The Geographic Information System and the provision of information to the public transport user: a study based on the Integrated Transport System of Florianopolis

Samuel Borges Barbosa, Federal University of Uberlândia, Brazil (osamuelbarbosa@gmail.com); Francisco Henrique de Oliveira, Rafael Faraco, Santa Catarina State University, Brazil (chico.udesc@gmail.com); Issa Ibrahim Berchin, University of Southern Santa Catarina, Brazil; João Marcelo Pereira Ribeiro, University of Southern Santa Catarina, Brazil; Gabriel Alfredo Alves Zimmer, University of Southern Santa Catarina, Brazil; Victoria Guazzelli Williamson, University of Florida, United States of America (vgwilliamson@ufl.edu); José Baltazar Salgueirinho Osório de Andrade Guerra, University of Southern Santa Catarina, Brazil (josebaltazar.guerra@animaeducacao.com.br); Gabriel Oscar Cremona Parma, University of Southern Santa Catarina, Brazil; and Felipe Teixeira Dias, Faculdades Integradas Padrão – FIPGuanambi Afya, Brazil (felipe.teixeira@fip-gbi.edu.br)

Abstract

Geographic Information Systems technologies enable city managers and citizens to identify the best routes and transports available, enhancing efficiency of urban mobility. This brief aims to present the challenges and possibilities of using GISs to improve information given to public transport users, focusing on the analysis of the Integrated Transportation System of Florianopolis, Brazil. The information given to the users of the Integrated Information System in Florianopolis is restricted to digital and printed timetables showing departure times of buses from each station. However, it does not show the geographical location of the buses, or a digital platform that displays the time of departure of the buses and their itineraries. In order to improve the quality and efficiency of the information given to the public transport users of Florianópolis through the Geographic Information Systems, it would to invest in some technologies: a real-time vehicle localization system; a panel system of real-time localization at bus stops, terminals, and inside the bus; a real-time information system on city traffic levels; a real time localization system on the internet.

The world faces a rapid urbanization process. Urban population increases by 2.1% each year and represents 54.8% of the world's population (World Bank, 2018). Such increase establishes new challenges for cities, requiring intensive planning to offer transportation, education, leisure, health, sanitation, clean water, energy, and safety (World Bank, 2018; UNEP, 2011; Dou et al., 2013). All the while, this imposes challenges for the environment through the largest consumption of natural resources and the biggest increase in pollution caused by both greenhouse gases and improper waste disposal (Grimmond et al., 2010).

Unplanned urbanization can turn these challenges into problems that result in non-efficient transportation and mobility, malfunction of sewage networks, the creation of slums, and increased corruption and pollution. These all have a negative effect on public health, resulting in vulnerable, unsustainable cities (Grimmond et al., 2010; Dou et al., 2013; Tsay and Herrmann, 2013). Through these findings, the following question was raised: What are the possibilities of using Geographic Information Systems to enhance public transportation? In order to answer this question, an analysis of the Integrated Transportation System of Florianopolis, Brazil, is presented below.

Methods

To achieve the purpose of this article, literature on sustainable cities, urban mobility and the use of GIS in the cities was reviewed. To further study and identify better practices for urban mobility, five transport systems were selected: Bogota (Colombia), Berlin (Germany), Linkoping (Sweden), Maastricht (Netherlands), and Willich (Germany). These five transport systems were selected due to three criteria listed as follows: (i) the systems are referenced in terms of service quality, (ii) on the use of GIS instruments in public transport, (iii) based on empirical knowledge of the authors, all of whom collected data through grounded research in these cities. The cases selected provided an integrated set of examples that allowed in-depth analysis of the use of GIS solutions in public transport and revealed that the transport services that these cities provide to users are of high quality (Hidalgo et al., 2013; Fallde and Eklund, 2015).

With the study of those five transport systems, the main information services provided to the transport user were identified: real time tracking system of the vehicle; real time location of the panels at bus stops, stations and inside the bus; real time information about traffic in the city; real time location on the Internet; information system through panels with maps in stations; information schedules; and destinations at bus stops.

After the presentation of the transport systems in the five mentioned cities, the Florianópolis transport system was presented. Investigated factors were the transport and traffic in the city of Florianópolis as well

as the main features of its integrated transport system. Finally, based on the literature and the cases analyzed, suggestions were made to improve the integrated transport of Florianopolis through recommendations dealing with the information provided to transport users.

GIS Contributions to ITS Florianópolis

Smart Cities require strong information technology services and telecommunications in city management, and include a variety of components that enable the transmission of information about the environment. This article is not limited to a discussion on electronic information systems, but also includes systems that are not yet present in Florianopolis, such as the panels with maps in the terminals (Salomon, 1986).

The ITS of Florianópolis has some information systems for users, such as timetables in terminals, digital displays, websites and applications available on the internet. However, with the analysis of information systems in other cities, presented above, we found that there are deficiencies in the solutions used in the Florianópolis ITS. These deficiencies can be seen as opportunities to improve the system, advancing the quality and effectiveness of the use of ITS Florianopolis.

Table 1 summarizes the best practices of GIS mapped in the cities analyzedthat could be replicated in Florianópolis (Parra, 2006).

It is possible to outline two methods of geographic information solutions for the Florianópolis ITS. The first is the use of printing systems such as maps and location schemes which can be displayed at the terminals, bus stops and inside the vehicles. This solution requires only a small investment and can be quickly implemented. The second solution is the use of digital systems that indicate real-time location of buses, allowing users to know the location of vehicles at the terminals, bus stops or even in their homes through internet applications.

To improve the quality of information of the ITS Florianópolis, this paper proposes the employment of Geographic Information Systems that will contribute to the Florianópolis ITS, allowing users to geographically locate different parts of the transport system. The analysis of the five cities presented, combined with the literature review, resulted in the mapping of six systems of information to users. These systems involve digital technology and printed information, are characterized as a technological innovation for the public transport system of the city of Florianópolis, and improve quality of service to users.

The real-time vehicle location systems are very common in modern public transport (Dziekan and Kottenhoff, 2007), as was observed in Berlin and Bogota, and could be applied in Florianópolis. Through GPS and wireless connections, vehicles and drivers of public transport can be tracked in real time. Through wireless communication, messages about vehicle location and passenger count can be quickly sent among drivers and supervisors in an effort to control traffic and maximize efficiency of transport(Chien et al., 2002).

A GPS all ows accurate monitoring of each vehicle on the road at any time and can be stored and manipulated by the GIS found in the central stations of traffic control. It is possible to use GPS to keep panels with information for users in different parts of the Public Transport System and show the next departure of buses at terminals and stops (Mintsis et al., 2004; Dziekan and Kottenhoff, 2007).

Three other systems functioning through Location System in Real Time were observed in selected cities. The first one in Berlin and Maastricht, is a system of location of real-time panels at bus stops, bus stations, and inside the bus. Data related to actual shipping location is transferred to a central control room where it is analyzed and processed, allowing the information to reach passengers (Dziekan and Kottenhoff, 2007). In real time, this system presents information that shows the next departure of trains and buses at bus stops (Chien, et al., 2002), and a key element in advanced information systems to users, it is a model that predicts the arrival of vehicles with reasonable accuracy (Mintsis et al., 2004), an important component of user satisfaction (Paulley et al., 2006).

A complementary system to real-time based transport is the information system of real-time traffic in the city. This system, observed in Maastricht, is as important as the other because it predicts the arrival of buses at stops or terminals (Pucher et al., 2005). In Maastricht, the traffic control provides better information to drivers and coordinates alternate routes throughout the day based on real-time information on traffic conditions (Lyons and Harman, 2002).

Another system, observed in the city of Berlin, is the real-time location system on the Internet. The rise of the Internet as a means of traditional communication has opened up a variety of data and information exchange opportunities (Dziekan and Kottenhoff, 2007). The network by the Transport Information System provi desinteraction between users and service providers, helping with real-time information about traffic in the

city and providing the exact location of public transport (Lyons and Harman, 2002).

The advent of the Internet has brought a substantial increase in the availability and functionality of transport on information services (both car and public transport). It has also increased widespread, easily accessible use of information services, which aids decision-making for a particular trip (Farag and Lyons, 2008). In addition, the internet isa cheaper alternative to the installation of panels in various parts of the Public Transport System (Lyons and Harman, 2002).

Traditionally, public transport companies provide information on schedules and service faress, mainly through rate schedules and fees. In Florianopolis, these assets are supplemented with marketing initiatives, including special offers (Dziekan and Kottenhoff, 2007; Lyons and Harman, 2002).

The transport information system of panels with maps at stations was observed in the cities of Bogota, Linkoping, and Berlin. Simple and traditional, Florianopolis Public Transport System does not have this system. The 'travel map' in the terminals and stops of the analyzed cities positively influences the view that those passengers have of public transport services (Wall and McDonald, 2007). Additionaly, service information including maps of routes and telephone or online information services are well evaluated by users (Paulley et al., 2006). The maps in the stations provide the user a possibility of transportation planning, aiding decision making (Lyons and Harman, 2002).

Another system that positively influences the users is the time information system and destinations at bus stops (Wall and McDonald, 2007). This system was observed in the town of Willich. The idea is that the passenger knows the scheduled departure of the transport time at the station and on the spot, and which route and the running time of a path, however this is merely an assumed probability that lacks precision (Hickman and Wilson, 1995). One way of mitigating this error is to make available a Real-Time System of Location Panels which should display the location of all buses in the terminal, at the bus stop, and inside the bus. An example to mitigate this error is availability of systems that show buses location and real-time at bus stops, stations and inside the buses.

Conclusions

The Integrated Information System (IIS) has been working efficiently in Florianópolis; however, due to population growth and the increasing number of cars, traffic jams are intensifying in the city. In this regard, improvements in public transportation may stimulate the reduction of individual transportation.

The information provided to the users of the ITS in Florianopolis are restricted to digital and printed timetables with the time of departure of the buses in the stations, however it does not show the geographical location of the buses. The online platform besides showing the time of departure of the buses, also shows their itinerary. There are also online apps that provide information about the buses location, however they are based on predictions and not constantly updated. Still, the ITS users need better and more effective information systems.

Accordingly, in order to improve the quality and efficiency of the informations given to the user of public transport in Florianópolis through the Geographic Information Systems, it would be interesting to invest in: a real-time vehicle localization system; a panel system of real-time localization at bus stops, terminals inside buses; a real-time information system on city traffic levels; a real-time localization system on the internet; an information system of panels with maps at the terminals; and an information system of times and destinations at the different bus stops.

Acknowledgments

The authors would like to thank Professor Francisco Henrique de Oliveira and Geoprocessing Laboratory (GeoLab) from Santa Catarina State University (UDESC) for their contributions in this paper. This research was conducted by the Research Centre on Energy Efficiency and Sustainability (Greens), from the University of Southern Santa Catarina (Unisul), in the context of the project: Building Resilience in a Dynamic Global Economy: Complexity across scales in the Brazilian Food-Water-Energy Nexus (BRIDGE), funded by the Newton Fund, Fundação de Amparo a Pesquisa e Inovação do Estado de Santa Catarina (FAPESC 2016TR557) and the Research Councils United Kingdom (RCUK). Faculdades Integradas Padrão – FIPGuanambi Afya.

References

Chien, S. I. J., Ding, Y. & Wei, C. (2002). Dynamic bus arrival time prediction with artificial neural networks. Journal of Transportation Engineering, 128, 429-438. Available at: http://dx.doi.org/10.1061/(ASCE)0733-947X(2002)128:5(429) (Accessed on 18.08.2018).

Dou, X., Li, S. & Wang, J. (2013). Ecological Strategy of City Sustainable Development. APCBEE Procedia, 5, 429 – 434. Available at:

http://dx.doi.org/10.1016/j.apcbee.2013.05.074 (Accessed on 18.08.2018).

Dziekan, K. & Kottenhoff, K. (2007). Dynamic at-stop real-time information displays for public transport: effects on customers. Transportation Research Part A: Policy and Practice, 41, 489-501. Available at: http://dx.doi.org/10.1016/j.tra.2006.11.006 (Accessed on 25.08.2018).

Fallde, M. & Eklund, M. (2015). Towards a sustainable socio-technical system of biogas for transport: the case of the city of Linköping in Sweden. Journal of Cleaner Production, 98, 17-28. Available at: http://dx.doi.org/10.1016/j.jclepro.2014.05.089 (Accessed on 01.09.2018).

Farag, S. & Lyons, G. (2008). What affects use of pretrip public transport information?: Empirical results of a qualitative study. Transportation Research Record: Journal of the Transportation Research Board, 2069, 85-92. Available at: http://dx.doi.org/10.3141/2069-11 (Accessed on 21.08.2018).

Grimmond, C.S.B. et al. (2010). Climate and More Sustainable Cities: Climate Information for Improved Planning and Management of Cities (Producers/Capabilities Perspective). Procedia Environmental Sciences, 1, 247–274. Available at: http://dx.doi.org/10.1016/j.proenv.2010.09.016 (Accessed on 01.09.2018).

Hickman, M. D., & Wilson, N. H. (1995). Passenger travel time and path choice implications of real-time transit information. Transportation Research Part C: Emerging Technologies, 3, 211-226. Available at: http://dx.doi.org/10.1016/0968-090X(95)00007-6 (Accessed on 21.08.2018).

Hidalgo, D., Pereira, L., Estupiñán, N., Jiménez, P.L. (2013). TransMilenio BRT system in Bogota, high performance and positive impact – Main results of an ex-post evaluation. Research in Transportation Economics, 39, 133-138. Available at: http://dx.doi.org/10.1016/j.retrec.2012.06.005 (Accessed on 17.08.2018).

Lyons, G. & Harman, R. (2002). The UK public transport industry and provision of multi-modal traveller information. International Journal of Transport Management, 1, 1-13. Available at: http://dx.doi.org/10.1016/S1471-4051(01)00002-7 (Accessed on 21.08.2018).

Mintsis, G., Basbas, S., Papaioannou, P., Taxiltaris, C. & Tziavos, I. N. (2004). Applications of GPS technology in the land transportation system. European journal of operational Research, 152, 399-409. Available at: http://dx.doi.org/10.1016/S0377-2217(03)00032-8 (Accessed on 01.09.2018).

Parra, F.R. (2006). Aportes para a melhoria da gestão do transporte público por ônibus de Bogotá, a partir das experiências de Belo horizonte e Curitiba [Contributions to the improvement of public transport management by bus from Bogota, Belo Horizonte and Curitiba experiences]. Papel Político. 11, 557-594. Available at: http://ref.scielo.org/gkf6zd (Accessed on 01.09.2018).

Paulley, N., Balcombe, R., Mackett, R., Titheridge, H., Preston, J., Wardman, M., Shires, J. & White, P. (2006). The demand for public transport: The effects of fares, quality of service, income and car ownership. Transport Policy, 13, 295-306. Available at: http://dx.doi.org/10.1016/j.tranpol.2005.12.004 (Accessed on 01.09.2018).

Pucher, J., Korattyswaropam, N., Mittal, N. & Ittyerah, N. (2005). Urban transport crisis in India. Transport Policy, 12, 185-198. Available at: http://dx.doi.org/10.1016/j.tranpol.2005.02.008 (Accessed on 01.09.2018).

Salomon, I. (1986). Telecommunications and travel relationships: a review. Transportation Research Part A: General, 20, 223-238. Available at: http://dx.doi.org/10.1016/0191-2607(86)90096-8 (Accessed on 01.09.2018).

Tsay, S.P. & Herrmann, V. (2013). Rethinking urban mobility: Sustainable policies for the century of the city. Carnegie Endowment for International Peace: Washington, DC. Available at: http://carnegieendowment.org/files/urban_mobility.pdf (Accessed on 01.09.2018).

UNEP (2011). Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication. Available at: www.unep.org/greeneconomy (Accessed on 01.09.2018).

Wall, G. & McDonald, M. (2007). Improving bus service quality and information in Winchester. Transport Policy, 14, 165-179. Available at: http://dx.doi.org/10.1016/j.tranpol.2006.12.001 (Accessed on 01.09.2018).

World Bank (2018). World Databank: Urban Population. Available at: https://data.worldbank.org/indicator/sp.urb.totl.in.zs?end=2017&start=2016 (Accessed on 18.09.2018).