MaaS as a driver of sustainable planning:

An evaluation of Dumfries' readiness

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DECLARATION

This dissertation is my own original work and has not been submitted elsewhere in fulfilment of the requirements of this or any other award.

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ABSTRACT

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Abstract:

Technology is shaping the future of mobility, and while doing so, it can also shape the layouts of cities and towns. To achieve that, technology offers numerous innovative solutions. Mobility-as-a-Service, MaaS, is one of them. Its essentials of car ownership reduction, transport integration, and user-centredness have the potential to revolutionise conventional inefficient transport systems that led to street-based spatial forms, traffic congestions, socioeconomic inequalities, greenhouse gas emissions, and air pollution. MaaS is often operated and studied in urban areas. Barriers to implementing MaaS in rural spaces have led to less MaaS rural solutions and case studies. However, rural areas can still benefit from MaaS. In the Northeast of Scotland MaaS trials are operating already, mixing urban and rural contexts. The Scottish Southwest however is yet to operate such schemes. The settlement of Dumfries, the regional capital of Dumfries and Galloway, in the Southwestern region of Scotland, shows a mixture or urban and rural features. This presented the opportunity to study the likely rollout of MaaS strategies in rural areas, while allowing to take on urban experiences to guide the implementation of MaaS solutions. Dumfries MaaS readiness was evaluated through the Modified MaaS Maturity Index from Thanos (2018), leading to a readiness score of 2.42, meaning Dumfries current transport system, ICT, demographics, and regulations, offer some usefulness to a MaaS implementation, but are below of what should be desirable to a fully supportive MaaS delivery. A fragile and fragmented PT, a significant reliance on personal vehicles, an ageing population, low rates of smartphone and personal internet usage, and an absent legal framework to regulate MaaS partnerships and deployment are the main barriers, contesting a population highly engaged with AT and willing to give up their cars should a more efficient PT be put in place. To improve Dumfries' MaaS preparedness, solutions like multi-modal transport master planning processes were revised, linking them to land use planning, both centred on Dumfries' residents and visitors. Lastly, 4 small-scale MaaS concepts are proposed, as a way to start building up preparedness and integrating the transport system.

Keywords: Mobility-as-a-Service, Dumfries, sustainable mobility, planning	
Originality Statement: I hereby declare that this Master's dissertation is my own original work, does not contain other people's work without this being stated, cited and referenced, has not been submitted elsewhere in fulfilment of the requirements of this or any other award.	**Signature:** Josué Arrieta Solís

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ACRONYMS

API: Application Programming Interface.

AT: Active Travel.

ATS: Active Travel Strategy.

CT: Community Transport.

DGC: Dumfries and Galloway Council.

D&G: Dumfries and Galloway (region).

DRT: Demand Responsive Transport.

EF: Evaluation Framework.

GHG: Greenhouse Gases.

ICT: Information and Communication Technologies.

IoT: Internet of Things.

IPCC: Intergovernmental Panel on Climate Change.

LDP: Local Development Plan.

MaaS: Mobility-as-a-Service.

MMI: MaaS Maturity Index.

MMRI: Modified MaaS Readiness Index.

NPF: National Planning Framework.

NTS: National Transport Strategy.

PT: Public Transport.

RTP: Regional Transport Partnership.

RTS: Regional Transport Strategy.

SDG: Sustainable Development Goals.

SWestrans: Southwest of Scotland Transport Partnership.

UN: United Nations.

VKT: vehicle-kilometres travelled.

CHAPTER 1.   INTRODUCTION

1.1 Rationale

Cities housed 56% of the world's population in 2021. By 2050, they are expected to shelter a 68%. As they grow, their functioning and dynamics become more complex, population increases, resources consumption rises, the overall living context becomes more active. Particularly, mobility and transport systems get more chaotic. This poses sustainability challenges, which along with a current climate crisis, call for urgent action (UN-Habitat, 2022).

The transport sector accounted for 15% (8,700 GtCO$_2$-eq) of the global net greenhouse gas (GHG) emissions in 2019. A 70% of those transport emissions were from road vehicles (IPCC, 2022). Transport is also a major source of particulate matter, ozone, and nitrogen oxide emissions. It contributes to resuspension of road dust, noise generation, and road injuries. All these threatening public human health, biodiversity, and vulnerable populations (Anenberg *et al.*, 2019).

In Scotland, transport accounted for 35.6% (14.8 MtCO$_2$-eq) of total 2018 GHG emissions, the largest emitting sector. Cars were the most emitting mode thereof, with a 39% share (Transport Scotland [TS], 2020a).   The Scottish Government has pledged to reach net zero by 2045 and has set targets to electrify and decarbonise public transport, reduce by 20% vehicle kilometres travelled (VKT), and phase out petrol and diesel vehicles (Scottish Government, 2021a). Transport and planning policies envisage more active travel, 20-minute neighbourhoods, urban-rural synergies, and a more efficient and egalitarian transport system (TS, 2020b; Scottish Government, 2021b).

Citizens' movements are essential for a thriving society, but today's mobility needs to be challenged, transformed worldwide. Cities can reduce current transportation models' negative impacts by combining more compact land uses, with less polluting and less car-dependent mobility alternatives. In doing so, they can look at digitalisation on demand for transport services (IPCC, 2022), benefiting from the Internet of Things (IoT), the Information and Communication Technologies (ICT), and big data.

Technology is shaping the future of mobility, covering a wide range of solutions (Arthur D. Little, 2018). Mobility-as-a-Service (MaaS) is one of them. It puts the citizens, the travellers, at the centre of transport solutions. It takes on a built-up transport infrastructure, aggregates the different transport modes into one single interface, and provides the end user with an array of options for fulfilling their mobility needs. Mainly, it aims at reducing car ownership and viewing mobility as an on-demand service. Therefore, it can enable the implementation of more sustainable transport and create data for urban and rural planning (Signor *et al.*, 2019).

Scotland has also foreseen a digitalisation of its transport system and the implementation of Mobility-as-a-Service. The government committed to a £2 million investment fund to support the testing of MaaS trials across the country, in Dundee, Inverness, St Andrews, and East Lothian (TS, no date). Those projects in the north and east of Scotland, englobe its urban-rural mixed nature. However, the Scottish south and west sides are yet to see MaaS deployment in their regions.

MaaS has been mostly studied in urban areas, leading to rural spaces offering a wide range of research opportunities. Dumfries and Galloway (D&G), to the Southwest of Scotland, is one of the most rural areas of the country (Dumfries and Galloway Council [DGC], 2017a). At present, none of the trials supported by the government operates there, nor any MaaS solution is foreseen for this region. Its regional capital, Dumfries, is D&G's biggest settlement. Dumfries is an urban area immersed in a rural context, capturing that same Scottish mixed nature.

Dumfries is a focal point, having the two largest employers in D&G, concentrating great commercial activity, having the busiest and most developed part of the bus network, and the most used rail station of the area (Stantec, 2022). The transportation sector in D&G was the second largest GHG emitter in 2018, generating 517 $ktCO_2$-eq, right after land use, responsible for 2,286 $ktCO_2$-eq (DGC, 2021). In 2019, the council declared a Climate Emergency, setting out a plan to become net zero by 2025, relying on innovative measures

and technological advances to reduce their region's contribution to climate change (DGC, 2019b).

These characteristics plus its urban-rural essence, present Dumfries as a relevant study subject for analysing whether a likely MaaS implementation can be useful for future transport digitalisation efforts and a more sustainable land planning. It was of interest hereby, to analyse whether Dumfries is ready for MaaS, trying to identify what current conditions could foster the operation of this technology, and what measures could improve or accelerate MaaS rollout.

This research aligns with this master's programme pillars, particularly with the sustainability and planning streams. The present research could offer planning authorities, policy makers, and transport providers, insights on how to adapt MaaS to Dumfries, and thus aid the planning processes towards sustainable cities and towns, better prepared to climate change impacts, respectful of biodiversity, more liveable, socially inclusive, and economically thriving.

1.2 Aim and Objectives

This research looked at understanding the current transport and planning context of D&G, focusing especially on the settlement of Dumfries and a likely operation of MaaS solutions. This master's thesis aim, and objectives are as follows.

1.2.1 Aim

Run a thorough evaluation of Dumfries' current transport conditions to foster a MaaS scheme to enrich its sustainable planning.

1.2.2 Objectives

- Analyse Dumfries' modal shares, and town planning state of the art.
- Propose a framework to evaluate MaaS readiness in Dumfries.
- Evaluate Dumfries' readiness to foster MaaS strategies.
- Propose a set of measures for Dumfries' MaaS implementation.

1.3   Research Outline

Trying to create new knowledge on MaaS and its operation in Dumfries covered a set of methods, including documentary review, interviews, observation, and running a readiness evaluation. This led to an analysis of Dumfries' transport and planning system, required to understand whether this settlement possessed favourable conditions for MaaS. This research is structured in 5 chapters. The 4 remainder ones start with a Literature Review on MaaS, its potential, and the research gaps identified on it, following with the defined Methodology for the study, then presenting the Results and Discussion, to ultimately close with Conclusions.

CHAPTER 2. LITERATURE REVIEW

2.1 Link between Planning and Transportation

Mobility is linked to cities' life, their activities, and their land uses (Rodrigue, 2013). As cities evolved, patterns of movements changed, and so did travels to and from school, work, shopping, leisure. These all mix now, creating an entangled structure. These changes turned the traditional home-work-home journeys into a myriad of mobility schemes, with even more trips carried out daily (Cruz and Sarmento, 2020). What is more, mobility is being influenced by factors such as income, gender, disabilities, spatial accumulation, urban form, and technology (Camagni, Gibelli and Rigamonti, 2002; cited by Rodrigue, 2013).

Those last two factors, urban form, and technology are interlinked in a way so that technology and other factors modify the urban forms, and vice versa. This interplay is especially discernible with transportation technology, the more radical changes and advances in it, the greater the effects on the cities' layouts. This is noteworthy, since many cities have opted for following a grid street pattern, resulting in 30% or more of urban space devoted to road or road-based land use, clearly evidencing the strong link between urban planning and transportation (Rodrigue, 2013; Hensher *et al.*, 2020e).

2.2 Technology as a solution to conventional transportation systems

As cities began to develop more rapidly, the transport systems suffered more fragmentation, became less predictable. Forecasting methods and planning were not able to provide the appropriate solutions (Cruz and Sarmento, 2020). This led to increases in motorization rates and traffic congestion, parking difficulties, public transport inadequacy, hurdles for non-motorised transport, land consumption and loss of public space, accidents and unsafe conditions, environmental pollution and energy consumption, and inadequate freight distribution (Rodrigue, 2013; Cruz and Sarmento, 2020; Song, Guo and Zhang, 2022). All this resulting in a prolonged and ongoing environmental, societal, and economic deterioration; a sustainability crisis, demanding the breakage of the traditional transport models.

Nascent technologies are a promise to revert those negative effects from the current obsolete, and inefficient transport systems. Innovative solutions such as shared mobility services (car/bike/ridesharing, etc.) or ride-hailing, are transforming the way people move. Their operations are based on digital platforms, ICT, and IoT (Kamargianni *et al.*, 2016; Signor *et al.*, 2019; Hensher *et al.*, 2020e). Thus, allowing mobility providers to obtain real-time data; managing million trips every hour; providing accurate and updated information, promoting sustainable transport; easing ticket payments, offering better mobility deals to passengers, etc. (Kamargianni *et al.*, 2016; Vaidian, Azmat and Kummer, 2019). Overall, providing a tailored and convenient travel experience to citizens.

2.3 Link between Planning, Transportation, and MaaS

Stemming from such innovations, Mobility-as-a-Service (MaaS) stands as the way to provide that ultimate connective component in a transportation system, unifying transport services and offering travellers to satisfy all their mobility needs, while encouraging them to a more sustainable lifestyle (Signor *et al.*, 2019; Bharule, Zhang and Shibasaki, 2022). It is through its disruptive nature that such technology can transform the way transportation models exist today, while also lead the reshaping of cities worldwide.

Building upon Song, Guo and Zhang (2022) who stated that transportation is the basic framework of urban spatial form, jointly with Rodrigue (2013) and his statement about how changes in transportation technology lead to changes on the layouts of cities and towns; an interplay between the spatial form, transportation, and MaaS, is created. Thus, converging to the premise that MaaS, as a technological disruptor, can transform current transportation schemes, ultimately driving the transformation of the spatial form and planning of cities and towns (see Figure 2.1Figure 2.1). To achieve that, the outdated automobile-orientated vision of cities shall be displaced by the influence of MaaS perspective of user-centredness and sustainability (Vergragt and Brown, 2007; Nikitas, 2018; Song, Guo and Zhang, 2022). Cities and towns devoted to people, not to cars.

Figure 2.1. Interplay between planning, transport technology, and MaaS.
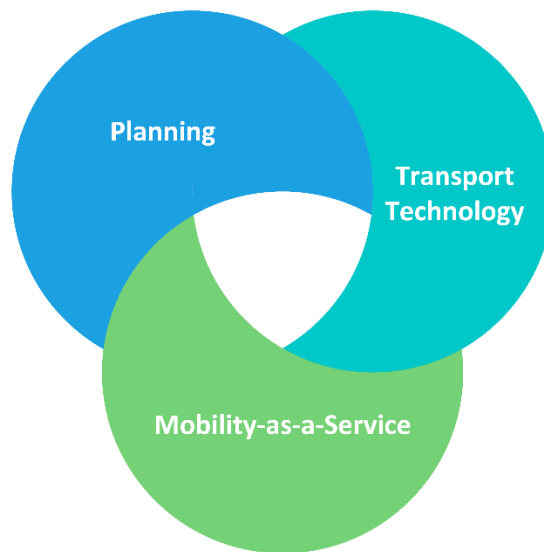
2.4 Conceptualising MaaS
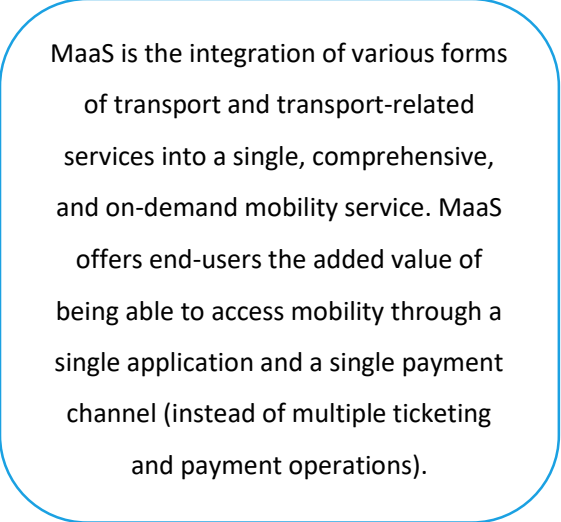
MaaS encounters multiple definitions due to ambiguity and a lack of consensus (Jittrapirom *et al.*, 2017). Depending on who looks at it, it can mean one, more, or different things on a spectrum (Hensher *et al.*, 2020d; Arthur D. Little, 2021; ITF, 2021b). Mobility-as-a-Service gained momentum in Finland, in 2014. However, the concept could date back to 1991 where in the United States of America (Mulley, 2017), Mobility Management aimed to link travel modes, match mobility suppliers with users' mobility preferences, and provide a channel for financial transactions (United States Department of Transportation, 1991, p. 16; cited by Mulley, 2017).

Sonja Heikkilä (2014), refers to MaaS as the provision, in a market of competing mobility operators, of individual and flexible mobility services in order to satisfy all mobility needs, thus reducing the need to own a vehicle. From Sampo Hietanen's (2014) perspective, MaaS is a distribution model whereby customers meet their transportation needs over one interface in which mobility services are bundled into a package and offered by service providers.

According to Jittrapirom et al., (2017), MaaS must allow the integration of transport modes, with tariff options such as mobility packages or Pay-As-You-Go charges. It should work an on-demand service, centred in the end-users, who have access to multimodal mobility services through a subscription scheme that allows them to customize their traveling preferences while receiving personalized recommendations and tailor-made solutions based on their accounts' profiles. To achieve all that and more, MaaS must be enabled by an array of technologies where multiple actors interact, creating a whole ecosystem that ultimately translates to a single digital platform where end-users, also called customers, travellers, or passengers, have access to all the necessary services for their journeys: trip planning, booking, ticketing, payment, real-time information, and much more.

Sochor et al., (2018), and Hensher et al., (2020a), coincide in viewing MaaS as a service centred in the travellers' transport needs, offering integrated multimodal transport options, with provision of travel information, payment options, and ticketing. Sochor et al., (2018), concluded from their analysis, that the description with the most components was the one provided by Arthur D. Little (2018). However, Arthur D. Little (2021) updating their analysis, built on the concept by MaaS Alliance, (2021), as seen in Figure 2.2.

Figure 2.2. MaaS Alliance definition for Mobilitiy-as-a-Service.

MaaS is the integration of various forms of transport and transport-related services into a single, comprehensive, and on-demand mobility service. MaaS offers end-users the added value of being able to access mobility through a single application and a single payment channel (instead of multiple ticketing and payment operations).

Although there are plenty of definitions, this review of meanings allows to understand that MaaS aims to integrate into one single interface (e.g., a smartphone app) the different transport modes in an area, while also integrating journey planning, booking, payment, and ticketing. So, the traveller just inputs onto the app where they are travelling to and from, and the app should offer the different transport options, timetables, prices, real-time data, and more, for them to decide and select according to their travel requirements.

More importantly, MaaS essence puts the users' mobility preferences and needs at the centre, while also strives for people to shed their private car usage, by seeking to increase usage of other mobility modes, particularly PT and active travel. These pivotal features exhibit the MaaS potential to shift mobility from one based on ownership to a mobility consumed as a service, yielding a seamless door-to-door connectivity (Hensher *et al.*, 2020e). Thus, underscoring the relevance in the statements from both Heikkilä and Hietanen (2014) in their MaaS approaches. Ultimately, MaaS presents itself as a disruptive technology, an innovation with the momentum and strength required to change the transportation systems through digitalisation (Whim, 2016). Likewise, as in a chain of events, disrupting cities and towns planning altogether.

2.5   MaaS outputs, sustainability, and barriers

MaaS has a strong focus on sustainability. On its quest to reduce car ownership, it induces a decline in traffic congestion further favouring the decarbonisation of the transport sector, reducing the high share of GHG emissions therefrom, and minimizing the risks to human health and ecosystems (Gould, Wehrmeyer and Leach, 2015; Wang and Ge, 2019; Singh, 2020). By promoting PT and multimodality, it allows a shift towards more sustainable alternatives to private car, favouring electric mobility and encouraging active travel (Jittrapirom *et al.*, 2017; Alyavina, Nikitas and Tchouamou Njoya, 2020).

Further reaping of MaaS benefits can help cities to strengthen their climate action, improve transport safety, find solutions to social inequality, accessibility, and inclusivity (Li, 2020). All this, proving to be a sustainable development measure (UN, 1987), directly linked to the 17 Sustainable Development Goals (SDG) from the UN. Especially, MaaS can be linked to SDG 11, about Sustainable Cities and Communities, aiming for inclusive, safe, resilient, and sustainable human settlements. Likewise, it relates to SDG 13 – Climate Action, taking urgent measures to tackle climate change and its impacts (UN, 2015).

Even more, at the city and town level, MaaS can work as a tool to manage mobility demand. The data derived from it would help make more efficient use of existing infrastructures, improve the traffic management, and help enhance sustainable mobility and public

transport planning (Signor *et al.*, 2019). It could help to attract and retain residents, businesses, and visitors, by personalizing services matched to the newcomers' lifestyles, and generating efficiency savings (Scott, 2018). Therefore, turning cities and towns into livelier and more economic thriving spaces, where, through better connection between places, boundaries are weakened and the public realm is used more efficiently (Song, Guo and Zhang, 2022).

All those MaaS benefits are dependent upon 2 significant factors, users' will to use such platforms, and a robust PT system. If citizens are uninterested or unwilling to support these initiatives, MaaS is likely to fail (Ho *et al.*, 2018). This also relates to the age of travellers, since the older they are, the less engagement there is to digital platforms and the less keen they are to give up their private vehicles. In addition, if by facilitating mobility, users switch to more automobile options like ride-hailing or carsharing, the decarbonisation opportunity will be missed (Alyavina, Nikitas and Tchouamou Njoya, 2020). On the other side, sustainable mobility is fundamentally built on PT, and so must MaaS (Signor *et al.*, 2019). To fulfil its purpose, PT must be efficient, appealing enough to minimise car dependency. Inaccessible, unaffordable, low quality PT systems obstruct MaaS deployment (ITF, 2021a).

Further other technological barriers like access to a smartphone, mobile phones battery life, network coverage, data privacy, and so on, can easily dissipate interest and reliance on MaaS (Alyavina, Nikitas and Tchouamou Njoya, 2020). Other difficulties relate to political will, governance structures, and current legislation. In many cases, MaaS must open its ways through inflexible, rigid legal frameworks (Karlsson *et al.*, 2020; Polydoropoulou *et al.*, 2020). To an optimal implementation, these and more obstacles are to be surmounted.

2.6 MaaS developments, research, and assessment

Case studies cover many cities, with a plethora of cases from European zones, given the remarkable momentum in the continent; albeit Asia and North America have also implemented MaaS. The Whim app in Helsinki, Finland; UbiGo in Gothenburg, Sweden; illustrate urban MaaS cases. Shobara MaaS and Emot in Japan, are some rural MaaS examples. Figure 2.3 collects some of their details based on Smith, Sochor and Sarasini, (2018); Fenton, Chimenti and Kanda, (2020); Hensher et al., (2020c, 2020b); and World Economic Forum, (2021).

Figure 2.3. MaaS examples in Europe and Asia.

Whim

It is the most renowned MaaS platform. It allows users to book and pay for PT, car rental, taxi, car and bike sharing schemes, offering Pay-As-You-Go tariffs, and 2 different monthly subscriptions (Hensher *et al.*, 2020c). The establishment of a national agenda endorsing MaaS, and the reform of the regulatory framework allowed Whim to come about and consolidate in Finland (Smith, Sochor and Sarasini, 2018).

UbiGo

It links PT with car and bike sharing, car rental, and taxi service. This trial reflected changes in transport patterns towards more PT and active modes, while making multi-modal travelling less expensive and more convenient. It faced obstacles between service providers and organisations as the institutional settings and regulations were not fit for MaaS (Fenton, Chimenti and Kanda, 2020; Hensher *et al.*, 2020c, 2020b).

Japanese MaaS scenario

More than 80 MaaS solutions in Japan, 80% of them operate in rural areas. These areas experience population decline, an ageing population, a reduced number of PT users, a decreasing PT profitability, and abandonment of its infrastructure. MaaS solutions benefitted from cooperation with existing transport companies, local governments, and local businesses. The different subscription schemes helped buses to increase stable revenue. MaaS included bus modes, and on-demand transport services. They targeted local residents (e.g., elderly people and other residents), and visitors. Their objectives were to maintain local transport (e.g., supporting travel in underserviced areas), and to harness the market potential of transport and commerce (e.g., capturing tourist demand) (World Economic Forum, 2021).

In Scotland, several trials started operating after the opening of the MaaS Investment Fund (MIF) in 2018. These trials offer services in both urban centres and rural areas, also trying to create connections between them, like in the East Lothian or the Highland and Islands. However, as they recently began operations and are still under evaluation, there is limited information about them. Figure 2.4 summarises some of their current aspects.

Figure 2.4. MaaS trials in Scotland.

Source: created from Transport Scotland, (no date); and Cassidy, (2022).

St Andrews	The Highland & Islands	East Lothian
University of St Andrews	**Go-HI**	**GoSEStran**
MaaS-ter plan to reduce traffic congestion and single person car use. Supports University's net zero targets. Integrates train, taxi, bike fleet, in a transport hub, simplifies ticketing.	App with the ability to plan, book, pay, and issue tickets for multiple modes. Integrates bike share, bus, DRT, ferry, train, car club, taxi, air. Target audiences: residents, business travellers, tourists.	App to plan, book, and pay. Physical and digital integration of transport, linking to mobility hubs. Aims to address transport poverty in rural areas. Integrates DRT, PT, taxi, e-bike hire, car sharing.

Dundee	Dundee	Dundee
My D&A travel	**GoNHS tayside**	**National Park Journey Planner**
App to plan, book, and ticket. Targeted to 23 000 college students, plus staff. Integrates AT, PT, train, cycle, bus.	Webapp for 120-140 patients pw, visitors, and staff. Aims to reduce anxiety, increase confidence, open up sustainable modes, empower staff. Integrates CT, cycle, bus, PT.	App, widget, and Webapp. Journey planner for PT, bus, cycle, AT. Covers Loch Lomond and the Trossachs National Park, with up to 4 million visitors per annum. Partners with visitor sites and businesses.

MaaS research has studied the willingness of people to use MaaS and change their travel patterns. Alyavina, Nikitas and Tchouamou Njoya, (2020), and Ho et al., (2018), concluded that despite considering MaaS as positive, people are not willing to change their travel behaviours. A closer look to MaaS in cities like 's-Hertogenbosch in the Netherlands (Fioreze, de Gruijter and Geurs, 2019), Rome in Italy (Corazza and Carassiti, 2021), and Lisbon in Portugal (Cruz and Sarmento, 2020), revealed the importance of the role played by users, as their willingness towards MaaS could hinder it or forward it to success.

Research has also undergone an assessment of how well prepared a city or area is to foster MaaS schemes, or how evolved and interconnected the transportation system is to operate under MaaS structures. Integration indexes and levels of integration were developed and employed by Kamargianni et al., (2016); Kamargianni and Goulding, (2018); Sochor et al., (2018); and Lyons, Hammond and Mackay, (2019). Figure 2.5 collects on them.

Figure 2.5. MaaS indexes.

MaaS Integration Index	MaaS Maturity Index
A mobility integration index with a scale from 0 to 10, which assesses the integration of ticketing, payment, ICT, and mobility packaging (Kamargianni et al., 2016).	A set of indicators to assess the readiness of a city for the implementation of MaaS. It is based on 5 dimensions: transport operators' openness and data sharing; citizen familiarity and willingness; policy, regulation, and legislation; transport services and infrastructure; and ICT infrastructure. It uses a scale from 0 to 1 to determine that readiness (Kamargianni and Goulding, 2018).
MaaS Typology Levels	**Levels of MaaS Integration LMI**
A MaaS typology with 5 levels of integration. Starting at level 0 in which there is no integration in the transportation system, with single services working separately, then adding up layers of integration until reaching a topmost layer, level 4, in which societal goals, policies, incentives, and more, are integrated (Sochor et al., 2018).	Based on the levels of autonomy defined by the Society of Automotive Engineers for the Connected/Autonomous Vehicles, whereby as the car autonomy increases the human intervention decreases. The LMI go from level 0 where there is no integration across modes, thus implying a higher cognitive effort from the user; to a level 5 with full integration of all conditions, resulting in the least cognitive user effort (Lyons, Hammond and Mackay, 2019).

The employment of such assessment tools revealed for instance in the UK, that London has a higher maturity and readiness (a 0.64 score) for operating MaaS strategies than the West Midlands (0.59) (Kamargianni and Goulding, 2018). As to the Levels of Integration, it is most common to find urban areas with low integration levels, from 0 to 2, while higher levels are still part of the medium to long term visions of cities, although Whim in Finland and UbiGo in Sweden are examples of that higher integration (Cruz and Sarmento, 2020).

These instruments provide a starting point for evaluating MaaS potential in cities, albeit the Maturity Index is not applicable to intercity transport or rural areas, while its indicators need to be revisited (Kamargianni and Goulding, 2018). Regarding the levels of integration, authors state they can be considered simplistic, and are open to subjectivity as well as interpretation, which can lead to different results (Sochor *et al.*, 2018). Despite being on early stages, and still needing polishing, the essential use of these tools in the assessment of MaaS potential in cities is unequivocal. Higher maturity indexes mean more ground for MaaS, while more integration is more appealing for travellers (Kamargianni *et al.*, 2016), consequently, better harnessing of MaaS benefits.

2.7 Research Gaps

Despite MaaS upswing momentum, it is still a nascent phenomenon which needs further research to deeply understand its functioning and fully deliver on its potential (Smith and Hensher, 2020). Though research has visited topics related to the definition of MaaS, the societal willingness and uptake, political structures and governance, preparedness of cities, and the levels of integration of transportation systems and MaaS, most of it has been centred on an urban perspective. This presents thereupon, the opportunity to build knowledge on the likeliness of future MaaS strategies in rural areas, as cases in those territories are scarce and concerns of whether such areas would be suitable for such initiatives are manifest (Hensher *et al.*, 2020d, 2020a).

Moreover, limited mention was found in the usage and incorporation of MaaS and its benefits for planning. Most research points at studying further on the implementation of MaaS, its barriers and drivers, more pilots, and ongoing schemes, however, there are research gaps on the need to pursue and research the specific inputs and tools MaaS can provide for cities and towns' planning and the improvement of their sustainability performance. Ergo, this research aimed to nurture, and expand on that knowledge, providing insights into the ways MaaS data and strategies can shape cities and towns. It aimed at studying what sort of outputs can be incorporated into the design of such spaces, their local development plans, and other planning instruments. It tried to prove, accordingly, the relation between MaaS and sustainable planning. For that purpose, and to help reduce these research gaps, the settlement of Dumfries, in the region of Dumfries and Galloway, served as an illustration.

Dumfries and Galloway (D&G) is located to the southwest of Scotland, United Kingdom. Nearly 45% of people in D&G lives in areas classified as rural (Scottish Government, 2022), making it the third highest ranked council area for rurality (Dumfries and Galloway Council [DGC], 2017). Dumfries is the capital of the region, classified as "other urban areas" under the urban-rural classification (Scottish Government, 2022). It is the most populated settlement, housing 34,040 inhabitants (National Records of Scotland [NRS], 2022) (see Figure 2.6).

Dumfries is expected to consolidate in 20 years its position as the regional capital, offering a vibrant town centre, minimising the need to travel, ensuring more sustainable economic growth, more active travel, and reducing carbon emissions (DGC, 2019b). To achieve those targets, challenges like climate change, dispersed and disconnected populations, and overcoming the perception of "the forgotten part of Scotland" are required to be overcome (DGC, 2019b; Stantec, 2022).

Such characteristics position Dumfries in a mixed environment in which rural settings challenges fuse with urban processes. That scenario, plus having the most developed part of the bus network, the busiest railway station, and not having an ongoing MaaS scheme, present the opportunity to study the likely rollout of MaaS strategies in rural areas, while offering options to take on urban experiences and learnings to guide the implementation of MaaS strategies.

Figure 2.6. Dumfries study area.

Source: Arrieta-Solís, J. *Dumfries study area* [JPEG Map], Scale 1:34,000, Settlements with Urban and Rural Population Data [Feature Layer], Updated 21 March 2022, Tom Sharples_ScotGov. Using: ArcGIS Online. [viewed on 16 June 2022]. Available from https://services2.arcgis.com/ppIFLOeUcdFMQzkH/arcgis/rest/services/Settlements_with_ Urban_Rural_and_Population_data/FeatureServer. District Borough Unitary Region [Shapefile]. Using: EDINA Digimap Ordnance Survey Collection. [viewed on 3 August 2022]. Available from: https://digimap.edina.ac.uk/.
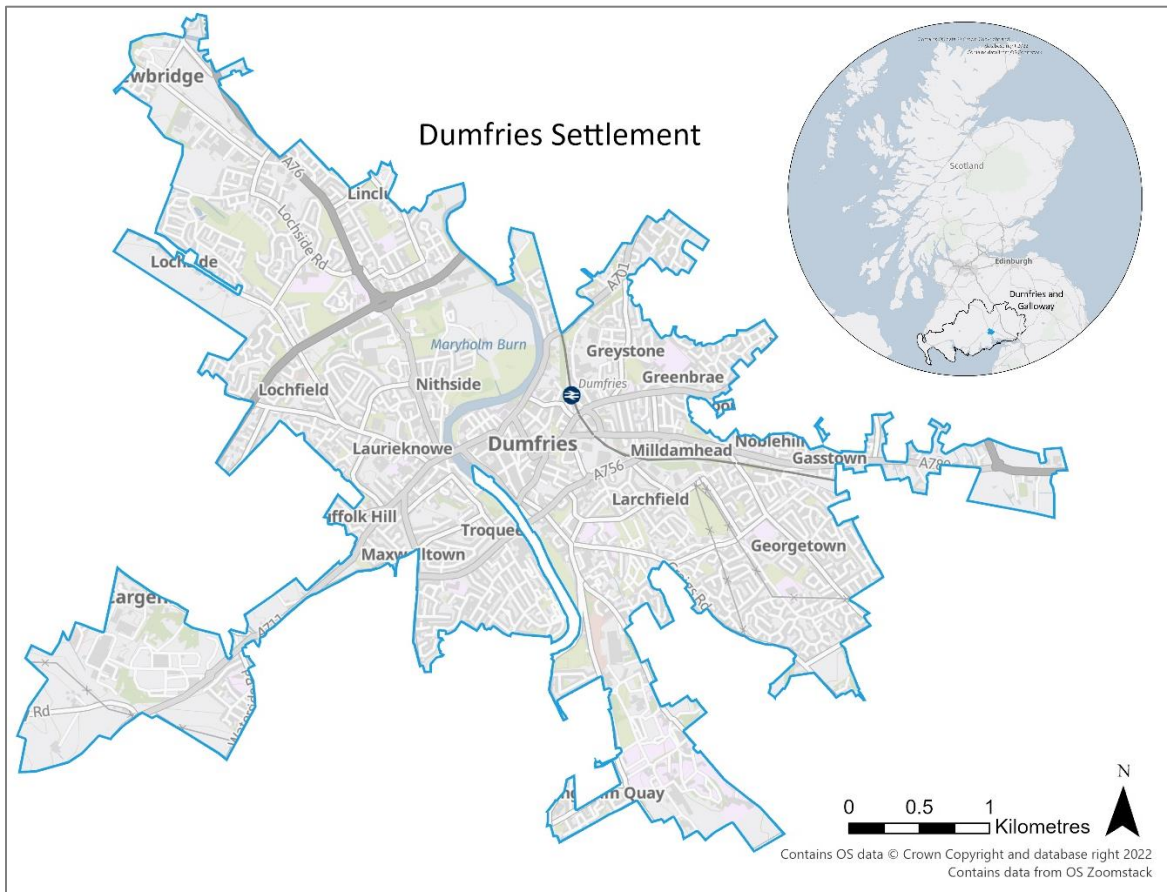
CHAPTER 3.   METHODOLOGY

Developing new knowledge around MaaS, requires a strategy that guides the researcher in the planning, execution, and monitoring of the study. A research strategy should be feasible, it should serve its purpose, and be suitable to answer the research questions defined. For that, it takes on research methods to collect and analyse data (Johannesson and Perjons, 2021b).

Both the research strategy and data collection are guided by a system of beliefs, and assumptions of reality, referred to as the research philosophy (Ryan, 2018; Saunders *et al.*, 2019; Johannesson and Perjons, 2021b). Adopting the appropriate philosophical research stance, starts with a consideration of the research questions. In doing so, this chapter presents the methodology followed, basing it on the outline proposed by Thomas (2017).

3.1   Research Design

This research tried to shorten the research gaps regarding the scarce examples of MaaS implementation in rural areas, and the limited study of MaaS inputs for sustainable planning. The analysis, focused on the area of Dumfries, tried to address the gaps through three main questionings. Firstly, what are the current conditions preparing Dumfries, immersed in a rural area, to adopt a MaaS strategy. In second place, what conditions are obstructing a successful adoption, and thirdly, what measures could increase Dumfries' preparedness to implement MaaS and reap sustainability benefits.

Responding to those research interrogations looked at a philosophical stance that aimed to make sense of the subjective and socially constructed meanings about the likeliness of MaaS being implemented in Dumfries (Saunders, Lewis and Thornhill, 2019d). This philosophy explored how reality is constructed and modified by the actors with an interest in it (Johannesson and Perjons, 2021a). It related to the presumption that having access to that reality can only be done through human perceptual and cognitive abilities (Uher, 2018). It therefore related to an interpretivist philosophical standpoint.

In line with that philosophical stance, this research followed a qualitative approach. This required deriving meanings from documentation and the citizens and authorities'

perceptions and views on mobility. Nevertheless, quantitative methods were also required as transportation analysis feeds on numeric data and indicators (Gudmundsson *et al.*, 2016) such as tonnes of GHG emissions, kilometres of cycle lanes, or socioeconomic variables as age and income. Consequently, this research converges to a concurrent mixed methods research. This multiplicity of methods was advantageous as one method supported the interpretation of the other one, by helping to explain viewpoints, and relationships between variables (Saunders, Lewis and Thornhill, 2019d).

Furthermore, this methodological combination spanned to cover a multipurpose research, incorporating features from descriptive, explanatory, and evaluative research. All three of them allowing to build a descriptive profile of the transportation system of Dumfries, to explain and evaluate its current conditions, to later draw conclusions on it. This research multiplicity extended to group the study in two strategies or design frames, a case study on the one hand, and an archival and documentary research on the other one (Thomas, 2017; Saunders, Lewis and Thornhill, 2019d).

It followed a case study structure because it had both an object and a subject. The former, being the analytical frame of MaaS and its drive of sustainable planning, while the latter, centred on Dumfries, exemplified, and illuminated the object (Thomas, 2017). However, it also entailed documentary research, with the scrutiny of government documents, statistics datasets, and similar others. Relating thereby to Saunders et al., (2019a) statement about the often employment of archival records and documentation by case study research. Therefore, both strategies were linked together, allowing an enhanced description of the object and subject as well, the evaluation of policies and strategies, or to run cross-checking of facts (Saunders, Lewis and Thornhill, 2019d). This whole design structure is summarised in Figure 3.1.

Figure 3.1. Research Design structure.
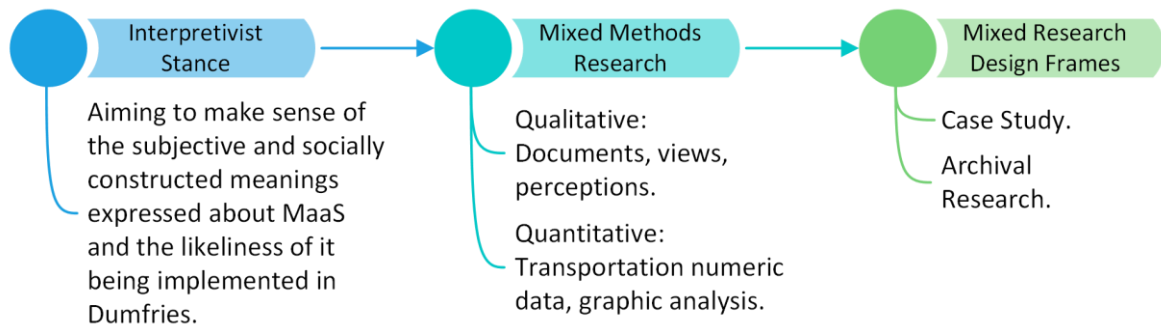
3.2 Ethics

Ethics involve the standards of behaviour shaping the conduct towards the rights of those participating in the study or being affected by it (Saunders, Lewis and Thornhill, 2019e, 2019a). This research abode by Glasgow Caledonian University (GCU) Research Ethics principles, policy, and procedure, as defined by the School of Computing, Engineering, and Built Environment (GCU, no date). Ethical Consideration Forms were filled in and approved (see Appendix 1). All participants involved were made aware of the implications of the study. They were offered a guarantee of confidentiality; and were offered to decline any participation should they did not feel like taking part.

3.3 Data Gathering

Three methods were employed for data gathering: Documentary Review, Interviews, and Observation.

3.3.1 Documentary Review

This initial step was divided in 2 stages. In its first stage, the Documentary Review expanded on the various frameworks and indexes to assess MaaS, as initially identified in the literature review. It explored whether there were other available ways to assess MaaS and mobility maturity at a city level, trying to deepen the understanding of those indexes, to shed some light on how to use and apply them. Doing this allowed to identify a suitable assessment scheme to be used as an **Evaluation Framework (EF)**, taking the form of a checklist. This EF was used to first frame the scope of all the subsequent methods employed; and second, to run the assessment of Dumfries' MaaS readiness.

To execute this initial review, the terms "MaaS maturity index" and "MaaS readiness index" were used as search criteria on the following scientific databases, and on Google.com to look for grey literature.

- Sciencedirect.com
- Scopus.com
- Semanticscholar.com

From each search, only the first 50 results displayed were analysed. Other frameworks or indexes covered or quoted in those results were also revised, as in a snowballing process (Wohlin, 2014). The results obtained were categorised according to their focuses, to help the analysis and the further selection of the suitable **EF**.

In the second stage, the Documentary Review covered an examination of a range of archival material, guided by the EF previously prepared. This review used secondary sources like reports and strategy statements, governmental documents, and more, associated with transportation, sustainability, and related topics. The information gathered was used to identify the mobility stakeholders to interview and fed the Readiness Evaluation analysis. These archival sources provided a faster, easier, and cheaper way to acquire information, useful for describing contexts, explaining linkages, drawing relevant conclusions, etc. (Saunders, Lewis and Thornhill, 2019d, 2019f).

3.3.2 Interviews

3.3.2.1 Participants

Transportation systems involve a series of contributors, each one with different interests and objectives. Their views and perceptions are important to better understand matters like governance, planning, and efficiency (Signor *et al.*, 2019). Participants in this study were classified in 4 categories, based on Rupprecht Consult, (2016), and Varlet et al., (2022), as seen in Figure 3.2. The documentary review served as the starting point for the identification of the different stakeholders, which was expanded on as interviews commenced and other relevant participants were brought up in the conversations.

Figure 3.2. Categorisation of stakeholders.

Source: based on Cré et al., (2016); Rupprecht Consult, (2016); Varlet et al., (2022).

Type of Stakeholder	Description
Planning Authorities	Decision-makers leading mobility plans or people who could provide political support and resources. E.g., local public authorities, transport authorities (Ministry, Council, etc.), mayors, heads of governments, political parties.
Institutional Stakeholders	Other departments within the local authority, public entities or organisations managing transport networks or working on urban mobility or nexus sectors. E.g., other municipal agencies, political bodies, higher level authorities, academia, public transport companies (municipal buses, trams, regional buses, etc.) and public providers of new mobility services (e.g., bike sharing), owners of transport infrastructure (roads, parking, interchange stations, etc.), national railway companies, port and airport authorities (when applicable).
Other Key Stakeholders	Stakeholders from different backgrounds interested in modifying mobility in their areas. Actors who can directly impact a project and its implementation in either a positive or negative way. Including civil society groups, business organisations, Non-Governmental Organisations and Associations, cycling organisations, private transport operators and providers of new mobility services (e.g., bike sharing, car sharing), community-led initiatives.
Citizens	All people, residents, or the public living and/or working in the study area of Dumfries. Individuals that are not affiliated with any specific group.

Stakeholders identified were prioritised according to their influence and stakes in mobility issues in Dumfries. This prioritisation was useful to direct the efforts and resources to those mobility partakers mostly related to the research topic. Thus, avoiding the involvement of actors lacking interest or knowledge, preventing to miss focus (Hujainah *et al.*, 2018). Participants were prioritised using an Influence-Interest Matrix,

Figure 3.3. Influence-Interest Matrix.

Source: adapted from UN-Habitat, (2001).
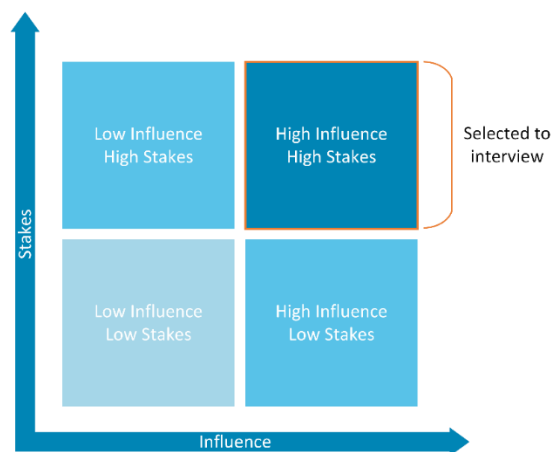
as seen in Figure 3.3. Those participants categorised as High Influence and High Stakes were selected to interview. No citizen was interviewed. Rather, for practical reasons and ease, their perspectives were taken from documents and surveys developed by the council.

3.3.2.2 Semi-structured interview

Conversations were held with the prioritised participants. Discussions derived from a semi-structured interview, guided by the EF; trying to establish rapport, and listening attentively (Thomas, 2017; Saunders, Lewis and Thornhill, 2019c). All interviews were held on Microsoft Teams, both for ease and a more efficient use of time. Each participant was contacted via email. Each was sent a brief overview of the research (see Appendix 2). They all received the Ethical Forms and returned them signed. An interview schedule with a list of topics and questions (like the one shown in Figure 3.4) organised the talk.

Each participant was asked a series of questions about Dumfries' MaaS readiness and the current transport system, MaaS and planning, their will to collaborate on MaaS initiatives, and the regulatory framework for MaaS operation. Questions were adjusted according to the type of participant and organisation. A detailed look of the questions posed can be found in Appendix 3. Those questions and topics became flexible as conversations went on and evolved depending on the answers received. The collected interview data was thereby mutually constructed, by the interviewee with their interpretations, and by the interviewer's response (Thomas, 2017; Saunders, Lewis and Thornhill, 2019c).

Figure 3.4. Example of a structure to prepare the interview schedule.

Source: adapted from Thomas (2017).
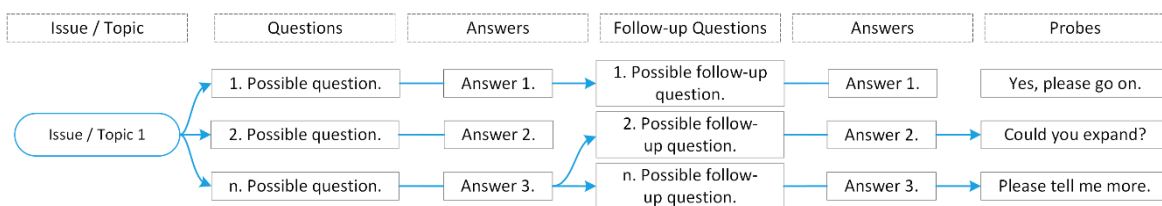
3.3.3 Observation

Understanding the interpretations of Dumfries' mobility stakeholders and policies implied taking practical engagement in the research. To achieve that, unstructured observation, also called participant observation, was carried out (Cohen, Manion and Morrison, 2018, p. 20; Uher, 2018). This consisted of a visit to Dumfries to collect primary data related to the different transport modes, their operation, usage, the citizenry engagement in active travel, and other aspects.

This involvement implied participating as an active user of the transportation system, a way to offer the study a view from within; trying to see the social world through the eyes of the participants, rather than an outsider (Cohen, Manion and Morrison, 2018, p. 20). It offered from first-hand, close-up insights of the transportation system, its efficiency, and reliability. It allowed complementing the data collected from interviews and documentary review, while identifying more topics to explore on and cross-check. Observations made were recorded through photographs, videos, and notes; later analysed (Thomas, 2017; Saunders, Lewis and Thornhill, 2019b). Topics looked at were proposed by the EF and organised in different contents, following Figure 3.5.

Figure 3.5. Checklist of contents for field notes.

Source: adapted from Cohen, Manion and Morrison, (2018, p. 554); citing Spradley, (1980, p. 78).

Space	The physical setting	Objects	The artefacts, physical things that are there	Time	The sequence of acts, activities and events
Actors	The people in the situation	Acts	The specific actions that participants are doing	Goals	What people are trying to achieve
Activities	The sets of related acts that are taking place	Events	The sets of activities that are taking place	Feelings	What people feel and how they express this

3.4 Procedure

These three methods were gathered in Table 3.1 whereby objectives, research questions, methods, and outcomes are all linked. Plus, Figure 3.6 exhibits the procedure diagram flow.

3.5 Analysis

3.5.1 Readiness Evaluation

Once all data was collected, the selected EF was used to run both a qualitative and quantitative analysis of Dumfries' MaaS readiness. Firstly, all aspects covered by the EF were assessed using the information collected from the documentary review, the interviews, and the unstructured observation. After describing, explaining, and analysing each topic from the EF, they were assessed using the scoring scale of the EF, as explained in section 4.2.1. Once the scoring was done, a criteria compliance analysis was performed, graphically displaying the results in a radar chart. Lastly, a SWOT analysis was developed to ease the identification of windows of opportunity for a MaaS implementation in Dumfries. This led to the presentation of a series of initiatives and recommendations to increase Dumfries' preparedness for MaaS.

3.6 Limitations

Several limitations were identified. The timeframe of the study was the most relevant. It did not allow for a validation of the EF results through a workshop, as explained in section 4.2.1. It did not allow either to interview more participants, especially those in rural areas similar to Dumfries and who have seen the deployment of MaaS, like East Lothian. What is more, many statistical data were not available for Dumfries alone. Data like GHG emissions, and number of vehicles per person, were some examples of this. However, data like smartphone uptake, and usage of internet for personal purposes were not even available for the D&G region. This made comparisons not possible sometimes and limited the analysis, as pointed out in each specific section. Limitations about the EF itself relate to its urban nature and further required testing. Likewise, other aspects are explained in sections 4.2.1 and 4.6.1 as the EF is used.

Table 3.1. Summary of methods and expected outcomes.

Objective	Research Question addressed	Methods	Expected Outcomes
Analyse Dumfries' modal shares, and sustainable planning state of the art.	What are the current conditions preparing Dumfries, immersed in a rural area, to adopt a MaaS strategy? What conditions are obstructing a successful adoption? What measures could increase Dumfries' preparedness to implement MaaS and reap sustainability benefits?	• Documentary Review. • Semi-structured Interviews. • Unstructured Observation.	Description of: • Dumfries' transportation system. • Dumfries' planning strategy, approach and scope. • Mobility stakeholders.
Propose a framework to evaluate MaaS readiness in Dumfries.	What are the current conditions preparing Dumfries, immersed in a rural area, to adopt a MaaS strategy?	• Documentary Review.	• An Evaluation Framework to assess the MaaS readiness of Dumfries.
Evaluate Dumfries' readiness to foster MaaS implementation.	What are the current conditions preparing Dumfries, immersed in a rural area, to adopt a MaaS strategy?	• Documentary Review • Semi-structured Interviews. • Unstructured Observation. • Readiness Evaluation.	• Multi-criteria compliance analysis. • Explanation and prediction of Dumfries' readiness to implement MaaS.
Develop a set of proposals for Dumfries' MaaS implementation.	What conditions are obstructing a successful adoption? What measures could increase Dumfries' preparedness to implement MaaS and reap sustainability benefits?	• Documentary Review. • Semi-structured Interviews. • Unstructured Observation.	• Criteria compliance analysis. Recommendations for: • A better MaaS implementation. • Dumfries sustainable planning.

Figure 3.6. Process flow for the data gathering and analysis.
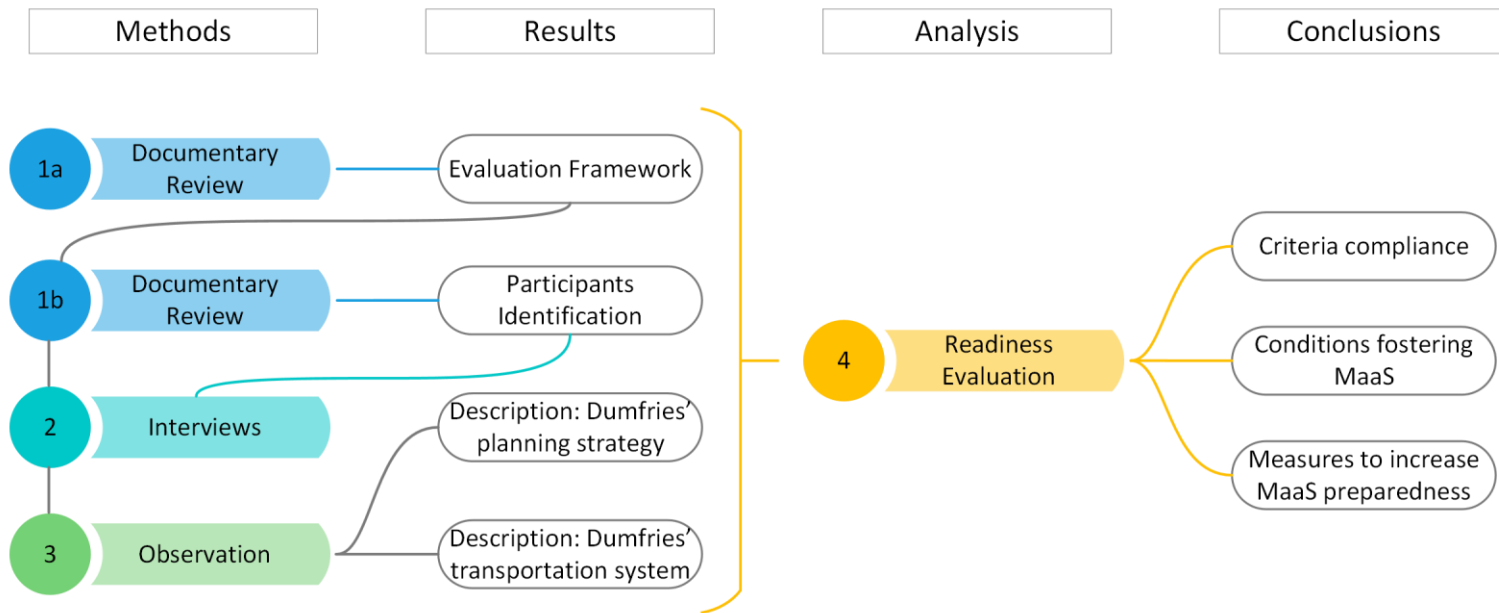
CHAPTER 4.   RESULTS AND DISCUSSION

Results are presented next, starting with a description of the case study Dumfries. Results follow the order of the objectives of this research, looking first at Dumfries' transport and town planning, then the selection of the EF, and the findings from the interviews and the observation. After that, the EF topics are used to evaluate Dumfries' MaaS readiness, to later analyse the evaluation results, and close the chapter with recommendations for increasing MaaS preparedness.

4.1 The Case Study of Dumfries

4.1.1 General characteristics of the area

D&G covers an area of 6,426 km^2 with approximately 200 miles of coastline (Coltart and Jackson, 2019). It has been a local authority region since 1973, comprising the counties of Dumfries, Kirkcudbright, and Wigtown; and the districts of Annandale and Eskdale, Nithsdale, Stewartry, and Wigtown (Cannon and Crowcroft, 2015). In 2021, its population was estimated at 148,790 inhabitants (NRS, 2022a), with Dumfries alone holding around a 23% of that total, 34,040 residents (NRS, 2022b).

D&G experiences a high agricultural activity, being its most significant economic sector, covering around a 70% of its area, while the woodlands cover a 25% approximately (D&G Online, 2021). That natural scenery plus its conservation areas results in some 735,000 overnight visits, and around 7,000 jobs (DGC, 2016; VisitScotland, 2021). Other key economic sectors are the creative industries, food and drink, health and social care; with digital businesses and renewable energy industries also playing important roles (Coltart and Jackson, 2019).

Dumfries as the capital of the region holds the highest population share, and concentrates most new developments, economic regeneration areas, and employment land (DGC, 2019b). Dumfries is the largest town in the Nithsdale area, where the two largest employers are found: the DGC, and the NHS D&G. In addition, Dumfries has the most important health centres of the area, the D&G Royal Infirmary, the Mountainhall Treatment Centre, and Midpark Hospital (Kirkpatrick, 2021). Major education facilities receive each year around

6,000 students at the D&G College, the University of Glasgow, and the University of West Scotland Dumfries Campuses (Complete University Guide, no date; UWS, no date; Rinaldi, 2017).

The town centre has a historic street pattern which reflects its origins as a medieval marketplace. Today, it preserves this commercial focus, turning it into the main shopping centre for the region. Even more, Dumfries' centre encloses residential uses, business, leisure, entertainment, cultural, and community facilities (DGC, 2019b). Despite that, Dumfries still faces a wide range of ongoing challenges stemming from the rural context it is immersed in. A series of hurdles they need to surpass in terms of environmental aspects, societal concerns, employment, mobility and transport connectivity, and several others further exacerbated due to the COVID-19 pandemic.

The Southwestern Scottish region's economic growth rate has been lower than the national average. D&G's economy grew at around 1.2% per year from 2009-2019, and employment decreased by 7.8%. The pandemic caused the economy to contract even more, with employment dropping a 7.2% from 2019-2020, while in Scotland it fell around 1.2% (Skills Development Scotland [SDS], 2022). This placed D&G as the local authority with the lowest employment rate, 67.1% from April 2020 to March 2021 (National Statistics, 2021). From October 2020-September 2021, that value increased to 70.8%, close to 62,200 people, but was still lower compared to Scotland's rate of 72.9% (SDS, 2022). Even worse, D&G's weekly earnings from 2015-2019 were among the lowest nationally, between £452-481 (DGC, 2020).

As the health crisis is overcome, sectors like accommodation and food, administrative and support service activities, and ICT, are forecast to witness the largest annual Gross Value Added (GVA) growth from 2021-2031. Notwithstanding, that recovery is likely to be slower than the national rate. While Scotland will recover its levels of employment by 2023, D&G is forecast to recover them by 2031. Plus, the employment expansion rate for the region is expected to be 0.2% annually, whereas the Scottish scene foresees a rate of 0.4%. Even

with that increase, 500 fewer people are expected to be employed in 2031 compared to 2024 values (SDS, 2022).

Scotland's population is ageing, same with D&G's (SDS, 2022). In 2020, the 45-64 age group was the largest, with around 43,828 residents. Conversely, the smallest group was those aged 16-24, with a population of 12,791. Between 1998 and 2020, the 25-44 age group decreased a 27.1%, whereas the 75+ group increased around 50%. The average age is expected to increase as more people are expected to live longer. More, D&G's population has decreased by 0.3%, while Scotland's population has risen by 7.7%. Likewise, projected population to 2028 foresees a decrease of 2.8% versus a national increase of 1.8% (NRS, 2021).

In terms of deprivation, and out of 32 local authorities, D&G ranked in the 20th place in the 2020 Scottish Index of Multiple Deprivation (SIMD), with just 9.45% of its data zones considered to be in the 20% most deprived in Scotland, that is 19 data zones. Comparing this value to other areas is not recommended, it is rather more valuable looking at concentrated deprivation or comparing domains (Scottish Government, 2020a, 2020b). Most of D&G's deprived zones are in Northwest Dumfries (see Figure 4.1), coexisting with other less deprived ones, adding to that plurality of Dumfries and its urban-rural features (DGC, 2020).

What is more, D&G as a region, is mostly deprived in terms of Access to Services, with a 39.30% of data zones in the 20% most deprived (see Figure 4.1). This is a manifest sign of weaknesses in the transport system, reflecting the rural make-up of the regional, and a population density of 24 residents per km^2 (DGC, 2017b, 2020; Scottish Government, 2020a). In addition, the region showed a high likelihood of digital exclusion. A 33% of its residents aged 16+ do not have formal qualifications (higher than the national average 27%), and 28% of the population experience fuel poverty against 25% in Scotland (DGC, 2020).

In the light of those conditions, the DGC is prioritising the economy build-up, to retain and attract young people into the region and develop their skills, working closely with the public,

private, and third sector, and trying to secure long term investment (DGC, 2017a). Moreover, through their planning policies they are aiming at a sustainable development, sustainable economic growth, reducing the impact of climate change, and creating high quality places (DGC, 2019b).

Figure 4.1. Multiple Deprivation in Dumfries in 2020.

Source: Arrieta-Solís, J. *The SIMD 2020 in D&G and Dumfries* [JPEG Map], Scale 1:1,496,979; 1:91,140, Settlements Urban and Rural Population Data [Feature Layer], Updated March 2022, Tom Sharples_ScotGov. Using: ArcGIS Online. [viewed on 16 June 2022][1]. District Borough Unitary Region [Shapefile]. Using: EDINA Digimap Ordnance Survey Collection. [viewed on 3 August 2022][2]. SIMD 2020 [Shapefile]. [viewed on 6 September 2022][3].

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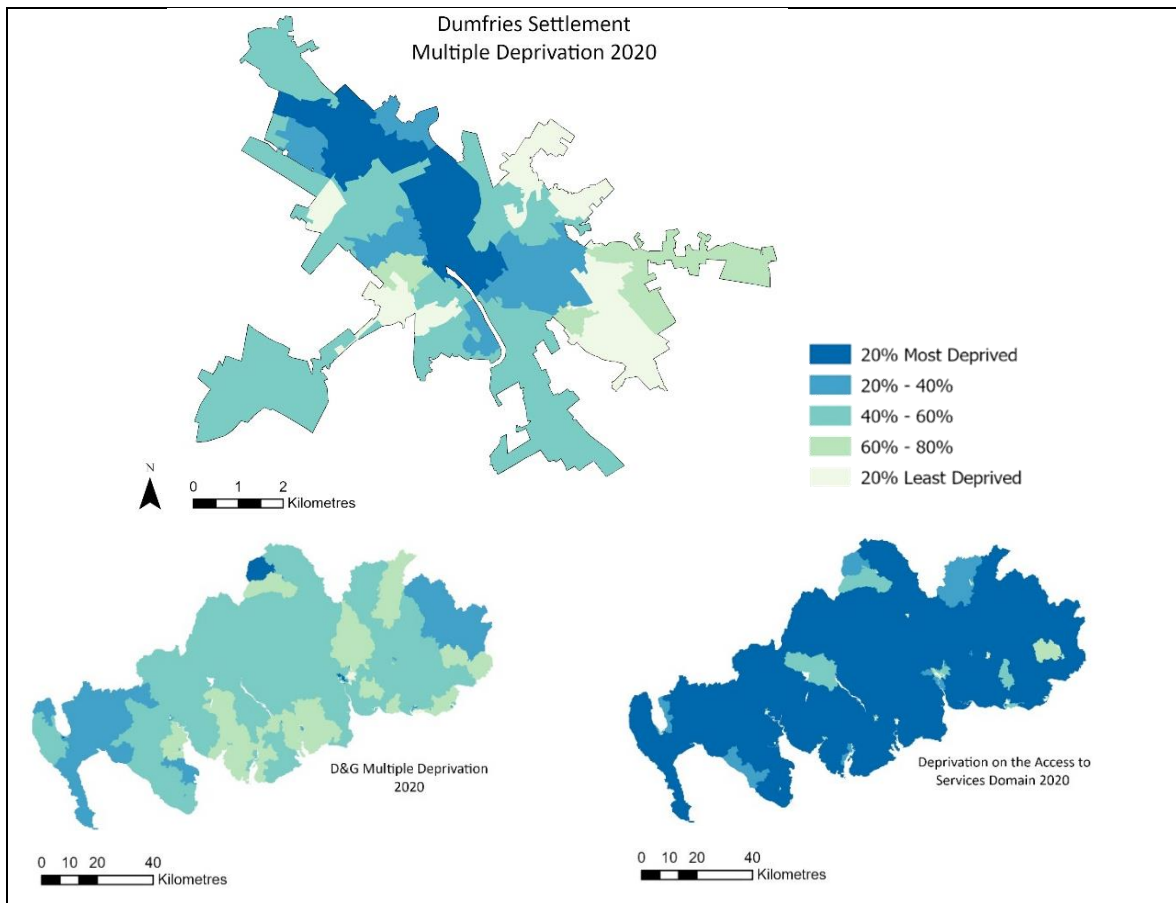
[1]Available from:
https://services2.arcgis.com/ppIFLOeUcdFMQzkH/arcgis/rest/services/Settlements_with_Urban_Rural_and_Population_data/FeatureServer
[2] Available from: https://digimap.edina.ac.uk/.
[3]Available from: https://maps.gov.scot/ATOM/shapefiles/SG_SIMD_2020.zip

4.1.2 About the planning and transport policies in Dumfries

The DGC as the local authority is responsible for the planning policies of their council area, setting out the rules and measures for the economic growth, the land use, and local transport strategies like the active travel ones. The regional transport planning is under the scope of the Regional Transport Partnership (RTP) for the Southwest of Scotland - SWestrans-, in charge of a range of planning, operational, and project delivery responsibilities, including the provision of local bus services (Kirkpatrick, 2021). The local authority and SWestrans share the same jurisdiction, covering the whole of the D&G region.

The DGC released the second iteration of the Local Development Plan (LDP) in 2019. This plan updates every 5 years. The LDP is based on the overarching premise that all development proposals must follow sustainability principles and aim to reduce GHG emissions. It seeks to create opportunities for a sustainable economic growth, promoting active travel and minimising the need to mobilise. All this, acknowledging the dispersed settlements and the high levels of private car usage. It visualises a population living and working locally, with smarter and more sustainable travels, linking trips and modes, thus reducing car dependency (DGC, 2019b).

Most of the developments are planned for Dumfries, and other centralities like Lockerbie, and Stranraer. The policies look at development designed for people, not for vehicles. Proposals designed to create safe, accessible, and inclusive places for all residents, increasing connectivity to nearby places, integrating sustainable energy and design measures. The LDP spans policies demanding developers to improve accessibility in their proposals by developing pedestrian, cycling and public transport facilities, and providing additional car and coach parks when required (DGC, 2019b).

Moreover, the LDP asks for developments to consider the relationship between transport and land use, as it has a strong influence on sustainable economic growth. Proposals should analyse the likely transport impacts to be then dealt with. Further, policies state buildings and facilities should be designed to prioritise the needs of pedestrians, cyclists, and public

transport user, over car and other motorised options. Plus, they are expected to be well served by sustainable modes and provide options for a modal shift from car (DGC, 2019b).

SWestrans has the statutory requirement to build a Regional Transport Strategy (RTS) every 15 years. The current one dates to 2008, seeking to improve transport links within D&G, contribute to improved economic growth and social inclusion, minimise the environmental impacts of transport, support vibrant places that provide employment, healthcare, and other needed services. This strategy highlighted issues such as a poor transport infrastructure, a rail and bus network serving only specific routes and not all settlements, infrequent services, unaffordable PT costs to unemployed people, and missing job opportunities due to a reliance on an inefficient PT or a lack of access to a car (SWestrans, 2008).

SWestrans recently initiated the process for an updated RTS. This has undergone the development of a Scottish Transport Appraisal Guidance Case for Change Report prepared by Stantec (2022). It went on public consultation, closing in early June 2022. This report describes the transport context of D&G taking on the South West Scotland Transport Study Initial Appraisal: Case for Change Report, a report produced on behalf of Transport Scotland (TS, the Scottish National Transport Authority). The report describes the transport context in D&G, setting out its baseline conditions, to lastly develop objectives for the new RTS (Stantec, 2022).

The report draws a scenario similar to the one portrayed in the 2008 RTS plus new issues related to the aftermath of the pandemic. The bus network and its operation are fragile, with any minor changes causing major disruption. There is uncertainty of future funding. A lack of frequent and direct services force people to own and rely on a car. It also stated that these transport connectivity issues have repercussions on accessing job opportunities and avoiding social inequalities in the region.

Besides, the report spans to provide an overview of the factors impacting upon transport demand in the future, such as transport technologies, shared mobility, MaaS, and Demand Responsive Transport (DRT). It also gathers on stakeholders' consultation inputs and

develops a set of objectives for the new RTS. For instance, improving walking and wheeling links, widening access to cycle usage, improving integration between bus and train, making ticketing more seamless, reduce bus service infrequency, among others (Stantec, 2022).

Furthermore, in 2021 SWestrans prepared a Transformation Programme, proposing a new PT delivery model to be phased from April 2022 until March 2024. It is a 3-tier framework, foreseeing a fully integrated, connected, and sustainable PT. Tier 1 includes a community level provision of tailored and flexible services, tier 2 involves supported local buses and community transport, and tier 3 comprises commercial local buses and rail. The programme aims to develop and implement an integrated transport hub with DRT services, community car clubs, and others. A digital platform will allow to plan and book journeys in real time, and design transport solutions to meet the needs of people. Through this programme, economic and social benefits are expected, by improving access to employment and health services, ensuring appropriate and affordable transport, and reducing isolation (Kirkpatrick, 2021).

All these planning instruments were built upon the prevailing national policies at the time they were prepared. The National Planning Framework 3 (NPF3) for the LDP, and the National Transport Strategy (NTS) for the RTS (SWestrans, 2008; DGC, 2019b). The Transformation Programme covered the Transport (Scotland) Act 2019, and the most recent NTS2. The new RTS and LDP strategies will require to cover the new policies and principles stated in the NPF4 and the NTS2, where topics like 20-minute neighbourhoods, active travel, and transport technologies like MaaS are revised (TS, 2020b; Scottish Government, 2021b).

4.2   Selecting the Evaluation Framework

The search of a suitable EF led to 43 relevant results. From that total, 22 references (a 51%) were found for MaaS Maturity or MaaS Readiness indexes. Almost all those 22 documents cited the MaaS Maturity Index (MMI) from Kamargianni and Goulding, (2018); suggesting its high relevance. Three other related indexes were also identified. The first one was a set of MaaS Readiness indicators aimed at local authorities to see how prepared they are to implement sustainable transportation systems and MaaS (Aaltonen, 2017). The second one was the MaaS Readiness Index (MRI) from Somers and Eldaly (2016) which assesses cities or countries preparedness to operate MaaS. The last index, created by Thanos (2018), was a modified version of that second one.

No indication was found as to an agreed framework for assessing MaaS readiness in geographic areas. Further, having access to these indexes' methodologies was not possible as they were not disclosed by the authors, or are still under refinement and require more testing. Such results meant the EF required could follow any of those 4 readiness indexes, however, the only available methodology was for the index from Thanos (2018), as explained in Appendix 4.

4.2.1   About the MMRI

The modified version of the MRI (MMRI) developed by Thanos (2018) contains 69 factors which are evaluated using a scoring scale ranging from 1 to 4, as seen in Figure 4.2. Compared to the MMI and the MRI, the author of the MMRI offers more insights and explanation on the index usage. This provides more ground to replicate the MMRI, and thus, allows to consider it as the best option for the EF required in this research. However, it must be underscored, due to the timeframe for the research, the process steps defined for the index were not entirely followed. Steps 2 and 3, requiring the data verification and a workshop with experts were not executed as proposed by Thanos (2018). They were rather run only by the researcher, basing them upon the documentation analysed, the observation, and the interviews held.

Figure 4.2. Scoring scale and Process of the MMRI.

Source: adapted from Thanos (2018).

Scoring Scale

4 — Totally supportive of MaaS

3 — Supportive of MaaS, but there are some gaps

2 — Some usefulness for MaaS, but below what would be desirable

1 — No service, or there is a critical barrier to be useful for MaaS

Process Steps

1 — Condensate data to describe the current situation in the case site

2 — Verify the data accuracy through an independent auditor

3 — Develop a workshop with mobility experts to evaluate the MMRI

The MMRI comprises a 5-layer structure (see Figure 4.3). On the top layer are 3 Pillars categorising the main foci of the index: Supply, Demand, and Regulation. Each pillar is associated to one of 3 Major Themes on the following sublayer: Availability of Transport and ICT, Customer Demand, and Government Support. Then, each major theme divides into evaluation topics on the further sublayers, the General and Specific Evaluation Topics Layers. Finally, deriving from the previous layers, the bottommost layer incorporates the 69 Scoring Factors to be assessed. The contents of the index are found in Table 4.1.

Figure 4.3. MMRI 5-layer structure.

Source: based on Thanos (2018).

Pillars

Major Themes Layer

General Evaluation Topics Layer

Specific Evaluation Topics Layer

Scoring Factors Layer
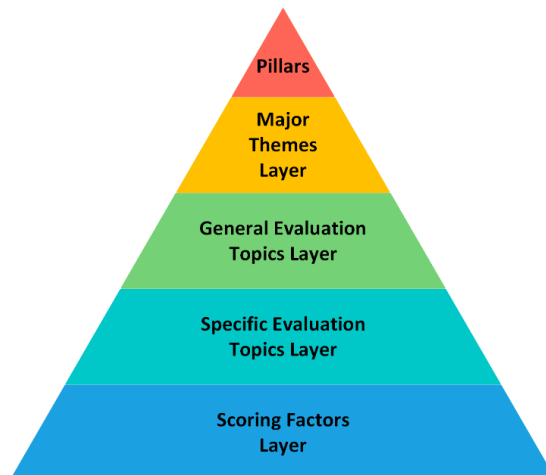
Table 4.1. MMRI pillars, levels, scoring factors, and weights.

Source: adapted from Thanos, (2018).

Pillars	Major Themes	General Topics	Specific Topics	Scoring Factors
Supply	Availability of transport, mobility and communication services and infrastructure (33.33%)	Active Transport (6.67%)	Walking (2.67%)	Modal split of walking (1.33%)
				Pedestrian infrastructure (1.33%)
			Cycling (2.67%)	Modal split of bicycle (1.33%)
				Cycling infrastructure (1.33%)
			Bicycle Share (1.33%)	Coverage and service density (0.44%)
				Service functions (0.44%)
				API's (0.44%)
		Public Transport (6.67%)	Public Transport Services (2.86%)	Modal split of public transport (1.43%)
				Public transport infrastructure (1.43%)
			Travel Planner (2.86%)	Coverage and service density (0.95%)
				Service functions (0.95%)
				API's (0.95%)
			On-demand Public Transport (0.95%)	Coverage and service density (0.32%)
				Service functions (0.32%)
				API's (0.32%)
		Individual Motorised Transport (2.00%)	Personal Vehicle (0.67%)	Modal split of personal vehicle (0.33%)
				Infrastructure of vehicular transport (0.33%)
			Taxi (0.67%)	Coverage and service density (0.17%)
				Coverage and service density of mobile app (0.17%)
				Service functions (0.17%)
				API's (0.17%)
			Individual On-demand Transport (0.67%)	Coverage and service density (0.22%)
				Service functions (0.22%)
				API's (0.22%)
		Flexible Vehicle Access (2.67%)	Rental Vehicles (0.44%)	Coverage and service density (0.11%)
				Coverage and service density of mobile app (0.11%)
				Functions of mobile service (0.11%)
				API's (0.11%)
			Shared Vehicles (1.33%)	Coverage and service density (0.44%)
				Service functions (0.44%)
				API's (0.44%)
			Parking (0.89%)	Coverage and service density (0.30%)
				Service functions (0.30%)
				API's (0.30%)

Pillars	Major Themes	General Topics	Specific Topics	Scoring Factors
Supply	Availability of transport, mobility and communication services and infrastructure (33.33%)	Flexible Trip Access (2.67%)	Private Collective On-demand Transport (0.89%)	Coverage and service density (0.30%)
				Service functions (0.30%)
				API's (0.30%)
			Shared Intraurban Trips (0.89%)	Coverage and service density (0.30%)
				Service functions (0.30%)
				API's (0.30%)
			Shared Interurban Trips (0.44%)	Coverage and service density (0.15%)
				Service functions (0.15%)
				API's (0.15%)
			Other Interurban Transport Services (0.44%)	Coverage and service density (0.11%)
				Coverage and service density of mobile app (0.11%)
				Functions of mobile service (0.11%)
				API's (0.11%)
		Additional Services (1.00%)	Food Delivery Services (0.33%)	Coverage and service density (0.11%)
				Service functions (0.11%)
				API's (0.11%)
			Grocery Delivery Services (0.33%)	Coverage and service density (0.11%)
				Service functions (0.11%)
				API's (0.11%)
			Logistic Services (0.33%)	Coverage and service density (0.11%)
				Service functions (0.11%)
				API's (0.11%)
		ICT Services (11.67%)	Mobile Devices (5.55%)	Availability of mobile devices (5.55%)
			Internet (5.55%)	Coverage and service density of Wi-Fi (2.78%)
				Coverage and service density of mobile internet (2.78%)
			Contactless Payments (0.56%)	Coverage and service density (0.28%)
				API's (0.28%)
Demand	Customer Demand (33.33%)	Demographical Considerations (16.67%)		General demographics of the case city (13.89%)
				Specific demographics of potential early adopters (2.78%)
		Attitudinal Considerations (16.67%)		Attitude towards new mobility services (8.33%)
				Attitude towards car ownership (8.33%)
Regulation	Government Support and Regulatory Environment (33.33%)			Level of political facilitation (9.52%)
				Public infrastructure investments (9.52%)
				Level of stakeholder collaboration (9.52%)
				Data security, privacy, and liability (4.76%)

Thanos (2018) assigned weights to each theme and factors as a way to identify after the scoring process which topics should be prioritised for a successful implementation of MaaS. The first 3 levels all weight the same, 33.33% each, as they are all interdependent and interlinked. As these levels subdivide, their weightings decrease as each single topic gets more specific. The General Evaluation Topics weighting more than 6% are considered critical for a fruitful operation of MaaS, and so, if poorly scored, they should be on the frontline of action. This type of prioritisation also serves the purposes of this research, as a means to determine what topics should be addressed with urgence.

The author highlighted limitations related to an imbalance in the weightings of the scoring factors. The pillars of customer demand and regulation have very few factors, but very highly weighted in comparison to the pillar of transport and ICT which aggregates much more factors but with lower weights. At the end, this could lead to disproportionate evaluations, strongly influenced by only the demand and regulation pillars.

4.3 Mobility participants in Dumfries

The archival research, observation, and interviews led to the identification of 71 mobility stakeholders. They were categorised in four groups (see Figure 4.4) and later prioritised.

Figure 4.4. Identification of mobility stakeholders in Dumfries.

Planning Authorities	Institutional Stakeholders		Citizenry
Dumfries and Galloway Council Swestrans Transport Scotland	D&G Council Buses National Rail Enquiries Network Rail NHS D&G	Police Scotland Scotrail Scottish Rail Holdings	All Dumfries citizens who are not officially affiliated to an organised body or entity.
Other key stakeholders			
Ae Forest Bike Shop and Cafe Barnhill Cabs Biker Buddies Borderlands Vehicle Leasing Brownriggs Thornhill Coaches Bustimes.org Cancer Cars Scotland ChargePlace Scotland Choose Another Way Community Transport Community Transport Association CoMoUK CTC D&G Cycle Centre Cycling Dumfries Cycling Embassy of Great Britain	Cycling Scotland Cycling UK in Scotland DG2 Wheels Dual the A75 Dumfries & District Ramblers Dumfries Cycling Club Energy Saving Trust Enterprise Car & Van Hire Excalibur Limos Freight Transport Association (Logistics UK) Galloway Community Transport Houston Coaches Liftshare Living Streets MaaS Scotland McCalls Coaches Mcleans Taxis & Coach Hire	Nithsdale Wheelchairs Paths for All Pedal on Parliament Physical Activity Alliance Power Bikes Road Haulage Association Scottish Association for Public Transport Scottish Cycling Solway Taxis South of Scotland Alliance South of Scotland Enterprise South West Scotland Community Rail Partnership Spokes Stagecoach Cumbria	Stagecoach West Scotland Stantec Ltd Sustrans Telfords Coaches The Association for Commuter Transport The British Horse Society The Care Shop Dumfries The Frothy Bike Co. TMac Van Hire Transform Scotland Traveline Scotland Visit Scotland Women's Cycle Forum Scotland Woodgrove Taxis

Following the Influence-Interest Matrix in Figure 3.3, the prioritisation of mobility actors, was done by scoring them from 1 to 4. The highest score 4 was given to those actors taking part in decision-making; authorities with the last say, both locally and nationally. Equally scored were those entities working closely with authorities, and those important transport operators in Dumfries. Smaller operators and organisations daily involved in the mobility sector, but whose power to influence is not of great impact were scored with 3. Those scored with 2, included players whose main goal is campaigning, funding initiatives, or their core business is not precisely mobility. Lastly, the lowest priority, score 1, was given to mobility participants whose range of action is narrower as they are small local commerce, whose business scope is freight and not part of the aim of the research, or organisations with a type of business different from mobility. The mobility partakers highly prioritised and selected to interview are included in Table 4.2, while the whole prioritisation analysis is found in Appendix 5.

Table 4.2. Dumfries' mobility actors prioritisation.

Stakeholder	Observations	Type of Stakeholder	Explanation for the prioritisation
Dumfries and Galloway Council (DGC)	The Local Authority of D&G. They design and implement mobility policies. They define the layout of the settlements through the LDP (https://www.dumgal.gov.uk/).	Planning Authorities	Local planning authority.
MaaS Scotland	It is a joint venture, operated by Technology Scotland and ScotlandIS. They have supported the inclusion of MaaS in the political agenda (https://maas-scotland.com/).	Other key stakeholders	Scotland's MaaS steering body.
Scotrail	Included in the SWestrans RTS. Owned by the Scottish Government and overseen by Scottish Rail Holdings Limited (https://www.scotrail.co.uk/about-scotrail). The only train operator that goes to Dumfries.	Institutional Stakeholders	The only train operator.
Stagecoach West Scotland	Private Bus Operator with the highest number of services operating ,30 (SWestrans RTS, p. 39) (https://www.stagecoachbus.com/about/west-scotland).	Other key stakeholders	The major private bus operator.
Stantec	Consultancy company on transport planning, transport strategies, mobility (https://www.stantec.com/uk). They developed the Southwest RTS STAG Case for Change Report of D&G.	Other key stakeholders	They worked side by side with SWestrans in analysing transport in D&G.
Sustrans	Charity that provides advice, support, and funding for active travel projects. They manage the National Cycling Network and run the I Bike project (https://www.sustrans.org.uk/our-blog/projects/2019/scotland/places-for-everyone).	Other key stakeholders	They work alongside DGC with active travel strategies and other mobility topics.
SWestrans	Southwest RTP covering. Public body responsible for the RTS (www.swestrans.org.uk).	Planning Authorities	Transport Planning Authority for D&G.
Transport Scotland	Scottish national transport authorities. Responsible for policies and strategies (https://www.transport.gov.scot/).	Planning Authorities	Scotland's high level transport authority.

4.3.1 Prioritised stakeholders' views

Viewpoints from prioritised stakeholders were summarised in the following Table 4.3, based on the questions presented in Appendix 3.

Table 4.3. Main findings from interviewed stakeholders.

Interviewee	Highlights and takeaways
Sustrans (Arrieta-Solís, 2022f)	• Sustrans has a person embedded in the Council who helps implementing AT. • They are working on an update of the ATS for which a public consultation was done. • In the area there are community-led transport projects, taxi drivers like McLean's Taxis count with mobile apps. Uber does not operate in the area, just apps like Just Eat, and Deliveroo.
Stantec (Arrieta-Solís, 2022e)	• The current transport system in quite fragmented, hindering MaaS implementation. • Bus system: commercially operated and hard for SWestrans to regulate. • Some bus routes have a very high per head subsidy cost. • MaaS in Dumfries should capture the bus network and identify where there may be gaps, to then ensure that there's a cycle hire or car share schemes available. • There would need to be a dedicated interchange between rail and bus. • Micro mobility (bike sharing, e-scooters, etc.) could encourage more AT. • Integrating all modes in one app, smartcard, or ticket would have a lot more people using PT. It could be integrated on an app, a website, or a phone line. • The DGC and SWestrans should be leading all this. • Transport operators are unlikely to collaborate unless there is a financial incentive. • A lot of people are unaware of what MaaS is and what the potential is. • Implementing MaaS could see the closure of some roads and shifting to pedestrianisation. More opportunities for 20-minute neighbourhoods, encouraging walking to local hubs, and further development for AT infrastructure, or in areas that might be lacking service facilities.
SWestrans (Arrieta-Solís, 2022g)	• There's a fragility in the transport network and current modes. • The commercial market has full control over their services. Where there is no commercial interest on services, RTPs take responsibility, to supply the demand. • Bus services are suffering from reduced number of passengers, fuel prices are rising, as well as wages. Drivers are limited. • SWestrans is working on a new sustainable 3-tier transport framework. • Car ownership is high because PT is limited. Younger people are more willing to adopt technologies. • Linkages between modes will encourage people to change their travel behaviour. • There's willingness among transport operators to share data, because with that they benefit their market. • A legal frame is needed to organise the process and how people and the system will work, to also provide protection to all actors. • No current bike hires work in Dumfries. • Co-Wheels does not work anymore, while Enterprise has a hire beside the railway station.
DGC Planning Team (Arrieta-Solís, 2022a)	• Transport service in D&G is very fragile. • Accommodating transport into planning is key, but there are limitations in the roles of the team to influence transport integration. • In a rural area there's a need to demonstrate how to totally move away from the car, maybe through car sharing options, or the smaller journeys by foot, bike, E bike, Taxi. • 20-minute neighbourhoods are being considered for future plans.

Interviewee	Highlights and takeaways
Scotrail (Arrieta-Solís, 2022c)	• New timetables have been introduced for Stranraer and Dumfries. • Changes in behaviour from the pandemic: people now commute only 2-3 days a week. But people are traveling by PT to longer distances. • MaaS should allocate people to their proper potential cost, identify the potential customers, and allocate them to the best transport mode. • Car use should be made more difficult where there is a valuable public transport alternative. Congestion charging in the city centres or road user charging. • At the Dumfries railway station there are ticket machines, there is free Wi-Fi, there are 134 car spaces, 20 bikes spaces, and contactless payments. • Scotrail cannot drive the interchanges with other modes.
Transport Scotland (Arrieta-Solís, 2022h)	• The Scottish Government included MaaS as part of its programme, which later resulted in the creation of the MaaS Investment Fund (MIF). • The MIF funded projects from Hitrans, Dundee City Council, and Tactran, the University of St Andrews, and Sestrans. Mixing rural and urban. No more funding foreseen after this. • These projects will identify best practices and barriers, for policies. • DRT is one of the things they are looking at. • Education and marketing on MaaS is essential for a better adoption by users. • The DfT closed a consultation process for the MaaS Code of Practice.
MaaS Scotland (Arrieta-Solís, 2022b)	• They play a coordinating role of the first 5 MaaS pilot projects in Scotland. • Pros for MaaS in Scotland: cluster of organisations and expertise, a degree of political buy-in, an easier access to the Scottish Government compared to the Westminster's one. Scotland is an excellent test bed for MaaS because it has a good mix of urban and rural areas. • Cons: a lack of evidenced-based data as to the real benefits and incentives from MaaS, transport is completely deregulated, multiple private operators within a geographical region, making integration harder and stakeholders' management complicated. With benefits and incentives still theoretical, operators are hesitant to participate, like the bus sector. • In the absence of that evidence base, the best is councils and RTPs to define what those MaaS benefits would be. • Finland case: if an operator wishes to work in a certain geographical area, they must abide by data sharing and standardisation requirements. • The voluntary DfT's Code of Practice might require a more legislative approach instead. • There is no clarity as to what the government sees for MaaS as part of its future transport. • There is no direct funding available for further MaaS projects. • SWestrans is the only RTP that is not a member of MaaS Scotland. • In Dumfries, MaaS could be of use for the uptake of CT, DRT, car clubs. Link AT to the Crichton Campus, or maybe some kind of DRT between the Crichton campus and the railway station. • Talking to other RTP in rural areas could help with ideas for implementing MaaS. • MaaS data can be used to pedestrianise an area or convert its functionality. MaaS could serve new housing or business developments. MaaS could look at working with employers to reward and incentivize their staff by taking PT rather than taking the car, or to incentivise people to shop locally.
Stagecoach (Arrieta-Solís, 2022d)	• A lot of that fragility has been driven over the last 5 to 10 years by a decreasing local authority budget, with no decrease in demand. • Two solutions: an increase of funding, or a decrease in the network. • In Dumfries there needs to be a reevaluation of what is needed rather than what has always been there. CT, EV, taxi operators that take the small numbers of passengers from dispersed communities to a central point with a mainline bus service. • Cost of operation has gone up, and travel patterns have changed. • Bikes can only be carried on coaches and not on buses. • There isn't an integrated ticket. • Absolutely open to collaborate on integration initiatives and MaaS strategies.

4.4 Unstructured observation of transport in Dumfries

Observations of the Dumfries' transport system are summarised in Table 4.4, some images are shown in Figure 4.5.

Table 4.4. Unstructured observations of Dumfries' transport system.

Field topic notes	Observations made on MaaS readiness aspects
Date	Monday, July 4th, 2022 (Walk around Dumfries, part of it with the D&G Sustrans Officer)
Space	The footpaths are present throughout Dumfries. Their conditions improve as they approach commercial areas or very frequented places like the railway station. Some places exhibit closed walking areas due to construction or maintenance activities. There are uneven surfaces, faulty tiles, or water deposits that make trips by foot difficult, making it even more complicated for physically impaired people. Streets show faded markings, same as cycle lanes and some crossings. Parking spaces were found all around the town centre, ranging from free spaces to residential, commercial, and private ones.
Actors	Many senior citizens are identified. Few tourists and other visitors were also spotted. Young people are seen mostly around parks, and open spaces. People are travelling by bus, by foot, cycle, wheelchairs, scooters, car, truck. Mobility actors identified include Solway Taxis, McLean's Taxis, Houston's Coaches, McCalls Coaches, Stagecoach. Food delivery like Just Eat, Marmaris, Canton Express. One car hire was identified: Enterprise.
Activities	Streets like the A780, the A701, and Whitesands Street, all show a high volume of traffic throughout the day. Whitesands is particularly busy in terms of buses, cars coming and going, and people driving, taking the bus, or walking and cycling. It can take up to 30 minutes to wait for a bus.
Objects	From the buildings, bus stops, railway station, charging stations, to all sort of different traffic and transport elements such as streetlights, pedestrian crossings, traffic signage on road and on the sides, the streets, the cycle routes, the footpaths, buses, taxis, cycle parking areas, etc. No bike hire schemes were seen. No outdoors free WiFi spots were identified. No on-demand services other than the taxis. Contactless payments are available on buses. Bus stops are far from the railway stations.
Acts	People are travelling by bus, others walk or cycle. There are people driving cars, riding scooters, or taking the train. There were people doing some shopping, having meals, enjoying the scenery, having outdoors activities, etc. The River Nith waterfront offers a wide area for all kinds of outdoor activities, gathering many children and women, young people, and locals exercising.
Events	Commuting, shopping, eating, playing, driving, running, working, etc.
Time	Travelling by bus from Glasgow took around 2 hours on a Stagecoach bus, same for the return trip. Once at the town centre, it takes around 15 minutes by bus to the Royal Infirmary, and some 40 minutes by foot to get to the University of West Scotland campus. At noon and around 5pm there was intense activity throughout the town, with peaks of people and vehicles everywhere.
Goals	Not too many people took the bus from Glasgow, and since there are different stops, not everyone was going to Dumfries. In Dumfries, people could be travelling to work, leisure, to have a meal with friends or family, to have a walk outside to take advantage of the nice weather. Some people were seen taking buses towards Royal Infirmary, they could be travelling for health reasons or similar, or simply to close by areas.
Feelings	It looked like people must wait too much sometimes as buses might not be in time. This seems to cause frustration and despair as it was seen on some people while waiting to take a bus.

Figure 4.5. Observation from visit to Dumfries.

Top left: Closed footpaht. Top right: Mobility scooter. Bottom left: EV charging support.

Right: Car park on Whitesands Street.

4.5   Readiness Evaluation

Dumfries' MaaS readiness was evaluated using the selected EF, the MMRI in Table 4.1. The evaluation was organised following the 3 major themes and their associated General Evaluation Topics (see Table 4.5). The evaluation considered as well, each Specific Evaluation Topic and Scoring Factor derived from the major themes and general topics. This same structure was used to present the Readiness Analysis in section 4.6.

Table 4.5. Topics used to evaluate Dumfries' MaaS readiness.

Major Themes	Availability of Transport and ICT	Customer Demand	Government Support
General Evaluation Topics	Active Transport	Demographical Considerations	Political facilitation, investments, collaboration, data privacy
	Public Transport		
	Individual Motorised Transport		
	Flexible Vehicle Access	Attitudinal Considerations	
	Flexible Trip Access		
	Additional Services		
	ICT Services		

4.5.1 Availability of transport, mobility and communication services and infrastructure

4.5.1.1 Active Transport

Active travel (AT) in Dumfries includes walking, cycling, and scooting. It has been envisioned by the DGC as the normal choice for short, everyday journeys, in their Active Travel Strategy (ATS) (DGC, 2014). Traffic calming measures and 20mph zones service AT. There are footpaths, and pedestrianised areas around the town, with Core Paths around the River Nith, and walking routes like the Burns Walk Circular or the Dumfries Parks and Riverside (see Figure 4.6). The latter, connecting facilities like the Royal Infirmary and the Crichton University Campus (TP&E, 2019).

Cycling can be done throughout Dumfries; however, the infrastructure might not be continuous or coherent in some areas. On-road cycling finds difficulties in navigating one-way streets and busy road links into town (TP&E, 2019). There are though, cycling routes available along the River Nith and Dockhead, including the approximately 14km of the National Cycle Network (NCN) Route 7 which runs across Dumfries (see Figure 4.6).

From a survey ran for the update of the ATS, it was found that 60% of respondents walk every day for any purpose, while 87% own or have access to a bike. Plus, 13% cycle daily for any purpose, 18% do it 4 times a week, and 20% at least once a month. The results also showed that the 3 most frequent reasons for active travelling are for leisure and recreation, keeping fit and exercising, and travelling to and from work. While a 14% and 33% found the current state of walking and cycling infrastructure in very poor and poor conditions, 41% found it in regular states, and only 11% and 1% of respondents considered the current AT infrastructure in good and very good conditions. A 37% strongly agreed on the need of more pedestrian-friendly areas in town centre. A 70% strongly agreed with having more cycling links between settlements, and a 67% strongly agreed on more active travel and access to open spaces as post-COVID life (DGC, 2022a). The survey's results used can be seen in Appendix 6.

Figure 4.6. Dumfries Core Paths and NCN.

Source: Arrieta-Solís, J. *Dumfries Core Paths and NCN* [JPEG Map], Scale 1:53,000, Settlements with Urban and Rural Population Data [Feature Layer], Updated 21 March 2022, Tom Sharples_ScotGov. Using: ArcGIS Online. [viewed on 16 June 2022][4]. Sustrans NCN [Feature Layer], Updated 17 May 2021, Tom Sharples_ScotGov. Using: ArcGIS Online. [viewed on 6 September 2022][5]. Core Paths [Shapefile].   Using: EDINA Digimap Ordnance Survey Collection. [viewed on 3 August 2022].
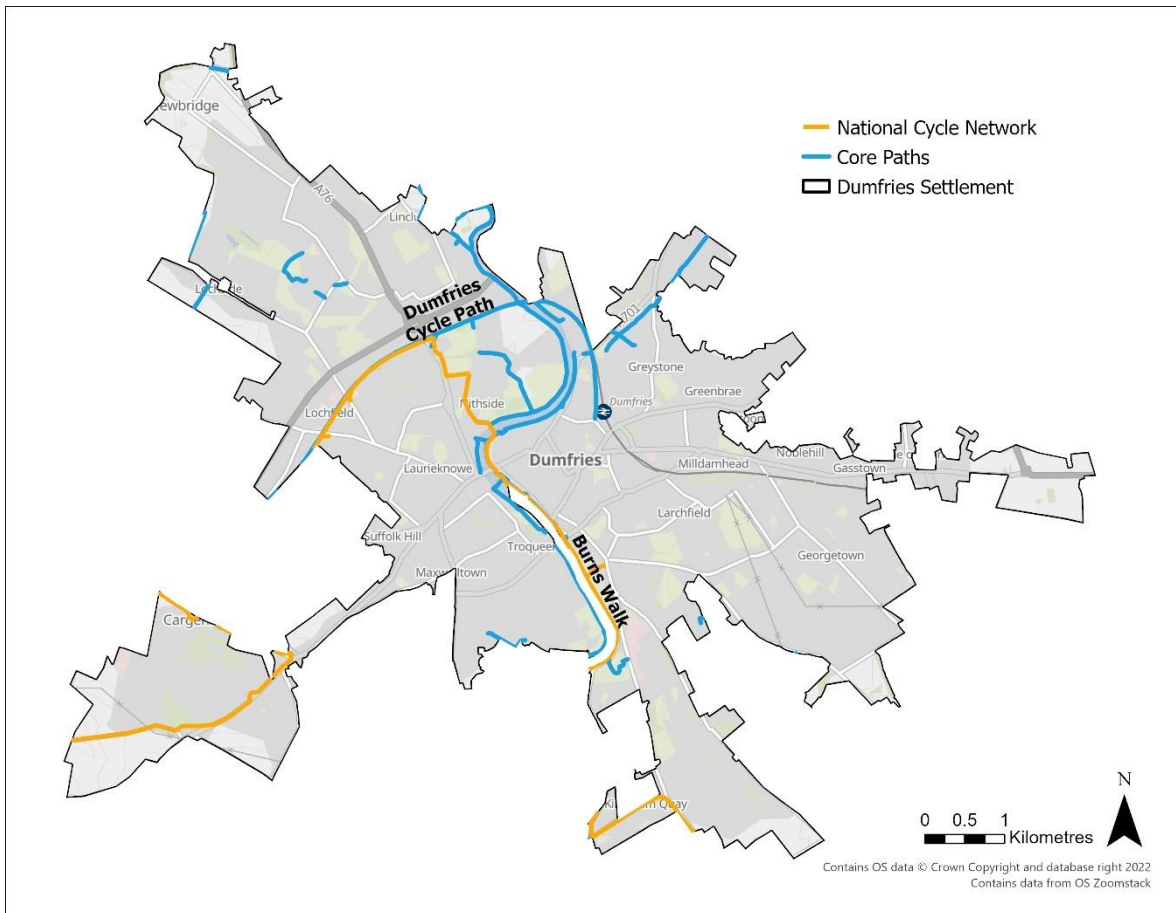
Those results show that a high share of Dumfries' residents walk every day, and although not too many people cycle daily, many do it weekly and the great majority has access to a bike. Results also demonstrated how AT is used for commuting, having a potential for healthier lifestyles, and reducing atmospheric emissions. This relates to initiatives like Bike2Go, Cycle2Work, I Bike from Sustrans, or 7 Stanes, encouraging residents to cycle more (DGC, 2014, 2022). Plus, the DGC launched the GoSmart website (gosmartdumfries.co.uk), to provide information on ways to travel by foot, bike, scooter, or even by bus, or carshare.

Respondents' perceptions on poor infrastructure conditions, a need of more pedestrianised areas, more cycling links, safer footpaths and segregated cycle lanes, all align with findings from Stantec (2022). From their report, they highlighted that walking is faced with poor links to bus and train. The surfaces and streetscape require improvement, there are obstacles on the footpaths, there is a lack of road crossing facilities, signage, and tactile paving. As to cycling, it finds hurdles around inappropriate cycling facilities, lack of secure bike parking, limited capacity for bikes on public transport, high costs of ownership and maintenance, and an absence of hiring and sharing schemes (Stantec, 2022). Overall, Dumfries has positive AT environment, with a mixture of traffic calming measures, local shops, and socialising spaces (TP&E, 2019). Nonetheless, the build-up around it must be ameliorated, and upgraded.

4.5.1.2 Public Transport (PT)

Dumfries' PT system is composed of the bus network, the railway, and Community Transport (CT). The current PT in D&G is being affected by connectivity issues (Stantec, 2022), showing manifest signs of fragility and fragmentation (Arrieta-Solís, 2022e, 2022f, 2022a). These situations have prolonged for years now as reported by Ministers of Scottish Parliament and councillors (SNP Dumfriesshire for Scotland, 2016; Galloway News, 2021). Figure 4.7 shows a description of these PT modes and their status.

The PT does not count with a unified interface where users can plan and book their journeys, pay for their tickets, issue them, and receive real-time information. Although options like Traveline Scotland and Moovit allow to plan a journey and see available transport modes, they do not allow to book or issue tickets. Paying for buses requires passengers to pay when they get on each bus, this makes trips more expensive and tedious (Arrieta-Solís, 2022f, 2022e).

Alternatives could be for example, the all-day tickets from Stagecoach, which can be joined up to tickets outwith Dumfries centre. Another one is getting a train ticket and adding a PlusBus ticket which allows unlimited daily bus journeys; but it only works on Stagecoach units (PlusBus, 2021). Another option is to apply for a free bus card through a National Entitlement Card (NEC). Plus, taxicard holders receive £100 credit towards the cost of taxis within the council boundaries. Moreover, the DGC operates a Dumfries Mobility Scooter Scheme through which residents and visitors with mobility limitations can hire and use mobility scooters for 2 hours in Dumfries centre (DGC, 2022c).

PT connectivity issues pose difficulties to residents with their commuting trips, their jobs, when accessing health, education, or leisure facilities. This leads to less people accessing jobs, increasing isolation, and greatly impacting that share of the population who is highly dependent on the PT network, especially vulnerable people, and the elderly. Lastly, altering the whole region's economy and public services. Even worse, such conditions are pushing people to increase their dependency on their private vehicle to fulfil their mobility needs.

Figure 4.7. Description of PT.

16 routes commercially served, 23 supported, and 8 operated by the council (Kirkpatrick, 2021). Major bus operator is Stagecoach West Scotland, followed by Houston's Coaches, both operating on a mixed commercial and supported basis. DGC buses are the third highest share of services, operating on fully supported schemes (Stantec, 2022).

Absent linkages to the railway station. Desynchronisation with trains' timetables. No ticketing integration. No dedicated bus station (TP&E, 2019; Stantec, 2022). A reduction of around 46% in passengers numbers in 2019-2021. SWestrans budgets stagnated, rises in subsidised per-passenger costs of supported buses, fuel prices and wages peaked, and a drivers crisis have impacted the services (Arrieta-Solís, 2022g; Stantec, 2022). A drop in financial resources forced to terminate the Dumfries-Edinburgh 101/102 service (Temlett, 2022).

One only train operator in Dumfries, Scotrail. Neither the DGC nor SWestrans has control over their operations. The service runs on the Glasgow Southwest Line, connecting to Glasgow and Carlisle (Kirkpatrick, 2021). The railway station in Dumfries receives the highest number of passengers in D&G. Most of the people using this station, around 51%, drive to the station, 24% of them walk, and 8% take the bus (Stantec, 2022).

Between Dumfries and Glasgow there are gaps of up to 2 hours during the day. There are issues with high fares, people using most of their disposable income for it, problems with bicycles on the trains, infrequent services, and sudden service cancellations (Stantec, 2022). As an effect of the pandemic, timetables were reduced, train's users dropped significantly, staff was reduced (Kirkpatrick, 2021).

Community Transport (CT) provides mobility solutions in places with underserved PT. It is a flexible and accessible passenger transport scheme owned and operated by community groups, working on a not-for-profit basis (CT Association UK, no date; CT Dumfries and Galloway, no date). They are not directly funded by any public entity, thus making them rely on external grant funding to remain sustainable (Kirkpatrick 2021).

CT is demand responsive but can operate as scheduled services on fixed routes. They service vulnerable, isolated people, often senior citizens, or people with disabilities, taking them to medical appointments or responding to emergencies (CT Association UK, no date; CT Dumfries and Galloway, no date). Cancer Cars Scotland, Woodgrove CT, and Galloway CT are examples (Cancer Cars Scotland, no date; CT Dumfries and Galloway, no date; DGC, 2019a).

4.5.1.3 Individual Motorised Transport

Individual modes include personal vehicles, taxis, and on-demand services. They use the road network and other infrastructure available (see Figure 4.8). Car ownership and use in D&G is higher than the national average (DGC, 2019). A 55% of respondents from the ATS survey said they use their private vehicle for daily journeys (DGC, 2022a). At a national level, 51% of journeys are made by car (Transport Scotland, 2022). While in average, in Scotland there are 591 private cars per 1000 people, in D&G there are 613 (National

Statistics, 2020). As to electric vehicles (EV), there are 193 units in Dumfries, 482 hybrid, and 58 chargers (EHoganKeogh, 2022).

Statistics also exhibit how in the D&G region the percentage of households without access to a car has dropped from 29.1% in 2001, to a 21% in 2019, while the share of households with 2 or more cars has risen from 18.5% to 35% in the same period. For the same period, those trends are similar nationally, households without a car went from 35.3% in 2001 to 28.6% in 2019; and homes with 2 or more cars rose from 19.1% to 29.4% (Transport Scotland, 2022). This supports the unfortunate fact that Stantec (2022) reported, being cars an important mobility option in Dumfries, just as it is in the entirety of Scotland as well. Stantec (2022) further explained that the poor connections between modes, unavailable direct services or frequent alternatives, and very dispersed catchment areas are part of the reasons of such a high car reliance. This evidently has repercussions on multimodality.

Figure 4.8. Road network and taxi services.

Dumfries is intersected by the A75 trunk road to the north, and has services from the A76, A701, A709, A710, and others. A vast traffic crossing and parking in the town, impacting AT and other transport modes, limiting access and reducing visibility (TP&E, 2019). From a Dumfries Parking Study 2013 report, it was found there were 2109 public on-street parking spaces for short and long stay, 455 off-street public short stay spaces, and 994 long stay, while 390 were private spaces (Topping, 2022).

Taxis work on-demand, covering all Dumfries. Some providers are Woodgrove, Solway, McLean's Taxis & Coach Hire, and Barnhill Cabs. McCleans for example own a phone app where a car can be booked, tracked, and paid when booking or contactless in the cab (McLean's Taxis, no date). Taxis are a link between modes, and some take part in CT. It was reported though that they can be expensive, not be suitable for people with disabilities, or might be perceived of as insecure (Stantec, 2022).

4.5.1.4   Flexible Vehicle and Trip Access

Besides the travel options mentioned above, there are two other alternatives available for intra and interurban services. The first one is a rental service provided by Enterprise Car & Van Hire. Their branch is beside the railway station, offering from small 4-passenger vehicles to sport utility vehicles, and different sizes of vans. The second option is ridesharing through Liftshare, a travel mode with which users can share rides with another user traveling the same or similar route. Users can be drivers offering a lift, or passengers asking for a ride (https://liftshare.com/uk).

The DGC has backed ridesharing and similar options in the past. Liftshare is today an option suggested on their GoSmart website. In previous years, Co-Wheels Car Club was also present (Arrieta-Solís, 2022f). Unfortunately, it was not sustainable due to a lack of supporters and other logistical problems. Even though only those options are currently targeted for Dumfries, additional services working around the United Kingdom and Scotland could also operate in the area. As illustrations, companies as Borderlands Vehicle Leasing, TMAC Van Hire, Hiya Car, Arnold Clark Car & Van Rental, and so many others could also offer vehicles and ways to mobilise.

4.5.1.5 Additional Services

Dumfries is covered by food delivery services like JustEat and Deliveroo. Plus, some restaurants offer their own delivery service, like Marmaris or Canton Express. They offer it through telephone call or mobile app. More, supermarkets like Tesco and Morrisons provide online shopping and home delivery. These types of deliver services also span to include others related to logistics and parcel sending, with providers like DPD and Royal Mail, or major retailers like Amazon.

4.5.1.6 ICT Services

Dumfries mobile network coverage is supplied by 4 different mobile network operators: BT EE, O2, Three, and Vodafone (Ofcom, 2021). All 4 of them have a good coverage in the area (see Appendix 7).

Other data related to ICT shows that for Scotland as a whole, the smartphones uptake has been increasing with the years. In 2017, the share of the scottish owning a smartphone reached a 70%, same for urban areas. In the rural, there was no significant difference, reaching a 69% (Ofcom, 2017). These numbers are not detailed for the D&G region, or even for Dumfries centre itself. This same situation is witnessed with other statistics from the Scottish Household Survey 2019 (Scottish Government and Ipsos MORI, 2021), whereby the values for people using internet according to different age groups are not provided for D&G. This, plus missing data for certain years, poses limitations to the analysis and comparability.

In Table 4.6 several ICT statistics are presented for both D&G and Scotland, covering the years from 2017 to 2019, whenever the data was available.

Table 4.6. ICT statistics in D&G and Scotland, in percentages for 2017, 2018, 2019.

Source: adapted from Scottish Government and Ipsos MORI, (2021).

ND: no data. *: decreases with age.

ICT Aspect	Dumfries and Galloway			Scotland		
	2017	2018	2019	2017	2018	2019
Adults using internet over time.	80	79	78	86	87	88
People using internet over time (ages 16-24).	ND	ND	ND	99	100	99
People using internet over time (ages 60+).	ND	ND	ND	63	65	66
Adults employing a mobile phone / smartphone for personal internet use.	69	68	ND	78	81	86
People employing a mobile phone / smartphone for personal internet use (ages 16-44).	ND	ND	ND	ND	96-91*	98-97*
People employing a mobile phone / smartphone for personal internet use (ages 45-75+).	ND	ND	ND	ND	80-29*	87-47*
Adults employing a mobile phone / smartphone / tablet to access personal internet use on the move.	15	32	ND	57	54	58
Adults confident to use public services online.	80	ND	ND	86	86	87

These statistics relate to the digital exclusion experienced in D&G and the difficulties to access internet. Compared to national values, D&G sees less people using internet over time, less adults using a smartphone for personal internet use, less people feeling confident to use public services online, and even less adults employing a smartphone or tablet to access personal internet use on the move. Plus, if national statistics are used to look at D&G's status, although they are not broken down for D&G or Dumfries alone, people aged 60+ are the group with the lowest share of people using internet over time, while almost all of those citizens between 16-44 make use of it. With an ageing population in D&G, the overall usage of internet is widely low.

4.5.2 Customer Demand

4.5.2.1 Demographic Considerations

General demographics from the characterisation of Dumfries in section 4.1.1 depict a town with an ageing population, whereby the internet and mobile uptake is low compared to national values, and employment and qualifications rates are again lower than Scottish averages. These issues defy the insertion and settlement of ICT and challenge the adoption of new technologies, their policies, and initiatives. It is that rurality of D&G from which Dumfries makes part that influences such socioeconomic environments.

4.5.2.2 Attitudinal Considerations

The willingness of citizens to shift from private car usage to more sustainable options is essential for MaaS. Results from the ATS survey (see Appendix 6) showed that only 6% of the respondents would not give up their car, while 64% are willing to do it, a 14% might do it, and a 16% do not drive. A 55% stated they use their private car for everyday journeys, a 28% walk, a 15% cycle, only 2% take the bus, and none takes taxis or the train.

From those results it is necessary to highlight different situations. Firstly, they present a contradicting scenario where, on one hand, travellers display a positive disposition for a modal shift from private vehicle and a high acceptance of AT. But on the other hand, results manifest the high reliance on own cars for daily journeys. Secondly, the low bus uptake reflects the weaknesses expressed by Stantec (2022), and the fragility and fragmentation of the PT (Arrieta-Solís, 2022f, 2022a). In third place, trying to explain why respondents do not use taxis or train could consider that taxis allow to connect first or last-leg journeys in further away areas, where no other alternative is available, or if there is a special need. Thus, to move around Dumfries, a taxi might not be necessary. Then, since the train connects Dumfries to cities like Glasgow to the north or Carlisle to the south, it is mostly used for long journeys, as suggested by Stantec (2022) and Scotrail's interviewee. Such long travels were not captured by this survey as results were scoped within Dumfries centre.

Besides the contradictory scenario between willingness towards AT and a high car usage, the perspectives from the survey underscore that people are more likely to depend less on

their private vehicle should efficiency and quality of PT are ameliorated and guaranteed. This highly coincides with positions from Stantec, SWestrans, and Sustrans, who through their interviews affirmed that better connections between modes and better footpaths and cycle lanes would attract more users. This, with a more efficient public system, integration of facilities, payments, and coordinated timetables altogether.

4.5.3 Government Support and Regulatory Environment

4.5.3.1 Political Facilitation, Investment, Collaboration, Data Privacy

MaaS has been making its way through the political agenda both in the United Kingdom and Scotland. The UK Department for Transport (DfT) closed in May 2022 a consultation process for a voluntary MaaS Code of Practice, while London has seen continuous quests to deploy MaaS solutions. In Scotland, the government and TS have included MaaS as part of the delivery plan of the NTS 2. With this, supporting various trials in Scotland, trying to cover a multiplicity of urban and rural environments. Results and evidence from those pilots will justify the demands for future investments and will guide forthcoming legal reforms and policies (Arrieta-Solís, 2022g).

Collaboration between mobility players is fundamental, and viewed possible among the different players in Dumfries, who expressed their willingness to take part in MaaS efforts (Arrieta-Solís, 2022c, 2022d, 2022f, 2022a). Despite that, there is currently a need of a legal framework that allows different mobility stakeholders and service providers to join negotiations on MaaS solutions (Arrieta-Solís, 2022f). Such needs are hurdles limiting partnerships and cooperation among relevant actors, and the action spaces of PT authorities as it happened in Finland and Sweden (Fenton, Chimenti and Kanda, 2020; Hensher *et al.*, 2020b).

That legal gap is in effect a great barrier, in Dumfries, in Scotland, and in the European Union member states as well. MaaS poses new legal challenges as to the appropriate collaboration structure needed for the different contributors to participate transparently and be able to protect their own interests while also delivering on the MaaS promises (Maas Alliance, 2017; Hensher *et al.*, 2020b; Brown *et al.*, 2022). So, there is a need for a set of

guidelines and rules that ensures users' and providers' data privacy and security, regulations that make operators and providers understand their roles in a defined MaaS ecosystem, that make them feel confident about being part of it, that clearly state their risks, incentives, and benefits. Regulations must look at requiring data openness and standardisation from operators, as the case in Finland did (Arrieta-Solís, 2022f, 2022g, 2022b).

Furthermore, there is no clarity yet from the government as to how to start this off, and imminent budgets reductions are obstructing all efforts desired for better transportation. No more funding means a halt in the rollout of new technologies, no more investment in enhancing fleets, improving services, building more infrastructure, and so forth. Plus, the MIF closed its funding in 2019, and there is no more direct funding available for further MaaS projects (Arrieta-Solís, 2022b, 2022g, 2022f, 2022c). All these issues slow down the uprise of MaaS, especially in a town like Dumfries.

4.6 Dumfries' MaaS Readiness Analysis

4.6.1 SWOT Analysis

The description and evaluation in the previous sections of Dumfries' transport and planning system is further studied through a SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) in Table 4.7. This eases the identification of the conditions fostering or hindering MaaS solutions, points out those areas where Dumfries could look at to increase their MaaS preparedness, and provides inputs for the subsequent MaaS Readiness Evaluation.

Table 4.7 SWOT analysis of Dumfries' MaaS Readiness.

Dimension	Strengths	Weaknesses	Opportunities	Threats
Availability of transport, mobility and communication services and infrastructure	• A high share of people walks, cycles, and wheels. • A high share of residents has access to a bike. • Both the current ATS and the LDP promote AT in their policies.	• Missing and unmaintained infrastructure. • Uneven, bumpy surfaces, lack of signage and tactile paving. • Absence of bike hire or sharing schemes. • Unsegregated cycle paths. • Lack of secure bike parking. • Limited capacity for bikes on PT. • High costs of bike ownership and maintenance.	• An ATS update to incorporate residents' views, and work on improvements identified. • A Case for Change Report identifying areas where to improve AT infrastructure. • More funding from the Scottish Government to invest in AT. • A NTS2 promoting AT as a relevant policy. • A NPF4 with policies encouraging new development with embedded AT aspects. • COVID-19 effects on modal shift and more work from home.	• High reliance on private car. • Dispersed settlement areas.
	• As most of the bus network is supported, it allows authorities to have better control and thus implement more changes. • Free bus travels for under 22s, the elderly, and NEC holders. • Taxicards from the DGC. • Dumfries Mobility Scooter Scheme. • Organised CT groups, servicing people with mobility impairment or far from PT options.	• Public transport is fragile and fragmented. • Reduced frequency in services, desynchronised timetables. • Missing infrastructure and links between modes. • Absent tariff integration options. • Absence of an integrated interface where to plan, book, pay, and issue tickets.	• New transport system envisioned by SWestrans. • Journey planners like Traveline Scotland and Moovit could evolve to provide booking, payment, and ticketing, and other MaaS solutions. • CT as a consolidated option in the region, to provide first or last-leg journeys, and more. • The DGC and SWestrans could find leverage from MaaS Scotland to incorporate more transport technology in the area.	• COVID-19 effects on modal shift, reducing passenger numbers due to more work from home. • High reliance on private car. • Lack of trust in the transport system. • Modal shift increases to more car-based options may hinder deployment of sustainable and massive modes. • Dispersed catchment areas. • Reduction in transport budgets. • Bus market deregulation. • Fuel prices and wages surges. • Drivers' crisis. • Unsustainable financial conditions for CT to thrive. • Absence of a well-structured legal framework to guide MaaS-related initiatives.

Dimension	Strengths	Weaknesses	Opportunities	Threats
Availability of transport, mobility and communication services and infrastructure	• Well-organised taxi and CT groups. • Working mobile apps for planning, booking, and paying in taxi services. In-cab payment, and contactless options.	• Taxis and CT can be expensive. • Some are not suitable for people with disabilities. • Perception of insecurity in taxis. • Their service might not cover all areas.	• SWestrans trying to consolidate CT in D&G. • CT could provide services in underserviced areas. • Taxi groups have their own apps which could be integrated into one option, or other apps from other modes.	• Price, tariff hikes. • Fuel prices surge. • Unsustainable financial conditions for CT to thrive. • High reliance on private car.
	• There is a car rental in Dumfries, and ride sharing is supported by the DGC GoSmart initiative.	• Not a lot of car hire or ridesharing options for residents and visitors to choose from.	• Past experiences with car sharing initiatives (Co-Wheels) can provide learnings to future initiatives. • An open market for companies to invest in D&G.	• High reliance on private car. • Modal shift increases to more car-based options may hinder deployment of sustainable and massive modes.
	• Consolidated delivery services in the area.	• There might not be a wide offer of products and services.	• Gamification could be embedded into a MaaS app to offer more services.	• Absence of a legal framework to guide MaaS initiatives. Price increases.
	• Good mobile network coverage throughout Dumfries centre.	• Mobile phone uptake and internet usage are among the lowest in the country. • Compared to Scotland, less people in D&G feel confident about using public services online, less adults employ a smartphone or tablet to access personal internet use on the move. • Older age groups use less internet and smartphones.	• Internet and mobile phone usage are growing with the years. • COVID-19 forced those sceptics to use more technological devices. More broadband and connectivity projects envisioned by the DGC as part of their LDP and local economic policies.	• Ageing population. • A probable surge of digital exclusion. • Changes in the network coverages. Drop of incomes preventing citizens from acquiring smartphones.

Dimension	Strengths	Weaknesses	Opportunities	Threats
Customer Demand	• More than half of Dumfries residents would be willing to move away from their car. • High bike access and ownership. • High share of people walking and cycling often.	• Low shares of people using smartphones for personal use, feeling confident about online public services. • Lack of trust in PT.	• Common transport options like CT or taxis can consolidate to become a leading service, allowing a modal shift. • Improving network coverage in D&G. More investment in broadband in D&G.	• High reliance on private car. • Inefficient PT system. • Ageing population. • A probable surge of digital exclusion. • Low mobile uptake and internet use. • Projected employment reduction.
Government Support and Regulatory Environment	• The presence of MaaS Scotland, demanding the for more investment and regulations. • Mentions of MaaS in transport policy (NT2). • Collaborative spirit from Scottish Government, Dumfries authorities and mobility providers. • SWestrans proposing improvements to PT.	• Scarcity of funds for MaaS. • Lack of legislation to regulate MaaS. • Scarce human resources at SWestrans and DGC with competencies on MaaS and its benefits. • SWestrans and the DGC not being part of MaaS Scotland.	• A voluntary set of guidelines in a Code of Practice from DfT. • TS works side by side with DfT and this could be beneficial for MaaS in Scotland. • Scottish MaaS pilots can provide best practices. • A new RTS can transform the current PT system.	• No foreseeable MaaS funding. • Absence of a clear position and line of action from the Scottish Government. • Reluctance from mobility and technology providers to collaborate with no legal framework to look after their interests and benefits. • Monopolies in case of partnerships.

4.6.2 The MMRI Evaluation

The results from the readiness evaluation and the MMRI show that Dumfries' MaaS Readiness value is 2.42. According to the scoring scale in Figure 4.2, this value means that considerations on current transport, ICT, demographics, and regulations, offer some usefulness to a MaaS implementation in Dumfries. However, they are below of what should be desirable to a fully supportive MaaS delivery. For a summarised visualisation and easier understanding, the results are presented for the General Evaluation Topics only. They are presented in Table 4.8 and Figure 4.9, the complete MMRI results are found in Appendix 8.

Table 4.8. Dumfries MMRI results.

Major Themes	Availability of Transport and ICT		Customer Demand		Government Support	
General Evaluation Topics	Active Transport	2.29	Demographical Considerations	1.50	Political facilitation, investments, collaboration, data privacy	2.25
	Public Transport	1.88				
	Individual Motorised Transport	3.33				
	Flexible Vehicle Access	2.30	Attitudinal Considerations	2.00		
	Flexible Trip Access	2.23				
	Additional Services	4.00				
	ICT Services	2.40				
Total Average			**2.42**			

Figure 4.9. Radar chart of Dumfries MMRI second level dimensions' results.
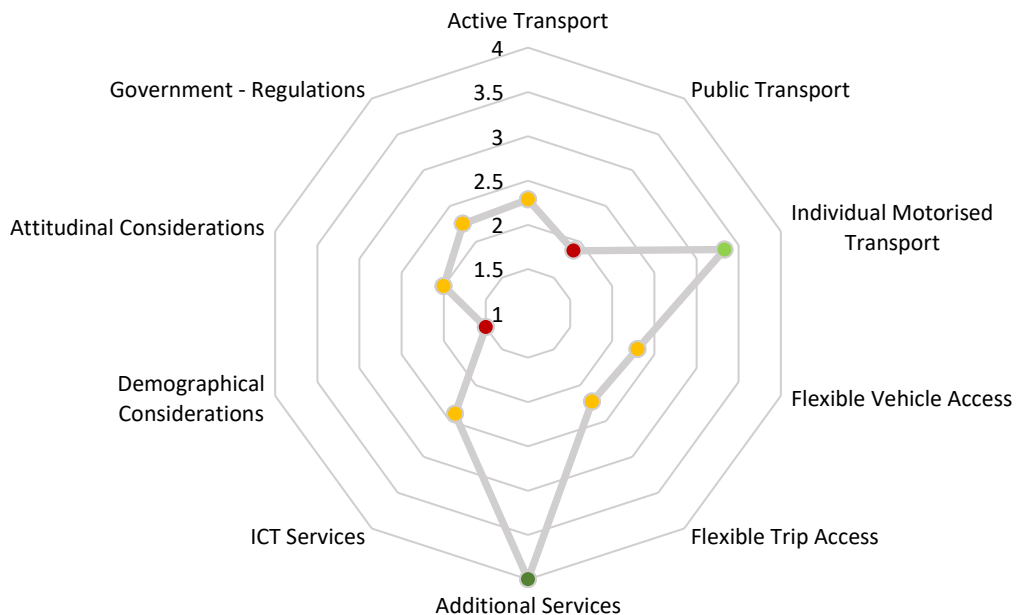
4.6.2.1 Dumfries' MaaS Readiness score in perspective

With very few MaaS readiness indexes, as stated in previous sections, not many cities' preparedness has been assessed. It makes it thereby difficult to compare Dumfries results to other geographic areas, or to compare these results to cities assessed with a different index. Moreover, the cities evaluated with these indexes are in highly populated urban contexts. Despite this, highlights from other cities can provide some benchmark of what these results mean.

Thanos' (2018) MMRI results for the city of San Luis Potosí in Mexico showed less preparedness than Dumfries, turning out a score of 2.03. Dumfries' AT, attitudes, and governmental environment are more robust, unlike the Mexican city. What both do share though, is an inefficient and dysfunctional PT, and a lack of bike hire schemes for example. Notwithstanding, differences between them both must be considered, because San Luis Potosí houses a bigger population and denser areas, i.e., 1 million inhabitants, and 640 people/km^2.

When looking at cities like London or the West Midlands, though they were assessed under a different index and house millions more inhabitants, it is manifest how mature and robust their transport systems are, and thus, exhibit a better MaaS readiness. Aspects like their tariffs' integrations, and the physical connectivity of infrastructure and transport modes illustrate this. In fact, the West Midlands for instance, already operate MaaS schemes, the Whim app from MaaS Global (see Figure 2.3). None of this is present today in Dumfries, thus relating to the low MaaS readiness score obtained.

Those are urban cases, but Japanese rural areas, though not assessed under any index, offer learnings of MaaS rollout. Their rurality posed a similar reality to the one in Dumfries. Their population is ageing, their PT was poorly integrated, and several areas were underserviced. Despite that scenario, they managed to create a transport strategy incorporating MaaS solutions. Through flexibility and customisation, they were able to address the weaknesses identified in their transport system, and their economic and social challenges.

The Scottish MaaS trials are still under scrutiny and therefore is difficult to compare their development to Dumfries. Nevertheless, at this stage, they can offer learnings from similar, closer realities; urban-rural, and semi-rural environments. The ways they are trying to approach their users' mobility needs, and the partnerships they are built on could provide best practises to Dumfries' authorities on how to be ready for MaaS.

4.6.2.2 A close-up of Dumfries' MaaS Readiness results

Dumfries' highest scores span the Additional Services and the Individual Motorised Transport factors. The first ones were assessed with a 4 score, the only full score, meaning they are totally supportive of MaaS. The second factors received a score of 3.33, being supportive of MaaS but with some gaps. It is imperative however to look at these results from their weightings in the whole MMRI. The Additional Services factors hold only a 1% of the total, owing them the lowest priority in the readiness evaluation. Their high score responds to the full Dumfries-wide coverage of apps like Deliveroo and Just Eat, and same for other operating groceries and logistics services. Though their priority is not high, adding these types of services onto future MaaS platforms could have an important uptake and added value to that provision.

MaaS apps can include rewards or motivational techniques directed to users. These are gamification or nudging elements used to incentivise eco-friendly travel behaviour and reward those users for their choice of sustainable travel or supporting local commerce. These incentives can include bonus schemes, discounts in retail stores, travel discounts, or similar (Sochor *et al.*, 2018; Bandeira *et al.*, 2022). With a widespread of delivery services and a high uptake, there are opportunities for MaaS developers to encourage their usage and influence travel behaviour to more sustainable modes or to support local economic initiatives.

Individual Motorised Transport score demonstrates the high dependency on private vehicle. The infrastructure built around it, the streets, the parking spaces, the dispersed settlements, and missing linkages with PT, they all make individual modes the number one option for residents. This high score must be seen with caution, though it only weights 2%

of the index, it presents one of the biggest obstacles to MaaS implementation, and yet at the same time, this is the greatest MaaS challenge, or opportunity perhaps, trying to induce that modal shift from private ownership to a more sustainable provision of a seamless door-to-door service.

On the opposite end and exposing the most significant weaknesses and barriers for MaaS rollout, are the Public Transport and Demographic Considerations factors with scores of 1.88, and 1.50, respectively. Such values indicate there is no availability of services, or there are critical barriers for those aspects to be useful for MaaS. Furthermore, these two aspects have important weightings assigned. PT weighs 6.67%, and demographic aspects hold a 16.67% of the total MMRI. Since they weight each more than 6%, they are considered major components in successful MaaS solutions.

PT's score represents the inefficiencies in Dumfries' PT system, reiteratively expressed by the interviewees, and vastly collected from the documentary review. This low score builds on the lack of infrastructure integrating different modes, an incoordination of timetables, infrequent services, an absence of integrated tariffs, high fares, areas with no service, etc. Signor *et al*., (2019), and the International Transport Forum (ITF, 2021a) are clear when stating that MaaS is founded on PT, and for PT to deliver on its goals, it must be efficient and attractive enough for people to reduce their car dependence.

The components for a comprehensive MaaS deployment in Dumfries, listed in Figure 4.10, are not in place at the moment. This absence of essentials illustrates the conventional transport systems and their inaptitude to cope with changing and evolving mobility patterns. Authors like Rodrigue, (2013); Cruz and Sarmento, (2020); and Song, Guo and Zhang, (2022) stated how those ill systems led to PT inadequacy, hurdles for pedestrians, cyclists, and people with disabilities, loss of public space, and environmental pollution. All are symptoms of the current transport system in Dumfries.

Figure 4.10. Conditions for MaaS deployment.

Source: adapted from Arthur D. Little, (2018).

Integrated Multimodal Physical Services	Integrated Mobility Platform and Apps		Tariffs Integration and Risk Governance Model
Well-integrated physical mobility infrastructures and solutions	Central multimodal platform to optimise trip allocation, routing, payment, and tracking	Customer interface with integrated functionalities: information, routing, booking, and ticketing	Multimodal tariffs integration and risk governance model for third-party services
Multi-modal transport masterplan (including timetable synchronisation)	Accessing data from individual operators and connecting to physical devices executing the transportation	Providing on-demand additional services	Integrated payment system (Pay-as-You-Go, pre-paid packages, monthly fee)

Demographic Considerations embrace even more important aspects. Not only they scored the lowest of all MaaS aspects (1.50), but them alongside the Attitudinal Considerations also hold the two highest weights of the MMRI. What is more, the Attitudinal Considerations scored 2.00 (some usefulness, but below desirable conditions), the third lowest score of all. So, these two sets of factors embody the greatest barriers MaaS platforms willing to be rolled out in Dumfries will have to surpass.

The demographics analysis in D&G exposed variegated factors that could hinder future MaaS schemes. Its economic growth rate has behaved slower than national averages, stagnating during the COVID-19 pandemic. The employment had fallen by 7.8% by 2019, with a higher drop of 7.2% only during COVID times (SDS, 2022), turning D&G into the local authority with the highest unemployment rate from April 2020 to March 2021 (National Statistics, 2021). Besides, people's weekly incomes have ranked among the lowest in Scotland (DGC, 2020). Consequently, as economy is affected, less opportunities there will be for residents to afford smartphones, technological devices, pay for internet usage, or subscribe mobility services.

It was also seen how as the groups age, the smartphone and internet use decrease. Dumfries' population is ageing, there are less adults using a smartphone for personal internet use or feeling confident to use public services online. All this has repercussions on MaaS deployment. Alyavina, Nikitas and Tchouamou Njoya, (2020) found that the older age groups are less likely to engage with technology. Such conclusion precisely describes the situation in D&G, whereby the population keeps growing older, and the smartphone uptake

is lower than national averages. This also explains the score obtained for the ICT aspects, 2.40, below desirable conditions. As residents do not engage with technology, they do not acquire smart personal devices. Plus, with no outdoor free Wi-Fi spots in the town, residents are not invited to use more internet. It must be highlighted once more, that economic and ICT statistics were found mostly for Scotland and D&G, with limitations for Dumfries-specific data.

As to the Attitudinal factors, they show two different sides. A positive one in which residents are willing to adopt more AT and only a small share would not be willing to shed their private vehicles (6% of the respondents from the ATS survey). Also, as the transport system ameliorates, passenger numbers will increase (Arrieta-Solís, 2022e, 2022f). This presents a great opportunity for a transformation of PT in Dumfries, and for MaaS as well. Ho *et al*., (2018), and Alyavina, Nikitas and Tchouamou Njoya, (2020), have concluded that willingness of users is a must for any MaaS success. Should the proper conditions be put in place in Dumfries, users could easily adopt MaaS solutions.

Nevertheless, the negative side exhibits that tenacious reliance on vehicles, where more than half of the population use them for daily movements (55% of respondents). This has been the case due to the lack of trust in the system, the pandemic effect on the timetables and frequency of services, the reduction in budgets, and all other reasons. Likewise, along with an ageing population, car usage spikes, as concluded by Alyavina, Nikitas and Tchouamou Njoya, (2020).

This also relates to that linkage between planning and transportation presented in section 2.1. Old planning strategies had a car orientation, favouring drivers while building a street pattern to connect dispersed areas. This car-centric planning led to the aforementioned negative impacts. Although the recent RTS and LDP's philosophies orientate more towards people and AT, their effects will take some time to be in place. Even more, Dumfries' land use and transport planning processes streams are decoupled, with the RTS and LDP following different paths. According to Hensher et al., (2020b), such disassociation of

processes was identified in Sweden as an obstacle to the operation of MaaS schemes. As such, Dumfries authorities shall find ways to fuse both planning processes.

Transport planning is compiled in the RTS led and designed by SWestrans, while the LDP and town's planning are commanded by the DGC. Two distinct entities, with different roles, each working on processes that should be integrated. The RTS covers a 15-year period, in dissonance with the LDP which updates every 5 years. What is more, planning and transport authorities are immersed in an institutional bureaucracy, restricted by their roles and legal responsibilities, decreasing budgets, and scarce specialised personnel.

The negative effects of economic, demographic, and attitudinal factors are widened when the transport system is inefficient. When summed up, a slowed economy, high rates of unemployment and an unaffordable and inaccessible PT, they make connectivity between places even harder, making it difficult for individuals to mobilise, to commute to work, to go to school, to have access to health care, to do groceries, or to simply move to leisure facilities. As a result, a vicious cycle appears, where economy and society contract, posing even more complicated and enduring challenges. Until these rooted systemic issues are resolved, MaaS is not likely to operate, and neither will its sustainability benefits be experienced.

The other scored factors in the MMRI reveal that Active Transport (2.29), Flexible Vehicle and Trip Access (2.30, and 2.23), and Government Support and Regulatory Environment (2.25), they all have usefulness for MaaS but do not comply with what would be desirable. The Active Transport score was low due to an absence of bike share or hire schemes. Flexible Access saw scarce car clubs, rentals, and share schemes, and the few ones present keep their data closed and inaccessible. As to regulations, though there is manifest collaborative spirit from mobility stakeholders in Dumfries, the absence of clear, well-defined regulatory guidelines, and a reduction in transport funds, forbid any incentivisation to participate in spaces that come about promoting new transport technologies.

4.6.2.3 The MMRI limitations

In a broader assessment of these results, it is important to state that the MMRI could also lead to a misinterpretation of the real conditions preparing Dumfries for MaaS. There is not an established agreed-upon index to measure MaaS readiness in cities or geographic areas. This had led to the creation of several frameworks, mostly centred on urbanity, being one of them the oft-cited MMI from Kamargianni and Goulding, (2018), but besides its methodology being privately and securely guarded, it is undergoing trials, and adjustments. The Thanos' (2018) index used here, shares this similar nature, where it is not a consolidated, widely tested model. The weightings for the factors were all assigned by the author himself, and might not fit all situations worldwide, reflecting a scenario that could stray off reality.

Based on the results from Dumfries, there are aspects where for example, data showed how AT is more developed and ready for MaaS than ICT factors, but according to the MMRI results Dumfries seems more ready in terms of the ICT dimensions. Even more, on that particular aspect, the Active Transport components evidence great dissonance. The lowest score for this topic was the bicycle share. Since Dumfries does not have a bike sharing or hire scheme, it was scored the lowest within this section. Nevertheless, a lot of people own or have access to a bike (around 87% of respondents) and a very low share of them do not cycle (around 15% of respondents). So, the total score for Active Transport was badly scored just for not having those schemes, although many people cycle and travel actively and there is infrastructure for it. Despite such findings, the MMRI should be looked at as a way to identify improvement areas where Dumfries could work on to try to build a better MaaS preparedness, a more robust transport structure, and thereupon comply with their citizens' mobility requirements.

4.6.3 Increasing Dumfries' MaaS preparedness to obtain sustainability benefits

Results showed the weaknesses and threats of Dumfries current transport system, demonstrating how unprepared Dumfries is for MaaS implementation. The current PT, its demographics, and the attitudes of its citizens are the urgent topics to work on. However, MaaS will also need Dumfries' transport system to digitalise. This must be structured on ICT, the IoT, and big data. Thus, incorporating technology will allow MaaS to transform transport, to ultimately induce changes on Dumfries spatial distribution, and so, proving the starting premise in section 2.3 and Figure 2.1, linking MaaS to transport and planning.

Approaching the desirable MaaS scenario necessitates a holistic network articulation, alignment between mobility stakeholders, citizens, and authorities on a common vision and strategy (Arthur D. Little, 2018; Signor *et al.*, 2019). This articulation and common vision are the basis to revolutionise the transport system and change people's travel behaviours, while moving towards a more sustainable planning, centred on the citizens. It is hereby proposed to develop and implement a multi-modal transport master plan (like the one in Figure 4.11). Additionally, 4 small-scale MaaS schemes are also proposed, which along with the plan can aid the PT amelioration and start increasing MaaS preparedness.

Figure 4.11. Example of a Dumfries sustainable transport master planning.
Source: adapted from Arthur D. Little, (2018), and Direction Générale de la Mobilité, (2013).

67
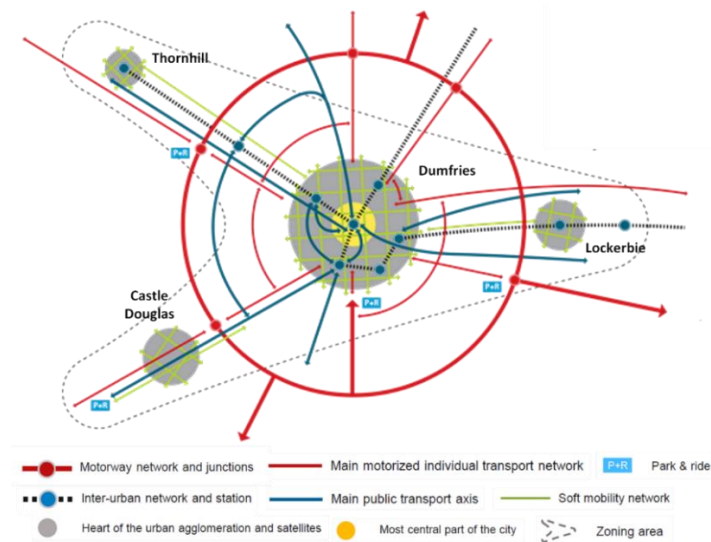
The multi-modal transport master plan will build upon the Transformation Programme intended by SWestrans (Kirkpatrick, 2021), and the 8 principles of sustainable urban mobility planning (SUMP) by Rupprecht Consult, (2019). Its aim will be to upgrade the transport system through a redesign of its commercial offering (see Figure 4.12) and the cocreation of the future LDP. Because without effective integrated land use and transport planning and attractive PT services in place, MaaS by itself will be unable to reduce car dependency (ITF, 2021a).

Figure 4.12. Fusion of SUMP principles and commercial offering redesign for Dumfries. Source: adapted from Arthur D. Little, (2018) and Rupprecht Consult, (2019).
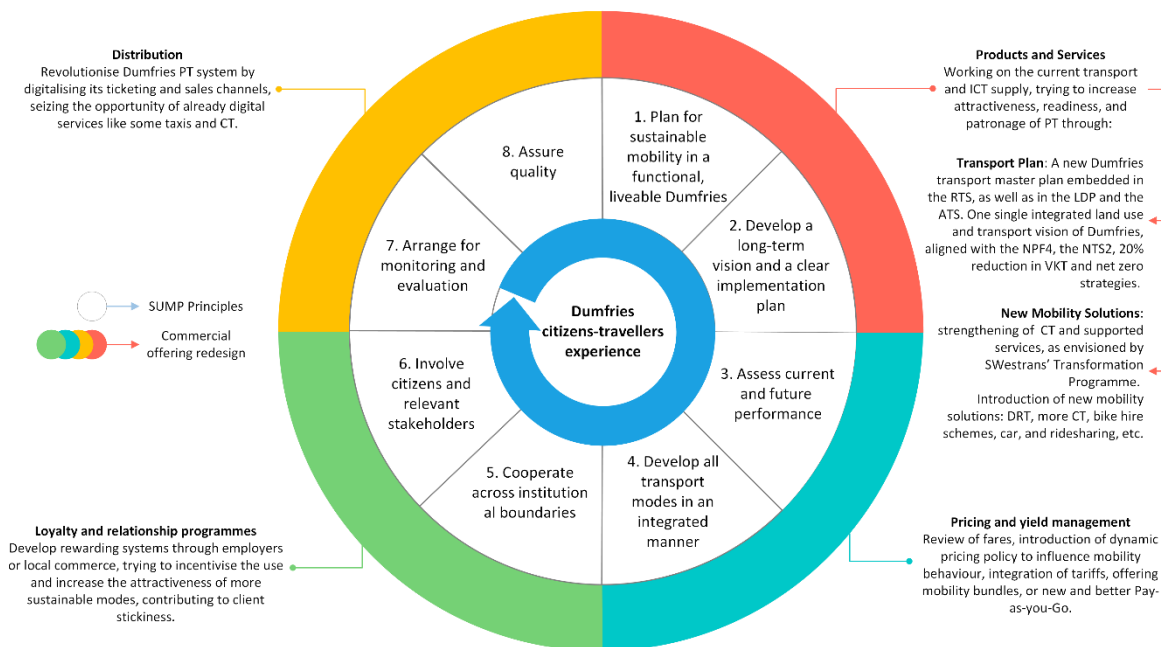
The digitalisation could start from implementing the Transformation Programme and creating the integrated transport hub. As the digital revolution expands, transport will gradually evolve towards MaaS (Arthur D. Little, 2018). This whole transformation could allow to rely on technology to offer new mobility options, increase passenger utilisation, and improve accessibility and quality of life, hence, maximising revenues and reducing total costs per passenger-kilometre (Arthur D. Little, 2018; Signor *et al.*, 2019). With a digital and more efficient transport system, Dumfries can aim to change travel behaviours, increase its MaaS readiness, and finally, reap sustainability benefits. Some of these potential benefits are included in Table 4.9.

Table 4.9. Potential MaaS sustainability benefits in Dumfries.

Environmental	Economic	Social
• Reduce car usage. • Encourage more PT and multimodality. • Shift to less polluting transport modes. • Encourage AT. • Promote electric mobility. • Improve air quality and noise levels. • Mitigate GHG emissions. • Contribute with DGC climate action goals.	• Create better access to job opportunities. • Attract visitors. • Retain residents. • Increase local commerce and boost economy by creating links to shops and leisure. • Increase tourism by reducing distances with better connectivity. • Obtain data on travel patterns and thus improve the traffic management. Obtain data to create more sustainable development plans. • Generate data to make more efficient use of existing infrastructures.	• Reduce health risks due to air pollution. • Mitigate noise annoyance. • Improve transport safety. • Increase accessibility for people with disabilities or mobility impairments. • Reduce isolation and loneliness with better transport links. • Reduce social inequality by providing access to affordable transport options. • Promote better health conditions by facilitating access to healthcare facilities.

As to the 4 MaaS schemes proposed, since MaaS is flexible and customisable, this allows solutions to be based on specific aspects. Designing these MaaS strategies requires a migration from socio-demographic customer segmentation to attitude-based mobility segmentation (Arthur D. Little, 2018). This is, moving from transportation solutions to satisfaction of mobility needs, understanding why people move and fulfilling their mobility requirements (see Figure 4.13). Accordingly, 4 proposals are presented in Figure 4.14.

Figure 4.13. Migration to an attitude-based mobility.

Source: adapted from Arthur D. Little, (2018).
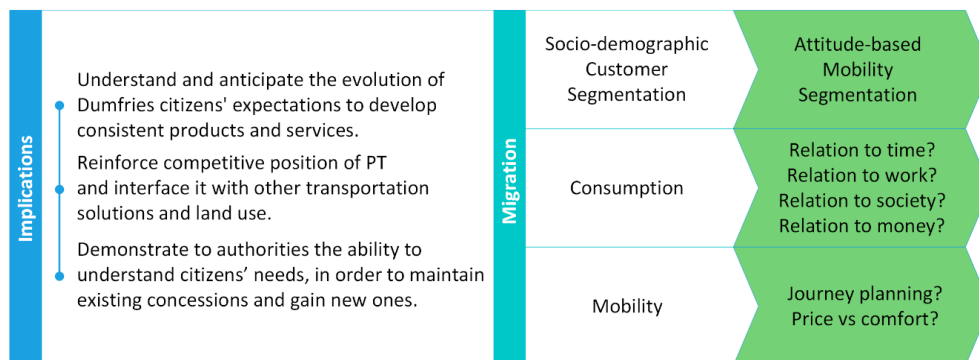
Figure 4.14. Dumfries MaaS proposals.

	Aim	Service Coverage	Mobility Needs	Transport Modes	Interface	Similar Experience
Proposal 1	Creating conditions for students to improve their mobility, while connecting commerce, culture, and academia, while including rewards and incentives for sustainable behaviours.	Linkages between the Crichton State and Dumfries centre.	Studying Working Shopping Leisure	CT, DRT, bike hire schemes.	Mobile app	University of St. Andrews, or My D&A Travel from Tactran
Proposal 2	Providing first or last-leg options for underserviced areas.	Dumfries centre surroundings.	Studying Working Health Etc.	CT, DRT.	Phoneline, website, mobile app	GoSestran, Japan
Proposal 3	Creating a working scheme with affordable and attractive fees in different modes, partnering employers, commerce, and transport operators. Including gamification. Similar to cycle to work scheme or the NHS ridesharing.	Dumfries centre.	Working mostly, but could also include health needs, or shopping, and others.	CT, DRT, taxis, bus, bike hire, etc.	Website and mobile app	GoNHS Tayside in Dundee
Proposal 4	Creation of a bike hire from the DGC and transformation of the GoSmart initiative into a more dynamic interface, allowing to rent bikes, pay for DGC buses tickets, and enhance the AT experience.	D&G region.	Tourism and leisure mainly, also including shopping, exercising, etc.	Bike hire, AT, bus.	Website and mobile app	GoHi in the Highland & Islands, Japan MaaS solutions.

CHAPTER 5.   CONCLUSIONS

Dumfries MaaS readiness evaluation using the MMRI, resulted in a score of 2.42. MaaS preparedness of the current transport system, the ICT infrastructure, its demographic and attitudinal aspects, and the regulatory environment, exhibit some usefulness for MaaS rollout, however, their status is below what is desirable. In consequence, although some specific aspects are already in place, MaaS and the digitalisation of Dumfries' transport and mobility face significant barriers.

Digitalisation of transport systems can support their transition to a decarbonised, more efficient, and democratic model. Transport technological solutions are numerous. MaaS, as one of them, has the potential to disrupt conventional transportation structures. It can offer better travel experiences, while providing inputs for more liveable, resilient, sustainable cities and towns.

D&G has declared a climate emergency, setting up the urgence needed for immediate actions towards an adapted, net-zero region. Both land use and transport are its largest emitters, requiring priority action. Technology, and MaaS, can be allies in the fight against climate change. But for Dumfries, and the whole D&G region, to harness their potential, they must surpass a series of challenges.

Dumfries MaaS unpreparedness reflects on its urban-rural context, with advantages and disadvantages therefrom. Its urban side exhibits its denser areas, with more PT provision, closer distances to jobs and education facilities, full mobile network coverage, and targeted economic and regeneration zones. Its rurality exposes a high car usage, low technological uptake, poor PT provision, dispersed catchment areas, low employment rates, and low weekly incomes.

While AT finds an optimistic ground for increasing its potential, and becoming the first option for movements, Dumfries' PT faces the most barriers, rendering it unattractive and inefficient. In response to a decaying PT, the citizens have relied on their personal vehicle as their main transportation source, which has shaped the town around car usage, and

street grid patterns. Notwithstanding, Dumfries' citizens show good disposition to move away from their private car to more sustainable options. This is a great opportunity for the decarbonisation of transport, a user-orientated town planning, and essentially, for MaaS. Should better PT conditions be put in place, and AT infrastructure is upgraded, more people will start walking, cycling, using the bus network, and reducing their dependency on personal vehicles.

There are other barriers to be surmounted. D&G sees less people using internet, or using a smartphone for personal internet use, less people feeling confident about online public services, and less people using a smartphone on the move, all less than national values. That adds to a slow-paced economy, partnered with low incomes. This situation was aggravated by the COVID-19 pandemic which brought down even more the employment rates, and the economic growth. These conditions, along with the weak PT, are the major barriers for MaaS rollout in Dumfries. Hence, authorities must work towards the amelioration of a dire scenario, trying to address a plethora of issues with scarce resources.

Although there are intentions for a different transport system, and mobility stakeholders seem approachable and interested in collaborating, the framework under which to promote these initiatives lack legal guidelines setting the game rules and outlining the rights and duties of every player. The Scottish Government does not manifest a clear line of work for MaaS rollout, there are no regulations for data openness, or further governmental MaaS funds. Similar legal challenges were faced in Sweden, Finland, and other EU members, and they now have robust and ongoing MaaS schemes.

Given the existing scenario in Dumfries, working on a multi-modal, integrated transport master plan could improve mobility performance and attractiveness, build back trust in the PT, and change travel behaviour. It should build upon SWestrans Transformation Programme and requires public and private mobility operators and stakeholders to contribute actively to its development. The identification of stakeholders in this research could be a base for this involvement, which should come at early stages. Their participation

ensures that the best technical solutions and balance between different interests and transport modes are found for the benefits of all citizens (Arthur D. Little, 2018).

Strong leadership and teamwork between DGC and SWestrans are pivotal. They are the ones called to set out a common vision and strategy, which must be centred on people, Dumfries' residents, and visitors. This vision must align with local context conditions, the DGC Climate Action Plan, the RTS, the ATS, and follow the LDP's sustainability principles. Likewise, it must align with national policies, like the NTS2 or the NPF4, while aiming at sustainability targets like the 20% reduction in vehicle-km travelled, and the net zero targets.

5.1 Recommendations

Despite Dumfries having a long way ahead for MaaS to take over, on the short run, the DGC and SWestrans can consider joining MaaS Scotland, and work together to build more MaaS preparedness. Moreover, small MaaS strategies could be rolled out. They can start simple, from small, then add on, and grow (Arrieta-Solís, 2022b). This way, Dumfries could redesign their "commercial transport and town offering".   They could aim at areas like Whitesands Street, continue on the river Nith waterfront and stretch all the way to the Crichton State, interlinking transport modes and territory.

5.2 Future Work

In the future, Dumfries could consider creating partnerships with other RTPs (especially rural RTPs like Sestrans or Hitrans), trying to learn from their experiences and thus increase their readiness. Dumfries could also aim to analyse how participatory urban processes and MaaS solutions can lead to changes in the spatial form of those areas targeted by the 4 MaaS schemes proposed here. They could also analyse how MaaS inputs for land use planning could point out areas in need of nature-based solutions and other climate change adaptation measures. Even further, they could help analyse how shifts from motorised modes to AT and PT change air pollution concentrations and flows, or how new data drive a redistribution of roads, AT infrastructure, or green areas.

Conclusively, even though MaaS finds numerous hurdles in rural areas, its flexibility allows it to adjust to different and changing environments. Dumfries' mix of urban and rural features gives it a broader spectrum of conditions where to implement this transport technology. Dumfries is yet to experience MaaS benefits on sustainability and planning. However, if MaaS essentials of car ownership reduction, transport integration, and people-oriented vision are placed at the core of transport and land use planning, the earlier Dumfries will witness a more sustainable, accessible, climate-resilient, and MaaS-prepared town.

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APPENDICES

Appendix 1. Ethics Conssideration Form.

Ethical Consideration Form – MSc in EM/CJ/BSE/SUE

Glasgow Caledonian University

School of Computing, Engineering and Built Environment

Department of Civil Engineering and Environmental Management

Part A – Background information

Name: Josué Arrieta Solís

Email Address: jarrie201@caledonian.ac.uk

Supervisor Name: Benjamin Fisher, José Dueñas

Supervisor Email Address: benjamin.fisher@gcu.ac.uk, jose.duenas@die.uhu.es

Intended Start Date for participant involvement: April 5th, 2022

[This date must be at least ONE Week after Submission Date]

Planned Submission Date: September 2022

Programme Name e.g. MSc in Environmental Management: Master in Urban Climate and Sustainability

Title of project: MaaS as a tool for sustainable mobility in cities: An evaluation of Dumfries & Galloway's readiness

Main aim of study: Thorough evaluation of D&G's current conditions to foster a MaaS scheme to enrich its sustainable urban mobility and city planning

Number of research participants: 10

Who are the research participants? Sustrans staff, personnel from Dumfries & Galloway Council, MaaS stakeholders from Scotland and other regions.

How will you recruit them for your study? Through emails, telephone calls, visits to their working places.

Are all participants aged 18 or over?   Yes   X❑ No ❑

Are all participants aware that participation is voluntary?   Yes   X❑ No ❑

Research Procedures: Questionnaires   Yes   X❑   No ❑

                                  Interviews   Yes   X ❑   No ❑

                                  Focus Groups   Yes   ❑   No ❑

                                  Usability Testing   Yes   ❑   No ❑

Other: *(please specify)*

Will any of these procedures cause discomfort, anxiety, stress

or embarrassment?   Yes   ❑ No X ❑

Is this unavoidable?   Yes X   ❑ No   ❑

If yes, please give details and explain how you will seek to minimise the impact of this.

(An extra page may be appended to this form)

Part B – University Checklist

Please indicate your response to the following questions and discuss your response with your supervisor.

Will you provide a written/oral explanation of the project to the subject?   Yes X❑   No ❑

Will you ask the research participants to fill in a consent form?   Yes X❑   No ❑

[Informed Consent may be assumed if a questionnaire is returned completed]

Will you explain to the participants that you are a student and

undertaking postgraduate studies?   Yes X❑   No ❑

Will you explain to the research participants that they may not

benefit from your study?   Yes X❑   No ❑

Will you offer your research participants the opportunity to decline

to take part? Yes X❑   No ❑

Will you offer your research participants the opportunity to withdraw

at any stage?   **Yes X❑   No ❑**

Will you offer a guarantee of confidentiality?   **Yes X❑   No ❑**

Will you offer anonymity?   **Yes ❑   No X ❑**

Will you adhere to the provisions of the Data Protection Act 1998?   **Yes X❑   No ❑**

Part C – School of Computing, Engineering and Built Environment Checklist

Stage of submission:

Full proposal   X ❑   Materials check   ❑

Involves under 18's   Yes ❑ No X❑

If Yes:

    Are they students *at the university*   *Yes* ❑*No* ❑

    Are they friends or family   *Yes* ❑ *No* ❑

    Are they vulnerable adults   *Yes* ❑ *No* ❑

    Has a parental consent process been set-up   *Yes* ❑ *No* ❑

    Will a responsible adult be present during the study   *Yes* ❑ *No* ❑

Involves schools/colleges/organisations   Yes X ❑   No ❑

If Yes: Yes ❑ No ❑

    School permission obtained   *Yes* ❑ *No* ❑

    Parental consent process set-up   *Yes* ❑*No* ❑

    Will a responsible adult be present during the study   *Yes* ❑*No* ❑

    Name of organisation

    Local authority: Dumfries & Galloway, Sustrans, other transport authorities or stakeholders

Involves people or data from health or community care   Yes ❑ No X ❑

[This is referring specifically to participants under the care of the NHS]

Involves data only (statistical study)   **Yes X** ❑   No ❑

Involves deception   Yes ❑ No X❑

Involves manipulation of negative emotions   Yes ❑ No X❑

Involves a potentially sensitive subject   Yes ❑ No X❑

(e.g. physical illness, mental illness, addiction, criminal activity, sexual conduct, racism, religion)

Part D - Declaration

I have read and understood the ethical guidelines issued by the School and this project does not involve anything that would contravene those guidelines, except those areas specifically indicated in this form, or appended to this form.

Signed: Josué Arrieta Solís   **Date April 6th, 2022**

(Student)

Signed: Benjamin Fisher   **Date April 7th, 2022**

(Supervisor)

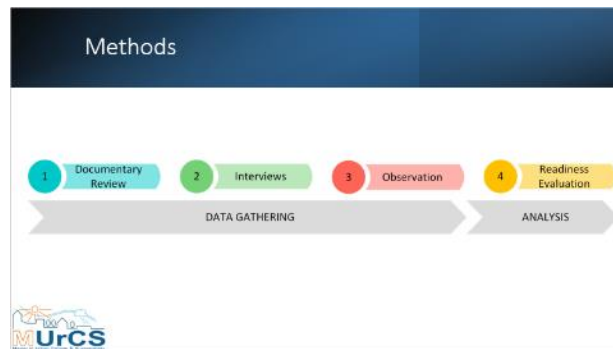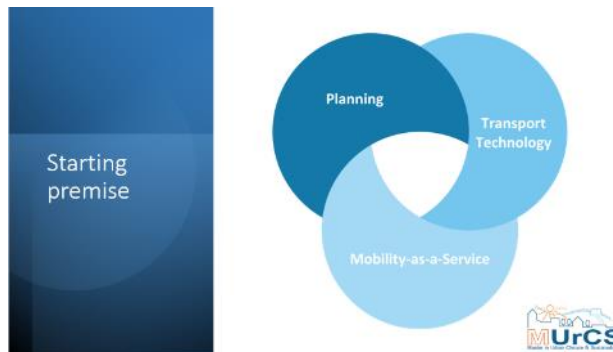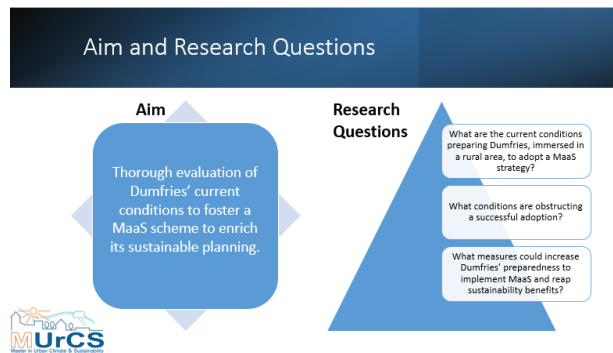*Please send the completed form to the Module Leader Dr Gholam Jamnejad*

gja@gcu.ac.uk

Appendix 2. Research brief overview slides for interviewees.

Appendix 3. Questions posed during interviews.

Interviewee	Questions	Follow-up Questions
Sustrans (Arrieta-Solís, 2022f)	• What is the role of Sustrans? • What is SWestrans role and its link with the DGC? • Who leads SWestrans? • What is the DGC's vision on AT and sustainable mobility? • Are there any MaaS initiatives in Dumfries? • Are there delivery apps operating in Dumfries? • What websites offer statistics about Dumfries? • Are there organisations offering mobility services and using technology to deliver them? • How is transport planning delivered in Dumfries? • What is the current situation of the PT in Dumfries? • How many train stations are there? • What is Dumfries population and its definition of urbanity and rurality?	• Are there policies or strategies about AT? • When will updates of the ATS be released?
Stantec (Arrieta-Solís, 2022e)	• I read from the RTS Case for Change Report there are some windows of opportunity for the public transport in Dumfries. Reduced number of passengers in buses, lack of parking facilities at train stations, lack of linkages between modes, reduction of subsidies for non-commercial routes, etc. These issues have been going a few years now, so, what's going on with the transport system? • Could this be the time for including new emerging transport technologies into Dumfries' transport system? • Would you say there could be rivalry or competition between new incoming modes and current ones? Especially public options? • The RTS mentions that the greatest opportunity lies in the field of Demand Responsive Transit (DRT), could you please expand on how could this be executed? • The RTS comments on the lack of integration in public transport services. With services not timed well to connecting services. Plus, issues with infrastructure's quality. So, what should be done for a better integration of transport modes? • Is the current transport infrastructure enough to support new mobility schemes, an increase in cars, bicycles, scooters, pedestrians? • Based on the previous question, is it viable in the current transport scenario, to integrate all transport modes in one single way? Maybe through a smartcard, a ticket, or even better in a smartphone app? • Is there an ongoing initiative or project that joins together all the modes and payment options in one single interface? Say a webpage or an app?	• What is the future scenario of the bus network given the reduction of passenger numbers and subsidies? • Where could those funds come from? • What's the time frame for the public transport to get these improvements implemented, in how many years will they get better, or will this just keep going worse and worse with the years? • Could MaaS provide solutions? Or instead, hinder its implementation? • How would you recommend implementing MaaS in Dumfries? • Will this pose any threat to public transport? • And there's no system implemented in Dumfries? • Doesn't it all discourage people? • The ATS says one thing, but reality is different. • Who allocates that funding? • Who should lead this?

Interviewee	Questions	Follow-up Questions
Stantec (Arrieta-Solís, 2022e)	• Thinking of mobility stakeholders and MaaS actors, how willing would you consider they are to collaborate towards a successful MaaS implementation? • About Dumfries population: what is their attitude towards new mobility technologies? • What is their attitude towards car ownership? The Active Travel Strategy says 1 in 5 households do not have access to car. While RTS says cars are an important mobility option. • Is the current regulatory framework enough for implementing MaaS in Dumfries? • How could giving up car ownership and switching to more public transport and sustainable modes (like biking, scooting, or walking) shape the layout of Dumfries? • How could that shift in travelling modes induce modifications to the LDP, land use, public spaces, commerce, and the way Dumfries works? • How to incorporate into the planning processes and outcomes, the data produced by MaaS, e.g., vehicle-km travelled by people, the shares of the different transport modes used, most used routes, peak-times, number of travellers per mode, etc? • Based on your experience, would you say MaaS is a driver for sustainable planning?	• Would mobility packages work or maybe Pay-as-you-go? Maybe integrating only public ones? Only a few of them, not the whole array of modes? • Not even on a website or an app like, not necessarily MaaS, but something to integrate different modes and other things. • Willing to open their data and share it? Real-time information, bus tracking, delays, disruptions. • Willing to work together towards specific common goals? Maybe with a financial incentive? • What are the weak areas? • How far in time could this be materialised? • Is Stantec already working on things like these, or is it under the scope or the things that you work on? • Are they included in regional transport strategies?
SWestrans (Arrieta-Solís, 2022g)	• How does transport planning work in the Southwest of Scotland as the Council does not have a specific transport department? • What is the role of SWestrans and D&G Council the planning of the transport system? • What is your reading or analysis of the current conditions of the transport system in Dumfries? I've read there is a reduction in the number of passengers in buses, lack of parking facilities at train stations, lack of linkages between modes, reduction of subsidies for non-commercial routes, etc. These issues have been going a few years now, so, what's going on with the transport system? • Could this be the time for incorporating new emerging transport technologies (carsharing, ridesharing, e-scooters, bikesharing, etc.) into Dumfries' transport system? • Is the current transport infrastructure enough to support/accommodate the income of new mobility schemes, an increase in cars, bicycles, scooters, pedestrians?	• Links to Transport Scotland • How are transport funds from Scottish Government allocated or distributed? • What are the main improvements to be addressed? • What is the future scenario of the bus network given the reduction of passenger numbers and subsidies? • Can all these transport modes coexist with the current options? Bus, rail, taxis, etc. • Timeframes? • Would mobility packages work or maybe Pay-as-you-go? • If financial incentive is offered, are they sitting at the table?

Interviewee	Questions	Follow-up Questions
SWestrans (Arrieta-Solís, 2022g)	- Could it be possible to achieve this integration of modes and services through one website, or mobile app? - Are there in Dumfries transport tariff packages, or bundles of various transport modes? - This integration in a single interface would imply lots of data to be managed, opened, and shared between transport operators, authorities, service providers, among others. Is the current regulatory framework flexible enough for this to be done? - Should SWestrans lead this? - How could giving up car ownership and switching to more public transport and sustainable modes (like biking, scooting, or walking) induce modifications to the LDP, land use, public spaces, commerce, and shape the layout of Dumfries? - Any possible further meetings or contacts to expand on specific topics? Contacts of Stagecoach, Scotrail and Transport Scotland? - Are scooters legal? - What happened to the bike hire schemes in Dumfries? - Co-Wheels, Enterprise, Liftshare?	- What should be the recommended strategies then to open up regulations and create policies that can put forward new transport technologies? - What sort of policies to look at? - Barriers / Enablers?
DGC Planning Team (Arrieta-Solís, 2022a)	- To start, I would like to ask some basics about planning topics and see how the national planning structure and policies filtrate to reach the regional and local levels. - When the Council starts preparing an LDP, what inputs and data are used for that? - Do you happen to have or know how much area is currently assigned to parking lots and how many parking spaces are there in Dumfries? - How much area is assigned to cycle lanes and footpaths? - The LDP2 envisages to minimise the need to travel and to integrate sustainable transport into development. However, private vehicle dependency is high in Dumfries, could this travel behaviour hinder the deployment of LDP's goals? - The LDP2 is trying to promote more sustainable transport modes as well as active travel. However, speaking to different people and reading various reports, the public transport in Dumfries is suffering from fragmentation, it has become fragile, and requires a makeover/transformation. How could the current planning vision of Dumfries provide solutions to that scenario?	- Looks like previous NPF were disassociated with local needs. - The current LDP already includes topics like climate change and active travel. - How does the LDP feed on the national policies or aligns with them? - How do you fit/allocate/accommodate transport planning (as in infrastructure, charging stations for EVs, bus stops, footpaths, cycle lanes, number of vehicles, routes used, number of passengers and people, cycling routes, walking areas, etc.) - Where do you get these data from? - Isn't that something that you include in these documents, that you as the planning team do? How do you evidence or include as part of the LDP as part of the land uses the different types of commerce and those things?

Interviewee	Questions	Follow-up Questions
DGC Planning Team (Arrieta-Solís, 2022a)	• Part of what is analysed about the transport system, is its lack of integration. Are there plans or actions from the DGC Planning Team to address this disassociation between different transport modes? Say, links from railway station to bus stops, and areas for active travelling between them? • Is the current transport infrastructure enough to support/accommodate new mobility schemes, an increase in cars, bicycles, scooters, pedestrians? • Active travel is greatly embedded in the LPD's philosophy. Do you think this opens up opportunities for 20-minute neighbourhoods strategies to be considered in the LDP? • Have you considered implementing LEZs in Dumfries? • LDP2 states in its Economy Strategy section that Access to superfast broadband will continue to be rolled out. Could you please expand on this? Does it mean you will offer WiFi in public areas or similar? Or is it to facilitate broadband infrastructure projects in Dumfries? • Do you have data on free WiFi spots or areas in Dumfries? • What is the difference between Policy OP3 and Policy T2? • How does SWestrans fit in the whole planning process? Do you work side by side with them when developing this LDPs?	• How is the work in partnership with SWestrans and other teams? • Where would you look at? Where would you try to find information to try to answer this? You mentioned earlier the census data. Maybe we can think of how many people are there in Dumfries, how many vehicles there are or how many people are using the bus to go from one place to another.
Scotrail (Arrieta-Solís, 2022c)	• Maybe we could start trying to see who Scotrail is, and all the transfer to the Scottish Government. • At a national level, what are the biggest issues you have found for people to choose the train as one of their major transport options? What barriers have you found when trying to acquire more customers? • About the fleet. What fuels do your trains run on? • Thinking nationwide, has Scotrail teamed up with other mobility actors to integrate your services with theirs? • It is reported that the transport system in Dumfries is fragile and is suffering from fragmentation. What is Scotrail's reading of this? • As you may know, Scotrail is the only railway operator that travels to and from Dumfries. The Dumfries station has a great catchment of passengers, and it's a busy one in the region. This positions Scotrail as an important mobility player. Analysis for the transport system in Dumfries identified a lack of linkages between railway station and other modes. People find it difficult to access the station, especially mobility impaired people. This not only prevents people from accessing transport but pushes them to rely on their car. Have you come across with this situation? Are there action plans to sort it out or improve it?	• Would you mind explaining who ScotRail Trains Limited is and who Scottish Rail Holdings Limited is and how they work? • Who should fund this? • Who should lead this?

Interviewee	Questions	Follow-up Questions
Scotrail (Arrieta-Solís, 2022c)	• Other issues flagged deal with bringing bicycles onto the train. Is that so? How to sort it out? • About the price. Some people have stated that it is not affordable for them to travel by train because it uses a high proportion of their disposable income. How could Scotrail provide more competitive and affordable fares? • Scotrail does not cover the whole region. Are there any expansion plans? (Stranraer-Dumfries, GWSL-WCML) • How many spaces does the car park have at the Dumfries station? • Is there cycle storage at the station? • Is there free WiFi at the station? • Do you have ticket machines? • What is your relationship with Dumfries stakeholders? Who do you work closer with? • This integration requires a strong commitment from all actors. Transport operators play a major role. Could this be something that Scotrail would be willing to take part in and collaborate? • How open would Scotrail be to open up their databases, interfaces, real-time information, users' data, and similar?	
Transport Scotland (Arrieta-Solís, 2022h)	• I would like to start at the national level, looking at the development of national transport planning policies and then how they infiltrate to the regional and local levels. • I would say that by having a role like yours, the Scottish Government's intention towards MaaS is quite evident. Would this mean a further, stronger, and more intense rollout of MaaS in Scotland? • Could local authorities and regional transport partnerships approach the Scottish Government, say Transport Scotland, and ask for funds? Or should the better way be through participation in tenders or bids, awaiting government's calls or invitations? • Are there reforms or bill proposals from Transport Scotland to address this? • What main actors should be involved? • The public transport system is reported to be fragile and fragmented. With a reduction in passengers numbers, missing linkages between transport modes, closure of bus routes. What can be done to provide solutions to this? Is it Transport Scotland's role to ameliorate this or influence in some way?	• When will this investment and funding be released? • Priority areas for MaaS rollout? • What about citizens and their willingness?

Interviewee	Questions	Follow-up Questions
Transport Scotland (Arrieta-Solís, 2022h)	• I hear SWestrans saying their funds are likely to be reduced, and this affects their range of action as to sustaining and improving the transport network. How could ensure mobility with this dire scenario? Moreover, this will also hinder MaaS efforts in the area. • Dumfries and Galloway as a region, has an ageing population and a low usage of mobile phones and internet. How could Transport Scotland help to tackle this, as this poses obstacles to more mobile transport apps, and MaaS as well? • How could MaaS impact local development plans in Scotland and especially in rural areas?	
MaaS Scotland (Arrieta-Solís, 2022b)	• Maybe we could start off with a quick recap of who MaaS Scotland is and what is your role in the whole MaaS structure in Scotland. • What is MaaS Scotland focusing on right now and what are the goals for the future? • Do you think Scotland is ready for a massive MaaS implementation? • What barriers are there to a successful massive MaaS rollout? • I've been speaking to different people, authorities, and transport consultants, and they say the current regulatory framework is rather inflexible, and inadequate for MaaS. So, in terms of legislation, what changes are required to the current regulatory framework? • What are your thoughts on the MaaS Code of Practice? Is this enough? • It is voluntary as I understand, shouldn't it attempt to have some legally binding approach? What are the strengths and weaknesses you see? • I know the MaaS Investment Fund is closed now, but do you see any additional funding from the government coming soon or in the short/medium-term? • Do you know of any ongoing MaaS initiatives in Dumfries? • As a region, D&G high unemployment rates, weekly incomes are among the lowest in the country, they have an ageing population, a low mobile phone uptake, dispersed settlements, and the public systems is fragile and fragmented. So, I wonder, could MaaS really be a solution to issues like this? • Where to start? What to do first? What should Dumfries look at when implementing MaaS strategies (recommendations)? • How could MaaS impact local development plans in Scotland and especially in Dumfries and rural areas? How could MaaS drive sustainable planning?	• What are the priority areas MaaS Scotland is working on right now? Especially, what your standpoint on rural areas? • How to overcome those barriers?

Interviewee	Questions	Follow-up Questions
Stagecoach (Arrieta-Solís, 2022d)	• What is Stagecoach's reading of the current conditions of the public transport in Dumfries? It has been said that PT is fragile and fragmented and is going through a series of hurdles. What does Stagecoach analyse from this? • What will be Stagecoach's response to this situation? What are you working on to be a part of the solution? • Some other issues have been manifested related to the frequency of services, timetables not matching those from the trains, and delays. Is there a plan to sort this out? • Drivers' crisis? • Bringing bikes on the coaches. • One of the things identified in the area is the lack of integration between the bus and the train for example. Is there a proposal to address this? • What about integrating tariffs with other modes? • MaaS relies on open data from operators. What is Stagecoach's standpoint on data sharing and opening up their APIs? • In case there is an initiative to integrate tariffs from different modes, and integrate the journey planners, plus booking, payment, and ticketing, would Stagecoach be willing to participate and join this initiative? • What conditions or requirements would Stagecoach bring to table of negotiations if they were to participate? • Who should lead such an initiative? • Who should fund it? • Stagecoach has teamed up with HITRANS to work on a MaaS solution for the Highland & Island. Are there any other partnerships similar to this one elsewhere in Scotland? • About the fleet. What fuels do your coaches run on? • Do you have Wi-fi on them? • Plug-in sockets?	• Do you work with PlusBus? • What other actors should join?

Appendix 4. Documentary Review results for selecting the evaluation framework.

There were 43 results relevant to the search criteria of "MaaS maturity index" and "MaaS readiness index". From them, 22 were specific to MaaS readiness in cities, around a 51% of the results, with the MaaS Maturity Index (MMI) from Kamargianni and Goulding, (2018) having the most citations. Additionally, 19% of the documents found referred to cities' urban mobility assessments. These are evaluation frameworks designed to assess the general mobility systems of cities, for instance, the Urban Mobility Readiness Index by Oliver Wyman Forum (2022), the Arthur D. Little Urban Mobility Index 3.0 (Arthur D. Little, 2018), or the Deloitte City Mobility Index (Deloitte, 2020a). With a 14% of the results, focuses on the impacts of mobility and the levels of MaaS were also identified. Lastly, one single reference was found about the mobility readiness in rural areas, the WDC Mobility Index Project from CARO (2022), which was still under construction (see Table 5.1 for summarised results, Figure 5.1, and Table 5.2 for all the results found).

Table 5.1. Relevant results found.

Focus	Count			
	MaaS Maturity Index	MaaS Readiness Index	Snowballing Results	Total
Cities' MaaS readiness	11	10	1	22
Levels of MaaS	4	2	0	6
Cities' urban mobility assessment	4	1	3	8
Impacts of MaaS or mobility systems	1	3	2	6
Rural mobility readiness	0	1	0	1
Total	20	17	6	**43**

Figure 5.1. Distribution of focuses of the relevant results.
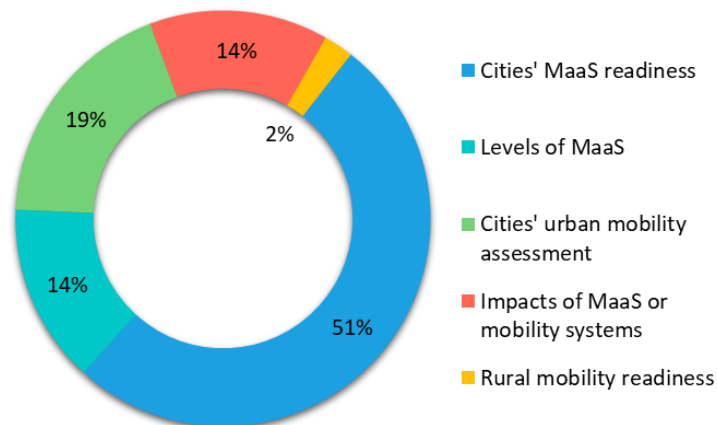
Based on these results, the EF required could follow one of the 4 readiness indexes found, as the other assessment schemes take a general mobility scope, not directly related to MaaS strategies. Moreover, just as there is no uniformity in the concept of MaaS, there was no indication found of an agreed method for evaluating its implementation. Further, current indexes are still under refinement and require more testing. This could mean thereupon, that any of the 4 indexes found could be useful. In the light of that, the MMI from Kamargianni and Goulding, (2018) seemed the most appropriate one since it elicited the most citations. Nevertheless, its full methodology has not been disclosed. In November and December 2021, two emails were sent to Maria Kamarginanni and other colleagues from the MaaSLab of University College London to ask about the methodology, but no answer was ever received. A contact was also tried to be made through their website's chat, with no success either. Even more, in his master's thesis, Thanos (2018) stated that in a personal communication with Richard Goulding he was told that the methodology of the MMI was not permitted to be shared. Therefore, with such limitations, this index is unfortunately not available to be used, despite it apparently being the most suitable one.

Regarding the MRI from Somers and Eldaly (2016), its paper vaguely explains how it is calculated. The authors explain it can provide a weighted summary score of an area, city, or country, based on 3 core themes. However, they only explain how to score the first core theme, about availability of transport services. This finding relates as well with Thanos (2018) observation about missing information to replicate this index. He also contacted the authors who told him that although some progress had been made with the MRI, it was still ongoing adjustments and were not able to publish it. It is not thereby possible to use this index either.

As to the modified MRI from Thanos (2018), more information was released by the author, which presents it as the possible option for this study.

Table 5.2. Relevant results from the search of an evaluation framework.

Search Term: MaaS Maturity Index							
Search Engine	Date Range	Filter Criteria			Relevant Results	Description	Focus
		Fields of study	Sorting	Total Results			
Semantic Scholar	From 2014	Business, Computer Science, Economics, Engineering, Environmental Science, Geography, Mathematics, Political Science, Sociology	By relevance	2650	The MaaS Maturity Index: Preparing Cities for the MaaS era (Kamargianni and Goulding, 2018).	Set of indicators to assess the readiness of a city for the implementation of MaaS. Based on 5 dimensions: transport operators' openness and data sharing; citizen familiarity and willingness; policy, regulation, and legislation; transport services and infrastructure; and ICT infrastructure. It uses a scale from 0 to 1 to determine that readiness. Used to evaluate the readiness of London and the West Midlands in the United Kingdom.	Cities' MaaS readiness
					Towards Sustainable MaaS: A roadmap for San Luis Potosí, MX, Using the MaaS Readiness Index (Thanos, 2018).	The author researched on MaaS readiness indexes trying to replicate one. He references the Maturity Index from Kamargianni and Goulding (2018), the MaaS Readiness Index Somers and Eldaly (2016), and others. After explaining that no index has its methodology publicly available, he developed a modified version of the Somers and Eldaly (2016) index, using a scale from 1 to 4. He then used this index to assess the MaaS Readiness of the City of San Luis Potosí in Mexico.	Cities' MaaS readiness

Search Term: MaaS Maturity Index							
Search Engine	Filter Criteria				Relevant Results	Description	Focus
	Date Range	Fields of study	Sorting	Total Results			
Scopus	From 2014	Environmental Science, Engineering, Earth and Planetary Sciences, Social Sciences, Business, Management and Accounting, Computer Science, Energy, Economics, Mathematics	By relevance	661	MaaS Maturity Index Study and Case Analysis in China (Li et al., 2020).	Though their paper is not readily available, their abstracts hints they evaluated the readiness of the city of Guangzhou by taking on the MaaS Maturity Index from Kamargianni and Goulding (2018).	Cities' MaaS readiness
					Key Fundamentals and Evaluation of a Thriving MaaS Ecosystem in China (Li et al., 2019).	Though their paper is not readily available, their abstract indicates that their research suggests some crucial indexes to assess the readiness of a city for MaaS implementation in China.	Cities' MaaS readiness
					On the path to MaaS: A MaaS checklist for assessing existing MaaS-like schemes (Arias-Molinares et al., 2022).	They create a 3 criteria checklist to describe the functionalities of MaaS schemes and analyse whether those schemes cover or not the elements needed to be labeled as MaaS.	Levels of MaaS
					The Ws of MaaS: Understanding MaaS from a literature review (Arias-Molinares and García-Palomares, 2020).	From a literature review, researchers cite the MaaS Maturity Index criteria from Kamargianni and Goulding (2018), referring to it as what is necessary for the implementation of MaaS.	Cities' MaaS readiness
					Investigating maturity requirements to operate MaaS: the Rome case (Corazza and Carassiti, 2021).	The authors base their evaluation of Rome's MaaS maturity on the MaaS Maturity Index by Kamargianni and Goulding (2018).	Cities' MaaS readiness

Search Term: MaaS Maturity Index							
Search Engine	Date Range	Fields of study	Sorting	Total Results	Relevant Results	Description	Focus
		Filter Criteria					
ScienceDirect	From 2014	Environmental Science, Earth and Planetary Science, Social Sciences, Computer Science, Engineering, Energy	By relevance	206	The Ws of MaaS: Understanding MaaS from a literature review (Arias-Molinares and García-Palomares, 2020).	Idem	Cities' MaaS readiness
					Smart transport: A comparative analysis using the most used indicators in the literature juxtaposed with interventions in English metropolitan areas (Chen and Silva, 2021).	A composite smart transport index agreggated in 3 groups. The first one includes private, public and emergency transport. The second one contains accessibility, sustainability and innovation indices (included MaaS). The third one is a composite index of the smart transport index. This smart transport index can reveal the overall development of the smart transport sector in a city.	Cities' urban mobility assessment
					How to measure the impacts of shared automated electric vehicles on urban mobility (Nemoto et al., 2021).	Researchers propose a set of indicators to assess the sustainability in the implementation of shared automated electric vehicles (SAEV). SAEV and MaaS are considered as emerging mobility innovations. To create those indicators, researchers list a set of frameworks to evaluate mobility such as the Deloitte Mobility City Index, the Qualcomm Urban Mobility Index, the Arcadis Sustainable Cities Mobility Index, among others.	Cities' urban mobility assessment

Search Term: MaaS Maturity Index							
Search Engine	Filter Criteria				Relevant Results	Description	Focus
	Date Range	Fields of study	Sorting	Total Results			
Google.com	From 2014	All types of results	Default	21500	MaaS Maturity Index (MaaS Lab n.d.).	General description of the MaaS Maturity Index from Kamargianni and Goulding (2018).	Cities' MaaS readiness
					MaaS Readiness Level Indicators for local authorities (Aaltonen, 2017).	A checklist to understand how prepared local authorities are to implement a more sustainable transport system, specifically addressing MaaS.	Cities' MaaS readiness
					The Ws of MaaS: Understanding MaaS from a literature review (Arias-Molinares and García-Palomares. 2020).	Idem	Cities' MaaS readiness
					Investigating maturity requirements to operate MaaS: the Rome case (Corazza and Carassiti, 2021).	The authors base their evaluation of Rome's MaaS maturity on the MaaS Maturity Index by Kamargianni and Goulding (2018).	Cities' MaaS readiness
					Next-Generation Transport: Increasing Urban Productivity with MaaS (Northend, Oguntoye and Packard, 2022).	Even though it does not present a MaaS maturity index, it makes references to the levels of MaaS integration and the Oliver Wyman Forum Urban Mobility Readiness Index.	Levels of MaaS

Search Term: MaaS Maturity Index							
Search Engine	Filter Criteria				Relevant Results	Description	Focus
	Date Range	Fields of study	Sorting	Total Results			
Google.com	From 2014	All types of results	Default	21500	Next-Generation Transport: Increasing Urban Productivity with MaaS (Northend, Oguntoye and Packard, 2022).	Even though it does not present a MaaS maturity index, it makes references to the levels of MaaS integration and the Oliver Wyman Forum Urban Mobility Readiness Index.	Cities' urban mobility assessment
					Urban Mobility Readiness Index 2021: Putting Sustainability in the Driver's Seat (Oliver Wyman Forum, 2022).	Index made up of 5 dimensions to rank cities in terms of infrastructure, social impact, market attractiveness, system efficiency, and innovation. Through 57 KPIs they allow identifying which cities are ready to excel in meeting their future mobility challenges.	Cities' urban mobility assessment
					Levels of MaaS (Opiola, 2018).	Set of levels to categorize the integration of MaaS initiatives, ranging from 0 to 6. The higher the level, the least required intervention from humans.	Levels of MaaS
					TravelSpirit Index of Openness for MaaS (TravelSpirit, 2017).	Tool to understand the current position and potential for developing an open MaaS model. It is based on 5 levels of Maturity openness that can be assessed for MaaS Customers, MaaS Providers, Data Providers, and Transport Operators.	Levels of MaaS
					Review of Whole Systems Simulation Methodologies for Assessing MaaS as an Enabler for Sustainable Urban Mobility (Muller et al., 2021).	Review of methods for assessing the sustainability of urban mobility systems. It reviews existing transportation simulation tools to evaluate the potential impacts of MaaS on the sustainability of a city. It uses a STEEP-based approach. It references mobility indexes like the Arthur D. Little's Urban Mobility Index and the Deloitte's City Mobility Index.	Impacts of MaaS or mobility systems
Total Relevant Results						20	

Search Term: MaaS Readiness Index							
Search Engine	Date Range	Fields of study	Sorting	Total Results	Relevant Results	Description	Focus
Semantic Scholar	From 2014	Business, Computer Science, Economics, Engineering, Environmental Science, Geography, Mathematics, Political Science, Sociology	By relevance	1160	The MaaS Maturity Index: Preparing Cities for the MaaS era (Kamargianni and Goulding, 2018).	Set of indicators to assess the readiness of a city for the implementation of MaaS. Based on 5 dimensions: transport operators' openness and data sharing; citizen familiarity and willingness; policy, regulation, and legislation; transport services and infrastructure; and ICT infrastructure. It uses a scale from 0 to 1 to determine that readiness. Used to evaluate the readiness of London and the West Midlands in the United Kingdom.	Cities' MaaS readiness
					Towards Sustainable MaaS: A roadmap for San Luis Potosí, MX, Using the MaaS Readiness Index (Thanos, 2018).	The author researched on MaaS readiness indexes trying to replicate one. He references the Maturity Index from Kamargianni and Goulding (2018), the MaaS Readiness Index Somers and Eldaly (2016), and others. After explaining that no index has its methodology publicly available, he developed a modified version of the Somers and Eldaly (2016) index, using a scale from 1 to 4. He then used this index to assess the MaaS Readiness of the City of San Luis Potosí in Mexico.	Cities' MaaS readiness

Search Term: MaaS Readiness Index							
Search Engine	Filter Criteria				Relevant Results	Description	Focus
	Date Range	Fields of study	Sorting	Total Results			
Scopus	From 2014	Environmental Science, Engineering, Earth and Planetary Sciences, Social Sciences, Business, Management and Accounting, Computer Science, Energy, Economics, Mathematics	By relevance	428	MaaS Maturity Index Study and Case Analysis in China (Li et al., 2020).	Though their paper is not readily available, their abstracts hints they evaluated the readiness of the city of Guangzhou by taking on the MaaS Maturity Index from Kamargianni and Goulding (2018).	Cities' MaaS readiness
					Key Fundamentals and Evaluation of a Thriving MaaS Ecosystem in China (Li et al., 2019).	Though their paper is not readily available, their abstract indicates that their research suggests some crucial indexes to assess the readiness of a city for MaaS implementation in China.	Cities' MaaS readiness
					Review of Whole Systems Simulation Methodologies for Assessing MaaS as an Enabler for Sustainable Urban Mobility (Muller et al., 2021).	Review of methods for assessing the sustainability of urban mobility systems. It reviews existing transportation simulation tools to evaluate the potential impacts of MaaS on the sustainability of a city. It uses a STEEP-based approach. It references mobility indexes like the Arthur D. Little's Urban Mobility Index and the Deloitte's City Mobility Index.	Impacts of MaaS or mobility systems

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Search Term: MaaS Readiness Index							
Search Engine	Filter Criteria				Relevant Results	Description	Focus
	Date Range	Fields of study	Sorting	Total Results			
ScienceDirect	From 2014	Environmental Science, Social Sciences, Computer Science, Engineering, Energy	By relevance	94	Multidimensional Indicator of MaaS systems Performance (Bandeira et al., 2022).	Researchers take on the work by Kamargianni et al., (2016); Kamargianni and Goulding, (2018); and Sochor et al., (2018) and create a classification based on 3 pillars: coverage of the MaaS platform, its functionality, and its sustainability performance. It is based on a points systems ranging from 0 to 30.	Levels of MaaS
					The Ws of MaaS: Understanding MaaS from a literature review (Arias-Molinares and García-Palomares, 2020).	From a literature review, researchers cite the MaaS Maturity Index criteria from Kamargianni and Goulding (2018), referring to it as what is necessary for the implementation of MaaS.	Cities' MaaS readiness
					How to measure the impacts of shared automated electric vehicles on urban mobility (Nemoto et al., 2021).	Researchers propose a set of indicators to assess the sustainability in the implementation of shared automated electric vehicles (SAEV). SAEV and MaaS are considered as emerging mobility innovations. To create those indicators, researchers list a set of frameworks to evaluate mobility such as the Deloitte Mobility City Index, the Qualcomm Urban Mobility Index, the Arcadis Sustainable Cities Mobility Index, among others.	Cities' urban mobility assessment

Search Term: MaaS Readiness Index							
Search Engine	Date Range	Filter Criteria			Relevant Results	Description	Focus
		Fields of study	Sorting	Total Results			
Google.com	From 2014	All types of results	Default	21400	MaaS Readiness Level Indicators for local authorities (Aaltonen, 2017).	A checklist to understand how prepared local authorities are to implement a more sustainable transport system, specifically addressing MaaS.	Cities' MaaS readiness
					MaaS Maturity Index (MaaS Lab n.d.).	General description of the MaaS Maturity Index from Kamargianni and Goulding (2018).	Cities' MaaS readiness
					Towards Sustainable MaaS: A roadmap for San Luis Potosí, MX, Using the MaaS Readiness Index (Thanos, 2018).	Idem	Cities' MaaS readiness
					Multidimensional Indicator of MaaS systems Performance (Bandeira et al., 2022).	Idem	Levels of MaaS
					The Ws of MaaS: Understanding MaaS from a literature review (Arias-Molinares and García-Palomares, 2020).	Idem	Cities' MaaS readiness
					MaaS - Now and In the Future (Schweiger, 2020).	Focuses on MaaS in rural areas providing several examples of cases studies. Describes the KOMPIS MaaS Evaluation Framework, which is based on a micro, meso, national, and societal level. This framework helps to identify economic, environmental, and social impacts of MaaS initiatives.	Impacts of MaaS or mobility systems

Search Term: MaaS Readiness Index							
Search Engine	Date Range	Filter Criteria			Relevant Results	Description	Focus
		Fields of study	Sorting	Total Results			
Google.com	From 2014	All types of results	Default	21400	WDC Mobility Index Project (CARO, 2022).	Mobility Index (under development) to measure current transport, mobility and accessibility in rural centres in the Western Region of Ireland. It will comprise of 30 indicators in themes like Economic and Employment activity, Quality of life and social inclusion, and Low carbon readiness.	Rural mobility readiness
					Investigating maturity requirements to operate MaaS: the Rome case (Corazza and Carassiti, 2021).	The authors base their evaluation of Rome's MaaS maturity on the MaaS Maturity Index by Kamargianni and Goulding (2018).	Cities' MaaS readiness
					Review of Whole Systems Simulation Methodologies for Assessing MaaS as an Enabler for Sustainable Urban Mobility (Muller et al., 2021).	Idem	Impacts of MaaS or mobility systems
Total Relevant Results					**17**		

116

Snowballing Results		
Relevant Results	Description	Focus
Arthur D. Little Urban Mobility Index 3.0 (Arthur D. Little, 2018).	It evaluates cities' mobility through 3 criteria: maturity, innovation, and performance. It uses a scale from 0 to 100 points.	Cities' urban mobility assessment
Deloitte City Mobility Index (Deloitte, 2020).	It is a survey to gauge the health and performance of the urban mobility. It is based on 3 themes: performance and resilience, vision and leadership, and service and inclusion.	Cities' urban mobility assessment
Urban Mobility Index 2017 (Cebr, 2017).	Examination of how cities are approaching the goal of sustainable mobility and the progress they have towards achieving zero emissions transportation solutions. It includes 20 indicatores aggregated in 3 major areas deemed necessary to achieve emissions free transportation: the status quo of the city, the conditions required for change, and the preparedness for the future.	Impacts of MaaS or mobility systems

Snowballing Results		
Relevant Results	Description	Focus
Sustainable Cities Mobility Index 2017 (Arcadis, 2017).	Index that explores how cities' mobility is performing in terms of social, environmental, and economic health mesures. It is based on 3 pillars: people, planet, and profit.	Impacts of MaaS or mobility systems
Is Australia ready for Mobility as a Service? (Somers and Eldaly, 2016).	Researchers introduce the MaaS Readiness Index, as a concept to answer whether a city or country is ready for MaaS. It includes 3 major themes: availability of transport services, customer demand, and government support and regulatory environment.	Cities' MaaS readiness
Urban Mobility Innovation Index (UMii, 2022).	Index that assesses a city's mobility innovation maturity, providing insights into how cities can support transportation innovation. It is composed by 3 mobility dimensions: readiness, deployment, and liveability.	Cities' urban mobility assessment
Total Relevant Results	**6**	

Appendix 5. Mobility stakeholders prioritisation analysis.

Stakeholder	Observations	Type of Stakeholder	Prioritisation	Explanation for the prioritisation
A e Forest Bike Shop and Café	A commerce promoted by the DGC and their GoSmart website https://gosmartdumfries.co.uk/ (https://www.facebook.com/AeBikeshopandCafe/)	Other key stakeholders	1	A retail store with not a great power or influence.
Barnhill Cabs	Fully licensed taxi hire service that caters for local runs, airport transfers, railway transfers, and other travel requirements in Dumfries (https://www.barnhillcabs.co.uk/).	Other key stakeholders	3	As a mobility operator has high stakes on MaaS topics.
Biker Buddies	A club promoting cycle awareness and fitness, especially for people with disabilities. It is promoted on the DGC and their GoSmart website https://gosmartdumfries.co.uk/ (https://buddiesdumfries.wordpress.com/biker-buddies/).	Other key stakeholders	1	A group or club to support cycling and wheeling, their aim is not influencing, and their stakes are low.
Borderlands Vehicle Leasing	They lease cars and vans, including green vehicles (https://www.borderlandsleasing.co.uk/about-us).	Other key stakeholders	3	As a mobility operator has high stakes on MaaS topics.
Brownriggs Thornhill Coaches	Included in the SWestrans Regional Transport Strategy (RTS). It is an organisation with a range of coaches and minibuses suitable for wedding hire, sporting events, day trips, private hire, contracts, airport transfers, school hires or stag and hen parties. They run bus services to and from Dumfries (http://brownriggsthornhill.co.uk/).	Other key stakeholders	1	According to SWestrans RTS it only has 1 service operated. It is not a big mobility player.
Bustimes.org	Although and unofficial site, they provide bus, coach, and ferry transport information (https://bustimes.org/regions/S).	Other key stakeholders	1	It aggregates timetables of bus operators, but its scope is nationwide, and it's not an official source.
Cancer Cars Scotland	One of the community transport initiatives. It was retrieved from communitytransportdg. It is a database of volunteer driving schemes for cancer treatment in Scotland. This website has a list of drivers in Dumfries, 1 is from the Red Cross, the other one is from Royal Voluntary Service. They aim at providing personal transport service to hospital appointments to those cancer patients (https://www.cancercars.co.uk/about/).	Other key stakeholders	3	One of the transport operators in Dumfries, showing high stakes in mobility.

Stakeholder	Observations	Type of Stakeholder	Prioritisation	Explanation for the prioritisation
ChargePlace Scotland	Referenced in the SWestran RTS. It is the national Electric Vehicle charging network. It aims to offer low cost, fast and accessible charge points as well as an interactive map to help EV owners plan their journeys and find the nearest available charge point (https://chargeplacescotland.org/about-us).	Other key stakeholders	1	Though it plays an important role in electric mobility, as a charging network its stakes and influence in Dumfries are low.
Choose another way	Part of what is promoted by the GoSmart website. It is Scotland's net zero strategy website, listing mitigation actions including active travel, EVs, public transport (www.chooseanotherway.com; https://www.netzeronation.scot/).	Other key stakeholders	1	It is more of a campaign than a true stakeholder but has a governmental position and nature.
Community Transport	Marketed by the DGC, Community Transport is a passenger transport scheme owned and operated by local community groups. They have been set up by people living in areas with very limited public transport and the services (http://communitytransportdg.co.uk/).	Other key stakeholders	3	Associates the different community transport organisations, showing high stakes in mobility.
Community Transport Association	Marketed by the DGC, the Community Transport Association (CTA) is a national charity that represents and supports providers of community transport (https://ctauk.org/).	Other key stakeholders	3	One of the transport operators in Dumfries, showing high stakes in mobility.
CoMoUK	A charity providing technical advice and consultancy to mobility stakeholders, playing a leading role in the UK's transition to integrated mobility solutions designed for the public good. (https://como.org.uk/about/)	Other key stakeholders	1	Their scope is nationwide, providing technical assistance mostly.
CTC Dumfries and Galloway	A club dedicated to cycle-touring and sociable cycling activities. They also have an interest in campaigning, locally and through contacts with other campaigning groups such as Spokes and Dumfries Cycle Campaign (http://www.dandgcycling.org.uk/).	Other key stakeholders	1	As they are more of a club for cycling, their influence and stakes are not significant.
Cycle Centre	A cycling shop, offering servicing, advice, bike park, bike fit, coffee shop, routes/clubs. They are part of a Cycle to Work Scheme (https://cycle-centre.online/).	Other key stakeholders	1	A retail store with not a great power or influence.
Cycling Dumfries	Cycling Dumfries is a group of local people who try and press for better cycling conditions. They campaign for better cycling conditions. Lobbying, Campaigning events, Encouraging cycling, Meeting up, Informing. They are very critical about several mobility aspects in Dumfries (https://cyclingdumfries.wordpress.com/).	Other key stakeholders	2	Is a great influencing actor by its campaigning efforts. As it is not a mobility player its stakes are not big.

Stakeholder	Observations	Type of Stakeholder	Prioritisation	Explanation for the prioritisation
Cycling Embassy of Great Britain	They want to see an end to cycling being pushed to the margins. They foresee a network of direct, well-designed, separated cycle routes that are safe even for young children to use (https://www.cycling-embassy.org.uk/).	Other key stakeholders	2	Although its influencing strength could be significant, its national coverage might dilute its efforts.
Cycling Scotland	Referenced by the ATS. They support and influence change to create a cycling-friendly nation. They monitor cycle networks, campaign for cycling road safety, and give training to improve skills (https://www.cycling.scot/what-we-do).	Other key stakeholders	2	Although they oversee cycling as major mode in multimodality, it has a nationwide projection which could dilute its power.
Cycling UK in Scotland	They work across Scotland for safe and free of congestions streets, clean air, and promote cycling. (https://www.cyclinguk.org/scotland).	Other key stakeholders	2	Although its influencing strength could be significant for several mobility topics, its national coverage might dilute its efforts.
Dumfries and Galloway Council (DGC)	See Table 4.2.	Planning Authorities	4	See Table 4.2.
DG2 Wheels	From GoSmart website. A commerce for bike servicing, repair, and sales (https://www.dg2wheels.co.uk/).	Other key stakeholders	1	A retail store with not a great power or influence.
Dual the A75	From SWestrans RTS. Their goal is to raise awareness and push all relevant authorities to upgrade the A75 to dual carriageway status (http://www.dualthea75.co.uk/index.html).	Other key stakeholders	2	As a campaigner, their influence is high, not their stakes in MaaS as they only represent on mode.
Dumfries & District Ramblers	Promoted by GoSmart website. Britain's biggest walking charity, to protect Britain's footpaths and promote walking. The Dumfries & District Group organises around 90 walks a year. They are part of Ramblers Scotland (https://www.dumfriesramblers.org.uk/).	Other key stakeholders	1	A group who organises walks, low influence and stakes.
DGC Buses	Public Bus Operator, mentioned in the SWestrans RTS. Run 15 bus services. Has third place in the share of services.	Institutional Stakeholders	3	As a mobility operator has high stakes. Plus, it's operated by the council.
Dumfries Cycling Club	Club running activities like road racing, sportives, audax, reliability rides and time trialling (https://www.dumfriescyclingclub.co.uk/).	Other key stakeholders	1	Not a significant mobility player as to decision-making.
Energy Saving Trust	Sponsor of active travel in Dumfries. It is an independent organisation working to address the climate emergency. They provide advice on energy efficiency and clean energy solutions (https://energysavingtrust.org.uk/). They can advise local	Other key stakeholders	2	Their main aim is not mobility, and they have a nationwide projection.

Stakeholder	Observations	Type of Stakeholder	Prioritisation	Explanation for the prioritisation
Enterprise Car & Van Hire	Situated behind the railway station. It is a car and van hire in Dumfries (https://www.enterprise.co.uk/en/car-hire/locations/uk/dumfries-sc16.html).	Other key stakeholders	3	As a mobility operator has high stakes on MaaS topics.
Excalibur Limos	They specialise in Wedding Cars and limousine hire in Dumfries & Galloway, Ayrshire, and Cumbria (https://www.excalibur-limos.co.uk/about).	Other key stakeholders	1	It is focused mostly on wedding and special events. They benefit from MaaS but are high influencer or have high stakes.
Freight Transport Association (Logistics UK)	They support, shape and stand up for, efficient logistics, with members from the road, rail, sea and air industries, as well as the buyers of freight services such as retailers and manufacturers whose businesses depend on the efficient movement of goods (https://logistics.org.uk/about-us).	Other key stakeholders	1	Though an important mobility player, it promotes freight transport which is not in the scope of this research.
Galloway Community Transport	They provide regular services to Castle Douglas, Dumfries, Newton Stewart, Ayr and Carlisle, excursions to places of interest and vehicle hire to members (with or without a driver) (https://www.gallowaycommunitytransport.org/).	Other key stakeholders	3	One of the transport operators in Dumfries, showing high stakes in mobility.
Houston Coaches	Included in SWestrans RTS. They have service buses that are used on council routes around Dumfries and Galloway (https://www.houstonscoaches.co.uk/). They are the second most important bus operator in the region.	Other key stakeholders	3	Important bus operator with 17 services.
Liftshare	Impulsed by GoSmart website. They offer a platform for ridesharing (https://liftshare.com/uk).	Other key stakeholders	3	As a mobility option, they have been supporting the work by MaaS Scotland.
Living Streets	UK Charity whose mission is to achieve a better walking environment and inspire people to walk more (https://www.livingstreets.org.uk/about-us/our-organisation). They are promoted by the GoSmart website.	Other key stakeholders	2	UK-wide campaigning organisation.
MaaS Scotland	See Table 4.2.	Other key stakeholders	4	See Table 4.2.
McCalls Coaches	Mentioned in the SWestrans RTS. They offer coach hire in Dumfries and Galloway (https://www.mccallscoaches.com/). Fourth most important bus operator in Dumfries.	Other key stakeholders	3	Important bus operator with 10 services.
Mcleans Taxis & Coach Hire	Mentioned by Sustrans and identified at a visit to Dumfries. Taxi business in Dumfries and Galloway with an operating fleet	Other key stakeholders	3	As a mobility operator has high stakes on MaaS topics.

Stakeholder	Observations	Type of Stakeholder	Prioritisation	Explanation for the prioritisation
National Rail Enquiries	They provide journey planning, real time information, ticket and fares information and a range of rail-related information to all rail customers (https://www.nationalrail.co.uk/46383.aspx).	Institutional Stakeholders	1	It is a nationwide organisation which aggregates only railways. No great influence or stakes in decisions.
Network Rail	Mentioned in the SWestrans RTS. They own, repair, and develop the railway infrastructure in England, Scotland, and Wales (https://www.networkrail.co.uk/running-the-railway/our-routes/scotland/).	Institutional Stakeholders	3	High stakes as a railway manager.
NHS Dumfries and Galloway	Referenced in the ATS. Health body in the region.	Institutional Stakeholders	2	Great influencer, but its focus is not entirely mobility.
Nithsdale Wheelchairs	Promoted by GoSmart website. Wheelchairs vendor (https://www.nithsdale-wheelchairs.com/).	Other key stakeholders	1	A retail store with not a great power or influence.
Paths for All	Scottish charity championing everyday walking for a happier, healthier, greener Scotland (https://www.pathsforall.org.uk/).	Other key stakeholders	2	They are more of an influence to decision-making rather than having high stakes.
Pedal on Parliament	They call on all Scotland's politicians, to sign up to proper funding for active travel, design cycling for all ages and abilities into Scotland's roads, implement and enforce safer speeds where people live, work and play (https://pedalonparliament.org/).	Other key stakeholders	2	Is a great influencing actor by its campaigning efforts. As it is not a mobility player its stakes are not big.
Physical Activity Alliance (PAA)	Mentioned in the ATS. Formed by the NHS, the DGC, and other stakeholders promoting AT.	Other key stakeholders	2	Can influence decision-making.
Police Scotland	According to the ATS, it increases compliance of pedestrianised areas and "No motor vehicle" restricted lengths of road.	Institutional Stakeholders	1	Not a mobility actor, but an entity that can be helpful depending on the initiatives.
Power Bikes	Promoted by GoSmart website. E-bikes vendor (https://powerbikes.uk/).	Other key stakeholders	1	A retail store with not a great power or influence.
Road Haulage Association	Over 100000 commercial vehicles currently operating on UK roads. They campaign on speed limits to roadside facilities, clean air zones to issues surrounding cross border traffic – sea or land. They ensure members' voices are heard on national issues as well as local roads policy (https://www.rha.uk.net/About).	Other key stakeholders	1	Though an important mobility player, it promotes freight transport which is not in the scope of this research.
Scotrail	See Table 4.2.	Institutional Stakeholders	4	See Table 4.2.

Stakeholder	Observations	Type of Stakeholder	Prioritisation	Explanation for the prioritisation
Scottish Association for Public Transport (SAPT)	They campaign for an efficient world-class transport system for Scotland, sustainable public transport for rural and urban communities, city streets free from road traffic pollution and congestion, co-ordinated train, bus and ferry services, transport integration (https://www.sapt.org.uk/).	Other key stakeholders	2	It can influence important bodies in terms of mobility.
Scottish Cycling	The national governing body of sport for cycling in Scotland and as a home nation partner of British Cycling. They help people get into cycling (https://www.britishcycling.org.uk/scotland/article/scst-scottish-cycling-about).	Other key stakeholders	1	Their national scope decreases their influence and stakes in Dumfries.
Scottish Rail Holdings	A Non-Departmental Public Body overseeing the governance of train operating companies. (https://www.scotrail.co.uk/about-scotrail. They act as the "owning group" of the operating company and provide separation between Transport Scotland as strategic policymakers and the direct management of train service delivery for ScotRail Trains (SRT) (https://www.railholdings.scot/who-we-are).	Institutional Stakeholders	3	High stakes in train modes.
Solway Taxis	Identified from visits to Dumfries. Taxi service in the area.	Other key stakeholders	3	As a mobility operator has high stakes on MaaS topics.
South of Scotland Alliance	A partnership with Dumfries and Galloway Council and Scottish Enterprise who support economic growth in the South of Scotland and campaign on issues which are common across both the Scottish Borders and Dumfries and Galloway such as: broadband, mobile phone coverage, european funding, small towns (https://www.scotborders.gov.uk/info/20062/strategies_plans_and_policies/703/south_of_scotland_alliance).	Other key stakeholders	3	As a supporter for better economy and technology access it has high stakes in MaaS related topics.
South of Scotland Enterprise	Mentioned in the SWestrans RTS. They work with people and businesses in communities right across the South of Scotland to grow its economy by providing investment, expertise and mentoring https://www.southofscotlandenterprise.com/.	Other key stakeholders	2	By supporting businesses and communities they can influence initiatives and promote different actions.
Southwest Scotland Community Rail Partnership	It is voluntary, not-for-profit organisation that aims to engage people in their local railways across Ayrshire and Dumfries & Galloway. It aims to promote social inclusion and sustainable travel by collaborating with train operators to bring about real improvements in terms of bringing stations back to life and making	Other key stakeholders	2	It has great influence as it engages with communities and transport operators.

Stakeholder	Observations	Type of Stakeholder	Prioritisation	Explanation for the prioritisation
Spokes	Spokes is the Lothian Cycle Campaign – a non-party-political voluntary organisation. They campaign for better conditions for cyclists, especially in Edinburgh and the Lothians (http://www.spokes.org.uk/).	Other key stakeholders	2	Although its influencing strength could be significant for several mobility topics, its national coverage might dilute its efforts.
Stagecoach Cumbria	Included in SWestran RTS. Routes to and from Carlisle - Dumfries. Only 3 services. (https://www.stagecoachbus.com/about/cumbria-and-north-lancashire).	Other key stakeholders	1	Reduced number of services.
Stagecoach West Scotland	See Table 4.2.	Other key stakeholders	4	See Table 4.2.
Stantec Ltd	See Table 4.2.	Other key stakeholders	4	See Table 4.2.
Sustrans	See Table 4.2.	Other key stakeholders	4	See Table 4.2.
Swestrans	See Table 4.2.	Planning Authorities	4	See Table 4.2.
Telfords Coaches	Mentioned in SWestrans RTS. They supply coach hire in Dumfries & Galloway as well as farther afield (https://telfordscoaches.com/).	Other key stakeholders	1	According to SWestrans RTS it only has 1 service operated. It is not a big mobility player.
The Association for Commuter Transport	Included in GoSmart Cycling Travel Map. It is an international association and leading advocate for commuter transportation and transportation demand management (https://www.actweb.org/i4a/pages/index.cfm?pageid=1#).	Other key stakeholders	2	As an international body its interests might not be as strong as other entities. Although its influencing strength could be significant in mobility topics.
The British Horse Society (BHS)	Mentioned in the SWestrans RTS. They protect and promote the interests of all horses and those who care about them. They have found issues with horses crossing roads and posing risks to drivers (https://www.bhs.org.uk/).	Other key stakeholders	1	Not a mobility actor, but it was highlighted in the Swestrans RTS as horses are an element of risk.
The Care Shop Dumfries	Promoted by GoSmart website. A store offering a wide variety of aids to assist mobility of the disabled (https://www.thecareshopdumfries.co.uk/).	Other key stakeholders	1	A retail store with not a great power or influence.
The Frothy Bike Co.	Bike Shop, Coffee Shop, Workshop. Has a Cycle to Work Scheme (https://www.thefrothybikeco.com/).	Other key stakeholders	1	A retail store with not a great power or influence.

Stakeholder	Observations	Type of Stakeholder	Prioritisation	Explanation for the prioritisation
TMac Van Hire	It is a van rental company offering service in Dumfries and Galloway (https://www.tmaccarcentre.co.uk/).	Other key stakeholders	3	As a mobility operator has high stakes on MaaS topics.
Transform Scotland	Sponsors of Cycling Travel Map. They campaign for walking, cycling and public transport to be the easiest and most affordable options for everyone (www.transformscotland.org.uk).	Other key stakeholders	2	High influences with their campaigning, but its nationwide scope decreases stakes.
Transport Scotland	See Table 4.2.	Planning Authorities	4	See Table 4.2.
Traveline Scotland	Up-to-date information on bus, rail, coach, air, and ferry services within Scotland, and from Scotland to other major parts of the UK. It has a journey planner with departures, and timetables (https://www.travelinescotland.com/).	Other key stakeholders	3	Potential MaaS Operator. But its scope is national and spanning to the UK, so its power decreases.
Visit Scotland	A website dedicated to tourism in Scotland and Dumfries and Galloway too (https://www.visitscotland.com/destinations-maps/dumfries-galloway/).	Other key stakeholders	1	As touristic sites have better connections they benefit, however, their influence and stakes in mobility are rather low.
Women's Cycle Forum Scotland	Organisation giving women a new voice in cycling, encouraging them to cycle and helping develop their leadership skills (https://womenscycleforum.wordpress.com/home/).	Other key stakeholders	1	As a club encouraging cycling, their influence and stakes are not significant.
Woodgrove Taxis	Part of Community Transport. They are a hackney and private hire taxi service covering Dumfries and the surrounding areas (https://woodgrovetaxis.co.uk/).	Other key stakeholders	3	One of the transport operators in Dumfries, showing high stakes in mobility.

Total of Stakeholders: 71.

Appendix 6. Results from a survey carried out by the DGC for the ATS Consultation.
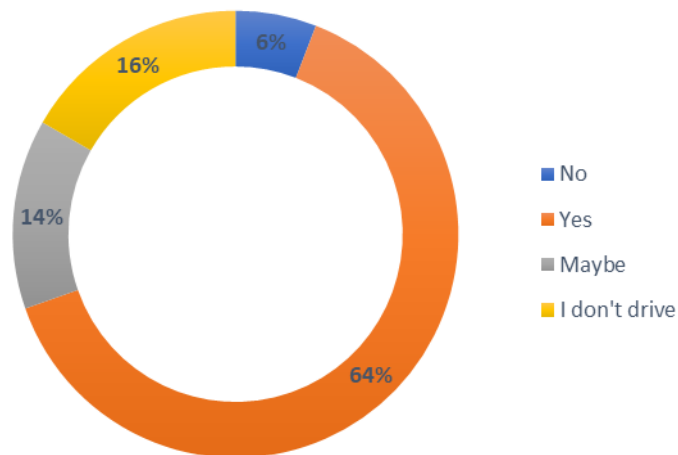
For a recent update of the ATS, a consultation process was carried out by the DGC. Part of that process included a public survey to collect data on topics like willingness to give up the private car, conditions encouraging AT, status of AT infrastructure, and the impacts of AT on health, economy, and the environment. The survey was run from January to March 2022, with 364 respondents from all D&G. The raw data from this survey was provided by the DGC as an input for the research. The dataset provided was filtered to only include respondents from Dumfries centre, that is, Postcodes DG1 and DG2. This brought the total 364 participations down to 102 respondents. From those 102 participants, 91 accepted to respond additional questions (DGC, 2022a).

The results for the initial set of questions answered by the 102 participants are presented next.

Question: Would you be willing to give up some of your car use to walk and cycle more?

Results:

Options	# Respondents
No	6
Yes	65
Maybe	14
I don't drive	17
Total	102

**Question**: What would encourage you to walk or cycle more?

Results highlights:

Having a pavement/walkway/cycle-way between Collin & Dumfries!!
Safe links between Collin & Dumfries
Decent footpaths and cycle paths along the main and side roads.
Safe cycle routes from my home
Better weather
Safer walking areas along roadways
Secure town centre cycle storage, extension of safe cycle routes
Less cars on the road
Safer cycling routes and better condition of the road network would encourage me to cycle more
Cycleways and uninterrupted cycle lanes
Safer routes, better infrastructure.
A safer environment - cycle lanes segregated from traffic, more zebra crossings, enforcement of parking restrictions
Safe cycle routes, secure bike storage
Better cycling and walking infrastructure, less traffic, more priority given to pedestrians and cyclists rather than to traffic flow. (for example road crossings give less than 10 seconds to cross), Awful crossing at Dock Park.
Physically barriered cycling infrastructure where motorist are unable to swerve into or park in cycling lanes.
Better cycle paths and pavements
Two things 1) Safe cycle lanes, separated from traffic AND from pedestrians (as they have in the Netherlands) 2) Secure places to leave the bike at the destination.
Better connected cycle routes with no gaps.
Local walking group to suit level of need and time
Segregated walking and cycling routes would make walking and cycling more appealing. Having pedestrian and cycle crossings more responsive to the button press so I'm not waiting as long to cross a road would also be great. Decreasing the amount of vehicular traffic and creating quieter roads better for cycling would enable me to do more journeys by bike comfortably.
Adequate walking and cycling paths which are not shared with motor vehicles.
More segregated cycle ways connecting through the town. Better cycle routes from the town along the main directions e.g. New Abbey Rd, towards Annan and Lockerbie. For walking, fewer cars sitting with idling engines, wider pavements, slower traffic, less traffic, more pedestrianised ways/lower volume of traffic streets e.g. one way systems. More trees and plants in urban setting. More efficient road crossings.
Nearer school bus stop

Question: Score the current state of walking and cycling infrastructure in Dumfries and Galloway?

Results:

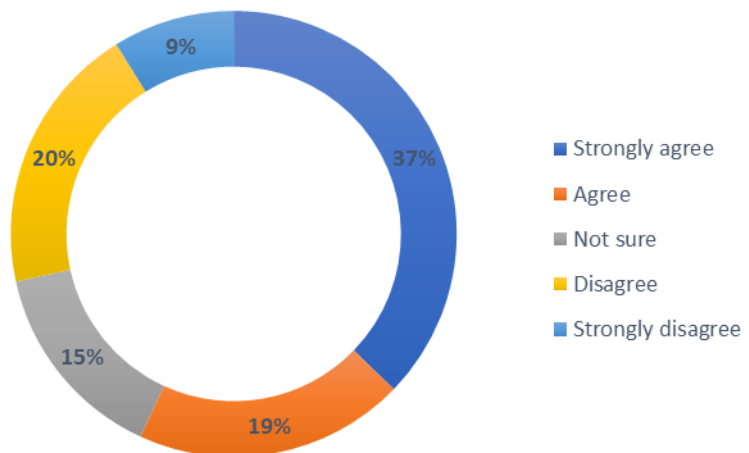| Options	Ratings	# Respondents
Very Poor	1	14
Poor	2	34
Regular	3	42
Good	4	11
Very Good	5	1
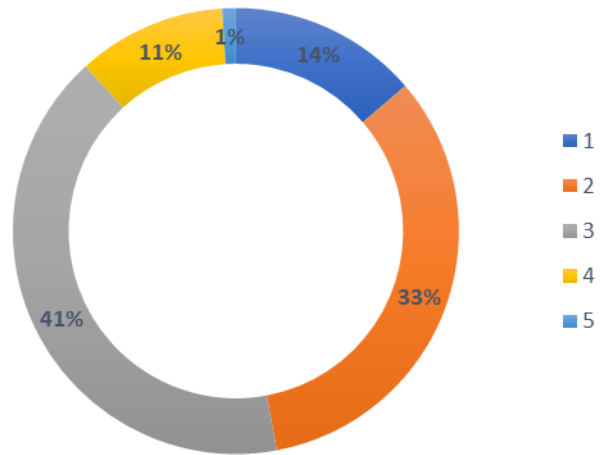
Question: How strongly do you agree with each statement?

Results:

a. We need more pedestrian-friendly areas in Town Centres

Options	# Respondents
Strongly agree	38
Agree	20
Not sure	15
Disagree	20
Strongly disagree	9

b. D&G need more and better cycling links between settlements.

Options	# Respondents
Strongly agree	71
Agree	23
Not sure	6
Disagree	1
Strongly disagree	1
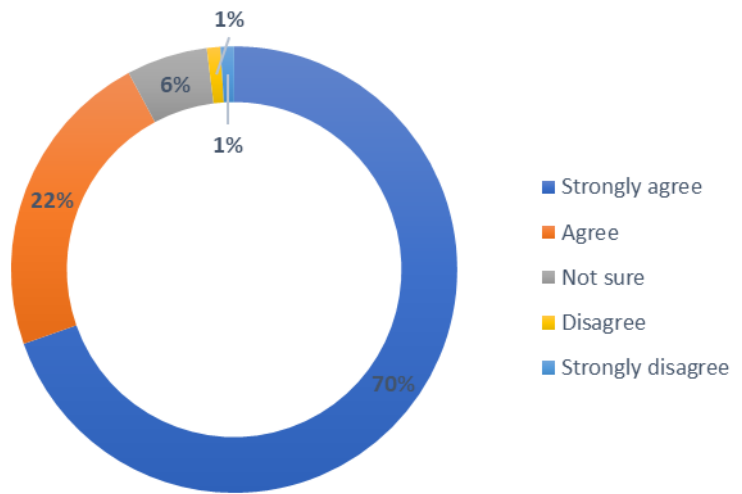
c. Post-COVID life should include more walking, cycling, and access to open spaces.

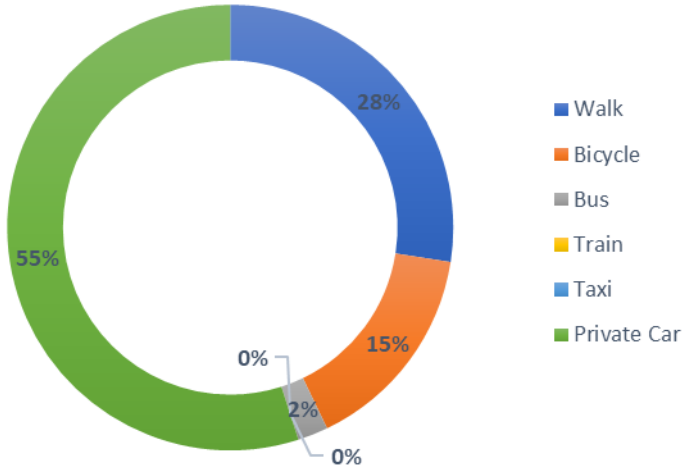| Options	# Respondents
Strongly agree	68
Agree	28
Not sure	2
Disagree	2
Strongly disagree	2
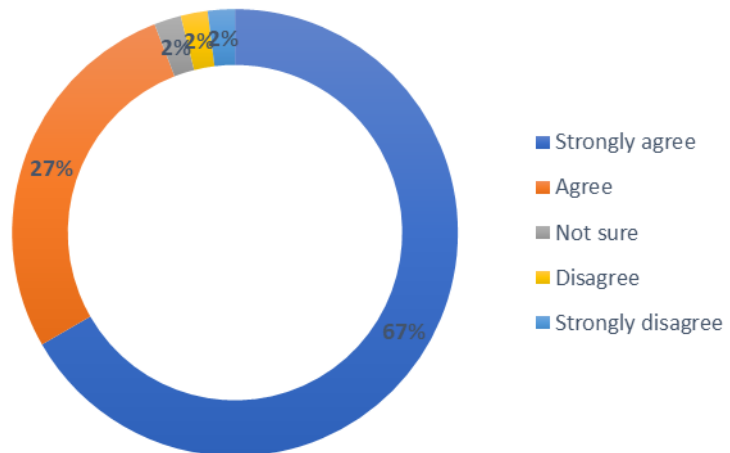
The results for the additional questions answered by 91 respondents are next.

Question: Which form of transport do you use most for daily journeys? (Daily journeys: going to work, school, the shop, the gym, the pub, etc)

Results:

Options	# Respondents
Walk	25
Bicycle	14
Bus	2
Train	0
Taxi	0
Private Car	50

Question: Do you own or have access to a bike?

Results:

Options	# Respondents
Yes	79
No	12
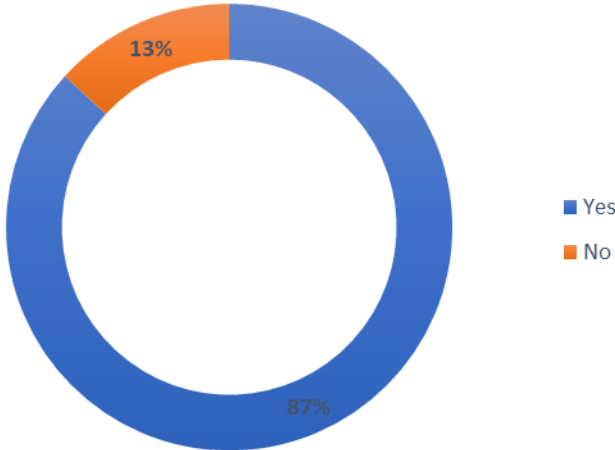
Question: How often do you walk for any purpose?

Results:

Options	# Respondents
Every day	55
Around 4 times a week	16
At least once a week	16
Monthly or rarely	3
I do not walk for more than 5 minutes	1
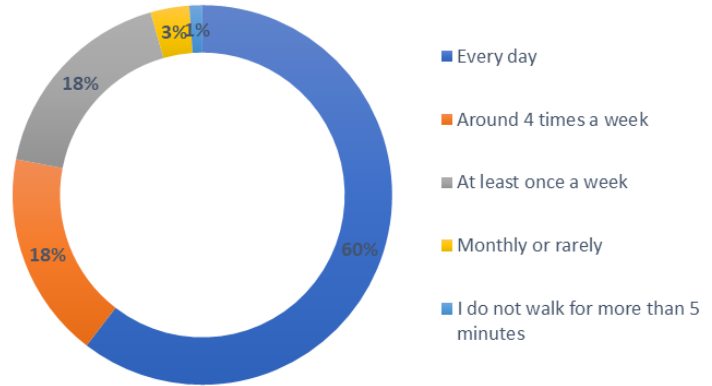
Question: How often do you cycle for any purpose?

Results:

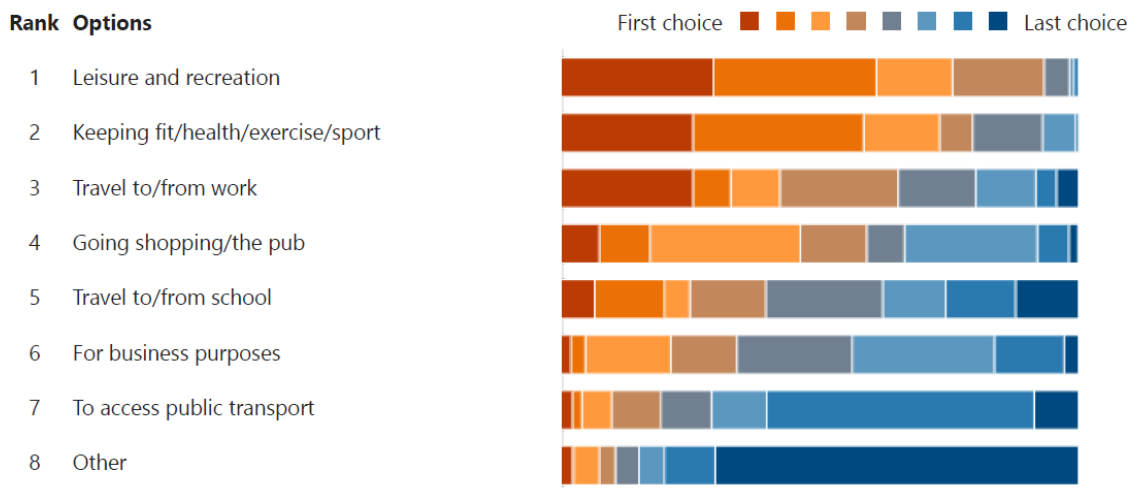| Options	# Respondents
Every day	12
Around 4 times a week	16
At least once a week	18
Monthly or rarely	31
I do not cycle for more than 5 minutes	13
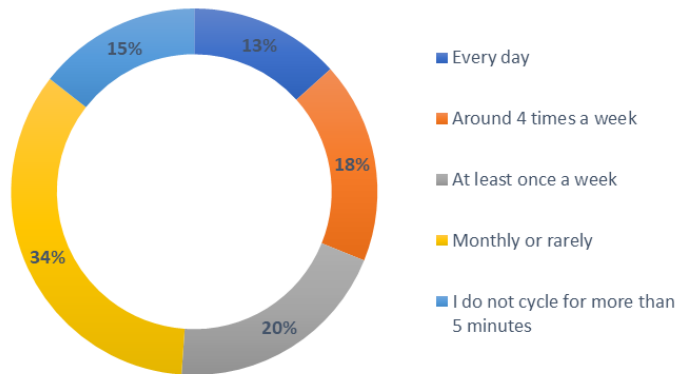
Question: What are your three most frequent reasons for walking, cycling, or wheeling?

Results for D&G:

As stated in the answers from the 102 respondents, encouraging more walking or cycling must build upon more links between areas and transport modes, better infrastructure, safer cycleways and footpaths, more pedestrian crossings, secure cycle storage, segregated cycle lanes, extension of cycle routes, and nearer bus stops. Only 1% of respondents considered the current state of walking and cycling infrastructure in very good conditions, whereas 14% and 33% considered it very poor and poor, respectively. A 41% and a 11% respectively considered the infrastructure being in a moderate and good condition. What is more, 37% strongly agreed on the need of more pedestrian-friendly areas in town centre, while 19% agreed, 15% were not sure, 20% disagreed, and 9% strongly disagreed. A 70% strongly agreed with having more cycling links between settlements, 22% agreed, 6% were not sure, and 1% each disagreed and strongly disagreed. For a more active travel and access to open spaces as post-COVID life, a 67% strongly agreed, a 27% agreed, and a 2% each were not sure, disagreed, and strongly disagreed.

From those 91 respondents, 87% own or have access to a bike, 60% walk every day, 18% walk around 4 times a week, another 18% do it at least once a week, 3% do it monthly or rarely, and 1% do not walk more than 5 minutes. Plus, 13% cycle every day, 18% do it around 4 times a week, 20% at least once a week, 34% do it monthly or rarely, and 15% do not cycle more than 5 minutes. The results also showed that the 3 most frequent reasons for active travelling are for leisure and recreation, keeping fit and exercising, and travelling to and from work. The 3 least frequent reasons are for business purposes, to access public transport, and other reasons.

Appendix 7. Network operators' outdoor coverage in Dumfries centre.
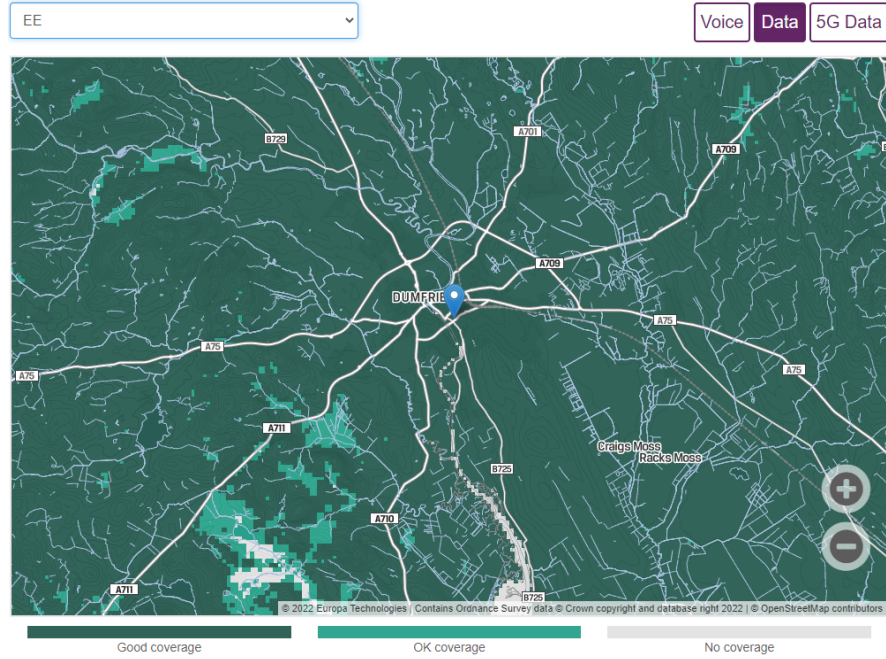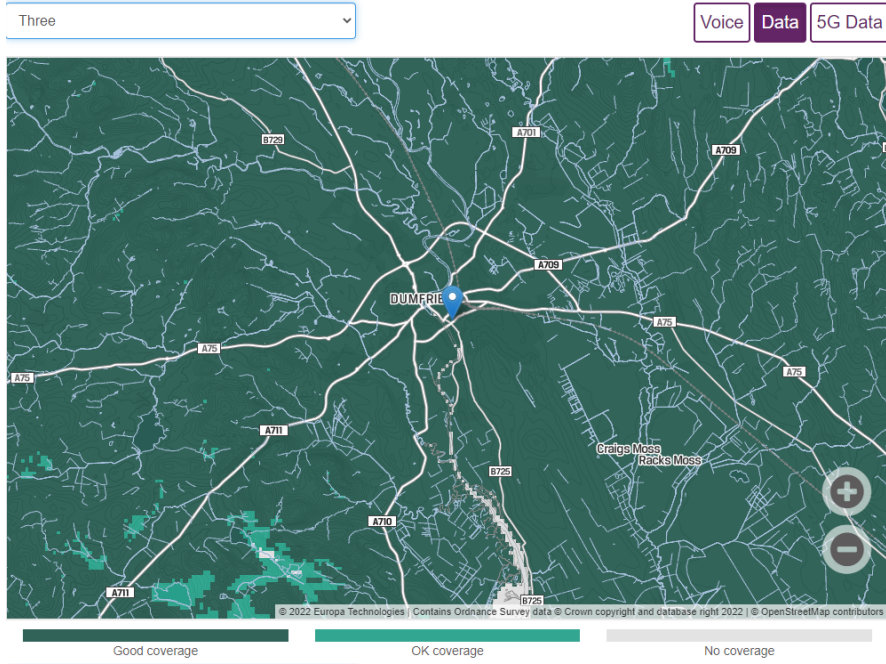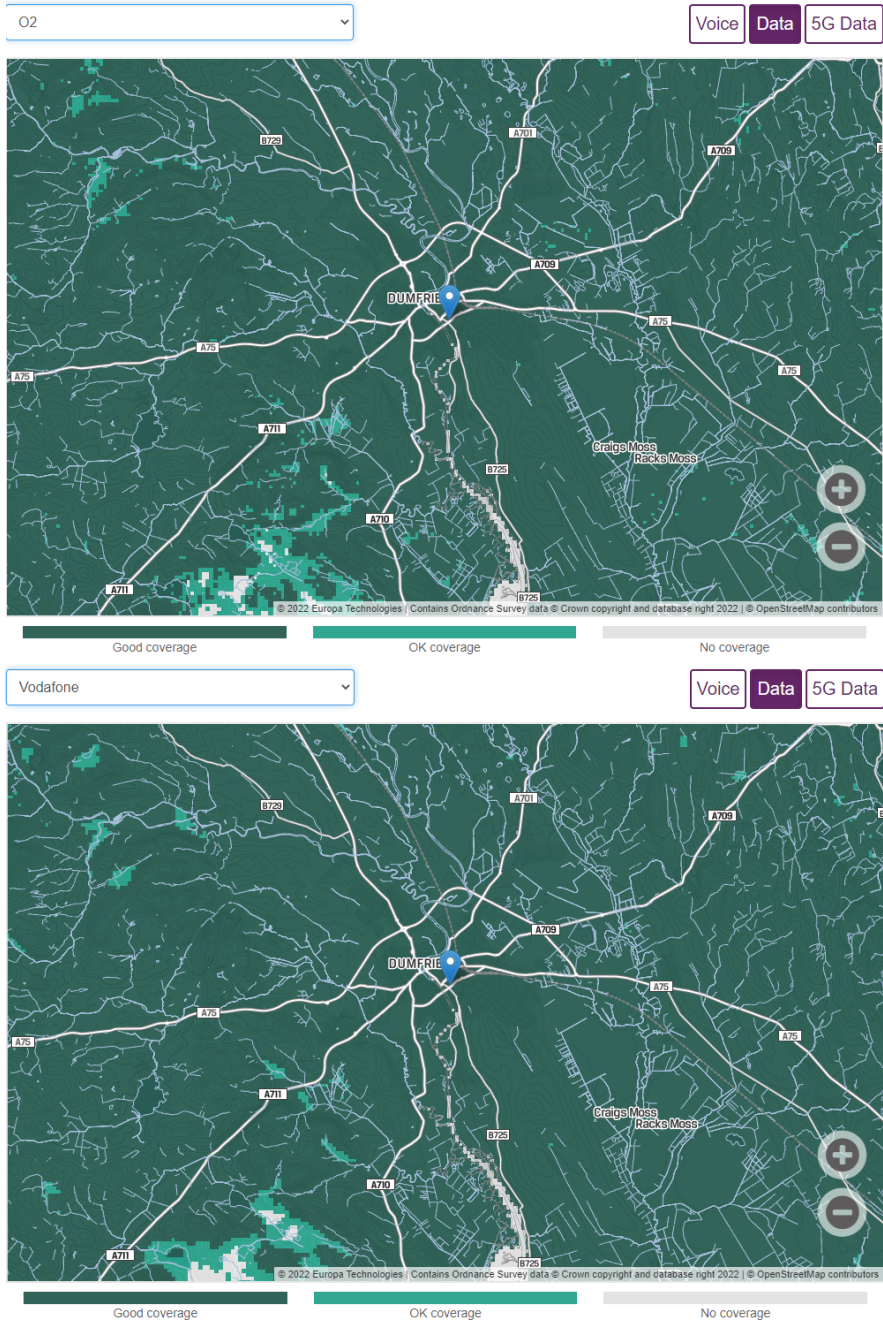
As at July 20th, 2022. Three, top left. EE, top right. O2, bottom left. Vodafone, bottom right. Dark green: good coverage; Light green: OK coverage; Grey: No coverage.

Source: Ofcom's mobile and broadband checker, 2021[6].

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6   Available   at   https://checker.ofcom.org.uk/en-gb/mobile-coverage#pc=DG12PS&uprn=137016962&vw=map.
Accessed on July 20th, 2022.

These results were obtained from the evaluation of each scoring factor on the bottommost layer of the index (see Table 5.3). This assessment fed on the information and data collected from the documentary review, the interviews, and the visit to Dumfries. The scoring followed a colour categorisation based on the index scale where 1: red, 2: yellow, 3: light green, 4: dark green. After scoring each factor, they were averaged to obtain the mean values for each level, as well as the total MaaS readiness evaluation score.

Table 5.3. Dumfries MaaS Readiness results.
Source: adapted from Thanos (2018).

Modified MRI Evaluation for Dumfries									
Pillars	Major Themes	General Topics	Specific Topics	Scoring Factors	Dumfries' MaaS Readiness Evaluation				Averaged Scores
					1	2	3	4	
Supply	Availability of transport, mobility and communication services and infrastructure (33.33%)	Active Transport (6.67%)	Walking (2.67%)	Modal split of walking (1.33%)				4	2.29
				Pedestrian infrastructure (1.33%)			3		
			Cycling (2.67%)	Modal split of bicycle (1.33%)				4	
				Cycling infrastructure (1.33%)		2			
			Bicycle Share (1.33%)	Coverage and service density (0.44%)	1				
				Service functions (0.44%)	1				
				API's (0.44%)	1				
		Public Transport (6.67%)	Public Transport Services (2.86%)	Modal split of public transport (1.43%)	1				1.88
				Public transport infrastructure (1.43%)	1				
			Travel Planner (2.86%)	Coverage and service density (0.95%)				4	
				Service functions (0.95%)	1				
				API's (0.95%)	1				
			On-demand Public Transport (0.95%)	Coverage and service density (0.32%)				4	
				Service functions (0.32%)		2			
				API's (0.32%)	1				

Modified MRI Evaluation for Dumfries									
Pillars	Major Themes	General Topics	Specific Topics	Scoring Factors	Dumfries' MaaS Readiness Evaluation				Averaged Scores
					1	2	3	4	
Supply	Availability of transport, mobility and communication services and infrastructure (33.33%)	Individual Motorised Transport (2.00%)	Personal Vehicle (0.67%)	Modal split of personal vehicle (0.33%)				4	3.33
				Infrastructure of vehicular transport (0.33%)				4	
			Taxi (0.67%)	Coverage and service density (0.17%)				4	
				Coverage and service density of mobile app (0.17%)				4	
				Service functions (0.17%)				4	
				API's (0.17%)	1				
			Individual On-demand Transport (0.67%)	Coverage and service density (0.22%)				4	
				Service functions (0.22%)				4	
				API's (0.22%)	1				
		Flexible Vehicle Access (2.67%)	Rental Vehicles (0.44%)	Coverage and service density (0.11%)			3		2.30
				Coverage and service density of mobile app (0.11%)			3		
				Functions of mobile service (0.11%)			3		
				API's (0.11%)	1				
			Shared Vehicles (1.33%)	Coverage and service density (0.44%)			3		
				Service functions (0.44%)			3		
				API's (0.44%)	1				
			Parking (0.89%)	Coverage and service density (0.30%)				4	
				Service functions (0.30%)	1				
				API's (0.30%)	1				

Modified MRI Evaluation for Dumfries									
Pillars	**Major Themes**	**General Topics**	**Specific Topics**	**Scoring Factors**	**Dumfries' MaaS Readiness Evaluation**				**Averaged Scores**
					1	**2**	**3**	**4**	
Supply	Availability of transport, mobility and communication services and infrastructure (33.33%)	Flexible Trip Access (2.67%)	Private Collective On-demand Transport (0.89%)	Coverage and service density (0.30%)				4	2.23
				Service functions (0.30%)				4	
				API's (0.30%)	1				
			Shared Intraurban Trips (0.89%)	Coverage and service density (0.30%)			3		
				Service functions (0.30%)			3		
				API's (0.30%)	1				
			Shared Interurban Trips (0.44%)	Coverage and service density (0.15%)			3		
				Service functions (0.15%)			3		
				API's (0.15%)	1				
			Other Interurban Transport Services (0.44%)	Coverage and service density (0.11%)			3		
				Coverage and service density of mobile app (0.11%)	1				
				Functions of mobile service (0.11%)	1				
				API's (0.11%)	1				
		Additional Services (1.00%)	Food Delivery Services (0.33%)	Coverage and service density (0.11%)				4	4.00
				Service functions (0.11%)				4	
				API's (0.11%)				4	
			Grocery Delivery Services (0.33%)	Coverage and service density (0.11%)				4	
				Service functions (0.11%)				4	
				API's (0.11%)				4	
			Logistic Services (0.33%)	Coverage and service density (0.11%)				4	
				Service functions (0.11%)				4	
				API's (0.11%)				4	
		ICT Services (11.67%)	Mobile Devices (5.55%)	Availability of mobile devices (5.55%)		2			2.40
			Internet (5.55%)	Coverage and service density of Wi-Fi (2.78%)	1				
				Coverage and service density of mobile internet (2.78%)				4	
			Contactless Payments (0.56%)	Coverage and service density (0.28%)				4	
				API's (0.28%)	1				

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Pillars	Major Themes	General Topics	Specific Topics	Scoring Factors	Dumfries' MaaS Readiness Evaluation				Averaged Scores
				Modified MRI Evaluation for Dumfries					
					1	2	3	4	
Demand	Customer Demand (33.33%)	Demographical Considerations (16.67%)		General demographics of the case city (13.89%)		2			1.50
				Specific demographics of potential early adopters (2.78%)	1				
		Attitudinal Considerations (16.67%)		Attitude towards new mobility services (8.33%)			3		2.00
				Attitude towards car ownership (8.33%)	1				
Regulation	Government Support and Regulatory Environment (33.33%)			Level of political facilitation (9.52%)		2			2.25
				Public infrastructure investments (9.52%)		2			
				Level of stakeholder collaboration (9.52%)				4	
				Data security, privacy, and liability (4.76%)	1				
				Total Average					2.42

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