Public Policy Framework supporting "Mobility-as-a-Service" implementation

Renata A. Lajas Custódio
University of Lisbon – Instituto Superior Técnico / Civil Engineering and Architecture Department, Lisbon, Portugal
Email: renatalajas@gmail.com

***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 "Mobility as a Service (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 paper is divided in six sections: the first and second focus on main goals, context and methodology. The third one covers the theoretical framework in the areas of "MaaS", "Public Policy" and "Urban Mobility levels of decision". The "MaaS System" in Finland was considered as an inspirational case-study for the proposal development, which corresponds to the fourth section. The fifth section covers the proposal of "MaaS Topology" and "Public Policy framework" and the conclusions represent the sixth section.

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 pretends 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**

I. MAIN GOALS AND CONTEXT

With the continuous growth of the world population and rising urbanization, urban sprawl is taking up the scene of human settlements and several challenges arise consequently inside the urban mobility system. Increasing levels of congestion and its related cost, in economic, social and environmental dimensions, affect greatly the quality of life.

At the same time, in a hyper-connected world, the Digitalization megatrend is reshaping lives worldwide. Accelerated advancements of ICT, that already changed Industrial processes and led us to Industry 4.0, are democratizing data, which is seen as the new "oil" of the XXI century. Enabled by digitalization, consumption attitudes are also shifting from "Ownership" to "Usership" and within this environment, also based on the existent diversity of transport services, "MaaS" emerges as a potential mobility disruption.

As with all "buzzwords" that baptize innovations or potential disruptions, some degree of confusion may arise when determining what a concept entails, which is the case of "MaaS". Paraphrasing an adage that reminds that "if a concept is everything, it is nothing"(cited in Klijn, 2008), it is of extreme importance to structure this new concept.

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 for its implementation, by each urban mobility management decision level and "MaaS" feature.

This paper is divided in six sections. The first two, respectively, contextualize the problem and refer the methodology used to fully answer the research question. The third section highlights the theoretical framework that was focused on three parts: i) the universe of "MaaS" questions; ii) Public policy and Policy Process theory and iii) Urban Management decision levels and Stakeholders. In the fourth section it was analysed the emergence of the "MaaS System" in Finland which was considered as an inspirational case-study for the proposal development, which corresponds to the fifth section. Finally, the conclusions are stated in the sixth section.

II. 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 121 documents, "MAXQDA" software (developed by "Verbi") was used, that facilitated its content analysis and was determinant to process around 5000 pages of information.

The emergence 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, three semi-structured interviews with Finnish stakeholders were conducted between August and September 2018 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 identification.

III. THEORETICAL FRAMEWORK

III.1. The Universe of MaaS questions – literature review

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 search of relevant publications was made using solely the expression "Mobility as a Service" in three search engines: Google Scholar, Scopus database and ISI Web of Science database in February and March of 2018. The results from all these databases reached 172 publications, that after a careful relevance analysis was downsized to 121 and, apart from peer-reviewed articles (37) and conference papers (45), it comprised also institution position papers and reports (25); Working Papers (3); Ms.C. and Ph.D. Thesis (11). There has been a continuous increment in the production literature through the last four years (2014-2018), especially on what concerns conference papers. It was found that with such low numbers of published articles, no journal can be recognized as being influential on what concerns MaaS-related studies. Almost hundred authors already wrote already 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, and in Figure 1, is shown the most common keywords from the selected scientific articles.

Several definitions of "MaaS" were then found in the literature review, and it is possible to group them in three approaches: 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).

Figure 1 - Keyword's Wordcloud of the thirty-seven peer-reviewed scientific articles *(source: Author*, https://www.jasondavies.com/wordcloud/)

Particularly, stemming out from this analysis the main characteristics considered are:

- The existence Transport Services diversity (existence of 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;
- 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".

A definition of "MaaS" will be established in this work after the restructuring of the concept in the proposal section (V).

III.2. Public Policy, Policy Process and Policy Instruments

"Public Policy", 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. This definition evolved, and Lasswell (1958) adds that on top of government decisions, it can be considered as a composition of two interrelated elements: *policy goals* and *policy means* (cited *in* Howlett, 2011)

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 "Strategic" level, the "Why?" - to the first level of operationalization – the

"Tactic" 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).

Understanding **policy making as a process**, entails a set of inter-related 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), where the "policy cycle" has its roots in *"systems theory and the pioneering work by David Easton on political systems (Easton 1965, 1966)"*. From the five policy process stages defined by Howlett (2011), this work will focus on the first two and the fourth: 1) Agenda-Setting; 2) Policy Formulation; 3) Decision-Making; 4) Policy Implementation; 5) Policy Evaluation.

Special attention is given to the relation of policy formulation and implementation through the definition of "**policy means or instruments**" and their importance in the enactment of polices, since they 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"* (Howlett, 2011).

Answering the question "What to choose from" concerning the choice of policy instruments does not have a straightforward answer. As it is revealed by Rist, Vedung, & Bemelmans-Videc (1998) there is a wide variety of classifications types of policy instruments, recognize that *"nowhere in the international literature (...) is to be found a uniform, generally embraced classification of policy instruments".* Several taxonomies were examined (Doern,1981 cited in Howlett & Ramesh, 1993; Rist, Vedung, & Bemelmans-Videc, 1998; Howlett, 2011; Macário, 2011), and the one chosen to support the proposal of Public Policy Framework was based in Howlett (2011).

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) 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 2). The author states 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"*

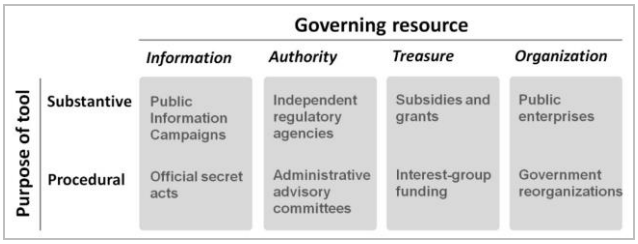

Figure 2 - Taxonomy of substantive and procedural implementation tools according to governing resource (source: Author, adapted from Howlett, 2011)

III.3 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).

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, leading to a consistent 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 dependency, 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 is a need to *"ensure clear distinction between the three levels of planning and control (strategic, tactical, 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, 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).

The three levels of planning and control, or decision levels adapted to this work, are defined as follows:

- **Strategic** - the level that corresponds to policy formulation phase, where the rationale behind the policy is established answering **the "Why" question;**
- **Tactic** - 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** – this level relates to "evaluation and monitoring", where it is decided specifically **"What"** to do in order to ensure the compliance with the strategical goals (Why) and the correlated and enabling policy means (How) that frame activities for final consumption of users.

In what concerns Stakeholders, which can be described as *"any group or individual who can affect or is affected by the achievement of the organization's objectives"*(Freeman, 1984), their responsibilities when acting in mobility systems are also dependent on the Political and administration organization context of a country as well as its whole ecosystem of agents.

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.

A high-level approach to stakeholder identification was conducted recurring to literature review, being the final categories inspired in the work of Macário (2011), and represented by the following group of Stakeholders: i) Politcal authorities; ii) Regulating authorities; iii) Technical authorities and agencies; iv) Operators; v)Suppliers; vi) Clients; vii) Other interest parties (e.g. NGO; Academia).

IV. MAAS IMPLEMENTATION CASE-STUDY: FINLAND

In this section the focus will be the characterization of the "inspiration" case study considering the chronology of the determinant moments of the "MaaS" implementation process in Finland.

The mission of the Finish Ministry of Transports and Communications (LVM) is to *"ensure that people have access to well-functioning, safe and reasonably priced transport and communications networks",* as so almost 10 years have passed since **1st Intelligent Transport Strategy** was launched in Finland and considered *"the world's first national ITS strategy covering all modes of transport"* (Ministry of Transport and Communications, 2009). This strategy paved the way for the beginning of this process since that with the proposed "**administration reform"** (performed in 2010) 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".*

The background for the implementation of a renewed transport policy in Finland was in place with this administration reform and at the same time, during 2010 began what is called the **"Transport Revolution programme"**, that aimed at "*developing a new mind-set for urban and transport planning and policies and policy implementation"* (Tuominen & Kanner, 2011).

The **second Intelligent Transport Strategy** is published in 2013, and 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", 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).

In 2014, there was already a strong support for sustainable and intelligent transport at the ministry level although business participation was still absent. Therefore, in the beginning of 2015, **LVM** in cooperation with **Tekes'** MaaS team, jointly launched a funding call, to fund 'pre-study' projects and consortium projects Mobility Operators, for Mobility Operators and other organisations such as current transport and technology providers who wanted to make their services compatible with the MaaS system. 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 (one of them was WHIM app).

The last policy milestone is the approval (**2017**) and enactment (2018) of **the "Act on Transport Services"** (nr. 320/2017, first called the "Transport Code"). This Act *"brings together legislation on transport markets and creates conditions for digitalisation and new business models in transport"*[1] where the key objective is the provision of customer-oriented transport services; *"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".* 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.

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[1] 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".*

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 (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

[1] https://valtioneuvosto.fi/en/artikkeli/-/asset_publisher/vuodenvaihteen-muutokset-lvm-n-hallinnonalal-1 *(accessed: 21.08.2018)*

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"*.

V. PROPOSAL TO STRUCTURE A MAAS PUBLIC POLICY FRAMEWORK

V.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 proposal relied on a "Topology" approach, considered as the mathematician term - the "study of space", instead of taxonomy or typology, since the rationale behind is not the categorization but the study of intensities and presence of core features, that determine the capabilities, maturity and configuration of a "MaaS" system.

V.1.1 General and Specific Analysis

The design of a general "MaaS User Journey", revealed to be a basis for the 'Topology' proposal (Figure 3).

Through the analysis of the User Journey scheme, it was possible to unveil the three pillars of a "MaaS system" (specific features): 1) the existence of choice related with the "**diversity of transport services"**; 2) "**Information" -** that allows the user to choose the mobility option most suitable to their needs; and **3) "Payment"** – the acquisition possibility.

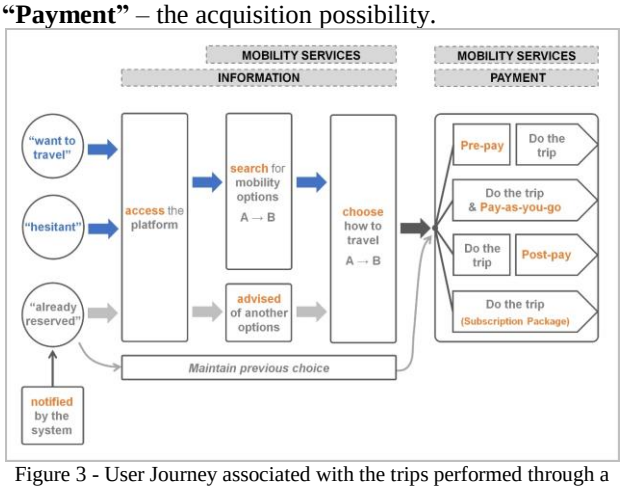

Figure 3 - User Journey associated with the trips performed through a "MaaS" system (source: Author)

During this analysis, two kinds of features were found: "General" and "Specific" Features. 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).

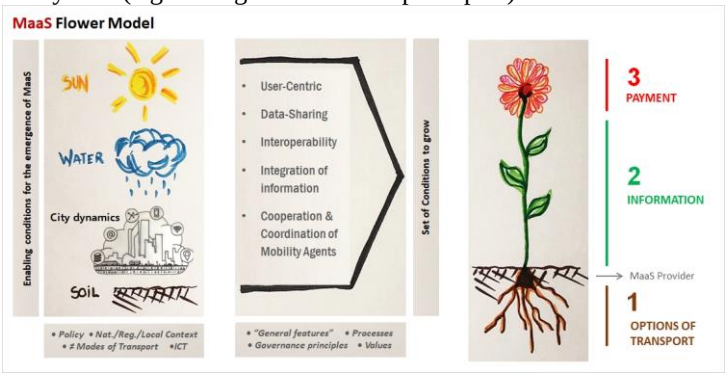

Figure 4 - "MaaS Flower Model" (Source: Author)

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". Different enabling conditions 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".

The different levels associated to the first "MaaS" pillar – **"Diversity of Transport Services"** – were defined following a rationale based on 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. Consequently, 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 levels of the second "MaaS" pillar – **"Information"** – "the enabler of choice", were based on the type of available data associated to each journey planner, since the journey planner is considered the interface of information and defines the capabilities and maturity of a "MaaS System". The Data considered was categorized as follows: i) Static (Sochor, Arby, & Karlsson, 2017); ii) Real-time (Gebhardt et al., 2016; Docherty et al., 2017); iii)Archived or Historical data (Giesecke, Surakka, & Hakonen, 2016); iv) Processed or analysed data (e.g. relying on data analysis and "big data analytics") (Sarasini et al., 2017; Ebrahimi, Sharmeen, & Meurs, 2018); v) Predictive data (e.g. equal to (iv) but with a focus on future events recurring to modelling techniques) (Belletti & Bayen, 2017); and vi) Crowd-sensed data (e.g. data produced and disseminated by the user or the crowd) (Heiskala, Jokinen, & Tinnilä, 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. In Figure 5, it is possible to see that the difference between each level corresponds to an increase in the type of data available.

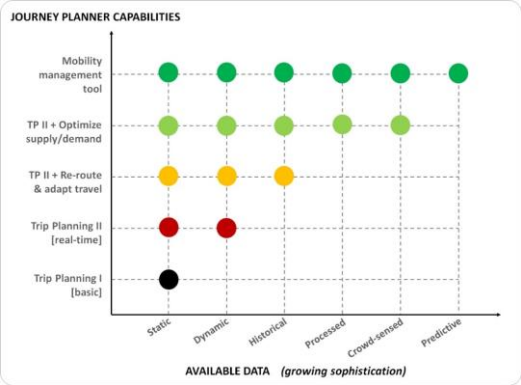

Figure 5 - Availability of data and corresponding "Journey planner capabilities" (Source: Author)

The levels associated to the third "MaaS" pillar – **"Payment"** – the "enabler of use" through the possibility to access different mobility services through a single payment, are categorized according to its increase flexibilization and tailor-made subscriptions, besides allowing a Pay-as-you-go function. Other aspect also considered is if there is a possibility of electronic access to the system (through e-ticket for instance).

V.1.2 "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 - 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 trade-off procedures

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

where: $V(a)$ is the overall value of option a; v_j is the (partial) value of option a on criterion j and 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)

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

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 (Table 1) match the levels respectively identified.

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

Table 1 - "MaaS Topology model" Criteria and respective descriptors of performance (source: Author)

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 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).

Based on indifference judgements that represent strengths of preference, and supported by the rational presented before (level proposal for each "MaaS" pillar), the results are represented in Figure 6, and 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 that the level C1.3 entails when there is a mixture of "Non-Self-Service" and "Self-Service" transport services.
- **"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).

- **"C3 - Payment"** - the importance of the existence of mobility packages, even in its simplest form in detriment of the possibility of having an electronic access to the system. Therefore, the indifference level from worst to best is represented in C3.3 (50 points). Considering 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).

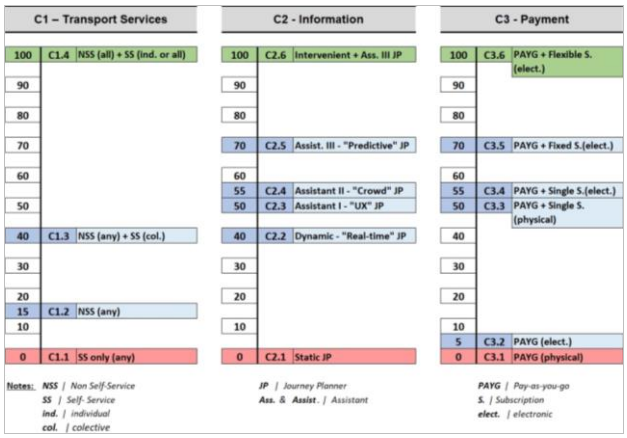

Figure 6 - Value Functions of the criteria: " C1 – Transport Services"; "C2 – Information" and "C3 – Payment" (source: Author)

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 first step of the trade-off procedure 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".

Considering "C1-Transport Services", 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".**

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.

The resultant system of equations is the one that is represented in Equation 2.

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

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)

V.1.3 "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".

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). Taken into consideration their performance scores in the criteria of the "MaaS topology model", the overall score (overall value level) can be observed in Figure 7.

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.)

Figure 7 - 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 8.

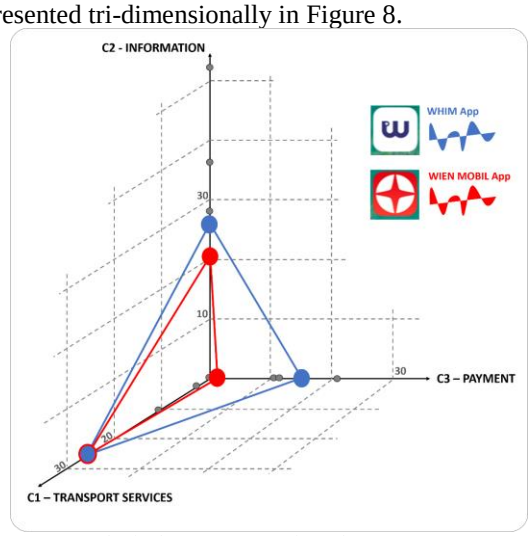

Figure 8 - Topological 3D representation of MaaS Systems: "WHIM" and "WIEN MOBIL" Apps (Source: Author)

V.2 Public Policy Framework proposal for "MaaS" implementation

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 pretends to wield" (Rosário Macário and Renata Lajas, October 2018)*

In this section 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.

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", "Tactic" and/or "Operational" decisions with the enabling of each one of the features identified. The result is presented in Table 2 - Decision Levels associated to each General and Specific MaaS Features (Source: Author).

The second step to build the Public Policy Framework, would be to consider independently the decision-making levels (only strategic and Tactic), 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. 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 3).

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.

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 highly dependent on the mobility context and specific agreements. The main question here is if the system is "Private-led" or "Public-led", since the latter encompasses a great involvement in the all the decision levels.

In what concerns the "Information" Pillar, the most important would be the first two levels (**C2.1** and **C2.2**) characterized by the existence of "Static" and "Real-Time" information.

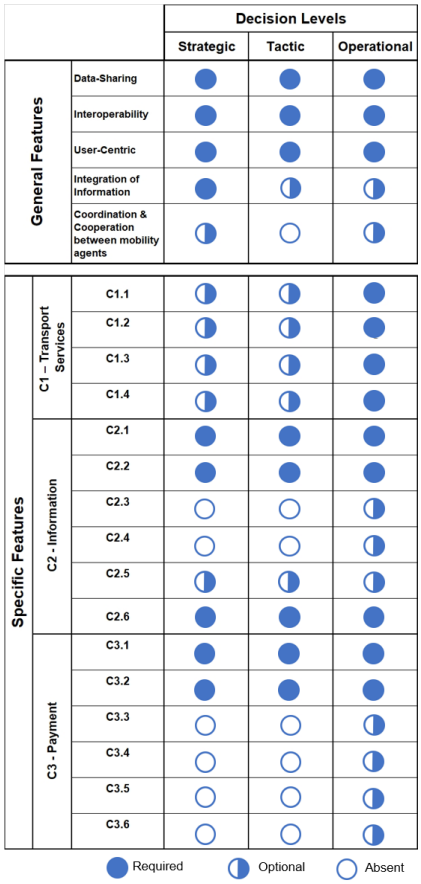

Table 2 - Decision Levels associated to each General and Specific MaaS Features (Source: Author)

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. 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, all the decision levels should be in place.

For the last pillar of a "MaaS System", **"Payment"** (Criterion C3), it is fundamental for all levels that besides "Data-Sharing" and "Interoperability", that 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. 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.

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 are not specific but instead indicative groups of stakeholders were identified in Table 3.

VI. Conclusions

The proposal of a Public Policy Framework encompassed a two-stage approach. The first stage consisted in the structuring of the concept of "MaaS", focused primarily on the identification of its "building blocks". This stage can be considered as 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 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.

Secondly, 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.

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 financial aspect is also 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 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).

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).

	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) (phy sical 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
S ● T ●	• 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 3 - Indicative Policy Instruments by MaaS feature, according to governing resource and purpose of tool (Source: Author, inspired on Howlett's (2011) Policy Instruments Taxonomy)

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Renata A. Lajas Custódio (Lisboa, 19-02-1982). Urban Engineer, University of Lisbon – Instituto Superior Técnico, Lisboa – Portugal (2005); Post-Graduation in Urban and Land Management, University of Lisbon – Instituto Superior Técnico, Lisboa – Portugal (2007).

Currently works in the Municipality of Lisbon as a POLICY ADVISER in the areas of Housing and Local development since 2013, and between 2009 and 2013 she worked as POLICY ADVISER in the Mobility Deputy Mayors Office.

She worked as FELLOW RESEARCHER at CESUR Investigation Center (Centre of Urban and Regional Systems from University of Lisbon) from 2006 – 2009. She worked also as an ADVISOR to the Secretary-General of IFHP (International Federation for Housing and Planning) in the Netherlands and CONSULTANT for the Department of Spatial Planning of the Municipality of Amsterdam (2007). Main publications:"Understnding Citizen's engagement and practices on sustainable mobility and energy efficiency in the deployment of Smart cities infrastructures"(Conference Proceedings "Energy for sustainability International Conference – Designing cities and communities for the future", 2017); "Low Emission Zones: Lisbon's Experience" (Journal of Traffic and Logistics Engineering, Vol.2 No.2, pp.133-139, 2014);"30 km zones – Road safety, life and vitality for Lisbon Neighborhoods" (Lisboa, Portugal: ed. Centro Rodoviário Português / Portuguese Road Center, 2013); "Portuguese National Sustainable Mobility Project – Conception Design, Main findings and Recommendations – Vol.I & Manual of good practices for sustainable mobility – Vol.II" (Lisboa, Portugal: ed. APA – Agência Portuguesa de Ambiente / Portuguese Environmental Agency, 2010); "The EXPO area and the pursuit of sustainability" (Porto, Portugal: ed. Paulo Pinho & Vitor Oliveira, 2009). Sustainable Mobility, Road Safety, Urban&Transport Planning and Management are her research interests.

Eng. Lajas Custódio is member of the Portuguese National Professional Association of Engineers since 2006, with the nr.56683.