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Conference Paper

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46th Congress of the European Regional Science Association: "Enlargement, Southern Europe and the Mediterranean", August 30th - September 3rd, 2006, Volos, Greece

Provided in Cooperation with:
European Regional Science Association (ERSA)

Suggested Citation: Pozoukidou, Georgia (2006) : Planning Support Systems' Application Bottlenecks, 46th Congress of the European Regional Science Association: "Enlargement, Southern Europe and the Mediterranean", August 30th - September 3rd, 2006, Volos, Greece, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:
https://hdl.handle.net/10419/118507

Planning Support Systems' Application Bottlenecks

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Abstract. Information technology, urban models and decision support tools have been and will continue to be an integral part of the decision making process in planning. Despite their unambiguous significance, they are underutilized in professional practice. This paper presents the results of a study on the applicability and effectiveness of a complex land use modelling tool in planning practice and agencies' decision making processes. The study intended to capture users' perspective and record their experiences when using the modelling tool. The basic research assumption was that there are certain functional and structural factors that could operate as obstacles, or bottlenecks, and block or delay the implementation of such systems. Twenty U.S. Metropolitan Planning Organizations participated in the research and were asked to evaluate the tool in the context of their planning and decision making practices. Based on the research results there are suggestions regarding the development, application and dissemination of Planning Support Systems in agencies and planning practice.

Keywords: Planning Support Systems, Urban Planning and Computer Tools, Urban Models, Land Use Modeling, Usability of Planning Tools

1. Introduction

Both history and current circumstances suggests that regional planning organizations will be major actors in the U.S. planning arena over the next decades. With the enactment of ISTEA and TEA-21, new requirements and responsibilities were brought to elected officials regarding transportation decision-making. Metropolitan Planning Organizations (MPOs) and State Departments of Transportation (SDOTs) are responsible for transportation and land use planning decisions and are required to assess the impact of their transportation policies on land use development. Hence, these agencies are now mandated to use sophisticated information management tools and complex land use modeling methods.

A literature review on computer use in planning suggests that there is a continuous failure to use complex planning methods, like urban models, and decision support tools in planning practice. As a result there is an inability of planning agencies to systematically assess the implications of their planning decisions and thus fulfill their role mandated by the new legislative requirements.

At the same time there is no substantial research regarding the factors that prevent agencies to effectively utilize such tools in everyday planning practices. This created an interest for exploring the use of Planning Support Systems in planning agencies, such as to identify the functional and structural factors that could operate as obstacles and block or delay the implementation of such systems in practice.

2. Decision-Making in Regional Governance; the New Status Quo

On June 9, 1998, President Clinton signed into law, the Transportation Equity Act for the 21st Century (TEA-21) authorizing highway, highway safety, transit, and other surface transportation programs for six years. TEA-21 was built upon initiatives established previously with ISTEA and Clean Air Act (CAA.). The new act combined the continuation and improvement of current programs with new initiatives to meet challenges such as: *improving safety* as traffic continued to increase at estimated record levels; *protecting and enhancing communities* and the natural environment where transportation is provided and; *advancing America's economic growth and competitiveness* domestically and internationally with efficient and flexible transportation.

With the enactment of ISTEA and TEA-21 new requirements and responsibilities were brought to elected officials regarding transportation decision-making. Metropolitan Planning Organizations (MPOs) and State Departments of Transportation (SDOTs) are responsible for transportation and land use planning decisions. Actually ISTEA gave MPOs more equality with the state transportation departments. After 10-years of minimal funding and responsibilities, MPOs were asked to be the key players in transportation planning for their regions. Designated by the Governor of each state, MPOs were responsible for creating and maintaining the transportation planning, programming, and funding systems at the metropolitan level. Typically, the boards of the MPOs included local officials and representatives of transportation providers, such as public and private transit operators. An MPO staff consisted of transportation planning professionals and administrators.

Large MPOs were leading the process of selecting projects to be undertaken with certain categories of federal funds. They were required to consider a wide range of economic, environmental, and social goals in deciding amongst their projects. Transportation Improvement Programs (TIP) were no longer wish lists of projects from which state officials could pick and choose as funding became available. MPOs had to create realistic lists and multi-year agendas of projects to match available funds. Furthermore, ISTEA doubled the funding of the MPOs operations and required the agencies to evaluate a variety of multimodal solutions to roadway congestion and other transportation problems. Also, MPOs were required to broaden public participation in the planning process and to examine that the investment decisions contributed were meeting air quality standards of the CAA.

TEA-21 provided the U.S. Department of Transportation (USDOT) with $120 million in funds for a six year period to encourage state, local, and regional agencies to partner with non-profits, private sector interests and each other in order to bring together transportation and land use decisions. The goal of the initiative was to create

funding sources for states, MPOs, and/or local governments that would better coordinate land use and transportation planning.[1]

More specifically the Act required that each MPO engaged annually in a process of updating its Transportation Improvement Program (TIP). TIP is basically a "list" of every highway, transit system, bridge, and any surface transportation project selected by the MPO to receive funds over the six year period. Each year, MPOs must decide what projects to include in their six year TIP. These decisions are based on a variety of factors, including travel demand, need for facility maintenance and repair, impacts of projects on local and regional economies, land-use, environment, and other areas. In addition, MPOs tracked projects, through various stages, toward implementation. These stages include federal and state reviews, improvement design and cost, construction scheduling, and actual construction over several years.

From a management perspective, all of the requirements, duties, and responsibilities called for increased sophistication of MPOs in the areas of information-management, decision-support and land use modeling techniques.

2.1 The need for an information management system

As mentioned earlier, TEA-21 created a new federal, state, and local partnership for transportation planning and programming, and shifted several duties and responsibilities to regional and local level transportation agencies. Nevertheless, some of its new requirements strained the capacities of many MPOs. For instance, TEA-21 required that a transportation planning and programming process should consider the impacts of projects on the economy, land use, environment, and historical and cultural resources, result in a "financially constrained" TIP (Transportation Improvement Program), weigh alternatives to highway solutions, and identify projects that were in "conformity" with applicable standards of the CAA.

As a result it became imperative for MPOs to have, in hand, sophisticated decision-making techniques that could adequately account for the impacts of TIP projects in terms of economic vitality, environmental protection and energy conservation in their region. However, the reality was that MPOs were not sufficiently equipped to fulfill their new role.

Preliminary research on tools and methodologies used by MPOs in decision making revealed that they used oversimplified methods and techniques to make their transportation and programming decisions. In most cases they were using "scoring criteria" to rank projects against objectives or goals identified in the planning process.[2] Each project was then prioritized according to the assigned score. Spreadsheets, such as MS Excel and Ms Access were used for applying such methods. It is worth mentioning that these techniques were mostly qualitative, and usually there were no quantitative measures to account for projects' implications.

In the absence of sophisticated planning tools, TELUS the Transportation Economic and Land Use System was developed to respond to the provisions of TEA-

[1]Hank Dittmar, TEA-21-More than a Free Refill, _____

[2]This research was conducted by the author in the form of informal interviews with MPOs representatives and web based search.

21. TELUS is an information-management and decision-support system that was designed specifically to help MPOs fulfill their legislative responsibilities.

The North Jersey Transportation Planning Authority (NJTPA), the fourth largest metropolitan planning organization, initiated the development of TELUS as a tool to help meet the TEA-21 legislative mandates. Between 1996 and 1998, the New Jersey Institute of Technology, the lead institution in the development of TELUS partnered with the Center for Urban Policy Research at Rutgers University and the North Jersey Transportation Planning Authority to design, develop, and implement the system. The NJTPA staff and the Authority's project steering committee largely guided the system's design, thus ensuring that the product would meet the needs of the MPO and fulfill the ISTEA mandates.

The design criteria required that the system would have an ease to use graphical interface, strong querying and sorting capabilities, a GIS integrated into the system and finally, computer models to identify economic and land use impacts of each project and investment.

According to NJIT, TELUS as a system is designed to allow for quick and efficient evaluation of alternative project scenarios and the financial implications of each, thus enhancing an MPO's ability to produce a financially constrained TIPs that would conform to air quality standards. All the components of TELUS were designed as informational and decision-support features; in an effort to avoid mysterious black boxes out of which answers would flow. In this sense, TELUS components were designed, to augment the MPO's decision-making process, but not to supplant it. TELUS was intended to strengthen the decision-making capability of MPOs and ensure that local elected officials, appointed officials, citizens, special interest groups, and others could participate knowledgeably and effectively in the transportation planning process.[3]

The system consists of three main components:

The *Automated TIP Component*, which builds a large database that contain key information (e.g. project description, location, cost, type of improvement, etc.) about every project in the TIP. Except simple housekeeping routines, using this information the system can perform more complex routines, such as identifying potential conflicts in the accessibility among projects being constructed at the same time.

The *Economic Component*, which uses an "Input-Output" model to analyze the investment made in a single project or group of projects as related to number of jobs that will be created, the impact on income, and the effects on local and state tax revenues (model outputs reflect impacts in the "home" county, adjacent counties, the region and the state).

The *Land-Use Component*, which uses a land-use model to project the location of new residential and nonresidential development, the location and amount of future population, household, and employment growth, and calculates the dollar value of travel-time saved as a result of transportation improvements.

[3] Pignatero Luis and Epling John. The TELUS story. Information Tool for Transportation Planning Makes its Début, TR News 210

When TEA-21 was passed by the Congress in 1998, the Act included the amount of $1 million per year over six (6) years toward the development and deployment of TELUS. The system was copyrighted and was free to any MPO wishing to use it.

In conclusion, TELUS is certainly an ambitious effort to modernize and computerize local governance. As a planning support system itself is an improvement and great addition to the decision making process of an MPO. Its three components will enable MPOs to enhance their analytical skills and involve quantitative methods, in addition to using their local knowledge in the planning processes.

3. The use of Planning Support Systems in practice

Over the last four decades, expensive, fragile, remote and hard to use mainframe computers have been replaced by small, inexpensive, easy to use microcomputers that get faster, cheaper, more powerful, and easier to use every day. Dramatic improvements in display capabilities, screen resolution, processing speed, and data storage capacities have also been made. An entirely new kind of software has been developed that make possible the outgrowth of more flexible and user- friendly tools; however, the reality in planning practice remains the same. Available evidence suggests that computers on planners' desks are continuing to be used largely to word process documents, maintain budgets, and store data in order to improve management and increase office efficiency, and not to perform genuine planning tasks (Klosterman, 1994). [4]

A survey conducted by the Journal of Urban Transportation Monitor (March 1996) supports this observation by revealing that only 20 percent of the MPOs that responded to the survey (71 from the 280 MPOs responded) are using some form of urban models. One would think that given the technology and planning tools (i.e. urban models) available this is an extremely low percentage. The editor of the Urban Transportation Monitor journal commented on the responses of MPOs to the different questions of the survey as follows:

> "This week's survey results show that only 20% of the Metropolitan Planning Organizations responding to the survey indicated that they use a regional land use forecasting model to establish future land use in the region for the purposes of transportation planning. The majority of MPOs use techniques that usually requires control totals to be established and then the allocation to zones are done by taking a variety of factors into consideration, such as zoning and subdivision regulations, permit tracking, and tracking of rezoning and subdivision development, community input, etc.

[4] It should be noted that within the context of this paper we consider that traditional concerns of planning and genuine planning tasks incorporate notions and processes like this of plan analysis, plan prediction, plan prescription, and plan evaluation, or in other words "the sketch planning process", a concept that has been first introduced and explored by Britton Harris, and which later became the conceptual base for PSS development (Harris 1960,1984,1989,2001).

> The techniques used by the majority of MPOs are time consuming. Because of this, it is difficult to evaluate alternative land use arrangements in combination with alternative transportation plans. This is one of the most important benefits of land use and transportation planning—the optimization of land use by taking transportation into consideration.
>
> If for various reasons the use of land use forecasting models is not acceptable, then it would be extremely beneficial to develop techniques that will automate the more "manual" techniques in use by most MPOs today.
>
> This will make the evaluation of alternatives less burdensome and the full benefits of transportation planning can be realized"
>
> *Daniel B. Rathbone, Editorial Urban Transportation Monitor (March 1996)*

Until now, we emphasized the need for computer tools that can help MPOs respond to their current and upcoming responsibilities as they formed by recent legislative evolutions. We also acknowledged the fact that we might have great modeling tools in our hands but not a lot of planning organizations are using them. The question that comes in mind is *why when there is such an obvious "need for" and "benefits from" using planning support tools there is only a small percentage of agencies that would actually utilize them in their everyday decision making processes.*

The purpose of the study, which the results are presented in this paper, was to provide answers to these questions based on the usability and applicability evaluation of such tools in agencies' planning processes. For that TELUM-Transportation Economic and Land Use Model was utilized as a case study of a PSS that is used by a number of regional planning organizations.

3.1 TELUM; Structural and functional description

As mentioned earlier in this paper, TELUM is TELUS's land use modeling component. In order for the user to understand the complexity that the process of land use modeling entails, figure 1 portrays in a very general way the interactions and interrelations amongst four basic agents: households, employers, developers, and government. Its purpose is to provide a structured way for the reader to think about land use modeling and to realize the implications, consequences, and reactions of any agent's actions. It also shows how land use modeling can be used to evaluate alternative governmental policies and investments.

For instance, starting with the developers, they use land to construct residential and non-residential space. Land consumption for residential and non-residential space depends on the demand for such space by households and businesses. Businesses, in turn, produce emissions and increase the demand for resources. Governments provide the infrastructure, services and set the policies. Policies have great implications in the land market by altering land prices and, consequently, the type of land uses.

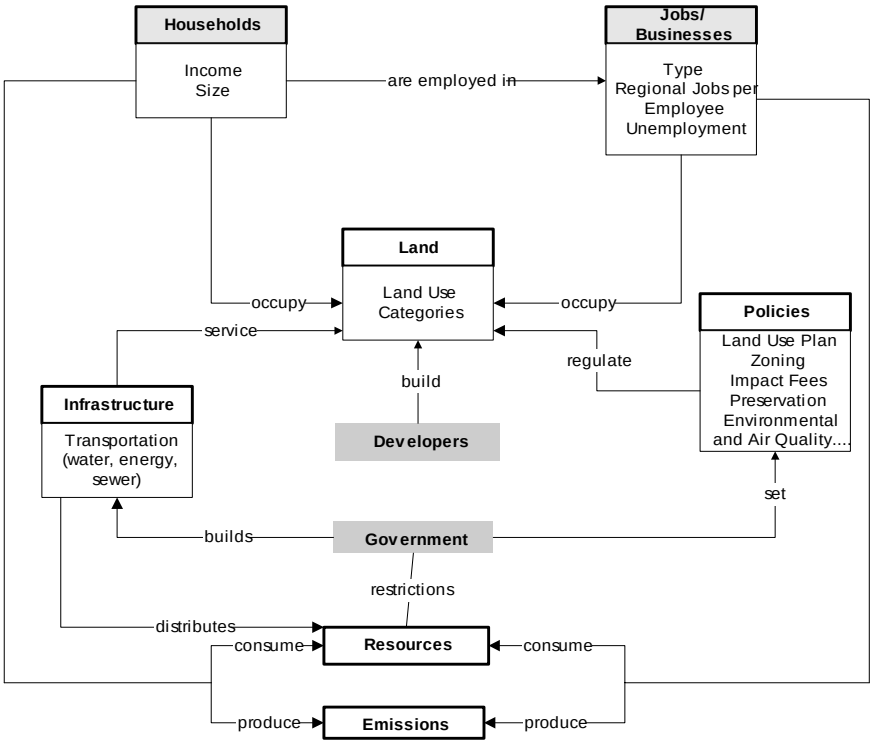

Fig. 1. Interactions represented in TELUM

Having this process in mind, TELUM attempts to replicate agents' interactions and record their consequences in a systematic way that will be easy for the user to comprehend. TELUM does not explicitly model every interaction amongst those agents, but it views them from an aggregative perspective. It focuses on how employment and their location choices affect the future location of the households, and in turn, the implications to the land use development patterns in the region. Actually, developers and government are more of exogenous factors to TELUM; nevertheless, they are important and should not be ignored since the main objective of modeling is to eventually do policy analysis.

The general configuration and overall structure of TELUM is shown in figure 2. The current and fully operational system consists of four main components. The first, and probably most complex component, is the Model Module which is associated with the computational utilities of the modeling process. The second is the Database Management System component, which is associated with preparing the data for analysis and display in various stages of the modeling process within the system. The third is the Geographical Information Systems (GIS) component, which is comprised of a GIS package that provides the user with visualization aids in various analysis phases. Finally, there is the Knowledge Based Systems (KBS), which is not a

component of TELUM, per se, but is there to support the function of the three distinct modules and to communicate with the user.

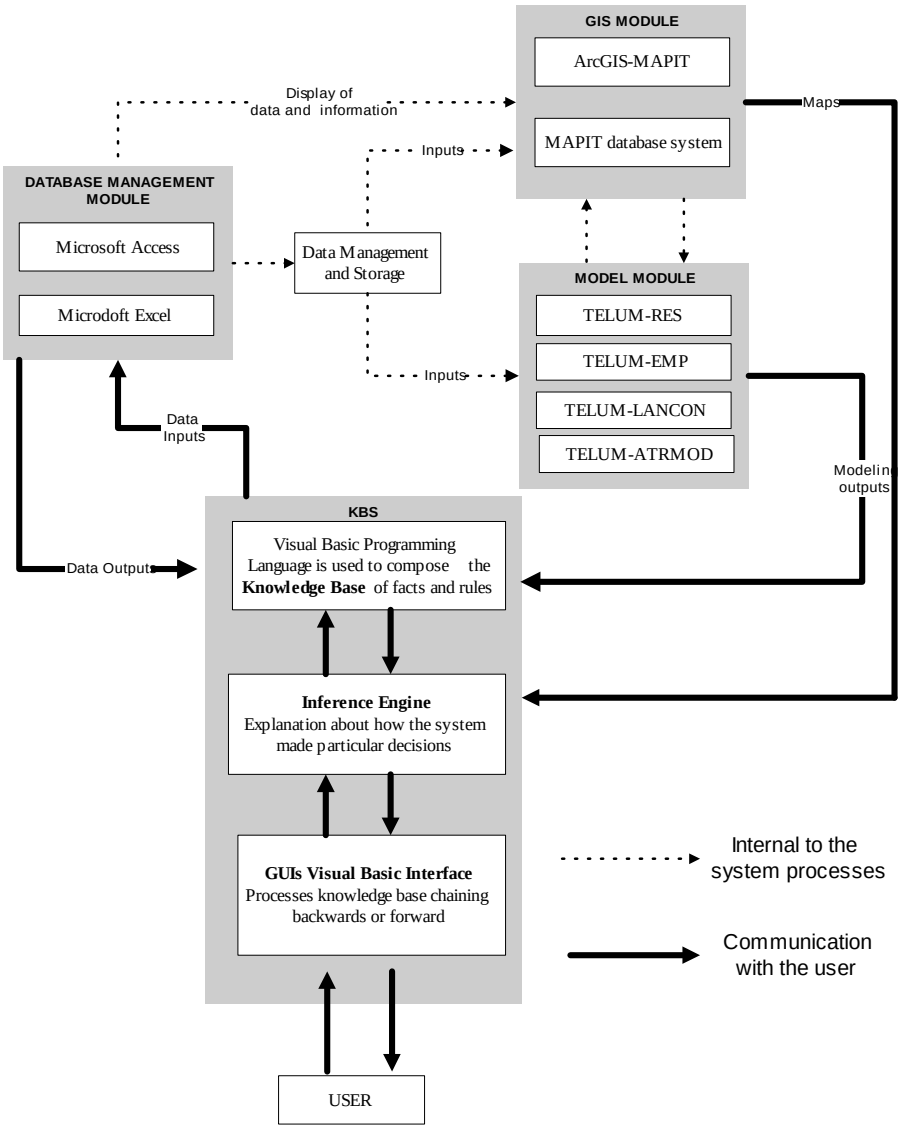

Fig. 2. TELUM Structural Overview

Figure 3 shows the internal structure and function of the Model Module of TELUM. It also portrays the interrelationships between the models, sub-models and their computational utilities. The chart itself is quite self explanatory. The modeling process starts with calibrating the model parameters for both TELUM-EMP (the employment allocation model) and TELUM-RES (the residential allocation model). It continues with forecasting employment and household growth and calculation of the

associated land demand. Based on this land demand, TELUM-LANCON estimates the change in the amount of land (per zone and locator type). If the user desires to make any changes in the forecasts produced by the model, i.e. incorporate local knowledge into the system, s/he can do that by adjusting the attractiveness of land through TELUM-ATRMOD. [5]

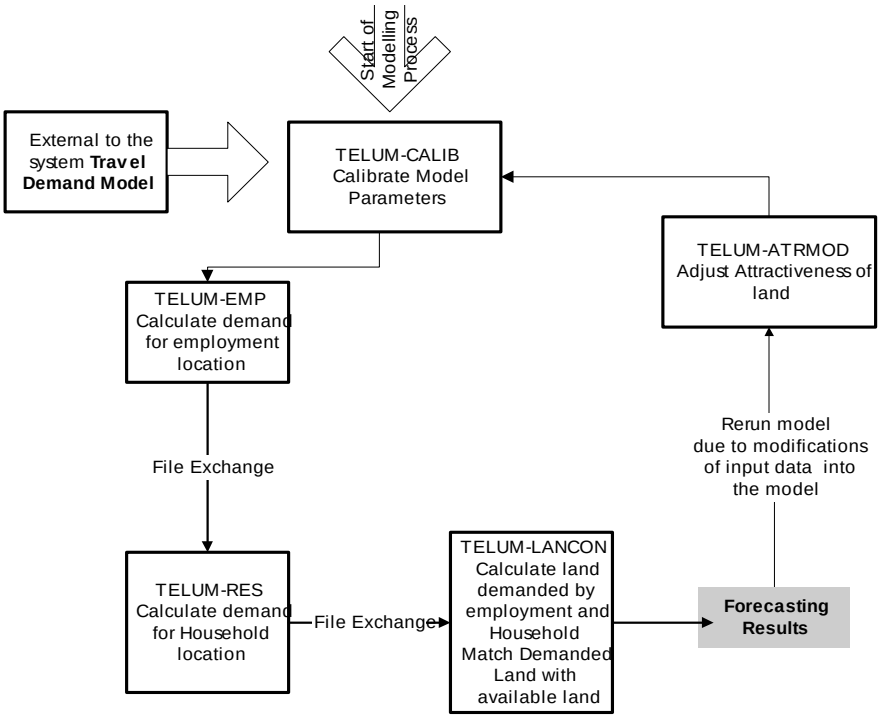

Fig. 3. Modeling process in TELUM's Model Module

[5] In more detail TELUM's model module consists of two major models: TELUM-EMP and TELUM-RES. TELUM-EMP, the Employment Allocation Model, locates employers/employees. TELUM-RES, the Residential Allocation Model locates households to place of residence. There is also an internal sub model, the Land Consumption model, LANCON, which calculates the land consumption consequences of the previously calculated employment and household location demand.

In order for these models to perform their task, they have to employ two major computational utilities. The first is TELUM-CALIB, a calibration process, which uses a modified gradient search technique to calculate TELUM-RES and TELUM-EMP parameters, or coefficients, that produce the best fit for the model equations to region's data. The second computational utility is TELUM-ATRMOD, the attractiveness modification program, which is used to prepare the residual variation from the calibration results for use in the subsequent forecasting procedures and to provide a systematic procedure for incorporating exogenous information from local planners.

The structural analysis made obvious that each module is essential to the modeling process and that functionally they (the models) and the process can be quite complicated. This exact fact, the complexity of the modeling task that is reflected in the structure and function of such systems, discourages the use of models especially when it comes to novice users. This is the part where Knowledge Based Systems (KBS) are found to be extremely useful since they could be used as a way to hide the complexity of the land use modeling task and virtually perform the task for the user. More specifically in the case of TELUM, KBS have been used *to transform and reduce the complexity of the land use modeling task, to interpret statistical results or inferring situation descriptions from available data, diagnose malfunctions over the modeling process and prescribe remedies, support the mathematical parts of modeling, like calibration, monitor and control expected outcomes, and to instruct specific tasks to the user.*

It is important for the reader to understand that what probably makes TELUM different from any other land use modeling tool is the way KBS have been used to increase the functionality and usability of the system such as to make it more user friendly and applicable in planning practice.

Finally it should be noted that there are very few studies regarding usability and applicability issues of such tools in practice and no studies examining their usability from user's perspective. Until now research on urban and land use models was mostly focused on increasing their statistical reliability discounting the significance and importance of their applicability in practice. Exception is a recent study conducted by Vonk, Greetman and Schot that examined application bottlenecks of planning support systems (Vonk, Greetman, Schot, 2005). Their research provided a good understanding of possible bottlenecks in the application of such tools in practice, however it was limited by the fact that their results were based only on PSS developers' perspective, ignoring in fact an equally important component; users' perspective.

4. Research Method

Given TELUM's complexity and scope of design it was interesting to explore how TELUM really fits planning practice. In order to achieve this we performed an evaluation on the applicability and effectiveness of *TELUM* in MPOs' land use planning processes, and its [*TELUM's*] usability and integration as a planning support system in their decision making process.

The purpose of TELUM's evaluation is to capture users' perspective and record their experiences when using it (TELUM) in everyday practice and evaluate its applicability in a setting of a small/medium sized planning organization. The research is based on the assumption that there are certain factors that can operate as obstacles, or bottlenecks, and block or delay the implementation of systems like TELUM in planning practice. A questionnaire identifying these factors was developed and distributed to TELUM users.

The following is a list of the nine major categories or groups of factors that we identified as potential bottlenecks in the implementation and adoption of TELUM. These are: user expertise, data requirements, system requirements, transparency and understandability, staffing and organization structure, planning practices, provider/consultant, and external barriers. For each one of them there is a detailed analysis, which includes a description of the category, what it represents, how it can be in bottleneck in the implementation of TELUM or a PSS in general.

User expertise: User expertise is a very important issue when utilizing TELUM or any PSS. It is well known in planning academia, and it has been mentioned in this paper, that one of the serious bottlenecks in the implementation of urban models in planning practice is their complicatedness. In the case of TELUM the use of KBS permitted and helped to create a planning support system that, according to developer's opinion, users with no modeling expertise can utilize. This category, User Expertise, and its factors will indicate to us if they were successful in their efforts.

The category "User expertise" consists of four factors: Expertise, Training, Confidence, and Assistance.

Expertise: Expertise is referring to the perceived level of expertise that the user should have in order to utilize TELUM. It should be noted that the perceived, by the user, level of expertise is relevant to their educational background, knowledge and experience in regard to modeling.

Training: Training is referring to the desire of the user to get familiarized with the features of the software through a formal training session.

Confidence: Confidence has to do with how the user feels when s/he uses TELUM and is related to the confidence in regard to technology, functionality and structure of TELUM and not to the validity of results and system outputs.

Assistance: TELUM was designed to function as a tool that would be easy to use by novice planning practitioners and to a certain degree replace the need of consulting by an outside land use expert. Under this notion the user should need little or no assistance to utilize TELUM.

Data Requirements: The success of modeling depends on the availability and quality of data inputs. At the same time data availability has always been a constraint factor in model design and in the implementation of models in planning practice. Needless to say, that TELUM has relatively low data requirements compared to the new generation of micro-simulation models. It will be interesting to see what users thought about TELUM's data requirements and how close to reality was the assumption that TELUM's developer made about users being able to easily acquire the few data needed for TELUM to operate.

"Data Requirements" index consists of 8 factors: Data Requirements, Cost, Availability, Quality and Quantity, Accuracy, Standardization, Preparation, Manipulation.

System Requirements: System Requirements indicator is related to the software and hardware specifications necessary for TELUM to run. Most of the time a PSS consists of numerous interconnected software packages. Likewise, TELUM brings together five different software packages that should communicate with each other when at the same time they should be flexible and easy for the user to operate. The factors that comprises "System Requirements" index are: Software, Hardware, Operation, Integration, and Additional Software.

Transparency and Understandability: Urban models' complexity has always been a major drawback in their application in planning practice. For decades now models have been closed "black boxes" that are understandable only to a few experts. As mentioned earlier the purpose of TELUM's development team was to simplify models and make them understandable and accessible not only to the few experts that are currently using them, but also to planning practitioners.

The "Transparency and Understandability" indicator is a measure to assess if and how much users understand and trust TELUM and its outputs. It is very common in planning practice not to use quantitative methods (simulation models, quantitative evaluation of alternative scenarios etc) to back up proposed plans and policy scenarios. TELUM could help planners chance such planning practices. In order for that to happen, users have to understand and trust the results and outputs of models, which in turns presuppose that users are able to understand model's underlying methodology and assumptions.

The factors that comprise *Transparency and Understandability* Index are; assumptions, functionality, understandability and transparency.

Staffing and Organization structure: Successful application of a PSS depends on the acceptance of the system by its users and the agency staff. Agencies often lack available staff with sufficient modeling knowledge to utilize computer software like TELUM. At the same time, it is imperative that management in planning agencies understand and support the use of such tools. The following extensive set of factors tries to identify potential bottlenecks in the application of TELUM that results from the organizational structure and norms of a planning agency.

The "Staffing and Organizational Structure" index is composed of 19 factors. These factors are classified in two distinct groups: characteristics of staff and planning professionals and characteristics and attitudes of the planning agency management teams.

The factors used to calculate the index were: Staff Commitment, Professional Perspective, Managerial Perspective, Staffing, Patience, Previous Experience, Job Improvement, User Friendliness, Previous use of PSS, PSS Awareness, Quantification of Benefits, Hesitance, Design Oriented Culture, Decision Making Process, Communication, and Internal Power Struggles.

Planning Practice: *TELUM* was designed such as to help planning practitioners that have little or no experience using modeling tools. The following set of factors explores why planning practitioners might conclude that TELUM, as a modeling and decision making tool, does not fit their planning practice needs. The *Planning Practice* index comprises of 6 factors: development goals, communicative goals, political goals, information type inconsistencies, appropriateness, and cost.

Provider/Consultant: The role of the developer/provider can be crucial in the implementation and acceptance of PSS in agencies. The *Provider* index was developed as a way to assess the desire or need for developers to provide help and support to agencies that utilize TELUM.

The reader should be aware that TELUM was designed with the scope to reduce (as much as possible) the dependence of the user/agency to an outside/external modeler or land use expert. This means that when we are analyzing user responses we should consider that TELUM was designed to eliminate the needing for consulting and operational support.

External Barriers: *External Barriers* refer to obstacles that are not directly related to the developer or the user, but are more general issues that affect the applicability of models in planning practice. It has been mentioned, several times now, that there is a continuous failure using computer tools in planning. This reoccurring failure might be related to the fact that professional planning schools do not provide adequate education that could help planners understand models and their whereabouts. *External Barriers* index basically represents the lack of appropriate professional quantitative education.

The goal was to create an index for each category that would measure and express the friction that this group of factors causes or the obstacles they set in the applicability of TELUM in planning practice. The friction indicator will be a derivative of the numerous factors that fall under this specific category and is nothing else but an average (mean) of all the individual factors. The value of the indicator (and its individual factors) can vary from 1 to 5, with one indicating that this group of factors does not create any bottlenecks and five that they create serious bottlenecks in the implementation of TELUM.[6]

In order for the reader to understand how friction indicators were created we will demonstrate how we calculated the indicator for the category of "User Expertise". The category of "User Expertise" consists of four factors: Expertise, Training, Confidence, and Assistance. For each one of the factors an interval scale was assigned. This scale aims to express the opinion and/or feelings of the interviewee/user in regard to the specific factor. For instance, in the case of factor "Expertise" user is asked to rank his/her feelings in regard to how much experience, they think, the user should have in order utilize TELUM. In the actual questionnaire this will be as follows:

In order to utilize TELUM software the user needs to have:

1	2	3	4	5
Little or no technical expertise		Some learning and expertise		Significant level of technical expertise

In this case 1 indicates that the user needs little or no expertise to use TELUM and 5 that the user needs to be a real expert in order to work with TELUM. The assumption that we are making is that if a significant level of expertise is needed to utilize TELUM then this can be a serious bottleneck in the implementation of the software in planning agencies. Under this notion a similar scale was developed for the second factor that comprises "User Expertise" indicator, Training;

Do you think that a training session will be helpful for you to better understand how TELUM functions?

1	2	3	4	5
Not helpful at all		Somewhat helpful		Very helpful

[6] The scale used is an Interval and Ratio Scale, meaning that the scale values 1 through 5 are not only mutually exclusive and ordered in a low to high order but they also have equal intervals between them.

In this case a response of 1 indicates that the user feels confident to operate TELUM without training and 5 means that s/he needs a lot of help to operate TELUM, which in turn could be a serious bottleneck. The average of all four factors that comprise "User Expertise" will be the friction indicator for this category.

Using this methodology, nine indicators were calculated for each one of the above mentioned categories. At the end we were able to quantitatively compare these categories amongst them and the 20 users that responded to the survey. In that way we were able to make inferences about which one of the categories could cause major bottlenecks and if different agencies find certain factors more of a bottleneck than others. The questionnaire was sent to the 20 MPOs via mail and email.

5. Results Analysis

The following table shows the ranking for the eight indices in an ascending order. The higher the score, the higher the implementation friction this index causes. According to the scores, the factors causing major bottlenecks are the extensive data requirements; lack of operational support from the developer or the provider of the software; and the limited understanding of TELUM's usability, due to lack of appropriate educational background (both for users and managers). With a lower score, but still a lot of chances to create bottlenecks, is the "high expertise" a user must have in order to utilize the TELUM and land use models, in general.

Index	Average of Factors
3. System Requirements	1.70
6. Planning Practice	1.93
4. Transparency & Understandability	1.94
5. Staffing & Organizational Structure	2.05
1. User Expertise	2.53
2. Data Requirements	2.81
7. Provider	2.96
8.External Barriers	3.00

Fig.4. Overall Rank of Indices

More specifically, models' extensive data requirements could be a bottleneck in their applicability, but not necessarily the one determining their use or not. Availability of data has always been a bottleneck in the implementation of models. Lee in his article "Requiem for Large-scale models" published in 1973, identified models' hungriness (for data) as one of the "seven sins" of large-scale urban models.[7]

[7] The "seven sins of urban models" as referred in the original article were hyper-comprehensiveness, grossness, hungriness (for data), wrong-headiness, complicatedness, mechanical ness, and expensiveness. A more detailed analysis can be found in Kolsterman's article "Large Scale Urban Models: Retrospect and Prospect, at the Journal of American Planning Association, v.60,1 (1994).

Today and 32 years after, someone would expect that availability of data would not be a problem in the applicability of models. Nevertheless the increased requirements of models as far as the quantity and quality of data used could be a major bottleneck in their implementation. For that developers should always consider data availability issues when designing planning tools and not take as granted that users have access to any kind and type of data.

Another issue that came up over the evaluation was the significance of developers' operational support in the acceptance of the tool. Lack of operational support from the provider, or the developer, that would familiarize the user with land use modeling concepts and processes could act as a bottleneck in the adoption and implementation of such systems in planning practice. Even the MPOs that used TELUM indicated that they would like to have some type of operational support from the provider of the software. Support could be in the form of individual or group seminars that would accustom the user with concepts and processes of modeling.

Lack of adequate and appropriate education of agency staff leads to low rates of absorbance and acceptance of a land use modeling system by its users and other agency staff. User responses indicated that the lack of appropriate education could create feelings of distrust and devaluation towards TELUM and its potential uses in agency planning practices, which in turn creates serious bottlenecks in the wide adoption and implementation, of the system. This is because users have to put extra effort in persuading the rest of the agency staff about the value and benefits of using such tools in planning practice.

Finally the determinant factor that advances the use of TELUM in an agency is *the way the managerial team(s) perceives TELUM's usability in the decision making processes and planning practices of the agency*. Current research revealed that inadequate support and encouragement from the managerial team were the factors that prohibited the implementation of TELUM in some agencies, in contrast with the agencies that used TELUM were the managerial attitude was really positive towards the adoption of the new tool in their practices. The *Staffing and Organization Structure* index is related to the characteristics of the staff and planning professionals that utilize TELUM and to the characteristics and attitudes of an organization's managerial team. The index reveals that in the agencies that used TELUM, managers and management team appreciated and acknowledged TELUM's ability to improve agency planning practices. Hence, these management teams encouraged their staff to use TELUM and were more appreciative and aware of the value that TELUM could add in their decision making process.

Finally it seems that there are some political attributes that come into play and affect the applicability of such tools in planning agencies. TELUM is a "politically neutral" planning tool that gives MPOs the opportunity to plan, test, compare, and debate scenarios on a case by case basis. It can also be used as a mitigation tool among conflicting interests. Nevertheless, one should not forget that planning is a highly political process and when scientific results contradict political perspectives of an agency's management team, then the benefits of using such tools might be disregarded.

In conclusion

It has been 45 years from the issue of Journal of American Institute of Planners (1960) were Britton Harris along with some other enthusiastic scientists embraced the idea of creating integrated modeling tools (PSS) that would help planners in their decision making processes. Today's reality is far away from what these planners had imagined. In order for us to continue believe that PSS could have a chance in planning practice, scientists and developers of such systems should start thinking about ways to make these tools more usable and applicable to planning practice. Otherwise each new PSS will remain in the hands of its developers without fulfilling their main role; to help planners do planning.

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