THE NEED OF TRAFFIC INFORMATION SYSTEMS INTEGRATION IN THE URBAN PLANNING PROCESS

GEORGE YANNIS, Research Associate
JOHN HANDANOS, Research Associate
JOHN GOLIAS, Associate Professor
National Technical University of Athens, Department of Transportation Planning and Engineering

Abstract

Today, the existing information systems have a great potential for supporting several activities related to traffic planning and management. The interconnection of these traffic information systems into a coherent integrated system will definitively facilitate the engineers' task and will open new horizons for the support of traffic related decisions. This systems integration can be very beneficial for the overall urban and environmental planning and management, especially in the transition era where continuous changes in the city patterns should be followed by respective changes in the traffic patterns.

1. Introduction

The tremendous growth of urban road traffic in the last decades transformed the form of the modern cities and the way of life of their citizens. The changing face of modern cities in the era of transition affects and is affected considerably by urban traffic developments. Traffic planning and management are indispensable elements of the continuous urban planning process of modern cities, whereas they started to be an indispensable parameter in the city environmental planning[1]. Management of the traffic flows and the road infrastructure as well as parking and safety policies require solutions to be incorporated in the overall urban planning process[2]. Only a pro-active policy in traffic planning and management can ensure success of the overall urban and environmental planning process[3,4].

In parallel, new technological developments have several applications in the field of urban traffic planning and management allowing for more sophisticated and appropriate solutions. Information systems concerning traffic data processing, capacity analysis and simulation, signalisation, safety management and other related issues are already used for more than two decades for urban traffic planning and management. Given the local character of the traffic problems, these systems have been developed at local level and very often independent to each other and independent to the overall urban planning process. Today, that several of these systems have reached an acceptable level of maturity and started to be used world-wide, it is time for their interconnection with each other and with the urban and environmental planning process.

The use of appropriate systems in the planning process can minimise future negative traffic and environmental implications, whereas their use in the management process can increase considerably the efficiency of the city traffic. The successful implementation of traffic flow improvements in a road or a road network, assisted by specialised information systems, has as result the improvement of the level of service, the increase of the travel speed, the decrease of the travel time and the restriction of the traffic congestion and traffic accidents. Furthermore, stops, delays and accelerations and decelerations of vehicles are limited, leading to the reduction of energy consumption and atmospheric pollution as well as to a more human form of the urban traffic. Finally, by improving traffic flow, some other alternative solutions - like the construction of uneven junctions which are much more expensive or the limitations in the use of passenger cars which are not easily accepted by the public - can be avoided.

The objective of this work is to present the necessity and the possibilities for integration of urban traffic information systems in the planning process. More precisely, it aims to identify the needs and the benefits from articulating several traffic information systems into a coherent urban planning approach. Furthermore, this work investigates possible problems and limitations of this systems integration and proposes alternative solutions.

This work is based on findings from research carried out in the field of urban traffic information systems where the possibilities as well as the limits of separate operation of the various systems have been identified. This work goes a step beyond by proposing systems integration at two levels; integration into a coherent traffic planning and management process and integration within the overall urban and environmental planning process.

2. Urban traffic information systems

Multiplicity of parameters affecting traffic and urban planning makes the use of information systems a necessary supporting tool for the success of the planning process. Existing urban traffic information systems provide very useful input to all stages of the traffic and urban planning process. This input is provided by each traffic information system separately and most often deals with only a specific traffic issue. The full exploitation of the potential of the above systems requires the combination of their results by the planners and the decision makers within the framework of the traffic and urban planning process. Today, the combination of the traffic systems results is carried out manually limiting thus substantially the alternative choices that the decision makers can evaluate.

There exist several types of traffic information systems covering a wide range of traffic issues[5]. These systems concern items with complexity that ranges from simple algorithms and computer programs for traffic counts to advanced models and information systems for the simulation and the management of the urban traffic. Traffic data collection and processing, capacity analysis and simulation, signalisation, management of parking, public transport and road safety, are some of the traffic science areas where applications of traffic information systems provide very useful solutions.

The exhaustive presentation of these traffic information systems overpasses the scope of the present work. Three characteristic groups of traffic information systems have been chosen and their characteristics and possibilities are presented in the following sections. These three groups of traffic information systems were chosen in order to demonstrate the potential and the benefits of their integration within the framework of traffic and urban planning process. The presentation of these three different types - in their contents and their philosophy - of traffic information systems is given in a sufficient degree of detail allowing for the formation of a complete picture of their role within the traffic and urban planning process. These traffic information systems concern traffic data processing, capacity analysis and road safety.

<u>Traffic data processing</u>

Data processing in the urban traffic planning and management is a key activity, on the quality of which all other activities depend. A wide range of specialised data must be collected and put together in order to allow further simple or complex traffic analysis. These data refer basically to : vehicle classification data, intersection turning movement volumes, midblock, crosswalk and corner pedestrian traffic counts, data from moving vehicle studies, data from radar speed surveys, vehicle delay data, data on arrival times and gap intervals, average arrival rate and average service rate.

An important number of systems for the recording and storage of all the above data is today available[6]. Some of the simple procedures, for which these systems may use all or part of the above data are: the estimation of the turning movements at an intersection when only the approach counts are known, the determination of the peak hour, the calculation of the peak hour volumes by lane movement, the calculation of the peak hour factor and the calculation of the 50^{th}, 85^{th}, 90^{th} and 95^{th} percentile speeds. More complicated , but still simple procedures, in which these data are used comprise the simulation of the performance of freeway bottlenecks and the measurement of the travel time benefits of changes in roadway design (through addition of capacity, increase in travel speed or improvement in roadway reliability).

More sophisticated systems are used for the calculation of delay, time to return to normal flow and queue length resulting from incidents on urban freeways, the estimation of the annual impact of urban freeway congestion in terms of congested travel, motorist delay and excess fuel consumption due to recurring congestion (caused by specific geometric deficiencies and heavy traffic) and motorist delay due to non-recurring congestion (caused by disablement and deficiencies and heavy traffic). Additionally, queuing models are used to analyse any number of single-phase, single-channel facilities, such as parking gates, cashiers, toll booths, garage entrances/exits or intersection approaches. Finally, specialised systems are used for the calculation of the effects of bus stop spacing on traffic, the isolated intersection signal setting and the bus signal pre-emption.

In general, traffic data processing systems can provide reliable and ready-to-use results in several specific traffic management cases. Their advantage consist mainly in the fact that they provide results responding directly and sufficiently to the problems addressed. On the other hand, in most of the cases, traffic data processing systems are neither interconnected between them nor linked to other traffic planning and management systems and consequently their results can not be used by other systems without prior further processing. Their inability to be incorporated in an integrated traffic planning and management approach is a major drawback of these systems.

Capacity analysis

The generation of traffic planning and management schemes which may improve the traffic flow, is often in practice, an iterative process, in which appraisal follows design and redesign until a satisfactory scheme emerges. In many cases, engineers work iteratively towards a single solution to the problem being addressed. In more complex circumstances, a number of alternative options may be developed, which are then subjected to formal assessment.

A range of systems is today available in order to assist traffic engineers in this continuous appraisal process through traffic capacity analysis and simulation[7]. The main characteristic of most of the systems is that they can tell the engineer how well his traffic scheme will work. In general, they do not develop the design automatically as they require, in several stages, additional data by the engineer for the various options proposed. Furthermore, very often each system concerns a certain traffic appraisal which is suited to a certain type of traffic management scheme. The various traffic management schemes may fall into one of the following groups a) schemes involving single junctions, b) schemes involving a network containing a group of junctions.

For schemes involving single junctions, a great number of systems is available today. These systems can be further classified according to the signalisation or not of the junction. Some more specialised systems concerning multi-leg and rotary intersections concern also this type of schemes.

The systems which analyse signalised intersections, determine the level of service based on delay methodology. Some of them may obtain different solutions using optimum cycle time, pre-determined cycle time and required cycle time or include procedures to estimate cycle length and signal timing, while other add optimisation options that produce the best possible capacity analysis for the given conditions, including optimised signal timings and signal phasing. These optimisation options allow the operations method of the capacity analysis to be used quickly and effectively for all aspects of signal analyses, including signal timing, planning studies, impact analysis and geometric design. Finally, there are systems that include important computations concerning the queue length, the service flow rates and the over-saturated delay.

On the other hand, in the systems dealing with the unsignalised intersection capacity analysis, the user enters traffic data in a standard format similar to the signalised templates and the programs calculate reserve capacity and level of service for each movement. More specialised systems can analyse very complex intersection geometric characteristics and signal phasing. Usually, the model parameters can be calibrated by the user. Features such as undetected movements, unequal degrees of saturation, green split priority to selected movements and variable cycle times and flows scales are available.

As far as the schemes involving a network containing a group of junctions is concerned, there exist systems that are designed for the integrated urban network or corridor analysis at a macroscopic level with traffic assignment capabilities[8]. They handle automobiles, trucks, buses and car-pools on freeways and surface streets in a single, integrated environment. The models usually used in these systems, represent traffic in terms of aggregate measures on each section of freeway. They can simulate geometric improvements, HOV lanes, bus operations, lane closures and incidents. Some other models simulate urban streets at different level of detail[9]. They model individual vehicle flow, providing a detailed evaluation of proposed operational improvements in a signalised network. For example, they can evaluate the effects of converting a street to one-way, adding lanes or turn pockets, moving the location of a bus stop or installing a new signal.

Other systems can be used in evaluating the operational effects of various traffic demand, types of traffic control and/or geometric configurations at individual intersections. They may be applied in evaluating existing or proposed intersection designs and for assessing the effects of changes in roadway geometry, driver and vehicle characteristics, flow conditions, intersection control, lane control and signal timing plans upon traffic operations. More complete systems, include multi-movement lane codes, intra-link lane change logic, and detailed intersection simulation logic. Additional actuated controller features include left turn extension, lag left turn hold, conditional service and simultaneous gap out.

All the above systems concerning either isolated intersections, or networks of intersections include procedures for the evaluation and/or optimisation of existing signal timing. These procedures may be used for the analysis and development of the optimal timing plan for a wide range of geometric configurations, detector layouts and phasing patterns available. A variety of measures of effectiveness including delay, operating costs, fuel consumption and emissions to determine the optimum timing settings for pre-timed, semi-actuated, fully-actuated or volume density controls with or without pedestrian actuations are used as well as for the optimisation of arterial progression. Furthermore, they calculate bay length and left turn capacity with and without a bay and they check the bay and warrants for unprotected left turns at signalised intersections. Some of the existing systems may be used for the analysis of various complicated left turn signal treatments with or without left turn lanes, including permitted, protected and permitted/protected and for the calculation of signal timing plans for interconnecting series of interchanges along continuous frontage. Finally these systems may be used for the optimisation of signal timings for large multi-arterial networks based on maximising platoon progression.

All the above systems for traffic capacity analysis, simulation and signalisation, cover broader traffic planning and management areas than the traffic data processing systems. Very often they use results of the traffic data processing systems. However, they present equivalent characteristics as far as the scope of their results and the systems' interconnection is concerned. Even though, most often, traffic capacity analysis and simulation systems provide reliable and ready-to-use results in several specific traffic management cases, in most of the cases, they are neither interconnected between them nor linked to other traffic planning and management systems. This leads to the duplication of the data input work and the limitation of the scope of their outputs and their overall usefulness.

Traffic safety

Traffic safety information systems are systems for collection and storage of traffic safety related data in such a way that data from different sources can be correlated and processed in order to provide conclusions on the role of various factors to traffic accidents. A traffic safety system can concern cases from a limited scale (in depth analysis of certain type of accidents in a certain axis) to a large scale (all types of accidents in the whole city). Very often safety systems contain many different sub-systems of small, medium or large scale.

Traffic safety information systems are basically considered as decision support systems because their main function is the provision of information of the accident causes to the various decision makers. Decisions taking into consideration results from the traffic safety systems can be either of very local significance (installation of traffic lights in a junction) or of a more general application (creation of calm-driving zones with speed limit of 30 km/h). Lately, the increasing importance of traffic safety issues in transport policy, makes that accident analysis results started to be also seriously considered in the urban planning process[10].

In general, traffic safety information systems are classified into three broad categories[11] depending on the number and type of sub-systems included: a) systems only with accident data files, b) systems with accident data files and links with other external data files, and c) systems containing accident and other data files. Other data files, usually contain information about the road network (road type, inside/outside urban area, etc.) the traffic (vehicle- and passenger- kilometres by road user type and network type, etc.) and other general data (population, vehicles, drivers, etc.)[12].

Even though efforts for linking traffic safety information systems with other data are intensified, related results remain poor, specially at urban level. Urban traffic data are rarely available and consistent and several approximation methods are used limiting the reliability of road accident analysis.

3. Integration of the traffic information systems

The description of the various traffic information systems revealed that there is a great potential of traffic information systems supporting several activities related to traffic planning and management. Today, engineers and planners dispose a wide range of tools for the support of the urban traffic planning and management process. However, outputs of these traffic information systems cannot be fully exploited in the traffic and urban planning process as far as these systems operate independently to each other. Each of the existing traffic systems deals with a specific traffic issue which is only a part of the overall traffic problem and which, in turn, is only a part of the overall urban and environmental planning problem.

Systems integration within the traffic planning process

The use of traffic information systems requires several iterations, leading to several results which the engineer has to elaborate and propose alternative scenaria of solutions to be chosen by the decision makers. Actually, the combination of the various systems' outputs into coherent traffic solutions is carried out manually by the engineer, limiting considerably the range of alternative solutions. Results of the traffic data processing systems do not necessarily fit directly to the capacity analysis and simulation systems and the engineer is obliged to transform data processing results in order to further process them.

The integration of the various traffic information systems into a coherent sequence of systems, from the initial traffic data processing to the proposal of alternative solutions scenaria has the potential to increase considerably the possibilities of the existing traffic information systems enhancing thus the quality of traffic and urban planning. The output data of the various traffic systems can automatically be transformed in a form allowing their further processing by another system, whereas the systems can allow for a wider range of input data facilitating their interconnection with other traffic systems.

In fact, this traffic information systems integration can be possible by the implementation of a number of appropriate adjustments to the existing systems allowing for matching input data from one system with output data of another. This integration should be realised with great attention in order to face in an efficient and accurate way all systems' particularities related to input and output processes.

Furthermore, the interconnection of the various systems could augment considerably the quantity and, most probably, also the quality of the proposed traffic solutions, as the results from the various systems would be more easily co-evaluated. The participation of the engineer would be more efficient as repetitive and laborious combinations of results would be carried out by the traffic systems themselves and the engineer will only evaluate the results. The co-evaluation of results from traffic data processing, capacity analysis and simulation and signalisation optimisation may reveal solutions which are not necessarily evident by the separate operation of the systems. Planners and decision makers will benefit a lot from this traffic systems integration as they will be supplied by a wider range of high quality alternative solutions, on the evaluation of which they can base their decisions.

In parallel, the various traffic problems are part of the overall urban traffic pattern and therefore respective solutions should not be considered separately but all together in the framework of the overall traffic pattern. Solutions to a certain traffic problem (e.g. operation of bus-lanes) could be incompatible with solutions to other traffic problems (e.g. pedestrians' safety or increase of the overall network capacity). Therefore, solutions to the various traffic problems should be considered altogether aligned with the hierarchised traffic improvement objectives. The efficient joint evaluation of the various traffic problems is possible only when all traffic information systems are integrated into a coherent sequence of systems allowing for the production of complete traffic solutions.

Systems integration within the urban and environmental planning process

Traffic issues are only a part of the overall urban and environmental planning process. The overall urban and environmental planning in a city aims at the improvement of the quality of citizens life which is only possible by the improvement of all city functions in an equilibrated way. The functioning of the transportation means and infrastructure should be co-ordinated with the existing and future land use and the social and cultural web of the city. The development of the transportation plan of the city can be successful only if it is aligned to the urban development plan of the city. Success of small, medium and large scale plans is possible only if transportation and urban planning parameters are continuously revised in the light of changes of each other. Furthermore, the transportation and urban planning should also be continuously revised taking into consideration the citizens' reaction in the planning and implementation processes[13].

Therefore, it is necessary that traffic solutions can be easily re-evaluated in the light of their effects to the overall transportation and urban development of the city. It is also necessary that traffic solutions are re-evaluated according to the results of their implementation and the respective citizens' reaction. This is only possible if the various traffic information systems are interconnected allowing for an easy-to-execute and efficient combined evaluation of their results within the light of the urban planning objectives and of the progress of their implementation. Furthermore, the direct production of complete traffic solutions through the integrated traffic information systems allows the improvement of the urban planning solutions as the impact of the solutions to the new traffic situation is also directly taken into consideration.

For example, the elaboration of alternative scenaria for land use in a certain area requires the simultaneous evaluation of respective alternative complete solutions for the traffic and transportation system. These solutions can be produced almost interactively only when the various traffic information systems are interconnected allowing for the direct extraction of complete results. Thus, evaluation of the various solutions can be carried out almost interactively and arguments concerning the final selection become more reinforced leading thus to a shorter and more reliable decision process. Furthermore, different time schedules concerning priorities of the various steps required can be tested on time. This procedure allows for the correct planning of all required interventions and minimises the probability that the proposed scheme becomes obsolete or requires re-design in order to meet the new needs emerging during the implementation procedure.

Environmental planning will also benefit a lot from the higher quality of traffic solutions[14] as a result of the integration of the various traffic information systems. The direct co-evaluation of the results from the various systems leads to the improvement of the level of service and of the travel speed, as well as to the decrease of the travel time and of the traffic congestion which fall exactly within the objectives of environmental planning[15]. Given that traffic is the crucial parameter in environmental planning, the integration of the various traffic information systems can offer valuable results for the environmental planning process of a city.

Requirements for the systems integration

The interconnection of urban traffic information systems into a coherent integrated system is not an easy task given that several uneven systems have to be put together. Therefore, the systems integration should follow a flexible approach allowing the efficient integration of every type of traffic information system. Models of traffic data processing should collaborate with capacity analysis systems as well as with traffic safety systems.

The efficient realisation of this traffic systems integration should follow a number of general rules[16]. The four basic principles applying to the integration of the various traffic information systems are summarised below:

- The integration of all sub-systems in a coherent integrated set where all its parts work together should ensure the optimisation of information flow between them and the outside world (data input and output procedures). Compatibility of the various traffic information systems is an important and difficult technical issue which must be addressed during the design of the systems integration.

- The value of all traffic information systems depends directly on the quality of data included and therefore it is essential that efficient data quality control and quality assurance checks take place in every stage of the data processing chain. This on going evaluation of the data should refer to data definitions, collection and processing practices as well as data compatibility and comparability among systems. Data is a precious resource for supporting urban planning and management policies and should be accorded appropriate attention in order to allow easy use by the engineers and planners and avoid invalid use by non specialists.

- It is essential that the structure and operation of the integrated traffic information systems are aligned to traffic and urban planning policy and its objectives. The traffic systems should have a set of goals towards which they can aim and by which they can be evaluated. The way traffic systems are developed and operated should clearly reflect their role as supporting tools for urban planning and management in the final view of improving quality of city life in the transition era. Generally, to be most effective, system goals and urban planning goals must be forged at the same time. Furthermore, because specific urban planning goals do not stay fixed for long, the traffic systems must continuously monitor the evolution of urban planning and traffic systems goals in order to ensure that the two stay aligned.

- An efficient management structure is necessary for the successful realisation of the integration of the traffic information systems. Appropriate organisational provisions are a prerequisite for the optimum integration of the various systems into a coherent integrated system[17]. Very often, failure of the systems integration is due to rather organisational than technical deficiencies. The optimisation of the information flow, from the data collection to the production of the results, requires an adequate organisational structure on behalf of the engineer, dealing with both small and large scale problems.

4. Conclusion

Today, the existing information systems have a great potential for supporting several activities related to traffic planning and management. The interconnection of the various traffic information systems into a coherent integrated system will definitely facilitate the engineers' task and will open new horizons for the support of traffic related decisions. This systems integration can in turn be very beneficial for the overall urban and environmental planning and management, especially in the transition era where continuous changes in the city patterns should be followed by respective changes in the traffic patterns. Planning and management of the traffic and the general urban environment should be able to evolve as the city life evolves and this is only possible if the supporting information systems can easily evolve as a whole towards the new traffic and urban reality.

The integration of the various traffic information systems will transform the notion of urban and environmental planning by creating a direct interrelation between traffic parameters and urban planning decisions. Urban planning and related decision making will obviously be more realistic as traffic parameters will be taken directly into consideration. Furthermore, this integrated approach in traffic information systems can be not only the first step towards integration of all related information systems in the urban planning process (traffic, transportation, land use, GIS, cost models, etc.) but also a very good example for equivalent systems integration in the field of land planning process. Further consideration is of course required for the improvement of the integration of information systems in the urban planning process as well as for the advancement of relevant systems integration in the context of global environmental and land planning. Care should be taken that this integration is flexible enough to adapt to the conditions of the current transition era where user needs and supporting systems evolve rapidly.

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