URBAN TRANSPORT INFRASTRUCTURE: A SURVEY

Idalia Flores[(a)], Miguel Mújica Mota[(b)]Salvador Hernández[(c)]

[(a)] Faculty of Engineering, UNAM
(b)Aviation Academy
Amsterdam University of Applied Sciences
[(c)]Technological Institute of Celaya

[(a)]idalia@.unam.mx,[(b)]m.mujica.mota@hva.nl
[(c)]salvador.hernandez@itcelaya.edu.mx

ABSTRACT
The urban transport infrastructure is one of the most important problems for the cities, and involves many aspects that concern to citizens, governments and the economical growth of the countries. The objective of this paper is to show how this issue has been studied in recent years, with emphasis in the use of simulation and optimization at the whole planning process. We also consider the important key topics as sustainability, costs and risks, mobility and environment impact. Some study cases are shown in order to clarify the concepts presented.
Key words: Urban transport, planning, simulation, optimization.

1. Introduction

Nowadays one of the bigger problems in cities is the transportation system and its infrastructure. There have been lots of studies and research in recent decades trying to find solutions. In general there is an economic impact when countries make an investment in this sector. Most of the studies on transport infrastructure, in particular, focus on its impact on growth. In the past two decades the analytical literature has grown enormously, with studies carried out using different approaches, such as a production function (or cost) and growth regressions, as well as different variants of these models (using different data, methods and methodologies), the majority of these studies found that transportation infrastructure has a positive effect on output, productivity or growth rate Calderon & Serven (2008). One of the pioneers was Aschauer (1991) who, in his empirical study, provided substantial evidence that transport is an important determinant of economic performance. Another example is the study of Alminas, Vasiliauskas and Jakubauskas (2009), who found that transport has contributed to growth in the Baltic region. Another study on the Spanish plan to extend roads and railways that connect Spain with other countries concludes that these have a positive impact in terms of Gross Domestic Product (GDP) Alvarez-Herranz & Martínez-Ruiz (2012). In a study of the railroad in the United States, it is mentioned that many economists believe that the project costs exceed the benefits Balaker (2006). However, the traditional model of cost-benefit assessment does not include the impact of development projects De Rus (2008). In these studies focused on growth, we see there is a bias towards economic rather than social goals. That is why it is important to emphasize the impact of transport infrastructure on development and not just growth.

Some papers that deal with economical and social impact are shown here.

In order to show the subject clearly, we will use a systems approach, dividing urban transport infrastructure according to Calgary (2009)
Urban Transport infrastructure:

- Transportation Planning
- Transportation Optimization
- Transportation Simulation

According to this system paradigm, this paper is focused on the description of the research made in the last five years, mainly considering optimization, and simulation and the intelligent systems. The structure of this paper is as follows. Section 2 shows the state of the art for the general transportation planning issue. Section 3 is devoted to transportation optimization and simulation techniques that have been used in different ways in accordance with the problems they are meant to solve. Section 4 is about intelligent transportation systems and how the development of new technologies interacts with the whole system and where they are being used. Short conclusions are given at the end.

The impact that transport infrastructure has in increase of the quality of life can be seen in the next figure:

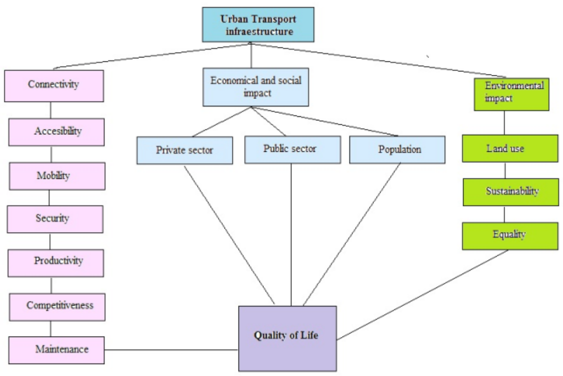

Figure 1 Impact of the transport infrastructure.

Three tables show some of the papers published about mobility and sustainability because they are close related. Later the other themes are shown along the paper.

2. Transportation Planning

Transportation planning covers a lot of different aspects and is an essential part of the system. According with Levy (2011), "Most regional transport planners employ what is called the rational model of planning. The model views planning as a logical and technical process that uses the analysis of quantitative data to decide how to best invest resources in new and existing transport infrastructure."

Phases for transportation planning

There are three phases: The first, preanalysis, considers what problems and issues the region faces and what goals and objectives it can set to help address those issues. The second phase is technical analysis. The process basically involves the development of the models that are going to be used later. The post-analysis phase involves plan evaluation, program, implementation and monitoring of the results, Johnston (2004).

Transportation planning involves the following steps:

- Monitoring existing conditions;
- Forecasting future population and employment growth, including assessing projected land uses in the region and identifying major growth corridors;
- Identifying current and projected future transportation problems and needs and analyzing, through detailed planning studies, various transportation improvement strategies to address those needs;
- Developing long-range plans and short-range programs of alternative capital improvement and operational strategies for moving people and goods;
- Estimating the impact of recommended future improvements to the transportation system on environmental issues, including air quality; and
- Developing a financial plan for securing sufficient revenues to cover the costs of implementing strategies.

Transportation planning process in Figure 2

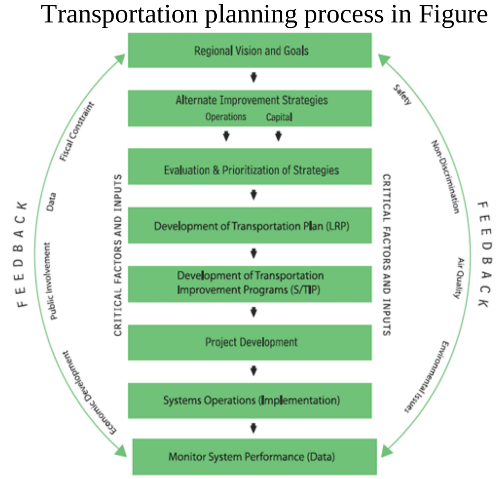

Figure 2 Transportation planning process. Source (FHWA, 2007)

Urban Infrastructure

Urban infrastructure, a human creation, is designed and directed by architects, civil engineers, urban planners among others. These professionals design, develop and implement projects (involved with the structural organization of cities and companies) for the proper operation of important sectors of society. When governments are responsible for construction, maintenance, operation and costs, the term "urban infrastructure" is a synonym for public works.

Road infrastructure is the set of facilities and equipment used for roads, including road networks, parking spaces, traffic lights, stop signs laybys, drainage systems, bridges and sidewalks.

Table 1 Sustainability in Urban Transport Infrastructure

Title/Year	Author(s)	Description
A new transportation system for efficient and sustainable cities: Development of a next generation variable speed moving walkway (2015)	David Rockwood, David Garmire	Authors address how to safely control and operate such walkways. In comparison with existing forms of public transportation, this mode of transportation allows lower latencies with higher throughput by operating continuously and allowing acceleration and deceleration of passengers
Sustainable urban transport (Book- 2011)	Carlos Felipe Pardo	Shanghai Manual – A Guide for Sustainable Urban Development in the 21st Century
Technology and the notion of sustainability (2010)	Sven Ove Hansson	Instead of choosing between weak and strong sustainability, the two notions should be included in the same analysis, since they are needed to account for different kinds of assets.
A bilevel multi-objective road pricing model for economic, environmental and health sustainability (2014)	Judith Y. T. Wanga, Matthias Ehrgott, Kim N. Dirks, Abhishek Gupta	Authors consider three objectives at the upper level: minimizing system travel time; total vehicle emissions; and negative health impacts, modeled as the level of pollutant uptake.
Strategies for Safer and Sustainable Urban Transport in Bangladesh (2002)	Md. Mazharul Hoque & Jobair Bin Alam	Emphasis has been placed on the mobility needs of the urban poor. Key transport issues and possible solution strategies for enhancing mobility, safety and the environment by means of better traffic management measures are further discussed in the light of major themes of the conference.
Sustainable Urban Transport Management and Its Strategies (2012)	Touba Amirazodi	Sustainable transport management considers the effects of transportation development on economic efficiency, environmental issues, resources consumption, land use and social justice and helps reduction of environmental effects.
Advancing Sustainable Safety (BOOK) National Road Safety Outlook for 2005-2020. SWOV Institute for Road Safety Research	Ed. Fred Wegman Letty Aarts	The Sustainable Safety vision of road safety is based on five principles. These principles are the functionality of roads, the homogeneity of mass and/or speed and direction, physical and social forgivingness, recognition and predictability of roads and behavior, and state awareness. This fact sheet describes the theories and scientific background on which these principles are founded.
Indicators for sustainable urban mobility –Norwegian relationships and comparisons (2012)	Vibeke Nenseth, Petter Christiansen and May Hald	Transport data for calculated greenhouse gas emissions at city level and for local emissions still need improvement to be more easily available. In the quantification of environmental goals in transport policy, increasing emphasis is put on the indicator relationships and distance-to target indicators.
Encouraging good practice in the development of Sustainable Urban Mobility Plans (In Press) (2014).	Anthony. D. May	The purpose of this paper is to review experience with the provision of such guidance, at a European and national level, assess the underpinning research and identify areas in which further research is needed. The paper reviews the background to the preparation of guidance at a European level and also at a national level in Belgium, France, Germany, Italy, Poland, Scandinavia, Spain and the UK.

Table 2 Mobility in Urban Transport Infrastructure

Title/Year	Author(s)	Description
Políticas de movilidad urbana e infraestructura urbana del transporte Documento de proyecto CEPAL (2009)	Jorge A. Lupano, Ricardo J. Sánchez.	The availability of adequate urban transportation infrastructure that allows goods and people to mobilize worthy, timely, reliable and economic way that integrates certainly common core of basic needs. Specially relevant for developing countries.
IRAP-FUPOL		http://movilidadamable.org/programas
Defining urban mobility indicators (2009)	Fabio Nussio POLIS Conference 2009	http://www.airqualitynow.eu/comparing_smi.php. To obtain a time-dependent indicator of traffic and mobility that is consistent and comprehensive requires in theory the continuous monitoring of the entire transport network, which implies measuring every few minutes the flow state (speed and density) of at least each major link. Today, through an advanced methodology based on the simulation of transport demand, of driver's route choice and of the traffic phenomenon.
Estimation of Performance Indices for the Planning of Sustainable Transportation Systems (2013)	Alexander Paz, Pankaj Maheshwari, Pushkin Kachroo, and Sajjad Ahmad	This study proposes a system of systems (SOS) and a fuzzy logic modeling approach. The SOS includes the Transportation, Activity, and Environment systems. The fuzzy logic modeling approach enables the treatment of the vagueness associated with some of the relevant data. Performance Indices (PIs) are computed for each system using a number of performance measures.
Sustainable Urban Transportation: Performance Indicators and Some Analytical Approaches (2002)	John Black, Antonio Páez, Putu Alit Suthanaya	The analytical framework for sustainable urban transportation analysis includes descriptive statistics—exploratory and graphical methods, spatial mapping, spatial statistics _to identify geographical patterns and to identify outliers in the data_, regression analysis, travel preference functions based on Stouffer's intervening opportunity.
Measuring Transportation Traffic, Mobility and Accessibility (2011)	Todd Litman	Traffic-based measurements (such as vehicle trips, traffic speed and roadway level of service) evaluate motor vehicle movement. Mobility-based measurements (such as person-miles, door-to-door traffic times and ton-miles) evaluate person and freight movement. Accessibility-based measurements (such as person-trips and generalized travel costs) evaluate the ability of people and businesses to reach desired goods, services and activities.
Mobility indicators and accessibility of transport (2007)	Peter Ľos	There are various indicators commonly used to measure and evaluate levels of mobility and accessibility. To what extent are these indicators suitable for the purpose of comparison between various cities and investigation of influence of accessibility on mobility, is the subject of discussion in this paper.
Can national survey data be used to select a core set of indicators for monitoring the sustainability of urban mobility policies? Working papers 2009-2011	Francesca Mameli, Gerardo Marletto	A national survey has been carried out to gather citizens.' perceptions over a basic conceptual framework of dimensions and objectives of urban mobility policies in order to provide a ranking of the associated performance indicators. The results showed that different sets of performance indicators may be chosen according to city size and transport modes mostly used by citizens.

Table 3 Mobility in Urban Transport Infrastructure Part 2.

Title/Year	Author(s)	Description
La Movilidad urbana. El reto de la sostenibilidad (2013)	Angel L. Cayuela Prieto	The problems generated by urban transport are result of the increase in the number of vehicle-km in circulation, and an efficient mobility is very important for this.
Hacia una estrategia nacional integral de movilidad urbana	Bernado Baranda Sepúlveda, Jorge Cañez Fernández et al.	This document intends to translate the proposal from the civil society becomes to design a national strategy for sustainable urban mobility in Mexico.
Planes Integrales de Movilidad Lineamientos para una movilidad urbana sustentable (2012)	Salvador Medina Ramírez, Jimena Veloz Rosas, Alfonso Iracheta Cenecorta y Jimena Iracheta Carroll	To give key elements to Mexican cities to plan and manage urban mobility through strategies focused on reducing car use, improve public transport and bicycle and pedestrian infrastructure elements.
Multicriteria decision making for sustainability evaluation of urban mobility projects (2013)	Anjali AWASTHI, Hichem OMRANI, Philippe GERBER	In this paper, authors investigate four multicriteria decision making (MCDM) techniques namely TOPSIS, VIKOR, SAW and GRA, fuzzy numbers for sustainability evaluation of urban mobility projects under qualitative data and demonstrate their application through a numerical example.
Strategic Directions and Ecosystems to Address China's Urban Mobility Challenges (2014)	François-Joseph Van Audenhove, Oleksii Korniichuk, Jeff Hou, Antoine Doyon	The report summarizes some of the key insights from the "Future of Urban Mobility 2.0" study and puts them in perspective by looking into specific challenges and opportunities within Greater China.
A GIS as a Decision Support System for Planning Sustainable Mobility in a Case-Study (2012)	Pietro D'Amico Ferdinando Di Martino and Salvatore Sessa	Authors support the strategic environmental assessment process of the Coordination Plan of the District of Naples through the selection of indicators set to monitor and evaluate the planned actions towards a sustainable mobility in the District. This process is implemented inside a GIS and its reliability is tested by linguistic hedges modelled from fuzzy sets.
SUMO – Simulation of Urban MObility An Overview (2011)	Michael Behrisch, Laura Bieker, Jakob Erdmann, Daniel Krajzewicz	SUMO is an open source traffic simulation package including net import and demand modeling components. Authors describe the current state of the package as well as future developments and extensions.
The Resilience of Road Transport Networks Redundancy, Vulnerability and Mobility characteristics. Ph. D thesis (2014)	Rawia Ahmed Hassan El Rashidy	This thesis is concerned with the development of a composite resilience index for road transport networks. The index employs three characteristics, namely redundancy, vulnerability and mobility, measuring resilience at network junction, link and origin-destination levels, respectively. The mobility indicator for road transport networks is formulated from two mobility attributes reflecting the physical connectivity and level of service. The combination of the two mobility attributes into a single mobility indicator is achieved by a fuzzy logic approach.

Urban infrastructure includes transportation infrastructure, which can, in turn, be divided into three categories: land, sea, and air, they can be found in the following modalities:

• Street networks, high or low-speed railway lines, together with such as bus stops, road signs, traffic lights, parking bays, and so forth. This applies to all the cases cited below:
• Infrastructure for mass transit or bike paths and footpaths
• Canals, bridges
• Ports, airports and lighthouses, etc.

Some papers published concerning transport planning are as follows:

Introduction to Multi-Modal Transportation Planning Principles and Practices (2012), Todd Litman
This paper summarizes basic principles for transportation planning. It describes conventional transport planning, which tends to focus on motor vehicle traffic conditions, and newer methods for more multi-modal planning and evaluation.

The Research on Practical Approach for Urban Transport Planning. This study developed by JICA(The Japan International Cooperation Agency)is the result of a huge experience in more than 60 countries, and its purpose is to contribute to the formulation of medium-to long-term development strategies for urban transport. A schema is shown next:

Some other papers concerning to planning are case studies in different countries and will be mentioned in section 5.

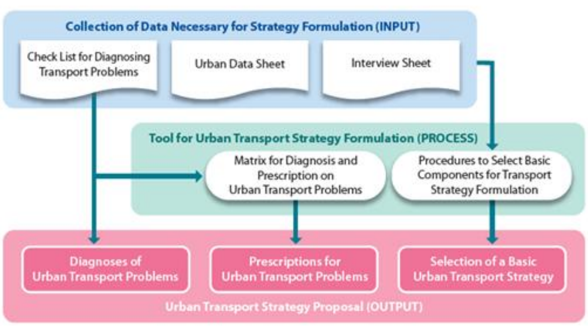

Figure3. Guidelines for formulating an urban transport strategy (Source JICA)

3. Transportation Optimization and Simulation

The goal of transportation optimization is to identify, evaluate and plan enhancements that optimize the operation of a transportation system. With this in mind many countries have specific policies for this and a lot of research has been developed over recent years to this end. Optimization deals mainly with networks operation, traffic, costs, maintenance, sustainability, mobility and management infrastructure. These aspects require balance between the performance of the structure and the total cost accrued over the entire life-cycle.
For instance in Worm and Harten (1996), the authors developed a Decision Support Model. "This model is a tool for the road manager to assist in generating an optimal maintenance plan for a road. Optimal means: minimizing the Net Present Value of maintenance costs, while the plan is acceptable in terms of technical admissibility, resulting quality, etc. Global restrictions such as budget restrictions can also be imposed."

There is a site that considers some principles for transportation optimization (http://www.jda.com/) "With the transportation management system market expanding, the time has come to clarify misperceptions and reveal the best practices in optimization. The Transportation Management System Investment must optimize beyond carrier selection and rates to address myriad constraints and granular functions that apply these three key principles:

1. One size does not fit all
2. The details matter
3. Concurrency is king".

Considering multi-objective optimization, there is the paper of Wanga et al. (2014) and proposed a bilevel multi-objective approach to optimize tolls in a road network. "Consider three objectives at the upper level: minimizing system travel time; total vehicle emissions; and negative health impacts, modeled as the level of pollutant uptake".

Another paper related to multi-objective is the one of Guerreiro et al. (2014). "In the Dial-a-Ride public transportation systems, each customer requirement is specified in terms of a pickup (origin), of a delivery (destination) and of a time window within it has to be satisfied. The aim is to find a set of routes, each assigned to a vehicle, in order to satisfy the set of requests, under capacity, time windows, precedence and pairing conditions. This paper addresses the problem with the aim of optimizing, at the same time, the maximum total ride time and the total waiting time. Then, a bi-objective PDPTW with a constraint on the maximum duration of each route is proposed and solved by a two-step approach."

From the network optimization point of view, it can be considered the next papers:

Fancello et al. (2014) developed an integrated performance indicator in urban road infrastructure for evaluating network functionality and the impact of transport system interventions. The complex indicator has been elaborated using a multicriteria algorithm, based on concordance analysis.

An interesting application for the optimization users is the one presented by Spiliopoulou et al. (2014) authors validate a macroscopic traffic flow model. "The reported study tests, validates and compares two well-known macroscopic traffic flow models in the special, but quite frequently occurring case, where congestion is created due to saturated freeway off-ramps. In particular, the comparison includes the first-order model CTM (Cell Transmission Model) and the second-order model METANET."

Travel time in a network is different in public and private transport, for this reason Salonen and Toivonen (2013). Analyzing the accessibility disparity between different travel modes is recognized as an efficient way to assess the environmental and social sustainability of transport and land use arrangements. “This paper aims to assess the comparability of different methods for calculating travel time by different travel modes. First, we briefly review the methods used in previous studies and identify different typical approaches, which we then compare. We use three computational models respectively for car and public transport (PT), implemented in our case study area, the capital region of Finland.”

The transport issue can be seen as a transportation network, and in this way the relationships among the main elements to analyze and study, figure 4 shows these ideas.

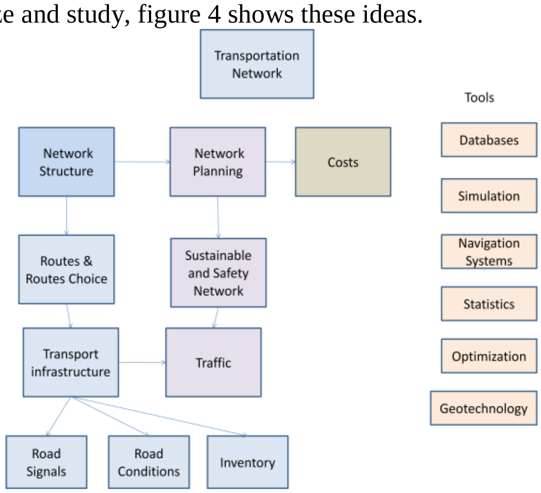

Figure 4 Transportation network

Transportation networks have as it can be seen in Figure 4 a traffic component, in this way simulation has been used with success. One paper is the one of Solecka and Żak (2014). “The paper presents the overall methodology of designing and assessment of transportation solutions that result in the integration of an urban public transportation system. The proposed approach is based on the application of heuristic – expert design of an integrated urban public transportation system, its simulation with the use of a computer-based macro-simulation system VISUM and its multidimensional – multiple parameter comparison with the existing solution.”

However, there is also the need to optimize an entire transportation network. There are two main methods for this, the exact and heuristics, though a hybrid that that combines them both can also be used. In most cases, though, some heuristic algorithms are used because of the size of the problems involved. This paper will show the new developments in this area.

In the case of networks, some routing studies have been developed using either genetic algorithms hybridized with Dijkstra algorithms to find the shortest routes, or just some advanced label algorithms as the one shown in Klunder, (2006).

As has already been mentioned, metaheuristics are used because they provide very good solutions in a short time, like the neural networks that are used by Yu et al (2011)

The exact methods we are referring to include branch and bound, branch and cut, dynamic programming. The location and routing problem presented by Belenguer et al (2011) uses branch and cut for the design of logistic networks. In this case the overall distribution cost may be excessive if routing decisions are ignored when locating depots. In order to overcome this problem they propose a branch and cut algorithm for solving it. The proposed method is based on a zero-one linear model reinforced by valid inequalities.
Berman et al (2011) gives us an example of search paths for service. In this paper an optimal search path is found for a service problem that is stated as follows: “A customer residing at a node of a network needs to obtain service from one of the facilities; facility locations are known and fixed. Facilities may become non operational with certain probability; the state of the facility only becomes known when the facility is visited. Customer travel stops when the first operational facility is found. The objective is to minimize the expected total travel distance”. This problem is NP-hard and a forward dynamic programming procedure is developed.

A micro-simulation related with trips consider single data and census data, Lovelace et al. (2014), studied the statistics on mode and distance of travel, which vary depending on a range of factors that operate at different scales. With this problem in mind they proposed “a spatial micro-simulation approach, which combines individual-level survey data with geographically aggregated census results to tackle the problem.”

Some transport simulators can be found in the following sites:
http://www.simulatorcentral.com/index.php/simulators/transport.html
http://www.simutrans.com/en/
http://www.aimsun.com/wp/
http://www.caliper.com/transmodeler/

A transport simulation table[1]:

1 https://upload.wikimedia.org/wikipedia/commons/7/71/Simulation_Table.JPG

Table 4 Types Of Simulation In Transportation

Time	State	Space		
		Continuous	Discrete	N/A
Continuous	Disc.	Real Transportation Systems * Traffic flow, pedestrians Dynamic traffic assignment		Discrete Event Systems * queueing inventory manufacturing
	Cont.	PDE Traffic flow models Pedestrian models		ODE vehicle motion car suspension queueing (fluid approx)
Discrete	Disc.		Cellular Automata * Traffic, pedestrians Land use Urban sprawl Random Number Generation	Discrete Event Simulation * queueing inventory manufacturing
	Cont.	Car-following models * Microscopic traffic flow models *	Numerical PDE methods Godunov, Variational	Numerical ODE methods Euler, Runga-Kutta time-series * ARIMA
N/A	Disc. or Cont.	Monte Carlo method * : use of pseudo-random number Simulation of static probabilistic problems Integration, Optimization		Econometric models trip generation, distribution, modal split Optimization static traffic assignment

For traffic some of them are:

Paid: traffic flow simulators:

- Quadstone paramics (microscopic)
- VISSUM (macroscopic)
- VISSIM (microscopic)
- AIMSUN

Free:

- Matsim
- SUMO (microscopic)
- Repast
- MAINSIM

There are also general-purpose discrete simulation software packages such as SIMIO, Promodel or Flexim, as well as other more specific packages, such as S Paramics, or Simleader.

The maintenance of urban infrastructure consists of a series of actions that require knowledge and experience about the needs of different types of infrastructure (bus stops, signage, benches etc.) to be done in the optimum manner. To achieve this, infrastructure can be changed, expanded and/or replaced in an efficient manner in order to meet the needs of the users of a city.
Some papers about maintenance are:

Hana, and Thakur (2014). In this paper authors explain the use of new material for maintenance since concrete, asphalt pavements, and ballast are removed during the re-construction of existing roads and have been increasingly recycled as aggregates for the construction of roadways. As they explain "This paper reviews recent research work on the use of geosynthetics to stabilize recycled aggregates in roadway construction and summarizes the main findings on permanent deformation, creep deformation, degradation, stress distribution, and/or crack propagation."

Another paper in the same way is the one of Corinthias et al (2014). "This study investigates the eco-burden effect of road construction in its maintenance phase along with the influence of above factors in shortening road life-cycle. By looking at previous studies which tend to focus on eco-burden in ideal condition of road life-cycle, this study throws new light on the effects of abnormal phenomena on road usage which shorten pavement life-performance as well as increase eco-burden impacts."

Urban transport infrastructure has a direct impact on people's daily lives, which can, in a positive or negative way (depending on its condition), affect the competitiveness of people in general and the country at large (depending on the competitiveness of its urban infrastructure on a global level).

There are many factors that lead to the growth of urban transportation, but we must not forget other important factors such as rural development, use of the countryside or urban development.

That is why forecasting and transportation data are two other important topics in this section, considering forecasting as an important tool for designing, building, operating, and maintaining models for forecasting the demand for transport. These models are built using optimization algorithms as well as simulation software.

Forecasting is used in Durango-Cohen (2007) in order to address performance prediction and maintenance optimization for transportation infrastructure facilities.

4. Technology for the Transportation Systems

The issue of the proper and efficient administration of urban transport infrastructure contains many technological, political, and social aspects. So it is necessary to use an interdisciplinary approach such as geotechnology, whereby digital technologies can be integrated for a spatial analysis of reality.

Geotechnology, in other words, is presented as a new vision of geographic space that enhances the field of computer systems using cybernetic human and electronic systems for the analysis of physical and social Buzai (2012) and its scope is ever expanding geoBlog (2007).

Some geotechnological tools are:

- Geographic Information systems (GIS).
- Global Positioning System (GPS).

GIS integrates hardware, software and data for capturing, managing, analyzing and displaying geographically referenced information. GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns and trends in the form of maps, globes, reports, and charts. A GIS helps us to answer questions and solve problems by looking at all the available data in a way that is quickly understood and easily shared. Some of the top 5 benefits that GIS has to offer are the following:

- Cost saving and increased efficiency
- Better decision making
- Improved communication
- Better record keeping
- Geographical management

Nowadays we are living in an era characterized by technological advances, mobile devices are much stronger, more efficient and capable than they used to be and for this reason a new type of commerce has been created, called Mobile Commerce, where people can make transactions through their mobile device. A subcategory of Mobile Commerce is Location Based Commerce whereby a mobile device can inform its user through a GPS system certain information that can make the user's life easier; for example a user can be informed whether he is near a gas station, hospital or restaurant. Thus we can see that geography and the technologies associated with it are connected with humans to such a degree that they can help us in our daily round. Location based m-commerce, according to Turban et al. (2008), can be divided into the following 5 categories:

i. **Location**: the service that can determine the place of a person.
ii. **Mapping**: the service relating to the creation of maps for specific locations.
iii. **Tracking:** the surveillance of a person through his/her route.
iv. **Navigation:** the creation of the ideal route between two locations.
v. **Timing:** the calculation of the time that a vehicle needs to cover a specific route.

The need for efficient transport networks means that their operation has become a primary focus, so intelligent transport systems have been used as tools to make this efficiency possible. ITS systems apply transport systems technology to solve problems and achieve optimum performance.

Some example of ITS can be found in these papers:
Astarita et al. (2014) propose an automated sensing system for monitoring of road surface quality by mobile devices.

South Korea continues to lead the way in digital opportunity with its recent, innovative and ubiquitous city projects. Author Dong-Hee Shin (2009) with his paper: Ubiquitous city: Urban technologies, urban infrastructure and urban informatics, analyze and evaluate the process of design and development of u-city.

Planning local public transport is done by Pensa et al. (2014), "This paper describes a visual tool for data analysis applied to a case in public transport. Our tool is based on geo-referenced dynamic maps, created with free Web GIS applications, and allows users to visualize data and interact readily with a large database of public transport service information"

Vaiana et al. (2014) use GPS and other technologies for the road safety, by developing a road safety performance index.

Simonyi et al. (2014) developed a smartphone application (i.e., an app) for facilitating the assessment of urban public transport services is presented and its applicability and versatility. Samples of the data collected and evaluated are presented in conjunction with public transport services in Budapest, Hungary.

Campos Ferreira et al.(2014) present an innovative ticketing solution based on customers' mobile devices, which intends to minimize the investment cost from the Public Transport Operators and customers' perspective, maximizing consumer's acceptance. Project was developed in Porto city.

Vitale et al. (2014) in their words "this paper presents a Decision Support System that relies on a logical network architecture characterized by the communication paradigm REST and powered by the use, on Client side, of smartphones that today have an enormous social relevance."

Blaschke et al. (2014). The amount of scientific literature on (Geographic) "Object-based Image Analysis – GEOBIA has been and still is sharply increasing. This article investigates these development and its implications and asks whether or not this is a new paradigm in remote sensing and Geographic Information Science (GIScience)".

Colomina, and Molina (2014) discuss the evolution and state-of-the-art of the use of Unmanned Aerial Systems (UAS) in the field of Photogrammetry and Remote Sensing (PaRS).

Belgiu et al. (2014) in their article Quantitative evaluation of variations in rule-based classifications of land cover in urban neighbourhoods using WorldView-2 imagery, analyze "the increasing availability of high resolution imagery has triggered the need for automated image analysis techniques, with reduced human intervention and reproducible analysis procedures".

The iRAP project uses technologies such as GIS and GPS with cameras in vans for the purpose of preventing road accidents and, when combined with ITS, can prove to be a really useful tool in the hands of the agencies responsible for the urban infrastructure, helping them to obtain in-depth knowledge of the state of the urban infrastructure in order to be able to meet future needs through a well-defined planning strategy. The International Road Assessment Programme (iRAP) is a registered charity dedicated to preventing the more than 3,500 road deaths that occur every day worldwide.

A Comment
There was more work but for lack of space was not possible to write down here, as environmental and social impact, connectivity, accessibility, security, more planning, and cases in many countries.

References

Alminas, M. Vasiliauskas, A. V. Jakubauskas, G. 2009. The Impact of transport on the competitiveness of national economy. Department of Transport Management, 24(2): 93-99.

Álvarez-Herranz, A. Martínez-Ruíz, M.P. 2012. Evaluating the economic and regional impact on national transport

and infrastructure policies with accesibility variables. Transport, 27 (4), 414-427.
Amirazodi, T. 2012. Sustainable Urban Transport Management and Its Strategies. World Academy of Science, Engineering and Technology Vol:6.
Aschauer DA. 1991. Transportation spending and economic growth: the effects of transit and highway expenditures. (Report). Washington, D.C: American Transit Association.
Astarita V., A., Vaiana, R., Iuele T., Caruso, M.A, Giofrè Vincenzo P., De Masi F. 2014. Automated sensing system for monitoring of road surface quality by mobile devices. Procedia - Social and Behavioral Sciences 111, 242 – 251.
Awasthi, A., Omrani, H., Gerber, P. 2013. Multicriteria decision making for sustainability evaluation of urban mobility projects. Working papers No 2013-01 January 2013 CEPS.
Balaker, T. 2006. Do economists reach a conclusion on rail transit? *Econ Journal Watch*, 3(3): 551.
Baranda Sepúlveda, B. Hacia una estrategia nacional integral de movilidad urbana. Movilidad Urbana Sustentable.ITDP México http://mexico.itdp.org/wp-content/uploads/Movilidad-Urbana-Sustentable-MUS_.pdf [Accessed July 2015].
Behrisch, M., Bieker, L., Erdmann, J., Krajzewicz, D. 2011. SUMO – Simulation of Urban MObility. SIMUL 2011 : The Third International Conference on Advances in System Simulation
Belenguer, J.M, Benavent, E., Prins,C., Prodhon, C., WolflerCalvo, R. 2011, A Branch-and-Cut method for the Capacitated Location-Routing Problem. Computers & Operations Research 38, 931–941
Belgiu, M., Draˇgu, L., Strobl, J. 2014. Quantitative evaluation of variations in rule-based classifications of land cover in urban neighbourhoods using WorldView-2 imagery. ISPRS Journal of Photogrammetry and Remote Sensing 87, 205–215.
Berman, O., Ianovsky,E., Krass, D. 2011, Optimal search path for service in the presence of disruptions, Computers & Operations Research 38, 1562–1571, Elsevier.
Black, J. Páez, A., Suthanaya, P.A. 2002. Sustainable Urban Transportation: Performance Indicators and Some Analytical Approaches, Journal of Urban Planning and Development.
Blaschke, T., Hay, G.J., Kelly, M., Lang, S., Hofmann, P., Addink, E., Queiroz Feitosa, R., van der Meer, F., van der Werff,H., van Coillie, F., Tiede, D. Geographic Object-Based Image Analysis – Towards a new paradigm. ISPRS Journal of Photogrammetry and Remote Sensing 87, 180–191.
Buzai, G. 2012. El ciberespacio desde la Geografía. Nuevos espacios de vigilancia y control global, Meridiano, Revista de Geografía No.1. Available from http://www.gesig-proeg.com.ar/documentos/articulos/2012-Buzai-Meridiano1.pdf. [Accessed 10 November 2012]
Calderón, C. Servén, L. 2008. Infrastructure and economic development in Sub-Saharan Africa. The World Bank Policy Research Working Paper, 4712.
Campos Ferreira, M., Nóvoa, H., Galvão Dias, T., Falcão e Cunhaa, J. 2014. A proposal for a public transport ticketing solution based on customers' mobile devices. Procedia - Social and Behavioral Sciences 111, 232 – 241.
Cayuela Prieto, A.L. 2013. La Movilidad urbana. El reto de la sostenibilidad. Instituto del Transporte y Territorio ETS. Ingenieros de Caminos UPV http://www.upv.es/upl/U0462089.pdf.
Colomina, I., Molina, P. 2014. Unmanned aerial systems for photogrammetry and remote sensing: A review. *ISPRS* Journal of Photogrammetry and Remote Sensing 92, 79–97.
Corinthias P., Sianipara, M., Dowakia, K. 2014. Eco-burden in pavement maintenance: Effects from excess traffic growth and overload. *Sustainable Cities and Society* 12. 31–45.
D'Amico, P., Di Martino, F., Sessa, S. 2012. A GIS as a Decision Support System for Planning Sustainable Mobility in a Case-Study. Contemporary Engineering Sciences, Vol. 5, no. 1, 9 – 32.
De Rus, G. 2008. *The Economic effects of high speed rail investment.* University of Las Palmas, Spain, Discussion Paper, 2008-16.
Dijkstra, A. 2011. *EN ROUTE TO SAFER ROADS. How road structure and road classification can affect road safety*. SWOV.Available from http://www.swov.nl/rapport/Proefschriften/Atze_Dijkstra.pdf. [Accessed 3 March 2013].
Dong-Hee Shin. 2009. Ubiquitous city: Urban technologies, urban infrastructure and urban informatics. *Journal of* Information Science, 35 (5), pp. 515–526.
Fancello G., Carta M. and Fadda P. 2014. A modeling tool for measuring the performance of urban road networks. Procedia - Social and Behavioral Sciences 111. 559–566.
Flores, I., Chatziioannou, I., Segura, E., Hernández, S. 2013. Urban Transport Infrastructure: A state of the art. Proceedings of the European Modeling and Simulation Symposium.pp.83-92.
Guerriero, F., Pezzella, F., Pisacane, O., Trollini, L. 2014. Multi-objective optimization in dial-a-ride public transportation. Transportation Research Procedia 3. 299–308.
Hana, J., Thakur, J.K. 2014. Sustainable roadway construction using recycled aggregates with geosynthetics. Sustainable Cities and Society 14.342–350.
http://www.irap.net/en/ [Accessed July 2015].
http://www.jda.com/ JICA [Accessed July 2015].
Hassan El Rashidy, R.A. 2014. The Resilience of Road Transport Networks. Redundancy, Vulnerability and Mobility characteristics. Ph. D thesis, Sep. 2014. The University of Leeds, Institute of Transport Studies, Faculty of Environment
Johnston, R. A. 2004. The Urban Transportation Planning Process. In S. Hansen, & G. Guliano (Eds.), The

Geography of Urban Transportation (pp. 115-138). The Guilford Press.Mult-Modal Transportation Planning.
Klunder,G.A. Post, H.N. 2006, The Shortest Path Problem on Large-Scale Real-Road Networks, *Networks* 182-194.
KPMG 2010. International, Success and failure in urban transport infrastructure projects. A study by Glaister, Allport, Brown and Travers KPMG's Infrastructure Spotlight Report.
Levy, J. M. 2011. Contemporary Urban Planning. Boston: Longman.
Litman, T. 2012. Introduction to Multi-Modal Transportation Planning Principles and Practices. Victoria Transport Policy Institute.
Litman, T. 2011. Measuring Transportation Traffic, Mobility and Accessibility. Victoria Transport Policy Institute.
Ľos, P. 2007. Mobility indicators and accessibility of transport. Slovak Journal of Civil Engineering. March.
Lovelace, R., Ballas, D., Watson, M. 2014. A spatial microsimulation approach for the analysis of commuter patterns: from individual to regional levels. Journal of Transport Geography 34, 282–296.
Lupano, J. A., Sánchez, R.J. 2009. Políticas de movilidad urbana e infraestructura urbana del transporte. Documento de proyecto Cepal y Gobierno de Francia.
Mameli, F., Marletto, G. 2011. Can national survey data be used to select a core set of indicators for monitoring the sustainability of urban mobility policies? CENTRO RICERCHE ECONOMICHE NORD SUD (CRENOS).Working papers 2009-2011.
May, A.D. 2014. Encouraging good practice in the development of Sustainable Urban Mobility Plans (In Press). Institute for Transport Studies, University of Leeds, LS2 9JT England, United Kingdom
Mazharul Hoque, Md, Bin Alam, J. 2002. Strategies for Safer and Sustainable Urban Transport in Bangladesh. Urban mobility for all. Proceedings of the 10th international Codatu conference, pp.559-565.
Nenseth, V., Christiansen, P., Hald, M. 2012. Indicators for sustainable urban mobility –Norwegian relationships and comparisons. Institute of Transport Economics. TØI Report 1210/2012.
Nussio, F.2009. Defining urban mobility indicators. http://www.airqualitynow.eu/comparing_smi.php.
Ove Hansson, S. 2010. Technology and the notion of sustainability. Technology in Society 32, 274–279.
Pardo, C.F. 2011. SUSTAINABLE URBAN TRANSPORT Chapter 4. Shanghai Manual – A Guide for Sustainable Urban Development in the 21st Century
Paz, A., Maheshwari, P., Kachroo, P., Ahmad, S. 2013. Estimation of Performance Indices for the Planning of Sustainable Transportation Systems. Hindawi Publishing Corporation Advances in Fuzzy Systems Article ID 601468, 13 pages.
Pensa, S., Masala, E., Arnone, M., Rosa, A. 2014. Planning local public transport: a visual support to decision making. Procedia - Social and Behavioral Sciences 111, 596 – 603.
Rockwood, D., Garmire, D.2015. A new transportation system for efficient and sustainable cities: Development of a next generation variable speed moving walkway. Sustainable Cities and Society 14, 209–214.
Simonyi, E., Fazekas,Z., P. Gáspár. 2014. Smartphone application for assessing various aspects of urban public transport. Transportation Research Procedia 3, 185 – 194
Solecka, K., and Żak, J., 2014. Integration of the urban public transportation system with the application of traffic simulation. Transportation Research Procedia 3, 259–268
Spiliopoulou, A., Kontorinaki, M., Papageorgiou, M., Kopelias, P., 2014. Macroscopic traffic flow model validation at congested freeway off-ramp areas. Transportation Research Part C 41, 18–29.
SWOV Institute for Road Safety Research, Advancing Sustainable Safety. National Road Safety Outlook for 2005-2020. Ed. Fred Wegman and Letty Aarts.
The City of Calgary, Transportation Department. Available from http://www.calgary.ca/Transportation/Pages/Transportation-Department.aspx. [Accessed 8 march 2013].
The International Road Assessment Programme (IRAP). Available from http://www.irap.net. [Accessed 7 January 2013].
Turban, E.; Aronson, J. E.; Liang, T. & Sharda, R. 2008. Decision Support and Business Intelligence Systems (eight edition). Pearson Education, ISBN 0-13-158017-5.
Vaiana, R., Teresa,I., Astarita,V., Carmine, V., Tassitani, A., Rogano, D., Zaffino C. 2014. Road safety performance assessment: a new road network Risk Index for info mobility. Procedia - Social and Behavioral Sciences 111, 624 – 633.
Van Audenhove, F.J., Korniichuk, O., Hou, J., Doyon, A. 2014. Strategic Directions and Ecosystems to Address China's Urban Mobility Challenges. The report summarizes some of the key insights from the "Future of Urban Mobility 2.0" study and puts them in perspective by looking into specific challenges and opportunities within Greater China.
Vitale, A., Carmine Festa, D., Guido, G., Rogano, D. 2014. A Decision Support System based on smartphone probes as a tool to promote public transport. Procedia - Social and Behavioral Sciences 111, 224 – 231.
Wanga, J. Y. T., Ehrgott, M., Dirks, K., Gupta, A. 2014. A bilevel multi-objective road pricing model for economic, environmental and health sustainability. Transportation Research Procedia 3, 393 – 402.
Worm, J.M., van Harten, A. 1996. Model based decision support for planning of road maintenance. Reliability Engineering and System Safety 51, 305-316.
Yu, B, Lam W, Lam Tam, M. 2011, Bus arrival time prediction at bus stop with multiple routes, Transportation Research Part C. Elsevier.