Accelerating Software-Intensive Innovation via Living Labs: Evidence from the AIAMO Project

Katharina Peine[1], Michael Ortgiese[2], Alexander Sohr[3], Lisa Schiffers[4] and Thomas Hornig[1]

[1] highQ Computerlösungen GmbH, Schwimmbadstr. 26, 79100 Freiburg, Germany
[2] Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Institut für Verkehrsforschung, Rudower Chaussee 7, 12489 Berlin, Germany
[3] Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Institut für Verkehrssystemtechnik, Technisches Transport- und Mobilitätsmanagement, Rutherfordstr. 2, 12489 Berlin, Germany
[4] ITS Germany - Bundesverband der Wirtschaft und Wissenschaft für Verkehrstechnologien und intelligente Mobilität e.V., Unter den Linden 10, 10117 Berlin, Germany

Abstract. In an increasingly digital world, the ability to innovate is crucial to the success of both economy and society, especially in connection with the growing use of artificial intelligence (AI). In order for such technologies to be developed and tested, open, practical environments for joint experimentation are needed. Living Labs offer a suitable framework for this. Using the example of the research project AIAMO (Artificial Intelligence And Mobility), led and coordinated by ITS Germany e.V.[1], this paper highlights how innovation processes can be established in a Living Lab to develop AI-based innovations in the mobility sector.

Keywords: Living labs, innovation, artificial intelligence, AI, AIAMO.

1 Introduction and intention of the paper: focus on innovation potential

Innovative capacity plays a central role in shaping technological and societal development, particularly in the context of ongoing digitalization and the increasing use of artificial intelligence (AI).[1] AI refers to systems and algorithms capable of learning from data and performing tasks that require decision-making under uncertainty.[2] Building on the open innovation paradigm, [3] previous studies suggest that collaborative and cross-sectoral development environments can reduce time-to-market and increase the effectiveness of innovation outcomes.[4] To this end, open, experimental environments in which new ideas can be tested together with partners from research and practice are necessary. Software platforms (in the context of this paper, particularly

[1] ITS Germany e.V. – Federal Association of Industry and Science for Transport Technologies and Intelligent Mobility – has been working at the interface between intelligent transport systems and mobility for more than 20 years

Submitted to: Proceedings ICSOB 2025, to appear in Springer LNBIP

in the area of mobility) are complex, especially due to the many systems and interfaces of the various partners – this effect is further amplified by the integration of AI: AI applications follow unprogrammed rules that are often inexplicable and incomprehensible.[5] This is why living labs are particularly well suited for their development, as they enable AI applications to be tested and further developed under real-world conditions, addressing socio-technical challenges such as acceptance, transparency, and targeted use. They promote participatory design, which is crucial for ensuring that the introduction of AI systems is sustainable and in line with the common good. Living Labs offer an environment that supports this kind of cooperation and collaboration between partners as well as the testbed for rapid prototyping in a real-world setting. This paper analyzes how innovation processes can be designed in a Living Lab in order to harness the potential of AI, using the research project AIAMO[2] (Artificial Intelligence And Mobility) as a case study.

2 Background: Living Labs and Artificial Intelligence – Synergies for Innovation

In recent years, Living Labs have become an effective tool for developing, testing, and implementing innovative technologies. They provide a real-world environment where researchers, companies, public institutions, and end users collaborate to design and refine solutions. As user-centered, open innovation ecosystems, Living Labs enable technologies to be developed and tested iteratively under everyday conditions, ensuring solutions are tailored to actual needs.[6] Such environments are particularly important for AI systems, as they directly address the interplay between technology, organization, and users.[7]

2.1 Basic principles and functioning of Living Labs

Living Labs are open innovation ecosystems characterized by four key principles. Observing these solutions are more responsive to societal needs and achieve greater acceptance:[8]

- *Multi-stakeholder participation*: Integration of various interest groups (business, science, public, users) into the innovation process.
- *User centricity*: Development and validation of technologies under realistic conditions with active user involvement.
- *Iterative approach*: Continuous improvement through feedback loops, rapid prototyping, and field testing.
- *Co-creation*: Joint idea generation, development, and implementation of solutions in a collaborative process.

[2] https://www.aiamo.de/de

Submitted to: Proceedings ICSOB 2025, to appear in Springer LNBIP

2.2 Artificial intelligence as a driver of innovation

AI refers to software- and hardware-based systems that use algorithms to automatically solve complex tasks and learn from data. Areas of application range from speech and image recognition to optimization tasks and data-driven decision-making in the mobility, healthcare, and energy sectors.[9]

AI systems enable new business models, increase efficiency, and create the basis for innovative services. At the same time, however, they require special care with regard to ethics, fairness, and data protection.[10], [11] This concerns particularly the area of mobility (subject of this paper) due to the sensitive movement data of road users, which play a major role als training input.[12]

2.3 The symbiosis: Why Living Labs are crucial for AI innovation and deployment

The integration of AI into operational systems with existing processes and infrastructures is complex and multifaceted. This is where Living Labs unfold their full innovation potential and challenges at the same time:

- *Real data and environments*: AI solutions benefit from validation through authentic data streams and usage conditions in the lab. Prototypes are tested not only under laboratory conditions, but also in real-life contexts – to the extent that this data is accessible.[13]
- *User integration*: The early and continuous involvement of users makes it possible to identify and compensate for bias in AI training and to increase acceptance, while a critical mass of users is both essential for success and challenging to attain simultaneously. [14]
- *Interdisciplinary collaboration*: AI projects require expertise in computer science, domain knowledge, and social science disciplines; Living Labs promote precisely this kind of collaboration. However, providing such a socio-technical environment is not straightforward.[7, 15]
- *Ethics and trust*: Especially for sensitive AI applications (health, mobility), the Living Lab provides a framework for discussing and implementing ethical standards and data protection requirements in a participatory manner. User acceptance of sensitive mobility pattern data tends to be low and difficult to secure.[10]

This potential can be further expanded in the future and the described issues must be addressed. By embedding AI solutions in Living Labs, both their usability and acceptance can be significantly improved. The following section illustrates a possible approach using the case study of AIAMO.

3 Case study: the research project AIAMO

AIAMO (Artificial Intelligence And Mobility) is a project funded by the BMDS in which 13 partners, led by ITS Germany e.V., are working together to develop AI-based

Submitted to: Proceedings ICSOB 2025, to appear in Springer LNBIP

environmental and mobility management systems that are more efficient, resource-efficient, safer, and tailored to specific needs. The AIAMO Living Lab pursues the goal of developing innovative AI applications in the mobility sector under real-world conditions and making them ready for use in real life. The AIAMO Living Lab is located at the interface between research, industry, and public actors. Here, interdisciplinary teams from AI development, mobility research, and user representatives develop solutions for real-time data integration, simulation platforms, and flexible test fields in urban areas. At regular AIAMOcamps, new developments are presented, integrated, rethought, and planned for the future. Methods such as Design Thinking and Open Innovation approaches are used to jointly define problems and develop solutions. Users are involved through feedback workshops, in which prototypes and working hypotheses are evaluated and adapted. This ensures a high degree of practical relevance and implementation potential.

In order to install AI applications in a living lab, it is necessary to set up a suitable environment that all parties have access. As an example, in this project this is achieved through the development of AIAMOnexus: As part of the project, an AI-based forecasting component was developed that uses machine learning models to analyze real-time and historical mobility data in order to identify traffic bottlenecks at an early stage. At the heart of the infrastructure is the AIAMOnexus.[5, 10] It combines the structured data access infrastructure of the integration zone with powerful AI models to provide curated, AI-optimized data for mobility management applications and handles the consolidation, processing, and quality assurance of heterogeneous data sources commonly used in traffic management, including traffic, environmental, and infrastructure data, and user information.[18] AIAMO uses AI methods for these processes, such as data cleansing, feature extraction, and merging of data from distributed information sources. The so-called AIAMOnexus can be used to connect both, external data sources (e.g. weather services, public transport systems, crowd data, digital twins) and external IT systems to the AIAMO environment. This creates an interoperable, expandable infrastructure that can integrate future requirements and new application scenarios (Fig. 1).

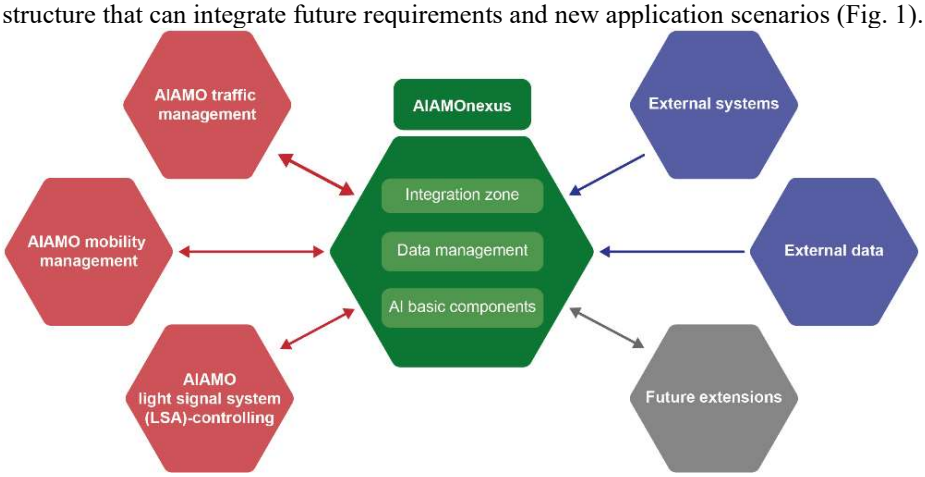

Fig. 1. AIAMO system components (ITS Germany & DLR).

Submitted to: Proceedings ICSOB 2025, to appear in Springer LNBIP

In future expansion stages, the architecture will be supplemented by additional system components which, as already envisaged in the project's target vision, will also enable strategically optimized planning of the entire mobility offering at city and regional level. These include components for long-term traffic forecasts, capacity-based service planning, and dynamic incentive systems for sustainable mobility behavior.

4 AI-based innovation at AIAMO Living Lab

AIAMO uses AI to systematically analyze and link mobility data and develop an AI database for innovative applications, such as intelligent traffic management systems that respond dynamically to current traffic conditions, thereby preventing traffic jams and improving traffic flow. Furthermore, AI can be used to make improved traffic forecasts in order to proactively control traffic flow. The AIAMO Living Lab is initially being established in the model city of Leipzig for AI-supported traffic control. A dense environmental data measurement network with 50 stations across the city is being set up for data collection. Currently, 20 of these stations are already in operation. The primary goal is to record air pollutants such as nitrogen dioxide (NO_2) and particulate matter. This data is linked to other traffic data, such as traffic density, vehicle types, or movement patterns, and systematically analyzed with the help of AI. In combination with environmental data from other sources, this creates a “digital twin” of Leipzig, i.e., a digital model that maps traffic and the environment in real time. This twin will then help to better understand traffic patterns and propose measures for optimal traffic control by suggesting routes for road users. The environmental data measurement networks can also be used to collect data on air quality and emissions for climate-friendly mobility decisions. A mobility app will make AI-based mobility services available to road users in such a way that they can be used intuitively and encourage people to adopt sustainable transport behavior.[19] A second AIAMO Living Lab is being set up in Landau in der Pfalz. While Leipzig is primarily responsible for environmentally sensitive traffic control in the AIAMO project, the focus in Landau i. d. Pfalz is on optimizing traffic flows with the use of AI.

For the first trial in the Living Lab, the Leipzig-based UFZ, as one of the project partners, will initially use the mytraQ editionAIAMO mobility app to improve operational mobility management based on AI-generated route suggestions provided by the AI-based routing of the DLR's digital twin.[20] The focus here is on developing and testing AI routing by linking mobility data, optimizing traffic flows, improving the organization of commuter traffic, and connecting public transportation more efficiently. What makes this project unique is that the results will be easily transferable to other cities and municipalities (Fig. 2).

Submitted to: Proceedings ICSOB 2025, to appear in Springer LNBIP

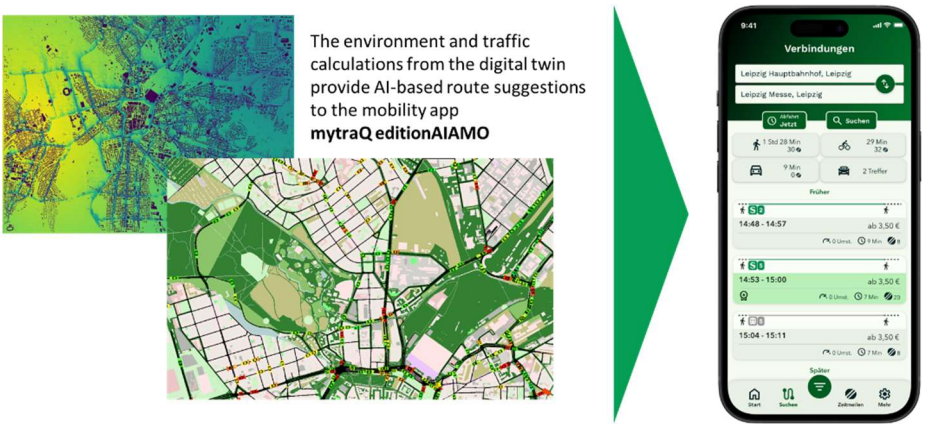

Fig. 2. mytraQ editionAIAMO: Measure-based route suggestions as an alternative for road users (highQ Computerlösungen GmbH).

5 Results, findings, and conclusion

The AIAMO Living Lab provides a platform for software-intensive innovation by developing and testing AI-supported systems for analyzing mobility data in order to adaptively control traffic flows and optimize individual mobility options for road users. The Living Lab enables a user-centered innovation process, as agile methods can be applied and prototypes can be evaluated with stakeholders, initially the UFZ, in iterative sprints, with improvements being integrated directly.
Key observations include:

- *Infrastructure requirements:*
  The integration of AI systems necessitates a dedicated, accessible, and interoperable infrastructure. AIAMOnexus was developed in response to this need and plays a central role in data integration and (AI) application deployment.
- *Data protection and governance:*
  The handling of sensitive mobility data requires a comprehensive, multi-perspective approach to data protection and ethical compliance. In AIAMO it is addressed by a multi-perspective data protection concept (especially technologies in accordance with European standards and data minimization).
- *User involvement:*
  Iterative co-development with stakeholders improves the alignment of AI systems with user needs and regulatory requirements. In AIAMO the Living Lab methodology also makes it possible to integrate various interest groups into the development process, including the city of Leipzig itself. This allows the needs of end users to be identified at an early stage and technical solutions to be continuously adapted. The work at the AIAMO Living Lab shows that AI innovations are particularly successful when users are closely involved in all development phases and agile, iterative methods are used. At

Submitted to: Proceedings ICSOB 2025, to appear in Springer LNBIP

the same time, technical and ethical aspects, especially data protection, must be given equal consideration. It is particularly noteworthy that cooperation in the Living Lab leads to practical AI solutions with a high level of acceptance which in turn increases the likelihood of them being commercially successful. Nevertheless, it remains a major challenge to obtain the heterogeneous data sources and then integrate them via the AIAMOnexus.

- *Transferability and scalability:*

While the modular architecture supports expansion, actual scalability depends on factors such as data availability, stakeholder engagement, and institutional support. The AIAMO Living Lab illustrates the transferability of the model to other fields of innovation such as energy or health. This scalability is particularly supported by AIAMO's modular architecture and governance structures. With editionAIAMO, a development framework is available to the ITS industry that enables direct access to the optimized AI data of the AIAMOnexus, thereby ensuring close integration of data and applications. In addition, AIAMOitip bridges the gap between research and market introduction by paving the way for sustainable business models and the long-term establishment of the technologies. Another success factor is European networking: with AIAMOgoesEurope, collaboration between research, industry, and public institutions is being strengthened at the European level, supported by a governance structure in which ITS Germany provides the technical leadership and ERTICO–ITS Europe takes over political coordination. In this way, AIAMO lays the foundation for scalable, interoperable mobility solutions across Europe.

Future research should therefore focus particularly on the further development of these transfer mechanisms and their contribution to a sustainable innovation culture. Nevertheless, there are limitations: success depends on sufficient resources, interdisciplinary openness, and political support. A major challenge lies in gaining acceptance for the solution among road users, because without a sufficient number of users within the Mobility Living Lab, it will be difficult to obtain valid results. Also, a major hurdle is the provision of or access to public mobility-related data within the Living Lab, which is needed to generate AI-generated mobility measures, as data owners protect their data and large data silos still exist. For further evaluation, the inclusion of measurement results should be examined in a follow-up article. Future research should focus more on the scalability of Living Lab approaches in the context of AI and their impact on long-term innovation cultures.

References

1. Bundesministerium für Bildung und Forschung (BMBF): BMBF-Aktionsplan Künstliche Intelligenz Neue Herausforderungen chancenorientiert angehen, URL: https://www.bmftr.bund.de/SharedDocs/Downloads/DE/2023/230823-executive-summary-ki-aktionsplan.pdf?__blob=publicationFile&v=1, accessed 25/08/29, (2023)
2. Copeland, B.J.: "artificial intelligence", In: Encyclopedia Britannica, 19 Aug. 2025, URL: https://www.britannica.com/technology/artificial-intelligence, accessed 25/08/19, (2025).

Submitted to: Proceedings ICSOB 2025, to appear in Springer LNBIP

3. Chesbrough, H.W.: Open innovation: The new imperative for creating and profiting from technology, Harvard Business Press, (2003).
4. Rauter, R., Globocnik, D., Perl-Vorbach, E., Baumgartner, R.J.: Open innovation and its effects on economic and sustainability innovation performance, In: Journal of Innovation & Knowledge, 19/4/4, pp.226-233, (2019).
5. Dell'Era, C., Landoni P and Gonzalez SJ.: Investigating the Innovation Impacts of User-Centered and Participatory Strategies adopted by European Living Labs, In: International Journal of Innovation Management, 18/23/05, pp. 1-20, (2018).
6. Dönitz, E., Stadler, K., Zern, R.: Roadmap Living Labs für eine Green Economy 2030. Langfassung mit Roadmaps in den Konsumfeldern Wohnen, Einkaufen und Mobilität, (2018).
7. Schaffers, H., Santoro, R.: The living labs concept enhancing regional innovation policies and instruments, In: 2010 IEEE International Technology Management Conference (ICE), Lugano, Switzerland, 2010, pp. 1-8
8. Bergvall-Kåreborn, B., Ståhlbröst, A.: Living Lab: an open and citizen-centric approach for innovation, In: International Journal of Innovation and Regional Development, 1(4), (2009), pp. 356–370.
9. Nikolinakos, N.T.: A European Approach to Excellence and Trust: The 2020 White Paper on Artificial Intelligence, In: EU Policy and Legal Framework for Artificial Intelligence, Robotics and Related Technologies - The AI Act. Law, Governance and Technology Series, 23/53/, pp. 211-280, Springer, (2023).
10. Bundesministerium für Bildung, Familie, Senioren, Frauen und Jugend: Gemeinsam im Wandel. Agenda für smarte Gesellschaftspolitik, URL: https://www.bmbfsfj.bund.de/resource/blob/179102/99450844ce3650c2d3f36c0e9f140952/gemeinsam-im-wandel-agenda-fuer-smarte-gesellschaftspolitik-data.pdf, accessed 25/08/29, (2023)
11. Santoni de Sio, F., Mecacci, G.: Four responsibility gaps with artificial intelligence: Why they matter and how to address them, In: Philosophy & technology, 21/34/4, pp. 1057-1084, (2021).
12. Bharadiya, J. P.: Artificial intelligence in transportation systems, a critical review, In: American Journal of Computing and Engineering, 2023/6/1, pp. 35-45, (2023).
13. Leminen, S., Westerlund, M., Nyström, A.-G. (2012). Living Labs as open-innovation networks. Technology Innovation Management Review, 2(9), 6-11.
14. Dutilleul, B., Birrer, F., Mensink, W.: Unpacking European Living Labs: Analysing innovation's social dimensions. Central European Journal of Public Policy, 10/4/1, pp. 60–85, (2010).
15. Storr, S.: Reallabore (Living Labs) zur Erprobung von Anwendungen Künstlicher Intelligenz, In: Künstliche Intelligenz und Öffentliches Wirtschaftsrecht. Nomos, Baden-Baden (2022), pp. 116-135
16. Goodfellow, I., Bengio, Y., Courville, A. (2016). Deep Learning. MIT Press
17. Daten vernetzen, Mobilität neu denken, Straßenverkehrstechnik, auf den Seiten der Straßenverkehrstechnik, URL: https://aiamo.de/download/pdfs/Sonderdruck_AIAMO_SVT.pdf, accessed 25/07/23, (2025).
18. FGSV: Arbeitspapier zur Gestaltung von Verkehrsmanagementstrukturen, FGSV Verlag, Köln (2009).
19. Peine, K., Hornig, T.: Social Mobility als Erfolgsfaktor des Mobilitätswandels, In: Straßenverkehrstechnik, 25/3/1, pp.224-225, (2025).
20. Dalaff, C., Sohr, A.: Digitale Zwillinge ermöglichen ein umweltsensitives Verkehrsmanagement, Straßenverkehrstechnik, In: Straßenverkehrstechnik, 25/6/1, pp. 396-398, (2025).

Submitted to: Proceedings ICSOB 2025, to appear in Springer LNBIP