Systems thinking for sustainability: Using ActorMaps to compare transport schemes

Rich C. McIlroy & John M. Preston

Transportation Research Group, University of Southampton

SUMMARY

Mobility as a Service (MaaS) is a smart mobility idea that aims to help people drive less by facilitating the combination of multiple modes of transport, planned, booked, paid for, and navigated through a single app. This apparent simplicity belies the complex structure of the underlying sociotechnical system. Here we take a systems ergonomics perspective, using Rasmussen's Risk Management Framework to analyse three current MaaS systems, i.e., Jelbi in Berlin, Floya in Brussels, and Breeze in the UK's Solent region, to proactively identify risks to success.

KEYWORDS

Mobility as a Service; Risk Management Framework; sociotechnical systems; sustainability

Introduction

Mobility as a Service (MaaS), a smart mobility system that brings together multimodal journey planning, ticketing, and route guidance, is an emerging, sustainable transportation concept. Current implementations provide a platform to plan multi-modal journeys (i.e., those involving two or more different transport modes) and buy tickets on a journey-by-journey basis. This research focusses on three real-world examples of such systems, applying a sociotechnical systems lens to compare the implementation of MaaS systems in Berlin (Germany), Brussels (Belgium), and the Solent region (south-central England) and map the stakeholders involved. In doing so, it offers insight into the similarities and differences between the implementations and provides a discussion of the organisational and governance structures we are likely to see dominate the future of Mobility as a Service. It does so in the theoretical context of Jens Rasmussen's Risk Management Framework (RMF; Rasmussen, 1997) with the aim of proactively identifying risks to the success of such schemes and, in turn, risks to transport sustainability. It takes a high-level, systems view and is based on discussions with key stakeholders in the three locations of interest.

AcciMaps and sustainability

The ActorMap tool, one part of the AcciMap method that is based on the RMF, was introduced by Rasmussen and Svedung (2000) as a way to visually represent the decision makers involved in a sociotechnical system and their hierarchical position in that system. It has previously been used as a stakeholder identification framework in the context of road safety (McIlroy et al., 2019); however, collisions are not the only negative externality of our transport system. There is merit in exploring the potential for the use of ActorMaps for stakeholder identification and framing in the context of sustainability. Therefore, just as Paul Salmon and colleagues did with their discussion of CWA and global challenges at the 2019 EHF conference (Salmon et al., 2019), we explore the use of a sociotechnical systems method in the context of sustainability.

The application of human factors and ergonomics (HFE) methods to sustainability challenges is by no means new, with Neville Moray calling for effort in this area over 30 years ago in his address to the International Ergonomics Association (Moray, 1995). Nevertheless, systems-based approaches to failure analysis are rarely applied to sustainability, despite this representing perhaps the greatest challenge (and most serious failure) faced by society today. The failure to achieve sustainability goals (in this context, the development and operation of a sustainable transport system) is one that systems ergonomics methods could help us understand and avoid.

With this impetus, this research uses the ActorMap tool as a form of proactive risk identification approach, in keeping with Rasmussen and Svedung's early descriptions of the approach (Rasmussen & Svedung, 2000). To this end, it uses the hierarchical system representation to facilitate the identification of actor and organisational related risks to the successful implementation of MaaS systems. Just as McIlroy et al. (2019) did in the context of road safety, we use the ActorMap in a comparative way, comparing the three MaaS implementations described above, i.e., the Breeze, Floya, and Jelbi systems of the Solent region, Brussels, and Berlin.

Method

To develop an ActorMap for each of the MaaS systems under analysis information was first gathered from publicly available transport and governmental websites. To validate the models, and to learn more about the functioning of each MaaS system, separate interviews were held with the programme managers for MaaS at each transport organisation running the scheme, i.e., BVG in Germany, STIB-MIVB in Belgium, and Solent Transport in the UK. In advance of each interview the initial ActorMaps were sent to each interviewee alongside an explanation of the method and the purpose of the study). Each interview lasted approximately one hour. Ethical approval for the study was sought from and granted by the University of Southampton's Ethical Committee (ID 93513). ActorMaps were edited based on notes made during the interviews, on the recordings, and on emailed responses to follow-up questions that were sent via email after the interviews were complete.

Results and discussion

The three completed actor maps are presented in Figures 1 to 3, below. Identified actors were categorised as governmental, public transport industry, other industry (including technology companies as well as non-transport focussed industry organisations), micromobility (including shared or hireable e-scooters and bikes), private hire transport (including car sharing or hiring and taxis), and end user and equipment. These categorisations are indicated using coloured shading in the figures below. The key is presented in Figure 4. The node with the thicker dashed surrounding line in each diagram indicates the main MaaS managing organisation in each setting.

Although laws, policies, standards, and guidelines set by organisations at the highest levels of the system are arguably most influential in terms of long-lasting system performance (i.e., by setting the conditions within which all else operates), the three interviewees all stated that there was minimal to no direct input from organisations at the highest national levels. The Breeze system in the UK differed in this regard only through its funding mechanism, with resources supporting the project coming directly from the Department for Transport. No other national governmental departments were identified as having a strong influence, though the interviewees did agree that the context of operation is shaped by policies set out by the organisations presented in the upper two levels, with funding decision taken at higher levels (e.g., on company car policies and public transport incentives) influencing use of the MaaS systems.

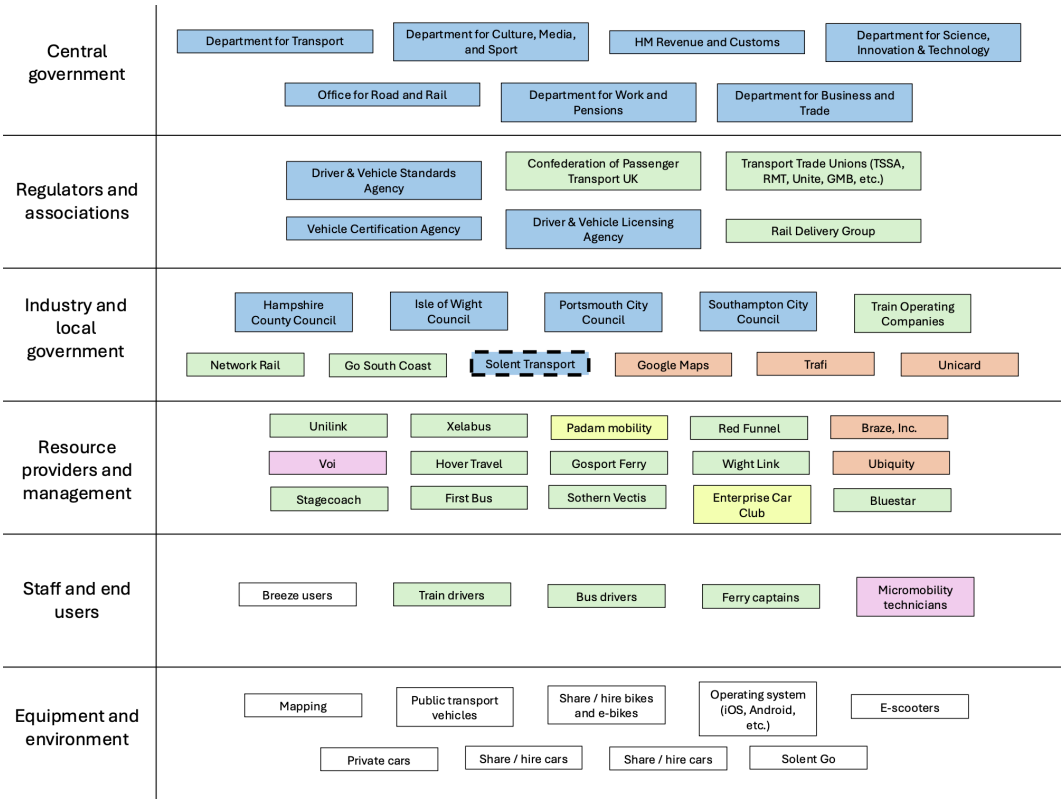

Figure 1. Actor map of the Solent region's 'Breeze' MaaS scheme. See Figure 4 for colour coding key.

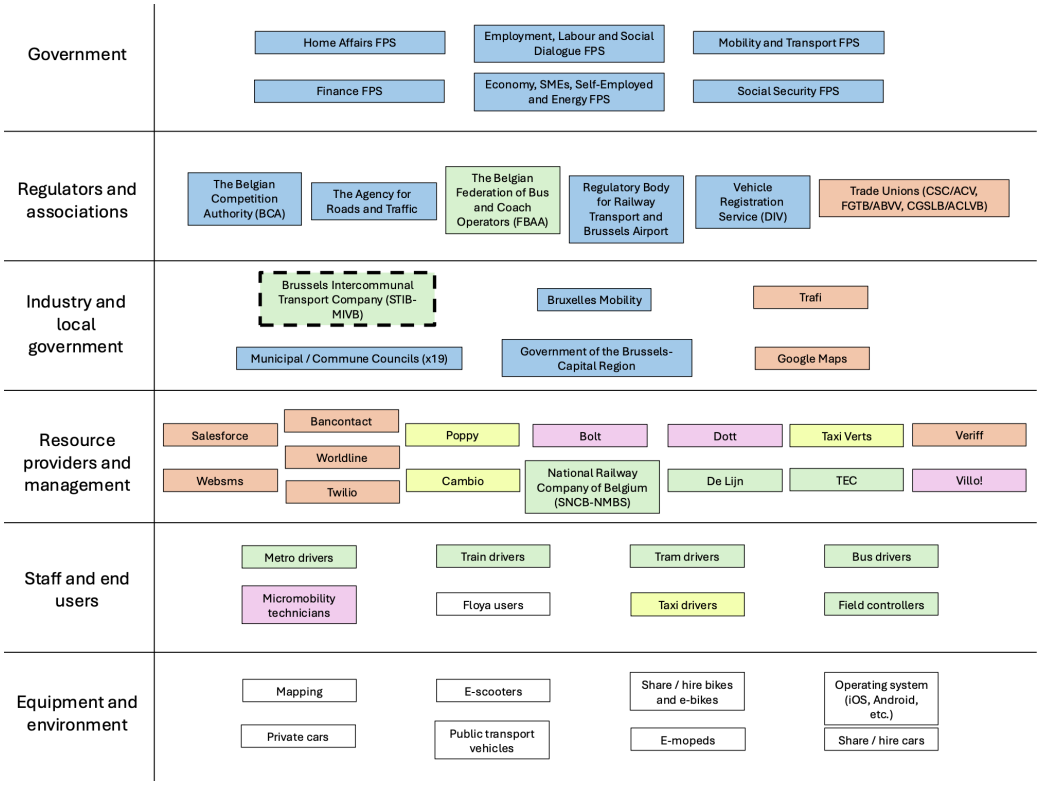

Figure 2. Actor map of the Brussels region's Floya MaaS scheme. See Figure 4 for colour coding key.

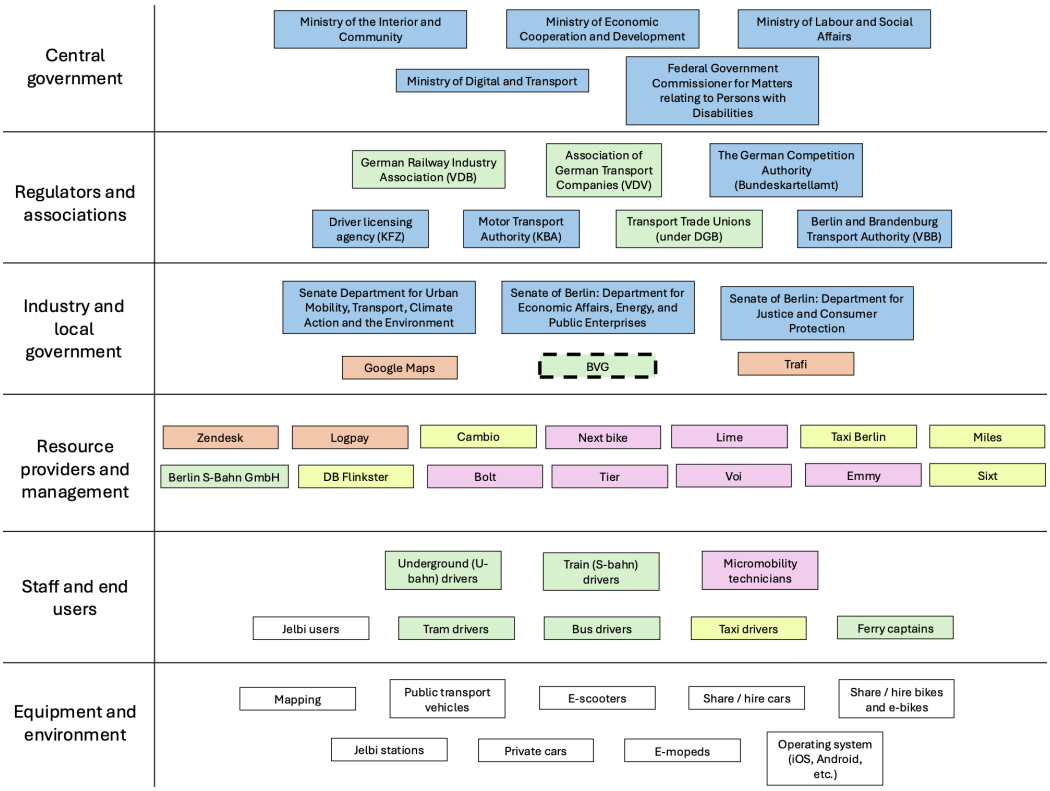

Figure 2. Actor map of the Berlin region's Jelbi MaaS scheme. See Figure 4 for colour coding key.

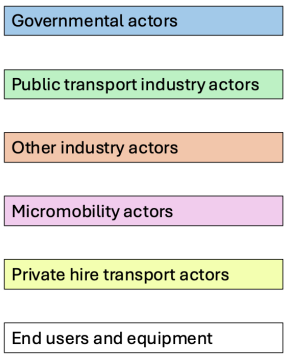

Figure 4. Actor Map colour coding scheme.

Influence from regulators and associations was noted by the Jelbi and Breeze programme managers in terms of the impact upon fare setting and regulation, with the Berlin and Brandenburg Transport Authority influential in this regard in Berlin, and the Rail Delivery Group having strict requirements for rail ticketing in the UK. The Association of German Transport Companies was also highlighted as placing requirements on digital ticketing and data exchange. In contrast, actors at this level were said to have only a very indirect influence over Floya in Brussels.

Beyond those examples, the three interviewees focussed primarily on actors residing at the central two levels, namely 'Industry and local government' and 'Resource providers and management'. These were the most immediately influential in terms of day-to-day system operations and were the levels where specific MaaS implementation differences were most notable (in addition to broader international governance and bureaucratic differences).

Although both Floya and Jelbi have more complex micromobility landscapes, with multiple companies operating and involved in the MaaS implementations, Breeze stood out as the most complex in terms of the governmental organisations and the number of public transport organisations involved. Public transport acts as the 'backbone' of MaaS (Alyavina et al., 2020; Mulley et al., 2023). The proliferation of separate companies therefore represents a major source of complexity and potential conflict, hence risk. In Brussels and Berlin, there is one main public transport company that runs local services, greatly simplifying the landscape in this regard. Moreover, and as mentioned above, those respective companies (i.e., STIM-MIVB and BVG) are the managers and operators of the MaaS systems in their jurisdictions. This is not the case in the Solent region where Solent Transport, an apolitical organisation that brings together all four local councils, is the manager of the MaaS system in operation. Not only does this involve additional, potentially conflicting commercial interests (e.g., with multiple, competing bus companies all needing to make new legal and working relationships with Solent Transport), it also requires the collaboration of four local authorities that may or may not be in the same economic situation or have the same political will to contribute to a scheme that is likely to always need subsidy (Kraus, 2024) (just like public transport more generally; Department for Transport, 2023).

The ActorMap diagrams presented above present visual representations of the stakeholders involved in three different implementations of Mobility as a Service (MaaS) across Europe, all of which are underpinned by software provided by the same MaaS technology provider (i.e., Trafi). The diagrams do not, however, present the links between the actors and organisations. Nevertheless, in developing and discussing the stakeholder landscapes of the three systems with their respective programme managers, and in the subsequent follow-up email communications, details did emerge regarding those relationships.

The most prominent of these was related to funding. In the case of Floya in Brussels, this is an initiative motivated by transport sustainability goals expressed at the national and city levels and carries the implicit acknowledgement that it will not be profitable, rather represents a public service that will always need funding and will continue to be funded (at least in the short to medium term). In Berlin, the Jelbi scheme is also considered part of the public transport offering and funded as a public service; however, there is also the expectation that some aspects of the scheme will generate revenue. For example, the Jelbi stations (represented at the 'Equipment and environment' level in the ActorMap) are physical mobility hub installations and represent a key aspect of the Jelbi business model. The Breeze app, in the Solent region, is currently wholly funded via a UK government research and development initiative; however, it has a goal of being financially self-sustaining without reliance on government subsidy. These funding mechanisms (and goals) are of course related to governance. Therefore, to use Göran Smith's typology (Smith, 2020), Brussels is a public controlled scenario, Berlin a public-private scenario and Solent a market-driven scenario, at least in some respects. This is a major risk to success in the Solent area. Public transport (argued to be the crucial to MaaS, as discussed above) in the UK is heavily subsidised by central government. It is done so as it is considered a public service whose benefits (to society) justify the costs. MaaS appears to be considered in this way in Brussels and Berlin (though perhaps to a slightly lesser extent in the latter). This does not appear the case in the UK. To overcome this risk, greater funding commitments from central government will be required. This presents a challenge given the challenging national economic backdrop.

Implications for ergonomics

The discussion of these aspects arose thanks to the structure provided by the ActorMap and its underlying Risk Management Framework. There exist many different approaches to stakeholder mapping (see Reed & Curzon, 2015 for a review), and we do not claim the ActorMap framework to offer a better or worse approach to doing so (comparative analysis would be required for that);

however, we do argue that the Risk Management Framework, as embodied in the ActorMap template, facilitates a hierarchical understanding of the relevant entities involved or interested in a system (in this case, MaaS), hence is highly useful. The ActorMap also facilitates discussions around communication between actors and the control and feedback mechanisms that exist in the system. One could reasonably argue that the STAMP method (Leveson, 2004) does this to a greater extent; however, resources are not always available to undertake a full STAMP analysis. The ActorMap is a far simpler tool, requiring less time and expertise to complete, yet still offering a hierarchical framework around which to base discussion with system stakeholders.

Rasmussen and Svedung (2000), in their book *Proactive Risk Management in a Dynamic Society*, discuss generic versions of the AcciMap and the ActorMap as tools for, as the book title suggests, *proactively* managing risk in complex systems. We have made the point above that risk (in a system failure sense) does not only relate to safety but also sustainability. A failure to ensure our transport system develops sustainably is a risk to society. We therefore need to be proactive when considering the implementation of interventions aimed at improving transport sustainability.

Although we discuss above the relationships between organisations represented in the ActorMaps, and how information about these relationships emerged in the ActorMap-facilitated discussions with the three MaaS managers, these are not represented on the ActorMap diagrams. Rasmussen and Svedung (2000) discuss role allocation in their chapter on generic ActorMaps; however, inclusion of interconnections is reserved for the AcciMap. Although this can be developed in a generic fashion, its nature lends itself more to events than on-going operations, given the multiple different activities undertaken by each organisation involved (i.e., it would be unwieldy to depict all activities undertaken by all parties in one diagram). As such, we would suggest a development of the ActorMap tool as a tool for stakeholder identification and mapping would be the inclusion of those interconnections. Indeed, our inclusion of colour coding to indicate the nature of each organisation involved is a methodological development of sorts; however, including interconnections would go further. This merits further methodological exploration, although one might reasonably suggest such an inclusion would move this closer to being a STAMP analysis. One of the main benefits of the ActorMap (over STAMP) is its relative simplicity. The extent to which further additions might tip the balance of utility and resource intensity one way or the other will require careful consideration, and likely be dependent on the specific application at hand.

A criticism that could be levelled at the analysis presented above, and at the RMF approach to risk analysis more generally, is that it does not explicitly evaluate risks in terms of the typical impact and likelihood metrics. It also does not have a formalised mechanism of indicating the influence or interest of each identified actor, the dimensions of Mendelow's oft-used stakeholder mapping and engagement matrix (Mendelow, 1981). The ActorMap helps frame discussions, and the template upon which actors are mapped can support a more in-depth understanding of systems hierarchies. Nevertheless, alone it is (arguably) insufficient as a risk analysis, management, and mitigation tool.

Conclusions

The transport sector (and society more broadly) faces a significant sustainability challenge. Systems ergonomics might help us to address that challenge; however, in the human factors and ergonomics literature, system failure has typically been viewed only in terms of safety, not sustainability. We demonstrate the utility of the ActorMap tool, and the Risk Management Framework on which that tool is based, for the identification of risks to the success of a sustainable transport scheme, namely Mobility as a Service. Further research would do well to compare different systems ergonomics methods in this context.

Acknowledgements

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References

Alyavina, E., Nikitas, A., & Tchouamou Njoya, E. (2020). Mobility as a service and sustainable travel behaviour: A thematic analysis study. *Transportation Research Part F: Traffic Psychology and Behaviour*, *73*, 362-381. https://doi.org/https://doi.org/10.1016/j.trf.2020.07.004

Department for Transport. (2023). *Official Statistics Rail factsheet: 2022*. Retrieved 07/08/2024 from https://www.gov.uk/government/statistics/rail-factsheet-2022/rail-factsheet-2022

Kraus, L. (2024). *Enhancing Mobility as a Service–Sustainability, Willingness to Pay and Profitability Aspects* Dissertation, Duisburg, Essen, Universität Duisburg-Essen, 2024].

Leveson, N. (2004). A new accident model for engineering safer systems. *Safety science*, *42*(4), 237-270.

McIlroy, R. C., Plant, K., Hoque, M. S., Wu, J., Kokwaro, G., Nam, V., & Stanton, N. (2019). Who is responsible for global road safety? A cross-cultural comparison of Actor Maps. *Accident Analysis & Prevention*, *122*, 8-18.

Mendelow, A. L. (1981). Environmental scanning--the impact of the stakeholder concept.

Moray, N. (1995). Ergonomics and the global problems of the twenty-first century. *Ergonomics*, *38*(8), 1691-1707.

Mulley, C., Nelson, J. D., Ho, C., & Hensher, D. A. (2023). MaaS in a regional and rural setting: Recent experience. *Transport Policy*, *133*, 75-85. https://doi.org/https://doi.org/10.1016/j.tranpol.2023.01.014

Rasmussen, J. (1997). Risk management in a dynamic society: a modelling problem. *Safety science*, *27*(2-3), 183-213.

Rasmussen, J., & Svedung, I. (2000). *Proactive risk management in a dynamic society*. Swedish Rescue Services Agency.

Reed, M. S., & Curzon, R. (2015). Stakeholder mapping for the governance of biosecurity: a literature review. *Journal of Integrative Environmental Sciences*, *12*(1), 15-38.

Salmon, P. M., Stanton, N. A., Read, G. J., Walker, G. H., Stevens, N. J., & Hancock, P. A. (2019). From systems ergonomics to global ergonomics: The world as a socio-ecological-technical system. Chartered Institute of Ergonomics and Human Factors Annual Meeting,

Smith, G. (2020). *Making mobility-as-a-service: Towards governance principles and pathways* Chalmers Tekniska Hogskola (Sweden)].