the reflections that occur from the built environment in a crowded city like Dublin, along with the difficulty of seeing around bends, makes them hesitant.
- Seamless CAV performance will be difficult to achieve in areas of high pedestrian activity and shared road space due to the programmed vehicle avoidance of vulnerable road users like pedestrians and cyclists.

3.2.3 Recommended measures

The following measures are recommended for connected and autonomous vehicles:

- **Develop a CAV integration strategy:** To address the potential opportunities that autonomous public transport vehicles could have in evolving the NTA's

operating model. The strategy would develop the NTA's position around when to engage productively, and when to invest.

- **Observe international trials and technology development:** Rapid improvements and progress will occur, but it will be some time before it filters down to meaningful changes for the NTA and the GDA.
- **Articulate a development path for procurement:** The NTA, or another Government agency, could have a development path in its procurement model to continually test and upgrade technologies that improve its operation and safety.
- **Collaborate with academic bodies, TII and the Future Mobility Campus Ireland:** The NTA can play an external advisory role to understand the impact and progress of the technologies being tested and deployed as part of the various C-ITS projects happening in Ireland. Additionally, the NTA should assess the impact, if any, that mainstream ADAS will have on the contracts for operation in place and going forward.
- **Consider impact on pedestrians and cyclists:** Investigate ways to ensure that the level of service provided to pedestrians and cyclists in cities is not detrimentally affected by the CAVs efficiency requirements.

3.3 Ride hailing and Carsharing

3.3.1 Overview and application

Ride-hailing services operate through apps that connect passengers and local drivers using their personal vehicles, essentially replacing or enhancing the traditional taxi services. Carsharing is a sub-group of the sharing economy and enables the short-term access to shared vehicles according to user needs, removing the need for ownership of transport assets. Like bike-sharing models, carsharing depends on ease of access and availability. In recent years some of these schemes have been withdrawn worldwide, often superseded by ride-hailing.

Type of Ride-hailing and Car Sharing	Description
Peer to peer (P2P) carsharing	Person-to-person lending of private vehicles typically managed by 3rd party digital platform. E.g. RelayRides.
Carsharing (Station-based vs Free-floating)	Pay for the hour/mile membership model, individuals sublease vehicles owned by a 3rd party. **Station-based:** advance booking for different types of vehicles accessed at fixed locations. Return to starting locations after use. E.g. GoCar. **Free-floating:** vehicles can be accessed at defined service areas upon availability. Park at any location within service area after use. E.g. ShareNow.
Fractional Ownership	Multiple individuals can subscribe to a vehicle (often luxury models) owned by a 3rd party. E.g. Auto Timeshare.
Ride-hailing	Private individuals sell rides to users on-demand to predefined destinations, e.g. Uber and Lyft.

Type of Ride-hailing and Car Sharing	Description
Ride-splitting	Similar to ride-hailing, but with limited success, this service organizes shared rides between multiple users taking the same route. E.g. UberPool and Lyft Shared rides.
Carpooling and Vanpooling	Grouping of travellers into a privately owned car or van, typically for commuting. E.g. CarpoolWorld listings.

In the Greater Dublin Area

- Carsharing companies in Dublin include GoCar, Yuko and Enterprise Car Club.
- In a study of 400 Yuko users, it was found that; members didn't use the service as a means of commuting, but for mobility for a variety of reasons outside their regular commute; car sharing was replacing public transport for longer distant trips.[42]
- Uber only operates as Uber Black in Dublin, a premium service. They were banned in 2017 from operating private car rides (their normal operation model in other countries).[43]
- FREE NOW, Dublin's biggest ride hailing provider, are teaming up with TIER to provide e-scooters in their service offering.[44]

3.3.2 Opportunities and challenges

Opportunities:

- Potential to exploit multiple service types (as lower cost services) to replace route-based services.
- Potential to collaborate with ride hailing companies who are expanding their services into micro-mobility. E.g. Dublin Cycle Buddy App to integrate Free Now e-scooter locations.
- Potential for ride hailing services to expand into the delivery of goods market.

Challenges:

- The already thin markets that the NTA must continue to serve for equity reasons, will be further eroded by multitudes of options available. If those thin markets evaporate that is a benefit, but if they become so small it is hard to justify operation, then costs rise.
- Dublin experienced a significant campaign against the introduction of ride hailing companies from the taxi industry, which was successful in blocking service introduction. This is still relatively fresh, and thus the opportunity to overturn this may have a high political cost.
- Numerous employment cases are before the courts, which if successful in categorising drivers of hailing services as employees will make it very difficult for these services to be commercially sustainable. If disability access was required, as it should be, they would not be able to succeed without market protection (just like taxis).

3.3.3 Recommended measures

The following measures are recommended when planning for ride hailing, car sharing, and other models:

- **Develop policy guidance:** To avoid creating more demand for more expensive service types when there is sufficient demand for route services.
- **Develop service guidelines:** That exploit additional service suppliers, particularly in low volume service areas and times.
- **Develop procurement methodologies**: That improve operational flexibility and customer benefits, but do not create onerous public commitments and do not enable service providers to enhance demand for low volume services at the expense of less costly service types.
- **Develop metrics:** To guide decisions that would reduce barriers to having a flexible approach to service contracting and delivery, such that process acts as a filter on flexible service expansion and contracted operators are not unintentionally incentivised to abandon marginal services.
- **Retain focus on how these options can support the public transport task:** While customers benefit from more private vehicle travel options, these modes don't address the congestion issues affecting Dublin's economic success. Retaining a focus on the role they can play in supporting greater public transport, use in an integrated manner, will be key.

4 New Mobility Models

4.1 Mobility Hubs

4.1.1 Overview and application

Mobility hubs in the current transport system are often public transport nodes such as stations, park & ride facilities, or airports. They group mobility options close together in key destinations, providing visibility of options to enhance consumer awareness of the choices, and encourage a shift from private car reliance when travelling to and from these places. To support transition from one transport mode to another, mobility hubs need to make these alternative options more attractive and more convenient.

Solely providing the transport options will not be enough to influence behaviour to more sustainable intermodal travel. The mobility hub must be carefully designed to ensure the transfer or waiting experience is as efficient, safe, and attractive as possible. It should also provide access to additional services that benefit the surrounding neighbourhoods and development, serving as a vital part of the urban fabric, integrating people as well as transport.

Beyond transportation, mobility hubs often house or facilitate access to a corollary of additional services for the travelling public, such as WIFI, wayfinding and tourist information, convenience retail, or emergency medicine. There is scope for further development of hubs to include community-specific services, adding to the cohesion of a neighbourhood. For example, hubs may become artist exhibition spaces, house co-working offices, dry-cleaning facilities, childcare and other services that contribute to placemaking and allow users to avoid trip-chaining.

Case Study of Mjärdevi Science Park, Sweden

The mobility hub framework helped to transition the business park 'Mjärdevi Science Park' to a more sustainable mobility system. It is situated on the periphery of Linköping City; 5km from the E4 Highway. The park is a workplace for 7,000 people - 58% of whom arrive by private car. The availability of large amounts of free car parking spaces encourages the heavy reliance and convenience of motorised cars even though 20 buses from 15 bus routes pass through the park's central square. To design the mobility hub, city planners focused on placemaking, clustering of services, repurposing parking spaces and providing mixed development. This created synergies between the employees and students around the park, as well as the companies nearby and the university they attend. They introduced modular and adjustable shelters for bike sharing/parking and bike repairing areas. These modular shelters also serve as social gathering spaces through the provision of indoor and outdoor public spaces by cafés and restaurants, as well as flexible areas for events and exhibitions to take place.[45]

In Ireland

- A planned upgrade of Heuston Station includes bike parking for 2,500 bikes. This could be a strong test case to apply a mobility hub approach, assisting with better management of public space and promoting multimodal and active travel.

4.1.2 Opportunities and challenges

Opportunities

- Reduce the complexity and expense of large scale interchanges in the public transport system.
- Major rail stations are suitable locations for mobility hubs, but wherever there are large numbers of people potentially travelling short distances who want certainty of transport supply, mobility hubs have potential.
- Potential to promote modal shift as users increasingly demand a smoother experience, and can be discouraged by perceived hassle. Mobility hubs can be at the heart of a seamless, multimodal journey that is attractive and convenient.
- Mobility hubs can create vibrant and useful public spaces that support the development of more cohesive neighbourhoods. As many journeys are made with the purpose of collecting children, performing household maintenance functions, and personal care, mobility hubs can be expanded to include childcare facilities, retail, or medical services.
- The expansion of mobility hubs beyond transport can help transition towards the model of the 15-minute city or 30-minute city. Hubs will allow for easier journey-planning and access to corollary services, helping to activate the public realm.

Challenges

- Realising successful, large-scale mobility hubs will take time, collaboration and co-financing. Looking beyond their transport functions and getting the buy-in from the multiple stakeholders involved can be a challenge.
- Dublin has limited legal supply of options and a good supply of services already. A business case would need proper scrutiny and select locations would need to be trialled. For long-term viability, mobility hubs will need to cater for the technology requirements of future modes/payment methods that do not yet exist; and the lifespan of built infrastructure far outstrips that of supporting technologies. Some future requirements are predictable and others are not – for example, we know we will need charging infrastructure for e-bikes, e-scooters, and e-car-share. Understanding and predicting future needs of hubs will be a challenge in designing and shaping the space.
- Designing spaces that are adaptable to future uses and functions as well as future technologies. It is not only the technology that will evolve but also consumer preference, behaviour patterns, and demands on use of public space for different functions, including e.g. childcare.
- There are some industry players reluctant to participate in mobility hubs as a concept because it highlights the differences in price and options compared to the competition in stark contrast. However, the nature of competition is likely to overcome initial reluctance.
- Planning conditions and the complexity of getting approvals are a barrier to developing mobility hubs, but the NTA is well versed in these challenges.

- Safety will be a concern both for transport and the hub's other functions. It will be important to find the balance between creating a public, non-consumption space that meets user needs in terms of mobility and other services, but that doesn't promote antisocial behaviour or discourage use of public transport.

4.1.3 Recommended measures

The following measures are recommended to plan and pilot mobility hubs in the GDA:

- **Develop a draft business case**: for a mobility hub to determine what missing information or data is required.
- **Pilot a mobility hub concept**: Heuston Station is a prime location for a mobility hub pilot as part of the planned upgrade – adding new services and options to improve the convenience of environmentally friendly mobility options, and introducing a central "destination" to the area.
- **Research new locations/possibilities for hub creation**: both in relation to integration of different modes on a smaller scale, e.g. integrated planning of public transport stops and shared mobility options, as well as in relation to the design and placement of larger-scale intersectional mobility hubs with supporting services.
- **Conduct a best practice review:** research into mobility hub creation across Europe to understand what has been successful in comparable jurisdictions.
- **Begin early engagement with stakeholders**: to raise awareness of the benefits of mobility hubs, e.g. increases in ridership, and the integrated planning of public transport stations with new and emerging mobility, other essential services, and civic space.

4.2 Mobility as a Service (MaaS)

4.2.1 Overview and application

Mobility as a Service describes a mobile application that allows a single consumer portal for all forms of mobility to be journey planned, procured and compared. Economic research points to pricing as the primary driver of behaviour change, and through MaaS, customers can be better informed about the price of different mobility options. At its core, MaaS is an economic tool to ensure informed consumers can make 'good' travel decisions that meet their specific needs.

MaaS was designed to allow a third party to bring together all the existing means of transport and allow customers to access their payment platforms through a single portal. Rather than relying on a third party, some transport authorities have become the MaaS providers, owning and operating the MaaS platform as well as the means of transport. As a product, MaaS exists to make money for the application and the transport providers. Depending on who ultimately "owns" the customer, the usefulness for creating public value is highly variable.[46]

Figure 1 - MaaS and the "Strategic Triangle". [47]

If considered for the GDA, MaaS would need to include an appropriate pricing strategy that provides financial incentives for users to trial other modes. The value of MaaS needs to be examined through user data from jurisdictions where it is already applied. Most MaaS users are already regular public transport users and benefit from the discounts available. In Norway, the single greatest mode shift was to taxi as the discounts in pre-paid packages made taxi use more affordable when public transport was scarce. The design of mobility packages, pay-as-you-go options, all-inclusive models, or capped taxi services, can help to kerb this along with other incentives that nudge customers.

In the Greater Dublin Area

- The existing pricing structure of public transport in Dublin is based on rewarding regular commuters and not on incentivising new entrants.
- The barrier to entry to get a Leap card with value is higher than most global solutions, and the ability to use public transport requires some knowledge of the length of journey and what the fare will be prior to use or committing to Leap early.
- The NTA has already gone to market with Next Generation Ticketing (NGT) and included a potential MaaS application platform within it.
- It is hoped the NGT will resolve these issues with a focus on increasing use, variable discounts based on policy objectives and an understanding of the volatility of transport patterns as the economy evolves in Dublin.

4.2.2 Opportunities and challenges

Opportunities

- The NTA has integrated the concept of MaaS into its NGT and has a base from which to proceed.
- If the NTA uses MaaS as a tool to achieve the balance of mobility and mode to achieve its service strategies, and controls the tool and the terms and conditions of use, it could use its dominant market position with its contracted operators via Dublin Bus, Bus Eireann and its partners at TII and CIE to create an integrated service offering of public and private service providers.

Challenges

- The alternative mobility service applications are already well established. Each provider, whether it be FreeNow, Bolt, the various cycle hires, car share schemes and the impending scooter operators are all fighting for market share and to incentivise customers to move to, and remain with them.
- Existing providers are sophisticated marketing platforms not encumbered by the latency of decision making that is required across Government. This means they are faster to implement solutions that work to their benefit, and might be reluctant to change or modify these to suit an integrated MaaS solution.
- Enticing new customers to the use of a single MaaS platform will require discounting and incentives.
- Finding transport provider participants may be difficult.
- Siphoning of customers: One of the reasons MaaS has faced challenges in the marketplace is that it exposes users to many new modes. Users that are new to a mode, e.g. bike-share, may decide that subscription directly to this service provider is either cheaper or more convenient for them than subscription to the MaaS provider.

For the underlying promise of MaaS in cities to be realised (that sufficient mobility opportunities will be presented and that private car use will diminish), success is dependent on an independent, non-market actor to take great care in ensuring openness and the embedding of public transport in the platform. The desire of private players to make money and thus offer seemingly attractive options requires constant vigilance to maintain public value. Public mass transit must remain the backbone of the MaaS ecosystem.

Parallel's with travel accommodation

A parallel to Mobility as a Service is travel accommodation booking. Initially every hotel had its own application and it was difficult to be found. Then some aggregators made a MaaS like platform, such as Booking.com, with certain providers to capture more clients, with the accommodation provider paying a fee. This was followed by super aggregators like Trivago, pulling multiple smaller aggregators through its portal, thus charging a fee to the aggregator, which then had to charge that also through to the accommodation provider. Increasingly the search engine functionality has allowed the consumer to avoid the aggregator altogether, secure a cheaper deal with the accommodation provider directly because there are not layers of fees

attached, and the aggregators are fighting in a decreasing customer market. For transport, the need for MaaS is already undermined by a slew of free transport integrator sites.

4.2.3 Recommended measures

The following measures are recommended to investigate the potential for MaaS in the GDA:

- **Develop a business case:** to fully articulate the business case that would make it viable, and the likely scenarios arising to understand the level of investment that would be required to acquire each mode shift sought.
- **Undertake full Dublin-based consumer research:** to inform the elasticities that would apply in nudging users from car use to a selection of other services.
- **Undertake market testing**: to determine willingness of transport service providers to participate in a MaaS platform, the price at which that participation dissolves, the level of commitment in terms and conditions that would be tolerable, the restrictions on data sharing that would be requested, and acceptability of limitations on customer poaching.

4.3 Total Mobility Pricing

4.3.1 Overview and application

Mobility pricing has been addressed in different forms throughout this background paper, on motor vehicle use, public transport pricing, competition for customers via MaaS, and pricing competition among transport service providers. Total Mobility Pricing considers the mobility market as a whole and coordinates pricing activities to maximise the behavioural change desired. This follows the economic doctrine that the greatest incentive to behaviour change is rational pricing. Rational in this case means visible pricing upon which a consumer can make an informed decision.

Governments already directly and indirectly influence prices through:

- Road use: including fuel excise, VRT, VAT and tolls, among other charges.
- Public transport: fare structures.
- Taxis: fares are approved by Government.
- Bike and scooter hire: city-based tenders to limit competition in return for improved market share and thus profitability.
- Parking: the local authority prices parking and manages supply through planning approvals, one of the greatest levers available to drive mode shift away from private car use.

There is a common misunderstanding of the concept of price in driving decision making, often taken literally to refer to how many euros a service will cost. However, price is multi-variant in its composition. Convenience is a significant driver of consumer behaviour with a pricing component; people are often willing

to pay more for simple or quick options. For example, someone might place a higher value on time when anxious, i.e., when they have a problem to solve.

The biggest problem with pricing strategies is the modal or sectoral approach, where the lack of coordination causes confusion, or where the savviest marketer creates the best reason to act in the mind of the consumer. The Government responsibilities in Dublin to manage travel demand and congestion, and reduce private vehicle trips, transport emissions, and mobility inequity, are all related to pricing and its application. As objectives of Government, they can also be at total odds with each other, and any one price setting can undermine the effectiveness of another.

In Ireland

- The suite of planning documents for transport is significant and well-articulated, but the issue of pricing is largely implicated rather than tackled directly.
- Governments already directly and indirectly influence prices.

4.3.2 Opportunities and challenges

Opportunities

- To look at the mobility market as a whole and coordinate pricing activities to maximise the behavioural change desired. This does not mean that Government controls the price of everything, which would be a challenge to the national economic model. It does require integration of thinking across vehicle, fuel and road user charging, public transport pricing and complementarity/subsidy or in-kind support of options that contribute to Government objectives.

Challenges

- Pricing is a sensitive topic.

4.3.3 Recommended measures

The following measures are recommended to commence coordination for total mobility pricing:

- **Coordinate a policy position on total mobility pricing**: to promote integration across modes and agencies and a focus on people and their behaviour in a way that would accelerate change, articulating:
  - What the behaviour shift desired is (including mapping capacity to absorb that shift);
  - What revenues must be maintained to fund infrastructure and services; and
  - How all of that changes overtime and then match that to each element that exists of pricing and shift them as a basket in an agreed manner.
- **Promote the concept of total mobility pricing:** As a primary provider of public transport services for Dublin, the NTA and public transport operators have a major stake in the outcomes.

- **Investigate the total mobility pricing requirements for the GDA:** As it has the greatest supply of mobility options and the greatest national mobility task, the GDA could be considered for investigating the governance, economic, financial and policy requirements that Total Mobility Pricing would require.
- **Develop a GDA trial for Total Mobility Pricing:** Subject to the initial investigation into the requirements, the GDA could be used as a trial area for Total Mobility Pricing implementation.

5 Planning for Change

This section provides guidance on the principles and approaches to planning for change associated with the integration of people, technology and mobility.

5.1 Focus on Outcomes

How the NTA embraces innovation, and how it appraises the benefits of innovation during a time of multiple shifts in how we live and move, will shape the future of Dublin.

Clarity of mission

It is tempting for Governments to focus on the most tangible things. Often infrastructure can be seen as more important than the services it supports; building something is a concrete commitment. But transport infrastructure only exists to provide services, and it is primarily what the service delivers that the customer experiences and values.

A governance framework enabled by an agreed set of policies, that articulate the aim of Government investments in transport infrastructure and services from the perspective of the end users, will increase understanding of what actions should be taken.

As technologies arrive and evolve, we can often think we must adopt them. But the benefits of adoption, whether it is necessary now or as a phased change, and whether the benefits change outcomes for people, all need assessment.

Clarity of mission, and testing against that mission, are the basis of quality public policy making and investment analysis.

The aim of the Greater Dublin Area transport system:

To provide a sustainable, accessible and effective transport system for the Greater Dublin Area which meets the region’s climate change requirements; serves the needs of urban and rural communities; supports economic growth and meets the future demand for travel for its citizens.

Maximise the return on public investment

In the case of Dublin, the use of a car is a far greater concern than the ownership of a car. A public authority such as the NTA faces the task of making the most socially beneficial mobility decisions the most attractive, wherever possible. This will involve a nuanced approach to maximise the return on public investment:

- Reducing reliance on public transport services where better network alternatives are available, such as cycling; and
- Increasing use of public transport in locations where private car travel currently prevails.

5.2 Enabling Change

Set clear strategic outcomes and targets

The combination of climate and transport infrastructure, services, and operations plans together create a relatively clear desire to increase the use of alternatives to private car use in Dublin for a range of outcomes. But these plans tend to address this aim in siloes. The fundamental outcomes, access to opportunity and clean air, both require people to change travel behaviour. There is great good to be had if the plans for infrastructure, operations and services all pull together towards nudging people, but they must be cogent, predictable, understandable.

Movement towards sub-targets set at three year spacing could help planners target their actions and decision makers filter out investments that do not contribute to the mission. These sub-targets can incentivise selection of the right actions, especially if every action is tested post implementation for its effect on moving towards outcomes. This allows course correction to occur and also prevents the multiple counting of outcomes by different actors.

Continuous assessment against the strategic outcomes

Regularly assessing the progress of technologies and innovations in service delivery against NTA's strategic plans for Dublin will reduce reactiveness and instead demonstrate active engagement and understanding. By openly discussing the gap between the disruptors' ability to deliver, and the needs of the NTA and its customers, it can also help the industry shape its offering more tangibly to solve arising issues. For example, adopting phone-based payments in the NGT, and allowing credit and debit card payments rather than a specific transport card, would remove a barrier to the use of public transport. In particular this would benefit infrequent public transport users. But if two factor authentication was required for a transaction it would slow boarding and disrupt services. If this issue is made clear to service providers, they could develop solutions to address it.

Rigorous post opening performance evaluation of significant investments will ensure that the investments are performing as expected and to enable course correction and lessons learned. This has proved internationally to improve Government transport investment performance including in France, US, South Korea and the UK, and is encouraged by the EU.

Identify the potential delivery against outcomes, and the available funding

Plan by outcome, rather than by mode, and be wary of any single mode project that claims strong benefits without thorough analysis of total network effects. Transport planning decisions should be defined around the benefits to people, place and environment, with vehicle related discussion considered as a data point, rather than the focus.

Taking the customer-centric point of view is important in the public realm. The secondary consideration is whether a technology change investment will enable the NTA to support Government in meeting its wider policy targets. To continue the example of the NGT, a question to answer is around what mode shift from private car to public transport might be achieved if phone-based payment without

an account was enabled, and how would that expedite reductions in emissions? If it did accelerate mode shift, what funding supports might be available for such an investment?

Understand the true cost of the change

When planning major service changes evaluate the wider benefits and effects, not just counting what happens to the service being evaluated. This will help determine the actual total costs and benefits of integrating and connecting people to the service being invested in.

Aim to understand whether the operational benefits for the NTA; whether the cost of change would be recouped through any operating cost savings over the life of the investment. This can help Government decide whether this is an NTA investment with operators, or something that requires a community service obligation top-up. For the NGT example, if it did transpire that a change in payment systems accelerated climate benefits and could be executed in a way that incentivised uptake, then it would be important to understand whether the cost of implementation and the ongoing cost of card provider fees would be covered by the improved systems, or would it create a further unrecovered operating cost that service providers would seek funding support for?

This whole of Government, whole of supply chain analysis to appraise opportunities arising from technology would enable clarity at all levels of decision making. Using the Public Spending Code and creating simple analytical tools that create the evidence chain required for submissions as practice, would simplify the management of change as it progressed towards reality.

Give the market clear direction

A great deal of public money can be wasted if Government is unclear on what it is seeking to achieve from its transport investments, and where clear market signals might be more valuable than grants or procurement. Similarly, being very clear on what will not be tolerated or enabled avoids wasted effort and investment. The ability of information technology to assist in encouraging people towards decisions that improve system benefits requires absolute clarity on what a system benefit entails, and the priority order of decision making.

5.3 Roles for Government

For Government to make decisions about what technology it will embrace, enable, support, or subsidise, it requires a guiding set of principles that enable appraisal of investment. The Public Spending Code is largely fit for purpose, but the tools used to develop business cases are not advancing at the speed of technology and are particularly poor at taking a whole of systems approach.

Integration in decision making is critical to reducing the cost of entry to market for emerging mobility technologies through creating certainty for public and private investors. The Greater Dublin Area Transport Strategy and this collection of discussion papers form a strong basis for determining the guiding principles for decision making.

A great deal of public money and effort invested into information technology can be wasted if Government is unclear on:

- What it aims to achieve from its transport investments;
- Where clear market signals might be more valuable than grants or procurement; and
- What will and will not be tolerated and enabled.

The role of Government is simply to set out:

- Clear direction on the outcomes;
- What the citizens should be expected to receive in order to change their behaviour;
- How success will be measured and monitored;
- How governance will be applied to integrate and ensure the maximum benefit is gained from each euro of taxpayer investment;
- The enabling systems for data, information sharing, compliance, audit and reporting are in place; and
- A clear narrative for all actors to adhere to.

5.4 Roles for the Private Sector

The role of the private sector, including semi-state corporations, is to implement the actions required to deliver on the outcomes sought by Government as a whole for the people of Dublin.

This includes being clear about:

- What can and cannot be done;
- What inhibitions to success entail;
- What a change management process would require in all of its dimensions; and
- What will or will not result in cooperation.

With Government setting the conditions for success it is much easier for the private sector to have confidence that investment in service provision will be supported or enabled, rather than running the risk of dispute and associated costs.

6 Recommendations

The below table summarises the recommended measures for the integration of people, technology, and mobility.

Topic	Recommended measure
Mobility data	
Mobility data	Develop a robust data policy
	Develop a Common Information Model
	Establish open standards
	Enhance open source tools
	Create a customer information test bed
	Develop, implement and monitor a GDA data mapping tool and dashboard
	Shape the Next Generation Ticketing
	Continuous effectiveness assessments
Connected, Autonomous, Shared and Electric Vehicles	
Electric bikes, scooters, and other personal mobility modes	Provide legal status
	Take an integrated planning approach
	Investigate implications of reliance on unproven mobility services
	Consider optimal market structure
	Create vehicle standards
	Identify the short public transport trips that could convert to micro-mobility
	Consider policy and regulations based on speed profiles
	Integrate with public transport
	Investigate optimal funding model for public transport integration
	Design inclusive infrastructure
Connected and autonomous vehicles	Develop a CAV integration strategy
	Observe international trials and technology development
	Articulate a development path for procurement
	Collaborate with academic bodies, TII and the Future Mobility Campus Ireland
	Consider impacts on pedestrians and cyclists
Ride hailing and car sharing	Develop policy guidance
	Develop service guidelines
	Develop procurement methodologies
	Develop metrics
	Retain focus on how these options can support the public transport task
New mobility models	
Mobility Hubs	Develop a draft business case
	Pilot a mobility hub concept at Heuston Station

Topic	Recommended measure
	Research new locations/possibilities for hub creation
	Conduct a best practice review
	Begin early engagement with stakeholders
Mobility as a Service	Develop a draft business case
	Undertake full Dublin-based consumer research
	Test the market
Total mobility pricing	Coordinate a policy position on total mobility pricing
	Promote the concept of total mobility pricing
	Investigate the total mobility pricing requirements for the GDA
	Develop a GDA trial for total mobility pricing
Planning for change	
Focus on outcomes	Set a clear governance framework, enabled by an agreed set of principles.
Enabling change	Set clear strategic outcomes
	Continuously assess against the strategic outcomes
	Identify the potential delivery against outcomes, and the available funding
	Understand the true cost of change
	Give the market clear direction
Monitor evolving demands	Develop a dedicated knowledge database and dashboard to interpret and present insights around: • The complexity of less regular commuting for a proportion of the work force, but possibly longer commutes when they do; • The potential decline in trip chaining as people work from home and walk/cycle kids to school; • The ability to mode shift more women into public transport and cycling; • The potential clustering of mid-week attendance in knowledge work settings; • The need to shift ticketing pricing incentives for irregular commuters; and • Changes in network capacity in the centre making it harder for some to drive and other factors can be layered into.

7 References

1. Hausemer P, Rzepecka J, Dragulin M, et al. *Exploratory Study of Consumer Issues in Online Peer-to-Peer Platform Markets*.; 2017. doi:10.2838/779064

2. Car sharing: number of users worldwide 2006-2025 | Statista. Statista. Published 2016. Accessed May 27, 2021. https://www.statista.com/statistics/415636/car-sharing-number-of-users-worldwide/

3. Booth R. Young adults have less to spend on non-essentials, study says. The Guardian. Published 2019. Accessed May 27, 2021. https://www.theguardian.com/inequality/2019/jun/20/young-adults-have-less-to-spend-on-non-essentials-study-says

4. Klein J. The WSJ Is Wrong, Young People Want Cars. The Drive. Published 2019. Accessed May 27, 2021. https://www.thedrive.com/news/27578/this-is-why-the-emwall-street-journalem-is-wrong-about-kids-and-driving

5. Rodier C. *The Effects of Ride Hailing Services on Travel and Associated Greenhouse Gas Emissions A White Paper from the National Center for Sustainable Transportation About the National Center for Sustainable Transportation Disclaimer*.; 2018.

6. Clewlow R. Can Mobility Services Ever Be Profitable? Forbes. Published 2019. Accessed May 27, 2021. https://www.forbes.com/sites/reginaclewlow/2019/10/25/can-mobility-services-ever-be-profitable/?sh=60860891b6fa

7. Charlton G. Which Ecommerce Payment Options do Customers Want? - SaleCycle. Sale Cycle. Published 2019. Accessed May 27, 2021. https://www.salecycle.com/blog/strategies/which-ecommerce-payment-options-do-customers-want/

8. *Big Data and Transport Understanding and Assessing Options Corporate Partnership Board Report Corporate Partnership Board CPB*. Accessed May 26, 2021. www.internationaltransportforum.org

9. Itf, Oecd. *Corporate Partnership Board CPB Safe Micromobility Corporate Partnership Board Report*.

10. Conger K. Uber begins background collection of rider location data | TechCrunch. Published 2016. Accessed May 24, 2021. https://techcrunch.com/2016/11/28/uber-background-location-data-collection/

11. US court dismisses lawsuit against LA's mobility data sharing requirement - Cities Today - Connecting the world's urban leaders. Accessed May 27, 2021. https://cities-today.com/us-court-dismisses-lawsuit-against-las-mobility-data-sharing-requirement/

12. Marshall A. Why Uber Is Fighting Cities Over Data About Scooter Trips | WIRED. Wired. Published 2019. Accessed May 27, 2021. https://www.wired.com/story/why-uber-fighting-cities-data-about-scooters/

13. Urban Mobility Index. Dublin Urban Mobility Index City Data. Published 2021. Accessed May 25, 2021. https://urbanmobilityindex.here.com/city/dublin/

14. Catapult Transport Systems. *MOBILITY AS A SERVICE EXPLORING THE OPPORTUNITY FOR MOBILITY AS A SERVICE IN THE UK*.; 2016.

15. DMTF. CIM | DMTF. Published 2019. Accessed February 12, 2020. https://www.dmtf.org/standards/cim

16. Bolton A. The Gemini Principles. Published online 2018. doi:10.17863/CAM.32260

17. Pedelec, S-Pedelec and e-bike: the differences. Accessed May 26, 2021. https://www.stromerbike.com/en/moments-did-you-already-know

18. *FAQs on EBikes, Pedelecs and Battery Scooters*.

19. Dublin Bikes scheme named as one of the most successful in the world - Dublin Live. Accessed May 27, 2021. https://www.dublinlive.ie/news/dublin-news/dublin-bikes-scheme-named-one-11798237

20. NOW TV dublinbikes to launch ‘e-dublinbikes’ hybrid electric option | Dublin City Council. Accessed May 27, 2021. https://www.dublincity.ie/news/now-tv-dublinbikes-launch-e-dublinbikes-hybrid-electric-option

21. Up to 1,000 electric bikes to be available for hire in Dublin. Accessed May 27, 2021. https://www.irishtimes.com/news/environment/up-to-1-000-electric-bikes-to-be-available-for-hire-in-dublin-1.4137549

22. Open Data for Dublin’s Bikeshare Services: Where to find it, how it’s used, what’s coming next… - Smart Dublin. Accessed May 26, 2021. https://smartdublin.ie/open-data-for-dublins-bikeshare-services-where-to-find-it-how-its-used-whats-coming-next/

23. Number of daily Dublin cyclists doubles to more than 95,000. Accessed May 26, 2021. https://www.irishtimes.com/news/ireland/irish-news/number-of-daily-dublin-cyclists-doubles-to-more-than-95-000-1.3230465?mode=sample&auth-failed=1&pw-origin=https%3A%2F%2Fwww.irishtimes.com%2Fnews%2Fireland%2Firish-news%2Fnumber-of-daily-dublin-cyclists-doubles-to-more-than-95-000-1.3230465

24. Irish bike sales surge: The counties and age groups spending most & least - Sticky Bottle. Accessed May 26, 2021. https://www.stickybottle.com/latest-news/irish-bike-sales-surge-the-counties-age-groups-spending-most-least/

25. What is an electric scooter and which should I get? Accessed May 27,

2021. https://www.gearpriest.com/what-electric-scooter-which-should-i-get/

26. Electric Scooters Market Size | E-scooters Industry Report, 2030. Accessed May 27, 2021. https://www.grandviewresearch.com/industry-analysis/electric-scooters-market

27. How fast are Electric Scooters? 2020 Updated Scooters Speeds. Accessed May 27, 2021. https://electricscootering.com/electric-scooters-fast/

28. Common Causes of E-Scooter Accidents. Accessed May 27, 2021. https://www.stlouis-personalinjury.com/blog/2019/september/common-causes-of-e-scooter-accidents/

29. E-Scooters in Germany. Accessed May 27, 2021. https://thegermanyeye.com/e-scooters-in-germany-3707

30. Belgium's fatal attraction to e-scooters continues to grow. Published 2019. Accessed May 27, 2021. https://www.brusselstimes.com/brussels/56629/deadly-accident-electric-scooter-brussels-success-grows/

31. More than half injured on e-scooters not wearing helmet. Accessed May 26, 2021. https://www.rte.ie/news/health/2021/0524/1223683-escooter-injuries/

32. AI e-scooter programme to begin in Dublin - Intelligent Transport. Accessed May 26, 2021. https://www.intelligenttransport.com/transport-news/122251/dublin-e-scooter/

33. Navya launches level 4 fully autonomous shuttle service in France | Association for Unmanned Vehicle Systems International. Accessed May 26, 2021. https://www.auvsi.org/industry-news/navya-launches-level-4-fully-autonomous-shuttle-service-france

34. Germany gives greenlight to driverless vehicles on public roads | TechCrunch. Accessed May 26, 2021. https://techcrunch.com/2021/05/24/germany-gives-greenlight-to-driverless-vehicles-on-public-roads/

35. AutoX Opens Real Robotaxi Service In China To The General Public. Accessed May 26, 2021. https://www.forbes.com/sites/bradtempleton/2021/01/27/autox-opens-real-robotaxi-service-in-china-to-the-general-public/?sh=70ce8c15a6fb

36. About - Future Mobility Campus Ireland. Accessed May 26, 2021. https://futuremobilityireland.ie/about/

37. Caulfield B, Kehoe J. Usage patterns and preference for car sharing: A case study of Dublin. *Case Stud Transp Policy*. 2021;9(1):253-259. doi:10.1016/j.cstp.2020.12.007

38. McGreevy R. Uber banned from operating private car rides in Ireland. The Irish Times. Published 2017. Accessed May 27, 2021. https://www.irishtimes.com/news/ireland/irish-news/uber-banned-from-

operating-private-car-rides-in-ireland-1.3169768?mode=sample&auth-failed=1&pw-origin=https%3A%2F%2Fwww.irishtimes.com%2Fnews%2Fireland%2Firish-news%2Fuber-banned-from-operating-private-ca

39. Gleeson C. Free Now to introduce e-scooter option on app in Ireland. Accessed May 27, 2021. https://www.irishtimes.com/business/transport-and-tourism/free-now-to-introduce-e-scooter-option-on-app-in-ireland-1.4504542?mode=sample&auth-failed=1&pw-origin=https%3A%2F%2Fwww.irishtimes.com%2Fbusiness%2Ftransport-and-tourism%2Ffree-now-to-introduce-e-scooter-option-on-app-in-ireland-1.4504542

40. Arup, RI.SE. *MOBILITY HUBS OF THE FUTURE Towards a New Mobility Behaviour*.

41. Farenden A, Lee-Williams T. *The Future of Mobility and Maas Governance and Orchestration*.; 2019. Accessed May 27, 2021. https://www.arup.com/perspectives/publications/promotional-materials/section/the-future-of-mobility-and-maas

42. Moore MH. *Recognizing Public Value*. Harvard University Press; 2013.