Transport System Telematics for Smart Cities Concept - A Case of Addis Smart Mobility Project

Frehaileab Admasu Gidebo[2(✉)] and Janusz Szpytko[1(✉)]

[1] AGH University of Science and Technology, Ave A. Mickiewicza 30, Krakow, Poland
szpytko@agh.edu.pl
[2] Addis Ababa Science and Technology University, Addis Ababa, Ethiopia
frehaileab.admasu@aastu.edu.et

Abstract. The mobility of people and goods from one place to another point is mounting from time to time in both developed and developing world. This is as result of rapid urbanization and lead to economic benefit in order to secure better income and ease of mobility access. Cities are indeed engines for new jobs and could be able to provide safer and proper movement of peoples and goods. Recently many of developing countries are taking in to consideration the agenda of smart cities and mobility concept and all urban mass transport must operate on low renewable and low emissions fuel, to promote access to sustainable urban transport system. However, many challenges poses the positive impact of cities such as traffic congestion, air pollution, environment degradation, unplanned transport infrastructure, lack of integration of transport system, nonexistence of environment friendly technologies and solutions, lack of government/policy makers commitment, rapid increasing number of motorized vehicles and absence of predictive maintenance mechanism and intelligent parking management systems. Hence, transport telematics is currently emerging technological solution as part of sustainable transport system and connects many of vehicle structures with remotely connected communication devices and is ensuring smart mobility. The subject of this paper is mainly aimed to examine applicability of the innovative management solution of transport telematics technology for smart cities mobility and its environment.

Keywords: Smart cities · Telematics · Mass transportation · Connected mobility · ICT

1 Introduction

The mobility of people and goods from one place to another point is mounting from time to time in both developed and developing world. This is as result of rapid urbanization and lead to economic benefit in order to secure better income and ease of mobility access. Cities are indeed engines for new jobs and could be able to provide safer and proper movement of peoples and goods. Recently many of developing countries are

J. Mikulski (Ed.): TST 2020, CCIS 1289, pp. 17–26, 2020.
https://doi.org/10.1007/978-3-030-59270-7_2

taking in to consideration the agenda of renewable energy and all urban mass transport must operate on low renewable and low emissions fuel, to promote access to sustainable urban transport system [1]. The most serious and recognized problems of urban mobility in recent years become traffic congestion, traffic accidents, and deterioration of the environment because of growing population, increasing urbanization, and increasing car ownership/private motorized vehicles [3]. Not only the mentioned challenges but also lack of proper management/coordination of urban transport network, absence of suitable technologies to overthrow problems, gap of practical knowledge and technical know-how are vulnerable issues of most cities particularly in developing countries [8].

In the other hand, such hurdles are pushing the users to look in to solutions in order to ensure ease and smart mobility by the help of intelligent information sharing system and real time based information for travellers. Moreover, it would be very important when passenger could able to make right decision in terms of choice of route selection that means start to end information, waiting and departure time based on correct, available and real time travelling information [2]. This indicates that information is critical decision making tool in the mobility of peoples and goods. Smart cities are results of having smart information, smart mobility, smart society and smart environment as well as smart system. Eco-driving is among the most important feature of smart city mobility with respect to reduction of fuel cost and giving advice to drivers for safer driving habits.

Obviously urban transport serves as veins to accelerate developments in industry, trade, education, health and other services in many ways. However, urban transport supply and effective management to meet the increasing trip frequency and mobility needs of the people and goods facing critical challenges. Hence, in order to maintain sustainable transport system and concept of smart city mobility principle; there must be existence of non-motorized zones, integration of public transport with bike lane and free walk ways, providing green technology or emission free cars, and implementing technological solutions related to smart cities concept and mobility [4]. Ensuring all the necessary modes of transport in the city has many positive impacts such as income generation, job creation, improving the wellbeing of the life and enhancing faster exchanges in terms of information, business, goods and communications.

Addis Ababa city has been launched the smart mobility project in order to align it with smart city concept mainly focusing to answer the city major mobility challenges. In this move, the project is expected to deploy ITS master plan and its architecture with respect to improvement of traffic management system and creation of integrated transport system with high quality and consistent operational goals. In addition to that, the project is anticipated to build traffic signals, car tracking systems, CCTV, ITS devices, road side sensors and others in main intersection corridors. In this research we tried to find the reasons why this project has been initiated and need assessed prior to implement the project. The following reasons with illustration have been identified as transport and mobility challenges in the city [13];

– **Traffic Congestion**: Despite the relatively low number of registered motor vehicles in Addis Ababa, even by Sub-Sahara African standard and the great success stories with th unprecedented expansion of the road and highway networks in the City in recent years, regular congestion has become a daily experience in the City. This congestion has resulted in a high frequency of traffic accidents, and high green house gas (GHG) emissions levels.

- **Pedestrian/Non-motorised facilitie**s e.g. walkways: Despite pedestrians constituting more than 55% of the trips generated in the city, there is still a lack of adequate and safe pedestrian facilities and inefficient traffic control and management systems resulting in poor safety conditions and frequent traffic accidents in the City.
- **Public Transport System**: Even though there has been a recent introduction of new public transport systems such as the Light Rail and bus systems such as Sheger and Anbessa, the public transport system remains largely informal. The system is characterised by inadequate supply to meet the growing demands, low quality and service delays due to congestion.
- **Traffic Management System**: Even with increased capacity of road networks, the capacity especially at junctions should be optimised with appropriate traffic management measures. The city still faces traffic management challenges, characterised by inadequately controlled junctions and inefficient enforcement measures and requires other traffic management interventions relating to parking management, signalization management, and road markings.

The city aimed to be benefited from this project as: 1) increasing the efficiency of use of highways- increasing road capacity, 2) improving road safety, 3) reduction in travel cost and time, 4) advance quality of environment through reduction in greenhouse gas emissions. By implementing this project in to the city; drivers-as direct users of the system, travellers, traffic system controllers and decision making officials are among the main frontline users/beneficiary of the system.

2 Objective of the Research

This research study is designed to examine the concept of smart city mobility with transport system telematics as an innovative technological solution. It is also aimed to introduce new approach in to the smart cities concept with integrated networking elements and systems.

3 Rationale of the Research

It is clearly known that transportation is critical factor in a day to day movement of peoples. Providing smooth flow of traffic system, free of accident and properly managed transport network systems as of reduction in pollution, accidents, and climate adverse impact. In the other hand, lack of e-ticketing system-integrated fair collection system, improper data exchanging platform has key consequences in to realization of the concept of smart cities We have listed here some of basic socio-economic problems as result of new roads construction or expansion projects in case of Addis Ababa city.

- Investing for new road construction is very expensive and time taking
- Abuse land use management
- Environment degradation
- Resettlement and right of way issues
- Exisitng utility collapse (Electric, Water and sewerage lines, Tele lines, etc.)

– Relocation of city residents

Using modern technologies in transport sector provides better management of the existing transport infrastructure. The faster growing in technological advancement and solutions in transport sectors is becoming preferred as an option regardless of investing in new road construction and expansion. Optimum decision making with relatively shorter period of time can be achieved by implementing transport system telematics (ITS) solutions and other tools.

4 Architecture of Addis Smart City Mobility Project

In order to workout with architecture of Addis smart mobility, the necessary criteria such as need assessment, functional and system requirements with respect users perspectives have been identified. As part of Intelligent Transport System (ITS) component, the main elements that make the architecture of city smart mobility are Vehicle Tracking System (VTS), Automated Fair Collection System (AFCS), CCTV Surveillance System and Passenger Information System (PIS). The Fig. 1 below is used to show the features of main and sub system of architecture of smart mobility in Addis.

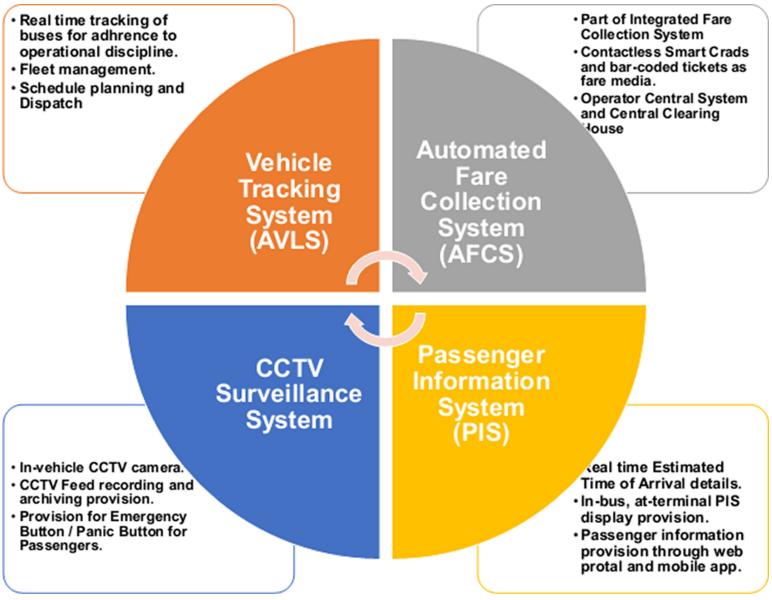

Fig. 1. System architecture of smart mobility in Addis Ababa [13]

According to above Fig. 2, this citywide architecture is fundamentally based on these functional systems and subsystem elements in order to bring the concept of smart city mobility. The system is used to describe the ITS components with respect to availability, reliability and maintainability. Each of the above system has comprised many

components and is capable to integrate with each other with respect to exchanging data/information and undertake the tasks as per the functional requirements.

5 Development of Smart Cities Concept and Mobility

Cities and mobility is entirely connected each other. Newly advanced technologies are creating the platform for more connected cities and smart mobility where cities are changing in cutting-edge paradigm called digital cities. Nowadays, everything related with technology is used to call smart; smart phone, smart energy, smart city, smart technology, smart decision etc.

In the concept of smart city, the meaning of technology, future development, and application are based primarily on the finding of methods how to make life easier and it would be the ultimate goal of smart city. Naturally, users of the "smart cities" system are inhabitants of the city, and therefore, the basic concept should support their commercial activities (employment), public activities (education, security, access to health care) and leisure activities (housing, culture, sport) through services [12].

According to [11] research indicates that smart cities can be divided into six different components:

- **smart governance** using ICT infrastructure in order to enhance the efficiency and transparency of public sector organizations in the management of public resources
- **smart economy** employ ICT and related technologies to improve productivity and to enhance and fortify online transactions for the promotion of e-commerce
- **smart human/social capital** aims to improve the people awareness level and promote active public participation through the provision of enriched information
- **smart environment** reduce pollution and resolve other environmental issues with the ultimate goal of improving urban/city sustainability through the use of technology
- **smart living** improved quality of life (e.g., security, housing quality, social cohesion, etc.) through the implementation of advanced technologies
- **smart mobility** focus on the efficient transport of people, attempts to use advanced ICT to optimize logistics and transportation systems and provide efficient, safe, and environmentally friendly services for passengers and freight

In this context, the urban eco-system would become more easier and convenient place as result of connected city system with many of intelligent components. With a connected environment, vehicles, infrastructure, and passengers can exchange information, either through a peer-to-peer connectivity protocol or a centralized system via a 4G or more advanced telecommunication networks [11]. The Fig. 2 is used to illustrate simple basic concept of smart city

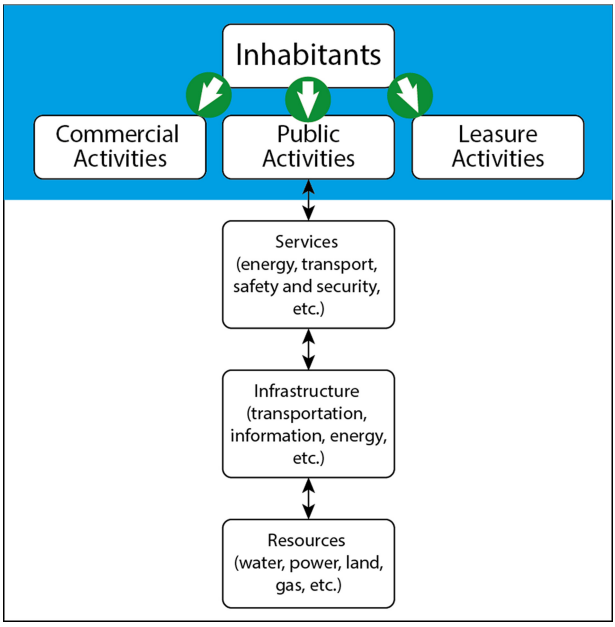

Fig. 2. The basic conceptual diagram of smart city [12]

6 Telematics for Smart Cities Mobility and Sustainable Environment

Application of telematics in to transport system has been widely used as result of its wide range functional performance and large number of system units. It has been widely introduced and implemented in modern systems of intelligent transport management and supervision and development of effective traffic control and maintenance systems [9]. In the other hand, the exchange of information-between vehicles to vehicle (V2V), and vehicle to infrastructure (V2I) and vehicle to passenger (V2P), in the cities could be critical component in transport system. Hence, telematics can facilitate this information exchange up on request or automatically. Therefore, telematics, which is a combination of solutions from areas such as transport, information technology and telecommunications, could serve as a response to the never-ending transport problems in urban areas [7].

Safety and environmental impact factors with respect to using various modes of vehicles in transport system can be seen as significant challenges in the cities. Reduction of greenhouse emission and optimal use of energy consumption in the cities are important parameters since the effects of health of urban community (noise, congestion, climate change, pollution) and severe traffic accidents could be minimized. Combination of new and existing traffic management as well as control of systems for the optimization of traffic flow on the highways are crucial features of traffic management system. Primary feature is the integration of traffic control subsystems (e.g. signalization, motorway and transit control systems) and the provision of dynamic checking in real time in a way that

reflects the changing traffic conditions [6]. In the Fig. 3 below, we used to illustrate the advancement of telematics system as part of smart city concept.

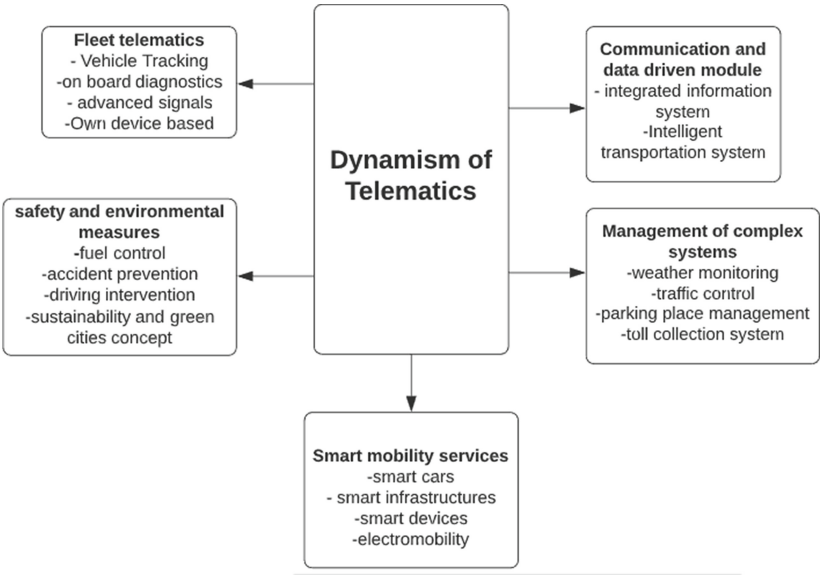

Fig. 3. The schematic diagram of dynamism of telematics system [own study]

Cities are experiencing with increasing number of motorized vehicles year by year. Each year, the carbon emission, air pollution, as well as accidents are increasing. The concept of being smart at smart cities would become under critical situation. Kos-Łabędowicz described that the concept of sustainable urban mobility is associated with objectives concerning optimisation of energy consumption and improvement of environmental indicators in urban areas [7].

The technological solutions are basically needed in order to tackle urban mobility problems and achieve the smart way of living. Collection of traffic data and information from relevant sources will produce positive effect in terms of decision making and data acquisition for users. In this regard, creating the means to use all the available resources in order to make smart mobility should be taken in to considerations. This implies that to ensure smart city mobility it is essential to make available all the means of transportation system in the cities with other integrated resources. Through discussion and awareness creation to all the stake holders in the cities are key step in the smart city and smart mobility concept. Telematics by itself can do nothing unless proper implementation and mechanism to avoid barriers in the cties well addressed. One connected technology solution that plays a significant role in the development of smart cities is vehicle telematics. Vehicle telematics is a tool used to monitor vehicle diagnostics and movements such as trip duration and length, location and CO2 emissions

7 Fleet Telematics Management for Urban Transport System

As we can see new devices and communication technologies are incredibly changing the trends of using the vehicles fleet management and exploitation mechanism. According to whitepaper of Vehco group, fleet (vehicles) management can include a range of functions, such as vehicle financing, vehicle maintenance, vehicle telematics (tracking and diagnostics), driver management, speed management, fuel management and health and safety management. Most importantly, implementing fleet management system has many benefits such as decreased costs for vehicle maintenance, decreased fuel costs, fewer accidents and with increasing productivity and safety. Fleet telematics can allow users to manage their own data and protect car theft as well as improve driver's behavior in order to optimize the decision making in every incident. The smarter the system works the more efficient use of fleet management would happen in the cities and urban transport system [4]. Vehicle telematics also helps to analyze and shape driving behavior and has been proven to reduce speeding, harsh braking and help eliminate preventable deaths caused by distracted driving.

Improving passenger transportation system at certain level in the cities has significant contribution in terms of increasing of quality of the services and access. A sustainable fleet management strategy is the one that aims to reduce environmental impacts through a combination of cleaner vehicles and fuels, fuel-efficient operation and driving systems. The simplified features in fleet management system can be seen in many aspects; for example, eco-driving, geo-fencing, vehicle tracking and fuel monitoring. Now days, many car insurance companies are also giving attention to implement telematics because of its dynamic features and system units. The insurer could give priority on the generated data during driving. At this trend, the fleet telematics has economic implication as result of avoiding unnecessary travel, changing the behavior of driver through ensuring safe driving system, minimizing costs related with congestion, maintenance and ensure productivity in day to day operation, and react to unforeseen events in real time situation.

Among many of fleet telematics features, vehicle tracking system is widely used and accepted by many users. Vehicle tracking system is used to track the location of vehicles in real time through the use of Global Positioning System (GPS) technology. This system can enables to establish a link between individual vehicles (buses) with the operations control center and provides a means to transport agencies to track the buses in real time. This system has also significant role in real-time monitoring of air quality transforming urban areas into smart Cities. Moreover, the concern and growth of using fleet management in transportation system is become rapidly increasing due a number of benefits. However, the level of using this system could be vary from users to users and as well as from country to country.

8 Availability and Reliability Problems of Transport System in Smart City

The disruptions of technologies in the smart cities are critical issues in terms of availability, reliability and maintainability. Smart cities are supposed to be packed with many of technological solution and systems. This has significant impact in any system which

is used to undertake the certain task or system. Transport systems, energy systems, ICT and other integrated approaches must evolve systems availability and reliability. When the city population grows the demand for using energy, transportation and mainly ICT solutions could be increasing. The unexpected downing of the system and failure to satisfy the expected demand will cause a divide. Then, the concept of city with respect to all the necessary positive results cannot be achieved easily as stated goal and visions unless availability, reliability and maintainability issues has given prior attention.

Furthermore, there is huge gap between well-developed cities and developing cities in terms of knowledge, practical skill and implementation process. The systems provided might be weak, lacking to work properly, inefficient and most of time it is not user friendly. In order to ensure highest percentage availability of the system devices, there must exist predictive maintenance schedule and fully functional devices. Hence, the system components and devices must show up scalable and capable of delivering required high performance and availability [4]

There is also need for reliability of transportation systems to provide all the necessary and reliable information/data to the travellers. Transport system is highly spectacle for dynamism and changes. Travel times are also most likely dependent on time and space due the basic reasons such as [16];

- recurring congestion such as the rush hour period,
- operational treatments for unexpected disruptions (e.g., traffic signal preemption for emergency vehicles and highway railway at-grade crossings), and
- traffic control devices and different roadway characteristics - weather conditions, emergencies and accidents.

Many systems comprising in the smart city that can be integrated each other and the systems should have flexibility through which the required modifications, additions of new functionalities can be carried out smoothly. Providing error free system is extremely useful for urban citizens and quality, availability and reliability of transport services are becoming vital in promoting urban public transport services [10].

9 Conclusion

The concept of smart city is very wide which comprises various systems and functions. This research critically examined the smart city concept with respect to smart mobility. We have investigated that there is some of misconceptions in the implementation of smart cities. In order to make happen digital cities, there must be awareness in different level from ordinary citizen to government official. Transport system telematics is among the one digital solution in the smart city concept. Implementing transport system telematics and its use in the smart cities has been deeply studied. The connected mobility system is a feature of smart cities as result of availability of data/information, choice to make the possible routes, and safe and comfortable travel system. The systems and devices availability and reliability could be considered as critical issues of the smart cities. Environment, free of emission, congestion and smooth mobility creates novelty in urban transportation through implementing efficient, effective, environmentally friendly and safe solutions in people and goods transportation.

Acknowledgement. The work has been financially supported by the Polish Ministry of Science and Higher Education. The work has been also supported by the UNESCO AGH Chair for Science, Technology and Engineering Education.

References

1. AGENDA 2063: The Africa We Want-A Shared Strategic Framework for Inclusive Growth and Sustainable Development, September (2015)
2. CIVITAS 2010: Policy Advice notes-Innovative information systems for public transport, Austria (2010). www.civitas.eu
3. Gidebo, F.A., Szpytko, J.: How to implement telematics into the urban public transportation system in Addis Ababa, concept study. In: Mikulski, J. (ed.) TST 2019. CCIS, vol. 1049, pp. 302–318. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-27547-1_22
4. Gidebo, F.A., Szpytko, J.: Reliablity assessment in Transport system, Addis Ababa case study. KONBiN J. **49**(4), 27–36 (2019)
5. ITS Report: Design and Supervision of the Installation of ITS/ICT Infrastructure and Systems for Anbessa Bus Operation, Addis Ababa, July (2019)
6. Kalašová, A., Krchová, Z.: Telematic Applications – Key to Improve the Road Safety, Archives of Transport System Telematics (2012)
7. Kos-Łabędowicz, J.: Telematics in sustainability of urban mobility. European perspective, Archives of Transport, System Telematics (2017)
8. Makino, H., et al.: Overview: solutions for urban traffic issues by ITS technologies. IATSS Res. **42**, 49–60 (2018)
9. Mikulski, J., Kedziora, K.: Current condition in the transport telematics. Inf. Commun. Technol. Serv. **8**(4), 84–89 (2010)
10. Mikulski, J.: The possibility of using telematics in urban transportation. In: Mikulski, J. (ed.) TST 2011. CCIS, vol. 239, pp. 54–69. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-24660-9_7
11. Sumalee, A., Ho, H.W.: Overview: smarter and more connected: Future intelligent transportation system. In: International Association of Traffic and Safety Sciences. Production and hosting by Elsevier Ltd. (2018)
12. Svítek, M.: Telematic approach into program of smart cities. Faculty of Transportation Science, Czech Technical University in Prague (2014)
13. TRANSIP: Transport Systems Improvement Project, Addis Smart Mobilty Project, Addis Ababa Ethiopia (2019)
14. Vehco Group (2018). https://www.vehcogroup.com/en/blog/whitepaper/5-trends-fleet-management-2018-and-onwards. Accessed 15 Jan 2020
15. https://ims.tech/opinion/smart-cities-telematics-technology/. Accessed 15 Jan 2020
16. Wu, Z.: Measuring reliability in dynamic and stochastic transportation networks, http://digitalcommons.unl.edu/civilengdiss/77. Accessed 15 Jan 2020