“Technical Levels of Integration”
From Shared electric Mobility providers to electric Mobility as a Service players

J. Roberto Reyes García
03-December-2019
## About me

University of Twente – Department of Design, Production and Management
Systems Engineering and Multidisciplinary Design (SEMD) Group

Electric Mobility Research Team

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Associate Professor</td>
<td>Dr. Ir. Maarten Bonnema</td>
<td>Chair of SEMD and Project Supervisor</td>
</tr>
<tr>
<td>PostDoc Researcher</td>
<td>Dr. Ir. Steven Haveman</td>
<td>Lead Researcher - Systems Engineering and Systems Modeling Research</td>
</tr>
<tr>
<td>Junior Researcher</td>
<td>Marlise Westerhof, MSc</td>
<td>Research on User Centered Design for Electric Mobility Systems</td>
</tr>
<tr>
<td>Junior Researcher</td>
<td>J. Roberto Reyes García</td>
<td>Research on Reference Architectures for data-driven systems and Electric Mobility Systems</td>
</tr>
</tbody>
</table>
About our project

The eMaaS project:
Develops and promotes an open ecosystem for eco-friendly Mobility as a Service

Our Goals:
• To support large scale adoption of EVs through new business models
• To connect EV sharing services to other eco-friendly modes of mobility

Project duration: 01/01/2018 – 01/06/2020
eMaaS project partners

Sweden

MoveAbout Sweden

Netherlands

GoodMoovs

University of Twente

Germany

[ui!] urban institute

Austria

MoveAbout Austria

Hungary

[ui!] urban institute Hungary Zrt.

For more info: www.emaas.eu
MaaS vs eMaaS

What is eMaaS?
MaaS vs eMaaS

eMaaS = MaaS + EVs?
MaaS vs eMaaS

eMaaS = MaaS + EVs?
MaaS vs eMaaS

\[ \text{eMaaS} = \text{MaaS} + \text{EVs} \]

The complementary goal of eMaaS, when compared to MaaS, is to provide users the possibility to go from A to B in an **eco-friendly** way. Therefore, **eMaaS** is meant to be **shared** and **electric**.
MaaS vs eMaaS

eMaaS = MaaS + EVs ?

The complementary goal of eMaaS, when compared to MaaS, is to provide users the possibility to go from A to B in an eco-friendly way. Therefore, eMaaS is meant to be shared and electric

eMaaS = MaaS + EMS + SeMS

eMaaS = electric Mobility as a Service
MaaS = Mobility as a Service
EMS = Electric Mobility Systems
SeMS = Shared electric Mobility Services
MaaS vs eMaaS

eMaaS = MaaS + EMS + SeMS ✔
MaaS vs eMaaS

\[ eMaaS = \text{MaaS} + \text{EMS} + \text{SeMS} \]

(Basic) Mobility as a Service ecosystem

* Icons from flaticon.com
MaaS vs eMaaS

eMaaS = MaaS + EMS + SeMS

(Basic) Mobility as a Service ecosystem

* Icons from flaticon.com
MaaS vs eMaaS

\[ \text{eMaaS} = \text{MaaS} + \text{EMS} + \text{SeMS} \]

(Basic) Mobility as a Service ecosystem

- User
- Mobile app
- MaaS Provider
- Charging Point Operators (CPOs)
- Electric Vehicle Supply Equipment (EVSE)

eco-friendly Transport Operators

* Icons from flaticon.com
MaaS vs eMaaS

eMaaS = MaaS + EMS + SeMS

(Basic) Mobility as a Service ecosystem

User → Mobile app → MaaS Provider → Charging Point Operators (CPOs) → Electric Vehicle Supply Equipment (EVSE)

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MaaS vs eMaaS

\[ e\text{MaaS} = \text{MaaS} + \text{EMS} + \text{SeMS} \]

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* Icons from flaticon.com
MaaS vs eMaaS

\[ \text{eMaaS} = \text{MaaS} + \text{EMS} + \text{SeMS} \]

(Basic) electric Mobility as a Service ecosystem

- User
- Mobile app
- MaaS Provider
- Charging Point Operators (CPOs)
- Electric Vehicle Supply Equipment (EVSE)
- (Non-electric) PT
  Secondary transport means
- eco-friendly Transport Operators

*Icons from flaticon.com*
Research questions

1. What are the technical functionalities of Mobility Service Providers?

2. How can the level of integration of the technical functionalities of Mobility Service Providers be determined?

3. What is the Technical Level of Integration of Shared electric Mobility Providers currently operating in the European market?
Research questions

1. What are the technical functionalities of Mobility Service Providers?
Research questions

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(Basic) (e)Mobility as a Service ecosystem

*Icons from flaticon.com*
Research questions

1. What are the technical functionalities of Mobility Service Providers?

(Basic) (e)Mobility as a Service ecosystem

User

Mobile app

TO-MP API

MaaS Provider

Transport Operators

* Icons from flaticon.com
Research questions

1. What are the technical functionalities of Mobility Service Providers?
Research questions

1. What are the technical functionalities of Mobility Service Providers?

(e)MaaS functional blocks

- Privacy & Regist.
- Planning
- Booking
- Trip Execution
- Payment
- Support
- Operator Info
- Asset Info
## Research questions

2. How can the level of integration of the technical functionalities of Mobility Service Providers be determined?

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Level</strong></td>
<td><strong>Description</strong></td>
<td><strong>Level</strong></td>
</tr>
<tr>
<td>0</td>
<td>No integration (single, separate services)</td>
<td>0</td>
</tr>
<tr>
<td><strong>Partial integration</strong> (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>
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<tr>
<td><strong>Advanced integration</strong> (completely possess ticket-, payment-, and ICT-integration)</td>
<td>2</td>
<td>Integration of booking and payment (multimodal trips with single tickets)</td>
</tr>
<tr>
<td><strong>Advanced integration with mobility packages</strong></td>
<td>3</td>
<td>Integration of the service offer (bundled subscription based multimodal mobility service)</td>
</tr>
<tr>
<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>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Full integration under all conditions: full operational, informational and transactional integration across modes for all journeys</td>
</tr>
</tbody>
</table>

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**Previous works on Levels of Integration**
Research questions

2. How can the level of integration of the technical functionalities of Mobility Service Providers be determined?

Previous works on Levels of Integration

Focus more on the user perspective, than on the Mobility Service Providers perspective

* Icons from flaticon.com
Research questions

2. How can the level of integration of the technical functionalities of Mobility Service Providers be determined?

Previous works on Levels of Integration

(Basic) (e)Mobility as a Service ecosystem

Focus more on the user perspective, than on the Mobility Service Providers perspective

* Icons from flaticon.com
Technical Levels of Integration (TLI) approach
From the Mobility Service Providers perspective

(e)MaaS core functional blocks
Technical Levels of Integration (TLI) approach
From the Mobility Service Providers perspective

(e)MaaS core functional blocks

Planning Mode (i)  Booking Mode (i)  Trip Execution Mode (i)  Payment Mode (i)  A&OI Mode (i)

How can the integration of these functional block be assessed?

The more functions integrated, the higher TLI
TLI approach – 5 levels of integration

<table>
<thead>
<tr>
<th>Category (Level)</th>
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</thead>
<tbody>
<tr>
<td>Full integration (5)</td>
</tr>
<tr>
<td>High integration (4)</td>
</tr>
<tr>
<td>Medium integration (3)</td>
</tr>
<tr>
<td>Low integration (2)</td>
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<tr>
<td>On-bus &amp; off-bus (1)</td>
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## TLI approach – 5 levels of integration

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<th>Function Integration</th>
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<tr>
<td>Non-integrated functions</td>
<td>Only A &amp; B (0)</td>
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<tr>
<td>Single-integrated functions</td>
<td>Low integration (1)</td>
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<tr>
<td>Two-integrated functions</td>
<td>Medium integration (2)</td>
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<tr>
<td>Three-integrated functions</td>
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# TLI approach – 5 levels of integration

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<tr>
<th>Function Integration</th>
<th>Category (Level)</th>
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<tbody>
<tr>
<td>Non-integrated functions</td>
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<td>(1) Only Asset &amp; Operator Information (A&amp;O)</td>
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<tr>
<td>Single-integrated functions</td>
<td>Low integration (2)</td>
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<tr>
<td>Two integrated functions</td>
<td>Medium integration (3)</td>
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<tr>
<td>Three integrated functions</td>
<td>High integration (4)</td>
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<tr>
<td>Four integrated functions</td>
<td>Full integration (5)</td>
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<tr>
<td>Non-integrated functions</td>
<td>Only A&amp;O (3)</td>
<td>Only Asset &amp; Operator Information (A&amp;O)</td>
</tr>
</tbody>
</table>
| Single-integrated functions | Low Integration (1) | 1a) Planning (P)  
1b) Booking (B)  
1c) Trip Execution (TE)  
1d) Payment (P) |
| Two-integrated functions | Medium Integration (2) | |
| Three-integrated functions | High Integration (3) | |
| Four-integrated functions | Full Integration (4) | |
TLI approach – 5 levels of integration

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3b) Booking and Payment (B+P)  
3c) Payment and Trip Execution (P+TE) |
| Four-integrated functions | Full Integration (4) | 4a) Booking, Trip Execution, and Payment (B+TE+P) |
TLI approach – 5 levels of integration

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<td>Low (1)</td>
<td>1a) Planning (P) 1b) Booking (B) 1c) Trip Execution (TE) 1d) Payment (P)</td>
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<tr>
<td>Two-integrated functions</td>
<td>Medium Integration (2)</td>
<td>2a) Planning and Booking (P+B) 2b) Planning and Trip Execution (P+TE) 2c) Planning and Payment (P+P)</td>
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<tr>
<td>Three-integrated functions</td>
<td>High Integration (3)</td>
<td>3a) Planning &amp; Booking &amp; Trip Execution (P+B+TE) 3b) Planning &amp; Booking &amp; Payment (P+B+P) 3c) Planning &amp; Payment &amp; Trip Execution (P+P+TE) 3d) Booking &amp; Payment &amp; Trip Execution (B+P+TE)</td>
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<tr>
<td>Four-integrated functions</td>
<td>Full Integration (4)</td>
<td>4) Planning and Booking and Payment and Trip Execution (P+B+P+TE)</td>
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<tr>
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<td>Low Integration (1)</td>
<td>1a) Planning (P) 1b) Booking (B) 1c) Trip Execution (TE) 1d) Payment (P)</td>
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<td></td>
<td>Medium Integration (2)</td>
<td>2a) Planning and Booking (P+B) 2b) Planning and Trip Execution (P+TE) 2c) Planning and Payment (P+P)</td>
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<tr>
<td></td>
<td>High Integration (3)</td>
<td>3a) Planning &amp; Booking &amp; Trip Execution (P+B+TE) 3b) Planning &amp; Booking &amp; Payment (P+B+P) 3c) Planning &amp; Payment &amp; Trip Execution (P+P+TE) 3d) Booking &amp; Payment &amp; Trip Execution (B+P+TE)</td>
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<td></td>
<td>Full Integration (4)</td>
<td>4) Planning and Booking and Payment and Trip Execution (P+B+P+TE)</td>
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<td>1b) Booking (B)</td>
<td>1b+) Booking for multiple modes of transportation (B (M))</td>
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<td></td>
<td></td>
<td>1c) Trip Execution (TE)</td>
<td>1c+) TE for multiple modes of transportation (TE (M))</td>
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<td></td>
<td>1d) Payment (P)</td>
<td>1d+) Payment for multiple modes of transportation (P (M))</td>
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<td>High Integration (2)</td>
<td>2a) Planning and Booking (P+B)</td>
<td>2a) Planning and Booking &amp; Trip Execution (P+B+TE)</td>
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<tr>
<td></td>
<td></td>
<td>2b) Planning and Trip Execution (P+TE)</td>
<td>2b) Planning and Booking &amp; Trip Execution (P+B+TE)</td>
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<td></td>
<td></td>
<td>2c) Planning and Payment (P+P)</td>
<td>2c) Planning and Booking &amp; Payment (P+B+P)</td>
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<td>Three-integrated functions</td>
<td>Midline Integration (3)</td>
<td>3a) Planning &amp; Booking &amp; Trip Execution (P+B+TE)</td>
<td>3a) Planning &amp; Booking &amp; Trip Execution (P+B+TE)</td>
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<td></td>
<td>3b) Planning &amp; Booking &amp; Payment (P+B+P)</td>
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<td></td>
<td>3c) Planning &amp; Payment &amp; Trip Execution (P+P+TE)</td>
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<td></td>
<td>Four integrated functions</td>
<td>Full integration (4)</td>
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<th>Levels of Integration</th>
<th>Technical Levels of Integration including only single mode of transport</th>
<th>Technical Levels of Integration including multiple modes of transport</th>
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</thead>
<tbody>
<tr>
<td><strong>Non-integrated</strong></td>
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<td>1b) Booking (B)</td>
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<td></td>
<td>1c) Trip Execution (TE)</td>
<td>1c+) TE for multiple modes of transportation (TE+M1)</td>
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<td></td>
<td>1d) Payment (P)</td>
<td>1d+) Payment for multiple modes of transportation (P+M1)</td>
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<tr>
<td><strong>Medium integration</strong></td>
<td>2a) Planning and Booking (P+B)</td>
<td>1a+) Planning and Booking for multiple modes of transportation (P+B+M1)</td>
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<tr>
<td></td>
<td>2b) Planning and Trip Execution (P+TE)</td>
<td>2b+) Planning and Trip Execution for multiple modes of transportation (P+TE+M1)</td>
</tr>
<tr>
<td></td>
<td>2c) Planning and Payment (P+P)</td>
<td>2c+) Planning and Payment for multiple modes of transportation (P+P+M1)</td>
</tr>
<tr>
<td></td>
<td>2d) Booking and Trip Execution (B+TE)</td>
<td>2d+) Booking and Trip Execution for multiple modes of transportation (B+TE+M1)</td>
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<tr>
<td><strong>High integration</strong></td>
<td>3a) Planning &amp; Booking &amp; Trip Execution (P+B+TE)</td>
<td>2a+) Booking and Payment for multiple modes of transportation (B+P+M1)</td>
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<td></td>
<td>3b) Planning &amp; Booking &amp; Payment (P+B+P)</td>
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<td>3d) Booking &amp; Payment &amp; Trip Execution (P+B+P+TE)</td>
<td>2d+) Booking and Trip Execution for multiple modes of transportation (B+P+TE+M1)</td>
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<tr>
<td><strong>Full integration</strong></td>
<td>4) Planning and Booking and Payment and Trip Execution (P+B+P+TE)</td>
<td>3a+) Planning and Booking &amp; Trip Execution (P+B+TE+M1)</td>
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**TLI** stands for **Transportation Linking Infrastructure**, which refers to the integration of transportation modes and services to provide seamless travel experiences for users.
<table>
<thead>
<tr>
<th>Function Integration</th>
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<tr>
<td>Non-merged functions</td>
<td>Only A&amp;O (0)</td>
<td>0) Only Asset &amp; Operator Information (A&amp;O)</td>
<td>5+) Only Asset &amp; Operator Information for multiple modes of transportation (A&amp;O (M))</td>
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<tr>
<td>Single-merged functions</td>
<td>Low integration (1)</td>
<td>1a) Planning (P) 1b) Booking (B) 1c) Trip Execution (TE) 1d) Payment (P)</td>
<td>1a+) Planning for multiple modes of transportation (P (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))</td>
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<tr>
<td>Two-merged functions</td>
<td>Middling integration (2)</td>
<td>2a) Planning and Booking (P+B) 2b) Planning and Trip Execution (P+TE) 2c) Planning and Payment (P+P)</td>
<td>2a+) Planning and Booking for multiple modes of transportation (P+B) (M) 2b+) Planning and Trip Execution for multiple modes of transportation (P+TE) (M) 2c+) Planning and Payment for multiple modes of transportation (P+P) (M)</td>
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<tr>
<td>Three-merged functions</td>
<td>High integration (3)</td>
<td>3a) Planning &amp; Booking &amp; Trip Execution (P+B+TE) 3b) Planning &amp; Booking &amp; Payment &amp; Trip Execution (P+B+P+TE)</td>
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<tr>
<td>Four-merged functions</td>
<td>Full integration (4)</td>
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3. What is the Technical Level of Integration of Shared electric Mobility Providers currently operating in the European market?

Previous research on European SeMPs

Business models in the shared electric mobility field: A market overview towards electric Mobility as a Service (eMaaS)

J. Roberto Reyes García*, Steven Haveman*, Marlise W. Westerhof*, G. Maarten Bonnema*

*University of Twente, Drienerlolaan 5, 7522 NB, Enschede, The Netherlands
3. What is the Technical Level of Integration of Shared electric Mobility Providers currently operating in the European market?

136 European Shared electric Mobility Providers

TLI approach application
3. What is the Technical Level of Integration of Shared electric Mobility Providers currently operating in the European market?
Results – Overview

Technical Level of Integration (TLI) of European Shared electric Mobility Providers (SeMPs)

- **Only A&OI**
  - Non-integrated functions

- **Low Integration**
  - Single-integrated functions

- **Medium Integration**
  - Two integrated functions

- **High Integration**
  - Three integrated functions

- **Full Integration**
  - Four integrated functions
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Number of SeMPs (N=128)

- Level 0: 0
- Level 1: 11
- Level 2: 51
- Level 3: 56
- Level 4: 10
Results – Level 1

SeMPs with a Low Technical Level of Integration
Results – Level 1

SeMPs with a **Low Technical Level of Integration**
Results – Level 1

SeMPs with a Low Technical Level of Integration

Planning (M)  
Booking  
Booking (M)  
Payment

Number of SeMPs  
(N_total=128)  
(N_valid=12)

L1-a⁺  
L1-b  
L1-b⁺  
L1-d
Results – Level 1 – Examples

SeMPs with a Low Technical Level of Integration

Planning (M)  Booking  Booking (M)  Payment

- moovit
- caruso
- MOVE ABOUT
- hirebike
- Google Maps
- Combitrip
- elektrip.nl
Results – Level 2

SeMPs with a Medium Technical Level of Integration
Results – Level 2

SeMPs with a Medium Technical Level of Integration
Results – Level 2

SeMPs with a Medium Technical Level of Integration

- (P + I + B) (M)
- B + P
- (B + P) (M)
- B + TE
- (B + TE) (M)
- P + TE
- (P + TE) (M)

Number of SeMPs:
- L2-e: 22
- L2-e+: 4
- L2-d: 9
- L2-d+: 2
- L2-f: 3
- L2-f+: 9

Legend:
- Planning
- Booking
- Payment
- Mode
- Execution
Results – Level 2 – Examples

SeMPs with a Medium Technical Level of Integration

(PL + B) (M)  B + P  (B + P) (M)  B + TE  (B + TE) (M)  P + TE  (P + TE) (M)
Results – Level 3

SeMPs with a High Technical Level of Integration
Results – Level 3

SeMPs with a **High** Technical Level of Integration
Results – Level 3

SeMPs with a **High Technical Level of Integration**

\[ B + P + TE \]

\[ (B + P + TE)(M) \]

SeMPs with a High Technical Level of Integration

Number of SeMPs:
- \( N = 128 \)
- \( N_{Partial} = 56 \)

- 50 SeMPs at \( L3-d \)
- 6 SeMPs at \( L3-d^+ \)
Results – Level 3 – Examples

SeMPs with a **High Technical Level of Integration**

\[ B + P + TE \]

\[ (B + P + TE) \ (M) \]
Results – Level 4

SeMPs with a **Full Technical Level of Integration**

\[ PL + B + P + TE \]

\[ (PL + B + P + TE) (M) \]
Results – Level 4

SeMPs with a Full Technical Level of Integration

$PI + B + P + TE$

$(PI + B + P + TE) (M)$

Number of SeMPs (N=128, N=10)

$L4$ $L4^+$
Results – Level 4 – Examples

SeMPs with a **Full** Technical Level of Integration

$PI + B + P + TE$

$(PI + B + P + TE) (M)$

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Logos: DB, GVH, BVG, Jelbi, HVV, Wiener Linien, moovel, REACH NOW
Remarks

• Although for eMaaS public transport is considered as a secondary means of transportation, PTOs are clearly leading the technical level of integration of (e)MaaS functionalities

• Because multimodal integration does not mean an extra functionality *per se*, in the TLI approach, multimodal offer does not mean a higher level in the scale

• Many SeMPs have more than one interface. Only the ones with more integrated functions were accounted for the results

• Some SeMPs have integrated multimodal capabilities but only for certain functions, in that case, the TLI does not offer a direct way to evaluate them. In this study,
  • 1) if most of the functionalities (>50%) are integrated for multiple modes of transport or multiple MSPs, then the MSP would be classified as if it would have all multimodal functions integrated
  • 2) if 50% (or less) of the functionalities are integrated for multiple modes of transport or multiple MSPs, then the MSP would be classified as if it would not have any multimodal functions integrated
Conclusions

1. The TLI approach offers an effective method to determine and easily visualize the level of integration of the technical functionalities of MSPs

2. The current state of the European Shared Electric Mobility (SEM) market already includes MSPs with a high- or even a full-level of integration with respect to their technical (e)MaaS functionalities

3. Integration for multiple modes of transportation is still lacking among most European SeMPs but the higher the TLI, the easier the integration of more transportation modes will be. Therefore, in order to become eMaaS players, MSPs should put more efforts on integrating as much functionalities as possible
Thank you for your attention!
Any questions?

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