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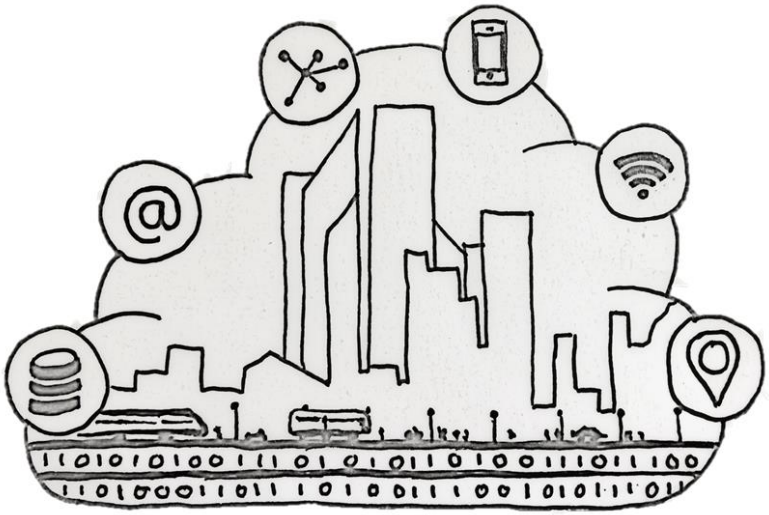

Public Policy Framework Supporting "Mobility-as-a-Service" Implementation

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Hereby I declare that the present document is an original work developed by me and that it fulfils all the requirements of the University of Lisbon's Code of Conduct and Good Practice.

Declaração

Declaro que o presente documento é um trabalho original da minha autoria e que cumpre todos os requisitos do Código de Conduta e Boas Práticas da Universidade de Lisboa.

Acknowledgments

"Values are what we care about. As such, values should be the driving force for our decision making. They should be the basis for the time and effort we spend thinking about decisions." (Keeney, 1992)

Everything that led me to what I am now and to what I present you derives from life.

Weather the life that happens around us, or the life we choose every day to happen with us. I've learned that how we see life is a matter of perception. It becomes a matter of choice, that drives us to decide how much energy we choose to allocate to each specific aspect of our journey.

In every step of the way and through everyone I have crossed paths with, I am thankful.

I am grateful for all that I've lived, for all the love we have shared, for all the friendliness I've encountered and give, for the obstacles I've overcome, for all the failures and disagreements I've had, for all the happiness I perceive and for all the hope and freedom I choose to have.

Freedom, courage and compassion guide everything I do, and the decisions I make. I am Love.

This work is dedicated to life and to those values.

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For the woman that runs with the wolves, Patrícia Xavier, and with whom I also learned how to run.

Time is precious. Enjoy every step of the way!

Special thanks to my Finnish interviewees and supporters: Krista Huhtala-Jenks; Sami Sahala and Sampo Hietanen.

Abstract

The continuous growth of world population and rising urbanization poses several challenges inside urban mobility systems. At the same time Digitalization megatrend is reshaping lives worldwide, and “Ownership” is shifting to “Usership”. Data is seen as the new “oil” of the XXI century, where “Open Data” availability becomes vital. Based on the existent diversity of transport services, “MaaS” emerges as a potential mobility disruption.

This work aims to propose a “MaaS Public Policy Framework” with a two-stage approach, first structuring “MaaS” concept and proposing a “MaaS topology” and secondly identifying policy instruments and indicative group of stakeholders responsible, by each urban mobility management decision level and “MaaS” feature.

This work is divided in four chapters: the first, focused on world and specific Urban Mobility trends and policy context and the second one on understanding the universe of “MaaS” questions. The “MaaS System” in Finland was considered as an inspirational case-study for the proposal development, which corresponds to the final chapter. The theoretical framework on public policy corresponds to the third chapter.

If “MaaS” is considered a Mobility Management tool, supported by a coherent public policy framework, besides allowing a value proposal and its articulation with supply and demand, ensuring all means of information and transaction between the two market sides, it will enable the feeding of monitoring functions that the authority intends to wield, which can have an important impact on the implementation of sustainable mobility policy goals and constitutes an opportunity to redefine public transport and its financing.

Keywords

Mobility-as-a-Service; Public Policy; “MaaS”; Policy Instruments; Mobility

Resumo

O contínuo crescimento da população mundial e dos níveis de urbanização colocam diversos desafios aos sistemas de mobilidade urbana. Ao mesmo tempo, a megatendência da Digitalização marca a atualidade e os "dados" são considerados o novo petróleo do séc. XXI. Os hábitos de consumo assentes na propriedade tornam-se rapidamente obsoletos, e baseado na diversidade de serviços transportes existentes, o "MaaS" emerge como uma potencial disrupção na mobilidade.

A presente dissertação tem como objetivo principal propor um Quadro de Políticas Públicas para a implementação de um "MaaS", baseado inicialmente na estruturação do conceito e proposta de topologia de "MaaS" e por fim na identificação dos instrumentos de política e grupos de atores responsáveis pela sua implementação, tendo em conta os diferentes níveis de decisão e as características de um "MaaS".

O trabalho desenvolve-se em quatro secções, sendo a primeira focada no contexto mundial e especificamente dos sistemas de mobilidade. A segunda incide no universo das questões "MaaS" e no estudo de caso Finlandês, inspirador no desenvolvimento da proposta apresentada por último. O enquadramento teórico associado às políticas públicas corresponde à terceira secção.

Se um "MaaS" for considerado uma ferramenta de gestão de mobilidade - que permita evidenciar uma proposta de valor e articula-la com a oferta e a procura, assegurando todos os meios de informação e transação entre estes, possibilitando funções de monitorização – poderá ter um importante impacto na implementação de objetivos de política associados à mobilidade sustentável e constitui uma oportunidade para a redefinição do transporte público e do seu financiamento.

Palavras Chave

Mobilidade-como-um-serviço; Políticas Públicas; "MaaS"; Instrumentos de Política; Mobilidade

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List of Acronyms

EPOMM	European Platform of Mobility Management
EU	European Union
FICORA	Finnish Communications Regulatory Authority
GDPR	General Data Protection Regulation
HKL	Helsinki City Transport
HLJ	Helsinki Region Transport System Plan
HSL / HRT	Helsinki Regional Transport Authority
ICT	Information and Communications Technology
IoT	Internet of Things
IT	Information Technologies
ITS	Intelligent Transport Systems
ITU	International Telecommunication Union
JP	Journey Planner
LVM	Finish Ministry of Transport and Communications
MaaS	Mobility as a Service
MCDA	Multi-Criteria Decision Analysis
MO	Mobility Operator
PAYG	Pay-as-you-go
POLIS	European Cities and Regions Networking for Innovative Transport Solutions
SDG	Sustainable Development Goal *(known also as the UN's Millenium Goals)*
SITRA	Finnish Innovation Fund
Tekes	Finnish Funding Agency for Technology and Innovation
UITP	International Association of Public Transport *(Union Internationale des Transports Publics)*
UN	United Nations

1. Introduction

1.1. Context and trends

1.1.1. General Context and Trends

Rising urbanization; ageing population; “climate change” and “digitalization”, are some of the global megatrends that shape our everyday lives and place important challenges and opportunities to sustainable development.

As the world’s population is expected to increase by 2.2 billion people between 2017 and 2050, reaching 9.8 billion people in 2050 (United Nations Department of Economic and Social Affairs, 2017) there’s also a demographic shift taking place. As highlighted by United Nations, life expectancy is increasing and fertility declining which leads to a demographic transition known as “population ageing” – rise of the proportion of population at older ages (United Nations & Department of Economic and Social Affairs Population Division, 2017). It is expected that this fast-growing age group will double by 2050, reaching nearly 2.1 billion, representing a quarter of the world population and 35% in Europe (by 2017 was 25%).

Alongside the projected population growth, there is an accelerated urbanization trend, where it is estimated an increase of urban population from 55% (4.2 billion in 2017) to 68% by the year of 2050 (United Nations, 2018)[1]. This urbanization megatrend is also expected to have repercussions in the total number of urban agglomerations with more than 10 million inhabitants, where by 2030 is estimated to reach a total of 43 megacities worldwide (most of them in developing countries). Urbanisation in the European Union is charactersied also by a high proportion of the population living in urban areas (72,4%); the expansion of urban areas, and the blurring of boundaries between urban areas and rural areas. Urbanisation impacts are diverse and whereas from the positive side there is a potential increase in opportunities; living standards; innovation and productivity, from the negative side *“it carries risks in terms of rapidly growing burden of resource use and pollution”* (European Environment Agency, 2015). It has been widely recognized scientifically that the climate is changing. Since the industrial revolution, particularly in the last 50 years, these changes are known to be “largely caused by human activity”, and the increase of greenhouse gas (GHG) emissions from fossil fuel burning is considered one of the primer sources.

At the same time, the advancement of ICT with computers, the internet and mobile phones led us to a hyper-connected and “online” new world with huge amounts of data being produced every second. The International Telecommunications Union states that today the number of mobile-cellular subscriptions exceeds 100 per 100 inhabitants (reaching 111.32 globally) (International Telecommunication Union, 2017). Comparing with UNICEF estimates that 2.3 billion people still

[1] https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html *(accessed 26.07.2018)*

"lacked a basic sanitation service" (2017)[2] it is possible to affirm that *"more people around the world have access to mobile phones than to improved sanitation"*. The same report from ITU reveals that the global penetration rate of mobile-broadband access spiked from 4.0 per 100 population in 2007 to 56.4 in 2017. Developed countries although almost reached 100 per 100 population, which represents more than four times if considered the less developed countries. Indeed, ITU notes that *"Smartphone traffic is expected to exceed computer traffic by 2020, while traffic from wireless and mobile devices will then account for two-thirds of all IP traffic".* Still after all these fast ICT progresses over the last fifty years, there is still a global "Digital Divide" phenomena today that can assume different perspectives whether if seen by age group; by region (urban/rural); by a country's economic development or by gender. In 104 countries, more than 80% of youth population use the internet, although being higher in developed countries (94%) than in developing ones (67%) (ITU, 2017).

Ahead, a new wave of ICT developments and a second digital revolution comprehending four key developments — the Internet of Things (IoT), cloud computing, big data analytics and artificial intelligence – is foreseen to impact society in numerous dimensions. From economical, businesses and industrial processes to living standards, consumer patterns and inclusion, this "digitalization megatrend" encompasses both challenges and opportunities that call for government action. In this context the fourth industrial revolution[3] has already initiated with the digital transformation of industrial markets towards a "cyber-physical system", materialized in *"disruptive digital solutions portrayed by data-driven services and integrated platform solutions optimizing at the same time customer interaction and access"*[4]. The creation of "the cloud" means *"that data is theoretically accessible anywhere, and the proliferation of smartphones means that anybody can access the data"* (Bouton, Knupfer, Mihov, & Swartz, 2015).

Data is widely known as the new "oil" of the XXI century and side-by-side questions on surveillance and privacy become of great importance as well. Huge amounts of data are generated every day around the world and it is expected to double its numbers every two years (e.g. in 2012 this value was estimated in 2.5 trillion gigabytes), consequently Big-data analytics is determinant to extract insights from raw data (descriptive, explanatory and predictive). Information is becoming virtually free as well as available in real-time, although the generalization of open-data availability will be determinant to foster *"more transparent, accountable, efficient, responsive, and effective governments and civil society and private sector organizations, and to support the design, delivery, and assessment of sustainable development goals at a global scale"* (*in* "Open Data Charter"[5]). As it is also referred by Finger & Razaghi (2017), the digitalization trend can have more implications for cities than the ones

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[2] https://www.unicef.org/wash/ *(accessed 26.07.2018)*

[3] "*Industry 4.0 is 'the comprehensive transformation of the whole sphere of industrial production through the merging of digital technology and the internet with conventional industry. In short, everything in and around a manufacturing operation (suppliers, the plant, distributors, even the product itself) is digitally connected, providing a highly integrated value chain." (European Parliament, 2015)*

[4] www.strategyand.pwc.com *(accessed 20.01.2018)*

[5] *"Open Data is digital data that is made available with the technical and legal characteristics necessary for it to be freely used, reused, and redistributed by anyone, anytime, anywhere.", source:* www.opendatacharter.net*: (accessed on 27.07.18)*

that are entailed in the concept of "Smart Cities"[6], *"namely first the implication for the management of urban infrastructure systems, second the implications for urban services, and third the implications for the governance of metropolitan areas more general"*.

From consumers perspective, digitalization provides convenience and allows for more informed choices and information gathering (Van Winden & De Carvalho, 2017). On what concerns consumption behaviour, digitalisation enabled the emergence of the digital economy, with traditional businesses going online, and the rise of the sharing economy. The latter, also known as "peer-to-peer" or "collaborative consumption" is seen as a social revolution that allows the sharing of resources across multiple platforms, and it is perceived as a global phenomenon that challenges the traditional notions of private ownership. The social media and mobile technology have enabled the expansion of sharing economy, that in Europe facilitated solely in one year €28,1bn worth of transactions[7] (May'15 – May'16), with an estimated 191 million citizens engaging in at least one transaction involving payment (Hausemer et al., 2017).

Within this shifting consumption patterns context and in line with the forefront users of internet mentioned before, great attention is thus dedicated to the *Millennials* generation - Generation Y (those that were born between 1980 to 1995). This generation grew up with technology, being also referred as "tech savvy consumers", and are used to constant access to information, actively apply digital media and digital technologies, are proficient in technological innovations and *"considered to be an audacious generation that is open to new challenges"* (Dewalska-Opitek, 2017). Knowing beforehand that consumers have the power to determine business models and strategies, several studies have characterized this generation that illustrate the impact on the way individuals work, make choices and communicate. As it is denoted by Dewalska-Opitek (2017), investigation shows that individuals of this generation are "*less interested in buying, and more interested in availability*", that is using, replacing then exclusive ownership of goods with lower-cost options from within a collaborative consumption or "usership", only possible with reciprocal trust among customers.

1.1.2. Urban Mobility Context and Opportunities

Cities drive innovation and productivity, representing higher job opportunities and living standards. Metropolitan areas above 0.5 million inhabitants will be responsible for 64% of global GDP by 2030, while in 2012 represented 55% (Floater & Rode, 2014).

With more and more people living in urban areas and the expected increase in the years to come, the phenomena of urban-sprawl will most likely aggravate simultaneously. Urbanization is thus a source of

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[6] *"Smart cities should be regarded as systems of people interacting with and using flows of energy, materials, services and financing to catalyse sustainable economic development, resilience, and high quality of life; these flows and interactions become smart through making strategic use of information and communication infrastructure and services in a process of transparent urban planning and management that is responsive to the social and economic needs of society"* (European Commission, 2013b) *(accessed 03.08.2018)*

[7] The statistics referenced belong to five sectors: accommodation, transportation, buying or selling of goods, on-demand professional services and sharing or renting of goods

innumerous challenges as well, e.g. in the domains of energy efficiency; water supply; transport infrastructure or the quality of the environment.

It is impossible for a Public Transport Infrastructure to serve indefinitely the on-going and foreseen expansion of urban-sprawl. Despite the impact of urban-sprawl in the increase of travel demand, there are efficiency resources rationales that poses limits to the supply of public transport infrastructure to a certain extent. Besides, whether if there is a fragmented transport network with high interchange density or a network composed by innumerous operators with multiple ticketing systems to cover increasing urban areas, all these realities have a high potential to drift away users.

The “first or last mile” issue becomes then an accessibility problem, especially for commuters, and social exclusion takes place in several ways for all population. According to Eurostat, 20.4% of people in the EU report ‘high’ or ‘very high’ levels of difficulty of access to good public transport (European Commission, 2018), and consequently one in five inhabitants potentially have lack of access to education, healthcare services, jobs and opportunities. In these cases, the private vehicle sometimes becomes an obvious mobility solution, if not the only one. Withstanding this fact is also the “mass car ownership” with the continuous growth on the global motorization rate, which saw an increase of 27% in a decade (2005-2015)[8], and the high levels of Motor Vehicles production ranging 90 million units a year. Along with the rising trend in car sales projected to reach 125 million/year – half of them foreseen in Urban Environment (Bouton et al., 2015) – the increasing levels of congestion (costing 1 to 4% of GDP) will continue to affect the quality of life specially on what concerns the human health. In Europe, congestion costs approximately EUR 100 billion, or 1 % of the EU's GDP, annually[9].

Congestion is one of the most well-known negative externalities of mass car ownership. With it comes many undesirable impacts on the environment, air and noise pollution, as well as in road safety. Longer commuting times are naturally associated with urban-sprawl because of higher travel distances, but congestion also plays an important role, especially on productivity losses. For example, TomTom’s Traffic Index for 2016[10] ranked London (25th position globally) as the European city with the highest amount of extra travel time needed when roads are congested (+40%), which represents in this specific case 152 hours lost per year. On what concerns environmental impacts, urban mobility accounts for 40 % of all CO2 emissions of road transport and up to 70 % of other pollutants from transport[9].

Interesting survey results on “traveller’s needs”, conducted in the UK by Transport Systems Catapult (2016) in 2015, revealed several “pain points” that travellers face during their journeys according to their needs of transport, as it is represented in Table 1.

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[8] http://www.oica.net/category/vehicles-in-use/ *(accessed: 28.07.2018)*

[9] https://ec.europa.eu/transport/themes/urban/urban_mobility_en *(accessed: 28.07.2018)*

[10] https://www.tomtom.com/en_gb/trafficindex/ *(accessed: 28.07.2018)*

	PROGRESSIVE METROPOLITES	URBAN RIDER	LOCAL DRIVER	DEPENDANT PASSENGER	DEFAULT MOTORIST
TRAVELLER FRUSTRATIONS	• Affordability • Late trains and buses • Rush hour • Parking • Reliable data connectivity	• Buses take too long • Need more bus routes • Taxis are expensive • Lack of flexibility	• Lack of practical public transport • Long journeys • Rush hour traffic • Expensive parking • Public transport inflexibility	• Unavailability of drivers • Unreliable buses • Lack of bus routes • Walking long distances • Lack of support during journey • Lack of flexibility	• Rush hour traffic • Cost of fuel • Parking • Wasting time • Delays

Table 1 - Traveller needs personae and their travel frustrations (Transport Systems Catapult, 2016)

Adding these results on what was already referenced before, the main pain points appointed are: congestion and delays; parking scarcity; reliability of public transport alongside with insufficient supply; and the direct relation of flexibility with accessibility to public transport. Overcoming these "pain points" can be a gold opportunity to enhance the "user's mobility experience" and at the same time reduce car dependency. Considering the Digitalization Megatrend, and the advancements in technology as a facilitator and enabler of this transformation, there will be a progressive entrance in the field of "Smart transport" where the customer is at the centre of reinvented or freshly new mobility solutions. The exponential growth of ride-hailing companies is a good example of the impact extent of digitalization on transport services. Uber for instance, already operates in 83 countries and 674 cities worldwide[11] and reached 40 million customers by month, with a gross revenue of $20 billion is currently valued in $68 billion (2017).

1.1.3. Urban Mobility System – Context, Strategy and Support

The urban mobility system can be metaphorically seen as "the blood that runs in the vessels of cities"[12]. This expression can be extremely graphic but nevertheless it is an image that transmits the importance of the mobility system to the lives and dynamics of cities as if we are speaking of the importance of blood circulation on living organisms, by which trades are made and a continuous flow is essential to life. It a sub-system inside a greater one that is the urban system.

Urban mobility systems can be defined as a structured and coordinated set of modes, services and infrastructures that ensure the displacement of persons and goods in the city, comprehending physical and material elements as well as an associated organizational and institutional context. Mobility by

[11] http://www.businessofapps.com/data/uber-statistics/ *(accessed 01.08.2018)*

[12] Inspired in: http://pmcruz.com/information-visualization/lisbons-blood-vessels *(accessed: 31.07.2018)*

itself can be seen as a process-oriented system that *"results from a sort of productive chain where several agents (authorities, operators, and users) intervene at different stages of the mobility chain (and also at different decision levels) to pursue the final objective that is to access a number of urban functions"* (Macário, 2011, p.55).

Most of urban mobility problems and challenges mentioned in the chapter before are related with sustainability. Whether if analyzed inside the wider perspective of "Sustainable Development", like the one that is stated in the well-known *Brundtland Report* - where the ability to meet the needs of the present cannot "compromise the ability of future generations to meet their own needs" (United Nations, 1987) - or narrow it down, where the focus relies on the own inefficiencies generated within the transport system.

Since the early years of the "Treaty of Rome" (1957) that Transport is one of the main policy concerns of the European Union, whether with the "Common transport Policy" or through several policy documents and strategies (white and green papers). Across the last twenty years, the EU has launched public debates, reflected, consulted and guided actions in the field of transport policy (transnational and local), and more recently advocates a shift to a more "Sustainable Urban Mobility System".

A cross-sectoral attention is given to "sustainability" in those different EU's strategy and policy documents, especially in what concerns environment and urban management and their multiple-sided and common challenges. Recurrently the "sustainable urban mobility" priority and following proposed actions are referenced in several documents related with the EU transport and urban mobility strategy. Since the Thematic Strategy on the Urban Environment (2004); passing through the "Green Paper" and "White Paper" on Urban Mobility (2007 and 2011); the Urban Mobility Package (2013)[13]; or the European Innovation Partnership in Smart Cities & Communities (2013)[14], among others.

Considering that cities will have a major role in the achievement of the "European Strategy 2020" goals, delivering a growth that is smart, sustainable and inclusive, so it is the proposed work of the European Commission *"towards a form of mobility that is sustainable, energy-efficient and respectful of the environment"*[15].

The general objective of the 2011 "White Paper" (European Commission, 2011) was then intended to define, according to POLIS (2015), a long-term strategy that would help the EU transport system to *"provide current and future generations with access to safe, secure, reliable and affordable mobility resources to meet their own needs and aspirations, while minimising undesirable impacts such as congestion, accidents, air and noise pollution, and climate change effects".* The 2011 White Paper established key goals for 2050, targeting a reduction of Europe's dependence on imported oil and the cut of carbon emissions in transport by 60% within this timeframe. Using resources more efficiently;

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[13] https://ec.europa.eu/transport/themes/urban/urban_mobility/ump_en *(accessed: 01.08.2018)*

[14] https://ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en *(accessed: 01.08.2018)*

[15] https://ec.europa.eu/transport/themes/sustainable_en (*accessed: 03.08.2018)*

pursuing the integration of different means of transport to promote multimodal travel with the support of the advancements on ICT, and the intention to define the necessary measures to provide seamless multimodal door-to-door mobility, are some of the initiatives proposed in the White Paper, that already anticipated the emergence of new mobility solutions we are experiencing nowadays.

In 2013, the "EU Urban Mobility Package" was launched, and great attention was given to the elaboration of Sustainable Urban Mobility Plans as a new approach to urban mobility planning, fostering a *"a better integration of the different urban mobility modes"* (European Commission, 2013a). This Communication aimed at leveraging action across all levels of government that would encourage Member States to create *"the right framework conditions for local authorities to develop and implement integrated and comprehensive strategies for better and more sustainable urban mobility".* Once again, the focus on "Urban Intelligent Transport Systems" considering its coordinated deployment (of smart technologies and ITS), is also referenced as a key enabler of urban mobility planning that support policy makers in achieving policy objectives, manage mobility and help change mobility behaviours.

With the recent approval in 2016 of the "Pact of Amsterdam" it was established the "Urban Agenda for the EU", that encompasses 12 priority themes and consequently established 12 thematic partnerships, being "Urban Mobility" one of them (European Union, 2016)[16]. The Urban agenda and the partnerships aim is to involve urban authorities in the design and implementation of EU policies strengthening at the same time its urban dimension. Taking into account the three pillars of EU policy making and implementation (better regulation, funding and knowledge), the partnership of Urban Mobility*, "seeks to facilitate a joint effort for more sustainable urban mobility"* (European Commission, 2018). Concretely this partnership, that entered the public feedback phase during 2018, projects mid and long-term focus within the four topics highlighted and their respective actions: 1) Active modes of infrastructure and public space; 2) New mobility services and innovation; 3) Public transport and accessibility; 4) Governance.

The proposed actions, measures and initiatives within the different EU policy strategy documents hereby briefly analysed are also in line with several of the United Nation's "Millennium Sustainable Development Goals" (2000), especially the *"SDG11-Make cities and human settlements inclusive, safe, resilient and sustainable"* and *"SDG13-Take urgent action to combat climate change and its impacts"*.

In parallel to this EU strategy evolution, the scientific community and practitioners witnessed and participated actively in the paradigm shift of transport planning from "predict & provide" to "aim & manage". In terms of transport planning, we have come from the traditional concern on operational aspects of transport, such as flow capacity and speed, to the current focus on "accessibility"; "sustainability – environmental & economic"; "social equity" and a balanced mobility system comprising all forms of transport. As stated by EPOMM, in the European Commission's vision, mobility management is determinant to a new mobility culture in cities (EPOMM, 2013). Mobility management is *"a concept for promoting sustainable transport (…) by modifying the habits and*

[16] http://www.urbanagendaforthe.eu/ *(accessed: 03.08.2018)*

behaviour of travellers", being at the core "soft" and "hard" policy measures. As referred by Banister (2008) *"demand management is effective in restricting access and reallocating space, and making more effective use of the available capacity"*, and therefore the author proceeds pinpointing that *"measures to encourage modal shift must be combined with strategies to make the best use of the «released space», so that there is a net reduction in traffic".*

Considering the world context and trends as well as the Urban Mobility context and opportunities mentioned in the previous chapters, the new concept of "Mobility as a Service – MaaS" is beginning to emerge as a potential disruption in the way mobility can be experienced. Being it the increase digitalization trend in transports; the advancement of ICT; the progressive shift of consumer habits towards "usership" or the greater attention given to user experience at the centre of business models, MaaS can take direct advantages from all these preconditions.

Despite all the diffuse understandings surrounding MaaS definition and that will be subject to a deeper study in this work, alike other players in the mobility system, MaaS providers and the whole MaaS ecosystem can have a determinant role in mobility management as well. Resource efficiency and the promotion of a more sustainable transport system, whether if speaking about the economic, social or environment transport dimension, can be accounted by this potential transport disruption.

As the United Nations proclaims in their "2018 World Urbanization Prospects":

> *"Urban growth is closely related to the three dimensions of sustainable development: economic, social and environmental. Well-managed urbanization, informed by an understanding of population trends over the long run, can help to maximize the benefits of agglomeration while minimizing environmental degradation and other potential adverse impacts of a growing number of city dwellers."*[17]

1.2. Problem Definition

With the continuous growth of the world population and rising urbanization, urban sprawl is taking up the scene of human settlements. Several challenges arise consequently inside the urban mobility system with the "last mile" problem, public transport inefficiencies, car dependency and rising motorization rates. Alongside with these challenges comes their negative impacts, such as the increasing levels of congestion and the related cost, both economic, social and environmental, that has strong impacts in the quality of life and intensifies the climate change phenomenon.

On the other hand, in a hyper-connected and online world, the digitalization megatrend is reshaping continuously the everyday lives of billion people worldwide. Accelerated advancements of ICT, that already changed Industrial processes and led us to Industry 4.0, are democratizing data. Data is seen as the new "oil" of the XXI century, nevertheless as privacy and surveillance issues arise, the availability of "open data" becomes of extreme importance in this context as well. Enabled by digitalization, consumption attitudes - mostly of younger generations *(Gen Y or Millennials)* - are

[17] https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html

changing from “ownership to usership”. This shift led to rise of the sharing economy in several business areas including the ones that are related with mobility.

Along with this brief global and urban mobility context, today one can also witness the existence of a high diversity of transport services in different cities around the world that altogether constitute the main drivers for the emergence of “Mobility as a Service”.

As with all “buzzwords” that baptize innovations or potential disruptions, some degree of confusion may arise when determining what a concept entails. In fact, in this case the concept of “MaaS” is surrounded by diffuse definitions throughout literature, practitioners and real examples, and each perspective encompasses different outlines of what is fundamental to be “MaaS”.

Paraphrasing an adage that reminds that “if a concept is everything, it is nothing”(cited in Klijn, 2008), the **first problem that this thesis intends to approach is to give structure to the concept of “MaaS” focusing on its building blocks**. In this way it will be possible to understand and propose different degrees or levels for each one of those building blocks, corresponding to different topological levels of “MaaS”, which in combination represent a specific “MaaS” configuration or pattern.

With a coherent structuration of “MaaS” and its topology classification, it will then be possible to further **identify what should be in place in terms of Public policy planning and public policy framework** (policy instruments) **as well as stakeholder responsibility** (inside each decision level of the urban mobility system) according to each corresponding set of building blocks inside the proposed topological levels. This exercise constitutes the second problem this thesis aims to give answer to. Concretely, the rational is to match the enabling policy instruments, as the course of action that derive from public policy design, to each set of functions (building blocks) identified in the “MaaS” topological levels, making then possible to further suggest, in what concerns the decision levels (Strategic, Tactic and Operational), “Who” does what, “Why” and “How”. Notwithstanding the importance of the “Evaluation stage” within the Policy Process, that corresponds to the operational level where the “Monitorization” of policies takes place, this dissertation will primarily focus on the Strategic and Tactic level of Public Policy.

1.3. Research methodology

The proposed work was developed first using an inductive logic followed by a deductive logic methodology. The work begins with an inductive logic approach, with *“data collection from which theoretical ideas and concepts emerge”*(Robson & McCartan, 2016), since it was needed to conduct a systematic literature review of the concept of “MaaS” and its fundamental questions. To analyse almost 120 documents, “MAXQDA” software (developed by “Verbi”) was used, that facilitated its content analysis and was determinant to process around 5000 pages of information.

The implementation of a “MaaS System” in Helsinki (Finland) was considered the inspirational case-study for the development of the Policy Framework proposal envisioned in this work. Besides official documents (laws) and websites, that constituted the initial base for the characterization of the case

study (the WHIM app), three semi-structured interviews with Finnish stakeholders were conducted in August and September of 2018 (National and Local level stakeholders as well as a Business stakeholder – MaaS Global CEO) to validate and gather more information on the case-study.

Afterwards, a deductive logic methodology was conducted in order to structure the “MaaS Public Policy Framework”, divided in two moments: i) the structure of the “MaaS” concept and design of the “MaaS topology proposal”, that relied on Multicriteria Decision Analysis model, and ii) the proposal of a Public policy framework, with the identification of implementation tools (policy instruments) and indicative group of stakeholders responsible for its implementation by each urban management decision level and “MaaS” core feature. The policy framework was anchored in the literature review of the theoretical framework on Public Policy and policy instruments, “Urban Mobility Decision Levels” and “Stakeholders” theory.

1.4. Document structure

The present work is divided in four chapters that comprehend an inductive logic research approach in the first three and culminate in a final chapter where a proposal is designed to fully answer the research question, through a deductive logic methodology.

The first chapter examines the world context and trends, the Urban Mobility context and opportunities, and the current policy context and strategies where the new concept of “Mobility-as-a-Service” (MaaS) is emerging as a potential mobility disruption.

The second chapter begins with the revision of literature in order to understand the universe of MaaS questions that characterize MaaS ecosystems, and that are fundamental for a preliminary overview of what is currently perceived as the “MaaS” building blocks and its concept structure. To complete the state of practice concerning MaaS deployment, an inspirational case-study research was performed – focused on Finland (and on the “WHIM app” from MaaSGlobal), which produced useful insights in terms of the policy process characterization and chronology, the overview of urban mobility decision levels implicated, and the stakeholders involved.

Thirdly, a specific literature review was completed, referencing the relevant theoretical framework for the development of the proposal, in two areas: i) “Public Policy” and “Policy Process” in the field of knowledge of “Political Sciences” and ii) the governance of Urban mobility systems, concerning the “Management Decision Levels” and “Stakeholders”.

Finally, the fourth chapter encompasses the proposal to structure a “MaaS Public Policy Framework”, divided in two parts: i) the structuring of “MaaS” concept and “MaaS topology proposal” and ii) and the identification of what should be in place in terms of Public Policy Framework (policy instruments) and stakeholder responsibility, according to each corresponding set of “building blocks” identified previously in the structure of “MaaS” concept and its correspondent ”Decision Level”.

2. State of Practice and Previous research

In this chapter the main goal is to conduct a first approach to the concept of “MaaS” to establish the “body of knowledge” already in place and that will be the starting point for subsequent analysis in the following chapters.

Dealing with an emerging concept such as “Mobility as a Service” requires a wide scope literature review, which can be based whether in peer-reviewed scientific articles published in journals, as well as in other sources, especially conference papers, where innovation can have one of its first sparkles. The flexibility underlying this systematic search is of foremost importance since the concept of “MaaS” is relatively new and according to several sources dates from 2014 with Heikkilä's first definition.

The search of relevant publications was made using solely the expression “Mobility as a Service” in three search engines: Google Scholar[18], Scopus database and ISI Web of Science database in February and March of 2018. The results from all these databases reached 172 publications. After a careful relevance analysis this initial number was downsized to 121 and, apart from peer-reviewed articles and conference papers, it comprised also institution position papers; Working Papers; Institutional Reports; Ph.D. Thesis and others. Most of the results are conference papers (45) and peer-reviewed scientific articles (37), the latter mainly in the transport field of knowledge. Institution Position Papers and Institutional reports, along with other kind of documents published by institutions (ONG’s; Platforms; Governments; Local Authorities, etc), are accounted as reports (summing up 25 results). Interesting work was also revealed in the 11 Thesis and 3 University Working Papers found.

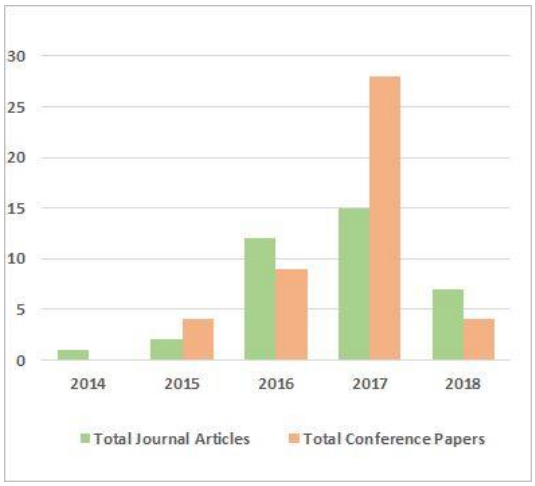

Figure 1 – Total Journal and Conference papers produced per year directly related with “Mobility as a Service” (source: author)

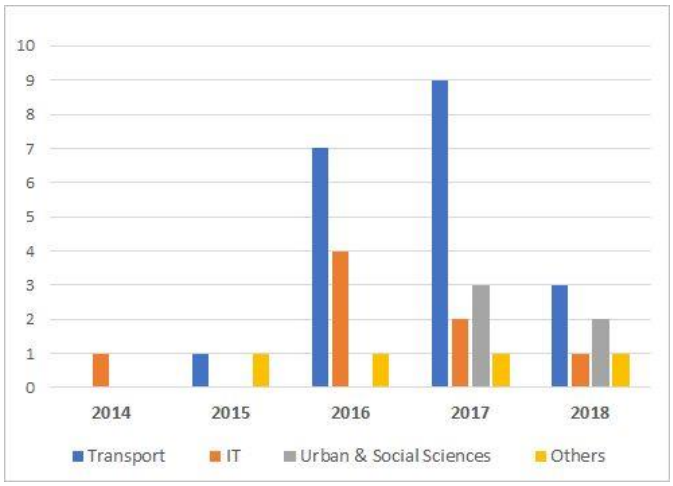

Figure 2 – Relevant peer-reviewed scientific articles per year (source: author)

There has been a continuous increment in the production literature through the last four years, especially on what concerns conference papers (Figure 1). From the thirty-seven scientific articles found relevant, the majority is related with the “Transport / Mobility” field of knowledge (20); followed by “Computer Science / IT” (8), and finally “Urban Planning and Social Sciences” (5) and four can be related to “other miscellaneous areas” (Business; Governance; Regulation) (Figure 2). Most of these

[18] https://scholar.google.pt/ ; https://www.scopus.com/ and https://app.webofknowledge.com, respectively.

scientific articles were published in different journals, a fact that is confirmed by the twenty-eight periodical titles for thirty-seven papers. With such low numbers of published articles, no journal can be recognized as being influential on what concerns MaaS-related studies, although “Transportation Research Procedia” stands out with four published publications.

Almost hundred authors already wrote about this concept and had their work peer-reviewed. There is a plethora of relations established with different perspectives and MaaS, e.g. through urban mobility; smart cities; urban planning; business models; innovation; IT or governance and policy. In Figure 3 is shown the most common keywords from the selected scientific articles.

Figure 3 – Keyword’s Wordcloud[19] of the thirty-seven peer-reviewed scientific articles (source: Author using wordcloud alghorithm[19])

2.1. MaaS Ecosystem – the universe of MaaS questions?

Answering “Why”; “How” and “What” opens the possibility to gain a deeper knowledge of “What is MaaS” under many perspectives. It is fundamental to structure the concept and to understand the central building blocks that shape its existence and condition further the proposal of topology.

What is MaaS?

According to the literature a wide range of “MaaS” definitions emerge in different areas, unlike multimodality and intermodality that are well-known concepts and frequently appointed as partial solutions to the provision of a more efficient and sustainable transport system. With “Mobility as a Service” the focus is wider and encompasses not only the right to choose the more convenient mode of transport but the ability and means necessary to make that choice possible, leading to seamless mobility and integrated management of all trip stages.

[19] https://www.jasondavies.com/wordcloud/ *(Wordcloud source algorithm – August’2018)*

There are references on “MaaS” dated before 2014 (G. Smith, Sochor, & Sarasini, 2017), and those relate to an experience in Sweden, with an R&D project (Go:Smart project) and the launching of UbiGo pilot during 2013-2014 (the “flexible traveller” MaaS pilot), and the Movense Ltd. workshop on “MaaS” (December 2013). It is also mentioned that Heikkilä's thesis (2014) is one of the first studies with a high focus on “MaaS” and it was also commissioned by the city of Helsinki. In her study, Heikkilä (2014) argued that the current organization of public transport didn’t support flexible multimodal mobility and her focus was on proposing an action roadmap for the city of Helsinki to change the paradigm of mobility. Moreover, the author defined therefore MaaS as:

> *“a scheme in which mobility services are provided as an individual and flexible service in a competing mobility operator market. (…) MaaS refers to circumstances, in which comprehensive supplies of mobility services are provided by mobility operators. Versatile services offered by the operators satisfy all mobility needs, thus decreasing the need to possess a car.” (Heikkilä, 2014)*

According to Jittrapirom et al. (2017), the “MaaS” concept was first comprehensively coined in 2014, during the 10th European ITS Congress that took place in Helsinki. Consequently, the definition of “MaaS” adopted by ITS Finland was the following:

> *“a mobility distribution model in which all of customer’s major transportation needs are met from a single platform by a single service provider that orchestrates each individual transport service component to meet a customer’s end-to-end service expectations.” (cited in Ovaska, 2017)*

The subsequent creation in 2015 of the public-private partnership “MaaS Alliance”[20], working as a focal point that promotes a common European approach to MaaS and contributes today to European policy-making among other activities, understands “MaaS” as:

> *“the integration of various forms of transport services into a single mobility service accessible on demand. (…) (implying) the use of a single application to provide access to mobility, with a single payment channel instead of multiple ticketing and payment operations.” (MaaS Alliance AISBL, 2017)*

Each author perspective culminates in their own definition for “MaaS”, and it is also widely acknowledged that there isn’t still a commonly accepted description by the scientific community (Smith, Sochor, & Karlsson, 2017; Kronsell, Karlsson, Sarasini, & Sochor, 2016; Polis Network, 2017). Indeed, some of the conceptualizations found, overlap goals and visions with core features and detailed system features to define MaaS. Apart from the ones already mentioned, other relevant definitions stemming out of peer-reviewed papers in “Transport” (T) and “Information technologies” (IT)

[20] The “Mobility as a Service (MaaS) Alliance” is a public-private partnership creating the foundations for a common approach to MaaS, unlocking the economies of scale needed for successful implementation and take-up of MaaS in Europe and beyond. The main goal is to facilitate a single, open market and full deployment os MaaS services. (http://maas-allianace.eu) *(accessed: 17.04.2018)*

and “Urban and Social Sciences” (U&SSc); conference papers; Institutional reports among other sources, are presented briefly in Table 2[21].

Author (year)	MaaS Definitions	Source
Hietanen (2014)	“Mobility as a Service (MaaS) is a mobility distribution model in which a customer’s major transportation needs are met over one interface and are offered by a service provider.”	Article in Press
Leviäkangas (2016)	“The concept of MaaS is relatively simple: bundling different transport means, public and private, into one easy-to-use package for the customer. The service is provided to the customer via mobile applications and payment is handled via a digital wallet.“	Peer-Reviewed (IT)
Y. Li & Voege (2017)	“The concept of MaaS is to use a single app to access and pay for various transport modes within a city or beyond; and the app will give options to allow a traveller to select the most suitable transport mode.”	Peer-Reviewed (T)
Veerapanane, Taylor, & Kaparias (2018)	“MaaS combines transportation services from public and private providers through a unified gateway that handles individual door-to-door trips, managing all stages of their creation and implementation (planning, payment, real-time monitoring, etc.). “	Peer-Reviewed (T)
Sprei (2018)	“is a bundling of services such as public transportation, car sharing, bike sharing and taxis. The idea is to offer a subscription or pay-per-use service that will cover different types of mobility needs and create a seamless intermodal travel.”	Peer-Reviewed (U&SSc)
Matyas & Kamargianni (2017)	"Mobility as a Service is a user-centric, intelligent mobility distribution model in which all mobility service providers’ offerings are aggregated by a sole mobility operator and supplied to users through a single digital platform."	Conference Paper
Eckardt, Aapaoja, & Sochor (2017)	"The great vision in the MaaS concept is to connect all available transport and mobility services together in a one-stop-shop package and hence offer an agile sustainable and effective competitor to private cars, which can be tailored according to the needs of end users."	Conference Paper
EPOMM (2017)	“Mobility as a Service (MaaS) is such a concept, combining services from public and private transport providers through a unified gateway that creates and manages the trip, which users can pay for with a single account.”	Institutional Position Paper
Transport Systems Catapult (2016)	"The Transport Systems Catapult has defined MaaS as using a digital interface to source and manage the provision of a transport related service(s) which meets the mobility requirements of a customer.”	Public-Private consultancy company
König et al. (2017)	“Multimodal and sustainable mobility services addressing customers' transport needs by integrating planning and payment on a one-stop-shop principle.”	"MaaSiFiE" - EU Project
MaaS Global (https://maas.global/)	“a way of combining options from different transport providers into a single mobile service, removing the hassle of planning and one-off payments”	MaaS Provider

Table 2 – List of MaaS definitions found in the Literature Review (accessed in February and March 2018) (source: author, based on literature review)

The focus of the present analysis will drift away from highly-related IT publications, and will concentrate on the fields of Transport, Urban and Social Sciences. Nevertheless, it is possible to find that the authors with an IT background tend to oversimplify MaaS definitions and reduce it to not more than the technological aspects of an ICT solution. For instance, “cloud computing” is evidenced in some literature as an inspiration for MaaS concept, e.g. *“(MaaS) applies the everything-as-a-service*

[21] An extended list of “MaaS” definitions found in Literature review can be consulted in Annex I

paradigm of Cloud Computing to transportation" (Callegati, Giallorenzo, Melis, & Prandini, 2016), only concerning a small part of the ecosystem.

As a result of MaaS definitions analysis, Jittrapirom et al. (2017) already suggested that "MaaS" can be thought as concept, a phenomenon or as a new transport solution. It is possible to acknowledge in this investigation that other authors emphasize its emerging and holistic character (Sochor, Karlsson, & Strömberg, 2016) to justify the existence of more than one transversal definition. Others rely more on a "ecosystem" approach (Matyas & Kamargianni, 2017) and almost all reference that "MaaS" is something "new". A "paradigm shift" (Kronsell et al., 2016), a "systemic innovation" (Surakka, Haahtela, HÄrri, Mich, & Horila, 2017) or a "disruption in mobility" providing a new way of thinking *"in terms of how the delivery and consumption of transport (or mobility) is managed"* (König et al., 2017), is also often referenced. Analysing the statements shown in Table 2 (and in the extended List – Annex I), it is possible to understand that there are three approaches to its characterization:

i. MaaS exists when a specific action occurs (and is defined by it);
ii. MaaS is what happens when some conditions exist (no direct action needed for MaaS to exist);
iii. MaaS understood as a Mobility Distribution Model (a model that enables a set of conditions that allow afterwards the occurrence of specific actions within the mobility system).

Circumscribing the existence of MaaS to the occurrence of specific actions, is the same as to focus on the access to mobility services through specific actions, whether related with the "purchasing ability" or related with the "means" of access (one interface, gateway, digital interface, app, etc). Some examples of this perspective can be shown when the authors define MaaS by: *"(…) buying mobility services as packages"* (Kamargianni, Li, Matyas, & Schäfer, 2016); "*(…) using a digital interface to source and manage the provision of a transport related service(s)"* (Transport Systems Catapult, 2016); *" (…) the ability to purchase access rights to an interoperable package of mobility services"* (Docherty, Marsden, & Anable, 2017); or by the *"(…) use a single app to access and pay for various transport modes"* (Y. Li & Voege, 2017).

The second perspective found, portrays MaaS as something that "happens" when certain conditions exist, and in this way establishes further insights on what can be understood as fundamental to its conceptualization. The "conditions" mentioned can be understood as the necessary relations between systems (transport; information; payment; data infrastructure; etc) and stakeholders (public and private transport providers; authorities; data providers, etc.) to allow new mobility experiences, in this case. Most of these authors define MaaS as the "Combination" or "Connection" of different transport modes or providers (public, private, shared, etc) through a unified gateway or based on one-stop-shop principle (Veerapanane, Taylor, & Kaparias, 2018; Eckardt, Aapaoja, & Sochor, 2017; EPOMM, 2017; Transport Systems Catapult, 2016). Most of them refer that this single interface allows the management of all stages of the trip (König et al., 2017; EPOMM, 2017; Veerapanane, Taylor, & Kaparias, 2018), although varying in the extent of the available functions. It is possible to underpin that

seamless and door-to-door trips, alongside with the focus on customer needs are a differentiating aspect associated to the existence of MaaS.

Realising MaaS as a “Mobility Distribution Model” encompasses the idea that MaaS exists when there is a coordinated scheme of relations, relying on several functions that enable the match of supply and demand of combined mobility services through one single interface (gateway), hence the distributional character. This perspective encompasses the actions and their enabling conditions that can take place inside a MaaS ecosystem. Particularly adds to this building blocks, the scheme of relations that need to exist in different levels of decision to enact the emergence of MaaS. This perspective comprises the fundamental concerns and represents a wider scope of MaaS conceptualization, that will be subject to greater attention in the following chapters.

Schematically, two perspectives can emerge when answering “Why?”, “How?” and “What?” questions: the planning side and the end-user perspective (Figure 4). The main difference relies on the “How” and “What” since the first one is focused on the supply side and the latter, on the user-journey of the customer. Concretely, from the planning side the “How” question is answered by the enabling conditions for a “MaaS System” to emerge and the “What” refers to the different configurations that characterize each “MaaS System” offerings.

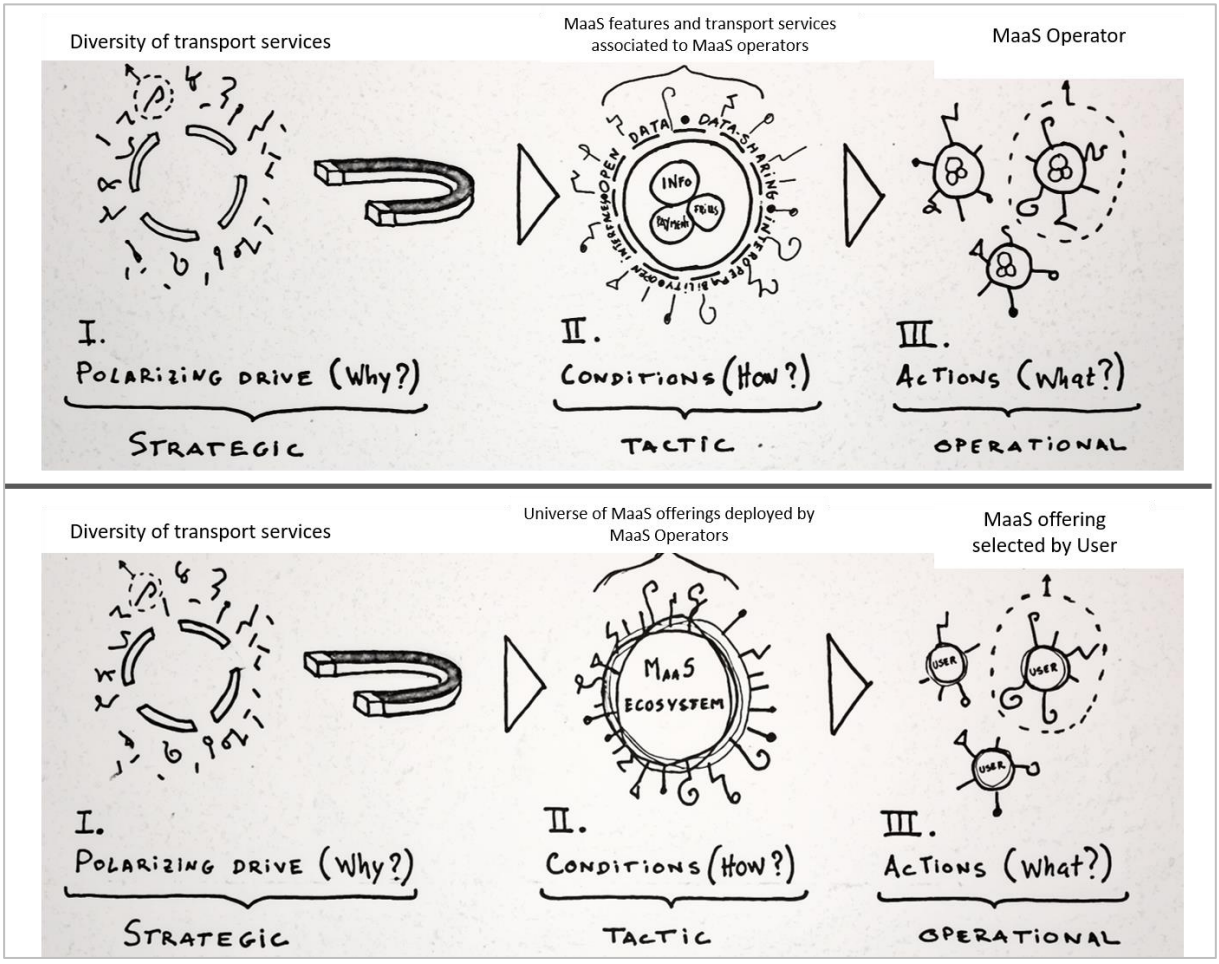

Figure 4 – Schematic representation of MaaS conceptualization from the perspective of the Planner and MaaS Operator (Top) and from the perspective of the User (Bottom) (Source: Author)

Considering the user perspective, the first level corresponds to the “polarizing drive” for the establishment of the necessary relations of Systems and Stakeholders to enable the emergence of MaaS, answering therefore the question: “WHY?”. The second level embodies the “conditions” or by other words all the relations that are formed and that enable the “Actions”, answering in this way the question “HOW?”. And finally, the “action” level where it is possible to acknowledge “WHAT” actions can be performed within this system given the conditions pre-established, answering the last question.

Particularly, and considering the different approaches to MaaS definition already analysed, it is possible to summarize the main characteristics underlined:

- The existence Transport Services information (the existence of transport options), allowing seamless travel and door-to-door trips;
- The access to mobility services is done through one interface based on one-stop-shop principle (or other designations, such as: gateway; digital interface; single app);
- This access encompasses integrated payment (single account) and the “purchasing ability” in a single interface;
- The interface allows a management of all the stages of the trip (planning, payment, etc.);
- It is a user-centric system, that matches supply and demand according to customers’ needs (flexibility);
- Depending on the existing payment conditions and ticketing options, it can be possible to have tailor made package bundles of mobility services, highlighting as well the “usership” concept associated with MaaS.

Moreover, it is obvious that technology is an important enabler of MaaS, but Co-operation and Co-ordination between mobility agents, Interoperability and Integration of information are also three aspects of extreme importance when designing MaaS ecosystem and the underlying relations between stakeholders; systems and infrastructure. To finish, one example of a reference architecture of MaaS ecosystem can be considered to explain abstractly how it works (Figure 5).

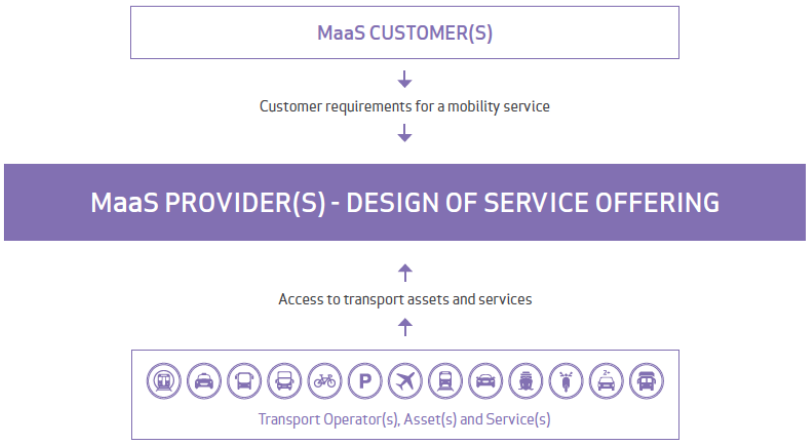

Figure 5 – Components/Stakeholders of MaaS Ecosystem: reference architecture of the system (Transport Systems Catapult, 2016)

2.2. MaaS implementation case study: Helsinki, Finland

In the process of reviewing the literature, the MaaS system operating in the city of Helsinki (Finland) stood out as an inspiration, inducing further research and the proposed analysis in this thesis.

In fact, numerous authors reference Helsinki's MaaS experience and Finland as being at the forefront of MaaS design and implementation (T. Casey & Valovirta, 2016), even the first one to initiate it worldwide (Y. Li & Voege, 2017). Declared as one of the most famous (Nikitas, Kougias, Alyavina, & Njoya Tchouamou, 2017) or as the best example of MaaS (EPOMM, 2017), Finland is seen as the country where MaaS was born (Dotter, 2016) with higher consistency and that lasts since its first appearance (2016).

In this chapter the focus will be the characterization of the "inspiration" case study in what concerns the Policy Process, focused on the "Policy Design" and "Policy Implementation" stages of the policy cycle, that led to the implementation of MaaS in the city of Helsinki. A chronology of the determinant moments of MaaS implementation process will be highlighted, as well as their main drivers. This case study will comprise also the actual "MaaS" ecosystem characterization and a brief introduction of Transport Sector context. Moreover, three interviews were conducted in order to gain a deeper knowledge on the case study as well as validating the process history research, ideas and facts.

The interviews comprehended different perspectives and levels of governance: **1) National Level** (Government and national policy perspective) - **Krista Huhtala-Jenks**, former adviser of the Minister of Transport and Communications of Finland (until 2017); **2) Local Level** - **Sami Sahala**, Forum Virium – Innovation Agency of the City of Helsinki (former work experience in the Helsinki Transport Authority - HSL) and 3) **Operational level** – **Sampo Hietanen**, CEO of MaaS Global, company that owns the "WHIM" app and that is currently operating in Helsinki, Finland; West-Midlands, UK and in Antwerp, Belgium.

2.2.1. Helsinki Characterization

Finland is a country with a relatively small population of 5.5 million people inside the European Union. The city of Helsinki is the capital of Finland and accounted 628,3 thousand inhabitants (in 2016) and belongs to the Region of Helsinki that concentrates a quarter of the country's population[22] (1.4 million) and 750.000 jobs.

The city of Helsinki has population density of 2.900 inhabitants/km^2 (for a land area of 216.5 km^2) and is considered to be the functional center of the given Region with more than half of the total jobs of the region. The city represents 43% of the total population in the Region and 55% of the Helsinki's Metropolitan Area (Figure 6). In fact, the disparity of population density values inside the Metropolitan Area are overwhelming, with the City of Helsinki reaching more than three times the neighboring cities'

[22]https://www.helsinkiregion.fi/hs/en/city-information/facts-about-helsinki/facts-about-helsinki *(accessed 16.08.18)*

population density[23]. In what concerns the population age structure, most of the city population is aged between 16 and 64 years old (62.1%).

The city of Helsinki registers a motorization rate of 404 cars per 1,000 inhabitants, which is lower than the one of the country – 594 cars/1,000 inhabitants (2016). The organization of the transport sector will be addressed in the following chapter, although it is important to reference that the modal share registered in 2017 within the Region was relatively balanced between public transport (30%) and private vehicle use (39%) and non-motorized modes (29%)[24].

Figure 6 – Finland; Helsinki Region; Helsinki Metropolitan Area; City of Helsinki associated geography (adapted by the Author)[25]

Finish population can be considered a highly mobile society with their 172 phones per 100 habitants' ratio and high internet usage statistics. Almost all its population between 16 and 74 years old are internet users – 93%, a number that grows if the reference is the city of Helsinki - reaching 98%. Indeed, concerning the EU Digital Economy and Society Index (DESI), which is *"a composite index that summarizes relevant indicators on Europe's digital performance and tracks the evolution of EU member states in digital competitiveness"* (Niggebrugge, Vos, & Lago, 2018), Finland ranks in second place in the EU-28.

Helsinki was described in Deloitte's "City Mobility Index" study as a city committed to innovation, *"leading the way with Future of Mobility concepts such as MaaS and shared mobility"*. With a public system *"highly reliable and accessible throughout the city"*, the city's goals *"include making public transit the No. 1 choice for travel by 2025 and phasing out private cars by 2050 through shared mobility, demand-responsive transport, and pedestrian-centric urban design"*[24].

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[23] https://www.hel.fi/hel2/tietokeskus/julkaisut/pdf/18_02_21_Statistical_Yearbook_2017.pdf *(accessed 16.08.18)*

[24] https://www2.deloitte.com/content/dam/insights/us/articles/4331_Deloitte-City-Mobility-Index/city-mobility-index_HELSINKI_FINAL.pdf *(accessed 17.08.18)*

[25] https://www.hel.fi/hel2/tietokeskus/julkaisut/pdf/16_06_16_Facts_about_Helsinki_2016_Askelo.pdf *(accessed: 16.08.2018)*

2.2.2. National Transport Sector Context

According to the website of the **Finish Ministry of Transport and Communications** (LVM)[26] one of its main goals is the provision of safe and secure communication connections and services. The mission of the Ministry is to *"ensure that people have access to well-functioning, safe and reasonably priced transport and communications networks"*[26]. One of the Ministry's main responsibilities is law drafting, particularly the implementation of EU legislation, that can be either discussed in government plenary sessions or issued by itself. In this way, the Ministry is considered a legislative authority in the transport and communications sector, and more broadly seen as the policy maker.

Four agencies and three companies are part of the Finish administrative branch of the transport and communications sector and its strategic performance guidance is provided by the given Ministry. Concretely, the Ministry guides and supervises the operation of its agencies and monitors their development. The ones that are relevant inside this context are the "Finish Transport Agency"; the "Transport Safety Agency (Trafi)" and the "Finnish Communications Regulatory Authority".

The **Finnish Transport Agency** is responsible for roads, railways and waterways and the development of the transport system (construction and maintenance), whilst the municipalities are responsible for their street networks. The **Finnish Transport Safety Agency (Trafi)** has responsibility for improving transport safety and the environment, being also responsible for transport related public authority functions. Lastly. the **Finnish Communications Regulatory Authority (Ficora)** ensures a reliable and smooth function of communications networks and markets and a secured position of the communication service user, especially in data protection and privacy.

The Ministry of Transport and Communications is also accountable to implement the strategic Government Programme within its sectors. Looking for the actual Government Program it is possible to notice that a *"cross-cutting theme in the Government Programme is digitalisation"*[26]*.* Therefore, one of the Ministry's aims is to create a favourable operating environment for services and new business models, enabling in this way the use of new digital services. It is in this context that becomes evident which areas, within the four **Ministry's areas of expertise**, are the ones that directly enable and support MaaS implementation: the **"Information"** and the **"Services"** ones.

From the perspective of the "information"[27] area of expertise, in relation to "MaaS" ecosystem implementation enablers and drivers, the ministry aims to *"increase the availability of information and open data and generate new business operations"*. The ministry considers that the *"openness of information is a prerequisite for new services",* and that by improving *"the access to data and by means of regulation, it will be possible to provide opportunities for data-based businesses".* Ensuring *"that services and networks are safe for the users"*[27]*,* another declared aim, is of upmost importance when considering the promotion of *"confidence in the security and privacy protection of services provided in the information society".*

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[26] www.lvm.fi *(accessed: 17.08.2018)*

[27] https://www.lvm.fi/en/information-en *(accessed: 19.08.2018)*

Another field that has expression in Finish transport policy is the promotion of "Automated Transport", where it is understood that *"transport information together with the transport and communications infrastructure form a platform for transport automatization".* Currently the government supports automation experiments and considers that the advancement of communications and vehicle technologies offers *"significant possibilities for improving the safety, efficiency and sustainability of traffic and transportation".*

From the perspective of "Services"[28] area of expertise, it is very clear the tonic on the provision and development of mobility services that are based on customer-needs and efficiency. According to the Ministry's website[28] the *"role of the public sector is to enable and create favourable operating conditions, and the responsibility for innovations and service development lies with the private sector".* Nowadays, one of the aims of the Ministry's transport policy refers that:

> *"Mobility will to a greater extent become a service in which physical mobility and digital services merge into a high-quality door-to-door service that meets the users' needs. In the future various transport service chains should work seamlessly together. This means a holistic change in the entire transport system and in the roles of the transport operators."*[28]

2.2.3. Regional and Urban transport context - Helsinki

Since 2010, the **Centres for Economic Development, Transport and the Environment (ELY Centres)** are part of the government's reform project for regional administration aiming a higher concentration of services and competencies in one regional institution. Concretely the areas of responsibility are: 1) Economic development, employment, competence and culture (E); 2) Transport and infrastructure (L); 3) Environment and natural resources (Y). According to its website[29], their role is to *"develop and support economically, socially and ecologically sustainable wellbeing alongside other operators"* being responsible for the government's regional implementation and development tasks. Currently there are fifteen of those centres throughout Finland, but not all have the same competencies.

Furthermore, the ELY Centres are important regional developers and distributors of EU funding[29], co-operating closely with the Regional Councils and other agencies. In what concerns transport, these entities are supervised by the Ministry of Transportation and Communication, and accommodate several responsibilities within the Transport system, e.g. transport system management; road safety; road Maintenance; subsidies for public transport; transport permits, among others.

From the perspective of strategy and land use planning at the regional level, the **Finish Regional Councils**, mandated by Finish Law, are *"joint regional authorities and their members are the*

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[28] https://www.lvm.fi/en/services *(accessed: 20.09.2018)*

[29] www.ely-keskus.fi *(accessed: 20.09.2018)*

municipalities in the corresponding geographical regions"[30]. Specifically, it is this entity that is responsible for regional development and land-use planning, encompassing the areas of land use, transport and environment policy objectives. The Council elaborates in this way "Development plans" in collaboration with the municipalities and public and private actors, taking also into account the National targets set by Government and Ministries. These specific plans and the implementation have mandatory legal consequences in the actions of local government authorities, and with its "implementation plan" comes also indicative funding and responsible actors. These Regional Councils receive its funding from its member municipalities and from the Government and the European Union, in what concerns regional development.

The **Helsinki-Uusimaa Regional Council** is the joint regional authority for the Helsinki-Uusimaa Region, where it is situated the only metropolitan area of the nation. This Region Council is composed by 26 municipalities (identical geographic area of the corresponding ELY centre) and it is home for a quarter of Finland's population, 14 Municipalities belonging to the Helsinki Region (Figure 7).

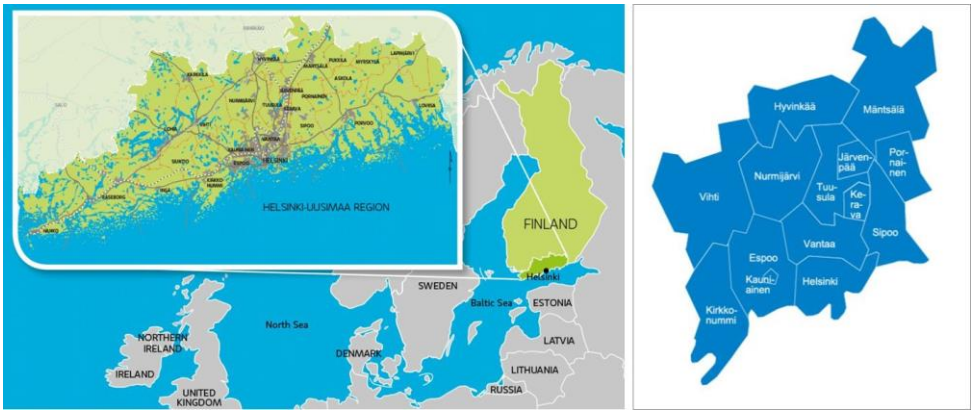

Figure 7 – (from left to right) Helsinki-Uusimaa Regional Council area; Helsinki Region Area (adapted by Author)

It is possible to foresee the importance of the Region of Helsinki when this region is the only one where the transport system planning isn't the responsibility of the Regional council (according to Regional Development Act) but instead is assigned to **Helsinki Regional Transport Authority** (HSL or HRT). HSL was created in 2010 and is a joint local authority whose member municipalities are Helsinki, Espoo, Vantaa, Kauniainen, Kerava, Kirkkonummi, Sipoo, Siuntio and Tuusula, although its operating area is the Helsinki Region. According to its website[31], HSL has several responsibilities, such as: i) planning and organizing public transport in the region being also responsible for the "Helsinki Region Transport System Plan (HLJ)"[32]; ii) procurement of bus, tram, metro, ferry and commuter train services; iii) approval of public transport fare and ticketing system as well as ticket prices; iv) public transport marketing and passenger information; v) Organizing ticket sales and ticket inspections.

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[30] https://www.uudenmaanliitto.fi *(accessed: 15.08.2018)*

[31] http://www.hsl.fi *(accessed: 18.08.2018)*

[32] http://www.hsl.fi/hlj *(Helsinki Region Transport Plan 2015) (accessed: 18.08.2018)*

Some 370 million journeys are made on HSL's transport services annually, being the City of Helsinki public enterprise **"Helsinki City Transport"** (HKL) one of its more important partners. As a matter of fact, whilst HSL manages the areas of traffic planning; contractor operations; ticket sales and passenger communications, and the HKL operates the metro, tram and one ferry line and owns the public transport infrastructure in Helsinki (tracks, stations, depots and rolling stock). In Figure 8 is possible to have an overview of the organization of the transport sector in Finland, with a special focus on the case of Helsinki.

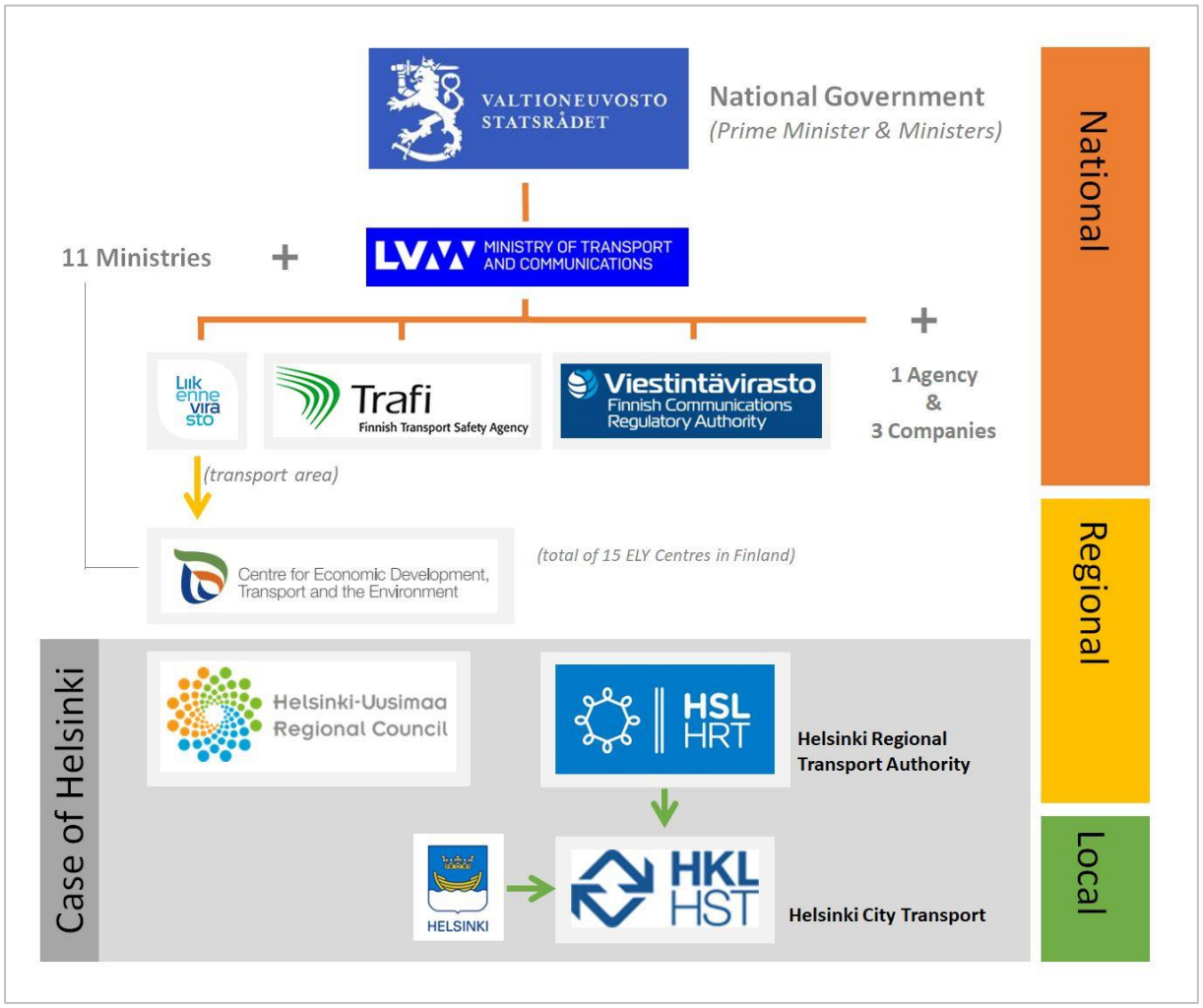

Figure 8 – Finish Transport Sector Organization with focus on Helsinki example (source: Author)

In what concerns the annual market for mobility services in Finland this value reaches 50 billion euros of which households spend annually roughly 16 billion and companies 33 billion euros (T. Casey & Valovirta, 2016). The same authors detailed that the public sector (both the central government and municipalities) subsidize mobility services (e.g. public transportation s) with 1 billion euros and also invest around 3 billion euros annually in transportation infrastructure (1.5 billion euros – government and 1.4 billion euros – cities and municipalities).

2.2.4. MaaS Implementation Process Chronology

In what concerns the chronology of the interrelated policy milestones, that altogether are assumed to form the process of implementation of MaaS in Finland, different sources reflect singular views that outline the context; the strategies, bills or programs determinant for its emergence. As Ovaska (2017) also refers, it is widely acknowledged that the history of MaaS in Finland has *"heavy ties to organizational changes and renewing policy-making practices within the Ministry of Transport and Communications"* which played an important role in the emergence of MaaS.

Therefore, the timeline described in this work aims to encompass what is commonly considered as the determinant moments, focusing on strategy and policy; policy instruments such as funding programs and bills as well as the operational ecosystem that emerged with the MaaS pilots in Helsinki and the cooperation between the public and private sector.

Policy, Strategies and Organizational Changes

In 2008, the first report delivered to the parliament on transport policy (Finnish ministry of Transport and communications, 2008) comprised four policy domains which would consubstantiate in a set of guidelines to reach 2020 objectives. A key aim of this **Transport Policy Report** (2008) is to improve "long-term sustainability in transport policy" and therefore the control of Climate Change is also acknowledged as a key priority in this matter. In fact, only "Climate Change and Public Transport" domain had references that concerned excessive car-use or the decreasing share of Public transport, and somehow related with the efficiency and sustainability of transport. Measures as "employer-subsidized commuter ticket system" as well as "preparation of guidelines for promoting pedestrian and bicycle traffic" were proposed in line with the objectives for 2020. A great emphasis is made in what relates to the coordination between land-use and transport planning in order to densify the urban structure leading to a reduction in transport needs. At the same time, it is intended that the "number of journeys in public transport has substantially increased, and the number of car journeys is not growing" for 2020. No direct reference is done to intermodality or the increase of flexibility of public transport, and it is even mentioned that there are *"practically no alternatives to cars in areas which do not have adequate supply of public transport services"* (Finnish ministry of Transport and communications, 2008).

The formulation of the **Intelligent Transport Strategy**, published in 2009, was considered *"the world's first national ITS strategy covering all modes of transport"* (Ministry of Transport and Communications, 2009). This strategy had a vision based on seven principles and simultaneously contained a programme of action. The principles ranged from the contribution to sustainable development, stress on usability and cost, to the compatibility of services or cooperation between public and private stakeholders and users. It is mentioned that by the "transport administration reform", with the foreseen creation of two new agencies in 2010 (Finish Transport Agency - FTA and Finish Transport Safety Agency – Trafi) the focus of transport administration would expand from individual transport modes to the transport as a whole and to the transport information structure. This shift in transport policy is of

foremost importance since it fosters *"a customer-oriented view of the entire transport system".* This document also establishes *"a way of thinking based on the four-step principle, which will shift the focus away from transport infrastructure management and towards customer-oriented transport system operations"*[33]. Real-time information concerning time and place, transport systems and transport network status and incidents are mentioned as environmental-friendly services that should be available in all intelligent transport services as well as electronic payment systems. Some key projects of this strategy, considered determinant within Implementation process of MaaS in Finland, are highlighted:

- Public transport services – National public transport payment system (1.a): *"Mobile payment and identification in wide use in public transport and in parking and mobility services"*
- Public transport services – Wireless broadband for all trunk network passenger train and buses (1.b): *"(…) Passenger interfaces continuously display real-time passenger information (…) Technology also provides passengers with real-time public transport information on stops along main public transport quality corridors and in large urban areas"*
- Public transport services – Open joint database for public transport (1.d): *"Public transport passengers have access to reliable, easy-to-use, real-time passenger information services throughout the trip chain. These services are founded on a joint database (…)"*
- Use of Public Information (8): *"The 'transport data warehouse' is a joint service of businesses and authorities, which provides businesses with static and real-time basic transport information (e.g. traffic and weather information) produced by the authorities. (…) The necessary public information is easily available to all for free or for a low price."*

Along with the Intelligent Transport Strategy came the **organizational changes** within the Ministry, shifting from a management based on silos relying on separated modes of transportation to an organization *"based on functional wholes, with emphasis on customers and solutions"* (Ovaska, 2017). On January 2010, the previously separated agencies for aviation, rail, road and marine transport of LVM were merged into a new transport infrastructure agency called the **Finnish Transport Agency**[34] and the **Finnish Transport Safety Agency (Trafi)**[35]. This shift is considered of foremost importance since it fosters an integrated and coordinated approach to transport planning and information, as well as it promotes a customer-oriented view of the entire transport system.

> *"The organizational changes were a big stepping stone along the transition from infrastructure-based thinking to customer-centric and solution-centric thinking. These changes happened in the early 2010s, and they were a big deal."*

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[33] "*According to the four-step principle, the first step in solving transport problems is to assess whether the problem can be fixed by influencing transport demand. Next, the possibility of increasing the efficiency of the existing transport infrastructure is reviewed. Only when small-scale improvements are found to be insufficient are new infrastructure investments considered."* (Ministry of Transport and Communications, 2009)

[34] Finnish Transport Agency - New agency resulting of the combination of the Finnish Road Administration, Finnish Rail Administration and the infrastructure management functions of the Finnish Maritime Administration.

[35] Traffi - New agency resulting of the combination of the Finnish Vehicle Administration, Finnish Civil Aviation Authority, Finnish Rail Agency and the maritime safety functions of the Finnish Maritime Administration.

*(*Minna Kivimäki*, Director-General of Services of the Ministry of Transport and Communications of Finland*, *in* Ovaska, 2017)

The background for the implementation of a renewed transport policy in Finland was in place and at the same time, during 2010 began what is called the **"Transport Revolution"** (Liikennerevoluutio). The "Transport Revolution" is a development programme launched jointly by SITRA and several ministries, such as the Ministry of Transports and Communications, as well as other partners[36], that aimed at "*developing a new mind-set for urban and transport planning and policies and policy implementation"* (Tuominen & Kanner, 2011). The central premise of this programme is *"to produce more and better with less",* taking into account that *"in a sustainable, people-centred service society, infrastructure, transport and logistics are regarded as services and sources of well-being, not simply as infrastructure investments or projects"* (Kostiainen & Linkama, 2011). The core idea underlined can be also understood as the improvement of the productivity and effectiveness of the new transport policy measures anchored on a comprehensive approach and shared agenda for vaious actors (housing, urban planning, transport, employment and finance - MALPE concept).

A new approach to transport and urban policy is set and a "mind chart" (the first outcome of this programme) describes the proposed areas that should be subject to future reform: i) transport and urban planning; ii) transport system funding and user prices; iii) service level acquisition and iv) service production. This new approach focuses on users – people, enterprises and other organizations – and its key concepts are services and service levels. As it is advocated in the "transport revolution mind chart": *"A sustainable and people-centred Finland needs a transport system that meets and adapts to the needs of users quickly, even in real time"* which is made possible by digitalization that can improve the existing services as well as generate new ones. Revolutionary services are appointed, and among them is the *"utilisation of transport data to a new level"* with several examples, e.g. *"traffic data market place"* for the exchange of transport information; *"mobility profile"* or the *"mobility account".*

As affirmed by *Kivimäki* in Ovaska (2017)*: "the Transport Revolution program was an important milestone in the development of Mobility as a Service. Although the term MaaS was not present in the program, the seeds of MaaS, i.e. the use of data, ICT, and services in transportation – were already coming together*". User-driven development of transport products and services as well; the creation of customised service packages leveraged by the availability of real-time information or the one-stop-shop principle applied to the info-market of transport, are some of the features of MaaS already specified in the document.

[36] "Transport Revolution" - Launched jointly by The Finnish Innovation Fund's Public Leadership and Management Programme and the Ministry of Transport and Communications, the Ministry of Employment and the Economy, the Ministry of Finance, the Ministry of the Environment, two national Transport Agencies, and two strategic centres for science, technology and innovation.

At the European level, following the 2008 Action Plan for the deployment of Intelligent Transport Systems (COM/2008/0886 final), the **European ITS Directive**[37] (DIRECTIVE 2010/40/EU) is published in 2010, establishing the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport.

In 2012, the second **Transport Policy Report 2012-2022**[38] to the parliament was submitted and a clear change from the previous one can be noticed through its aims to reduce passenger kilometres or redirect traffic towards more sustainable transport modes, no clear mention was made to MaaS ecosystem features. Although it is with the same minister of transport and communications, *Merja Kyllönen*, that an informal association is established - the **"New Transport Policy Club"**[39] – with the purpose of *"inform and provide new perspectives to transport policy-making, and meetings were organized and chaired by director-general Kivimäki"* (Ovaska, 2017). According to the same author and based on a series of interviews conducted in his Master Thesis, specifically with the Director-General *Kivimäki*, these discussions revealed to be fruitful and determinant for the development of MaaS. Indeed, it is in 2013 that in one of its meetings (Mustio meeting) subscription-services of mobility are discussed and quoting *Kivimäki*: *"The message was that we should begin experimenting and piloting. The importance of services, using open data, and building services on open data was also highlighted".*

The **second Intelligent Transport Strategy** is published in 2013 by LVM, and it is taken as a concretization of the vision issued in the first strategy, relying on its original foundational objectives and principles. This strategy advances key projects in the areas of "*real-time information within the transport system"* (data collection, processing and distribution); open data as well in the area of *"integrated public transport system"*. The latter with a reference to door-to-door trip chains and *"interoperable payment system"* following a *"single payment method, one-stop-shop"* (Finnish Ministry of Transport and Communication, 2013). The strategy assigns responsibility to stakeholders and establishes a timeline to develop these key projects, but still doesn't specifically mentions the MaaS concept although once again, some of the MaaS building blocks are already addressed.

The concept of MaaS was not very clear still and that's why that the **2014 Aalto University Master Thesis of Sonja Heikkilä** (Heikkilä, 2014) is referenced as being the first comprehensive document that synthetizes the different ideas behind MaaS, making it possible to communicate it more effectively. The other added value of this thesis relies on the proposal of a roadmap of policy suggestions to implement MaaS in Helsinki. In June 2014 parallel to the 10th European ITS Congress held in Helsinki, **LVM launches a factsheet**[40] **defining MaaS** as a *"paradigm change in transport*

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[37] DIRECTIVE 2010/40/EU of the European Parliament and of the Council of 7 July 2010, published in the Official journal of European Union, 2010.08.06, L207 *(accessed: 20.08.2018)*

[38] https://www.lvm.fi/-/finland-s-transport-policy-lines-for-the-future-set-out-789463 *(accessed: 20.08.2018)*

[39] Informal association of politicians and civil servants (mainly from LVM), big cities, industry stakeholders (including both incumbents and start-ups from transport and telecommunications), ITS Finland and Tekes (the Finnish Funding Agency for Innovation) (Ovaska, 2017)

[40] https://www.lvm.fi/documents/20181/798198/Fact+sheet+16-2014+-+Mobility+as+a+Service/4ab2de51-856d-4589-9b1c-4141e0635a89?version=1.0 *(accessed: 21.08.2018)*

(and) a mobility distribution model in which all users' major transport needs are met over one interface and are offered by a service provider" specifying that typically *"services are bundled into packages similar to those of mobile operator services*".

In January **2016**, a new **administrative reorganisation** was performed in the **departments** within the Finish Ministry of Transport and Communications, with the Services Department, Data Department and Networks Department comprising the Transport and Communications Policy Departments.

In the field of policy, the last recognized milestone developed during the implementation of MaaS pilots in Finland is the reform of the transport sector regulation that started to be prepared in 2016 and it was led by the minister of Transport and Communications *Anne Berner*. This legislation was approved by Finnish Parliament in October 2017 as a unified "transport act", the **"Transport Code"** (Liikennekaari), also formally known as the **"Act on Transport Services"** (nr. 320/2017).

This Act *"brings together legislation on transport markets and creates conditions for digitalisation and new business models in transport"*[41] where the key objective is the provision of customer-oriented transport services. LVM[42] states that this act brings changes *"to the current state of the transport market that is strictly regulated and guided by public measures"* promoting *"fairness of competition in the passenger transport market and competitiveness of the service providers of both passenger and goods transport".*

According to LVM[43] the aim is to *"review the transport system as a whole, make market access easier and promote the interoperability of the different parts of the transport system"* and at the same time "*lighten regulation".* Considering that *"future transport will rely on the interoperability of information and information systems, as well as the openness of interfaces"* this code also *"lays down provisions for the interoperability of ticket and payment systems"*[44]. This code will promote the *"introduction of new technologies, digitalisation and innovative business concepts, making uniform and mobile travel chains possible"* as well as open data standards for all transport service providers. This act is widely recognized as the corner stone that enables Mobility as a Service in Finland.

Provisions on Interoperability and ticket payment systems towards the use of a single trip ticket on door-to-door travel chains are some of the focus areas of this legislation. As Minister *Anne Berner* points out, a transformation for a more user-centric transport service and the important role of open data to that extent, played a crucial role in the law design:

> *"The point of departure for the entire reform has been to offer transport users good and flexible services and freedom of choice. The Act on Transport Services makes it possible to examine transport as a whole, as one service. The opening of data is central in this change and is emphasised in the second stage of the Act"*

[41] https://valtioneuvosto.fi/en/artikkeli/-/asset_publisher/vuodenvaihteen-muutokset-lvm-n-hallinnonalal-1 *(accessed: 21.08.2018)*
[42] https://www.lvm.fi/en/act-on-transport-services *(accessed: 21.08.2018)*
[43] https://www.lvm.fi/en/-/transport-code *(accessed: 21.08.2018)*
[44] https://valtioneuvosto.fi/en/artikkeli/-/asset_publisher/liikennekaari-eduskunnan-kasittelyyn *(accessed: 21.08.2018)*

Alluding to Minister *Berner* inquiry in Ovaska (2017), this Finnish law intends to enable MaaS by legally obligating service providers to provide data openly to other service providers and in this way allow a more flexible combination and development of new services:

> *"The heart and fundamental premise of Transportation Code is that all providers have their data accessible through open interfaces. (…) including timetables, prices, availability, possibly location-based data. On top of this you would be able to create data-driven mobility operators, like the MaaS Global, that create new, demand-based services. (…) However, this also allows incumbent companies to develop entirely new services."*

The main objectives of this Act, as referenced by G. Smith, Sochor, & Sarasini (2017), citing the Ministry are to *"promote the creation of new service models, ease market entrance, dismantle national regulation that limits competition and reduce the level of public guidance"*. Indeed, according to an interview done by *ITS International*[45] (2017) to the Finnish Minister of Transport and Communications, one of the main goals is to transform the way transport policy is perceived and governed from silos to one entity:

> *"No longer are we doing transport policy and communications policy. We are doing policy for networks, for services, for data management and data handling to bring different fields together. And that has helped us understand what MaaS is all about and the kind of legislation and regulation it needs. (…) We have to look at the transport system as one entity - with no borders and the ability to share data on payments, tickets and location".*

The Finnish Transport Agency would be obligated to open data received on the use of services through open interface, in a form where it cannot be linked to individual users, service providers or services. Likewise, it is referenced in the same *LVM press* release[41] that the future offer of *"trip chains and combined services would be eased by enabling acting on another's behalf (…) incorporating tickets for all modes of transports (..) as well as seasonal products or discounts into a combined mobility service".*

Concretely, as it possible to perceive in Figure 9, the "Act on transport services" distinguishes several obligations that 'Integrated Mobility Services' and 'Mobility Services' must comply. The 'Integrated Mobility Services' mean the formation of travel chains and other service packages in return for remuneration by combining the mobility services offered by different service providers. The 'Mobility Services' encompass two branches: 1) the 'Transport Services' (public or private, or combination of services related to transport), that is then split in 'Goods' and 'Passenger' Transport services and 'Taxi and vehicle-for-hire' services; 2) the 'Support services' – services that support transport services, being specified as 'Brokering and Dispatch Services', that englobe data services for instance.

[45] http://www.itsinternational.com/sections/comment-interview/interviews/leading-finlands-transport-revolution/

This act specifies the granting requirements of different transport service 'licences' as well as other types of obligations. These obligations have different natures (Figure 9):

i. Provide information to passengers, concretely the "service offer" and the basis for calculating the price);
ii. Provide information to authorities (periodical submission), especially in what concerns starting and termination of service, the total remuneration and costs as well as the 'offer' and 'actual demand' information;
iii. Make available 'Data' and 'Sales & Tickets' interfaces (open interface) in what concerns the interoperability of data and information systems, to mobility service providers and the provision of integrated mobility services;
iv. Obligation to Verify and Inform, especially in what concerns the activity of transport services within the activity of a 'Brokering and Dispatch Service provider'

In January of 2018, the first provision of the "Act on Transport Services" entered into force, but the first and second phase of the "Act on Transport Services" (also called "Transport Code") was enacted on the 1st July 2018 and has two parts (G. Smith, Sochor, & Sarasini, 2017): a) It aims at lowering permit requirements and tearing down silos between transport markets through deregulation and b) It focuses on enhancing the use of open and interoperable data interfaces. The Code obliges incumbents as well as new entrants to the transportation market to provide their operational data as well as their single tickets for third-party resale and use – *"The underpinning idea of the Code is to take advantage of digitalization and enable both the development of better and more agile transport services, and the integration of them into MaaS offerings"*.

Meanwhile is also relevant to recognize that other relevant strategies that promote sustainable or technically advanced forms of transport were published widening the support for MaaS, such as the **National Strategy for Walking and Cycling** (2011); the **Environmental Strategy for Transport 2013–2020**; and **National Energy and Climate Strategy** (2013).

At the European Level, and with the aim to stimulate European development towards MaaS, in 2016 call of the **EU Horizon 2020**, a special topic was launched with 25M€, the «*MG-6.1 Innovative concepts, systems and services towards 'mobility as a service'».*

Of worldwide scope of action, although specially focused in Europe is the activity of MaaS Alliance, established as a public-private partnership in 2015 and already referenced in chapter 2.1.1. The **MaaS Alliance** contributes to European policy-making and is an active voice of MaaS community for awareness and advocacy. The Alliance works to establish the foundation for a common approach to MaaS and its main goal is to facilitate a single, open market and full deployment of MaaS services, *"for successful implementation and uptake of MaaS in Europe and beyond"*[46].

[46] https://maas-alliance.eu/ *(accessed: 17.04.2018)*

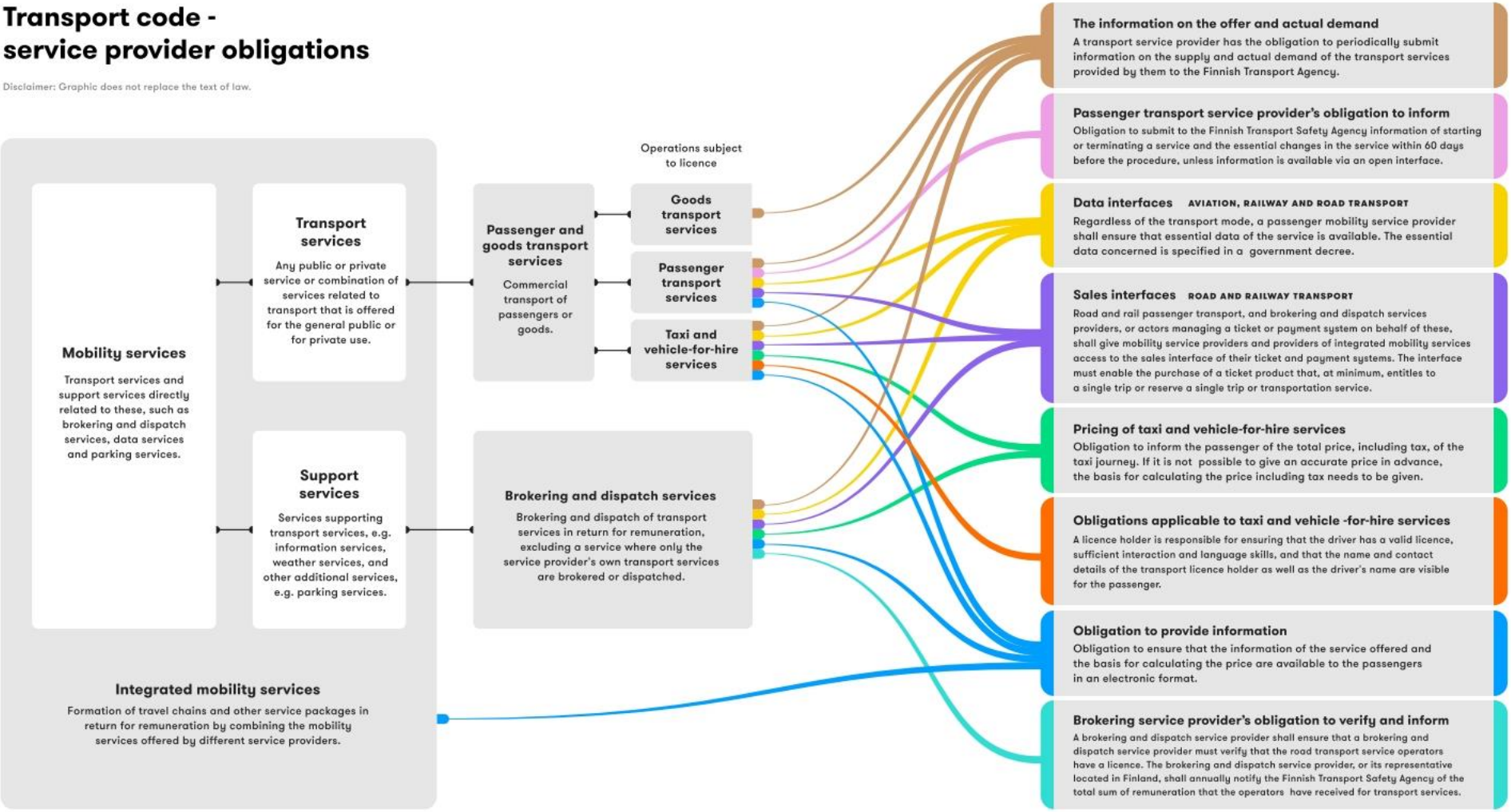

Figure 9 – "Transport Services Act" also known as the "Transport Code" – Service Provider Obligations (Ministry of Transport and Communications of Finland, 2017)

Programmes and operational pilots

In 2014, as it was described, there was already a strong support for sustainable and intelligent transport at the ministry level and among various stakeholders from private and public sectors, although business participation was still absent. Reports[47] exist that before the launching of the 2015 funding campaign for MaaS pilots in Finland, Tekes[48] (Finnish Funding Agency for Technology and Innovation) and LVM promoted awareness workshops and "activation campaigns" to encourage the development of new technologies and services, although proved to be insufficient since there was a lack of engagement from transport providers.

Therefore, in the beginning of 2015, **LVM** in cooperation with **Tekes'** MaaS team "Smart Transport – Smart Services & Digitalization", jointly launched a **double funding call** (in parallel: 'pre-study' projects and consortium projects Mobility Operators call) **for Mobility Operators** (MOs) – organisations that would design, develop and manage MaaS projects – and for other organisations such as current transport and technology providers who wanted to make their services compatible with the MaaS system. 'Pre-study' projects would receive 50.000€ to study the feasibility of pilot schemes; create MO business models, study pre-conditions for MaaS operations and, ideally, evolve into consortium project applications to test pilots in a real transport environment.

As it can be understood in the overview of Finland case study by Eltis Platform[49], the mandatory requirements for projects eligibility in this call, elucidate what is considered as the building blocks of MaaS considered at that time:

i. Analyse the mobility needs of one or more user groups and generate door-to-door services that match their profiles;
ii. Integrate several transport modes by utilising and combining the interfaces of travel schedules, location data and payment systems of multiple transport services, such as public transport, taxis and shared cars;
iii. Travellers should be able to search and compare the length and cost of alternative travel options; book and pay for the service (including the whole travel chain); and then receive instructions on how to use their chosen package.

Eight 'pre-studies' were funded, and in the end several MaaS-related pilots were performed around Finland during 2015 and 2016. Total figures reported by Tekes in 2015 and 2016 account with almost 5,5 M€ channelled to 31 MaaS projects funding. A set of pilots were afterwards tested throughout 2015-2016 in Finland, and according to Smith, Sochor, & Sarasini (2017) some of them relevant:

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[47] http://tipconsortium.net/wp-content/uploads/2018/08/finland-TLHC-v5.pdf *(accessed: 24.08.2018)*

[48] Tekes is a Finish Funding Agency for Technology and Innovation, under the Ministry of Employment and the Economy, that is also part of the public-sector R&D and innovation and its mainly focused on Applied Research and Business R&D. For example, in 2015 Tekes funded with 575 M€ around 2600 projects, from which almost one third were channelled to R&D loans to companies and other third to R&D grants for companies and public organizations.

[49] http://www.eltis.org/discover/case-studies/finlands-innovative-drive-towards-single-multi-modal-transport-service-package *(accessed: 03.08.2018)*

- The telecom giant **Telia Finland Oy** (previously Sonera) developed a MaaS application called **Reissu**, and conducted two pilots, one for commuters in the city of Hämeenlinna and one for tourists heading to the ski resort Ylläs, before selling the brand to the Finnish company Semel Oy in December 2016;
- **Tuup Oy**, a start-up company, launched the first version of a MaaS application in April 2016. So far, it enables purchasing PT tickets in Turku and hailing taxis in some areas, as well as exclusive access to Kyyti, a taxi-pooling service that currently is available in Oulu, Turku and Tampere;
- **MaaS Global Oy** (previously MaaS Finland Oy), a start-up company formed out of 23 partner organizations that assumed the role of MaaS operator, launches in October 2016 a beta test service in Helsinki – WHIM – that offers a test package of public transport, taxi and rental car rides.

Besides this joint funding program, **'Export Finland'** (Finpro) launched a growth program for MaaS, aimed at helping Finnish MaaS-related ventures, to attract international investors and to and seize global business opportunities (G. Smith, Sochor, & Sarasini, 2017).

Policy and strategies today (from 2016 onwards)

Some major steps are referenced in this chapter, although not very extensively, just to have an overview of the Finnish actions in the field of MaaS and ITS.

Even though it was acknowledged as a 'conservative' move from **HSL**, the fact is that they opened **"single Tickets API's"** in December 2016 which can be seen as a move forward in the direction of interoperability, fundamental in MaaS business operations. In fact and according to a study carried out by Audouin & Finger (2018), in the views of many interviewees, *"HSL is seen as having "slow[ed] the (MaaS) progress" (Forum Virium – Innovation Agency)*" where *"the main "problem" (SITO – private consulting company) pertaining to the behaviour of HSL actually laid in its decision to only open to MaaS Global its single-ticket API (in December 2016), and not to open the seasonal ticket APIs, which was synonymous with an unsustainable solution from a financial point of view for the MaaS operator (LVM)".*

The **Interoperability of ticket and payment systems (LIPPU) project**, responsibility of FICORA (Finnish Communications Regulatory Authority), is part of the implementation of the Act on Transport Services, being focused on the removal of barriers to the development of new services that utilise digitalisation. Launched in 2017 with the purpose to *"prepare in collaboration with the industry, the interface specifications required for the interoperability of the ticket and payment systems to enable ticket products to be intermediated and the associated payments forwarded"*[50]. One of the main conclusions revealed by FICORA is that there was a clear need for the LIPPU project since *"interoperability cannot be acquired on market terms without government support"*[50]. Since Finland's

[50] https://www.viestintavirasto.fi/attachments/LIPPU-loppuraportti-FINAL_EN.pdf *(accessed: 25.08.2018)*

target is an “Open MaaS” Market, the MaaS model should be based on open interfaces that opens the market for a large number of competing MaaS operators, who can create service palettes from just the transport and other services they want to provide. The LIPPU project already finished the preparation of the technical interface specifications for single tickets, travel chain related incidents, accessibility, and ticket validity, which allowed the pilot phase to begin (FICORA, Finnish Transport Safety Agency, & Finnish Transport Agency, 2017).

Other relevant milestone in Helsinki Region is attributed to **HSL**, that since April 2018 **opened the sales interface for third parties**, in a clear direction of MaaS support[51]. More recently it was published in September 2018, a decision by TRAFI that rules that this interface must be changed because it is not compliant with the law in terms of what is defined as an “open interface”.

It was also announced by **HSL** that the **“seasonal tickets”** will be added to this ‘Open MaaS Interface’ by November 30th 2018, which according to Audouin & Finger (2018) it will give MaaS Operators *“hope regarding the end of the single-ticket API issue”.* The authors highlight the importance of this issue, denoting that *“for a long time, MaaS, through the Whim solution, has been stuck in a cul-de-sac because of HSL's refusal to open its seasonal ticket APIs”.*

Several other strategies and programmes published in the meantime support direct or indirectly MaaS and Sustainable Transport goals, e.g. the “**Digital Program of Finland 2016-2018**”[52]; an action program for digital accessibility of transports – **Action Programme “Making digital transport and communication services accessible”**[53] or the **“National Growth Programme for the Transport Sector 2018-2022”.** A diagram of the Chronology of the emergence of MaaS process in Finland, by decision level and civil society events is made in Figure 10

[51] https://www.hsl.fi/en/news/2018/hsl-launch-maas-interface-open-everyone-2-april-14619 *(accessed: 24.08.2018)*

[52]https://www.liikennevirasto.fi/documents/21386/115391/Digital+program+2016-2018_presentation_pdf/dc98d8cb-6323-474a-8957-dde84f7e226c *(accessed: 24.08.2018)*

[53] http://julkaisut.valtioneuvosto.fi/handle/10024/80806 *(accessed: 24.08.2018)*

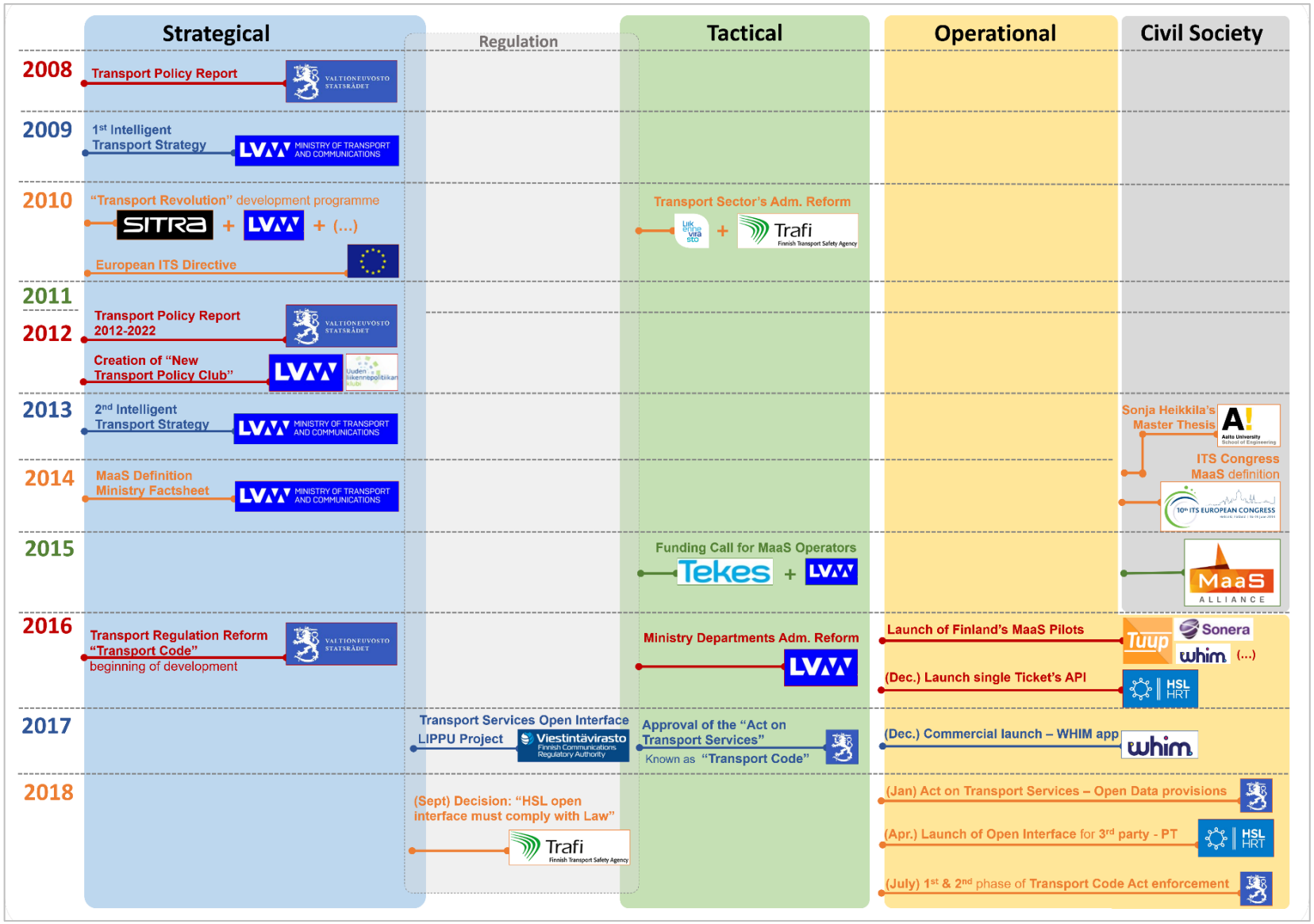


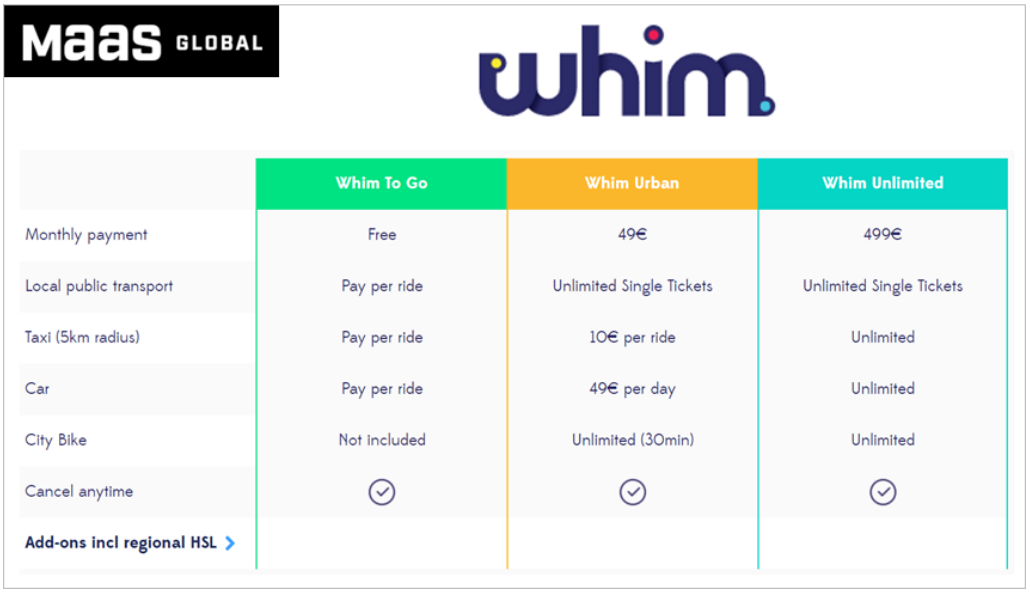
Figure 10 – Chronology of the MaaS emergence Process in Finland, by Decision Level and Civil Society events (Source: Author)

2.2.5. Helsinki's MaaS Mobility Operator – MaaS Global Oy and WHIM app

MaaS Finland was launched in 2015, resulting of a group of eight investors led by Transdev (Veolia), and in total 23 partners including diverse research organizations, ITC and transport companies, besides transport operators. The company started operations in February of 2016, following up Tekes call on Mobility Operator's to fund the development of MaaS projects and pilots, raising a total of 2.2M€ (from Tekes and private Investors).

The company's aim according to its official website[54] is *"to provide people an alternative to owning a car – an alternative that is not just equally good, but much better. By fulfilling people's every travel need, complemented by attractive value-added services, we are enabling a future of easy, efficient and sustainable mobility."* In June 2016 "MaaS Finland" changed its name to "MaaS Global", a name that according to its CEO *Sampo Hietanen* supports better the company's global approach, taking into account the foreseen expansion of the MaaS service internationally.

The WHIM app was launched in October 2016 as a beta test in Helsinki, and it was based on established agreements with Finland's rail and city public transport companies (HSL – municipalities, region and extended region) as well as other private transport providers (e.g. TaksiHelsinki and Lahitaksi – taxis; Sixt, Toyota car rentals and Hertz – car rental; Go Veho - local car rental; ALD Sharing and City Bike). Today the WHIM app allows access to all forms of transport by a monthly subscription travel plan (package) or "pay-as-you-go" modality (Figure 11). Moreover, the application incorporates other functions, such as: i) synchronization of mobility needs with user's calendar allowing the planning of trips in advance, ii) journey planner with routes and timetables, iii) adjustment of transport alternatives based on user's preferences and travel history data, iv) navigation and real-time information at all stages of the journey and v) initially, there was a rewarding sistem with points when the user made sustainable and smart transport choices.



	Whim To Go	Whim Urban	Whim Unlimited
Monthly payment	Free	49€	499€
Local public transport	Pay per ride	Unlimited Single Tickets	Unlimited Single Tickets
Taxi (5km radius)	Pay per ride	10€ per ride	Unlimited
Car	Pay per ride	49€ per day	Unlimited
City Bike	Not included	Unlimited (30min)	Unlimited
Cancel anytime	✓	✓	✓
Add-ons incl regional HSL >			

Figure 11 - WHIM app subscription plans for Helsinki Region (source: https://whimapp.com, accessed 01.09.18)

[54] https://maas.global/company/ *(accessed: 10.02.2018)*

The WHIM app is live commercially since December 2017 in Helsinki; April 2018 in West Middlands (Uk) and since October 2018 in Antwerp (Belgium), being currently announced in Amsterdam (Netherlands) and preparing the expansion to Singapoore. Currently, in Helsinki, *"the percentage of trips made with public transport and it's all close to ninety percent" (Sampo Hietanen, 2018)* using the app

Throughout 2016-2018, MaaS Global raised a total of 21.2M€, that apart from the initial capital the company added up 10M€ of "seed capital" in 2017 and 9M€ of "venture capital" in August 2018. Besides Transdev, Veho Oy and Karsan Otomotiv Sanayii, that are among the Finnish company's older shareholders, big players joined the investor club of MaaS Global in 2017. In Fact, the second fund round, that was led by Toyota Financial Services of Japan and its insurance partner Aioi Nissay Dowa Insurance Company, raised 10M€ and allowed MaaS Global to incorporate very important partners for R&D and internationalization.

In what concerns the associated WHIM business model several authors gathered sparsely information on the revenue system, user journey and access to the system and the nature and rational of MaaS global agreements with transport providers. Besides the literature review, it was conducted by the Author an interview with Sampo Hietanen - the CEO of MaaS Global – on the 25th of September 2018 (Annex V), that allowed further insights on MaaS Global and the WHIM MaaS System.

Considering the access to the system, the packages are not restrictive about the quantities the user can access of each transport provider, but instead a service level is guaranteed on what concerns public transport and a price is set for each unit (trip, time, etc) of travel in other modes. Initially in Helsinki, one way to access those individual transport services was also through the exchange of "WHIM points" associated to each subscribed package. Although, nowadays and according to Sampo Hietanen's interview for this work (Annex V), despite existing the technical possibility to use WHIM points, for now the app is not using this system.

> *"(the users didn't) really relate to them (WHIM points) and since we also want to get more away from production-based pricing into value based, and because the users didn't feel comfortable with them, we skip them for a while. To some extent we are planning on using them more as reward points." (Sampo Hietanen, 2018)*

In terms of governance, Ovaska (2017) identifies WHIM as beeing a *"somewhat closed platform",* where the transportation provider's access to and interaction within the platform are contractually governed, based on billateral agreements. All fees and pricings are based on these agreements and acording to Sampo Hietanen in Ovaska (2017), the company becomes a customer for each service provider, who sets the rules of service.

Further on, concerning the revenue and pricing system when the app used a point system, König et al. (2016) reveals that the more points are associated to the subscription plan chosen, *"the lower the cost per point".* In what concerns profit, an explanation is suggested by Ovaska (2017) when the author refers that *"Whim makes money by subtracting the cost of purchased services from the revenue of the subscription packages".* The author proceeds arguing that as MaaS Global is a customer to its

partners, paying for the tickets and services bought through WHIM, *"the more services are bought (…) the less profit is left for MaaS Global".*

The scattered information on the business model and profit rationale was explained in person by the CEO of MaaS Global during the interview:

> *"The idea of how we make money kind of ensures that we stay on the sustainable road, meaning that the only way for us to make money in this is that we become your mobility operator, (…) and for us to give you a car or taxi every time is expensive (…) How we make profits is that you feel confident and that you have the same value as you get with your car (…) and at the same time every time you walk or use public transport, those are cheap kilometres that we have to produce for you. So of course, it's in our interest to even incentive you and give you money if you walk." (Sampo Hietanen, 2018)*

When questioned about the potential contradiction of existing within the MaaS offering a "WHIM car", Sampo answered that the availability of the car is in a certain way necessary for the business but only as a mean and not an end in itself:

> *"(WHIM provides) different forms of getting into your car when you need it, because it's extremely vital for the people skipping their cars. (…) So, we want to make it as easy as possible so that they feel comfortable in not owning a car, which means that there are different types of subscriptions (…) however you want it. We are giving the access not the ownership. It's hard to get people to drop their cars without give them access to cars." (Sampo Hietanen, 2018)*

Summarizing WHIM business model rationale, Sampo reveals that WHIM does not live off from commission's, but instead:

> *"The whole concept idea is that we sell a different thing than what we buy we sell you a service promise, a value-based offering, and we buy in the production based offering that the transportation service providers are now giving out. That's what they do." (Sampo Hietanen, 2018)*

Finally, when asked about the redefinition of public transport and the existent subsidies for public transport use, Sampo agrees that it those subsidies should be enlarged to users that choose other modes that feed in the public transport, generating an interesting opportunity to manage mobility.

> *"I think that once this MaaS concept gets further and more and more people use a mobility operator like us, it gives more options for the cities and governments to play with incentives to make sure that the sustainability goals are met." (Sampo Hietanen, 2018)*

3. Theoretical Framework

This chapter will focus on the theoretical framework considered to be the most relevant for this work in the areas of "Political Sciences", in particular "Public Policy" focusing on the "Policy process" and "Policy analysis" required for the implementation of MaaS concept. The second pertinent area is the governance of an "Urban Mobility System", in terms of Institutional Environment, Stakeholders and Decision levels. Identifying the types of stakeholders, their relations and dependencies as well as their corresponding "Level of decision" positioning, will be also one of the aims of this segment.

3.1. Political Sciences: Public Policy, Policy Process and Policy Instruments

"Policy" can be understood as what concerns the questions of "What is Public". The term "policy" has Greek origins (*politiká*) and derives from the *polis* term. Taking into account that "policy" can be understood as the "science or art of governing" what is public in a society ecosystem, the policy questions addressed are intimately related with "Public Policy". The importance of "policy" has also its roots on the transformative and direct impact on everyday people's lives, being it relational or organizational, but with a common goal that is the increase of society well-being.

As it is suggested by Hogwood and Gunn (1984) cited by Kay (2006), the word "policy" can have many uses: *"policy as a label for a field of activity (for example, foreign policy); policy as an expression of general purpose or the intended path towards a desired state of affairs; policy as a specific proposal; policy as a decision of government; policy as a formal authorization (for example, legislation); policy as a programme of activity; (…)".*

In this work the focus is **"Public Policy"**, that can be defined with great simplicity according to Dye (2013), as *"anything a government chooses to do or not to do"*. This definition expresses two concerns. First, the 'government' is a determinant element to the enactment of public policy and second, it implies 'choice', that by itself relates to the promotion of the well-being of its citizens. Howlett (2011) explains that an evolution of this definition was done by *Harold Lasswell* in 1958, informing that *Lasswell* understood also public policy as government decisions but considered it as a composition of two interrelated elements: *policy goals* and *policy means*. The policy goals would be the *"basic aims and expectations governments have in deciding to pursue (or not) some course of action*", while the policy means are the techniques used to attain the chosen goals. In Figure 12, a representation by Howlett (2011) shows that policies are composed of goals and means that range from the most general level - that it can be assumed as the "Strategical" level, the "Why?" - to the first level of operationalization – the "Tactical" level, that answers to the question "How to?". And finally, following this logic of the "principal components of public policies" based on Howlet & Cashore (2009) in Howlett (2011), the last level would be the specific programme settings level that deals with "on-the-ground" measures and corresponds to the "Operational" level" (answering the "What?", or What has to be done for the monitorization of the implementation of "goals" and "means" in terms of public policy).

Policy component	Policy Level		
	Governance Mode: high-level abstraction	**Policy regime: programme-level operationalization**	**Programme settings specific on-the-ground measures**
Policy goals	**General Abstract policy aims:** The most general macro-level statement of government aims ad ambitions in a specific policy area	**Operationalizable policy objectives:** The specific meso-level areas that policies are expected to address in order to achieve policy aims	**Specific policy targets:** The Specific, on-the-ground, micro-requirements necessary to attain policy objectives
Policy means	**General policy implementation preferences:** The long-term preferences of government in terms of the types of organizational devices to be used in addressing policy aims	**Policy Tool choices:** The specific types of governing instruments to be used to address programme-level objectives	**Specific policy tools calibrations:** The specific 'settings' of policy tools required to attain policy targets
	Strategic	**Tactic**	**Operational**

Figure 12 - Adapted by the Author from Howlet & Cashore (2009), in Howlett (2011)

Kay (2006) also emphasizes that policy is primarily related with choice that can assume different forms: *"the choice of objectives; the choice of reasons for (in)action; the choice of policy instruments; the choice of how to respond to the consequences of policy outputs".* In fact, the author cites Howlet and Ramesh (2003) that accentuate this understanding: *"Public policy is, at its most simple, a choice made by a government to undertake some course of action".*

Public policy can be defined as a set of interrelated decisions taken by one or a group of public stakeholders with power legitimacy (competence and capacity of decision conferred by law), about the goals and means to achieve them when facing a specific situation or problem *(inspired in the definition of Jenkins-Smith (1978) cited by Deel & Hill (2009)*).

Policy design depends on context, and this context is formed in several ways by the interrelation of several specific backgrounds, being it the political, societal, historical among others. Howlett (2011) addresses this topic recognizing that the policy environment is a factor affecting policy design. The author proceeds quoting *Clemens & Cook* (1999) and defines policy design as *"an activity or a set of activities which takes place within a specific historical and institutional context that largely determines its content".*

Understanding **"policy-making" as a process**, entails the recognition *of "a set of interrelated stages through which policy issues and deliberations flow in a more or less sequential fashion from 'inputs' (problems) to 'outputs' (policies)"* (Lasswell, 1958 cited by Howlett, 2011).

As resembled by Kay (2006) the notion of a **policy cycle** has its roots in *"systems theory and the pioneering work by David Easton on political systems (Easton 1965, 1966)".* The author proceeds making several references of definitions for policy cycle, and citing Colebatch (1998), pinpoints that for them the policy cycle was a way to imagine the *"policy process as an endless cycle of policy decisions, implementation and performance assessment".*

Howlett (2011), like Lasswell, also proposes a model for the process approach to Public Policy-Making based on different stages, designating concretely five stages in the process: i) Agenda-Setting;

ii)Policy Formulation; iii) Decision-Making; iv) Policy implementation and v) Policy evaluation. Indeed, the author establishes a correspondence between the stages of the policy formation and the stages of applied problem solving (Figure 13), because he states that *"policy-making is viewed as an instrumental problem-solving activity*".

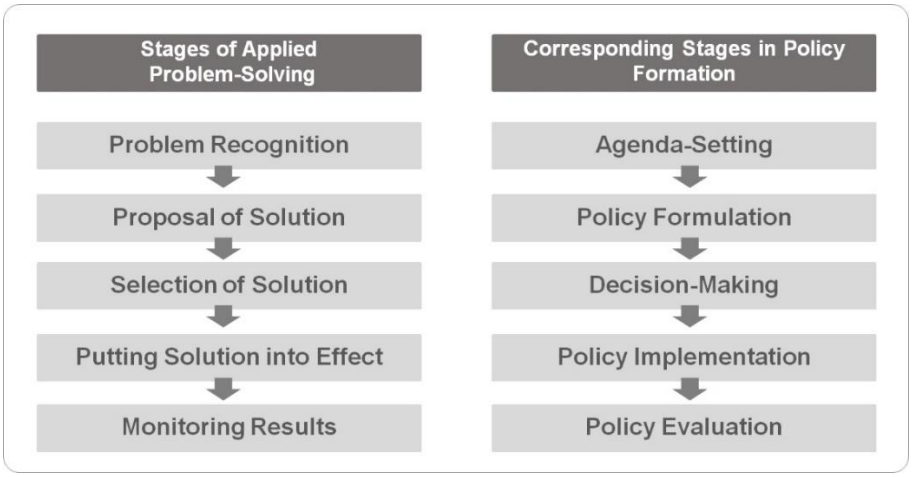


Figure 13 – Five stages of the policy cycle and their relationship to applied problem-solving (Howlett (2011), adapted by the Author)

Following Howlett's (2011) brief explanation of each stage, it is possible to summarize them as follows:

i) ***Agenda-Setting*** *– refers to the process by which problems come to the attention of governments;*

ii) ***Policy Formulation*** *– refers to how policy options are formulated within government;*

iii) ***Decision-Making*** *– Is the process by which governments adopt a particular course of action or non-action;*

iv) ***Policy Implementation*** *– relates to how governments put policies into effect;*

v) ***Policy Evaluation*** *– refers to the processes by which the results of policies are monitored by both state and societal actors*

The policy process is seen as something dynamic and not prescriptive or causality determined. Therefore, often reality doesn't strictly follow a predetermined order as the one shown in the "stages-model", but nevertheless it exhibits some degree of articulation between its main elements. Used as a guide to policy-making or to conduct policy analysis, one of the main advantages of the "Stages-model" is that it facilitates the comprehension of the process and enables the understanding of its properties present and what kind of stakeholders can be involved in each phase.

According to Kingdon (1995) (cited in Fischer, Miller, & Sidney, 2007), the **"Agenda-Setting"** is perceived as *"the list of subjects or problems to which governmental officials, and people outside the government closely associated with those officials, are paying some serious attention at any given time".* The author introduces the notion of "policy window" and compares it to the "launch window" for space flights when the latter is seen as an opportunity window to proceed with the launch. The policy window is also perceived as an opportunity to act, and it just opens for a short period of time. He also argues that the policy window can be opened by the emerging of a pressing problem (what is called a

‘problem window’) or by an event in the political stream (‘political window’). Either, by each one of the two situations mentioned, both will search in the ‘policy stream’ (production of alternatives - solutions) for solutions or for proposals, respectively. Moreover, the “Problem” or “Political” stream can structure per se the Governmental agenda, although, as it is also analysed by Fischer, Miller, & Sidney (2007), Kingdon states that the probability to rise in the decision agenda is higher when there is an intersection of those two with the ‘policy stream’. According to Fischer, Miller, & Sidney (2007) the ‘Agenda-setting’ *“results in a selection between diverse problems and issues. It is a process of structuring the policy issue regarding potential strategies and instruments that shape the development of a policy in the subsequent stages of a policy cycle.”*

Sometimes the agenda-setting is developed at the same time as the **Policy Formulation** stage. As soon as the problem is well defined and inscribed in the Policy Agenda, the policy alternatives (proposals to solve the problem) are developed and criteria are determined to select the most suitable one. The study of the alternatives is based on prospective actions recurring to projections or conjectures for instance.

According to Dye (2013) *“policy formulation is the development of policy alternatives for dealing with problems on the public agenda”.* Among other instances that exist, the author refers that this stage can occur in *“government bureaucracies; interest group offices; legislative committee rooms; meetings of special commissions; and policy-planning organizations, otherwise known as think tanks”.* When referring to the distinguish characteristics of policy formulation, Howlett (2011) quotes *Charles Jones (1984)* and proceeds explaining that it is in this stage *“that means are proposed in order to see if and how they could resolve a perceived societal problem or government goal”* and according to this author it encompasses the consideration and discussion of several elements: a) problem conceptualization; b) theory evaluation and selection; c) specification of objectives; d) programme design; e) programme structure.

After the Policy Formulation stage and legitimate decision in place, the next stage relevant for this work is the **Policy Implementation** phase. As Dye (2013) refers “implementation is the continuation of politics by other means”, meaning that the policymaking process doesn’t end with the approval of a law and its signing by the president. Rather, it shifts *“to the bureaucracy, to the departments, agencies, and commissions of the executive branch”*. As highlighted by the author: “*Implementation involves all of the activities designed to carry out the policies enacted by the legislative branch (which) must translate laws into operational rules and regulations”*.

For Howlett (2011), the idea of the policy process is used *“to view policy-making in essentially pragmatic terms”* meaning for instance that ***“policy means or instruments*** *are often viewed as technical mechanisms used to attain policy goals and as existing only in the stages of ‘policy formulation’ – when policy means are proposed, and ‘policy implementation – when they are put into effect”.* It is true that public policy goes beyond instruments - seen as tools or combination of tools – an idea reinforced by Flanagan, Uyarra, & Larangja (2010) that state that *“the content of public policy is broader than action. (…) policy also plays rhetorical and performative functions (…) and can be an end in itself”.*

But on the other hand, and with the focus on policy implementation, several authors naturally focus on "instruments" or "policy tools" unveiling their role and importance in the enactment of policies. In fact, Howlett & Ramesh (1993) streamline the meaning of "policy instruments" as "tools of governance", as they represent for the authors *"the means and methods by which governments effect their policies".* Others, like van Nispen (1995) also consider instruments as "means of government intervention" but are more straight forward pinpointing their main goal of its use: *"to accomplish goals* (of policy) *or to solve problems".*

As it is mentioned in Macário (2011) the element of "exertion of power" is added and instruments can then be defined as *"the set of tools (techniques, norms, procedures, etc.) used by governments and public authorities to exert power in their attempt to produce any social change".* The author proceeds stressing that is of *"utmost importance to have a clear view on the possible forms these instruments can take to choose the appropriate combination (i.e., packaging) in the planning of their actions"*.

van Nispen (1995) recalls that a policy instrument doesn't appear isolated but part of a policy theory, especially in what concerns the "causal relations between causes and effects". The author affirms that the study of policy instruments is *"geared to the [re]construction of final relations, being a species of the genus causal relations"* where the *"goal-attainment is considered to be the dependent variable while instruments are seen as one of the independent".*

Therefore, the following question would be its choice in order to produce the desired effects: *Why* and *What* to choose from. First, the choice must be "*prompted by aspects close to the ones used in appraisal of governments"* as it is referred by Macário (2011) quoting *Van der Doelen (1998)*, such as:

- Effectiveness - *"which represents the capacity of the instrument to realize the specified goals, considering also the side effects that might result from the use of the instrument"*
- Efficiency - *"which relates to the input–output/outcome ratio of the instrumentation process"*
- Legality – *"which refers to the degree of correspondence (or fitness) of administrative action in the designing and implementation with the relevant formal rules, as well as with the principles of sound administrative processes, which can raise concerns of equity and motivation"*
- Democracy – *"which refers to the degree to which administrative action in design and implementation is in accordance with the existing norms for the relationship between citizens and governments"*

Second, in relation to the question "What to choose from", as it is revealed by Rist, Vedung, & Bemelmans-Videc (1998) there is a wide variety of classifications types of policy instruments, and they recognize this fact pinpointing that *"nowhere in the international literature on policy analysis and public administration is to be found a uniform, generally embraced classification of policy instruments".* Therefore, stemming from the literature review, some classifications will be highlighted, not with an uniformization goal but as a demonstration of several point of views that structure the reasons for policy instruments selection.

Starting from Doern's work (Doern, 1981; Phidd and Doern, 1983; Tupper and Doern, 1981) mentioned in Howlett & Ramesh (1993) as one oft-cited political science approach, where they view

"decisions on policy instruments as choices made from a continuum of instruments ranged according to the level of state coercion required for their implementation". They assumed that all instruments were "more or less substitutable" and tendentially the first choice would fall on the least coercive means.

In a work developed by Vedung (in Rist, Vedung, & Bemelmans-Videc, 1998) the author states that there are two approaches to instruments taxonomy in the literature: "*the 'choice versus resource approach' and the 'maximalist versus minimalist approach'".* In the first dichotomy the difference relies on whether the instruments should be classified *"from the viewpoint of the basic choices that government can make (the choice of "doing nothing" included)"* or alternatively considering that the government already decided to do something, and it is a matter of choosing the resources needed. The second approach the difference is between the provision of a "full list of possible policy instruments or, alternatively "only some fundamental types (…) should be categorized".

The same author gives the example of the "choice approach" model with the "*fourfold classification drawn from Charles W. Anderson's textbook Statecraft"* explaining that this categorization stems out from *"a common theme in the literature: the degree of coercion exercised by government toward the subjects of control".* When facing a public problem, Anderson's classification from 1977 is divided into four types of responses, that range from complete freedom (i) to complete government coercion (iv): i) Market mechanisms; ii) Structured options; *iii)* Biased options*;* iv) Regulation*.*

On the other hand, one example of the "resource approach" model, can be the taxonomic model called as "Sticks, Carrots and Sermons". This threefold classification of policy instruments is divided in *"regulations, economic means, and information"*, where Vedung (in Rist, Vedung, & Bemelmans-Videc, 1998) resumes it to whether *"the government may either force us, pay us or have us pay, or persuade us".* The author proceeds explaining the relations between the governor and the governee for those three cases: i) Regulation; ii) Economic means, either positive or negative and iii) Information.

Evolving from Hood's taxonomy of policy instruments, Howlett (2011) organizes instruments according to four categories of governing resources, dividing them in two types of instruments: i) i)substantive – *"those directly providing goods and services to members of the public or governments"* and ii) procedural – *"rather than affect the delivery of goods and services, their principle intent is to modify or alter the nature of policy processes at work in the implementation process"* (Figure 14).

		Governing resource			
		Information	*Authority*	*Treasure*	*Organization*
Purpose of tool	Substantive	Public Information Campaigns	Independent regulatory agencies	Subsidies and grants	Public enterprises
	Procedural	Official secret acts	Administrative advisory committees	Interest-group funding	Government reorganizations

Figure 14 – Taxonomy of substantive and procedural implementation tools according to governing resource (source: Author, adapted from Howlett, 2011)

Independent from the governance mode (legal, market, network or corporatist), the author states that *"while policy goals are manifold and alter over time, the choice of policy means is context driven and resource contingent, the toolbox with which (policy) designers must work is essentially generic"* (citing Majone, 1989). The author proceeds reinforcing that despite the complexity potential of the reasons behind the government choice of policy instruments to implement its policy goals, *"the set of possible choices is limited in nature, bound as they are to the limited number of types of different governing resources they have at their disposal".* In his book *"Designing Public Policies – Principles and instruments",* Howlett (2011) sets out and describes "the basic subtypes and most common individual kind of implementation instruments used in contemporary policy designs", which in this work are reproduced in Annex II .

Policy instruments may be arranged in packages, in the same way that a policy structure and programme rarely rely in just one measure. The appropriate packaging of instruments to enact a given policy programme in real-life conditions depends on the context and space where the policy is going to be implemented, therefore a "one size fits all" approach is unrealistic.

As Macário (2011) refers, due to the multi-objective character of the policies in the area of Urban Mobility Systems, is common the joint (simultaneous or not) use of several instruments. The author states, quoting Rist, Vedung, & Bemelmans-Videc, 1998, that the *"packaging of policy instruments can be formed in three different ways: vertical, horizontal, and chronological packaging".* In vertical packaging one instrument is used to promote or restrain another in a lower level hierarchy as for horizontal implies the use of two or more instruments for the same purpose. The chronological relates the selection of diverse instruments with a time order, aiming at a sequential impact.

The author recognizes that there is a wide variety of possible instruments, but its choice must be supported by the four appraisal aspects referred earlier in this chapter, considering the given problem to be solved. It is highlighted that management (or steering) instruments are tools that allow enactment in the system at any decision level - strategical, tactical and operational - enabling the monitoring and correction of the evolution of the Urban Mobility System (Macário, 2011). Thus, based on the work developed in the MARETOPE[55] European Project (EC & TIS.PT, 2002) referenced in Macário (2011), the instruments required to support system management in Urban Mobility are then enumerated:

- **Instruments of institutional character** (e.g., institutional design such as the creation of metropolitan authorities, observatory of urban mobility, committees for stakeholder's representation, and political fora);
- **Instruments of political character** (e.g., integrated measures aiming to complement the policy defined at strategic level and induce behavioural adjustment in the agents). These were referred as presenting a wider diversity and were divided into three categories:

[55] *"MARETOPE - Managing and Assessing Regulatory Evolution in Local Public Transport Operations in Europe"*, European funded project of the Fifth Framework Program – Urban Transport, DG TREN (EC & TIS.PT, 2002)

- **Supply-side instruments**, addressing the quantitative and qualitative characteristics of supply;
- **Economic instruments**, also referred as demand management instruments, inducing the behaviour of the agents through the price mechanisms; or
- **Regulatory instruments**, addressing market rules.

- **Instruments of contractual character** (e.g., incentives and penalties related with performance, extension or abbreviation of the duration of contract or concession, and issues related with formal interaction between agents);
- **Instruments of procedural character** (e.g., tendering processes, technical licensing, monitoring processes, surveys for clients satisfaction, and quality assurance mechanisms); or
- **Instruments of persuasive (or informational) character** (e.g., all means to influence people through transfer of knowledge by way of communication of the rationale supporting the arguments and persuasion.

The model chosen to illustrate a set of instruments related with Urban Mobility Systems (Annex III) was based on the work of Macário (2011), and relies on the combination of organization and managerial instruments with policy instruments, designated as instruments of 'political character'. It is cautiously mentioned that the selection of these instruments depend on the type of problem and also on the "adequacy of the organizational setting institutional framework to ensure proper control of its implementation" (Macário, 2011).

Policy instruments are flexible and evolve over time. Moreover as Flanagan et al. (2010) *refers "the kinds of interaction seen may change over time and from context to context and place to place, because of the wider institution and actor environment in which they operate can also change"*. Therefore, the author establishes that "*if complementarity is not a simple matter, nor is substitution"* concluding that "*it seems difficult to imagine two different policy instruments could ever be perfect substitutes"*. Bressers and O'Toole (2005, cited by Flanagan et al., 2011) also refer that *"there will always be a fundamental uncertainty about which aspect of (an) instrument is actually responsible for any observed effect"*. There is no optimal and static portfolio of instruments, but as it is referred by Flanagan et al. (2011) *"interactions and trade-offs between policy instruments is fundamental to the policy mix concept"* paving the way to the understanding that *"policy dynamics are more probabilistic than deterministic"*.

3.2. Urban Mobility System, Levels of Decision and Stakeholders

Mobility by itself can be seen as a process-oriented system that *"results from a sort of productive chain, where several agents (authorities, operators, and users) intervene at different stages of the mobility chain (and also at different decision levels) to pursue the final objective that is to access a number of urban functions"* (Macário, 2011).

Starting from Kay's (2006) point of view about institutions and their central role in contemporary social science theory, primary attention is given to institutional theory and its representation based on IRIMS Project[56] (Salazar et al., 2016; Lund, Kerttu, & Koglin, 2017). Kay (2006) underpins that Institutions *"give a structure to a world that is complex and in which there are a multitude of temporal processes underway at different levels".* For the author, the various structures that exist at different scales within the policy system *"act as institutions in shaping agents' decision making in the formulation and implementation of policy".*

The two working papers related with the IRIMS Project (Salazar et al., 2016; Lund, Kerttu, & Koglin, 2017) meant to understand the *"obstacles and opportunities for policies, programs and projects in the multilevel collaborative context that characterises Integrated Mobility Systems".* The *IRIMS project* was grounded on Neo-institutionalist theory, where the concept of institutions is defined broadly as comprising *"regulative, normative, and cultural-cognitive elements that, together with associated activities and resources, provide stability and meaning to social life"* (Salazar et al., 2016 citing Scott, 2014). This research project establishes a classification of institutions based on three levels: *i)* Macro – based on the the national level *"where national visions, action plans and goals,(…)as well as legislation, subsidies and taxes are generated"; ii)* Meso – including *"a variety of institutions; public institutions on the regional and local levels, private organizations, public/private hybrids and not-for-profit civil society actors"; iii)* Micro – a level that is related to the individual as a citizen, a taxpayer and a user of Integrated Mobility Systems. This institutional classification supports a general overview to stakeholder identification, which will be subject of further development in this chapter, as well as it establishes a first approach to decision levels.

Understanding the nature of decisions which are intimately connected with policy making within the Urban Mobility System, is of extreme importance to have a coherent and effective policy framework, with clear respect for the principles of democracy and legality, leading to a policy process with the highest efficiency potential. Moreover, matching the nature of decisions (decision levels) with the stakeholders responsible for its implementation according to their mission and role, is also of outmost importance. In fact, after defining "Why" and "How", only with this matchmaking practise is possible to understand "Who" has the responsibility to do "What" and "When", resulting in a clear roadmap to policy implementation and evaluation.

According to Macário (2011), the allocation of responsibilities within each decision level cannot be object of generalization because of its highly contextual dependent, especially at the political and administrative organization (as well as culture). Although, among the several principles of good practices to establish a management model for Urban Mobility Systems, the author reinforces that there's a need to *"ensure clear distinction between the three levels of planning and control (strategic, tactic, and operational), or decision levels, with different organizational requirements and functional roles and a clear allocation of these roles to different institutions, whenever possible"* (citing *Anthony,*

[56] IRIMS – Institutional fRameworks for Integrated Mobility Service; website: https://www.svet.lu.se/en/research/research-projects/irims-institutional-frameworks-for-integrated-mobility-services *(accessed: 10.02.2018)*

1989; EC, TIS.PT, 1997). A clear separation between these levels provides higher consistency to the distinct phases of policy-making and implementation, resulting in a *"network of institutions (i.e., authorities, operators, and third parties) linked by varying degrees and forms of interaction"* (Macário, 2011). One main characteristic associated to interaction is "coherence"[57], which is fundamental in what concerns the vertical consistency and within the concertation of decisions throughout all institutions involved in the different levels.

The three levels of planning and control, or decision levels, are defined as follows:

- **Strategical** – *"The main concerns relate with long-term decisions"* and it is *"where the mobility policy and objectives (…) are defined"* (Macário, 2011).
  In this work it will be assumed as the level that corresponds to policy formulation phase, where the rationale behind the policy is established answering **the "Why" question**;
- **Tactical** – *"The main concerns are medium-term decisions"* and it is *"where the respective policies are defined translating the strategic goals into operational specifications, assuring the effectiveness, and coherence of the system*" (Macário, 2011).
  In this work this level corresponds to the policy implementation phase, where strategies, goals and visions (the Why) are matched with the necessary package of policy tools (means) to its operationalization, answering in this way **the "How" question**;
- **Operational** – The main concerns are *"short-term and related to management of services and resources"* and it is *"where transport services are produced and consumed"* (…)*"usually supported in well-defined rules"* (Macário, 2011).
  In this work, the operational level is the level that relates to "evaluation and monitoring", where it is decided specifically **"What"** to do in order to ensure the compliance with the strategic goals **(Why)** and the correlated and enabling policy means **(How)** that frame activities for final consumption of users. This task can be translated to which type monitorization and specific actions should exist to guarantee that the policy goals are being implemented correctly, in what concerns the desired and expected changes. This level answers **the "What" question**.

The decision levels associated to the management of Urban Mobility Systems stated in Macário (2011) act as an inspiration for the present work. This tripartite decision structure was adapted to a systemic view since one of the goals of this work is to establish a policy framework that is part of a policy process, instead of a "quality management model for urban mobility systems".

Stakeholders Theory and Identification – Mobility System

As it was referred before when mentioning the non-generalizability of the duties associated to each decision level, the same succeeds with the provision of stakeholder's responsibilities acting in mobility

[57] "*Coherence is given by the alignment of decoupled objectives down through the different decision levels assuring that the objectives settled at the strategic level will be well derived into adequate goals for the tactical and operational levels"* (Macário, 2011)

systems for instance. The Political and administration organization context as well as the whole ecosystem of agents, varies from country to country. Despite this fact, in this chapter it will be proposed a generic identification of the main typical agents that act in the Mobility System, depicting at the same time their roles and missions.

One of the first definitions of 'Stakeholder' belongs to Freeman (1984), being described as *"any group or individual who can affect or is affected by the achievement of the organization's objectives".* As it is referenced in Donaldson & Preston (1995), the stakeholder theory represented a model that describes *"what a corporation is"*, where the corporation is seen *"as a constellation of cooperative and competitive interests possessing intrinsic value".* Prodan & Fanjul (2011) also state that *"the stakeholder approach is envisioned as an alternative way to understand a company and its environment"*, standing as a management perspective that goes beyond profit maximization function and takes into account the needs and interests of other groups. The authors highlight that several studies (citing *Freeman, 1984; Mitchell et al., 1997; Spitzeck & Hansen, 2010*) justify the importance of Stakeholder management with "*the direct relationship between it and the long-term survival of organizations".*

Throughout the years, the stakeholder concept and the theories that followed about it were applied to different knowledge areas. It is in this sense that a parallel approach is drawn between the importance of the identification of stakeholders in the management practices associated to organizations and the policy formulation and implementation stages of the policy process. In all the phases of the policy process, different stakeholders, sometimes the same but with different roles, should be accountable in the policy design process, taking into account for example their expectations or their needs, among other intrinsic characteristics.

In fact, stakeholder identification and management are a matter of identifying determinant relations between agents in the case of policy design approach. Referring to organizations, Fontaine (2005), although referring to organizations, details that *"a very common way of differentiating the different kinds of stakeholders is to consider groups of people who have classifiable relationships with the organization".*

Indeed, by understanding within the universe of stakeholders, their roles, missions, contributions, expectations, power and strategy, a contextual adapted management strategy can be implemented throughout the entire policy process. Prodan & Fanjul (2011) identify that the importance of stakeholders' management is explicitly mentioned in the project management definition[58] given by 'Project Management Institute' (citing *PMI, 2008*), claiming that in this conceptualization is clearly revealed that *"stakeholders management is crucial for effectively and efficiently implement a project".* In this case, and redirecting it to the 'policy process', the same statement can be affirmed in order to attain a coherent and effective policy framework, with clear respect for democracy and legality principles, leading to a policy process with the highest efficiency potential.

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[58] Project management definition: *"Managing a project includes adapting the specifications, plans and approaches to different concerns and expectations of the various stakeholders"* (PMI - Project Management Institute, 2008 in Prodan & Fanjul, 2011)

Within the myriad of methods for the identification of Stakeholders, their characterization and engagement strategies, developed throughout the last four decades, Prodan & Fanjul (2011) casted the main methods applied in this field in a comprehensive state-of-the-art section (citing *e.g. Mitchell et al., 1997; Savage et al., 1991; El-Gohary et al., 2006 or Jepsen & Eskerod, 2009*).

Considering that the scope of this work isn't a 'policy transfer' study but a proposal of a public policy framework that supports MaaS implementation, a generalist approach to stakeholder identification was conducted recurring to literature review. Thus, the rationale followed for stakeholder analysis relied on its Identification, as well as the characterization of their roles *("i.e., specific work assignments for decision-making duties")* and missions *(i.e., purpose or the reason why institutions exist and the philosophy guiding their strategic choices)* within the Mobility System, as also stated by Macário (2011).

For the author, looking at *"all sorts of flows exchanged between institutions (and) decision-making agents (…) within the system",* is a way to understand the nature and scope of interactions[59] between institutions. As accentuated by Macário (2011), by defining their function in the mobility system, these entities *"have their departure point to move into a certain direction and to define purpose and values to guide their characteristic actions and reactions"*, establishing in this way the *"patterns of their institutional behaviour".* Disregarding specific policy processes and specific national context, and instead focusing on commonly referenced stakeholders in a urban mobility systems, it is possible to identify in Table 3 typical entities that interact in the mobility system.

Adapting this general identification of Stakeholders to a "MaaS" ecosystem, special attention should be given to the entities that are most commonly acknowledged to be determinant for its conception, development, implementation and operation. Most authors identify "MaaS" ecosystem stakeholders considering only the "implementation and operation" phase of the system, disregarding a more holistic approach that encompasses the initial stages of the policy process (policy formulation and policy implementation stages).

On another perspective and resulting from a stakeholder's survey to understand the transformation potential of mobility innovations with a focus on MaaS, Surakka et al. (2017) identified the following main stakeholders: 1) Public administration - National, Regional and Local level as well as Public funded platforms/organization; 2) Transport Companies – Public (National, Regional, Local), Private Transport companies and Transport Associations; 3) Associations & NGO – Chamber of Commerce, citizen group, NGO and lobby; 4) Planning & research – Consulting and planning offices, public research institutions; 5) Industry – companies or representatives that don't offer transportation services; 6) Political parties.

[59] Interaction represents *"the coherent transfer of information between any two basic elements of the system*" (Macário, 2011)

Nature and roles of entities	Type of entity
Political authorities	• National government (e.g. Ministry of: transport, land-use, environmental, communication, etc.) • Regional government (and/or metropolitan gov.) • Local government
Regulating authorities	• Transport authorities • Economic authorities • Fiscal authorities • Communication authorities
Technical authorities and agencies	• Transport authorities • Traffic authorities • Land use authorities • Environmental authorities • Safety authorities • Security authorities • Communication authorities • Economic authorities • Funding Agency • Innovation agency • Insurance authorities
Operators	• Public transport operator • Developers (i.e. land use “operators”) • Private transport providers (Ride-hailing; Ride-sharing; Shared transport providers: car, motorcycle, bike, etc.) • Electronic Mobility Platform Operators • Emergency services • Other service operators
Suppliers	• Vehicle industry • ICT industry • Infrastructure industry • Insurance Industry • Management information systems • Staff • Consumables • Etc
Clients	• Traveller / transport user • Transport user/consumer group (e.g. cyclist association) • Local residents • Local businesses
Other interest parties	• Non-profit organizations • Community organizations (e.g. neighbourhood associations, etc.) • Other interest group / activist group (e.g. green lobby; pro-roads lobby) • Research community (e.g. Educational institutions / Academia research centres) • Practitioners and Professional Associations (e.g. Engineers association, etc.) • Media • Private Investors

Table 3 – Nature and role of entities interacting in an urban mobility system (source: author, completed and adapted from Macário, 2011 - p.84)

Other relevant research on this area is the work done under the Project MaaSiFie[60], where it is identified a more comprehensive overview of MaaS Stakeholders (Annex IV), addressing also their roles, responsibilities and obligations (König, Eckhardt, Aapaoja, Sochor, & Karlsson, 2016a).

The nature of decisions (decision levels) that each one of the stakeholders undertakes can be diversified. Although some entities are bounded to a specific level of decision due to their intrinsic characteristics (e.g. 'transport system providers' from the point of view of the policy process are classified in the "operational decision level"), generalizations should be avoided due to the specific dependencies of the mobility system configuration according to each country context and culture. Therefore, in this work the stakeholders and decision levels will only be analysed jointly in chapter 4.2 and following the inspirational MaaS experience in Finland, in order to propose a Public Policy framework for the implementation of MaaS.

[60] MAASiFiE - CEDR Transnational Road Research Programme 2014 (Mobility & ITS), Source: https://www.vtt.fi/sites/maasifie/results *(accessed: 13.02.2018)*

4. Proposal to structure a MaaS public policy Framework

Shaping a “MaaS Public Policy Framework” will firstly rely on the structuring of the “MaaS” concept and a proposal for “MaaS topology” and secondly, with respect to each set of “MaaS building block”, a Public Policy Framework (policy instruments) and correspondent indicative stakeholder responsibility is proposed, within each “Decision Level”

4.1. MaaS Topology proposal

The ‘MaaS Topology’ proposal aims to structure different possible configurations of MaaS, corresponding to ‘levels of materialization’, that are intimately associated with differentiated degrees of its core features - system functions and their relations. The analysis and reinterpretation of the previous literature review concerning the intrinsic features of MaaS and the study of their relations, will be essential to the ‘topological proposal’ for this new concept.

Since the future proposed MaaS ‘levels’ will be generated by different intensities (degrees) and mixes of the ‘building blocks’ identified (MaaS core features/functions), a theory construction based on “taxonomy” was out of scope for this work. The main reason depends on the fact that this proposal will not rely on the classification or categorization “*of the subject matter into a number of mutually exclusive categories which, together, retain the exhaustive character of the original* (phenomena)” (Howlett, 2011).

The idea is not also to have discrete variants and categories but instead, taking into consideration a wider scope, the aim is to have gradients of intensity associated to the MaaS ‘building blocks’ identified that together with the proposed combination of different features, results in different ‘MaaS Levels’. For this reason, a ‘Typology’ is not applicable either since its final product is a categorial contrast of types (K. B. Smith, 2002). Topology, on the other hand, allows for gradients and the attribution of meaning by degree[61]. In this case, topology allows overlapping of the ‘building blocks’ in the definition of MaaS different levels and the resulting patterns are not mutually exclusive.

Topology, considered as the mathematician term - the “study of space”, can have a sequence of parallelisms with the term ‘Transport Network Topology’ and the latter with ‘MaaS topology’. Within the field of ‘transport network topology’[62] it is performed the study of the arrangement of the nodes and links that form a transport network. Knowing that the fundamental elements of ‘transport network topologies’ are the ‘network geometry’ and the ‘level of connectivity’, a parallel can be withdrawn while referring to the ‘level of access’ and the ‘functions/actions’ allowed within MaaS and Mobility System.

Proceeding, in this concrete case the access to each level of MaaS in terms of degree of development of the present features and their relations, as well as the capabilities or the resulting actions/functions available within each level inside the mobility system, will be the fundamental elements of the

[61] http://academic.brooklyn.cuny.edu/education/jlemke/papers/myrdene.htm *(accessed: 20.09.2018)*
[62] https://transportgeography.org/?page_id=623 *(accessed: 20.09.2018)*

proposed ‘MaaS topology”. In this way, a pattern is created, resembling an identity for each ‘MaaS level’ that allows to infer the maturity degree as well as the capabilities associated to a specific “MaaS system” in place.

4.1.1. General analysis

From more than 350 text segments retrieved, of nearly one hundred documents (Journal articles, conference papers and institutional reports and position papers), it was possible to build an overview of the spectrum of the general and specific features of MaaS. Concretely, **“Integration”** and **“Payment Options”** have starred as the most frequent, followed by specificities about the **“Access to the System”** and **“User-Centric”** solutions. Attention was also dedicated to **“Technology”** and **“Business Models”** as well as the importance of **“Real-time Information”** and **“Interoperability”**.

This approach allowed for a systemic view in terms of the capabilities of a “MaaS” solution as well as it triggered the design of a general “user journey”, which revealed to be a basis for the ‘Topology’ proposal (Figure 15).

The ‘User Journey’ designed contemplates two initial moments: 1) “willingness to travel” and 2) “hesitation to travel”, but that can be induced by the system to perform the trip (with e.g. gamification, marketing, etc.) or the user is ‘not sure’ about the destination, asking the system to suggest it as long as it fulfils the function of the trip (where the user can be induced to perform a trip with the highest value in terms of its user preferences, e.g time, money, comfort, etc). The third initial stage (“already reserved”) of the user journey only exists if there is a notification from the system as a precondition. Not all the systems have this capability, which is highly dependent on the availability of “real-time information” and “data analysis”, and in some cases may be dependent as well on the possibility of the “user preferences” registration by the system. Nevertheless, even though this case is conditioned by a previous interaction with the “MaaS system”, it was also represented since it relates to the “proactivity” and “assistance” potential properties of the system.

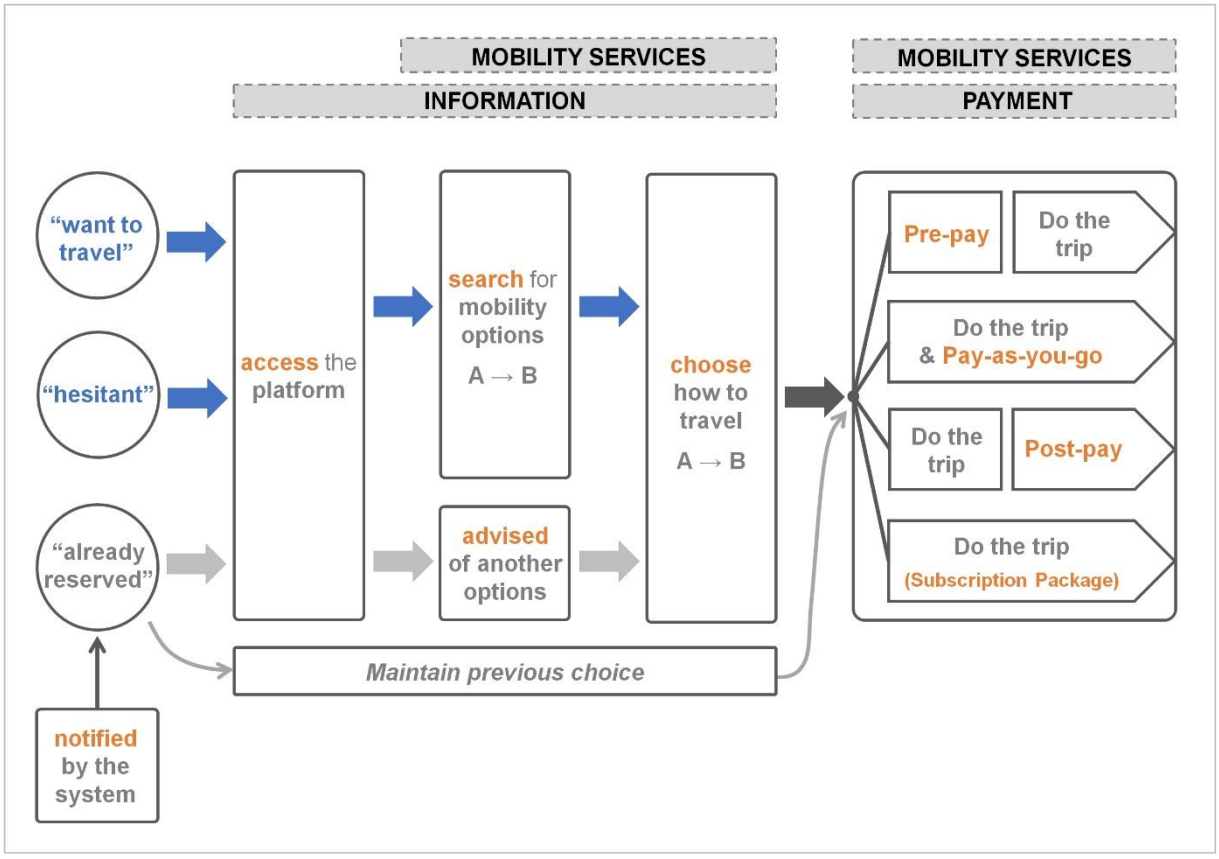

Figure 15 - User Journey associated with the trips performed through a "MaaS" system (source: Author)

Diversity of transport services is the basis for the "MaaS System". The **existence of choice** can be directly translated into the number of the different transport options available within the "MaaS" system and their efficient territorial capillarity in a geographical area. Therefore the existence of different **transport services,** thus allowing choice, will be considered the first "pillar" of "MaaS" (Gebhardt et al., 2016; Dotter, 2016; Sochor, Strömberg, & Karlsson, 2015; UITP, 2016; MaaS Alliance AISBL, 2017;).

The first set of interactions in the "user journey" are related with the **access to information** and the **information *per se***, that allows the user to choose the mobility option most suitable to their needs. It is proposed in this way, that the second 'pillar' of "MaaS' will be **'Information'**. The second set of interactions within "MaaS" system is the **"acquisition possibility"**, or as it is represented in Figure 15: the **"payment"**, which will correspond to the third 'pillar' of "MaaS".

During this analysis, two kinds of features were found: "General" and "Specific" Features. This chapter is dedicated only to the first ones. The "general" features are those that are not precisely associated with specific operational details of the "MaaS System", but instead are materialized by the existence of a set of features or represent the governance established outside the system (e.g. strategic and tactical principles). These features represent in this way the founding and enabling properties of a "MaaS System", where the value proposal and business model are anchored and the basis for the governance of the entire system is established. Concretely, it was found six "general" features that are intrinsically connected with the emergence of a "MaaS System": "User-Centric"; "Data-Sharing";

“Interoperability”; “Integration”; “Coordination & Cooperation” (Table 4) and the enabler mean “Technology”.

One fundamental feature that is vital for the whole existence of a “MaaS system” is the availability of **“Open Data”**, that can be broken down in terms of **“Data-Sharing”** (Transport Systems Catapult, 2016; Docherty et al., 2017 ; Sarasini, Sochor, & Arby, 2017 ; Mulley, Nelson, & Wright, 2018). and **“Interoperability”** of data and data interfaces *(e.g. transport service information; sales interface; ticket interface, etc)*, encompassing the relevant aspect of the definition of “data standardization” formats (Giesecke, Surakka, & Hakonen, 2016; Ambrosino, Nelson, Boero, & Pettinelli, 2016; Pasquale, 2017; Kamargianni & Matyas, 2017).

Relying on the progressive *“servitization”* of mobility, the “user” should be at the centre of the “MaaS system” and therefore it should designed as a **“User-Centric”** system (Giesecke, Surakka, & Hakonen, 2016; Docherty et al., 2017; Pasquale, 2017; EPOMM, 2017; MaaS Alliance AISBL, 2017).

The **“Integration”** of information in one single gateway, as well as other perspectives of what is considered important in terms of integration, is also one of the most cited features, and considered determinant for the existence of a “MaaS System” (S. Li, Luo, & Hampshire, 2017; Polis Network, 2017; König et al., 2016b; Veerapanane et al., 2018).

“Coordination & Cooperation” of mobility agents, that is closely related with integration, stresses the importance of the “MaaS ecosystem” stakeholders relations and governance principles of the system (Rantasila, 2015; Karlsson, Sochor, & Strömberg, 2016; Docherty et al., 2017).

“General” features	Insights based on literature review	References
“User-Centric”	• The user should be at the ‘heart’ of the ecosystem • From modal-centric to a user-centric mobility system • Provide mobility services that reflect the needs of the customer • The perspective is on the traveller experience • The system offers tailor-made mobility solutions • Personalization of services through predicted traveller situation	Sochor et al., 2016; Giesecke et al., 2016; Dotter, 2016; Sochor, Arby, & Karlsson, 2017; Docherty et al., 2017; EPOMM, 2017; MaaS Alliance AISBL, 2017; Pasquale, 2017; Mulley et al., 2018
“Integration”	• Of multiple modes of transport, collective and private • Of data and information • Booking, payment and tickets in one platform • Of physical infrastructures • Of local mobility policies • Of actors and stakeholders – organizational • Of new concepts and solutions • Of Mobility Packages • ICT – technological services and systems	Gebhardt et al., 2016; Ambrosino et al., 2016; Kamargianni et al., 2016; Dotter, 2016; Sochor et al., 2017; König et al., 2017; Pasquale, 2017; Matyas & Kamargianni, 2017; Docherty et al., 2017; Polis Network, 2017; S. Li et al., 2017; Wittstock & Teuteberg, 2018; Veerapanane et al., 2018
“Interoperablility”	• Of interfaces standards [data, modes, vehicles] • Of data and information • Concerning booking, payment and tickets in one	Ambrosino et al., 2016; Pasquale, 2017; Giesecke et al., 2016; König et al., 2017; MaaS Alliance

	platform • Of business apps of travel industry players • Within intelligent traffic systems • ICT – technological services and systems	AISBL, 2017; Kamargianni & Matyas, 2017; Matyas & Kamargianni, 2017; (ulley et al., 2018
"Data-Sharing"	• Concerning open access to data of transport services • Allows to structure the match of supply/demand • Allows to optimize the service of transport operators • For modelling and data analytics purposes (e.g. historical and real-time data) • Allows knowledge of user travel patterns and revealed preferences • Allows to adapt user's travel choices • Enables predictive modelling of flows in Mobility System	Heiskala, Jokinen, & Tinnilä, 2016; Transport Systems Catapult, 2016; Belletti & Bayen, 2017; Hensher, 2017; Arneodo, Castelli, & Botta, 2017; Polis Network, 2017; Pöllänen, Utriainen, & Viri, 2017; MaaS Alliance AISBL, 2017; Docherty et al., 2017; Sarasini et al., 2017; Mulley et al., 2018
"Coordination & Cooperation"	• In terms of "MaaS" vision for the transport sector • For an interconnected transport sector • Among different actors and stakeholders in the transport network • To allow for discounts in transport fares	Rantasila, 2015; Ambrosino et al., 2016; Kamargianni et al., 2016; Karlsson et al., 2016; Docherty et al., 2017
"General" features	**Insights based on literature review**	**References**

Table 4 – Insights on "General Features" associated to "MaaS System" based on literature review (source: author)

With the digitalization trend of the transport sector and related with "open data", "interoperability" standards for "data-sharing" and "integration" principles present in a "MaaS System", relies the **"Technology"** enabler dimension. Since detailing technological solutions is out of scope of this work, some references are although made concerning the analytical and modelling processes they enable, which relates to the potentialities of the "MaaS System" functions.

4.1.2. Specific analysis

The "user journey" designed in Figure 15, helps to build a perspective definition of "MaaS system" based on the user interaction with the system and its type of "user experience". This perspective was an inspiration to the analysis of the "specific features" that a "MaaS system" entails. This analysis exercise sets the basic working environment for a "MaaS topology proposal", and it starts with a simple scheme – the "MaaS Flower Model" (Figure 16).

The analogy with nature – depicting "a flower" structure - intends to demonstrate that such as a specific 'flower' needs an adequate climate and a set of conditions to grow and to blossom, so does a "MaaS System". Departing from the "general features" identified in the previous chapter, the intention is to get a closer view on the "specific features" that will allow the characterization of "MaaS" pillars: its specific core features.

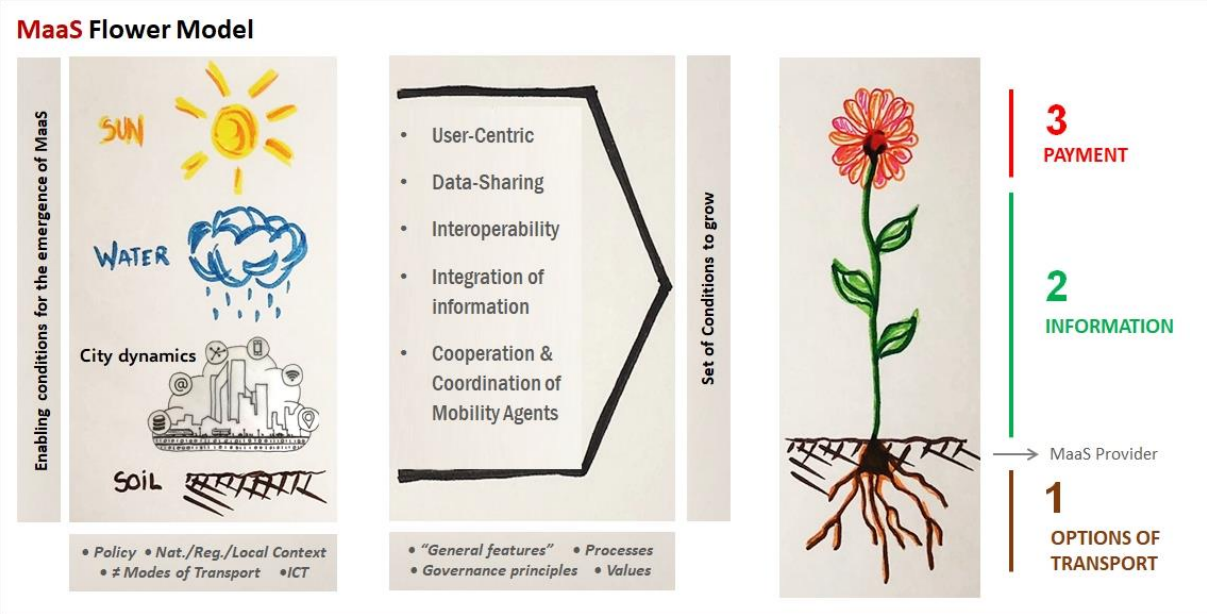

Figure 16 – "MaaS Flower Model" (Source: Author)

Already mentioned alongside the "user journey" approach, three pillars were considered the core features of MaaS: **1)** Different **transport services**, which are the basis for user choice through the MaaS Aggregator/Provider; **2) Information**, regarded as "enablers of choice" and **3) Payment**, stared as the service acquisition possibility or "enablers of use".

Different enabling conditions (e.g. National, regional and local context; policy and regulations, etc.) or the presence or absence of some of the "general features" already mentioned, generate different patterns of "MaaS systems", or following the analogy: different "flowers". These different patterns are here considered as the different topological levels of "MaaS".

Diversity of Transport Services - 1st Pillar

As explained before, the diversity of transport services that exist in a geographical area are considered the basis for a "MaaS system" due to the "possibility of choice" it entails. Since one of MaaS goals is the delivery of "door-to-door seamless mobility" as a service, the existent displacement options must ideally cover the whole trip from A to B as seamlessly as possible (Sochor et al., 2015; S. Li et al., 2017; MaaS Alliance AISBL, 2017; Kamargianni & Matyas, 2017).

Ensuring this depends on many factors, such as: i) the demography and the geographic limits that the MaaS system intends to cover; ii) the existent transport networks and infrastructures, iii) the land use and consequent dispersion of activities in the territory; iv) the incorporation of mass transport services subject to "Public Service Obligation" (whether public or private); v) the incorporation of other mobility services (playing the roles of MaaS partners); vi) availability (related with capacity by numbers, reliability, flexibility and diversity by type), and in another level, vii) the inclusion of peer-to-peer sharing, multiplying many-to-many matching mobility possibilities.

The rationale subjacent for the creation of degrees of transport services available in the system is supported by two principles: 1) 'the degree of choice', which is intimately associated with the nature of the transport services: collective or individual concerning 'non-self-service' or 'self-service' transport services; 2) 'capillarity', which is associated to the aggregated offer that is available in the "MaaS System" and to the "seamless mobility experience" of the user within that system.

Considering that the categorization of transport services can be split in two types: 'Non-self-service' and "self-service services" (weather subject to 'Public Service Obligation' or commercial), and in a second tier both types can be either 'collective' or 'individual', the proposed levels for MaaS first pillar, "Transport Services", are:

- **Self-service** transport (only);
- **'Non-Self Service'** transport (collective or collective and individual);
- **'Non-Self-Service'** (collective and/or individual) **and 'Self-Service' collective** transport;
- **'Non-Self-Service' and 'Self-Service'** (individual or collective and individual) transport.

In this respect it was disregarded the distinction between private and public capital source, since the main concern considered relevant is the regulation in place associated with "Public Service Obligations", and by itself this distinction didn't add more information to the system performance. The only distinction made, was the separation of the first level from the second, where the proposed order points to a higher value attributed to the existence of mass transport instead of just "self-service". Other aspect that it was also not taken into account is the nature of the service - "Public Service Obligations" or "Commercial Services" - since it wasn't considered explanatory in terms of transport reliability.

Information – 2nd Pillar

Considering the 'user journey' described in 4.1.1 the access to information constitutes a fundamental step in a "MaaS System" and is considered the second 'pillar' of MaaS. It is the information, anchored in open data access, data-sharing and interoperability of data interfaces (and ICT) of the different transport providers (Giesecke et al., 2016; Matyas & Kamargianni, 2017; Mulley et al., 2018), that allows the possibility to perform an informed choice of which mobility service is most suitable to the user's needs.

Two questions structure the choice previously mentioned: "**How the access to information** takes place?" and "**What kind of information** is there to be accessed?".

Indeed, the first question relates to what can be called the front-office of the system, where several types of access can exist (therefore, the question: 'How?'), and independently of the mean of access, numerous authors reference that it should be based on a **"One-Stop-Shop" principle** (Y. Li & Voege, 2017; MaaS Alliance AISBL, 2017; Kamargianni & Matyas, 2017). Expressions ranging from "Centralized Platform" (Kamargianni et al., 2016) or "Digital Platform" (Sochor, Strömberg, & Karlsson, 2015a), to "Unified Gateway" (Veerapanane et al., 2018) and "One Interface" (Matyas & Kamargianni,

2017, MaaS Alliance AISBL, 2017) translate the “one-stop-shop” principle into different ICT terminologies that stress the importance of a “single” point of access to the information and mobility services. Next, the **levels of access to information** were defined considering two properties: 1) Digital/Non-digital and 2) Offline/Online:

- **Non-digital Offline** – which is represented by “on-street information points” (e.g. mobility information shops) (Ambrosino et al., 2016; G. Smith, Sochor, & Karlsson, 2017b);
- **Digital Offline** – e.g. “call-center” (Kamargianni et al., 2016);
- **Digital Online** - which include “apps” and/or “web-portal” (Sochor et al., 2016; Ambrosino, Nelson, & Gini, 2016; Matyas & Kamargianni, 2017).

Proceeding in the user journey, and after the ‘registration’ and ‘authentication’ procedures (Sochor et al., 2015b; Veerapanane et al., 2018), the answer to the second question takes place when defining “What” information can be accessed in the following phases. Most authors identify the **“journey planner” as the central element concerning information on mobility services** (Ambrosino, Nelson, & Gini, 2016; G. Smith, Sochor, & Karlsson, 2017b ; Ahtela & Viitamo, 2018; Veerapanane et al., 2018), along with the availability of a “centralized booking system”, when needed to perform the trip (Kamargianni et al., 2016; Sochor et al., 2016).

The Finnish “Act on Transport Services” (Chapter 2 “Interoperability of data and information systems” - Section 1 “Essential data concerning mobility services”) refers that the minimum essential mobility services data is described as follows: *“Regardless of the mode of transport, a provider of passenger mobility services shall ensure that essential, up-to-date data on its services **is freely available** from an information system (**open interface**) in a standard, easy to edit, and computer-readable format. At minimum, this **essential data shall include information on routes, stops, timetables, prices, availability and accessibility**”.*

The ‘journey planner’ can be understood as an interface with aggregated static information of mobility services in its simplest version, or one the other extreme can assume an interventive role on the overall mobility system for instance. Nevertheless, since the backbone of this interface and of a ‘MaaS system’ in general, is the access to open data, different types of data are laid out by authors and summarized as follows:

- **Static data** - Information on different mobility services supply characteristics (Sochor et al., 2017);
- **Dynamic data** - Information on different mobility services supply characteristics based on real-time information, where the location of vehicles is considered for instance (Gebhardt et al., 2016; Docherty et al., 2017);
- **Archived or Historical data** - related with passenger travel history and overall mobility services demand data (Giesecke et al., 2016);
- **Processed or analysed data** - relying on “data analysis” and “Big data analytics”, to uncover travel behaviour patterns; revealed preferences of travellers; business intelligence and KPI’s

for monitoring purposes, among other functions but with a focus on the potential to learn from past events (Sarasini et al., 2017; Ebrahimi, Sharmeen, & Meurs, 2018);

- **Predictive data** – relying on "data analysis", "Big data analytics" and/or modelling techniques with a focus on future events and predictive character (supply and/or demand), e.g. "yield reliable estimates of the locations and times corresponding to demand for mobility" (Belletti & Bayen, 2017);
- **Crowd-sensed data** – data produced and disseminated by the user or the crowd (active user/participatory sensing) , that will depend firstly on the potentialities of the journey planner to receive that information, but that can help to optimize the mobility system performance (e.g. in terms of overall User experience; system monitorization; information about disruptions of service or emergencies, etc) (Heiskala et al., 2016);

The combination of these different types of data, will shape the journey's planner potential of choice for the customer, its predictive power and the overall efficiency of the mobility system (e.g. optimization supply/demand; intervening power, etc.) which is also associated with network effects of high levels of demand using this system. The type of data available and its consequent possible potential actions across the mobility system through a specific journey planner (journey planner capabilities), are schematically represented in Figure 17. In this scheme, it was disregarded the necessary technology related with the availability of the given type of data, since it was out of scope of this work. Therefore, the x-axis was ordered based on the relative "sophistication level" of the available data *per se.*

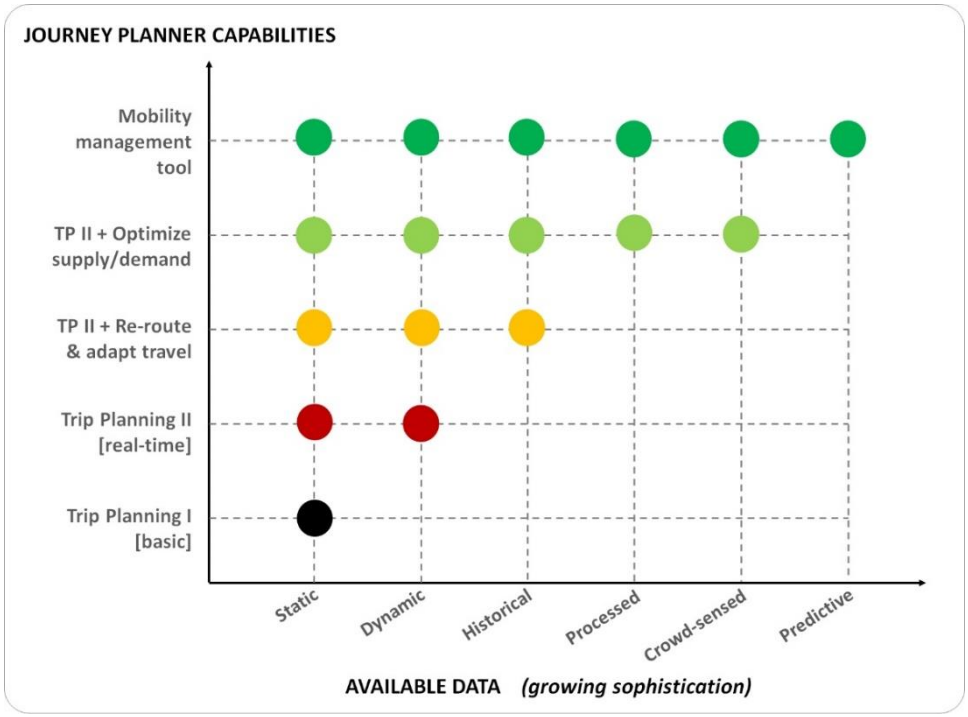

Figure 17 – Availability of data and corresponding "Journey planner capabilities" (Source: Author)

This figure intends to show that the "journey planner capabilities" represented levels are incremental, since the difference between each level corresponds to an increase in the type of data available. In this scheme is possible to observe that the most powerful "journey planner" is the one that can be used as a "mobility management tool" and that can encompass all the specified types of data.

Both, first and second tier of the “Journey Planner Capabilities” rely on mobility services information, but the only difference is that “Trip Planning I” just considers static data and “Trip Planning II” includes real-time data allowing an up-to-date multimodal mobility planning at all trip stages. The third tier adds “Historical data” that, if related with demand can input in the system the “travel behaviour patterns” of users in past trips, in conjunction with real-time data (e.g. disruptions and/or emergency management) allows the “re-route” of the travel.

The fourth and fifth tier involve different degrees of intervention in the mobility system, respectively: i) optimization of supply and demand within the considered mobility services and ii) potential intervention in the mobility system (that includes overall traffic system and optimization of supply and demand) through a holistic “Mobility Management” perspective. The main difference of the information available between the fourth (“TP II + Optimization of supply/demand”) and fifth tier (“Mobility Management tool”) is the incorporation of predictive data, that stems out of overlapping of real-time information and data analysis and modelling in three branches: i) “predicted traveller situation” (Heiskala et al., 2016; Hensher, 2017; Belletti & Bayen, 2017); ii) “real-time route and vehicle information” (Ambrosino, Nelson, & Gini, 2016; Matyas & Kamargianni, 2017) and iii) “forecast of traffic flows” (Heiskala et al., 2016).

After acknowledging the existence of different types of data and understanding the relation between its availability and the “Journey Planner capabilities” it was possible to answer to the second question: “What information is there to be accessed?”, through the definition of the reference levels for a “Journey Planner.

The proposed “Journey Planner” levels are all anchored on “digital online solutions” and are ordered incrementally from lower to higher capability potential, as follows:

- **Static Multimodal Journey Planner** – based on “static” mobility services data;
- **Dynamic Multimodal Journey Planner** – based on “static” and “real-time” mobility services data;
- **Assistant & Dynamic Journey Planner I** – based on “static” and “real-time” mobility services data, as well as individual “user preferences” data to assist a tailored travel choice (including notifications from system, re-routing and adaptation of travel choice in all trip stages);
- **Assistant & Dynamic Journey Planner II** – based on “static” and “real-time” mobility services data; individual “user preferences” data and “Crowd-sensed” data, to assist a tailored travel choice and allow the optimization of supply/demand relying as well in feedback from users in real-time;
- **Assistant & Dynamic Journey Planner III** – based on “static” and “real-time” mobility services data; individual “user preferences” data; “Crowd-sensed” data and “Predictive Data” based on modelling and data analytics techniques (estimates of demand and supply – location and time, as well as predicted traffic system situation) allowing an optimization of supply/demand in real-time (or for instance destination suggestions for a specific desired trip function, given the real-time situation of the mobility system and the user’s “value of time”);

- **Intervenient, Assistant & Dynamic Journey Planner** – based on all the properties of the "Assistant & Dynamic Journey Planner III" and encompassing an intervenient capacity in the mobility system that can assume a role of a "mobility management tool" (e.g. "prioritizing traffic control"; "management of congestion", etc).

Apart from these types of available data, considered central for the different "Journey Planner capabilities" and the definition of "Journey Planner" levels, there are also references to various "frills" that represent "extra" functions, most of them related with an enrichment of the "user experience". These aspects were not considered in this work due to the high dependence on the subjectivity of each user and user preferences. Nevertheless, and not disregarding its importance, several references are quoted in the following list, that exemplifies its variety:

- Application functionalities related with the check of balance; bonuses; trip history; customer support (FAQ) (Sochor et al., 2017) and comparison calculators with private vehicle (Matyas & Kamargianni, 2017)
- Possibility of "using social media"; social media sharing; direct contact between end-users (Giesecke et al., 2016; Matyas & Kamargianni, 2017);
- Inducing participation and sustainable travel behaviours: gamification (Schweiger, 2017); Incentive design for participation / crowd-sensed data (Heiskala et al., 2016); reward sustainable travel choices (Wittstock & Teuteberg, 2018);
- On board information and entertainment (Wittstock & Teuteberg, 2018); Interactive map (Kamargianni et al., 2016); Augmented reality on board;
- Inclusion of transport related services (Sochor et al., 2017); monitoring of air quality, speed and passenger load (Wittstock & Teuteberg, 2018).

Payment – 3rd Pillar

As stated in the beginning of this chapter, the second set of interaction within the "MaaS system" is the "acquisition possibility" or by other words the "enabler of use", hereafter identified fundamentally as **"Payment"** (Matyas & Kamargianni, 2017; Sochor et al., 2017; Polis Network, 2017; Wittstock & Teuteberg, 2018). Despite abundant references to **"Ticketing"** as an important function inside a "MaaS System" (Ambrosino, Nelson, Boero, et al., 2016; König et al., 2016b; Sochor et al., 2017; Pasquale, 2017), in this work it was considered that the possibility of issuing a "ticket", or other title that enables the use of a mobility service, is implicit and a consequence of "payment", a rational also shared by other authors (e.g. Sochor et al., 2017; Y. Li & Voege, 2017). Thus, concerning "Ticketing", references to the main questions raised around this feature will be addressed further on, in the perspective of its contribution to a seamless "user experience".

"Payment" is the core feature that distinguishes a "MaaS system" from a common "Journey Planner" independent of its degree of sophistication. Identical to the "information" pillar, the questions of "How" and "What" remains pertinent and can be rephrased into: "How the payment works?" and "What kind of payment options exist?".

Before going deeper in the specificities associated with "Payment", first is important to stress the **enabling conditions** for this "feature" to exist and be incorporated in a "MaaS System". Considering what is expressed in the Finnish "Act on Transport Services" (Finland Governement, 2017) - Section 2 ("Interoperability of Ticket and Payment systems") from chapter 2 – there should be in place an **open access** to all mobility services providers **sales interfaces, which include their ticket and payment systems**. Moreover, the same "Act" stresses that *the "communication between back-office systems shall be possible through an interface"* using generally applied technology, and that a competent authority shall approve that those *"systems meet the **requirements of interoperability**"* as defined by the legislation, advising all agents to *"**work in co-operation** to facilitate the necessary practical arrangements*". Once again the **open access to data**, particularly in terms of "ticket and payment interfaces", is highlighted as fundamental to a "MaaS System", which is sustained as well by Ambrosino, et al. (2016); Y. Li & Voege (2017) and Polis Network (2017), for instance. Therefore, the consequent possibility for **"3rd party re-sell of tickets"** is one of the differentiating enabling aspects of this core feature.

What is commonly referred as a disruption that is triggered by a "MaaS system", and that also concerns the "Payment" feature, is the possibility of **accessing different mobility services through a single payment** (MaaS Alliance AISBL, 2017; Veerapanane et al., 2018). There is also reference to the importance of **e-payment methods**, which is something that is indispensable within the desired "user experience", since the "MaaS System" analysed in this work is anchored in digital online solutions. Diverse "payment tools" are emphasized - such as credit cards, smartphone based payments, 'PayPal' accounts, etc. (Kamargianni et al., 2016; Ambrosino, Nelson, Boero, et al., 2016) – with a special reference to **"Open Payment Methods"** (Y. Li & Voege, 2017), where the aim is that the system can target the widest audience possible relying on high levels of flexibility. **One bill** (single/aggregated invoice) versus separate bills (separate invoices) are also pointed by authors as an advantage that streamlines the purchasing process (Sochor et al., 2017; Veerapanane et al., 2018) or as a concern (e.g. *"division of responsibilities"* difficulty, higher *"cost"* and *"end user integrity"* impediment associated to *"extra layers"* as stated in G. Smith, Sochor, & Karlsson, 2017b).

The most alluded aspects in relation with "Ticketing" inside the "MaaS System", are expressed in terms of the minimization of the travel harness considering the emission of just **one ticket** - **ticket integration** - instead of separate tickets. Ticket integration relies beforehand on interoperability and open access, as explained before, and can be materialized in different ways through **"Smart Ticketing"** solutions (e.g. e-ticket and mobile app; SmartCard; SmartWatch; Smartphone, etc.) (Ambrosino, et al., 2016; Kamargianni et al., 2016; Pasquale, 2017; Hensher, 2017; Veerapanane et al., 2018).

Focusing on "What" the payment entails, is possible to uncover one of the most cited features of a "MaaS System": the **"Mobility Packages" or "Bundles"** (Sochor et al., 2016; Kamargianni et al., 2016; Hensher, 2017; Mulley et al., 2018; Veerapanane et al., 2018). Within the "Mobility Packages" what is bought is the mobility "service promise" chosen according to user needs, and that vary in terms of flexibility and availability of options within a given "MaaS System". Other interesting payment

option is the **"Pay-as-you-go"**, often cited as a flexible, free of use and a good fit for trying out the system with no compromise (Transport Systems Catapult, 2016; Hensher, 2017).

Considering that the scope of the "MaaS System" studied in this work relies on "digital online solutions", the different levels of "Payment" listed below considered aspects like the flexibility and the potential matching of the mobility service package to the "user's needs", ranging from a more restrictive situation to the highest flexible offer:

- **Pay-as-you-go** (PAYG) (system access through **physical** means only) (Hensher, 2017);
- **PAYG and Single Subscription** (system access through **physical** means only)
- **PAYG and Single Subscription** (system access through **electronic** means) – only one type of subscription package (I. C. M. Karlsson et al., 2016);
- **PAYG and Fixed Subscription** (system access through **electronic** means) – in this level the user can choose the mobility package that presents the best fit for their needs, although the offer available is fixed or predetermined (Hensher, 2017);
- **PAYG and Flexible Subscription** (system access through **electronic** means) – in this level the user can choose the mobility package that presents the best fit for their needs, where besides predetermined packages there is the option for the user to tailor-made and adapt (Sochor et al., 2016).

4.1.3. 'MaaS Topology' Proposal

As it was affirmed in the beginning of this chapter, the 'MaaS Topology' proposal aims to structure different possible configurations of "MaaS" systems corresponding to 'levels of materialization' of its core features, to infer the maturity degree as well as the capabilities associated to a specific "MaaS system" in place. Topology, considered as the mathematician term - the "study of space", applied to "MaaS" will generate patterns or spatial configurations that correspond to different "MaaS" identities.

Since the "MaaS System" is based on three pillars, as explained in the previous chapter – Transport services, Information and Payment – the topology approach followed will rely on a **3-Dimensional** system, being each pillar associated with each axis. For this to be possible the units in all axis must represent identical value. For this reason, it was applied a **Multi-Criteria Decision Analysis** (MCDA) model, from the knowledge field of Decision Theory, that with the application of the Multi-Criteria Additive Value Model (Equation 1) allows a coherent and consistent transformation of each axis's Local Value in Global Value through the determination of the value of weights (scalling constants) within the additive model of MCDA. In other words: *"the key idea is to construct scales representing preferences for the consequences, to weight the scales for their relative importance, and then to calculate weighted averages across the preference scales"* (Department for Communities and Local Government: London, 2009).

$$V(a) = \sum_{j=1}^{n} w_j v_j(a) \quad , \qquad \text{with} \ \sum_{j=1}^{n} w_j = 1 \ \text{ and } \ w_j > 1 \ (\mathrm{j} = 1, \dots, \mathrm{n})$$

where: $V(a)$ is the overall value of option a ; $v_j(a)$ is the (partial)value of option a on criterion j
w_j is the weighting coefficient of criterion j, with $j = 1, \dots, n$.

Equation 1 – Additive Value Model equation (Phillips & Bana E Costa, 2007)

The weights in this model are scaling constants that *"represent the correspondence between value units on one criterion compared to another"* (Phillips & Bana E Costa, 2007) and don't reflect the 'importance' of the criteria. As it is pinpointed by Keeney (1992) cited in " Phillips & Bana E Costa (2007): *"A major error in multi-criteria modelling is the attempt to assign weights that reflect the 'importance' of the criteria without reference to any considerations of ranges on the value scales and how much each one of those ranges matters to the decision maker".*

These types of models are built anchored in a socio-technical approach that is supported by **"Decision Conference"** or "Decision Conferencing", which according to Phillips & Bana E Costa (2007) is portrayed as a *"gathering of key players who wish to resolve important issues facing their organisation, assisted by an impartial facilitator who is a specialist in decision analysis and works as a process consultant, using a model of relevant data and judgements created on-the-spot to assist the group in thinking more clearly about the issues".*

It is out of the scope of this work building a process of "Decision Conference", although it is recognized that it should be the decision process to follow in order to assemble a Multi-Criteria model based on value judgements of key players (e.g. Decision conference composed by diverse group configurations based on the universe of stakeholders identified in Table 3 and according to the goals of the model). Instead, the value judgements considered are supported by the literature review and the reflections and arguments of the author outlined in this work, focusing on more coherent and consistent results than the ones using a "point-scheme", where a basic addition rule is infringed: it is not possible to perform addition operations with itens that have different natures and value systems.

Methodologically, the model building process has three phases: **1) Structuring; 2) Evaluation** and **3) Testing**.

Structuring phase

The **structuring phase** encompasses the **definition of criteria and descriptors of performance** (ordered impact levels) that operationalize those criteria. The criteria considered in this model match the three "MaaS" pillars identified, and the correspondent descriptors of performance were already described in detail in the previous chapter. Although, according to MCDA theory, individual criterion and family of criteria should fully respect a set of properties[63], and therefore some of the descriptors of

[63] A set of criteria should be complete (it should cover all aspects of a decision problem), operational (the criteria can be meaningfully used in the analysis), decomposable (the set of criteria can be broken into parts to simplify

performance had to be adjusted according to this (Table 5). One of the main concerns is to have independent criteria, avoiding pitfalls such as impossible configurations of "MaaS Systems", besides the coherence of the model.

C1 – Transport Services	C2 - Information	C3 - Payment
1.'Self-service' transport (only) **2.'Non-self-service' transport** (collective or collective and individual); **3.'Non-Self-Service'** (collective or collective and individual) **and 'Self-Service' collective** transport; **4.'Non-Self-Service'** (collective or collective and individual) **and 'Self-Service'** (individual or collective and individual) transport.	**1. Static Multimodal Journey Planner** ("Static" data) **2. Dynamic Multimodal Journey Planner** ("Real-time" data) **3. Assistant & Dynamic Journey Planner I** ("User preferences" data) **4. Assistant & Dynamic Journey Planner II** ("Crowd-sensed" data) **5. Assistant & Dynamic Journey Planner III** ("Predictive" data) **6. Intervenient, Assistant & Dynamic Journey Planner**	**1.Pay-as-you-go (PAYG)** (**physical** access only) **2. Pay-as-you-go (PAYG)** (**electronic** possibility) **3.PAYG and Single Subscription** (**physical** access only) **4.PAYG and Single Subscription** (**electronic** possibility) **5.PAYG and Fixed Subscription** (**electronic** possibility) **6.PAYG and Flexible Subscription** (**electronic** possibility)

Table 5 – "MaaS Topology model" Criteria and respective descriptors of performance (source: Author)

Concerning criterion **"C1-Transport services"**, if one of the base principles of "MaaS" is the possibility of choice, there must be at least theoretically, two transport services to choose from. Although it could be necessary as a minimum level more types of transport services, depending on the connectiveness of the network and the seamless possibility that a potential trip choice entails considering the overall mobility system context. This deeper analysis focused on the level of service and the capillarity potential of the transport network existent in a given territory and its adherence with the needs of users within a territorial dynamic, is out of scope for this work. Therefore, as explained in the previous chapter, a proxy was defined based on the type of transport – "Non-Self-Service" and "Self-Service" - and the type of access to the system (collective vs. individual). Anchored in these reasons, clearly one single type of transport service cannot exist as a first level of C1 criterion, thus transforming this aspect in a question of eligibility. Following, the reason to choose as a first level "self-service transport", disregarding if collective or individual, in detriment of "Non-self-service transport" is related with the higher capacity of the latter, and not the flexibility. Although flexibility is important, it was considered availability more important.

the process), nonredundant (to avoid the problem of double counting), and minimal (the number of criteria should be kept as small as possible). (Malczewski, 2018)

In respect to criterion **"C2 – Information"**, all the levels presuppose that there is a "digital online" solution to access the system, enabling in this way all possible configurations of "MaaS Systems" (e.g. any kind of Assistant Journey Planners). The levels maintained the same order than the one it was already reasoned in the previous chapter, which are correlated with the type of data that the system encompass. Technologically, it was assumed a correlation between the ordered set of data types and its subjacent analytic potential and user experience consequential improvement, considering that each upper level incorporated the data potentialities of the immediate lower level.

Considering criterion **"C3 – Payment"**, the levels maintain the previous order, and follow the principle of the increasing flexibility of the mobility packages offered with the consequential improvement on the user's needs matching, and therefore attractiveness. The only remark goes to the maintenance of the first level - "Pay-as-you-go" based only on physical access to the system – due to the communication that a system requires to allow this type of payment, considered as a free pass for the user. It was also assumed that for the more elaborated types of mobility packages – "Fixed" but allowing choice and "Flexible" – it was needed an electronic access possibility besides the physical one.

Evaluation phase

The **Evaluation phase** is composed by two parts, first the **creation of value functions** for each criterion and secondly the **assessment of the criterion weights**.

The **value function** process explained shortly can be understood as the creation of *"scales anchored at their ends by the most and least preferred options on a criterion* (where) *the most preferred option is assigned a preference score of 100, and the least preferred a score of 0.* (…) *Scores are assigned to the remaining options so that differences in the numbers* (or levels) *represent differences in strength of preference"* (Department for Communities and Local Government: London, 2009). In Figure 18 is possible to see the result of the value functions associated to each criterion.

A creation of scales based on indifference judgements that represent strengths of preference, and supported by the rational presented before, the main fundaments were:

- **"C1-Transport Services"** – It was valued more the passage from Level C1.2 to C1.3 than from C1.1 to C1.2, due to the diversity, capacity and availability increase the level C1.3 entails when there is a mixture of "Non-Self-Service" and "Self-Service" transport services. The level C1.3 was not considered an indifference level and therefore it was not attributed 50 value points. Instead, the difference in attractivity from C1.3 to having all configurations of "Non-Self-Service" and "Self-Service" transport services (C1.4) is higher than the passage from C1.1 to C1.3.
- **"C2 - Information"** – The highest difference in attractivity between consecutive levels considered, is the incorporation of "Real-Time data", which transforms a Static Journey Planner into a Dynamic one (valuing 40 points). Next, it was considered equivalent the passage from C2.1 to C2.3 (from "Static JP" to "Assistant Dynamic JP I") and from C2.3 to

C2.6, due to the power capability that the journey planner entails for the user. The benefits of the incorporation of “Crowd-sensed” data are highly depending on network effects, and therefore are only more interesting when there are high levels of user participation. Therefore, the passage from C2.3 to C2.4 was considered the one with the smallest difference in attractivity. In what concerns the passage from an “Assistant, Dynamic and Predictive JP” to a level where the only difference is the added “intervention” capability, that can be even seen as a mobility management tool (C2.5 to C2.6), it was attributed the same value of the passage from “Dynamic JP” to the highest level of “Assistant JP” (C2.2 to C2.5).

- **“C3 - Payment”** – The first observation relies on the importance of the existence of the mobility packages, even in its simplest form in detriment of the possibility of having an electronic access to the system. This is so because all the means of payment are considered digital based and possible in real-time. Therefore, it represents the highest consecutive value difference in all the existent levels and corresponds to the indifference from the last level and the highest level referenced to C3.3, with a value of 50 points. Secondly, the value of electronic possibility of access represents the same points weather in the passage from level C3.1 to C3.2 or C3.3 to C3.4. Taking into account that the increase in flexibility of the payment packages is more valued, the passage from “Fixed Subscription” (C3.5) to “Flexible Subscription” (C3.6) is valued higher (30 points) than the passage from “Single Subscription” (C3.3) to “Fixed Subscription” (C3.5) (20 points).

C1 – Transport Services		
100	C1.4	NSS (all) + SS (ind. or all)
90		
80		
70		
60		
50		
40	C1.3	NSS (any) + SS (col.)
30		
20		
15	C1.2	NSS (any)
10		
0	C1.1	SS only (any)

C2 - Information		
100	C2.6	Intervenient + Ass. III JP
90		
80		
70	C2.5	Assist. III - "Predictive" JP
60		
55	C2.4	Assistant II - "Crowd" JP
50	C2.3	Assistant I - "UX" JP
40	C2.2	Dynamic - "Real-time" JP
30		
20		
10		
0	C2.1	Static JP

C3 - Payment		
100	C3.6	PAYG + Flexible S. (elect.)
90		
80		
70	C3.5	PAYG + Fixed S.(elect.)
60		
55	C3.4	PAYG + Single S.(elect.)
50	C3.3	PAYG + Single S. (physical)
40		
30		
20		
10		
5	C3.2	PAYG (elect.)
0	C3.1	PAYG (physical)

Notes: ***NSS*** | *Non Self-Service*
SS | *Self- Service*
ind. | *individual*
col. | *colective*

JP | *Journey Planner*
Ass. & ***Assist.*** | *Assistant*

PAYG | *Pay-as-you-go*
S. | *Subscription*
elect. | *electronic*

Figure 18 - Value Functions of the criteria: ” C1 – Transport Services”; “C2 – Information” and “C3 – Payment” (source: Author)

The second and last part of the evaluation phase is the assessment of criteria weights. The **criterion weights** are *"scaling constants that represent the correspondence between value units on one criterion compared to another"* (Phillips & Bana E Costa, 2007), was performed using the trade-off procedure.

The **trade-off procedure** is a weighting procedure that successively compares two fictitious alternatives at a time in two criteria (composed by best and worst level in each one of the criteria compared), considering that these alternatives have the same performance in the remaining criteria. The procedure aims at uncovering the indifference between the two fictitious alternatives by either worsening the best level of the reference (or preferred) criteria or improving the worst level of the second alternative (in the preferred criteria as well). The pairwise trade-off comparison process is repeated for the remaining criteria, reaching j-1 criteria comparisons (since one of the fictitious alternatives corresponds to the reference or most preferred criteria). Taking into consideration that the total sum of the weights (w_j) is equal to one, their result is given by the computation of a j-1 criteria equation system, in this case performed by the Inverse Matrix Method.

The first step is to understand what the reference criteria is to establish the reference basis for the pairwise comparisons. Considering the goals of "MaaS system", already portrayed and discussed in this work, and its "user-centric" focus to provide "seamless mobility", the question that needs to answered is the following: "for which one of the Criteria would the swing from worst to best level be valued more, considering that all the criterion are valued at their worst level?".

Recapturing the rationale already explained for criterion "C1-Transport Services", being the "seamless property" of travel highly dependent on context, and considering that is more important to have a "Journey Planner" at its highest level ("C2-Information") than a more flexible "payment option" to access the system ("C3-Payment"), **the most important "worst-best swing" was the one verified in criterion "C2-Information".**

Proceeding, it was performed a pairwise comparison of fictitious alternatives between C2 and C3 and C2 and C1. The question protocol at this stage would be: "Considering a fictitious alternative "a" that score best in C2 [$v_2(a)$=100] and worst in C3 [$v_3(a)$=0], and an alternative "b" that scores best in C3 [$v_3(b)$=100] and worst in C2 [$v_2(b)$=0], what would be the value of alternative "a" in criterion C2 [$v_2(a)$=?] that would make alternative "a" indifferent from alternative "b" (remaining all the other values the same)?".

For the first pairwise comparison, C2 and C3, it was considered that the indifference point was the one corresponding to level C2.2 [$v_2(a)$=40]. The justification for this choice relies on the following value judgement: «For the same level of transport services, it is considered that having the most flexible and user friendly mode of payment and a "Static" Journey Planner would be similar to have just a "Pay-as-you-go based only on physical means of access to the system" and a "Dynamic" Journey Planner (that incorporates "real-time" information)». For the second pairwise comparison, C2 and C1, it was considered that the indifference point was the one that corresponds to level C2.3 [$v_2(a)$=50]. This indifference value judgement was supported by the following rational: «For the same mode of

Payment, having a higher choice in what concerns transport services but a static Journey Planner doesn't allow to fully take advantage of the user experience and interaction with the system. Which was considered equal to having a reduced transport choice but combined with an "Assistant Dynamic Journey Planner I", enhancing the potential user experience.».

The resultant system of equations is the one that is represented next:

$$\begin{cases} 40w_2 - 100w_3 = 0 \\ 50w_2 - 100w_1 = 0 \\ w_1 + w_2 + w_3 = 1 \end{cases}$$

Equation 2 – System of equations used in the assessment of the Criteria weights (source: Author)

The assessment of the criteria weights is the final part of the evaluation phase, and the result can be written directly in the final equation of the "MaaS Topology" multicriteria model, as it is represented in Equation 3.

$$V(a) = 0{,}263 * v_1(a) + 0{,}526 * v_2(a) + 0{,}211 * v_3(a)$$

Equation 3 – "MaaS Topology" multi-criteria model equation (source: Author)

4.1.4. 'MaaS Topology' Application

The proposal of "MaaS Topology" anchored on MCDA model, suggests a methodologic approach that translates into one common reference system the fundamental concerns (here the "MaaS core features") associated to the definition of a "MaaS System". Therefore, with this methodology it is possible to establish value-judgements and design a preference intensity scale that altogether materializes the notion of compensation and allows the calculus of the overall values associated to each analysed alternative (i.e. each "MaaS System").

For this methodology to be scalable and to have a more correct adherence to reality, the value-judgements and the design of the preference intensity scale should be supported and validated by a pool of users (in different contexts) through stated preference surveys, besides for instance the process of MCDA decision conference already mentioned before. Nevertheless, the model as it is presented can be used as a benchmarking tool, allowing deeper insights on a specific "MaaS" identity, or as support to decision management, foreseeing necessary actions for further development of a given "MaaS System".

Since it was out of the scope of this work a comprehensive validation of the model with user surveys, but instead the idea was to develop a first approach of a "MaaS Topology" proposal using MCDA methodology, the validation was performed by testing the model with two existent "MaaS systems": the "**Whim" app** (from *MaaS Global* – Finland) and the "**Wien Mobil" app** (from *Wiener Linien* - Vienna, Austria). The second "MaaS System" analysed in this work and launched in June 2017 at Vienna, was

chosen because it is referenced by UITP[64] as a success story and one of the main differences is that it is public-led instead of private like “Whim”.

WHIM			
Performance	Overall Value Level		
100	26.32	C1.4	NSS (all) + SS (ind. or all)
50	26.32	C2.3	Assistant I - "UX" JP
70	14.74	C3.5	PAYG + Fixed S.(elect.)

WIEN MOBIL			
Performance	Overall Value Level		
100	26.32	C1.4	NSS (all) + SS (ind. or all)
40	21.05	C2.2	Dynamic - "Real-time" JP
5	1.05	C3.2	PAYG (elect.)

Table 6 – Performance and correspondent Overall Value in the three criteria of the MCDA “MaaS Topology” model (source: Author)

In terms of “MaaS Topology”, the two alternatives are represented tri-dimensionally in Figure 19.

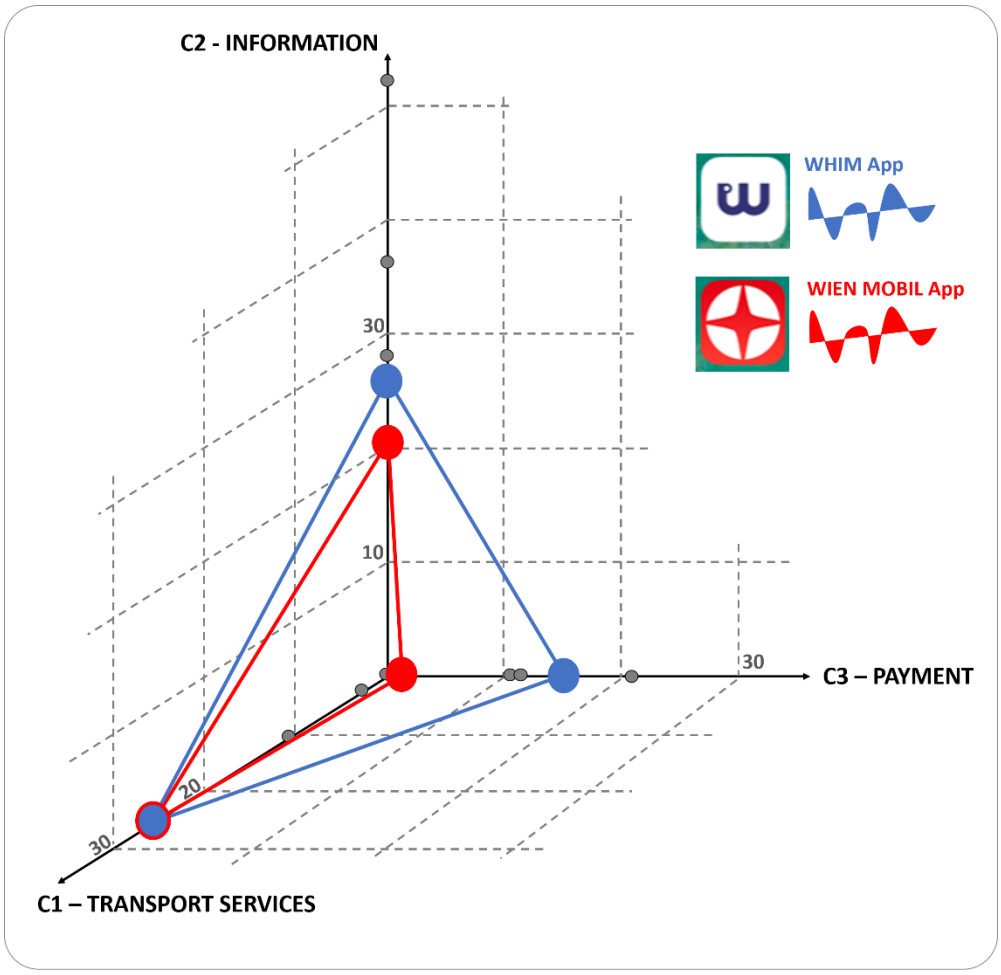

Figure 19 - Topological 3D representation of MaaS Systems: “WHIM” and “WIEN MOBIL” Apps (Source: Author)

[64] https://www.uitp.org/The-Mobility-as-a-Service-MaaS-success-story-WienMobil

The overall values of the analysed “MaaS Systems” are the following: WHIM app – 67,38 points and WIEN MOBIL app – 48,42 points. In the graphic (Figure 19) it’s is possible to see that the main difference between both apps lies in the “C3 - Payment” axis. In fact, WIEN MOBIL presents only Pay-as-you-go, besides public transport ticket offers for all kinds of situations, but a subscription package including more than one service doesn’t exist, which is very different from the WHIM offer (Figure 20).

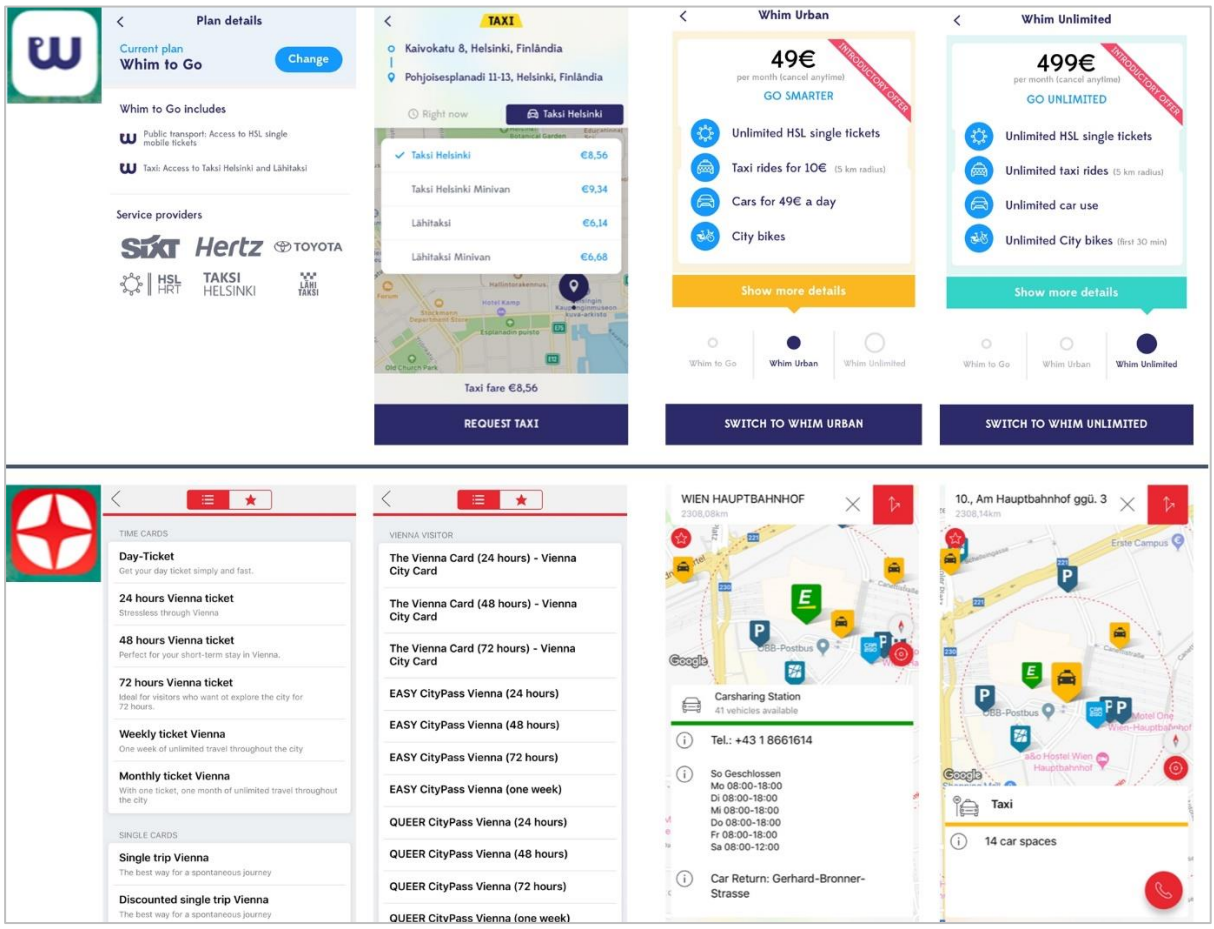

Figure 20 – Payment options of the two analysed MaaS apps: WHIM (top) and WIEN MOBIL (bottom) (Source: Author, based on WHIM and WIEN MOBIL apps)

4.2. Public Policy Framework proposal for “MaaS” implementation

In this chapter the main goal is to identify what should be in place in terms of Public Policy Framework (policy instruments) as well as stakeholder responsibility (indicative, since the scope of this work doesn’t belong to the field study of policy transfer), according to each corresponding set of “building blocks” identified previously in the structure of “MaaS” concept and its correspondent topology.

Alongside with the theoretical framework analysed and with the restructuring of “MaaS” concept performed in the previous chapter, the present proposal will be developed anchored in the following definition of “MaaS”:

“MaaS is a mobility management model that allows the emphasis of a value proposal and its articulation with supply and demand, ensuring all the means of

information and transaction between the two market sides, and where it is also enabled the feeding of monitoring functions that the authority intends to wield"
(proposed by: Rosário Macário and Renata Lajas, October 2018)

Firstly, it's important to recognize that there are not strictly defined and isolated topological levels of "MaaS Systems" but instead, a wide spectrum with numerous configurations possibilities given the different combination of levels or degrees identified in each one of the three pillars that identify a "MaaS System". Therefore, the Public Policy Framework proposed will be anchored in the "General features" and "Specific features" that structure the concept of "MaaS", and not the configuration nor the resulting pattern itself.

To do so, the understanding of the nature of decisions which are intimately connected with policy making within the Urban Mobility System, is of extreme importance to have a coherent and effective policy framework. It is for this reason that the first step to build the Public Policy Framework is to identify the relation of "Strategic", "Tactical" and/or "Operational" decisions with the enabling of each one of the features identified. The result is presented in Table 7.

The second step to build the Public Policy Framework, would be to consider independently the decision-making levels, and focusing on each feature at a time, identify which types of policy instruments would best fit the purpose or the enabling of that feature. For this task, the reference taxonomy used was the one of Howlett (2011), where the author references policy instruments through the governing resource type and the purpose of the tool, highlighting reference examples in each category (Chapter 3.1 and Annex II).

To complete this step, and within the decision levels of the Urban Mobility System, it was performed an indicative identification of stakeholders to establish responsibility relationships in what concerns the implementation of each policy instrument proposed (Table 8)

In what concerns the general features associated to "MaaS", the **"Data-Sharing"** and **"Interoperability"** are considered one of the most important ones, since everything on "MaaS" relates to information and specially "Open Data", as it was already referenced before. These two features, depending on the national context, are enabled by visions and strategies (strategical level) and tactical decisions, that can range from laws to regulation related to "data standardization" for instance. Monitoring actions and entities are especially relevant to the enabling of these features, since they are determinant to the well function of a "MaaS System".

Following, the next general feature of a "MaaS System" analysed is its desired **"User-Centric"** philosophy. This feature is present on all levels of decision, especially because it gives structure to the rationale behind the "MaaS" philosophy in all the service value it entails. The "User-centric" approach is a distinguishing feature, and in what concerns "strategic decisions" can be incorporated in Visions or strategies that set out what kind of market is aimed. In terms of tactical and operational decisions, issues related with "consumer rights" and "consumer protection" should be subject to regulation. Other policy instruments, that can stem out from strategic decisions and correspondent tactical

implementation forms, such as “financial implementation tools” as subsidies, can have a great impact in this feature.

			Decision Levels		
			Strategic	Tactic	Operational
General Features		Data-Sharing	●	●	●
		Interoperability	●	●	●
		User-Centric	●	●	●
		Integration of Information	●	◑	◑
		Coordination and Cooperation between mobility agents	◑	○	◑
Specific Features	C1 – Transport Services	C1.1 **‘Self-service’ transport** (only)	◑	◑	●
		C1.2 **‘Non-self-service’ transport** (collective or collective and individual);	◑	◑	●
		C1.3 **‘Non-Self-Service’** (collective or collective and individual) **and ‘Self-Service’ collective** transport;	◑	◑	●
		C1.4 **‘Non-Self-Service’** (collective or collective and individual) **and ‘Self-Service’** (individual or collective and individual) transport.	◑	◑	●
	C2 - Information	C2.1 **Static Multimodal Journey Planner** (“Static” data)	●	●	●
		C2.2 **Dynamic Multimodal Journey Planner** (“Real-time” data)	●	●	●
		C2.3 **Assistant & Dynamic Journey Planner I** (“User preferences” data)	○	○	◑
		C2.4 **Assistant & Dynamic Journey Planner II** (“Crowd-sensed” data)	○	○	◑
		C2.5 **Assistant & Dynamic Journey Planner III** (“Predictive” data)	◑	◑	◑
		C2.6 **Intervenient, Assistant & Dynamic Journey Planner**	●	●	●
	C3 - Payment	C3.1 **Pay-as-you-go (PAYG)** (**physical** access only)	●	●	●
		C3.2 **Pay-as-you-go (PAYG)** (**electronic** possibility)	●	●	●
		C3.3 **PAYG and Single Subscription** (**physical** access only)	○	○	◑
		C3.4 **PAYG and Single Subscription** (**electronic** possibility)	○	○	◑
		C3.5 **PAYG and Fixed Subscription** (**electronic** possibility)	○	○	◑
		C3.6 **PAYG and Flexible Subscription** (**electronic** possibility)	○	○	◑

● Required ◑ Optional ○ Absent

Table 7 - Decision Levels associated to each General and Specific MaaS Features (Source: Author)

Next, **“Integration of Information”** and **“Coordination and cooperation”** of mobility agents can be analysed together since these features, are perceived generally as values of the system but have more impact in the operational level related to “Business”. Nevertheless, “Integration” can be subject to tactical and operational decisions. In this respect, the monitorization of the integration level,

concretely if it fits the purpose of policy goals, and the regulation actions in what concerns the competition market created and the protection of consumer rights.

Considering the specific "MaaS" features (divided in three pillars) identified in this work and correspondent levels, the first pillar to be analysed is the "Transport Services" one (formerly identified as Criterion 1 – C1).

All the four levels (**C1.1**; **C1.2**; **C1.3** and **C1.4**) of the specific feature **"Transport Services"** are analysed together, since all relate to different configurations of transport service available, which are here considered highly dependent on the mobility context and specific agreements. Besides the different configurations of transport services being intimately related with the presence of the enabling general conditions already mentioned, where public policy plays an extremely important role – "data-sharing" and "interoperability" – in terms of the presence of strategic and tactical decisions, both will concern the leadership of the "MaaS" system. If the system is "Private-led", public policy intervenes only in the tactic/operational level on matters of market and competition regulation. If otherwise the system is "Public-led", besides necessary agreements, strategic and tactical decisions should be in place primarily considering vision or strategy and direct government through organizational implementation tools, respectively. For instance, in terms of Strategic and consequential Tactical decision level, if the "MaaS System" strategically is considered a "Mobility Management tool" promoting a more sustainable mobility, the repercussions in other public policy fields (strategic and tactical decisions) can be cross-sectorial (e.g. Environment, Land-Use and Housing policies for instance). Despite the leadership of the system, several policy instruments can be implemented, especially financial with multiple objectives, that can range from the support of "MaaS" pilots, to subsidies for the user and tax-incentives for greener choice travel.

The **"Information"** (formerly identified as Criterion 2 – C2) was defined as the second pillar of the "MaaS system" and encompasses six levels which are related with type, sophistication of data and the capabilities of the associated Journey Planner, considered as a central element concerning information on mobility services. "Data-Sharing" and "interoperability" once again play a determinant role as enabling conditions to the existence of any Journey Planner identified. In what concerns strategic, tactical and operational decisions identified as directly enabling and monitor the levels of information, the most important would be the first two levels (**C2.1** and **C2.2**) characterized by the existence of "Static" and "Real-Time" information. The policy instruments associated to these two levels correspond to the ones that enable in different decision levels the "Data-Sharing" and "Interoperability".

Next, the **C2.3** and **C2.4** levels are considered to be strictly connected to "MaaS" business side, since it encompasses the "User-Preferences" data and "Crowd-Source" data, enhancing the capabilities of the given Journey Planner with a "user-centric" perspective. Although actions on the monitoring decision level in terms of the enforcement of GDPR should be taken (privacy and individual data protection). Proceeding to level **C2.5**, if the "Predictive" data and "Big Data" analytics, require more information than the one generated by the Business operation solely - for instance incorporating the "prediction of traffic situation" considering the whole mobility system - strategic and tactical decisions

should also be taken into consideration, with the deployment of Organizational implementation tools (e.g. to allow stakeholder involvement, etc).

On the other hand, if the vision for a “MaaS System” is to use it as a mobility management tool (level **C2.6**), allowing or not an interventive power in the overall mobility system, besides the management of user travel function matching with best value-for-money destination according to current mobility conditions of the system (being it Value of time, cost, or other user preference), all the decision levels should be in place. In this case strong Strategic and Tactical decisions should be made, since it would shift completely the way mobility is perceived and could be accomplished especially with Organization and Financial implementation tools.

For the last pillar of a “MaaS System”, **“Payment”** (Criterion C3), it is fundamental for all levels that besides “Data-Sharing” and “Interoperability”, that all the “Payment and Ticketing interfaces” are open access and that it is allowed the selling of tickets by a third party, especially the ones belonging to public transport. Once again, only the first two levels (**C3.1** and **C3.2**) will be analysed, since all the remaining are strictly related to the Business operational side, the levels that correspond to the existence of different types of mobility packages (**C3.3**; **C3.4**; **C3.5** and **C3.6**). Nevertheless, regulation concerning the right to information and price calculation, prevention of biased information, consumer protection and rights, and related to market creation and competition, should be in place in the operational decision level – the monitoring.

Concerning **C3.1** and **C3.2** levels, the existence of “Pay-as-you-go” systems, despite the access to the system (physical or electronic), will allow by default technically all the other packages, and for this to be possible strategic or tactical decisions depending on the context should be in place considering at least two aspects: i) open sales and tickets interfaces and ii) possibility for 3rd party reselling of tickets. The operational decisions related concern the monitoring and regulation of law compliance among other specific aspects.

Due to the specificities of each country organization and its context (e.g. governance, administrative, bureaucratic, etc.), with clear consequences in the functions associated to each decision level, the stakeholders appointed responsible for the implementation of the proposed policy instruments (Table 8) are not specific but instead indicative groups of stakeholders.

	Features	Policy Instruments (by governing resource and purpose of tool)		Levels of Decision and indicative group of Stakeholders	
				Strategic	Tactic
S ● T ●	• Data-Sharing • Interoperability • C2.1 Static Multimodal Journey Planner ("Static" data) • C2.2 Dynamic Multimodal Journey Planner ("Real-time" data) • C3.1 Pay-as-you-go (PAYG) (physical only) • C3.2 Pay-as-you-go (PAYG) (electronic)	Auth. (subst.)	**Direct Government Regulation [1]**: *Laws, independent regulatory commisions.*	Political autorities	Technical authorities and agencies; Regulating authorities
			Market Creation and Mantenance tools [2]: *establishing of limits and permits*	Political autorities	Technical authorities and agencies; Regulating authorities
			Visions and strategies: *Policy Vision, Strategic options and plans [6]*	Political Authorities	
		Org. (subst.)	**Direct Government [3]**: *Line departments, central support agencies*	Political autorities	Technical authorities and agencies
		Org. (proc.)	**Network management tools**: *Creating or reorganizing government agencies [4], Legislative and executive oversight agencies [5]*	Political Authorities	Technical authorities and agencies; Regulating authorities
	• User-Centric	Auth. (subst.)	**Visions and strategies**: *Policy Vision, Strategic options and plans [6]*	Political Authorities	
			Direct Government Regulation [1]: *Laws (consumer rights protection)*	Political autorities	Technical authorities and agencies
		Org. (proc.)	**Network management tools**: *Legislative and executive oversight agencies [5]*	Political Authorities	Regulating authorities
		Fin. (subst.)	**Tax- or royalty-based financial instruments [7]**	Political Authorities	Regulating authorities
			Cash or Tax-equivalent financial tools [8]: Favourable insurance and loan guarantees, Vouchers for public services	Political Authorities	Technical authorities and agencies; Regulating authorities
	• C2.6 Intervenient, Assistant & Dynamic Journey Planner	Auth. (subst.)	**Visions and strategies**: *Policy Vision, Strategic options and plans [6]*	Political Authorities	
		Org. (subst.)	**Direct Government [3]**: *Line departments*	Political Authorities	Technical authorities and agencies
		Org. (proc.)	**Network management tools**: *Creating or reorganizing government agencies [4]*	Political Authorities	Technical authorities and agencies
		Fin. (subst.)	**Tax- or royalty-based financial instruments [7]**	Political Authorities	Regulating authorities
S ● T ◑	• Integration of Information	Auth. (subst.)	**Visions and strategies**: *Policy Vision, Strategic options and plans [6]*	Political Authorities	
			Market Creation and Mantenance tools [2]		Technical authorities and agencies; Regulating authorities
		Auth. (proc.)	**Policy network activation and mobilization tools [9]**: *Public consultation, stakeholder and consensus conferences*		Technical authorities and agencies; Operators; Suppliers; Clients; Other interest parties
S ◑ T ◑	• C1.1 'Self-service' transport (only) • C1.2 'Non-self-service' transport (collective or collective • C1.3 'Non-Self-Service' (collective or collective and individual) and 'Self-Service' collective transport • C1.4 'Non-Self-Service' (collective or collective and individual) and 'Self-Service' (individual or collective	Auth. (subst.)	**Direct Government Regulation [1]**: *Laws (access standards to service provision)*	Political Authorities	Technical authorities and agencies; Regulating authorities
		Org. (subst.)	**Direct Government [3]**: *Line departments, central support agencies*	Political Authorities	Technical authorities and agencies
		Org. (proc.)	**Network management tools**: *Legislative and executive oversight agencies [5]*		Regulating authorities
			Quasi-governmental organizational forms [10]: *Partnerships and contracting out*	Political Authorities	Technical authorities and agencies; Operators, Suppliers
		Fin. (subst.)	**Cash or Tax-equivalent financial tools [8]**: Favourable insurance and loan guarantees, Vouchers for public services	Political Authorities	Technical authorities and agencies; Regulating authorities
			Cash-based financial tools [11]: Grants, subsidies and user fees	Political Authorities	Technical authorities and agencies; Regulating authorities
		Fin. (proc.)	**Policy network creation tools [12]**: *Interest group creation (support to start-ups)*	Political Authorities	Technical authorities and agencies; Operators, Suppliers
	• C2.5 Assistant & Dynamic Journey Planner III ("Predictive" data)	Org. (subst.)	**Direct Government [3]**: *Line departments*	Political Authorities	Technical authorities and agencies
		Org. (proc.)	**Network management tools**: *Legislative and executive oversight agencies [5]*	Political Authorities	Regulating authorities
S ◑ T ○	• Coordination and Cooperation between mobility agents	Auth. (subst.)	**Visions and strategies**: *Policy Vision, Strategic options and plans [6]*	Political Authorities	
		Auth. (proc.)	**Policy network activation and mobilization tools [9]**: *Public consultation, stakeholder and consensus conferences*		Technical authorities and agencies; Operators; Suppliers; Other interest parties

Governing Resources: Authoritative (Auth.) | Organizational (Org.) | Fianacial (Fin.) | Informational (Info.)
Purpose of tool: Substantive (subst.) / Procedural (proc.)
Decision Level: Strategic (S) | Tactic (T)

● Required ◑ Optional ○ Absent

Table 8 - Indicative Policy Instruments by MaaS feature, according to governing resource and purpose of tool (Source: Author, inspired on Howlett's (2011) Policy Instruments Taxonomy)

5. Conclusions

The proposal of a Public Policy Framework encompassed a two-stage approach: first, the structuring of the "MaaS Concept", that allowed the development of a "MaaS Topology Proposal" (based on its specific features) and secondly, the identification of indicative implementation tools (policy instruments) and group of stakeholders responsible for its implementation by each urban management decision level and "MaaS" core feature.

Concretely, the structuring of the concept of "MaaS" focused primarily on the identification of its "building blocks" which were considered the starting point to establish a common understanding related to the identification of the founding pillars of "MaaS" concept. Taking into consideration the "MaaS Flower Model" proposed (inspired in a typical "user-journey" associated to a "MaaS System"), it was possible to understand the relation between the enabling conditions and its specific core features, and afterwards create a "MaaS topology proposal", supported by a Multicriteria Decision Analysis model. Afterwards, with a clear vision of what the policy formulation and implementation phases entail within a policy process, especially in what concerns policy instruments, and taking to consideration the nature and role of stakeholders ("Who?"), it was possible to propose a set of policy instruments ("How?") to enable each general and specific feature associated to the "MaaS System" ("What?"), as well as indicative group of stakeholders responsible for its implementation, by each decision level.

At the end of this work it was possible to fully answer the problem definition and build a coherent Public Policy framework that supports the implementation of a "MaaS System", within the governance of an "Urban Mobility System".

In what concerns challenges and barriers in respect to a "MaaS System" implementation, they stem out from different sectors, e.g. institutional; regulation related; technological and Operational from a business perspective. The most referenced ones fall on the non-availability of "Open-data"(Gebhardt et al., 2016; Heiskala et al., 2016; Van Winden & De Carvalho, 2017) that allow "data-sharing"; standards and "interoperability of data"(Y. Li & Voege, 2017; G. Smith, Sochor, & Karlsson, 2017b) as well as lack of "cooperation" among mobility agents (M. Karlsson, 2017) and access to "sales and tickets interfaces" with consequence on 3rd party reselling of tickets (Nikitas et al., 2017). These portrayed challenges are taken into account in the policy framework proposal under the proposal of different policy, whether by strategic visions, or by laws and regulations with implicit enforcement. Still related to the sharing of "Data", several authors also mention concerns about the "privacy" of data or "data security" (Van Winden & De Carvalho, 2017; Wittstock & Teuteberg, 2018), which can be overcome by GDPR implementation and for instance, inspired in Finland's example, all the standards are defined by central government agency (FICORA) as well as the shared data platform its owned and managed publicly by other specialized central government agency (Trafi).

Often, and to some extent related to "cooperation" and "coordination" issues, the "fragmented" organization of the transport sector, arranged in silos, is highlighted as a challenge (T. R. Casey, Ali-Vehmas, & Valovirta, 2017; Schweiger, 2017; G. Smith, Sochor, & Karlsson, 2017b). In this respect, at the tactic level steeming out from strategy, it is possible to start change the transport sector

organization environment with a adminstrative and competences reorganization of Ministries, Agencies or Transport authorities towards horizontal organization, as Finland did more than once in the last 10 years with the creation of the FTA and Trafi for instance.

The financial aspect is also several times proclaimed as a challenge, normally related with legislation and regulation related with subsidies of public transport (Nikitas et al., 2017; M. Karlsson, 2017; Y. Li & Voege, 2017; Mulley et al., 2018). This aspect brings an important question that is related with the redefinition of the role of Public Transport. The public transport can gain a bigger importance and increase its shares once the "MaaS" concept evolves and disseminates throughout the world in the years to come. The shift from "transport operators' subsidy scheme" to a "user" based subsidy one, whom can freely choose any transport service or "MaaS offering", can be an opportunity for the growth of the public transport share and not otherwise, as it is referenced by some authors quoting Public Transport Stakeholders (e.g. "cannibalization of Public Transport", "fear of losing the relationship with the customer" and "fear of losing the brand" are among some of the concerns) (M. Karlsson, 2017; G. Smith, Sochor, & Karlsson, 2017a). For instance, a user that chooses a "MaaS" offering that operates in the last/first mile but that is used to feed the public transport can be eligible to subsidy, instead of only subsidizing the public transport operator, or subsidize the user but restricted to public transport.

Frequently is also declared as a challenge the excessive "governance of Mobility led by technology" or the lack of "leadership" and defined roles associated to the "business models" of "MaaS" (M. Karlsson, 2017; Finger & Razaghi, 2017), or as Sampo Hietanen refers (CEO of MaaS Global):

> *"The main barrier is lack of common market vision, common market goals, both on the public and private side.(…) this comes to the point that the market vision should not be set by us, it should be set by political leadership.(…) Regulation can be used, but (…) if the government sets out a clear vision of how they want the markets to be played out, then the companies will follow that, even without the regulation" (Sampo Hietanen, interviewed by the Author in 25.09.18)*

If "MaaS" is considered as a Mobility Management tool, as argued in this work, its implementation is aligned in all the decision levels, stemming out firstly from a strategic vision what type of system the proposed policy framework supports. A "MaaS" system concept implemented as a mobility management tool will have a higher potential in terms of monitoring capabilities of the mobility system, where it is possible to actively increase the efficiency of the transport system and at the same time have an active role in the promotion of sustainable mobility goals among other cross-sectorial policy goals (e.g. land-use, environment or housing policy).

Future work can focus on the study of challenges related to the unclear proof that "MaaS reduces traffic congestion" (Hensher, 2017; Mulley et al., 2018), only possible when the concept has a higher implementation degree, and the issue of universal accessibility with the challenge of "equitable access to a MaaS System" (Schweiger, 2017).

6. Annexes

Annex I - Extended List of MaaS definitions found in Literature Review

Author (year)	Citation of MaaS definition	Source
Heikkilä (2014)	"a scheme in which mobility services are provided as an individual and flexible service in a competing mobility operator market. (…) MaaS refers to circumstances, in which comprehensive supplies of mobility services are provided by mobility operators. Versatile services offered by the operators satisfy all mobility needs, thus decreasing the need to possess a car."	Master Thesis – Aalto University
Hietanen (2014)	"Mobility as a Service (MaaS) is a mobility distribution model in which a customer's major transportation needs are met over one interface and are offered by a service provider. (…) The vision is to see the whole transport sector as a co-operative, interconnected ecosystem, providing services reflecting the needs of customers. The boundaries between different transport modes are blurred or disappear completely."	Article in Press
ITS Europe, 2014	"a mobility distribution model in which all of customer's major transportation needs are met from a single platform by a single service provider that orchestrates each individual transport service component to meet a customer's end-to-end service expectations."	Institution
MaaS Alliance, 2015	"the integration of various forms of transport services into a single mobility service accessible on demand. (…) (implying) the use of a single application to provide access to mobility, with a single payment channel instead of multiple ticketing and payment operations."	Public-Private Partnership
Kamargianni, Li, Matyas, & Schäfer (2016)	"The term "Mobility as a Service" stands for buying mobility services as packages based on consumers' needs instead of buying the means of transport. Via "Mobility as a Service" systems consumers can buy mobility services that are provided by the same or different operators by using just one platform and a single payment. MaaS platforms usually provide an intermodal journey planner, a booking system, easy-payment, and real time information."	Peer-Reviewed (T)
Dimitrakopoulos, Bravos, & Stabologlou (2016)	"MaaS bridges the gap between public and private transport operators, envisaging the integration of all the fragmented tools (planning, booking, real time information, payment and ticketing) a traveler needs to conduct a trip."	Peer-Reviewed (IT)
Leviäkangas (2016)	"The concept of MaaS is relatively simple: bundling different transport means, public and private, into one easy-to-use package for the customer. The service is provided to the customer via mobile applications and payment is handled via a digital wallet."	Peer-Reviewed (IT)
Sochor, Karlsson, & Strömberg (2016)	"Mobility as a service (MaaS) is an emerging concept that entails a mobility distribution model in which a customer's major transportation needs are met over one interface and are offered by a service provider, in other words, "combining all forms of personal transport together into seamless trip chains, with bookings and payments managed collectively for all legs of the trip."	Peer-Reviewed (T)
Docherty, Marsden, & Anable (2017)	"(…) 'Mobility as a Service' (MaaS), where individuals' ownership of vehicles is increasingly replaced by "usership", that is the ability to purchase access rights to an interoperable package of mobility services (car, taxi, bus, rail, bike share) owned by others, usually corporate, providers."	Peer-Reviewed (T)
Li, Luo, & Hampshire (2017)	"Mobility-as-a-Service (MaaS) is a solution that integrates multiple modes of transport into seamless trip chains. (...) allows a shift from personally-owned vehicles towards easy mobility services by combining transportation services from public and private providers through a unified way."	Peer-Reviewed (T)

Y. Li & Voege (2017)	“The concept of MaaS is to use a single app to access and pay for various transport modes within a city or beyond; and the app will give options to allow a traveller to select the most suitable transport mode.”	Peer-Reviewed (T)
Mulley, Nelson, & Wright (2018)	“MaaS is variously defined but the essential idea is to see transport or mobility not as a physical asset to purchase (e.g. a car) but as a single service available on demand and incorporating all transport services from cars to buses to rail and on-demand services”	Peer-Reviewed (T)
Veerapanane, Taylor, & Kaparias (2018)	“At its core, MaaS combines transportation services from public and private providers through a unified gateway that handles individual door-to-door trips, managing all stages of their creation and implementation (planning, payment, real-time monitoring, etc.). “	Peer-Reviewed (T)
Sprei (2018)	“is a bundling of services such as public transportation, car sharing, bike sharing and taxis. The idea is to offer a subscription or pay-per-use service that will cover different types of mobility needs and create a seamless intermodal travel.”	Peer-Reviewed (U&SSc)
Rantasila (2015)	"The concept of MaaS is relatively simple: bundling different transport means, public and private, into easy-to-use service to end-customer. (…) The idea behind intelligent transport services like MaaS is to utilize possibilities of ICT and mobile devices for better user experience."	Conference Paper
Surakka, Haahtela, HÄrri, Mich, & Horila (2017)	"Mobility as a Service (MaaS) is an example of a systemic innovation, where sustainable mobility services addressing different customers’ transport needs are integrated with traveller information and ticketing/ payment services."	Conference Paper
Matyas & Kamargianni (2017)	"Mobility as a Service is a user-centric, intelligent mobility distribution model in which all mobility service providers’ offerings are aggregated by a sole mobility operator and supplied to users through a single digital platform."	Conference Paper
Eckardt, Aapaoja, & Sochor (2017)	"Mobility as a service (MaaS) is an emerging mobility concept that heavily relies on digitalization and an end-user oriented approach. The great vision in the MaaS concept is to connect all available transport and mobility services together in a one-stop-shop package and hence offer an agile sustainable and effective competitor to private cars, which can be tailored according to the needs of end users."	Conference Paper
Ebrahimi, Sharmeen, & Meurs (2018)	" (...) an innovative concept that has recently emerged to offer door-to-door mobility services. MaaS potentially enhances accessibility and efficiency of transport systems by identifying more deeply the supply and demand patterns. MaaS is believed to provide sustainable and user-centric services and to offer unique opportunities to bundle (latent) travel demand, to organize the smart use of existing systems and support orchestrated and/or self-organizing innovative travel services in which an interface automatically matches travelers’ demand and supply.”	Conference Paper
EPOMM (2017)	“Mobility as a Service (MaaS) is such a concept, combining services from public and private transport providers through a unified gateway that creates and manages the trip, which users can pay for with a single account.”	Institutional Position Paper
Polis Network (2017)	“‘Mobility-as a-Service' has been marketed as a new transport concept that may change or disrupt current models of transport provision, particularly in urban areas. The concept of MaaS claims to offer a personal mobility package based on lifestyle needs and delivered through an IT model."	Institutional Position Paper
Transport Systems Catapult (2016)	"The Transport Systems Catapult has defined MaaS as using a digital interface to source and manage the provision of a transport related service(s) which meets the mobility requirements of a customer. This definition seeks to encapsulate the vision of a MaaS Provider offering their customer, any type of travel experience using any type of transport service, public or private. (...) MaaS is a new concept that offers consumers access to a range of vehicle types and journey experiences."	Public-Private consultancy company
König et al. (2017)	“Multimodal and sustainable mobility services addressing customers' transport	"MaaSiFiE" -

	needs by integrating planning and payment on a one-stop-shop principle."	EU Project
MaaS Global (https://maas.global/)	"a way of combining options from different transport providers into a single mobile service, removing the hassle of planning and one-off payments"	MaaS Provider

Annex II – Howlett's (2011) Policy instruments taxonomy

	Purpose of tool	
Governing Resource	**Substantive**	**Procedural**
Authoritative implementation tools	**Visions and Strategies** • *Policy visions, strategic options and plans* **Direct government regulation** • *Laws* • *Independent regulatory commisions* **Indirect government regulation** • *Delegated professional regulation* • *Voluntary or incentive regulation* **Market creation and maintenance**	**Policy network activation and mobilization tools** • *Advisory Councils* • *Public consultation, stakeholder and consensus conferences*
Organizational implementation tools	**Direct government** • *Line departments* • *Central support agencies* • *Social and health insurance and pension plans* **Quasi-governmental organizational forms** • *Public enterprises and other corporate forms* • *Organizational hybrids (alternative service delivery)* • *Partnerships and contracting out*	**Network management tools** • *Staff or central (executive) agencies* • *Tribunals and other quasi-judicial bodies* • *Creating or reorganizing government agencies* • *Establishing analytical units* • *Establishing clientele units* • *Establishing gov. reviews, ad hoc task forces, commisions, enquiries and public hearings* • *Legislative and executive oversight agencies*
Financial implementation tools	**Cash-based financial tools** • *Grants, subsidies and user fees* **Tax- or royalty-based financial instruments** • *Tax- or royalty-based financial expenditures* • *Excise taxes* **Cash or Tax-equivalent financial tools** • *Preferencial Procurement* • *Favourable insurance and loan guarantees* • *Vouchers for public services* • *Sales and states assets at below price markets*	**Policy network creation tools** • Interest group creation ***Network mobilization tools*** • *interest group alterations/manipulation/co-optation*
Information implementation tools	**Information dissemination tools** • *Exhortation and moral suasion* • *Information campaigns* **Information and knowledge colection tools** • *Judicial inquiries and executive commisions* • *National statistical agencies* • *surveys and polling*	**Information release tools** • *Freedom of information legislation* **Information release prevention tools** • *Censorship* • *Official secret acts* • *Privacy acts*

Observation: in *"italyc"* are represented *examples of implementation tools*

Annexx III – Urban Mobility Policy Instruments (source: Macário, 2011)

Supply element	Use	Political instruments		
		Supply side	Regulatory	Economic
Land use		• Brownfield development • Mixed-use development • Public transport-oriented development • Pedestrian and cycling friendly site development • Decentralization of nonservice employment • Decentralization of retail	• Location policy (ABC-like) • Protection of sites from development (green belt) • Road corridors development control • Transfer of development rights • Building regulation, building permits • Density standards • Purchase, preemption rights	• Land taxation • Value capture • Development in-kind requirements • Public land banking • Developer fees • Development funding, disbursements
Infrastructure (transport networks)	Walking	• Creation of pedestrian areas	• Car-free zones	
	Cycling	• Expansion of existing bike lanes		
	Individual car use	• Expansion of existing road network • Road maintenance and clearing priority	• Restricted access at certain times	• Road pricing • On-street parking pricing
		• Traffic calming facilities • Access control devices • Designation of on-street parking supply • Regulation of off-street parking supply	• Restricted access to certain types of vehicles • Speed limits • Parking time constraints • Enforcement of parking measures • Parking regulations in building codes	• Off-street parking pricing
	• Car pooling	• Dedicated HOV lanes	• Company mobility plans	
	Taxi	• Dedicated lanes		
	Public buses	• Bus lanes	• Bus prioritization • Quality regulations • Information provision and marketing	• Public transport fare level
	Trams, light rail, and rail and metro lines	• Expansion of existing network	• Quality regulations • Information provision and marketing	• Public transport fare structure • Concessionary fares • Subsidies to operators • Infrastructure charges

Source: Adapted from TRANSPLUS guidelines (2003, p. 16).

Supply element	Use	Political instruments		
		Supply side	Regulatory	Economic
Infrastructure (transport terminals)	Bus stations Railway stations	• Expansion of park and ride lots		• Infrastructure charges • Space renting, multifunctional use • Exploitation of real estate value capture in catchment areas
	Metro stations	• Park and ride facilities • Bike and ride facilities		
	Freight terminals	• Building/expansion of terminals for city freight distribution		
Vehicle fleets	Private vehicles		Pollutant and noise emission standards	• Fuel taxes • Vehicle ownership taxes • Incentives for alternative fuels vehicles • Variable vehicle-related fees
	Public buses			• Fuel taxes • Incentives for alternative fuels vehicles
Information technology	Private transport	• ITS driver information		
	Public transport	• ITS driver information • ITS fleet management and control • ITS real-time passenger information system		

Annex IV- Mobility Stakeholders roles, responsibilities and obligations (source: König, Eckhardt, Aapaoja, Sochor, & Karlsson, 2016a)

Level	Stakeholder	Roles, responsibilities and obligations
National Road Authorities and Ministries	Ministry of transportation	Legislator, responsible for transport policy and strategies; enabler of test and pilots through legislation; financing infrastructure investments Implementation
	Transport Agency/ Road Administration	Implementation of transport policy, strategy and investments; (long-term) plans and guides for the national development of (new) transport services; (the owner of national transport infrastructure)
	Transport safety agency/ authority	Issues permits; regulations, approvals and decisions; prepares legal rules regarding the transport sector;
Local Authorities	Regional/local transport agency	Plans, organizes and manages public transport in the region and improves its operating conditions; provides locations of stations and

		stops
	The city and city planning department	Strategic urban and city planning; responsible for transportation and traffic planning; responsible for the local infrastructure
MaaS Operator	MaaS company, public transport operator, PPP etc.	Combines the existing transport services into a single mobile application on the “one-stop-shop” principle and provides personalised transport plans tailored to customer needs; responsible for customer service and user experience
Transport service Providers	Public Transport, Rail, Bike Sharing, Car Clubs, Ride Sharing, Taxi	Depending on the type of service it may range from: providing fares, real-time information, schedules, booking information, vehicle information, etc.
Logistics Service Provider	Logistics Operators, freight operators, 3rd party logistic, etc.	Provides management of the flow of goods and materials between points of origin to end-use destination. May handle shipping, inventory, warehousing, packaging, security functions and dispatching
Mobile service provider	3rd party technology, ICT and service providers	Provides key enabling technology and services (e.g., mobile ticketing and payment) to MaaS operator and transport service providers

Table 9 – Stakeholder’s Roles, responsibilities and obligations of the MaaS Business Ecosystem (adapted from (König et al., 2016a)

Annex V – interview transcription of Sampo Hietanen (CEO of MaaS Global – WHIM App) conducted by the Author on the 25th of September 2018

1. Renata Lajas: I think before, whim points were part of the mobility packages. Do they still exist, or you don't have them anymore?

Sampo Hietanen:: We have them (Whim Points) as a sort of technical possibility and the ideology is still in the background, but we stopped using them since people found them a bit too complicated.

They didn't really relate to them and since we also want to get more away from, let's say, production-based pricing into value based, and because the users didn't feel comfortable with them, we skip them for a while. To some extent we are planning on using them more as reward points.

2. Renata Lajas: How do you encourage the use of public transport if that's the case or not, or if you are planning to do it with that kind of gamification of the rewards points?

Sampo Hietanen: Yes, for the subscriptions that we are launching later on, which will get you there, which means that people pay for service level from a set rate for them and then we provide them with the option that is now available for this service level that they bought.

On that one we also have upgrades, but we also have, if you accept more public transport, then we can give you reward points that will end up in something beautiful afterwards, so we intend to use that.

Even without using money incentives we've been able to get people to go more the towards public transport than we expected.

3. Renata Lajas: Do you monitor the after/before behaviour f users when using WHIM?

Sampo Hietanen: We do monitor. We did one study of pre-after with the early subscribers, but now with a lot of users we haven't done a research of before-after. We are just launching a research with a consultancy where they go they will try to go after the before-after behaviour.

But even so I just looked at the percentage of trips made with public transport and it's all close to ninety percent, so I would say it's quite respectable already.

4. Renata Lajas: I also saw that some references to the wind car so what is it? And I wanted to know if it's going to be available or if it is available already?

Sampo Hietanen: The Whim car is available already. It is different forms of getting into your car when you need it, because it's extremely vital for the people skipping their cars that they ask: do I get a car when I need it?

So, we want to make it as easy as possible so that they feel comfortable in not owning a car, which means that there are different types of subscriptions. You can subscribe to five days of a car or seven days of a car; however you want it. We are giving the access not the ownership. It’s hard to get people to drop their cars without give them access to cars.

5. Renata Lajas: So somehow, it's an add-on to the mobility package?

Sampo Hietanen: Yes. It is an add-on to the “urban” package and for the unlimited version it is included.

6. Renata Lajas: If people don’t own a car, that will solve the question because they will use it, but for the long run there are still kilometres travelled in car? what is your position to that criticism? It can be seen as also not drifting away people from the car really but somehow from the ownership only. What do you think?

Sampo Hietanen: The way of trying to be really realistic in this and saying that: “no, since we have cars also available that it's not good”. We try to look at it from the end user perspective first, and only then when you have sold them the option that you can live without the car, you can try affecting them the other way. And trying to overlook at it from a system perspective and this is what we get now: people end up buying less cars.

Almost whatever the results are, trough us it probably ends up being better than people owning their cars. And so far, it seems that the results are actually quite good, in that people still end up using more public transport then they did before.

The idea of how we make money kind of ensures that we stay on the sustainable road, meaning that the only way for us to make money in this is that we become your mobility operator, we take care of all your rights and for us to give you a car or taxi every time is expensive (…).

How we make profits is that you feel confident and that you have the same value as you get with your car before they're willing to pay that much, and at the same time every time you walk or use public transport, those are cheap kilometres that we have to produce for you. So of course, it's in our interest to even incentive you and give you money if you walk.

This is what we're doing in UK: for example, we reward you pounds every day if you don't use a car or a taxi.

7. Renata Lajas: So, it's somehow a way to drive people for a more sustainable behaviour?

Sampo Hietanen: Yes, but if we don't have the cars available it's really hard to keep the prior price as high as people are willing to pay for their cars and this is really essential for us and the price point would stay high.

8. Renata Lajas: You are saying that you need to put the price in the cars high for people to understand that they can use a car but as it is also more expensive for you in the business to have those kilometres travelled in the car, you put it a little bit higher, that's correct?

Sampo Hietanen: No, in a way that the monthly price for subscription we want to have people think of the same number that they have in how much they're willing to spend for their cars. And let's say that people are willing to pay, let's say 500 euros for owning a car, we definitely want them to pay same for a whim. That gives us much more room to serve them with different things.

We know also that the number of kilometres travelled remains constant. So that means that we roughly have to provide you with about five hundred, two thousand kilometres a month which means that every kilometre is going to cost.

So, we did a review of all your trips for a month and the more of those kilometres you make with cheap moments the better it is for our profits. Meaning that walking, biking, using public transport is always on a positive side giving your car or taxi is then on the negative side. Because if you only use car or taxi probably we cannot get a high enough price from you so that you feel comfortable paying, but it's important the keep the price perception closer to the cars but produce it in a more sustainable way, that's how we make profits

9.Renata Lajas: I'm going to quote Li (2017) just to ask you If this statement is true. He says that: “MaaS Global, which is regarded as the first maas, does not make profits from resale of public transport tickets. Its profits may largely rely on business cooperation with car rental companies and taxi”. I found it intriguing.

Sampo Hietanen: That’s not true. Just because this person cannot understand how we make money does not mean that he's right by imagining that themselves. The thing is, like I explained it, to be your operator, to you give you unlimited travel and make sure that you travel smartly, that's how we do it.

The problem with many years is that they think that the only way of making business in the digital world is to live on Commission's. This is not the case.

It's the same as if the car industry would sell you a Mercedes and they wouldn't sell your Mercedes but they would give you a big list off: here's your windshield, here's your transmission and here's your gearbox and we just make a make a margin, we just make a commission out of all of this. No. They find the pieces and make that into packages and they sell your Mercedes, that's the difference.

We're not just living off the Commission's. The whole concept idea is that we sell a different thing than what we buy it we sell you a service promise, a value based offering, and we buy in the production based offering that the transportation service providers are now giving out, that's what they do.

So, instead of selling a ticket, or kilometre or an hour we sell you a monthly package.

10.Renata Lajas: Then if the user, travels most of the time in public transport and only sometimes by car or taxi, and as most of those kilometres, as you said, are cheaper (the ones associated with more sustainable modes), the better because it's somehow a surplus that stays on the company, right?

Sampo Hietanen: Exactly. To make sure that: okay, you're willing to pay 500 euros of this and that the production cost of delivering you unlimited travel is less, that's simple as it is. Changing the business model that way.

11.Renata Lajas: That's very interesting, because there are a lot of quotes in the literature, especially in the business model part that are not really correct, that's what I saw now. I was a little bit intrigued about that aspect and I think generally people are as well.

Sampo Hietanen: Honestly, and in that sense is a vital notion, if we were to put in a corner where only packages that we would be able to sell would be pay-as-you-go, then that would put us in a market where, of course, we would try to put people for the more valuable parts of the offering that give us better margins, which would be the car.

But this is still quite, let's say, it’s a low profit market even for that. So, we're not aiming to have just Pay-as-you-go.

12. Renata Lajas: For instance, in terms of subsidy on public transport, if it is consumed through your system the public transport the subsidies work the same way, correct?

Sampo Hietanen: Yes, the subsidies in public transport are not meant for public transport companies, they’re meant for the end-users and whether the trip price comes through us or someone else shouldn't make a difference. So in a way we were just, I would say, if we put our infrastructure with the public transport we are a digital reseller. If a person gets a subsidized ticket from this quiosk why shouldn’t they get from our quiosk as well.

13. Renata Lajas: I think maybe the extended question would be: normally the subsidies are for public transports, whatever the mean that they are bought. But there is somehow a question being raised that asks for a rethinking on transport subsidies.

Could the subsidies also be enlarged for other modes of transport that feed the public transport network? That is not already generally available, I believe.

Sampo Hietanen: That’s a good question, actually. Should any type of sustainable mode be subsidized and how that can happen. It's an intriguing question that I think that once this MaaS concept gets further and more and more people use a mobility operator like us, it gives more options for the cities and governments to play with incentives to make sure that the sustainability goals are met.

I am saying that the providers of MaaS services should be private players but it should be really well looked that at it is regulated in a way that it also meets the sustainability goals of the city. So, how the market looks like should not be owned by us, that should be owned cities and governments.

They should really be the puppeteers and where the puppets. Then at the same time, make sure that the markets are such that you know we can compete. So, it needs to be an open competitive market and at the same time made in a way that it starts fulfilling the sustainability goals of the cities, which is quite doable. You can do that, as long as you set the market regulation in a correct way.

14. Renata Lajas: Taken into consideration sustainable mobility policy goals of cities, how would a city and an operator met this kind of goals - if it would be enforced by regulation for instance or by special subsidies?

Sampo Hietanen: There's quite a lot of things that you can do. I would say that this new concept give much more opportunities for cities, because, let's be honest the cities and the governments have been losing everyone has the transport policy of more sustainable modes, more public transport, more walking and biking and still the car keeps on being the winner in all of this

Now, if we find other solutions there are new methods, and public transport has been to reflect on the hand of the cities to provide and now there are more options for playing. Not just being one of the producers, meaning public transport, but you can start being much more active on how do you set up the market regulation, how do you do tax incentives for those who are more sustainable, how the pricing of public transport work so that there's the different operators you know fulfil the goals of sustainability, etc.

I would say that there's new tools to be played with, but it doesn't say that MaaS on its own would somehow become good for the city.

In any disruption there are scenarios where it doesn't look good. And sort of the fear I have with the cities is that we would have more of the “American model”, where the MaaS operator is: everything combined other than public transport. That would really be a shock for the whole public transport, so that everything starts to be creating towards the private car instead of integrating the words public transport. There are scenarios that are not nice like these.

15. Renata Lajas: So, in your opinion for sure the public transport needs to be inside MaaS?

Sampo Hietanen: Definitely. Because otherwise we will have every new innovation against public transport. And this is not how the public transport ends up winning or they will end up being in a better position where they can be the soul and backbone of all of this. That everybody feeds in to, and sort of be the platform for all new mobility innovations. But they have to understand the role of not being at the top of everything but the enabler of everything. That's a big change.

16. Renata Lajas: For instance, in Finland I saw also the chronology of the process of the emergence of MaaS and in the policy part and the laws that were made and so on. I have one timeline that I produced, and I saw and noticed that you found very important the “Act on transport services”. It was somehow a game changer (the “Transport Revolution” first and then the “Act on transport services” – the regulation). It was somehow a cornerstone for the MaaS emergence. Do you think those were the most relevant, or do you think there's another major milestone in the process? What is your opinion?

Sampo Hietanen: Well, I think those were, from the public side the ones that enabled quite a lot. Maybe the Helsinki City Policy, in 2013 or 2014 that they made, is also important.

17. Renata Lajas: Do you mean the Heikkilä MsC thesis done in 2014, with the support of the City of Helsinki?

Sampo Hietanen: That was sort of a help for the strategy – the MsC thsesis was an important piece, it was part of it, but the strategy started before the Master Thesis: the initial ignition and the principles were already formulated.

18. Renata Lajas: In your opinion what are the main barriers or challenges today for MaaS?

Sampo Hietanen: The main barrier is lack of common market vision, common market goals, both on the public and private side. There's a lot of debate on how we do it, and this is blocking any movement that people are trying to go.

In a way that there seems to be some people, some players are going out to play football the others want to do some other thing and that then nothing happens, there is no game happening.

I suppose that lack of market vision and now this comes to the point that the market vision should not be set by us, it should be set by political leadership.

The vision should be from the cities and governments than it is easier for the companies to deploy.

19. Renata Lajas: But do you think it's just a matter of strategy and vision or do you think it's also a matter of regulation to say who does what in the market?

Sampo Hietanen: No, I would say that there's no necessary regulation. Regulation can be used, but this can happen without regulation. If the if the government sets out a clear vision of how they want the markets to be played out, then the companies will follow that even without the regulation. There's no regulation that is banning us from working on this way, so stating a clear vision of the market would now be more beneficial and faster, I would say, than actual regulation.

20. Renata Lajas: Ok, you can do it also with the incentive taxing, as you said, and other policy instruments.

Sampo Hietanen: Even just by stating that this is the market we want if it doesn't happen on someway then we will regulate, and I think that's enough.

In a way if they just do a couple of things, if the city's government say that we want our citizens to have MaaS providers and from those MaaS providers they should have access to everything from one-stop shop that's one thing.

And the second thing is, which is just as important, is that we want our citizens to have a choice of an operator, so it's not just going to be WHIM there will be others. That you get to choose who you will get the access from. And then certainly we want our people to have roaming subscription, so that they work in the whole area but even abroad.

If you just state these three things there's the rest should follow. It means you want to know open market competitive approach, you want competitiveness you're not going to be the provider yourself and so on. So many things follow from that.

21. Renata Lajas: Are flights included somewhere in the future?

Sampo Hietanen: Of course, for the higher subscriptions the flights will be there, and the reason is because people can dream it and if they can dream, than someone will produce it as well, definitely.

22. Renata Lajas: So, it's interesting for you to reach somewhere in the future the flights as well?

Sampo Hietanen: Of course, if you want to pick a dream than the car, what's a bigger dream the having: open highways is open world? And that is what we are already discussing with the companies.

23. Renata Lajas: And what about blockchain is it expected as well?

Sampo Hietanen: Probably at some point, but not so completely relevant at this stage.

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