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Development of Mobility as a Service (MaaS) for intercity travel & rural/island areas: the case study of Greece

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Abstract

The specific features and requirements of island regions and rural areas make Mobility as a Service (MaaS) an attractive and evolving concept in the realm of Intercity/Rural/Island transportation. The primary goal of this research is to provide qualitative insights relative to the added value and development of MaaS for the previously mentioned transport services through a case study from Greece, a country with approximately 250 inhabited islands. In island settings, the primary societal motivation for MaaS is to enhance the accessibility of islands and improve individuals' access to multiple transport services. MaaS is found to have a strong potential to act as an enabler for more efficient transport and better accessibility to remote/island locations, acting in a complementary manner with currently applied "external" measures such as the Greek "Transport Equivalent". To further assess the potential, development and impact of MaaS a focus group comprised by key-representatives from industry and academia stakeholders is created. The MaaS Ecosystem, as described by the experts, is comprised of the MaaS Provider, all the intercity/rural/island transport providers currently operating in the Greek market, MaaS Enabling entities (associations, regulators, investors, research institutions), the Integration Drivers and the customers. The issue of transport providers' liability in case of disruptions and existing market regulations constitute, according to the results, an important challenge towards development of an Intercity MaaS, which needs to be addressed by legislative studies in a pan-European level. Most likely user groups for Intercity/Rural/Island MaaS are young people and digitally educated people, whilst less likely patronage groups are the elderly and "vulnerable" population groups. Relative to the external environment, high degree of fragmentation of the intercity transport industry combined by "autonomous" behavior of actors ("silo effect") appears to be the greatest threat towards MaaS whilst anticipated capital investments in infrastructure and vehicles, which are foreseen in the proxime future, are the greatest opportunities.

Keywords Mobility as a Service (MaaS), Mobility-as-a-Service, Intercity travel, Rural areas, Island areas, Stakeholder Insights

1 Introduction

1.1 Definitions and terminology

Mobility as a Service (for the remainder of this paper abbreviated as "MaaS") is an innovation in delivery of transport services that emerged during the last years. There are numerous definitions in literature for MaaS, a review of which may be found in the work of Sochor et al. [1] and Jittrapirom et al. [2]. Kamargianni et al. [3] defines MaaS as following: "Mobility as a service is a user-centric, intelligent mobility distribution model in which

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all mobility service providers' offerings are aggregated by a sole mobility operator and supplied to users through a single digital platform". It is evident that according to the previous definition MaaS heavily relies on a digital interface to consolidate a plethora of mobility services with varying prices, frequencies, capacities and quality characteristics into one single mobility bundle offered to the end-customer in a unique personalized manner.

To establish a terminology for this study, it is essential to provide clear definitions for the terms "urban" and "rural" that will be utilized throughout this research. While there is no universally accepted definition for the term "urban environment," as acknowledged by Kjærup [4], it is generally understood to encompass not only the city center but also Suburban/Periurban areas, defined as towns within a commutable distance to the city center. Therefore, in the context of this study, the term "urban area" encompasses both a city and its suburbs located within a commutable distance. On the other hand, "rural areas" are defined as non-urban regions, typically sparsely populated, and situated at a considerable, non-commutable distance from urban areas.

1.2 Rural areas, island regions and the development of MaaS

Although relatively new, the concept of MaaS has attracted a lot of attention during the last years resulting in a rapidly growing body of literature. It is generally acknowledged that there is wide research on MaaS in the context of an urban environment (considering only land transport modes), while there are relatively few studies covering the development of MaaS in an Intercity/Rural/Island transport context. Such works are those of Eckhardt et al. [5] and Papaioannou et al. [6]. Given that a substantial proportion (30.6%) of the EU population lives on rural areas [7] and out of those 22.4% are at risk of poverty and social exclusion [7], the provision of reliable, frequent, resilient, and inclusive transport services is of crucial importance for these communities. The application of innovations such as MaaS have a strong potential to contribute towards the latter, as it presents a strong potential in increasing the accessibility of rural areas Alyavina et al. [8], Papaioannou et al. [6], Pangbourne et al. [9], as well as the accessibility to transport services for individuals residing in remote areas Eckhardt et al. [5].

The characteristics of the transportation industry present notable variations across different spatial scales (such as urban, interurban/suburban, regional, long-distance, etc.). The main principles that apply for MaaS in urban areas cannot be extended to intercity/rural/island MaaS in a straightforward manner, as Vasiliev et al. [10] reports, for the following reasons. At first, in urban areas, transit demand is concentrated into a given area which in practice is limited within the limits of a city and its suburbs. On the other hand, rural areas and islands contain relatively few permanent residents, leading to sparce population densities. This difference in the settlement pattern of urban and rural areas is reflected in the service frequency of transport modes [11]. Transport services in spatial scales greater than urban areas usually operate in significantly lower frequencies than urban transit. Allard et al. [12] mentions that achieving a comprehensive understanding of the connections between all available transportation modes is imperative for effectively planning intercity public transport services while maintaining high (subjective and objective) quality of travel for the end-users. Due to the aforementioned points, integration of transport services into one single mobility bundle is particularly difficult in intercity/rural transport, compared to urban areas.

MaaS in Intercity transport & rural areas faces commercial challenges that are not present in urban transportation. According to a plethora of literature sources (Hensher et al. [13], Wong et al. [14], Jittrapirom et al. [2], Kamargianni et al. [15], etc.) the main societal motivation for MaaS in general is to shift from private car ownership and usage to a subscription-based (more sustainable) mobility service. In many European cities, vehicle owners are highly discouraged by authorities/regulators to use their private car through relevant policies. Example of such policies include measures for mitigation of private car use within the city limits (such as London Congestion Charge Zone Toll, Athens Traffic Ring, Denmark's Parking regulations [parking disc] etc.). These policies are designed to promote ridership of non-private transport modes such as public transport, taxi, ride hailing, micro-mobility etc., on which MaaS is based [16]. Consequently, it is reasonable to infer that the previously mentioned car restrictions indirectly promote MaaS to some extent, when/where available. On the contrary, in rural areas/islands conditions are favorable for private car utilization, as such measures do not exist and additionally plenty of parking spaces are available in very close proximity to almost any point. In addition, due to the diverse density and quality of transportation networks in island and rural areas, private vehicles often emerge as the most convenient alternative mode of transportation [17]. This is consistent with Matsuzawa [11], who reported that public transport in rural (and island) areas does not provide adequate level and quality of service, thus private cars become the dominant transport mode in these areas. Consequently, car users need to be convinced that MaaS is a better option for them than taking their private car in order to buy it.

Finally, it worths mentioning that public transport in most cities of the world is highly subsidized by state entities, as it recovers less than 80% of its running cost [18]. As Hensher et al. [13, 19] notes, any attempt from the side of public transport to offer more customer-centric or advanced (on demand) services has been associated with the need for subsidies. On the other hand, transport in rural areas and intercity travel is operated (to a great extent) by private entities (e.g., airlines, ferry operators, bus operators, train operators etc.) and is – to a great extent – profitable. A private entity needs – by default – to innovate in order to prevail over competitive firms or to maintain its market shares. Thus, it is more likely that private companies may invest in MaaS to benefit from its advantages and receive potential new clients or greater market shares.

1.3 Research questions

As analyzed in the previous sections, there is a need to further assess the implications of MaaS in intercity travel and rural/island areas. The aim of this paper is to assess how the MaaS concept can work in intercity travel and rural/island areas, through a case study about Greece. The main research questions that this paper will address are the following:

- What is the Societal Added Value and Business Potential of MaaS in Intercity Transport & Rural/Island areas?
- What are the different Actors that may participate in a MaaS Scheme for Intercity Transport & Rural/Island Areas? How will they interact within a MaaS scheme?
- What is the External Environment (business opportunities and threats) of MaaS in Intercity Transport & Rural/Island Areas??

The remaining paper consists of 4 sections, as follows: Sect. 2 presents a review of current State of the Art and State of Practice on MaaS for Intercity (IC)/Rural/Island transportation. Section 3 presents the research approach of the paper and Sect. 4 presents the results. Finally, Sect. 5 concludes the paper while discussing important findings and their implications for policy makers, industry stakeholders and researchers.

2 State of the art and state of practice

The literature review is mainly based on journal peer-reviewed papers, whilst also includes grey literature (theses) and conference papers. Initially a first search on the Scopus database was performed, followed by search on other reputable databases such as Google Scholar, a "snowball" search in the references cited in the recovered papers and manual search in relevant journals and the proceedings of relevant conferences. Literature review took place during April 2023 and October 2023.

MaaS is an innovation in the way transport services are delivered, and its main beneficial characteristics according to literature are the following:

- One-Stop Shop integration/ Subscription Service: MaaS aspires to bring together several transport modes into one single service [15], which is afterwards offered to customers through a single platform. A registration to the platform is usually required, followed by a subscription [2]. MaaS subscriptions may be either Pay as You Go (PAYG) or package subscription.
- Demand-responsive transport (DRT): MaaS provides transport solutions subject to the customer's requisites [20] and offers to the customers real-time information on their trip.
- Interaction between Multiple Actors: MaaS is highly based on the partnership of several (private/public) actors. The willingness to collaborate and avoidance of "silo" business strategy is essential for successful development and operations of a MaaS scheme [16, 21].
- Customization & Personalization: Travel packages can be customized by the end-users, through the user interface of the MaaS Platform. Additionally personal preferences (in previous similar situations) may affect future MaaS package proposals to its users [2], subject however to sensitive personal data treatment by the MaaS Provider.

Nevertheless, there are often reported some barriers towards the development of MaaS. According to Hasselwander et al. [22] , barriers on the supply side of MaaS outweigh those on the demand side. The main barriers found in literature are:

- Unwillingness of Transport Operators to Collaborate [22] or to share data [16, 22]. Lack of trust between private/public sector or among different entities of private sector is also frequently reported as a barrier (Rehme et al. [23], Hasselwander et al. [22], Pickford et al. [24], Jittrapirom et al. [25].
- Regulatory Framework: The regulatory landscape in numerous countries/regions either imposes challenges or prohibits essential procedures crucial for the development of MaaS (Hasselwander et al. [22], Polydoropoulou et al. [16], Karlsson et al. [26], Eckhardt et al. [5], Surakka et al. [27], Konig et al. [28].

Examples are third-party ticket sales [29], price increase of MaaS bundles because of regulations [16] or inflexible routing of transport modes such as ferries [6].

- Technology-related Barriers: Development and Implementation of MaaS depends largely on availability and exchange of detailed data such as booking, pricing and ticketing data [30]. Availability of Open Application Programming Interfaces (APIs) and standardized data formats are considered crucial for the implementation of MaaS [16], while their absence constitutes a significant infrastructural barrier.

MaaS presents a strong potential to improve the quality of transport services for intercity/rural areas and making them more reliable, efficient, and personalized travel [11]. For this reason, many scholars highlight the need for further investigation of MaaS in intercity/rural travel. For instance, Vasiliev et al. [10], who are discussing the experience from Russia, highlight the development of MaaS in rural areas and intercity transport as an "urgent scientific and practical task". Additionally, Papaioannou et al. [6] mention that numerous stakeholders of intercity/island transportation identify MaaS as a necessity for tourism in the Greek islands and support that MaaS or MaaS-similar transport schemes are going to be developed in the proxime future.

Due to its unique offerings, MaaS is associated with a potential on contributing towards abating the problem of transport poverty in rural areas, as acknowledged by several works such as Nelson et al. [31], Papaioannou et al. [6], Ince et al. [32] , Eckhardt et al. [33] and Eckhardt et al. [5]. According to Gleeson et al. [34], "Transport Poverty" occurs *"when a household is forced to consume more travel costs than it can reasonably afford"*. This phenomenon is strongly present in the majority of the European Islands, as, generally speaking, their residents pay a higher proportion of their income for transport services and simultaneously have a lower GDP per capita than the European mainland population [35]. Transport poverty, according to Lucas et al. [36] is comprised by 4 sub-concepts, which are mobility poverty, accessibility poverty, transport affordability and exposure to transport externalities. One of the main factors contributing to transport poverty is the need for private car ownership and utilization due to the lack of quality public transport alternatives [36]. According to Pritchard [37], MaaS aspires to be one of the potential solutions to the problem of car dependency, thus it also has a positive impact on transport poverty. MaaS is found to increase accessibility of a region as according to Schweiger [38] it aspires to offer both door-to-door mobility services without car ownership needed and a better level of service than private cars. Also, MaaS increases accessibility to transport, having a positive impact on the total expenses that households spend for transportation services Eckhardt et al. [5], Karlsson et al. [39]. Finally, it has the potential to create new markets through the dynamics it creates on transport data availability, which allow transport businesses to become aware of currently unexploited and non-serviced travel demand [20].

The potential of MaaS in intercity travel and its contribution to enriching and modernizing current services remain to a high degree unexplored, as – to our knowledge – relevant literature is scarce compared to its urban counterpart. Merkert et al. [40] notes that transport operators in intercity scale face the issue of potential travel cost increase in case of disruption more frequently and to a greater extent than urban transport providers. Transport on different spatial scales has been developed on different commercial bases, thus, they have totally different approaches to mitigate the impact of disruptions. Merkert et al. [40] highlight the assumption that "intercity travel operators are more aware than urban transit providers relative to the profiles and needs of their customers" as a potential drive for collaboration of intercity travel providers in institutional level (similarly to IATA in air transportation). IATA has played an important role in enabling cooperation between airlines through alliances, joint ventures and code-sharing agreements. Consequently, customers may perform a single booking and payment for all the components of their trip, even if operated by different airlines within the same alliance. Utilization of the same GDS (Global Distribution System) provided by IATA is a key fact for the latter. The same principle is proposed to be applied to other transport industries such as rail or ferry.

As already mentioned, the greatest challenge for development of MaaS in intercity travel and rural/island areas is to combine its offerings with the transport market's status quo. As seen in Table 1, service area, type of travel, frequency of services, booking options and ownership of transport businesses alternate significantly between urban, rural and intercity travel. A comparative analysis based on Merkert et al. [40], Hensher et al. [13] and Papaioannou et al. [6] is performed in Table 1.

Industry experience in MaaS for intercity and rural-area transport is also limited compared to its urban counterpart. A desktop review of schemes was performed, as well as a review of the academic literature that describes such schemes, such as Mulley et al. [41]. Figure 1 shows current industry experience on MaaS for Intercity Travel/Rural Areas.

The Schemes reported on Fig. 1 are operated either by National/Local Rail Operators (such as NS Business Card, Qixxit, Willer, Izuko), Public Transport Authorities

Table 1 Comparison of intercity transport market with urban and Rural/Island transport. Own Elaboration from Merkert et al. [40], Hensher et al. [13] and Papaioannou et al. [6]

Attribute	Urban transport	Rural & Island Areas transport	Intercity travel
Service Area	Urban Areas	NUTS2/NUTS3 Areas	National
Type of Travel	Mainly Short Trips for Commuting	Longer than urban areas, sometimes commuting	Long/Overnight trips
Booking	No pre-booking	Pre-booking may be available	Pre-booking Required
Service Frequency	Very High	High, but Lower than urban areas	Low
Operator's Ownership Status	Mainly Public Sector/Some Private Companies	Mainly Private Sector/Some Public Companies	Private Sector/Some Public Companies

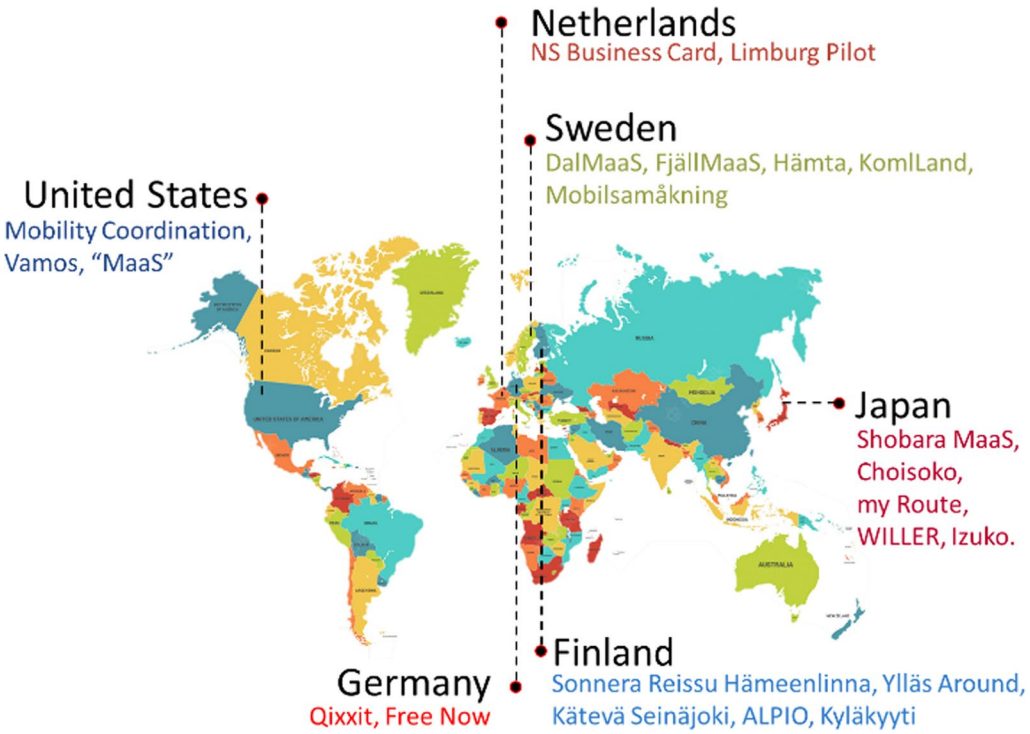

Fig. 1 MaaS in Rural and Intercity Travel Context. Sources: Mulley et al. [41], Roumboutsos et al. [42], Own Desk Research, Own Elaboration

(such as Kätevä Seinäjoki) or Local Civic Organizations (such as Mobilsamåkning, DalMaaS etc.). Mulley et al. [41] mentions that MaaS in rural areas is mostly implemented by pilots, which have a short active period. According to the same authors, there are enough indications that the technological readiness for MaaS exists, and consequently the research community should focus on the analysis of the Intercity/Rural MaaS Ecosystem (i.e. Actors and their role) and the development of adequate business models. This paper contributes towards the latter.

More specifically, this work aims to fill the previously described research gap through further enlighten how MaaS can be developed in a national-level area (including intercity, rural and island area trips). For this purpose, Greece is selected as our case study as a country with about 250 inhabited islands, where 17% of the total population lives. Implementation of a national-scale MaaS in such a state is particularly challenging due to the small populations living over vast areas and/or numerous remote islands.

3 Research approach

In order to gain insights on how MaaS can be developed for both intercity travel and rural/island area transport services in Greece, the following methodology (Fig. 2) comprised of three sequential steps has been developed and applied. The first step includes a thorough literature

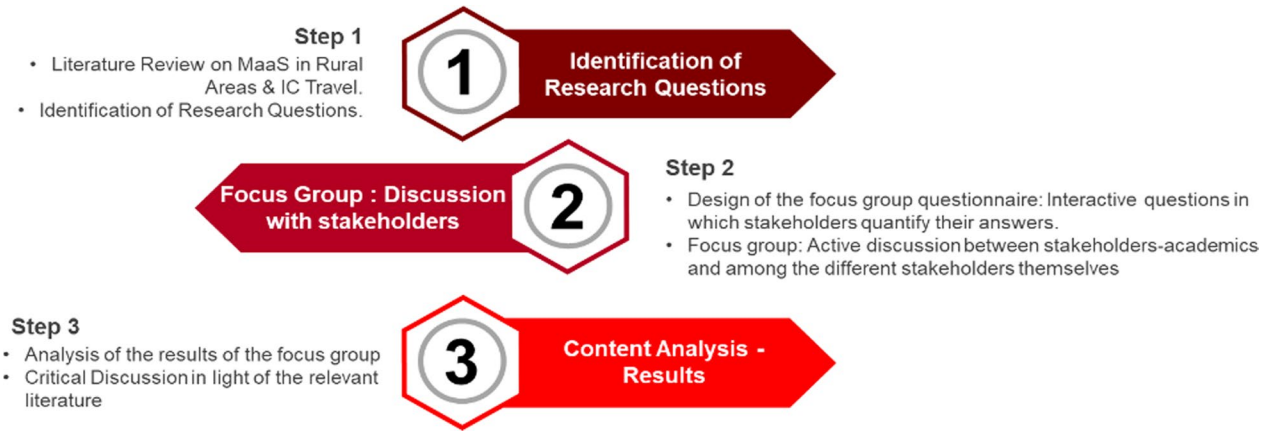

Fig. 2 Research Methodology

review to acquire insights on the existing knowledge and research initiatives on MaaS for IC travel and rural/island areas, as well as desk research and analysis of existing IC related MaaS applications. The second step concerns the implementation of a focus group with 8 representatives from both industry and academia. A focus group is highly based on the assumption that "The perspectives, insights, and recommendations from individuals possessing strong academic expertise and substantial industry/professional experience in a particular field (often called "experts") are considerably more likely to be accurate than those from individuals with limited or no experience on the same field". All the participants of the focus group were selected based on their experience in the passenger transport industry or MaaS and have at least 15 years of experience in their field of expertise, thus they may be considered as "experts". Finally, in the last (3rd) step we analyze and critically discuss the information gained through the previous steps.

Figure 3 indicates the structure of the focus group, the participants' status and its duration. The focus group was comprised of 8 people from both industry and academia,

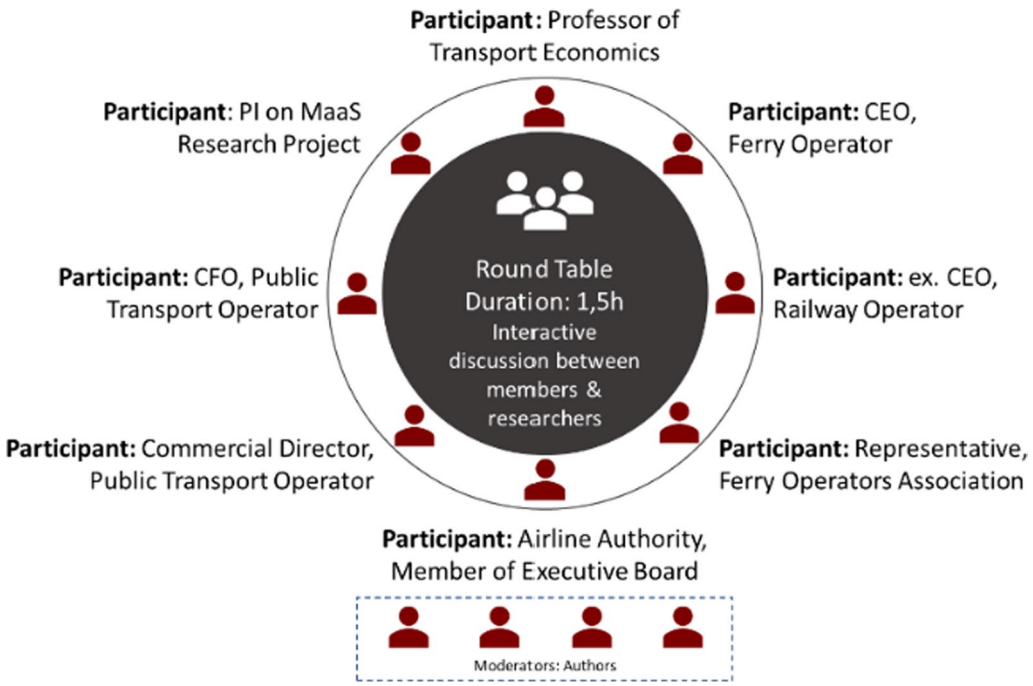

Fig. 3 Structure of the Focus Group

and had a total duration of 90 min. The topics that were discussed were relevant to the business potential of MaaS, the contribution of MaaS as an enabler of efficient and sustainable transport, MaaS Actors and their interactions, potential revenue allocation and external environment. The focus group was recorded, and content analysis was performed to classify the information gained in the focus group into different thematic topics, which are analyzed in the next paragraphs.

During the focus group the guests were highly encouraged to share their views with the other participants. In addition to verbal discussion among stakeholders, all of them had the opportunity to vote (through the utilization of their smartphones) on questions presented by the researchers, facilitating the quantification of their perspectives when required.

4 Results

4.1 The business Potential of MaaS

Currently, there is no previous experience in Intercity MaaS in Greece. However, the experts indicated three existing travel integration packages that have MaaS characteristics, shown at Table 2.

According to experts, the technological readiness for MaaS exists in many, but not the total of transport businesses. Air transport, Maritime Transport and Railway are at a higher level of technological readiness than other modes, as also reported by Papaioannou et al. [6]. The majority of intercity transport businesses in Greece offer online booking and ticketing, at least for long-distance routes (interregional or intercity). All the Greek airlines offer online booking and purchase of tickets for all their available routes, whilst the ferry industry uses two Computer Reservation Systems (CRS) systems for bookings and ticketing of all ferry tickets within the country. Train operators (a monopoly at the moment) offer online booking and ticket purchase between any origin-destination (O-D) pair of train stations and the majority of intercity public bus operators offer online ticket purchase at least for the intercity routes. Availability of online booking and ticketing infrastructure is essential for development of MaaS [30]. Furthermore, MaaS also requires data exchange and dynamic data (e.g., real-time traffic data, disruptions, etc.) according to Polydoropoulou et al. [16]. As a result, the technical aspects of data exchange (data formats, APIs) need to be addressed for the development of MaaS.

The experts highlighted that the primary challenge for MaaS in intercity travel and rural/island areas is the increased level of complexity compared to its Urban counterpart. All of them agreed that MaaS can be applied in intercity travel but numerous barriers currently exist as analyzed in the next paragraphs.

One of the main barriers/constraints that were mentioned by the experts is the liability of transport providers in case of disruptions. Especially from the participants coming from the maritime transport sector, this issue was strongly indicated as very important, due to the relatively high degree of uncertainty with which passenger maritime transport is associated. More specifically, long-distance ferries are frequently experiencing delays due to "force majeure" conditions such as unexpected bad sea/wave conditions or potential obligatory involvement on Search and Rescue (SAR) Operations (especially in the East Aegean, in which refugee crises arise often). On the other hand, land transport providers mentioned that for land transport the issue of liability may be resolved more easily, due to the lower degree of uncertainty that land transport modes have, compared to sea travel.

In 2018, the European Package Travel Directive came into force, which defines 6 types of package travel. Thus, as highlighted by the participants, at the moment, if one books simultaneously travel tickets and accommodation through the site of an airline, the airline is liable in case any issues arise relative to the accommodation. According to the experts, the issue of liability is less important for travel packages in urban areas as negative consequences from disruptions are negligible or of minor importance, compared to medium/long-distance travel. Potentially for this reason, as the majority of MaaS literature focuses

Table 2 Currently Existing Intercity Travel Packages with MaaS Characteristics in Greece

Name of package	Provided by	Description
Train + Taxi	Trainose (since 2022 renamed "Hellenic Train" – rail operator)	Customer buys a door-to-door package, including intercity travel by train and taxi ride for the first and last mile of the trip
Sail & Rail	Attica Group (ferry operator) in collaboration with Hellenic Train (rail operator)	Includes 1 round trip between Italy and Greece within a 1-month period, 30% reduction on all accommodation changes, Free TRAINOSE rail/bus transfer from the international port of Patras to the domestic port of Piraeus, Unlimited ferry trips on the Greek islands within a 1-month period & 30% discount on all additional trips (beyond the 6 days)
Aegean Travel Packages	Aegean Airlines	Booking of Flights and Accommodation package

on urban areas, operators' liability is in general rarely addressed as a barrier. Pagoni et al. [43] recommends that the EU Commission should take actions in order to develop a pan-European regulatory plan for passengers' rights for multimodal transport chains. Another interesting suggestion found in the academic literature is the participation of insurance companies on the MaaS ecosystem, as indicated by Kamargianni et al. [15]. According to this work, MaaS unveils fresh business prospects for insurance companies, offering them opportunities to broaden their portfolio and increase revenue.

A considerable barrier towards IC/Rural MaaS in Greece, according to the experts, is that Greek transport market is still highly regulated. At the moment KTEL (Local Associations of Public Buses) are the only entities allowed to provide intercity travel by bus. KTEL are allowed to operate only within their local area (defined as the NUTS3 (Nomenclature d' Unités Territoriales Statistiques Level 3) region: every KTEL is a monopoly within its region) and between the capital of their NUTS3 and any other capitals of other NUTS3 regions of Greece. Private entities (e.g. tour operators, bus companies etc.) may offer only services that are characterized as "tours"/"private transport" or "paratransit". In no case they are allowed to provide scheduled transport services for the public, according to current law. Additionally, taxis have constraints on carrying passengers outside the city that they are legally based, and a public service vehicle license or a taxi license is a prerequisite for offering ride hailing services according to the existing law (No. 4530/2018). The legal framework for ferry routings (Law 2932/01) does not allow (in the general case) routings of ferries for duration less than 1 year, leading to possible shortage of capacity in many links during summer season. Transport industry regulations need either minor or major revisions, depending on the transport sector, to enable the development of Intercity MaaS in Greece. Similar findings are also reported by the literature; strict regulations are identified as a barrier towards the development of MaaS according to several sources, such as Hasselwander et al [22]. Polydoropoulou et al. [16], Karlsson et al. [26], Eckhardt et al. [5], Surakka et al. [27], Konig et al. [28], etc. For instance, in many countries it is not allowed to third parties other than the operators to sell transport tickets [29] or in some cases, such as Budapest, the prevailing legal framework makes the price of a MaaS bundle/ticket more expensive than the same ticket sold directly from the operator to an individual [16, 21].

The issue of personal data processing and storage was imposed by stakeholders as important to be resolved for successful application of MaaS. The same concern was also expressed in the work of Cottrill [44] who mentions that General Data Protection Regulation (GDPR) may affect the development of MaaS in the future. MaaS platforms should facilitate "privacy by design", and all involved parties of a MaaS Scheme should have a consistent and clearly conveyed to the user approach on personal data treatment.

4.2 MaaS as an enabler of a more efficient transport network for small islands

As already discussed in both paragraph 1.2 and Sect. 2, limiting car use and shifting towards subscription-based mobility (considered as more sustainable) is at the moment reported in literature as the main societal motivation for MaaS. However, in the island context, sea and air transport are the only available modes for connection with mainland or other islands. In this case, the main societal motivation for MaaS is to enable a more just and efficient transport system through increasing accessibility of remote islands, reducing transport poverty, and improving perceived/objective quality of transport in the island regions.

According to the experts, provided that adequate revisions to legal framework will be performed, MaaS shall contribute to a more efficient and sustainable maritime transport network in Greece, through enabling the "Least Sea Distance" model. One of the primary modifications that are required is the recognition of a "hub & spoke" service between a small island and the capital of its NUTS3 region (i.e. a trip: Origin – Stopover Port – Destination) as equivalent with a direct service. Law "2932/01" does not recognize "hub and spoke" services as "transport services" and requires only direct services to be performed.

The principle of a "Least Sea Distance" transport network is at the moment applied in several remote island clusters. A specific example of such island cluster is the Faroe Islands in the North Atlantic. Long-Distance Ferry from North Denmark (Hirtshals) or Iceland (Seyðisfjörður) calls only in the capital (Torshavn), where the airport also is located. Then the traveler may reach the majority of the Faroese Archipelago in no more that 3 h through combining bus and local ferry. The transport network of the Faroe Islands is depicted in Fig. 4.

The "Least Sea Distance" principle may be transferred to the Greek islands as well, according to the experts. Similarly to the Faroese Archipelago, Greece has numerous clusters of remote islands comprised by several small islands near a larger one. Such examples are Irakleia, Schinousa, Koufonisi and Donoussa all located near Naxos, Antiparos located near Paros, Kimolos located near Milos and Oinoussai & Psara located near Chios. The "Least Sea Distance" Transport network (as proposed by the experts) shall be applied to the previously mentioned cases, considering however the special

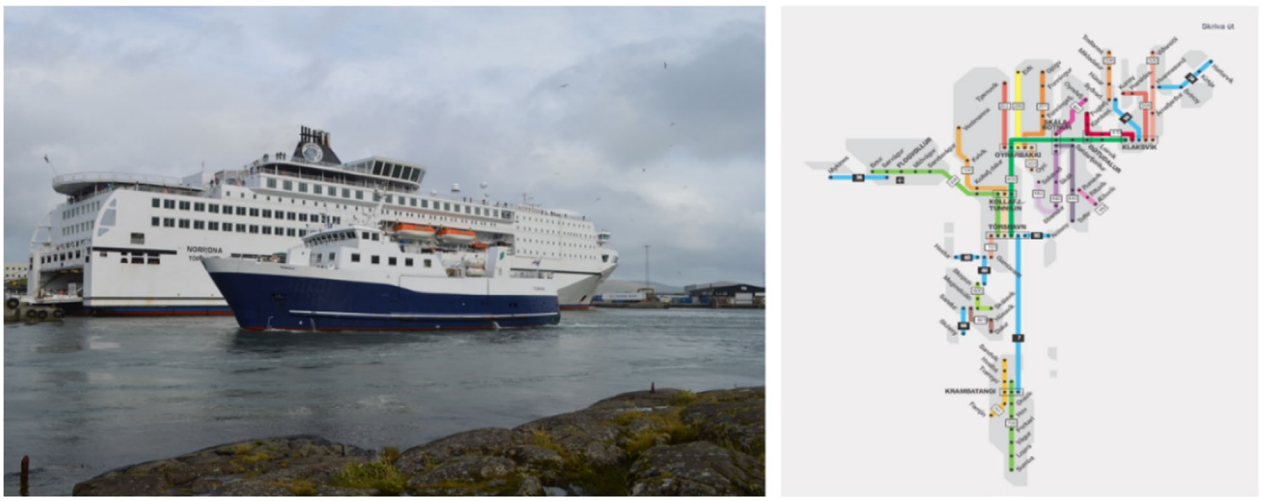

Fig. 4 "Least Sea Distance" Transport Network in the Faroe Islands. Long Distance Ferry & Local Ferry (left) and map of the network (right), showing sea connections in blue color. Source: Own picture, map from: transitmap.net/faroe-islands/

geographical aspects of each area. A specific example of a "Least Sea Distance" transport network in Cyclades, as highlighted by the experts during the focus group, is depicted in Fig. 5. In this example, the ferry from Piraeus (green and red line) calls in the capital of Paros (Parikia) and then a traveler may reach small Cyclades (the islands south of Naxos) faster, through an intermodal transport chain of 2 bus trips and 2 sea trips (indicated by blue lines on Fig. 5). Of course, the traveler may also reach Paros or Naxos through air transport as well, similarly to the Faroese archipelago where one may reach Torshavn from mainland Europe either by ferry or plane.

A similar finding is presented by the work of Panou et al. [45]. According to Panou et al. [45], service bundling is significant for increasing market penetration of low share transportation services, provided however that the entity which provides the service bundling selects the optimal bundling strategy among "pure bundling" and "mixed bundling". Depending on the competition status of different markets, "pure bundling" (i.e. offering of only the bundle and not the individual services) is a good option for non-competitive markets, whilst "mixed bundling" (i.e. offering of both the service bundle and the individual services) is a good option for competitive markets. In the case of Fig. 5, the experts highlighted during the focus group that the "mixed bundling" scheme is preferable.

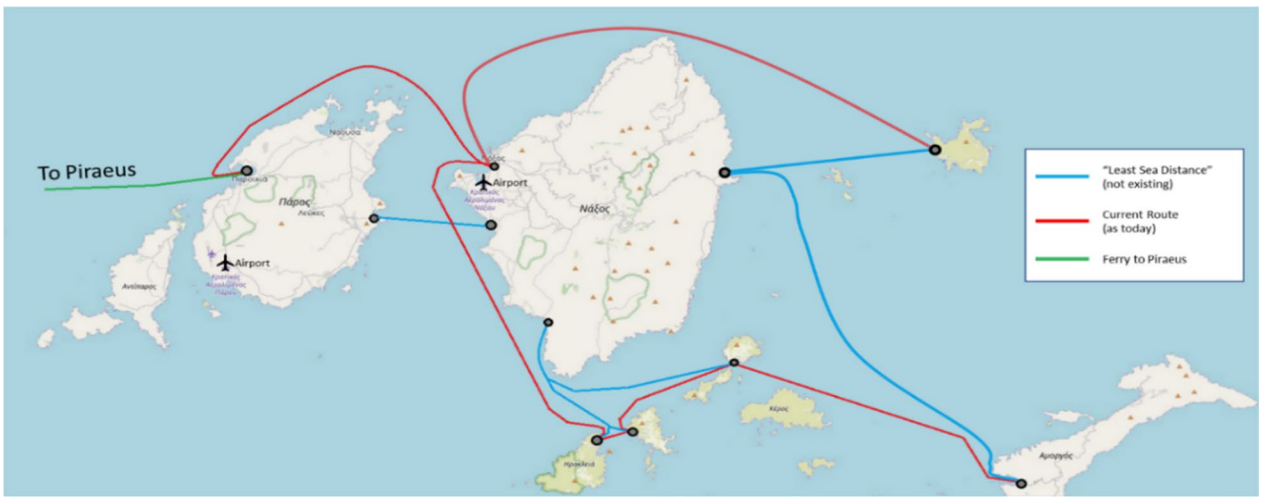

Fig. 5 A "Least Sea Distance" Ferry Network in the Cycladic Islands proposed by the experts. Own elaboration

As already mentioned, MaaS has plenty of advantages such as the ability of offering to end-users personalized and seamless planning and payment of a multimodal transport chain. These natural advantages of MaaS can act as enablers for the development of a multimodal transport network in the islands, as the one in Fig. 5. Thus, through combining maritime/air transport with local land transport in islands, one may reach small islands in a faster and more efficient way than taking a direct ferry from Piraeus. The latter is also beneficial for operators as it provides economies of scale and network economies to them. As a result, MaaS can be considered as an innovation that has a potential to increase accessibility of small islands.

4.3 Main actors of an IC/rural MaaS scheme – the MaaS ecosystem

All the experts recognized "all available transport modes for intercity and rural areas travel" as "essential" for being core partners of an IC/Rural Travel MaaS Scheme, but always considering the infrastructure constraints and special needs/requisites imposed by the geography of specific areas.

All the participants of the focus group coming from transport operators emphasized the importance of public transport services as the "connecting link" between different intercity modes. For instance, for an intercity trip between Thessaloniki and Paros, using train between Thessaloniki and Athens and ferry/air transport for the route Athens-Paros, public transport is the link between the Central Railway Station of Athens and either the Port of Piraeus or the Athens airport respectively. A potential major disruption in the Athens public transport network could lead to a missed sail/flight. Similarly, in the "Least Sea Distance" network of Fig. 5, bus connections between two ferry terminals on the same island (and their reliability) play crucial role as they are the "connecting links" between the successive ferry trips towards small islands.

Additionally, according to the experts, infrastructure operators in small islands need to participate in the MaaS scheme, collaborating with ferry operators and local public transport/taxi providers in order to secure the optimal management of their (limited) capacity. This will lead to a better level and quality of service than "business as usual", in which each one of the previously mentioned modes operates in a "selfish routing" manner. Finally, tour operators are recognized as "experts" in planning and management of current multimodal transport chains in Greece by all the participants of the focus group. Consequently, the involvement of tour operators in a MaaS scheme, at least as enablers, would be beneficial in terms of added knowledge and experience. Tour operators may be core partners of a MaaS scheme as well, as they can ease the degree of complexity that arises when planning a multimodal transport chain for passengers through: (i) "consolidating" different passengers in a paratransit service (nowadays tour operators offer paratransit services regularly, especially when referring to airport/port transfers) and (ii) offering advice and support to passengers regarding their accommodation and activities.

Based on the experts' input and discussion during the focus group, the MaaS Ecosystem for Intercity and Rural/Island Transport is defined as shown in Fig. 6. A business ecosystem is the equivalent of a natural biological ecosystem and refers to defining all the actors of a business sector and the interactions among them. The MaaS provider is the key entity of the MaaS Scheme, as its role is the integration of separate mobility services into one single product, which is distributed to end-users. MaaS Core Partners are the Intercity and Rural transport mobility providers, which include "all available transport modes for intercity and rural areas travel". Their role is to physically provide mobility to MaaS customers. Also, as highlighted by the experts, the role of ferry terminal operators or airport operators as the interface between different IC transport providers is essential, and thus those actors should be considered as "core partners" as well. E-Ticketing providers and software developers act as Integration Drivers as they develop the APIs, Ticket Distribution Systems, applications and user interfaces that are needed for the implementation of MaaS.

There are various Actors that may be involved in the development of Intercity/Rural MaaS without having

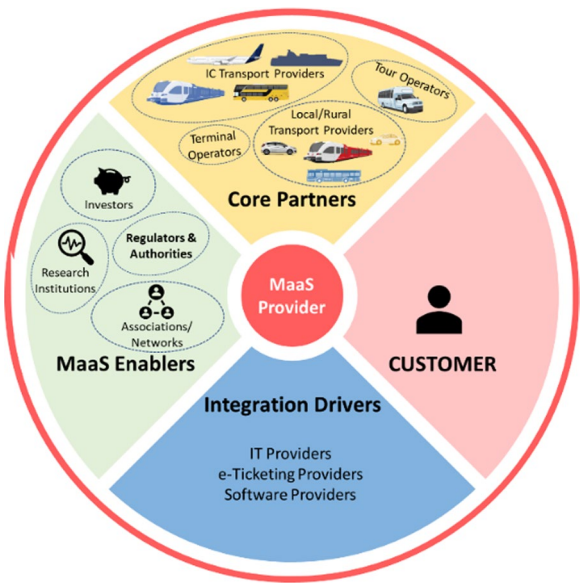

Fig. 6 MaaS Ecosystem for Intercity and Rural Transport in Greece. Own Elaboration based on expert's input

direct role to it. Those stakeholders act as "Enablers" of MaaS. For instance, regulators/public authorities need to balance the protection of consumers' rights with a culture of experimentation in order to enable the continuous improvement and upgrade of existing mobility products through MaaS. The role of Associations as MaaS enablers is of great importance as they may enable and enhance collaboration between several actors of a transport sector (e.g. the ferry sector, the rail sector etc.). According to the experts, associations (which in practice are comprised by businesses that share the same external environment) may have an active role in developing the technological assets that are needed for MaaS, for instance a common CRS system. Also, associations may enhance commercial collaboration between transport providers, which in Greece currently exists in ferry sector (in terms of joint ventures). A similar finding is reported by Merkert et al. [40] who indicate that the role of IATA has been crucial in the development of common-basis e-ticketing systems and distribution capability standards globally. Research institutions assess the economic reasoning and technical innovations behind the development of a MaaS Scheme. Finally, investors are essential for the successful establishment of MaaS, as according to Pagoni et al. [43] the development of technological assets needed for MaaS can be a significant burden for MaaS actors, especially the smaller ones.

The customer is the end-user of the MaaS product. Customers are those who express their requirements on the platform of the MaaS Provider relative to the end product (e.g., availability of each mode in the package, time of departure, PAYG or Package integration, place of departure/arrival, etc.), and after receiving feedback from the provider they may buy the integrated mobility product.

Figure 6 depicts the MaaS Ecosystem (Actors and Interaction among them) for IC/Rural Transport:

4.4 Operator of a MaaS scheme

The MaaS Provider may in general be either a public entity, a private entity or a combination of the previous formulating a Public Private Partnership (PPP). The experts had different views on which of the three options (Public, Private or PPP) is the optimal. However they all agreed in the principle that "The MaaS Provider should bring added value to the total MaaS product in order to offer to the end-users an attractive product". According to the majority of the experts, a private or PPP operator would be better than a public authority as (i) At the moment only private operators have the technical assets needed for the development of MaaS and (ii) As the experts said "*Consumers' rights may be better protected in legal disputes that may arise between two private entities (an individual MaaS User and a private/PPP corporation) due to the fact that these disputes are, according to current experience, easier and faster to resolve than those between an individual (the MaaS user) and the public sector*". All the participants of the focus group also agreed that a private/PPP operator has flexibility advantages over a public operator. A private/PPP MaaS operator would avoid bureaucratic burdens/requisites that are often present when referring to the Greek public sector. However, public authorities or publicly owned transport operators according to the experts, need to be present in a MaaS Scheme due to the social character of several transport services, such as ferry/air transport services in remote islands.

A practical difficulty in the establishment of a PPP MaaS operator would be, according to experts, that the public part of the PPP (e.g. an authority) needs to legally justify why it chooses to collaborate with the specific private partners that are involved in the MaaS Scheme (and not other partners that may attempt to develop a competing MaaS scheme). Public entities (mainly public transport operators), in order to participate in a MaaS Scheme need to have – according to the experts – the flexibility (from a legal perspective) to collaborate with any private entity whenever they consider a business opportunity in the same manner that private businesses do. This is a prerequisite, according to the focus group, for public entities, to participate in a MaaS scheme.

The potential of tour operators acting as the MaaS Operator was also discussed extensively during the focus group by the experts. According to them, the entity that will undertake the role of MaaS operator should preferably be one that operates in multiple regions, rather than a single region only. This is also in accordance with current practice: as already mentioned both Qixxit and NS Business Card MaaS schemes are operated by national-level railway operators, and also WILLER is operated by a local train operator. As the Greek railway network has very low spatial coverage compared to Germany and the Netherlands, and intercity bus travel (KTEL) is fragmented to NUTS3 regions, there is potential for significant involvement from large-scale tour operators to even undertake the role of the MaaS Operator. This can be attributed to their national-level experience in planning and offering tourism packages, frequently integrating both transport and accommodation. Also tour operators have great experience in offering paratransit services (i.e., "consolidating" various passengers into one single service from multiple origins towards a single destination or vice versa). Finally, they are experts in advising and supporting passengers with their bookings for transport (especially ferries towards the islands) and

accommodation, an essential task for MaaS that adds significant value to it.

The revenue allocation among MaaS partners was addressed by the participants as one of the most important parameters of a MaaS Scheme. According to the experts, it is very important before the final setting of the MaaS scheme to ensure that the proposed revenue allocation model is clearly defined for all participants. There is currently no previous experience in Greece on MaaS revenue allocation, thus a "prototype" needs to be built and further research needs to be performed on this field. The revenue allocation model of MaaS (depending on the governance model selected: MaaS Broker or MaaS Coordinator) constitutes an essential part of the legal terms in which different partners should agree, according to the experts. Finally, after a relevant question by the researchers, the stakeholders agreed that in a MaaS scheme there may be actors that participate with limited role, only in order to add value to the bundles available, although very few MaaS Subscribers may include these actors' products in the MaaS bundles they create/buy.

4.5 Potential user groups

Digital education of users was addressed by the focus group participants as extremely important for the successful application of MaaS in IC travel. According to the experts of the focus group, the most likely users of IC/Rural MaaS are young people and people who are generally familiar with digital technology. On the other hand, elderly people and "vulnerable" population groups are less likely to become IC MaaS users. The former is in accordance with Roh et al. [46] who mention that during their research elderly people were found to have significant difficulties with MaaS applications. Also, O'Hern et al. [47] report that private motorized transport is the most frequent transport mode utilized by elderly people. Given the fact that the highest level of digital skills is found in residents of cities [7], residents of rural areas and islands may be considered as potentially less familiar with digital technology. Thus, the user interface of a MaaS platform and its user friendliness is crucial for its success.

The participants of the focus group were asked to quantify on a Likert Scale (1–5) how likely is that each of the following groups will use IC/Rural/Island MaaS. In this scale 1 represents "Not at all Likely", 2 stands for "Slightly Likely", 3 for "Somewhat likely", 4 for "Likely" and 5 is used for "Extremely Likely" The average score (1–5) of the experts' answers (N = 8) is shown in Fig. 7:

As seen the least likely group to use MaaS are families (who are usually dependent by private car) and vulnerable groups, such as elderly or people with mobility limitations.

4.6 MaaS external evironment

The external environment of a business is comprised of multiple factors that are beyond of its control, but affect both directly and indirectly its operations, revenues, and constraints. During the focus group, the experts were provided with seven elements (previously found in the literature), and were asked to evaluate whether they are considered as "threat" or "opportunity" for the development of IC or rural MaaS in Greece, and a discussion of the findings followed. Quantification was based on a scale between "–2" and "2", where "2" stands for "Strong Opportunity", "1" stands for "Opportunity", "0" stands for "Neutral", "-1" stands for "Threat" and "-2" stands for "Strong Threat".

Figure 8 presents the mean values of the answers provided by the experts. The experts consider that the "Need for Investments in New Infrastructure" and the "Need for Investments in Vehicles" are opportunities, since both infrastructure and fleet in IC transport are foreseen to undergo important upgrades in order to facilitate the future transport demand. This is an opportunity for MaaS, as the involvement of the option of MaaS in planning of new infrastructure and transport operations presents a strong potential of increasing efficiency and offering economies to all involved parties. The same principle also applies to "Decarbonization of Transport Industry". MaaS will be, according to the experts, associated with the development of on-demand services which deploy smaller vehicles (such as small ferries, or electric minibuses) and are able to run solely on renewable energy sources due to their lower energy consumption.

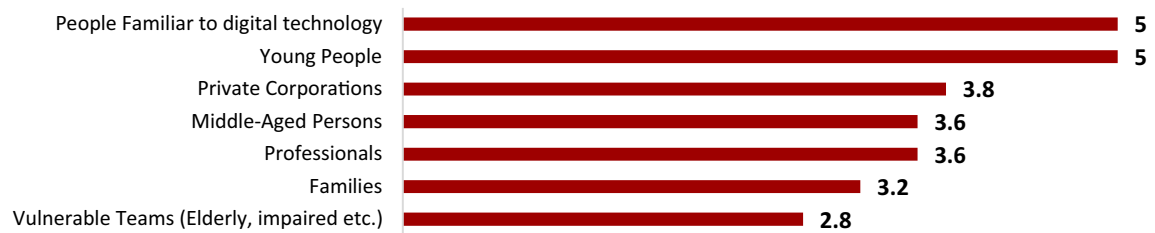

Fig. 7 Potential User Groups of IC/Rural MaaS for Greece. Source: Experts' input, own elaboration

Fig. 8 External Environment for MaaS in IC/Rural Transport in Greece. Source: Experts' Input, Own Elaboration

On the other hand, market regulations and the car ownership index (vehicles per capita) are classified as threats, as they act against the development of MaaS. Pritchard [37] also highlighted that for the case of IC MaaS/Rural Area MaaS, end-users who are not captive riders of public transport will need to be convinced that MaaS has added value to them for switching from private car to multimodal transport chains offered by MaaS (Fig. 9).

The experts were finally asked to quantify the importance (on a Linkert scale between 1 and 5) of the following threats for the development of MaaS. In this scale, 1 stands for "Not Important", 2 for "Slightly Important", 3 for "Important", 4 for "Very Important" and 5 for "Extremely important". As expected, the silo effect (generalized "autonomous" behavior of a business and total unwillingness to collaborate) is highlighted as the most important threat of all. This is in accordance with the previous works of Eckhardt [5] and Pagoni et al. [43]. On the other hand, lack of trust among various stakeholders is highlighted as "Important" for all the different categories. The experts consider that trust can be built among different stakeholders over time through continuous effort, negotiations and development of a "cooperation culture". Lack of technological readiness or unwillingness to share data are both classified as "Very important" threats, as expected.

5 Conclusions

The characteristics of MaaS described in the previous sections make it an attractive and evolving concept in the realm of Intercity/Rural/Island transportation. MaaS allows users to plan, book, and pay for multiple modes of transportation through a single platform, a fact that significantly improves passengers' experience, as trip chains from/towards islands (or even sometimes rural areas) are by definition multimodal. However, as already mentioned, to our knowledge, there is scarcity of literature for the development of MaaS in non-urban environments. Table 3 summarizes the main societal added value of Intercity/Rural/Island MaaS along with the main barriers associated with it, compared to urban MaaS.

The main added value of Intercity/Rural MaaS is different than the one of Urban MaaS, which is the transition from private car ownership/usage to a subscription-based mobility service. As already discussed, IC/Rural/Island MaaS offers the integrated planning and seamless payment of multimodal chain trips, which may: (i) increase the accessibility to remote regions and accessibility of their residents to transport through reducing the

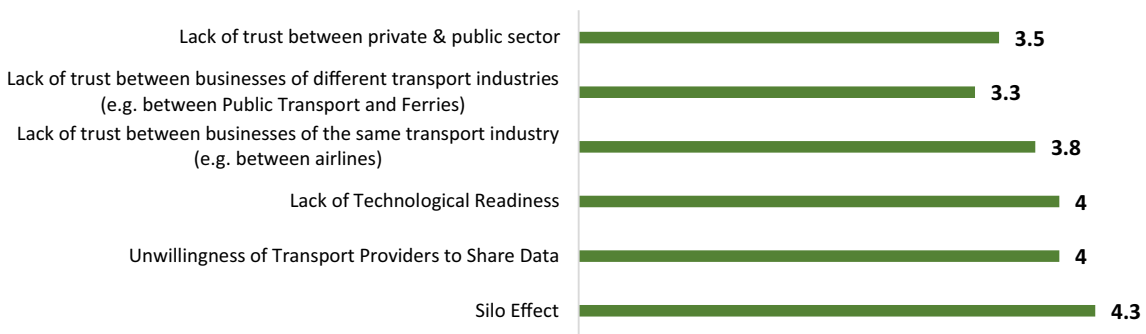

Fig. 9 Challenges for MaaS in IC/Rural Transport in Greece. Source: Experts' Input, Own Elaboration

Table 3 Main Societal Added Value of IC/Rural MaaS and main barriers, compared with urban areas

	MaaS for Rural, Intercity and Island Transport	Supported by:	MaaS in Urban Areas	Supported by:
Main Societal Added Value:	Increasing accessibility of remote areas and accessibility to transport services	This work, Papaioannou et al. [6], Eckhardt et al. [5]	Shifting from Car utilization to more sustainable transport modes	Hensher et al. [19], Wong et al. [14], Jittrapirom et al. [2], Kamargianni et al. [15]
	Planning of better connections in intermodal trips to increase perceived/objective quality of service	This work, Allard et al. [12]		
	Reducing Transport Poverty	This work, Nelson et al. [31], Papaioannou et al. [6], Ince et al. [32] , Eckhardt et al. [5]		
Main Barriers Towards MaaS:	Unwillingness to collaborate/ cooperate	This work, Eckhardt et al. [5], Rehme et al. [23]	Unwillingness to collaborate/ cooperate	Pagoni et al. [43], Polydoropoulou et al. [16]
	Liability of Operators in case of disruptions	This work, Pagoni et al. [43]	Lack of Standardized Data formats and APIS	Pagoni et al. [43], Polydoropoulou et al. [16]
	Regulatory Framework	This work, Papaioannou et al. [6]	Regulatory Framework	Hasselwander et al. [22], Polydoropoulou et al. [16], Polis [48]
	Unavailability of Technological Assets	This work, Papaioannou et al. [6]		

cost that they spend for their trips; (ii) promote coordination of time schedules of different transport services which does not necessarily exist today – and consequently reduce travel time/cost for many origin–destination pairs; (iii) offer to travelers information of which they are not aware such as real-time updates about their trip or new route/itinerary suggestions; and (iv) offer to transport operators information relevant to currently non-explored markets, opening to them new business opportunities. The previous are of particular importance for Greece and other states with similar geomorphology (such as Croatia, Denmark etc.) as, in general, residents of European islands pay a higher proportion of their income for transport services and simultaneously have a lower GDP per capita than the European mainland residents [35].

The previously described facts are resulting in the important issue of transport poverty (described analytically in the work of Lucas et al. [36]). MaaS has the potential to contribute towards a more "just" transport system, a target that is also supported by the European Green Deal. At the moment such policy targets in Greece are mainly fulfilled by external measures, such as the state subsidization of the "price difference" between the average transport price per mile that island residents pay compared to mainland population. This is often found in literature as the "Transport Equivalent" measure and is analytically described in the work of Lekakou et al. [49]. Thus, MaaS and external measures such as the "Transport Equivalent" may act in a complementary manner towards "justice" among urban, rural and island populations in terms of their mobility. Furthermore, the positive impact of MaaS is, as highlighted by the experts, not limited in transport affordability. The participants of the focus group indicated that MaaS may act as an enabler of more efficient transport networks in small islands and proposed a specific geographic area in the Cycladic islands as a first case study for further research. This, however, exceeds the scope of this paper and is going to be assessed in future work. Tourism, considered a very important industry for island states, is also positively affected from bundling of transport services, as indicated in the work of Panou et al. [45].

All experts acknowledged the significance of "all available transport modes for intercity and rural areas travel" as integral components within an IC/Rural Travel MaaS Scheme. However, the constraints of infrastructure and the unique needs or requisites imposed by the geography of specific areas need always to be considered. The MaaS Ecosystem includes 5 types of entities, the "Core Partners", "Enablers", "Integration Drivers" and the "Users", along with the "MaaS Provider" which is the key entity.

The main barriers for the development of MaaS are relatively similar in both urban and IC/Rural MaaS as they include unwillingness of actors to collaborate/cooperate and share data, operational limitations imposed by regulatory framework and technological issues. However, it is interesting that in the case of IC/Rural MaaS, liability of operators in case of disruptions seems to be a major issue, that does not apply in urban MaaS as level of service of the participating transport modes is high, leading to low waiting times if the commuter misses one service. It is mentioned by Liimatainen & Mladenović [50] that there is a need for further study on the topic of operators'

responsibility and legislation relevant to user rights. Pan-European regulatory framework for passenger rights needs to address the issue of operators' responsibility within MaaS schemes, as mentioned also by Pagoni et al. [43]. At a lower level, however, and until such a framework is developed, the issue of liability of operators needs to be discussed and be clearly defined by all involved parts in a MaaS scheme beforehand. An interesting solution would also be the participation of insurance companies in a MaaS Scheme.

Young people and digitally educated people are the most likely patronage groups for IC/Rural MaaS, whilst vulnerable groups such as elderly or disabled people are the less likely. Finally, the "silo effect" and market regulations are among the greatest threats regarding the successful operations of a MaaS Scheme.

Although the number of participants of the focus group is relatively small, they originate from key decision-makers of the intercity & rural transport industry, and they all have outstanding experience in their field. Thus, the results are considered trustworthy and informative.

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Availability of data and materials
Findings from the focus group are included in the paper. For further information please contact the first author.

Declarations

Competing interests
The authors declare no competing interests.

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