TEL Grants Programs Identifying Information Cover Sheet

Title: Simulating the Interaction of the Growth of Networks and Land Use

Contact information:

- **o name – David Levinson**
- **o department – Civil Engineering**
- **o college – Institute of Technology**
- **o campus address – 500 Pillsbury Drive SE**
- **o telephone number - 612 625 6354**
- **o fax number - 612 626 7750**
- **o e-mail address – levin031@umn.edu**

Grant Proposal: **Simulating the Interaction of the Growth of Networks and Land Use**
By David Levinson

Proposal Abstract: This research will develop a web-based travel demand model and a network forecasting model for use by Civil Engineering and Urban and Regional Planning students in their courses. The software will allow students to test hypotheses about the effects of various behavioral, land use, economic, and network decision on resulting traffic levels and future network investment and market location (land use) decisions. This will apply previous research by the PI to in-class education.

Introduction:
In 1900 there were 240 km of paved road in the United States (Peat 2002), and this total had increased to 6,400,000 by 2000 (BTS 2002) with nearly 100% of the U.S. population having almost immediate access to paved roadways. Similarly, in 1830 there were 37 km of railroad in the United States, but by 1920 total track mileage had increased more than ten-thousand times to 416,000 km miles, and since then, rail track mileage has shrunk to about 272,000 km (Garrison 1996, BTS 2002). The growth (and decline) of transportation networks obviously affects the social and economic activities that a region can support, yet the dynamics of how such growth occurs is one of the least understood areas in transportation, geography, and regional science. This lack of understanding is revealed time and again in the long-range planning efforts of metropolitan planning organizations (MPOs), where transportation network change is treated exclusively as the result of top-down decision-making. Research by the PI has shown that changes to the transportation network can be modeled as the result of numerous small decisions (and some large ones) by property owners, firms, developers, towns, cities, counties, state department of transportation districts, MPOs, and states in response to market conditions and policy initiatives

This project aims to translate the PI's research in Network Growth and Transportation Planning models to useful classroom tools (See Figure 1). Learning how markets and policies translate into facilities on the ground is essential for students to understand and improve forecasting, planning, policy-making, and evaluation, and to move metropolitan planning processes beyond methods developed in the 1950s that are still in use today.

There is a considerable literature on "learning by doing" and developing multimedia computer applications. An examples is Lerman (2002). This literature will be reviewed in depth in the specification task. The PI's own research will form the core of the substantive models in the proposed application. Resnick (1997) has utilized simple programming languages (like Logo) to allow students to develop their own crude simulators. This is clearly important, however it is impractical to expect students to both develop software in a course and then use it to understand behavior at a detailed level, as both are very time consuming tasks of themselves. Rather a program, which takes care of the user interface issues is more appropriate for a substantive course in transportation, while a software development project would be most appropriate for a course in computer science or a research project.

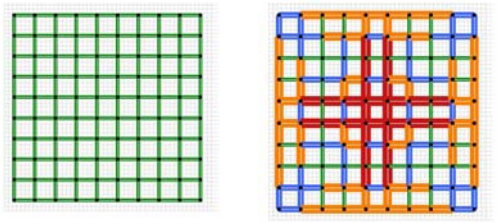

Figure 1: *The evolution of an undifferentiated network (left) to a hierarchical one (right) using simple travel demand and network investment rules (link width and color indicates link speed).*

Programmatic Significance
The curriculum in Introduction to Transportation Engineering (CE3201), Urban Transportation Planning (CE5212) Transportation Systems Analysis (CE5214), and Networks and Places: Transportation, Land Use, and Design (PA8202) devote a considerable amount of time to having the students understand travel behavior, transportation forecasting methods, and network growth. Presently this is done with pencil and paper problems, as well as traditional lectures, as the software that is used in practice to model travel demand is complex, and the objective is to teach the substance, not a particular software package.

Moreover, the software that is available is platform–dependent, and uses old modeling methods and ideas. However, research has found that "learning by doing" is an important component of the education process.

Evaluation Plan

There are several methods to determine whether the project is feasible and useful. First, we can assess whether students learn more, and better understand, the processes underlying travel behavior. This will be determined by reviewing coursework, quizzes, and term papers and comparing with previous years prior to the introduction of the model. Second students will be asked to provide an evaluation of the lab exercises and whether they were worthwhile. In particular, the proposal anticipates a two-phase implementation. The first is a pilot phase, which will be evaluated, and lead to modifications of the models and software to improve their usability. The second phase will test the revised models, and will be assessed, leading to recommendations for future refinements of the models.

Timetable and Budget

	Total	TEL	Department Match
RA Graduate Student Salary and Fringe RA 25% Time 11 Months	$14,000	$12,000	$2,000
TA 25% Time 9 Months	$6997		$6997 Salary
	$4559		$4559 Fringe
Equipment	$2000		$2000 (in-kind)
Software	$1000		$1000 (in-kind)
Supplies	$1000		$1000 (in-kind)
PI Salary (1 mo.)	$6940		$6940 (in-kind) Salary
	$2173		$2173 (in-kind) Fringe
Total	$38,669	$12,000	$13,556 $13,113 (in-kind) $26,669 (Total)

A graduate student will be doing most of the work on the project, beginning as a Research Assistant who will modify the software that was developed as part of previous research, and then as a Teaching Assistant for CE3201-Introduction to Transportation Engineering and CE5214–Transportation Systems Analysis to implement the educational objectives and administer the study. The student will be a 50% TA for two semesters, with one-half of the time associated with implementing the project, the remaining time will be more traditional grading and teaching recitation (so we count the student as a 25% TA for two semesters). The PI will supervise the graduate student in the software development throughout the year and assist the graduate student in applying the research in a lab component in the above-mentioned courses.

Related Research:

The PI has made research in the area of Transportation Network Growth and Travel Demand Modeling central to his research program. He is currently engaged in two related projects. First, "If They Come Will You Build It", funded for $84,546 by the Minnesota Department of Transportation through the Center for Transportation Studies, conducts empirical modeling related to the mission of this proposal. The researcher participates in a second project, the Sustainable Transportation Applied Research Initiative, conducted by the Humphrey Institute, focusing on the theme of "Places and Networks: New Hierarchies in Access and Activity, which funds 1 graduate student per year for an anticipated 5 years. This project has allowed the PI to support a research assistant to begin examining the application of agent based models for transportation network dynamics. This research forms the basis of the model that the PI hopes to bring to the classroom.

Tasks & Timeline: It is anticipated this will occur over 2 school years.

Task 1. Specify model software. This task will begin with a review of the literature in simulation, education, learning-by-doing, as well as the substantive areas of transportation planning models and network growth models. The literature review will lead to a specification of the educational objectives of the model, identifying what is feasible to accomplish in the project, and what will need to be kept for future projects. This task will also specify the model and estimate default model parameters and ranges. Using the reviewed literature and previous research by the author, the model structure and parameters will be established for the model. *1 semester*

Task 2. Adapt travel demand and network forecasting models to educational platform Software developed as part of the PI's earlier research projects will be adapted and modified to meet the needs of transportation planning education. *1 semester*

Task 3. Pilot test model The model will be tested as an assignment for one of the PI's courses. After the assignment, the students will be surveyed about qualities of the model, things that worked well and didn't, and suggestions for future changes. An assessment will be made as to how well the software met its educational objectives. *1 semester*

Task 4. Refine model Based on the results of the pilot test, the software will be modified for subsequent use. *1 semester*

Task 5. Final report - This task will summarize findings and produce a final report. It will provide implementation guidelines other educators to implement the research conducted as part of this project. *1 month*

Collegiate and Department Support

This project is consistent with Departmental goals and objectives. The Department has four core objectives related to undergraduate education, two are related to this project: *(A) To produce graduates with a strong fundamental scientific and knowledge base and critical thinking skills required for engineering problem formulation and problem solving. (C) To produce graduates with an understanding of their obligations as professional civil engineers to protect human health, welfare, and the environment.* It is also consistent with the mission of the Institute of Technology, which "*is to provide programs of instruction, research and service/outreach that are appropriate to a research university and that are responsive to the needs of the state, the nation, and the world communities*."

The proposed research will enable students to learn by simulating, the next best thing to learning by doing, and the only practical approach in a field such as transportation that involves the decisions of millions of individual actors daily. It will thus enable them to critically think about transportation problems and solutions, and will produce graduates who understand the impacts of transportation decisions of human welfare and the environment. To that end, the Department of Civil Engineering is providing support by (1) giving the PI time to pursue this project during the school year (an in-kind match), (2) Supporting the graduate student working on the a teaching assistant who will have as a major task the development and evaluation of this software for courses, (3) dedicating the use of a computer and software for the graduate student to develop the software, and (4) providing a cash match of $2000 to fund the graduate student on the project as a Research Assistant to port the software from a research product to one suitable for the classroom.

Phase 2: Mentorship Phase

The products developed in the primary development phase will be disseminated to colleagues in Civil Engineering and Urban and Regional Planning. In Civil Engineering, Professor Gary Davis, who alternates teaching CE3201 with the PI, will be instructed in the use of the software and encouraged to use it in his courses. In Urban and Regional Planning, Kevin Krizek, who co-teaches PA8202: Networks and Places with the PI, and also teaches Transit Planning will also be trained in the software and shown its applicability. In addition, Teaching Assistants for both courses will also be given instruction in the software, and encouraged to use it. This will aid in the long term dissemination of the research as those Teaching Assistants will eventually become instructors themselves.

References

BTS (Bureau of Transportation Statistics) (2002) Transportation Indicators http://www.bts.gov/transtu/indicators/Transportation_System_Extent_and_Use.html

Garrison, W. L. (1996) *CE250 Course Notes* University of California at Berkeley mimeo.

Lerman Steven R. (2002?) Some Criteria for the Evaluation of Multimedia Computer Applications http://design.chosun.ac.kr/ddl/hdb/data/mul/lerman2.htm

Peat, F.D. (2002) *From Certainty to Uncertainty: The Story of Science and Ideas in the Twentieth Century*. National Academy Press: Washington DC p. xiii

Resnick, Mitchel (1997) *Turtles, Termites, and Traffic Jams: Explorations in Massively Parallel Microworlds* (Complex Adaptive Systems) MIT Press