DEVELOPMENT OF THE ROMANIAN CITIES BASED ON A EUROPEAN SMART CITY CONCEPT

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***Abstract**. At the European level, a new concept and a new direction in city development are arising based on new technologies and new approaches of urban life, this being called "Smart City". A city becomes "smart" when the city management and the citizens employ smart strategies, smart tools, smart technologies and smart results of applying to all smart things in the urban area and to the area influenced by the city. The authors present the state of the art in terms of conceptual approach as well as in terms of technological approach at the European level with the goal to move Romanian cities towards this target based on European recommendations and experiences. The authors have developed a methodology for smart city modeling as a reference for future urban development. Based on this methodology the target or reference model will be compared with a real model of the city in terms of discovering necessary actions to fill the gaps or differences between models. The paper is focused on the smart mobility component of the city and authors performed a correlation between the different components of the smart city and among the high-level functions of smart mobility. The paper is concluded with some recommendations and future research activities to elaborate a more detailed model employing software tools (for instance, Matlab and Simulink) and including more variables.*

***Keywords**: Smart City; mobility; intelligent transport systems; ICT and urban development.*

Introduction

Pollution and the transformation of the natural environment are two important issues and urban area has to solve the problems generated by them. Smart solutions are now the best approach in solving these problems. The application of these smart solutions in the context of a city was launched a few years ago and the new concept is called Smart City.

The smart city concept could be a good way to reach the objective of the city in terms of providing a high level of the quality of life in the urban area as well as a high level of economic context for regional and national development. The city has to be analyzed as a complex system with various components and the relationship between them (Neirotti et al., 2014). This concept is approached in Urban Agenda - in strategic initiatives of the European Commission and many regional and national initiatives are going to support it (European Urban Agenda, n.d.). The European Union, as well as the member states, is involved now in the development of this concept and in finding the best models and practical tools to improve the administrative process of cities in a smart manner.

A simplified model of a smart city was elaborated in the project Smart Cities ("European Smart Cities," n.d.) and the main 6 components of this model are presented in Figure 1. Several European projects and several scientific articles support this concept and there is a special request in the elaboration of a new model based on the existing urban systems and existing technologies in terms of filling the gaps between the city and new concept, called the smart city. The main issue is the existence of a huge gap between the theoretical concept and a conceptual tool for real applications in urban areas.

One important topic for the smart city and smart mobility in cities is the intelligent transport system. The European Commission is focused on Intelligent Transport Systems (ITS) as a main instrument, which is able to support urban policy goals in different areas such as travel and traffic information, traffic and demand management, smart ticketing and smart payment or urban green and smart logistics. The focus is to be on the citizen and the integration of all ICT and ITS could be a solution for urban mobility-centered on citizens. Action Plans on ITS and on Urban Mobility are the best policy documents which support the EC approach (the ITS Action Plan has the main objective in setting up an ITS collaboration platform to promote ITS initiatives in the area of urban mobility and the Action Plan on Urban Mobility offers assistance on ITS applications for urban mobility). With the Urban Mobility Package, the EC reinforces its supporting measures in the area of urban transport by:
- Experiences, best practices, and cooperation
- Financial support,
- Research and innovation for urban mobility challenges,
- Involving the Member States and enhance international cooperation.

"Together towards competitive and resource-efficient urban mobility" Com (2013) 913 – defines the concept of sustainable urban mobility plan and the main results of the project are subordinated to this new concept of Sustainable Urban Management Plan (SUMP) as a main urban management tool (European Commission, 2013).
Another important European initiative created more than 10 years ago, which is

supporting the development of the smart city concept - Eltis - represents now Europe's main observatory on urban mobility. It is financed by the European Union under the Intelligent Energy - Europe (IEE) Programme. Eltis provides the information, good practices, tools and communication channels needed to help to turn cities into models of sustainable urban mobility.

The authors have developed the concept presented in this paper based on some European strategic documents and one example would be the City and Innovation Manifest (stated during The City Innovation Summit Barcelona 2014), which is a good start in terms of turning on an innovative approach to urban mobility.

A good experience was gained from SMARTCITIES project (funded by Interreg North Sea Programme) especially on establishing networks (academic, public authority and industry), citizens oriented projects, and the paper extracted these orientations for a better modeling process. Another important European project, which has constituted a base for the approach presented in the paper, is Smart-Cities of TU WIEN and its main result, the model of European Smart City (as well as benchmarking procedure for smart cities). EPIC project is important for its results in terms of creating a Living Lab based on the following aspects: user-driven open innovation, connected smart cities and web-based services and the most important input for this proposal is the example of creating living labs in the different urban environment and with different technologies.

The concept is closely connected to the results of Open Cities Project (funded by the European Union) especially to two of them: The Pan-European Platform (platforms for Crowdsourcing, Open Data and Open Sensor Networks) and Future Internet Services & Ideas (applications and ideas especially in the realm of mobile devices and Augmented Reality applications). The mentioned projects were used as a source of information in conjunction with the results of European project CITADEL (as a promoter of 'Open Data' and User-Driven Innovation Systems in terms of developing 'high speed' Mobile Applications that can be shared by citizens across Europe). The iCITY project intends to develop and deploys an approach to allow third parties for creating, deploying, operating and exploiting services based on the use of available public information, digital assets and Opened Information Systems in cities (Jjumba & Dragićević, 2011; Stevens, Dragicevic & Rothley, 2007).

Another category of information and results, very useful for deployment of this concept in the paper, is coming from the European projects focused on mobility. Co-Cities is a good example of this type of European research projects and it is a pilot project to introduce and validate cooperative mobility services in cities and urban areas. An important result is the development of a dynamic 'feedback loop' from mobile users and travelers to the city's' traffic management centers and added elements of cooperative mobility to traffic information services. CO-GISTICS is the first European project fully dedicated to the deployment of cooperative intelligent transport systems (C-ITS) applied to logistics and the results of the project could support the mobility approach in terms of freight and logistics in an urban area (Salanova Grau et al., 2016). The application of new ICT technologies, such as cloud computing and Internet of Things are, in logistics could accelerate the development of the smart city and smart mobility in an urban area (Nemtanu, Schlingensiepen & Buretea, 2015). Project focused on Internet technologies could also support the deployment of the proposed project and good examples are MOBiNET - which is "the Internet of (Transport and) Mobility" (it is an Internet-based network linking travelers, transport users, transport system operators, service providers, content providers and transport infrastructure) (Roth, Montavont & Noël, 2011; Mahadevan et al., 2006) – and MOVEUS - the main goal of Moveus Project being to design, implement, pilot, evaluate, disseminate and exploit a number of novel ICT tools for smart mobility in the context of smart cities, directly addressing real users' needs while promoting a habit-change in their daily lives.

Another important aspect is to transfer the intelligence from the humans to the city through different systems, an example could be the autonomic behavior of human body transferred to the autonomic transport system (the example of ARTS) (Schlingensiepen et al., 2014). The European cities and their trend in development are analyzed in terms of defining the best model for a smart city at this time (after some transformations of the city in a smart one, it need new models to be smarter and smarter). Some initiatives, like Urban Audit, have already defined a set of key performance indicators to measure the smartness of the city (Caragliu, Bo & Nijkamp, 2011).

The authors investigated in this paper one of the most important components of a smart city, which is smart mobility. The extension of this investigation from one component to all identified components of a smart city will be addressed in future work and the recommendations will be proposed.

The concept

The new concept of the smart city is related directly to new technologies as well as new approach in terms of sustainability. At the European level, a 6 components model was proposed. This new model has to be adapted to the Romanian context, a set of measures would be necessary to link a real Romanian city with a model, which is derived from the European model of a smart city. All the components of the model should be designed for different sizes of the city and the authors have proposed three levels of city's size: large, medium and small.

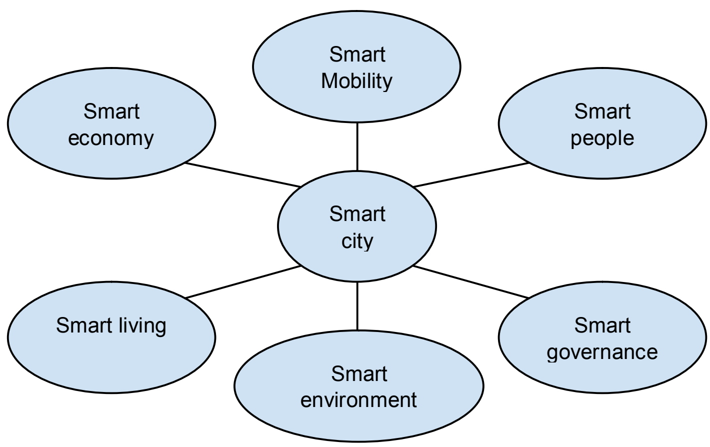

Figure 1. The main components (functional areas) of the smart city's model ("European Smart Cities," n.d.)

Figure 1 presented as the model of a smart city is the upper part of a conceptual model based on the functional decomposition of the system. Every component (out of 6) will be decomposed into high-level functions and smart mobility will be the subject of this operation in the paper. The pyramidal approach (the extension of the model) of this conceptual model is presented in Figure 2.

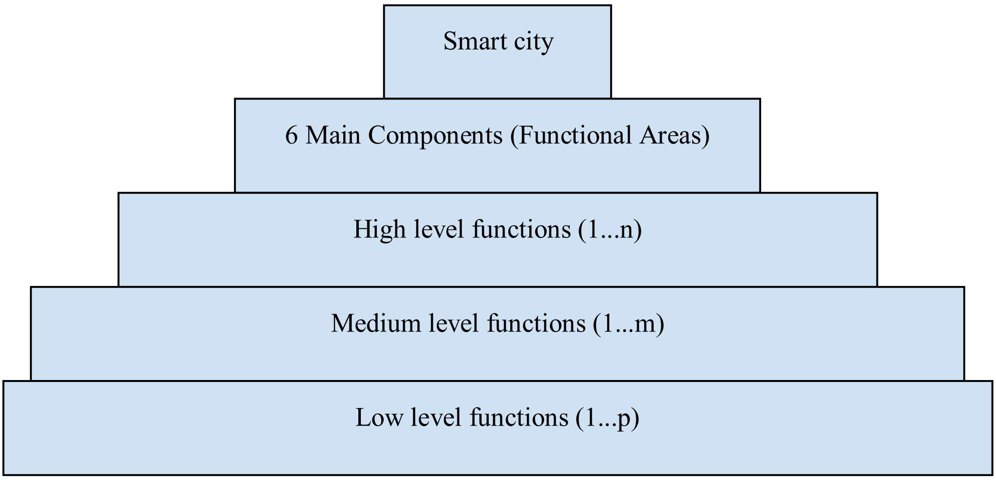

Figure 2. The extension of the conceptual model

Every main component is composed of (high level) functions and these functions could be further decomposed into medium level functions and low-level functions (it depends on the complexity of the high-level functions).

For the main component, the Smart Mobility, a list of high-level functions is the following:

- Demand management (DM) - the main functionality is to collect real information about the demand for mobility and transport in urban area;
- Public transport management (PT) - the management of public transport system;
- Traveler information and planning management (TIP) - the system should collect information and should process all this information in terms of providing planning and traveler information support;
- Traffic management (TM) - the management of all types of traffic in urban area (vehicles, bicycles, pedestrians etc.);
- Autonomic cars and systems support (ACS) - support systems for autonomic cars as well as the autonomic traffic management systems;
- Freight management (FM) - the management of freight transport and urban logistics;
- Mobility as a Service (MaaS) - the mobility as a service is oriented to the mobility needs of the citizens and should provide multimodal trip solutions;
- Law enforcement support (LE) - the enforcement of law and transport rules (including pollution rules in urban area);
- Fee collection and financial support (FC) - the collection of fees and taxes as well as the financial support for public transport and multimodal solutions;
- Parking and other modes support (POM) - the system should provide support for parking management as well as for other transport modes;

- Strategies and policies support (SP) - the system should collect and process data/information for strategies and policies;
- Security (SEC) - the system should protect itself and other systems (export of security).

The relations among all these high-level functions are presented in Figure 3 and the approach is to define the dependencies between all functions in terms of revealing the behavior of the smart mobility component.

After the definition of these dependencies, next step is to integrate the sub-model of smart mobility in the smart city model and to create all links and relations among the high-level functions of smart mobility and any other component of the smart city model.

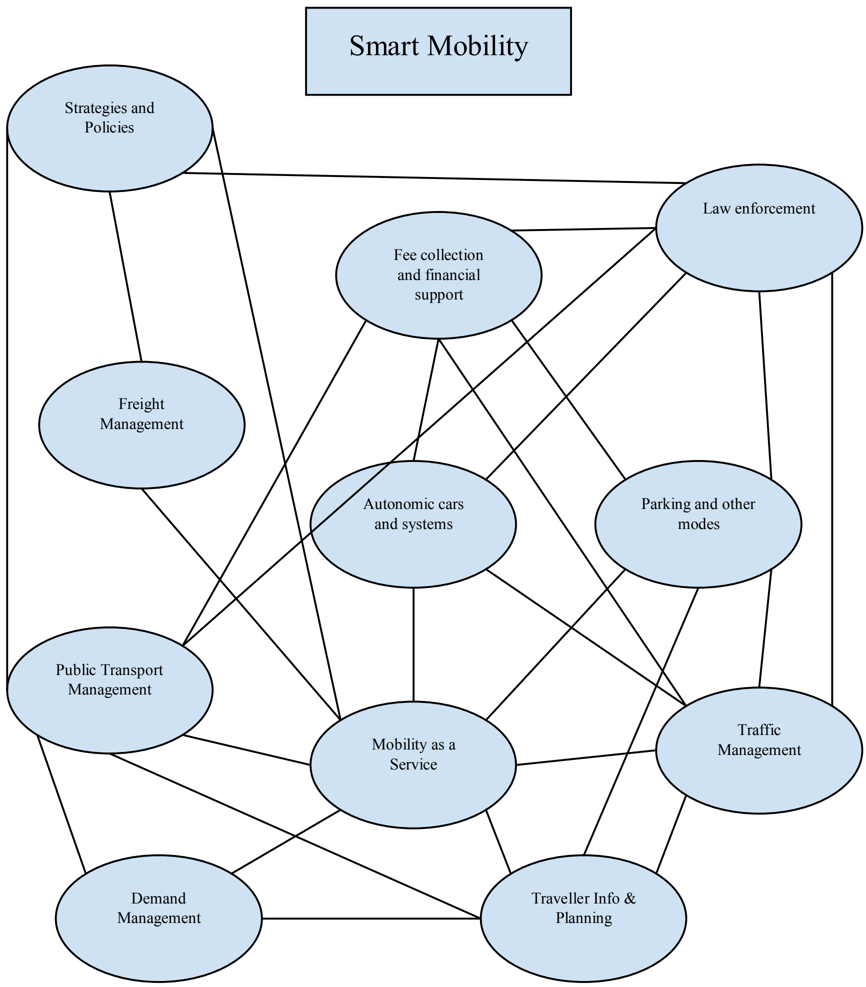

Figure 3. High level functions of Smart Mobility

These relations or dependencies among the high-level functions should define also the logical data flows between functions. Every logical function has a set of data as inputs and will generate a set of data as outputs. A function is able to collect data from various functions or other entities and after the stage of processing data; the function will generate data to other functions or entities (where entities could be other functions of other components of smart city model or other systems). All collected data will be sent using a data flow or logical data flow. This data flow could be decomposed into various low-level data flows based on the same principle presented for functions.

Methodology

The main scope of this methodology is to pave the way for the implementation of this new concept of smart cities in Sustainable Urban Mobility Plan (SUMP), as a strategic tool, for Romanian cities. The objective is to find the gaps/differences between the real city (and the associated model) and the ideal smart city (the target model). All gaps will be filled using actions that are parts of the sustainable urban mobility plan.

Figure 4 is presenting the steps that are mandatory to follow in terms of providing a real and connected model of the smart city and to adapt the model to the real context of the city.

The selection of the European model focused on mobility (the authors have selected the 6D model of the smart city as the main target model and the functional area/main component of it is smart mobility) is the starting point of the process and the authors decided to choose the European smart city model in terms of unifying the approach at European level. The methodology could be applied to all reference models that are selected by the user.

After the selection of the model, the next step is to define the main components of the smart city as well as the high-level functions of each component. In fact, the main component is a functional area, which is defined by a set of high-level functions, and the definition of these high-level functions will define the main component itself.

The third step of the methodology is to consider this selected and defined model as a reference or a target model and to develop a model of the city with existing and implemented components and functions. The model of the real city is a dynamic model and after the implementation of specific actions, this model will be changed.

The fourth step is to identify the differences between the target model and the model of the real city. This comparative assessment will generate a list of requested functions and the main challenge is to find the best actions to fulfill the requests in terms of reaching the smart level of the city.

Another important issue is the adaptation of the model to Romanian context and the construction of the model connected with the local factors (these factors will define the environment of the city and they could be defined as STEEP factors - social, technological, economic, environmental and political). The STEEP factors are directly involved in defining the model as well as the result of the comparative assessment and the actions of SUMP.

The first version of the model or starting model will be refined and adapted to the local context. The refining model will be used to find the gaps and the actions needed. The actions are selected based on the expertise and best practices in the domain.

The authors recommend to use a software environment to create the model and one solution is to use a LabVIEW and Matlab environment (this solution will open the door for both mathematical model and hybrid model, with some real components as part of the model).

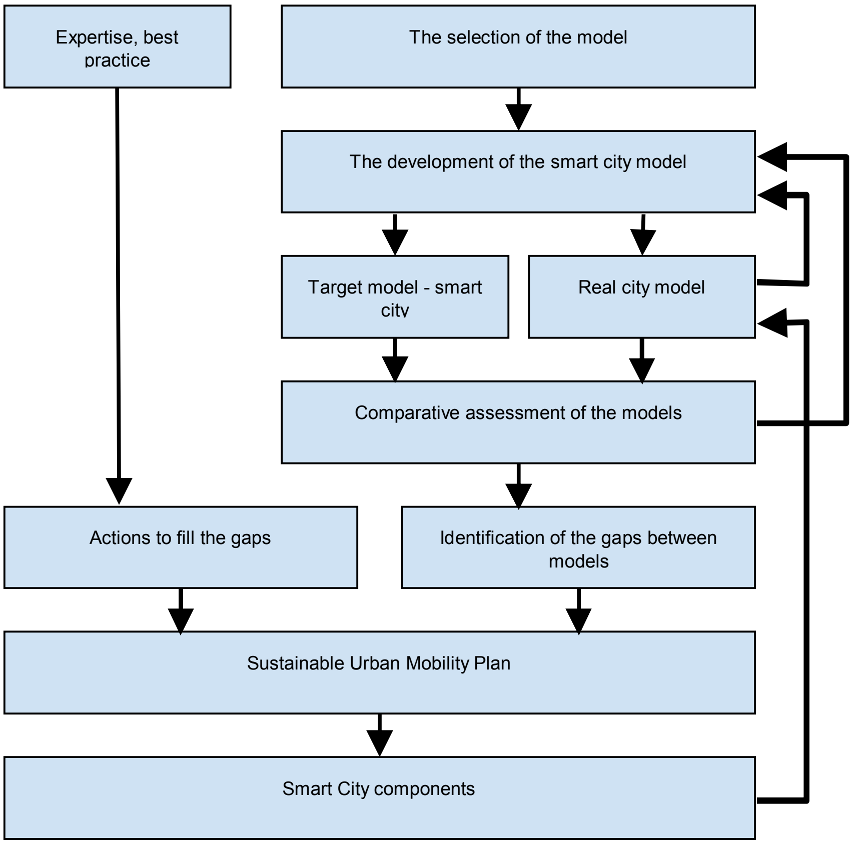

Figure 4. Methodology of using models in comparative assessment

Results

The research is based on comparative assessment between two models of the city: a model for a smart city (target or reference model) and a model for the actual state of the city (real model). At this stage a methodology is proposed and the first two steps are have already done: the selection of the model (the selected model is the model proposed by Smart Cities project with the details added by the authors) and the development of the model (in this phase the authors have proposed a model for smart mobility and the decomposition of this important component of a smart city into high, medium and low-level functions.

After the validation of the methodology and the validation of the model for smart mobility, based on the same approach, all components will be detailed in functions and the reference model of the smart city will be ready for the comparative assessment. Using the reference model or target model the next step is to elaborate a real model of an existing city.

Based on these two models a comparative assessment will allow the researchers to identify the main gaps between real model and the target model and to define some actions to fill the gap and to transform the real model into the target model (this is the main objective, to transform the city - real model - into a smart city - target model).

The comparative analysis of these two models (target and real) is identifying the gaps and based on this analysis a set of the actions is needed to move the analysis in the direction of filling the gaps and to achieve the final result, the smart city as a target model.

All the defined actions will be integrated into the SUMP and the smart city concept will be used in the definition of the strategic objective of the city.

Conclusions and recommendations

The modeling activity has the main scope the development of a representation of a real thing or system using a specific language or a set of symbols/graphical elements. The model could be simple or complex, the complexity of a model is able to generate a more comprehensive representation of reality but it requires skilled developers to deal with the model.

In this case, the modeling activity is based on a top-down approach and the simple model is extended systematically with a number of iterations based on the requests and the details needed in the comparative assessment. The model is a reduced representation of the reality that is more proper to be analyzed and processed by various specialists and systems and the main role is to create an instrument for an understanding of the urban system as well as the components of the urban system.

The reference model (target model) is the ideal model and the actions of the SUMP have to be defined in terms of moving the city in the direction of a smart city. On one hand, if the target model is far to the real city model, the city need a huge number of actions and this initiative could not be accepted by politicians (to invest more money in a concept), on the other hand, if the target model is simplified, after the implementation of the actions only a few elements of the smart city will be visible and the actions will not be efficient. Another important issue is the structure of the smart city, the components of the smart city. The complexity of the model is directly connected with the number of components or functional areas.

The methodology proposed by the authors is designed for mobility and sustainable urban mobility plans but it could be applied to all components of a smart city. The main challenge is to export the methodology to all components and to create a framework for modeling of smart cities in terms of identifying the gaps and the actions to bridge the gaps.

SUMP is a strategic tool for development of the transport system in the urban area in terms of providing a high level of mobility in cities. The SUMP has to be elaborated using the target model as the main objective for final result: the smart city. The paper presented the methodology that will be applied by the authors on Romanian cities in terms of providing sufficient data and inputs for smart city development in Romania.

The results of the paper are ready to be adapted to all components of a smart city as well as to different types of cities (small, medium and large) and the model will be a tool for the elaboration of different strategies at the local and regional levels. One important output based on the results of this research will be the coherence and the interdependency between different components of the city and the possibility to demonstrate these in a single strategic document (at municipal and regional level).

The city managers are the main target audience of the results of this paper and the model as well as the concepts presented in the paper will help city managers to do strategic activities as well as planned actions in the direction of a smart city (as a target of their activity as city managers). The concepts are strongly related to European initiatives in terms of having a common European approach and to facilitate the access to different European resources (requested for a smart city). The city managers will use the methodology presented in the paper to adapt their actions during the process of implementing the smart city components and to identify the opportunities as well as the threats in doing this.

The next research steps are to create a functional model in laboratory based on the methodology and the hypothesis of this paper and using two software environments: LabVIEW and Matlab. Matlab software will facilitate the construction of the mathematical model of a smart city, especially through the definition of the smart function of the city, the inputs, and the outputs. The LabVIEW programming environment will facilitate the integration of the mathematical model into a complex multilayer model and the extension of the model with real components.

References

Caragliu, A., Bo, C.D., & Nijkamp, P. (2011). Smart Cities in Europe. *Journal of Urban Technology*, 18(2), 65–82.

European Commission (2013). Together towards competitive and resource-efficient urban mobility. COM.

European Smart Cities. (n.d.). Retrieved from http://www.smart-cities.eu/.

European Urban Agenda. (n.d.). Retrieved from http://ec.europa.eu/regional_policy/sources/consultation/urb_agenda/pdf/swd_2015.pdf

Jjumba, A., & Dragićević, S. (2011). High-Resolution Urban Land-use Change Modeling: Agent iCity Approach. Applied Spatial Analysis and Policy, 5(4), 291–315.

Mahadevan, P., Rodriguez, A., Becker, D., & Vahdat, A. (2006). MobiNet: a scalable emulation infrastructure for ad-hoc and wireless networks. ACM SIGMOBILE Mobile Computing and Communications Review, 10(2), 26–37.

Neirotti, P., De Marco, A., Cagliano, A. C., Mangano, G., & Scorrano, F. (2014). Current trends in Smart City initiatives: Some stylised facts. *Cities*, 38(1), 25–36.

Nemtanu, F.C., Schlingensiepen, J., & Buretea, D. (2015). Cloudification of urban logistics. *Supply Chain Management Journal*, 6(2). Retrieved from https://drive.google.com/file/d/0B4dxx8_8gi7lWFRWU2czTlNuQ2M/view.

Roth, D., Montavont, J., & Noël, T. (2011). MOBINET: Mobility management across different wireless sensor networks. In *2011 IEEE Wireless Communications and Networking Conference* (pp. 351–356). IEEE.

Salanova Grau, J.M., Rusich, A., Mitsakis, E., Ukovich, W., Fanti, M.P., Aifadopoulou, G., & Papadopoulos, C. (2016). Evaluation framework in Cooperative Intelligent Transport Systems (C-ITS) for freight transport: the case of the CO-GISTICS speed advice service. *International Journal of Advanced Logistics*, 5(1), 30–43.

Schlingensiepen, J., Mehmood, R., Nemtanu, F.C., & Niculescu, M. (2014). Increasing sustainability of road transport in European cities and metropolitan areas by facilitating autonomic road transport systems (ARTS). In *Sustainable Automotive Technologies 2013* (pp.201–210). Heidelberg: Springer.

Stevens, D., Dragicevic, S., & Rothley, K. (2007). iCity: A GIS–CA modelling tool for urban planning and decision making. *Environmental Modelling & Software*, 22(6), 761–773.