

Microsimulation, Freeway System Operational Assessment, and Project Selection in Southeastern Wisconsin: Expanding the Vision

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Microsimulation, Freeway System Operational Assessment, and Project Selection in Southeastern Wisconsin: Expanding the Vision

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1. ABSTRACT

The purpose of this paper is twofold. First, it discusses a proposed process for objectively selecting potential freeway improvement projects using microsimulation and other analytical techniques. Second, it describes the resulting microsimulation software requirements, the project team's experience with its original software choice, and criteria used to evaluate two relatively new simulation packages.

The context is the Southeast Wisconsin Freeway System Operational Assessment (FSOA), a detailed examination of the safety and operational performance of the Metropolitan Milwaukee freeway system. The project began in 1999 and has evolved since that time. Initially, microsimulation was viewed solely as a tool for identifying *localized* sites with operational problems. As the project and software technology evolved, microsimulation emerged as the basis of an ongoing process for analyzing *systemwide* freeway operations. The need to integrate FSOA with other studies and the District's project selection process became clear.

Microsimulation is a relatively new type of computer modeling that performs detailed stochastic analysis of traffic operations on a series of roadway segments by simulating the motion of cars, second by second. In an integrated project selection process, output data from microsimulation can serve as input for engineering economic analysis, which in turn provides an objective basis for selection of projects implementing the freeway reconstruction program. Only the most advanced microsimulation software has the power necessary to accomplish a task of this complexity. The team evaluated the PARAMICS and VISSIM packages. Both offer significant advantages compared to CORSIM, and PARAMICS was recommended as the basis for further simulation work.

2. INTRODUCTION

The Southeast Wisconsin Freeway System Operational Assessment (FSOA) is a detailed examination of the safety and operational performance of the Metropolitan Milwaukee freeway system (Figure 1). The purpose of FSOA is to identify locations with performance problems (high crash rates, severe traffic congestion, poor travel time reliability, etc.) and to develop strategies for improving them by altering geometry and/or traffic control. When completed, this analysis can be used to establish a prioritized, strategic approach to system improvement, and to provide guidance when major elements of the system are reconstructed in the future.

Microscopic simulation is a relatively new type of computer modeling that performs very detailed analysis of traffic operations on a series of roadway segments by simulating the motion of each car—thousands of cars in all—second by second. Microsimulation is a stochastic process that allows for random fluctuations in traffic conditions and driver behavior; it differs significantly from conventional four-step transportation modeling which uses deterministic methods to approximate travel conditions on a macroscopic (usually regional) level. In the FSOA project, microsimulation is being used to visualize traffic problems and explore the complicated interactions between different parts of the transportation network: *Where does the freeway back up? How heavy does the flow have to be for a backup to occur? Can we fix it by changing the ramp meter timing, or will that back traffic onto the arterial? What if we lengthen the ramp?*

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Microsimulation will also be used to provide statistical output that can be used for further analysis: *Is it worth spending \$1 million to fix this problem?*

When the FSOA project began, microsimulation was envisioned primarily as a means of analyzing traffic flow to study areas of the freeway system that suffer from chronic flow problems and to test various alternatives for solving the problems. As the project has developed, it has become clear that FSOA must go beyond this purely analytical function, and also put in place a process for assuring that solutions to freeway issues are systematically implemented when the freeway system is rebuilt in the years ahead.

3. PROJECT SELECTION IN SOUTHEASTERN WISCONSIN.

Like many highway agencies, WisDOT District 2 currently uses a project selection process that is based on a combination of objective analysis and the intuition of District staff (Figure 2). This “programming” process begins with a somewhat artificial division of the available funding into “pavement” and “bridge” categories. Within each category, the District’s Needs Identification Team receives relatively detailed information about pavement and bridge condition; the group must then identify specific highway improvement projects that address documented needs. Usually, the group uses the “worst first” approach.

Concerns have been raised about the District’s current project selection process. For example, while pavement and bridge needs are addressed during the programming process, other issues such as safety and operational problems are not evaluated until Preliminary Engineering begins; this can lead to significant changes in project cost and scope, which in turn cause instability in the District’s overall construction program.

While the existing selection process has worked for a relatively small improvement program, the District is now beginning to plan for the multi-billion dollar reconstruction of the Metro Milwaukee freeway system. This will create new challenges:

- The reconstruction program is likely to be about five times the size of the District’s current freeway program.
- It will become increasingly necessary to make “apples-and-oranges” comparisons between dissimilar options. The reconstruction projects potentially involve combinations of multiple elements—not only pavements and bridges, but also geometric changes, auxiliary lanes, collector-distributor roads, Intelligent Transportation System infrastructure, lighting and signal system replacement, sound wall replacement, ramp meters, environmental and aesthetic improvements, etc.
- The potential scope of each project could vary over a wide range. The best option may not be immediately obvious, so a systematic methodology will be needed to prevent the scoping process from bogging down.
- The Wisconsin Department of Transportation prefers to keep its projects relatively small; construction contracts valued at over \$10 million are rare. Therefore, for the purposes of project management and letting, it will probably be necessary to divide the task of rebuilding the freeway system into a few hundred projects. It will not be possible to build them all at once, so the scope of each project and its order in the sequence of projects will be interdependent.
- Given the size of the reconstruction task, funding will be an issue. To assure that legislators and the public remain confident in the process, it will be important to

assure that sure each project delivers the greatest possible value for each dollar invested.

These challenges are not unique to WisDOT District 2. In its *Assent Management Primer*, the Federal Highway Administration made a number of observations about the program management challenges facing state DOTs in the years ahead. The report's authors noted that, "If current trends continue...DOTs will be facing increased system and budget needs with limited...resources." "Transportation officials may need to compete for funding with other publicly supported programs, such as education." With regard to the shortcomings of traditional program selection methods, the authors observed that "success [is] often measured in terms of controlling backlogs, not in optimizing system performance, maximizing return on investment, or minimizing user impacts" and "[most DOTs] are not able to evaluate trade-offs between various classes of assets, for example highways versus bridges." Observing that "[p]ublic skepticism of government...has led to demands that government be more accountable and operate more like a private business," they called for a "fact-based, reproducible, systematic approach [that] can enhance the dialogue among decision-making bodies regarding capital investment levels." (3)

To address these challenges, the FSOA project team recognized the need a project selection process that would integrate the results of its own analysis with the recommendations of other major guiding documents such as the Southeast Wisconsin Freeway Study, Regional Transportation Plan, ITS Plan, and State Highway Plan (Figure 3). The process should provide a way to synthesize the recommendations of the various plans and transform them into distinct freeway reconstruction projects of well-defined scope and buildable size. The intent is to create a process that is efficient, consistent and objective, so that the implementation of the reconstruction program can proceed smoothly. The FSOA team anticipates five main elements of this process:

1. Conceptualization of alternatives.
2. Testing the alternatives to assure that they actually solve the problem. This would be done with microsimulation.
3. Comparison the alternatives to see which ones deliver the greatest value for money. This would be done with engineering economic analysis (benefit/cost) software tools.
4. Presentation of the analysis results to the Needs Identification Team. This would take the form of a Project Appraisal Report that documents both tangible and intangible costs and benefits of each project.
5. Prioritization and sequencing of the projects by the members of the Needs Identification Team, leading to project implementation.

While benefit/cost analysis cannot replace the judgement of an experienced Needs Identification Team, it is a well-established technique that can assist managing a complex transportation program. "[T]he father of modern cost benefit analysis, J. Dupuit, wrote his classic paper in 1844." [4]. "In most countries, it is in the transport sector that the techniques of cost-benefit analysis have been most highly developed in theory and most widely put into practice. Established cost-benefit procedures exist, for example, for inter-urban roads, urban public transport, and urban road projects..." (5) Benefit/cost analysis is a key tool for Asset Management: "[t]he Asset Management approach incorporates the economic assessment of

trade-offs between alternative investment options, both at the project level and at the network or system level, and uses this information to help make cost-effective investment decisions.”(6)

Engineering economic analysis software provides a basis for systematically identifying the costs and benefits associated with rebuilding, operating, and maintaining segments of the Southeast Wisconsin freeway system. It is a data-intensive tool. Fortunately, much of the necessary data can be obtained from microsimulation: in the process of determining the technical feasibility of an alternative, much of the data needed to determine its financial feasibility is also created. For example, travel time information from the microsimulation model can be fed to the economic analysis software, which can compare the benefits of various build and no-build scenarios.

Therefore, the microsimulation software plays a pivotal role in the District’s ability to manage the large number of projects inherent in reconstructing an ageing freeway system. In the next section, we discuss the specific software requirements this entails, and the advantages and limitations of some available microsimulation software packages.

4. MICROSIMULATION’S ROLE IN FSOA

4-1 Issues with CORSIM

At an early stage of the FSOA project, microsimulation was viewed primarily as a tool for relatively localized analysis of freeway operational issues. In the spring of 1999, an evaluation of the various microsimulation programs was conducted. The evaluation method consisted of a literature review to identify candidate software packages and testing of three candidate packages on a small network. This evaluation was limited mainly to the microsimulation software marketed in the US at that time. The evaluation found that while some of the competing programs had attractive features, the CORSIM 4.2 package developed by the Federal Highway Administration appeared to be the preferred choice for use in the FSOA project as a simulation tool (1, 2).

While CORSIM is a useful tool for the evaluation of traffic operations in small networks, its application to the FSOA project was not as straightforward as anticipated. As the FSOA project continued, it became clear that it was necessary to model *systemwide* traffic interactions. In moving forward with this work, a number of software issues were uncovered; they are summarized in Table 1. These problems caused the model development to be quite cumbersome and contributed to unrealistic simulation results. Extensive effort was expended in attempts to develop temporal solutions to overcome these problems.

The most critical issue was the combined effect of CORSIM’s network size limitation and its lack of local calibration adjustment. A typical transportation model consists of links and nodes. In a microsimulation model, a link represents a segment of roadway with uniform characteristics, while a node represents a point where the characteristics change. A node is required at each intersection, each point where a lane is added or dropped, and each change in grade or curvature. Currently, the FRESIM model within CORSIM is limited to 500 nodes. FSOA’s CORSIM model of the Marquette Interchange in downtown Milwaukee required 430 nodes, and the Marquette Interchange is just one element the Metro Milwaukee freeway system.

To work around the fact that CORSIM 4.2 was capable of modeling only 500 nodes, it was proposed to divide the Metro Milwaukee freeway system into 8 separate sub-models. In

practice this proved extremely cumbersome: linking the sub-models is a manual process which introduces substantial complications and sources of error into the modeling process.

The core of the Milwaukee freeway system is a loop consisting of five major system interchanges in close proximity. For example, the Marquette Interchange (I-94/I-794/I-43) is just two miles from the Stadium Interchange (I-94/US 41/Miller Park Way). Because of CORSIM's network size restrictions, the Marquette Interchange and the Stadium Interchange could not be in the same model, yet the eastbound morning peak hour traffic in the Marquette routinely tails back into the Stadium, and the westbound evening peak hour traffic in the Stadium often tails back into the Marquette. Consequently, the propagation of shock waves through the queues between the two interchanges could not be accurately modeled with CORSIM, reducing the value of the overall modeling effort.

Another substantial issue with CORSIM is the cumbersome network editing tools provided in the package. These tools are time-consuming to use, and the network editor, ITRAF, has a tendency to distort the intended geometry. As a result, most modelers who use CORSIM eventually resort to a lengthy process of manually editing the text files that encode the network parameters. While this may not be a major issue for a small networks, it is a substantial concern when modeling a network as large as the Metropolitan Milwaukee freeway system.

As the FSOA team looked ahead to the alternatives evaluation phase of the project, balancing the sub-models promised to be a substantial effort: each proposed change would have to be entered in each of the affected sub-models, and each sub-model would have to be adjusted to correctly represent new boundary conditions--traffic flows from adjoining sub-models. Since the Milwaukee system is a loop, it seemed likely this would require an iterative process. Moreover, because CORSIM modeling involves three completely separate batch processes for network editing, simulation, and visualization, the time required to discover and correct a simple network coding error can be substantial.

CORSIM is a mature software product that began in the 1970s with two FORTRAN programs developed for the Federal Highway Administration, UTCS-1 (Urban Traffic Control System) for surface streets and INTRAS for freeways. Subsequently, these models underwent extensive modifications and enhancements. The extended model of UTCS-1 was renamed NETSIM, while INTRAS became the predecessor of FRESIM. In the 1990s, NETSIM and FRESIM were integrated under a single user interface, TSIS, more popularly known as CORSIM (CORridor SIMulation). Therefore, CORSIM consists of four main elements, the freeway model FRESIM, the arterial model NETSIM, the network editor ITRAF, and the animation viewer TRAFVU. At times, the elements do not seem to be completely integrated with one another.

The issues associated with CORSIM's unusual software engineering structure are also recognized by Federal Highway Administration's NGSIM (Next Generation Simulation) team, which wrote:

In spite of its widespread use, CORSIM does have its limitations. It is unable to model very large networks and provides limited capability to model various Intelligent Transportation System (ITS) technologies, such as dynamic message signs (DMS), wide-area surveillance, adaptive cruise control, or route navigation systems. There are limited multi-modal capabilities for transit, pedestrians, or bicycles. With CORSIM's roots dating back to the 1970s, the software, written in FORTRAN, has become increasingly brittle and difficult to maintain. The source code is complex and difficult-to-read, with poorly documented software and modeling algorithms. The underlying traffic algorithms also reflect the state of knowledge of 1970s. (10)

4-2 Expanding the Vision for Microsimulation Modeling

The difficulties encountered with CORSIM prompted the FSOA project team to reconsider its choice of software. At about the same time, the developers of two advanced European microsimulation programs began marketing their software in the US. These products--which have gained considerable attention in the transportation modeling community--are PARAMICS (PARALLEL MICROSIMULATION) and VISSIM. On-site demonstrations of both packages were held in Milwaukee in early 2001. The apparent capability and flexibility of these advanced tools, combined with a greater awareness of the scope of the future freeway reconstruction task, prompted a re-examination of the potential for microsimulation in the FSOA project. The project team began to recognize that a more powerful simulation program would expand the benefits of FSOA and address more of the Wisconsin DOT's business needs. This expanded vision resulted from several functionalities that a model would ideally provide for the project, as detailed in below. These general requirements in turn led to the development of the specific model evaluation criteria described in Table 3.

- **Detailed Analysis of Complicated System Geometry.** To make good decisions about future modifications of the freeway system, the software needs to accurately account for the changes in traffic flow that originate from seemingly subtle changes in roadway geometry. With its limited level of geometric detail, CORSIM lacks the flexibility to model certain situations that occur on the Milwaukee freeway system without resorting to modeling "tricks." Examples include certain collector/distributor systems, "crossover" or "braided" ramps, and grade-separated ramps.
- **Fast Alternatives Evaluation.** One of the key benefits of microsimulation is the ability to test "What If" scenarios. Unfortunately, the process of testing such scenarios using CORSIM is inhibited by its tedious network editing process. A newer microsimulation with a graphical user interface could edit the network more rapidly, possibly using an aerial photograph or CADD file as the base map. This would allow a much larger range of alternatives to be tested, increasing the likelihood that an optimal or nearly-optimal solution will be identified.
- **Realistic Simulation of Incidents and Events.** As congestion on the Southeast Wisconsin freeway system has increased, the system has become more sensitive to the effect of incidents: travel times have become less predictable, especially near downtown Milwaukee. Currently, when an incident occurs and large numbers of motorists divert to local streets to bypass it, they can overwhelm the capacity of the alternate route, resulting in chaotic traffic patterns on streets that are normally slow but reliable. Therefore, the capability to model incident diversion realistically is highly desirable.
- **Travel Time Reliability Analysis.** An offshoot of incident modeling is microsimulation's ability to provide data for analyzing travel time reliability. The preparation of travel time reliability estimates requires multiple microsimulation runs under varying traffic and incident conditions, so the ability to batch-process various scenarios is desirable. A weighted average of various scenarios could then be incorporated in engineering economic analysis to help determine which transportation strategies provide the best value for money.
- **Keeping Local Traffic on the Local System.** An origin-destination study prepared for the project revealed that there is extensive use of the Southeast Wisconsin freeway system for short-distance trips (a journey of just half a mile on the freeway is not unusual). Such trips make the freeway flow more turbulent (especially if the little trip requires lane changes) and probably contribute disproportionately to the degradation of freeway flow. Therefore, an eventual goal of the model would be to examine potential strategies for encouraging local traffic to remain on the arterial system.
- **Network Balance.** The concept of "network balance" refers to assuring that the available capacity on various parts of the transportation system is proportionate. When poor signal timing at an arterial street causes traffic to back up onto the freeway, or a long queue at a ramp meter backs up traffic onto a local arterial, the system is

imbalanced. In principle, CORSIM can do this type of analysis, but in practice the network size restrictions limit the extent to which the adjoining arterial streets can be modeled.

- **Ramp Meters, Traffic Signals & Roundabouts.** CORSIM has limited capabilities for the modeling of traffic signals and ramp meters, while the newer microsimulation products enhanced capabilities for modeling both fixed-time and actuated signals. CORSIM is not able to model roundabouts, but some newer microsimulation packages have this capability.
- **Public Transportation, River & Rail Crossings.** The freeway system does not operate in isolation. The traffic patterns on local streets can affect the operation of freeways, and these patterns are in turn strongly influenced by the interface between street traffic and other modes of transportation. Therefore, the strength of the public transportation element of the microsimulation package was deemed a relevant consideration.
- **One-Of-A-Kind Traffic Control Devices.** The Milwaukee freeway system includes Variable Message Signs (VMS), which are an example of a one-of-a-kind traffic control device. While each VMS may contain identical electrical circuitry, its effectiveness in creating changes in travel behavior is a function of the location of the sign and the message it displays. VMSs are an important element in the freeway traffic management system, and it would be necessary to include them in certain freeway alternatives. This requires that the microsimulation package have a facility for building a “custom” traffic control device and assigning realistic parameters reflecting the way it will affect traffic, a feature is not available in CORSIM.
- **Increasing Network Detail Over Time.** It is intended that FSOA will become an ongoing process, not simply a one-time project. Therefore, the microsimulation network will become a re-useable District resource, much like a GIS coverage or a CADD base maps. In the future, the FSOA simulation model can serve as a base for more detailed project-level alternatives analysis: as preliminary engineering is conducted on potential construction projects, it would be desirable to extract portions of the network, add detail, and model specific project alternatives. Completed projects can then be incorporated back into the master simulation model. This allows greater detail to be added over time and provides a process for keeping the model up to date. The capacity to import and export portions of a network was therefore considered important.
- **Future Applications.** The capacity of the software to incorporate future customized software elements was considered important for the long-term value of the model. For example, although there are no immediate plans to do so, the capability to link the model to real-time data from the Traffic Operations Center could eventually be useful as an incident management tool and as a training tool for System Operators.

Recent research in the area of travel demand forecasting has demonstrated that peak period transportation demand is in part a function of the level of congestion. Therefore, another potential future application would be to develop a feedback process that redistributes travel demand temporally as congestion intensifies.

- **Other Potential Applications in System Operations.** There appear to be a large number of potential uses for advanced microsimulation in projects such corridor management. While these fall outside the scope of the FSOA project, such capabilities would enhance the value of the model for others in the District.

4-3 Candidate FSOA Microsimulation Tools

Three candidate tools—Quadstone PARAMICS 3.0, VISSIM-L4 3.51, and CORSIM 5.0—were selected for detailed evaluation. When it became clear that the latest version of CORSIM, Version 5.0 did not resolve the fundamental network size limitation of previous versions, it was dropped from further evaluation. CORSIM 4.2 characteristics were retained in the evaluation matrix for comparative purposes.

Paramics Description. The following description was provided by the software publisher (7) :

The Paramics development has its roots in a large number of research and development projects. Initially work was done...in project IMAURO under the European Community DRIVE-I scheme, and later the

Edinburgh Parallel Computing Centre (EPCC) collaborated on a UK Department of Transport LINK-TIO project. This work provided the prototype system that was then transformed into the current commercial software...via two UK Department of Trade and Industry (DTI) projects in 1993 and 1994. The Paramics development team have already been presented with three awards for their software - the 1994 Scottish Strategic IT Award for Technology Transfer, and the 1995 and 1996 Computerworld Smithsonian Prize for Outstanding Contribution to Information Technology.

Since [commercialization], Quadstone [the publisher] has continued to develop the software to meet the needs of users in the ITS and microsimulation market around the world and offer comprehensive technical support, advice and training to our customers. At Quadstone, the core simulation and visualisation software, now named Paramics Modeller, has been developed further to now include enhanced vehicle actuated signal control, improved navigation with full 3D modelling, tooltips, upgrades to editor GUI and many more new features... There is also a Parallel version of Quadstone Paramics, which is currently being used at three research sites in USA, Japan and Singapore. All software development has come through consultation with customers, academic research bodies and transport professionals worldwide, in conjunction with innovative ideas from Quadstone staff.

VISSIM Description. The following description was provided by the software publisher (8):

With PTV [the publisher] simulation, complex traffic flows are displayed in a clear graphical way. Within a short amount of time, multiple scenarios of either urban or regional (i.e., arterials, freeways) character can be simulated and visualized. VISSIM analyses the traffic impacts of physical and operational alternatives before structural and operational measures are realized. As a result of its comprehensive system analysis, VISSIM allows for an optimal integration of transportation infrastructure design and operation and thus provides a noticeable cost-reduction.

VISSIM can model more detail than other microscopic traffic simulators. Doing this, all motorized road users as well as crossing pedestrians are considered. VISSIM is suitable for both inner- and outerurban traffic, so that the application possibilities are enormous.

The 3D animation of traffic flows (comparable to video sequences) makes VISSIM an ideal tool for presentations to non-technical audiences, it is to say to decision-making bodies.

Typical applications of VISSIM

- Comparison of junctions with regard of design alternatives (roundabouts, unsignalized and signal controlled; grade separated interchanges)
- Design, test and evaluation of vehicle-actuated signal control operations
- Capacity analysis and testing of transit priority schemes
- Capacity analysis of heavy rail including block section operation
- Analysis of toll plaza facilities
- Impact analysis of route guidance systems and variable message sign systems, interchanges, special lanes, etc.

All traffic situations are displayed in an realistic and convincing way.

4-4 Evaluation Strategy

The FSOA team had already developed a CORSIM 4.2 model of the Marquette Interchange, and decided to test PARAMICS 3.0 and VISSIM-L4 3.51 by modeling the same area with each package. Three test tasks were identified. It was decided that if a product was not successful in Task 1, it need not be subjected to Tasks 2 & 3.

Task 1: The purpose of this task is to ensure that the package is able to generate simulation results reasonably comparable with the observed data. Build the test model and replicate the existing conditions during the morning peak period. Demonstrate simulation results in terms of animation and performance measures. Calculate the GEH statistic (a form of chi-squared statistic used to analyze model validation acceptability) for major flows and screenlines (9):

$$GEH = \sqrt{(M-C)^2 \div [(M+C)/2]}$$

where M=Modeled Flow and C=Observed Flow

Document the level of effort required to obtain a $GEH < 5$ for more than 85% of all individual flows and a $GEH < 4$ for all or nearly all screenlines, in accordance with the guidelines contained in Appendix B of *Traffic Appraisal in Urban Areas* (also known as Volume 12 of the UK Highways Agency's *Design Manual for Roads & Bridges*) (9).

Task #2: The purpose of this task is to test the capability of the model to handle a large network. Create a loop with more than 1800 nodes and links and more than 40 miles of freeway. Simulate traffic on the network and evaluate model performance including graphical display speed.

Task #3: The purpose of this task is to check that the package is able to model incident-related diversion realistically. Add some arterial streets to the test model around the Marquette Interchange, providing alternative routes to the drivers. Assume that two groups of drivers—local and long-distance travelers—exist and have different route selection criteria. Create an incident and develop an incident management strategy for the incident, including ramp metering and signal timing plans to accommodate diverted traffic. Demonstrate how the two groups select routes and summarize network performance by driver group.

4-5 Evaluation Results

The results of the evaluation will be documented in a forthcoming FSOA technical memorandum, and are included here only in summary form. Table 3 summarizes the main findings. In meeting the FSOA project's demanding requirements, both PARAMICS 3.0 and VISSIM 3.51 offered significant advantages compared to CORSIM 4.2. PARAMICS 3.0 appeared to be the most suitable package at this time. Further refinements of the VISSIM software are currently underway, and it is likely that VISSIM will become an even stronger competitor in the future.

The simulation software market is dynamic. Additional packages such as AIMSUN have been released on the US market subsequent to the scoping of the FSOA software evaluation. Extensive software development is ongoing by various firms, and readers are cautioned had the FSOA model evaluation occurred at a later time, or for a project with somewhat different functional requirements, different conclusions might have been reached.

5. CONCLUSIONS & RECOMMENDATIONS

The FSOA project has evolved substantially since its inception in 1999. Over time, it has become clear that the CORSIM 4.2 software originally selected for FSOA microsimulation is not adequate for the task, principally but not exclusively because of CORSIM's severe network size limitations. The goals of FSOA microsimulation have also evolved; it is now looked upon not only as a tool for identifying localized sites on the freeway system that have operational problems, but also as the basis of an ongoing process for analyzing solutions to traffic operations problems on a systemwide scale. Moreover, it has become clear that there is a need to integrate

the FSOA with other, more recently-initiated studies such as the Southeast Wisconsin Regional Freeway Study. Microsimulation is one of the tools that will be necessary for this integration. The travel time information from FSOA microsimulation will serve as a key data input for benefit/cost analysis, which in turn will provide an objective basis for the selection and sequencing of projects implementing the multi-billion dollar reconstruction of the Southeast Wisconsin freeway system. Only the most advanced microsimulation software is likely to have the power necessary to accomplish a task of this scope and complexity. Therefore, a careful evaluation of state-of-the-art microsimulation software was conducted, and PARAMICS was recommended for further simulation work on the project. The simulation software market is dynamic, and had the evaluation been conducted at a later time it is quite possible that a different conclusion would have been reached.

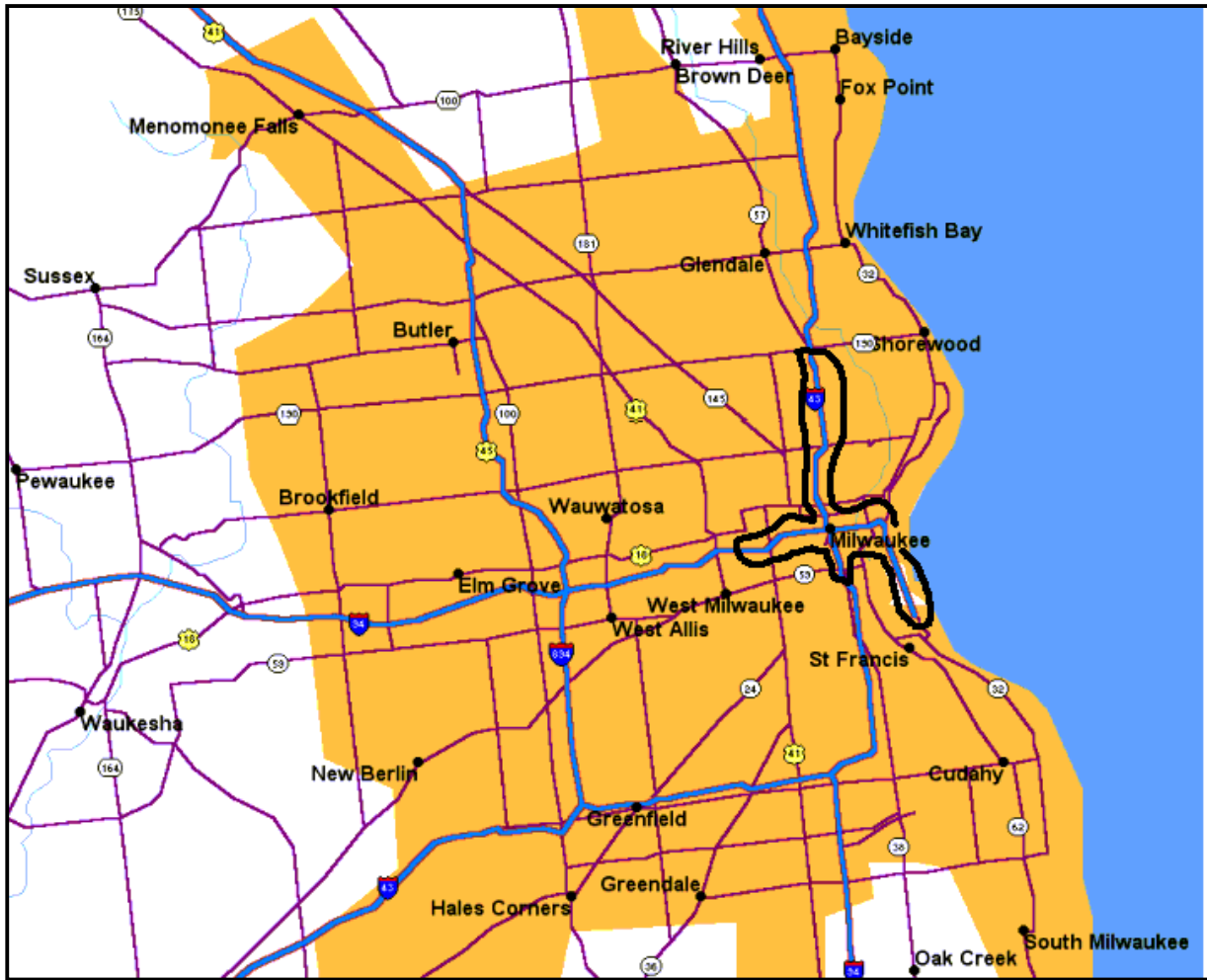


FIGURE 1. Project Study Area and Marquette Interchange Model Boundary

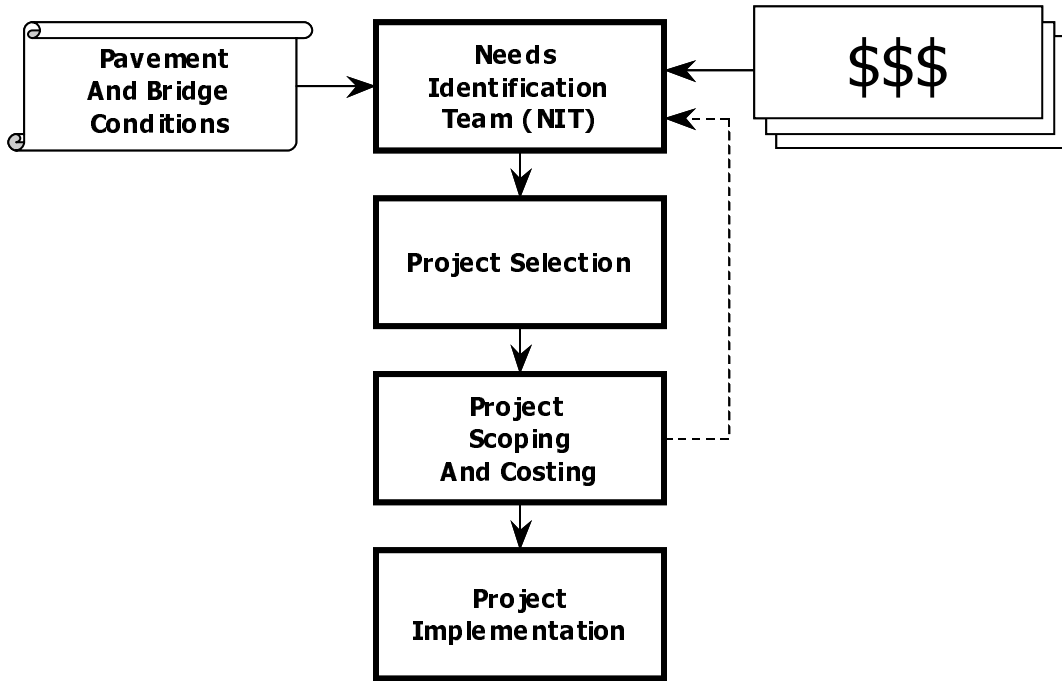


FIGURE 2. Existing WisDOT D2 Project Selection Process

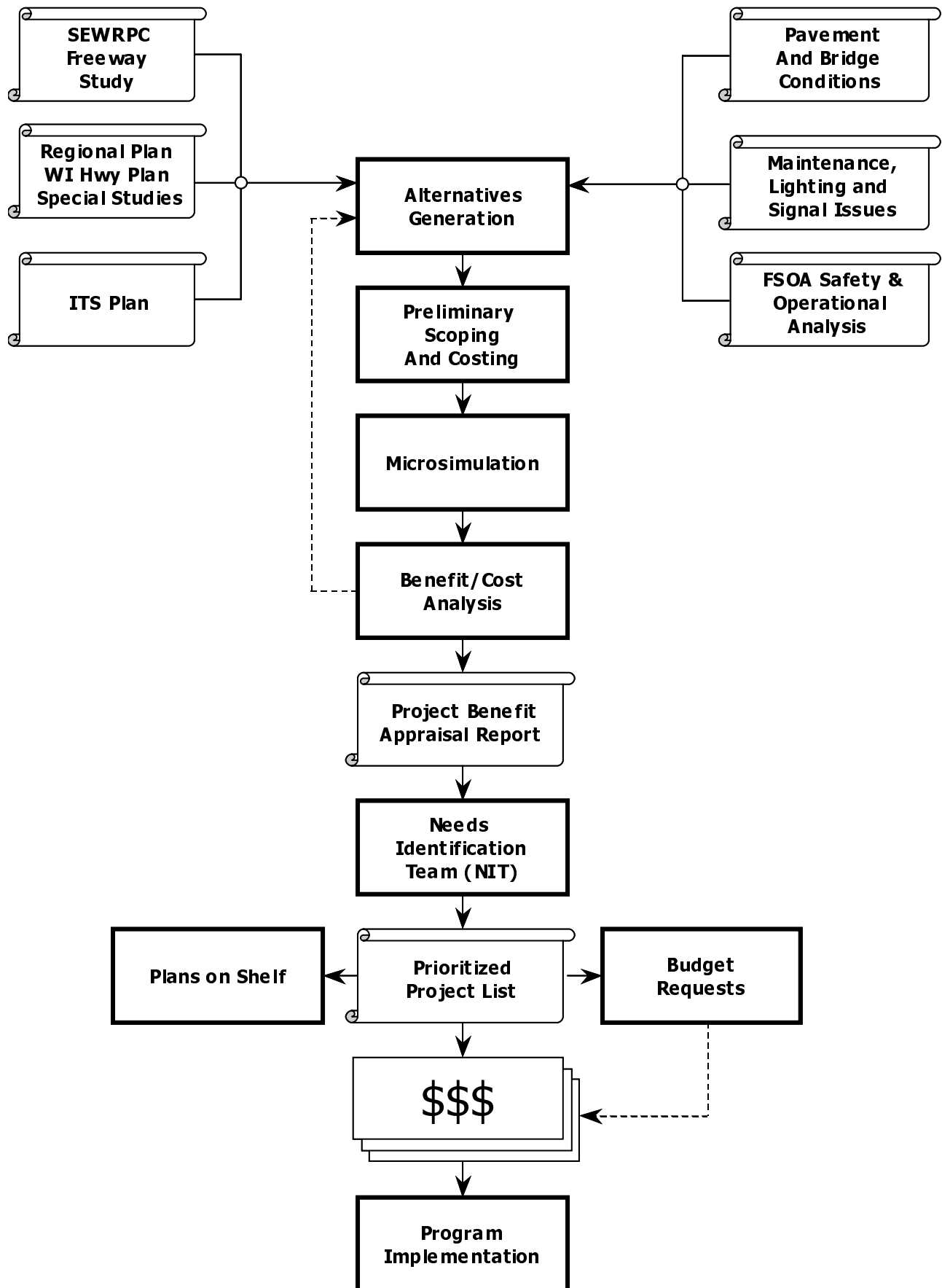


FIGURE 3. Proposed WisDOT D2 Project Selection Process

Issue	Consequences for FSOA
Small Network Size	<ul style="list-style-type: none"> - Unable to model entire SE Wisconsin freeway network in one piece. - Difficulty transferring data between sub-area models. - Unrealistic modeling of shock waves and congested areas.
Global Calibration Only	<ul style="list-style-type: none"> - Cannot localize calibration parameters to account for different driving styles that occur in different parts of network. - Cannot correctly calibrate all parts of a large network; significant traffic issues may be masked by the calibration settings, or indicated in the model where no actual problem exists. - Cannot control vehicles missing their destination exits.
Network Management Problems	<ul style="list-style-type: none"> - Difficult to combine sub-area files prepared by different modelers. - Difficult to divide the network building task among staff. - Difficult to enlarge network or increase detail over time.
Tedious Network Editing	<ul style="list-style-type: none"> - Low initial cost of software offset by high labor cost. - Difficult to assure that network is modeled correctly. - CORSIM network building tool does not work properly; often must edit network parameters manually in large text files. - Number of alternatives that can be modeled limited by high level of resources needed to complete each model run.
Software Treats Freeways and Arterials Differently	<ul style="list-style-type: none"> - Vehicle characteristics are not the same when vehicle is operating on freeway vs. arterial street.
Software Simulates and Animates Separately	<ul style="list-style-type: none"> - Unable to control geometry in an animation file.
No Control Over Fleet Mix	<ul style="list-style-type: none"> - Cannot localize the characteristics of the modeled vehicles to accurately reflect the current mix of cars and light trucks found in Wisconsin. - Cannot adjust the characteristics of the modeled vehicles to reflect likely changes in the fleet mix in the future.
Simplistic Vehicle Routing Algorithm	<ul style="list-style-type: none"> - Unrealistic modeling of incidents--incidents do not affect route choice. - Unable to develop diversion strategies
Incomplete Documentation	<ul style="list-style-type: none"> - Unable to determine how the model works so that its limitations and quirks are fully understood. - Difficult to understand error messages

TABLE 1. Limitations and Issues Affecting Modeling of the FSOA Network Using CORSIM 4.2/4.32

1	Network Size Limit: Scale/extent of the network that can be modeled (in technical terms, the maximum number of links and nodes that can be accommodated in the model).
2	Network Representation: Extent to which the model can accurately represent the geometry of the road system.
3	Traffic Flow Representation: Number of traffic flow algorithms embedded in the model, such as car-following logic, lane-changing logic, and vehicle generation logic.
4	Detail of Output: Amount of information about network performance (measures of effectiveness) available after simulation, without post-processing the data.
5	Network Merge: Ability to combine separate areas into a single model—and conversely—to divide an existing model into sub-models. A model with merge capability increases the efficiency of staffing utilization, since it allows various modelers to combine their work.
6	3-D Modeling: Ability of the model to represent and display vertical elements of roadway geometry, such as steep terrain and grade-separated interchanges.
7	Traffic Composition: Extent to which the model gives the user control over local traffic characteristics such as fleet composition, vehicle dimensions, and truck percentage.
8	Animation: Quality of the model’s visual representation of traffic conditions.
9	Input Data Requirements: Amount of input data required to develop, calibrate, and validate the model successfully.
10	Network Coding/Editing: Amount of time and effort required to enter roadway geometry, traffic control, and other roadway characteristics into the model; make changes in these characteristics; and quickly create scenarios representing potential alternatives.
11	Input/Output Review: Extent to which the model can easily display various input/output data graphically for the purpose of network review and analysis.
12	VISTA (GIS) Interface: Anticipated amount of effort required to share data from the model with “VISTA”, the GIS-based tools the FSOA project will use to overlay various roadway data.
13	Economic Analysis Interface: Anticipated amount of effort required to share data from the model with engineering economic analysis (benefit/cost) software.
14	Incident Management Analysis: Potential ability of the model to simulate real-time adjustments in vehicle routing resulting from incidents.
15	Actuated Signal Control Devices: Potential ability of the software to model semi-actuated, fully-actuated and interconnected traffic signal systems and ramp meters.
16	User-Defined Traffic Control (API): Potential ability of the software to model user-defined traffic control devices such as variable message signs. Also includes ability to import real-time traffic data from a Traffic Operations Center and ability to accommodate custom-developed software modules through macros and/or an Application Programming Interface (API).
17	Public Transportation: Ability of the program to model the interaction between road traffic and public transportation modes such as bus and rail.
18	Calibration/Validation Results: Ability of the model to meet (with reasonable effort) the Validation Acceptability Guidelines contained in the UK Highways Agency <i>Design Manual for Roads & Bridges (9)</i> .
19	Program Integrity: Overall quality of the software engineering, including freedom from program crashes and freedom from unexpected, illegal, or illogical behavior in the modeled traffic.
20	Technical Support: Quality, accessibility, timeliness, and accuracy of the vendor when handling technical support questions from the model evaluation team.
21	Documentation: Quality, readability, reliability, and usefulness of the program’s technical manual, error messages, on-screen help files, and web-based user assistance documents.
22	Record of Large-Scale Freeway Applications: Sufficient number of other transportation agencies and consultants that are using the program to model large urban freeway networks.
23	Software Cost per Copy: Number of dollars charged for the first single license; CORSIM \$500, PARAMICS and VISSIM over \$10,000 depending on features ordered.

TABLE 2. Descriptions of Evaluation Categories

	EVALUATION CRITERIA	CORSIM	PARAMICS	VISSIM
A. Model Capability				
1	Network Size Limit	◇	◇◇◇	◇◇◇
2	Network Representation	◇	◇◇◇	◇◇◇
3	TRAFFIC FLOW REPRESENTATION	◇◇◇	◇◇◇	◇◇◇
4	Detail of Output	◇◇	◇◇◇	◇◇
5	Network Merge	◇	◇◇◇	◇
6	3-D Modeling	◇	◇◇◇	◇◇
7	TRAFFIC COMPOSITION	◇	◇◇◇	◇◇◇
8	ANIMATION	◇◇	◇◇◇	◇◇
B. Ease of Use				
9	Input Data Requirements	◇◇◇	◇	◇◇
10	Network Coding/Editing	◇	◇◇◇	◇◇
11	INPUT/OUTPUT REVIEW	◇	◇◇◇	◇◇
C. FSOA Application Requirements				
12	VISTA (GIS) Interface	◇◇◇	◇◇◇	◇◇
13	Economic Analysis Interface	◇◇	◇◇◇	◇
14	Incident Management Analysis	◇	◇◇◇	◇◇
15	ACTUATED SIGNAL CONTROL DEVICES	◇	◇◇	◇◇◇
16	USER-DEFINED TRAFFIC CONTROL & API	◇	◇◇◇	◇◇◇
17	PUBLIC TRANSPORTATION	◇	◇◇	◇◇◇
D. Other				
18	Calibration Results	◇◇	◇◇◇	◇◇
19	Program Integrity	◇	◇◇◇	◇◇◇
20	Technical Support	◇	◇◇	◇◇◇
21	Documentation	◇	◇◇	◇
22	Record of Large-Scale Freeway Applications	◇	◇◇◇	◇◇
23	Software Cost per Copy	◇◇◇	◇	◇
FINAL Rating				
◇◇◇		4	17	9
◇◇		4	4	10
◇		15	2	4

Legend:

◇◇◇ = very good ◇◇ = acceptable ◇ = needs improvement, incapable or expensive

TABLE 3. Summary of Final Evaluation Results

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