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# TRACKING RESEARCH *AN AGENDA FOR URBAN DESIGN AND PLANNING*

## INTRODUCTION

Is there a future for tracking research in the context of urban design and planning? What about urban design and planning in the context of a world in which ubiquitous tracking might become an everyday phenomenon?

Tracking technologies seem to offer a door into the candy-store-of-their-dreams for researchers in urban studies. Potentially, everything can be tracked and traced, from people to goods and from vehicles to animals; specific places, routes or behaviour can be monitored, and individual people, their social networks or whole masses of people examined.

Tracking technologies are particularly interesting for urban design and planning in comparison to older techniques used to conduct research on human behaviour, such as travel and activity diaries. Tracking technologies make it possible to collect large datasets on human behaviour with a high level of accuracy, combining directly temporal and spatial data. Tracking technologies make it relatively easy to link additional information in databases to data on time-space paths. Moreover, tracking data is potentially highly communicative, since it is possible to make the data visually available and (real-time) accumulated, both individually and/or collectively. With trackable (even GPS-equipped) mobile phones entering the arena, it is possible that researchers will no longer need to worry about selecting a representative sample, as they

can simply track 'everybody'. Moreover, location-based services are rapidly developing and are thus an economic drive for the spreading of tracking devices. This means that the devices might be ultimately ubiquitous, thus rendering concerns about the deployment of tracking devices for research purposes obsolete.

In light of this technological advancement, the possibilities opened up by using tracking technologies in academic research would seem to be immense. But is this actually the case? This book has shown that the initial phase of technological development offers promising vistas from a multitude of disciplines. However, it also shows that the application of tracking technologies can be quite complicated. After the openings given in the previous chapters, the goal of this last chapter of the book is to synthesise a future agenda for the application of tracking technologies in urban design and planning. This future agenda will be developed below on the basis of four lines of inquiry. These reflect the set up of the roundtable workshops at the expert meeting *Urbanism on Track*:

- The possibilities for integrating navigation issues that are part of daily life and urban design matters
- The possibilities for using tracking research as an evaluative, analytical or explorative tool in urban design
- The possibilities for support in decision-making in planning processes by tracking
- The possibilities for raising the value and validity of data and data collection relevant to urban design and planning

Firstly, the following section sketches the suppositions held by researchers on the relevance of tracking technologies, in particular amongst experts dealing with tracking technologies in relation to urban design and planning. Against this background, the subsequent sections examine the above-mentioned four lines of inquiry. The paper concludes by formulating a future agenda for the application of tracking technologies in urban design and planning in a number of pragmatic ways.

## BACKGROUND: SUPPOSITIONS ON TRACKING TECHNOLOGIES

The expert meeting *Urbanism on Track* provided some interesting insights into the underlying suppositions and viewpoints on the role of new technologies, in particular tracking technologies, in the context of urban design and planning (see illustration 13.1). Firstly, 5 major levels can be set apart with regard to attitudes towards the relation between tracking technologies and urban design and planning, ranging from scepticism (level 1) to utopianism (level 5) (see also Schaick, 2008). The table of illustration 13.1 differentiates between two sub-levels for pragmatic attitudes (3a and 3b) and two sub-levels for the utopian attitudes (5a and 5b).

Distinctions can also be made between different types of arguments that support attitudes to technologies. These arguments express the often implicit, though sometimes explicit, value judgements on the role of new technologies in the field of urban design and planning in particular and society in general. Moreover, these value judgements are linked to the suppositions held by researchers on the relationship between technology, the city and people's behaviour. Several authors describe the way in which the introduction of ICTs into daily life since the 1990s has caused several shifts to occur in the relationship set out above, as did the introduction of 'old' new technologies such as rail transport and telephone in the past (Graham and Marvin, 1996).

There are three main challenges to these suppositions:

- The introduction of advanced tracking technologies forces researchers to question suppositions on human spatial behaviour, as qualitatively, if not quantitively, it changes people's activity behaviour.
- The socio-technical context of urban research is continuously and rapidly changing. The continual development of new technologies for use in daily life means that people's behaviour in a certain environment is not a given. The confusion about how cities are actually affected by developments in telecommunications has remained since it was first pointed out by Graham and Marvin (1996). This means that with the introduction of new technologies, the choice of subjects for urban research is under pressure to shift.
- The introduction of tracking technologies might change the nature of urban research. It gives researchers the possibility of developing new research questions in light of the accuracy and amounts of data, of adopting new research techniques due to new data collection / generation / computation / combination possibilities, and of communicating the outcomes of research in new ways, due to the possibilities of visualisation. Moreover, the interaction of users with these technologies, while tracking technologies are used by researchers to observe behaviour, needs special attention.

In light of the different basic attitudes towards tracking technologies, these challenges can be crystallised into a range of possible applications and directions for developing tracking technologies in urban design and planning. **Illustration 13.1** shows that the basic attitudes differentiate ideas about the development of applications of tracking technologies along three lines:

- the degree to which assumptions can be made on the influence on people's behaviour by ICTs, in particular tracking technologies (undermining suppositions on people's behaviour held by urban designers and planners)
- the degree to which assumptions can be made on changes in the spatial-physical conditions of people's behaviour, either by the introduction of ICTs or other factors (changing the subject of urban design and planning)

**Illustration 13.1**

**The introduction of tracking technologies in the urban design and planning domain: suppositions, challenges and reactions.**

| | Basic attitude | Changing suppositions on activity behaviour in urban design and planning | Changing subject of urban design and planning | Changing nature of research in urban design and planning |
|---|---|---|---|---|
| **1** | "The results of studies using advanced tracking technologies are useless to urban design and planning" | Urban design and planning should not concern itself at all with suppositions on human behaviour, as it is changing too fast to be accounted for in designs | Focus on urban ground plan and physical-technical transformation of cities | Urban design and planning focuses on relationships with technical fields of study (e.g. civil engineering) instead of social (spatial) sciences. |
| **2** | "It is not going to be that dramatic a change, but – as designers - we need to become aware of activity behaviour in general and advanced tracking technology is a good tool for that purpose" | No major changes - basic biological functions are determining for activity behaviour; some qualitative changes are acknowledged | Durée of the physical environment will remain the stable factor in making urban designs and plans. Accommodating faster changing processes such as changes in mobility behaviour through spatial flexibility and gradual adaptation | Visualisation is used as an additional layer in urban analysis |
| **3a** | "The more data – the better our models – the better we can plan" | Based on contemporary body of knowledge in time geography | Spatial transformation modelling combined with activity-based traffic modelling. Focus on operationality of models. | Advanced tracking technologies provide large amounts of data as input in models; tendency towards linking databases and data mining; testing existing hypotheses and models. |
| **3b** | "Advanced tracking technologies provide a great instrument to get experts from different disciplines on one table" | During a planning process, expert opinions clash in organised environments and produce a new shared expert opinion | Decision support systems | Playful use of advanced tracking technologies; raising awareness about activity behaviour; visualisation is used as a communication instrument between experts |
| **4** | "Behaviour is changing, so we need new physical conditions" | Activity and mobility behaviour changes both qualitatively and quantitively due to the introduction of advanced tracking technologies | Exploring new spatial-physical conditions for activity and mobility behaviour; new concepts for urban design and planning, for example with regard to accessibility | Project-based ex-ante and ex-post research using advance tracking technologies; new conceptualisations of city-ICT relationships. |
| **5a** | "In time, physical interventions will become second to real-time urban management" | Real-time interaction of mobile and immobile information devices leads to new and controlled activity and mobility patterns | Urban planning is concerned with the (real-time) management of urban flows and rhythms rather than with making physical changes to cities. Planners as Big Brother. | Research focuses on finding new mappings and conceptualisations of the city; going beyond the same type of research conducted, for example, using diaries. |
| **5b** | "The availability of advanced tracking technologies will lead to empowerment of civil society groups in urban development and management" | Pervasive computing leads to new types of social networks with power to act because they have information about the urban system they live in. | Urban planning has become a bottom-up process emerging from civil society groups organising their space using ICTs. No place for urban designers and planners. | Research focuses on mapping social networks |

- the degree to which assumptions can be made with regard to ongoing changes in scientific urban research and its basic hypotheses under the influence of ICTs (changing the nature of scientific research in urban design and planning)

Against this background, we can start working towards a realistic future for tracking in relation to urban design and planning. The subsequent sections provide the building blocks for a research agenda on the basis of the roundtable workshops held at *Urbanism on Track*.

## LOOKING AT TRACKING AS PART OF DAILY LIFE

An initial perspective for a future research agenda can be developed if we look for answers to questions arising from tracking as part of daily life. The most obvious fact is that the development of tracking technologies has been linked to the development of location-based services – of which navigation is the most mature – since GPS technology was freed from the military straightjacket in which it was launched several decades ago. For a few years now, the combination of several different tracking technologies has offered us a wide range of possibilities for application (see chapter 3). Researchers acknowledge that the commercial application of tracking technologies cannot be ignored. Moreover, this should be taken as an opportunity for the development of academic applications of tracking technologies.

From this perspective, two approaches prevail in discussions between researchers. Firstly, examples are emerging of the side-by-side development of (a) services based on tracking technologies and (b) spatial interventions that anticipate the (omni)presence of tracking technologies in daily life. From this perspective, tracking technologies are primarily seen as a technique to observe behaviour. Examples can be found on three spatial scales at least, distinguished by different modes of transport and communication, namely pedestrian mobility, vehicle-based mobility and mobile communication.

Pedestrian mobility is a major theme for developers of location-based and location-aware services (see chapters 5 and 7). However, at this stage, it cannot be stated that tracking and walking are intensely linked all the time and everywhere. Pedestrian behaviour linked to tourism and leisure activities seems to be of particular interest for developers of commercial applications. With regard to academic research, tracking technologies offer a particular advantage over paper diaries for registering exact routes taken and the kind of trips that research subjects easily forget, typically 'quick' trips by foot from the home or the office such as posting a letter. However, raising the accuracy of tracking data on leaving indoor environments still needs to be a major point of improvement. In addition, pedestrian mobility should be seen as part of a greater mobility chain. This is why, in general, research on pedestrian mobility benefits greatly from a combination of research techniques.

The integration of tracking devices in vehicles is growing. Since a few years ago, car-based mobility has become intensely connected to the technological development of tracking technologies. The increasingly widespread use of navigation devices strongly depends on tracking technologies. The latest developments point to the further integration of mobile phone tracking with navigation devices for the purpose of detecting traffic jams. Other vehicles are being tracked as well. The tracking of taxis, buses and lorries is becoming increasingly common, especially from the point of fleet management, logistics or theft prevention. In particular, road pricing is an example of an application that has a direct relevance to urban design and planning. The advantage of tracking data collected in this way is that datasets often include a very clearly defined group of users, making the interpretation of data relatively easy. However, it also limits future possibilities for research, as ownership of these datasets is not quickly transferred or shared with researchers.

Over the last decade, mobile communication has become the most ubiquitous technology available for providing possibilities for tracking people. Mobile phones have a high level of penetration on a global level. Theoretically, this development can supply an endless source of data for researchers. In particular, the combination of mobility data with communication data could be interesting with a view to investigating social or business networks.

Another approach to tracking as part of daily life is to focus more on the way in which tracking technologies change people's behaviour when they actively use or passively carry a tracking device. In this case tracking can be, but is not primarily, used as a technique for observation. Two examples of research subjects in this light are research on how the use of tracking technologies changes people's mental maps (see also chapter 11), and research on how the use of tracking technologies changes people's time and space use. Although these are relevant research subjects, this chapter focuses on tracking technologies as research instruments.

What conclusions can we draw from looking at tracking technologies as part of daily life? In his essay *Sensing Human Society*, Shoval (2007; cf. chapter 2) states: "The fact that an ever-increasing proportion of human society constantly carries a tracking device at all times and in all places creates new possibilities for spatial research." Researchers are expected to increasingly exploit and depend – or at least count - on familiarity with and the future ubiquity of tracking devices. This dependency makes it crucial to develop ways to work across the borders between university and commercial operators and interactively with the users of these technologies. In this light, understanding user-technology interaction is central to the future development of research.

This perspective shows that it is crucial to be aware of biases related to the dominant mode of transport in research projects. Dominant categories are pedestrian tracking, automobile

tracking by in-vehicle GPS devices and the tracking of public transport vehicles such as buses or other service transport such as taxis or cargo vehicles. One bias in such research is the neglect of multimodality in travel chains or activity chains. This can be dealt with by deploying tracking devices over longer periods of time and having devices carried 'on the body'. The introduction of the mobile phone as a tracking device that can be used for tracking research might solve some of these problems. However, several researchers have warned that mobile-phone tracking is not the ultimate answer to all research questions to tackle using tracking devices. Moreover, each of these technologies fails to solve the omission of people that are not using these technologies. It would seem that a strategy of tailor-made technologies is best for academic purposes, while for general purposes, the integration and compatibility of technologies is necessary with a view to get coverage by tracking technologies in as many different environments as possible. This, in turn, could lead to new applications in academic research.

## EVALUATION, ANALYSIS AND EXPLORATION WITH THE HELP OF TRACKING

A second perspective on a future research agenda can be developed when moving from a focus on user-technology interaction towards the interaction between the urban designer and tracking technology. This section examines the possibilities of using tracking research as an evaluative, analytical or explorative tool in urban design. Exploration, analysis and evaluation are essential elements of any urban design and planning process. For exploration, analysis and evaluation by using tracking technologies to be of value, it is important that results can be directly linked to the development of spatial strategies and the physical design of space.

The use of tracking technologies as an evaluative tool links up to the desire of urban designers to test the effects of spatial interventions. Although tracking people for this purpose seems to be a logical step, it is not simple. Hardly any longitudinal studies have been conducted (notable exceptions are the MOBIDRIVE dataset (Axhausen, Zimmermann, Schönfelder, Rindsfüser & Haupt, 2002), see Schönfelder, Axhausen, Antille & Bierliare (2002) on matching longitudinal data from different sources, and the work of Ahas, Aasa, Silm, Aunap, Kalle & Mark (2007) on aggregated mobile phone data over the course of a year). Moreover, no studies using tracking technologies are known to have purposefully tested a situation before and after spatial interventions. This may be due to the fact that the technique is relatively new and still in development – most studies so far can be regarded as pilot studies, and research has only structurally focussed on tracking techniques in the last couple of years. Another or further explanation could be the fact that there are structural problems in applying tracking technologies this way, such as a lack of willingness to commission longitudinal research from within spatial planning practice. However, examples are available of actors in planning practice

having commissioned research on activity patterns for spatial planning purposes using diaries (see Boelens, Sanders, Schwanen, Dijst & Verburg, 2005).

Data from GPS devices offer simple possibilities to visualise individual tracks. This makes tracking data available for the visual analysis of spatial structures. For other tracking devices, there are a host of experiments using visualisation for the purpose of visualising rhythms, flows or places where people stop and look around (see chapter 8). Two types of visualisations have been greatly stimulated by the introduction of tracking technologies, namely dynamic visualisations (movies) and interactive visualisations. Tracking is associated with different ways of developing interactive imagery, e.g. updating and correcting, adding photographic material to tracks and the interactions embedded in location-based services (see also chapter 12).

By tracking specific target groups such as the inhabitants of a city or visitors to a city, children, women or ethnic groups, the use of tracking technology can help analyse specific patterns of use and analyse the problems that particular groups encounter when moving around a city. Specific household configurations have not been used much as a starting point in tracking research, but have been in diary-based activity research.

Deploying tracking devices as an explorative tool might help in developing more user-oriented spatial scenarios. The awareness of the importance of use aspects is prevalent in the field of spatial planning and design, although to a limited degree (e.g. see from different angles Klaasen (2005) and Gehl & Soholt (2002)). The application of tracking technologies in the education of planning professionals and in concrete design and planning projects can be an important step forwards in the development of awareness of people's activity patterns. In particular, the deployment of tracking devices in a workshop environment amongst different stakeholders in a planning process might help to build understanding in a playful way by using tracking-based visualisations as a medium. The combination of other media such as photograph, digital notes or recordings could enrich this approach (cf. chapter 9).

What can we conclude from looking at tracking technologies from the perspective of urban design? The main added value of tracking technologies in this regard literally lies in getting the user in the picture. Further, the evaluation of spatial interventions has been firmly placed on the agenda by participants of *Urbanism on Track*. Finally, the perspective of urban designers can draw special attention to the importance of visualising tracking data.

## DESIGN AND DECISION SUPPORT BY TRACKING

Moving away from more or less hands-on approaches to tracking devices, this section examines how tracking technologies might become part of a wider array of instruments used by urban designers and planners. The focus in this section is on the possibilities of a role for tracking technologies in computer-aided decision-making in planning processes.

The introduction of tracking technologies in daily life necessitates the rethinking of the theoretical frameworks for research on activity patterns, such as those developed in the field of time geography. A major application of tracking technologies is the use of tracking data for modelling activity behaviour (see chapters 10 and 11). Such models are used as decision support systems in spatial planning processes. With regard to modelling activity behaviour, tracking plays a double role in influencing people's behaviour and at the same time provides a tool to investigate that behaviour, as set out earlier in this chapter. Researchers generally expect higher accuracy from their models when they use tracking data instead of data from travel diaries. Another expectation is that tracking research can be carried out in less time and at less cost, and can collect greater amounts of data than when using traditional research techniques.

A number of initial experiments indicate the possibility of real-time input in the management of urban spaces (see chapter 8). Particular areas of application could be traffic management or the management of events. This could have major implications for the way in which public space and roads are designed, although the technology is too new to anticipate the precise effects. Although it may risk becoming futuristic, the real-time management of urban spaces is an interesting avenue of future research.

Another angle from which design and decision support can be regarded is the use of geographic information systems and in a broader sense the use of layer approaches (see chapter 4; for a critical review of layer approaches see e.g. Schaick & Klaasen, 2007). Tracking data can be superimposed on geographical and functional maps, either in a database or with visual map overlays. The confrontation between different datasets or different types of visual information can support the making of design choices.

What can we conclude from looking at tracking technologies from the perspective of computer-aided decision support? As addressed in the preceding section, visualisation as a mediating instrument is highly important in supporting decision-making in design and planning processes. The pursuance of a higher level of accuracy is the main driver for the large scale use of tracking technologies. The limits of what is possible when using tracking technologies for design and decision support have not yet been reached.

## VALUE, VALIDITY AND ACCESS TO DATA: PRAGMATICS AND IMPLICATIONS

The last perspective for a future research agenda on tracking technologies in urban design and planning goes back to basics – tracking data. In this section, we focus on raising the value and validity of data and data collection relevant to urban design and planning. What kind of datasets are referred to here? What level of accuracy is needed, desired and feasible? This last section, in which building blocks are developed for a future research agenda for tracking technologies in urban design and planning, looks at enriching tracking data, data collection methods and the relevance of scale and concludes by addressing privacy.

Firstly, the information directly derived from the raw data is generally not sufficient to draw significant conclusions about behaviour or activity patterns. Additional information is required to answer most research questions relevant to spatial planning, e.g. on the type of activity, who the activity was carried out with or the question of whether the tracking device was carried all the time and by the right person (cf. Lee-Gosselin, 2002). Additional data can be collected simultaneously or indirectly from other sources (see Verbree, Maat, Bohte, Nieuwburg, Oosterom & Quak, 2005; Janssen, Wets, De Beuckeleer & Vanhoof, 2004). It can also be derived from the raw data or from previously obtained information through the use of algorithms or other computational techniques (see e.g. Wolf, Guensler & Bachman 2001). To decide on relevant research questions and methods of collecting additional data and to interpret results, research teams are currently developing multidisciplinary teams, including several technology specialists, database specialists, geographers and planners. The last group is generally limited to transportation specialists, although spatial planners or urban designers are occasionally included in research teams (see e.g. Institute for Mobility Research IMOB at University Hasselt, Belgium).

Secondly, researchers have pointed out a trend whereby data-mining is slowly gaining ground over data-gathering. It is becoming easier to collect large amounts of data, both in terms of time and number of people. The big question remains 'who are these people?' and even more interesting 'who are they not?' A shift is occurring from selecting a sample of the population in which researchers deploy devices to the development of data-mining procedures and to procedures that depend on voluntary uploading of data by individuals. However, data-mining cannot solve all data problems. The ownership and accessibility of large datasets for example, such as mobile phone location data, is still often limited to the companies collecting the data.

Thirdly, the scale and scope of tracking research projects will always determine the desired level of accuracy and vice versa. Scale and scope are determined by the spatial activity pattern in which research is interested, the time grain of research samples, and the number of people

tracked. Both the method and the outcome differ substantially when the research is spatially limited to a small area, e.g. a train terminal or to a large area, e.g. regional activity patterns, or to the relation between areas and trips of different scales, e.g. in research on tourist travel patterns. The differences between tracking studies focussing on a single activity, on activity chains or on complete activity patterns each need different levels of accuracy and other additional data. Most researchers seem to agree on 7-day periods as the most relevant and feasible time unit for tracking an individual's activity pattern, but research not focusing on activity patterns on an individual level does show different temporal grains (e.g. research on the use of a public space in one day and night). Choices with regard to the temporal scale of a study can be, but are not *necessarily* related to the spatial scale or to the number of participants and vice versa. Important factors in how choices are made regarding the scale and scope of research projects are the accessibility of data (e.g. related to the research budget) and the logistics of the distribution of devices. The size of the group of respondents is also important as this can lead to differences in the logistics of research and other requirements for data management, but also to other types of research claims, for example on the aggregate effects of behaviour.

Fourthly, when looking at the expert opinions during *Urbanism on Track*, the different ethic implications of using tracking technologies were not guiding in considering the future of urban design and planning in light of advanced tracking technologies. Future research should put privacy back on the agenda.

What can we conclude from looking at tracking technologies from the perspective of data? From a technology-driven approach, we need to turn towards an approach that prioritises the reason for conducting the research in the first place. This means that technology-driven research has to connect up to concrete policies in urban design and planning. It also means that the characteristics of a research project should logically connect to what it is necessary to know. This sounds logical, but as we are still in the early stages of this research field, research experiments are often driven by what is possible rather than what we need to know. To make the right choice between GPS, mobile phones or other technologies, a decision has to be taken as to both the level of accuracy and the additional data required.

## LOOKING BACK AT *URBANISM ON TRACK*: AN AGENDA AND SOME CONCLUDING REMARKS

The goal of this last chapter of the book was to formulate a future agenda for the application of tracking technologies in urban design and planning. The chapter has followed four lines of inquiry, looking at tracking technologies from different perspectives: tracking technologies as part of daily life, the possibilities of using tracking research as an evaluative, analytical or

explorative tool in urban design, the possibilities for support in decision-making in planning processes by tracking and lastly the value and validity of data and data collection. However, during the expert meeting *Urbanism on Track*, the themes discussed in this chapter failed to provide ready-made agendas for future research in urban design and planning. The immediate results of the expert meeting were fragmentary, overlapping, of different orders and unfairly biased towards a positive approach to new technologies. This chapter has reconstructed a number of basic underlying principles through a critical review of the results of the expert meeting. The reading of the results in this chapter is coloured by an emphasis on their relevance for urban design and planning, stronger than the immediate input of the participants would have indicated. This is an indication that tracking technology has yet to gain firm ground in urban design and planning. The question can therefore be asked as to whether there is a future for tracking research in urban design and planning.

Although the enthusiasm expressed in this book suggests that there is indeed a future for tracking technologies in urban design and planning, it cannot be taken for granted that urban designers and planners will embrace tracking technologies immediately and completely. Neither can it be assumed that researchers and designers will now take the step from collecting and processing data in the context of travel behaviour studies or activity behaviour studies to actually applying the knowledge acquired when making an urban design or drawing up a plan. It is a fallacy to think that tracking technologies can miraculously solve all problems in urban design and planning related to applying knowledge to researching human behaviour (cf. Ter Heide & Wijnbelt, 1994). With regard to using tracking technologies in the context of urbanism, it is important for technology-oriented researchers to be aware that the main language of urban design and planning is visual. In addition, the possibilities of using tracking technologies – e.g. the integration of temporal and spatial data and the integration of individually collected data and aggregated data – should be fully exploited with a view to rendering them relevant to urban design and planning. However, there is no magic recipe for optimising the relevance of tracking research.

In this light, against the backdrop of basic attitudes with regard to tracking technologies in the context of urban design and planning (see illustration 13.1), a number of preferences for approaches can be stated for various specialised fields of knowledge. These have been simplified and are based on the findings of the expert meeting *Urbanism on Track*. Transportation-oriented scientists prefer a modelling and simulation approach. Urban designers seem to prefer an approach focussing on the increasing awareness of human behaviour. Spatial planners and to a certain extent geographic information specialists seem to prefer multi-tier and/or multi-method approaches. Geographic information specialists and transportation specialists both trust that in the long run, answers will be provided by the development of extensive databases or data warehousing. More generally supported by different

specialisations are (1) the application of longitudinal measurements using tracking technologies before and after spatial interventions and (2) multi-actor, multidisciplinary approaches to planning. However, both these approaches are said to encounter significant problems in research and planning practice. Several ways forward can be conceived of.

In the short term, possibilities are (a) the raising of funds for multidisciplinary work, (b) developing a discourse on privacy and ethical considerations with regard to using tracking technologies in the context of urban planning and design, (c) developing a road map for implementation in urban design and planning, (d) starting using tracking technologies in participatory planning processes as a *serious gaming* tool, (e) developing sophisticated visualistion tools and principles, building from geovisualisation, but focussing more on meaningful representations for planning and design processes.

Other goals can be pursued within relatively longer terms. Research can be strengthened both in terms of effort and multidisciplinarity; (a) creating conditions for comparative research using data from studies using tracking technology. Different lines of research could focus on standards and/or the compatibility of tracking data, data warehousing and supportive comparative research on transportation systems and urban systems alike; (b) operationalising behavioural and decision models based on tracking data; (c) developing new ways of collecting data using innovative tracking technologies or innovative applications of tracking technologies for specific design and planning-oriented research, for example the development of longitudinal studies.

Attempts to formulate longer-term research goals may run the risk of becoming futuristic. Both technological advancements and societal trends become highly insecure and unpredictable on this time horizon. Two tiers of thinking seem to dominate discussions on this long-term research future: (a) real-time planning and (b) sustainability. However, within the context of this chapter, these subjects are too extensive to be further developed. We can conclude however that tracking technologies are here to stay. It can be regarded as the task of multiple disciplines to develop – in cooperation – applications of tracking technologies in urban design and planning that, metaphorically speaking, go beyond "building iron bridges as if they were made of wood", as a participant at the expert meeting stated. In the end, the message of this chapter, and perhaps of this entire book, is that it is not simple to apply or even integrate tracking technologies in urban design and planning. It is however definitely worthwhile.

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