PROCEEDINGS AND RECOMMENDATIONS

Workshop on Models in Support of
ADVANCED TRAFFIC MANAGEMENT SYSTEMS (ATMS)

Palm Coast, Florida, May 16-19, 1999

For
University of Florida Transportation Research Center
Center for Microcomputers in Transportation
Gainesville, Florida

September 30, 1999

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Acknowledgements

These proceedings summarize the views, discussions and recommendations expressed at the **Workshop on Models in Support of Advanced Traffic Management Systems (ATMS)**, held in Palm Coast, Florida, May 16-19, 1999, as interpreted by the author. These interpretations may not represent the exact views of the original authors and presenters, the University of Florida, ITS America, or the Federal Highway Administration.

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1. Executive Overview

These proceedings summarize the views, discussions and recommendations expressed at the **Workshop on Models in Support of Advanced Traffic Management Systems (ATMS)**, held in Palm Coast, Florida, May 16[1]-19, 1999. The approximately 40 participants included developers, users and other individuals interested in traffic modeling as a support tool for ATMS, both from the public and private sectors.

The format for the workshop consisted of technical presentations followed by two levels of breakout sessions, as follows:

Plenary Session: The Role of Modeling in ATMS Deployment

- "Development of Models and Algorithms for ATMS"
- "So, What is the Use of ATMS?"

Invited Session: Review of FHWA Software Development

- "ITS Deployment Analysis System (IDAS)"
- "Dynamic Traffic Assignment (DTA)"
- "Traffic Research Laboratory (TReL), Traffic Software Integrated System (TSIS)/CORSIM"
- "TRANSIMS"
- "RT-TRACS"
- "TurboArchitecture"

Breakout Sessions (Level I)

- Integrated Hardware/Software Systems
- Dynamic Traffic Assignment (DTA)
- Optimization and Control Algorithms
- User Needs in Modeling

Breakout Sessions (Level II)

- What Simulation for What Purpose?
- How Do We Leverage Resources?
- Software Development Standards and Practices
- Legal Issues in Model Development

Workshop Recommendations

Each breakout session resulted in specific problems and recommendations. The preliminary problems and recommendations, presented at the workshop, were summarized into the four overall recommendations presented here in order of priority.

The reader should refer to the full report for the background of these recommendations, which should be considered the consensus from those attending the workshop.

[1] A welcome reception was held on Sunday and the actual program began on Monday the 17th.

Problem: **Lack of a Clear FHWA Position on User Support**.

Recommendations:

- FHWA must clearly state its position toward model application users and develop a plan to accomplish its stated objectives. Adoption of the Free Software Foundation model, as suggested in Recommendation No. 2 will provide the clearer picture of FHWA's role in different stages of the software life-cycle.
- The participants recommended that FHWA, but not R&D, should provide, or ensure that others provide, the user assistance and support necessary to apply CORSIM and other modeling tools to real world situations. This assistance should include the following:
  - improved education and training on traffic models and tools, where the various applications, including their strengths and weaknesses, are discussed;
  - information about the various tools, including their capabilities and limitations, so users can make an educated choice;
  - this information should be made available through an updated *Traffic Models Handbook* and/or through the World Wide Web,
  - recommended procedures and methods to assist users with model application and calibration, and
  - creation of a traffic software user group so users can help each other.

Problem: **Difficulties Associated with Model Development and Software Rights.**

Recommendations:

- FHWA should explore the Free Software Foundation model and consider it as a mechanism to enhance and support future FHWA-developed research software.
- FHWA should appoint an advocacy group with no commercial interest, to manage the FSF model and related matters.
- FHWA should charge ITE's Transportation Software Developers' Task Force to pursue roles and responsibilities and refine this recommendation. Furthermore, FHWA should educate users and developers on this process.
- Once research software is ready to go over to user software, the ongoing support (financial, maintenance and technical) must all be thoroughly worked out ahead of time.
- Existing efforts should continue and perhaps be strengthened so that TSIS/CORSIM is widely used not only as a standalone package, but also as an engine for a number of third-party packages.
- FHWA should explore the possibility of a pooled-fund study where states contribute to software development.
- Users need to be included in this software development process so that user-friendly and field-friendly software is developed.
- The issue of government-sponsored software rights must be clearly explained to both FHWA personnel and developers, as well as users.

Problem: **Lack of Data for Traffic Research Purposes**.

Recommendations:

FHWA should:
- continue supporting traffic flow research,
- disseminate sources of traffic data for traffic modeling,
- identify data that are missing but critical to traffic modeling,
- request more traffic data sources that could be made available to traffic professionals, and
- create a Web site for this purpose.

Problem: **Lack of Understanding of the Benefits of ATMS Modeling and Applications.**

Recommendations:

FHWA should:
- encourage users to promote their "success stories" to help "sell" the benefits of the tools they utilize,
- encourage developers of models, software, and systems to clearly describe the practical benefits of their work to decision-makers, and show how using these tools can enhance mobility and safety, and
- develop a stand-alone publication or Web site, or utilize existing publications for this purpose.

2. WORKSHOP GOAL AND PURPOSE

These proceedings summarize the views, discussions and recommendations expressed at the **Workshop on Models in Support of Advanced Traffic Management Systems (ATMS)**, held in Palm Coast, Florida, May 16-19, 1999. The 40 plus participants[2] included developers, users and other individuals interested in traffic modeling as a support tool for ATMS, both from the public and private sectors. They openly expressed their opinions and ideas, and contributed to the discussions and recommendations.

Goal

The goal of the workshop was to address the importance of traffic modeling and software applications in the Advanced Traffic Management Systems (ATMS) area.

Purpose

The purpose of the workshop was twofold:

[2] The participant list is included in appendix A.

- to assess and critique the current status of traffic software systems developed by the Federal Highway Administration (FHWA), and
- to provide feedback to sponsors and developers, particularly to FHWA, concerning the systems that they are developing.

3. Sponsors

The following organizations made this workshop possible[3]:

- Federal Highway Administration, Office of Operations, Research and Development (R&D);
- Institute of Transportation Engineers (ITE), Transportation Software Developers' Task Force;
- ITS America (ITSA), ATMS Committee; and
- University of Florida Mc*Trans* Center.

4. Technical Program Review

The workshop consisted of:

- state-of-the-art presentations on support systems, traffic assignment, simulation, deployment, traffic control plans, ITS architecture and other topics related to Advanced Traffic Management Systems (ATMS), and
- breakout sessions to discuss specific issues related to these topics and generate specific recommendations.

Agenda: Monday, May 17, 1999

Introduction by Workshop Co-chairs

- *Raj Ghaman, Federal Highway Administration, Office of Operations, R&D*
- *Charles E. Wallace, ITSA ATMS Committee and the University of Florida*

Technical Presentations

The Role of Modeling in ATMS Deployment

- *Raj Ghaman, FHWA, Chair*
- "Development of Models and Algorithms for ATMS," Pitu Mirchandani, The University of Arizona
- "So, What is the Use of ATMS?," Rick Denny, Odetics ITS

Review of FHWA Software Development

- *Pitu Mirchandani, The University of Arizona, Chair*
- "ITS Deployment Analysis System (IDAS)," Gene McHale, FHWA

[3] The blue underlined organization names in this list and elsewhere are hot links in the electronic version of this document.

- "Dynamic Traffic Assignment (DTA)," Michael Summers, Oak Ridge National Laboratory (ORNL)
- "Traffic Research Laboratory (TReL), Traffic Software Integrated System (TSIS)/CORSIM," Gene Daigle, ITT Industries
- "TRANSIMS," Gene McHale, FHWA
- "RT-TRACS," Farhad Pooran, PB Farradyne
- "TurboArchitecture," Ron Giguere, FHWA

Agenda: Tuesday, May 18, 1999
Breakout Sessions, Level I

Integrated Hardware/Software Systems
- *Darcy Bullock, Purdue University, Chair and Reporter*
- *Marc Bounds, Florida Department of Transportation, Recorder*

Dynamic Traffic Assignment
- *John Leonard, Georgia Institute of Technology, Chair and Reporter*
- *Mike Summers, ORNL, Recorder*

Optimization and Control Algorithms
- *Raj Ghaman, FHWA, Chair*
- *Farhad Pooran, PB Farradyne, Recorder and Reporter*

User Needs in Modeling
- *Russ Bond, Massachusetts Highway Department, Chair*
- *Nadeem Chaudhary, Texas Transportation Institute, Recorder and Reporter*

Agenda: Wednesday, May 19, 1999
Breakout Sessions, Level II

What Type of Simulation for What Purpose?
- *Ken Courage, University of Florida, Chair and Reporter*
- *Mithilesh Jha, MIT, Recorder*

How Do We Leverage Resources?
- *Gene McHale, FHWA, Chair*
- *Rekha Pillai, ORNL, Recorder and Reporter*

Software Development Standards and Practices
- *Brad Mears, ITT Industries, Chair and Reporter*
- *Roelof Engelbrecht, TTI, Recorder*

Legal Issues in Model Development
- *Otto Wildensteiner, U.S. Department of Transportation, Chair*
- *Debbie Curtis, FHWA, Recorder*

- *Mike Summers, ORNL, Reporter*

Presentation of Preliminary Recommendations

Where Do We Go from Here? Observations and Preliminary Recommendations

- *Juan M. Morales, J.M. Morales & Associates, P.C., Recorder and Reporter*

5. Summaries of Technical Presentations

<u>Introduction by Workshop Co-Chairs</u>

Raj Ghaman, FHWA, Office of Operations, R&D

Mr. Ghaman welcomed the workshop participants and stated the goals and objectives of the workshop. He reiterated the desire of the Federal Highway Administration to obtain feedback to steer the direction of the FHWA ATMS R&D Program in the software development/modeling arena. He also encouraged an open discussion and brainstorming on all the topics to be covered. He mentioned his desire to focus the discussion on R&D and the usable products that it produces.

Mr. Ghaman indicated that the advice resulting from the workshop would be valued by FHWA and would indeed make an impact on the direction of the ATMS R&D Program.

Charles E. Wallace, ITS America ATMS Committee and University of Florida

Dr. Wallace started his brief introduction by describing the history of the ATMS workshops, which started in Florida in 1992. He indicated that the workshop presented a perfect forum to express open opinions and to consult with peers in the area of models in support of ATMS. He recognized the sponsors of the event and reiterated its objective of providing FHWA with feedback on ATMS modeling. Dr. Wallace also indicated that the workshop's proceedings would include specific recommendations to FHWA and encouraged all to contribute to those recommendations. He also reviewed the workshop program and explained the role of chairs, recorders and reporters.

<u>The Role of Modeling in ATMS Deployment</u>

Raj Ghaman, FHWA, Chair

Mr. Ghaman introduced the session by stating the importance of modeling to the ATMS program. He indicated that traffic modeling was particularly valuable when analyzing "what-if" scenarios. He also posed several questions to the attendees to generate discussion and participation. For example, he asked about the future of CORSIM and what the next steps should be. He indicated that even though CORSIM was now a stable model application, FHWA is looking at alternatives, including not only continuing with CORSIM development but also considering other models, such as Paramics, and Autonomous Agents Simulation (AASim). He encouraged everyone to provide their thoughts in this regard.

A question was asked regarding why, if CORSIM was stable, FHWA was looking at alternatives. Mr. Ghaman stated that any new alternatives would be a “parallel effort” to CORSIM development and maintenance, particularly because evaluation of Dynamic Traffic Assignment (DTA) in real-time was not possible with the existing CORSIM. It was also indicated that CORSIM was written in FORTRAN, most of it quite some time ago, and that it is difficult and expensive to maintain. One participant stated that use of CORSIM was being required by several state DOTs but that CORSIM could not simulate several conditions, such as one controller controlling two intersections. An FHWA representative indicated that while new features are being incorporated in the CORSIM enhancement list, it takes time and resources to implement all of these.

Mr. Ghaman also mentioned the availability of a CORSIM Training course, being developed by ITT Industries for the National Highway Institute (NHI) and a computer-based training (CBT) package soon will be available.

A question was asked about the eventual possibility of simulating roundabouts with CORSIM, like SIDRA can. Mr. Ghaman indicated that traffic calming was a relatively low priority for his division, since it did not apply to the National Highway System. He indicated, however, that pedestrian and bicycle modes would be high priority, and could possibly be incorporated into CORSIM in the future.

An audience participant indicated the need to explain the limitations of the CORSIM model to users. This participant indicated that the tool was being misapplied because the users did not understand its limitations. It was agreed that these limitations (such as the incorrect emulation of roundabouts) needed to be better publicized.

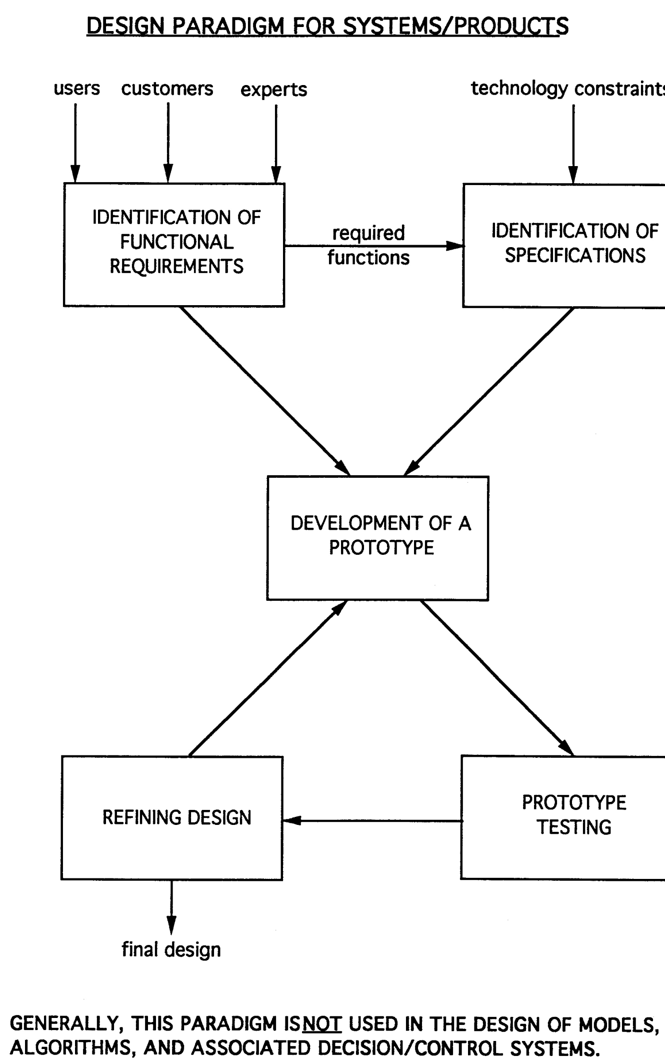
Another participant raised the issue of adding environmental measures of effectiveness (MOEs) to CORSIM, and asked whether any coordination with the Environmental Protection Agency (EPA) was occurring. Another participant indicated that there is an ongoing National Cooperative Highway Research Program (NCHRP) project that is combining two existing environmental models.

A participant inquired about ongoing research to make CORSIM an “on-line” model. Mr. Ghaman indicated that that research was in progress. He described the concept of “hardware in the loop” and the availability of the Controller Interface Device (CID). He referred the participants to the Route 7 Signal Preemption Study performed by ITT Industries in the Traffic Research Laboratory (TReL).

Another participant indicated that FHWA had a difficult task of identifying its model “users.” Who are the real users of these modeling tools, the researchers or the practitioners? Should FHWA support both? Their needs and levels of expertise are different. Discussion of this topic was encouraged. It was also mentioned that the Research Technical Advisory Group (RTAG), which communicates needs to FHWA, could be used to forward specific recommendations in this regard. Discussion of this issue set the stage for significant discussions later in the workshop.

Development of Models and Algorithms for ATMS
Pitu Mirchandani, The University of Arizona

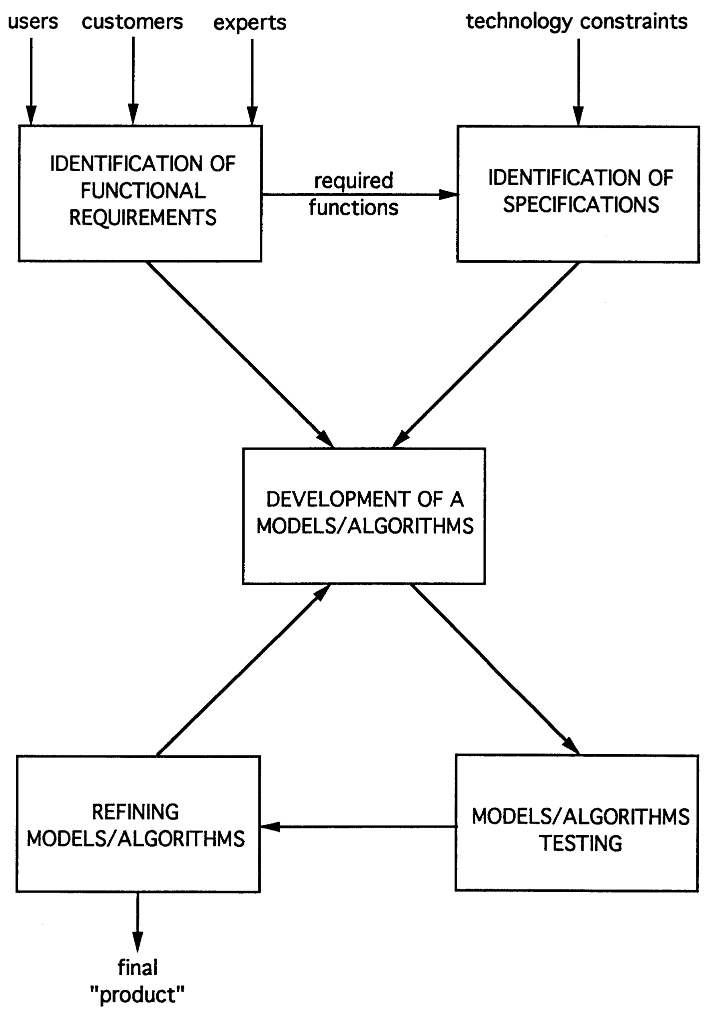
Dr. Mirchandani's presentation centered on the need to develop not only better, but also more usable, ATMS models and algorithms. He recognized the fact that the developed models and algorithms are "products" but that it is important to recognize that tradeoffs need to be made to increase applicability and user acceptability. Dr. Mirchandani explained the typical modeling process, in which real-world data, perceptions and conceptualizations are translated into analytical and simulation models using algorithms and other numerical methods. These models and algorithms have requirements that need to be met. This process should be similar to the industrial engineering process, called the "Design Paradigm for Systems/Products," shown in the figure below.



Under the Design Paradigm for Systems/Products process, users, customers and experts identify the functional requirements of the products. Utilizing the required functions, the specifications for the product are identified so that a prototype can be developed and tested, within technology constraints. Based on the result of the testing and other input, the product design is refined and a final design is produced. Generally, this paradigm is not used in the design of models, algorithms, and associates decision/control systems.

Dr. Mirchandani then presented a similar process that would apply to models and algorithms called the "Design Paradigm for Models/Algorithms (M/A)," as shown in the figure below.

DESIGN PARADIGM FOR MODELS/ALGORITHMS



This process would involve similar steps:

- users, customers and experts identify functional requirements;
- utilizing the required functions and within technology constraints, specifications are identified;
- the M/A are developed;
- the M/A are tested;
- the M/A are refined; and
- the final “product” is produced.

Dr. Mirchandani then explained the typical ATMS considerations for requirements and constraints. These considerations include:

- objectives/measures (e.g., safety, delay, travel times),
- the applications (off-line, on-line, or real-time),
- the attributes (data needs, computational complexity, communication needs), and
- platform affordability/constraints.

He indicated that to effectively design M/A it is imperative to match the ATMS requirements and technology constraints with M/A uses and attributes, as it is done when products are designed.

Dr. Mirchandani gave several examples, including how computation response time is dictated by how fast a decision is needed, perhaps every second versus every minute. With on-line systems, for example, the “field” provides the data and measurements through established communication channels and the “system” provides the decisions when the system is ready. With real-time systems, on the other hand, the “field” provides the data and measurements as well but, serving as a client, it also requests decisions. The “system” then provides these decisions when requested by the client.

In defining M/A requirements for real-time traffic control, for example, we should ask the following questions:

- What are the available inputs and when are they available?
- What are the required outputs?
- What are the objectives of the decision/controls, if any?
- What resources (time, computational resources, communication resources, etc.) do we have to solve this problem? and
- Are there any other constraints of the decision-makers and/or system?

Utilizing RT-TRACS (Real-time, Traffic-Adaptive Control Systems), and real-time Dynamic Traffic Assignment as examples, Dr. Mirchandani further described these requirements.

So, What is the Use of ATMS?
Rick Denny, Odetics ITS

Mr. Denny's presentation focused on the practical uses (applicability) of ATMS, specifically how simulation is used as a traffic management tool. He indicated that if decision-makers do not understand why ATMS is important, our ability to model it is irrelevant.

Mr. Denny emphasized the importance of "selling" ATMS "products" to decision-makers and politicians. For example, when describing the benefits of ATMS, certain benefits are harder to sell than others. For example, the impact of ATMS in reducing congestion, particularly recurrent congestion, is a harder sell than the impact of ATMS in incident management (non-recurring congestion).

Developers need to "market" their products and their benefits, always concentrating on those that offer the largest potential. For example, the potential of ATMS in improving freeway capacity is small compared to the potential of ATMS in improving signalized arterial operations, particularly during off-peak periods.

Another point he stressed was the need to keep in mind the decision-maker's needs. Engineers work mainly with numbers, but sometimes a graphical representation of a problem is more appropriate and would yield better results. We need to use the right presentation tool for the right job, depending on the audience. An audience participant indicated, however, that numerical results are still needed, as in the case of throughput, for completeness of analysis.

Review of FHWA Software Development
Pitu Mirchandani, The University of Arizona, Chair

The purpose of this session, Dr. Mirchandani indicated, was to provide a status report on various software development activities of FHWA.

ITS Deployment Analysis System (IDAS)
Gene McHale, FHWA

Mr. McHale described the background and status of the IDAS project and the software being developed under the project. IDAS is being developed by ORNL and other consultants. IDAS will provide Metropolitan Planning Organizations (MPOs), state transportation departments, and other transportation planning organizations with a capability to support ITS deployment. The primary objective of this project is the design, development, testing, and demonstration of a computerized analysis system suitable for assessing the impacts of alternative ITS deployments that are a part of transportation investment strategies. With this sketch-planning tool, these planning organizations will be able to assess the benefits and costs of alternative deployments.

Current planning models do not accommodate ITS, so a tool for that purpose was needed. IDAS is an interim tool to be used while more sophisticated planning models (e.g., TRANSIMS) are developed. For that reason, IDAS needs to be developed quickly.

Mr. McHale then described the scope of the IDAS project:

- develop functional and technical requirements (with assistance from a steering committee),
- software design,
- rapid prototype development,
- test and evaluation (both internal and external), and
- develop documentation.

Mr. McHale provided an overview of the IDAS methodology. IDAS uses the output of travel demand models and, after allowing users to add ITS components to the transportation network, it determines the additional costs and benefits of these components. IDAS also incorporates its own travel demand model to facilitate the analysis of added ITS functions.

There is an established hierarchy that is used in this benefit/cost analysis. It considers ITS improvements, components, and equipment.

He then described the overall software structure, which includes five basic modules:

- input/output interface,
- alternatives generator module,
- benefits module,
- cost modules, and
- alternatives comparison module.

Mr. McHale explained that the cost values used in IDAS are consistent with the National ITS Architecture. The alternative comparison modules are based on built-in tables. The IDAS user has the option to change the default cost and benefit values within the model.

He next covered the status of the IDAS development. The "Build 1" phase is complete and available to interested parties. It is currently being tested in Tucson, Arizona. "Build 2" is near completion. Its testing will take place in Chicago, Miami, and San Francisco. Its delivery is scheduled for November 1999.

Additional information on IDAS, and its availability, can be found at:
http://www-cta.ornl.gov/cta/research/idas/index.htm.

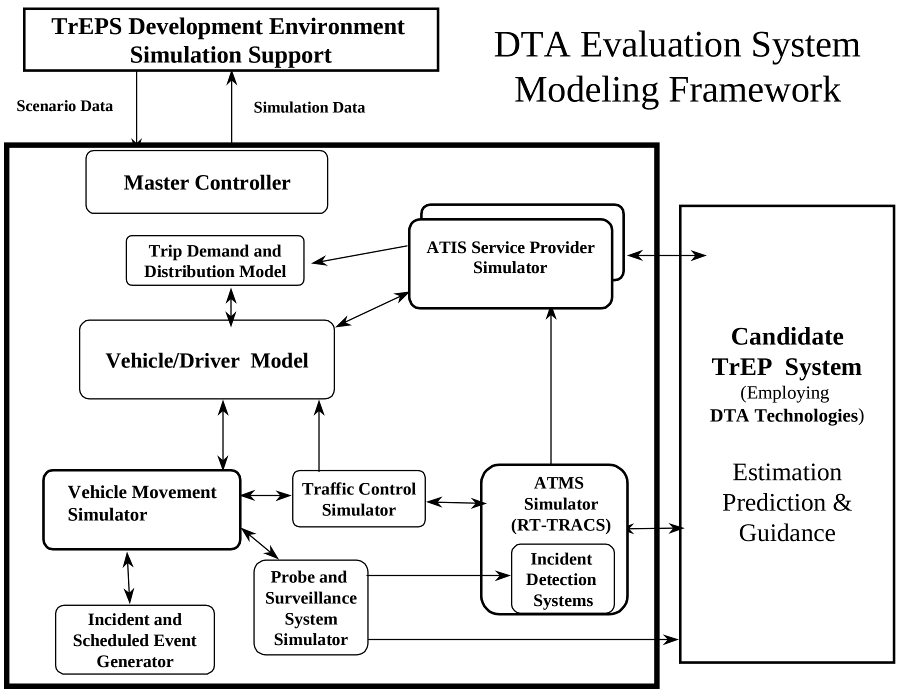
Dynamic Traffic Assignment (DTA)
Michael Summers, Oak Ridge National Laboratory (ORNL)

Mr. Summers' presentation centered on real-time DTA systems and the on-going DTA research being sponsored by FHWA. His presentation was co-authored by ORNL's Rekha S. Pillai, who was also present.

The DTA system uses advanced traffic models to analyze data, especially real-time surveillance and incident data, to provide consistent information to both ATMS and Advanced Traveler

Information Systems (ATIS) for meeting various traffic management, operation, and control objectives. Thus, the DTA system can be considered as a principal cognitive element of ITS and, very importantly, forms a bridge between ATMS and ATIS.

The specific system presented, called Traffic Estimation and Prediction System (TrEPS), forms this bridge, as shown in the figure below.



ORNL is providing technical management support to the FHWA in the research, development, testing, and deployment of such systems.

Mr. Summers described how DTA "fits" in the National ITS Architecture. DTA is the "predictive model" described in the architecture. He further explained that DTA is an ATMS support system.

Mr. Summers then described the FHWA (R&D) DTA project:

- Phase 1, Functional DTA Systems, is being developed by the Massachusetts Institute of Technology (the DynaMIT System), the University of Texas (Dynasmart-X) and the University of Wisconsin (DynaSaur).
- Phase 1.5, Independent Laboratory Evaluation, has the following schedule:
  - Software acceptance (1998-99),
  - Benchmark evaluation (1999-2000) under multiple simulation environments and common scenarios; and
  - Traffic Management Center (TMC) evaluation (1999-2000) to assess deployment viability and identify other real-time issues.

- Phase 2, Adaptive Control Systems, ACS–based DTA Development

Mr. Summers described the DES (DTA Evaluation System). DES is a future "product" conceived to evaluate dynamic traffic assignment models. There are various simulation environments that are being considered to evaluate DTA, such as:

- Paramics (by Quadstone),
- MITSIM (by MIT), and
- DTA CORSIM (FHWA, supported by ITT Industries).

Mr. Summers expressed his belief that DTA systems needed to be accessible to researchers and mentioned the availability of a new DTA Interface Control Document (ICD) that he developed. He also described the Free Software Foundation (FSF) model and its applicability to DTA, indicating that access to source code would be of great benefit to researchers. The FSF eliminates restrictions on copying, redistribution, and modification of computer programs.

He concluded by describing the TrEPS[4] system in more detail. It is a complex system that combines many advanced technologies such as traffic models, software architecture, computers, communications, surveillance systems, etc. to address dynamic transportation issues in real time. While the need for TrEPS is clear, research and development into the best combination of these technologies are not complete. In addition, traffic models pertaining to travelers' responses to ATMS and ATIS are still in the early stages of research. Development of TrEPS will help address these issues and provide ITS with traffic prediction capability for proactive traffic management purposes.

Additional information can be found at:
http://www-cta.ornl.gov/cta/research/dta/index.htm.

TRAFFIC RESEARCH LABORATORY (TREL), TRAFFIC SOFTWARE INTEGRATED SYSTEM (TSIS)/CORSIM

Gene Daigle, ITT Industries

Mr. Daigle suggested that traffic signal control was slowly moving towards automated control. Under that assumption it is important to work toward a dynamic control system (DCS) that will allow for real-time algorithm switching.

Mr. Daigle mentioned that DCS is a high priority item for the Traffic Research Laboratory (TReL). TReL is a laboratory facility supported by ITT Industries for FHWA. It is located at the Turner Fairbank Highway Research Center in McLean, Virginia. Other areas of research being performed at the TReL include the following:

[4] We use "TrEPS" and "DTA" somewhat interchangeably in this context.

- signal priority/preemption research (ITT Industries recently completed a signal preemption study for Route 7 in Virginia, where the impact of emergency vehicle preemption was quantified utilizing CORSIM under the “hardware-in-the-loop” concept),
- adaptive control systems (ACS) assessment and characterization, and
- traffic simulation, particularly CORSIM.

Mr. Daigle mentioned the recent significant enhancements to CORSIM, such as the improvements in the weaving logic. He graphically compared the weaving results of an old version of CORSIM against a newer version on the Baltimore-Washington Parkway in Maryland, indicating that the new version very closely matched field observations, while the old version bore little resemblance to reality.

He offered the TReL to be used as a transportation technology testbed, particularly as we move toward the concept of a simulated TMC.

Mr. Daigle described the evolution of TSIS and characterized TSIS as a mechanism to allow CORSIM to be integrated with other tools. He indicated that the acceptance of CORSIM in the user community is growing and that, as a result, coding errors (“bugs”) are now surfacing. These bugs are being handled according to a priority scheme developed in close consultation with FHWA.

He indicated that TSIS 4.3 (a “maintenance” version) will soon be released through Mc*Trans*. TSIS 5.0 is scheduled to be released this coming winter. Finally, Mr. Daigle encouraged user feedback to further enhance the TSIS/CORSIM package.

Additional information on TSIS can be found at: http://www.fhwa-tsis.com/. Additional information on the TReL can be found at: http://www.fhwa-tsis.com/trel/index.html.

TRANSIMS
Gene McHale, FHWA

Mr. McHale’s presentation described the Transportation Analysis and Simulation System (TRANSIMS), and categorized it as a next generation planning model; TRANSIMS is a micro-scopic approach to regional traffic modeling.

TRANSIMS is a set of new transportation and air quality analysis and forecasting procedures developed to meet the Clean Air Act, the Intermodal Surface Transportation Efficiency Act, the Transportation Equity Act for the 21st Century, and other laws and regulations. It consists of mutually supporting simulations, models, and databases that employ advanced computational and analytical techniques to create an integrated regional transportation system analysis environment. By applying advanced technologies and methods, it simulates the dynamic details that contribute to the complexity inherent in today’s and tomorrow’s transportation issues. Results from the integrated simulations will support transportation planners, engineers, decision makers, and others who must address issues of environmental pollution; energy consumption; traffic congestion; land use planning; traffic safety; intelligent vehicle efficiencies; and the transportation infrastructure effect on quality of life, productivity, and economy.

TRANSIMS models create a "virtual metropolitan region" with a complete representation of the region's individuals, their activities, their vehicles (or even non-vehicular modes) and the transportation infrastructure. Trips are planned to satisfy the individual's activity patterns. TRANSIMS then simulates the movement of individuals across the transportation network, including their use of vehicles such as cars or buses, on a second-by-second basis. This virtual world of travelers mimics the traveling behavior of real people in the region. The interactions of individual vehicles produce realistic traffic dynamics from which analysts using TRANSIMS can estimate vehicle emissions and judge the overall performance of the transportation system.

The scope of TRANSIMS includes considering individual households and travelers when performing the micro-simulation, including individual vehicles and drivers. The model is also intermodal, that is, it considers other modes of transportation such as transit. It also includes a detailed transportation network, air quality modeling and an "analyst toolbox." It can perform the modeling as an activity-based or as a trip-based model.

The TRANSIMS prototype will be tested in Dallas and Portland. Its schedule development is as follows:

- development of the "core software" is ongoing,
- a request for proposals is scheduled for release in the summer of 1999 to select a contractor to commercialize the package, including a more user-friendly interface, and
- early deployment for up to six MPOs.

Further questions on TRANSIMS should be directed to Fred Ducca, FHWA Office of Planning and Environment, (202) 366-5843. Additional information can also be found at:
http://www-transims.tsasa.lanl.gov/index.html.

RT-TRACS
Farhad Pooran, PB Farradyne

Mr. Pooran explained that RT-TRACS (Real-Time Traffic Adaptive Control System) was a generic name given to a group of real-time traffic adaptive control algorithms. RT-TRACS aims to provide traffic signal system control based on predicted, rather than historically measured, traffic conditions. While various DTA systems are still undergoing theoretical research to advance the state of the art, a variety of systems are being subjected to experimentation in real-world traffic networks.

The goal of RT-TRACS is to develop a platform capable of selecting the optimum adaptive control algorithm based on certain conditions. The algorithms currently under study are the following:

- Optimized Policies for Adaptive Control (OPAC),
- Real-time Hierarchical Optimized Distributed Effective System (RHODES), and
- Real-Time Adaptive Control Logic (RTACL).

The anticipated features of these algorithms include the following:

- a domestically-developed system, sponsored and supported by FHWA,
- a fully distributed architecture,
- no pre-stored timing plan development,
- no vendor-specific software,
- PC-based system (Microsoft Windows™ NT),
- easy to maintain, and
- National ITS Architecture-compliant.

All three algorithms are being field tested, using different controller types, firmware, detector types and communication systems. The following are conducting field tests:

- OPAC: Reston Parkway, Reston, Virginia (arterial highway);
- RHODES: State Route 522, Seattle, Washington (network); and
- RTACL: North Chicago, Illinois (grid network).

As an example, Mr. Pooran described in detail the OPAC field demonstration conducted on the Reston Parkway. It included three segments, one running isolated OPAC. Type 2070 controllers were used to test the "coordinated" OPAC algorithm. The demonstration included coordination with the side-street signals. Some of the evaluation issues (problems) encountered included bad weather, construction along the artery, and the existence of a pedestrian-actuated signal for a pedestrian/bicycle path in the vicinity of the Reston Town Center.

The study included a before and after study of travel times through the artery, comparing time-based coordination to OPAC. Mr. Pooran categorized the project as a success since results indicated that OPAC performed close to the best (optimized) signal plan available.

He described future plans in this area:

- upgrade and operate the Reston Parkway system,
- conduct a field demonstration with multiple adaptive algorithms,
- evaluate "light" adaptive systems, and
- full deployment of RT-TRACS.

TURBOARCHITECTURE

Ron Giguere, FHWA

Before describing the TurboArchitecture software package, Mr. Giguere briefly described the National ITS Architecture, which was developed to meet the need to integrate the various ITS systems, develop standards, and make interoperability possible.

The ITS Architecture provides a "framework" on which to develop interoperable systems. It also identifies standards requirements, system functions, vocabularies, etc. It consists of user services and logical and physical architectures, all of which can be used to develop regional, or even project-level, architectures.

TurboArchitecture is a high-level interactive software package designed to aid transportation planners and system integrators, both in the public and private sectors, in the development of ITS regional architectures. The tool will offer a "jump start" toward conformance with the National ITS Architecture. TurboArchitecture should be released during the late fall of 1999.

The package, which is being developed by Lockheed-Martin and Odetics ITS, is Windows-based. Among its capabilities are the development of multiple and custom ("tailoring") architectures, but it is not meant to be a complete end-to-end solution.

Additional information can be found at http://www.itsa.org/public/archdocs/national.html.

6. Summaries of Breakout Sessions

Breakout Sessions, Level I

Integrated Hardware/Software Systems

- Darcy Bullock, Purdue University, Chair and Reporter
- Marc Bounds, Florida Department of Transportation, Recorder
- Participants: Raj Salem, Roelof Englebrecht, Mike Waugh, Mike Bowley, Debbie Curtis, Ken Courage

This group, in a brainstorming session, discussed several key issues related to their topic. The group broadly interpreted their charge to include discussing issues related to controller upload/download and system integration. The group organized and prioritized their issues and ideas by ballot.

The following six areas (and associated discussions) were ranked the highest:

- Integration design issues. The fundamental issue was providing the necessary tools so that "good signal system" designs could be implemented on field equipment with a reasonable expectation that the field equipment would perform as modeled. For example, there is widespread variation in the definition of offset in coordinated signal systems. Care should be taken to ensure consistency. Two of the major themes of this topic were 1) running simulation with either hardware-based control algorithms or vendor-supplied software module, and 2) attempting to update traditional signal timing design programs so they reflect the capabilities/operation of modern traffic-actuated signal controllers. The output of the design programs should be in a format that facilitates easy implementation on field equipment without the need for translation.

- Application Program Interfaces (APIs). TSIS/CORSIM is a very valuable product when universities, research organizations, and commercial organizations can interact with it via APIs. One of the real strengths of CORSIM is its simulation engine and its tremendous potential when used with third-party supplied modules such as CID interfaces; vendor-specific control algorithms; batch processing/analysis procedures; and real-time modification of database elements such as traffic demand, turning movements, and timing parameters. For example, there are many people interested in interacting with CORSIM using a more structured database than the 'TRF' file currently supports. The current direction of moving toward standard APIs and a flexible database architecture should continue. Particular care should be taken so that the database is interactive and people can change all (or nearly all) parameters during the simulation such as turn percentages, paths, demand volumes, and controller parameters. The database should be structured so that it can easily support remote read/writes via a TCP/IP type connection over the Internet. Existing efforts should continue, and perhaps be strengthened, so that CORSIM/TSIS is widely used, not only as a standalone package, but as an engine for a number of third-party packages

- Education and training. There are no recommended practices for *designing* modern closed loop signal systems. In contrast to, for example, structural engineering, traffic engineering is somewhat in the dark ages in this respect[5]. The group felt that practitioners underused simulation and various other design tools. They believed that improved education and training would speed the adoption of simulation and facilitate the application of models that can be "tweaked" to work with software/hardware systems. An example is the application of the Skarbardonis[6] procedure for adjusting the offsets obtained from TRANSYT-7F so they work more efficiently in coordinated-actuated signal systems.

  An up-to-date signal timing design manual is desperately needed. Procedures for quantitatively assessing the performance (travel time and delay, fuel consumption, etc.) of existing and proposed signal systems need to be documented. On-line resource centers with searchable traffic system databases might also be useful to practitioners.

- Standards. There are no clear procedures for states to evaluate new NTCIP-compliant (National Transportation Communications for ITS Protocol) devices to see if they are really compliant. There needs to be some procedures developed for states to use.

- Operations. Downloading of signal timings to field controllers and uploading of signal timings to simulation programs is important. There is a need to develop on-line evaluation procedures for traffic operations centers. This likely involves integrating modeling with on-line data sources.

- Procurement and acquisition. Low-bid practices used by states and localities do not ensure "best buys." There are too many different systems for agencies to choose from and nobody really wants to admit when they are "burned" by vendors. Component-oriented acceptance testing procedures do not really test whether components work together as an integrated system.

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[5] [Editor's note: one such tool is available, although it is in need of updating. Refer to the Methodology for Optimizing Signal Timing (M|O|S|T), Volume 1: Reference Manual, Prepared for the Federal Highway Administration (FHWA), COURAGE & WALLACE, Gainesville, FL, December 1991, and available from Mc*Trans*.]

[6] [Editor's note: see Skarbardonis, A., "Progression Through a Series of Intersections with Traffic Actuated Controllers," Volume 2, User's Guide, Report No. FHWA-RD-89-133, 1989, available from Mc*Trans*.]

Dynamic Traffic Assignment (DTA)

- John Leonard, Georgia Institute of Technology, Chair and Reporter
- Mike Summers, ORNL, Recorder
- Participants: Shiow-Min Lin, Bin Ran, David Lucas, Rekha Pillai, Henry Lieu, Bob Winick[7]

The group discussed the potential users of DTA and the modeling framework for the DTA Evaluation System (DES).

The potential users identified by the group included the following:

- traffic management centers (TMC), the first FHWA priority, specifically,
  - adaptive control system (ACS), and
  - TMC decision support systems (DSS);
- information service providers (ISPs);
- researchers;
- MPOs and other planners; and
- advanced public transportation systems (APTS) operators.

The modeling framework for DTA systems was discussed, particularly how it forms a bridge between ATMS and ATIS.

Critical issues and actions identified included the following:

- More representative name. The group felt that the DTA name was ambiguous and that it means different things to different people. Because of that, it was important to:
  - emphasize estimation and prediction,
  - differentiate between DTA and other systems,
  - present DTA as a second-tier provider, and
  - be clear on the boundaries between DTA and other systems.
- Broader involvement. Recommendations discussions included:
  - break simulation systems up into sub-problems that different people can work on,
  - have multiple contractors involved in DTA research and development,
  - develop a problem statement database and research agenda,
  - conduct specialty workshops (TRB, ITS America, ITE), and
  - clarify the software/model development process.
- Software rights issues[8]. Recommendations discussed included:
  - explore the Free Software Foundation model and its applicability to DTA work,
  - make systems available for downloading by interested parties,
  - create an advocacy group,

[7] Note: Mr. Winick and several others participated in multiple workshops.

[8] Also see the Level II breakout session on Legal Issues.

  - take advantage of volunteer contributions, and
  - develop a list of frequently asked questions (FAQ)
- Incremental rollout and deployment. The group discussed whether DTA was "just" a freeway system and how to use DTA in isolated sub-regions. The group also discussed how to deploy sustainable DTA systems and at what stage it would be feasible to make the prototype systems available for deployment. Based on that discussion, the following recommendations were presented:
  - develop an incremental rollout and deployment plan,
  - plan to leverage legacy systems,
  - deploy systems that build upon themselves over time,
  - provide self-learning of traveler behavior, and
  - develop a research agenda to address deployment issues.

Finally, the group identified a series of DTA-related research topics that need to be addressed:

- problem size, approach, computing power and platform issues;
- traveler behavior modeling issues;
- how to deal with real surveillance data quality;
- how to model the behavior of future travelers;
- determining the operational value of predictive information in future ITS deployments;
- estimating how much the cost of required surveillance system capability may be reduced by DTA estimation algorithms; and
- determining how to adapt DTA modeling to cellular phone company-based surveillance systems.

Optimization and Control Algorithms

- Raj Ghaman, FHWA, Chair
- Farhad Pooran, PB Farradyne, Recorder and Reporter
- Participants: Susan Walker, Gene Daigle, Mithilesh Jha, Larry Owen, Pitu Mirchandani

The group centered their discussion on the following major topics:

- simulation and optimization,
- congestion,
- queue estimate versus queue measurement,
- effect of driver behavior,
- traffic flow theories,
- understanding the mechanism of congestion,
- ramp metering–to use or not to use, and
- toll plaza simulation.

The group formulated the following recommendations as related to simulation and optimization:

- Simulation recommendations:
  - conduct a literature search to compile all available information on traffic modeling theories;
  - obtain data to better understand driver behavior in the lane-changing process;
  - contact universities and manufacturers for available field data collected by video detectors;
  - develop an inventory of resources on congestion; and
  - incorporate queue estimate models of OPAC, RHODES, etc. to the actuated control logic of simulation models.
- Optimization recommendations:
  - combine freeway ramp metering and arterial signal networks for real-time corridor control,
  - allow researchers access to NADS (National Advanced Driver Simulator), and
  - investigate the impact of Variable Message Signs (VMS) messages on drivers' behavior so their use and effectiveness can be improved.

User Needs in Modeling

- Russ Bond, Massachusetts Highway Department, Chair
- Nadeem Chaudary, TTI, Recorder and Reporter
- Participants: Bill Brownell, Brad Mears, Qiong Liu, Marilda Hoover, Gene McHale, Liang Hsia

The majority of users participating in this discussion were involved in transportation planning or traffic operations, not ITS, per se; therefore, the issues discussed reflect those experiences. The distinction as it relates to models is that existing simulation models such as CORSIM are static and are used off-line. Simulation models that are in the process of being developed or adapted for ITS applications will be dynamic and will be used on-line.

The group discussed existing traffic models and user needs. The main issues discussed were as follows:

- models' reliabilities and the fact that models and their tools are often misapplied resulting in improper results and lack of trust;
- more data are needed on the validity of models and calibration procedures;
- there is a substantial need for training so models are properly applied and results are trusted (there is a perception that FHWA is not providing sufficient training);
- the role of FHWA in model development and user support is not clear, which creates confusion among both developers and users;
- the benefits of simulation may be dramatic, but are usually not demonstrated, nor are they documented; there is a need to see demonstrated success of model usage;
- there are numerous success stories, but they have not been well documented or advertised;
- there is persistent confusion over the relationship between CORSIM, NETSIM, ITRAF and others;

- there is a perception that CORSIM does not work properly, mainly because it is often misapplied; and
- there is a question as to whether CORSIM should be reengineered, and if so, should the states support a pooled fund study to do this, since many states require the use of CORSIM.

BREAKOUT SESSIONS, LEVEL II

What Type of Simulation for What Purpose?

- Ken Courage, University of Florida, Chair and Reporter
- Mithilesh Jha, MIT, Recorder
- Participants: Russ Bonds, Bill Brownwell, Qiong Liu, Marilda Hoover, Shiow-Min Lin, Darcy Bullock, David Lucas, Eil Kwan

The group first identified areas of application for simulation models as follows:

- field data surrogate,
- evaluation of alternatives,
- feasibility studies,
- pre-deployment studies,
- education and training,
- on-line information and control, and
- public demonstrations.

The major issues discussed included the following:

- there is a need to develop a modular simulation engine with the following characteristics:
  - "plug and play" design,
  - external control,
  - geometric and operational conditions, and
  - vehicle movement and driver behavior;
- encourage creative inputs from others;
- whether CORSIM should be reengineered or continue with existing architecture and code;
- there should be a standard communication between control simulation and vehicle simulation;
- there is a need for bench-mark testing, including at least the following:
  - extensive data sets, including origin-destination data,
  - inter/intra-model comparisons,
  - systematic testing of all features, and
  - comprehensive validation of the models;
- there is a wide gap between model developers and users, indicating the need for more:
  - calibration, validation and sensitivity analysis,
  - assistance with model calibration, and

  - enhancement of predictive capability of simulation models to make them applicable for on-line ITS applications; and
- fundamental research in traffic behavior is needed, specifically with:
  - time-dependent aggressiveness,
  - time of day effect (commuters),
  - enhancing car-following and lane changing logic, and
  - opposed movement in CORSIM.

After discussing these issues, the group made the following recommendations:

- develop a modular simulation engine with these major components:
  - external control module, and
  - external vehicle movement module;
- develop a common data scheme with connectivity to various models and field hardware;
- conduct fundamental research in traffic behavior with these ramifications:
  - this research may result in a new set of models, and
  - a significant data collection effort may be required;
- make users better aware of models and related tools, including:
  - providing a detailed description of the parameters, definitions, features and limitations, and
  - providing a systematic method for calibration by users.

How Do We Leverage Resources?

- Gene McHale, FHWA, Chair
- Rekha Pillai, ORNL, Recorder and Reporter
- Participants: Pitu Mirchandani, Larry Owen, Susan Walker, Bob Winick, Ed Lieberman

The group first defined "resources" in the context of ATMS. The resources identified by the group included the following:

- money resources: fiscal resource, public, private, over time, available capital, operating;
- people resources: time, expertise, range of skills;
- data resources: information, knowledge, archived knowledge;
- software resources: model applications;
- infrastructure resources: hardware, equipment, communications networks, etc.; and
- intangible resources: institutional and professional networks.

The process of "leveraging" these resources was defined in terms of the following:

- the realization that goals cannot always be accomplished due to resource constraints;
- the need to identify champions and partners, with the following roles:
  - champion: sponsorship role, and
  - partner: contributing role; and

- the importance of having different organizations joining together and sharing resources to satisfy their individual goals.

To clarify this process, members of the group discussed various examples of leveraging resources. A successful example discussed was how the City of Tucson, The University of Arizona, FHWA, and ITT Industries are working together on an operational test of real-time traffic adaptive control and on an open-architecture communication system.

The group then discussed the traditional and non-traditional ways of leveraging fiscal resources:

- traditional:
  - federal grant and aid programs, (typically a shared process),
  - cost sharing among agencies (varying levels), and
  - research programs [IDEA Program, Small Business Innovative Research (SBIR)], which can augment other programs; and
- non-traditional:
  - consortia, cooperative research,
  - pooled funds (states band together), and
  - royalties that result from the sale of products.

The group also identified institutional and fiscal impediments to leveraging, for example:

- how traditional competitive (low) bid requirements may adversely impact selection of the best offer,
- how the preservation of intellectual property rights may impact selection, and
- how conflicting agendas should be resolved.

In the area of leveraging human resources, the group discussed the following issues:

- the importance of training and how it can affect model usage and perceptions,
- the importance of continuing professional capacity building,
- how inter-governmental personnel agreements (IPAs) can be a resource,
- the importance of supporting federal and university research in the ATMS area, and
- the importance of professional exchange forums.

In leveraging data, information, and knowledge resources, the group identified the following issues:

- use of Web sites to share information, such as:
  - model awareness, user groups, real world data, sample input files, and
  - the accessibility of models and tools;
- the importance of conducting conferences, workshops, forums, and symposia;
- the need to conduct marketing and outreach;
- the need to provide training through the National Highway Institute (NHI), Mc*Trans*, private companies and others; and

- the importance of standards compliance, particularly with the NTCIP.

In leveraging software resources[9], the following issues were discussed:

- using the Free Software Foundation Model and how it might be considered for developing ATMS models and tools, to *theoretically*:
  - allow sharing of source code, to expedite development through multiple research channels,
  - allow for more technical support, and
  - allow for faster development and improvement of software;
- the provision of discounted or free software to universities and organizations to hopefully:
  - create new users, and
  - develop a larger market; and
- the need to beta-test new tools, and to involve *real* users in the process[10].

In leveraging infrastructure resources, the group discussed the following issues:

- how computer and other hardware vendors can be utilized to test ATMS tools;
- how state and local agencies can be used, for example, to:
  - test traffic control equipment,
  - develop an infrastructure database, and
  - serve as a testbed for ATMS tools; and
- how TMCs can be used to:
  - leverage facilities, hardware, personnel, data, etc., and
  - evaluate emergency management procedures.

Finally, the group discussed issues specific to ATMS:

- leveraging is absolutely essential when deploying ATMS tools;
- awareness should be augmented, by, for example:
  - documenting successful examples,
  - conducting and documenting case studies, and
  - identifying the target audience (e.g., policy makers and users);
- the need to identify champions;
- the need to take the initiative to continue the development and application of ATMS tools; and
- the fact that leveraging is a continuous process.

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[9] [Editor's note: The ITE Transportation Software Developers' Task Force was formed with this, among other goals, in mind. Such leveraging as common databases, software interoperability, and seamless interfaces between applications are examples of the features the task force is pursuing.}

[10] [Editor's note: FHWA has been conducting independent testing and beta testing on its principal simulation package, TSIS/CORSIM, for five years via a contract with Mc*Trans*. This has led to many improvements, but most users are aware that more improvements, particularly in functionality of certain models, are still needed.]

Software Development Standards and Practices

- Brad Mears, ITT Industries, Chair and Reporter
- Roelof Engelbrecht, TTI, Recorder
- Participants: Nadeem Chaudary, Liang Hsia, Marc Bounds, Raj Salem, Mike Bowlen

The group started their discussion by stating a few perspectives related to software acquisition and development. The discussions covered both model applications as well as "systems" or ATMS software.

- Software acquisition perspectives:
  - traditionally, the Federal Government and states fund the development and maintenance of traffic software,
  - people in charge of acquisitions don't always know how to evaluate bidders and have problems determining pre-qualifications and determining the required documentation,
  - industry standards, such as NTCIP, help with software acquisition, and
  - at the user level, there is often funding available for software development, but not for software maintenance;
- software development perspectives:
  - consultants and universities provide most software development services;
  - there is sometimes confusion among developers as to how the tools they develop will be used (research versus real-world applications).

The important issues identified by the group were:

- whether the programming should be done by engineers with computer science backgrounds or by programmers with engineering experience, but in any case, traffic engineers who develop software need software engineering training;
- the operation and maintenance of software systems are frequently ignored, which results in:
  - poor software upgrade maintenance,
  - poor version control,
  - poor documentation, and
  - poor reliability;
- the fact that customers typically inherit the responsibility for maintaining (system) software but do not have adequate documentation needed for that task;
- it is easier to develop only the *core model* engine and then let others develop the support tools;
- quality control standards for software acceptance are needed;
- universities and the private sector should cooperate better in model development; and
- the existence of professional software development and management standards is not widely known and therefore not generally required.

Action points and recommendations from this group included the following, namely, someone should:

- develop a training course and guidelines on how to manage (primarily system) software acquisitions, including:
  - specific contract requirements, and
  - providing funds for operations and maintenance;
- develop a common file structure/translator; and
- develop Web-based technical support.

Finally, the Florida DOT, Texas Transportation Institute (TTI) and ITT Industries representatives described their experiences with software development.

Legal Issues in Model Development

- Otto Wildensteiner, U.S.DOT, Chair
- Debbie Curtis, FHWA, Recorder
- Mike Summers, ORNL, Reporter
- Participants: John Leonard, Farhad Pooran, Charles Wallace, Mike Waugh, Juan Morales

Mr. Wildensteiner started the session by discussing the typical legal process, which includes the following steps:

- Congress passes statutes, then
- agencies translate those statutes into regulations.

Over the years there have been a number of misconceptions about government-funded software development, namely:

- if the government pays for it, the government owns it, and
- if the government owns it, then it is in the public domain and may not be copyrighted.

Government regulations pertaining to software development are included in the Federal Acquisition Regulations (FARs), specifically 48 CFR 52.227-14. The specific language contained therein is *automatically* included in all software development requisitions. The pertinent language applicable to this issue is given in the box on the next page, with key language emphasized in bold.

Mr. Wildensteiner highlighted some key points, including:

- contractors own the software and its copyright, except for special cases provided otherwise in the contract,
- the government has the right to use the software, but not the right to distribute government-sponsored-software to the public if the contractor owns the copyright,
- contractors *may* assign copyright to the government,
- specific language in the contract *may not* supercede the FARs, and

- if the contractor fails to exercise his right to obtain copyright to the software, the government may assume unlimited rights.

Excerpts from 52.227-14 -- Rights in Data - General

(a) *Definitions. "Computer software,"* as used in this clause, means **computer programs**, computer databases, and documentation thereof.

…

(c) *Copyright* --

(1) *Data first produced in the performance of this contract*. Unless provided otherwise in paragraph (d) of this clause, the Contractor may establish, without prior approval of the Contracting Officer, claim to copyright subsisting in scientific and technical articles based on or containing data first produced in the performance of this contract and published in academic, technical or professional journals, symposia proceedings or similar works. The prior, express written permission of the Contracting Officer is required to establish claim to copyright subsisting in all other data first produced in the performance of this contract. When claim to copyright is made, the Contractor shall affix the applicable copyright notices of 17 U.S.C.401 or 402 and acknowledgment of Government sponsorship (including contract number) to the data when such data are delivered to the Government, as well as when the data are published or deposited for registration as a published work in the U.S. Copyright Office. For data other than computer software the Contractor grants to the Government, and others acting on its behalf, a paid-up, nonexclusive, irrevocable worldwide license in such copyrighted data to reproduce, prepare derivative works, **distribute copies to the public**, and perform publicly and display publicly, by or on behalf of the Government. **For computer software, the Contractor grants to the Government and others acting in its behalf, a paid-up nonexclusive, irrevocable worldwide license in such copyrighted computer software to reproduce, prepare derivative works, {"distribute copies to the public" is <u>absent</u>} and perform publicly and display publicly by or on behalf of the Government.**

(2) *Data not first produced in the performance of this contract*. The Contractor shall not, without prior written permission of the Contracting Officer, incorporate in data delivered under this contract any data not first produced in the performance of this contract and which contains the copyright notice of 17 U.S.C.401 or 402, unless the Contractor identifies such data and grants to the Government, or acquires on its behalf, a license of the same scope as set forth in subparagraph (c)(1) of this clause; provided, however, that if such data are computer software the Government shall acquire a copyright license as set forth in subparagraph (g)(3) of this clause if included in this contract or as otherwise may be provided in a collateral agreement incorporated in or made part of this contract.

In a related matter, Mr. Wildensteiner informed the group that, by law, the U.S. Government cannot acquire an original copyright on any material, but it can trademark (or service mark) and patent materials, specifically software, as long as the ownership issue is properly disposed. The government can be assigned ownership and copyright by the otherwise rightful owner. [These have important ramifications on the way the U.S.DOT handles software development.]

This introduction generated a series of questions and discussion, which resulted in the following points:

- use of a “work-for-hire” clause in a software development project does not supersede the FAR;
- the FAR does not allow for distribution of contractor-developed software unless the government owns the copyright in the software;
- a contractor may require extra compensation for assigning the copyright;
- a potential conflict of interest usually arises between the market potential of software versus the contract requirements;
- contractors having (legitimate) sole access to source code and software copyrights from previous work may lead to non-competitive development; and
- contractors have the following options regarding their intellectual property:
  - they may “give up” their rights to intellectual property included in the software, or
  - they may retain all rights and sell the product.

Problems may arise if these conditions occur:

- the most competent and knowledgeable contractor chooses not to participate in the project,
- only one contractor understands the code, which leads to contractor dependency, or
- there is the appearance that the government endorses one vendor’s commercial product.

Over the years the tradition of government-sponsored software development, coupled with development and distribution practices, has led to several dogmas, namely:

- the traffic engineering community is conditioned to expect highly subsidized software,
- research software often become “user-based” products, so there is the perception that researchers’ needs are not being met,
- conversely, often users’ needs aren’t sufficiently considered in software development,
- relying on contractors to help develop the technical direction of software can lead to a conflict of interests, and
- there is currently limited access to the government-developed source code.

To address these issues, the group concluded that FHWA should examine the use of the Free Software Foundation model for research software development. The problem, however, is whether ATMS models have sufficient users to make the FSF model work.

The group then proposed the following recommendations, first regarding software development practices:

- consider research-oriented software separately from user-oriented software;
- for research software, FHWA should consider the FSF model and when used, process and appoint an advocacy group, with no commercial interests, to help manage the software development, and configuration control; and

- FHWA R&D contracts need to have a specific line item for the value of contributed intellectual property rights if FHWA expects the contractor's rights to vest to the government.

In the general software-development policy arena, the group offered these recommendations for FHWA:

- FHWA's R&D should not be providing directed user support—this is an operations role;
- educate the community on the subjects of "intellectual property" and "public domain;"
- define the software's target audience (commercial or research) and development process early;
- develop a model of roles to be played by stakeholders in the software process;
- charge ITE's Transportation Software Development Task Force to pursue roles and responsibilities and refine the recommendations resulting from this workshop; and
- the Federal Government must explain this process to developers and users, as well as educating its own employees.

7. WORKSHOP RECOMMENDATIONS

The specific recommendations of the breakout sessions were analyzed and combined into broader recommendations. The format for the recommendations is as follows:

- Problem: Describes the problem identified by the participants.
- Who is Affected? Describes who is affected by the problem.
- Who is Responsible? Describes, in the view of the participants, the entity responsible for solving the problem.
- Recommendation: Describes the specific recommendation to the responsible entity.

The recommendations are presented in order of priority. *Readers should recall, however, that more detailed recommendations are contained in the foregoing summaries of the individual breakout sessions.*

Recommendation No. 1

Problem: **Lack of a Clear FHWA Position on User Support**. Simulation and other traffic models are becoming more mainstreamed and are routinely being applied to real-world situations. Computerized model applications such as CORSIM are no longer just for research and development but also are practical tools used in the field. FHWA has not demonstrated a continuing commitment to the users of these tools, yet many states are requiring their use to justify investing in multimillion dollar projects. States and other applying agencies lack the information needed to make educated decisions regarding the use of traffic models.

With the abolishment of FHWA's Offices of Implementation and Technology Applications, there is a serious need for technical information, training, technical assistance and user support. Whose role is it to provide technical support to model users? Certainly support centers like

Mc*Trans* offer some degree of technical assistance, but not in-depth modeling applications. As a result, information on detailed traffic modeling has been sparse and tools are often misapplied. This has resulted in confusion within the user community to the point where model results often are not trusted. The proliferation of tools, add-ons, and utilities has resulted in further confusion.

Who is Affected? Users who are trying to apply, or are thinking of applying, these tools, particularly CORSIM, to real-world situations are severely affected by this problem. Developers are also affected, since the tools they develop are often misapplied.

Who is Responsible? Participants felt that it was the responsibility of FHWA (but not R&D) to play a leadership role in providing the user support needed, particularly if the tool in question (i.e., CORSIM) was developed by FHWA.

Recommendations:

- FHWA must clearly state its position toward model application users and develop a plan to accomplish its stated objectives. Adoption of the Free Software Foundation model, as suggested in Recommendation No. 2 will provide the clearer picture of FHWA's role in different stages of the software life-cycle.
- The participants recommended that FHWA, but not R&D, should provide, or ensure that others provide, the user assistance and support necessary to apply CORSIM and other modeling tools to real world situations. This assistance should include the following:
  - improved education and training on traffic models and tools, where the various applications, including their strengths and weaknesses, are discussed;
  - information about the various tools, including their capabilities and limitations, so users can make an educated choice;
  - this information should be made available through an updated *Traffic Models Handbook* and/or through the World Wide Web[11].
  - recommended procedures and methods to assist users with model application and calibration, and
  - creation of a traffic software user group so users can help each other.

Recommendation No. 2

Problem: **Difficulties Associated with Model Development and Software Rights.** Developing new models and tools, and enhancing existing ones, is a time- and resource-consuming process. It requires commitment and dedication from developers and sponsors alike. Also, with CORSIM, for example, incorporating user-conceived enhancements is time consuming because only the CORSIM support contractor can make these changes and user-supported modifications and enhancements are often at odds, at least in terms of priority, with the sponsor's objectives. The Free Software Foundation (FSF) approach was suggested as a potential model to follow to solve this problem since it would allow others to also have access to the source code. The FSF model

[11] [Editor's note: the Transportation Research Board Committee on Traffic Signal Systems, with potential support from other committees, has launched a concept for creating such a site. The hold-up so far has been the lack of adequate volunteer resources to bring this to fruition.]

eliminates many restrictions on copying, redistribution, understanding, and modification of computer programs.

Furthermore, there is a lot of confusion regarding ownership of government-sponsored software. Are the rights owned by the government or by the developer? Is this software public domain?

Who is Affected? Model sponsors, developers, and users are all affected by this problem. Sponsors are constrained by uncertain funding resources and dynamically changing priorities. Model developers are operating in an unstable legal environment (the reasons stated particularly in the Legal Issues Workshop) and other developers cannot easily develop their own add-on utilities and enhancements. Users are also affected since they are forced to wait for new versions to be released, which may take a long time, and they are frequently excluded from the traffic software development process.

Who is Responsible? Participants felt that it was the responsibility of the model sponsors, particularly FHWA, and developers to enhance and improve the models.

Recommendations:

- FHWA should explore the Free Software Foundation model and consider it as a mechanism to enhance and support future FHWA-developed research software.
- FHWA should appoint an advocacy group with no commercial interest, to manage the FSF model and related matters.
- FHWA should charge ITE's Transportation Software Developers' Task Force to pursue roles and responsibilities and refine this recommendation. Furthermore, FHWA should educate users and developers on this process.
- Once research software is ready to go over to user software, the ongoing support (financial, maintenance and technical) must all be thoroughly worked out ahead of time.
- Existing efforts should continue and perhaps be strengthened so that TSIS/CORSIM is widely used not only as a standalone package, but also as an engine for a number of third-party packages.
- FHWA should explore the possibility of a pooled-fund study where states contribute to software development.
- Users need to be included in this software development process so that user-friendly and field-friendly software is developed.
- The issue of government-sponsored software rights must be clearly explained to both FHWA personnel and developers, as well as users.

Recommendation No. 3

Problem: **Lack of Data for Traffic Research Purposes**. As models become more mainstreamed, their level of utilization will increase. It is imperative to continue to research traffic flow theory so it can be incorporated into existing and future models. This is particularly true with the proliferation of ITS and the development of on-line applications. Data needed to validate and calibrate the models are often missing.

Who is Affected? Developers of traffic models are affected by this problem.

Who is Responsible? Participants felt that it was the responsibility of FHWA's R&D to continue funding traffic flow research, particularly the "high-risk" research, and to make these traffic research data available to the community.

Recommendations:

FHWA should:

- continue supporting traffic flow research,
- disseminate sources of traffic data for traffic modeling,
- identify data that are missing but critical to traffic modeling,
- request for more traffic data sources that could be made available to traffic professionals, and
- create a Web site for this purpose.

Recommendation No. 4

Problem: **Lack of Understanding of the Benefits of ATMS Modeling and Applications.** The benefits associated with models that support ATMS are not well or widely known. This is due in part to the confusion among the user community. Decision-makers do not have a clear picture of these benefits and, as a consequence, question whether these models should be supported.

Who is Affected? Both model developers, sponsors and users are affected by this problem. If decision-makers do not realize the benefits of the tools they develop, it would be difficult for developers to achieve a sustainable level of development.

Who is Responsible? Model users, sponsors and developers are responsible. It is their responsibility to "sell" the benefits of the tools they develop and use to decision-makers.

Recommendations:

FHWA should:

- encourage users to promote their "success stories" to help "sell" the benefits of the tools they utilize,
- encourage developers of models, software, and systems to clearly describe the practical benefits of their work to decision-makers, and show how using these tools can enhance mobility and safety, and
- develop a stand-alone publication or Web site, or utilize existing publications for this purpose[12].

[12] As noted earlier, the TRB Traffic Signal Systems Committee, in cooperation with several other committees is contemplating a Web site to be an information clearinghouse for traffic software applications. The ITE Transportation Software Developers' Task Force is a likely co-sponsor as well. If this were in fact pursued, it would serve this recommendation.

8. CONCLUDING REMARK BY THE EDITOR

The workshop was deemed a success by all who expressed an opinion about it. It produced significant inputs to FWHA. To further the discourse about the legal issues, the steering committee has suggested a special panel or conference session—or at least a workshop—to be held at the Transportation Research Board Annul Meeting in January 2000. Those interested may contact Charles Wallace at the coordinates given in appendix A.

APPENDIX A

LIST OF ATTENDEES

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