FHWA TRAFFIC SIMULATION MODELING WORKSHOP

AUGUST 21-22
FALLS CHURCH, VIRGINIA

WORKSHOP PROCEEDINGS

PREFACE

The Federal Highway Administration (FHWA), Office of Travel Management and Office of Operations Research and Development (R&D), are undertaking a bold new strategy for planning and developing the next generation of traffic simulation models. This "next generation" simulation model (NGSIM) would follow on the steps of current FHWA models, mainly the CORSIM model and associated utilities, by addressing its strengths and weaknesses, and by taking advantage of improved technology and computing power.

Part of the planning process in developing NGSIM involves seeking input from experts and stakeholders involved with traffic simulation.

The purpose of this 1 ½-day workshop was to solicit input from a group of stakeholders in traffic simulation and model development. The workshop consisted on a plenary session on the first day and several break out sessions on the second day. The plenary session included traffic simulation and CORSIM overview presentations, as well as discussions on FHWA needs and approaches to model development.

The workshop concluded with a series of recommendations and findings. These proceedings document the workshop, and its findings and recommendations.

The workshop was held at the facilities of the Virginia Tech Northern Virginia Center, in Falls Church, Virginia, August 21-22, 2000.

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I. EXECUTIVE SUMMARY

Overview

The Federal Highway Administration (FHWA), Office of Travel Management and Office of Operations Research and Development (R&D), are undertaking a bold new strategy for planning and developing the next generation of traffic simulation models. This "next generation" simulation model (NGSIM) would follow on the steps of current FHWA models, mainly the CORSIM model and associated utilities, by addressing its strengths and weaknesses, and by taking advantage of improved technology and computing power.

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KEY POINTS

The group concluded that a new traffic simulation tool was needed, particularly to assess Intelligent Transportation (ITS) technologies and to integrate with the TRANSIMS. Although the CORSIM model was adequate for simulation of an integrated network of surface streets and freeways, it could not simulate very large networks, a key need in assessing ITS technologies at a regional level. Also, computing technologies now made possible the development of a more sophisticated tool, which would meet the research, evaluation and design

The break out sessions resulted in a series of recommendations, particularly a suggested process, using a staged (and eventual concurrent) design/development, for FHWA to consider

The suggested process would be as follows:

- Develop an architecture. This architecture would include the operational design concept, data flows and data definition. This would provide a clear picture of the requirements of this “New Generation Simulation Model (NGSIM)”

- Define the scope of services. Under this activity, a business plan would be developed, where the institutional relationships and the roles and responsibilities of all stakeholders are clearly defined.

- Model Design. Define all software requirements, including software design documents, interface design documents and other documents.

- Identify and evaluate existing models and/or source code which may be applicable and usable in the new model.

- Build initial (alpha) model

- Conduct testing validation and verification (beta testing)

- Integrate/test the new model with other existing models (for compatibility)

- Distribute and support (both public and private depending on their respective roles) the new model. Also establish maintenance/configuration management requirements.

The participants also recommended identifying all opportunities for partnership and cooperation early during the process

Consider establishing an advisory/oversight committee, or utilizing an existing one such as the Institute of Transportation Engineers Transportation Software Developers’ Task Force or the Transportation Research Board Joint Traffic Models Task Force. This committee would oversee the development of the model and assure integration and public-private partnerships. These decisions can be made more logically within a well planned/maintained process.

The remaining issues fell into three broad groups, summarized as follows:

- Those that should be resolved before development:
  - Mechanism for professional and industry oversight;
  - Degree of standardization required:
    - Software development,
    - Documentation, and
    - Interface specification;

  - Degree of support for TSIS 5 in the interim period;

- Those that should be resolved during development:

- Public domain, Free Software Foundation model, proprietary products, etc.;
- How to involve the private sector as a partner;
- Tradeoffs between competing functional requirements—risks and cost effectiveness;
- Degree of calibration/validation required; and
- Homogeneity of model:
  - Time resolution,
  - Microscopicity,
  - Analytical components.

- Those that are continued and on-going:

  - Top-down vs. bottom up funding justification; and
  - R&D interests vs. user interests.

II. WORKSHOP PROGRAM

Day 1: Monday, August 21, 2000

1:00 pm	Welcome / Purpose of Workshop	George List
1:15 pm	Background	
	• Simulation Overview	Ken Courage
	• CORSIM Overview • Major Driving Forces • FHWA Approach	Ron Giguere
2:00 pm	Feasibility Study	Charles Wallace
2:45 pm	Break	
3:00 pm	Request For Information (RFI) Discussion • Overview, General Consensus, Feedback	George List
4:15 pm	Lessons Learned - TRANSIMS	Fred Ducca
4:45 pm	"Homework" Assignment / Preview of Day 2	George List
5:00 pm	Adjourn	

Day 2: Tuesday, August 22, 2000

8:00 am	Welcome and Breakout Instructions	George List
8:30 am	1st Breakout Group Discussions	
	"Functional Requirements and Prioritization for Users' Needs"	
	• Group 1. **Research** Users' Functional Requirements • Group 2. **Transportation Planning** Users' Functional Requirements	
	• Group 3. **Operational Analysis** Users' Functional Requirements • Group 4. **On-line** Users' Functional Requirements	

9:45 am	Break	
10:00 am	Continue 1st Breakout	
10:30 am	Breakout Group Reports	George List
12:00 am	Lunch Break	
1:00 pm	Open Discussions of Breakout Results	George List
2:00 pm	Breakout Instructions	George List
2:15 pm	Break	
2:30 pm	2nd Breakout Group Discussions	

"Options for FHWA Program Implementation"

- Group 5. Software Engineering Approaches
- Group 6. Maintenance /Tech Support / Source Code Access
- Group 7. Performance / Software Interface Requirements

- Group 8. User Interface Requirements

3:30 pm	Breakout Group Reports	George List
4:30 pm	Workshop Recommendations	Charles Wallace
4:45 pm	Workshop Wrap-up and Next Steps	Ron Giguere
5:00 pm	Adjourn	

III. Workshop Proceedings

Welcome / Purpose of Workshop — George List

The workshop started with brief remarks by Ron Giguere, welcoming all to the workshop. Giguere stated the purpose of the workshop: to seek input regarding the future of FHWA traffic simulation program. After going over the workshop logistics, Giguere introduced the workshop moderator, George List.

List's opening remarks can me summarized as follows:

- This workshop is part of an evolutionary process for seeking input
- FHWA believes that traffic simulation is a valuable tool
- FHWA is currently studying the feasibility of developing a "next generation" traffic simulation model (NGSIM)
- FHWA would like to formulate its plans for the future and is seeking input from those present

List reviewed the agenda for the workshop and conducted self-introductions.

Background

Simulation Overview — Ken Courage

Courage started his presentation by describing the current environment of traffic simulation software. Under the existing environment, there are several simulation packages available, including FHWA's CORridor SIMulation (CORSIM) package, which is distributed as part of the Traffic Software Integrated System (TSIS). Courage characterized this environment as confusing due to the level of competition and the variety of choices.

He indicated the need to develop a new model, to advance the state of the art and to take advantage of advances in technology and computing power.

To develop this new model, Courage described three alternatives:

- **Alternative 1: Do nothing.** Under this alternative, the current condition would continue, resulting in continuing confusion and a proliferation of models.

- **Alternative 2:** Select one of the existing models as a starting point. One model would have to be selected. Currently, none of the existing models meets all the requirements of FHWA.

- **Alternative 3:** Develop a "next generation" simulation model (NGSIM). If this avenue is pursued, the NGSIM must:

- Do the right things
- Do them correctly
- Accommodate other people's models and utilities
- Create an environment of private sector support instead of competition

To accomplish those goals, Courage proposed developing a core model interfaced with an input interface and an output interface.

These two interfaces would then be accessible to the user via a graphical interface device (GUI). In this fashion, changes to the core model would be transparent to the user and would allow input from others.

A required element would be "professional community oversight", required to produce a technically sound model.

By following this developing mode, Courage believes a better, more flexible model can be developed.

CORSIM OVERVIEW **RON GIGUERE**
MAJOR DRIVING FORCES
FHWA APPROACH

Giguere started his presentation by indicating the need for establishing the rules and the process for advancing the state-of-the-art in transportation modeling.

He divided his presentation into three areas:

- Overview of CORSIM
- Major driving forces for NGSIM
- FHWA approach for charting the course

Overview of CORSIM

In his overview of the CORSIM simulation model, Giguere discussed its customers, major strengths, functional deficiencies, and design deficiencies.

He indicated there are approximately 1,100 registered users of CORSIM worldwide and listed the following customers of CORSIM:

- FHWA R&D program
- FHWA HQ & Field technical assistance
- Practitioners (e.g., State & local government & consultants)
- Universities (research & education)

Giguere categorized the strengths of CORSIM as follows:

- Its ability of simulate an integrated network of surface streets and freeways
- Microscopic vehicle simulation
- Sophisticated vehicle movement logic
- Detailed traffic signal control logic
- Animation output (TRAFVU)
- Long history of CORSIM component (NETSIM & FRESIM) application

Among the functional deficiencies of CORSIM, Giguere listed the following:

- Very limited capabilities in assessing ITS technologies
  - Dynamic Message Signs (DMS)
  - No wide-area surveillance
  - No in-vehicle guidance
  - Other
- Not a multi-modal simulation system
  - Limited transit capabilities

As for CORSIM's design deficiencies, Giguere listed the following:

- Unable to simulate large networks
- Difficult and expensive to maintain and enhance the code
  - Huge, poorly structured legacy Fortran code
- Different system design approaches in the surface street and freeway logic
- Limited "plug-n-play" capabilities to interface with other models and applications
- Lack of updated documentation
  - Of the software, its underlying theory, and calibration procedures

Major driving forces for NGSIM

Giguere moved on to describe the driving forces behind the need for a "new generation" traffic model, which he called NGSIM, as follows:

- The Research and Development (R&D) needs
  - <u>Specifically</u>, a tool to support FHWA R&D projects such as:
    - Adaptive Control Systems (ACS)
    - Traffic Estimation and Prediction System (TrEPS)
    - Advanced Traffic Controller
    - ramp metering algorithms
    - other
  - <u>Generally</u>, a tool to analyze:
    - intelligent transportation systems technologies
    - advanced hardware components
    - advanced software components (e.g., algorithms)

    - And, a tool which is:
        - easily upgradeable
        - well documented
        - analytically valid
- Practitioner needs
    - Generally, a tool that provides:
        - traffic operations, transportation management and ITS analysis capabilities
        - multimodal considerations
        - emissions assessments
        - a user interface that is "easy" to use
        - output data that is "easy" to interpret and is consistent with other analyses
        - animation features
    - A tool that is
        - well documented
        - validated
        - "easily" calibrated
- Regulatory and program initiatives
    - A tool that conforms to the ITS National Architecture
        - supports interoperability
        - support integration
        - allows for ITS to be incorporated into the transportation planning process
- Interfaces with other products
    - Such as with TRANSIMS, considered to be the next generation planning model
        - The NGSIM should be designed to "plug in" where the current TRANSIMS microsimulator module resides
        - Allow TRANSIMS to take advantage of higher fidelity model for sub-network analyses
        - Allow NGSIM to use planning inputs such as individual origin / destinations and trip chains

While making these points Giguere emphasized two particular points:

- The traditional boundaries of planning models and operations modules are overlapping
- All ITS projects receiving funds in whole or in part from the Highway Trust Fund, including the Mass Transit Account, must comply to the ITS National Architecture

FHWA approach for NGSIM

Giguere discussed the following topics:

- Assumptions
    - It is not feasible to modify CORSIM to address current deficiencies and meet future needs
    - No existing simulation models meet all future needs

    - There are a wide variety of options available for the design and development of NGSIM
- Objectives of NGSIM
    - Develop a simulation model that meets the research, evaluation and design requirements for transportation systems 5-10 years in the future
    - Minimize development costs and time without sacrificing quality
    - Partner whenever technically and legally feasible
    - Complement current FHWA model and product development
- Decision process
    - Will involve the following steps and target dates:
        - CORSIM reengineering study - 1999
        - Initiation of Feasibility Study - 3/00
        - Request for Information (RFI) - 6/00
        - Legal Issues Workshop - 6/00
        - Simulation Workshop - 8/00
        - Completion of Feasibility Study - 9/00
        - FHWA Management Review - 9/00
        - Initiation of Contractual Process - 10/00
- Action items for this workshop
    - Identify the analysis and research needs for the next 5-10 years
    - Develop list of (preferably rank-ordered) modeling requirements to address these needs
    - Establish potential architectures and software engineering features to accommodate the requirements
- Basic questions Giguere posted to the group:
    - What is the logical "jumping off" point?
    - What are reasonable expectations for outside participation in adding functional and user interfaces?
    - Who should be responsible for configuration control, maintenance and support?

Giguere concluded his presentation by posting a final question: What role should FHWA play in advancing the state-of-the-art in transportation modeling?

FEASIBILITY STUDY — CHARLES WALLACE

Wallace provided an overview of a feasibility study, conducted by Courage & Wallace, to determine the options available to FHWA in replacing CORSIM with a new or reengineered microscopic simulator. As part of the study Courage & Wallace would also establish requirements for the new model, examine alternative approaches for its development, and address other issues such as cost, time and licensing issues.

The study included the following seven tasks:

1. Identify FHWA's traffic modeling requirements
2. Assess the current CORSIM
3. Assess other existing models
4. Identify key issues
5. Hold a stakeholders forum
6. Develop and assess alternative approaches
7. Document in a Final Report

Wallace listed their data sources for Task 1:

- FHWA info papers
- "Smartest": Algers, S., E. Bernauer, M. Boero, L. Breheret, C. Di Taranto, M. Dougherty, K. Fox and J-F. Gabard, "Review of Micro-simulation Models," University of Leeds, London, prepared for the European Commission, Transport RTD Program of the 4th Framework Program, August 1997
- RFI, May-June 2000
- Legal Issues Workshop, June 20, 2000
- Their own knowledge

He listed the following FHWA modeling requirements listed in their scope:

- Ability to model large arterial and freeway networks
- Simulation fidelity of 1 sec, 1/10 sec and 1/100 sec
- Operability on PC, Local Area Network (LAN), *Internet* platforms
- Microscopic modeling
- User-friendly interface for data entry by practitioners
- Post-processor with graphic and animated capabilities
- Object-oriented modularity
- Open architecture
- Distributed processing capabilities
- Drive and vehicle characteristics modeling behavior
- Traffic assignment functionality
- Pedestrian and bicycle capability

In describing the Smartest-suggested telematics, Wallace referred the attendees to the following website: http://www.its.leeds.ac.uk/smartest/

Wallace listed the RFI-suggested requirements, as follows:

- Integration with real traffic control devices for hardware-in-the-loop traffic simulation
- Collect measures of effectiveness (MOEs) on user-selected individual vehicle(s)
- Improve the human model
- Travel choice behavior
- Allow path-based routing

- Facilitate geometric design, sight distance evaluation, work zone analysis, etc.
- Improve interoperability with other software products
- Proper validation and calibration

Wallace described the C&W suggested functionality that the NGSIM should have, based on the data collected on Task 1:

- Implementation of ITS elements and appropriate driver response, for freeways and arteries, as appropriate, such as:
  - DMSs for route guidance and advanced warning of incidents and like events
  - Pre-trip route selection and in-route guidance with dynamic rerouting based on events
  - Full range of ramp control strategies, from simple fixed-time metering to flow balancing (coupled with a dynamic ramp optimization model)
  - HOV and other special-use lane designations (and accompanying traffic interaction models)
  - Real-time (simulated) wireless route guidance
  - Dynamic route assignment
- Collision-avoidance modeling
- Traffic-responsive signal control, in addition to the standard pre-timed and traffic-actuated modes
- Connectivity with optimizers for intersections, ramps and traffic assignment models
- Connectivity with data gathering processes and databases for acquiring input data
- Connectivity with office productivity tools for displaying results in tabular, graphical and animated modes
- Commercial vehicles
- Database-driven data sources
- Full compatibility with other advanced software tools, both traffic and non-transportation (e.g., statistics, etc.)

Wallace continued his presentation by listing some of the current MOEs generated by the CORSIM model:

- Link MOEs:
  - Vehicle trips
  - Vehicle miles
  - Total travel time
  - Move time
  - Total delay time and average
  - Total time (min/mi)
  - Queue delay
  - Control delay
  - Stopped delay
  - Stopped percentage
  - Average volume

    - Average speed
    - Average occupancy
    - Storage (%)
    - Phase failures
    - Avg. queue length
    - Max. queue length
    - Number lane changes
    - Discharge per lane
    - Fuel & emissions
- Person MOEs:
    - Miles of travel
    - Trips
    - Delay
    - Travel time
- Link MOEs:
    - Vehicles in
    - Vehicles out
    - Lane changes
    - Current content
    - Average content
    - Vehicle miles
    - Vehicle minutes
    - Total time
    - Move time
    - Total delay
    - Ratio move/total
    - Total. Veh-min/veh-mi
    - Delay Veh-min/veh-mi
    - Volume, density, speed
    - Link type
    - Fuel and emissions
- HOV (similar, but also by person)

In describing C&W's assessment of CORSIM, Wallace listed the following:

- Limited functionality, particularly in ITS
- CORSIM code is obsolete, difficult to maintain, enhance and grow
- Input process is awkward
- Outputs are very unfriendly
- TRAFED is better than a text editor, but not ideal
- TRAFVU very good
- Documentation is considerably deficient, both user and program

Under Task 3, C&W assessed the following additional models:

- AIMSUN2/GETRAM
- DRACULA
- FLEXSYT II
- HUTSIM
- INTEGRATION
- MITSIM
- PARAMICS
- SimTraffic
- Texas
- TRANSIMS[1]
- VISSIM
- WATSim

Wallace then listed the key FHWA-identified issues:

- Availability of source code
- Cost of unlimited/limited license
- Functional capabilities of the model
- Complexity of model input requirements
- Complexity of software codes
- Estimated cost of re-engineering effort
- Funding options (e.g., public-private cost sharing, federal-state pooled funds, etc.)
- Estimated time to complete re-engineering effort
- Legal aspects (including software ownership issues)
- Implications with respect to ongoing software maintenance and technical support
- Other key issues
    - Development paradigm:
        - FHWA go it alone
        - Public-private partnership
        - Free Software Foundation model
    - Peer review:
        - Isolated R&D
        - Advisory group
        - Oversight group
    - Architecture requirement:
        - Patchwork quilt
        - Holistic approach
        - Role of the Internet and the World Wide Web (WWW)

[1] *TRANSIMS is a special case; while not expected to replace CORSIM, NGSIM should interface with it.

Task 5 of the feasibility study was to conduct a stakeholder forum, which was the purpose of this workshop. Wallace indicated that the results of this workshop would be vital in FHWA's decision process, and will be documented in C&W's final report. He described the framework for this workshop by posting the following question to the group:

- Who are the major stakeholders?
- What are the modeling/software application needs?
- What are the roles and responsibilities of the various stakeholders?
- What direction should FHWA take in the future with respect to traffic simulation?
- What should the NGSIM modeling suite look like and how should it be developed?

Under Task 6, Assessment of Alternative approaches, Wallace indicated that C&W expects to offer several options with pros and cons (development paradigm and oversight regimen) but that the final decision was FHWA's.

Under Task 7, Documentation, Wallace indicated the following:

- Final report to contain summary of project and recommendations of Task 6, based considerably on Task 5
- C&W will attempt to get peer review, but time is critical

REQUEST FOR INFORMATION (RFI) DISCUSSION OVERVIEW, GENERAL CONSENSUS, FEEDBACK **GEORGE LIST**

List referred the attendees to the handout entitled "Next Generation Simulation Model: Responses to the Request for Information." He highlighted the responses to the RFI, as follows:

- Only 14 "significant" responses had been received.
- The "gap" between planners and traffic engineers is closing, to the point where both could use the same planning/operational tools.
- No response suggested than an adequate model exists today.
- Respondents who attempted to provide a complete list of current models were in general agreement on the content.
- Various models were proposed as the logical starting point for future development.
- The list of models proposed included:
  - TSIS/CORSIM
  - DynaMIT
  - Dynasmart
  - Paramics
  - VISSIM
  - Integration

- WATSim
- TransModeler
- MITSIM
- SimTraffic
- AIMSUN2

- The shortcomings of the specific models listed included the following:
  - Support for multi-modal networks.
  - The ability to model ITS technologies.
  - Ability to model large networks in real time.
  - Integration with real traffic control devices for hardware-in-the-loop traffic simulation.
  - Be able to collect performance statistics on any user-selected individual vehicle.
  - Lack of documentation.
  - Lack of proper validation and calibration.
  - Lack of transparency.
  - Lack of modularity.
  - Lack of scalability.
  - Inadequate consideration for extensibility or integration with existing packages.
  - Failed to keep up with the rapid change of technology.
  - Lack of calibration and validation.
  - Weakness in the human model.
  - Representation of travel choice behavior.
  - Limited user base (for some models).
  - Software architecture.
  - Lack of adaptive signal control algorithms.
  - Not path-based.
- While not unanimous, there was a feeling that some existing models were adequate for design purposes. CORSIM was mentioned most frequently as the logical choice for this purpose.
  - None are adequate for geometric design, sight distances, work zones
  - Signal timing optimization: Respondents felt that existing models were adequate
  - Integration among models is weak
  - Research tools need upgrade for general use
  - Input and output processing typically needs enhancement
- Some respondents suggested that the design task is less demanding than the research task, while others suggested that design is a more demanding application.
- Some respondents mentioned examples (either general or specific) from the defense or aerospace industries, however there was no consensus on specifically what we should be drawing from where.

As for the questions as to what are the most important requirements for the next generation model, List summarized the responses as follows:

- These items were put forth as two different questions, but respondents tended to answer them as a single question by referencing their response to either the previous of next question.
- Respondents who answered this question generally indicated that all of the technical features identified by FWWA were essential to some degree. There was not a clear trend with respect to which features were most important. Most respondents seemed reluctant to suggest that a particular feature was unnecessary. A couple of respondents suggested that specific features were most important for some purposes.
- It was generally recognized that all requirements can't be met immediately and that a phased implementation would be necessary.
- A number of respondents suggested that 3D animation might be of lesser importance, especially if it slows down the simulation.

When asked what other requirements (features currently not simulated by CORSIM) should be considered, List highlighted the following:

- Improved recognition and treatment of site-specific parameters.
- Improved treatment of human factors in the logic.
- Explicit recognition and treatment of parking and terminal operations.
- Improved modeling of vehicle-vehicle and vehicle-system interactions.
- User interface improvements.
- External control logic (hardware in the loop, etc.).
- Mechanical enhancements (network size, time resolution, simulation speed, etc.).
- Connectivity to other software and processes.
- Improved multimodal treatment (Buses, bikes, pedestrians, etc.).
- Enhanced recognition of ITS measures.
- Explicit treatment of special features (toll plazas, preemption, VMS, etc).
- Improved documentation.
- Enhanced route/path choice options and logic.
- Ability to model more complex intersections, including roundabouts.

List discussed the issue of CORSIM re-engineering. He indicated that the term re-engineer was not well defined. When asked if CORSIM re-engineering was the best option, there were positive and negative responses.

List indicated that when asked whether it was advisable to retain TSIS and TRAFVU, respondents drew both qualified and unqualified “yes” and “no” responses. The most common response was a qualified “yes.” TRAFVU appeared to have more support than TSIS.

As for the issue of where should the code reside, the responses indicated that there was clearly a substantial support for the Free Software Model, combined with a recognition of the intellectual property rights of the developer. A 2/3 majority favored free and open availability of the model source code. The others favored controlled availability with specified conditions. Nobody suggested that it should not be available.

As for source code maintenance and support, List indicated that he majority of the respondents felt that FHWA should have a role in software maintenance, varying from subsidization to complete responsibility. Maintenance and enhancement were recognized as important topics. The importance of a design that facilitates maintenance and enhancement was stressed. It was generally recognized that the specific arrangements for maintenance and enhancement would depend to some extent on the contractual framework under which the software was developed.

List's presentation generated a series of questions/comments, including the following:

- Time-steps should be longer than one second and should be a user-input.
- There was an under representation of the current user community among the respondents.
- Debugging is a difficult task and should no be taken lightly.
- Calibration has to be emphasized.
- There should be a linkage between the Highway Capacity Manual and CORSIM.
- A long-term vision is needed; CORSIM will still be used for the near future.
- 3D representation is a trivial matter and its implementation should be left to the private sector.
- In defining the technical requirements, it is important to understand how this model is going to be used.

LESSONS LEARNED - TRANSIMS — FRED DUCCA

Ducca provided an overview of the Transportation Analysis and Simulation System (TRANSIMS) model. He highlighted that fact that TRANSIMS can simulate individuals, as opposed to vehicles. TRANSIMS is categorized it as a next generation planning model, which provides a microscopic approach to regional traffic modeling.

TRANSIMS consists of integrated 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 methodologies, 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 effect of the transportation infrastructure 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 vehicular and 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.

Ducca indicated that TRANSIMS took six years to be developed, and like NGSIM, it encountered a lot of resistance at the beginning of its planning process. TRANSIM currently runs under the Linux operating systems and there are no plans to develop a Windows version.

He described the data flows of the TRANSIMS model and how its microsimulator works on a trip basis, broken into specific legs of the individual’s trip. Each trip starts and ends with walking. A vehicle and an individual follow the same plan when a vehicle is occupied.

He encouraged the participants to allow a relationship between TRANSIMS and NGSIM.

Among the lessons learned, Ducca organized them into categories, as follows:

- Programmatic requirements
    - Tie technical development to program needs (Federal interest)
    - Planning requirements
        - Environmental justice
    - Air quality requirements
        - Conformity
    - ITS systems architecture
    - Case law (he used a Chicago case as an example)
    - Identify end users and how they deliver the program
- Computational requirements
    - Hardware capabilities will change
    - Operating systems will change
    - Build models to future hardware capabilities
        - Processing speeds doubles every 18 months
    - In tradeoff between hardware and program requirements, favor program requirements
- Technical requirements
    - Be open to new approaches, new paradigms
    - Program requirements should define technical methods
- Real world tests
    - Need to test in the real world
    - Involve users in the development

    - Test on "dirty" data
- Input from user community
    - Does it meet user needs?
    - Keep in front of the user community (TRB, ITE, ASCE, etc.)
- Deployment and Maintenance
    - Plan for deployment and training
    - Ongoing maintenance
    - Look for private sector involvement
- Validation/sensitivity testing
    - Tie to program requirements
    - Fidelity to meet requirements
    - What makes a difference
    - Three types of validations
        - Software functions as designed
        - Acceptable as an analytic procedure
        - Does it replicate the real world

"HOMEWORK" ASSIGNMENT / PREVIEW OF DAY 2 GEORGE LIST

Towards the end of the first day, List separated the attendees into four breakout groups. Each break out group would focus on the functional or analytical requirements (e.g., what do we need to be able to model) as opposed to implementation requirements (these would be discussed in the 2nd break out Session). When discussing functional requirements, the groups should consider factors such as:

- **priority** of the function
- **level of fidelity** needed for the function
- **level of effort** needed for implementing the function
- **time urgency** for implementation of the function.

The expected outcome of this session was a list of recommendations to FHWA with supporting discussions documented. Each group was asked to present a report to the whole group following their break out session.

The four breakout groups, and their instructions were as follows:

- **Group 1. Research Users' Functional Requirements**
    - This group represented users who apply models primarily for research studies (e.g., universities or other researchers/consultants).
- **Group 2. Transportation Planning Users' Functional Requirements**
    - This group represented users who apply models for transportation planning analyses (e.g., MPOs or state DOT planners or consultants).
- **Group 3. Operational Analysis Users' Functional Requirements**
    - This group represented users who apply models on operational analyses (e.g., state or local traffic engineers or consultants).
- **Group 4. On-line Users' Functional Requirements**

- This group represented users who apply models for on-line analyses (e.g., traffic management center operations, independent service providers (ISPs), etc.)

Each group was asked to consider, as a minimum, the following major functional areas and discuss and document functional requirements for each area as they relate to the group:

- Traveler Modeling (e.g., traveler response to information, driver behavior, origin/destination, etc.)
- Vehicle Modeling (e.g., performance characteristics by vehicle type, intelligent vehicles, etc.)
- Roadway Modeling (e.g., lanes, shoulders, ramps, intersections, etc.)
- Transit Modeling (e.g., bus routes, rail operations, transfer points, etc.)
- Traffic Control Modeling (e.g., traffic signals, route signs, dynamic message signs, ramp meters, HOV, HOT, etc.)
- Pedestrian Modeling (e.g., model pedestrians as travelers, only model pedestrians' effect on signal control, etc.)
- Bicycle Modeling (e.g., bicycle lanes, bicycle paths, bicycles in traffic stream, etc.)
- Emissions Modeling (e.g., emission modeling capabilities, input to separate emissions models, etc.)
- Other Modeling (Toll Operations, Commercial Vehicle Operations, Other)

Each group was assigned a recorder and an FHWA representative to provide support.

DAY 2: TUESDAY, AUGUST 22, 2000

WELCOME AND BREAKOUT INSTRUCTIONS — GEORGE LIST

1ST BREAKOUT GROUP DISCUSSIONS
"FUNCTIONAL REQUIREMENTS AND PRIORITIZATION FOR USERS' NEEDS"

After discussing their assignments during the early morning, each group presented their findings, as follows:

BREAKOUT GROUP REPORTS

GROUP 1. RESEARCH USERS' FUNCTIONAL REQUIREMENTS

John Leonard presented Group 1's approach:

- Discussion Approach
  - Enumerate problems statements
  - For each problem statement, identify specific functional requirements (needs, etc.)
  - Identify commonalities between all functional requirements,
  - Prioritize (FHWA advisory committee)

The group suggested that this approach be followed during the preliminary stages of this project.

- Uses of "research" models
  - Accurate evaluation of existing system
    - Need to make models more transparent for calibration and validation across regions
  - Comparison of potential designs
  - Creation / testing of new low-level models
    - Algorithms, devices, drivers, vehicles, designs
  - Testing and "burn in" of new devices
    - National architecture data flows, data flow optimization
  - Training ("operator in the loop")
- At-grade rail crossings
  - Traveler – modeling of driver response to control devices
  - Vehicle –
  - Roadway – more precise, more diverse representation of at-grade crossings
  - Transit – interactions of rail with control devices
  - Traffic control modeling – "software in the loop" for development of new algorithms
  - At-grade rail crossings
- Ramp metering algorithms

  - Traveler – response to ramp control (both from path perspective and at ramp itself
  - Vehicle – multiple cars per green, alternate vehicle performance characteristics
  - Roadway – need for diverse set of HOV (HOT) and ramp configurations
  - Traffic control – need to control ramp meters externally (creation of new algorithms, e.g., multiple cars per green)
  - Ramp metering algorithms
  - Transit – bus
  - Pedestrian, bicycle – none
  - Emissions – need for output of velocities and accelerations
  - Other – need for varying levels of fidelity ("microscopicity") for different portions of the network
- Dynamic routing and control
  - Traveler – response to information (e.g., impact dynamic messages)
  - Vehicle – precise control of individual vehicles (adaptive, path-based control "on the fly"), geo-location of vehicles
  - Roadway – geo-location of roadway, larger networks, spillback between sub-regions
  - Traffic Control – vehicle/control communications
  - Dynamic routing and control
  - Transit
  - Pedestrian
  - Bicycle
  - Emissions – velocities and accelerations
  - Other needs
- Advanced traveler information
  - Traveler – desire flexibility to experiment with alternate behaviors and decision processes "plug and play"
  - Vehicle – fleet composition, use of vehicle probes, path-based simulation
  - Roadway – diverse set of roadway configurations
  - Transit – comparison between modes
  - Advanced traveler information
  - Traffic control – new surveillance approaches, new control approaches, incident modeling
  - Pedestrian, bicycle – interaction between pedestrians and bicycles and vehicles
  - Emissions – velocities and accelerations
  - Other modeling needs – impact of new information devices on driver "awareness" and safety
- Multimodal terminal simulation
  - Detailed models of pedestrians (jay walking), vehicles, transit, parking (including illegal parking), and all that stuff in one big package
  - (Special event management)
  - Impacts of weather
  - Geometries, sight distances
  - (XYZ position, velocities, acceleration)

- Functional requirements
  - Consideration 3D geometries (for sight distance evaluation, impacts of grade on capacity, etc.)
  - Support for varying fidelities (differing time scales, different levels of detail across sub-regions, e.g., macro/micro/mesoscopic)
  - Support for defensible calibration and validation
  - "Operator in the loop" / "hardware in the loop" / "driver in the loop" for training in RT
  - Functional requirements
  - Hooks into system (first resort)
    - For developing of new control devices
    - For tracking vehicles
    - Path-based routing
  - Access to the source (last resort)
    - For hacking (just for fun!)
    - "You never know what you will need"
  - Safety as an MOE
  - Proper experimental framework
    - move away GUI
  - Functional requirements
  - Hardware/operator/driver in the loop
  - Concurrent multi-scale modeling
  - Path-based
  - Driver response to info (behavior)
  - Precise vehicle XYZ (position, velocity, acceleration)
  - Safety

GROUP 2. TRANSPORTATION PLANNING USERS' FUNCTIONAL REQUIREMENTS

Vassili Alexiadis presented Group 2's approach:

- Composition of breakout group
  - FHWA Headquarters and field offices -- 2
  - Metropolitan Planning Organizations (MPOs
  - State DOTs
  - Traffic engineers for counties, cities, etc.
  - Consultants -- 4
  - Research – 2
  - Software Developer – 1
  - University - 1
- Is there a need for simulation models in the planning context?
  - Proposed rulemaking: Integration of ITS in the transportation planning process

- **Planning:** Alternatives analysis, screening, and selection (existing planning tools cannot handle screening very well). Air quality. Projections into future. Capture time dependency of travel.
- **Traffic Operations:** Optimization of **selected** alternative for design, implementation, testing, operation, and maintenance
- **On-line:** System optimization real-time

- Simulation is the medium to bridge schism between planners and traffic engineers. Two paradigms:
  - European: Integrate planning and simulation models into one
  - American: Use inputs outputs to connect two types of models
- What is best practice in the market today and why?

Functional Areas[2]	**Pr**	**Fid**	**Eff**	**Urg**
Traveler Modeling (e.g., traveler response to information **(assignment, mode shift, temporal shift, induced/foregone demand,** origin/destination, **trip chain,** etc.) • External trip tables + synthetic ability • Need assignment, temporal shift, mode choice, … available • Levels of traveler information affecting trip table • Focus on traveler modeling rather than vehicle modeling	H			Same as in Pr
Vehicle Modeling (e.g., performance characteristics by vehicle type, intelligent vehicles, **AVCSS, AHS**, driver behavior etc.) • Emissions, AQ, and energy (H) • Safety (H) • Is forecasting noise larger than model accuracy? – M	M	L		
Roadway Modeling (e.g., interchanges, lanes, shoulders, ramps, **roundabouts,** • Intersections and interchanges - H • **MF and HOV lanes - H** • **Truck lanes – H** • **Medium fidelity to capture weaving/merging and individual lanes**	H	M		
Transit Modeling (e.g., bus routes, rail operations, transfer points, etc.)	H	M		

[2] Pr = Priority, Fid. = Fidelity, Eff = Effort, Urg. = Urgency, L = Low, M = Medium, H = High

• Need rail transit simulation both in terms of mode choice and traffic operations • Paratransit in API • Access to external trip chaining				
Traffic Control Modeling (e.g., traffic signals, ramp meters, HOT, etc.) • Simulator for optimizing traffic signals and ramp meters in steady state conditions • Ability to compare between different operational methods	H	M		
Traveler Information Systems (supply – pre-trip, en-route, etc.) route signs, dynamic message signs, • Ability to locate VMS, chose between pre-trip ATIS vs. en-route • MF – Macro	M	M		
Pedestrian Modeling (e.g., model pedestrians as travelers, only model pedestrians' effect on signal control, etc.) • Effect of pedestrians on traffic - API	H	L		
Bicycle Modeling (e.g., bicycle lanes, bicycle paths, bicycles in traffic stream, etc.) • Allow for bike lanes	H	L		
Emissions **and Energy** Modeling (e.g., emission modeling capabilities, input to separate emissions models, etc.) • Provide output to emissions and AQ models • Fuel consumption internal • * Depends on EPA requirements	H	*		
Other Modeling • Toll Operations **(dynamic and basic),** H-LF • Commercial Vehicle Operations, H-LF • **Port Operations**	H	L		
Safety Modeling • **Provide output on exposure to risk to be used by safety models**	M	L		

GROUP 3. OPERATIONAL ANALYSIS USERS' FUNCTIONAL REQUIREMENTS

Dolf May reported for Group 3. He indicated that their discussion concentrated in ranking the assigned functional areas based on their importance:

He presented the following ranking, starting with the most important functional area:

FUNC. AREA	DETAIL
a. Traveler Modeling	Traveler response to information, behavior, path-based, dynamic guidance, weather
b. Traffic Flow Characteristics.(Added by the group)	Car following, lane changing, gap acceptance, weaving, anticipation, conflict analysis, response to clearance interval
Roadway Modeling	Lanes, shoulders, ramps, intersections, pavement condition, V-H alignment, weather, traffic calming (roundabouts, etc.), merge, U-turns, min. link length
Traffic Control Modeling	Signals (including pedestrians, preemption, coordination, adaptive, etc.), route signs, lane control VMS, HOV, HOT, Toll plazas, lane control, lane closures, variable speed limit
Vehicle Modeling	Performance characteristics. by vehicle type, IVI
MOEs (Added by the group)	
Transit	
Other	
Emissions	
Pedestrians	
Bicycles	

GROUP 4. ON-LINE USERS' FUNCTIONAL REQUIREMENTS

Larry Owen presented Group 4's approach and discussed the following topics:

- What distinguishes on-line usage?
- Requirements unique to on-line
- Guidelines
  - priority of the function
  - level of fidelity needed for the function
  - level of effort needed for implementing the function
  - time urgency for implementation of the function.On-line
  - Communicating with external devices
  - External input out of control of user
    - Event driven
    - Dynamic demand
  - Timing is everything
    - Real-time system operation
  - Stochastic nature of simulation!
    - Deterministic option?
  - Who

      - ATMS operators
      - ATIS operators
        - Public and Private sectors
- Applications - ATMS
  - Testing
    - Simulate traffic flow detector information
  - Fill in when detector fails
    - Traffic flow
    - Cameras
  - Evaluate traffic management strategies
    - Local
      - Work zone
      - Incident
      - Signal optimization
    - Global
      - Signal timing
  - Emergency service providers
- Applications - ATIS
  - On-line travel advisory
  - Route guidance
  - Opportunity for public/private partnership
- Requirements
  - Functional requirements
    - Self calibration
    - Network topology
    - Stochastic nature
  - Interface requirements
    - Pick up dynamic control strategies
      - Real-time traffic signal control timing
    - External O-D information
    - Communication with external devices
      - Common database
  - Performance requirements
    - <<real-time for evaluation
    - Real-time
- General High Priority Features
  - Vehicle and mode modeling
  - Driver modeling
  - Detector interfaces
    - Probe
    - Traffic flow
    - Emissions

Owen then presented the group's prioritized list of functional areas:

	Priority	Fidelity	Effort	Urgency
Self-calibration	High		High	High
Network topology	High	High		
Stochastic nature	Medium		Low	High
External O-D	High			
External devices	High	High	Medium	High
Faster than real time	High	Low	High	High
Real-time	High	High	Low	High

OPEN DISCUSSIONS OF BREAKOUT RESULTS — GEORGE LIST

After the four presentations, an open discussion followed. The following joint commonalities and points were raised:

- The need for varying fidelities
- Must be multi-scale
- Suitable for both planning and operational analyses
- Vehicle vs. people-based
- Input from external models and other sources
- Interoperability
- Tie to the ITS National Architecture
- Use a system engineering development process
- Model information chains
- There is a policy directive to model the ITS National Architecture
- The output should be usable by other models
- The need to integrate ITS into a traffic operations model
- Define the ITS components the model should model
- "Multiple personality" model
- O-D data and dynamic routing

BREAKOUT INSTRUCTIONS — GEORGE LIST

2ND BREAKOUT GROUP DISCUSSIONS

The second breakout group discussions followed, consisting of four new groups: "Options for FHWA Program Implementation."

The focus for this break out session revolved around four topics, each assigned to a separate group. When discussing their topics, groups were to consider factors such as:

- **pros and cons** of each approach
- **level of effort** for each approach

The expected outcome of this session is a list of **recommendations to FHWA** with supporting discussions documented. The groups were asked to share their recommendations to the whole group following their break out session.

The following four groups were created:

- **Group 5. Software Engineering Approaches**
  - This group discussed options for the most appropriate software engineering approaches to consider (e.g., build on current modeling platform, start from scratch, separate requirements development from software development work, develop multiple prototypes and downselect, build modeling framework only, etc.)
  - Discussions included, but were no limited to, the following areas:
    - Building upon a current model versus starting "from scratch"
    - Separating the different software development "stages" into separate efforts (e.g., requirements development, system design, coding, etc.) versus one large effort
    - Developing multiple prototypes and downselecting and building upon the best prototype
    - Initially developing a core model and interface and subsequently conducting multiple development efforts for the various model components
    - Software Design approaches including object-oriented, distributed processing, client-server, other.
    - Software languages including C++, Java, other.
    - Other

- **Group 6. Maintenance / Tech Support / Source Code Access**
  - This group focused on issues beyond software development. For example, who/how should the model be maintained, who/how should technical support be provided, who should have access to source code, etc.
  - Discussions should include, but not be limited to, the following areas:
    - What are the options for maintenance of the software in terms of funding, roles, and responsibilities?
    - What are the options for providing technical support for the software (who provides, who pays, etc.)?
    - How should access to software source code be provided (e.g., to all, only to FHWA & developer, to all upon request, etc.)?
    - What are the documentation requirements for the model?
    - How should model validation and calibration be supported? What is needed in terms of tools, data, and documentation?
    - What are FHWA's roles and responsibilities with respect to maintenance, technical support, training, continued software development, etc.?

- **Group 7. Performance / Software Interface Requirements**

- This group focused on the performance and software interface requirements of the model. On performance, for example, how fast should the model run, what types of platforms should it run on, do we design for multiple and distributed processing, etc. On software interface, for example, how should software interfaces be documented, what standards should be incorporated, what other models do we need to interface with, etc.
- This group considered the following major areas and discussed and documented performance and software interface requirements for each area as it related to their group.
  - Computer platform
  - Computing speed
  - Size of transportation network, number of vehicles
  - Other
  - What standards should be used for software interfaces?
  - How should the interfaces be documented?
  - What other software, models, types of models, or hardware should the NGSIM interface with?
  - Other

Group 8. User Interface Requirements

- This group focused on how the user interfaces with the model. For example, what type of features do we need in a GUI, data input features, output capabilities, animation capabilities, etc.
- The group considered the following major areas and discussed and documented user interface requirements for each area as it related to their group
  - Data Input (e.g., graphical user interfaces (GUI), file transfers from GIS, models, or software, etc.)
  - Run-Time Interface (e.g., adding an incident "on-the-fly", stopping / restarting simulation, etc.)
  - Data Output (e.g., output measures, statistical & graphing features, file exports, etc.)
  - Animation (e.g., 2-D versus 3-D, run-time animation versus post-processed animation (re-play), etc.)

"OPTIONS FOR FHWA PROGRAM IMPLEMENTATION" BREAKOUT GROUP REPORTS — GEORGE LIST

GROUP 5. SOFTWARE ENGINEERING APPROACHES

John Leonard presented the topics discussed by Group 5:

- Definitions (what is an architecture?)
- Development process
  - Considerations and needs

    - Best balance between public and private development
    - Promotion of private / university / public contributions
- Functional requirements
- Procurement issues
    - Fund a design (specification of framework)
    - Then, promote a community to deploy
        - Using a combination of funding sources
- Design issues
    - One prototype?
    - Bake off?
- Design document needs
    - End user requirements
    - Software design requirements
- Lessons from IDASA clear set of requirements simplifies development and testing
    - Panel representing user communities provided input
        - DOT, MPO, FHWA field staff
    - Steps followed
        - Functional requirements
        - Design
        - Implementation / coding
        - TestingWhat is an Architecture?Definitions of modules
    - Relationships between modules
    - Related to (can be mapped to) functional requirementsExamples: Object model, state model, logic model, software model, logical architecture, physical architectureArchitecture ConsiderationsShould accommodate eventual concurrent development
    - Should accommodate "phased" functional requirements over time
    - Should accommodate both public and private development efforts (contributions)
    - Should accommodate opportunities for private entrepreneurship
    - Should promote transparency (available source)The group endorsed Courage proposal of a "core" model
    - Separation of "core" from GUI / tools
    - Features of "Core"
        - Open architecture
        - Availability of source code
- Management Process
    - Advisory group (a la NCHRP panel?)
        - Review work of contractor
        - Stakeholders offer input, guidance, review
    - Volunteer model (TRB / HCM model?)
        - TRB model? NTCIP model? Federal support for travel? Others?
    - Contractor model ("Cathedral")
    - Parallel activity

Group 5 concluded with the following recommendations:

- FHWA should adopt the NCHRP process
- Form an advisory group (lasts forever)
- Develop user requirements
  - 6 months
- Develop functional requirements
  - 2 person years, 6 months
- Develop software specifications

Group 6. Maintenance /Tech Support / Source Code Access

Ray Derr presented the findings of Group 6. He discussed the following topics:

- Maintenance - Owner is responsible
  - Configuration Control for Open Architecture
  - Module Certification paid by vendor
  - Money is made in application of models
- Source Access - Up to the owner
  - Pros
    - Not our responsibility unless we are the owner
    - Needed infrequently
  - Cons
    - Possibility of many versions that are difficult to support
- Technical Support - Limited DOT support
  - Combined training and support
  - The California model
  - Local Technical Assistance Program (LTAP)
  - Listserv of Users
  - Threaded Discussion Website
  - Connected to maintenance
  - Provide similar interface to TSIS
  - Timely
  - Vendor module
- Calibration - Design for Easy Calibration
  - Need a decent set of defaults since most users don't change them
  - Guidance needed on what to calibrate, when to calibrate and how to calibrate
- Documentation – Must be good and complete
  - Workbook for Training
    - Modular
  - Publish the interfaces early
  - Formal software documentation
    - Procedures
  - User -
    - Reduce need for training and tech support
    - Application-oriented

- On-line help
  - Consistency {NTCIP center to center}
- Training - Modularity
  - Different Levels
  - On-line/CD ROM
  - Tailored to user
  - Minimize need
  - Underlying theory
  - Application
  - Emphasize Calibration
  - Interpretation of Output
  - DOT sponsored/ consultant provided
  - Vital to use/success
  - If vendor supplied, who does the modifications when software changes?
  - Vendor marketed
  - Application training provided commercial.
  - The National Highway Institute

GROUP 7. PERFORMANCE / SOFTWARE INTERFACE REQUIREMENTS

Ed Lieberman presented the findings of Group 7. He covered the following points:

- Scalability
  - For a full range of applications
- Priority for NGSIM is high
- Computing needs vary
- Access high end computers through the web
- The speed and length of simulation is important
- NGSIM should be object oriented for survivability
- NGSIM should be able to interface with old TRF files
- Configuration management of interfaces is important
  - Taylor to specific needs
- Source code should be made available
  - One sanctioned model
  - Allow for private sector variations
- The connectivity of third party software to the "core" should be very user friendly
- Real time applications
  - Interface to third party is needed
  - Provide the option to function on real time
- Consider the impact of the internet
- Document interfaces at API level (high priority)

GROUP 8. USER INTERFACE REQUIREMENTS

Michael Trueblood presented the findings of Group 8. He discussed the following points:

- Data Input
  - GUI – Graphical user interface -- Essential (provide one but allow plug-in models)
  - Some users will prefer a GUI, while others prefer a text oriented basis
  - GIS Interface to build network
  - Text editor for inputting/editing data – Database/spreadsheet format so other programs can use the data
  - User friendly and flexible
  - One size does not fit all
  - Allow for real time applications with other programs
  - Standard for data entry from other programs (Tranplan, etc.)
  - Old Legacy data should allow file conversion
- Run Time Interface
  - "On-the-fly" incidents should be reserved for on-line applications.
  - Allow user friendly means for inputting restrictions (eliminate left turns, adding lanes, etc.)
  - Need to decide what items can be changed "On-the-fly" (geometry versus to adding detectors)
  - What type of animation do we want? Real time etc.
- Data Output
  - Ability to export output files into spreadsheets (GIS)
  - Average of multiple runs
  - Real time graphs
  - Data output that should be output (safety measures, conflict analysis). Needs further discussion. What do users need for output?
  - Allow for real time output
  - Animation
  - Definitely 2D. Allow output for 3D plug-in.
  - View animation while running as well as final simulation run
  - Possibly add different file types to the animation files so one can view an animation file without having the simulation package.

4:30 PM SYNTHESIS AND INTERPRETATION OF RECOMMENDATIONS

CHARLES WALLACE & KEN COURAGE

The inputs from this workshop are but one of a number of sources inputs—there are other realities that will influence FHWA in their decisions.

Courage stated the overarching mission of the workshop, namely to determine:

- What do we want to do?
- How do we do it right?

Wallace summarized the discussions held during the workshop. He characterized the following points as the tenets by which the development may proceed:

- Open architecture, cross-platform;
- Modularity, object-oriented languages (as just suggested by Ed Lieberman);
- Scalable, expansible, distributed processing;
- Core functionality with optional, replaceable functions;
- Support interfaces with other domain modeling systems (e.g., planning, environmental, freight processing, TRANSIMS, office productivity products, etc.);
- Path-based, dynamically reassigned human responsiveness;
- ITS functionality and control; and
- Interfaces with real world systems are integral parts—not purely traffic simulation.

The process tenets he highlighted included the following:

- Separate modeling (R&D, etc.) and software development process:
  - R&D track, including model validation, and
  - Software development track.
- A systems engineering approach suggests dealing with the first of these well out in front of the latter, although a concurrent process is feasible.
- The first step needs to be to develop an architecture (a development framework as John Leonard described) of the traffic modeling environment:
  - Develop the high-level requirements ("user service" requirements), both for R&D and practitioners;
  - Develop data definitions, flows, classes, etc.;
  - Interface protocols (MIPs, APIs, etc.);
  - Internet/Web influence;
  - Road map for development; and
  - Resources: National ITS Architecture, DOD Simulation environment, and CORSIM et al. themselves.

The suggested process would be as follows, using a staged (and eventual concurrent) design/development:

- Macro Step 1:
  - Architecture development
    - Operational Concept Design
    - Data definitions, data flows, etc.
  - Project-level scope of services
    - Business plan
    - Institutional relationships
    - Roles and responsibilities

- Macro Step 2:
  - – Design (software requirements, Software Design Documents, Interface Design Documents, etc.)
    - Recycle of existing models and/or code
  - – Build (Alpha Test);
  - – Testing Validation &Verification and beta-test;
  - – Software integration and testing of multiple products;
  - – Distribution/support (both public and private depending on their respective roles); and
  - – Maintenance/configuration management.

There are many opportunities for partnerships:

- Advisory/oversight function (e.g., ITE Transportation Software Developers' Task Force, TRB Joint Traffic Models Task Force)
- Systems integration
- Public-private partnerships

These decisions can be made more logically within a well planned/maintained process.

ISSUES AND PRIORITIES **KEN COURAGE**

The remaining issues (some of which are identified here) fall into three broad groups, summarized as follows:

■ Those that should be resolved before development:

- Mechanism for professional and industry oversight;
- Degree of standardization required:
  - – Software development,
  - – Documentation, and
  - – Interface specification;
- Degree of support for TSIS 5 in the interim period;

■ Those that should be resolved during development:

- Public domain, Free Software Foundation model, proprietary products, etc.;
- How to involve the private sector as a partner;
- Tradeoffs between competing functional requirements—risks and cost effectiveness;
- Degree of calibration/validation required; and
- Homogeneity of model:
  - – Time resolution,
  - – Microscopicity,
  - – Analytical components.

- Those that are continued and on-going:

  - Top-down vs. bottom up funding justification; and
  - R&D interests vs. user interests.

Subsequent discussion suggested other issues:

- Activity-based modeling? (Tom Maze)
- Continuing dialog (several)

Courage closed the discussion with the suggestion that the closing of the workshop was indeed the *end of the beginning of dialog!*

WORKSHOP WRAP-UP AND NEXT STEPS — RON GIGUERE

Giguere closed the workshop by thanking all present for their participation and contributions over the past two days.