Rethinking Technology-Based Services to Promote Citizen Participation in Urban Mobility

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ABSTRACT
Cities are complex and dynamic systems in which a network of actors interact, creating value through different activities. Cities can, therefore, be viewed as service ecosystems. Municipalities take advantage of digitalization to implement a service-dominant logic in urban and mobility planning and management, developing strategies with which citizens, local authorities, and other actors can create value together. While citizens are offered a better service experience, local authorities use citizens’ input to improve decision-making processes. This research considers that designing an integrated service supported by an integrated information system can respond to current challenges in decision-making and information access for transport and mobility. Through a multidisciplinary methodological approach, this work proposes some guidelines to design an integrated information system to improve citizens’ participation in urban planning and mobility services.

KEYWORDS
Co-Creation, Decision-Making, Information Systems, Participation, Urban Mobility, Service Design, Service-Dominant Logic

INTRODUCTION
For several years, cities have been implementing smart solutions to improve many of their services. Transportation is especially relevant due to its essential role in citizens’ daily lives and its significant environmental impacts. Although other sectors are steadily decreasing emission levels, that is not the case of the transport sector (European Union, 2017).

The premise for this work is that improving the way citizens interact with local authorities will improve both the decisions made by planners in designing better urban and mobility plans, and it will improve citizens’ behavior towards the transportation systems. This will impact the harmful effects of transportation systems on the sustainability of cities.
The link between sustainability and technology is visible in the evolution of the concepts of *smart cities* and *sustainable cities*. Some authors currently adopt the term *smart sustainable city* since it reflects both the technological and the sustainability perspectives (Ahvenniemi et al., 2017). In this context, some technological solutions are naturally linked to the current high levels of digitalization, and terms such as *digital city* and *information city* were common before the universal adoption of the term *smart city* (De Jong et al., 2015). Considering that cities are dynamic complex systems, other authors also apply a service-dominant (S-D) logic to the study of urban systems. This leads to an evolution of the *smart city* concept to *smart cities as a service system* (SCSS) (D’aniello et al., 2020; Polese et al., 2019).

The increasing level of digitalization and usage of information and communication technologies (ICT), along with a rising awareness of the climate changes, have been changing the way people use transports, also impacting urban mobility solutions and business models. This period of organizational and institutional changes, implemented alongside technological developments, is considered not only a socio-demographic transition but a socio-technical transition (Spickermann et al., 2014). Following the same trend of technological-based businesses, the service design science has strongly embraced information technologies, allowing for new services to adapt to the digital world (Grenha Teixeira et al., 2017; Lusch & Nambisan, 2015; Patrício et al., 2011). This is accomplished by designing multi-channel services, including digital channels (Patrício et al., 2008).

In a service exchange, value is co-created through physical or virtual interactions between networks of suppliers and customers (Frow et al., 2014; Patrício et al., 2018). According to the service-dominant (S-D) logic, value is co-created with customers, as they assume an active, connected and informed role in the value creation process (Vargo & Lusch, 2008).

Considering the three elements of the framework presented by Lusch & Nambisan (2015) – service ecosystems, service platforms, and value co-creation – this work adopts an S-D logic to design an integrated approach to urban and mobility challenges. This perspective is justified as it is assumed that citizens’ well-being must be central in planning activities. Therefore, citizens should be involved in the design of new solutions by sharing information and ideas. In line with the idea of a *smart city service system*, this paper presents research in mobility services, going beyond the traditional one-to-one interaction of local authorities and citizens, including interactions between citizens with different profiles. From the citizens’ perspective, these interactions can simplify the process of obtaining information. From the point of view of service providers, these interactions can improve their service level, as more customers are fulfilling their needs. Such an approach also contributes to research in the area of service design, since it considers that customers can create value not only with the service provider but with other customers, becoming, therefore, service providers themselves.

Improving citizens’ involvement is also a requirement of Sustainable Urban Mobility Plans (SUMP) (Rupprecht, 2019), with stakeholders’ participation being viewed as a precondition for sustainable mobility (Lindenau & Böhler-Baedecker, 2014). The importance of involving stakeholders in the design of smart sustainable cities is twofold: (1) it improves public participation in policy design processes; and (2) it enhances knowledge co-creation by promoting information sharing and transparency (Deligiannidou & Amaxilatis, 2016). Since solutions for smart sustainable cities are supported by technological tools, the involvement of stakeholders should also be included in the design of those tools, as a way to assure their success.

The basis for this work was set in previous papers where a conceptual framework for an integrated information system (Duarte et al., 2019) and the application of an S-D logic approach in this context (Duarte et al., 2020) were presented. The framework highlights the importance of understating the decision processes of the different stakeholders and improving how stakeholders access the information that feeds those decisions. Some lessons were learned from different existing methods, leading to the methodological approach presented here, resulting in a set of guidelines that can be used to develop an integrated information system in an urban mobility environment.
This paper focuses on applying an S-D logic to promote participation and collaboration among urban stakeholders, thus increasing value co-creation for both citizens and local authorities. Citizens will have easier access to better information, which will lead to better decisions, thus improving their behavior towards urban mobility (e.g., compliance with regulations). Local authorities will have easier access to information required to design urban and mobility policies, thus improving their decision-making processes. Although many efforts have been made to improve citizens’ engagement in this context, to the best of our knowledge, S-D logic has not yet been applied. Therefore, this multidisciplinary approach, encompassing Service Design and Information Systems Architectures, will expectedly add significant value to the existing literature in urban mobility.

The paper is organized as follows: the next section presents some theoretical background from the methods considered in designing the methodological approach; then, the methodology and its application to a small case study in Porto’s metropolitan area, in Portugal, are described. The paper ends with some conclusions and considerations for future work.

**BACKGROUND**

The broader topic of this research might be viewed as *smart sustainable cities*. This idea reflects the adoption of technological solutions to improve citizens’ quality of life under economic and environmental sustainability (De Jong et al., 2015). But the concept that better reflects the proposed approach is *city as a service system* (Polese et al., 2019), whose mindset helps to implement an S-D logic in the context of urban mobility. The emphasis given, in this work, to Service Science is justified by the fact that service design approaches have the potential to reshape mental models, as they promote the understanding of how actors’ perceptions and actions change existing institutional arrangements, which are critical to the way value is co-created (Vink et al., 2019).

The specific research topics of this work cover different areas. At an intermediate level, the addressed issues are urban planning, transportation systems, and urban mobility. At a lower level, the four dimensions considered in the methodology (social, urban, technological, and decision-making) are associated with: service design; information systems and enterprise architecture frameworks; and participation in decision-making processes.

Social and urban dimensions are addressed by integrating multiple groups of stakeholders. This integration is achieved by adopting service design methods that consider the context in which a service is provided and the network of participants. Since the urban context is considered here as a service system, and urban stakeholders interact in the society, these two dimensions are covered by service design approaches.

Moreover, multicriteria decision analysis (MCDA), more specifically multicriteria group decision-making, helps understand how stakeholders can participate in decision-making processes, thus handling the social dimension as well.

The technological dimension is covered by the analysis of existing methods and tools for communication. This involves topics such as Information Systems (IS) and Enterprise Architecture Frameworks (EAF).

Based on a multidisciplinary literature review of these topics (service design, information systems and enterprise architecture frameworks, and participation in decision-making processes), the next sections briefly describe the main characteristics of the methods used during this work.

**Service Design Methods**

Service design methods emerge from the service science research, an interdisciplin ary scientific discipline that brings together engineering and management concepts, with many ideas being adapted from marketing, IS, and process-oriented management (Furrer et al., 2016; Grenha Teixeira et al., 2017; Ordanini & Parasuraman, 2011). Concepts such as service innovation, service design,
and service-dominant logic have emerged throughout the years, laying the foundations for service research (Lusch & Nambisan, 2015; Patrício et al., 2011; Vargo & Lusch, 2008). Service design is usually considered a stage of the design of new services, but it became a methodological approach to innovation (Grenha Teixeira et al., 2017). Hence, service science can be considered the umbrella of the research of services, where service design methods are used to achieve service innovation by applying a service-dominant logic.

As the concepts mature, so do the frameworks that relate those new concepts (Lusch & Nambisan, 2015; Vargo & Lusch, 2008) and the service design methods. These methods have, in fact, evolved, integrating models and artifacts used in marketing, operations management, decision-making, and IS (Grenha Teixeira et al., 2012, 2017; Patrício et al., 2008).

The method known as Service Design for Value Networks (SD4VN) (Patrício et al., 2018) is built considering the current understanding of the complexity of service systems and the importance of value co-creation at the network level (Lusch & Nambisan, 2015). SD4VN was presented as a method to address the challenge of services design at the network level, taking into account value co-creation in an actor-network with many-to-many interactions. It can be seen as an extension of Multilevel Service Design (MSD) (Patrício et al., 2011) that integrates other research topics such as Customer Experience Modelling (CEM) (Grenha Teixeira et al., 2012).

MSD approaches service design from a strategic perspective (service concept) and drills down to an operational perspective (service encounter). This is the same approach found in SD4VN. The main differences rely on the fact that, at the strategic level, SD4VN analyses the customer’s experience before designing the service concept by integrating CEM. Since it focuses on the network level with many-to-many interactions, it studies the actors involved in providing the service rather than considering only one service provider and one customer (Grenha Teixeira et al., 2012; Patrício et al., 2011, 2018).

**INFORMATION SYSTEMS AND ENTERPRISE ARCHITECTURE FRAMEWORKS**

Enterprise architecture frameworks (EAF) were designed to improve the efficiency of companies’ processes using IS. They typically include guidelines, methods, models, and tools to design IS (Danny et al., 2019). In this context, information systems are mainly used to support management tasks. This type of IS is commonly referred to as Management Information Systems (MIS). Some examples are enterprise resource planning (ERP) systems, decision support systems (DSS), and Customer relationship management (CRM) software solutions.

From the EAF found in the literature, two were selected for this work: the Zachman Framework that addresses problems in a multidisciplinary way (Malyzhenkov et al., 2018) and considers multiple stakeholders’ perspectives (a key aspect in the urban context); and the enterprise architecture design (EAD) proposed by Velho (2004) that has the advantage of already being based on the main existing frameworks, including the Zachman Framework.

The Zachman Framework considers six abstractions and six types of participants (Zachman, 2011). Its matrix structure helps to relate models and tools to each pair abstraction/stakeholder. As a result of the hierarchical organization of stakeholders’ roles (from planner to user, including the owner, designer, builder, and implementer), the matrix rows are associated to different management levels (Figure 1).

For the current work, the interest of the Zachman framework is rather on the columns of the matrix that are associated with the six abstractions analyzed. They are presented in the form of the questions each stakeholder can make (what, how, where, who, when, and why) (Urbaczewski & Mrdalj, 2006; Zachman, 2011). Each question relates to information required to design the IS. For instance, when designing the data architecture, one is answering what data is needed. But when designing the processes and interactions, one is answering how users interact with the system.

While Zachman presents the framework to design an IS from scratch, Velho presents EAD as an improvement of an existing IS. EAD has a strong focus on the organizational level of the enterprise,
more than the IS itself. Technology is presented as a support to the business processes that better fit the strategy defined in the planning phase.

The eleven phases of EAD can be grouped into four layers (Duarte, 2014). These four layers (Figure 2) summarize the main methodological stages: planning; current situation; situation to be implemented; and implementation and management plan. The IS details are described in the third stage (situation to be implemented), where application, data, and technological architectures are defined (Velho, 2004).

As referred, EAD reflects the importance of aligning the strategy of the organization with the implementation of new technology. In a city, the organizational structure is more rigid, and the strategy may vary depending on political issues. Nevertheless, the methodological approach and the guidelines for the design of the architecture can be useful in the urban context and in public administration in general.

### STAKEHOLDERS’ PARTICIPATION IN DECISION-MAKING PROCESSES

The level of engagement of each stakeholder group depends on the attention given to that group. In 1969, the participation ladder proposed by Arnstein already stated that citizens’ participation could vary from being manipulated (non-participation) to being completely in charge of the decision (citizen-control). Intermediary levels of involvement may be defined through consultation or partnerships (Lindenau & Böhler-Baedeker, 2014).

Considering the case of public transportation, Finka et al. (2017) argue that a structured procedure may increase participation levels from passive to active. They propose a procedure of six phases (stakeholder mapping, spread of information, collection of information, intermediate discussion, engagement, and partnership/empowerment) and proper tools for each phase. Following this procedure may help elevate the level of participation in the participation ladder.

In urban and mobility planning, the role of the decision-maker is played by local authorities. Nonetheless, the complexity of the network of stakeholders suggests that other stakeholders should participate in the process. Some Multicriteria Decision Analysis (MCDA) principals were therefore adopted in this work (de Almeida et al., 2015), with ideas retrieved from the multi-actor multicriteria analysis (MAMCA) method, which was developed to support the evaluation of policies and help in

<table>
<thead>
<tr>
<th>Planner (Context/Scope)</th>
<th>Executive perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner (Concept)</td>
<td>Business Management perspective</td>
</tr>
<tr>
<td>Designer (Logic/System)</td>
<td>Architect perspective</td>
</tr>
<tr>
<td>Builders (Physics/Technology)</td>
<td>Engineer perspective</td>
</tr>
<tr>
<td>Sub-contractor/Implementer (Components/Detailed Representation)</td>
<td>Technician perspective</td>
</tr>
<tr>
<td>Worker/Users (Operations/Product)</td>
<td>Enterprise perspective</td>
</tr>
</tbody>
</table>

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Figure 1. The Zachman Framework for Enterprise Architecture – stakeholders’ perspectives (adapted from Zachman, 2011)
policy design and decision-making considering the participation of multiple participants (Macharis et al., 2012). MAMCA falls into the Multicriteria Group Decision-Making methods (MGDM), more specifically as one type of Social Multicriteria Analysis (SMCA). It is an extension of classical MCDA methods, having the advantage of including stakeholders in a very early stage of the process (Macharis et al., 2009).

During two phases of the method (stakeholder analysis, and criteria and weights definition), stakeholders are analyzed and profiled, and they also participate with inputs regarding the alternative scenarios and their evaluation criteria.

**METHODOLOGICAL APPROACH**

As presented above, in this work we have adopted a methodological approach based on concepts, frameworks, and methods from several areas. This approach is the materialization of a conceptual framework developed at the beginning of the research (Duarte et al., 2019).

The developed conceptual framework (Figure 3) is based on the premise that better access to information leads to better decisions. Understanding the decisions made by the different groups of stakeholders is necessary at the very beginning of the process. Based on the knowledge acquired in this first stage, it is possible to infer the information they need and then find the data sources that provide that information. Instead of collecting all available data, only the required data is collected, leading to a more efficient and effective procedure, where the stakeholders themselves can be sources of information relevant to other stakeholders.

The acquisition and processing layers describe the technological requirements, corresponding to the application and technological architectures from the EAD. The visualization layer considers the

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**Figure 2. Enterprise Architecture Design – layers and phases**

<table>
<thead>
<tr>
<th>I. Planning</th>
<th>Initiation</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Strategic-operational summary</td>
</tr>
<tr>
<td>II. Current situation</td>
<td>Business architecture</td>
</tr>
</tbody>
</table>
| III. Situation to be implemented | Policy architecture I  
Management information systems and technologies principles |
|             | Data architecture | Application architecture |
|             | Technology architecture |
|             | Policy architecture II  
Governance model |
| IV. Implementation plan and change management | Implementation plan |
|             | Conclusion and transition to implementation |

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interactions users have with the service through digital channels. This layer is related to the design of the service encounter that can be achieved using the service experience blueprint.

This conceptual framework is related to the dimensions considered in this paper and to the abstractions of the Zachman Framework, as shown in Table 1.

The context and business levels of the Zachman framework focus on understanding the strategic aspects of the IS design. In the scope of this work, the decisions made by stakeholders in the urban environment are the “context”, being therefore related to the decision-making and urban dimensions.

Then, social interactions are analyzed in order to understand how value can be co-created by the stakeholders, thus including the social dimension considered in this work. Here, we describe who interacts, when, and what the interaction is. The social dimension is considered in the visualization layer again, where the description of how the interactions will occur is presented.

The technological dimension relates to the design of the information system architecture that will support the existing interaction in a digital form. Thus, it is associated to the technology level, answering the how (technological processes) and where (software applications) questions.

From this conceptual framework, a methodology emerged, based on the idea that to develop an integrated information system, it is necessary to understand the social and urban dimensions of the service, the technological requirements of the supporting information system, and the interaction between the participants. This resulted in a three-phased methodology (Figure 4): understanding the service concept; designing the information system; and designing the interaction processes. The phases of the methodology and the methods used in each phase relate to the conceptual framework,
as shown in Table 2. The following subsections provide more details about the different phases of the methodology.

**Phase 0 – Planning**

According to the proposed framework, before starting the design of the information system to support the existing services, the decisions made by each group of stakeholders should be mapped. However, this task can be quite extensive, and to make it possible in an efficient way, the methodology proposes the creation of types of decisions per stakeholder.

By using business process mapping tools, we can map decisions and graphically represent high-level processes. Another option would be to organize the types of decisions in three levels (strategic, tactical, operational) for each stakeholder group.

**Phase 1 – Understanding the Service Concept**

Phase 1 is mostly exploratory. It aims at understanding the structure and the activities of the local authorities (service providers) and studying the stakeholders participating in each activity, thus reflecting the social and urban dimensions of this work.
This phase is similar to the design of the service concept from MSD. For this context, the service concept is analyzed at a network level, as proposed in SD4VN, considering many-to-many interactions in an actor-network. This will help to understand how value is co-created in the network of actors. Despite the hierarchical structure of the system (city, institutions, citizens), value is co-created through many-to-many interactions between different groups of stakeholders, as suggested in the SD4VN method. Since this is a qualitative approach, semi-structured or unstructured interviews should be performed with both municipalities and citizens, in order to describe the existing services. Completing this phase answers the *who* and *what* questions of the Zachman framework.

**Phase 2 – Designing the Information System Architecture**

After the characterization of the current service concept, it is possible to restructure the IS architecture (ISA). In urban management, and considering budget and institutional constraints, the goal is not to innovate the service offering but to improve the service provision processes. That is why the new ISA must consider existing resources and recombine those resources. From an S-D logic perspective, the objective is to increase resource integration (Lusch & Nambisan, 2015).

The process must include a multilevel analysis of the application architecture, i.e., some applications may be used only by some of the stakeholders, according to their role. Such an approach follows the EAD guidelines, where Data, Information, and Technological architectures are part of the third layer, describing the situation to be implemented.

Determining existing channels, at the end of this phase, answers the *where* abstraction of the Zachman framework.

**Phase 3 – Designing Interaction Processes**

Designing interaction processes consists of designing the service touchpoints, through which the citizen can access the service, including the different channels’ interfaces. The resulting processes and their efficiency will depend on the municipality’s organizational structure, which must be respected by those processes.

The Service Experience Blueprint (SEB) can be used to design the multi-channel interaction processes, by defining each participant’s tasks and considering different utilization scenarios. These scenarios can be detailed using *sketches*, a technique that is commonly adopted in the design context.

In a first iteration of the design of each channel’s interfaces, we can use low fidelity prototypes, such as rather simple *mockups*. As the process evolves, the prototype’s quality and features should also evolve until reaching a level where it can be tested in a real case.

Phase 3 answers the *how* abstraction of the Zachman framework.

**DESIGNING TECHNOLOGY-ENABLED SERVICES FOR URBAN PLANNING AND MOBILITY**

This section briefly describes the main results of applying the methodology presented in the previous section. It includes: the analysis of the existing service offering and stakeholders interactions (phase 1); the guidelines for designing an integrated information system (phase 2); and the guidelines for designing the interaction processes, namely the available channels (phase 3).

In a short description, the work previously published is summarized here, in order to provide the required context. Then, the results of each phase are detailed. This description also serves as a validation of the multidisciplinary approach, developed following the Design Science Research (DSR) guidelines, as presented by Peffers et al. (2012), who mentions case studies and illustrative scenarios are common forms to evaluate new methods in this context.

This small case study was developed in the Porto Metropolitan Area (AMP – Área Metropolitana do Porto), in the North of Portugal. The study includes seven of the 17 municipalities that are part of AMP.
The sample considers: five central municipalities closer to the central business district (CBD) and with diversified land use, including urban, industrial, and rural neighborhoods; one strongly industrialized municipality in the north of the CBD; and one municipality that is mostly rural, in the south of the CBD.

The data collected during the first phase of the methodology (understanding the service concept) was used to describe the current services and processes of each municipality. For this purpose, simple and semi-structured interviews, where processes were described by the participants, were made. Since the processes are different in each municipality, the resulting guidelines reflect the main successful procedures adopted by each city. The information collected in this stage was also used to develop the guidelines presented in phases 2 and 3.

**Results of Phase 0 – Planning**

This section briefly describes the results of the work done regarding the first layer of the framework – decision mapping. This was the first step in collecting data at the beginning of the research.

In a first analysis, four groups of stakeholders were identified: urban and mobility planners; citizens; transport operators; and logistics service providers. Then, for every group, the decisions they make have been listed. Since this case study focuses on the interactions between citizens and municipalities, the results only show these stakeholders’ data. (Table 3).

It is important to note that a decision of the municipality directly affects the supply of transportation systems, while a decision of a citizen will impact the demand side of these systems. A strategic decision is one that has a long-term impact. Accordingly, finding a new job will be considered a strategic decision of the citizen.

The groups of stakeholders were reviewed during phase 1, where citizens were divided into subgroups and services. The service mix offered by the city was associated with the different decisions.

**Results of Phase 1 – Understanding the Service Concept**

The main objective of this phase is to characterize the core services that are available to the citizens when interacting with the municipalities, i.e., the stakeholders involved and the activities through which they interact. This will answer the who question (stakeholders – who participates in the decision-making process?) and the what question (services – what services are available and what value is created?).

The information was collected through interviews with staff of the municipalities, performed to obtain details regarding these interactions. From this information, it has been possible to understand the value offered to citizens through these services.

The identified stakeholders were organized into three tiers (Table 4). The first-tier refers to their role in the city as a service system. The service providers or facilitators are the national, regional, and local authorities, along with the urban services, while the customers are the citizens.

The second-tier puts together stakeholders according to their primary service offering (urban planning vs. mobility planning; passenger transport vs. logistic service provider; etc.). Regarding the

| Table 3. Examples of strategic, tactical, and operational decisions made by stakeholders |
|---------------------------------|-----------------|---------------------|
| **Decision levels**            | **Urban and mobility planners** | **Citizens**        |
| Strategic                       | Urban master plan | Moving to a new home   |
|                                 | Urban mobility plan     | Finding a new job    |
| Tactical                        | Changing lanes         | Buying a new vehicle  |
|                                 | Adding/removing traffic lights |                |
| Operational                     | Maintenance operations | Choosing a daily route |
citizens (customers), the second-tier explicitly considers their role, which depends on their position in the system and on the time of the day. This happens because a person’s perspective towards the system changes according to the role played in each moment of the day. For example, a travelling citizen will have different needs, whether he/she chooses to go by car, to take the public transport, or use a soft mode.

Finally, the third-tier views the stakeholders taking into account some specific characteristics (e.g., collective transport vs. individual vehicle). The third-tier for citizens is not detailed here for the sake of clarity, as for each second-tier group, there are many third-tier subgroups. Some groups could even have more tiers. For instance, it is possible to differentiate rail and bus in public transport operators. However, for the purpose of this analysis, the tiers defined here were considered to be enough.

When the system is viewed as a network, where there are many-to-many interactions, the role of the service provider can vary depending on the generated value and on the service that the customer is seeking. In general, local authorities become the service provider (black arrow in Figure 5), having urban services and national and regional entities as service facilitators that help provide the service through secondary interactions (grey dashed arrows in Figure 5). However, in some municipalities, responsibilities are not centralized, and this may result in citizens having to seek the same service more than once. For instance, it may happen that the local authorities manage information regarding bus stop shelters, but the bus schedule is managed by the transport operator. In these cases, the citizen can contact directly urban services and not the local authorities (grey arrow in Figure 5).

If the citizen knows who he/she contact, this decentralization removes some pressure from central services. But, if that does not happen, the citizen may make the same complaint to the central services and to the transport operator. In practice, this may increase the complexity of the process by creating duplicated cases since the citizen contacts both entities.

At this stage, the different services identified were grouped into five main offerings: public consultation, licensing, information requests, complaints/suggestions, and problem-solving. Depending
on the organizational structure of the municipality, the competencies to deal with these issues may be centralized or spread across different departments.

In the cases considered in this study, information requests, complaints/suggestions, and problem-solving are dealt with as if they were all “complaints”. They were analysed separately since they require different participants and different actions. Though “problem-solving” was considered a separate service, the beginning of the process can be very similar to a “suggestion” or a “complaint” depending on how the citizen deals with the issue.
To better understand the value created in these services and how this value can be increased, services were compared in terms of the number of participants and in terms of the actions required from the local authorities (Table 5). This will later help to select the best channels for each service.

A brief analysis showed that the more participants are involved, the more complex the process is, and the more time it takes for the customer to receive an answer. Some processes cannot be changed because of local regulations, but the transparency of a project may help to manage citizens’ expectations.

The operational cases with immediate response are more likely to be solved with only two participants (the citizen and local authorities). However, depending on the issue presented by the citizen, it may be necessary to involve urban services. The same happens for the licensing service. Complaints and suggestions only require two participants since they end after a simple interaction to exchange information. When a suggestion requires a more significant intervention (e.g., changing the size of a sidewalk), it is then transferred to a list of activities for improvement and maintenance.

The only process where there are multiple participants is the public consultation. In this case, local authorities lead the process. Still, it must involve the participation of a diversified set of citizens and the different urban service providers. In this case, we consider that there are many participants, as it is a process open to anyone interested in participating.

The complexity of the process is also related to the decision at hand. Citizens’ operational decisions are usually based on information requests, while citizens’ strategic decisions may depend on licensing, for example when they are planning a new construction.

The case is different for the municipality since suggestions, for instance, can feed an operational decision but can also be quite complex and be used to feed a master plan, hence becoming a strategic decision.

Quite often, the effectiveness of the processes is more influenced by the organizational structure than by the level of digitalization. Results also show that more horizontal institutions have better results in communicating with citizens, since it is easier for a citizen to reach the person who can really help him/her.

**Results of Phase 2 – Guidelines for Designing the Information System**

This phase of the methodology aims to describe the characteristics of the IS that will foster participation and increase the engagement of citizens with the urban services. This section describes some of those characteristics with a focus on the software applications that must be made available. Choosing the existing channels for the service exchange will answer the where question of the Zachman Framework.

<table>
<thead>
<tr>
<th>Example</th>
<th>Participants</th>
<th>Immediate response / analysis</th>
<th>Level of impact</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Public consultation</strong></td>
<td>Many</td>
<td>Analysis</td>
<td>Strategic</td>
</tr>
<tr>
<td>Consulting the population to propose changes to regulation before it is finalized.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Licensing</strong></td>
<td>2+</td>
<td>Analysis</td>
<td>Tactical</td>
</tr>
<tr>
<td>Submitting a request to build a ramp for a private garage.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Information request</strong></td>
<td>2+</td>
<td>Immediate response</td>
<td>Tactical or operational</td>
</tr>
<tr>
<td>Seeking information about a process or a service.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Complaints/ suggestions</strong></td>
<td>2</td>
<td>Analysis</td>
<td>Tactical or operational</td>
</tr>
<tr>
<td>Informing authorities that traffic lights are not working.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Problem-solving</strong></td>
<td>2+</td>
<td>Immediate response</td>
<td>Operational</td>
</tr>
<tr>
<td>Asking for help in filling in a form.</td>
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</tbody>
</table>
In a network of actors with many-to-many interactions, the IS must allow the different stakeholders to interact and access information to enable fast and smooth interactions and improve their results. In the information provided by the municipalities, there are multiple channels through which value can be exchanged, in person, or using a digital interface.

The goal of the new IS architecture is to integrate existing resources so that communication can be enhanced, thus increasing the level of participation and engagement of citizens in re-designing mobility services.

To define how stakeholders interact and share information, rethinking the multiple information systems as one integrated system, through which different stakeholders can share and access information, is needed (Figure 6). This study aims at improving existing services, mainly by changing some of the internal processes performed, but possible changes to the organizational structure of the municipality are outside the scope of this work.

The analysis of the five main service offerings results in an IS architecture that allows stakeholders to interact directly with any other stakeholder in the network. Instead of more traditional dyadic interactions (citizen - local authority - public transportation operator), a direct interaction between any pair of stakeholders (citizen - citizen, citizen - public transport operator, etc.) can take place. In the end, this will be the choice of the local authority.

One of the municipalities in the study mentioned that they prefer to centralize and manage all information that reaches the citizens. This is possibly a valid approach for complaints and problem-solving scenarios where the local authority acts as a moderator. However, a collaborative approach has the potential to reduce the workload of the municipalities. Interacting with other citizens can generate value when direct interaction with the municipality fails. To ensure the information is the same for everyone, a central server and a database storing data from various sources should be accessible by the different stakeholders.

Figure 6. Integrated information system
Moreover, according to the users’ activities, other software may be built on the IS (web, desktop, mobile). For instance, the person(s) responsible for responding to citizens’ requests should have a desktop application that integrates requests from different sources. Still, citizens should have a mobile application to send requests and receive notifications, allowing real-time communication.

All these applications will have access to the same information and should be tailored to enhance the experience of each stakeholder group, with a particular focus on the citizens. Moreover, to be in contact with the different types of users, municipalities normally use e-mail and digital platforms that follow standardized procedures, without forgetting the traditional telephone.

To respond to the digitalization challenges, four main potential solutions based on Web 2.0 technologies were identified: chat rooms and messaging solutions; web forums; social networks; or mobile applications (Table 6). These solutions present different characteristics regarding the number of participants, type of interaction (see next section), and response time. These characteristics were considered to be those that have the highest impact on the user experience.

Despite the advantages of social networking in connecting customers, interviewees showed some concerns about the quality of information shared on those platforms, requiring some type of moderation. One of the interviewees said that a mobile application owned and controlled by the city would be more easily accepted, enabling collaboration between citizens, and allowing collected information to be used in future city planning decisions.

In short, the IS should consider the following aspects:

- **Multilevel integration**: A centralized database will allow a multilevel exchange of information (e.g., strategic decisions can use the historical data from complaints and suggestions).
- **Multi-channel**: Different applications should be available for each stakeholder profile, thus creating an inclusive service offering.
- **Knowledge co-creation**: Sharing information and making it accessible to all stakeholders improves the decisions made by all stakeholders.

### Results of Phase 3 – Guidelines for Designing Interaction Processes

The interaction processes will somehow reflect the customer experience of the citizen towards the municipality. To provide a good experience a good flow of activities during the service should be assured.

This section presents a scenario to show how and when a process may fail and how it can be improved, by describing an interaction process with answers to the how question of the Zachman Framework. This example involves citizens and local authorities.

Consider the owner of a private car who wishes to shift to soft modes but needs relevant regulation information (in fact, the availability of such information may have an essential role in the adoption of new transport modes by many citizens).

The conventional process to find information on regulations involves searching for online information (indirect interaction with the municipality) and directly contacting the city services by using info desk channels. However, there are two possible moments when the interaction may not be successful, thus deteriorating the user experience.

### Table 6. Interaction tools and their characteristics

<table>
<thead>
<tr>
<th>Tool</th>
<th>Type of interaction</th>
<th>Participants</th>
<th>Moment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chat rooms and messaging</td>
<td>Direct</td>
<td>One-on-one</td>
<td>Instantaneous</td>
</tr>
<tr>
<td>Social networks</td>
<td>Direct and indirect</td>
<td>Community</td>
<td>Continuous</td>
</tr>
<tr>
<td>Web forums</td>
<td>Direct</td>
<td>Community</td>
<td>Continuous</td>
</tr>
<tr>
<td>Mobile applications</td>
<td>Indirect</td>
<td>Community</td>
<td>Continuous</td>
</tr>
</tbody>
</table>
The first failed interaction may happen when the citizen (the system user) searches for information and does not succeed in getting it. This may be caused by several reasons such as: the user does not know where to search; the user finds the information but is unable to understand it; the information had not been made available by the municipality; the information the user finds is incomplete.

If this step is not completed successfully, the user will still need to contact the municipality directly. Results show that some municipalities receive too many requests or complaints and can seldom answer quickly and in due time. That is when a second unsuccessful interaction may occur. To overcome this problem, introducing the possibility of getting information through other channels can have significant advantages for both the user and the municipality.

Since contacting the municipality can be quite slow due mainly to waiting times, promoting contacts among citizens can have considerable benefits, with fewer requests being generated. Therefore, there will be two main advantages on the service provision side: more resources available to assign to other tasks; and more capacity to answer more requests.

In the long term, redesigning the process of obtaining information can be beneficial for everyone. Some citizens will not even need to contact the municipality, those who need to do it will be better served, and the city will provide a better service level and have a better resources management.

In this example, the citizen does not require real-time information, as there is no immediate decision depending on that information. However, in some cases, access to information needs to be faster, such as when planning a trip and deciding the transportation mode and the route.

The example also shows the advantages of having multiple channels available, allowing for the user to select the channel that better fits the situation, regarding timing and quality of information (Table 7). The existence of multiple channels that allow many-to-many interactions will reduce vertical communications (citizen – institutions) and increase horizontal communications (citizen – citizen).

In short, the interaction processes should consider the following goals:

- **Increase usability**: Good indirect interactions reflect the quality of the service and reduce direct interactions.
- **Involve citizens**: Allowing horizontal interactions can reduce pressure from vertical interactions.

### Table 7. Types of interactions between urban stakeholders

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>Interaction between active stakeholders</td>
<td>Asking for information about new transport prices (through phone, e-mail, a web forum, etc.) and receiving an answer through the same channel</td>
</tr>
<tr>
<td>Indirect</td>
<td>When a stakeholder searches for information through official channels without contacting the other stakeholder</td>
<td>Searching for information about transport schedules on a website</td>
</tr>
<tr>
<td>Horizontal</td>
<td>Interaction between stakeholders of the same group</td>
<td>Interaction between two citizens</td>
</tr>
<tr>
<td>Vertical</td>
<td>Interaction between a service provider and the customers</td>
<td>Interaction between a citizen and local authorities</td>
</tr>
<tr>
<td>Main</td>
<td>Interaction between a service provider and the customers</td>
<td>Interaction between a citizen and local authorities</td>
</tr>
<tr>
<td>Supporting</td>
<td>Interaction between a service provider and another service provider to solve a case raised by a third party (customer)</td>
<td>Interaction between local authorities and a public transport operator, to answer a complaint of a citizen</td>
</tr>
</tbody>
</table>
• **Involve all third-party participants:** When possible, create bridges between other service providers and the customer, facilitating the supporting interactions.

**CONCLUSION**

The complexity of stakeholders’ interactions in an urban environment, particularly for urban mobility, raises new and more significant challenges in terms of information sharing. In this context, the multidisciplinary approach developed in this work is a contribution to improve the understanding of these problems and, consequently, the quality of their solutions.

In practice, current technology developments allow redesigning decision-making and information sharing processes by explicitly including the participation of different stakeholders. Implementing these developments in an urban context means integrating concepts from urban mobility, service design, information and communication technologies, and decision-making processes.

The work described in this paper showed how stakeholders can have better access to information and improve their decisions, and resulted in the proposal of a set of guidelines to design an integrated IS that follows a service-dominant logic. Using service design concepts helps to better understand the value network that can be developed if the proper tools are used to enhance communication between citizens.

One of the processes where citizens can clearly co-create value is information sharing. Since some citizens can already have information that may be useful to others, the IS should include mechanisms for citizens to interact not only with local authorities but also with other citizens. This work contributes to the definition of stakeholders’ profiles and to the design of tools to enhance their communication, and to value citizens’ perspective.

One goal of bringing stakeholders closer was to increase value co-creation by improving citizens’ engagement in urban planning and mobility. Co-creation should be present in different moments: during urban and mobility planning activities (co-creating the city), when sharing information (co-creating knowledge), and during the design and development of technology-based services (co-creating tools and services).

Integration is also visible in the multilevel characteristic of the IS, since the information from daily interactions can be used to feed future strategic decisions. Therefore, reinforcing an integration perspective can be considered one main contribution of this research as it balances the integration of stakeholders, information, research domains, and management levels.

However, this work still presents some limitations, namely, the budget constraints of the public sector that limit the possibility of implementing the proposed guidelines in the existing services. In one of the studied municipalities, this limitation was overcome by providing some suggestions on improving communication using social networks instead of completely redesigning the service. This action could, at least, create some proximity between the city and the citizens.

Also, constraints imposed by the Covid19 pandemic led, in some cases the interview format to be redesigned for online platforms. Although this did not represent a major limitation in the research, it imposed some adaptations in the list of interviewees. In this broad context, a future interesting research line would be on the interactions of logistics service providers and transport operators as municipality partners in providing services to citizens.

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