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Designing next generation multimodal traveler information systems to support sustainability-oriented decisions☆

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ABSTRACT

This article explores functionality that could be included in the next generation multimodal travel information system to support sustainability-oriented decisions. It identifies situations in the journey's three phases, pre-, on- and post-trip that have the potential to change travel patterns and also transport choices that the individual makes in order to perform activities in their daily life. Requirements on a traveler information system were derived from these situations and choices. The identified requirements are then transferred into functionalities in a travel information system that has potentials to encourage decisions that could lead to lower energy usage. Nine traveler information systems for multimodal and public transport travel are systematically investigated to find out if they include the proposed functionality. The investigated systems are in operation primarily in Sweden, Germany, the UK and one has global coverage. The investigation results in a discussion about future opportunities with proposal to encourage sustainability oriented travel decisions in the next generation travel information system.

1. Introduction

The Intelligent Transportation Systems (ITS) veteran Joseph Sussman predicts the arrival of a new era in transport, in which transport and information systems are interrelated (Sussman, 2005). ITS have long been focused on traffic efficiency and safety, primarily for car traffic. More recently, ITS has also included environmental aspects. However, ITS has not been used to control traffic or give advise to travelers due to environmental reasons to any great extent. Traveler information systems have mainly been available as in-vehicle systems and web-based solutions. The spread of smart cell phones, increased capacity and greater speed of mobile broadband have increased the opportunity to develop systems for travelers who use public transportation, bicycle, walk or use multiple transport modes.

The European Union (EU) target for the transport sector is to reduce emissions of greenhouse gases (GHG) by at least 60% by 2050 compared with 1990 (EU, 2011). The EU and its member states have set targets to move towards means of travel that use less energy. This implies provision of accessible travel information to allow for change to a transport system that meets the requirements for optimization of the transport network, efficient use of land, lower energy use and GHG emissions (EU, 2011). Another EU target is to establish a framework for multimodal transport information, management and payment systems to promote awareness of the availability of alternatives to individual conventional transport not later than 2020 (EU, 2011). The term "multimodal" is here meaning that different modes of transport such as walking, bicycling, public transportation and car are presented side-by-side and/or in different combinations. There is a great expectation that traveler information can inform and influence choices (Lyons, 2001) and by doing so lead to less demand for fossil fuels and thus reduces environmental pressures. Information and Communication Technology (ICT) can influence traffic by modifying the transport intensity of the economy (freight or passenger transport per unit of gross domestic product) and the modal split (Hilty et al., 2004) as cited by (Hilty et al., 2006). If the total passenger transport continues to increase, ICT would heavily stimulate the growth of public transport and slow down the growth of private car traffic because of the ICT-induced time efficiency gains for the user of the public transport and an ICT-induced time utilization effect which increases the shares of activities a passenger can perform during travel time (Hilty et al., 2004) as cited by (Hilty et al., 2006).

☆ Thematic issue on Modelling and evaluating the sustainability of smart solutions.

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Innovation in transport can be physical (e.g., vehicles), focused on methods (e.g., information systems) or institutions (organization structure and interaction) (Fan et al., 2007). In the present article the focus is on methodological innovations of specific interest in multimodal traveler information systems and their potential to contribute to environmentally favorable development.

The first aim of this paper is to identify requirements of functionality that could enable multimodal traveler information system to support sustainability-oriented decisions. What decisions regarding the individual's daily activities could lead to lower energy use and what functionality could support these decisions? The second aim is to make a systematic investigation of how well the proposed functionality is covered by existing traveler information systems.

2. Evolution of traveler information systems

Traveler information systems have existed since the late 1960s and have evolved with the technological developments that have brought new opportunities for improved communication and information dissemination. The emergence of computer systems, the internet, navigation systems such as Global Positioning System (GPS), map data, and mobile technologies have made it possible to expand and improve these systems.

A previous generation classification of traveler information systems made by Adler and Blue (1998) mainly focused on systems for motorists. To also comprise public transportation in the generation classification, the evolution of traveler information systems for public transportation in Stockholm is presented next to the development of the systems for motorists in the following.

The *first generation* traveler information systems arose in connection with the emergence of computer technology in the late 1960s and early 1970s. Traffic information was provided separately for motorists and for public transportation travelers and was characterized by one-way communication. It was possible to improve traffic flow on congested roads and also to make road users aware of the disturbances and traffic incidents through dynamic message signs and highway advisory radio (Adler and Blue, 1998). At the end of 1980 the timetable for public transport in Stockholm was computerized and made available through interactive voice response (IVR) via phone for travelers (SL, 2010). Different keys on the phone (*#) were combined with numbers to retrieve timetable information.

Second-generation systems aimed at motorists and were developed during the 1990s to become advanced traveler information systems with dynamic route guidance and real-time traffic conditions using two-way communication through an interactive user interface. They were designed to provide personalized trip advice (Adler and Blue, 1998). Navigation systems for route guidance were primarily embedded within in-vehicle systems or handheld navigation devices. The systems used satellite navigation systems (GPS) and were quite expensive. At the same time the emergence of the internet made it possible to substantially improve information about journeys for public transport. Stockholm Public Transport (SL) opened its first website in 1997 (SL, 2010). Two years later, the voice mail service was converted into an internet service and all timetables were presented in PDF format, which made it possible for travelers to search the schedules on the SL website (SL, 2010). In early 2000, the first version of the SL travel planner was launched and soon afterward it was also accessible via a WAP service for WAP-enabled cell phones (SL, 2010).

Adler and Blue (1998) envisioned that the *third generation* of traveler information systems for motorists would be the result of a combination of second generation ATIS and Artificial Intelligence (AI) to create Intelligent Traveler Information Systems (ITIS). ITIS would remember travel patterns and choice of routes from the previous session for each driver so that data already entered into the system would not be lost. The system would be able to evaluate the accessibility of roads from this information, have a dialogue with the driver during the trip and provide personalized route guidance (Adler and Blue, 1998). Car navigation systems of today have usually no information about other modes of transport (Rehrl et al., 2007). Some internet-based systems have information for multiple transport modes and possibilities to compare different transport modes. Third generation systems for public transportation make use of smart cell phones, mobile broadband, GPS functionalities, Web 2.0 functionalities such as user-generated content and open Application Programming Interface (API) (enabling systems or system components to communicate with each other to exchange data or functionality).

The data available cover the street network, the public transport network and timetables, transit stations, parking lots, pedestrian paths, the cycle path network, map data, and environmental data. The systems are available via any internet-enabled device. Apps are adapted to the cell phone's smaller user interface and capacity. The development of mobile broadband has made it possible to find information during the trip, which is crucial for travelers using public transportation. Apps for smart cell phones have increased the spread of traveler information systems.

3. Research process

The work presented in this article was carried out in steps. First, the scientific literature was selected from a literature review made previously, where more than 100 articles published between 1996 and 2010 were included. The selected articles covered the following topics: society's motives and desired goals for traveling and transport, different perspectives of traveler's motives for traveling, traveler's choice of means of transport, user need and different functionalities.

Activities connected to journeys are often divided into two phases; pre-trip and on-trip (Rehrl et al., 2007; Adler and Blue, 1998). After an analysis of situations where it is most likely that a change of travel pattern occur a third phase, post-trip, is added as a separate phase.

A model structure for choices related to an individual's daily activities is developed to demonstrate how different decisions could lead to lower energy usage and thereby lower GHG emissions. The model structure is based on the structure of choices used in the regional model of the Swedish national travel demand forecasting tool SAMPERS (Beser and Algers, 2002). Mobility Management measures applied by the Swedish Transport Administration (Swedish Transport Administration, 2012) and the traffic hierarchy applied in the district Stockholm Royal Seaport (City of Stockholm, 2010) are used to indicate if an individual's choices leads to lower energy use, lower transport demand and the use of efficient modes of transport.

The traveler's need for information and communication functionalities to be able to make transport choices with the least environmental impact was analyzed. Requirements on a traveler information system were *first* identified for the different phases of the journey (pre-, on- and post-trip) (Fig. 1) and *second* for the different alternatives in the model structure of transport choices (Fig. 2). The identified requirements were then transferred into a proposal for functionalities in a travel information system.

The list of proposed functionalities were then used as an analytical framework (Tables 3–6) to examine whether the functionality is implemented in the systems available today. For the examination, nine traveler information systems are selected (Table 1) on the basis that they cover different geographical areas (global, European, national, regional, or city-wide), include