

DESIGNING FOR TRANSITIONS IN RURAL TRANSPORT

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ABSTRACT

Rural areas are less attractive and sustainable for people and businesses alike, partially due to inadequate transport services. In this paper, we address transport-related challenges in rural Norway. The focal aspect of our approach is to define a set of values for the design and mechanisms of transitioning towards more sustainable rural transport making a real-life difference for people living in rural areas. We connect UN sustainability goals and transition design to discuss how these can be operationalized and used throughout the design process seeking to innovate rural transport. Reflecting on how to find the initial ‘leverage points’ to scaffold the transition to more sustainable transport systems, we explore the possibility of introducing relevant Key Performance Indicators early on in the design process. We report on our experiences and findings regarding the Key Performance Indicators and discuss their role in design-led innovation processes.

KEYWORDS

Sustainable HCI, transition design, leverage points, key performance indicators, transportation systems.

1. INTRODUCTION

It has been almost two decades since the field of Human-Computer Interaction (HCI) tried to reconcile its inherent dichotomies between research and design by focusing on designing for values, that is, “*HCI must be objectively systematic and reliable in the pursuit of subjective value. Traditional disciplines have delivered truth. The goal of HCI is to deliver value*” (Cockton, 2004). Although the HCI community has been working toward establishing its sustainability agenda for more than a decade, during the era of fast social, environmental, and technological changes, views forwarding incremental reductions (e.g., in energy consumption, individual changes in behavior patterns) are no longer enough (Bendor, 2018; Fredericks et al., 2019; Light, 2019; Light et al., 2017). The community is now focusing on larger, at scale, systemic solutions toward sustainable development (Fredericks et al., 2019; Knowles et al., 2018; Silberman and Interpreter, 2013). We position the work presented in this paper within this discussion, in which we focus on the mitigation of challenges that rural communities experience with the transport sector.

Good transport systems can contribute to the sustainable development of rural areas and provide people with novel opportunities, such as the freedom to settle where they want and increase wellbeing (“*Ta heile Noreg i bruk - Meld. St. 13,*” 2013). The rapid development of Intelligent Transport Systems, sharing economies and Mobility-as-a-Service (MaaS) concepts (Alliance, 2017), presents a novel set of potentially better solutions within the sector. In particular, the development of MaaS concepts for rural areas is acutely

needed (“Developing rural services,” 2017). These concepts are considered enablers of combining transport services from different providers through a unique service platform in which transport needs can be custom tailored. At present, MaaS proposals do not cover a spectrum of needs; for example, transport-induced CO₂ emissions are not covered (Alliance, 2017). According to the World Bank, CO₂ emissions are one of the major contributors to climate change, with transport being responsible for more than 20% of the global CO₂ emissions (www.data.worldbank.org/indicator). Furthermore, some services had to be stopped because of high costs despite their high popularity (Skollerud, 2014). The coronavirus pandemic in 2020 unexpectedly allowed the world to directly witness the impact of traffic and industry emissions on air quality (Watts and Kommenda, 2020).

The challenge is to offer an efficient transport system that provides good transport services to everyone and, at the same time, keeps financial and environmental costs low. This is especially difficult to achieve in sparsely populated rural areas, where the distances are considerable and transport resources are limited. Transport systems, being critical centralized infrastructures (Tomlinson et al., 2015), need to move toward decentralization (ibid.), but such transformations cannot be done hastily. They involve multiple stakeholders, sometimes with conflicting interests, require an interdisciplinary approach, and need to continually adapt to changes in regulations, mobility patterns, and technology. Thus, finding an adequate approach to tackle this challenge is crucial and requires a more systemic approach.

Recently, transition design (TD) has been proposed as an approach to lead transitions toward more sustainable futures and is suitable for addressing wicked problems, such as climate change, over-consumption, pollution, and poverty (Escobar, 2018; Irwin, 2018; Tonkinwise, 2015). It is based on a sustainable, multi-perspective (cross-disciplinary), value-based, long-term, forward-looking design and contributes to a better understanding of societal transitions (Zolfagharian et al., 2019). As such, TD aligns well with our problem of looking into appropriate solutions for rural transport systems. It builds on the premises of TD and, in particular, on leverage points that may help initiate and carry out sustainability transitions (Abson et al., 2017).

In this paper, we introduce and discuss sustainable transport Key Performance Indicators (KPIs) as a tool focusing on leverage points, such as CO₂ emissions, to address sustainability in TD processes. Concerned with real-life solutions and visible improvements in rural transport services, we focused on how KPIs could align with both sustainability goals and the TD framework. The motivation to explore KPIs is based on our need to identify and consider performance measures already in the design process and use them as building blocks in a larger innovation project aiming to develop a MaaS solution especially tailored for rural areas in Norway.

In what follows, we first discuss existing frameworks that point toward sustainable futures. We then describe the Sustainable Transport KPIs and report our first practical experiences with a prototype for finding alternative transport routes that help reduce CO₂ emissions.

2. TOWARD SUSTAINABLE FUTURES

Long-term visions for desirable global futures, co-created by the United Nations (UN), were articulated through the UN Sustainable Development Goals (SDGs) (“Sustainable Development Knowledge Platform,” 2015). For this work, SDG 9 (*Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation*) is of particular relevance, as it addresses the importance of efficient transport systems and services as the key drivers of economic development. The document (ibid.) defines specific targets related to each goal (e.g., develop quality, reliable, sustainable, and resilient infrastructures, with a focus on affordable and equitable access for all, promote inclusive and sustainable industrialization, increase the access of small-scale industrial and other enterprises), as well as specific indicators that might help reach these targets (e.g., finding out what proportion of the rural population lives within 2 km of an all-season road, number of passengers and freight volumes by mode of transport). The SDGs are not mutually independent. Working with transport systems also relates to other goals, such as SDG 13 (*The Climate Action*), SDG 11 (*Sustainable Cities and Communities*), and SDG 12 (*Responsible Consumption*).

The Doughnut, Kate Raworth’s iconic model of an economy that respects both social needs and the ecological boundaries of the planet, is another way of framing sustainable development (Raworth, 2017, 2012). The doughnut represents a developmental space that is safe and just for all, respecting a social well-

being boundary that no one should fall below, and an ecological ceiling of planetary pressure that we should not go beyond.

Building on these and on UN and Norwegian policy documents, such as the UN's policy document on sustainable transport ("Mobilizing Sustainable Transport for Development," 2016) and the Norwegian Transport Plan 2018–2029 (Samferdselsdepartementet, 2017), a list of specific transport-related goals is suggested (Samferdselsdepartementet, 2017). These goals highlight the need for reliable and available transport that is accessible for all, shortened travel time, and a good capacity for passengers and goods, and aim to double the global rate of improvement in energy efficiency ("Mobilizing Sustainable Transport for Development," 2016).

Recently, a Norwegian guide for the development of sustainable, productive, and resilient cities and local communities has been introduced to support local and regional authorities, community groups, researchers, entrepreneurs, and other stakeholders (DOGA, 2019). It describes the basic principles for sustainable development, prioritizing climate and the environment and promoting inclusion and co-creation in design processes. Furthermore, the guide proposes the following phases to move from these principles toward smart and sustainable cities and communities: understanding, creating, experimenting, learning, and building. At present, the guide only offers a set of key questions related to each of these phases. Measures, tools, and best practices are to be added as the guide evolves.

In summary, there are considerable design and research activities that aim to lay out alternative paths toward more sustainable futures. Nevertheless, at this moment, the approaches that can demonstrate good results in practice are not many.

The TD community strives to bridge the more abstract principles of sustainable development and concrete, designed outcomes. The approach forwards the following four main areas of research and design activities (Irwin, 2018) that support transitions in a sustainable direction: 1) finding and using the appropriate theories of change that support socio-technological transformations; 2) understanding and developing visions for transitions; 3) working with the mindset and posture, including values, that are appropriate for transitions (e.g., precautionary, explorative, reflexive, critical, participatory, local, situated); and 4) discovering and using new ways to design that lead to impactful, large-scale solutions contributing toward a more sustainable future (Knowles et al., 2018). In contrast to traditional HCI design approaches (including the more systemic ones, such as service design, experience design, and sustainable design), which tend to frame problems within relatively limited spatio-temporal contexts and identify a limited number of stakeholders and potential conflicts of interests, TD calls for a more holistic approach that considers the development of ecological and environmental literacy, takes a long-term perspective, and re-thinks potential solutions beyond financial and commercial interests. The role of design in TD has been further elaborated by Boehnert, Lockton, and Mulder as follows: "*designing for transitions involves designing how transitions are conceived, enacted, governed and managed*" (Boehnert et al., 2018). However, Van Selm and Mulder also point out the lack of case studies with real users to test the TD framework and associated processes and tools (van Selm and Mulder, 2019). Furthermore, the lack of actionable components (Ceschin and Gaziulusoy, 2016) and methods for the phase in which a design intervention is implemented, with one being in the *waiting and observing* phase before the next intervention can take place, has also been identified (van Selm and Mulder, 2019).

Our aim is to understand and fill these gaps when working on making rural transport more sustainable, a case in which we chose the actionable components (KPIs) in work with real users, which might enable designed outcomes with good performance measures in real life.

3. KPIs IN SUSTAINABLE TRANSPORT

KPIs are commonly used to measure the performance of an organization or an activity (Fitz-Gibbon, 1990). They might be quantitative, such as the number of new customers in marketing, or qualitative, such as employee satisfaction in human resource management. Expanding on this idea, we used KPIs to operationalize our design for transitions. We developed sustainable transport KPIs as an instrument to be used throughout the whole lifecycle of the project to scaffold continued focus on sustainability. Within the TD framework, these KPIs offer leverage points that help promote changes through design until a desired outcome is achieved.

A project that we describe here aims to develop tools and services for MaaS specifically tailored for sparsely populated rural areas. The main idea is to create a holistic system for transport planning that dynamically coordinates the transport of people and goods to make the most of transport resources. New services and tools for planning are to include carpooling, car sharing, transport on demand, and use of mini-buses and taxis for transport optimization. The project was driven by the overall goal to “*Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all,*” which is UN Sustainable Target 9.1 (“Transforming our world: the 2030 Agenda for Sustainable Development,” 2015). However, the indicator associated with this target, passenger and freight volumes, is not comprehensive enough. For example, the above-mentioned Norwegian national goals (Samferdselsdepartementet, 2017) include shortened travel time and sustainable transport systems for all, in addition to a good capacity for passengers and goods. Although more specific, the latter set of goals also does not capture the full complexity of transport in rural areas.

4. DATA GATHERED WITH SUSTAINABLE TRANSPORT KPIS

The idea for the project evolved through a dialog between the problem owner (county municipalities’ transport section) and the researchers in several meetings and workshops, resulting in a joint research proposal to design MaaS for rural transport. In this initial phase of the work, a list of KPIs was created, starting with the above-described UN and national goals and input from experts in transport planning and HCI. The list was then expanded with additional indicators using a radar chart (see Figure 1) in two workshops with eight experts to assess the importance of KPIs on a scale from 1 (not important) to 3 (very important). The KPIs found to be most relevant for this project were costs (for passengers, transport providers, and the municipalities), travel and waiting times for passengers, distance, utilization of resources, reduced used of private cars measured in kilometers, increased income from ticket sales, impact on the environment, the last mile (distance to the pick-up point), and drivers’ workload. The radar chart was designed to show a passenger’s perspective (e.g., pick-up at home, travel time, waiting time, ticket price, environment) and a transport provider’s perspective (e.g., drivers’ workload, operating costs), but it also had an open category (allowing both providers and passengers to add new indicators).

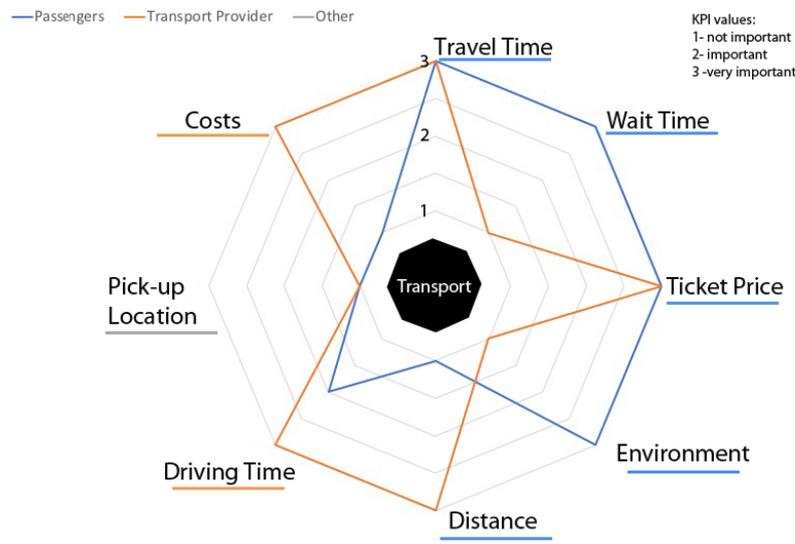


Figure 1. The radar chart was used to elicit the most relevant KPIs for passengers and transport providers.

In what follows, we present how sustainable transport KPIs were used, and we give some examples of the insights gained from their usage.

4.1 Relating KPIs to present concerns and future visions

In the next phase, the project stakeholders engaged in workshops to map the current problems, creating a map of stakeholder concerns, and the relation between these and the visions for transition (Irwin, 2018). The KPIs that emerged as the most significant through this work included passenger and freight volume, monetary and environmental costs, utilization of transport resources, travel time, and waiting time. These were further developed through workshops discussing concerns related to public transport in the rural county participating in the project.

For example, the discussion on the utilization of resources revealed that there are many small entrepreneurs with vans and minibuses that constitute available resources, as their use is not optimized at present. These small entrepreneurs were then included in the list of project stakeholders that should participate in the user studies in later phases of the project.

Furthermore, discussions on passenger/freight volumes and costs revealed the importance of these topics for many stakeholders in rural areas. The core issue here is that in scarcely populated areas, the passenger/freight volumes are low in a range of transport types. One way of keeping costs at an acceptable level is to allow combining different transportation types in future solutions. The need to include a broad range of stakeholders in the TD process surfaced again here. Working actively on expanding the list of stakeholders in the project with new ones who might benefit from joining the project was defined as an important project goal.

In the discussion on travel/waiting time, the issue of motivating citizens to change their transportation habits was raised. One stakeholder framed this issue as follows: *“We transport people from the place they don’t want to start their travel to the place they don’t want to end it at a time which is not convenient for them. People simply want to go from A to B when they want. And there is already a perfect solution. It is called a private car. The question is how to compete with it. How do we motivate people to use public transport?”* Exploring how to encourage people to engage in more environmentally friendly behaviors became one of the larger project goals.

Sustainable transport KPIs enabled us to be more specific when envisioning the future. They helped us structure our discussion about expectations and tangible, measurable goals for the project. One of the examples we used was a calculation of the expected benefits from considering two KPIs: environmental cost and passenger volume. We calculated the expected benefits for the environment (reduced CO₂ emissions and fuel consumption) and the increased income for transport service providers. The calculations showed that if two persons used public transportation from Folldal to Alvdal/Tynset (two small Norwegian municipalities) instead of their private cars 250 days a year, the reduction in driving distance would be approximately 200 km per day, reducing CO₂ emissions by approximately 6 kg and the fuel consumption by approximately 3,000 L, whereas the public transportation ticket fares would amount to approximately €5,000 in benefits for the public transport provider.

In summary, working explicitly with KPIs at the very start of the project has helped strengthen the research agenda and set a range of practical goals for the project. When working with sustainable transport KPIs, doing concrete exercises and providing examples helped grasp the extent that changes might bring.

4.2 Designing Interventions

The next phase of the process involved *“looking up and down system levels in space, and backward and forward in time”* (Irwin, 2018) and implied understanding how the problems and concerns are amplified or mitigated at different system levels and seen from different time perspectives. We started this phase by collecting users’ insights and identifying how the current situation amplified the set of problems. Interviews with project stakeholders were used for the latter. The interviewees had a broad understanding of the needs and problems related to public transport in the rural area we observed. We recruited 13 participants (six females and seven males) from the public sector. Four of them were decision makers in leading municipality positions, and nine were employees working with transport daily, both at the strategic and tactical levels. We conducted 11 individual interviews and one interview with two persons at the same time. Three interviews were conducted over the phone, whereas the remaining ones were done in face-to-face meetings. During the interviews, the participants were asked to envision the public transport of their dreams and then critically reflect on it (i.e., find obstacles to using it). They were also asked to reflect on what is important for them

when they use public transport or want to send goods. They were shown the radar chart and asked to explain what is important for them and why. We asked them first to answer these questions as citizens of the county (passengers) and then to answer the same questions from the perspective of their work position. After discussing the KPIs we presented, we asked them if they could think of their own indicators.

The participants first talked about their own experiences when using public transport and what would be needed to motivate them to take a bus or train instead of their own car. We found that the way in which they weighted different KPIs depended on the situation (that is, there was no single answer). For example, when asked about the importance of ticket prices and travel time, one participant said, *“I take the bus to work and for leisure activities. When I have children with me, I take the bus rarely. It has to do with costs. When you have three kids with you, then you drive yourself. It is cheaper. And this is, this is a challenge. It has to do with costs and not to mention time.”*

The participants added several new indicators, such as the quality of the driver’s service, the quality of real-time information, and the quality of waiting places, and argued for their importance when designing new services. The quality of the driver’s service was explained as follows: *“I wrote a ‘good driver,’ and, by this, I mean more than his driving style. I mean a driver who is pleasant to meet on the bus, a driver who is professional and provides good service. It is these three [indicators] that are very important.”*

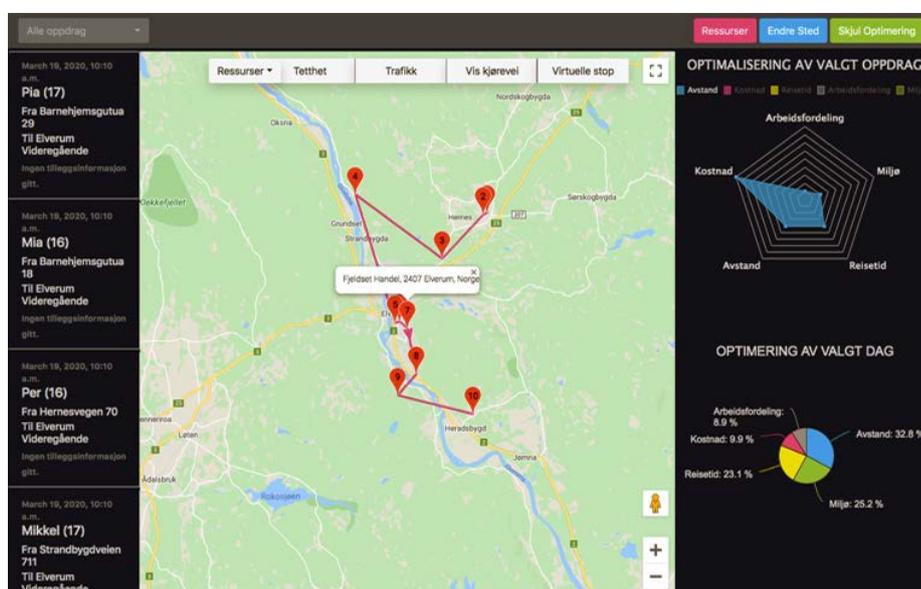


Figure 2. Front-end prototype of a transport planning tool (in Norwegian). The radar chart and the pie chart on the right have five KPIs: drivers’ workload, the environment, travel time, distance to the pick-up point, and costs. Incoming orders are listed on the left side of the screen. The map for the proposed route is shown at the center.

Discussing environmental KPIs, the participants often considered the problem from a broader perspective. KPIs helped them understand situations that contributed to current environmental problems. Two participants explained how the environmental impact of transport is related not only to the planning of transport services but also to the planning of development. One participant said, *“It is also about how we plan municipality development, where to place the kindergarten in relation to residential areas.”* Another participant said, *“We would like to be involved much earlier in the development of new residential areas and roads. When they build an area without a space for the bus to turn, it is too late.”* Furthermore, discussing environment KPIs helped identify the importance of collaboration among different stakeholders. One participant explained how their planning of school bus services depended on school plans: *“It does not help to plan being in front of school A at 8:15 a.m. and in front of school B at 8:30 a.m. if school B starts at 8 a.m. We have to negotiate with them or drive one bus to school A and another to school B, which is bad for the environment.”*

Insights gained helped us define design goals and engage in prototyping different solutions. For example, the goal to *“motivate the increased use of public transport”* led to some design ideas and suggested solutions. One of the proposed solutions explicitly used sustainable transport KPIs. Figure 2 shows the front-

end prototype for a transport planning tool. The envisioned functionality aims to enable operators to work with transport planning and explore the effects of different transport solutions on KPIs. The radar chart in the upper right-hand side allows the operator to prioritize different sustainable transport KPIs for a journey. A user (a passenger, a customer ordering the transport of goods, or an employee at the transport center) can choose priorities for a particular trip using the radar chart; for example, low costs are prioritized over the distance to the pick-up point, travel time, and impact on the environment. An optimization tool that is a part of the system we are developing proposes an optimized solution (a travel route shown at the center of Figure 2) according to the chosen criteria. The pie chart in the lower right corner of the screen summarizes the journeys during a selected day according to KPIs.

In summary, TD methods, tools, and techniques can be used to create design interventions, including prototypes of more sustainable solutions, featuring KPIs as a way to evaluate choices.

5. CONCLUSIONS AND FUTURE WORK

We bring the idea of KPIs from business management into TD. Our first experience showed that sustainable transport KPIs were useful for mapping the problem, mapping stakeholder concerns, envisioning the future, obtaining user insights, identifying the current situations that contribute to the problem, and designing interventions. They enabled us to keep the focus on sustainability and have common themes through the projects. The insights gained through different phases of the project allowed us to work toward sustainable solutions. KPIs and the associated radar charts worked very well to initiate and structure the discussion in workshops and interviews. They worked well for both individual and group interviews and for both online and face-to-face interviews. However, it was easier to follow up on participants' opinions with additional questions during face-to-face interviews. The indicators also made the analysis of the collected data straightforward, as the data collection was already structured around KPIs (e.g., workshops and interviews), or KPIs were used to generate the coding schema (e.g., content analysis of the related projects). This work adds KPIs as an instrument to operationalize design for transitions, fulfilling the need for actionable components and methods (Ceschin and Gaziulusoy, 2016) (van Selm and Mulder, 2019).

Although KPIs showed their usefulness, more studies are needed to further elaborate when and how they could be successfully used. We applied KPIs on a project within the transport sector, and we believe that the same approach might be useful for other domains. As this is ongoing work, we have not yet applied sustainable transport KPIs to evaluate the effect of the interventions introduced by the project. Nevertheless, we believe that sustainable transport KPIs can be beneficial for measuring the short- and long-term effects of TD projects, serving as leverage points that scaffold the transformation from the current situation to a sustainable one. Future work includes further development of this instrument for a better understanding of its role in real-life transitions toward sustainable rural transport.

ACKNOWLEDGEMENT

The project 'Smart Transport in Rural Areas' is funded by the Research Council of Norway, the Transport 2025 program (grant nr. 296639). We thank the project partners Innlandstrafikk, Folldal Municipality, EnTur and Hospital Innlandet for their contribution to this work. Especially, we thank Lasse Jordbru for his insight into challenges of rural traffic and to Ophelia Prillard for prototype implementation.

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