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REVISIÓN

Pedestrian systems design

Diseño de los sistemas peatonales

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ABSTRACT

Transport systems as components of mobility systems have become key elements for the development of cities. However, most efforts have been made to improve on motorized transport systems, leaving out the non-motorized ones including the pedestrians. Lately there has been a clear trend worldwide regarding awareness about the importance of walking to raise levels of quality of life, especially in cities. This phenomenon, coupled with the shortage of parking in relation to the amount of vehicles, fuel costs, and other considerations has shifted attention to pedestrian systems. This paper presents a discussion of the context in which pedestrian systems are immersed, how they are defined, what is their significance, how they are designed and finally, concludes on what is the trend in their representation and what are the "gaps" or lacks in modeling of these systems. This paper concludes that there is a tendency to analyze pedestrian systems with a microscopic vision and to neglect their recognition as transport systems.

Keywords: Computational cultural modelling, Sociotechnical systems, System analysis and design, System identification, Urban development.

RESUMEN

Los sistemas de transporte como componentes de los sistemas de movilidad se han convertido en elementos clave para el desarrollo de las ciudades. Sin embargo, la mayoría de los esfuerzos se han enfocado a mejorar los sistemas de transporte motorizado, dejando de lado a los no motorizados, como el sistema peatonal. Recientemente se nota una clara tendencia en todo el mundo con respecto a la concientización sobre la importancia de caminar para elevar los niveles de calidad de vida, especialmente en las ciudades. Este fenómeno, unido a la escasez de estacionamientos con respecto a la cantidad de vehículos y gastos de combustible, entre otros, ha desplazado la atención hacia los sistemas peatonales. Este artículo presenta una discusión del contexto en el que están inmersos los sistemas peatonales,

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cómo se definen, cuál es su significado, la forma en que se diseñan y, finalmente, se analiza la tendencia en su representación y las "brechas" o carencias en el modelado de estos sistemas. Se concluye que existe una tendencia a analizar los sistemas peatonales con una visión microscópica y descuidar su reconocimiento como sistemas de transporte.
Palabras clave: análisis y diseño de sistemas, Desarrollo urbano, Identificación de sistemas, Modelamiento computacional de la cultura, Sistemas sociotécnicos.

INTRODUCTION

The fast urbanization has also raised traffic densities in the cities. As a consequence, people and transport currier have been pushed to demand on trip time to reach their destination. That traffic has taken the attention of public and private authorities in the developed as well in the developing countries (Carsten, Sherborne & Rothengatter, 1998), because the intensification of urban life and the markets, transport has become an inherent system to humans. This phenomenon has moved international organizations that are coming together, combining efforts to make joint analysis in searching for solutions for the design of public policies in order to support the development that can reach the needs of cities, regions and countries.

The transformations in the urban environments have made people use different transport modes, including pedestrian transport, an intrinsic alternative to human beings, which has gained especial attention because of its contribution to the standard of living in cities. As a result, both researchers and planners have proposed discussions and studies on the issue in order to deliver ideas to support decision-making processes on public policies and planning. This paper aims to give an overview of the context in which pedestrian system is presented, as well as its definition, what is its importance, how they are conceived, what means its representation. The conclusions lead with the trends for the representation of pedestrian systems in the transport network and point out the possible "gaps" where planning need to work on proposing advancements for pedestrian systems.

TRANSPORT SYSTEMS

OECD and the International Transport Forum established a Joint Center for Transport Research in 2004 in order to investigate all means of transport to support policymaking in member countries and contribute to the ministerial meeting of the Forum (OCDE, 2011). Furthermore, the European Union mentioned in their announcements that transport is without any doubts an important economic growth factor; however, it is also associated with most of the environmental, economic and social costs generated today, particularly those referring to traffic accidents. This is a reason why the World Health Organization (WHO) declared from 2011 to 2020 the decade for the prevention of accidents and together with the Pan American Health Organization (PAHO) adopted an action plan on road safety to prevent injuries caused by traffic.

Definition

The Mexican Institute of Transport, after doing a broad review of the discussions on the issue, defines transport as a process, which is a set of actions that is constantly repeated; it aims at changing the position in space of people and/or things, that its utility is greater than elsewhere. It is a complex phenomenon, with special features, even also dependent on different approach to analysing (Islas & Zaragoza, 2007).

A transport system is made up of four interacting elements: the infrastructure, the vehicle, the operator and the regulations and rules. The first relates to the physical basis required for the transport

operation, such as roads, sidewalks, traffic lights or roundabouts (Transit Cooperative Research Program, 1999); the vehicle is the mechanism that allows the transfer of people or things; the transport operator is the person responsible for driving the vehicle; and the last, which refers to the rules and regulations, determines how to move from one place to another, regulate and standardise the operation for the actors involved in the transport services (Transportation Research Board, 2000). The traffic phenomena are a consequence, among others, of the transport operation (Islas & Zaragoza, 2007).

At the National Traffic Code of Colombia (NTCC), traffic is defined as the movement of people, animals or vehicles on a public or private road, opened to the public. Transport is defined as the movement of people, animals or things from one point to another using a physical basis to move. Based on that, it can be assured that one moves on traffic when a transport mean is available, but it is also possible to move without transport. In general, transport is multimodal, multi-sectorial, multi-problematic and multidisciplinary (Transportation Research Board, 2000). It can be said that a transport system is what allows the movement of people or things, through vehicles, operators, infrastructure and rules or regulations. Considering this point of view, it is possible to say that one can move when a type of transport is available, but also one can move without transporting anything.

Transport representation

The transport modelling refers not only to the estimated demand of users who want to move from one place to another in the city, but it is necessary to consider its complexity, involving other variables like actors and events (Duarte, 2011). Additionally, the costs and externalities generated for users and operators (Novaes & Gonçalves, 1996) must be considered. Moreover, it might be seen not solely as a phenomenon in which the object of study is the action of users group of a transport system, but it involves institutions, regulations and even cultural aspects that directly or indirectly affect the management of transport systems (Hensher & Button, 2005).

Beimborn & Kennedy (1996), cited by Duarte (2011), presented a list of steps for modelling transport, whose main elements are the land use, trips forecasts, the impacts of transport in land use, quality of life, etc. Land use has direct correlation with transport system in the cities (Montezuma, 2000). The modelling process makes the balance between demand and supply for specific land use and transport system (Beimborn & Kennedy, 1996). In fact, trip forecasts are the heart of transport modelling. Given its complexity, traditional methods divide a study area in travel zones (TAZ by Travel Analysis Zones). Modelling seeks to identify what are the interactions on travel occurring between a TAZ and other zones; therefore, the method dismiss trips occurring within each TAZ. This means that walking and cycling are not taken into account in the travel arrangements correlations, what is considered a major weakness of this type of models (Duarte, 2011). The following tools can be mentioned as important information technology for the representation and simulation of transportation systems: MEPLAN, INTEGRATION, IHDSM, TWOPAS, TRANSIMS, VISSIM, TEAPAC, AIMSUN, HCM/Cinema, WATSIM and CORSIM.

PEDESTRIAN SYSTEMS

Urban mobility refers to the different displacement generated within the city through networks of local connection (Jans, 2009), that is the ability to overcome distances in the urban spaces (Vasconcellos, 2001). According to Gonçalves, urban mobility is explained by "the movement of people and goods in the space by using the available transport infrastructure and technology in order to access city life" (Gonçalves 2014, p. 264). In fact, the mobility system consists of three transport systems: motorised and non-motorised vehicles, and walking (Transportation Research Board, 2000). Pedestrian

systems allow people to displace to access to the different places they need in their daily life, such as working places and education institutions (OPS-WHO, 2011).

Furthermore, mobility systems consist of several transport systems, which correspond to each of transport modes: terrestrial, maritime and air modes (Gonçalves & Silva, 2007). In this case, the pedestrian system is part of the terrestrial mode and specifically within the urban transport system, but in general, there are pedestrians also in the rural area.

The objective of urban transport is defined in the transport planning manual of the city of Bogotá as aiming "permitir la movilización de bienes y personas en condiciones preestablecidas de precio, confort y seguridad en el menor tiempo posible"[1] (Secretaría de Tránsito y Transporte, 2005). These displacements can be made with or without a mean of transport. In fact, in the case of pedestrian systems, the vehicle and the transport operator may be actually associated with the pedestrian itself. In conclusion, we can say that a pedestrian system is a transport system that has as vehicle and operator the pedestrian itself.

Pedestrian systems importance

In practice, as the cities become more geographically widespread, pedestrian movements also increase (for example, to access mass transit systems or to park vehicles in allowed areas). Pedestrian system is desirable, among other reasons, to prevent high traffic densities of private vehicles and congestions. Furthermore, people are becoming aware that walking improves their quality of life. It is also true that in any society there are individuals whose economic conditions make walking the only option for them to move. The growth of pedestrian movement and volumes in certain areas of cities can cause pedestrian congestion, affecting vehicular traffic in interaction points of pedestrians-vehicles. In fact, in the report on pedestrians, road safety and space of 2011 it was highlighted the importance of walking and the need for policies that promote pedestrian systems (OECD, 2011).

Data of 2007 shown that the adjusted mortality rate by traffic injuries in the world was 18.8 per 100,000 population, while in the Americas was 15.8 per 100,000 population (OCDE, 2011). The numbers for the Americas point out that 39% of people who die in the region due to road traffic injuries are vulnerable road users (pedestrians, cyclists and motorcyclists), while 47% are occupants of motorised vehicles (OCDE, 2011). In the United States and Canada the adjusted mortality rates caused by traffic injuries have dropped considerably in the last 30 years: the features are about 13.9/100,000 population and 8.8 / 100,000, respectively. In South America, only Colombia recorded a decrease in the mortality rate in 10 years till 2007; two countries in the Caribbean, the Bahamas and Jamaica, have reported similar trends in more recent periods.

Elements of pedestrian systems

The elements of pedestrian systems can be analysed focussing on the levels strategic, tactical and operational, considering the interrelation of the levels and the impacts on decision of each level. At the strategic level may initially identify infrastructure-related decisions, the budget, public policies and regulations (Gonçalves, 2014). At the tactical level, we can identify the campaigns, fines applied for irregularities and information. In the operational level are essentially pedestrians relations. The pedestrian systems elements and their decision-making process can be identified at the strategic, tactical and operational levels, considering that these levels are correlated. At the strategic level it is identified the decisions related to infrastructure, budget and regulations (Gonçalves, 2014). At the tactical level are campaigns, information and fines. The pedestrian's interrelations can basically be observed at the operational level.

1 In English: to allow movement of goods and people under predetermined conditions of price, comfort and safety in the shortest possible time.

The abstractions of pedestrian systems made by various authors in different publications (Venuti & Bruno, 2007; Seyfried *et al.,* 2006; Leden, Garder, & Johansson, 2006) have given the instruments for modelling at specific issues within the system, in general supporting decision-making at operational level. Furthermore, transport systems have certain elements that enable their functionality and their inner-inter relationships. These elements are essential for planning and modelling; it is what supports the design of sustainable networks (Gonçalves & Silva, 2007; Novaes & Gonçalves, 1996). The identification of pedestrian systems elements become more important considering there is a lack of formal definition of them, despite being recognized as subsystems of mobility systems. Prior to identify and describe these elements a description of system's actors is considered.

People who affect or are affected (stakeholders) by the pedestrian mobility systems are pedestrians, decision makers, owners of public spaces and vehicle users (motorised, non-motorised, public, private, etc.). According to the Road Transportation Authority (RTA), guidelines for planning pedestrian mobility, a pedestrian is considered any person who walks, including people who ride wheelchairs motorised or not, that cannot travel more than 10 km/h at floor level; people pushing motorised or non-motorised chairs, and people using recreation tools or wheeled toys (RTA, 2002).

According to RTA (2002), decision must be taken at the Local Governments (planning and management authorities) who can delegate the task of planning pedestrian mobility. For one hand, commercial and services areas normally see as desirable the facilities for pedestrian accessibility to their stores and buildings. On the other hand, vehicle users see themselves affected by the interaction with pedestrians through different ways, usually associated with having to share the roads at pedestrian crossings or violations of signalling and traffic regulations by involved parts.

The elements of pedestrian systems structure (the arrangement and the position of the parts within a whole), stands out as the main framework to a regulatory body, which is called city. The city is responsible for developing policies, overall design and makes modifications to the pedestrian system, seeking to ensure its sustainability, development and evolution (Mobility Departments or Local Councils).

The City has the planning, management and control of mobility system, infrastructure and regulations related to pedestrians. Moreover, the city is responsible for the design and implementation of campaigns to improve the performance of pedestrian system. These may be type informative (looking for informing people about certain events, features, etc.), preventive (looking for avoiding undesirable actions or phenomena) and corrective (looking to change certain behaviour or trends that is not desirable for the system).

Fines are also part of the mobility system (Ipsos Napoleón Franco, 2012). They can be type administrative or criminal sanctions seeking to punish non-compliance. The city conducts traffic control (Transportation Research Board, 2000) through different ways even make use of the infrastructure and regulations that might be executed by the police or traffic surveillance personal. The pedestrian mobility has as its protagonist pedestrians, which interact with each other, vehicles and infrastructure (Jerez & Torres, 2011) that make displacement to almost any place. In especial, the displacements can be classified into those that are made by pedestrian areas such as sidewalks; those made to cross through permitted areas (Transit Cooperative Research Program, 1999), such as zebra crossings; and those made to cross not allowed areas.

The vehicular mobility has drivers and they have vehicles. Vehicle is seen as a passive entity, managed by the driver. Nevertheless, it has a behaviour that depends on its technical and mechanical condition and how it is conducted. The driver behaviour depends on the environment, people interrelations at specific moment and the physical place in where they are.

Infrastructure is a component of the mobility system that refers to the physical structure of a

system. Infrastructure can be changed by the City aiming to respond to changings of pedestrian traffic (Secretaría de Tránsito y Transporte, 2005) or to raise traffic safety and comfort reflected in numbers of accidents, fines or risks that pedestrians are exposed. The infrastructures in the City constraint behaviour of vehicles and pedestrians as it put restrictions on the physical spaces in which they move. These restrictions seek the comfort of the actors and their safety within the framework of rules and policies (Transit Cooperative Research Program, 1999). In general, the infrastructure can be divided into pathways and signalling (Jerez & Torres, 2011). The first contains gazebos and bridges; additionally, the pathways can be vehicular traffic lanes, cycle routes and footpaths. The second, signalling, consists of vertical and horizontal signals and traffic lights. The last component of pedestrian system structure is regulations (Transit Cooperative Research Program, 1999), which means International, National and City regulations regarding pedestrians and vehicles. Overall, regulations restrict the behaviour of pedestrians, drivers and vehicles, at different levels, looking to generalise and standardise this behaviour so that they can preserve the life and comfort of the actors in the system.

Analysis focus

Pedestrian systems have been analysed based on different approaches. Mostly the studies focus on some aspects or elements of the system; therefore, delivering partial results for the analysis, and does not give a global view of the entire system. Among these approaches it can be considered mainly the intelligent transport systems, academic studies to represent specific situations on pedestrian behaviour, technical standards and rules for dimensioning elements of pedestrian systems, and city mobility plans, especially those dedicated to pedestrian mobility.

The "Intelligent Transportation Systems" (ITS) are part of a research devoted to propose intelligent solutions to mobility problems by analysing the relationship between infrastructure and vehicles in order to affect it through the use software, hardware, devices and algorithms to improve the welfare and efficiency of this relationship. The focus given by studies using ITS considers people from the point of view of safety and accessibility; however, it is not common that studies take into account pedestrians interactions, within their own logics and needs. The solutions proposed by ITS are not based on a comprehensive view of the problem, although efforts have been made to expand them, for example through the fusion of models and data (W.-D. Yang & Wang, 2012). The literature on ITS can be classified into three groups: those related to electronic development, to algorithms and to infrastructure. The first are for example alarms, traffic lights, sensors, GPS, among other developments, such as the use of ISA (Intelligent Speed Adaptation) in vehicles (Ma & Andréasson, 2005). On the issue of infrastructure ITS solutions are related to bridges, intersections and design, among other studies. And on the subject of algorithms, those solutions are related to traffic light synchronization (Chen, Chen, Lin, & Mao, 2007). There are other studies where ITS approach has also explicitly included pedestrians, such as a proposal of tools to improve pedestrian traffic without affecting vehicular movement (Carsten *et al.,* 1998); also it was developed a framework for the analysis and evaluation of safety for vehicles, including pedestrians (Kulmala, 2010) crash risk and consequence, (2. Likewise, it was presented a study on the impact of installing counters showing how much time is left for pedestrians to cross the streets (Keegan & O'Mahony, 2003). Overall, the ITS approach has not comprehensively taken into account pedestrian systems, but have focused on evaluating the response of pedestrians and vehicles to the implementation of tools and technologies.

The second approach for the analysis of pedestrian systems relates to academic studies, which in almost all cases have attempted to respond to specific problems and have made adaptations of

techniques, usually mathematical type to represent pedestrian systems. One of the techniques used for making decisions regarding pedestrian mobility simulation is especially used to represent the behaviour of pedestrians in specific situations, rather than to make macro representations of pedestrian system.

Most studies address some particular feature of pedestrians, such as the modelling of the phenomena affecting their movements (Löhner, 2010); individual behaviour and the behaviour due to the interaction with other pedestrians (Zhang & Han, 2011); displacement (Jian, Lizhong, & Daoliang, 2005; Suma, Yanagisawa, & Nishinari, 2012; Ezaki, Yanagisawa, Ohtsuka, & Nishinari, 2012; Gotoh, Harada, & Andoh, 2012; Tian, Huang, & Liu, 2010); definition of criteria to evaluate the relation of door-to-door displacement and infrastructure (Gonçalves, 2012); social strength, speed and density in the groups (Seyfried, Steffen, & Lippert, 2006); and the types of pedestrians in crosswalks (J. Yang, Deng, Wang, Li, & Wang, 2006).

With regard to the representation of pedestrians flow, there have been modelling for different features such as a simulation study of bottlenecks in areas with high pedestrian traffic (Cepolina, 2009); pedestrian movement modelling differentiating restricted and unrestricted systems, including various features of pedestrians to make more accurate models (Robin, Antonini, Bierlaire, & Cruz, 2009; Antonini, Bierlaire & Weber, 2006); and a stochastic model to represent the dynamics of pedestrians flow considering psychophysical and psychological characteristics (Kholshevnikov, Shields, Boyce, & Samoshin, 2008). Other examples are: A model of pedestrian flow with conservation of mass and moments (Jiang & Zhang, 2012); integration of mathematical models with a simulation with a platform called GETRAM and a traffic assignment software (Montero, Codina, & Barcel, 2001); and finally, a microscopic simulation model of two levels (Xi & Son, 2012). Although the mentioned tools considered certain features to represent the pedestrian flow, it is not visible an overview of pedestrian systems and the integration of the features what was previously identified in other studies.

The movement of pedestrian groups was modelled, performing their behaviour inter and intra group (Löhner, 2010); pedestrian movement using two axis (Jian *et al.,* 2005); individual behaviour and behaviour due to interaction with other pedestrians (Zhang & Han, 2011); anticipation of pedestrians (prediction if the place where one intends to move will be busy or not) (Suma *et al.,* 2012); repulsion towards other pedestrians (Ezaki *et al.,* 2012); backflow of pedestrians in congested systems (Gotoh *et al.,* 2012); the way the route is chosen, based on experience (Tian *et al.,* 2010); social force, speed and pedestrian density (Seyfried *et al.,* 2006); pedestrians types in crosswalks: the law-abiding and the opportunists (Yang *et al.,* 2006); characterization of pedestrian movement to simulate their behaviour (Löhner, 2010). Observing these studies, it is seen that each focuses on specific phenomena that represents partial features and do not evaluate their interrelations within the whole system.

Furthermore, some studies used simulation trying to make the representations in a more comprehensive manner. For example, a microscopic simulation model took into account not only perpendicular crosswalks, but it considered also various phenomena such as bottlenecks and route preferences (Guo & Tang, 2012); moreover, a model for estimating performance measures of pedestrian systems using queuing theory (Lovas, 1994). It was developed a waiting time model for pedestrians aiming to minimize bottlenecks, used to measure the effectiveness of evacuations(Fang et al., 2011); a simulation model that takes into account the interaction with vehicles and pedestrians using cellular automata (Tian *et al.,* 2010); a micro simulation model based on agents having three levels (López-Neri, Ramírez-Treviño, & López-Mellado, 2010); and a model of micro simulation and network optimization to evaluate time and cost for vehicles and pedestrians by varying the timing of traffic lights (Ishaque & Noland, 2007).

However, despite these studies show a more global view, they are limited to the operational level of pedestrian systems.

Other studies presented tried to include more variables them those listed above. For instance, there are some proposing to provide inputs from the use and the adaptation of techniques for the analysis of pedestrian systems. Unfortunately, these studies presented the same shortcomings mentioned above. For example, an autonomous multi-human simulation (Shao & Terzopoulos, 2007); a multilevel simulation with multi-agent holonic systems and scheduling engine Gaud et al, 2008). A model using dynamic spatial discretization (Antonini *et al.,* 2006); a stochastic model to represent the dynamics of the flow of pedestrians (Kholshevnikov *et al.,* 2008); and a model with Petri network to simulate the timing of traffic lights at an intersection (Dotoli & Fanti, 2006).

It is possible to affirm that simulation has been widely used for the representation and analysis of pedestrians, especially from the micro simulation approach. However, it has been used only in specific situations and there is no evidence of its use with systemic approaches. In fact, the commercial software available for pedestrian's simulations is focus primarily, towards the operational level. Despite the improvements of these computational tools, mostly they provide support for making operational decisions and in a few cases for tactical decision-making, but a comprehensive view is not evident in decision-making processes relating to pedestrian systems. Nevertheless, there are studies that have contributed significantly to the characterization of pedestrians (Tom & Granié, 2011; Jesins, 1973; Hatfield & Murphy, 2007; Cambon de Lavalette *et al.,* 2009; Milligan, Poapst, & Montufar, 2012). One advantage of the available studies is that they offer lots of information about the behaviour of pedestrian systems, including identification of influential variables, even these information are biased.

The third approach is the analysis of the technical standards for modelling pedestrian systems. The Highway Capacity Manual (HCM) is a reference publication broadly known and used by decision makers in transport systems. It contains concepts, guidelines and procedures for calculating capacity and services quality of various elements of road network and pathways, and it evaluates the impacts of mass transit, pedestrians and bicycles in the performance of these systems. The analysis presented in the HCM manual focus primarily to the vehicles; so that does not explicitly identify all the elements of transport systems. It identifies three basic elements that affect driving a vehicle and the driver environment. Within the elements of 'environment' are pedestrians, bicycles and buses, as well as physical spaces. In fact the HCM Manual proposes the aggregation of individual elements of urban systems for the analysis (Transportation Research Board, 2000).

In Colombia there is the 'Planning and Design Handbook' for traffic and transport management developed by the Colombian Bureau of Transport. It aims to strengthen the planning, design, implementation and monitoring of studies and projects, developed to the city of Bogotá (Secretaría de Tránsito y Transporte, 2005). Furthermore, there are some specialised manuals and pedestrian systems publications. Within these manuals is the Colombian 'Urban Pedestrian Infrastructure Manual', developed by Universidad Pedagógica y Tecnológica de Colombia. The manual presents the most important elements of pedestrian systems infrastructure based on an extensive literature review and among them is the HCM (Jerez & Torres, 2011). Although it is a very valuable publication, its scope does not extend beyond the characterization of infrastructure.

It is worth to mention studies developed in various countries, like the guidelines for designing master plans for pedestrian and bicycle mobility (Burbidge, Vyas, Julie, & Mitman, 2012); the Best Practices Manual for planning and design of pedestrian systems of Sacramento (STAQ, 2005); a handbook to orient the incorporation of pedestrian infrastructure in the transport system of the city

of Washington, USA (Otak, 1997); a book of the Roads and Traffic Authority of Australia on how to write mobility plans (Road Transportation Authority, 2002); and a handbook on how to plan and design for pedestrians, of the Department of Transportation, city Western-Australia (Department of Transport Western Australia, 2012). The publications mentioned concentrates the discussion on infrastructure and other issues such as policies; however, these studies does not present a discretionary analysis of the pedestrian systems elements shown in the previous section.

The study identified various pedestrian mobility plans developed in different cities. These plans also provide an approach for the analysis and representation of pedestrian systems; however, as it was seen in the handbooks, there are certain elements of pedestrian systems that are not taken into account in all publications. Among the most cited by technicians and literature were considered the San Diego, Madrid, León, Ourense, New York, Leon, Dublin, Grangegorman and Eugene. The first feature analysed refers to mobility plans that is specifically dedicated to pedestrian system or only includes pedestrians' elements; the second one was the current state (shows whether the plans take into account the elements and/or the statistics of the system at the time of planning). In the other items (goals, strategies and actions, cycling, infrastructure, budget, signalling, campaigns, fines, safety, education, diffusion, evaluation), it was only revised the recognition of the elements in the plans, no matter how deeply they were analysed.

The results of the mobility plans analysis shown they do not cover all elements of pedestrian systems; moreover they do not present the relationships between them. It was observed that the plans lack an integrated and comprehensive view. Furthermore, it is necessary to explicit internal correlations of the systems elements, the orientation about the feedback relationships and the expansion and revision for the plans, in order to propose more integrated and effective plans for cities.

FINAL CONSIDERATIONS

The different approaches of pedestrian systems studied have in common the statements for decision-making on infrastructure. Although some of them take into account the behaviour of pedestrians, as key players, only do so with respect to certain characteristics, usually those related to travel. However, other actors in the system as decision makers or those doing the monitoring are not taken into account, except in some cases of mobility plans and handbooks. Also, the influence of other features of pedestrian systems such as budget, campaigns, etc., does not appear on the contents of the analysed studies. Moreover, it is worth to highlight the need for a systemic view of the dynamics of pedestrian's behaviour.

The current state analyses indicate that the representation of pedestrian systems is oriented to operational features and lacks a systemic view of pedestrian mobility. It was observed on the studies a tendency to microscopic analysis, which is far from the classical representations of transport systems. Apparently the pedestrian system has not been recognized in practice as an important transport system for cities such as the vehicular system or the public transport system. It is only since the last decade that specific plans for pedestrian mobility start to be presented for some urban areas.

Finally, in the studies analysed it was observed a clear influence of traffic accident statistics in decision-making, indicating a reactive behaviour of technicians and decision makers, regardless a deeper prospective analysis or forecasts based on actors behaviour and the correlations of influence and feedback between elements of the pedestrian system and its environment.

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