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JRC Future Mobility Solutions Living Lab (FMS-Lab): conceptual framework, state of play and way forward

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Contents

Abstract

Our mission in creating the Future Mobility Solutions Living Lab (FMS-Lab) at the European Commission's Joint Research Centre (JRC) is to bring the Living Lab (LL) concept much closer to the policy, academic and industrial realms. In particular, we are using the JRC FMS-Lab as a human-centred policy design and regulatory-support tool to test a variety of mobility-related policy and regulatory approaches in a real-life environment.

We have applied some of the existing LL methodologies to our FMS-Lab, distinguishing the activities at a macro (organisational), meso (project) and micro (individual) level. In particular, at a meso level, we suggest a framework tailored to different types of JRC LLs projects that distinguishes four categories of projects based on their respective objectives: business model validation projects, projects focused on the co-creation of solutions, technical validation projects and impact assessment projects. We claim that such an approach would allow for quicker identification of the most suitable methods and tools in each specific case, thus leading to higher efficiency and effectiveness in implementing LL projects. Based on our experience of implementing the LL, we have identified the main challenges and related recommendations to take into account when setting up a LL. Challenges range from adopting more inclusive approaches and an effective LL governance structure to the active and continuous engagement of citizens and all stakeholders. Recommendations include the need to set up a multi-stakeholder governance framework for the LL and to seek opportunities with other mobility LLs for transferability, scalability and replication of the LL results and processes.

The FMS-Lab aims to stimulate scientific debate on the use of LLs to address mobility challenges and accelerate the co-creation of innovative mobility solutions contributing to the smart and green urban transformations. Through multi-stakeholder collaborations, we aim to build a network of mobility LLs to promote complementarity and evolve LL research in a consistent and robust manner, advancing all together towards a safe, sustainable and smart human-centred mobility. Specifically, this report sets a theoretical basis on which to support the on-going and future work of the JRC FMS-Lab and other related JRC LLs activities in different thematic areas. Other LL practitioners, researchers, innovators and policy makers could also find value in the present work, understanding how the existing LL theories and practices can be applied to the mobility context to support the development of both new mobility solutions and new policies with a human-centric approach.

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We would also like to show our gratitude to the team working on living labs at the EIT Urban Mobility Knowledge and Innovation Community (KIC), with whom we have had valuable discussions around the application of the Living Lab methodology in the urban mobility context.

Besides, we are extremely grateful to the European Network of Living Labs (ENoLL), for the continued support and advice in developing our Living Labs. In particular, we have benefited from the experienced living lab practitioners who took part in their 2020 Virtual Learning Lab and shared with us their knowledge and experiences in the field. We have also gained unique insights from the interactions we had with peer living labs participating in the ENoLL Mobility Working Group.

We are also thankful for the opportunities given by SMEs and start-ups participating in the mobility Living Lab, for their enthusiasm and professionalism in bringing forward long-term projects and trustworthy relationships.

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The work by Andromachi Mourtzouchou has been carried out for the JRC at its Ispra site.

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Executive summary

Mobility is central to our economy and society but brings with it significant negative side effects, from road accidents, to greenhouse gas emissions and congestion. While new policies strongly rely on new transport technologies in response to such challenges, the new transport solutions do not fully meet people's needs and expectations. Co-creation and experimentation in real-life settings, as enabled in Living Lab (LL) environments, can help overcome this problem. In 2019, the European Commission's Joint Research Centre (JRC) set up the Future Mobility Solutions Living Lab (FMS-Lab) in Ispra (Italy) in order to engage citizens and relevant public and private players in the co-creation of innovative mobility solutions. This report sets out a theoretical basis to support JRC FMS-Lab and other related JRC LLs activities through a review and application of some of the main existing LL methodologies. It also suggests a framework tailored to different types of JRC LLs projects. The experience of the first two years of implementation has revealed the main challenges and related recommendations to take into account when setting up a LL.

Policy context

The United Nations 2030 Agenda for Sustainable Development includes Sustainable Development Goal (SDG) 11: Make cities and human settlements inclusive, safe, resilient and sustainable, with the specific Target 11.2: Addressing the access provision by 2030 to safe, affordable, accessible and sustainable transport systems for all. In line with the SDGs, the development of smart and sustainable cities is also a high priority in EU policy. Notably, the European Green Deal covers a set of policy initiatives by the European Commission with the overarching aim of making Europe climate neutral by 2050 (e.g. the Climate Pact, the New European Bauhaus). In 2020, the European Commission adopted a strategy for sustainable and smart mobility, paving the way for the EU transport system to achieve its green and digital transformation and become more resilient to future crises. The sustainable and smart mobility strategy promotes citizen engagement activities to involve people in the co-design of the future transport system, to increase awareness about the potential added value of new technologies and to ensure that the development of transport systems properly addresses people's diverse needs. To achieve this, the strategy points to the establishment of a network of 'European Living Labs'. Living Labs are also a cornerstone of the zero pollution action plan from the European Commission to contribute to the development of local actions for green and digital transformation. Similarly, the new European Urban Mobility Framework is highlighting the role of European cities as "*"living laboratories" where new solutions to common challenges are designed, tested and implemented*" and emphasising that "*public discussion and the "co-creation" of new mobility concepts is vital for their public acceptance*".

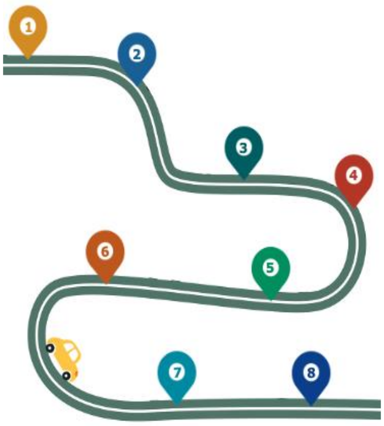
Key conclusions

In an attempt to clarify the concept of LLs and its underlying layers, we are providing a conceptual framework for LLs which takes into consideration both the existing literature and our own experiences in implementing LLs at the European Commission's JRC. In particular, we have applied the conceptual framework for transdisciplinary collaboration processes in LLs by Kalinauskaite et al. (2021), the different phases of innovation development based on the FormIT methodology (Ståhlbröst and Holst, 2013), and the living lab integrative process from Mastelic (2019). We also provide a classification of the FMS-Lab using the LL framework from Veeckman et al. (2013). Future steps of the FMS-Lab will regard the application of the later stages of these LL frameworks.

Based on the experiences gained until now with LL projects involving external entities (through the JRC 'Call for expressions of interest - Pilot living labs at the JRC'), we claim that a tailor-made approach is needed in order to accommodate different types of JRC LLs projects. We identify four distinct categories of projects, based on their main objectives, acknowledging that a project could belong to more than one category: business model validation projects, projects focused on the co-creation of solutions, technical validation projects and impact assessment projects. Specific steps and co-creation methods are applied in each project category, some of which are common to all four project types.

Two years after the start of our FMS-Lab, we have reflected on the main challenges and propose some recommendations (Figure 1).

Figure 1 List of recommendations linked to the main identified challenges



Recommendations

1. Start by planning, including defining what is the aim of the LL, who are the target users and stakeholders, and making a time plan of the activities
Challenges addressed: 1, 2, 4, 5

2. Define early on the ways to effectively engage users and all stakeholders
Challenges addressed: 1, 2, 3, 8

3. Set up a LL steering committee
Challenges addressed: 6, 7

4. Identify the needed physical infrastructure and equipment, as well as **key performance indicators** for the experimental phase, and secure **resources** considering use and maintenance
Challenges addressed: 8

5. Develop communication strategy and tools
Challenges addressed: 9

6. Check the application of LL principles
Challenges addressed: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

7. Identify and share lessons learnt in view of future LL activities and share them with other LLs
Challenges addressed: 9, 10, 11

8. Think about the possibilities for transferability, scalability and replication of the obtained results and process
Challenges addressed: 9, 11

Challenges

1. Achieving inclusivity
2. Actively engaging citizens and other types of stakeholders across the stages of the innovation development process
3. Finding effective ways to engage users in the LL activities
4. Engaging the users and actively developing the LL projects during the Covid-19 pandemic
5. Being resilient in the face of unpredictable events
6. Aligning stakeholders' values within the LL
7. Adopting an effective LL governance structure
8. Obtaining management sponsorship
9. Transferring knowledge within and beyond the LL
10. Assessing the impact of the LL
11. Ensuring the sustainability of the LL

Source: own elaborations.

Main findings

This report provides a theoretical basis on which to support the on-going and future work of the JRC FMS-Lab and related JRC LLs activities in different thematic areas. Though LLs are not consistently defined in the literature, the most common definition is by the European Network of Living Labs (ENoLL) which outline LLs as "*user-centred, open innovation ecosystems based on systematic user co-creation approach, integrating research and innovation processes in real life communities and settings*". There are five central elements in LLs: multi-method approach, user engagement, multi-stakeholder participation, real-life setting and co-creation (Evans et al., 2017).

In this work, we have applied some of the existing LL methodologies, distinguishing the activities at a macro (organisational), meso (project) and micro (individual) level. In particular, we have found that:

– The conceptual framework from Kalinauskaite et al. (2021) serves to initiate and facilitate transdisciplinary collaboration processes in complex research and innovation ecosystems like LLs. It aims at implementing co-creation approaches at the macro and meso levels of the LL in order to achieve and maintain stakeholder alignment through a common vision.

– The FormIT methodology from Ståhlbröst and Holst (2013) covers the cycles of concept design, prototype design and innovation design. Each cycle is divided in four iterative phases: Explore, Create, Implement and Evaluate. We provide a checklist with key actions for each phase.

– A more recent methodology is the 6-step Living Lab Integrative Process from Mastelic, (2019), which focuses on open discussion and confrontation of ideas on barriers and drivers to build a common vision of the main challenge to be tackled in the LL.

The experience of the first two years of implementation of the FMS-Lab has led to the proposal of a framework specifically tailored to the different types of JRC LLs projects. Besides, we have identified some main challenges and related recommendations to take into account when setting up a LL. The FMS-Lab aims to evolve the existing LL theories and practices with a particular application to the mobility context, stimulating scientific debate on the use of LLs to address mobility challenges in order to support the co-creation of innovative mobility solutions contributing to the smart and green urban transformations. Our vision is to bring the LL concept much closer to the policy, academic and industrial realms and most importantly, to use the JRC FMS-Lab as a people-centred policy design and regulatory support tool to test a variety of mobility-related policy and regulatory approaches in real life environments. Through multi-stakeholder collaborations we aim to build a network of mobility LLs to promote complementarity and evolve the LL research in a consistent and robust manner and all together advance towards a safe, sustainable and smart people-centred mobility.

Related and future JRC work

This work has been carried out in the framework of the JRC LLs (including its open 'Call for expressions of interest - Pilot living labs at the JRC' by external entities) and is closely interlinked with the activities carried out by other JRC LLs, e.g. the JRC Digital Energy Solutions Living Lab (DES-Lab). Ongoing work of the JRC in the fields of sustainable transport and citizen engagement is also closely related to the present work. The FMS-Lab will continue applying the different LL frameworks presented in this report, through LL projects aimed at engaging the JRC population and general citizens and at generating policy-relevant insights towards a safe, sustainable and smart people-centred mobility.

Quick guide

LLs enable the co-creation of innovative solutions with citizens and public/private stakeholders as well as their experimentation in real-life environments. Through LLs, policies can be shaped around citizens' needs, values and expectations, promoting a higher technological uptake. The JRC FMS-Lab is gathering data about citizens' concerns and desires of future mobility. In the last 12 months, the FMS-Lab has engaged more than 1000 users in mobility workshops, surveys, interviews, focus group discussions and other citizen engagement activities. This report presents the journey followed in setting up a mobility LL at the JRC pursuing a sustainable and smart mobility in the future. Based on the experience collected so far, we share some challenges and give recommendations to set up a LL. The FMS-Lab will continue its engagement activities and will refine the present LL framework based on its own experiences and the knowledge and insights exchanged with peer LLs in the mobility field. This report is organised along five main Chapters. Chapter 1 introduces the present work and presents the policy context. Chapter 2 presents the theory and approaches behind LLs. Chapter 3 applies the LL framework, methodologies and methods/tools described in Chapter 2 to the specific case of the JRC FMS-Lab. Chapter 4 outlines the main challenges experienced during the implementation of the FMS-Lab, provides recommendations and presents on-going community-building activities. Finally, Chapter 5 gives some conclusions from the present work.

1 Introduction

Mobility fuels our economy and society but comes with significant negative side effects, from road accidents to greenhouse gas emissions and congestion. These negative effects are intensified in urban areas that face complex, intertwined challenges related to climate change, pollution, energy efficiency, urban mobility, water, waste, food and resource efficiency, health and well-being and social innovation (European Commission, 2019a). While new policies strongly rely on new transport technologies in response to such challenges, the new transport solutions do not fully meet people's needs and expectations. Potential benefits from new transport solutions will largely depend on if and how people will use them. It is hard to develop impactful solutions without experimenting them first in real-life settings, which requires expensive and complex interventions. This motivated the creation of the Future Mobility Solutions Living Lab (FMS-Lab) at the European Commission's Joint Research Centre (JRC) site in Ispra (Italy), where citizens, researchers, public authorities and industrial players are engaged in the co-creation of innovative mobility solutions. Through the FMS-Lab, we are gathering data that gives a wide picture of citizens' concerns and desires of the future mobility. In the last 12 months, we have engaged more than 1000 users in mobility workshops, surveys, interviews, focus group discussions and other citizen engagement activities. And we aim to engage the whole JRC population (of over 3,000 colleagues) over the course of 2022. Thanks to the living lab (LL), we can move closer to a safe, sustainable and smart human-centred mobility.

The FMS-Lab is part of the bigger JRC Living Labs (JRC LLs) initiative, aimed to promote the co-creation of high-quality, policy-relevant and user-oriented solutions, in particular in relation to smart cities. The JRC LLs enable the testing of innovative technologies, methodologies and policy approaches in real life conditions – effectively becoming a tool to test a variety of policy and regulatory aspects (e.g. effective, efficient and acceptable ways of regulating and managing interaction between autonomous vehicles, people and the surrounding environment). In the application of the LL open innovation people-centred approach, we are facing a series of challenges and learning good practices along the way, which we feed back into our LL strategy and operation with the aim of fine tuning the LL framework and making it value-creating for the involved researchers, public authorities, industry and citizens as a whole. This report aims to present the journey of setting up a mobility LL at the JRC, highlighting the main challenges and opportunities in view of reaching a smart and sustainable mobility in the future. It also provides an outlook towards the next steps of the mobility LL.

1.1 Policy context

In Europe, 84% of the population is expected to live in cities by 2050 (Desa, 2018), compared to the current 75% (Vandecasteele et al., 2019). As urbanisation continues to grow both in Europe and worldwide, policies targeting sustainable development become more important than ever. The 2030 Agenda for Sustainable Development (United Nations), which was adopted by the United Nations Member States in 2015, identifies 17 Sustainable Development Goals (SDGs). SDG 11 (Make cities and human settlements inclusive, safe, resilient and sustainable) presents Target 11.2: "*by 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons*" (SDSN).

In line with the SDGs, development of smart and sustainable cities is also a high priority of European policymakers. In fact, one of the Green Deal (European Commission, 2019a) Missions is "*Horizon Europe Mission on Climate-Neutral and Smart Cities*" (European Commission, Missions in Horizon Europe). The Horizon Europe missions will bring together numerous stakeholders, and will emphasise the importance of experimentation and systemic approach.

Moreover, the Horizon Europe work programme intends to involve local communities in working towards a more sustainable future in initiatives that seek to combine societal pull and technology push. Supporting local communities and starting citizens' dialogue is of utmost importance to the Commission, in recognition that citizens should be the driving force of fair green and digital transitions. Two exemplary initiatives supporting sustainable growth and community development are the Climate Pact and the New European Bauhaus (European Commission, New European Bauhaus). There are multiple other urban European initiatives such as the Smart Cities Marketplace, Concerto programmes, Sharing Cities, District of the Future, Community of Practice on Cities, City Science Initiative and Covenant of Mayors, to name a few. It is crucial to note that the initiatives aim to foster collaboration between involved stakeholders, support policymaking, research and innovation creation, as well as facilitate citizen engagement.

In December 2020, the European Commission adopted a strategy for sustainable and smart mobility together with an Action Plan of 82 initiatives for the next four years (European Commission, 2020b). This strategy paves the way for the EU transport system to achieve its green and digital transformation and become more resilient to future crises such as the COVID-19 pandemic. As outlined in the European Green Deal (European Commission, 2019a), the goal is to achieve a 90% reduction in greenhouse gas emissions from transport in order for the EU to become a climate-neutral economy by 2050, while also working towards a zero-pollution ambition. These ambitious targets will be delivered by a smart, competitive, safe, accessible and affordable transport system. The sustainable and smart mobility strategy promotes citizen engagement activities to involve people in the co-design of the future transport system, to increase awareness about the potential added value of new technologies and to ensure that the development of transport systems properly addresses people's diverse needs. The strategy points out the establishment of a network of 'European Living Labs' to engage citizens at a local and practical level. The Action Plan of the strategy includes the revision of the 2013 Urban Mobility Package by 2021 in order to promote and support sustainable and healthy transport modes. The new European Urban Mobility Framework (European Commission, New Urban Mobility Framework) is highlighting the role of European cities as *"living laboratories" where new solutions to common challenges are designed, tested and implemented*" and emphasising that "*public discussion and the "co-creation" of new mobility concepts is vital for their public acceptance*".

As a cross-cutting policy initiative, the zero pollution action plan (European Commission, 2021) contributes to the United Nations 2030 SDGs, and the 2050 climate-neutrality goal, the clean and circular economy goals and restored biodiversity goals set by the EU. Thus it is part of multiple European Green Deal initiatives, amongst others, and aims to speed up pollution reduction and achieve the 2050 vision of a Healthy Planet for All. To this aim, the zero pollution action plan sets key targets for 2030 and outlines several flagship initiatives and actions for 2021-2024. One of these flagship initiatives address the launch of LLs for green and digital solutions and smart zero pollution to help develop local actions for green and digital transformation.

In order to improve the quality of urban life and ensure sustainable development, cities take various actions: including addressing scientific and technological innovation, building an accessible information society, establishing inclusive and livable communities and promoting a systemic approach for development. This systemic approach calls for synergies between subsystems (e.g., climate, energy, mobility, technologies, health and well-being, social innovation, circular economy).

A variety of aims in upgrading urban areas has been reflected in a plethora of new city labels, such as 'Smart Cities', 'Creative Cities', 'Intelligent Cities' or 'Knowledge Cities'. These categories cover mostly similar approaches to smart and sustainable urban development, as they are not strictly defined or classified. Moreover, the approach to design a "*Smart City*" also varies. Top-down design results in an implementation of a technocratic idea of a ''control room'' where the city uses Information and Communication Technology (ICT) and data to reduce the inefficiencies at city level. Nevertheless, cities are about the people that live in them, and therefore finding innovative solutions to citizens' everyday challenges should be the top priority. With Lindsay claiming "*The smartest cities are the ones that embrace openness, randomness and serendipity - everything that makes a city great''* (Lindsay, 2011). The view of a human-centred city is promoted in the report titled "*The Human-Centred City: Opportunities for Citizens through Research and Innovation : A Public Summary*" (European Commission, 2019b): "*…cities should leverage the opportunities offered by innovation in order to become more human-centred… To be a city for citizens where citizens become city-makers and shapers, makers and co-creators of their evolving urban development is not an entitlement. It means being an active citizen concerned both with the local context and the urgency of addressing the global context*".

Therefore, there is a need to develop a dynamic mix of technology and citizen participation: a platform for citizens to meet with public sector and private sector and all together form the city according to their needs and desires, consciously considering, testing and developing the whole spectrum of technology and innovation. Urban LLs are an exemplary form of such a platform, easing the deployment of useful and accepted innovations within a city. As, "*a city is "smart" when that city can integrate and synchronize formal leadership and endogenous democratic participation in the IT-based urban ecosystem. Smart cities are both creative and intelligent. Smart cities are hybrid models combining democratized open innovation with central city support, coordination, and monitoring*" (Ben Letaifa, 2015).

LLs can contribute to these policy objectives, hence the set-up of the JRC LLs at the European Commission. LLs will gradually be integrated at the JRC sites by turning them into experimentation environments and demonstrators for advanced technologies and citizen engagement in smart and sustainable cities.

1.2 Purpose of this report

This report aims to provide a theoretical basis for JRC FMS-Lab and other related JRC LLs activities, through a review and application of some of the main existing LL methodologies, as well as an analysis of the JRC LLs projects. We also share the experience of setting up the FMS-Lab since 2019, identifying some key challenges and recommendations.

This report is organised along five main Chapters. Chapter 1 introduces the present work in particular the vision and objectives of the JRC LLs and its position in the current policy context. Chapter 2 presents the theory and approaches behind LLs. Chapter 3 applies the LL framework, methodologies and methods/tools described in Chapter 2 to the specific case of the JRC FMS-Lab. Chapter 4 outlines some of the main challenges experienced during the implementation of the JRC FMS-Lab and provides some recommendations with a special focus on current and future community-building activities. Finally, Chapter 5 gives some conclusions from the present work.

The present report supports on-going and future FMS-Lab projects, whose outcomes will be used to refine the theoretical basis presented. It seeks to guide other stakeholders involved or interested in multi-stakeholder and human-centric approaches in the mobility field, in particular LL practitioners, researchers, innovators and policymakers. While Chapters 2 and 4 could be particularly helpful for stakeholders (including policymakers) who wish to apply the LL approach and/or understand its potential and challenges, Chapter 3 is of most interest to anyone currently operating LLs.

1.3 Vision and objectives of the JRC Living Labs

The vision of the JRC LLs is to become a people-centred policy design tool for innovative EU policies related to smart cities, in line with the JRC mission of providing independent scientific advice and support to EU policy. To this end, we are positioning the JRC LLs as a regulatory-support tool to test a variety of policy approaches in real life environments. This ambitious vision requires a crosscutting, multi-stakeholder approach that can both anticipate and respond to evolving policy needs. With digital and green recovery as top political priorities of the Commission, the JRC LLs is a tangible example of co-creating innovative solutions for smart and green urban transformations. In keeping with open innovation principles, we are opening our sites and broadening collaboration, enabling European SMEs to test and demonstrate new technologies at our sites, and sharing results with Commission services as well as external actors.

In July 2019, the JRC launched a call for expressions of interest (Joint Research Centre, 2019) to co-create smart city solutions in two of our research sites (Ispra and Petten), in particular addressing future mobility solutions and digital energy solutions. The call is open to public and private organisations in EU Member States and countries associated to the EU Research Programme Horizon 2020, and addresses in particular small and medium-sized enterprises, including start-ups. JRC sites can be compared to small towns, agglomerating people, infrastructure and services. It is especially true for the Ispra site that operates in almost complete autonomy regarding its infrastructure, energy, water, logistics, mobility, safety and security. By inserting innovative solutions into the day-to-day functioning and operation of the site, we make them visible and tangible for our staff, other researchers, policymakers, businesses and citizens. Both the Ispra and Petten sites of the JRC provide unique opportunities for co-creating LL projects with organisations looking to experiment and evaluate innovative concepts and technologies in a pre-competitive, yet real-life environment.

Call for expressions of interest – Pilot living labs at the JRC

Applicants can benefit from the following assets and services, provided by the JRC:

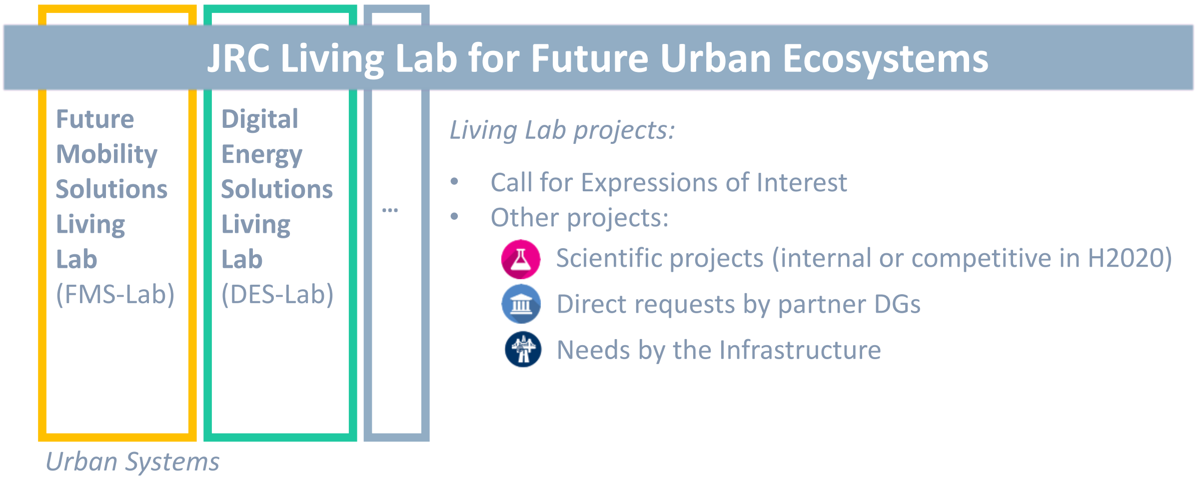
- A city-like test environment, located in the town of Ispra in Northern Italy with some 2,500 people on the site daily (including JRC staff and visitors), over 200 buildings, 36 km of internal roads, and all the logistics services that are necessary to run a small town, including energy generation and water provision. All this is in a fenced-in area of some 167 ha providing a safe and secure environment, in which the JRC applies Italian law (related to safety, transport, highway code and suchlike) under its own responsibility. The JRC Petten site is part of a larger campus hosting other research organisations in the energy and health fields, with some 250 staff and 26 buildings.
- State-of-the-art laboratories and technical support, including smart grid interoperability laboratories and vehicle testing facilities as well as special technical infrastructure (e.g. ground or aerial sensing or specific infrastructural adaptations) on the Ispra site.
- Scientific expertise across a wide range of topics combined with knowledge of the policy context including expertise in real-time simulation, blockchain and cyber-security research, as well as high-performance computing, to mention but a few.

- Advanced digital infrastructures, including facilities for smart grids, smart homes, smart mobility and advanced communication testing, all of which rely on the international high-speed data network for research and education.
- Future deployment and commercialisation advice.

All resources, services and materials made available by the JRC and by the applicant in support of the collaborative project are considered 'in kind' and no money flows either way.

Besides the call for expressions of interest, JRC LLs projects are coming from internal or competitive scientific projects (e.g. Horizon 2020), direct requests from policy Directorates-General (DGs) (e.g. to support the development of a specific regulation), and infrastructure needs (e.g. to inspire novel transport models and services which could be deployed at specific JRC sites) (Figure 2).

Figure 2 JRC Living Lab for Future Urban Ecosystems, including active living labs according to different urban systems and the nature of the living lab projects



Source: own elaborations.

The objectives of the JRC LLs are the following:

- *To test how the Living Lab approach can support the design and monitoring of EU policies;*
- *To act as independent EC-internal environment where to validate selected research projects;*
- *To provide a test-bed for start-ups and SMEs to experiment with their innovative technologies;*
- *To encourage users to co-create solutions and co-evaluate results (Users include mostly staff and visitors but aiming to engage the general public as well, to the extent possible in each specific LL project; users can include special profiles such as professional drivers from the JRC Ispra logistics department or from other organisations, experts in specific fields from the JRC and beyond);*
- *To propose a harmonised methodology for developing and upscaling LLs and to foster fundamental scientific debate around LLs;*
- *To identify gaps in current standards and regulations for smart city technologies;*
- *To enable international collaboration in the field of smart cities to develop and promote unified regulatory, organisational and technical standards of smart cities concepts;*
- *To support, in line with the Ispra site development plan 2030, the JRC strategy towards site modernisation;*
- *To test user adoption and behavioural change towards more sustainable energy and mobility;*
- *To encourage more sustainable behaviours through awareness-raising actions in the energy and mobility areas.*

With mobility being central in our modern society and the ever-increasing challenges it poses, there is an impending need to look for effective solutions through participatory approaches that engage citizens and a diversity of public / private stakeholders. LLs have been proposed as a powerful tool to verify the usefulness of new mobility solutions in improving transport (Alonso Raposo et al., 2019). In particular, Alonso Raposo et al. (2019) state that "*EU policymakers should establish a network of European living labs where innovative mobility solutions are tested and rolled out with the direct involvement of citizens*". The FMS-Lab aims to study how new mobility solutions will transform the transport system to meet citizens' needs and achieve the SDGs set by our society. The FMS-Lab has started several initiatives to understand a crucial yet often neglected dimension when talking about the future of transport: people's expectations, trust and concerns about emerging technologies.

Furthermore, in view of supporting innovation policy, we aim to use the JRC LLs to improve the understanding of the interlinkages between emerging technologies and their regulation. The JRC LLs provide an environment for early identification of regulatory challenges of novel technologies and solutions, and they enable the exploration and validation of approaches for addressing them.

Testing and demonstrating technologies and solutions are never purely technical activities. Various policy and regulatory questions inevitably surface in the process that require careful consideration and solving. With the JRC LLs projects, we want to extract these regulatory learnings and insights, and share them - not only with other LL practitioners and innovators, who grapple with similar questions - but equally with public authorities that set the regulatory frameworks at national and EU level. In this way, the JRC LLs can implement and promote the concept of LLs as a holistic innovation-support tool: supporting at once the development of innovative solutions and the regulatory governance of innovation.

The outlook is to develop the JRC LLs into an experimental in-house regulatory-support tool for the European Commission, which has at its core a structured involvement of non-traditional policy actors, e.g. researchers, innovators and citizens. Our aspiration is to be able to anticipate and respond to the needs for regulatory support by the European Commission, and thereby contribute to improving design and implementation of regulations, policies and standards, assessing their benefit and efficiency, and providing feedback on their performance. This approach is also in keeping with the Better Regulation agenda of the European Commission, which aims to involve citizens, businesses and stakeholders in the decision-making process (European Commission, Better Regulation: why and how). Please see examples of the application of this approach in Sub-section 3.3.1.

To facilitate the reading of this document, we are providing below some definitions of terms used to refer to some specific JRC LLs or FMS-Lab work:

- *We talk about **LL projects** when we refer to any project developed in the context of a LL.*
- *With **LL solutions** we mean the innovations which are co-designed and tested in a LL.*
- *We refer to **JRC LLs projects** meaning projects carried out in the context of the JRC LLs (in the energy and/or mobility areas). Thus these are LL projects too.*
- *We talk about **FMS-Lab projects** when we refer to projects developed in the framework of the FMS-Lab, i.e. mobility-related projects which use the JRC Living Labs and the living lab methodology.*
- *When we talk about the **four categories of FMS-Lab projects** (as discussed in 0), we mean the different types (broad categories) in which we can classify the FMS-Lab projects.*

2 What is a Living Lab? A review of some main definitions and methodologies

This Chapter provides a review of the existing definitions of LLs and an analysis of their core elements. In addition, it describes some main LL methodologies and presents some references regarding the assessment of impacts of LLs. This Chapter could thus be of interest for new practitioners in the LL domain as well as other stakeholders who wish to apply the LL approach and/or understand its potential, including policymakers.

CHAPTER 2 – Key messages

- Though no specific definitions of LLs are consistently used in the literature, the most common definition is by the European Network of Living Labs (ENoLL) which outlines LLs as "*user-centred, open innovation ecosystems based on systematic user co-creation approach, integrating research and innovation processes in real life communities and settings*".
- There are five central elements in LLs: multi-method approach, user engagement, multi-stakeholder participation, real-life setting and co-creation (Evans et al., 2017).
- Ståhlbröst and Holst (2013) identified 5 key principles of LLs, Value, Influence, Sustainability, Openness and Realism, which could guide the impact assessment of LLs.
- Schuurman (2015) identified 3 distinct levels of analysis in LLs: macro/organisational level, meso/project level and micro/individual level.
- At a macro level, the LL is seen as a public-private-people partnership that encompasses different stakeholders, organized to carry out LL projects and LL research. The conceptual framework from Kalinauskaite et al. (2021) serves to initiate and facilitate transdisciplinary collaboration processes in complex research and innovation ecosystems like LLs. It aims at implementing co-creation approaches at the macro and meso levels of the LL in order to achieve and maintain stakeholder alignment through a common vision.
- The meso level of the LL encompasses the LL individual projects that are part of the entire LL constellation. At a meso level, the FormIT methodology from Ståhlbröst and Holst (2013) covers the cycles of concept design, prototype design and innovation design. Each cycle is divided in four iterative phases: Explore, Create, Implement and Evaluate. We provide a checklist with key actions for each phase. A more recent methodology is the 6-step Living Lab Integrative Process from Mastelic, (2019), which focuses on open discussion and confrontation of ideas on barriers and drivers to build a common vision of the main challenge to be tackled in the LL.
- The micro level encompasses the LL research steps undertaken in LL projects, including: co-creation workshops, world cafes, interviews, field tests, ethnography studies, to name a few.
- Ballon, Van Hoed, and Schuurman (2018) provide the first systematic impact evaluation of a set of LL projects, concluding that LL projects can provide significant added value for participating companies. They refer to the macro and meso LL levels by Schuurman (2015) to indicate that each level could be evaluated according to specific variables: at the macro level, collaboration and interaction variables (e.g. knowledge transfer), criteria reflecting how end-users and other stakeholders are able to influence the innovation development process; at the meso level, value generated by the LL projects (e.g. to the solution provider, such as economic value).
- The value generated by a LL project goes beyond the economic aspects to cover for example the environmental and social impact.

2.1 Living Lab definitions

Although there have been many attempts to define what a LL is (Table 1), no specific definitions are consistently used in the literature and the term is at risk of becoming a buzzword (Leminen, 2015). The definition of LLs that is most commonly used in the literature is by ENoLL (ENoLL) that defines LLs as "*user-centred, open innovation ecosystems based on systematic user co-creation approach, integrating research and innovation processes in real life communities and settings*". Other existing definitions are given in Table 1, ordered by date of publication from the oldest definition to the most recent one.

Table 1 Living Lab definitions

Author/s (year)	Definition
Følstad, 2008	"Living labs are environments for innovation and development where users are exposed to new ICT solutions in (semi)realistic contexts, as part of medium or long-term studies targeting evaluation of new ICT solutions and discovery of innovation opportunities" (p. 116)
Ballon, Pierson, and Delaere, 2005 as mentioned in Westerlund and Leminen, 2011; Leminen, 2013	"Living Labs are physical regions or virtual realities, or interaction spaces, in which stakeholders form public-private-people partnerships (4Ps) of companies, public agencies, universities, users, and other stakeholders, all collaborating for creation, prototyping, validating, and testing of new technologies, services, products, and systems in real-life contexts"
Björgvinsson, Ehn, and Hillgren, 2012	"…an open innovation milieu where new constellations, issues and ideas evolve from bottom-up long-term collaborations amongst diverse stakeholders" (p. 41)
Seys et al., 2013	"We can define Living Labs as a research approach where users are considered as co-partners in the process of innovation and where they can materialize their own needs, aspirations and wishes in their real-life context through active involvement" (p. 4)
Dell'Era and Landoni, 2014	"A Living Lab is a design research methodology aimed at co-creating innovation through the involvement of aware users in a real-life setting" (p. 139)
Ballon and Schuurman, 2015	"Living labs typically refer to co-creation and appropriation of innovations by users, often in a (online or offline) community setting, and also involving business stakeholders" (p.2)
Schuurman, 2015	"We define Living Labs as an organized approach (as opposed to an ad hoc approach) to innovation consisting of real-life experimentation and active user involvement by means of different methods involving multiple stakeholders, as is implied in the Public-Private-People character of Living Labs" (p. 8)
Ståhlbröst in Evans et al. 2017	"An orchestrator of open innovation processes focusing on co-creation of innovations in real-world contexts by involving multiple stakeholders with the objective to generate sustainable value for all stakeholders focusing in particular on the end users"
Georges and Gilbert, 2017	"A Living Lab is an open innovation ecosystem taking place through a public-private-people partnership that aims to develop new products, services, businesses or technologies through active user involvement and co-creation as of the early stages of the innovation process by using multiple innovative methodologies to create, test and validate innovations in real-life settings within multiple and evolving environments" (p. 43)
Nesti, 2017	"Living labs are both a physical space where, and a methodology through which, stakeholders, particularly users, participate in the development, testing and evaluation of a product or a service assisted by experts, using an open-driven approach to innovation" (p. 270)

Author/s (year)	Definition
Dekker, Contreras, and Meijer, 2019	"Living labs are a research and design methodology applied by research institutes in co-operation with public and private partners for developing and testing innovations in co-creation with users in real-life settings" (p. 5)
Mastelic, 2019	"A Living Lab is an innovation intermediary, which orchestrates an ecosystem of actors in a specific region. Its goal is to co-design products and services, on an iterative way, with key stakeholders in a public private people partnership and in a real-life setting. One of the outcomes of this co-design process is the co-creation of social value (benefit). To achieve its objectives, the Living Lab mobilises existing innovation tools and methods or develop new ones" (p. 197)

Source: own elaborations.

In the figure below (Figure 3), we have identified the most frequent keywords that are used to describe and define what a LL is (Table 1). The bigger and bolder the word appears, the more often it's mentioned within the definitions.

Figure 3 Keywords in definitions of Living Labs

Source: own elaborations.

These definitions clearly underline the importance of active user engagement in the innovation process. Nevertheless, in many cases, the term LLs is used to describe testbeds which lack the co-creation element. In testbeds, users assume a passive role, limited to testing and providing feedback on an innovation. On the contrary, LLs involve users in all stages of the innovation process, collaborating towards a new product or service and making sure the opportunities for contribution are equal for all. Georges and Gilbert (2017) compared LLs and testbeds and found the main differences related to: (1) the context which is controlled in testbeds and real-life in LLs; (2) users' contributions which in LLs are valued equally compared to other stakeholders; and (3) the fact that LLs address user needs from ideation until commercialization. The situation is similar with pilots or demonstrations, that usually have short-term goals and focus on the validation of a solution/technology involving end-users and/or technology providers. These different terms are analysed in (Ståhlbröst et al., 2018).

When the whole city is seen as a LL that focuses on long-term scaling of innovation co-creation, the concept of Urban Living Lab (ULL) emerges (Ståhlbröst et al., 2018). However, a unified definition of an ULL is missing, including its objectives, challenges addressed, stakeholders and how to engage them in the innovation process, as well as what an urban context is. Bylund (2014) refers to the following definition of ULLs given by JPI Urban Europe: *"[An urban living lab] is a forum for innovation, applied to the development of new products, systems, services, and processes, employing working methods to integrate people into the entire development process as users and co-creators, to explore, examine, experiment, test and evaluate new ideas, scenarios, processes, systems, concepts and creative solutions in complex and real contexts*". As emphasised by Bylund (2014) in ULLs, "*urban innovation ecosystems are not domesticated but a vibrant co-creator when we aspire to shape workable solutions*".

By contrast, the development of rural areas with the support of the LL approach is the focus of rural LLs (see e.g. LIVERUR project). Rural LLs are defined as "*an approach that facilitates digital transformation processes in rural areas by engaging quintuple helix actors including rural residents and natural environments throughout the digitalization of society in real-life setting*" (Habibipour et al., 2021). The Quintuple Helix model adds natural environment as a new subsystem (helix), with the aim of generating and promoting a sustainable development of society (Carayannis, Barth, and Campbell, 2012). It emphasises how sustainability could be addressed as part of the overall knowledge transfer, communication and promotion of solutions both towards policies (policy making and regulations) and the public (citizens behavioural change). The rural LL framework is for piloting digital innovations in rural contexts, and it is focusing on the key principles i.e., openness, realism, value creation, influence, and sustainability (Ståhlbröst, 2012) that guide the innovation processes in a LL context.

The concept of "*living labs as a service*" has started to emerge (Schuurman et al., 2019). This concept refers to LLs offering services such as designing the idea-generation processes, planning or carrying out real-world tests of innovation and pre-market launch assessments (Ståhlbröst and Holst, 2013). These LLs play the role of innovation intermediaries between entrepreneurs and users.

Living labs can also be used as an agile governance tool that can help understand and shape the interface between emerging technologies and regulation of innovation. Living labs bring human-centred and co-creative approaches to the realm of agile policy-making that seeks to foster responsible innovation governance and address societal challenges. As such they can be counted amongst other agile policy-making tools such as innovation testbeds, policy labs and regulatory sandboxes (defined in List of abbreviations and definitions).

The rapid development and deployment of emerging technologies, and the accompanying changes of society, call for a more adaptive, human-centred, sustainable and inclusive policy-making. To meet the needs and values of the governed, including the solution providers and the communities involved, the governance ecosystem should be co-designed with multiple stakeholders and allow for rapid iteration (World Economic Forum, 2018). Experimentation environments, such as test beds and living labs, offer opportunities to co-develop governance mechanisms in tandem with emergent technologies, as experimentation with innovation often entails experimentation with laws and regulations, such as privacy laws and liability regimes (Engels, Wentland, and Pfotenhauer, 2019).

LLs bring to experimentation activities an in-built focus on users/citizens and the social implications of innovation. With their highly adaptive and engaging set-up, living labs can be used to experiment with new governance approaches in two ways. On the one hand, they can be used to co-create innovative products that support public governance, such as new public services. On the other hand, they can be used to design and test regulatory frameworks, or to develop and evaluate public policies.

There are examples of innovation test beds used as policy instruments that have feedback mechanisms to collect evidence and information on the limitations of existing regulatory framework to address novel technologies, contributing to the development of legal and technical regulations (Rosemberg et al., 2020). LLs can be employed as a policy instrument in a similar fashion, supporting and guiding the development of regulatory frameworks alongside the development of innovative technologies and solutions. The unique advantage of LLs is its human-centred approach that can help understand and shape the transformation of both technology and society.

2.2 Key elements of Living Labs

LLs can be seen as an ecosystem, an environment or an approach/methodology. They can benefit research and innovation projects that address societal challenges by putting citizens at the heart of the innovation development process. In general, LL definitions, even the early ones, include the terms of "*co-creation*", "*stakeholders*" and "*real-life setting*". Leminen (2015) in his definition suggested in Table 1, included seven key characteristics of LLs identified in the literature: the real-life environment, the public-private-people partnerships (4Ps), the importance of users, the difference with a testbed, and the multiple stakeholders, their roles and their in between collaboration. In Evans et al. (2017), five central elements are mentioned: multi-method approach, user engagement, multi-stakeholder participation, real-life setting and co-creation. Two years later, Hossain, Leminen, and Westerlund (2019) found as main key elements of the LLs the real-life environments, the stakeholders, the activities, the business models and networks, the methods, tools and approaches, the challenges, the outcomes and the sustainability. Even if LLs share some common key elements (Table 2), they can be implemented in numerous ways.

Table 2 Key elements of a Living Lab

Key elements of a LL	Description
Real-life setting	LL experiments usually take place in an uncontrolled **real-life setting**, in the daily environment of users, for example, a street, a neighborhood, a city; allowing to take into account the variety of possible and unpredictable situations.
Co-creation	**Co-creation** is a process during which engaged stakeholders, especially citizens, can align their objectives and develop innovative products and services. This process increases acceptance of new technologies and thus the chances of their success.
Active user involvement	**Active user involvement** enables citizens to influence the development of innovative solutions from its ideation phase.
Quadruple helix stakeholder involvement	**Quadruple helix stakeholder involvement** implies the engagement of representatives from public authorities (e.g., local/regional/national governments), industry (e.g., start-ups, SMEs, etc.), academia (e.g., universities and research institutes) and civil society (i.e., citizens) within one innovation ecosystem. It allows to move from an expert-driven innovation to a user-centric innovation.
Multi-method approach	A **multi-method approach** allows the application of multidisciplinary competences, towards the development of "*out of the box*" innovations.

Source: own elaborations based on ENoLL.

The complexity of the LL concept has led to various categorisations which help to understand the broad possible forms of application. Literature distinguishes three types of LL environments: a) semi-realistic environments, b) real-life environments and c) networks and communities (Følstad, 2008; Dutilleul, Birrer, and Mensink, 2010; Dekker, Contreras, and Meijer, 2019; Ballon and Schuurman, 2015). A second existing classification focuses on the fact that LLs can be driven by different actors, like a) users (user-driven), b) providers (provider-driven), c) enablers (enabler-driven) and d) utilizers (utiliser-driven), and this affects the focus and duration of the collaborative innovation effort (Leminen, 2015). LL environments can also be classified in: a) research LLs, b) corporate LLs, c) organisational LLs, d) intermediary LLs, and e) time limited LL (Ståhlbröst and Holst, 2013).

Ståhlbröst and Holst (2013) identified 5 components of a LL, all of which are centred around innovation: ICT and Infrastructure facilitating the cooperation and co-creation among all types of stakeholders; Management in terms of ownership, organisation, and policy aspects of the LL; Partners and Users promoting collective intelligence; Research representing the collective learning and reflection; and Approach representing the LL methods and techniques. The authors also identified 5 key principles of LLs:

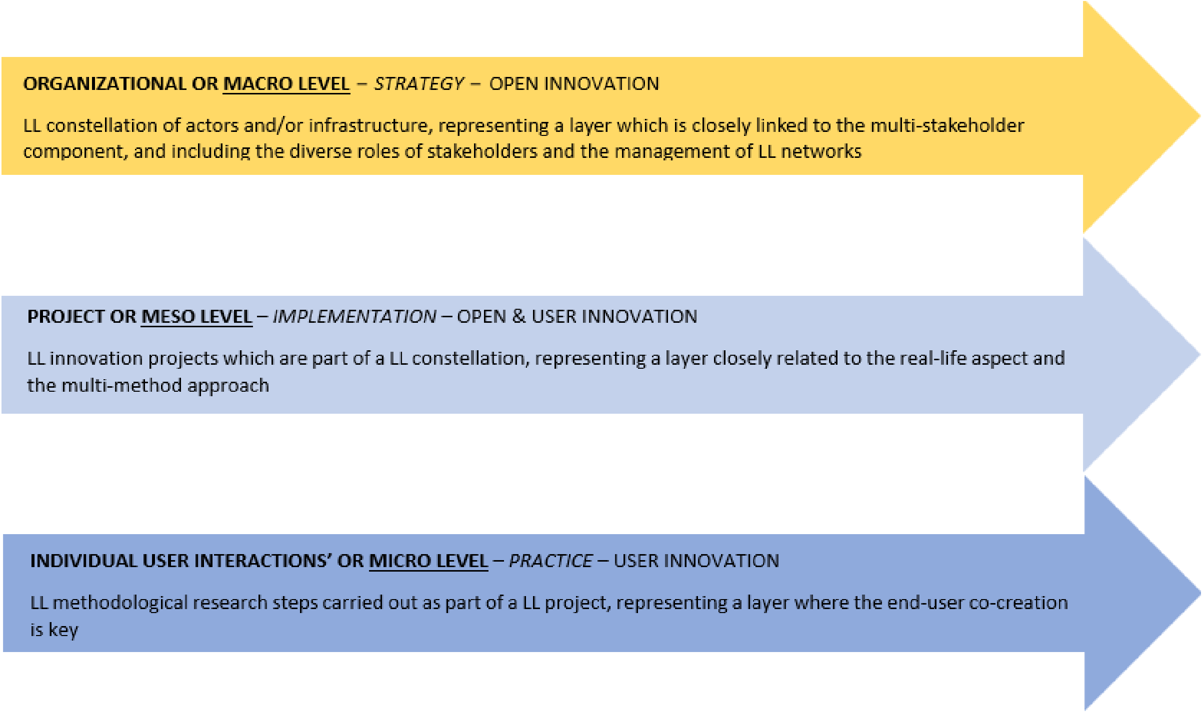
- *Value: creating value for all stakeholders including users.*
- *Influence: stimulating the influence of users on the innovation and development processes,*
- *Sustainability: taking responsibility for the environmental, social and economic effects created by LLs*
- *Openness: adopting an adequate level of openness with regard to ideas, activities and results allowing to cooperate and share in a multi-stakeholder milieu*
- *Realism: orchestrating realistic use situations and understanding users' behaviour relative to those.*

2.3 Living Lab approach and methodologies

LLs are primarily associated with the open innovation and user innovation paradigms (Hossain, Leminen, and Westerlund, 2019). Open Innovation implies "*that valuable ideas can come from inside or outside the company and can go to market from inside or outside the company as well*" (Chesbrough, 2003). User innovation is defined as the "*phenomenon of new products and innovations being developed by customers and end users rather than by manufacturers*" (von Hippel, 1988 as cited in Weber and Geerts, 2011). Schuurman et al. (2019) describe LL projects as a structured approach to open and user innovation.

Schuurman (2015) identified three distinct levels of analysis in LLs (Figure 4).

Figure 4 Macro, Meso and Micro levels in Living Labs and their links to open and/or user innovation paradigms



Source: own elaborations (adapted from Schuurman, 2015).

These different levels are further described next, presenting some applicable methodologies.

2.3.1 Macro level of the Living Lab

2.3.1.1 Stakeholder identification and engagement

At this level, a LL is seen as a public-private-people partnership that encompasses different stakeholders, organized to carry out LL projects and LL research.

LLs apply a multi-stakeholder approach that usually follows the Quadruple Helix model (Carayannis and Campbell, 2009; Arnkil et al., 2010), which includes stakeholders from the public sector, academia, citizens, and industry. This range of stakeholders can benefit from the LL in different ways, e.g. the public sector can obtain a higher return on R&I investment, researchers can have access to real case studies implementing an innovation, citizens can contribute to the co-creation of innovative solutions, and companies can get users' feedback and new ideas leading to a better service. The engagement of multiple stakeholders (including users) is key for the innovation development. In order to keep stakeholders engaged in a LL, clear value/benefit for all stakeholders needs to be created. Ståhlbröst et al. (2018) identify the following main roles in an ULL (Table 3), translated to a more general LL framework in the context of this report. Some stakeholders could adopt more than one role. Sometimes the boundaries between roles are not clearly delineated.

Table 3 Main roles in a Living Lab

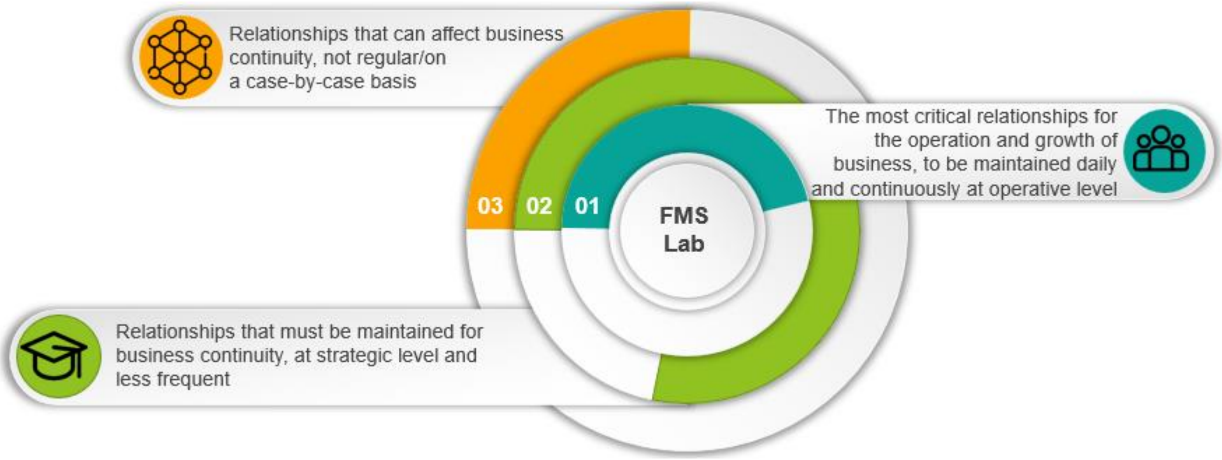
LL roles	Description
LL manager	Manages everyday practices of the LL; is the lead person of the LL; develops LL projects, ensuring that the LL is maintained and used by its intended users and that it creates value for the city where it is implemented.
Human interaction specialist	Implements human-centred interactions; analyses the results from different human interaction methods; plans the innovation process; designs concepts and principles; carries out need-finding studies, testing and evaluation activities.

LL roles	Description
Pilot manager	Facilitates the implementation and test of the innovation; plans, coordinates and implements real world experimentations; coordinates the interactions between different LL roles (e.g. solution providers, users, problem owners, and project manager) during pilot activities; plans and builds relationships among LL stakeholders; disseminates insights from stakeholders' interactions.
Panel manager	Recruits and interacts with a panel of citizens, users, and other actors involved in test/evaluation activities, collaborating with the human interaction specialist and taking good care of communication aspects (e.g. invitations), privacy protection, etc.; distributes information about experimental pilots externally; contributes to pilot activities with a secondary role. Note: *In most cases, a Pilot manager and a Panel manager are roles adopted by the same person, given that organisations do not always have the resources to split them in two different persons*.
Project manager	Manages a city development project (beyond the LL); often acts as initiator deciding potential actors to engage in a project.
Solution provider	Develops and provides the solution to be tested; develops use cases; implements the innovation; tests and disseminates research results.
User	Uses the solution once it is fully implemented; provides contextual insights and information about needs, values and goals in a specific situation/scope; discusses and evaluates ideas, concepts, prototypes, final solutions. It is possible to distinguish users from '**affectees**', with the latter referring to people who can be affected by the implementation of the solution without being a 'user' of it (e.g. people living in the city or visiting the area where the solution is implemented, but without directly interacting with the solution). It is important to involve them as well in the LL as they provide valuable insights regarding their needs, expectations and experiences related to the situation in which the solution is implemented. Besides, another possible distinction is between users and '**problem owners**'. Whereas a user can be one person, problem owners can be the city 'owning' for instance a specific mobility problem. Problem owners search for solutions to specific problems; sometimes can be the ones initiating the LL activities; participate in the identification of needs based on their knowledge about the problem area.
Financers	Funds the research and/or development of the innovation as well as the LL activities; participates in decision-making processes through project reviews and feedback actions.
Context provider	Owns the land where the solutions are implemented, i.e. is the provider of the real-world context; can influence how and where the solution can be developed (e.g. expressing infrastructure requirements and needs).

Source: own elaborations based on Ståhlbröst et al., 2018.

Stakeholders can also be classified into three tiers according to the type of relationship with the LL (Figure 5).

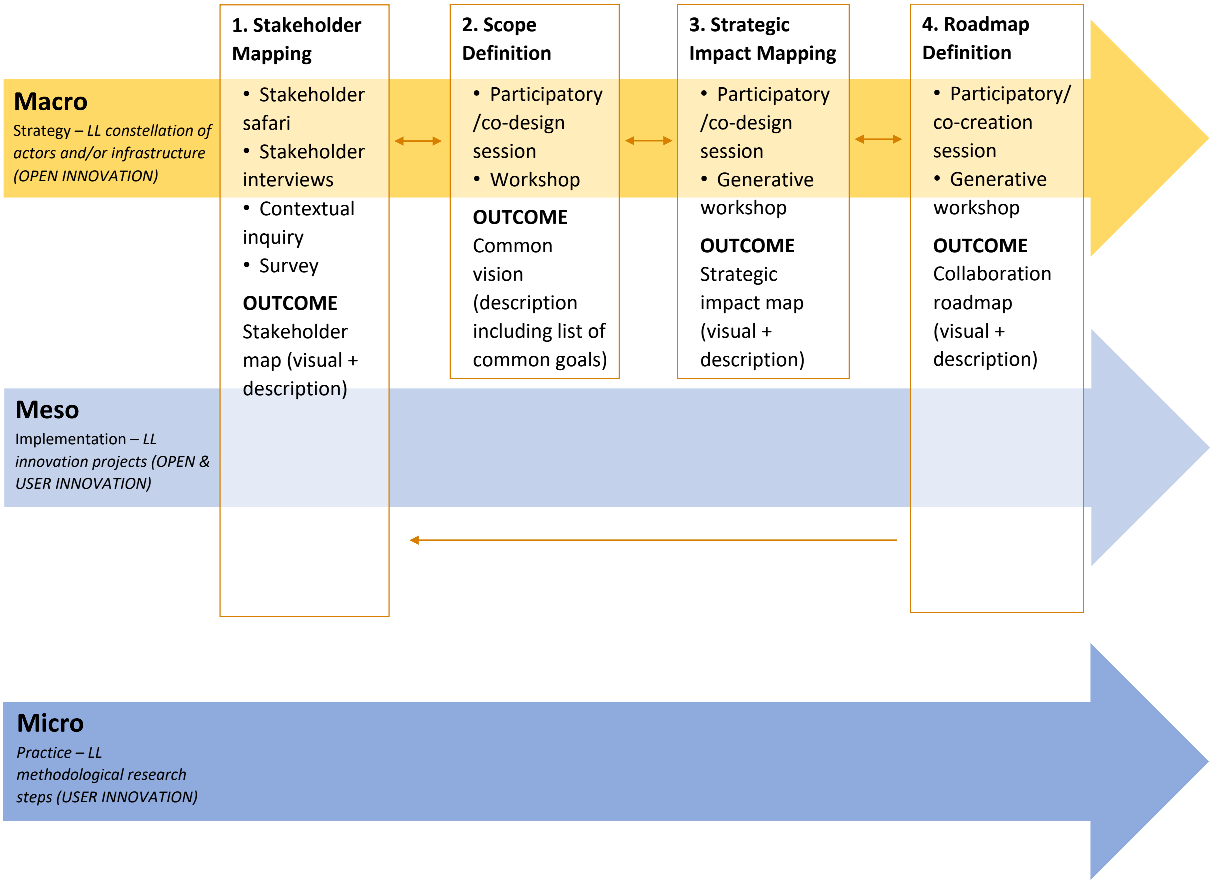
Figure 5 Tier 1, Tier 2 and Tier 3 stakeholder levels



Source: own elaborations based on the presentation of Omar Onur from the Basaksehir Living Lab at ENoLL Virtual Learning Lab 2020.

Kalinauskaite et al. (2021) have suggested a conceptual framework to initiate and facilitate transdisciplinary collaboration processes in complex research and innovation ecosystems like LLs. The framework includes the following four stages: stakeholder mapping, scope definition, strategic impact mapping, and roadmap definition. It aims at implementing co-creation approaches at the meso and macro levels of the LL (as implementation and strategic levels of the LL), extending the usual co-creation with citizens and end users taking place at the micro level (Figure 6). By doing so, the authors claim it is possible to achieve and maintain stakeholders' alignment, which is seen as crucial to ensure a common vision is shared by all players and leading to successful collaborations. Transdisciplinary collaboration facilitates the integration of different points of view, methodologies and approaches and can potentially lead to the creation of long-term sustainable alliances able to respond to dynamic and complex societal challenges.

Figure 6 Macro level in Living Labs: a conceptual framework for improved transdisciplinary collaborations, including links with the Meso level of the Living Lab



Source: own elaborations based on Kalinauskaite et al. (2021).

2.3.1.2 *Living Lab environment*

At this macro level, we could also see LLs as an environment, encompassing material, immaterial and contextual elements of the LL. In particular, Veeckman et al. (2013) identify the following LL building blocks from the perspective of the LL environment: technical infrastructure, ecosystem approach, level of openness, community, lifespan, scale and real-world context (Table 4). This type of classification is helpful to analyse how the different LL building blocks contribute to the outputs of LL innovation projects. LL practitioners could benefit from a common LL classification scheme as it would allow to assess the capacity and maturity level of LLs and fine-tune their value proposition.

Table 4 Operationalization of the Living Lab framework – Living Lab environment building block

Building block – LL environment
Technical Infrastructure
1. No technical infrastructure
2. Infrastructure without monitoring and technical testing
3. Infrastructure with basic monitoring and technical testing
4. Infrastructure with extensive monitoring and in-depth technical testing
Ecosystem Approach
1. No value creation and sharing for all involved stakeholders in the living lab ecosystem (e.g., stakeholders are chosen randomly)

2. Value creation and sharing to some of the stakeholders in the living lab ecosystem (e.g., missing links in the value chain, no equal contribution of all stakeholders)
3. Value creation and sharing for most of the stakeholders in the living lab ecosystem
4. Value creation and sharing for all involved stakeholders in the living lab ecosystem (e.g., long-term engagement and identification with the project)
Level of Openness – Intellectual Property Rights
1. Exclusive regarding results and information generated in the living lab
2. Little of the results and information generated in the living lab are shared (e.g., only brief updates or summaries)
3. Most of the results and information generated in the living lab are shared (e.g., presentations), but some results need to be kept confidential
4. Inclusive regarding results; everybody has access to the results and generated knowledge
Level of Openness – Partnerships
1. Completely exclusive partnership (e.g., exclusively controlled by a single actor)
2. Semi-exclusive partnership (e.g., only open to members of a consortium)
3. Inclusive partnership: everyone is welcome to use the platform but access is limited in time and space
4. Inclusive partnership: everyone is welcome to use the platform with no time or space limitations
Community
1. No community
2. Mostly a passive community
3. Neither passive nor active community (equal shares)
4. Mostly an active community
Real-World Context
1. A laboratory setting
2. Real-world context with severe limitations on time or space (e.g., geographical limitation, required skills or devices)
3. Real-world context with some time or space limitations
4. Real-world context without any limitations
Lifespan
1. Short-term project (<6 months)
2. Medium-term project (6 months–1 year)
3. Long-term project (1–2 years)
4. Very long-term project, with the possibility to live on permanently (>2 years)
Scale
1. Not involving any users (N=0)
2. Small scale (<100 users)
3. Medium scale (100–500 users)
4. Large scale (>500 users)

Source: Veeckman et al., 2013.

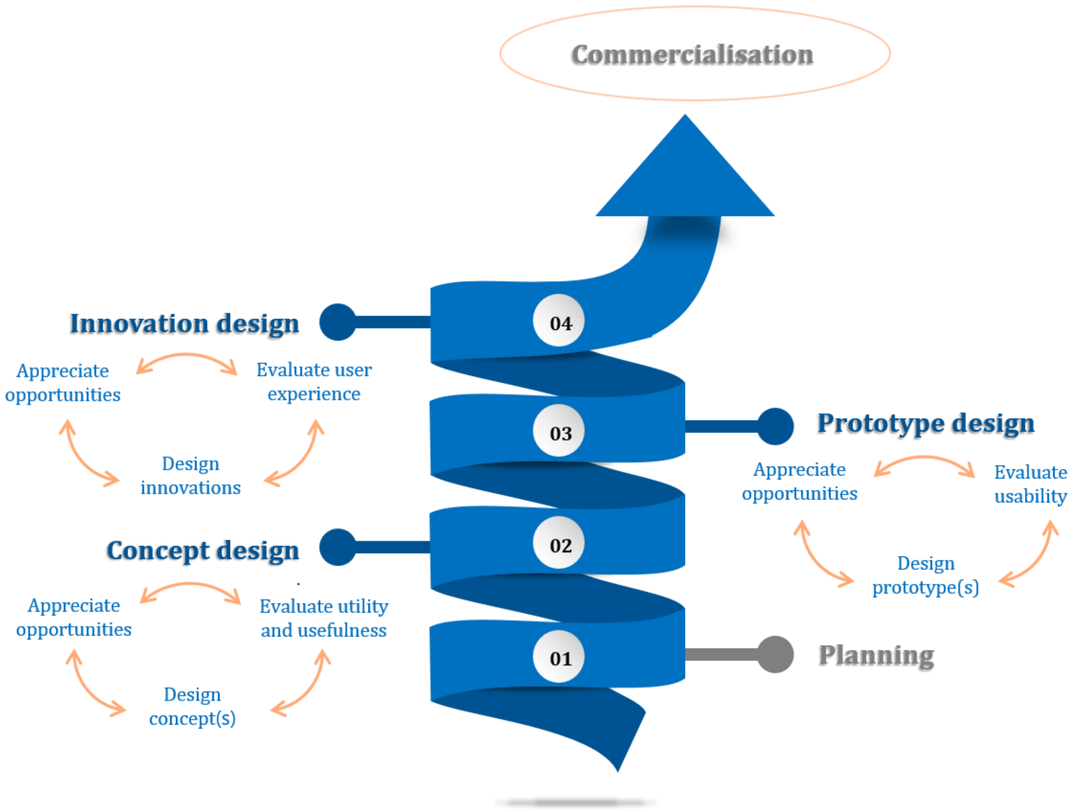
2.3.2 Meso level of the Living Lab

The meso level of the LL encompasses the LL individual projects which are part of the entire LL constellation. Grounded in a quasi-experimental approach, LLs implementation include a pre-measurement, an intervention (real-life experiment) and a post-measurement (as suggested by Schuurman, De Marez, and Ballon (2013). Along these lines, Evans et al. (2017) distinguish three main stages within LL projects, following the innovation development phases:

- *Exploration: to know the 'current state' and design possible 'future states';*
- *Experimentation: to test in real-life one or more proposed 'future states';*
- *Evaluation: to assess the impact of the experiment compared to the 'current state' and iterate the 'future state'.*

This 'action-oriented' perspective (i.e. actions taken along the different phases of the innovation process) can be matched with a 'progress-oriented' one, meaning the focus is put on the progress from a concept to a mature innovation. From this perspective, we can highlight the FormIT methodology (Ståhlbröst and Holst, 2013) (Figure 7) as an iterative method covering the cycles of concept design, prototype design and innovation design. Each cycle is then divided into four phases: Explore, Create, Implement and Evaluate, which are repeated iteratively. These four phases can be extended to cover two additional steps at the beginning and end of the innovation process, namely: Planning, (Exploration, Co-creation, Implementation, Test and Evaluation) and Adoption. FormIT was developed at Botnia Living Lab in Luleå University of Technology in Sweden with inspiration from soft systems thinking, appreciative inquiry, and need finding.

Figure 7 FormIT methodology



Source: own elaborations based on (Ståhlbröst and Holst, 2013).

In particular, each phase includes a number of key actions:

1. PLANNING: Background and type of the innovations to be developed in LL, its aim, vision and scope, relevant skills needed, context of innovation development, barriers and risks of setting up and running it, target user group, timeframes and stakeholders involved.

2. EXPLORATION: Vision and scope of the innovation, technical equipment needed, context influencing the innovation, competences and resources needed, ways to motivate and engage stakeholders, ways to promote an open and fruitful dialogue with stakeholders.
3. CO-CREATION: Concepts, prototypes and innovations are co-created, designed and developed. Data acquisition and recording strategies during the co-creation activities, other supportive tools, compliance check of LL principles, added value for each stakeholder.
4. IMPLEMENTATION: Concepts, prototypes and innovations are implemented and tested in real-world contexts. the activities that the context of innovation supports, the available physical infrastructure, identification of stakeholders who can experiment with the innovation and check if Living Lab principles are addressed.
5. TEST & EVALUATION: Concepts, prototypes and innovations are evaluated with a formative approach, looking for ways to improve. the definition of the aim of the test and evaluation of the innovation, the data collection methods will be used, the duration of the test, the technical equipment deeded and the technical infrastructure already available, the number of users and the selection criteria, their ethical considerations and a check if Living Lab principles are addressed.
6. ADOPTION: Main adopters of the innovation, understanding of the social, physical, technical, organisational context, the possible barriers and possible ways to tackle them and a final check if Living Lab principles are addressed.

Table 5 below presents a checklist applied to the different phases of the LL, addressing the meso/project level of the LL, i.e. with the questions referring to a particular LL project (thus to a specific LL solution). However, there are some phases (especially the planning phase) which are closely related to the macro level. For example, the questions presented at a planning phase necessarily address some general LL aspects (e.g. the LL vision and scope), which are then translated to a project level (e.g. the innovation vision and scope).

Table 5 Checklist for the different phases of the Living Lab innovation development process

	Planning	Exploration	Co-creation	Implementation	Test & Evaluation	Adoption
Vision, Aims & Scope	What is the LL vision and scope?	What is the innovation vision and scope? What problem does the innovation aim to address or what opportunity does the innovation aim to exploit? What contextual factors might influence the innovation development?	Are the LL key principles addressed in the co-creation phase (i.e. Value, Influence, Sustainability, Openness, Realism)?	Which activities (mobility practices) are supported with the innovation? Are the LL key principles addressed in the implementation phase (i.e. Value, Influence, Sustainability, Openness, Realism)?	What is the aim of the test and evaluation of the innovation? Are the LL key principles addressed in the test and evaluation phase (i.e. Value, Influence, Sustainability, Openness, Realism)?	In which social/physical/technical/ organisational context is the innovation planned to be adopted? What barriers are associated with the adoption of innovation? How should the identified innovation adoption barriers be tackled? Are the LL key principles addressed in the adoption phase (i.e. Value, Influence, Sustainability, Openness, Realism)?
Stakeholders including Citizens	Who are the relevant stakeholders to involve (from e.g. the public sector, private sector, academia, citizens)? Who are the target user groups (e.g. citizens, visitors, customers, potential users, non-users)? Who has the power to influence the ideas? Who participates in the decision-making process?	What competencies and resources are necessary for the innovation development (e.g. ICT expertise, manufacturers, service providers, customers, citizens)? How to motivate different stakeholders and users to be engaged in the innovation development process (e.g. winning a prize, monetary incentives, learning, technology in return)? How to keep them engaged? How to form a positive dialogue and contact with the relevant stakeholders? Is stakeholder participation and LL innovation development managed through an open call?	How should citizens be engaged in the innovation development process (e.g. interviews, workshops, focus groups, gamification, observations, scenarios, narratives)? What value is co-created in the process for all stakeholders?	Who can experiment with the innovation? Who would need to be involved in order to make it possible to implement the innovation (e.g. solution providers, context providers)?	How many users need to be recruited for innovation test and evaluation? What is the selection criteria (e.g. age, gender, occupation, technical skills, knowledge and competence)?	Who are the main adopters of the innovation in a LL context?

	Planning	Exploration	Co-creation	Implementation	Test & Evaluation	Adoption
Equipment & Infrastructure		What technical equipment does the innovation require?	What ICT infrastructure is needed for co-creation activities (e.g. hardware, software, data – public/private, networks - 4G/fibre/etc.)? How to record the collected data from the co-creation activities (e.g. camera, notes, audio)?	Which physical infrastructure exist (e.g. streets, parking lots, electricity, 4G?	Which data collection methods need to be used in the innovation test and evaluation (e.g. observations, interviews, focus groups, diaries, questionnaires)? What technical equipment does the innovation test and evaluation require? Which technical infrastructure is available in the context to test and evaluate innovation (e.g. fiber, wi-fi, 4G, sensors, IoT)?	What would be needed to scale up the solution beyond the LL context (e.g. does the solution rely on a scalable technology?)?
Ethical and Legal issues	Are there any ethical questions to be considered before starting the innovation development? What risks could exist when setting up the LL?			Which legal aspects need to be taken into consideration in order to make it possible to implement the innovation (e.g. existing regulation, permits)?	What ethical considerations need to be handled during the test and evaluation process (e.g. informed consent form)? What are the costs and benefits of the engagement for the citizens?	Are there any legal barriers for having the solution operating in the real world?
Time plan	What deadlines need to be met?				How long should the innovation test last?	

Source: Abbdolrasoul Habibipour, from Botnia Living Lab, at ENoLL Virtual Learning Lab 2020.

In addition to FormIT methodology, other LL approaches or methodologies exist (see e.g. Almirall, Lee, and Wareham, (2012) describing the LL methodologies from the Belgan iLab.o or the Helsinki LLs). More recently, the Living Lab Integrative Process has been developed by Mastelic (2019). It is presented as a standardised method in six steps (Figure 8) which focuses on open discussion and confrontation of ideas on barriers and drivers to build a common vision of a challenge, drawing on a unique combination of design thinking, social marketing and social practices theory. It was developed by the Energy Living Lab from the University of Applied Sciences Western Switzerland (HES-SO) and is now being applied by the JRC Living Labs, both in the field of energy and mobility (see how it is applied to the mobility LL in Section 3.4).

Figure 8 Living Lab Integrative Process framework

Source: Adapted from Mastelic (2019).

In Veeckman et al. (2013), methodological aspects of LLs are represented with the following building blocks: evaluation, context research, co-creation and user role (Table 6); complementing the perspective of the LL environment presented in Table 4. Indeed, the authors demonstrate that the LL environment shapes the projects and point at the need to reframe innovation activities according to intended inputs and outcomes.

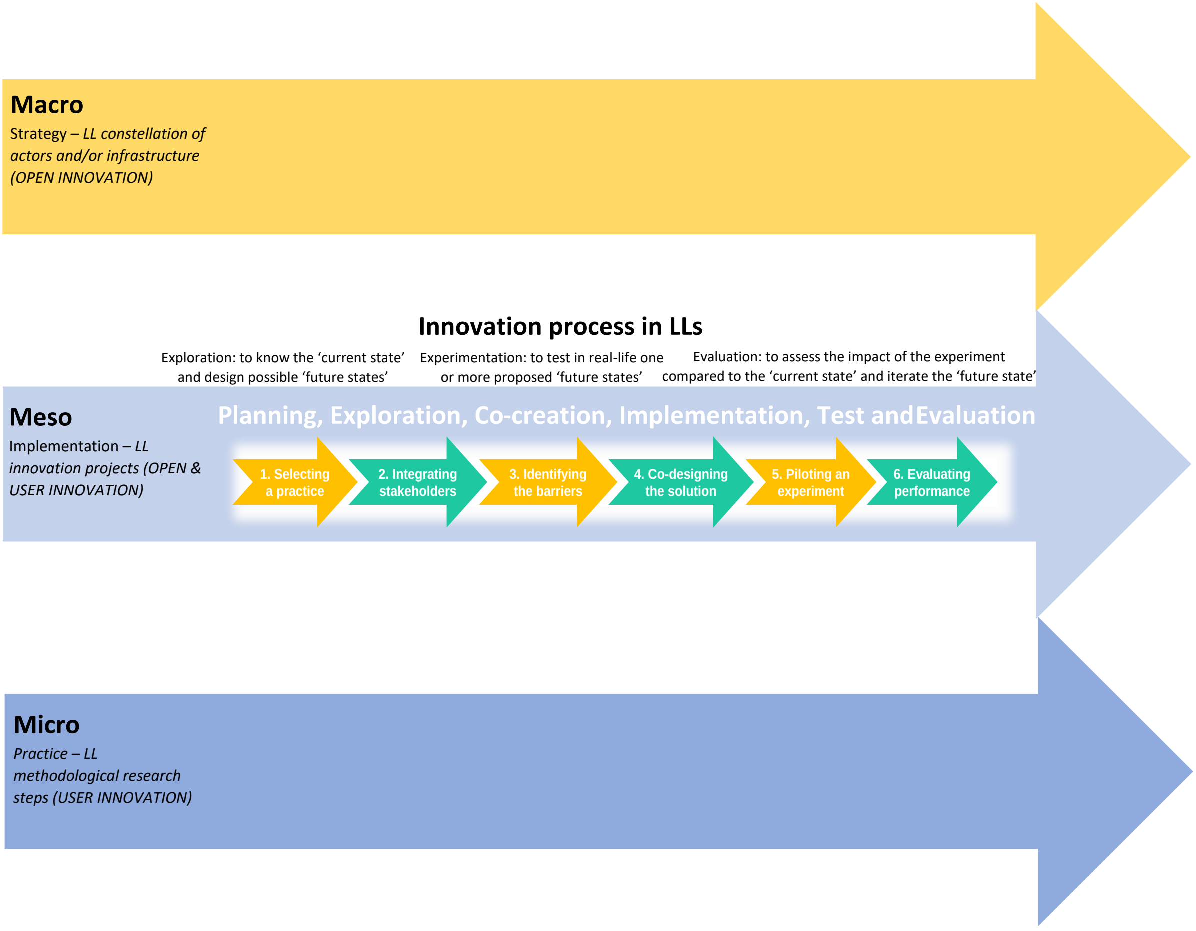
Table 6 Operationalization of the Living Lab framework – Living Lab approach building block

Building block – LL approach
Evaluation
1. No evaluation by users
2. Limited evaluation by users (e.g., post survey)
3. Evaluation by users through an interactive process (e.g., focus groups)
4. Multiple possibilities for feedback and evaluation by users (e.g., before, during, and after an activity)
Context Research
1. The usage context is not considered at all
2. The usage context is moderately considered (e.g., a short survey)
3. The usage context is substantially considered using advanced techniques (e.g., surveys, diaries)
4. The usage context is considered using more advanced techniques (e.g., ethnography tools, observations) and is viewed as a critical element that influences usage behaviour
Co-Creation
1. No interaction with users
2. User feedback is captured, but users have no decision-making power in the innovation process
3. User feedback is captured (iterative), which may lead to some modifications/alterations of the innovation
4. User feedback is captured (iteratively); user can make changes to the innovation themselves; the user is part of the innovation process
User Role
1. Informant
2. Tester
3. Contributor (creating with the user)
4. Co-creator (creating by the user)

Source: Veeckman et al., 2013.

Figure 9 shows the innovation development process in LLs taking place at a meso level.

Figure 9 Meso level in Living Labs: innovation process in Living Lab projects



Source: own elaborations.

2.3.3 Micro level of the Living Lab

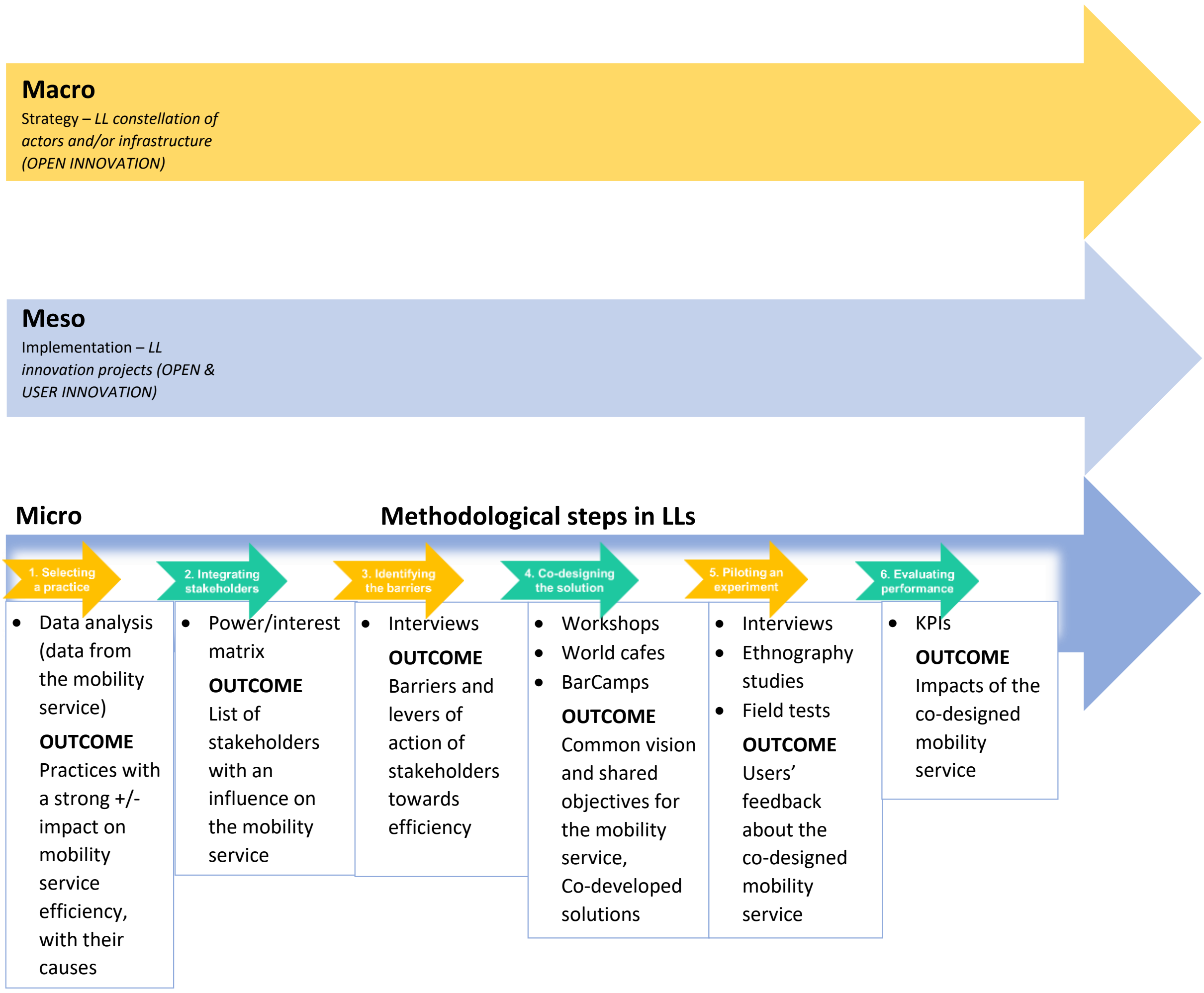
The Micro level addresses the LL research steps undertaken in LL projects, i.e. the individual user involvement activities (Figure 10). At this level, resources and capabilities of the LL organisation are applied in separate activities in which users and stakeholders are engaged. It therefore applies a combination of multiple methods and tools.

Some relevant resources that support the selection of suitable methods and tools are the following:

- *The Action catalogue (http://actioncatalogue.eu/): an online decision support tool to help researchers, policy-makers and other stakeholders find the most suitable method to conduct inclusive research.*
- *CMD Methods Pack (https://cmdmethods.nl/): a catalogue that supports design research planning in any Communication and Multimedia Design (CMD) project.*
- *The ENoLL LL toolkits (https://enoll.org/publications-list/toolkits/): a set of materials such as guidelines, tips & tricks, playbooks, toolkits, and others to support co-creation, end user engagement, real-life experimentation, in LLs.*
- *Service Design Tools site (https://servicedesigntools.org/tools): a selection of co-design tools based on the stage of the design process, stakeholders to engage in the design process, aspects of the service under focus, types of representation to use.*

To reduce cost and complexity of LL operations, Leminen and Westerlund (2017) point at the use of standardized innovation tools and/or processes. However, these authors also suggest that standardization can reduce the enthusiasm of LL activities among LL stakeholders. They distinguish the following four archetypes of LLs: linearizers (predefined linear innovation process and a standardized set of tools), iterators (iterative nonlinear innovation process but predefined set of tools), mass customizers (predefined linear innovation process but flexible customization of innovation tools), and tailors (iterative nonlinear innovation processes and customized tools). The use of standardized tools and predefined linear innovation process decreases the complexity of innovation activities, which in turn leads to predefined incremental innovation outcomes in LLs. However, adopting iterative, non-linear innovation processes and customized innovation tools increases the likelihood of achieving an undefined and novel innovation outcome.

Figure 10 Micro level in Living Labs: methodological steps and users/stakeholders involvement (focus on the Living Lab Integrative Process from Mastelic, 2019)



Source: own elaborations.

2.4 Impacts of a Living Lab

There is a lack of studies on the effectiveness of LLs (Ballon, Van Hoed, and Schuurman, 2018). Schuurman et al. (2019) refer to the complex nature of innovation activities and the many potential factors influencing innovation outcomes as the main reasons for a lack of evidence in this regard and point at the need for clearer reporting of LL activities to overcome this knowledge gap.

Both the importance of demonstrating the value of LLs to their stakeholders and the difficulty of assessing the impact of LLs are emphasised by Ståhlbröst (2012). The author points at the key LL principles to guide the impact assessment of LLs: Value, Influence, Sustainability, Openness and Realism, though without providing specific guidance on how to operationalise or assess these principles.

To evaluate the success of a LL, Veeckman et al. (2013) indicate the need to consider the innovation outcome (e.g. tangible outcomes), which is affected by a number of ingredients (citing the work of Leminen, Westerlund, and Kortelainen, 2012a; Leminen, Westerlund, and Kortelainen, 2012b): strategic intention, passion, knowledge and skills, other resources and partners in the LL network (as indicated by Leminen, Westerlund, and Nyström, 2012).

Ballon, Van Hoed, and Schuurman (2018) provide the first systematic impact evaluation of a set of LL projects, concluding that LL projects can provide significant added value for participating companies. This study revealed that participating companies most frequently appreciate that LL projects allow the incorporation of external points of view from users and other stakeholders into innovation processes, improve new offerings and test the product-market fit. These effects are translated into economic effects in terms of investments (for each public euro invested in the LL projects under evaluation, 1.5€ was realised in follow-up private investment and an additional 11€ are foreseen), employment (for each euro invested by public support agencies in all LL projects, 8.7€ had been realised in employment) and turnover (for every 1€ of invoiced LL budget. 6€ of revenues were realised, and an additional 30€ were expected in the following two years). In this publication, the authors refer to the macro and meso LL levels by Schuurman (2015) to indicate that each level could be evaluated according to specific variables:

– *The macro level: collaboration and interaction variables (e.g. knowledge transfer), criteria reflecting how end-users and other stakeholders are able to influence the innovation development process.*

– *The meso level: value generated by the LL projects (e.g. to the solution provider, such as economic value).*

It is important to emphasise that the value generated by a LL project goes beyond the economic aspects to cover for example the environmental and social impact.

To assess the impact of the JRC LLs and FMS-Lab, we need to define the Key Performance Indicators (KPIs) reflecting the JRC LLs and FMS-Lab objectives and thus addressing the perspective of the different stakeholders. For example, KPIs of the FMS-Lab could give an answer to the following questions: What policy impacts have been achieved? Which scientific outputs (e.g. papers, reports) have been produced? Have the tested solutions produced positive effects in mobility – e.g. reduced emissions, shorter travel times? Have the LL solutions been scaled up after the LL experiments?

Ballon, Van Hoed, and Schuurman (2018) point at the need to make a number of informed choices prior to the impact evaluation:

– *The object of the evaluation: delimiting the scope of the evaluation),*

– *The object of measurement: identifying what to measure through both qualitative and quantitative indicators such as realisation of the objectives of the LL, opinion of participating stakeholders, or effects of the LL on companies' employment, investment, turnover, and*

– *The evaluation approach: building a causality chain of the LL effects, based on the initial objectives.*

In order to define the scope of the evaluation, the following two dimensions are considered: timeframe of the effects (short-term, mid-term, long-term) and who is affected (involved companies, consumers or users, society). Based on the time dimension, the authors recommend that a systematic monitoring of effects of LL projects is done at two instances: at the end of a given LL project and (approximately) two years after it is completed. In their attempt to measure the impact of LLs, the authors highlight the difficulties in establishing causal links between iterations of multiple stakeholder inputs and functional outputs, business outcomes and socio-economic impacts. A possible solution to such challenge is to adopt a contribution analysis approach, which aims to confirm that an intervention is a contributory cause, without the need to specify to which extent. The authors point at the use of a mixed-methods approach encompassing a combination of both qualitative and quantitative inputs and methods suitable for the scope of the evaluation.

3 How to set up a mobility Living Lab? Experiences from the JRC Future Mobility Solutions Living Lab

This Chapter applies the LL collaborative framework, methodologies and methods/tools described in Chapter 2 (thus covering the macro, meso and micro LL levels) to the specific case of the JRC FMS-Lab, in particular relying on:

– *The conceptual framework for transdisciplinary collaboration processes in LLs by Kalinauskaite et al. (2021),*

– *The different phases of innovation development based on the FormIT methodology Ståhlbröst and Holst (2013) and*

– *The living lab integrative process from Mastelic (2019).*

We also provide a classification of the FMS-Lab using the LL framework from Veeckman et al. (2013). Overall, we describe the journey of implementing the FMS-Lab in the Ispra site, providing a state of play of some of its on-going and future activities. Chapter 3 could thus be of interest for other LL practitioners who wish to know more about the practical application of some LL methodologies.

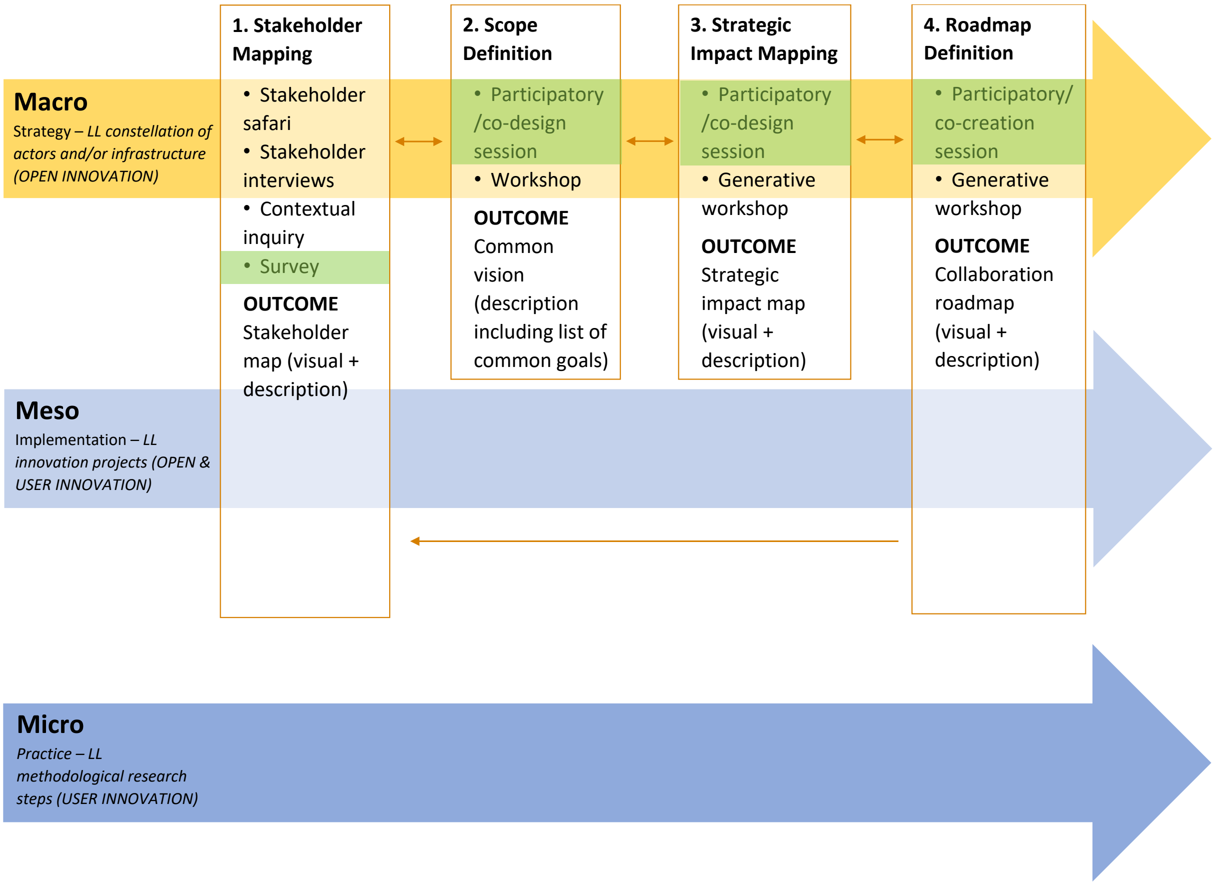
CHAPTER 3 – Key messages

- We have applied some of the existing LL methodologies, distinguishing the activities at an organisational or macro level, project or meso level and individual user interactions' or micro level.
- In particular, we have applied the conceptual framework for transdisciplinary collaboration processes in LLs by Kalinauskaite et al. (2021), the different phases of innovation development based on the FormIT methodology (Ståhlbröst and Holst, 2013) and the living lab integrative process from Mastelic (2019). We also provide a classification of the FMS-Lab using the LL framework from Veeckman et al. (2013).
- Following the conceptual framework from Kalinauskaite et al. (2021), we apply the four collaboration stages to the FMS-Lab: stakeholder mapping, scope definition, strategic impact mapping and roadmap definition. In stage 1, we have provided an overview of all the relevant FMS-Lab stakeholders, classifying them according to the type of relationship with the LL in Tier 1, 2 and 3 levels. Besides, Table 7 describes the JRC FMS-Lab practitioners and their main roles in the LL. With stage 1 almost completed, the FMS-Lab will continue applying the following three stages.
- Related to the different phases of innovation development, we have applied the checklist presented in Sub-section 2.3.2 to the FMS-Lab, following each innovation development phase on a per-project basis. We take one of the on-going FMS-Lab mobility projects as an example, namely: the co-design of an innovative social ride-sharing service.
- In the application of the Living Lab Integrative Process from Mastelic (2019), we follow its six steps with a focus on the first four steps to present: step 1 involving a workshop with JRC staff organized in 2019 and a 2020 JRC Ispra mobility survey, step 2 presenting a the FMS-Lab stakeholders in a power/interest matrix, step 3 including a mapping of existing mobility LLs, user interviews in the context of a ride-sharing service and focus groups about vehicle connectivity and automation and finally, step 4 refers to the example of the co-design of an innovative social ride-sharing service. Steps 5-6 represent future steps to be addressed.
- Based on the experiences gained until now with LL projects involving external entities (through the JRC 'Call for expressions of interest - Pilot living labs at the JRC'), we claim that a tailor-made approach is needed in order to accommodate different types of JRC LLs and FMS-Lab projects. We identify four distinct categories of projects, based on their main respective objectives, acknowledging that a given project could belong to more than one category: business model validation projects, projects focused on the co-creation of solutions, technical validation projects and impact assessment projects. Specific steps and co-creation methods apply in each project category, some of which are common to all four project types. The overall master project flow of stakeholder activities for all four identified project categories/objectives is presented in Figure 18. A selection of possible FMS-Lab activities and tools is shown in Table 16.
- Future steps of the FMS-Lab will regard the application of some later stages from these LL frameworks.

3.1 Applying the Living Lab conceptual framework for transdisciplinary collaboration processes (Macro and Meso levels)

Following the conceptual framework from Kalinauskaite et al. (2021), we apply the four collaboration stages to the FMS-Lab: stakeholder mapping, scope definition, strategic impact mapping and roadmap definition. The main motivation for using this framework lies in the possibility to implement co-creation approaches at the macro and meso levels of the LL, i.e. at both the strategic and implementation levels of the LL (**Figure 11**). This would lead to co-creation being implemented at the three levels of the FMS-Lab. The main benefit that stems from it is to reach stakeholder alignment in sharing a common vision of the LL in response to mobility challenges, which can result in more successful and sustainable collaborations.

Figure 11 Macro level (and its links with the Meso level) in JRC Future Mobility Solutions Living Lab, highlighting the main methods being applied



Source: own elaborations based on Kalinauskaite et al. (2021).

3.1.1 Stage 1: Stakeholder mapping

Firstly, we need to gain an overview of all the relevant FMS-Lab stakeholders. The JRC FMS-Lab applies the Quadruple Helix model to engage stakeholders from the public sector, academia, citizens, and industry. Table 7 describes the JRC FMS-Lab practitioners and their main roles in the LL.

Table 7 Main roles in the JRC Future Mobility Solutions Living Lab

LL roles	FMS-Lab practitioners
LL manager	**Smart Mobility Project Portfolio leader** – oversees the work of the FMS-Lab to connect the LL strategy and projects with other activities of the Sustainable Transport Unit of the JRC, in particular those falling within the Smart Mobility Portfolio. **FMS-Lab scientific coordinator** – manages FMS-Lab everyday scientific practices and acts as the lead person of the LL. She/he ensures the LL is maintained and used by its intended

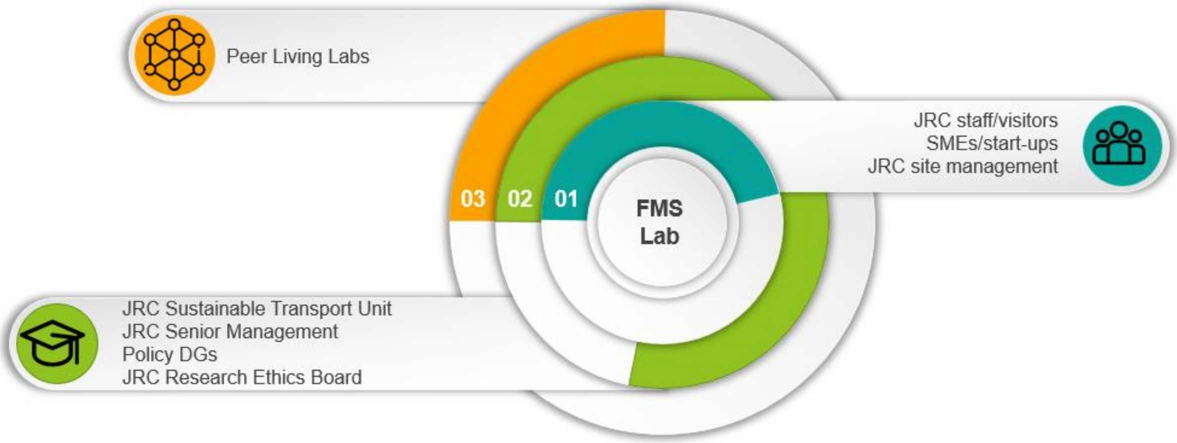
LL roles	FMS-Lab practitioners
	users and that it creates value for them. The **JRC FMS-Lab Scientific team** is then in charge of implementing the LL activities, and includes the following roles specified below: Human interaction specialist, Pilot manager, Panel manager. **JRC LLs Management and Evaluation board** – evaluates the applications received through the Call for expressions of interest - Pilot living labs at the JRC and manages the full application process until a collaboration agreement is signed between the LL applicant and the JRC. This board also takes care of the relationships with policy DGs of the European Commission and across JRC units, as well as the relationships beyond the JRC with other LLs and organisations of relevance. It also ensures the LL is maintained and used by its intended users and that it creates value for them.
Human interaction specialist	**FMS-Lab Human interaction specialist** – implements human-centred interactions; analyses the results from different human interaction methods; plans the innovation process; designs concepts and principles; carries out need-finding studies, testing and evaluation activities (member of the **JRC Scientific team**).
Pilot manager	**FMS-Lab Pilot manager** – facilitates the implementation and test of the innovation; plans, coordinates and implements real world experimentations; coordinates the interactions between different LL roles (e.g. solution providers, users, problem owners, and project manager) during pilot activities; plans and builds relationships among LL stakeholders; disseminates insights from stakeholders' interactions (member of the **JRC Scientific team**).
Panel manager	**FMS-Lab Panel and Community manager** – recruits and interacts with a panel of users and other actors involved in the different stages of the LL, deals with ethics and privacy matters in collaboration with the JRC Research Ethics Board, and takes care of communication aspects (e.g. posts in the Commission's intranet 'Connected'), including with external entities (member of the **JRC Scientific team**). **JRC Research Ethics Board (REB)** – ensures that JRC research complies with ethics standards and principles of the EU framework programs. The REB promotes these standards and carries out the ethics appraisal for the JRC research projects. REB is part of the JRC Framework for Scientific Integrity and Research Ethics (SIRE).
Project manager	**JRC FMS-Lab Scientific team** – manages JRC activities from the Sustainable Transport Unit (C.4) and initiates living lab projects in support of a smart and sustainable mobility across Europe, and contributing to the JRC Strategy for 2030 to turn JRC sites into smart, efficient, open and sustainable environments.
Solution provider	**SMEs and start-ups from the mobility field** – develop the innovations and define use cases for the specific Ispra site, implementing them and testing them with the LL approach.
User	**JRC staff and visitors (mostly from the JRC Ispra site)** – provide contextual insights and information about their mobility needs, values and goals and contribute to the co-creation and evaluation of mobility solutions specifically addressed to their site and commuting travels. **JRC Support Services and Site Management team** – in addition to having a management role, can act as owner of specific mobility problems and aims to find solutions to these specific problems. **Policy Directorates General of the European Commission** – who provide insights into the EU policy priorities and needs and contribute to the co-creation of mobility solutions in the FMS-Lab.
Financers	**JRC Sustainable Transport Unit** – co-funds the LL activities (e.g. with economic and human resources which support specific LL projects) and participate in decision-making processes through project reviews and feedback actions. **JRC Support Services and Site Management team** – co-funds the LL activities (e.g. with economic and human resources which support specific LL projects) and participate in decision-making processes through project reviews and feedback actions.

LL roles	FMS-Lab practitioners
	JRC Senior management – participates in decision-making processes regarding the LL in line with the JRC strategic directions.
Context provider	**JRC Support Services and Site Management team** – in addition to having a problem owner role (problem owners can be the city 'owning' for instance a specific mobility problem, as explained in Table 3), owns the land where the mobility solutions are implemented, thus contributing how and where the solution can be developed. **JRC Ispra Safety Office** – ensures that all the LL activities happen in safe and secure conditions, by implementing suitable procedures that involve all the LL actors. **JRC Senior management** – sets the policy and research priorities to which the FMS-Lab projects are responding. **JRC Legal team** – ensures the FMS-Lab activities are conducted within the applicable legal frameworks (in particular through the provision of tailored collaboration agreement documents and related documentation).

Source: own elaborations based on Ståhlbröst et al., 2018.

JRC FMS-Lab stakeholders can be classified according to the type of relationship with the LL. A first attempt to map the FMS-Lab stakeholders according to these levels can be found in Figure 12. Achieving a deeper understanding of individual stakeholder profiles, roles, ambitions, goals and relationships would be strongly desirable, using stakeholder maps as an output of this stakeholder analysis (future work to be undertaken, e.g. via a stakeholder survey). As the developers of this framework indicate, stakeholder maps represent an invaluable tool to understand and monitor stakeholder organisation in the collaborative processes taking place at the macro (LL) and meso (project) levels of the LL. For this reason, we suggest distinguishing between stakeholders present at the level of the LL (macro level) and those that are project-specific (meso level).

Figure 12 Stakeholders of the JRC Future Mobility Solutions Living Lab, mapped in three relationship levels



Source: own elaborations.

3.1.2 Future steps: Stage 2: Scope definition, Stage 3: Strategic impact mapping and Stage 4: Roadmap definition

At present, the FMS-Lab has almost completed Stage 1 Stakeholder mapping. In pursuing the following Stage 2 Scope definition, FMS-Lab stakeholders would be invited to define the scope of collaboration, through the co-creation of a common vision and the definition of SMART (Specific, Measurable, Achievable, Realistic, and Timely) goals for the LL (future work to be undertaken via e.g. a participatory/co-design session). This would facilitate the alignment of stakeholders' expectations, ambitions and individual goals, as well as the definition of a joint strategy to realize the common vision.

At present, the JRC FMS-Lab has the following specific objectives:

– *Discover new and emerging mobility behaviours and patterns as a result of introducing new mobility solutions,*

– *Bridge the innovation gap between technology development and the uptake of new mobility products and services in support of innovative SMEs and start-ups;*

– *Assess the socio-economic and regulatory implications of new mobility solutions and bring this knowledge to the policy making process.*

The JRC Ispra site where the FMS-Lab is located is particularly suitable for testing the real-world behaviour of future mobility solutions (such as automated driving systems) since it contains all the infrastructure and environmental elements typical of both rural and urban contexts. It includes a wide variety of infrastructural elements, from straight road segments to curves, to roundabouts, various types of zebra crossing areas, different layouts of parking areas, different types of asphalt conditions, etc. In addition, its management department is able to directly contact all staff members through email broadcasts which can be particularly effective to invite the staff to participate in co-design activities. The only current limitation of the site to test future mobility solutions is the limited availability of advanced connectivity infrastructure but an experimental 5G/6G network is being developed on site at the moment. The urban characteristics of the JRC Ispra site are reflected in Figure 13, which represent key features of the FMS-Lab environment.

Figure 13 JRC Future Mobility Solutions Living Lab fiche with key characteristics

FMS-Lab fiche

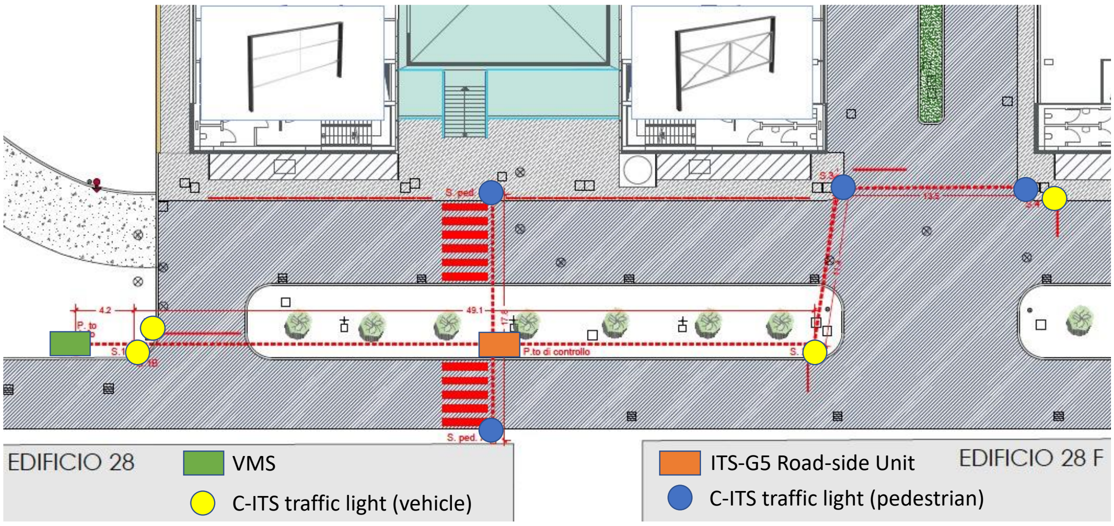
The JRC Ispra site, Italy

- **170 ha** – Largest site of the JRC; **213,000 m^2 managed space**
- Around **2,250 people** present on site every day (+ ca. 200 visitors/day) with real daily needs
- More than **80 buildings** heated/staffed
- **36 km of roads**
- **Fully fenced** site; **Italian law applied under JRC responsibility**

Source: own elaborations.

In particular, there is an urban test-track which has been instrumented with the necessary tools to allow safe and effective testing of new mobility solutions. It is composed of a 600 m long closed circuit with three intersections and a roundabout. The area is normally closed to road traffic and therefore it has higher flexibility for hosting vehicle tests. Figure 14 shows how the configuration of the infrastructure has been modified to introduce two points for pedestrian crossing regulated by Cooperative Intelligent Transport Systems (C-ITS) via traffic lights and a variable message sign to signal users about the arrival of other vehicles. The area is in addition served by a commercial 4G Long-Term Evolution (LTE) communication (a base station is available on site) and therefore any strategy based on direct cellular communication with the user can also be implemented.

Figure 14 Layout of the cooperative traffic lights, the road side unit and the variable message sign installed at JRC Ispra



Source: own elaborations.

Besides, in order to validate the capability of automated driving systems to safely interact with other road users, a series of soft targets for vehicle safety testing have been procured (Figure 15). All safety targets are compliant with EU standards for vehicle safety tests and allow the test of various types of driving scenarios without risks for vehicles, drivers and other road users. These safety targets include:

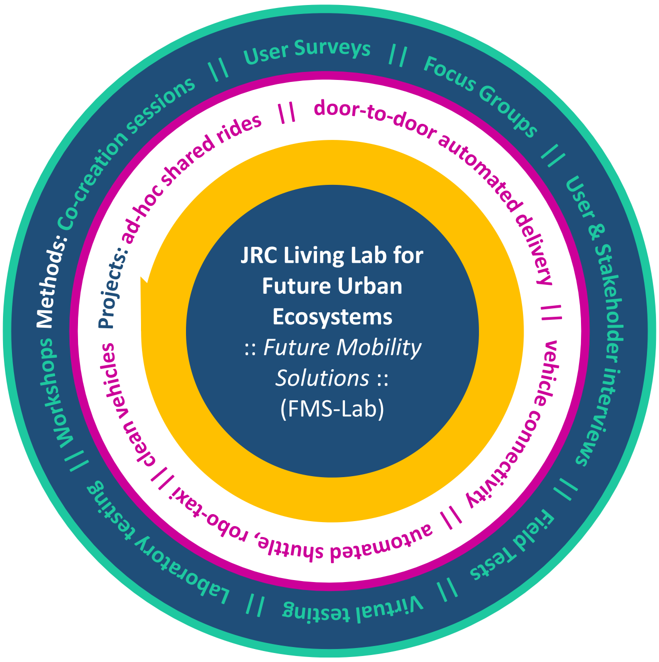
– *a two-dimensional (2D) soft vehicle target*
– *a two-dimensional (3D) foam vehicle target*
– *a pedestrian dummy (adult)*
– *a pedestrian dummy (child)*
– *a dummy cyclist*

Figure 15 Example of targets used for vehicle safety testing

Source: own elaborations.

Figure 16 shows the main projects under development and main methods being applied by the JRC FMS-Lab.

Figure 16 JRC Future Mobility Solutions Living Lab projects and methods (meso and micro levels respectively)



Source: own elaborations.

In terms of scope and as specified in the JRC Call for expressions of interest, the FMS-Lab targets mobility solutions such as:

- *ad-hoc shared rides*
- *door-to-door automated delivery*
- *vehicle connectivity and communication (Vehicle-to-everything, V2X)*
- *automated shuttle, robo-taxi*
- *clean vehicle solutions*

At Stage 3 Strategic impact mapping, stakeholders can jointly determine the LL strategy, focusing on the available and needed capabilities, relevant strategic areas and activity lines-directions which are reflected in a strategic impact map (future work to be undertaken via e.g. a participatory/co-design session).

Similarly, Stage 4 Roadmap definition uses the strategic impact map to define the way to realize the co-created strategy (future work to be undertaken via e.g. a participatory/co-creation session). This stage encompasses the roadmap, including the definition of required actions, processes, projects and their milestones and expected outputs to realize the common vision in a given timeframe. The roadmap is thus bridging the initiation (planning) and operationalisation (implementation) phases of the LL collaborative initiative. This is the reason why this stage touches upon the meso level of the LL.

3.2 Classification of the JRC Future Mobility Solutions Living Lab at a Macro and Meso level

Following the LL environment building blocks, we classify the JRC FMS-Lab at present as follows (Table 8).

Table 8 JRC Future Mobility Solutions Living Lab classification – as an environment

Building block – LL environment
Technical Infrastructure
1. No technical infrastructure
2. Infrastructure without monitoring and technical testing

3. Infrastructure with basic monitoring and technical testing
4. Infrastructure with extensive monitoring and in-depth technical testing
Ecosystem Approach
1. No value creation and sharing for all involved stakeholders in the living lab ecosystem (e.g., stakeholders are chosen randomly)
2. Value creation and sharing to some of the stakeholders in the living lab ecosystem (e.g., missing links in the value chain, no equal contribution of all stakeholders)
3. Value creation and sharing for most of the stakeholders in the living lab ecosystem
4. Value creation and sharing for all involved stakeholders in the living lab ecosystem (e.g., long-term engagement and identification with the project)
Level of Openness – Intellectual Property Rights
1. Exclusive regarding results and information generated in the living lab
2. Little of the results and information generated in the living lab are shared (e.g., only brief updates or summaries)
3. Most of the results and information generated in the living lab are shared (e.g., presentations), but some results need to be kept confidential
4. Inclusive regarding results; everybody has access to the results and generated knowledge
Level of Openness – Partnerships
1. Completely exclusive partnership (e.g., exclusively controlled by a single actor)
2. Semi-exclusive partnership (e.g., only open to members of a consortium)
3. Inclusive partnership: everyone is welcome to use the platform but access is limited in time and space
4. Inclusive partnership: everyone is welcome to use the platform with no time or space limitations
Community
1. No community
2. Mostly a passive community
3. Neither passive nor active community (equal shares)
4. Mostly an active community
Real-World Context
1. A laboratory setting
2. Real-world context with severe limitations on time or space (e.g., geographical limitation, required skills or devices)
3. Real-world context with some time or space limitations
4. Real-world context without any limitations
Lifespan
1. Short-term project (<6 months)
2. Medium-term project (6 months–1 year)
3. Long-term project (1–2 years)
4. Very long-term project, with the possibility to live on permanently (>2 years)
Scale
1. Not involving any users (N=0)
2. Small scale (<100 users)

3. Medium scale (100–500 users)
4. Large scale (>500 users)

Source: own elaborations based on Veeckman et al., 2013.

Similarly, following the LL approach building blocks, we classify the JRC FMS-Lab at present as follows (Table 9).

Table 9 JRC Future Mobility Solutions Living Lab classification – as an approach

Building block – LL approach
Evaluation
1. No evaluation by users
2. Limited evaluation by users (e.g., post survey)
3. Evaluation by users through an interactive process (e.g., focus groups)
4. Multiple possibilities for feedback and evaluation by users (e.g., before, during, and after an activity)
Context Research
1. The usage context is not considered at all
2. The usage context is moderately considered (e.g., a short survey)
3. The usage context is substantially considered using advanced techniques (e.g., surveys, diaries)
4. The usage context is considered using more advanced techniques (e.g., ethnography tools, observations) and is viewed as a critical element that influences usage behaviour
Co-Creation
1. No interaction with users
2. User feedback is captured, but users have no decision-making power in the innovation process
3. User feedback is captured (iterative), which may lead to some modifications/alterations of the innovation
4. User feedback is captured (iteratively); user can make changes to the innovation themselves; the user is part of the innovation process
User Role
1. Informant
2. Tester
3. Contributor (creating with the user)
4. Co-creator (creating by the user)

Source: own elaborations based on Veeckman et al., 2013.

3.3 Applying the Living Lab innovation development phases (Meso and Micro levels)

3.3.1 Innovation development phases: the example of a JRC Future Mobility Solutions Living Lab project

The checklist presented in Sub-section 2.3.2 is applied to the FMS-Lab, following each innovation development phase on a per-project basis. First solutions that have started to be co-designed and tested at the FMS-Lab during 2021 are a ride-sharing application and a few mobility services based on automated vehicles (mainly for people) and automated droids (for freight). Notably, these tested solutions cover not just the support to technological development but also the regulatory-support dimension of the JRC LLs. The latter is addressed from two perspectives:

– On the one hand, the FMS-Lab activities support the collection of evidence and information on how existing regulatory frameworks hinder or support the development of innovative technologies (representing the case of regulated technologies). An example of this case is the FMS-Lab project dealing with the testing of an automated vehicle on public roads, for which regulation in EU is fragmented and based on national initiatives. In many cases (like for example in Italy with the "Smart Road" decree 28/2/2018 of the Italian Ministry of Infrastructures and Transport) the testing is only allowed for retrofitted automated vehicles, namely vehicles in which the automated driving logic has been implemented in standard commercial vehicles having achieved their normal safety approval. This approach is sub-optimal as automated driving requires a complete rethinking of the vehicle design and many start-ups are basing their value proposition on this aspect. For them testing on public roads is not possible as they need to build prototypes not based on existing commercial vehicles. The FMS-Lab is able to overcome this limitation offering the possibility to test also prototypes and concept vehicles in a challenging real world, and yet controlled, environment. Furthermore, with the experience built by testing these prototypes on the JRC infrastructure we are able to support the development of the regulation on the type-approval of automated vehicles, currently being developed at EU level, both for what concerns the requirements for automated driving systems and the relative validation methods.

– On the other hand, the FMS-Lab activities can guide the development of future regulatory frameworks (representing the case of unregulated technologies). For instance, the FMS-Lab project dealing with automated delivery droids, for which regulation does not exist (e.g.: regulation on droids testing, regulation on droids' certification) helps understanding the regulatory needs of a type of technology that will make use of the pedestrian walkways, and thus that on the one hand needs to safely interact with all types of road users, and on the other hand needs to be able to be detect whether the delivery may concerns dangerous goods that could be used for terroristic actions.

Plus, in this regulatory-support function, the FMS-Lab activities could support the assessment of the overall impact of new technologies on mobility, e.g. to study whether automated vehicles, ride-sharing, last mile delivery solutions, etc. really contribute to a more sustainable urban mobility or not.

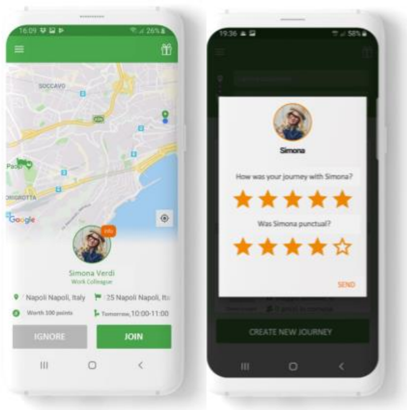
As an example, the following tables focus on one of the on-going FMS-Lab mobility projects: the co-design of an innovative social ride-sharing service (Table 10, Table 11, Table 12, Table 13, Table 14, Table 15). Colours reflect the different innovation development phases as presented in 0. Each phase indicates its status: completed, on-going, to start.

Figure 17 JRC Future Mobility Solutions Living Lab project fiche with key characteristics

FMS-Lab project fiche

Co-design of an innovative social ride-sharing service (2021-2022)

- **Innovation vision & scope:**
  - Smartphone application that allows to use the time spent travelling in whatever mode of transport (car, train, on foot, etc.) to meet people, nurture friendships, create new work opportunities and collaborations and reduce the impact on the environment
- **Main objectives**:
  - Verify the users' desirability towards the ride-sharing service
  - Test and fine-tune the ride-sharing application (e.g. usability)
  - Understand the potential impacts of using the app
- **Stakeholders**:
  - JRC staff and visitors (from all sites: Seville, Geel, Karlsruhe, Brussels, Petten and Ispra), Inputspace Start-up, JRC scientific unit, JRC infrastructure and support services



Social ride-sharing application developed by Inputspace Start-up

Source: own elaborations.

Table 10 Planning phase of the JRC Future Mobility Solutions Living Lab project: the co-design of an innovative social ride-sharing service

	Planning	FMS-Lab
	COMPLETED	
Vision, Aims & Scope	What is the LL vision and scope?	**Vision:** to promote people-centred policy design and test mobility-related policies and regulatory approaches in real life environments to ultimately reach a safe, sustainable and smart people-centred mobility **Scope:** new mobility solutions such as ad-hoc shared rides, door-to-door automated delivery, vehicle connectivity and communication (V2X), automated shuttle, robo-taxi, clean vehicle solutions
Stakeholders including Citizens	Who are the relevant stakeholders to involve (from e.g. the public sector, private sector, academia, citizens)? Who are the target user groups (e.g. citizens, visitors, customers, potential users, non-users)? Who has the power to influence the ideas? Who participates in the decision-making process?	**Stakeholders:** JRC staff and visitors (from all sites: Seville, Geel, Karlsruhe, Brussels, Petten and Ispra), Inputspace Start-up, JRC scientific unit, JRC infrastructure and support services **Target user groups:** JRC staff and visitors (from all JRC sites: Seville, Geel, Karlsruhe, Brussels, Petten and Ispra), potentially involving JRC families and surrounding communities **Power to influence the ideas:** all stakeholders **Participation in the decision-making process:** all stakeholders
Ethical and Legal issues	Are there any ethical considerations to be considered before starting the innovation development? What risks could exist when setting up the LL?	**Ethical considerations:** ethical assessment including inclusivity (engaging all JRC employees), General Data Protection Regulation **Risks:** lack of support from one of the stakeholder groups (e.g. lack of users demand), uncertain mobility habits and preferences in the current pandemics, lack of financial and human resources, legal issues (e.g. privacy, insurance)
Time plan	What deadlines need to be met?	**Deadlines**: deadlines corresponding to the following key project phases: Desk analysis (31/01/21) Value proposition design and hypothesis prioritization (15/03/21) Design and concept storytelling (22/04/21) User research (qualitative and quantitative) (30/09/21) Value proposition re-design (31/10/21)

Source: own elaborations.

Table 11 Exploration phase of the JRC Future Mobility Solutions Living Lab project: the co-design of an innovative social ride-sharing service

	Exploration	FMS-Lab
	COMPLETED	
Vision, Aims & Scope	What is the innovation vision and scope? What problem or opportunity does the innovation aim to contribute to? What contextual factors might influence the innovation development?	**Innovation vision and scope**: The service consists of a smartphone application that gives the opportunity to use the time spent travelling in whatever mode of transport (car, train, on foot, etc.) to meet people, nurture friendships or develop new ones, create new work opportunities and collaborations and reduce the impact on the environment **Problem / opportunity it addresses**: individual use of cars, opportunity to socialise to make the most of the time you spend traveling **Contextual factors**: COVID-19 health measures, changes in working schedules and patterns, organisational promotion of the app

Stakeholders including Citizens	What competencies and resources are necessary for the innovation development (e.g. ICT expertise, manufacturers, service providers, customers, citizens)? How to motivate different stakeholders and users to be engaged in the innovation development process (e.g. winning a prize, monetary incentives, learning, technology in return)? How to keep them engaged? How to form a positive dialogue and contact with the relevant stakeholders? Is stakeholder participation and LL innovation development managed through an open call?	**Competencies and resources**: software development expertise, customers (critical mass of drivers/users) **Motivation of stakeholders' participation**: for users - filling the travel dead times in profitable and sustainable ways through the new travel alternatives provided by the ride-sharing service **Engagement over time**: frequent, concise and meaningful exchanges highlighting added value **Dialogue and contact with stakeholders**: language adaptation to each stakeholder, honest communication, active listening **Stakeholder participation and LL innovation development**: it is managed through an open call for expressions of interest from which a collaboration agreement has been defined and signed with Inputspace Start-up
Equipment & Infrastructure	What technical equipment does the innovation require?	**Technical equipment**: Users' personal smartphones, internet connectivity, ride-sharing application

Source: own elaborations.

Table 12 Co-creation phase of the JRC Future Mobility Solutions Living Lab project: the co-design of an innovative social ride-sharing service

	Co-creation	**FMS-Lab**
	ONGOING	
Vision, Aims & Scope	Are the LL key principles addressed in the co-creation phase (i.e. Value, Influence, Sustainability, Openness, Realism)?	Compliance with LL key principles: Value: ✔ Influence: ✔ Sustainability: ✔ Openness: ✔ Realism: ✔
Stakeholders including Citizens	How should citizens be engaged in the innovation development process (e.g. interviews, workshops, focus groups, gamification, observations, scenarios, narratives)? What value is co-created in the process for all stakeholders?	**Citizens engagement**: we have already conducted interviews with JRC Ispra staff as potential users of the ride-sharing application. And we are currently running a survey with JRC staff from all sites. **Value co-creation:** corresponding to each stakeholder, like: *Scientific directorates:* gain insights into new technologies and innovation processes, acquire knowledge of LL methodology and tools *Ispra staff*: get user-driven feedback on new technologies, deliver added-value services to staff *Technology providers:* have access to users, labs and infrastructure in a city-like environment at no cost, receive support from scientists working on site and users *Infrastructure and support providers:* co-create a modern site with innovation and experimental services *Policy DGs:* co-create EU policies and regulation
Equipment & Infrastructure	What ICT infrastructure is needed for co-creation activities (e.g. hardware, software, data – public/private, networks - 4G/fibre/etc.)? How to record the collected data from the co-creation activities (e.g. camera, notes, audio)?	**ICT infrastructure**: collaboration platforms (e.g. Webex, Teams, Miro board), online survey management system (i.e. EU Survey), internet connection, data from JRC Ispra 2020 mobility survey. **Data recording**: notes, video and audio.

Source: own elaborations.

Table 13 Implementation phase of the JRC Future Mobility Solutions Living Lab project: the co-design of an innovative social ride-sharing service

	Implementation	FMS-Lab
	TO START	
Vision, Aims & Scope	Which activities are supported with the innovation being developed? Are the LL key principles addressed in the implementation phase (i.e. Value, Influence, Sustainability, Openness, Realism)?	**Activities supported with the innovation**: social commuting, social weekend and holiday travels, community-building **Compliance with LL key principles:** Value: ✔ Influence: ✔ Sustainability: ✔ Openness: ✔ Realism: ✔
Stakeholders including Citizens	Who can experiment with the innovation?	**Stakeholders experimenting with the innovation:** all stakeholders
Equipment & Infrastructure	Which physical infrastructure does exist (e.g. streets, parking lots, electricity, 4G)?	**Physical infrastructure**: transport infrastructure (e.g. streets, parking lots, bike lanes, etc.), electricity, 4G, wifi

Source: own elaborations.

Table 14 Test & Evaluation phase of the JRC Future Mobility Solutions Living Lab project: the co-design of an innovative social ride-sharing service

	Test & Evaluation	FMS-Lab
	TO START	
Vision, Aims & Scope	What is the aim of the test and evaluation of the innovation? Are the LL key principles addressed in the test and evaluation phase (i.e. Value, Influence, Sustainability, Openness, Realism)?	**Aim of the test and evaluation**: verify the users' interest in the ride-sharing service, test and fine-tune the ride-sharing application (e.g. usability), understand the potential impacts of using the app **Compliance with LL key principles:** Value: ✔ Influence: ✔ Sustainability: ✔ Openness: ✔ Realism: ✔
Stakeholders including Citizens	How many users need to be recruited for innovation test and evaluation? What is the selection criteria (e.g. age, gender, occupation, technical skills, knowledge and competence)?	**Number of users**: 10% of the JRC staff (to decide which specific sites can take part of the test and evaluation) **Selection criteria**: age, gender, car ownership/access, commuting distance
Equipment & Infrastructure	Which data collection methods need to be used in the innovation test and evaluation (e.g. observations, interviews, focus groups, diaries, questionnaires)? What technical equipment does the innovation test and evaluation require?	**Data collection methods**: interviews, travel diaries, questionnaires **Technical equipment**: Users' personal smartphones, internet connectivity, ride-sharing application **Technical infrastructure**: wi-fi, 4G, collaboration platforms (e.g. Webex, Teams, Miro board), online survey management system (i.e. EU Survey)

	Which technical infrastructure is available in the context to test and evaluate innovation (e.g. fiber, wi-fi, 4G, sensors, IoT)?	
Ethical and Legal issues	What ethical considerations need to be handled during the test and evaluation process (e.g. informed consent form)? What are the costs and benefits of the engagement for the citizens?	**Ethical considerations**: informed consent form **Costs and benefits for citizens**: Costs: time Benefits: new travel alternative, opportunity to socialise
Time plan	How long should the innovation test last?	**Duration of the test**: 9-month experimentation

Source: own elaborations.

Table 15 Adoption phase of the JRC Future Mobility Solutions Living Lab project: the co-design of an innovative social ride-sharing service

	Adoption	**FMS-Lab**
	TO START	
Vision, Aims & Scope	In which social/physical/technical/ organisational context is the innovation planned to be adopted? What barriers are associated with the adoption of innovation? How should the identified innovation adoption barriers be tackled? Are the LL key principles addressed in the adoption phase (i.e. Value, Influence, Sustainability, Openness, Realism)?	To be analysed in a later stage
Stakeholders including Citizens	Who are the main adopters of the innovation in a LL context?	To be analysed in a later stage

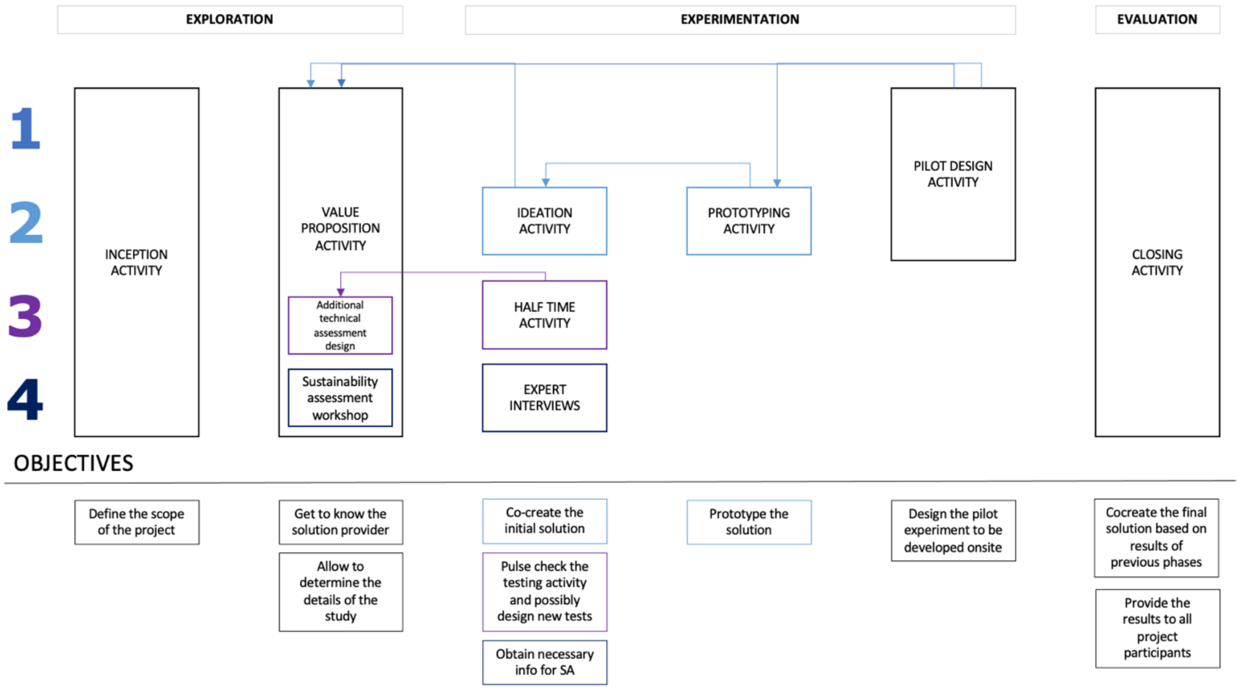
Source: own elaborations.

3.3.2 Acknowledging the diverse categories of JRC Future Mobility Solutions Living Lab projects

Based on the experiences gained so far in implementing different LL projects with external entities (mostly industrial parties like SMEs and start-ups acting as technology providers/developers, i.e. solution providers, who apply to the JRC Call for expressions of interest), we claim that a tailor-made approach is needed in order to accommodate different types of LL projects.

The overall master project flow of stakeholder activities for all four identified project categories/objectives is presented in Figure 18. The graph is divided by project phase (upper part of the figure, i.e. meso level), the activities that involve the FMS stakeholders (middle part, i.e. micro level) and the objectives to attain after each of the activities (lower part). The arrows represent the iterative nature of the LL process and indicate the opportunity to enrich the results of the previous activities during the following phases of the project.

Figure 18 Meso level in JRC Future Mobility Solutions Living Lab, with link to micro level and objectives per project phase



Source: own elaborations.

We identify four distinct **categories of projects**, based on their main respective objectives, acknowledging that a given project could belong to more than one category:

1. **Business model validation** where the solution provider aims to better understand the target group/s of users and validate the solution with target group/s representatives.
2. **Co-creation of solutions** where the solution provider aims to leverage the involvement of potential users to enhance the solution through user co-creation.
3. **Technical validation** where the solution provider aims to perform technical tests in a semi-controlled setting at the LL.
4. **Impact assessment** where the aim is to assess the potential environmental, economic and social impacts of the innovation.

We devise herein a conceptual framework for the FMS-Lab meso level, which identifies steps based on the previously presented innovation development process and suggests several co-creation methods to apply in each step.

Each project, no matter to which category it belongs, starts off with the exploration phase with an **inception activity** between the LL manager and the solution provider to better understand the needs and desired outcomes of the collaboration. The aim of such introductory workshop is to agree on the project objectives and activities to carry out in the project, i.e. identifying which category/ies the LL project will be addressing. Based on the workshop outcomes, the LL manager draws the project timeline and a proposal of the activities and tools to use during the project.

Once the project timeline is accepted, a **value proposition activity**, involving all quadruple helix stakeholders is organised. The workshop is designed to understand the problem the technical provider wants to address and the value proposition it brings. The workshop follows one of the previously established methodologies: Value Proposition canvas (B2B International), Solution canvas (UNLEASH) or the Triple Layered Business Model canvas (Joyce, Paquin, and Pigneur, 2015). Additional activities, serving specific project objectives such as design of indices useful in an impact assessment or design of the technical feasibility tests, could also be included in this phase of the project (thus being helpful for projects from categories 3 and 4).

The experimentation phase of the project is different for each category. However, there are still certain synergies among them. For the co-creation projects, an **ideation activity** follows the value proposition one. The ideation activity is designed to develop and enhance the idea, working mostly with identifying and/or improving potential solution, crystalising and developing the value proposition, and identifying the potential customer segments having all stakeholders involved in the process. Thereafter, the co-creation projects go into the **prototyping activity**, during which the co-designed idea is fine-tuned with all involved stakeholders.

The next step of the co-creation project – **pilot design activity** is also followed by business model validation projects. Pilot design activity consists of user identification study (surveys interviews, diary studies etc.), workshop between the FMS-Lab and an interested start-up during which assumptions and questions that this stage should answer are listed (activity diagrams, design specifications), and expo/demo on-site followed by user experience interviews and/or workshops.

The experimentation phase for technical validation projects consists of installation of ICTs and other required equipment, conducting the technical assessment tests designed during inception activity and a **half-time activity,** which allows all involved stakeholders to re-evaluate the running tests (choosing new locations, designing new tests), and possibly start a new pathway in a different project category.

For the impact assessment projects, the experimentation phase consists of **expert interviews/workshops** that allow to fill in any data gaps and clarify the used indices for the assessment. Thereafter the analysis is made according to a chosen methodology using collected data.

The evaluation phase of the project is common to all of the identified project categories and pursues the organisation of a **closing activity** to summarise the project outcomes of the study for all stakeholders involved in a project. During the closing workshop, elements of co-creation are also used, and attendees are asked to co-create the desired solution road map and finalise the solution canvas.

In addition to the activities that involve the stakeholders, the FMS-Lab team along with the technical provider team performs other activities which are selected and fine-tuned on the basis of the desired project outcome. Those activities could include a market analysis, data collection and modelling for impact assessment or installation of ICT devices onsite to respond to technical assessment needs. Those activities are planned and designed for each of the projects conducted at the FMS Lab. Moreover, there are numerous complementary tools to enrich and better design the project. Table 16 lists possible FMS-Lab activities and related tools.

Table 16 Selection of possible JRC Future Mobility Solutions Living Lab activities and tools

Tool	Market Analysis	User identification	Ideation	Prototyping	Pilot Experiment	Impact Assessment
Benchmarking	●					
Best practices	●	●	●	●	●	●
Literature study	●					●
Interview	●	●			●	●
Survey	●	●			●	●
Diary study		●				
A day in the life study		●				
Focus group		●	●	●		●
Morphological chart			●			
World café workshop			●	●		
Storytelling workshop				●		
Sketching workshop				●		
Tinkering workshop				●		
Expo/ demonstration					●	
Sustainability assessment						●

Tool	Market Analysis	User identification	Ideation	Prototyping	Pilot Experiment	Impact Assessment
Life-Cycle Analysis						•

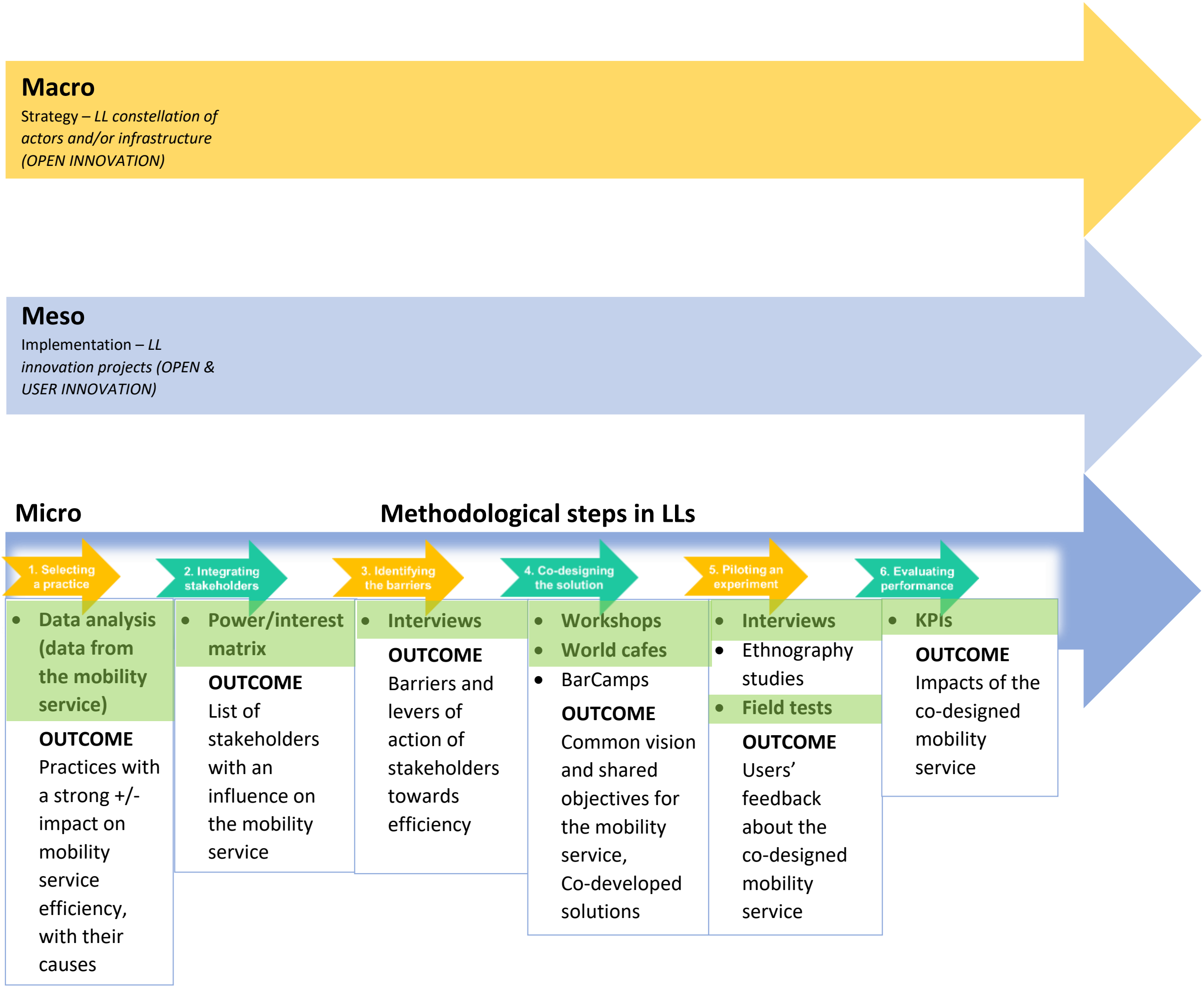
Source: own elaborations.

3.4 Applying the Living Lab Integrative Process (Meso and Micro Levels)

At the micro level, we first reflected which LL archetype corresponds to the FMS-Lab (as described in Sub-section 2.3.3). Our self-assessment is that the FMS-Lab could fit under the *iterator* archetype, which points at the application of an iterative non-linear innovation process but with predefined set of tools. While the use of iterative non-linear innovation processes contributes to a higher likelihood of achieving novel innovation outcomes, the application of standardized tools supports a reduction in the complexity of innovation activities.

Following the Living Lab Integrative Process from Mastelic (2019), we apply its six steps to the FMS-Lab projects. In doing so, we adopt a multi-method approach which encompasses the following methods (but not only): co-creation workshops, world cafes, user and stakeholder interviews, focus groups, user and stakeholder surveys, field tests, observations, virtual testing, laboratory testing (some of which are displayed in Figure 19 in relation to the Living Lab Integrative Process). In the steps described below, we are mentioning examples from a variety of FMS-Lab project activities.

Figure 19 Micro level in JRC Future Mobility Solutions Living Lab



Source: own elaborations.

3.4.1 Step 1. Selecting a practice

The purpose of this first step of the LL integrative process is the study of the available data on the mobility system of interest (i.e. in this case, mobility at the JRC Ispra site), the selection of mobility practices that are identified as "*a problem to be solved*" and their definition, looking at the "*roots*" of the problem rather than just describing their effects. In particular, this step can focus on the selection of 1-3 practices that have a strong impact on the efficiency of the mobility system under study (e.g., taking the car instead of walking, driving a private vehicle without any passengers, charging users for road use).

For the FMS-Lab case, this step has encompassed the organisation of a workshop with JRC staff on 14 May 2019 and a JRC Ispra mobility survey in September 2020. Results from these two activities are reported below.

3.4.1.1 2019 JRC Living Labs Workshop at Ispra

A workshop with JRC staff was organised on 14 May 2019 with the aim of understanding the context, including the main mobility problems and needs of the JRC Ispra staff. A second objective was to gather user feedback about the implementation of a mobility LL at the JRC, especially to explore their concerns with regard to the experimentation activities.

In practical terms, the workshop consisted of providing a brief explanation on the scope and motivation of the FMS-Lab, followed by a collaborative dialogue around the following questions:

1. How can JRC mobility be improved? Which mobility technologies would you use at the JRC sites?
2. How should the experiments be carried out? Which are the concerns in the testing of new mobility options at the JRC?
3. Do you have any final suggestions to the transport team?

To stimulate the discussion, pictures of some alternative innovative mobility solutions were presented (Figure 20).

Figure 20 Alternative innovative mobility solutions used to stimulate the discussion

Source: own elaborations.

Some **highlights** from the workshop are given below.

In reply to the question "*How can JRC mobility be improved? Which mobility technologies would you use at the JRC sites?*", workshop participants expressed:

- **preference over autonomous taxi, shuttle and ride-sharing service**, among the pictures given (Figure 20);
- that an emission-free site needs sustainable internal transport solutions, encompassing electric bikes, scooters, shuttle… used in a shared way;
- the need to think about simple solutions first, such as walking or cycling; plus the need to **make safer and ease the use of soft mobility modes** (e.g. through walking or biking paths extensive through the site, bike lanes available outside the JRC, limiting cars speed to 30 km/h);
- the wish to **improve public transport**, e.g. several electric buses per day, smart organisation of business bus, improving as well the mobility for visitors with electric buses;
- that **e-charging points and electric** vehicles could be made available for staff, with charging points accessible to privately owned vehicles too;
- that we can **make the sharing of site bicycles more effective**, easing the **location of site bicycles**, e.g. by increasing the **number** of them, making them available in each building;
- the willingness to **decrease the use of the private car and parking needs** (freeing up space for other uses, like green areas); to note however that, if mobility inside the JRC becomes more car-free, parking needs outside the site might increase (unless a global solution is found), and this requires careful consideration to not shift mobility problems to other locations or even worsen the problems;
- **concerns about transport options beyond the JRC** and especially to and from Malpensa / Linate airports, including electric car rental (e.g. e-vai) with sharing options or flexible bus shuttle services (including weekend travel); some participants indicated that, for the transport to the airport, an autonomous shuttle could take people to the entrance, where the navette would collectively transfer employees to the airport;
- that the site could **give information on available parking spots** throughout the whole site (saving time, reducing pollution);
- that **automated vehicles could be used for goods delivery as well as for passengers' transport**; for goods, the use of drones was highlighted, e.g. for postal activities or food delivery, while for passengers, autonomous shuttles could be made available to go from distant buildings to cafeteria during lunchtime (with specific pick-up points);
- that a **survey on mobility needs** could be distributed to staff at the beginning, addressing both users' mobility and logistics; this would help in the design / selection of effective solutions (e.g. by identifying the more frequent movements, pick-up areas); also participants explained we could **collect actual mobility data** to understand e.g. how many cars enter the site every day, how many of them move within the site, how many people use the bus, etc. and as an example, buses and shared bikes/cars within the site could be monitored for this purpose;
- that it would be helpful to identify and engage "**alpha users**" who could lead by example, e.g. through the European Commission's intranet Connected;
- the desire to have **apps for booking mobility services** on demand, including start/end points, time requirements, shared trip, etc. which would need to be developed ensuring usability and accessibility of any software/apps to be used for mobility purposes;
- the possibility of **optimising the organisation of meetings and new building construction** activities, making them closer to the interested people and therefore limiting their mobility needs;
- the idea of **promoting car-free days** inside the site, making available shuttles and electric bikes, as well as **organising green driving competitions** several times a year (and making results available for all JRC workers), as well as other gamification approaches to encourage sustainable mobility choices;
- that we can **collaborate with neighbouring authorities** (city, province levels) e.g. to arrange/coordinate local buses (to European school, to Milan…), planning from outside towards inside the JRC and thinking about the whole society and not only JRC staff needs;

- that the **JRC site can be used as a test lab/environment** where the most promising solutions can then be brought outside, following a multi-step approach;
- concerns about why **external staff** cannot access electric bikes and other transport alternatives offered by the JRC.

In conclusion, the general perception is that there is **a need to improve mobility at the JRC Ispra site**. The LL approach needs to **consider not just the mobility inside the JRC but also beyond its borders**, to avoid shifting / worsening the problems at external locations. There is an overall agreement on the need to decrease the use of the private car versus more sustainable modes, including biking, walking or using public transport. In achieving this, participants in the discussions have emphasised the use of (autonomous) **shuttles and ride-sharing services** as valid alternatives to move within the site in a more sustainable way.

Responses to the second question "*How should the experiments be carried out? Which are the concerns in the testing of new mobility options at the JRC?*" revealed the idea that **technologies need to have an added-value**, e.g. moving towards a low-carbon mobility, rather than just be pursed for the sake of technology. Broadly speaking, JRC staff is **willing to participate in the testing activities** with start-ups coming to the site and agree to have their mobility monitored for the purpose of research and services/technologies optimisation (of course, protecting personal data in accordance with current legislation).

The last question "*Do you have any final suggestions to the transport team?*" brought the proposal of creating a **questionnaire on current mobility habits and needs**, as a first step in the process of implementing the JRC Ispra Living Lab on Mobility. It would be useful to understand aspects like number of trips, origin-destination, and so on, so that the proposed services can actually be of added-value in addressing the mobility needs of people on site.

3.4.1.2 JRC Ispra Mobility Survey 2020

The JRC Ispra Mobility Survey 2020 aimed to scope out pre- and expected post-pandemic commuting practices amongst JRC Ispra site staff. Past and expected e-charging habits were also included. It was also responding to the suggestions expressed in the 2019 workshop with JRC staff. The objectives of the survey were the following:

- *To untangle the mobility habits and needs of Ispra site staff for the research activities of the Living Lab;*
- *To measure initial acceptance for the living lab solutions being implemented on-site;*
- *To support the development of new Ispra Site Mobility Plan, fostering modern and sustainable mobility solutions to staff.*

The survey was launched on 28 September and closed on 15 October 2020 and attracted 608 responses, corresponding to more than a quarter (28.4%) of the Ispra staff population.

Pre-COVID mobility habits

Vast majority of the respondents live in close proximity to their workplace. With 70% of staff living within 20km from the site and 28% in three bordering villages (Ispra, Cadrezzate con Osmate and Brebbia). Despite, the proximity to the workplace, the JRC population opts to commute by car (76% of commuters), with other transport modes falling behind: bicycle (8%), JRC bus (6%), car-pooling (2.5%), walking (2.3%), and public transport (0.2%). Nevertheless, 38% of car commuters once asked about the reason for car usage claimed lack of alternatives, thus supporting the development of alternative solutions by the living lab.

Post-COVID mobility habits

The survey also tried to grasp the foreseen changes in the mobility preferences of the JRC staff. With results showing that the share of car-bound commuting could still increase by 7% as compared to the pre-pandemic preferences. Nevertheless, numerous respondents also consider using the sustainable modes more often with a 40% increase in the likelihood to use a bike and 30% increase in the likelihood to walk. Moreover, the respondents showed interests to explore the carpooling option in the future, as long as the trip is made with a friend, colleague or a household member.

Post-COVID (tele-)working habits

The survey indicated that there is a strong preference towards teleworking post-pandemic, as almost 10% of respondents would like to remain teleworking every day, and 87% at least once per week. In contrast almost three quarters of the respondents have hardly ever teleworked before the Covid-19 pandemic. The same trend is visible in the preference for event attendance, with 60% of respondents would like to limit their missions and attend the majority of events virtually.

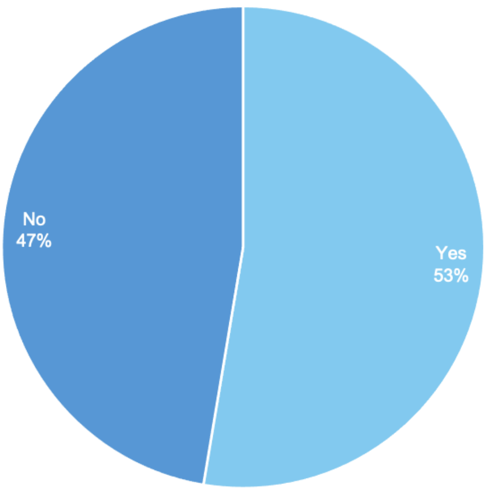
Those results pinpoint the fact that the mobility of the JRC population is not going to be what it was before the pandemic, and all of the current living lab activities should take into consideration the changes in everyday mobility patterns that the pandemic triggered.

Living Lab Acceptance

The survey was used to obtain the initial acceptance for the two LL solutions, to be tested on site: autonomous shuttle and an autonomous delivery droid. The objective was to find out to what extent the staff is willing to use those services in place of the solutions they opt for currently. The results showed that more than half of the respondents would like to use an autonomous shuttle (53%) (Figure 21) and on-demand autonomous delivery services (60%), with over a third of respondents claiming willingness to use the service at least three times per week (Figure 22 left). Moreover, when asked about the purpose of using the droid, 70% of respondents opted for lunch delivery with delivery of work and personal items being the close second (Figure 22 right).

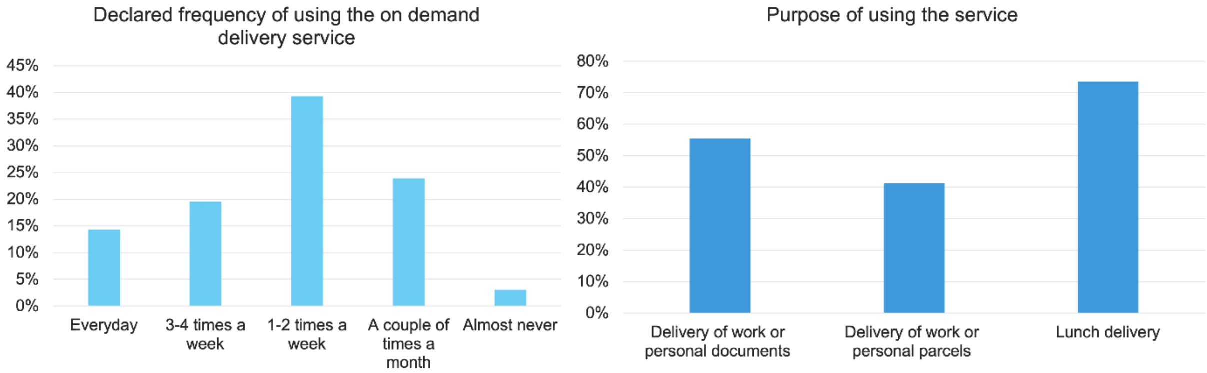
As the survey was conducted in collaboration with the Digital Energy Solutions Living Lab (DES-Lab), it also inquired about the acceptance of the proposed solutions with regard to Electric Vehicle (EV) charging preferences. The survey revealed that currently around 7% of respondents own an EV, i.e. full electric or plug-in hybrid, while 37% intend to buy one within the next three years. Moreover, almost 80% of respondents would like to charge their vehicle on site free-of-charge and in exchange would provide data on their car's charging session to be used by DES-Lab for research purposes.

Figure 21 Responses to the question "*Would you use an autonomous shuttle provided at the JRC Ispra site?*"



Source: own elaborations.

Figure 22 Survey responses inquiring about the usage of autonomous delivery droids, in particular frequency of use (left) and purpose (right)



Source: own elaborations.

3.4.2 Step 2. Integrating stakeholders

Step 2 of the LL integrative process focuses on the identification of the stakeholders who have influence over the mobility system of interest and are part of a given FMS-Lab project (Table 17). It is suggested to place stakeholders on the power/interest matrix, on the basis of present assumptions.

Table 17 Power-Interest Matrix, filled in with examples of stakeholders of the JRC Future Mobility Solutions Living Lab

Level of Interest \ Level of Power	LOW	HIGH
HIGH	Users (e.g. JRC staff, visitors), Ispra staff representation	JRC Scientific Directorates, Policy-makers (policy DGs), Technology providers
LOW	Peer Living Labs	Senior management of JRC

Source: own elaborations.

3.4.3 Step 3. Identifying the barriers

In third place, the barriers and levers of action of the different key stakeholders are researched through qualitative interviews. Focus is on their perceptions regarding the level of power and interest, their motivations, and barriers.

The FMS-Lab has addressed this step in different ways: firstly, by mapping the existing mobility LLs by means of a survey and individual interviews; secondly, by interviewing users in the context of a ride-sharing service; and thirdly, by engaging citizens in focus group discussions about vehicle connectivity and automation.

3.4.3.1 Mapping the existing mobility Living Labs landscape

LLs are a fast-growing community and increasingly accepted as a prominent form of open innovation (Hakkarainen and Hyysalo, 2016). As in any kind of community, there is a constant movement of members, projects completed and new ones starting.

Due to this tendency and with a view to preparing the implementation of the FMS-Lab in Ispra, JRC attempted to make this first inventory of the existing mobility-related (mainly or secondarily) LLs in Europe and beyond. The main aim of this activity was to take stock of the existing mobility Living Labs and conduct a meta-analysis on the basis of their scope, the technologies addressed, the applied methodologies and tools and especially to define the position of FMS-Lab on the LL map.

At the same time, with this data collection and other parallel activities, we wanted to build a community of mobility LLs so that a scientific debate about LLs in the mobility field could be fostered and there could be an exchange of best practices, and an identification of synergies and collaboration opportunities (e.g. in specific research projects, targeted citizen engagement activities, publications).

This initial idea was strengthened by the collaboration with the European Institute of Innovation and Technology (EIT) Urban Mobility Knowledge and Innovation Community (KIC) that contacted in parallel a similar mapping exercise with some differences in the approach (EIT Urban Mobility, 2021). In our case, we started from the information provided through the website of ENoLL identifying the LLs in which mobility was mentioned as domain of primary or secondary interest and then this sample was enriched with LLs found in the literature review. We identified 26 LLs in Europe and beyond (Figure 23 and Figure 24), and asked them to fill in a sheet with open questions asking for information on their fields of interest, their recent projects, the share of funding, the stakeholders involved etc. After this first contact, we provided also the possibility for virtual interviews to the interested LLs. We received 8 forms and 4 requests for interviews.

Figure 23 Sampled Living Labs

Source: own elaborations.

Figure 24 Mapping of the sampled Living Labs

Source: own elaborations.

In reality and given the data gathered so far, it is difficult to make comparisons since LLs are a complex and broad concept. Another barrier identified is that the term LL is differently interpreted and adopted. Leminen (2015), noted that the term *Living Lab* is at risk of becoming a buzzword in the innovation domain because it lacks a consistent or commonly accepted definition. Apart from the LLs which were members of ENoLL and thus already possessed certain criteria which enabled them to obtain ENoLL membership, the line between LLs and testbeds remains blurred.

In our attempt to identify the testing locations, we noticed differences in the sizes mentioned that ranged from 1.5 km^2 to 1,285.61 km^2. This could be explained from the fact that some LLs mentioned as testing area their campus and some others a whole metropolitan area of city from which they receive real time data for their experimentations. In one case, no size was mentioned because of the lack of a physical lab. The majority of them use a combination of physical and digital infrastructure for their testing activities: laboratories, control rooms, equipped and non-equipped public roads, test tracks, digital simulators, etc. The number of potential users followed the same line. Some LLs consider as users only people working in their campus, while others consider the whole city, and a few of them do not see any restriction on the number of potential users, setting it as unlimited.

The objectives mentioned were both one-dimensional and multidimensional, mainly in accordance with their fields of interest. There were LLs focusing on the creation of a flexible and safe environment to test Connected and Automated Vehicles (CAVs), so that a seamless transition from virtual to controlled to public test environments could be achieved. Public-private collaboration in testing and demonstration activities fosters transparency and cross-collaboration. For some others the main objective was the engagement of all stakeholders with an effective co-creation and co-design strategy to raise the level of knowledge and competences. Some LLs mentioned objectives more oriented to the market, and specifically to the utility to identify market barriers for the implementation of solutions and how to make contact with market actors through targeted dissemination activities. Others with a more strategic look, mentioned as objective the need to enable digital transformation in areas and sectors where its uptake is not sufficient like in Cities, Mobility and Logistics and Public Health.

Concerning the methodological approaches implemented in each LL, the replies varied. Triple-Helix Model, Quadruple Helix Model, Innovatrix Methodology, Service Design Methodology and mixed methods are the main approaches. The Triple-Helix Model refers to a set of interactions between academia, industry and government while the Quadruple Helix brings together stakeholders from public institutions (city level, regional, national and European policy), private organisations (start-ups and SMEs), as well as academia (universities, researchers, research organisations) and citizens. Innovatrix Methodology (Schuurman et al., 2019) is built upon existing business model and innovation management tools. It helps to scope the user involvement, focuses on a limited number of customer segments and at the same time allows practitioners to capture the iterations and pivots that were made during an innovation project. Service Design Methodology is a human-centered design approach based on role-play and theatrical interactions that places equal value on the customer experience and the business process.

When asked to indicate the field(s) of interest, we noticed that there were LLs with a single field of interest while others mentioned a broader research focus area with many fields of interest. This question aimed to identify common interests and potential synergies with other LLs. The list of activities proposed to this question was a selection based on TRIMIS (Transport Research and Innovation Monitoring and Information System) technology database (Tsakalidis et al., 2020) and in line with fields that could be of interest to the FMS-Lab. At the same time, each LL had the possibility to expand it, adding new fields not included in the list. The main fields of interest among the LLs contacted are connected and automated vehicles and mobility as a service followed by advanced driver assistance systems, drones, and electric road vehicles. From the replies received, none of these LLs indicated as field of interest alternative fuels, dynamic road space management, electromagnetic fields, life cycle analysis and water transport. As additional fields of interest, LLs mentioned vehicle component design, benchmarking, CAV driver training, fleet management, mobility as a service for people with reduced mobility, and smart waste management.

During the interviews, participants further elaborated on their experiences so far within LLs. They admitted that a shared understanding of LLs cannot be built due to the lack of a certification process and of a common definition consistently used in the literature. As a result, exchange of information among LLs is limited.

They also mentioned how difficult it is to engage with citizens in reality, use an easy-to-understand language, try to meet their expectations and as a final step to create a "*possible future*" for all. At the same time, they highlighted difficulties related to the General Data Protection Regulation (GDPR) or legal issues that take too much time to be solved and constitute an important barrier for their projects. Another interesting point that surfaced was that LLs could benefit from satellite LLs able to support their activities especially when related to testing an innovation with different users or in different environments or in case of lack of a dedicated infrastructure.

To sum up, this mapping activity was a first attempt to exchange with other mobility-related LLs, to explore their domains of interest and to share ours, to develop synergies and to help us better place ourselves on the current LLs landscape. Apart from good practices, our intention was to also identify challenges that require more attention so that a better scalability of mobility solutions could be achieved in the future. The same vision was shared by other LLs, and with the support of ENoLL, we could contribute to the creation of a network of mobility LLs to exchange views on the priorities and to define a common roadmap.

3.4.3.2 Interviews with users of a ride-sharing service

In the context of the FMS-Lab project on a ride-sharing application, 10 online interviews with JRC staff were conducted in order to investigate their willingness to use it, reasons that may prevent them from using it, how well the service would fit their daily mobility, and the mobility patterns the application could serve. The project has reached the quantitative research stage and a questionnaire has been launched to assess the users' interest in this new ride-sharing concept across the different JRC sites, e.g. how interesting the value proposition of this service is for users and how much they would be willing to use it. In the long run, if there is a positive assessment of the application, the aim is to launch a real ride-sharing service that JRC colleagues could use to satisfy their mobility needs in a sustainable way. The service consists of a smartphone application that gives the opportunity to use the time spent travelling in whatever mode of transport (car, train, on foot, etc.) to: meet people, nurture friendships or develop new ones, create new work opportunities and collaborations, reduce the impact on the environment and save money.

3.4.3.3 Focus groups with citizens about connected and automated vehicles

Focus group discussions organized in the context of Living Labs aimed to deepen knowledge on user perceptions and expectations towards CAVs and to further explore concepts that previously arose in the Eurobarometer survey 496 (European Commission, 2020a) on "*Expectations and Concerns from a Connected and Automated Mobility*". JRC in collaboration with the German Aerospace Center and the University of Cantabria, organized 15 focus groups in Italy, Germany and Spain. In total 72 participants with and without expertise on CAVs took part, living in 23 EU and non-EU countries.

Focusing mainly on participants' expectations and concerns, their experiences with autonomous driving assistance systems, CAVs' acceptance and willingness to use, benefits and threats of CAVs both at individual and societal level and the view of a future traffic and transport system were some of the topics explored.

Results showed that attitudes towards CAVs were predominantly positive across the participants. Increased safety and accessibility, improved travel experience for both drivers and passengers were highlighted by participants as benefits that could support CAVs' deployment. However, a variety of concerns were raised during the discussions related to privacy, responsibility in case of accident, and increase in maintenance and repair costs; these aspects could significantly hamper or delay CAVs acceptability.

During the second half of 2021, the focus group activity will be extended to cover different groups of users and additional topics that emerged spontaneously in previous sessions and they will also have strong synergies with the LL projects that will start experimentation activities on JRC Ispra site.

3.4.4 Step 4. Co-designing the solution

Steps 4-6 belong to the solutions space, most of which still needs to be developed in the FMS-Lab. One good example of this step 4 is the on-going FMS-Lab project dealing with the co-design of an innovative social ride-sharing service, presented in Sub-section 3.3.1. The aim of step 4 is to bring together the key stakeholders (e.g. in workshops, world cafés), and work together towards the development of a common vision and shared objectives for the mobility system under study. It is important to ensure representation of the four stakeholder types: industry, public authority, citizens and research. A space for dialogue among stakeholders is offered. Solutions are co-developed with users. A design thinking approach has been applied in the case of the ride-sharing project of the FMS-Lab, where co-design sessions, interviews and surveys are being carried out with the active participation of the industry, research and site management teams of the JRC, and users.

3.4.5 Future steps: Step 5. Piloting an experiment and Step 6. Evaluating performance

Steps 5-6 represent future activities of the FMS-Lab, though some initial experimentation work has started. These steps address the implementation and test of the co-designed solution/s. Feedback about how to improve the mobility system under study is collected through e.g. interviews and ethnography studies. We will use agile methods to allow for as many iterations as necessary without the need to wait for a final prototype.

Step 6 of the LL integrative process establishes the measurement and verification plan before the pilot and recurrently evaluates the results. Different methods are applied to verify the conclusions (e.g. qualitative and quantitative, simulation and real).

As Mastelic (2019) describes, a final 7^{th} step would address the communication of the results of the project to all stakeholders, celebrating and sharing the success so that others can replicate it, in accordance with the open innovation and open science paradigms, which advocate integrated collaboration, co-created shared value and knowledge sharing.

4 Main challenges, recommendations and community-building efforts of the JRC Future Mobility Solutions Living Lab

Based on the experience gained so far, we highlight a number of challenges and key recommendations on how to set up a LL in the mobility domain. We also provide an outlook for the on-going community-building activities with a view to establishing an international network of mobility LLs. This Chapter could thus be of interest for both LL practitioners and other stakeholders (e.g. policymakers, academia) who wish to know more about how to handle the challenges in LLs and identify networking opportunities in the LL field.

CHAPTER 4 - Key messages

- Challenges encompass achieving inclusivity by engaging citizens from all societal groups; actively engaging citizens and other types of stakeholders in all the stages of the innovation development process (exploration, experimentation, evaluation); finding effective ways to engage users in the LL activities through trust-building efforts and value-added initiatives; developing LL projects during COVID-19 pandemic; adopting an effective LL governance structure; among others.
- As recommendations, we highlight the importance of starting any LL work by planning and defining aims, target users and stakeholders, and ways to effectively engage users and all stakeholders throughout the LL project; setting up a LL steering committee to support the strategic and operational activities of the LL with a clear and shared strategic direction and vision, developing communication strategy and tools; checking compliance with LL principles in all the stages of the LL process; identifying opportunities for transferability, scalability and replication of the obtained results and process through collaborations with other mobility LLs; among others.
- The FMS-Lab has been nurturing collaborations with the following key players in Europe, with which a memorandum of understanding exists: EIT Urban Mobility Knowledge and Innovation Community (KIC), European Network of Living Labs (ENoLL), and Milano Innovation District (MIND).
- These collaborations represent opportunities for scaling up the activities of the FMS-Lab, which pave the way to a higher impact of the LL work, allowing to assess replicability of LL activities and transferability of results from LL research. Through multi-stakeholder collaborations we aim to build a network of mobility LLs to promote complementarity and evolve the LL research in a consistent and robust manner and altogether advance towards a safe, sustainable and smart people-centred mobility.

4.1 Challenges and lessons learnt from the set-up of the JRC Future Mobility Solutions Living Lab

Two years after the start of the FMS-Lab, we have collected a number of insights about what has worked and what has not and have framed these in the broader perspective of other LLs in the mobility field. It is part of an on-going learning experience to take a step closer towards the vision of the FMS-Lab.

We start by listing some of the **main challenges** we have experienced at the FMS-Lab:

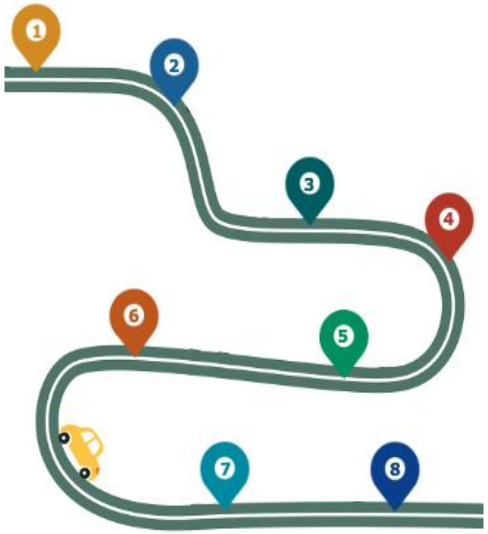
1. **Achieving inclusivity**: engaging citizens from all societal groups in the LL activities. FMS-Lab faces the limit of the JRC staff socio-demographic and socio-economic characteristics (e.g. education, income, age). In some projects, we have had an overrepresentation of high-level education groups (e.g. PhD) or underrepresentation of some age groups (e.g. older adult). In the latter case, the use of specific digital collaborative platforms has also played a role demanding digital skills for participation.
2. **Actively engaging citizens and other types of stakeholders across the stages of the innovation development process** (exploration, experimentation, evaluation): Not all FMS-Lab projects reach the LL with the same Technology Readiness Level (TRL), which means that some co-design and other engagement activities are not feasible. For example, if solutions come in at a high TRL, the co-design of the solution might not be feasible.
3. **Finding effective ways to engage users in the LL activities**: to make users find value in participation and to keep them engaged throughout the activities. In some cases, co-design workshops have not benefited from the intended attendance of users (in terms of number) even if they were widely advertised. We see the need to build trust and recognition for the FMS-Lab over time.
4. **Engaging the users and actively developing the LL projects during the COVID-19 pandemic**: it has posed difficulties in the organisation of co-creation activities as well as in the trust and relationship building activities. As an example, the online setting used in our focus groups has limited the interaction between users, compared to what a physical setting would have allowed.
5. **Being resilient in the face of unpredictable events**: like technical breakdowns during the testing activities, which might affect the original work plan or put at risk the LL project. Moreover, some experimentation activities have been delayed because of the lack of staff onsite due to the pandemic.
6. **Aligning stakeholders' values within the LL**: to achieve a common mission that balances the different interests and goals of each stakeholder. It has not been easy to involve some stakeholder types in the FMS-Lab activities, like public authorities which so far have not been directly involved, probably because of a lack of clear value creation opportunities.
7. **Adopting an effective LL governance structure**: which requires an organisational change to achieve commitment at all working levels (strategic and operational). As we are still in the early years of implementation of the FMS-Lab, the organisation is still evolving towards the set-up of a well-functioning steering committee.
8. **Obtaining management sponsorship**: to secure the availability of adequate resources, predominantly encompassing physical, human and financial resources, which are essential for an adequate development of the LL activities.
9. **Transferring knowledge within and beyond the LL**: to ensure that knowledge generated in the LL is properly communicated to the various stakeholders, to share results and experiences with other LL practitioners and research/policy actors for transferability, replication and scalability. In the past two years, we have managed to actively interact with other peer LLs (more details in Sub-section 3.4.3.1 and Section 4.2) participating in events of common interest in the LL domain. Communication activities could be reinforced to establish new possible connections.
10. **Assessing the impact of the LL**: to understand the real impacts of the LL on the environment, economy and society. We identify the need to define a LL impact assessment framework with some main KPIs applied at the level of the JRC LLs and a specific set of KPIs related to the mobility field. At present, we have not fully defined indicators to measure the impact of the FMS-Lab activities.
11. **Ensuring its sustainability**: to assess and make sure the LL can be financially sustainable over time. It is important to assess the LL impact over time looking in particular at the use of resources and at the mechanisms that sustain its activities (e.g. the call).

Some experts indicate that challenges 6, 7 and 8 are the ones which are usually the most underestimated. In the future, we can expect additional challenges related to our FMS-Lab, like financial sustainability of scaling one of the LL solutions, changes in SME/start-up's strategy, etc.

From the journey of the FMS-Lab and our experiences in establishing a network of mobility LLs with the support of key players in Europe, we can provide a few **key recommendations** to consider when establishing a LL (we indicate in brackets the main challenges addressed as listed above; see them represented in Figure 25 below):

1. *Start by planning, including defining the aim of the LL, the target users and stakeholders, and making a time plan of the activities (main challenge/s addressed: 1, 2, 4, 5).*
2. *Define early on the ways to effectively engage users and all stakeholders, answering the questions, 'what value does the living lab provide to them', 'what's in it for them?' and 'how can we motivate them to participate?', making use of the many useful engagement tools and methods (main challenge/s addressed: 1, 2, 3, 8).*
3. *Set up a LL steering committee to support the strategic and operational activities of the LL. Clear strategic direction and vision are needed, in alignment with all involved players (main challenge/s addressed: 6, 7).*
4. *Identify the needed physical infrastructure and equipment, as well as key performance indicators for the experimental phase, and secure resources considering use and maintenance (main challenge/s addressed: 8).*
5. *Develop communication strategy and tools to communicate properly and often, in honest ways (also when things go wrong) to the involved stakeholders, using different dedicated channels (main challenge/s addressed: 9).*
6. *Check the application of LL principles (i.e. Value, Influence, Sustainability, Openness, Realism) in all the stages of the LL process (main challenge/s addressed: all).*
7. *Identify and share lessons learnt in view of future LL activities and share them with other LLs (main challenge/s addressed: 9, 10, 11).*
8. *Think about the possibilities for transferability, scalability and replication of the obtained results and process, especially relying on collaborations with peer LLs (main challenge/s addressed: 9, 11).*

Figure 25 List of recommendations on how to set up and run a Living Lab, linked to the main challenges identified by the JRC Future Mobility Solutions Living Lab



Recommendations

1. Start by planning, including defining what is the aim of the LL, who are the target users and stakeholders, and making a time plan of the activities
Challenges addressed: 1, 2, 4, 5

2. Define early on the ways to effectively engage users and all stakeholders
Challenges addressed: 1, 2, 3, 8

3. Set up a LL steering committee
Challenges addressed: 6, 7

4. Identify the needed physical infrastructure and equipment, as well as **key performance indicators** for the experimental phase, and secure **resources** considering use and maintenance
Challenges addressed: 8

5. Develop communication strategy and tools
Challenges addressed: 9

6. Check the application of LL principles
Challenges addressed: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

7. Identify and share lessons learnt in view of future LL activities and share them with other LLs
Challenges addressed: 9, 10, 11

8. Think about the possibilities for transferability, scalability and replication of the obtained results and process
Challenges addressed: 9, 11

Challenges

1. Achieving inclusivity
2. Actively engaging citizens and other types of stakeholders across the stages of the innovation development process
3. Finding effective ways to engage users in the LL activities
4. Engaging the users and actively developing the LL projects during the Covid-19 pandemic
5. Being resilient in the face of unpredictable events
6. Aligning stakeholders' values within the LL
7. Adopting an effective LL governance structure
8. Obtaining management sponsorship
9. Transferring knowledge within and beyond the LL
10. Assessing the impact of the LL
11. Ensuring the sustainability of the LL

Source: own elaborations.

4.2 Way forward towards community-building: Partnerships and collaborations to create an international network of mobility living Labs

As highlighted by Greve et al. (2021), further opportunities to connect communities of LLs should be sought in order to progress with the LL field and make it grow in a consistent and robust manner. The authors emphasise the importance of maintaining cohesion by reaching out to other LL researchers in an effort to plan LL research efforts more strategically.

So far, the FMS-Lab has been nurturing collaborations with the following key players in Europe (Figure 26), with which a memorandum of understanding is in place:

– *EIT Urban Mobility Knowledge and Innovation Community (KIC)*

EIT Urban Mobility (KIC) is an initiative of the European Institute of Innovation and Technology (EIT) that aims to encourage positive changes in the way people move around cities in order to make them more liveable places. Using cities as LLs, EIT Urban Mobility brings together all key players in urban mobility to create together with citizens, more efficient mobility solutions creating at the same time accessible public space.

EIT Urban Mobility has recently published a European inventory of urban mobility LLs (EIT Urban Mobility, 2021), and is aiming to advance the understanding of how LLs can contribute to the fundamental transformation of the present urban mobility system. We cooperate with EIT Urban Mobility in an effort to bring forward the urban mobility LL movement in Europe.

– *European Network of Living Labs (ENoLL)*

The European Network of Living Labs (ENoLL) is the international federation of benchmarked Living Labs in Europe and beyond. The Network was founded in 2006 under the auspices of the Finnish European Presidency and since then has grown in 'waves' of LLs, with the last wave in 2021, where ENoLL has welcomed 19 new members. ENoLL counts today over 150 active LL members in Europe and worldwide (488 historically recognized LLs since it was founded) and is present in five continents in addition to Europe acting as a platform for best practice exchange, learning and support, and LL international project development.

Together with ENoLL partners, we have created a working group on mobility as part of ENoLL's action-oriented Task Forces and under the leadership of the Thessaloniki Smart Mobility Living Lab (HIT/CERTH). Such a community of mobility LLs can benefit from the working group activities to exchange good co-design and co-creation practices in mobility LLs, share data and results on the broad impacts of new mobility solutions, and jointly organise mobility-focused events (for example in the context of the annual Open Living Lab Days organized by ENoLL).

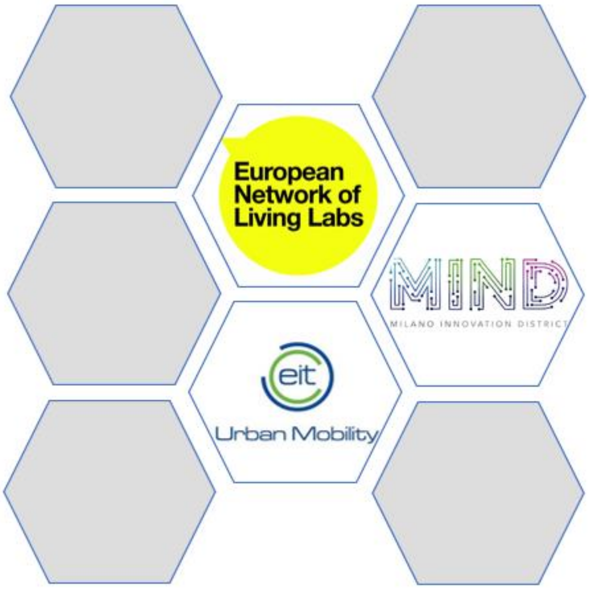
– *Milano Innovation District (MIND)*

Milano Innovation District (MIND) is the scientific project promoted by a public/private partnership composed among others of the different political levels in Italy (Government – Ministry of Finance, Regione Lombardia, Comune di Milano). It encompasses some key projects like the Human Technopole in the Life Science area; the research hospital Galeazzi; the Campus of scientific faculties of the Milan University; and has a strong LL dimension, as well as a focus on education. MIND is based on the former Expo area (1 million m^2; 4 billion € in investment; 40,000 people/day expected in 2025) and is described as "*the place where to experience new ways of working, of doing research, of living and of being together*".

The collaboration between MIND and JRC Living Labs will focus on sharing co-design/co-evaluation methodologies, as well as on scaling up the LL activities developed in the JRC Ispra site with the involvement of its staff to the MIND urban environment with a large and mixed population.

It is important to note that the collaborations with the organisations mentioned above go well beyond the mobility thematic area, involving other topics and other JRC directorates and units.

Figure 26 JRC Future Mobility Solutions Living Lab partnerships towards the creation of an international network of mobility Living Labs



Source: own elaborations.

These collaborations represent opportunities for scaling up the activities of the FMS-Lab, which pave the way to a higher impact of the LL work, allowing to assess replicability of LL activities and transferability of results from LL research.

We aim at continuing these close collaborations and at creating new linkages with other key players in the LL and transport domains towards the establishment of an international network of mobility Living Labs. The openness of the FMS-Lab and JRC Living Labs is also evident from the currently existing opportunity under Horizon Europe research and innovation framework of the EU, where applicants can seek possibilities of involving the JRC in order to valorise the relevant expertise and physical facilities of JRC in demonstrating and testing energy and mobility applications of the JRC Living Lab for Future Urban Ecosystems (Joint Research Centre, 2019).

5 Conclusions and future plans

Throughout this report, we have aimed at laying out a theoretical basis to support the on-going and future work of the JRC FMS-Lab and related LL activities in other thematic areas. We have applied some of the existing LL theories to the FMS-Lab, adapting the framework to different types of our projects. The experience of these first two years of implementation has led to the identification of some main challenges and related recommendations to take into account when setting up a LL. In particular, challenges encompass achieving inclusivity by engaging citizens from all societal groups, actively engaging citizens and other types of stakeholders in all the stages of the innovation development process, developing LL projects during the COVID-19 pandemic, and adopting an effective LL governance structure, among others. As recommendations, for instance, we have highlighted the importance of implementing the elementary ingredients of LLs, like the use of a real-life setting, and the value-creation focus, which need to be maintained during the LL operations. We have also emphasised the need to set up a multi-stakeholder governance framework for the LL and to seek opportunities with other mobility LLs for transferability, scalability and replication of the LL results and process. By connecting and collaborating with other LLs, we can foster fundamental scientific debate in the LL field to make it grow in consistent and robust ways.

Through this report, and based on both the existing LL literature and our own experiences, we propose a tailor-made approach for the JRC LLs projects which, according to their main objective/s, distinguishes four categories of projects: business model validation projects, projects focused on the co-creation of solutions, technical validation projects and impact assessment projects. We claim that such an approach would allow for a faster identification of the most suitable methods and tools in each specific case, thus leading to higher efficiency and effectiveness.

As to the next steps, the FMS-Lab will continue applying the different LL macro, meso and micro level frameworks, via a combination of different methods and in close cooperation with all other FMS-Lab stakeholders and users. The goal is to evolve the LL theories and practices with a particular application to the mobility context, stimulating scientific debate on the use of LLs to address mobility challenges in order to facilitate the co-creation of innovative mobility solutions contributing to the smart and green urban transformations.

We also aim to bring the LL concept much closer to the policy, academic and industrial realms, and importantly, to use the JRC FMS-Lab as a human-centred policy design tool and a regulatory-support tool to test a variety of mobility-related policy and regulatory approaches in real life environments. The LL approach will also support start-ups and SMEs in designing, testing and demonstrating new mobility technologies at our Ispra site, guiding the modernisation of our sites towards more open, more efficient, more sustainable and smarter environments. To this end, future plans also address rolling out the LL concept to other JRC sites and areas.

These ambitious goals will necessarily rely on multi-stakeholder collaborations, which represent an opportunity to develop a common understanding and shared language about LLs, including its underlying mechanisms and methodologies. Through these collaborations, we aim to build a network of mobility LLs to promote complementarity across different LLs and evolve the research in the LL field in a consistent and robust manner and altogether advance towards a sustainable and coordinated implementation of LLs in the urban mobility context. Ultimately, to jointly reach a safe, sustainable and smart people-centred mobility.

References

Almirall, E., M. Lee, and J. Wareham, 'Mapping Living Labs in the Landscape of Innovation Methodologies', *Technology Innovation Management Review*, Vol. 2, No. 9, 2012.

Alonso Raposo, M., B. Ciuffo, P. Alves Dias, F. Ardente, J. Aurambout, G. Baldini, C. Baranzelli, et al., *The Future of Road Transport: Implications of Automated, Connected, Low-Carbon and Shared Mobility*, *EUR (Luxembourg. Online)*, Publications Office of the European Union, LU, 2019.

Arnkil, R., A. Järvensivu, P. Koski, and T. Piirainen, *Exploring Quadruple Helix: Outlining User-Oriented Innovation Models*, University of Tampere, Institute for Social Research, Work Research Centre, 2010.

B2B International, 'What Is the Value Proposition Canvas?', *B2B International*, n.d. https://www.b2binternational.com/research/methods/faq/what-is-the-value-proposition-canvas/.

Ballon, P., J. Pierson, and S. Delaere, 'Test and Experimentation Platforms for Broadband Innovation: Examining European Practice', *ERN: Innovation (Topic)*, 2005.

Ballon, P., and D. Schuurman, 'Living Labs: Concepts, Tools and Cases', Vol. 17, No. 4, April 1, 2015.

Ballon, P., M. Van Hoed, and D. Schuurman, 'The Effectiveness of Involving Users in Digital Innovation: Measuring the Impact of Living Labs.', *Telematics Informatics*, Vol. 35, No. 5, 2018, pp. 1201–1214.

Ben Letaifa, S., 'How to Strategize Smart Cities: Revealing the SMART Model', *Journal of Business Research*, Vol. 68, No. 7, *Special Issue on The Spirit of Strategy*, July 1, 2015, pp. 1414–1419.

Björgvinsson, E., P. Ehn, and P.-A. Hillgren, 'Agonistic Participatory Design: Working with Marginalised Social Movements', *CoDesign*, Vol. 8, No. 2–3, June 1, 2012, pp. 127–144.

Bylund, J., *Renaturing Cities by Urban Living Labs*, 2014.

Carayannis, E.G., and D.F. Campbell, ''Mode 3' and 'Quadruple Helix': Toward a 21st Century Fractal Innovation Ecosystem', *Inderscience Publishers*, Vol. 46, No. 3–4, *International Journal of Technology Management*, 2009, pp. 201–234.

Carayannis, E.G., T.D. Barth, and D.F. Campbell, 'The Quintuple Helix Innovation Model: Global Warming as a Challenge and Driver for Innovation', *Journal of Innovation and Entrepreneurship*, Vol. 1, No. 1, August 8, 2012, p. 2.

Chesbrough, H.W., *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Harvard Business Press, 2003.

Dekker, R., J.F. Contreras, and A. Meijer, 'The Living Lab as a Methodology for Public Administration Research: A Systematic Literature Review of Its Applications in the Social Sciences', *International Journal of Public Administration*, Vol. 43, No. 14, 2019, pp. 1207–1217.

Dell'Era, C., and P. Landoni, 'Living Lab: A Methodology between User-Centred Design and Participatory Design', *Creativity and Innovation Management*, Vol. 23, No. 2, 2014, pp. 137–154.

Desa, U.N., 'World Urbanization Prospects: The 2018 Revision, Key Facts', *New York: NY. Available Online at: Https://Population. Un. Org/Wup/Publications/(Accessed December 20, 2018)*, 2018.

Dutilleul, B., Birrer, and W. Mensink, 'Unpacking European Living Labs: Analysing Innovation's Social Dimensions', *Central European Journal of Public Policy*, Vol. 4, No. 01, 2010, pp. 60–85.

EIT, 'Innovation', *European Institute of Innovation & Technology (EIT)*, August 8, 2018. https://eit.europa.eu/our-activities/innovation.

EIT Urban Mobility, *EIT Urban Mobility Knowledge Base of Innovative Solutions in Urban Mobility and Living Labs: Final Report*, Breda, the Netherlands, 2021.

Engels, F., A. Wentland, and S.M. Pfotenhauer, 'Testing Future Societies? Developing a Framework for Test Beds and Living Labs as Instruments of Innovation Governance', *Research Policy*, Vol. 48, No. 9, 2019, p. 103826.

ENoLL, 'European Network of Living Labs (ENoLL)', *European Network of Living Labs*, n.d. http://enoll.org/about-us/.

European Commission, *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Pathway to a Healthy Planet for All EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil'*, COM (2021) 400 final, Brussels, May 12, 2021.

———, 'Open Innovation 2.0', Text, *Shaping Europe's Digital Future - European Commission*, December 4, 2013. https://wayback.archive-it.org/12090/20210424003212/https://ec.europa.eu/digital-single-market/en/open-innovation-20.

———, *Special Eurobarometer 496: Expectations and Concerns from a Connected and Automated Mobility - Portale Open Data dell'Unione europea*, 2020a.

———, 'Sustainable and Smart Mobility Strategy –Putting European Transport on Track for the Future (Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions COM(2020) 789 Final)', December 9, 2020b.

———, *The European Green Deal*, Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, 2019a.

———, *The Human-Centred City: Opportunities for Citizens through Research and Innovation : A Public Summary*, Publications Office of the European Union, LU, 2019b.

European Commission, Better Regulation: why and how, 'Better Regulation: Why and How', n.d. https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how_en.

European Commission, European Social Fund, 'European Social Fund - European Commission', n.d. https://ec.europa.eu/esf/home.jsp?langId=en.

European Commission, Missions in Horizon Europe, 'Mission Area: Climate-Neutral and Smart Cities', Text, *European Commission*, n.d. https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/missions-horizon-europe/climate-neutral-and-smart-cities_en.

European Commission, New European Bauhaus, 'New European Bauhaus-About the Initiative', n.d. https://europa.eu/new-european-bauhaus/about/about-initiative_en.

European Commission, New Urban Mobility Framework, 'Sustainable Transport – New Urban Mobility Framework', n.d. https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12916-Sustainable-transport-new-urban-mobility-framework_en.

European Commission, Smart Cities and Communities, 'Smart Cities and Communities | Shaping Europe's Digital Future', n.d. https://digital-strategy.ec.europa.eu/en/policies/smart-cities-and-communities.

Evans, P., D. Schuurman, A. Ståhlbröst, and K. Vervoort, *Living Lab Methodology Handbook*, 2017.

Følstad, A., 'Living Labs for Innovation and Development of Information and Communication Technology: A Literature Review', *Electronic Journal of Virtual Organisations*, Vol. 10, No. 5, 2008, pp. 99–131.

Georges, M., and Q. Gilbert, 'The « Living Lab » Concept: Exploration and Clarification of This a Priori Catchall Term in the Innovation Landscape', Louvain School of Management, Université catholique de Louvain, 2017.

Greve, K., R.D. Vita, S. Leminen, and M. Westerlund, 'Living Labs: From Niche to Mainstream Innovation Management', *Sustainability*, Vol. 13, No. 2, 2021, p. 791.

Habibipour, A., J. Lindberg, M. Runardotter, Y. Elmistikawy, A. Stahlbrost, and D. Chroneer, 'Rural Living Lab: What It Is That and How It Is Shaped?', 2021, pp. 127–141.

Hakkarainen, L., and S. Hyysalo, 'The Evolution of Intermediary Activities: Broadening the Concept of Facilitation in Living Labs', *Technology Innovation Management Review*, Vol. 6, No. 1, 2016, pp. 45–58.

Hinrichs-Krapels, S., J. Bailey, H. Boulding, B. Duffy, R. Hesketh, E. Kinloch, A. Pollitt, S. Rawlings, A. van Rij, and B. Wilkinson, 'Using Policy Labs as a Process to Bring Evidence Closer to Public Policymaking: A Guide to One Approach', *Palgrave Communications*, Vol. 6, No. 1, 2020, pp. 1–9.

von Hippel, E., *The Sources of Innovation*, Oxford University Press., New York, 1988.

HIT/CERTH, 'Thessaloniki Smart Mobility Living Lab - HIT/CERTH', n.d. https://www.smartmlab.imet.gr/.

Hossain, M., S. Leminen, and M. Westerlund, 'A Systematic Review of Living Lab Literature', *Journal of Cleaner Production*, Vol. 213, March 10, 2019, pp. 976–988.

Joint Research Centre, 'Call for Expressions of Interest - Pilot Living Labs at the JRC', Text, *EU Science Hub - European Commission*, June 24, 2019. https://ec.europa.eu/jrc/en/research-facility/living-labs-at-the-jrc/call-expression-interest-future-mobility-and-digital-energy-solutions.

Joyce, A., R.L. Paquin, and Y. Pigneur, 'The Triple Layered Business Model Canvas', *A Tool to Design More Sustainable Business Models. ARTEM Organizational Creativity International Conference. Nancy, France*, 2015.

Kalinauskaite, I., R. Brankaert, Y. Lu, T. Bekker, A. Brombacher, and S. Vos, 'Facing Societal Challenges in Living Labs: Towards a Conceptual Framework to Facilitate Transdisciplinary Collaborations', *Sustainability*, Vol. 13, No. 2, January 2021, p. 614.

KIC, 'EIT Urban Mobility', *EIT Urban Mobility*, n.d. https://www.eiturbanmobility.eu/.

Lee, C.H., 'Establishing Design Thinking as a Third Culture in Learning and Creative Environments', *LEADING THROUGH DESIGN*, 2012, p. 501.

Leminen, S., and M. Westerlund, 'Categorization of Innovation Tools in Living Labs', *Technology Innovation Management Review*, Vol. 7, No. 1, 2017, pp. 15–25.

Leminen, S., 'Coordination and Participation in Living Lab Networks', *Technology Innovation Management Review*, Vol. 3, No. 1, 2013, pp. 5–14.

———, 'Q&A. What Are Living Labs?', *Technology Innovation Management Review*, Vol. 5, No. 9, 2015, pp. 29–35.

Leminen, S., M. Westerlund, and M. Kortelainen, 'A Recipe for Innovation through Living Lab Networks', *ISPIM Conference Proceedings*, The International Society for Professional Innovation Management (ISPIM), 2012a, p. 1.

———, 'Service Innovation Strategies in Living Labs Networks', *International Service Research Conference (SERVSIG), Helsinki, Finland, June 7-9, 2012*, 2012b.

Leminen, S., M. Westerlund, and A.-G. Nyström, 'Living Labs as Open-Innovation Networks', *Technology Innovation Management Review*, No. September, 2012, pp. 6–11.

Lindsay, G., 'Not-So-Smart Cities', *The New York Times*, September 24, 2011. https://www.nytimes.com/2011/09/25/opinion/sunday/not-so-smart-cities.html.

LIVERUR, 'H2020 Innovative Business Model in Rural Areas | LIVERUR', *Liverur | Living Lab Research Concept in Rural Areas*, n.d. https://liverur.eu/.

Mastelic, J., 'Stakeholders' Engagement in the Co-Design of Energy Conservation Interventions :', *ArODES*, Université de Lausanne, 2019. https://hesso.tind.io/record/4081.

MIND, 'Milano Innovation District (MIND)', *Milano Innovation District (MIND)*, n.d. https://www.mindmilano.it/.

Nesta, *INVITATION TO TENDER-How to Design and Run an Innovation Testbed - What Is the State of the Art?*, n.d.

Nesti, G., 'Living Labs: A New Tool for Co-Production?', in A. Bisello, D. Vettorato, R. Stephens, and P. Elisei (eds.), *Smart and Sustainable Planning for Cities and Regions: Results of SSPCR 2015*, *Green Energy and Technology*, Springer International Publishing, Cham, 2017, pp. 267–281.

Rosemberg, C., X. Potau, F. Dijkstal, A. Vinnik, C. Tiriduzzi, A. Daved, and K. Blind, 'Regulatory Sandboxes and Innovation Testbeds. A Look at International Experience and Lessons for Latin America and the Caribbean', 2020.

Schuurman, D., 'Bridging the Gap between Open and User Innovation? : Exploring the Value of Living Labs as a Means to Structure User Contribution and Manage Distributed Innovation', Dissertation, Ghent University, 2015.

Schuurman, D., L. De Marez, and P. Ballon, 'Open Innovation Processes in Living Lab Innovation Systems: Insights from the LeYLab', *Technology Innovation Management Review*, Vol. 3, No. 11, 2013.

Schuurman, D., A.-L. Herregodts, A. Georges, and O. Rits, 'Innovation Management in Living Lab Projects: The Innovatrix Framework', *Technology Innovation Management Review*, Vol. 9, No. 3, 2019, pp. 63–73.

SDSN, 'Goal 11. Make Cities and Human Settlements Inclusive, Safe, Resilient and Sustainable – Indicators and a Monitoring Framework', n.d. https://indicators.report/goals/goal-11/.

Seys, C., D. Schuurman, T. Evens, B. Baccarne, and A. All, 'The Innovation Struggle: Panel Based Living Labs to the Rescue?', *XXIV ISPIM Conference: Innovating in Global Markets: Challenges for Sustainable Growth*, 2013.

Ståhlbröst, A., A. Habibipour, D. Chronéer, I. Vaittinen, S. Zalokar, and C. Mafe, *UNALAB ULL FRAMEWORK-D2.1 Deliverable*, 2018.

Ståhlbröst, A., 'A Set of Key Principles to Assess the Impact of Living Labs', *International Journal of Product Development*, Vol. 17, No. 1–2, 2012, pp. 60–75.

Ståhlbröst, A., and M. Holst, *The Living Lab: Methodology Handbook*, Vinnova., 2013.

Tsakalidis, A., K. Gkoumas, M. Grosso, and F. Pekár, 'TRIMIS: Modular Development of an Integrated Policy-Support Tool for Forward-Oriented Transport Research and Innovation Analysis', *Sustainability*, Vol. 12, No. 10194, 2020.

United Nations, 'Transforming Our World: The 2030 Agenda for Sustainable Development | Department of Economic and Social Affairs', n.d. https://sdgs.un.org/2030agenda.

UNLEASH, 'Solution Canvas', n.d. https://unleash.org/wp-content/uploads/2019/05/Solution-canvas.pdf.

Vandecasteele, I., C. Baranzelli, A. Siragusa, J.-P. Aurambout, I. Vandecasteele, V. Alberti, M. Alonso Raposo, et al., *The Future of Cities: Opportunities, Challenges and the Way Forward*, *EUR (Luxembourg. Online)*, Publications Office of the European Union, LU, 2019.

Veeckman, C., D. Schuurman, S. Leminen, and M. Westerlund, 'Linking Living Lab Characteristics and Their Outcomes: Towards a Conceptual Framework', *Technology Innovation Management Review*, No. December 2013: Living Labs and Crowdsourcing, 2013, pp. 6–15.

Weber, M., and S.A. Geerts, 'Customer Involved Open Innovation: Innovation of New Products with End Users and Customers', *Handbook of Research on Trends in Product Design and Development: Technological and Organizational Perspectives*, IGI Global, 2011, pp. 259–288.

Westerlund, M., and S. Leminen, 'Managing the Challenges of Becoming an Open Innovation Company: Experiences from Living Labs', *Technology Innovation Management Review*, Vol. 1, No. 1, 2011.

World Economic Forum, *Agile Governance Reimagining Policy-Making in the Fourth Industrial Revolution*, White Paper, January 2018.

List of abbreviations and definitions

2D	Two-dimensional
3D	Three-dimensional
4G	Fourth generation
4Ps	Public-private-people partnerships
Bn	Billion
CAV	Connected and Automated Vehicle
C-ITS	Cooperative Intelligent Transport System
CMD	Communication and Multimedia Design
Co-creation	Collaborative development of new value (concepts, solutions, products and services) together with experts and/or stakeholders (such as customers, suppliers etc.). In the context of policy-making it is the principle of co-creation is the process of creating new public policies and services *with* people and not *for* them (European Commission, European Social Fund).
COVID-19	Coronavirus disease 2019
DES-Lab	JRC Digital Energy Solutions Living Lab
Design Thinking	Creative and productive approach that is very fluid and not tied to set understandings but rather focused on the application rather than accumulation of knowledge. There are a number of approaches that need to be incorporated in teaching design thinking. These ideas include an approach that is project and team based and promotes an accommodating learning style, focusing on innovation and expanding an understanding of technologies used in developing a project. Participatory action research objective, and participant observation methodologies in the research and analysis of a project, can also be incorporated in order to develop better communication between researchers and project participants (Lee, 2012).
DG	Directorate-General
EC	European Commission
EIT	European Institute of Innovation and Technology
ENoLL	European Network of Living Labs
EU	European Union
EV	Electric Vehicle
FMS-Lab	Future Mobility Solutions Living Lab
GDPR	General Data Protection Regulation
ha	Hectare
HES-SO	Energy Living Lab from the University of Applied Sciences Western Switzerland

ICT	Information and Communication Technology
Innovation	Process, including its outcome, by which new ideas respond to societal or economic needs and demand and generate new products, services or business and organisational models that are successfully introduced into an existing market or that are able to create new markets and that provide value to society (EIT, 2018).
Innovation test bed	Controlled or bounded environment for testing new technologies and innovations (Nesta).
IoT	Internet of things
JRC	Joint Research Centre
k	Thousand
KIC	Knowledge and Innovation Community
km	Kilometre
Km^2	Square kilometre
KPIs	Key Performance Indicators
Living Lab	User-centred, open innovation ecosystems based on systematic user co-creation approach, integrating research and innovation processes in real life communities and settings (ENoLL).
LL	Living Lab
LTE	Long-Term Evolution
m	Meter
m^2	Square meter
MIND	Milano Innovation District
N	Number
PhD	Doctor of Philosophy
Policy lab	Physical space set up for the purpose of conducting workshops or activities for policymaking (Hinrichs-Krapels et al., 2020).
Quadruple Helix	Operational model where government, industry, academia and civil participants work together to co-create the future and drive structural changes far beyond the scope of what any one organisation or person could do alone (European Commission, 2013).
R&I	Research and Innovation
REB	JRC Research Ethics Board
Regulatory sandbox	Regulatory approach that allows live, time-bound testing of innovations under
SDG	Sustainable Development Goal

SIRE	Scientific Integrity and Research Ethics
Smart City	Place where traditional networks and services are made more efficient with the use of digital and telecommunication technologies for the benefit of its inhabitants and business. A smart city goes beyond the use of information and communication technologies (ICT) for better resource use and less emissions. It means striving for sustainability through smarter urban transport networks, upgraded water supply and waste disposal facilities, and more efficient ways to light and heat buildings. It also means a more interactive and responsive city's administration, safer public spaces and meeting the needs of an ageing population (European Commission, Smart Cities and Communities).
SMART	Specific, Measurable, Achievable, Realistic, and Timely
SME	Small and mid-size enterprise
TRIMIS	Transport Research and Innovation Monitoring and Information System
TRL	Technology Readiness Level
ULL	Urban Living Lab
V2X	Vehicle-to-everything
Wi-fi	Wireless fidelity

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