

## Prototyping sustainable mobility practices: User generated data in the smart city

### Author(s) and affiliation(s):

**Alan-Miguel Valdez PhD**, Corresponding author

Research Associate, Department of Engineering and Innovation at the Open University,  
Milton Keynes, UK

[alan.valdez@open.ac.uk](mailto:alan.valdez@open.ac.uk)

**Matthew Cook PhD, FRGS**

Senior Lecturer in Innovation and Sustainability, Department of Engineering and Innovation  
at the Open University, Milton Keynes, UK

[matthew.cook@open.ac.uk](mailto:matthew.cook@open.ac.uk)

**Per-Anders Langendahl PhD**

Visiting Research Fellow, Department of Engineering and Innovation at the  
Open University, Milton Keynes, UK

[per.anders.langendahl@slu.se](mailto:per.anders.langendahl@slu.se)

**Helen Roby PhD**

Research Fellow, Faculty of Business and Law,  
The Open University Business School, Milton Keynes, UK

[helen.robby@open.ac.uk](mailto:helen.robby@open.ac.uk)

**Stephen Potter PhD**

Emeritus Professor of Transport Strategy, Department of Engineering and Innovation at the  
Open University, Milton Keynes, UK

[stephen.potter@open.ac.uk](mailto:stephen.potter@open.ac.uk)

### Abstract

Although smart cities are now the subject of a growing literature, there is a paucity of research which considers how smart city projects develop on the ground. This paper begins to address this concern by exploring the development of a transport application, MotionMap, within the MK:Smart smart city programme. MotionMap aims to provide city-wide real-time transport information services. It is being developed through an ongoing dialogue sparked by the interaction of lead users and prototypes of a smart transport app. We draw on insights from Strategic Niche Management and social practice theories to explore how 'smart' might be integrated within and potentially transform the plurality of mobility practices that exist in cities.

**Keywords:** Transport, Social shaping of technology, Technology & Innovation Studies, Open innovation

### 1 Introduction

City managers struggle to cope with growing demands for energy, water and transport that result from the rapid growth of urban population (UN, 2014). The rising demand for city resources cannot be met with a proportional increase in the provision of urban infrastructures, as cities are constrained by physical, environmental and financial limits to growth. Development of so called ‘smart cities’ has been initiated to address these concerns (Hollands, 2008; Kitchin, 2014a). Smart technologies are claimed to improve the efficiency of public service delivery, the sustainability of the urban environment, and the quality of life of citizens (Cisco, 2012; BIS, 2013). The specific mechanisms through which such technologies may develop and the promised benefits may be delivered, however, remain vague (Greenfield 2013, Kitchin 2014b, p 163).

We follow the development of a smart application through the case of MotionMap. MotionMap is a mobile phone application for smarter transport being developed in the city of Milton Keynes (MK) as part of MK:Smart, a UK Government funded smart city programme ([www.mksmart.org](http://www.mksmart.org)). Once MotionMap is made available to the public in 2017, it will connect users with information and cloud-based services (e.g. booking and billing systems), supporting more informed, flexible and spontaneous travel choices. This research looks at the development process that took place between Spring 2014 and Autumn 2016. A series of citizen engagement workshops facilitated the exploration of existing and envisioned transport practices in Milton Keynes through the interaction of lead users and increasingly functional prototypes of the MotionMap application.

The development of MotionMap took place in an experimental space provided as part of the MK:Smart programme (MK Smart 2014a). Little is known about socio-technical interactions within such experimental spaces and the practices (in this case transport) which emerge from these and form the foundation of everyday life in the smart city (Watson 2012, Nyblom 2014, Raven et al. 2016). This paper begins to address this gap in knowledge. We make use of two complementary perspectives, those of Strategic Niche Management (SNM) (Kemp et al. 1998, Smith and Raven 2012, Raven et al. 2016) and social practice theory (SPT) (Shove et al. 2012, Watson 2012).

SNM, a perspective associated with various conceptions of socio-technical transitions, offers a strategic, context-sensitive framework for the creation and development of experimental spaces for promising new technologies (Hoogma et al. 2004, Geels et al. 2016). One criticism of this approach is that it is focused on general strategies, providing limited insight into the contingency, messiness and context specificity of socio-technical configurations in the making. SPT, which is ideally suited for the study of on-the-ground processes of sociotechnical change, is increasingly being used to complement approaches based on socio-technical transition analysis (Turnheim et al. 2015, Geels et al. 2016).

## 2 Conceptual framework

Urban artefacts, remnants of earlier investments and planning decisions, may become obstacles for those who aspire to bring about urban innovation (Graham and Marvin 2001, Hommels 2005). In the case explored in this research, a road system developed in the 1960s has defined Milton Keynes as a city for the car (Llewelyn-Davies et al. 1970a: p27, Clapson 2013: p56). Today, the potentially adverse effects of high car dependence on the economic development and environmental sustainability of MK are becoming increasingly evident. Traffic growth of some 60% is expected in MK by 2026 (MK Council, 2012), but only an extra 25% capacity can be provided through conventional measures such as road expansions. Even if the additional traffic could be accommodated it would be incompatible with the city's Low Carbon Living strategy (NHBC Foundation 2010) and its long-term transport vision and strategy (MK Council 2011:p15).

Milton Keynes, like many other aspiring smart cities, is striving to use information technologies to change the use of physical infrastructures (MK:Smart 2014a, MK:Smart 2014b), exploring the use of large scale data and analytics to make cities more efficient and to develop transferable solutions for sustainable urban growth (MK:Smart, 2014a). Thus, MotionMap can be studied in the context of a growing interest in urban scale low carbon living experiments that challenge the obduracy of existing infrastructures (Bulkeley et al. 2014).

It may be possible to distinguish elements with varying degrees of obduracy within a socio-technical network (Law 1987, Bulkeley et al. 2014). However, it is unwise to assume that social elements are more obdurate than technical ones or vice versa (Hommels 2005, Switzer et al. 2013). One approach that has been usefully applied for approaching socio-technical change in transport is that of Strategic Niche Management (SNM) (Hoogma et al. 2004, Schot and Geels 2008, Raven et al. 2010). SNM presumes that sustainable technologies require temporary protection whilst the performance, price and supporting infrastructures develop. Niches are conceived as protective spaces where such development can take place (Kemp et al. 1998, Hoogma et al. 2004). Initially, protection was provided predominantly through supply-side measures to counteract cost differentials or performance characteristics (e.g., regulations, tariffs and taxes). More recent developments in SNM emphasize the role of niches as spaces for sense-making and nurturing (Smith and Raven 2012, Raven et al. 2016). The niche becomes a space where actors can learn together, articulating expectations and creating support networks for innovative technologies.

Socio-technical transition approaches such as SNM can be usefully applied to guide the development and management of experimental spaces, but their toolkit has limited capabilities for engaging with the complexities of local practices (Geels et al. 2016). There is a growing interest in the use of social theoretical approaches to provide a complementary perspective, with the expectation that such bridging will provide a richer multi-dimensional understanding of socio-technical change as it unfolds (Watson 2012, Cohen et al. 2013, Turnheim et al. 2015, Geels et al. 2016).

In contrast to more simplistic approaches that see social change in terms of technological determinism or individual choices, an assemblage of various social practice theories has been developed to study social change empirically, emphasising everyday routine practices as the key unit of analysis. Innovation happens as new practices emerge, existing practices persist and practices no longer warranted disappear. This exceptionally heterogenous body of literature is prominently associated with theories of Bourdieu and

Giddens (Bourdieu 1977, 1979; Giddens 1984) that seek to explicate the relationship between agency and structure (Kennedy et al 2015: pp 7-17). Here, we particularly follow the work of Elizabeth Shove, whose approach to SPT elaborates on Giddens's framework, conceptualizing daily life as a recursive dialogue between self and place. Shove's work, as usual for recent scholarship in the field, is closely tied to the issue of climate change. SPT is used to explore the everyday practices of households which in aggregate give rise to significant environmental impacts (Shove and Walker 2010; Shove et al. 2012), providing insight on the processes that lead to a particular dominant structure of personal mobility or, in the case of this research, identifying elements that hold the most potential for change.

We therefore apply SNM and SPT to describe the co-design of a smart mobility app within an experimental space. We contribute to the growing body of literature which explores the relationships and links between these two approaches. There are indications that such a pluralistic approach might prove fruitful (Watson 2012, Langendahl et al. 2016, Geels et al. 2016), but this is still an emerging area of research. Work in the area has not sought to integrate, fuse or hybridise those two approaches in an overarching universal theory (Watson 2012); insight on their interplay, rather than synthesis, is sought (Geels 2010, Geels et al. 2016, Watson 2012). Our novel contribution to this dialogue is in providing a case study of an experimental space where industry and government actors make a deliberate attempt to modulate change in the urban level, and where a smart application was co-designed through a practice-oriented dialogue with lead users. To enable SPT to be operationalized empirically, this study will follow the analytical framework developed by Shove et al. (2012), which argues that practices are comprised of three elements:

**Competence** – the skill and knowhow of practitioners

**Meanings** – symbols, norms and collective conventions that govern action

**Material** - physical objects, such as goods and infrastructures

The elements of practice provide a template for the qualitative analysis of data collected in a series of citizen innovation workshops to explore the co-constitution of the technical and the social.

### 3 Method

This paper presents a case study to explore a smart transport application, following a SNM case study format adapted from Hoogma et al. (2004: p66). Qualitative analysis informed by SPT is performed to shed light onto the iterative exploration of existing and envisioned practices through the interaction of lead users and prototypes. Our analysis is based on data collected and subsequently analysed using a clustering and coding method (cf. Miles and Huberman, 1994). Workshop participants were recruited through a purposive strategy targeting potential lead users (Von Hippel 1986, Hienert et al. 2007). Thus, we did not seek a representative sample of the MK population, engaging instead with participants with strong needs, direct experiences of the transport problems being addressed, and hopefully a higher interest in adopting and championing MotionMap. Four of the workshops were open to the general public but targeted citizen groups interested in specific transport issues, who were contacted through community coordinators (Community Action: MK); the remaining two workshops were closed and the participation of specific project partners was sought (MK:Smart partners and prospective entrepreneurs interested in developing data-driven business models). Community Action MK has extensive links to the voluntary and community sectors, which allowed us to recruit participants from transport-related interest

groups (e.g., the MK bus users group, the cyclists touring group). Given the low levels of bus usership, walking and cycling by commuters in MK (4%, 7% and 3%), this was necessary so we could reach the populations of interest.

12-40 participants attended each workshop and were separated into smaller groups.

Workshop guides were used to stimulate group discussions. Data were collected through notes taken by workshop facilitators, from feedback forms provided to participants, and from incidental outputs of the group exercises (for example, sticky notes and flipboard sheets with notes from brainstorming sessions).

Workshops were preceded by a description of the planned design for MotionMap and the data sources feeding into it. Participants engaged in discussions about prototypes and mock-ups of MotionMap and envisioned how the application could be integrated into their existing or desired travel practices. Their inputs were used to develop a specification and prioritise the development of new features. New prototypes and new scenarios were introduced for subsequent workshops, making the collaboration iterative. The semi-structured discussions prompted by the prototypes were messy, with participants talking about their concerns, practices and the competences, meanings and materials that constitute them. Through this discussion, the researchers sought to identify ways in which MotionMap could be linked to and appropriated into existing and envisioned transport practices.

## **4 The experiment**

The unit of analysis for the SNM case study is defined as “the experiment” to stress the idea that learning is central in SNM. This learning goes beyond the technical. Experiments must engage with user needs, societal benefits and negative effects of existing and emerging technologies, questioning existing preferences and finding ways of building new ones. (Hoogma et al 2004: p5). While MK:Smart was not a formal SNM experiment, the SNM perspective was useful for studying the situated learning processes that took place in Milton Keynes.

### **4.1 Setting and Context of the experiment**

Milton Keynes, which now has a population of over 250,000 people, was built to a distinct design dating from 1969-71 that sought to facilitate the use of the private car for all journey purposes (Llewellyn-Davies et al. 1970a): a one kilometre grid of high capacity, high speed ‘grid roads’ (Figure 1) and extensive car parking, coupled with low density development. This land use design that disperses and elongates journeys is systematically hostile to most forms of travel other than the private car. MK is consistently ranked last or near-last in car dependency scorecards (Campaign for Better Transport, 2014). Because of high car dependence and rapid population growth, traffic growth of some 60% is expected by 2026 (MK Council, 2012), but local authorities can only provide an extra 25% capacity through junction improvements and other measures.



*Figure 1. A segregated pedestrian and bicycle overpass crossing the "grid road" in Milton Keynes.*

This issue is not exclusive to Milton Keynes. Indeed, as the problems of unsustainable automobility become more widespread, there is an emerging interest in smart demand management solutions as an alternative to the increasingly ineffectual provision of infrastructure. Providers of such smart solutions claim that they will increase environmental sustainability and economic competitiveness of the city (Cisco 2012, BIS 2013). The smart city solutions developed in MK are emblematic of this growing global trend.

#### **4.2 Objectives and Project Organization**

MK:Smart is a £16 million smart city programme based in Milton Keynes that explores the use of large scale data and analytics to make cities more efficient, leading to transferable solutions for sustainable urban growth (MK:Smart, 2014a). MK:Smart includes various teams of university and industry partners with expertise in the various aspects of urban and data management infrastructures necessary to develop smart applications. Such applications are expected to offer personalized advice and information so users can make 'smarter choices' (MK:Smart, 2014b). For example, the MotionMap smart transport application draws on data from several networks of sensors, connecting users to real-time information about the movement in the city such as routing, public transport timetables, delays and real-time indicators of pedestrian and vehicular density and activity. Through travel planning advice complemented with real-time information users are expected to develop more efficient and convenient transport practices (MK:Smart 2014b). Development is led by the University of Cambridge. The application and its sensing infrastructure are developed by private sector technology start-ups. Researchers from the Open University, including two of the authors of this paper, have explored user requirements and the development of business models.

MotionMap, currently available as a prototype, can be compared to commercial applications such as Google Maps or Waze. Many of these applications facilitate route and time shifting so that car users can use roads more efficiently, increasing capacity without enlarging the road network (Khoo et al. 2016). Like its commercial counterparts, MotionMap provides multi-modal routing and congestion warnings. However, MotionMap is intended to also contribute to public policy objectives, providing a platform for exploring a variety of approaches to mobility in the city. Data captured through the application and the related sensing infrastructure will feed back into city dashboards and inform the traffic models used by planners. MotionMap is considered necessary for the long-term transport strategy of the city and is expected to evolve into a widely used application that can support seamless multimodal travel within the city (MKF2050, 2016). The high availability of personalised information on travel choices could have a similar, if not greater, impact to that of Personalised Travel Plans, which can achieve traffic reductions of up to 11% (Cairns et al, 2008).

Design and deployment of “busyness” sensors were two of the most important tasks for the MotionMap team. MotionMap largely relies on automated image analysis for monitoring “busyness”, measured in terms of the number of vehicles occupying a given space (a stretch of the road, an intersection, a car park). Sensors and visualizations were demonstrated through a series of prototypes. As such, sensor deployment for MotionMap has been limited to a level needed for concept proving. The deployment includes visual analytics sensors installed:

- In 10 buses on a single route out of the 20 major bus routes in the city;
- At selected parking areas in the city centre monitoring a total of 140 spaces out of a total of 21,000 spaces available in central MK;
- At three of the 124 roundabouts in the grid road system to monitor traffic flows.

While sensor coverage does not yet allow the delivery of practical applications, it is sufficient for demonstration purposes. The experiment produced technical knowledge related to the development and deployment of sensors, visualizations, and data management structures. Knowledge about the social dimension of the experiment was also produced through the iterative interaction and co-creation of prototypes and practices that took place within a series of lead user workshops described in the following section.

## **5 Learning and Visioning within the Niche, and the Co-Creation of Smart Transport**

This section draws on social practice theory to explore the links between MotionMap and transport practices. Here, the experimental space provided a venue for learning and visioning through dialogues inspired by interaction of users and prototypes. Following Shove et al (2012), the results are structured around elements of practices, materials, meanings and competences. The elements mentioned by workshop participants range from road surfaces and layouts (material objects), and familiarity with the bus schedules (competences) to ideas - for example, about safe and flexible commuting (meanings).

### **5.1 Automobility in Milton Keynes**

75% of the commuters in Milton Keynes are either drivers or are passengers in a car (MK Council 2015). Even with the growing environmental agenda, MK’s high car

dependency has remained deeply entrenched. This is a major economic concern as the road network is beginning to reach capacity in the face of rapid population and employment growth.

### **5.1.1 Materials**

MK's car-orientated design, dating from 1969-71, has a one kilometre grid road system of high capacity, high speed roads extensive car parking, low density development and dispersed traffic generating land uses. Even though the 1971 *Plan for Milton Keynes* stated that 'the provision of a good public transport system is a public responsibility of the highest priority' (Llewelyn-Davies et al 1970a, Vol 1 para 133), this desire was not reflected in the selected land use structure and overall urban design. Despite the published plan containing goals to achieve high quality public transport and safe pedestrian movement, the Plan's *Transport Technical Supplement* admitted that:

*'...in the light of the selected land use plan, the provision of a competitive form of public transport does not make practical sense. This consideration of maximisation of freedom of choice has therefore been discounted.'* (Llewelyn-Davies et al. 1970b, Vol 2, p.34)

In other words only major subsidies could counteract the structural hostility of such a car-oriented design towards public transport. In the 1980s, bus deregulation and privatisation made such subsidies illegal outside London. MK developed much as expected, with high car use and mediocre public transport (Potter 1997). Even the segregated bicycle and pedestrian paths (known locally as the Redways) are associated with a use lower than for comparable cities. A land use design that elongates journey distances is systematically hostile to most forms of travel other than the car.

### **5.1.2 Meanings**

Participants considered that driving was the most efficient, comfortable and reliable means of travelling locally, providing the highest degree of autonomy and control. Alternatives were only considered when health issues prevented them from driving. With the exception of participants based in historic areas with limited parking, participants considered that drivers in MK were largely free from the physical and environmental constraints placed on car use elsewhere. Any approach that challenges the use of the car thus faces substantial opposition.

### **5.1.3 Competences**

Workshop participants assumed they were competent drivers (excepting those that were absolutely unable to drive). Here, being a competent driver was not discussed only in terms of the ability to control one's vehicle, but also in terms of the ability to select optimal routes and times for travel. Car users assume that they are already doing the best they can do, and that new information and/or competences would not change their behaviour. They considered that the potential benefits of improving their driving competences would mostly be negligible, as they did not think that improved information would save more than a few seconds off their commuting time or a few pennies in fuel costs.

### **5.1.4 Implications for MotionMap**

The workshops revealed that drivers cannot easily envision alternatives to their existing practice. Participants saw their peak hour commute as something unavoidable and real time information would have a limited effect on their choice of times and routes because their transport practices were linked to work practices. They generally considered that

current traffic levels in the city were acceptable and were predominantly satisfied with the status quo. There was no real acceptance or concern about traffic congestion seriously worsening. This set of attitudes indicated that MotionMap should not so much aspire to erode car commuting directly. Rather, MotionMap can make alternatives more realistic. Given that it is not possible to accommodate future car use growth, one value that MotionMap could provide is to enable motorists to be prepared for the more difficult motoring conditions that will inevitably arise from the continued population and employment growth in MK.

## **5.2 Redways: Walking and Cycling in Milton Keynes**

7.9% of the commuters in MK walk to work, and 3.1% use a bicycle. While they are different practices, the workshops suggest that they share many problems.

### **5.1.1 Materials**

Various commercial and governmental actors in the city cultivate the image of MK as a place with a good cycling and pedestrian infrastructure because it has a separate 300 km network of shared-use paths, which thread their way through most areas of the town. These 'Redways' are generally 3m wide paths shared by cyclists and pedestrians with a red tarmac surface (Franklin 1999). However, the network was designed primarily for leisure (Clapson 2013 p 15,16,64), and participants considered them pleasant but difficult to use for commuting. Distances are elongated by circuitous and poorly signed routes, and lighting is insufficient or non-existent in some sections. Cyclists felt further endangered by the system's poor layout, with sharp bends, steep gradients, bollards, slippery bridges, loose gravel, mud, and flood-prone underpasses. While those features are not prevalent, participants experienced them frequently enough to give concern, particularly when venturing in unfamiliar sections.

### **5.2.2 Meanings**

Redways were seen as pleasant enough by participants using them predominantly for leisure trips. Commuters, however, reported finding them unsafe, confusing, or treacherous when venturing outside of very familiar routes. This was particularly a concern for cyclists wishing to travel at realistic commuting speeds, and for pedestrians after dark. There was a feeling that improving conditions of the Redways is not a priority for the city administrators, particularly when it comes to providing sufficient lighting for safety. Thousands of lights were turned off or dimmed in 2012 due to budget cuts, and workshop participants still suspect that budget concerns may lead to city managers downplaying the problem of dark footpaths. Workshop participants see the Redway network as a maze of largely indirect and poorly signed local paths.

### **5.2.3 Competences**

Familiarity with the Redways is an important competence for pedestrians and cyclists in MK. Workshop participants felt generally discouraged in using them unless they were familiar with a particular route because of the steep learning curve and the perceived high personal cost of failed attempts (in terms of lost time, aggravation, or even perceived risk of bodily harm). Workshop participants saw a potential for using MotionMap to support the competences required for safe navigation by pooling/crowdsourcing knowledge of the Redways network.

### **5.2.4 Implications for MotionMap**

The possibility of using MotionMap for navigation, which was part of its original design, was welcome but was not considered sufficient by workshop participants unless complemented by road reports generated through automated and crowdsourcing methods. For example, the accelerometers that are integrated with some smartphones can produce

automatic reports regarding bad surfaces, steep gradients and unexpected sharp bends. There was interest in complementing automatically generated data by crowdsourcing information about hazards like glass on the roads, areas with insufficient illumination, or flooded underpasses. By providing advance notice of the hazards users can plan alternative routes, or ensure that they are riding at a safe speed when they approach problematic sections of the roads.

### **5.3 Public Transport in Milton Keynes**

6.1% of the trips to work in MK are made by bus, minibus or coach. This is considerably lower than in cities of a comparable size (e.g. Nottingham)(Campaign for Better Transport 2014). Using a bus is seen as the least desirable alternative. The land use design of the city is hostile to public transport operations, and cannot support high-frequency services.

#### **5.3.1 Materials**

The low density of MK and the design of the grid roads do not fit the operational needs of public transport. Workshop participants blamed the grid layout for long walks to the bus stops, and for long waits when aggravated by the perceived unpunctuality of some services. The problem is sometimes compounded by issues with other components of the multi-modal journey (with one participant reporting, for example, that a 20 minute walk in the dark along an isolated footpath was needed to reach the nearest bus stop).

#### **5.3.2 Meanings**

Using the bus was viewed as a distress purchase when all other options are exhausted, and even advocates like members of a local bus users group described this mode of transport as a resource for the most vulnerable. Public transport use in MK is often associated with a loss of control, giving control to unaccountable and sometimes unreliable actors. Bus users stated that bus companies appear to dictate their own rules with little accountability to users or local authorities. Data on scheduling, routing and incident reporting was not trusted, as there was a perception that ‘it’s very easy to manipulate data if you are a bus company’. Confusing or unreliable scheduling information regularly led to situations where users were left ‘feeling like mugs’ waiting for buses that were not there. Some users were suspicious that the tracking devices were disabled when delays were expected as to preserve statistical averages for punctuality, further contributing to the feeling of being deceived.

#### **5.3.3 Competences**

Use of public transport in MK was found to be a challenging, information-intensive practice. Participants felt that they lacked the level of knowledge of the routes, schedules and connections required to avoid excessive waiting times. Multi-route and multi-modal journey planning was seen as requiring too much time and effort among various sources of information. Even finding basic information required prerequisite knowledge about bus stops and routes at the origin and destination points. Additionally, regular users of public transport stated that the available information provided by the bus companies was unreliable. The buses were reported to regularly miss their schedule. Many stops have real time information boards and there is a smartphone application for the routes of the main operator. The app claims to provide real-time information about the location of the buses, but users did not trust the information. Users reported that sometimes they would spend 20-30 minutes waiting for a bus that, according to the app, was two bus stops away. Their rough estimate was that the information was accurate for 80%-90% of the journeys.

### 5.3.4 Implications for MotionMap

Public transport users were particularly enthusiastic about MotionMap, seeing potential applications originally unforeseen. Particularly, they were interested in providing their own crowdsourced, real-time reports about the location of buses. This information would be of immediate use to other bus passengers, and the accumulated records provided by this monitoring activity would make transport providers more accountable. This would counteract the existing disempowering relationship between users and service providers. At the moment, transport providers are the sole gatekeepers of information needed by users, and there is limited accountability for delays or interruptions to the service. Shifting this relationship so that users become information generators and holders is valued and would be a radical step. MotionMap can provide a new practice for using the public transport system, with the competences embedded in the device replacing the guesswork and loss of control that make existing practices unappealing.

### 5.4 Epilogue and future prospects - Evolution of the MotionMap concept

The mock-ups that were used for the initial workshops were intended to be very abstract and open to interpretation. For example, one of the very first mock-ups was a static image of a 'heat map' whose was left intentionally ambiguous so it could be interpreted, for example, as an indicator of traffic congestion or as pedestrian density. Those limited prototypes were refined in an iterative fashion, with results from the workshop feeding into the specifications used by the software development team. Abstract mock-ups were followed by non-functional mock-ups in which the expected functionality was made more explicit (Figure 2). Later, interactive prototypes with limited functionality and a real connection to sensors deployed in the city centre became available (Figure 3).

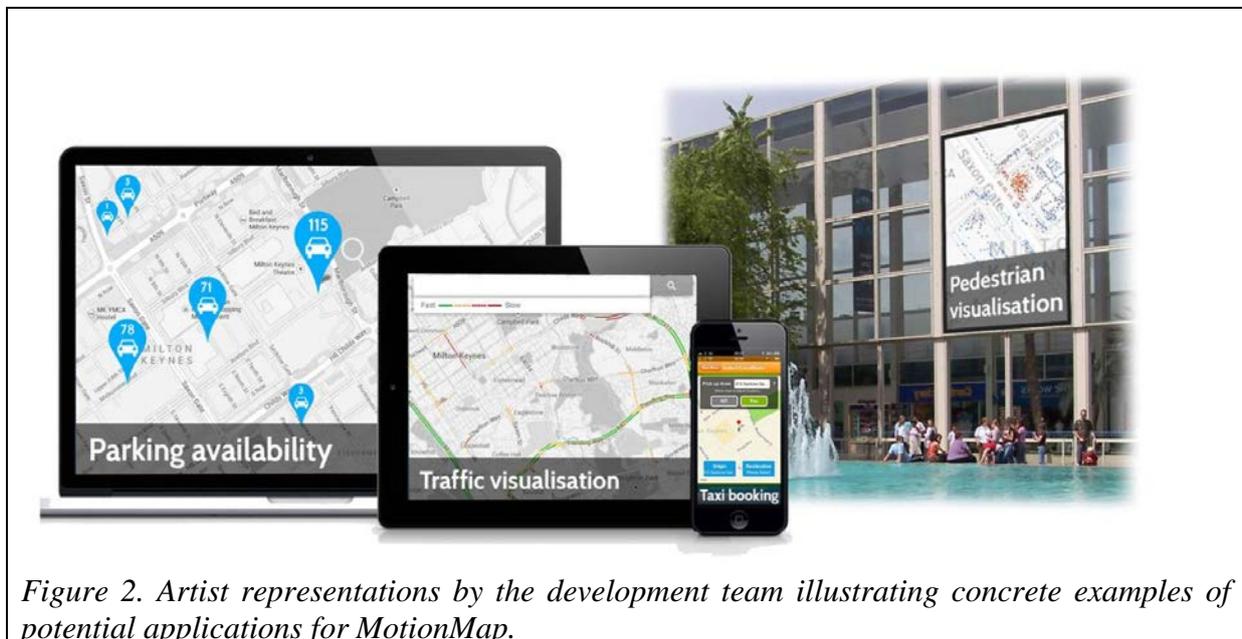


Figure 2. Artist representations by the development team illustrating concrete examples of potential applications for MotionMap.

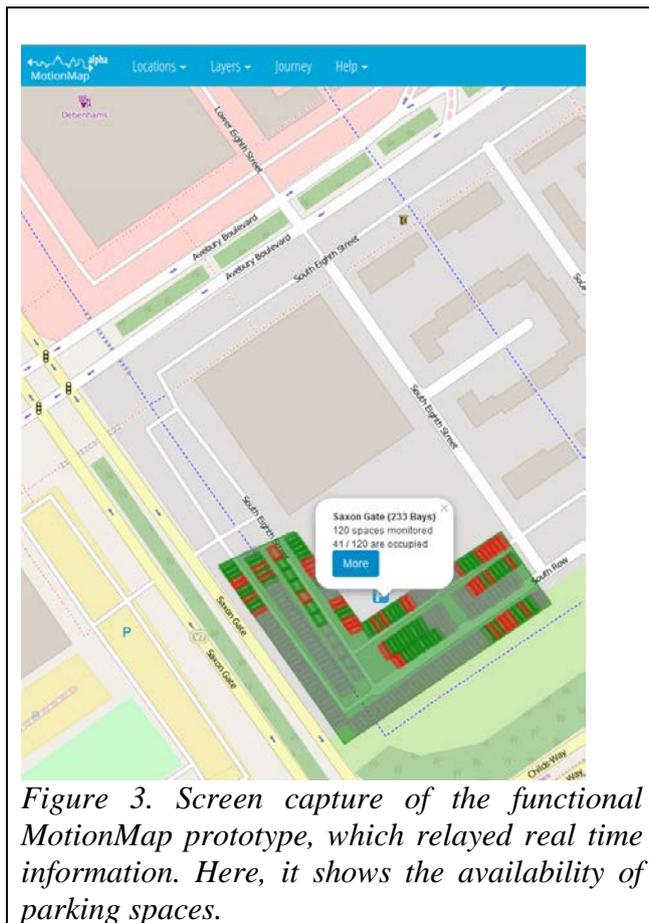


Figure 3. Screen capture of the functional MotionMap prototype, which relayed real time information. Here, it shows the availability of parking spaces.

A common premise in the discourse of smart cities is that information will transform users of smart applications into more competent and satisfied users of city services (Morozov 2013; Halpern et al. 2014), with the benefits predominantly stated in terms of increased efficiency. The design of early MotionMap prototypes assumed that users would value transport information if it helped them to travel more efficiently, avoiding congestion by changing the route or time of their journeys. This view was challenged through the iterative interaction of users and prototypes, leading to a redefinition of the functionality. Instead of prioritizing the efficiency, developers concentrated on features that would facilitate multimodal travel. This vision of smart transport was also reflected in local policy. MotionMap was made part of the long term transport strategy for MK. MotionMap is envisioned as an enabler of new forms of mobility to ensure everyone who lives, works, studies or does business in the city is able to “move freely and on-demand” (Transport innovation task and finish group, 2016; MKFC2050, 2016).

Our observations are consistent with those other studies exploring the intersection of ICTs and emerging transport practices. The dominant visions of the smart city in policy and corporate literature are focused on the increasingly efficient use of city resources (Cisco 2012, BIS 2013, Söderström et al. 2014), but practice-oriented research in smart mobility has prioritized choice and flexibility instead. Information is used to facilitate increasingly multimodal travel, hopefully reducing private car ownership. This research suggests that social practice theory is usefully applied to identify neglected informational needs of people at the moment of making travel choices. Henriksson et al. (2014) and Nyblom (2014) observe that current developers of traffic management, mobility and travel services are often blind to significant parts of the whole spectrum of social practices. While predominant commercial

approaches focus on duration as the key attribute influencing travel choices, research shows that users are sensitive to uncertainty regarding the stressfulness, comfort and security of their journeys (Nyblom 2014). The sensitivity to those frequently ignored variables is also highly dependent on context. For example, a degree of uncertainty that would be acceptable for leisure travel may be intolerable when traveling for a business appointment, or when picking up children from daycare (Nyblom 2014).

Uncertainty in travel choice may be managed through experience or through increased availability of information but also through social cooperation, either face to face or technologically-mediated (Bartle et al. 2013, Nyblom 2014, Henriksson et al. 2014). User generated travel information was highly trusted in comparison to information supplied by transport providers and government agencies. Such information has been found useful in an instrumental sense, and is also found to promote positive feelings and an increased sense of group membership (Bartle et al. 2013). This seems particularly relevant to the case of Milton Keynes, as a lack of trust in the alternatives contributes to the perception that automobility is the safest and most empowering transport choice.

## 6 Conclusion

In this research, we outlined an experimental process in which a smart transport app was co-designed. We used complementary perspectives provided by SNM and SPT to explore this complex socio-technical process (Turnheim et al. 2015, Geels et al. 2016). The prototype described did not have sufficient functionality as to make it available to the general public. This level of functionality has been achieved only recently, so further research will be needed to assess the degree to which a design shaped by lead users may respond to the needs of the wider general public. Future research may fruitfully explore the processes through which envisioned practices might become actual, and the processes through which elements of the practices and socio-technical networks associated with smart cities may travel. Urban innovation is complex, contingent and cannot be easily transferred to other cities in blueprint form. Rather, the concepts and design principles travel, stimulate and shape innovation in various locales (Cook and McAloone 2014). We may hope that innovations developed within MK:Smart may inspire, motivate and guide innovation elsewhere, undertaken by local actors to meet local challenges. It is in this spirit that we discuss how this research has shaped the vision of smartness for this particular project:

MotionMap was originally conceived as routing and sensing app, but the workshops identified the need for a platform through which users can benefit from their collective intelligence to overcome informational gaps that introduce uncertainty into their transport practices. The competent performance of transport practices like cycling and public transport commuting can be deceptively information-intensive, and city managers and transport providers are the main gatekeepers of such information. Shifting this relationship so that users become information generators and holders, making the invisible visible, is valued and would be a radical step (Harrison and Donnelly 2011).

One potential downside of such an approach comes from the risk of reinforcing the antagonism of users and providers of transport services. Information about transport flows in the city can be used to make more informed decisions, reducing the barriers for adoption of more sustainable forms of mobility. However, this information could be used to exert

pressure on service providers. The crowdsourced approach for smart journey information could develop in a number of ways: It could reinforce the antagonism between users and providers; it could produce data that the providers will accept as valid, leading to performance improvements; or it could reshape the relationships between organizations and users. Those possibilities are present in the envisioned application and will require further research.

The design produced through this iterative process gave rise to a vision of a smart city application augmented by the collective intelligence of its users. This vision of the smart city would mainly support one of the three core elements of practice, namely, competences. Materials were assumed to be predominantly obdurate, but smart technologies may be applied to enable their use in new configurations, with smart technologies supporting the automation of complex competences with steep learning curves which would otherwise act as barriers to the adoption of more sustainable practices. While acts like catching a bus or riding a bicycle may appear to be simple, planning a complete journey may require complex competences, such as knowing the most efficient bus connections accounting for the reliability of different lines, or knowing what are the most direct and safe cycling routes. This suggests that in the context of smart cities smart devices are also competent devices. The provision of real time traffic information, crowdsourced collective intelligence, and other capabilities of the MotionMap may enhance the competences of users and reframe the meanings of different forms of transport in the smart city. Indeed, its presence may transform trajectories of everyday transport practices, perhaps toward more sustainable ones.

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