From Shared electric Mobility Providers (SeMPs) to electric Mobility as a Service (eMaaS) players – A first approach to assess the Technical Level of Integration of Mobility Service Providers' functionalities applied to the European (e)MaaS market

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Abstract

In this paper we present an approach to evaluate to what extent Mobility Service Providers (MSPs) can be considered (e)MaaS players. Following that approach, we conduct an analysis of 128 MSPs, specifically Shared electric Mobility Providers (SeMPs), currently operating in the European market. The goal of the analysis is twofold. Firstly, it aims at demonstrating the applicability of the proposed approach. Secondly, it aims at offering an overview of the current state of the market concerning the Technical Level of Integration (TLI) of European SeMPs. Our results show that, on the one hand, most of the SeMPs currently operating in Europe have a medium to high TLI. However, those levels are mostly not applicable for multimodal (i.e. for multiple modes of transport or multiple MSPs) interfaces but for single-mode interfaces. On the other hand, our results also show that there are already some SeMPs in the current European market that have fully integrated functionalities, in that case, SeMPs mostly have multimodal interfaces. Based on the analysis and discussion presented in this paper, we concluded that the TLI approach offers an effective technique to determine, and easily visualize, the level of integration of the technical functionalities of MSPs.

Keywords: Market overview; Mobility as a Service (MaaS); electric Mobility as a Service (eMaaS); Mobility Service Providers (MSP); Shared electric Mobility Providers (SeMPs); Technical Levels of Integration (TLI)

1. Introduction

In the last few years, new mobility concepts such as Mobility as a Service (MaaS) and electric Mobility as a Service (eMaaS) have emerged. These concepts respond to the increasing demand for shared mobility and multimodal passenger transport services. When compared to MaaS, eMaaS has the complementary goal of providing users the possibility to go from A to B in an eco-friendly way (Reyes García, Lenz, Haveman, & Bonnema, 2019). Therefore, eMaaS has its focus on electric mobility systems and shared electric mobility services. Following the working definition of eMaaS proposed by Reyes García et al. (2019), that is:

> electric Mobility as a Service (eMaaS) refers to the integration of multiple forms of (electric) transport modes –including public transport– and shared electric mobility services (e.g. e-car sharing, e-bike sharing, e-scooter sharing, e-bus, e-taxi) into a single mobility service that allows travellers to plan and go from A to B (and/or from B to C and/or vice versa) in an eco-friendly and seamless way. The service is offered through a single customer-centred interface and it also involves the prearrangement of electric mobility technologies and infrastructure (e.g. charging stations, energy contracts). (p.2)

Shared electric Mobility Providers (SeMPs) are obvious candidates to become the transport option for eMaaS' users. However, as with MaaS, the eMaaS model does not yet have ready-to-go solutions, which is proven by the currently very limited list of (e)MaaS[1] providers (Reyes García, Haveman, Westerhof, & Bonnema, 2020). This can be explained due to the fact that "at the core of MaaS is the notion that it will deliver an 'integrated solution' of different functions" (Haveman, Reyes García, Felici, & Bonnema, 2019, p. 3). However, the actual integration of such functions, and therefore its implementation, remains quite a challenging task (Lyons, Hammond, & Mackay, 2019) for mobility service providers that are willing to enter (or stay competitive in) such a mobility market.

As a continuation of a previous work by the same authors of this paper (Reyes García et al., 2020), this work explores the technical functionalities[2] of Shared electric Mobility Providers (SeMPs) in order to assess their level of integration with respect to (e)MaaS. The research presented here is situated in the context of the eMaaS project (eMaaS project, 2018). Therefore, the scope of the analysis is limited to the European Shared Electric Mobility (SEM) market. However, our findings show that many players in the SEM market do not offer exclusively electric vehicles (EVs) or electric mobility services. Therefore, throughout this paper we have used the term 'electric' between parentheses [i.e., (electric)] or its abbreviation (e-) to refer to those providers or services that are not exclusively electric but do offer or contain EVs within their fleets or services.

The focus of the study is on eMaaS project partners' origin countries. The list of evaluated mobility providers includes SeMPs from: Austria, Belgium, Denmark, Finland, France, Germany, Hungary, The Netherlands, Norway, Sweden, Switzerland and the United Kingdom. The list of SeMPs includes[3] (e-)car sharing providers, micro (e)mobility providers (e.g. (e-)bike- and (e-)scooter- sharing), Multi Transport Integrators[4] and Multimodal Trip Planners[5].

Providers outside the scope of this study are: ride sharing providers (i.e. carpooling), taxi companies, ride hailing operators (e.g. Uber), traditional[6] car rental providers, traditional bike rental providers, single-mode (non-electric) public transport operators[7], and community-based[8] car- and bike-sharing programmes. The list of all SeMPs assessed in this study is presented in the appendix.

Goal, research questions and outline

The goal of this paper is to provide an effective approach for the evaluation of the Technical Level of Integration (TLI) of upcoming (e)MaaS players, and to offer an overview of the current state of the market concerning European Shared electric Mobility Providers and their TLI. The research questions that lead our analysis are:

1 Throughout this paper, we use the form (e)MaaS to refer to both, MaaS and eMaaS.
2 Throughout this paper, the terms "function" and "functionality" (and their plural connotations) are used interchangeably.
3 Although eMaaS is founded on, and promotes only eco-friendly mobility, this study is focused specifically on electric mobility. Hence, non-electric bike sharing providers were not considered for the market research conducted for this study.
4 A Multi Transport Integrator (MTI) is a mobility provider that offers the service of multiple modes of transportation on a single contract. An example of a MTI is the NS railways in the Netherlands which offers a mobility smart card that can be used to access all modes of Public Transport in the country and also (e-)car sharing and bike sharing services. In this study, mobility providers under this category offer at least three different modes of transportation.
5 A Multimodal Trip Planner (MMTP) is a digital tool, usually in the form of a mobile app or website portal, where users can plan a trip combining or by means of different modes of transportation. A common example of a MMTP is the Google Maps trip planner.
6 Traditional- car rental and bike rental providers are referred in this study as those providers that do not focus their business on offering electric vehicles as part of their mobility service, and/or the renting process has to be done on site, in front of a desk.
7 Public Transport Operators (PTOs) were only selected for this study if they offer electric mobility and integrate multiple modes of (electric) transportation as part of their mobility service. For example, the Dutch railways (NS), which in addition to the (electric) train service also offers (e-)car sharing and bike sharing services. An example of single-mode (non-electric) PTOs are traditional local bus operators, which are therefore excluded from this study.
8 Community-based sharing mobility refers to car sharing or bike sharing programmes that are exclusively for the use of a closed group of people (usually neighbours in a village or small community) and the general public or businesses cannot hire or have access to the service.

1) What are the technical functionalities of Mobility Service Providers in the European market?
2) How can the level of integration of the technical functionalities of European Mobility Service Providers be determined?
3) What is the Technical Level of Integration of Shared electric Mobility Providers currently operating in the European market?

The outline of this paper is as follows. In section 2, we present the research background of our proposed approach for the assessment of the level of integration of the technical functionalities of Mobility Service Providers (MSPs), that is, the Technical Level of Integration (TLI) approach. In section 3, we describe this approach and in section 4 we present the methodology followed to assess MSPs with it. In section 5, based on the implementation of the TLI approach, we present and discuss the results of the assessment of 128 Shared electric Mobility Providers currently operating in the European market. Finally, in section 6 we present the concluding remarks of our study and we offer an outlook for future work.

2. Research background

Based on the levels of integration of MaaS schemes proposed by the works of Kamargianni, Li, Matyas, and Schäfer (2016); Sochor, Arby, Karlsson, and Sarasini (2018), and Lyons et al. (2019), we defined criteria to assess to what extent the technical functionalities of Mobility Service Providers (MSPs) are integrated into a single interface. Although the levels of integration used as reference are mostly focused on multimodal MaaS schemes, in this work we also include single-mode mobility providers under the understanding that such providers offer (electric) Mobility as a Service as well. That is what we actually are aiming to assess, to what extent MSPs can (or will) be considered (e)MaaS providers, regardless if (currently) operate as single or multimodal mobility providers.

Table 1. Different levels of integration of MaaS schemes

<table>
<tr><th colspan="2">Kamargianni et al. (2016)</th><th colspan="2">Sochor et al. (2018)</th><th colspan="2">Lyons et al. (2019)</th></tr>
<tr><td>Level</td><td>Description</td><td>Level</td><td>Description</td><td>Level</td><td>Description</td></tr>
<tr><td></td><td></td><td>0</td><td>No integration (single, separate services)</td><td>0</td><td>No integration: no operational, informational or transactional integration across modes</td></tr>
<tr><td rowspan="4">▼</td><td rowspan="2">Partial integration (partially possess ticket-, payment- and ICT-integration)</td><td>1</td><td>Integration of information (centralised information, and/or multimodal travel planners, and/or assistant)</td><td>1</td><td>Basic integration: informational integration across (some) modes</td></tr>
<tr><td rowspan="3">2</td><td rowspan="3">Integration of booking and payment (multimodal trips with single tickets)</td><td>2</td><td>Limited integration: informational integration across (some) modes with some operational integration and/or transactional integration</td></tr>
<tr><td rowspan="2">Advanced integration (completely possess ticket-, payment-, and ICT-integration)</td><td>3</td><td>Partial integration: some journeys offer a fully integrated experience</td></tr>
<tr><td>Advanced integration with mobility packages</td><td>3</td><td>Integration of the service offer (bundled subscription based multimodal mobility service)</td><td>4</td><td>Full integration under certain conditions: some but not all available modal combinations offer a fully integrated experience</td></tr>
<tr><td></td><td></td><td></td><td></td><td>5</td><td>Full integration under all conditions: full operational, informational and transactional integration across modes for all journeys</td></tr>
<tr><td></td><td></td><td>4</td><td>Integration of societal goals (influencing user behaviour through incentives enabled by dynamic data sharing between transport planning and MaaS operators)</td><td></td><td></td></tr>
</table>

Table 1 shows an overview of the levels of integration of MaaS schemes, as presented by Kamargianni et al. (2016), Sochor et al. (2018), and Lyons et al. (2019). Although there is a clear commonality between the levels presented by those authors, no direct association should be made between them. Likewise, the structure of Table 1 exposes the commonalities between the different levels, but it does not attempt to portray a direct correlation between them.

The levels of integration proposed by the authors presented in Table 1, all derived from different perspectives. The levels proposed by Kamargianni et al. (2016) focus on the integration of mobility modes for an intermodal and seamless journey. In turn, the levels of integration proposed by Lyons et al. (2019) focus on "the user perspective regarding the mobility system beyond the private car, while Sochor et al. (2018) focus upon the customer, provider and business perspectives" (Lyons et al., 2019, p. 29). Thus, a level 2 MaaS scheme in the scale proposed by Sochor et al. is not necessarily a level 2 MaaS scheme in the scale proposed by Lyons et al. Furthermore, the levels proposed by Lyons et al. and the ones proposed by Kamargianni et al., are incremental levels, meaning that higher levels of integration include the characteristics of the lower levels. Contrary, the ones proposed by Sochor et al. are not necessarily dependent on each other. That means that, for example, a level 3 MaaS scheme should not necessarily own a level 1 MaaS scheme's features.

Furthermore, from a scoring system viewpoint, the work by Kamargianni et al. (2016) also presents a MaaS integration index that can be used to differentiate MaaS schemes between each other. By means of this index, the authors offer a score system based on four types of integration. The first type of integration is based on the capability to offer multimodal modes of transport, referred by the authors as *Ticket integration*. The second and third types of integration are based on the technical functions of *Planning* and *Booking*. Finally. The fourth type of integration refers to the inclusion of *Mobility Packages* by the MaaS schemes.

Although the MaaS integration index (Mii) proposed by Kamargianni et al. (2016) already offers a tool to evaluate the degree of integration of MaaS schemes, the Mii gives an unbalanced priority to the evaluation categories. On the one hand, the *Ticket integration* category can score higher than one point depending on the total number of different modes of transport offered by MaaS schemes. In the example offered by the authors, MaaS schemes could score up to six points only from this category. On the other hand, for the rest of categories the maximum score is one point. This means that, for example, if a MaaS scheme only offers one of the functionality assessed by the Mii (e.g. *Booking*), but this functionality is offered for five different modes of transport, then the total score for that MaaS scheme would be six points (one point for the *Booking* integration and five points for the *Ticket integration*,). In contrast, if a MaaS scheme offers all (four) types of integration evaluated by the Mii, but the MaaS scheme is only applicable for two modes of transport, the total score for that MaaS scheme would be six points as well (four points for having all types of integration, and two points for the *Ticket integration*). Then, if those two MaaS schemes were compared based on the Mii, the outcome would be a very subjective result. That is, is the first MaaS scheme really at the same level of integration than the second MaaS scheme even when the first one does not include mobility packages and users cannot pay for the mobility services on the same interface (which are features that the second one does have)? Or the other way around, is the second MaaS scheme really at the same level of integration than the first one even when the latter only offers multimodal mobility and the second one is only applicable for a single mode of transport? As with this example, many others could occur where the Mii method would not be convenient to actually differentiate between MaaS schemes.

In an attempt to offer a more balanced assessment of the level of integration of Mobility Service Providers (MSPs), our proposed approach is focused specifically on the technical functionalities of MSPs and how these functionalities are linked to each other. In that sense, contrary to the existing approaches, the levels of integration proposed in this work focus more upon the Mobility Service Providers' (MSPs) perspective than upon the users' perspective. To make a distinction between our proposed approach and the previous works presented in Table 1, we refer to it as the *Technical Levels of Integration (TLI)*. The following section presents a description of all the levels in our TLI approach and offers an overview of the levels represented as stacks of functional blocks.

3. The Technical Levels of Integration (TLI) approach

Within a(n) (e)MaaS environment, Mobility Service Providers (MSPs) users should have the possibility to access information about mobility assets, plan, book, pay, and get access to assets (i.e., vehicles) for the execution of their journey through a single interface. In that sense, in this study, MSPs will be assessed according to their capacity to fulfil those technical functionalities (i.e., access information, plan, book, pay, trip execution).

Based on the levels of Mobility as a Service (MaaS) schemes introduced before, in this section we present our proposed approach for the assessment of the Technical Levels of Integration (TLI) of Mobility Service Providers (MSPs). For a better visualisation of the levels in our approach, the technical functionalities have been represented as modular functional blocks. The visualisation of functional blocks is inspired by the technical specification of the *Transport Operator – MaaS Provider Application Programming Interface (TOMP API)* presented by Felici, Van den Belt, Reyes García and Baart (2019), where the main functions of MaaS providers are represented by 8 functional blocks. Since the TLI approach focuses more on the MSPs' perspective than on the users' perspective, the 'privacy & registration' and the 'support' functions used by Felici et al. (2019) have been excluded for now.

Moreover, in the TLI approach, the functional blocks 'Asset Information' and 'Operator Information' presented in Felici et al. (2019) have been merged into a single 'Asset and Operator Information' (A&OI) functional block. Thus, the TLI approach is founded upon the five functional blocks shown in Fig. 1:a). These are: *Asset & Operator Information* (A&OI), *Planning* (Pl), *Booking* (B), *Trip Execution* (TE) *and Payment* (P). Each cube-shaped block depicted in Fig. 1 represents each of the technical functions (for one mobility mode) used to describe the TLI approach. The 'Mode (i)' denoted on the lateral side of the cube-shaped functional blocks refers to the type and number (i) of (electric) transport mode(s) offered by the applicable Mobility Service Provider (MSP).

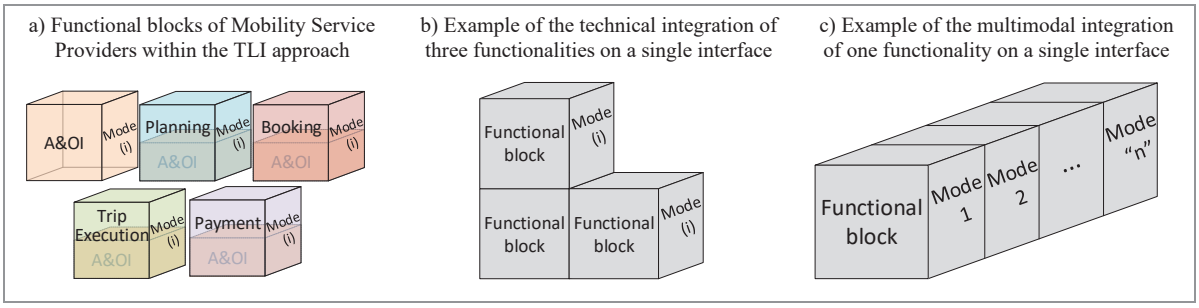


Figure 1. Functional blocks utilised to describe and provide a better overview of the Technical Levels of Integration of MSPs' functionalities

As shown in Fig. 1:a), the *Planning*, *Booking*, *Trip Execution* and *Payment* functions have the A&OI function embedded as part of their own. Furthermore, for a simple understanding of the TLI, the levels representing it can be seen as stacks of functional blocks. For instance, Fig. 1:b) shows an example of an MSP which would have three functionalities integrated on a single interface. As further explained in the next paragraphs, that represents a certain level in the TLI approach.

Additionally, the integration of functions (on a single interface) from multiple modes of transport or multiple MSPs is also taken into account within the TLI approach. However, this type of integration has only been considered as an additional capability and not as a core integration feature, because it does not imply the integration of more technical functions (which is the focus of the TLI approach). Therefore, multimodal integration has only been included as a sublevel within the TLI. A superscripted-plus-sign ($^{+}$) next to each sublevel has been used to indicate if multimodal integration is included. Fig. 1:c) shows an example of how the multimodal integration of one functionality into one single interface is visualised within the TLI approach.

With the representation of the technical functionalities of Mobility Service Providers (MSPs) as modular blocks, an overview of the TLI can be visualised in Table 2. As shown on the first column of the table, each level in the TLI approach is based on the number of integrated functionalities that compose it. The TLI represent an incremental scale. Therefore, the more blocks linked together (that is, the more integrated stacks), the higher the TLI. There are five TLI. For a more explicit description of them, in addition to the numerical classification (from 0 to 4), they have also been categorized as "Only A&IO", "Low integration", "Medium integration", "High integration" and "Full integration".

From the first row of Table 2, it should be noted that the *Asset & Operator Information* (A&OI) functionality has been considered as the only "non-integrated" (Level 0) function in the TLI approach. The reason for this is that, in the context of (e)MaaS, all other technical functionalities (i.e., *Planning*, *Booking*, *Payment* and *Trip Execution*) cannot be performed without having asset and/or operator information available. For example: 1) it would not be possible to *Plan* or *Book* a trip without information about the mode of transport or asset(s) available, or without information about route(s) or time-schedules. 2) It would not make sense to *Pay* for the usage of an asset or mobility service without knowing which type of asset or mobility service that one is paying for. And 3) it would make no sense to *Execute* a trip without having information about the asset or transport operator that one can (or should) use.

In turn, as shown in the second row of Table 2, at the "low integration" category (Level 1) the *Planning*, *Booking*, *Payment* and *Trip Execution* functions are considered as "single-integrated" functions. The difference between Level 0 and Level 1 in the TLI approach is that in Level 1 the functionalities are considered to be integrated in the sense that they have the *Asset & Operator Information* (A&OI) function integrated into themselves, even if are single functions and not connected to another one. Whereas the A&OI function could be offered by MSPs even if it is not linked to, or integrated into, any other function at all. This can also be seen in Fig. 1:a).

At the "medium integration" category (Level 2), shown in the third row of Table 2, Mobility Service Providers (MSPs) have the capability to offer any two of the technical functions integrated on a single interface. In addition, these technical functions could also be applicable for multiple modes of transport or multiple MSPs, as will be described for the sublevels $2a^{+}$), $2b^{+}$), $2c^{+}$) and $2d^{+}$) in Table 3.

In the "high integration" category (Level 3), presented in the fourth row of Table 2, any three technical functionalities are integrated on a single interface. At this level, it is also possible to have any three of the technical functionalities applied for multiple modes of transport or for multiple MSPs, as will be described for the sublevels $3a^{+}$), $3b^{+}$), $3c^{+}$) and $3d^{+}$) in Table 3.

Finally, in the "full integration" category (Level 4), as the name implies, all four technical functionalities are fully integrated with each other on a single interface. The bottom row at the third column of Table 2 shows the four functionalities integrated on a single interface for only one mode of transport, whereas the last cell in Table 2 shows the integration of all four functionalities when applicable for multiple modes of transport or multiple MSPs.

An important remark of the levels presented above is that any Mobility Service Provider (MSP) identified by the TLI approach as offering multiple modes of transport (i.e., any MSP classified with a (+) mark) should be considered to have a benefit. However, it should not be considered explicitly with a higher TLI than MSPs that include only single modes of transport. In Table 2, the TLI including multiple modes of transport are represented on the right side, while TLI including only single modes of transport are represented on the left side. A description of the technical functionalities and each of the TLI are fully explained in Table 3.

Table 2. Overview of the Technical Levels of Integration (TLI) of Mobility Service Providers' functionalities using stacks of functional blocks

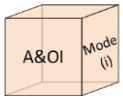
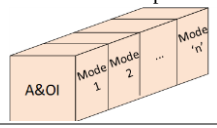
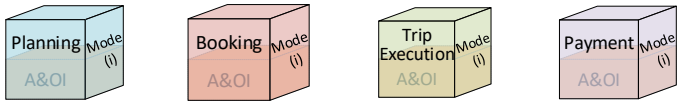
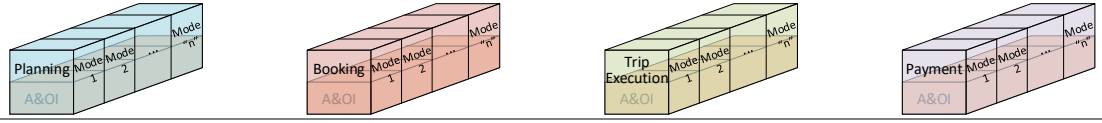
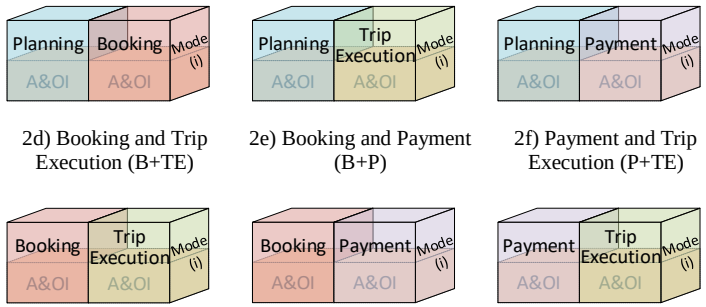
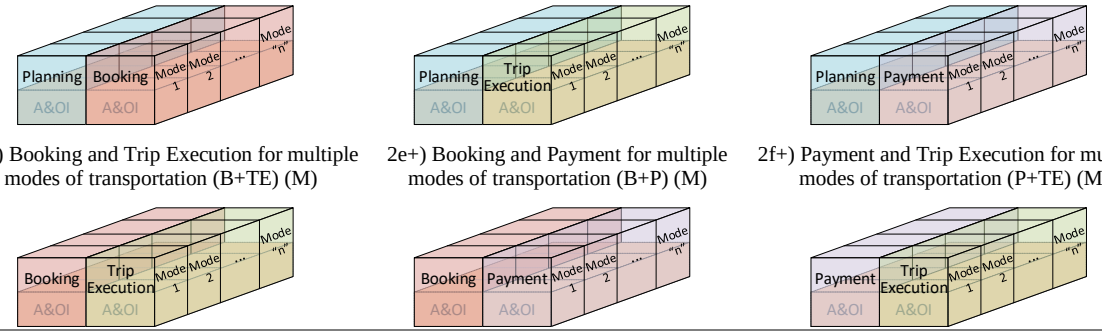
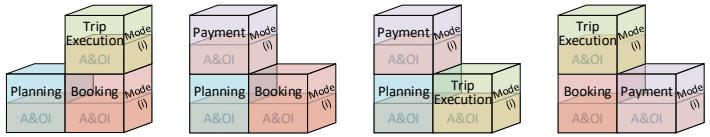
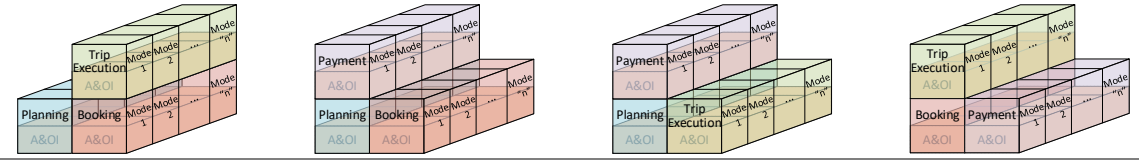
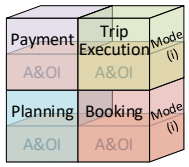
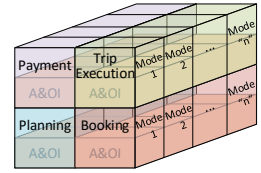
Function Integration	Category (Level)	Technical Levels of Integration including only single modes of transport	Technical Levels of Integration including multiple modes of transport
Non-integrated functions	**Only A&OI (0)**	0) Only Asset & Operator Information (A&OI) 	0+) Only Asset & Operator Information for multiple modes of transportation (A&OI (M)) 
Single-integrated functions	**Low integration (1)**	1a) Planning (Pl) 1b) Booking (B) 1c) Trip Execution (TE) 1d) Payment (P) 	1a+) Planning for multiple modes of transportation (Pl (M)) 1b+) Booking for multiple modes of transportation (B (M)) 1c+) TE for multiple modes of transportation (TE (M)) 1d+) Payment for multiple modes of transportation (P (M)) 
Two integrated functions	**Medium integration (2)**	2a) Planning and Booking (Pl+B) 2b) Planning and Trip Execution (Pl+TE) 2c) Planning and Payment (Pl+P) 2d) Booking and Trip Execution (B+TE) 2e) Booking and Payment (B+P) 2f) Payment and Trip Execution (P+TE) 	2a+) Planning and Booking for multiple modes of transportation (Pl+B) (M) 2b+) Planning and Trip Execution for multiple modes of transportation (Pl+TE) (M) 2c+) Planning and Payment for multiple modes of transportation (Pl+P) (M) 2d+) Booking and Trip Execution for multiple modes of transportation (B+TE) (M) 2e+) Booking and Payment for multiple modes of transportation (B+P) (M) 2f+) Payment and Trip Execution for multiple modes of transportation (P+TE) (M) 
Three integrated functions	**High integration (3)**	3a) Planning & Booking & Trip Execution (Pl+B+TE) 3b) Planning & Booking & Payment (Pl+B+P) 3c) Planning & Payment & Trip Execution (Pl+P+TE) 3d) Booking & Payment & Trip Execution (B+P+TE) 	3a+) Planning & Booking & Trip Execution for multiple modes of transportation (Pl+B+TE) (M) 3b+) Planning & Booking & Payment for multiple modes of transportation (Pl+B+P) (M) 3c+) Planning & Payment & Trip Execution for multiple modes of transportation (Pl+P+TE) (M) 3d+) Booking & Payment & Trip Execution for multiple modes of transportation (B+P+TE) (M) 
Four integrated functions	**Full integration (4)**	4) Planning and Booking and Payment and Trip Execution (Pl+B+P+TE) 	4+) Planning and Booking and Payment and Trip Execution for multiple modes of transportation (Pl+B+P+TE) (M) 

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Table 3. Proposed approach for the assessment of the Technical Level of Integration (TLI) of Mobility Service Providers (MSPs)

Level	Category	Number of integrated functions	Functional Capabilities	Sub-Level		Description
0	**Only A&OI**	*Non-integrated functions*	*Asset & Operator Information (A&OI)*	0)	A&OI	Functionality that allows for accessing information about transportation asset(s) (e.g., availability schedules, real-time location, type of asset) and/or transport operator(s) (e.g., type of mobility service, stations, time-schedules, prices). This functionality would also allow for the time-wise planning of a trip (i.e., planning in terms of date and time).
				0+)	A&OI (M)	If possible to access asset(s) and operator information from multiple modes of transport or multiple mobility providers, via a single digital interface.
1	**Low integration**	*Single-integrated functions*	*Planning (Pl)*	a)	Pl	Functionality that allows to plan a journey, both time-wise and route-wise. In this context, the *Planning* functionality is based on information about mobility assets and transport operators, and on route information. Therefore, if the functionality does not allow for the planning of routes but only for the planning of time and/or date(s), then the functionality should be referred as *A&OI* only, and not as *Planning*.
				a+)	Pl (M)	If possible to combine multiple modes of transport or multiple mobility providers for the Planning (as described above in this table) of a trip, on a single interface.
			Booking (B)	b)	B	Functionality that allows to make a reservation for the usage of (a) specific asset(s), mobility service, or (a) seat(s) on a specific transport or from a specific mobility service provider.
				b+)	B (M)	If possible to reserve (an) asset(s) from multiple modes of transport or multiple mobility providers via the same single interface.
			Trip Execution	c)	TE	Functionality that allows for the execution of a trip by means of a smart interface. That is, to open/close, lock/unlock, or active/deactivate (an) asset(s) through a digital ticket/key or smart card. Getting a PIN code on the smart interface is considered as a digital key/ticket.
				c+)	TE (M)	If possible to do *Trip Execution* (as described above in this table) using multiple modes of transport or multiple mobility providers, through a single (digital or smart) interface.
			Payment	d)	P	Functionality that allows for the payment for the utilisation or reservation of (a) transport asset(s) or for (a) trip(s), via a digital or smart interface (e.g., website, mobile app, smart card). It could be done in automatic after the registration of the payment method in such interface.
				d+)	P (M)	If possible to pay for the utilisation or reservation of a(n) asset(s) (or trip(s)) from multiple modes of transport or multiple mobility providers, via a digital interface.
2	**Medium integration**	*Two integrated functions*	Planning & Booking	a)	Pl + B	*Planning* and *Booking* (both, as described above in this table) are possible via the same single interface.
				a+)	(Pl+B) (M)	If possible to do *Planning* and *Booking* (both, as described above in this table) for multiple modes of transport or multiple mobility providers via the same single interface.
			Planning & Trip Execution	b)	Pl + TE	*Planning* and *Trip Execution* (both, as described above in this table) are possible via the same single interface.
				b+)	(Pl + TE) (M)	If *Planning* and *Trip Execution* (both, as described above in this table) for multiple modes of transport or multiple mobility providers are possible via the same interface.
			Planning & Payment	c)	Pl + P	Planning and *Payment* (both, as described above in this table) are possible on the same single interface.
				c+)	(Pl+P) (M)	If possible to do *Planning* and *Payment* (both, as described above in this table) for multiple modes of transport or multiple mobility providers via the same single interface.
			Booking & Trip Execution	d)	B + TE	Booking and Trip Execution (both, as described above in this table) are possible via the same single interface.
				d+)	(B + TE) (M)	If *Booking* and *Trip Execution* (both, as described above in this table) for multiple modes of transport or multiple mobility providers are possible via the same interface.
			Booking & Payment	e)	B + P	*Booking* and *Payment* (both, as described above in this table) are possible via the same single interface.
				e+)	B + P (M)	If *Booking* and *Payment* (both, as described above in this table) for multiple modes of transport or multiple mobility providers are possible via the same interface.
			Payment & Trip Execution	f)	P + TE	*Payment* and *Trip Execution* (both, as described above in this table) are possible via the same single interface.
				f+)	(P + TE) (M)	If *Payment* and *Trip Execution* (both, as described above in this table) for multiple modes of transport or multiple mobility providers are possible via the same interface.
3	**High integration**	*Three integrated functions*	Planning & Booking & Trip Execution	a)	Pl + B + TE	*Planning*, and *Booking*, and *Trip Execution* (all, as described above in this table) are possible via the same single interface.
				a+)	(Pl+B+TE) (M)	If *Planning*, and *Booking*, and *Trip Execution* (all, as described above in this table) for multiple modes of transport or multiple mobility providers are possible via the same interface.
			Planning & Booking & Payment	b)	Pl + B + P	*Planning*, and *Booking*, and *Payment* (all, as described above in this table) are possible via the same single interface.
				b+)	(Pl+B+P) (M)	If *Planning*, and *Booking*, and *Payment* (all, as described above in this table) for multiple modes of transport or multiple mobility providers are possible via the same interface.
			Planning & Payment & Trip Execution	c)	Pl + P + TE	*Planning*, and *Payment*, and *Trip Execution* (all, as described above in this table) are possible via the same single interface.
				c+)	(Pl+P+TE) (M)	If *Planning*, and *Payment*, and *Trip Execution* (all, as described above in this table) for multiple modes of transport or multiple mobility providers are possible via the same interface.
			Booking & Payment & Trip Execution	d)	B + P + TE	*Booking*, and *Payment*, and *Trip Execution* (all, as described above in this table) are possible via the same single interface.
				d+)	(B+P+TE) (M)	If *Booking*, and *Payment*, and *Trip Execution* (all, as described above in this table) for multiple modes of transport or multiple mobility providers are possible via the same interface.
4	**Full integration**	*Four integrated functions*	Planning & Booking & Payment & Trip Execution	4)	Pl+B+P+TE	*Planning* of a trip (as described above in this table) and reservation of, payment for & access to (a) specific asset(s), to make the (planned) trip is possible via the same single interface.
				4+)	(Pl+B+P+TE) (M)	*Planning* of a trip (as described above in this table) and reservation of, payment for & access to (a) specific asset(s), for multiple modes of transport or multiple mobility providers, to make the (planned) trip is possible via the same single interface.

As previously mentioned, the Technical Level of Integration (TLI) approach denotes an incremental scale. This has been represented by multiple levels and categories described in Table 3. Having incremental levels means that the higher the TLI, the more integrated functionalities a Mobility Service Provider (MSP) has. However, having more functions integrated does not necessarily mean that the functions from a lower level are also integrated. For instance, a Level 3-MSP which has integrated the *Booking*, *Payment* and *Trip Execution* functionalities (as shown in the fourth row of Table 2) is still missing the integration of the Planning function, which a Level 1- or Level 2-MSP could have integrated (for example as shown in the second and third rows of Table 2). In that sense, the TLI approach represents an incremental but non-inclusive scale.

Although the levels in the TLI approach are similar to those previously presented in the works by other authors (see Table 1), as also stated before, the main difference of this approach is that it exclusively focuses on the integration of technical functionalities. Contrary to the other approaches, in the TLI approach, the integration between modes of transport is just a sub-classification in each of the main levels, not a major criterion for the assessment of to which level an MSP would belong. Moreover, the direct correlation between the number of functionalities and the technical level of integration makes the TLI approach very easy to understand and to apply. For instance: 1) in the approach presented by Kamargianni et al. (2016), the proposed levels of integration are still "loosely categorised" (Sochor et al., 2018, p. 4) as demonstrated with an example of the application of the MaaS integration index proposed by the authors, the outcome could be very subjective. 2) In the approach by Sochor et al. (2018), the results of its implementation could also be subjective because there is some room for interpretation of the levels within their topology (Sochor et al., 2018). In contrast, the TLI approach attempts to avoid those issues by providing a comprehensive classification of multiple sub-levels and categories and by only considering the integration of functionalities as the main criterion to differentiate them. This also makes the application of the approach and the identification of the technical level of integration of MSPs a straightforward process.

4. Methodology to apply the TLI approach

In this section, we describe the process that was conducted for the assessment of the Shared electric Mobility Providers (SeMPs) in our study, and for the application of the Technical Level of Integration (TLI) approach presented in the previous section. As mentioned before, the research presented here is a continuation of a previous work of the same authors of this paper (Reyes García et al., 2020), in which the business models of European SeMPs are analysed in the context of electric Mobility as a Service (eMaaS). In this study, we utilise the list of SeMPs resulting from that work as a base for the list of SeMPs evaluated here. The list used in this paper is an updated version that excludes SeMPs that do not operate anymore in Europe (e.g. the e-car sharing provider *EkoRent*) or that do not operate anymore at all (e.g., the e-car sharing provider *Tellis*). It includes a few new SeMPs currently operating in Europe (e.g., the Multi Transport Integrator *Jelbi*). In addition, the names of some SeMPs that now operate under a new name have been updated (e.g., for the (e-)car sharing provider *Citiz*, which was previously branded as *City Roul*). The list of all SeMPs evaluated in this study is presented in the appendix.

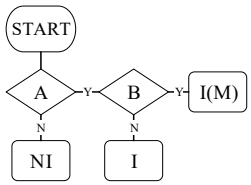
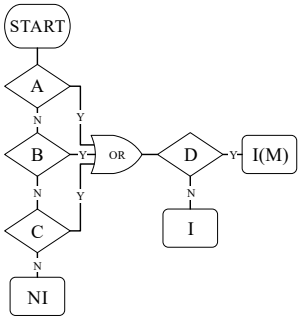
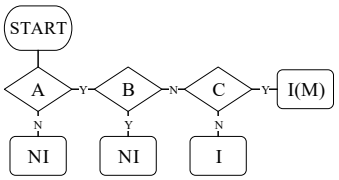
The overall process for the assessment of the technical functionalities of Mobility Service Providers (MSPs) following the TLI approach can be described in three simple steps. These steps are: 1) identify the interfaces used by the MSP, 2) determine which functions are integrated in the identified interface(s), and 3) assign the correspondent TLI to the MSP in accordance to the type and number of integrated functions in its interface(s).

Thus, in order to assess the TLI of the Shared electric Mobility Providers (SeMPs) under study, we firstly conducted research to identify which interfaces are used by each of those SeMPs for the integration of their technical functionalities (i.e., *Asset & Operator Information*, *Planning*, *Booking*, *Payment* and *Trip Execution*). Based on the information provided in the SeMPs' official websites, we identified three main interfaces for the integration of their technical functionalities, namely website, smart card, and mobile

app. In some cases, particularly for (e-)bike sharing providers, other interfaces such as a tablet or a digital device embedded in the (e)bikes, or a machine located at their stations for the payment and/or (un)locking of the (e)bikes, were also identified and considered for the analysis.

Secondly, we determined which functionalities from each SeMPs are integrated in each of their interfaces. To do so, we designed the assessment scheme presented in Table 4. The process described in Table 4 is based on the functionalities' descriptions presented previously in Table 3. By following all the steps (from 1 to 5) presented in Table 4, it can be determined whether or not the functions are integrated into the SeMPs' interfaces. The information needed to answer the questions in the process described in Table 4 was obtained from the SeMPs' official website and/or from the Google's mobile app market place[9].

Table 4. Assessment scheme for determining which technical functionalities are integrated into Mobility Service Providers' interfaces

Step	Function	Decision criteria	Process flow
1	*Planning*	A. Does the interface provide information about the possible routes to execute a trip? B. Does the route information include multiple modes of transport or multiple MSPs?	For steps 1 and 2: 
2	*Booking*	A. Does the interface allow for the reservation of a specific asset or trip? B. Is it possible for multiple modes of transport or multiple MSPs?	
3	*Trip Execution*	A. Does the interface allow to open or unlock transportation assets? B. Does the interface allow for travelling with a digital ticket? C. Does the interface allow to get a code to open or unlock transportation assets? D. Is it possible for multiple modes of transport or multiple MSPs?	For steps 3 and 4: 
4	*Payment*	A. Does the interface allow for the payment for the utilisation or reservation of a transportation asset or for a trip? B. Does the interface allow for the registration of a payment method and then automatic payment is possible for the utilisation or reservation of a transportation asset or for a trip? C. Is the payment deducted automatically from the interface, after the reservation or utilisation of a transportation asset or after the execution of a trip? D. Is it possible for multiple modes of transport or multiple MSPs?	For step 5: 
5	*Only Asset & Operator Information*	A. Does the interface provide information about transportation assets (e.g., availability schedules, real-time location, type of asset) and/or transport operator(s) (e.g., type of mobility service, stations, time-schedules, prices)? B. Does this interface also integrate any of the other functionalities? C. Is the information provided applicable for multiple modes of transport or multiple MSPs?	Legend: N: No; Y: Yes; NI: Not Integrated; I: Integrated; I(M): Integrated Multimodal

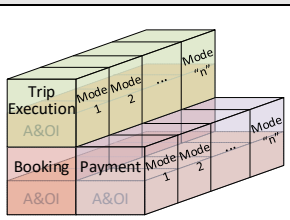
Finally, with the results obtained from the previous step and based on the levels and sublevels provided in Table 3, we assigned the correspondent Technical Level of Integration (TLI) to each of the Shared electric Mobility Providers (SeMPs) in our study. For the analysis, three different raters individually identified the available SeMPs' interfaces and assessed the integration of their functions to determine the TLI of each SeMP. To ensure consistency, the raters followed the methodology described in this section and used the assessment scheme presented in Table 4. However, the degree of agreement between the individual raters was not assessed.

9 https://play.google.com/store/apps

Below, an example of the application of the process described in this section is presented for one Mobility Service Provider (MSP). The MSP under evaluation is one from our list of European SeMPs, that is, *Lime*, a micro (e)mobility provider with operations all around the world.

1) Identify the interface(s) used by the MSP.
   - From the information available at *Lime*'s official website, it is recognized that a mobile app is the main interface used by this SeMP.
2) Determine which functions are integrated in the identified interface(s).
   - Based on the information available at *Lime*'s official website, and on the overview information of the *Lime*'s mobile app at the Google's mobile app market place, the process described in Table 4 is followed. The results are presented in Table 5.

Table 5. Results from the process to determine which technical functionalities are integrated in Lime's mobile app

Interface: Mobile app	**Process Flow evaluation**					**Functionalities integrated:**
Step	A	B	C	D	Result	
1 – Planning	N	N	-	-	NI	
2 – Booking	Y	Y	-	-	I(M)	
3 – Trip Execution	Y	-	-	Y	I(M)	
4 – Payment	Y	-	-	Y	I(M)	
5 – Only A&OI	Y	Y	-	-	NI	

3) Assign the correspondent Technical Level of Integration (TLI) to the MSP in accordance to the type and number of integrated functions in its interface(s).
   - From the results found in step 2), it became clear that *Lime*'s mobile app has three technical functionalities integrated. Since the TLI is directly connected to the number of technical functionalities integrated, it can already be inferred that *Lime* has a Level 3 – high integration level.
   - To know which specific TLI Lime belongs to, its exact functionalities are to be taken into account. From Table 5, *Lime*'s mobile app integrates the following functionalities: (B+P+TE) (M)
   - Finally, comparing the results obtained in Table 5 with the description of the sublevels of Level 3 provided in Table 3: Lime has a Level 3-d$^{\pm}$) *Technical Level of Integration* (TLI).

In the next section, we present the complete results of our study. Although we do not present the step-by-step process as in the previous example, the methodology presented in this section was followed as described. As will be explained in the next section, all interfaces from each Shared electric Mobility Provider in our study were analysed, but only the ones with the higher level of integration are presented in the final results.

5. Results and Discussion

Based on the Technical Levels of Integration (TLI) approach presented in §3 and following the methodology described in the previous section, in this section we evaluate the level of integration of the technical functionalities of 128 Shared electric Mobility Providers (SeMPs) currently operating in the European market. The goal of the analysis presented in this section is twofold. Firstly, it aims at demonstrating the applicability of the TLI approach presented in the previous section. Secondly, it aims at giving an overview of the current state of the market with respect to the technical level of integration of European SeMPs.

One of the first findings encountered when conducting the Technical Level of Integration (TLI) analysis was that many of Shared electric Mobility Providers (SeMPs) under study have their functionalities integrated in more than one interface (e.g., website, and/or mobile app, and/or smart card). For the presentation of the results, we have considered only one interface per SeMP. The decision was to include the results only

from the interfaces with the higher level of integration, that is, the interfaces that have more functionalities integrated. In case that two or more interfaces from a same SeMP have equal number of functionalities integrated, then the interface with more scalability[10] capacity was presented as the main Technical Level of Integration result. The results of the assessment are shown (in alphabetical order) in Table 6.

Table 6. Technical Level of Integration (TLI) of Shared electric Mobility Providers (SeMPs) with respect to (e)MaaS functionalities

Shared (electric) Mobility Provider	TLI	Shared (electric) Mobility Provider	TLI	Shared (electric) Mobility Provider	TLI
1. 2EM	L2-e) [a]	44. free2move	L3-d) [b]	87. OurGreenCar	L2-e^{+}) [*, a]
2. aimo	L3-d) [b]	45. GoAbout	L4^{+}) [b]	88. Partago CVBA	L2-d) [b]
3. Amber	L2-d) [b]	46. GoMore	L2-d) [a, c]	89. Poppy	L2-d^{+}) [b]
4. BattMobiel	L2-d) [b, c]	47. GoodMoovs	L2-d^{+}) [b]	90. Postfossil	L2-e) [*, a]
5. Bilkollektivet	L1-b) [*, a]	48. Google Maps	L1-a^{+}) [a, b]	91. privateshare	L3-d) [*, b]
6. Billy	L3-d) [b]	49. goUrban	L3-d) [b]	92. Radiuz	L2-e+) [*, a]
7. Bird	L3-d) [b]	50. GreenGo	L2-d) [b]	93. RUHRAUTOe	L2-e) [*, a]
8. blinkee.city	L3-d) [b]	51. GreenMobility	L2-d) [b]	94. Scooty	L3-d) [b]
9. Bluecub	L2-e) [*, a, b]	52. GreenWheels	L3-d) [*, b]	95. Share a starcar	L3-d) [b]
10. Bluely	L2-e) [*, a, b]	53. GVH	L4^{+}) [b, e]	96. Sharoo	L3-d) [b]
11. book-n-drive	L2-d) [*, b]	54. Hertz 24/7	L3-d) [b]	97. Shuttel	L2-f^{+}) [*, d]
12. bycyklen	L2-e) [*, a]	55. Hirebike	L1-d) [b]	98. SnappCar	L3-d) [a, b, c]
13. Cambio	L2-e) [*, b]	56. HiyaCar	L3-d) [b]	99. Spinlister	L2-e) [a, b]
14. Car2go	L3-d) [*, b]	57. HVV	L4^{+}) [b]	100.stadtauto	L3-d) [b]
15. Car Amigo	L2-e) [a]	58. I Travel Business Card	L2-f^{+}) [d]	101.stadtmobil	L2-e) [*, a, b]
16. CareCar	L1-b) [*, a]	59. INDIGO weel	L2-f^{+}) [b]	102.Switchh	L2-f^{+}) [d]
17. Cargoroo	L3-d) [b]	60. Jelbi (BVG)	L4^{+}) [b]	103.TADAA!	L3-d) [b]
18. caruso	L1-b) [*, a]	61. JUMP	L3-d) [b]	104.TaM	L2-f) [*, d, h]
19. Carvelo 2 Go	L2-e) [b]	62. Juuve	L3-d) [b]	105.teilAuto	L3-d) [b]
20. Cityscoot	L3-d) [*, b]	63. Kyyti	L4^{+}) [b, f]	106.TIER	L3-d) [b]
21. Citiz	L3-d) [b]	64. LetsGo	L2-e) [a, b]	107.tim	L2-f^{+}) [*, d]
22. Clem	L2-e) [a]	65. Lime	L3-d+) [b]	108.Totem Mobi	L3-d) [b]
23. Co cars	L2-e) [*, a]	66. ListNride	L1-b) [a]	109.TripGo	L1-a^{+}) [a, b]
24. co-wheels	L2-e) [*, b]	67. Mo.Point	L2e+) [*, a]	110.Troty	L3-d) [b]
25. Combitrip	L1-a+) [a]	68. Mo2Drive	L3-d) [b]	111.TURNN	L2-a^{+}) [*, b]
26. Coup	L3-d) [b]	69. MOBILEEEE	L3-d) [b]	112.TURO	L2-e) [*, b]
27. Deelootoo	L3-d) [b]	70. mobility	L23) [*, a, b]	113.UFO Drive	L3-d) [b]
28. Deutsche Bahn	L4) [*, b]	71. MobilityMixx	L2-f^{+}) [d]	114.Urbee	L2-e) [a, b]
29. de Mobiliteits Manager	L2-f^{+}) [d]	72. MOL Limo	L3-d) [b]	115.Urbi	L2-e^{+}) [b]
30. DriveCarSharing	L2-e) [*, a]	73. Moov'in.paris	L3-d) [b]	116.Vélib'	L2-f) [*, d]
31. DriveNow	L3-d) [b]	74. Moovel DE	L4^{+}) [b]	117.voi	L3-d) [b]
32. Drivy	L3-d) [b, c]	75. Moovit	L1-a^{+}) [a, b]	118.VRN	L2-f^{+}) [*, d]
33. E-car club	L3-d) [b]	76. MouvNGo	L1-b) [*, a]	119.We Drive Solar	L2-d) [b]
34. e-WALD	L2-f) [d]	77. MoveAbout	L1-e^{+}) [*, b]	120.Wheesy	L3-d) [b]
35. ecarregio	L3-d) [*, b]	78. Movelo	L2-d) [b]	121.Whim	L4^{+}) [b]
36. Elektrip	L1-b) [a]	79. My-e-Car	L1-b) [*, a]	122.Wiener Linien	L4^{+}) [*, b, e, h]
37. Eloop	L3-d) [b]	80. MyWheels	L3-d) [*, b, c]	123.Wij Mobiliteitskaart	L2-f^{+}) [d]
38. emmy	L3-d) [b]	81. Nabobil	L3-d) [b, c]	124.WIND	L3-d) [b]
39. Enuu	L3-d) [b]	82. NS railways	L4) [*, b, g]	125.XXImo	L3-d^{+}) [*, b, c]
40. Enterprise car club	L3-d) [b]	83. ÖAMTC easy way	L3-d) [b]	126.Yelo Mobile	L3-d^{+}) [*, b]
41. Family of Power	L2-e) [*, a]	84. Olympus	L3-d^{+}) [b]	127.ZenCar	L2-e) [*, b]
42. Felyx	L3-d) [b]	85. Onzeauto	L3-d) [b]	128.Zipcar	L3-d) [*, b, c]
43. Flinkster	L3-d^{+}) [b]	86. Oui Car	L3-d) [*, b]		

Notes:
[*] Has more than one interface for the integration of (e)MaaS' technical functionalities.
[a] Applicable for the website.
[b] Applicable for the mobile app.
[c] *Trip Execution* functionality is integrated with the exception for some specific asset(s) or mode(s) of transport.
[d] Applicable for the smart card.
[e] *Booking* functionality only applicable for Public Transport.
[f] *Payment* functionality counted as integrated (based on the information available in website), but not clear from the information of the mobile app's functionalities if *Payment* is actually integrated.
[g] *Planning* functionality multimodal, all other functionalities only applicable for train services.
[h] *Payment* and *Trip Execution* functionalities only applicable for Public Transport.

10 For example, a mobile app is considered as a more scalable interface than a smart card. The reason is that a mobile app has the capacity to integrate all (e)MaaS technical functionalities (i.e., Planning, Booking, Payment and Trip Execution). In contrast, the Booking or Planning functionalities are not possible to be integrated into a smart card.

To offer a first glance of the current state of the market, with the outcomes presented in Table 6, Fig. 2 shows an overview of the overall results of our analysis. From the figure, it can be observed that none of the Shared Electric Mobility Providers (SeMPs) evaluated in our study have *Asset and Operator Information* (A&OI) as a non-integrated function on their interfaces. In fact, most SeMPs in our study (approx. 83%) have either medium or high level of integration with respect to their (e)Maas functionalities. In contrast, only a few of the evaluated SeMPs have fully integrated (approx. 8%) (e)MaaS functionalities or a low level of integration (approx. 9%).

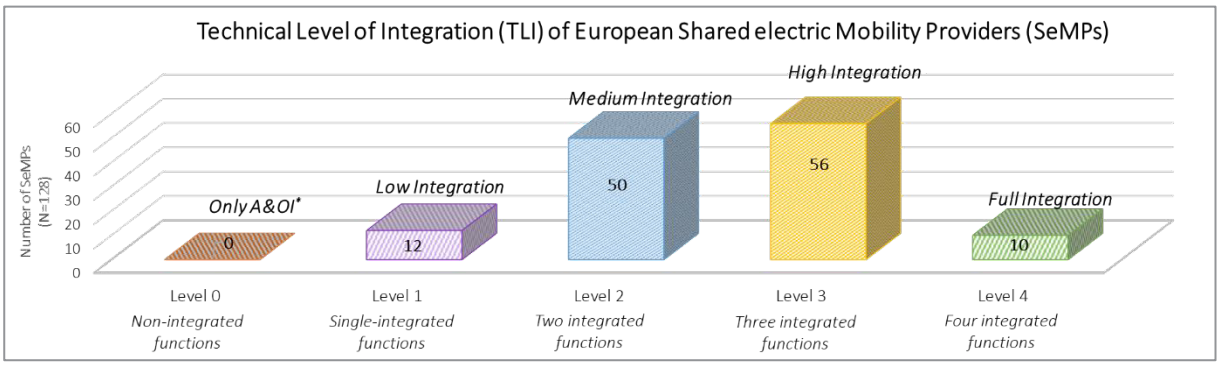


Figure 2. Overview of the results from the assessment of the TLI of European SeMPs' functionalities on a single interface

In more detail, Fig. 3 shows all the sublevels considered for the assessment of the Technical Level of Integration (TLI) of European SeMPs. From this figure, it becomes clearer that from those Shared electric Mobility Providers (SeMPs) having fully integrated functionalities, 80% have them for multiple modes of transport or multiple mobility providers. Fig. 3 also shows that the sublevel 3-d) (i.e., the integration of *Booking*, *Payment* and *Trip Execution*) is clearly the most frequent TLI among the evaluated SeMPs (approx. 40% of the total evaluated SeMPs belong to this sublevel). The outcome at this specific sublevel also offers a very good insight about which function, in general, European SeMPs are currently missing if aiming to become fully integrated (e)MaaS players, that is, *Planning*. The integration of the *Planning* functionality is further discussed later in this section.

At the medium integration level shown in Fig. 3, the sublevel 2-d) outstands. Although only approx. 17% of the evaluated Shared electric Mobility Providers (SeMPs) have the *Booking* and *Planning* functionalities integrated as a pair on a single interface, these two functions are also integrated with other functions at higher levels, as seen is levels 3d), 3d+), 4) and 4+). In this sense, the integration of the *Booking* & *Payment* functionalities together, is the most prevalent in our assessment, with approx. 72% of all evaluated SeMPs having both of these functionalities integrated on a single interface. Lastly, Fig. 3 also shows the breakdown of the sublevels at the low integration level. In specific, the results presented in the figure show that the *Booking* functionality (both for single and for multiple modes of transport or multiple mobility providers) and the *Planning* functionality (but only for multiple modes of transport or multiple mobility providers) are the main functionalities still offered as single-integrated functions by the SeMPs evaluated in our analysis.

When looking at specific functions, there are two main observations that can be highlighted from Fig. 3. Firstly, the vast majority of the evaluated Shared electric Mobility Providers (SeMPs), approximately 88%, have the *Booking* functionality integrated. Due to the nature of the services under study, this result is not surprising.

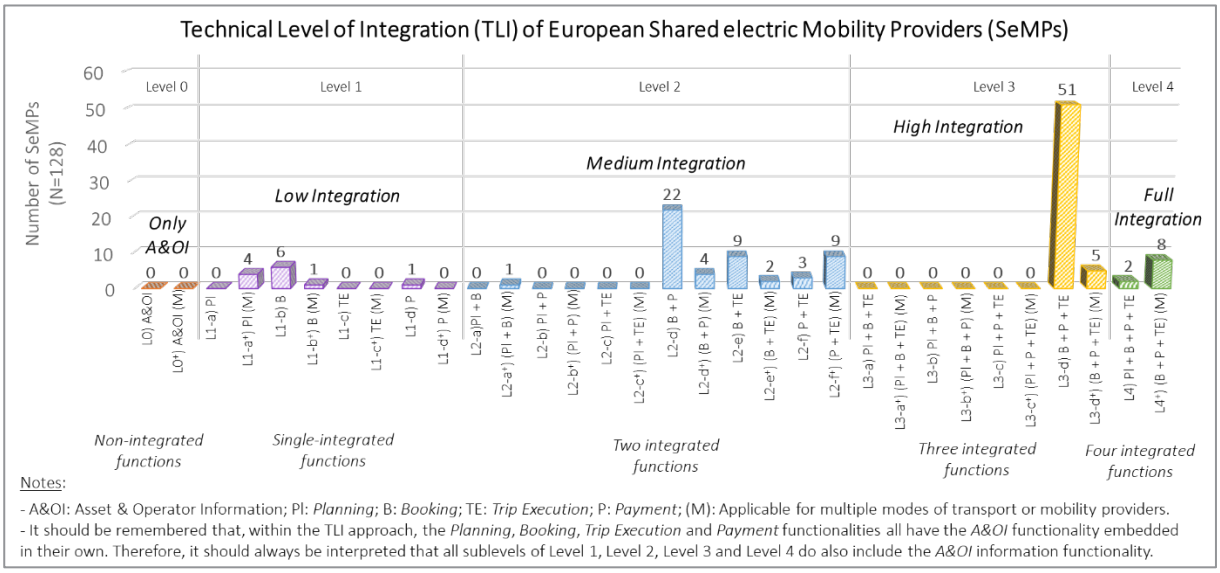


Figure 3. Detailed overview of the results from the assessment of the TLI of European SeMPs' functionalities on a single interface

However, it is worth noticing that the Booking functionality is mostly integrated as a single-mode function, while Booking for multiple modes of transport or multiple Mobility Service Providers has been integrated with other functionalities only by approx. 16% of the total evaluated SeMPs, and by approx. 19% of the SeMPs that have the Booking functionality integrated. In some cases, Shared electric Mobility Providers' (SeMPs) business models are formulated in such a way that there is no need for the *Booking* functionality, because their operating model works without the reservation of specific assets. In that case, and only when such SeMPs have all other functions (i.e., *Planning*, *Payment* and *Trip Execution*) integrated on a single interface, they can be considered as fully integrated mobility providers. However, as shown in the results of our analysis for the sublevels L3c) and L3c+), we did not encounter any SeMP under this situation.

Secondly, it is remarkable that the *Planning* functionality is integrated by just a few of the evaluated SeMPs (approx. 12%). Moreover, when integrated, it is mostly by Level 4 SeMPs (67% of the total cases). Contrary to the *Booking* functionality, the *Planning* function is more common among SeMPs that have it available for multiple modes of transport or multiple mobility providers (approx. 87% of the total cases where Planning is integrated). The fact that only few of the evaluated SeMPs have the *Planning* functionality integrated is understandable because, in the context of this research, the *Planning* function has been defined as having the capacity *to plan a journey both route-wise and time-wise* (see *Level 1a*) in Table 3). Thus, in our analysis, SeMPs that have a "planning" function that is based only on time schedules and does not offer possible routes to execute a trip, were not counted as having the Planning functionality integrated. However, "time-wise planning" would be possible by having certain *Asset & Operator Information* (A&OI) available (e.g. time schedules, asset(s) availability). In that sense, all those SeMPs in our study that have the *Booking* functionality integrated (which is only possible by having A&OI available), would have that kind of "planning" integrated too. Therefore, if the *Planning* functionality would have been defined like that (i.e., only as time-wise planning), all SeMPs evaluated in our study as highly integrated SeMPs would have become "fully integrated" SeMPs. For a truly seamless journey experience, as stated in our eMaaS working definition and intended by the (e)MaaS models, we believe that the *Planning* function should always be considered as proposed in this paper. In fact, Level 4-SeMPs found in our analysis demonstrate the possibility to integrate such a functionality with any of the other (e)MaaS functionalities.

Similarly, *Payment* as a single-integrated function was only counted for one SeMP. This is explained due to the facts that, firstly, there are not many SeMPs that have an interface with only *Payment* as a single-integrated function. As demonstrated by the results at the medium integration- and high integration-levels, the *Payment* functionality is commonly integrated with the *Booking* or *Trip Execution* functionalities (see sublevels L2: d, d+, f & f+; and L3: d & d+). In the context of mobility services, it is difficult to conceive interfaces (such as a mobile app, a smart card or a website) where these functions are not integrated. Secondly,

even though some SeMPs do have interfaces with only *Payment* as a single-integrated function (e.g., Public Transport Operators or (e)bike sharing providers where there is no need for the reservation of a specific assets, that is, there is no need for *Booking*), those interfaces were not counted as part of the results. The reason is that, as mentioned before, only one interface per SeMP was considered for the presentation of the results, that is, the interfaces with more functions integrated. Thus, if such SeMPs have interfaces with more (e)MaaS functionalities integrated than the one for single-integrated *Payment*, then those interfaces are the ones that were considered for the results. Thirdly, during the course of our analysis, we encountered many SeMPs that offer automatic billing and payment for their services, via direct debit or by credit card (i.e., users only need to register their bank data on the website or mobile app and then the payment goes automatic after using the service). For those cases, we considered the *Payment* functionality as to be actually integrated into the interface from where it is automatically deducted and which also integrates other functionalities (e.g. *Trip Execution* for a smart card or *Booking* for a mobile app).

Concerning *Trip Execution*, Fig. 3 shows that it is the only functionality that was not counted as a single-integrated function for any of the evaluated SeMPs. However, this is because (as mentioned before) only one interface per SeMP was considered for the presentation of the results. Moreover, only the interfaces with the most functions integrated (per SeMP) were included. During the course of our analysis we did encounter some SeMPs that have an interface with *Trip Execution* as a single-integrated functionality (e.g. e-bike sharing providers with a PIN lock/unlock device mounted on the bikes), but these SeMPs are not represented in Fig. 3 because they also have at least another interface with a higher level of integration.

6. Concluding remarks and future work

In this paper we presented an approach for the assessment of the *Technical Level of Integration (TLI)* of Mobility Service Providers (MSPs) and we specifically evaluated 128 Shared electric Mobility Providers (SeMPs) based on that approach. With the analysis and results presented in this paper, we demonstrated that the proposed TLI approach offers an effective method to determine, and easily visualize, the level of integration of the technical functionalities of MSPs. Although in our study we use the TLI approach specifically for the assessment of Shared SeMPs, it should not be understood that its application is limited only to that type of MSPs.

The results of our study showed that the current state of the European Shared Electric Mobility (SEM) market already includes Mobility Service Providers (MSPs) with a high- or even a full-level of integration with respect to their technical functionalities. However, most of the MSPs in the European SEM market still lack the integration with respect to multiple modes of transport of multiple MSPs. In our proposed Technical Level of Integration (TLI) approach, we did not considered the latter as an extra functionality. It was reflected that for a balanced assessment between MSPs the integration of multiple modes of transport should not be directly compared to the core (e)MaaS technical functionalities. The reasoning behind this decision is that we perceive these kind of integrations as different. The integration of multiple modes of transport does not imply the integration of an extra functionality per se, because the same technical functionalities would remain applicable either for single or for multiple modes of transport. In that sense, we did take the multimodal integration into account but only as a benefit for MSPs at the same level of integration, and not as an extra functionality that would give MSPs a higher level of integration.

An important remark is that during the course of our study, we encountered a few examples of MSPs that have integrated multimodal capabilities but only for certain functions. Even though the classification of the main TLI (i.e., Level 0 to Level 4) would not be affected, with our current approach it was difficult to assess to which sublevel those kind of MSPs would exactly belong. Therefore, the decision was made to: 1) if most of the functionalities (>50%) are integrated for multiple modes of transport of multiple MSPs, then the MSP would be classified as if it would have all multimodal functions integrated. Or, 2) if 50% (or less) of the functionalities are integrated for multiple modes of transport of multiple MSPs, then the MSP would be classified as if it would not have any multimodal functions integrated. In both cases, we attached a footnote

to clarify the applicability of the multimodal functional capability. In future work this will be solved by also including subclassifications of the (+) levels to make sure any possible combination among the functional blocks is covered.

Another remark is that the degree of agreement between the different raters of the Technical Level of Integration (TLI) evaluation in our study was not assessed. For the analysis presented in this paper, three different raters individually identified the available interfaces and assessed the integration of the functions to determine the TLI of the Shared electric Mobility Providers in our study. To ensure consistency in the process, the raters followed the methodology described in §4 and used the assessment scheme presented in Table 4. However, in the current paper we did not measure the degree of agreement between the individual raters. For future implementations of the TLI approach, the assessment of MSPs by different raters is recommended in combination with an inter-rater reliability test (e.g., Cohen's Kappa) to ensure the reliability of such an evaluation.

As a final remark we would like to (re)emphasize that the current paper is a continuation of a previous work of the same authors of this paper (Reyes García et al., 2020). In that sense, in order to avoid repetition of certain information, we did not include details about the Shared electric Mobility Providers in our study (e.g., business models, differences between mobility services, operating countries). In the short-term future, as we expect for the technical functionalities of Mobility Service Providers, both the previous and the current work will be integrated themselves.

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Appendix

List of Shared electric Mobility Providers included in our study. Adapted from Reyes García et al. (2020).

Shared (e-)Mobility Provider	Type of (e-)Mobility Service
1. 2EM	(P2P) (e-)Car sharing
2. aimo	e-Car sharing
3. Amber	e-Car sharing
4. BattMobiel	(shared) e-Car leasing and (e-)bike leasing
5. Bilkollektivet	(e-)Car sharing and e-bike sharing
6. Billy	e-Bike sharing
7. Bird	e-Kick scooter sharing
8. blinkee.city	e-Scooter sharing (Moped)
9. Bluecub	e-Car sharing
10. Bluely	e-Car sharing
11. book-n-drive	(e-)Car sharing
12. bycyklen	e-Bike sharing
13. Cambio	(e-)Car sharing
14. Car2go	(e-)Car sharing
15. Car Amigo	(P2P) (e-)Car Sharing
16. CareCar	e-Car sharing
17. Cargoroo	e-bike sharing
18. caruso	(e-)Car sharing
19. Carvelo 2 Go	e-Bike sharing
20. Cityscoot	e-Scooter sharing (Moped)
21. City Roul	(e-)Car sharing
22. Clem	e-Car sharing & other services
23. Co cars	(e-)Car sharing and e-bike sharing
24. co-wheels	(e-)Car sharing and e-bike sharing
25. Combitrip	Multimodal Trip Planner with shared mobility options
26. Coup	e-Scooter sharing (Moped)
27. Deelootoo	(e-)Car sharing
28. Deutsche Bahn (Connect GmbH)	Multi Transport Integrator with shared (e-)mobility options & Train Trip Planner
29. de Mobiliteits Manager	Multi Transport Integrator with shared (e-)mobility options
30. DriveCarSharing	(e-)Car sharing
31. DriveNow	(e-)Car sharing
32. Drivy	(P2P) (e-)Car sharing
33. E-car club	e-Car sharing
34. e-WALD	e-Car sharing
35. ecarregio	e-Car sharing
36. Elektrip	e-Car sharing and e-ride sharing
37. Eloop	e-Car sharing and e-car rental
38. emmy	e-Scooter sharing (Moped)
39. Enuu	Light Electric Car Sharing
40. Enterprise car club	(e-)Car sharing
41. Family of Power	e-Car sharing
42. Felyx	e-Scooter sharing (Moped)
43. Flinkster	(e-)Car sharing
44. free2move	Car sharing and (e-)Mobility Transport Aggregator
45. GoAbout	Multi Transport Integrator & Multimodal Trip Planner with shared (e-)mobility options
46. GoMore	(P2P) (e-)Car sharing, (shared) (e-)car leasing and (e-)ride sharing
47. GoodMoovs	(Corporate) e-Car sharing and e-bike sharing
48. Google Maps	Multimodal Trip Planner with shared (e-)mobility options
49. goUrban	e-Scooter sharing (Moped)
50. GreenGo	e-Car sharing
51. GreenMobility	e-Car Sharing
52. GreenWheels	(e-)Car sharing
53. GVH	Multi Transport Integrator & Multimodal Trip Planner with shared (e-)mobility options
54. Hertz 24/7	(e-)Car sharing
55. Hirebike	(e-)Bike sharing
56. HiyaCar	(P2P) (e-)Car sharing
57. HVV	Multi Transport Integrator & Multimodal Trip Planner
58. I Travel Business Card	Multi Transport Integrator with shared (e-)mobility options
59. INDIGO weel	Micro (e-)mobility sharing (bikes & e-scooters (Moped))
60. Jelbi (GVH)	Multi Transport Integrator with shared (e-)mobility options & Multimodal Trip Planner
61. JUMP	Micro e-mobility sharing (e-kick scooters & e-bikes)
62. Juuve	(e-)Car sharing
63. Kyyti	Multimodal Trip Planner with shared mobility options and on-demand ride sharing
64. LetsGo	(e-)Car sharing
65. Lime	Micro (e-)mobility sharing (e-kick scooters & (e-)bikes)
66. ListNride	(P2P) (e-)bike sharing
67. Mo.Point	(e-)Car sharing and (e-)bike sharing
68. Mo2Drive	(e-)Scooter sharing (Moped)
69. MOBILEEEE	e-Car sharing
70. mobility	(e-)Car sharing & e-scooter sharing (Moped)
71. MobilityMixx	Multi Transport Integrator
72. MOL Limo	(e-)Car sharing
73. Moov'in.paris	e-Car sharing
74. Moovel DE	Multi Transport Integrator with shared (e-)mobility options
75. Moovit	Multimodal Trip Planner with shared mobility options and Maas platform
76. MouvNGo	e-Car sharing
77. MoveAbout	e-Car sharing and e-bike sharing
78. Movelo	(Corporate) e-Bike sharing
79. My-e-Car	e-Car sharing
80. MyWheels	(P2P) (e-)Car sharing
81. Nabobil	(P2P) (e-)Car sharing
82. NS railways	Multi Transport Integrator with shared (e-)mobility options
83. ÖAMTC easy way	e-Scooter sharing (Moped)
84. Olympus	Multi Transport Integrator with shared (e-)mobility options
85. Onzeauto	(shared) e-Car Leasing & car sharing
86. Oui Car	(P2P) (e-)Car sharing
87. OurGreenCar	(Corporate) e-Car sharing and micro e-mobility sharing (e-kick scooter and e-bikes)
88. Partago CVBA	e-Car sharing
89. Poppy	(e-)Car sharing & e-scooter sharing (Moped)
90. Postfossil	(e-)Car sharing
91. privateshare	(P2P) (e-)Car sharing
92. Radiuz	Multi Transport Integrator with shared (e-)mobility options
93. RUHRAUTOe	e-Car sharing
94. Scooty	e-Scooter sharing (Moped)
95. Share a starcar	e-Car sharing
96. Sharoo	(P2P) (e-)Car sharing
97. Shuttel	Multi Transport Integrator with shared (e-)mobility options
98. SnappCar	(P2P) (e-)Car sharing
99. Spinlister	(P2P) (e-)Bike sharing
100. stadtauto	(e-)Car sharing
101. stadtmobil	(e-)Car sharing
102. Switchh	Multi Transport Integrator with shared (e-)mobility options
103. TADAA!	e-Car sharing
104. TaM	Multi Transport Integrator & Multimodal Trip Planner with shared (e-)mobility options
105. teilAuto	(e-)Car sharing
106. TIER	e-Kick scooter sharing
107. tim	Multi Transport Integrator with mobility hubs and shared (e-)mobility options
108. Totem Mobi	Light Electric Car Sharing
109. TripGo	Multimodal Trip Planner with shared (e-)mobility options

110.	Troty	e-Kick scooter sharing
111.	TURNN	Multimodal Trip Planner, Multi Transport Integrator (mobility card) with shared (e-)mobility options and Mobility consultancy
112.	TURO	(P2P) (e-)Car sharing
113.	UFO Drive	e-Car rental
114.	Urbee	e-Bike sharing
115.	Urbi	Multi Transport Integrator with shared (e-)mobility options
116.	Vélib'	(e-)Bike sharing
117.	voi	e-Kick scooter sharing
118.	VRN	Multi Transport Integrator & Multimodal Trip Planner with shared (e-)mobility options
119.	We Drive Solar	e-Car Sharing
120.	Wheesy	e-Car Sharing
121.	Whim	Multi Transport Integrator
122.	Wiener Linien	Multi Transport Integrator & Multimodal Trip Planner with shared (e-)mobility options
123.	Wij Mobiliteitskaart	Multi Transport Integrator with shared (e-)mobility options
124.	WIND	e-Kick scooter sharing
125.	XXImo	Multi Transport Integrator with shared (e-)mobility options
126.	Yelo Mobile	e-Car sharing
127.	ZenCar	e-Car sharing
128.	Zipcar	(e-)Car sharing

Notes:

- Peer-to-peer (P2P) refers to a business model where consumers directly interact to get/offer vehicle sharing services via an online platform.
- An “e-” preceding the type of mobility service indicates that the SeMP uses only electric vehicles (EVs) for providing its service. Whereas an “(e-)” indicates that those providers or services are not exclusively electric but do offer or contain EVs within their fleets or services.