TECHNICAL REPORT

ISO/TR 4447

Intelligent transport systems — Mobility integration — Comparison of two mainstream integrated mobility concepts

Systèmes de transport intelligents — Intégration de la mobilité — Comparaison de deux grands concepts de mobilité intégrée

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Contents

Page

Foreword

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This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Transport systems and services have remained unchanged for long periods of time and are characterized by slow incremental innovations. However, urbanization, changes in climate and demographic and societal changes are some of the major trends that have had an impact on transport systems and services over the last decades. Combined with the implementation of intelligent transport system (ITS) services and Internet of Things (IoT), new transport concepts have been developed. User requirements on efficiency, availability and interoperability have also been driving forces for new transport concepts for integration of multimodal, existing and new transport services as described and implemented in mobility concepts like "mobility as a service" (MaaS) and "mobility on demand" (MOD). Connected and autonomous vehicles will also have a significant effect on how travellers plan and implement their journeys between multiple modes of transportation in the integrated mobility environment.

Integrated mobility concepts are evolving around the world, mostly based on the MaaS and MOD concepts. Hence, there is a need for a generic, common and world-wide concept description mapping all existing and foreseen concepts for interoperable, integrated and seamless multimodal transport services.

The objective of this document is to describe the MaaS and MOD concepts focussing on the relevant services and role models. Further, the objective is to compare the two concepts searching for commonalities that can build a bridge between the MaaS and MOD concepts and form a basis for a common understanding. This could further be used for a convergence towards one world-wide integrated mobility concept description. Establishing a common understanding and terminology will enable greater world-wide collaboration on integrated mobility implementations.

This document is based on a literature review of the references listed in the Bibliography and describes the state-of-the-art for the two mainstreams in integrated mobility, i.e. the MaaS and MOD concepts.

This document includes a proposal for issues for further elaboration and possibly standardization, including:

— an enterprise view on the integrated mobility service;

— a functional view on the integrated mobility service;

— a physical view on the integrated mobility service.

Intelligent transport systems — Mobility integration — Comparison of two mainstream integrated mobility concepts

1 Scope

This document describes the core services and roles and responsibilities models in the "mobility as a service" (MaaS) and "mobility on demand" (MOD) ecosystems. The description is based on a literature review of the references listed in the Bibliography.

This document also includes a comparison of the basic services and roles and responsibilities in order to map any similarities that can potentially be used for bridging and merging the two mainstream concepts in integrated mobility, i.e. MaaS and MOD.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

4 Abbreviated terms

API	application programming interface
ARC-IT	Architecture Reference for Cooperative and Intelligent Transportation
CTSA	common transport service account
DOC	Department of Commerce (US)
DOD	Department of Defence (US)
DOE	Department of Energy (US)
DOL	Department of Labour (US)
DSS	decision support system
ERTICO	European Road Transport Telematics Implementation Co-ordination Organisation
ICT	information and communication technologies
IT	information technology
ITS	intelligent transport systems

MaaS	mobility as a service
MOD	mobility on demand
PAYGO	pay-as-you-go
PSP	payment service provider
PTA	public transport authority
SET-IT	Systems Engineering Tool for Intelligent Transportation
UCL	University College London
USDOT	United States Department of Transportation

5 The two mainstream concepts within integrated mobility

5.1 Introduction

There are two mainstream concepts today concerning integrated mobility. The first one is the European mobility as a service (MaaS) concept represented by the MaaS Alliance which is hosted by ERTICO – ITS Europe. The term "MaaS" is described in Reference [1].

The other mainstream concept is the mobility on demand (MOD) concept, led by the US Department of Transportation (USDOT), with the MOD Alliance serving as a coalition of interested stakeholders. The term "MOD" is described in Reference [2].

Both the MaaS and MOD Alliances have members from transport authorities, cities, transport service providers and private sector companies, for example intelligent transport systems (ITS) industry, and research institutes. A cooperation between ERTICO – ITS Europe, ITS America and ITS Asia-Pacific was established in 2019.[3]

5.2 The MaaS role and responsibility model

The role and responsibility model described in Reference [4] was one of the first role and responsibility models developed by MaaS. It had only three roles: transport operators, MaaS operator and users. The simple model from 2015 was further developed and University College London (UCL) has, as one of the partners in the MaaS Alliance, developed a role and responsibility model which is described in Reference [5] and Reference [6]. These are the references used in this document for the description of the MaaS role and responsibilities model.

The current situation from a users' point of view is shown in Figure 1. A transport service user very often requires an individual interface for each transport service provider. A migration from today's scenario to the MaaS model enables the mobility service user to have one interface concerning access rights, carrier of access rights (media), contract and payment.
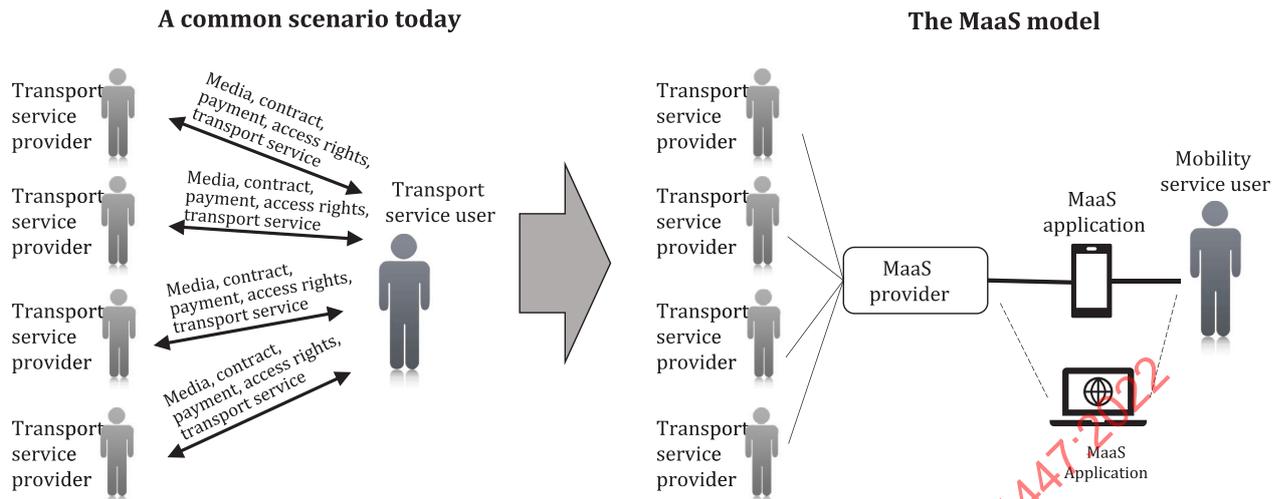
A common scenario today

The MaaS model

Transport service provider

Media, contract, payment, access rights, transport service

Transport service provider

Media, contract, payment, access rights, transport service

Transport service provider

Media, contract, payment, access rights, transport service

Transport service provider

Media, contract, payment, access rights, transport service

Transport service user

Transport service provider

Transport service provider

Transport service provider

Transport service provider

MaaS provider

MaaS application

MaaS Application

Mobility service user

Figure 1 — Current and MaaS model situation (based on Figure 1 in Reference [6])

The actors in the MaaS ecosystem described in Reference [6] are distributed on three different layers: Core business, Extended enterprise and Business ecosystem, as shown in Figure 2 (based on Figure 2 in Reference [6]).

The Core business layer consists of the MaaS provider, customers/users, transport operators and data providers.

The MaaS provider is an intermediate between the transport operators and the customers/users. The main responsibility of the MaaS provider is to use the offers from the transport operators, buy capacity from the transport operators and resell it to the users. The MaaS provider can optimize the demand (customer/user request) based on the offers from the different transport operators, the user requirements and preferences and the dynamic status information as regards transport infrastructure and service level.

The main responsibility of the customers/users role is to define a request together with the customer/user's preferences and choose the preferred transport modes for their trips. In Reference [6], the customer is considered as the passenger, but it is also said that there is a need for defining who could be the customers of the MaaS providers.

The transport operators sell their capacity to MaaS providers and provide access to their data via secure application programming interfaces (APIs). The dynamic status on the transport service status is very important and the transport operators are encouraged to have sensors reporting on the status of the transport modes.

The data providers offer data and analytics capabilities to MaaS providers. Data from the transport operators are processed, and they also collect data from many other sources, e.g. customers media, social media, etc. The data collection and processing also includes data on transport modes and infrastructure status needed by the MaaS provider in order to optimize the mobility service.
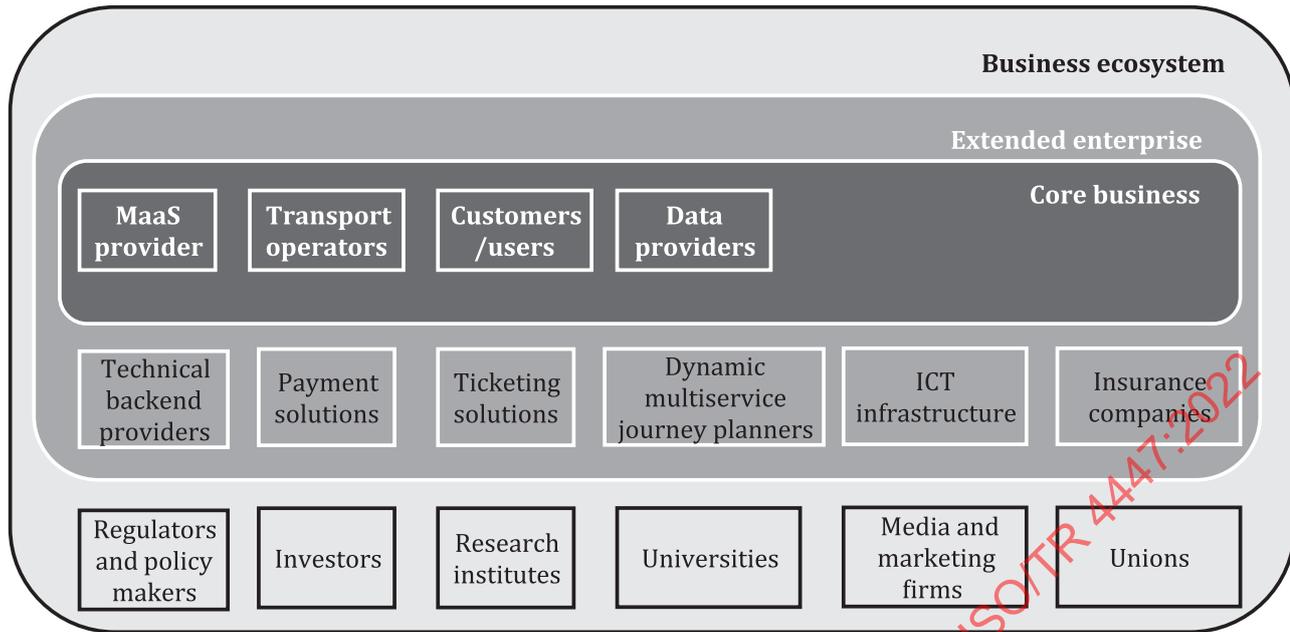
Figure 2 — The MaaS business ecosystem (based on Figure 2 in Reference [6])

The extended enterprise level includes 6 different actors. These are shortly described below:

— Technical backend providers enable the MaaS model by providing big data availability and cloud computing.

— Payment solution providers support the MaaS provider with payment solutions, e.g. credit cards, smartphones and PayPal accounts.

— Ticketing solution providers support the MaaS provider with ticketing technology with the main goal of providing solutions enabling the customer to access as many transport services as possible with one medium carrying the ticket or the access rights.

— Dynamic multiservice journey planner providers support the MaaS Provider with journey planners that cover all available transport modes in an area. The journey planner is also assumed to become dynamic considering the status of the infrastructure and the transport modes, e.g. service level (demand/capacity) in infrastructure and transport modes and means.

— Information and communication technologies (ICT) infrastructure providers support the MaaS provider by the provision of Internet connectivity. High-speed and high-capacity internet connections are crucial for customer access to the MaaS provider, both for request-for-mobility services and real-time status information on their chosen transport modes and means.

— Insurance companies are mentioned as an actor in the MaaS extended enterprise. Their main responsibility will be to handle claims on compensation for 'not-provided' mobility services.

The business ecosystem includes 6 different actors. The most important actor is shortly described below:

— Regulators and policymakers are responsible for the provision and regulation for open standards and interoperable data formats. They can also ensure a sustainable development of the MaaS market as well as fair competition, financing, customer rights, privacy and security, mobility service quality standards, social inclusion and user safety.

5.3 The MOD role and responsibility model

The most extensive documentation of MOD is found in Reference [7], published by USDOT. The MOD ecosystem is described in a supply and demand framework with the MOD stakeholders and the MOD enablers.

5.3.1 The supply and demand side of MOD

The supply and demand side of MOD is shown in Figure 3 (based on Figure 2 in Reference [7]).

MOD marketplace supply side
— Public transportation services
— Non-public transportation services
— Goods delivery
— Transportation facilities and vehicles
— Transportation operators
— Transportation mgm/information systems

Multimodal transportation operations management

Decision support system (DSS)

Demand side
— Travelers
— Goods
— Time of ride/delivery request
— Origin/destination request
— Occupancy and vehicle type/Size
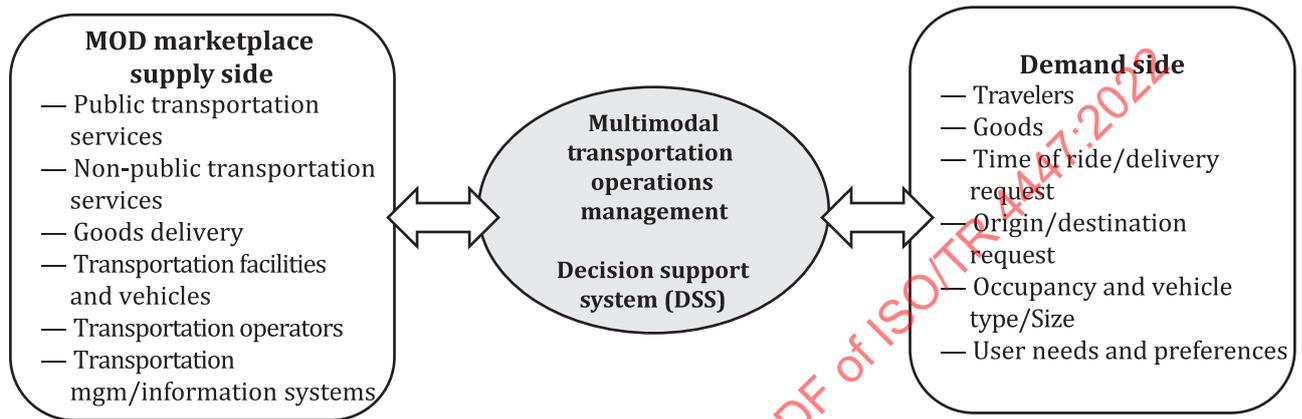— User needs and preferences

Figure 3 — The supply and demand side of MOD

The supply side of the ecosystem (MOD marketplace) consists of the actors and objects providing transport services for people or goods delivery:

— public transport services, e.g. transport services provided by bus, metro, tram and ferries;

— non-public transport services, e.g. shared services, taxis, car rentals, micro mobility and private cars;

— goods delivery, e.g. intercity freight transport, urban deliveries and last- and first-mile services;

— transportation facilities including parking, tolls, roadways and highways;

— vehicles, e.g. public transport vehicles, private vehicles, goods-delivery vehicles, emergency vehicles and autonomous vehicles;

— transport operators, e.g. public transport operators, taxi companies, companies like Lyft and Uber and companies providing shared transport means, e.g. car, bikes and el-scooters.

— transportation and information systems, e.g. payment systems for parking, toll and public transport, signal systems, mobile apps for trip planning and payment, fleet management systems and navigation systems.

— transport information services including schedule information, dynamic message signs, etc.

The demand side of the ecosystem covers the users of the mobility service and their needs, choices and preferences. This can be covered by the term "user requirements". The following are described as being part of the demand side:

— all travellers, including pedestrians, riders, drivers and cyclists, where the traveller could be of any age, with or without disabilities, etc.;

— goods and merchandise that require transport services (deliveries);

— time of use of the transport service (e.g. ride, drive, delivery) which can affect the transport means to be used, e.g. availability and frequency of a delivery service;

— origin, i.e. destination request defining the location of the mobility service which affects the route, mode and means choice;

— mode and means demand based on occupancy, size or type of vehicle;

— user needs and preferences concerning how the mobility service is recommended to take place, for example, travelling alone, travelling together with other (public transport, shared rides), comfort requirements, e.g. always a seat or a limited occupancy, inclusion or exclusion of specific transport modes and means etc.

5.3.2 The MOD stakeholders

The MOD stakeholders are described below.

— Federal Government that has many branches that can influence MOD, including US Department of Transport (USDOT), Department of Energy (DOE), Department of Labour (DOL), Department of Commerce (DOC) and Department of Defence (DOD) amongst others. All can play a role in establishing transportation strategies, policies and legislations affecting the MOD.

— State and local authorities, including regional and local governments, city municipalities, metropolitan planning organizations and local authorities. They all play a role in implementing policy and regulations, issuing permits and managing public transport. They are also in charge of strategic urban and traffic management planning and responsible for the local infrastructure.

— Public transit agencies, including all agencies that provide public transportation, e.g. by means of buses, trams, metro, subway and ferries.

— Transportation/traffic managers, including transportation management centres that monitor the operations, allocate resources as necessary and respond to the needs of the network.

— MOD operators, including operators of all forms of MOD services, public or private sector, that provide mobility or delivery services.

— Transport service providers, including bikesharing, car rentals, carsharing, ridesourcing and microtransit and paratransit service providers.

  NOTE   Paratransit refers to "*public or group transportation, as by automobile, van, or minibus, organized to relieve the congestion of mass transportation.*"[23]

— Logistics service providers, including logistics management and goods-delivery providers dealing with the flow of goods from origin to destination. This also includes warehousing, packaging, security and dispatching functions.

— Apps and mobile service providers that are third-party ICT services and providers enabling on-demand service, mobile ticketing, payment and navigation services.

— Consumers that are the ultimate end users of MOD services who affect the system by their type of demand and requirements.

6 A comparison of the MaaS and MOD concepts on a service level

The MaaS and MOD concepts can be compared on a service level to describe commonalities and differences to see whether a common approach is feasible. The MaaS and MOD concepts partly use different terms for the comparable services, as shown in Table 1.

Table 1 — Comparison of MaaS and MOD concepts on a service level

Service	MaaS	MOD	Comparison/Comment
Mobility service	The MaaS description in Reference [1] describes the mobility service as "*the integration of various forms of transport services into a single mobility service accessible on demand.*"	The MOD description in Reference [7] does not include a specific definition of the term "mobility service" although the term is used through the whole report and there are several examples of mobility services.	Based on how the term is used in MaaS and MOD there seem to be no major differences in the usage except that a mobility service in MOD also covers the transport of goods; see "Transport service" below.
Transport / transportation service	Not specifically defined in the MaaS references; covers all types of services but limited to transport of persons.	The term "transportation service" is mostly used in Reference [7] but is not specifically defined.	The main difference between MaaS and MOD is that the MOD concept also includes the transport of goods. The MOD term "transportation service" is related to three different categories of services: — public transportation services, e.g. transport services provided by train, bus, metro, tram and ferry; — non-public transport services, e.g. shared services, taxis, car rentals, micro mobility, and private cars; — goods delivery services, e.g. intercity freight transport, urban deliveries and last- and first mile services. ISO/TS 14812 defines the term "transport service" as a service that delivers one or more material entities from one location to another to satisfy a transport need. A note to entry says that the material entities delivered can be people and/or goods.
Payment service	In MaaS this is called payment or payment solutions.	In MOD this is called payment, payment system and payment service.	The service is described both in the MaaS and MOD models, but different terms are used. The definition of the term "payment service" has not been found in any ISO International Standard, but the term has been defined in Annex 1 of Reference [8] by eight points, including:

Table 1 *(continued)*

Service	MaaS	MOD	Comparison/Comment
			— "*execution of payment transactions, including transfers of funds on a payment account with the user's payment service provider or with another payment service provider*";
			— "*execution of payment transactions where the funds are covered by a credit line for a payment service user*";
			— "*issuing of payment instruments and/or acquiring of payment transactions*".
ICT service	In MaaS the ICT services are covered by the Technical backend providers and the ICT infrastructure, focussing on internet connectivity.	In the MOD document the ICT service is both part of the services provided by apps and mobile service providers and the technology enablers.	The service is described both in the MaaS and the MOD models but with slightly different terms and content. In short, the service includes the use of software and hardware for management and communication of information needed for the provision of the mobility service.
Transport infrastructure service	Not described in the MaaS ecosystem.	In the MOD model the transport infrastructure service is related to the state and local authorities as being responsible for the local infrastructure, the transportation/traffic managers that manage the transport networks and the infrastructure enablers that are in charge of transportation infrastructure (e.g. roads, sidewalks, rail tracks).	According to Reference [9]: "*Transport infrastructure means all routes and fixed installations of the three modes (road, rail and inland waterway) of transport being routes and installations necessary for the circulation and safety of traffic.*" Implicitly, the transport infrastructure service will be the use of the road, rail and inland waterway routes and installations. For example, a railway company using the rail infrastructure and the fixed installations owned and operated by the transport authorities that will become transport infrastructure service providers.

Table 1 *(continued)*

Service	MaaS	MOD	Comparison/Comment
Information service	The MaaS concept relies heavily on interoperable data availability, including data from transport service providers, users, social media, sensors installed along the infrastructure and sensors installed in the transport means. The data is recommended to be stored and retrieved in a fast, reliable, and secure manner which calls for big data solutions and cloud computing.	The MOD model describes the information service both as part of the Apps and mobile service and as part of the Emerging technologies which include services like big data, data analytics, machine learning, artificial intelligence and virtual reality.	The information service is part of both the MaaS and MOD models.

The services described in Table 1 are shown in Figure 4 as the main and common services that can be a common platform for the MaaS and MOD models.
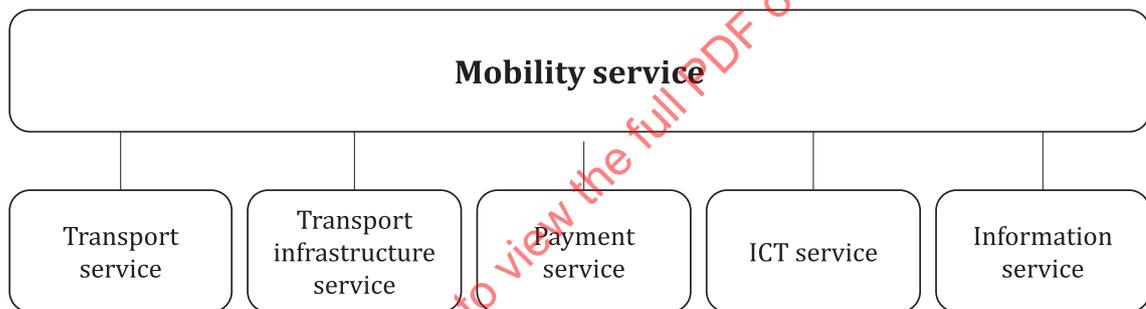

Figure 4 — Services that can become a common service platform for integrated mobility

7   A comparison of the MaaS and Mod concepts on a role level

7.1   Introduction

In this document, the term "role" is an abstract object performing a set of functions as defined in Reference [10]. Another term often used instead of functions is responsibilities, where the responsibilities are reflected in functions or vice versa. The role usually has a name reflecting the main functions or responsibilities of that role. An entity with the responsibilities of planning, building, and maintaining a road network can for instance have the role name "road network operator".

An actor is a real-life person, association, organization, legal entity, authority or another (sub)system performing a coherent set of functions when interacting with the system within a particular use case as defined in Reference [10], or fulfilling the responsibilities of a role. A national road administration can for instance be an actor fulfilling the responsibilities of the role road network operator.

An actor can fulfil more than one role. A national road administration can for instance be an actor both fulfilling the responsibilities of the role road network operator and the responsibilities of the role traffic manager in those cases where the road administration is also in charge of the utilization, the service level and the 24/7 management of the road network.

The responsibilities of a role can also be shared and/or delegated between two or more actors enabling flexible and individual implementations of the abstract role model.

The term role used in this document covers terms like stakeholder and enabler (MOD ecosystem) and actor (MaaS ecosystem).

7.2   Common MaaS and MOD roles

7.2.1   MaaS provider and MOD operator

The MaaS provider responsibilities are described in Reference [4] where the MaaS provider is called the MaaS operator. The most common functions and responsibilities are divided into three categories:

1) Human- and business-related:

— liaising with other mobility operators and integrators with clearly defined contractual obligations;

— transparent and fair treatment of transport service providers when aggregating their services based primarily on end-user preferences;

— understanding that a successful MaaS operation can result in improved operations and revenue for all mobility operators.

2) Process-related:

— collaborating with stakeholders to ensure payment and ticketing integration, defining parameters such as fare policies and discounts;

— sharing real-time information with stakeholders related to service status and issues to ensure continuity of customer service;

— adhering to MaaS customer service norms.

3) Technological:

— implementing an information technology (IT) system to set up services, publish data, set up tariffs, interface with third-party modules and to integrate different public and private transport service providers;

— promoting interoperable interfaces in the ecosystem (for transport service providers and other service providers);

— sharing anonymized data with the city, and other mobility stakeholders as well as with other integrators.

The MaaS white paper[4] also includes some very general principles regarding liabilities and insurance schemes in case of non-compliance of the service promise or incidents.

The description of the responsibilities of the MOD operator in Reference [7] is less detailed, i.e. to provide mobility or delivery services. In Reference [11] the MOD operator is called the MOD service provider and is defined as "*a critical supplier of on-demand mobility and delivery services*".

7.2.2   Customer and consumer

The user of the mobility service is called a customer in the MaaS concept[6] and a consumer in the MOD concept. The term user is also used in some MaaS literature. None of the concepts clearly defines the responsibilities of the customer/consumer but implicitly[6] defines the following main responsibilities:

— register as a user of mobility services;

— define the mobility demand and preferences;

— choose between the offered mobility services and book the selected service;

— pay for the mobility service used.

The term used in ISO 24014-1 is customer and passenger. The passenger is often the same person as the customer but that is sometimes not the case, for example, if a parent books and pays a transport service for a child or an employer books and pays for a transport service for an employee. The same scenarios will also be the case for many mobility services.

7.2.3 Transport operators, transport service provider and public transit agencies

The MaaS white paper[4] includes a figure [Figure 5: MaaS value chain participants and key processes (University of Tampere, 2016)] that describes the main responsibilities (key processes) of the transport operator (called service provider in the figure). The transport operator responsibilities are:

— offer products with attributes, e.g. price, routes, points-of-interest and terms and conditions. In Reference [10], a product is described by a set of usage, pricing, and commercial rules defined by the product owner, e.g. a public transport authority (PTA);

— accept and confirm customer bookings forwarded by the MaaS operator;

— reserve capacity based on bookings;

— monitor the timetable (which in this document is interpreted as monitoring the status of the transport means against the timetable) and act in case there are major delays or lack of service;

— re-route the transport means if required;

— receive payments from the customer via the MaaS operator.

Due to the differences in funding sources and governance of different transport modes in the US, the MOD concept defines three types of transport operators: public transit agencies (publicly funded passenger transport); transport service providers (privately funded passenger transport); and logistics service providers (privately funded goods delivery).

The MOD description of the responsibilities of the public transit agencies in Reference [7] is described as:

— Provision of public transportation including city buses, trolley buses, trams (or light train), rapid transit (metro and subway), ferries and paratransit. This also includes human service transportation centres.

The responsibilities of the transport service providers are described as:

— Provision of non-public transportation services including taxis, car rentals, microtransit, ridesourcing, personal vehicles, volunteer drivers and other shared services (e.g. carsharing, ridesharing, bikesharing and scootersharing).

The MOD description of the responsibilities of the logistics service providers in Reference [7] covers the following:

— managing and running the flow of goods and material from origin to destination;

— handling inventory, warehousing, packaging, security and dispatching functions.

The term used in Reference [10] is "service operator". The main responsibility is to provide a service to the customer against the use of a product.

7.2.4 Payment solution provider and payment system provider

Both MaaS and MOD concepts include the payment for the mobility service as a crucial attribute of the MaaS and MOD concept. The MaaS term is payment solution provider. The MOD concept does not describe a specific role dedicated to the payment of the mobility service other that describing payment service as one of the responsibilities of the stakeholders called apps and mobile service providers.

The term payment system is often used, so implicitly a MOD role dedicated to payment could, as an assumption, be called a payment system provider.

Neither the MaaS nor the MOD concepts described in References [6] or [7] uses the term payment service provider (PSP). The term payment service provider is defined in Reference [1] and refers to credit institutions, electronic money institutions and payment institutions, for example.

The main responsibility of the payment solution provider/payment system provider will be to enable the user of the mobility service to pay for the use of the mobility service. Some examples of payment solutions are given in Reference [16]: Pay-as-you-go (PAYGO), monthly subscription, credit cards, smartphones and PayPal accounts. Some examples of payment solutions are also given in Reference [22]: public transport payment account, credit/debit cards, account-based payment.

The term used in Reference [11] is payment provider. Payment solutions for fare management are reported in References [12] and [13].

7.2.5 ICT service providers

The term ICT service provider is neither used in the MaaS nor the MOD concept so the heading ICT service provider is just used as a common term for the technical backend providers and IT Infrastructure and ICT companies (MaaS) and technology enablers (MOD). Both MaaS and MOD have only high-level descriptions of the responsibilities of the roles covered by the term ICT service provider.

The roles of technical backend providers and IT infrastructure in MaaS have implicitly the responsibilities of providing reliable backend systems enabling on-demand cloud computing services and big data availability. Technology-specific actors mentioned in Reference [15] are also part of this role.

The role of ICT companies in MaaS, which are more actors than roles, have the responsibility of providing high-speed internet and widespread geographical internet coverage.

The MOD concept does not describe ICT providers in the same way as in MaaS. Instead of naming specific roles related to the provision of ICT services, the MOD concept describes enabling technologies. Implicitly, the providers of these technologies are part of the MOD ecosystem. The technologies contributing to the provision of mobility services described in Reference [22] are the following:

— wireless networks and mobile technologies, providing a reliable and secure communication infrastructure;

— location-based technologies, providing accurate positioning and mapping technologies;

— automated vehicles applications, like automated taxies, automated shuttle buses and automated services providing first-and-last mile travel to destination and mobility hubs;

— connected vehicles, sending and receiving information about their movements in the network offering new opportunities to provide more responsive and efficient solutions in real time and in the long term;

— smart infrastructure with ICT at its core, which is the integration of sensors, networked communications and computing hardware and software into physical infrastructure, e.g. roads, streets and rail networks;

— information and communications technology, which has enabled travellers to manage considerable amounts of data. It has also improved and extended the access and availability to transport systems and travel information for travellers with disabilities;

— universal design, which enables a user-centric approach to develop travel products that take into account different human abilities, skills, requirements and preferences;

— mobile devices and apps, which are increasingly causing travellers to use smartphone transportation apps to meet their mobility needs. This is also based on the increasing availability of data, data management and data sharing;

— connected travellers, who exchange data between themselves and vehicles, transport infrastructure and backend systems.

MOD data management is critical in the provision of the mobility service provision, and data management in MOD requires a more organized strategy around data sharing and management.

7.2.6 Regulators and policy makers, federal government and state and local authorities

The regulators and policy makers are described in Reference [16] as key actors (roles) that could enable the MaaS market. The responsibilities of the regulators and policy makers are described as the following:

— provide and regulate for open standards and interoperable data formats;

— provide policy frameworks and recommendations for the sustainable development of the market, fair competition, financing, passenger rights, privacy and security, service quality standards, social inclusion and safety.

The federal government in MOD (in this case addressing several US Departments) has, according to Reference [22], the following responsibilities:

— play a role in establishing transportation strategies, policies and legislations;

— implement those strategies and make investments in pilot programmes;

— provide guidance for nationwide development of strategies put forth.

The state and local authorities have the following responsibilities:

— play a role in implementing policy and regulations;

— issue permits;

— manage public transport in the region;

— improve transportation operations;

— provide strategic urban planning and traffic planning;

— be responsible for the local infrastructure.

7.3 Roles solely described in the MaaS concept

7.3.1 Dynamic multiservice journey planner providers

In the MaaS concept and ecosystem there is a role called "dynamic multiservice journey planner provider". According to Reference [6], the responsibilities of this role are the following:

— provide journey planners with new capabilities and especially intermodal planning capabilities that include all the available transport modes in an area;

— provide journey planners that are dynamic, i.e. have the capabilities to adjust to a variety of anomalies, e.g. network disruptions, high capacity, unexpected or unwanted events such as traffic accidents on the road and signal system failure in rail systems;

— dynamically evaluate the most cost-effective ways to get from A to B given the status of the transport network and the capacity of the transport service providers in real time.

7.3.2   Data providers

The MaaS concept also describes a role called "data provider". According to Reference [6], the responsibilities of this role are the following:

— offer data and analytics capabilities to MaaS providers;

— process the data of the transport operators and collect data from a range of different sources, e.g. customer mobile phones, social media, sensors in vehicles and infrastructure, etc.;

— store the retrieved data in a fast, reliable and secure manner;

— exploit advances in big data and cloud computing to provide a platform for large scale data management;

— ensure data security and privacy by using the latest encryption tools and protocols;

— manage the data and distribute them to actors in the MaaS ecosystem in an interoperable format.

7.3.3   Ticketing solution providers

The MaaS concept describes a role called "ticketing solution provider". It is stated that since MaaS services are offered via smartphones the best ticketing solution would be electronic wallets stored in the smartphone. However, the mobility provider has to take into account that the transport service operators also base their ticketing systems on other media than smartphones, e.g. contactless smart cards and electronic devices carrying a unique identity used for linking the traveller to a central account. The main responsibility of the ticketing solution provider is described as finding ticketing solutions that enable the traveller to access as many transport services as possible with only one ticket. This would be in line with the core idea of MaaS to offer a simplified journey experience to the users of the mobility service.

7.4   Summary of the MaaS and MOD roles

Figure 5 shows a summary of the MaaS and MOD roles. It is not necessary for the MaaS and MOD roles to have exactly the same responsibilities due to different ways of describing the responsibilities, but overall, they are comparable.

Key

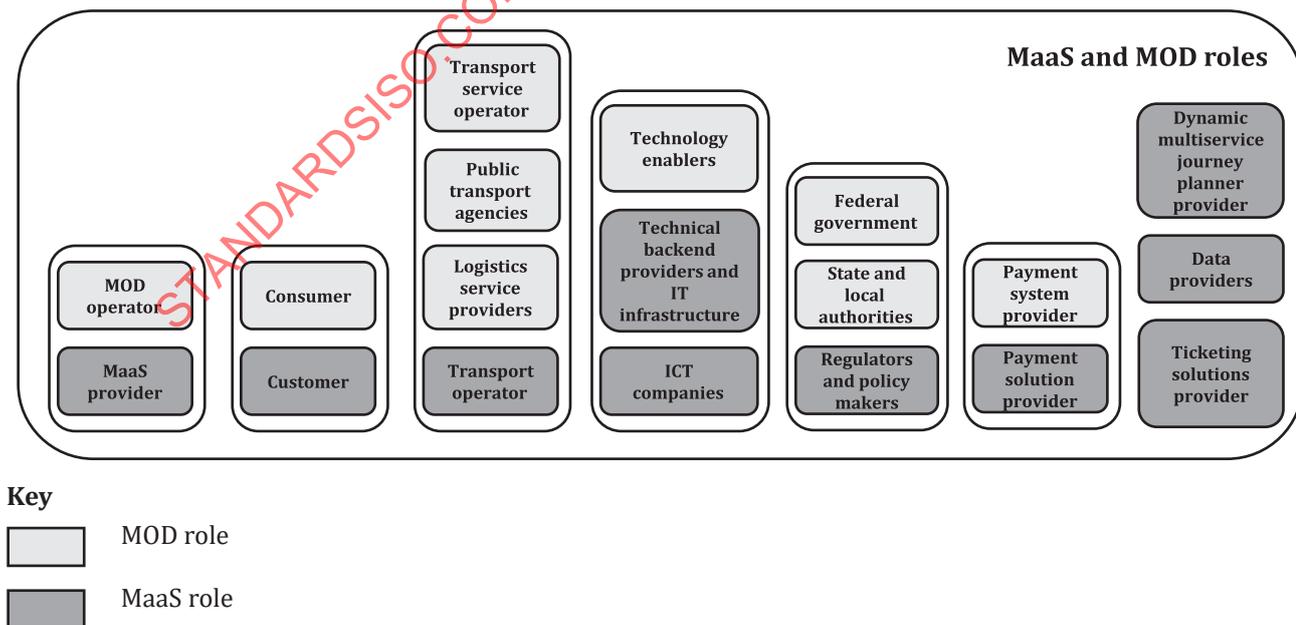|	
(light)	MOD role
(dark)	MaaS role

Figure 5 — Groups of MaaS and MOD roles with comparable responsibilities