Argonne NATIONAL LABORATORY

RTSTEP

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Regional Transportation Simulation Tool for Evacuation Planning

Transportation Research and Analysis Computing Center

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1. Introduction

Large-scale evacuations from major cities during no-notice events – such as chemical or radiological attacks, hazardous material spills, or earthquakes – have an obvious impact on large regions rather than on just the directly affected area. The scope of impact includes the accommodation of emergency evacuation traffic throughout a very large area; the planning of resources to respond appropriately to the needs of the affected population; the placement of medical supplies and decontamination equipment; and the assessment and determination of primary escape routes, as well as routes for incoming emergency responders. Compared to events with advance notice, such as evacuations based on hurricanes approaching an affected area, the response to no-notice events relies exclusively on pre-planning and general regional emergency preparedness. Another unique issue is the lack of a full and immediate understanding of the underlying threats to the population, making it even more essential to gain extensive knowledge of the available resources, the chain of command, and established procedures. Given the size of the area affected, an advanced understanding of the regional transportation systems is essential to help with the planning for such events. The objectives of the work described here (carried out by Argonne National Laboratory) is the development of a multi-modal regional transportation model that allows for the analysis of different evacuation scenarios and emergency response strategies to build a wealth of knowledge that can be used to develop appropriate regional emergency response plans.

The focus of this work is on the effects of no-notice evacuations on the regional transportation network, as well as the response of the transportation network to the sudden and unusual demand. The effects are dynamic in nature, with scenarios changing potentially from minute to minute. The response to a radiological or chemical hazard will be based on the time-delayed dispersion of such materials over a large area, with responders trying to mitigate the immediate danger to the population in a variety of ways that may change over time (e.g., in-place evacuation, staged evacuations, and declarations of growing evacuation zones over time). In addition, available resources will be marshaled in unusual ways, such as the repurposing of transit vehicles to support mass evacuations. Thus, any simulation strategy will need to be able to address highly dynamic effects and will need to be able to handle any mode of ground transportation. Depending on the urgency and timeline of the event, emergency responders may also direct evacuees to leave largely on foot, keeping roadways as clear as possible for emergency responders, logistics, mass transport, and law enforcement.

This RTSTEP project developed a regional emergency evacuation modeling tool for the Chicago Metropolitan Area that emergency responders can use to pre-plan evacuation strategies and compare different response strategies on the basis of a rather realistic model of the underlying complex transportation system. This approach is a significant improvement over existing response strategies that are largely based on experience gained from small-scale events, anecdotal evidence, and extrapolation to the scale of the assumed emergency. The new tool will thus add to the toolbox available to emergency response planners to help them design appropriate generalized procedures and strategies that lead to an improved outcome when used during an actual event.

2. Executive Summary

The City of Chicago awarded the RTSTEP project to Argonne in mid-December 2010. Work on the project started right away to accomplish the rather large task in the short time frame allotted to the project. Several subcontractors had been lined up in advance, and appropriate contracts had been pre-negotiated. These subcontracts could only be established after the acceptance of the master contract with the City, but Argonne was able to do so quickly because the RTSTEP project had been planned for a long time and the subcontracts were largely ready for signatures when the master contract was finally awarded.

The following subcontractors participated in the RTSTEP project:

- AECOM – a top engineering and design firm. TRACC's contract was established with David Roden, a Senior Consulting Manager specializing in the development of advanced transportation simulation software. David Roden is the primary developer of USDOT's TRANSIMS transportation systems modeling application the forms the basis for RTSTEP. AECOM developed the underlying simulation software components with special regards to the needs of the RTSTEP project. AECOM also brought their team with special expertise in the application of transportation models to the table, and worked both on the normal day model and the evacuation scenarios.
- IIT – The Illinois Institute of Technology has been working on TRANSIMS simulations in the City of Chicago for a couple years now, based on funding by the Federal Highway Administration. Their independent project also involved CMAP and CDOT, the Chicago Department of Transportation. IIT became a subcontractor in the RTSTEP project to provide hands-on labor on the detailed editing of the Chicago highway network, traffic signals, intersection details, and more, and also worked on the normal day model by establishing equilibration methodologies and test cases.
- NIU – Northern Illinois University has worked with TRACC in the past and has relevant experience in the application of TRANSIMS. NIU's existing work on pedestrian simulations and movement of individuals in buildings and special venues such as stadiums was used for the RTSTEP project to address the demand on the transportation system at special events.
- CMAP – The Chicago Metropolitan Agency for Planning was another important subcontractor and provided model components and data to the project. The RTSTEP project depends heavily on socio-economic data and the demand on and response of the underlying transportation

network. CMAP originally provided their metropolitan simulation network to TRACC's TRANSIMS model, and has improved the network in a collaborative effort with TRACC and NIU several years back. As the coordinator of data collection, standardization, and distribution to the region, CMAP was an essential contributor to RTSTEP.

- NORC is part of the University of Chicago, and specializes in social science research and public policy. NORC supported TRACC's work on the evacuation decision survey that was part of the effort to determine appropriate demand on the transportation network. NORC reviewed the survey and helped shape it so that it is statistically relevant.
- Independent Contractors: A number of independent contractors working with Argonne have been involved with the project as well, such as in software development, system administration, consulting, meeting support, and general project management.

Starting in January 2011, bi-weekly coordination meetings were held with all subcontractors, OEMC, and others. These meetings were held at 10:00 on every second and fourth Thursday of the month. To document the RTSTEP effort, monthly reports were delivered to OEMC, detailing the ongoing work of all subcontractors and staff at Argonne. These meetings were particularly important to coordinate remote collaborators. With about 8 people at TRACC directly involved in the RTSTEP project, and 20 or more personnel working for the subcontractors, the team was sizable and effective communication was important to coordinate everybody's efforts.

Training is an essential part, both in the development and application of RTSTEP. TRACC held a three day training course on TRANSIMS and the plans for RTSTEP on January 19 to 21, 2011. This training course was also broadcast over the internet to subcontractors and other people interested in this technology. Part of the training was repeated on February 24th at OEMC due to the fact that some participants were unable to attend the training classes at Argonne due to their job responsibilities. Final training classes are scheduled for December 2011 and will be held at Argonne and at OEMC respectively.

A summary of work performed on each individual task is provided in the next chapter of this document. The project was mostly implemented by August 31, 2011, and OEMC and Argonne decided to implement a no cost time extension to wrap up some of the technical details and refine some of the features, such as the visualization capabilities, case studies, ortho-imagery, and such. OEMC and IEMA also established connections with GIS departments across the region to explore additional data sources useful for distribution with the final application. Work was finalize by November 30, 2011, and training courses will be held in December 2012 due to scheduling conflicts of participating individuals that made it advisable to postpone these training course until after the end of the project.

3. Summary by Task

3.1. Task 1: Refinement and Extension of the Existing Road and Transit Network

The original highway network of the TRANSIMS model was developed with a focus on analyzing the Chicago Business District in great detail. This effort was funded in 2008 by the Illinois Department of Transportation. Refined regional analysis requires refining other areas in the region to increase the fidelity of and applicability to emergency evacuations. The network improvements were implemented by TRACC staff and subcontractors from AECOM and IIT.

3.1.1. Key Deliverables

- Evaluation of data sources, methodologies, and available resources to upgrade the TRANSIMS highway network to support the regional aspects of emergency evacuation planning sufficiently. Results and recommendations will be discussed with OEMC in advance of actual network modifications.
- Implementation of a more robust TRANSIMS normal day model. The goal is to allow more flexibility when assigning different traffic patterns that are driven by a specific event and a specific emergency response to the event.
- Implementation of the network changes agreed upon between transportation modelers and emergency responders on the basis of a priority list. The implementation will be performed in several stages to allow stable intermediate networks to be available for the implementation of the other tasks under this statement of work.
- Documentation of all network changes, documentation of data sources and procedures, and electronic maps and hard copies of the improvements; integration with OEMC resources as necessary.

3.1.2. Progress Summary for Task 1

Work on this task started in December 2011. Much of the early work was performed by the team from the Illinois Institute of Technology under direction of Prof. Zongzhi Li. Prof. Li was working with a team of 6 students on both the RTSTEP project as well as an independently funded project for FHWA that IIT is working on in collaboration with the City of Chicago Department of Transportation, the Chicago Metropolitan Agency for Planning, and other collaborators. Before their involvement with TRACC as a subcontractor under the RTSTEP project, the IIT team focused on improving and validating the Chicago Business District model. Staff at TRACC defined individual work assignments that were implemented by students from IIT to address high priority network editing. The team at IIT also worked on the adjustment procedures for Origins and Destinations in the original demand model, as well as calibration of the traffic assignment process for normal days. This work formed necessary foundation for RTSTEP due to the fact that the normal day is in fact the starting point for deviations caused by evacuation trips.

AECOM was also heavily involved with this task. A work planning meeting was held in January 2011 on defining individual responsibilities, and AECOM was working on the conversion of the underlying data to the new TRANSIMS 5 format. TRANSIMS 5, which was still under development at the time, has also been modified to better perform as part of the RTSTEP application. Throughout the project, AECOM was developing the underlying software library that drives the individual tools that TRANSIMS consists of. This library called SysLib will be frequently mentioned throughout this report. The library serves the purpose of standardizing the underlying software approaches and objects to make higher level programs more effective and less error prone.

By March 2012, TRACC, AECOM and IIT finished much of the work on the network supply model, correcting insufficiencies and introducing a number of network enhancements. A large number of modifications were made to the network. The sections of I-294, I-90, I-290, I-355, I-88, I-57, I-55, I-65 and I-80 have been realigned to match the ortho-imagery. Missing ramps and loops were added to replace simplified straight links from the original CMAP network. A new feature for the NetPrep tool was implemented at TRACC. This feature allows to read in the Open Street Map (OSM) network data and to generate a routable TRANSIMS network from this open source project. The TRANSIMS network was modified based on the OSM data. Specifically, the nodes which correspond to arterial road intersections were aligned to match those of the OSM data. Also, the Chicago Business District (CBD) area signal timing and phasing data originally prepared by IIT for the version 4 model of TRANSIMS was converted into the new version 5 format.

To obtain an accurate traffic assignment result, it is important to mimic the real life transportation network details as detailed as possible. Significant effort was spent on refining the locations of activity locations (the abstract equivalent of homes and work locations, or rather the start and end locations of all trips that are simulated in a given model) and intersection controls (such as traffic signals and stop signs). Activity locations (the trip loading and unloading points) are spatial locations that represent dwelling units, employment locations, social and recreational facilities, and shopping centers. These locations either produce or attract trips. Activity locations were synthesized based on the area type (business district, rural area, etc.) and facility type (highways, major and minor arterials, local streets, ramps, etc.). In some situations, the activity locations were not generated properly using the default settings in TRANSIMS. For example, there were no activity locations generated on Lower Wacker Drive, while there are quite a few loading docks and parking spots located on that street. Some of those changes were automated and some required manual tweaks. Also the traffic assignment process had to be calibrated. Traffic assignment is the process of calculating a path for each of the travelers on the network based on the current understanding of congestion patterns. For the validation of the model assignment result, field link counts were used. The TRANSIMS Router, along with several other TRANSIMS utilities, was used to perform the assignment. To mimic real live traffic volumes, several of the TRANSIMS Router attributes were adjusted. For example, facility bias factors and distance values were adjusted. Those parameters are specific to a given geographical region. Facility bias helps modeling a situation in which a traveler does not necessarily choose the fastest route but rather prefers to take a highway, even if it takes longer.

The RTSTEP team also worked on increasingly accurate models of traffic signals. In a transportation model, it is very important to replicate real life traffic signal timing and phasing because the transportation network is a highly sensitive dynamical system. This means that a small change in the intersection control timing and phasing may lead to large changes of traffic patterns in a relatively large area. However, it is impractical to manually input the information for all of the traffic signals in the model region; there are 3000 signals alone within the limits of the City of Chicago. A more practical approach was to manually code the traffic signals for "critical intersections." Those are intersections that are part of evacuation routes as well as intersections with large traffic volumes under normal circumstances. There are approximately 430 of those intersections in the model area covering the Chicago metropolitan region. Unfortunately, intersection control data is currently not available in machine-readable format but rather available as engineering documents scanned into PDF files. TRACC along with AECOM developed an Excel tool which streamlined the process of converting the data into the TRANSIMS format. The tool also performs quality control and helps to minimize human error.

To address the need for model validation, the AECOM team established quality control procedures for the process of extracting traffic volumes from CMAP's EMME2 network and used this to validate the TRANSIMS Router assigned volumes.

Work on converting and testing the traffic signal locations as well as their timing and phasing was completed in June. It was determined that there is no clear pattern to distinguish whether an intersection is controlled by a traffic signal versus a traffic sign. Thus, it was shown that this process could not be fully automated, i.e. the location of traffic signals could not be accurately synthesized at a reasonable error rate. The group from TRACC and AECOM developed a list of actual traffic signal locations which also contains the cycle length for each of the signals and developed a program to convert this data into the TRANSIMS format. The TRACC team also validated 300 of the traffic signals manually coded by IIT in the central business district. A number of shortcomings were fixed. Several short links (length < 18m) in the highway network were modified or deleted to prevent problems in the Microsimulator, one of the TRANSIMS tools. Due to the design of this simulation algorithm, the traffic flow could not be accurately estimated on links shorter than 18m. Some of those short links corresponded to real live links and were artificially modified; some of those were coding errors from the previous version of the network and were removed.

Finally, toll data was refined in the normal day model for the metropolitan region. In the previous revision, the tolls were the same for trucks and passenger cars, while they are different in real life. Previously, there was no distinction between express (for I-PASS users) and cash lanes. The accurate representation of toll stations on the network allows predicting path choices as well as to estimate the traffic density and speed on the toll links more accurately. A good estimation of "normal day" driver's behavior affects travel patterns during an evacuation period. The group from AECOM developed and documented the network conversion process for the Chicago Metropolitan Are network. The set of scripts and documentation was developed which would allow replicating the process for a different geographical area. Usually, network conversion is a very time consuming process. Keeping in mind that the potential customers of the RTSTEP toolbox are local transportation or emergency management authorities which usually are very limited in terms of man power, the new process will allow preparing network data while having very limited resources.

3.2. Task 2: Development of Tools to Evaluate Evacuation Routes and Strategies

An important task within the overall RTSTEP project is the modeling of evacuation routes. TRANSIMS has been developed as a general purpose traffic forecasting tool and does not distinguish between normal roadways and designated evacuation routes at present. Nevertheless, the underlying components are readily available in TRANSIMS, such as the capability of prohibiting turns by time of day, preempting and manipulating traffic signals, closing and reserving lanes for specific types of vehicles, and much more. Lane reversals, such as those implemented during counter-flow evacuation scenarios, can be readily modeled and are already a standard feature of TRANSIMS. The work in this area focuses on the development of a tool that allows emergency responders to define the characteristics of emergency evacuation routes with a degree of flexibility and automation.

3.2.1. Key Deliverables

- Determination of the procedures used by emergency responders to implement the establishment of emergency evacuation routes. Discussion of findings with OEMC and emergency response planners to set the priorities for implementation of modeling tools.
- Development of tools to configure evacuation routes with a reasonable degree of simplicity and to run TRANSIMS on the basis of the resulting modified network.
- Development of tools to evaluate rail options, to allow for capacity planning, and to determine the impact on target communities.
- Documentation of the tools and training of emergency response planners in the use of the tools

3.2.2. Progress Summary for Task 2

At the beginning of the project in December 2010, TRACC staff developed a short document titled “”RTSTEP Technical Proposal” that was discussed in detail at semimonthly team meetings. This document described the anticipated software development needs for RTSTEP, both in an idealistic way (e.g. what the tool would look like under ideal circumstances, with unlimited funding, and with unlimited implementation time), as well as under the existing time and funding constraints of the RTSTEP project. The approach served TRACC well in the past - taking a step back from considering only immediate needs and allowing for a more consistent and more extensible development approach. The main issue was weighing the cost of the implementation of complex graphical inputs and representations against the more simple programming approaches. The goal was to create a user interface that is open for future enhancements and will not limit itself to a few features of immediate urgency.

As the proposal was discussed, it was found reasonably feasible. Some of the work was directly related to TRACC’s visualization work, while other components were related to the development of the underlying TRANSIMS tools by AECOM. Another design goal of the RTSTEP Technical Proposal was the optimization of workflow between the geographically separated developers, and to more clearly delineate individual components and their interactions. The appropriate methodologies also depended heavily on the target user community. It is difficult to precisely define the typical user of the final product, but it was clear that emergency responders needed to be involved early in the project to ensure that the software would meet their needs. From the perspective of a software developer, the needs of emergency responders and evacuation planners are also difficult to predict, and it was important to start the dialog early in the process of establish such a project. At Argonne, TRACC participated in a number of discussion groups and expert panels on the scientific aspects of national security issues, and TRACC. TRACC staff is also on the transportation subcommittees of both the Illinois Terrorism Task Force and the Regional Catastrophic Preparedness Teams. Having had access to emergency response planners from different organizations, such as IDOT, CTA, PACE, the Red Cross, the State Police, and many other organizations helped to create appropriate feedback during the development of the RTSTEP application.

TRACC staff also performed literature research, and prepared presentations on the underlying technologies to a number of groups in the Chicago Region. TRACC was also looking at the effects of improvised nuclear devices on the transportation infrastructure as part of an ongoing effort in the Chicago region to be better prepared for IND events.

A major effort under this task was the development of the EvacNet tool as part of the TRANSIMS toolbox. The EvacNet tool has three main functions with regards to modifying the highway network for emergency evacuations: (1) establishing turn prohibitions; (2) enforcing lane use restriction; and (3) evacuation route planning. The three main functions require three input files. New formats and input functions were designed for the EvacNet input files. The turn prohibition function prohibits use of a turn for certain vehicles for a given time period during the evacuation. The input for this function is called Evac_Turn_Penalty'. The lane use restriction function is to restrict lane use on a link for certain vehicles for a given time period during evacuation. The SysLib data structures were utilized for Evac_Lane_Use and Evac_Turn_Penalty. Evac_Route has been defined its own data and file structure in EvacNet.exe showing below.

EvacNet.exe is capable of reading all supply elements of a normal day network and then output them to the 'EvacNet' directory, which forms the base network for case studies. Network supply changes related to evacuation are saved in this particular folder. A new control key for Evac_Routes file was created, called EVAC_ROUTES_FILE, which can be used in the EvacNet.ctl control file. According to the Evac_Routes input, EvacNet.exe changes the normal day model's signal plan, timing plan and phasing plan. A set of candidate evacuation routes was defined as part of this approach. This set of evacuation routes includes most of the freeways and a large number of arterial roads. The team refined the candidate routes and improved the connectivity of the evacuation routes network to create more realistic evacuation simulation capabilities.

Laying the foundation for the behavioral evacuation demand model, EvacNet was updated to include links affected by individual scenarios, and the development of the evacuation response survey intended to provide information on how individuals respond in various evacuation scenarios. Two IIT students, Yifang Liu and Fei Qu, worked closely with Kuilin Zhang to update the candidate evacuation routes set and the inputs for EvacNet, testing the functionality of EvacNet, and defining segments for both freeway and arterial corridors for the heuristic rule based evacuation network design procedure.

The EvacNet tool is capable of not only identifying stretches of road dedicated to evacuation routes and access points for those routes, but also computes the traffic signal timing and phasing to optimally accommodate evacuation traffic. There are two distinct types of intersections - intersection of two evacuation routes, and intersection of an evacuation route and non-evacuation route. For the intersection of two evacuation routes, the flow is allowed on both adjunct roads, and for the latter case only the movements associated with evacuation traffic has green phases assigned to them. In order to allow off-ramp exits, lane use restrictions for evacuation vehicles only in evacuation zones were included, and both lane_use and turn_penalty were updated to the latest version of SysLib., the central TRANSIMS software library The evacuation network plans for the Wrigley Field case study were refined and scenario tests for the proposed evacuation scenarios were conducted.

3.3. Task 3: Tools to Model Populations, Evacuation Trips and Background Traffic

TRANSIMS, just like any other traffic simulation package, cannot readily predict the destinations of evacuees who are able to evacuate by car or transit. Identifying likely destinations is clearly a pressing issue for emergency responders, and a large part of the work will focus on the implementation of tools that simplify running the models under different assumptions to test and compare the responses of the transportation network to varying demand. Evacuation trips also do not exist in a vacuum; a significant portion of the traffic on the road may be driven by normal day demand, such as trips to work by people outside the affected areas. Thus, this task also focuses on creating a robust normal day model for the Chicago Metropolitan Area that forms the basis for all evacuation models.

3.3.1. Key Deliverables

- Evaluation of currently available methodologies for the modification and synthesis of evacuation trips and the compatibility with and impact on the existing TRANSIMS model.
- Development of tools that allow for the creation and modification of evacuation trip destinations. This will also affect the origin of these trips and their start times, in particular for evacuees that either live in the affected area or that have already arrived there.
- Development of algorithms and tools to increase the fidelity of the simulation and to resolve problems caused by some artifacts of the TRANSIMS approach that cause poor fidelity of the simulations in highly congested areas.
- Evaluation and subsequent implementation of building egress models and pedestrian simulation as necessary to increase the fidelity of the model in areas where evacuation on foot will be the most likely mode.

- Integration of the modified trip and activity data with the TRANSIMS model to simplify parameter studies and the comparison of different scenarios and assumptions fed into the process by emergency preparedness planners.

3.3.2. Progress Summary for Task 3

A new tool called EvacDemand was proposed by TRACC to be developed as a part of TRANSIMS. TRACC staff developed detailed specifications for the features required to be implemented within the new tool. One of the proposed features would allow the visualization software TransimsVIS to be linked with EvacDemand through an interface. This allows the modeler to select and modify evacuation-related demand parameters right on the map. For example, it is possible to modify origins and destination of evacuation trips, and to assign weights to certain activity locations to make them more or less attractive. Users are able to specify a time span for trip start times for each of the origins. The proposed tool was discussed in detail during bi-weekly project progress meetings.

A literature review was also performed to learn how other models in the past have handled demand modification under evacuation scenarios. The literature review was also looking at surveys that have been conducted to get evacuation responses, including response time, compliance rates, destination types, etc.

A prototype of this tool was developed by March. The work for scenario specifications was also finalized and then integrated with the Visualizer (developed under Task 4) as well as EvacNet. The team worked on designing the underlying behavioral model which forms the basis for the modeling response of the evacuees under simulated conditions.

For calibration of the behavioral models that have been developed, the TRACC team decided to prepare and perform an evacuation decision survey. A random sample of a population from the Chicago Metropolitan Area was surveyed. The goal was to collect basic demographic information on the responders, as well as the location data of all members of the households. The second part of the survey presented one of several scenarios to the participant, and asked for the participant's anticipated response to that scenario.

By April, the team improved the evacuation network design tool EvacNet, refined candidate evacuation route sets for both freeways and arterials, and designed a heuristic rule based procedure for defining evacuation network plans for given extreme event sites, shelter locations, and budget constraints. Two students from the Illinois Institute of Technology, Yi Liu and Xi Lu, worked closely with Kuilin Zhang on refining candidate evacuation route sets, preparing the inputs for EvacNet, and defining the key rules for the heuristic rule-based evacuation network design procedure.

The evacuation network plan design is essentially a network redesign problem. In this study, a set of candidate evacuation routes was defined. Given a set of candidate routes, extreme event sites, evacuation demand, and corresponding shelter locations, the evacuation network plan design problem finds a subset of optimal evacuation routes, to determine corresponding traffic management and operational strategies (e.g. turn prohibition, lane use restriction, contra-flow lane, and signal re-timing) to maximize network throughput for evacuation zones or minimize clearance time, with minimum impacts to the normal demand satisfying a set of capacity, budget, and time constraints. The main decision variables for designing the evacuation network plan in this study are the accessibility of intersections from other approaches, lane use restriction, and turn prohibitions.

EvacDemand allows evacuation analysts to input evacuation scenario information and baseline travel information and then modifies the baseline travel information to respond to the evacuation scenario specified. By May, the following capabilities were implemented: creation of demonstration scenarios, incorporation of final network data into scenarios, and completion of the evacuation simulation modeling process. Work has also continued with the development of the evacuation response survey intended to provide information on how individuals respond in various evacuation scenarios. The survey design was finalized and pilot testing began in May to improve the survey in response to pilot respondent suggestions. Since the approach of using maps is considered innovative, the National Opinion Research Center researchers suggested developing quick video tutorials on how to answer those questions which ask a respondent to specify a location on a map.

In order to improve the fidelity of the demand model, a microscopic model of the event locations has been built by the research team from NIU. The information of three locations of interest (Wrigley Field, Sig Flags and Chicagoland Speedway) was collected and analyzed. The annual number of visitors at Six Flags was obtained as well as collecting the land use, employment, and demographic information of the surrounding area. Capacity and similar demographic and employment information was collected for other locations. In addition, the NIU team analyzed the structure of Wrigley Field as well as locations and characteristics of each of the entrances/exits in the Field. The number of seats per block and possible flow at the exits was estimated. The software chosen for this analysis, after evaluating eight different software solutions, was LEGION. An AutoCAD model of the Wrigley stadium along with the model of Sig Flags Great America was created. Models of both of the locations were used in the LEGION simulator to get preliminary results on the behavioral model of the people during the evacuation.

3.4. Task 4: Development of Visualization Methodologies to Compare Scenarios

The massive amounts of data resulting from TRANSIMS runs are not easily interpreted without the help of powerful visualization tools. TRACC has developed significant contributions to TRANSIMS visualization techniques and developed additional tools as necessary to present results in a meaningful and easy-to-use fashion to emergency response planners. The applicability of different visualization strategies was determined as an early part of the RTSTEP project and is an integral part of much of the scope of work.

3.4.1. Key Deliverables

- Development of visualization concepts, both static and in form of videos, that will suit the needs of emergency response planners and illustrate the differences between given scenarios effectively.
- Implementation of the necessary software and tools to create such visualizations both in batch mode and with a certain level of interactivity.
- Documentation of the tools developed under this task. Training in the effective use of the tools.

3.4.2. Progress Summary for Task 4

RTSTEP has a need for both a tool which can be used to configure transportation management options for evacuation studies as well as a tool which can visualize the final results of the evacuation case studies. The original TransimsVIS software was developed by TRACC to aid in the visualization of generic TRANSIMS results. The tool was pseudo-3D, python-based, and semi-interactive – it included many features including visualizations of: vehicle trajectory, regional congestion, regional signal patterns, transit ridership, vehicle paths, car following, vehicle speeds, and more. It also included features such as movie creation, waypoint selection for cinematic camera movements, and side-by-side comparisons. But there were many motivations to re-code a new version of the visualizer for use in the RTSTEP project, based on TRACC's capabilities and the ready availability of high-end graphics cards on typical desktop computers.

The development of TransimsVIS 2.0 proceeded through a number of phases. First, the basic program structure was designed and the integration with TRANSIMS version 5 was conceptualized. Coding began with TRANSIMS integration followed by a framework for performance testing. The next development was the navigation framework, followed by the visibility testing algorithms. This was followed by a network drawing algorithm and all the corresponding optimizations. After this, the ortho-imagery algorithm was designed as well as a general framework for multithreading. It also includes a comprehensive optimization of each feature to ensure perfect performance on even slower machines and an attempt to run on specialized hardware such as the mini lambda system at TRACC. The mini lambda system is a synchronous multi-tile high resolution display system, which was constructed to improve the modeler's capabilities in network editing, visualization, and analysis. It has been used for high end demonstrations throughout the project.

A major development was for the TransimsVIS software to support evacuation visualizations. An important part of this work was the development of a compression algorithm for vehicle data. Since the execution of regional simulations for every second of the day is very expensive from a disk storage perspective, this compression scheme cuts that space requirement down by a factor of 4 or more. Along with the vehicle compression algorithm, a multithreaded method was developed that can load vehicles from the disk drive to the visualizer very efficiently; the method resembles a web video which has a similar buffer. This procedure is combined with a vehicle rendering step that computes the geometry of all vehicles loaded. The development also included data plot visualizations.

Of pressing concern was adjusting the software to handle the regional demands of the Chicago network. With over 27 million daily trips and covering over 10,000 square miles, the Chicago Metropolitan Area pushes any visualization software to the limit. This limitation required upgrades to the vehicle loading procedure, data plot computation procedure, and the ortho-imagery loading routine. In addition to these upgrades, the framework was put in place to identify model elements (initially just links and nodes), and display their attributes. Finally, it was important early in the project to start testing the software among the RTSTEP group to identify bugs and to gather more comprehensive feedback. This involved establishing a new branch of the TRANSIMS source code control archive and updating the software to run on more generalized input data.

The software features also a waypoint system and an interpolation feature. In addition, a large degree of restructuring was done half way through the project that doubled performance for drawing the data plot, and increased vehicle trajectory visualization speed by 20%. It cut overall memory usage by 30% as well. The restructuring paved the way to easily incorporate new visual elements specific to evacuation visualizations.

In May, development continued on the TransimsVIS software to support evacuation visualization. It included four major feature additions: probe vehicles, improved data plot intelligence, 3D vehicle models, and additional satellite imagery. Development also began on the link plot feature, which is a mesoscopic visualization aimed at communicating information which is relevant at the link-by-link scope.

Along with changes in the TransimsVIS, one of the Microsimulator's output data files was modified. Snapshot file fields were expanded to include waiting time, time difference, and user data fields in the compressed and standard output. The simulation plan data was expanded to include activity duration and leg schedule time. The Microsimulator tracks the difference between the scheduled time and the actual time at each time step. All of those extra pieces of data in the Snapshot file are to be used for visualization purposes to support the evacuation case studies effort.

By late June, development culminated in the TransimsVIS software to support evacuation visualizations in a very comprehensive manner. It included new link plots and 3D vehicle models while zoomed in. In addition, it included several new features: 3D building models, strategic routes visualization, and evacuation area visualization.

The final version of the tools allows for several different modes of operation, both to configure and to evaluate evacuation scenarios. All available ortho-imagery from USGS and other sources was layered into a single large scale mosaic to make a complete map available across the entire metropolitan region. Heat plots and bar graphs on top of roads allow for comprehensive analysis of aggregate information, while the addition of a generic GIS capability allow for the inclusion of user-provided data sets to enhance the modeling capabilities.

3.5. Task 5: Integration of the Transportation Model with the Dispersion Model

TRANSIMS has the unique capability to consider the movements of individual travelers through and around a contaminated area. This capability makes it significantly easier to determine the exposure of individuals to radiological hazards because of their accumulative nature. Without a transportation component, the determination of the level of exposure would be limited to the assumption of a statistically immobile population. With TRANSIMS, the radiological exposure can be aggregated on an individual personal level while moving on complex paths through the time-dependent dispersion cloud, whether by train, bus, or walking or in a personal vehicle.

3.5.1. Key Deliverables

- Development of strategies for integration between a dispersion model and RTSTEP. Evaluation of methodologies and determination of the best feasible approach. Discussion with OEMC on the level of integration.
- Modification of TRANSIMS tools and development of utilities to implement the integration. Establishment of a framework that can be used by modelers to set up specific scenarios and start the necessary TRANSIMS runs to obtain results.
- Documentation of the tools developed under this task. Training in the effective use of the tools.

3.5.2. Progress Summary for Task 5

The National Atmospheric Release Advisory Center (NARAC) of Lawrence Livermore National Laboratory (LLNL) provides operational services, tools, and expertise for preparedness, response, and recovery from dispersion events. The services include dispersion event modeling, analysis and guidelines for response actions. It can be a valuable resource for various event information including weather data, hazardous substance, geographic and demographic data, and other measurement and observations. TRACC requested access to this system to simulate dispersion events and to integrate them with the RTSTEP project. This work was originally to be performed in a companion project between the City of Chicago and Argonne, but it was decided to delay this project.

TRACC staff then investigated several packages available on the market for computational fluid dynamics (CFD) modeling. To develop a meaningful interface to RTSTEP, TRACC explored the use of CFD and other dispersion modeling tools. The exploration of dispersion modeling tools should lead to generic interfaces that can be replaced in the future with more specific interfaces as needed.

The size of the problem, which arises while modeling plume dispersion, is of significant size. It was initially decided to explore the STAR-CCM+ CFD code for modeling of a small region surrounding the source. STAR-CCM+ was chosen because TRACC has an in-house expertise with this package. It was decided to also take a look at mesoscopic modeling tools for the rest of the domain. The meso-scale models predict large grain atmospheric conditions over a large area.

To address the computational challenges, an initial computational fluid dynamics (CFD) model has been developed for a small urban area. This helped with developing and verifying various modeling methods and capabilities. The model developed consisted of a small urban area with generic building geometries. The area was 120m x 120 m. Analysis was done on a volume of fluid (air) surrounding the buildings. To perform the finite element model (FEM) analysis, the volume was meshed with a polyhedral volume mesh. The simulation model was solved numerically. The simulation model was described by a boundary value problem with the following boundary conditions: East, Top = pressure outlet, North, South = symmetry outlet.

By April, the focus of Task 5 was to develop a steady-state air flow model. First, the steady-state air flow model was being developed, providing an initial condition for the subsequent plume dispersion model. As discussed above, those models are limited in terms of the size of the domain, but are a good start and can be a good starting point for surrogate mesoscopic dispersion models.

The steady-state model means that the dispersion is time independent and some averaged solution is considered. Since the plume generation is expected to vary in time, it is necessary to develop an unsteady flow model and perform transient analysis. This is accomplished by Star-CCM+, redefining the model as unsteady flow model, and associating the boundary condition with a user function for time varying flow speed at the plume inlet.

With the addition of the gaseous component and solid particle phase, the simulation model was also solved in an unsteady state mode. The multi-component, multi-phase dispersion model was further refined by including the effects of gravity, earth boundary layer, and particulate restitution factors.

To scale the modeling capabilities up, a set of tools was developed for constructing 3D models of the buildings based on their foot print geometry and approximate height based on data provided by OEMC. The extrusion from footprint data created urban canyons with an approximated geometry of all buildings within the city limits. It allows not only visualizing all of the building in TransimsVIS , but also using the models in the computational fluid dynamics software to predict gas flow with in a large domain which includes all of the buildings. The TRACC team identified a meshing scheme and flow parameters which lead to the conversion of the computation methods for calculating flow of methane and aluminum dispersed through a rectangular window inside the domain.

As a case study, a plume dispersion model was developed for the Wrigley Field area. Using python scripts, the buildings in the Wrigley field area of 3 or more stories were created. As part of the final scenario, a series of reference models were developed. For the application to suburban areas, a volume measuring 3.2 km by 3.2 km by 2 km was created with no buildings. The plume inlet was centered 200m from the wind inlet. Originally, the inlet was a cylinder due to the problems with the sphere inlet in the Wrigley simulations. With no buildings in this model, the surface wrapper was no longer necessary.

Concurrently, TRACC continued to evaluate additional software tools with mesoscopic modeling capabilities. TRACC obtained a copy of the HPAC toolbox (Hazard Prediction and Assessment Capability) developed by the Defense Threat Reduction Agency (DTRA). The TRACC team tested the HPAC software from DTRA. In contrast with the CFD models HPAC uses “rough” aggregated statistical models for predicting the impact of an explosion. However, the advantage of using HPAC is the amount of computing time needed is much less compared to CFD calculations as well as availability of predefined parameters for different type of threats.

3.6. Task 6: Case Studies

Significant effort is needed for the development of a few representative case studies that highlight the methodologies used and the capabilities that result from the RTSTEP project. The case studies will be defined in greater detail early in the project in consultation with emergency response planners and OEMC. The scenarios defined during the 2009 RCPT Summit in Chicago (July 15 and 16, 2009) will serve as the basis for these developments. The scenarios will also form the basis for training materials and training courses planned to transfer the technology to emergency response planners before the end of the RTSTEP project.

3.6.1. Key Deliverables

- Detailed definition of the postulated events, determination of likely response strategies with regards to transportation, and determination of the need for additional data.
- Determination of the need for model refinements to best addresses the questions to be answered by the case studies. Determination of the scope of road and transit network refinement in the affected areas.
- Determination of likely destinations for evacuees, the establishment of mass transportation, and the location and capacities of emergency shelters that will be used.
- Detailed results from case studies performed as part of this work, such as data, graphs, animations, and presentations.
- Detailed documentation of the processes, assumptions, methodologies, and limitations of the scenarios developed as case studies.
- Training materials based on the case studies that are suitable for teaching the methodology to emergency response planners to be identified by OEMC.

3.6.2. Progress Summary for Task 6

A significant number of changes were implemented within the Microsimulator tool. Those changes more realistically simulate heterogeneous traveler behavior. Facility-based traveler behavior keys were changed to traveler-type based keys, and a facility biased factor was added. Those changes allow simulating different driver behavior based on the facility type. For example, the car following distance is generally larger on a highway compared to an average car following distance on a minor road. More traveler types using nested logic were enabled, and the use of a unique random number seed for each traveler was implemented. This feature will allow distinguishing driver behavior by type. For example, an aggressive driver tends to change lanes more frequently compared to a less aggressive one.

During the month of February subarea processing (unsimulated, macroscopic, mesoscopic, and microscopic) was implemented. This is an extremely important feature for modeling a large scale transportation network because it is impossible to build a high fidelity model of the network supply for the entire region. It is associated with a tremendous modeling and computing effort, and is not cost effective. This feature will allow using mesoscopic or macroscopic simulation for remote areas which do not impact the transportation network performance significantly and thus are not required to be accurately modeled and simulated with a microsimulation technique. This approach saves development time as well as speeds up the computing time necessary to run a model on a computer.

The Microsimulator was then extensively tested and many bugs were corrected. Lane swapping logic was added which allowed improving the accuracy of the simulation results. The Router and PlanSum were enhanced to improve consistency between Router and PlanSum link delay files. Plan processing routines were enhanced and reports to summarize and compare travel times and trip lengths were added. Data conversion routines were enhanced to convert plan, pocket lane, and signal timing information accurately. Data processing and conversion tools for transit networks, count and volume data were enhanced.

A large number of changes were made in the core TRANSIMS executable. The major improvement is the implementation of the Message Passing interface (MPI) capabilities that were added to several key executables such as the Router and PlanSum. This allows utilizing massively parallel computers with distributed memory (when separate compute nodes are connected with each other through a network). The TRACC cluster is an example of such a machine. The new MPI implementation was tested and debugged. Other major changes were done in the Microsimulator. Various Microsimulator algorithms were tested and Microsimulator performance was improved. Calibration keys for facility type and traveler type controls were added to Microsimulator. The Microsimulator's driver behavior and data structures were improved. Parallel to improving the performance of the code, different compilation procedures was tested on the TRACC cluster to identify the optimal combination of compiler and optimization flags. Proper compilation of a code into an executable is crucial and can save hours of computing time for a single model run.

The TRANSIMS software was modified so that the lane use restrictions can be applied based on a vehicle type. For example, it is possible to model a lane on a stretch of road which is dedicated to emergency vehicles or model lanes which can be used only by IPASS users. The traveler type usage within the ConvertTrips tool was enhanced. Now a modeler has more control of how a traveler type is to be assigned to a trip. For example, as an input to the model, a number of vehicle trips from zone A to zone B are given. The mode of transportation and departure time is also part of the input. ConvertTrips based on the trip attributes and a distribution of a random variable assigns a travel type to each of the trips. For example, travelers who use in-vehicle GPS navigation could be distinguished from those who do not. Different traveler types would choose different paths. For example, an IPASS user is more likely to take a toll road compared to the traveler who does not have an IPASS. The capability to control assignment of traveler types on to trips brings an extra level of accuracy in to the model.

A new simulation algorithm was implemented within the Microsimulator tool. The new simulation algorithm is a macroscopic queue-based algorithm. The name macroscopic comes from the fact that the traffic flow model is based on macroscopic properties, like the relationship between vehicle density and average speed on a link. The disadvantage of the new algorithm is that the lane changing mechanics are not modeled. On the other hand, the data requirements as well as run time is significantly less compared to the previously used mesoscopic simulation algorithm. The run time is 10 times faster when the mesoscopic simulation technique is used.

Significant effort was spent on the MPI version of the Microsimulator. Logic was added to set and restrict the partition range considered by MPI machines. MPI communications, data structure packing and unpacking, and machine specific network data partitioning were implemented. Travelers, vehicles, and boundary link occupancy data transfers between MPI machines was implemented and boundary issues were addressed.

The TRANSIMS software was modified so that the modeler has more control on selecting and identifying travelers whose plans go through a certain geographical area, for example through an evacuation zone. The MPI framework for the simulator module was also improved. When an MPI environment is used, the transportation network is partitioned and every individual machine is “responsible” for one of those partitions.

Some of the core data structures were modified. The changes allow for a friendlier user interface to model lane restrictions on the network. A new tool called Relocate allows a user to seamlessly move transportation demand data from one network revision to another. This makes the process of synchronizing travel plans and network data much easier. A large number of bugs identified during case studies in the Router box were fixed. The new version of the Router allows obtaining more stable and consistent results. The logic in the traffic simulator was modified and enhanced. This allows eliminating some of the factors which lead to an artificial congestion on the network. Transit vehicles can now be simulated. The new routing algorithms for transit have been implemented in August. This allows having a full scale transit model. The software compilation scripts were moved to and tested on the TRACC cluster, which is more reliable compared to the machines used at AECOM.

The case studies concentrated in this study on the development of the software and in the evaluation and implementation of features necessary to create a tool that is suitable for use by emergency responders. Particular scenarios that are described in great detail in section 5 of this report include Wrigley Field, Naperville, and Six Flags Great America. The tool was developed to configure different scenarios in any area in the region, and the chosen scenarios are highlighting different aspects of the modeling needs.

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4. Network Coverage by County

The overall extend of the model area is shown in Figure 4.1. It covers approximately 10,000 square miles, and stretches from Milwaukee in the North to Kankakee in the South, and Rockford in the West to Michigan in the East. The network is a modeling network that includes all important streets in the model area, and is more refined in densely populated places.

The maps on the following pages provide a basic understanding of the highway network as it is used in the underlying RTSTEP and TRANSIMS models. Figure 4.1 shows the model network in red. The figure illustrates the general topology of the network, showing that the model area is largely bounded by some major exit points along the Interstate highway system. Cities and towns on the boundary of the model area are modeled relatively sparsely. As a consequence, the details for smaller towns like Kankakee may be far more detailed than the details for Milwaukee. Coverage for the 16 Counties in the Combined Statistical Area are excellent, as demonstrated in the maps in this chapter.

For all the remaining maps in this chapter (Figure 4.2 to Figure 4.21), the existing full road network is shown in red, while the road network used in RTSTEP is indicated in blue.

Data layers such as Hospitals, schools, police stations, and fire stations have been provided by CMAP, OEMC, IEMA, and GIS experts from the different counties. An example for enhanced data provided by a county is shown in Figure 4.11 and Figure 4.12 for Kankakee County.

The maps in this chapter have been created using the ArcMap software from ESRI, a tool commonly available to GIS departments at participating counties. Layers are provided as part of the RTSTEP application.

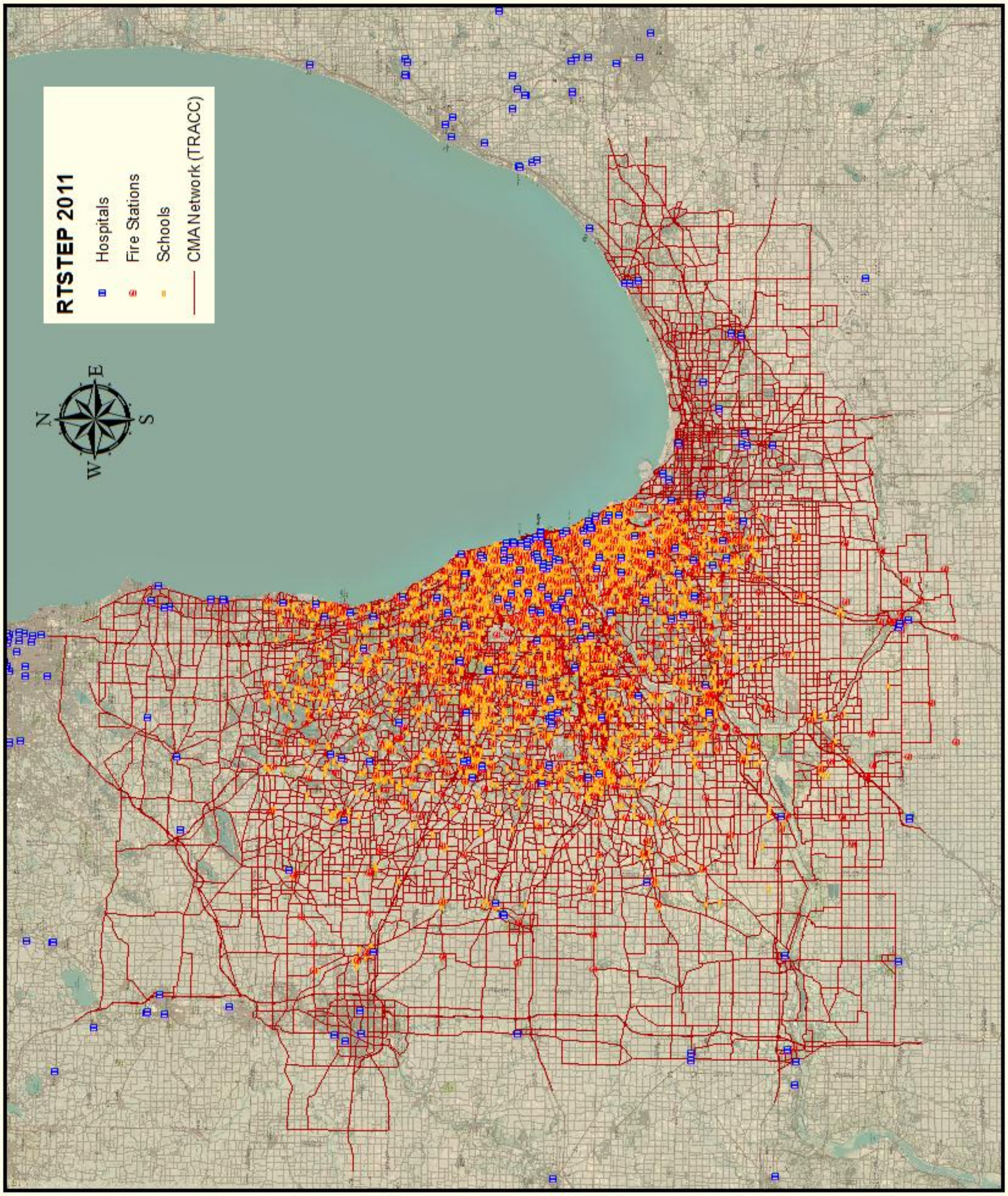


Figure 4.1: Extent of the Chicago Metropolitan Area highway network used for RTSTEP

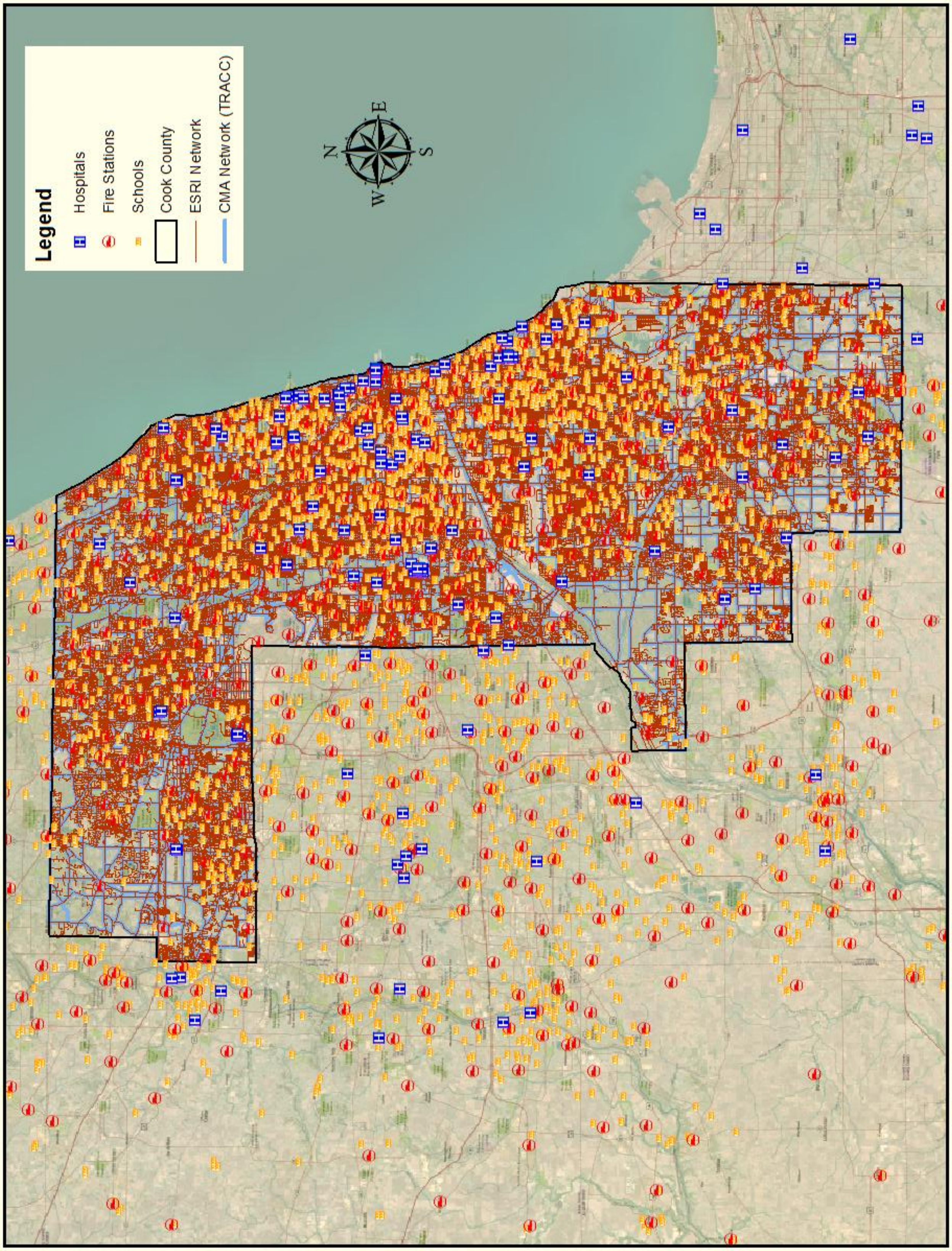


Figure 4.2: Cook County

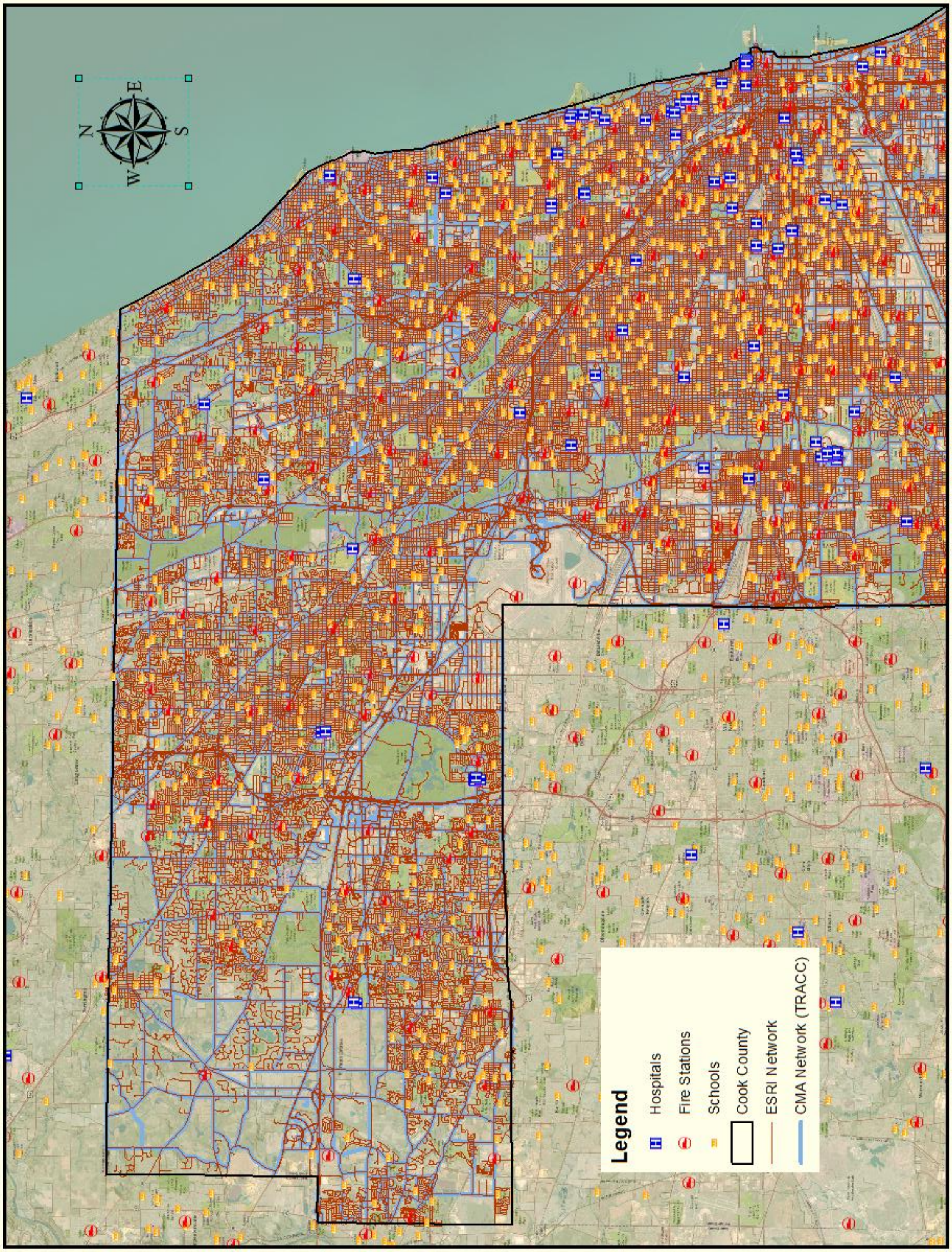


Figure 4.3: Northern Cook County

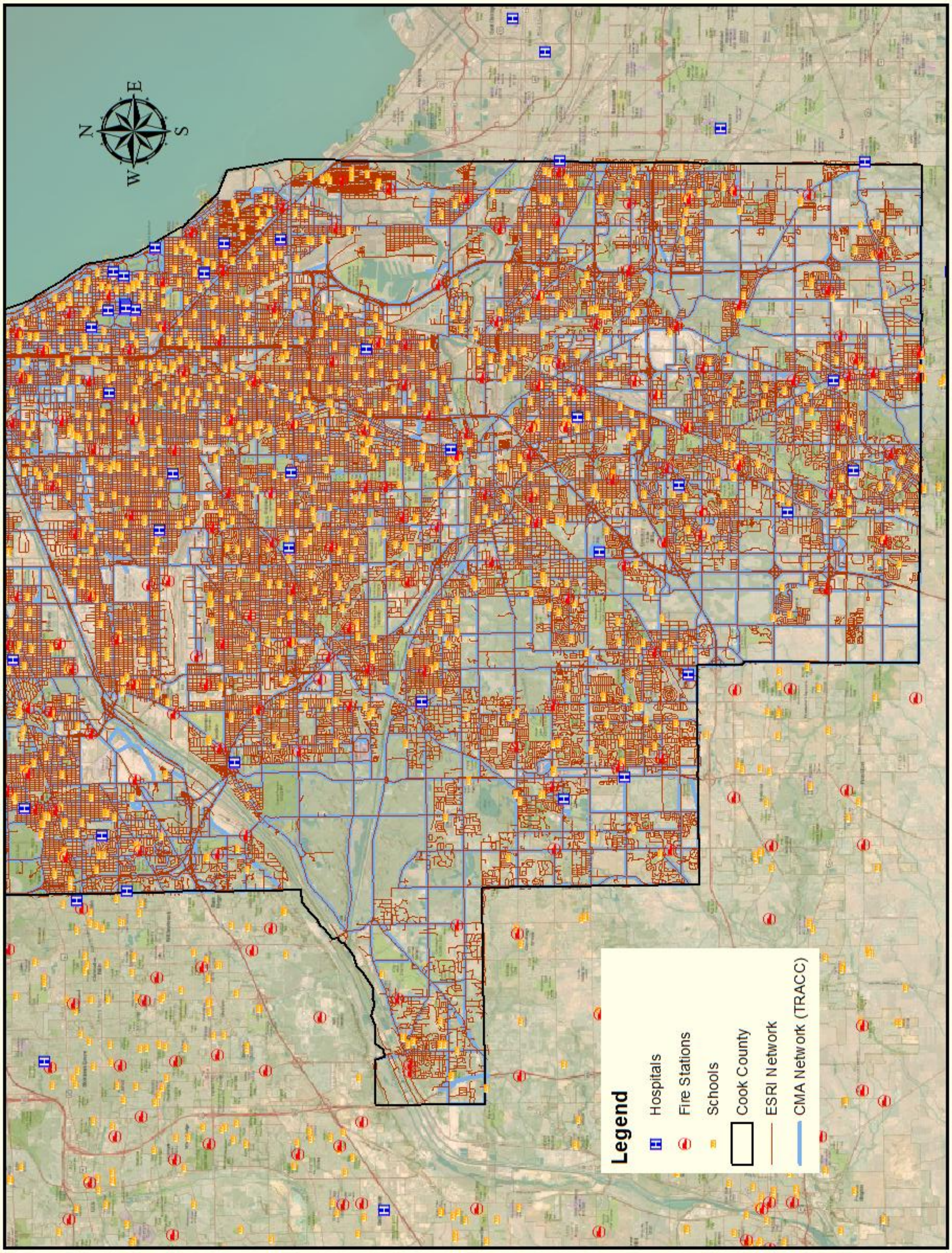


Figure 4.4: Southern Cook County

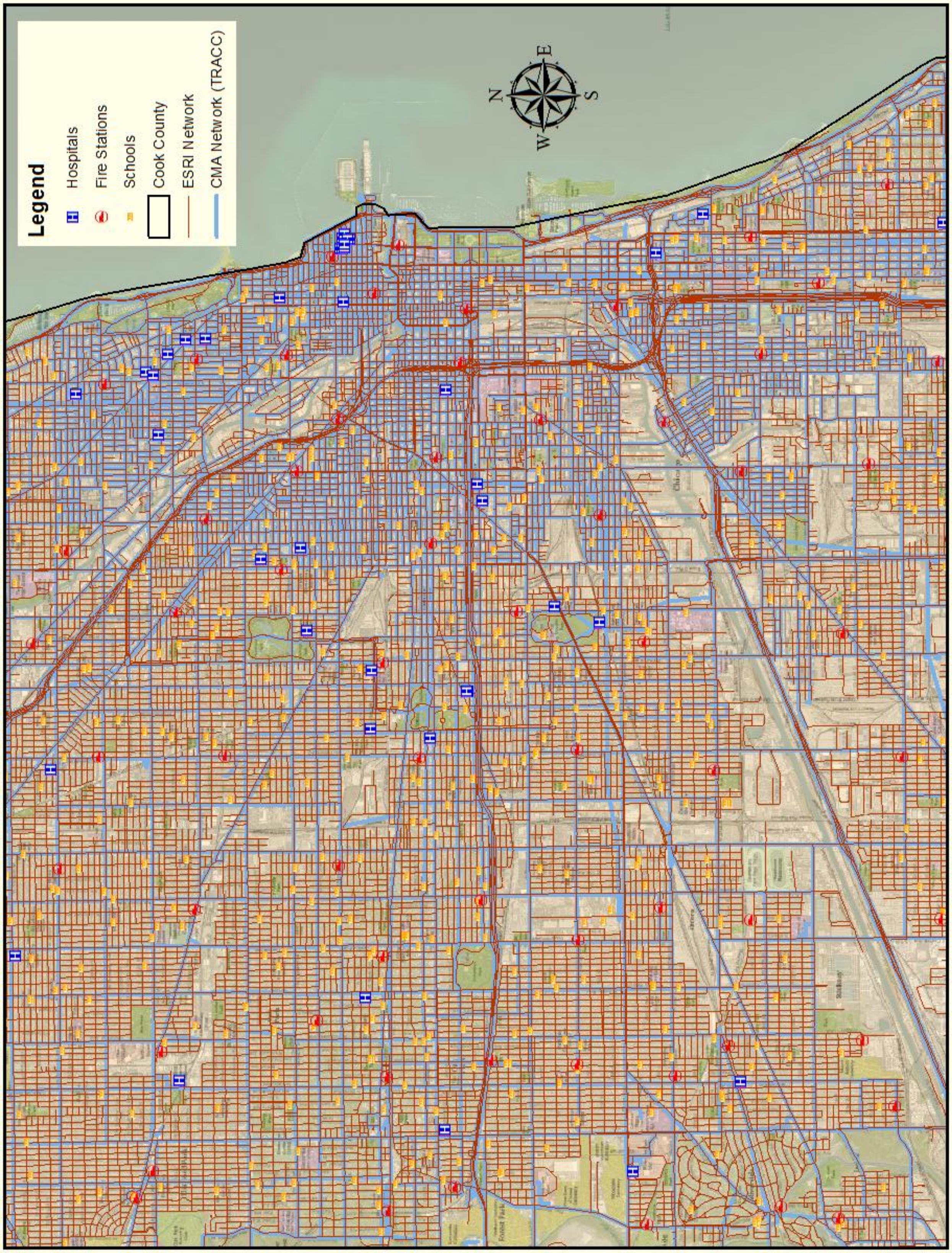


Figure 4.5: Chicago Business District and Surrounding Area

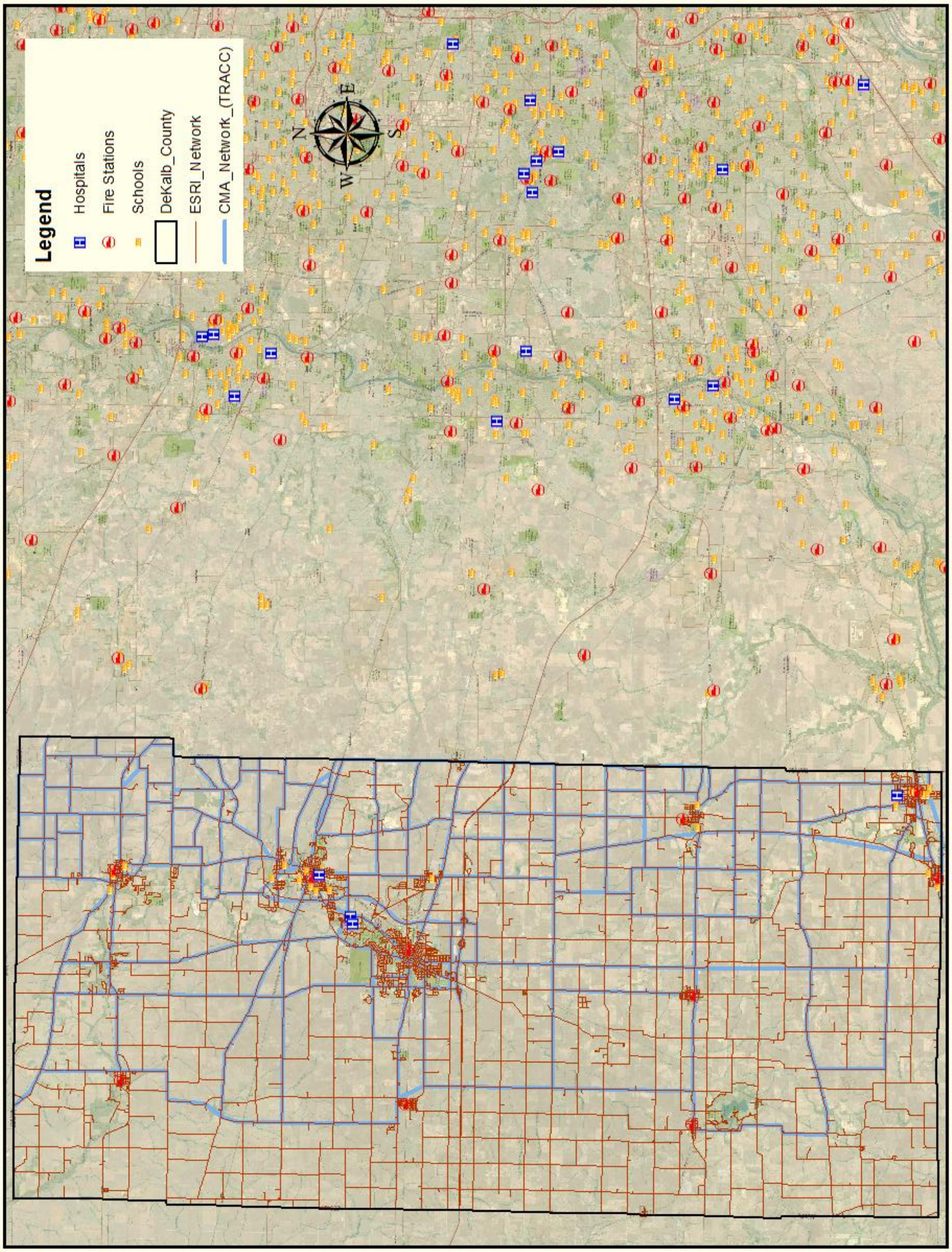


Figure 4.6: DeKalb County

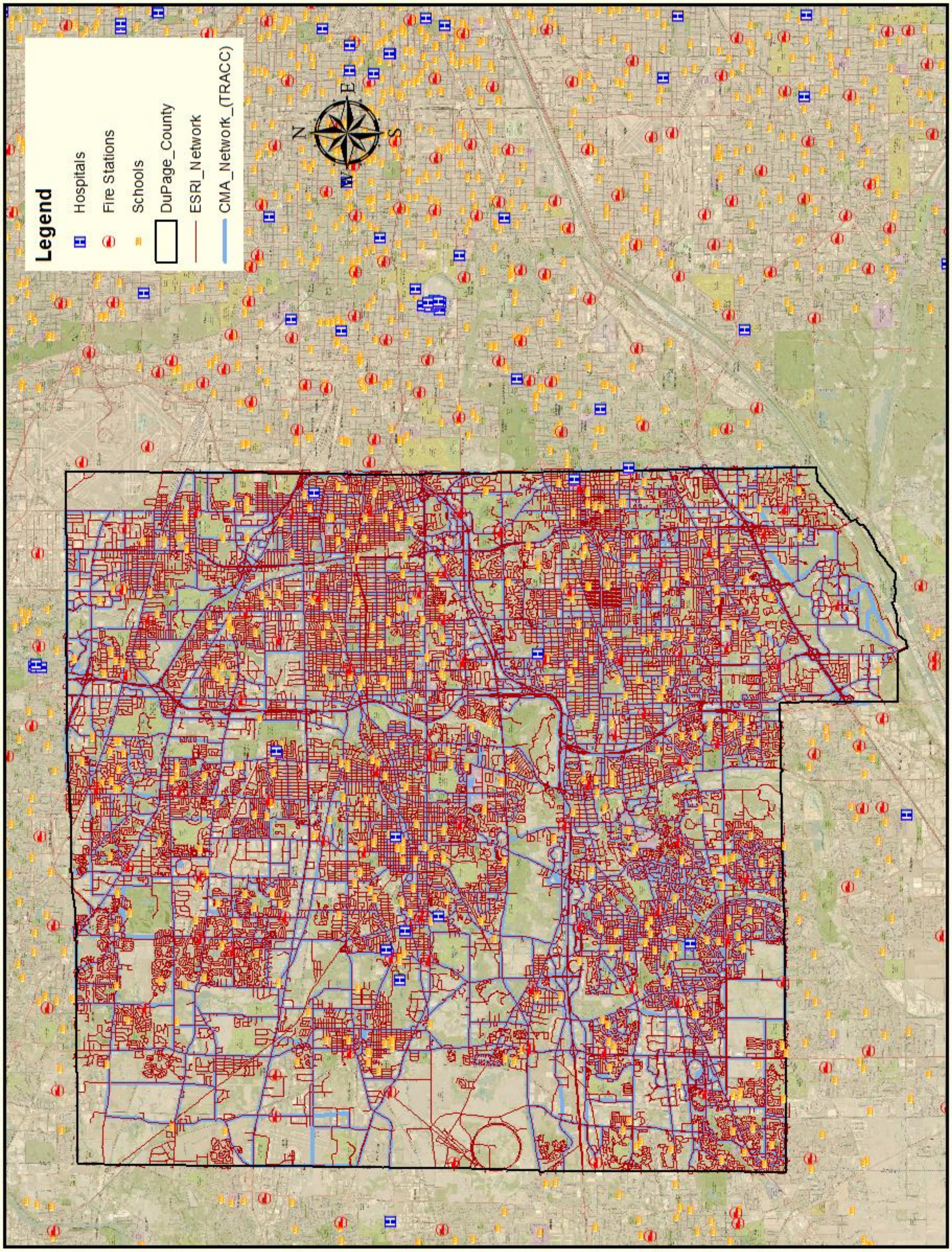


Figure 4.7: DuPage County

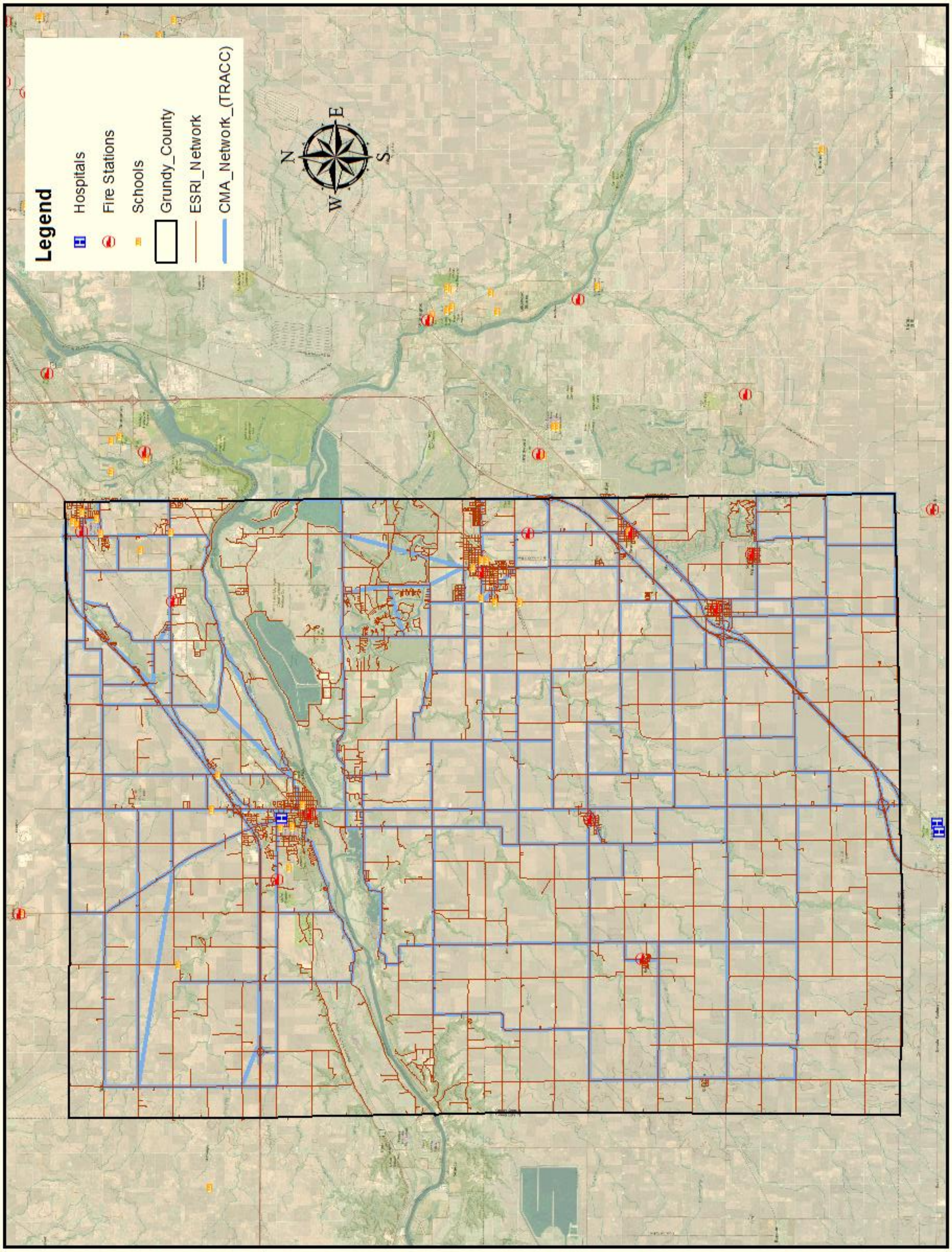


Figure 4.8: Grundy County

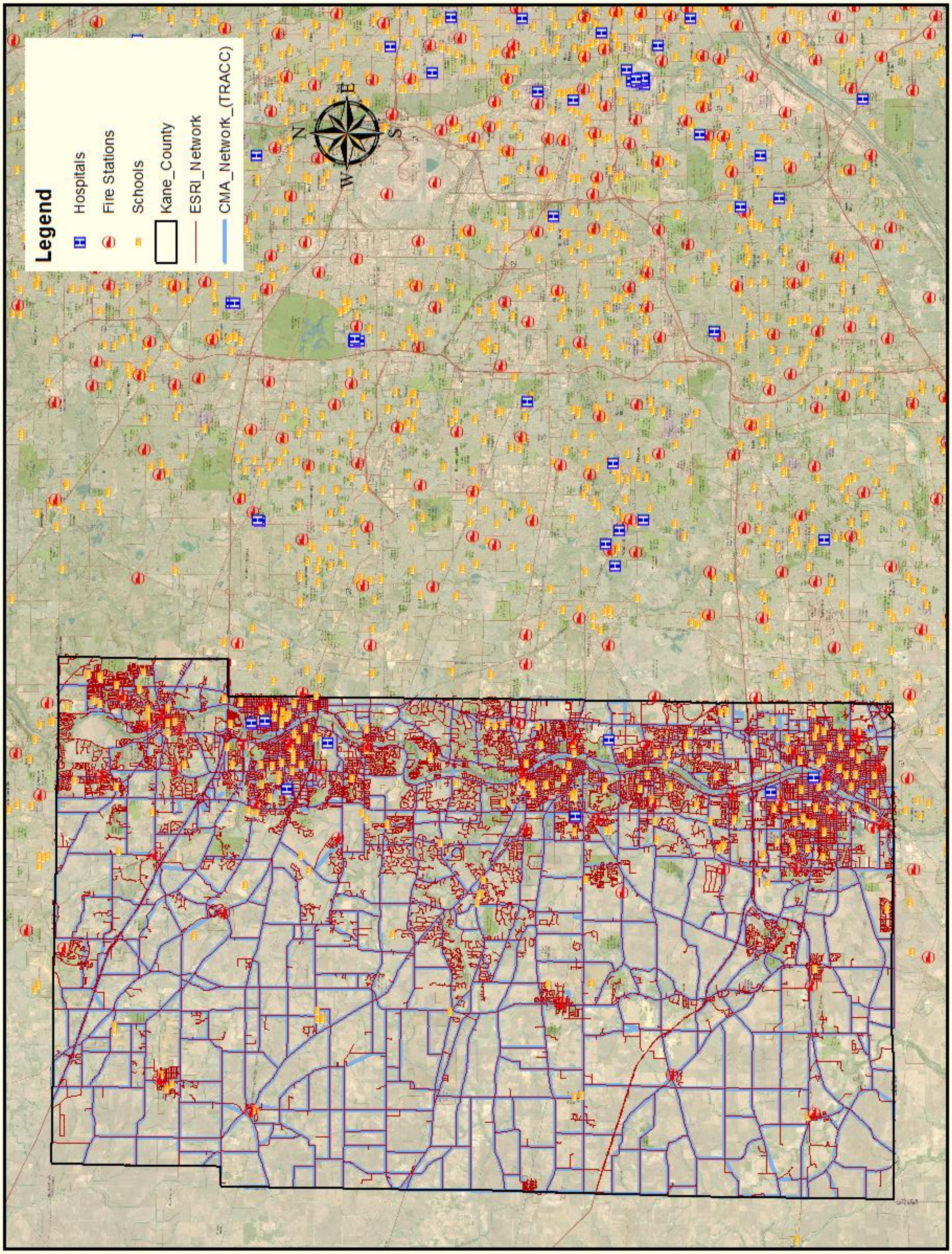


Figure 4.9: Kane County

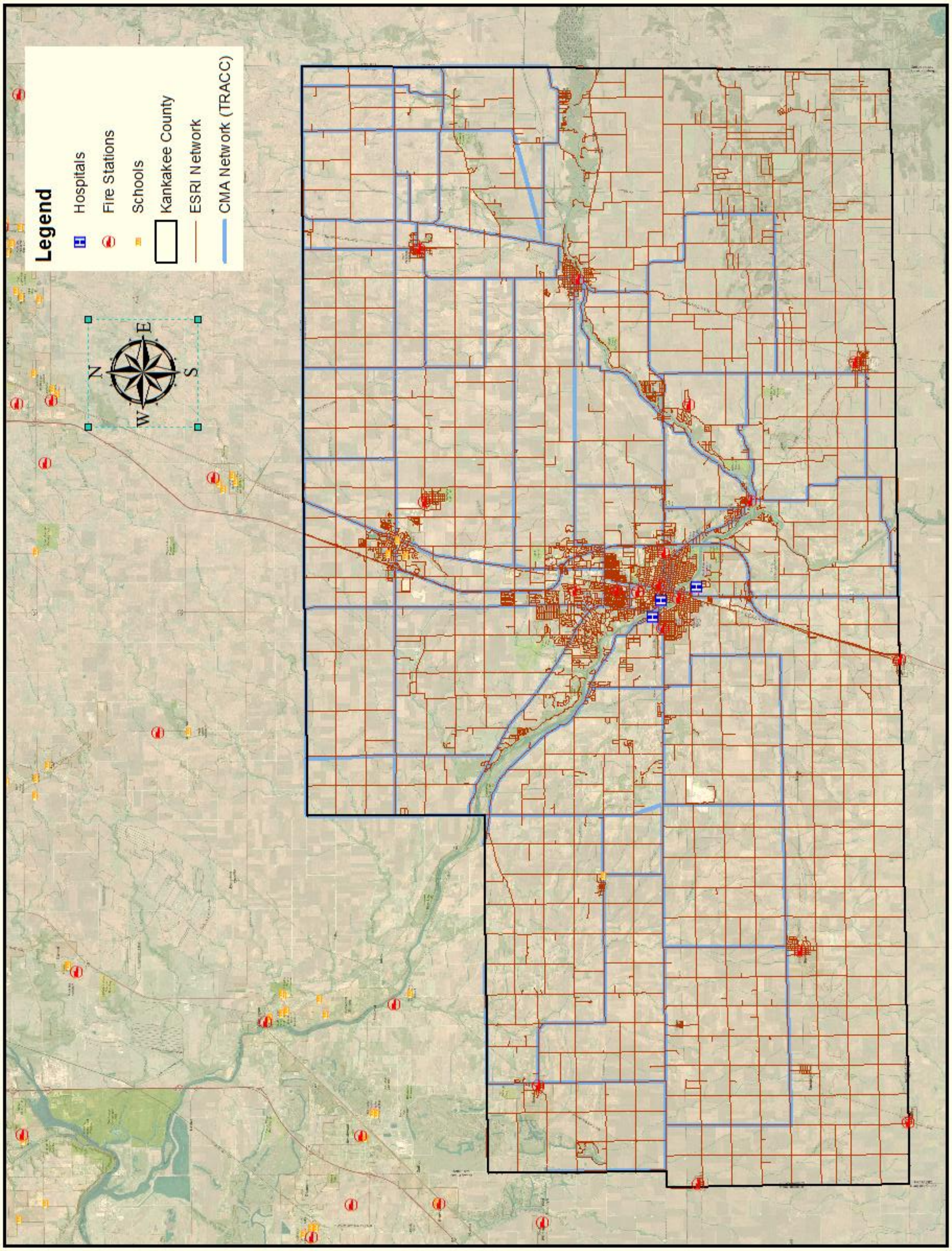


Figure 4.10: Kankakee County (based on CMAP and other regional data)

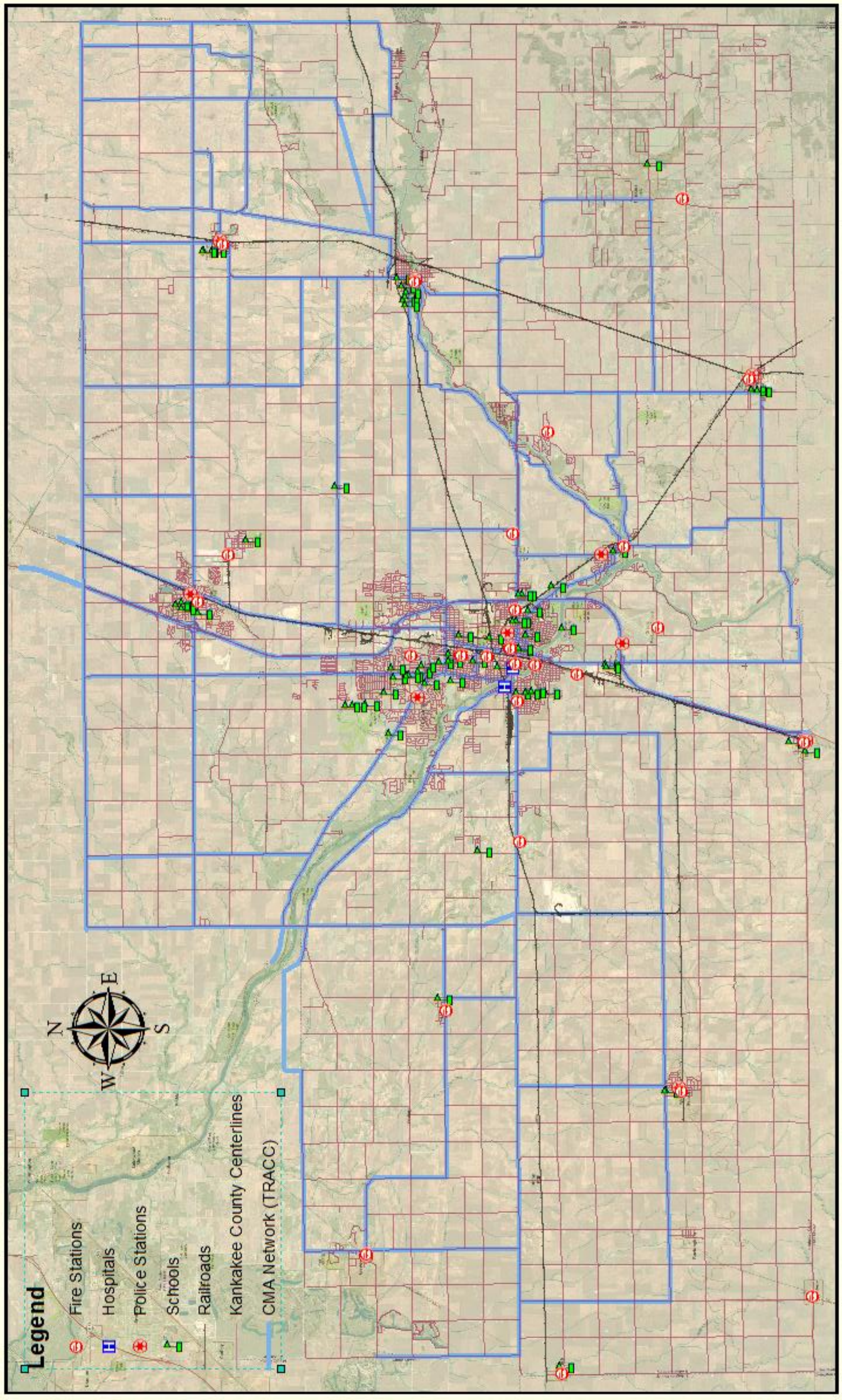


Figure 4.11: Kankakee County (detailed data layers have been made available)

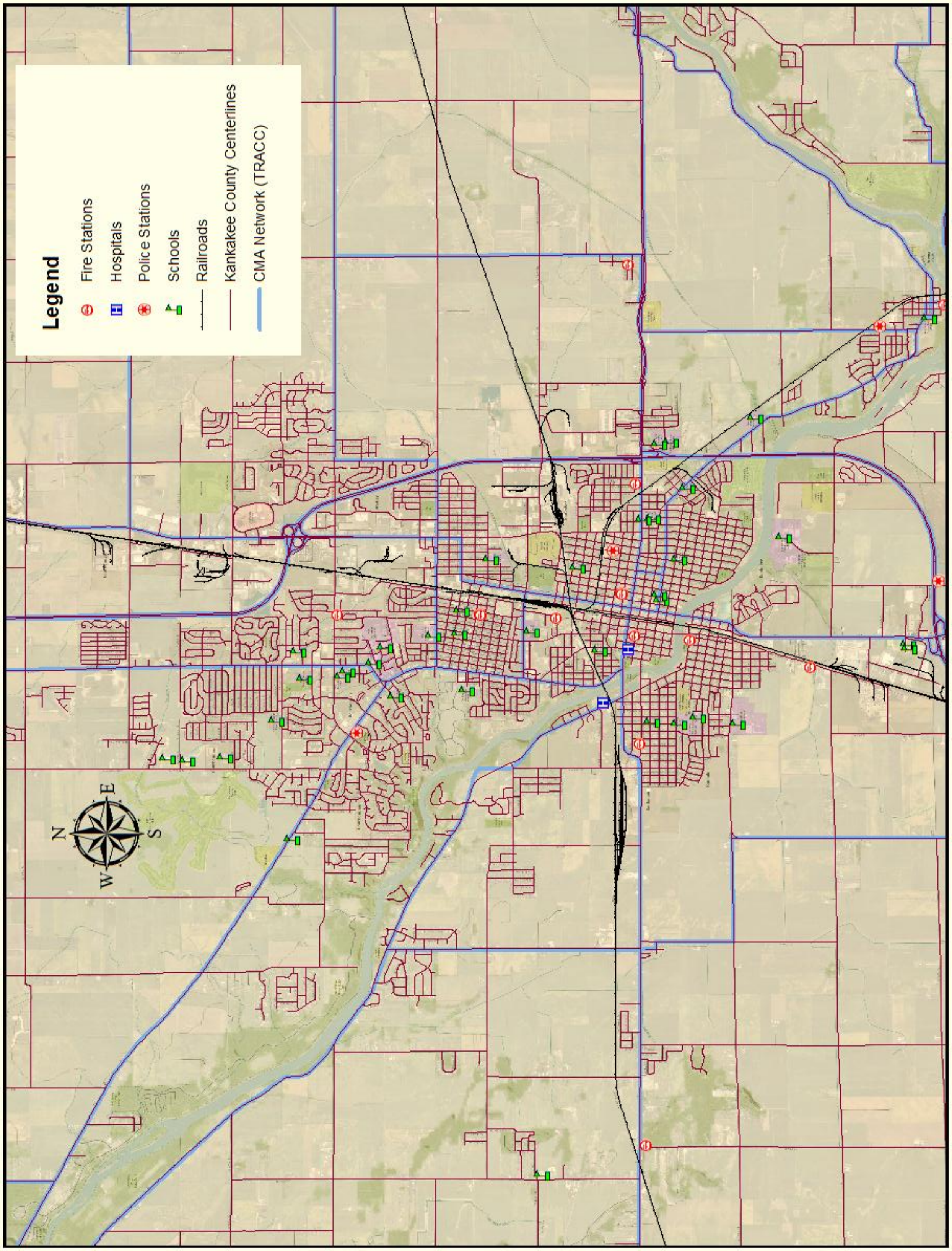


Figure 4.12: Kankakee (detailed data layers have been made available)

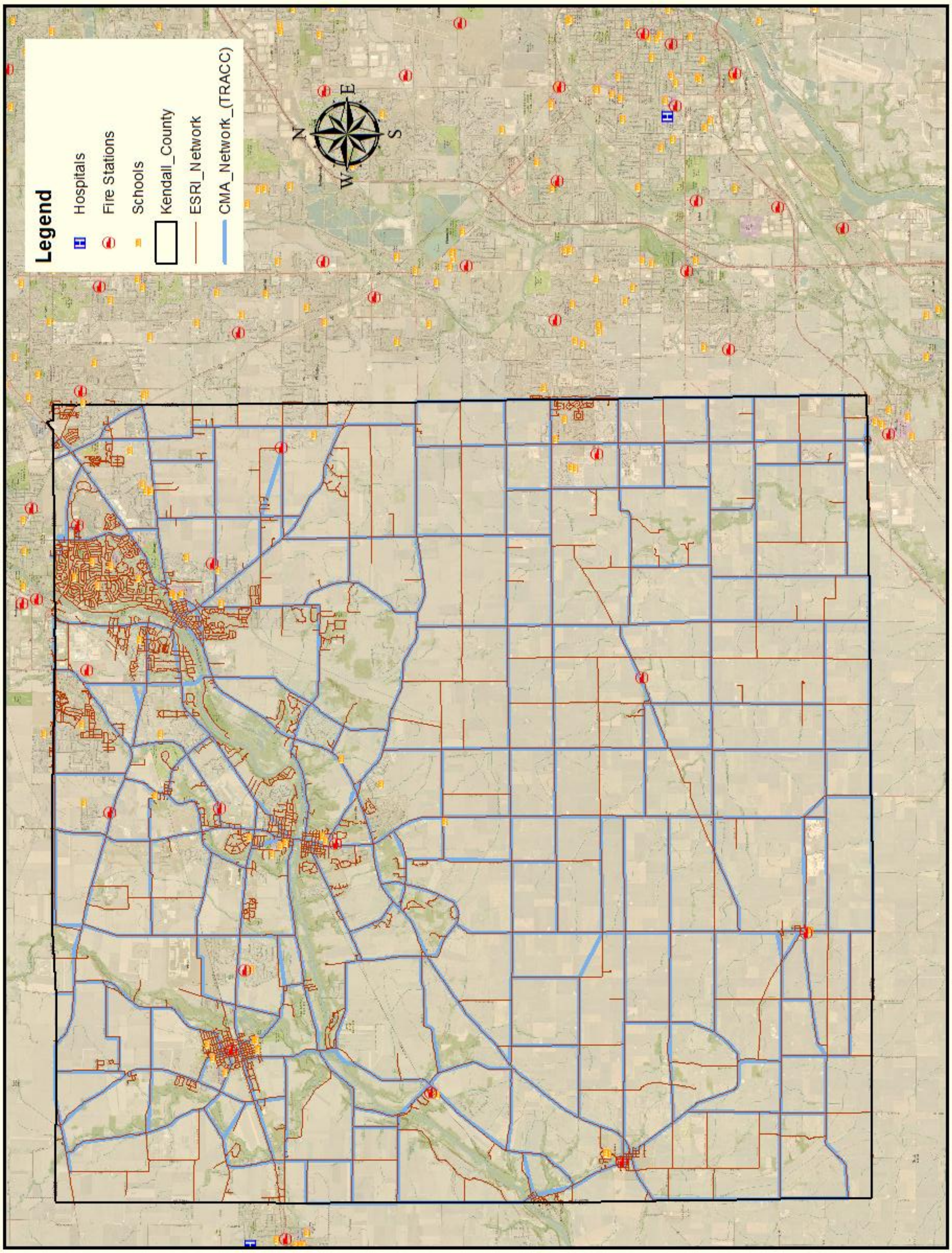


Figure 4.13: Kendall County

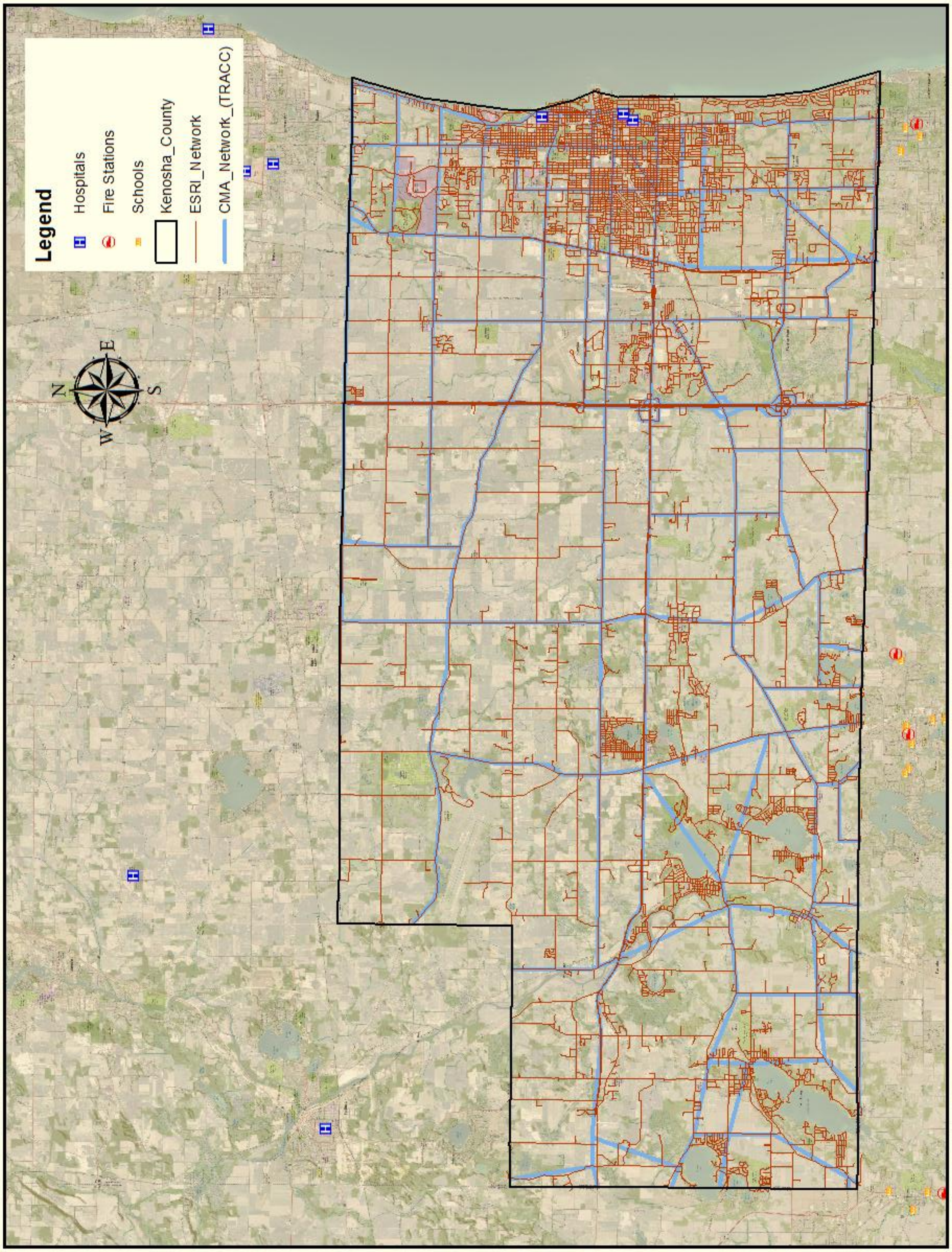


Figure 4.14: Kenosha County

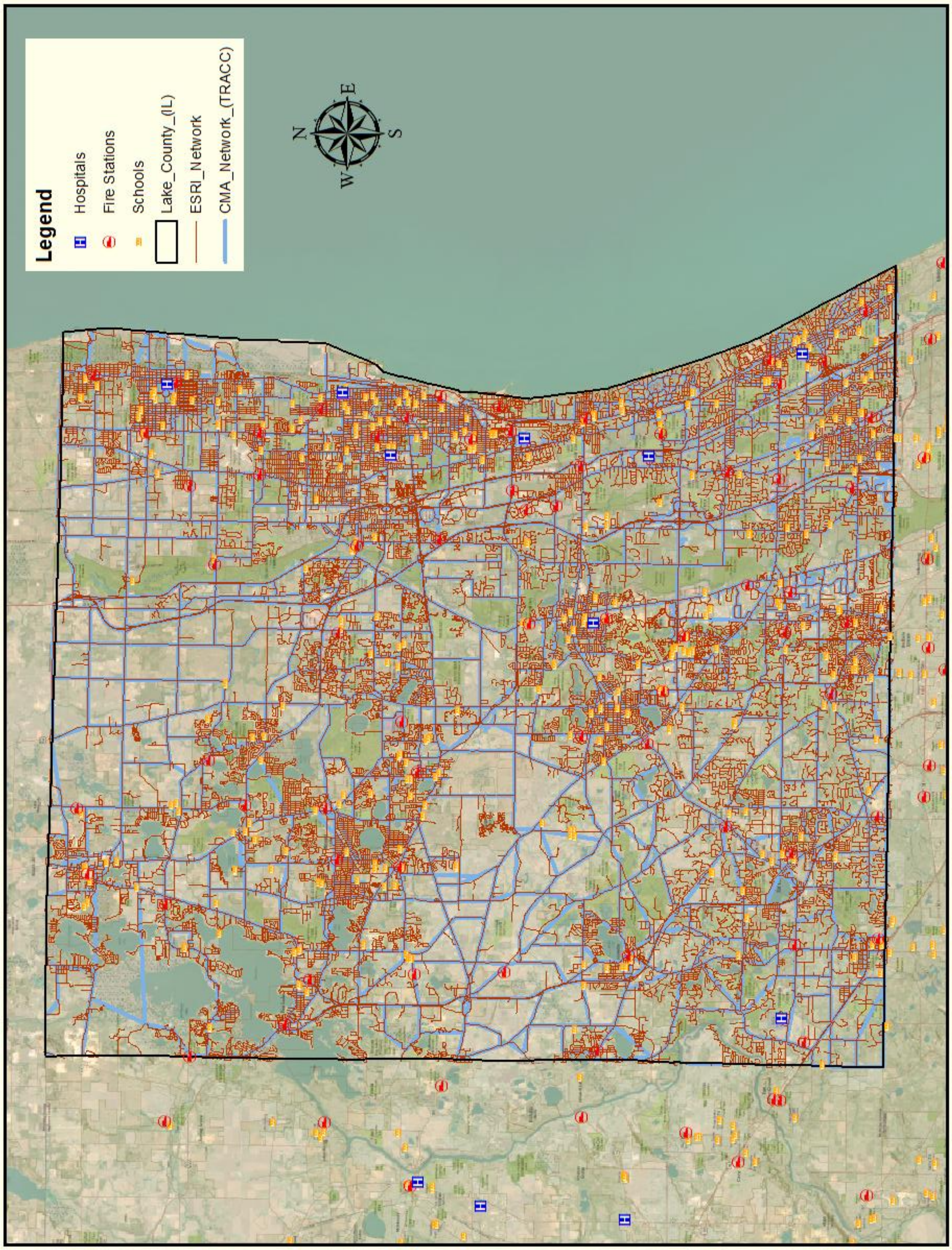


Figure 4.15: Lake County (Illinois)

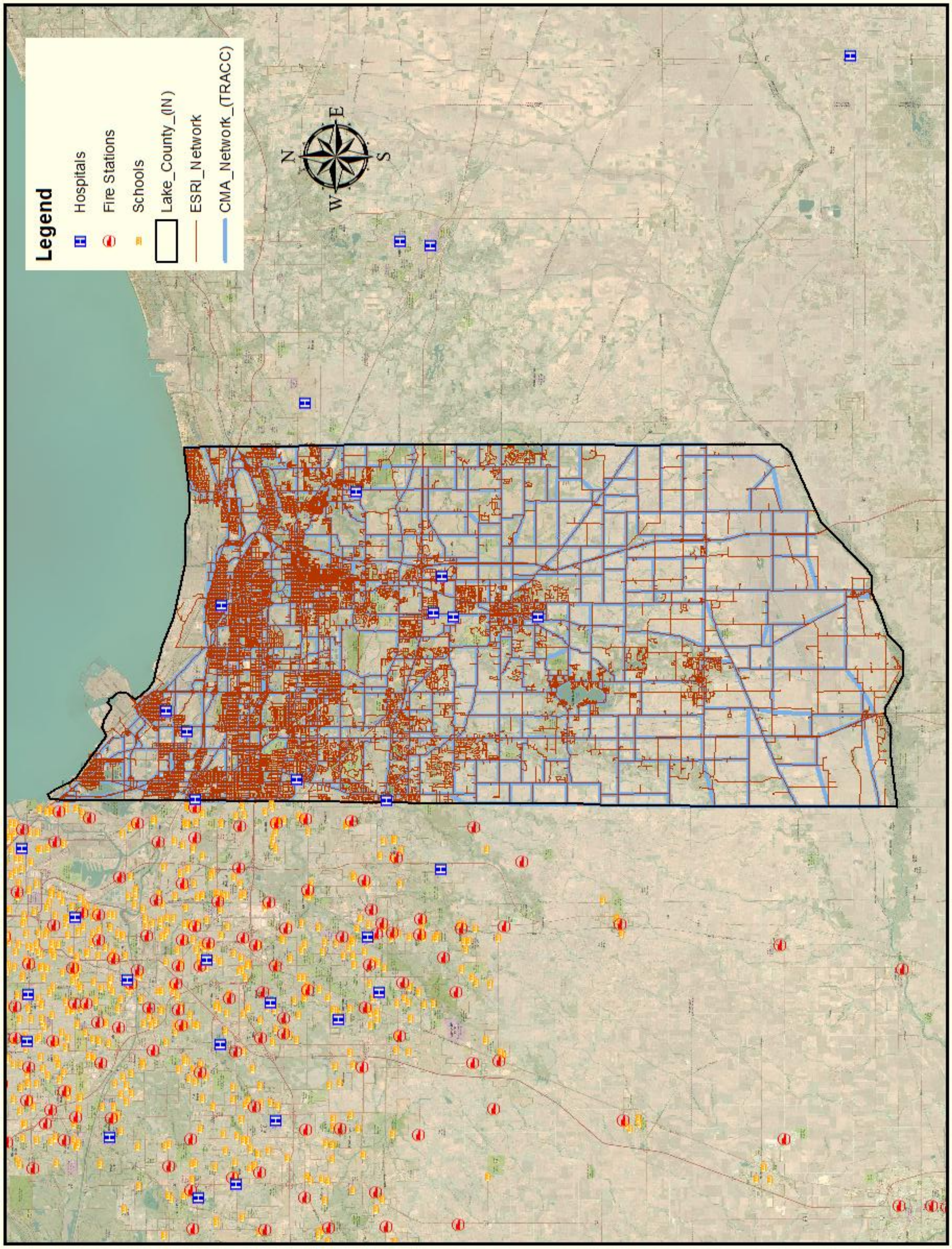


Figure 4.16: Lake County (Indiana)

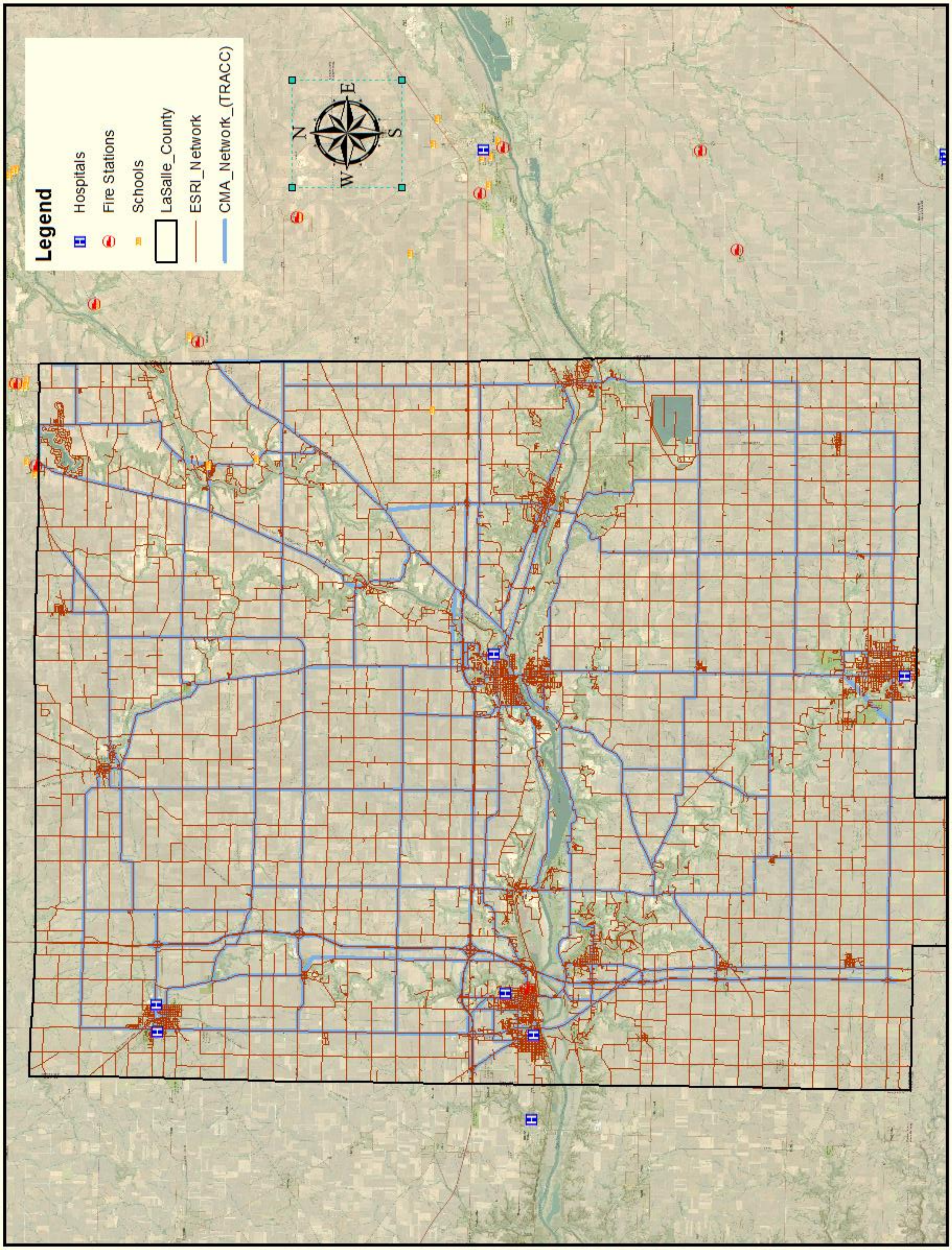


Figure 4.17: LaSalle County

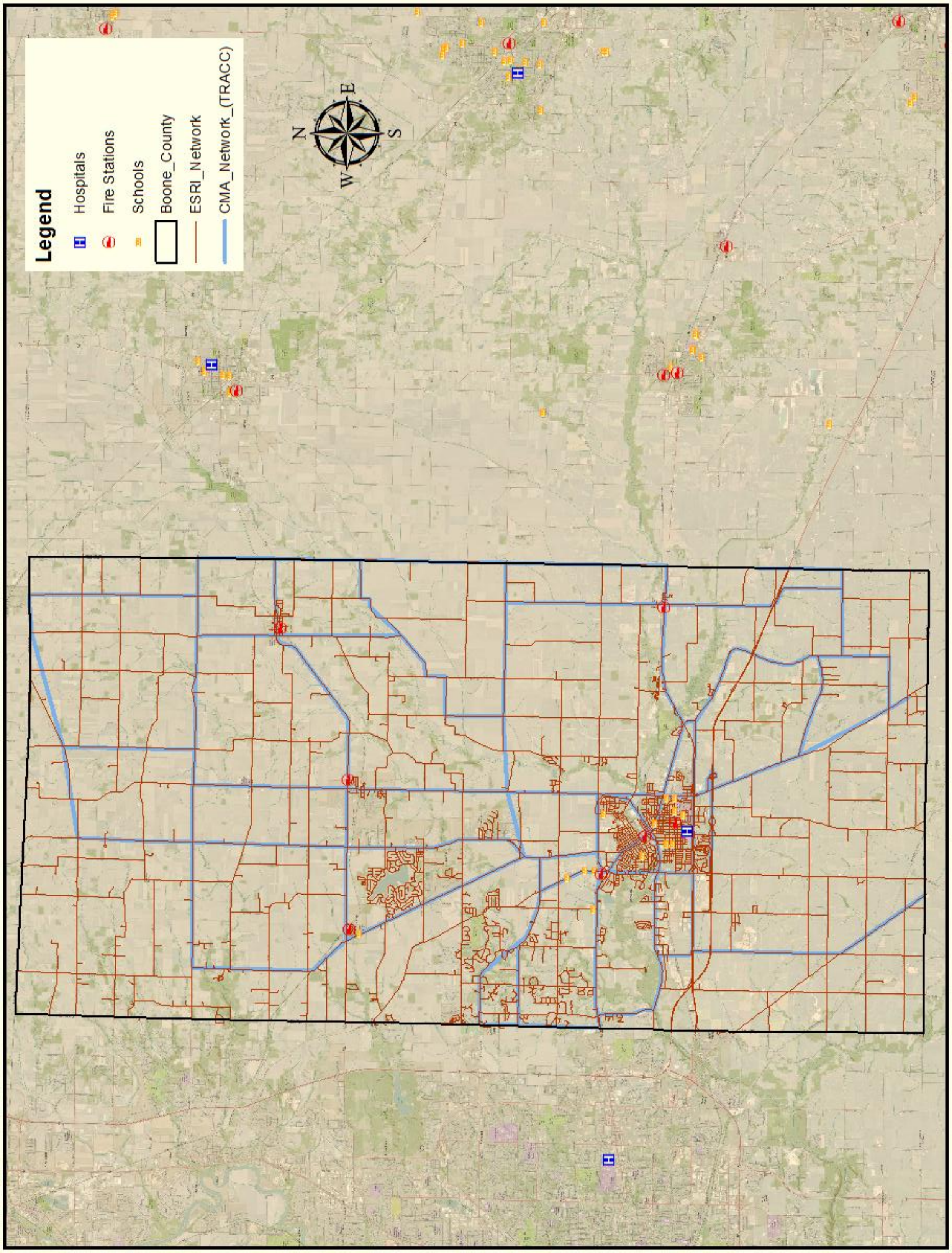


Figure 4.18: McHenry County

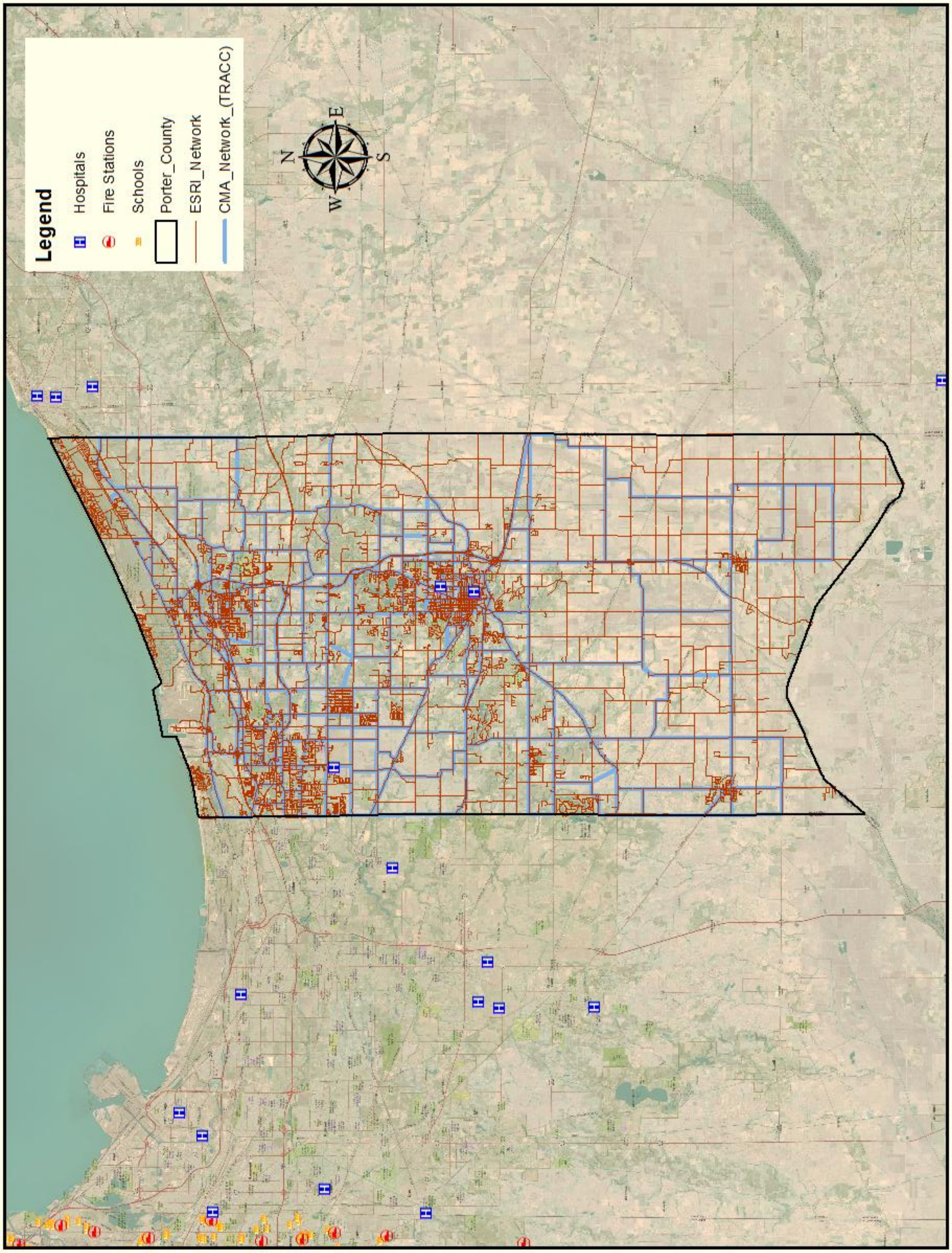


Figure 4.19: Porter County

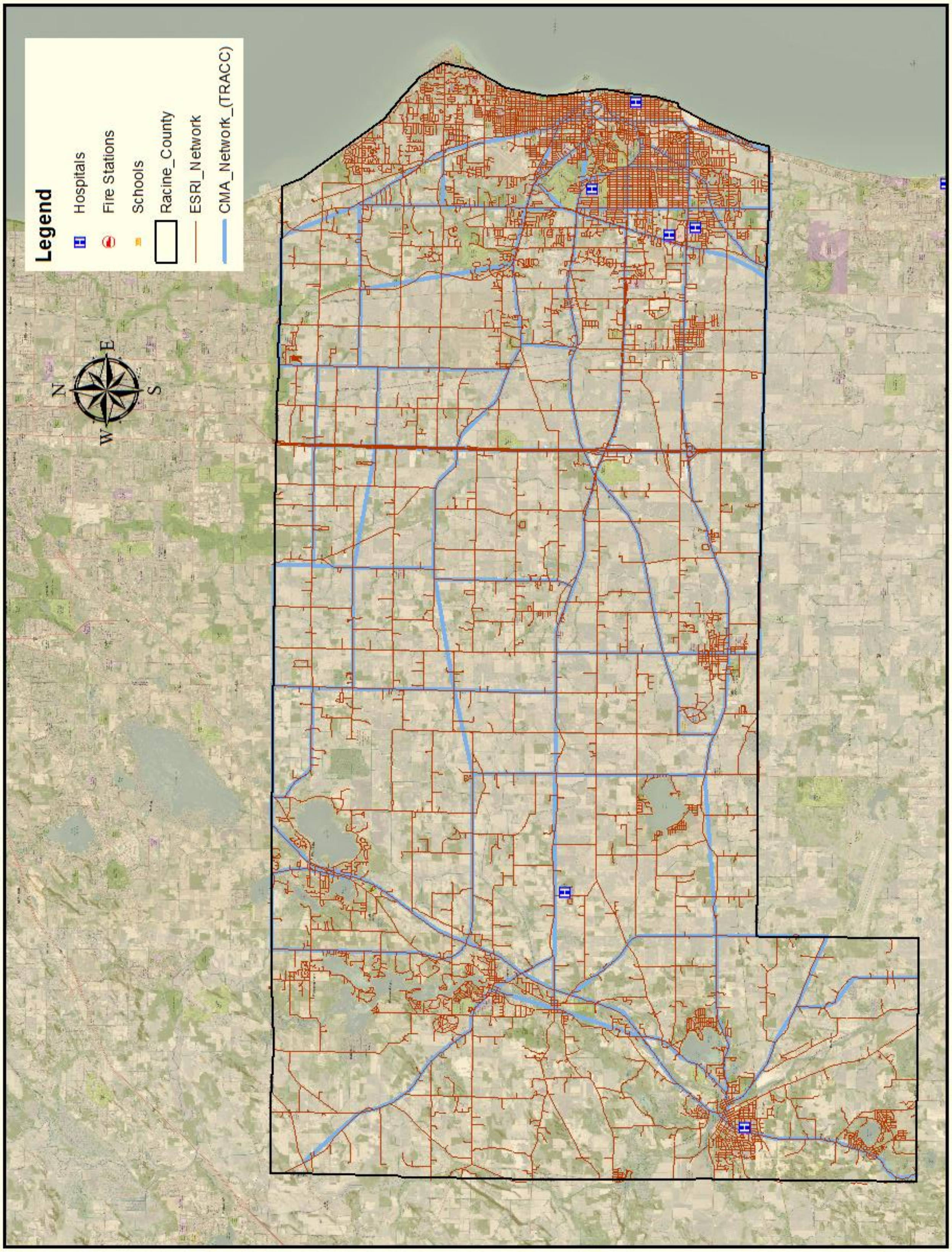


Figure 4.20: Racine County

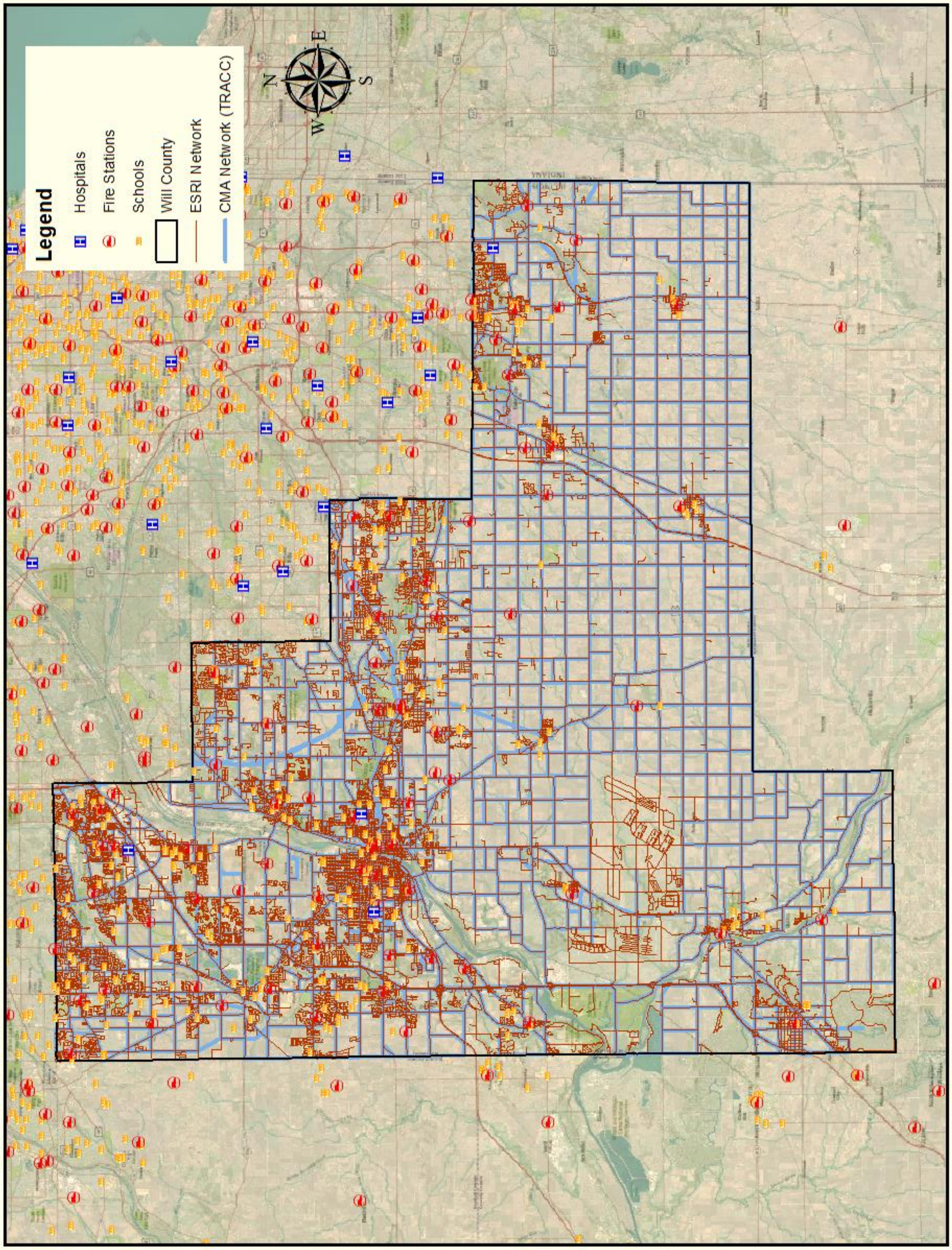


Figure 4.21: Will County

5. Case Studies

5.1. Wrigley Field

5.1.1. Scenario Description

Wrigley Field is a baseball stadium in Chicago that has served as the home ballpark of the Chicago Cubs since 1916. It has a 41,159 seats with standing room at least 42,374 seats of capacity. Located in the community area of Lakeview, Wrigley Field sits on an irregular block bounded by Clark (west) and Addison (south) Streets and Waveland (north) and Sheffield (east) Avenues. The area surrounding the ballpark contains residential streets, in addition to bars, restaurants and other establishments called Wrigleyville. Figure 5.1shows the location of the Wrigley Field Stadium in the Chicago Metropolitan Area. Figure 5.2 shows a satellite image and 3D building of the Wrigley Field Stadium.

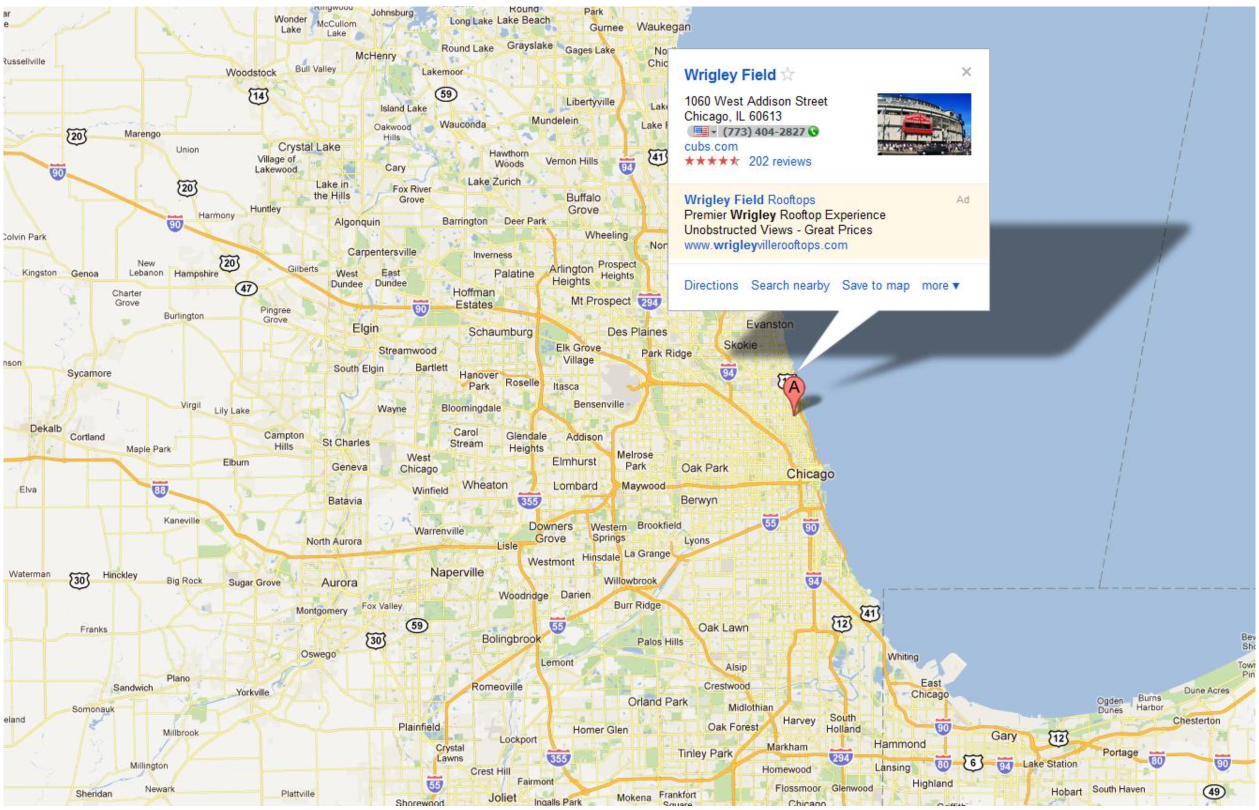


Figure 5.1: Wrigley Field Stadium

Figure 5.2: Satellite Image and 3D Building of the Wrigley Field Stadium

Figure 5.3: A Baseball Game at Wrigley Field Stadium

We assume that an evacuation scenario is as follows. At noon, there is an on-going game between the Chicago Cubs and the St. Louis Cardinals at Wrigley Field. There is a deafening noise from just beyond the northeast corner of the stadium. People in the vicinity of the stadium are experiencing significant breathing trouble, as acrid smoke and dust swirls into the air above the Lakeview neighborhood. As the first fire engine pulls through the gates, the crew is startled by an alarm they've never heard, coming for a new "radiation detector" provided to responders by the Illinois Terrorism Task Force and mounted on the dashboard of their apparatus.

5.1.2. Scenario Definition

Using the TransimsVIS tool, selecting the Evacuation Menu, we define the Naperville Station Scenario in the following steps. The TransimsVIS manual describes the details of the functions of the Evacuation Menu.

Step 1: Define Evacuation Area

We define two evacuation areas with different severity levels as in Figure 5.4 and the corresponding parameters of these two evacuation areas are shown in Figure 5.5. Based on these definitions, TransimsVIS will output two evacuation scenario files: evac_response in Table 5.1 and evac_zone in Table 5.2.

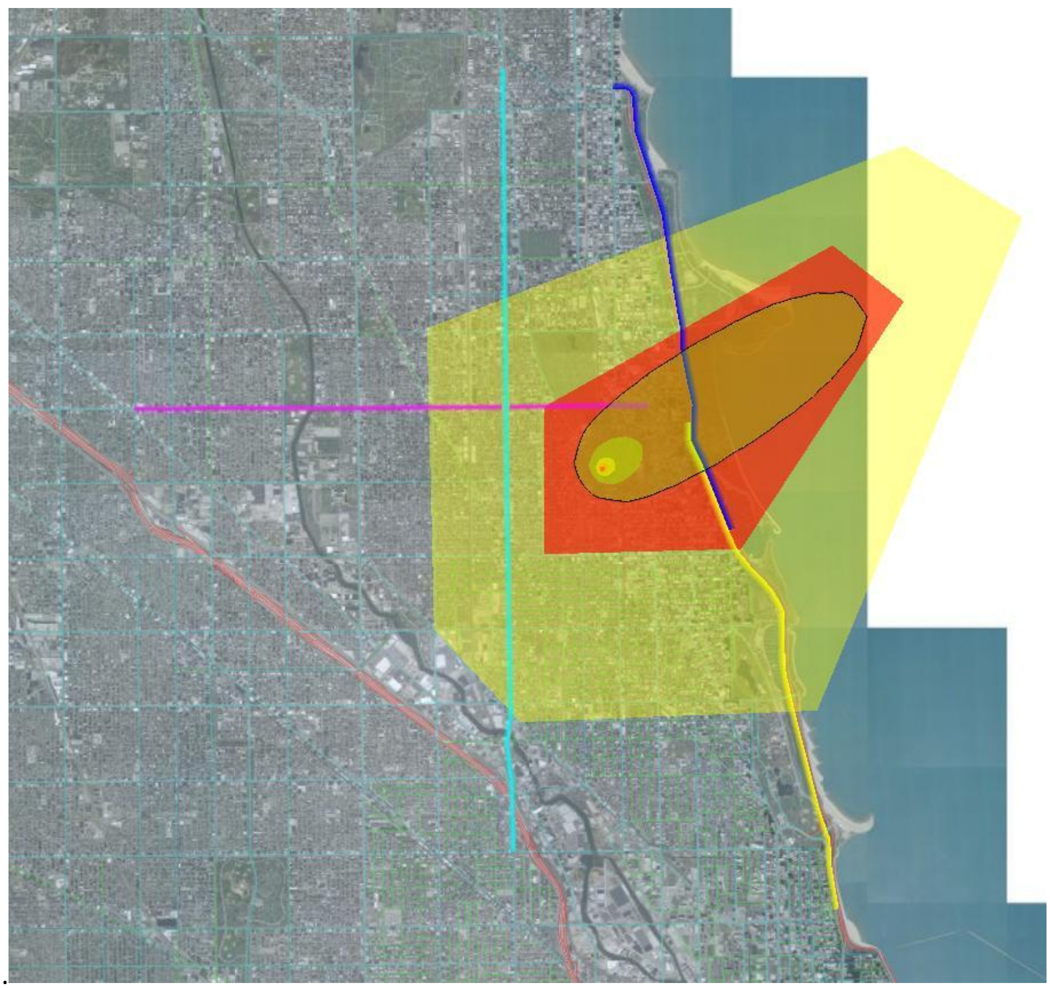


Figure 5.4: Evacuation Areas in the Wrigley Field Stadium Scenario

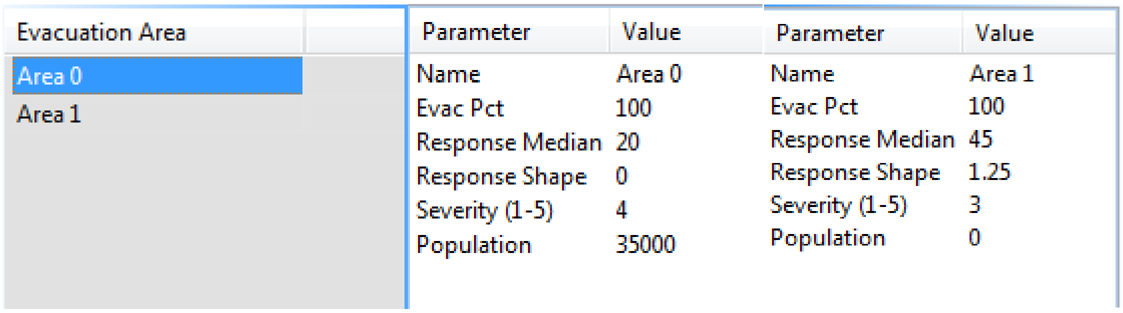


Figure 5.5 Parameters of Evacuation Areas in the Wrigley Field Stadium Scenario

Table 5.1 Evac_Responses

EVENT	LEVEL	DISTRIBUTION	COMPLIANCE	RESPONSE	EVAC_VEHICLE	NAME	POPULATION
1	4	LOG-LOGISTIC,20,1.5	100	0	94	Area 0	35000
1	3	LOG-LOGISTIC,45,1.75	100	0	93	Area 1	0

Table 5.2 Evac_Zones

EVENT	ZONE	POP	LEVEL	START	END
1	48	0	3	12:00	24:00:00
1	49	0	3	12:00	24:00:00
1	50	0	3	12:00	24:00:00
1	51	0	3	12:00	24:00:00
1	52	0	3	12:00	24:00:00
1	78	0	3	12:00	24:00:00
1	79	0	3	12:00	24:00:00
1	80	0	3	12:00	24:00:00
1	137	0	3	12:00	24:00:00
1	143	0	3	12:00	24:00:00
1	149	0	3	12:00	24:00:00
1	155	0	3	12:00	24:00:00
1	160	0	3	12:00	24:00:00
1	161	0	3	12:00	24:00:00
1	163	8750	4	12:00	24:00:00
1	164	8750	4	12:00	24:00:00
1	165	0	3	12:00	24:00:00
1	166	8750	4	12:00	24:00:00
1	167	8750	4	12:00	24:00:00
1	168	0	3	12:00	24:00:00

<u>Step 2: Define Evacuation Shelters</u>

We define eleven evacuation shelters for this scenario in Figure 5.37. The corresponding parameters are shown in Figure 5.7. Table 5.3 shows the output of the definitions of evacuation shelters.

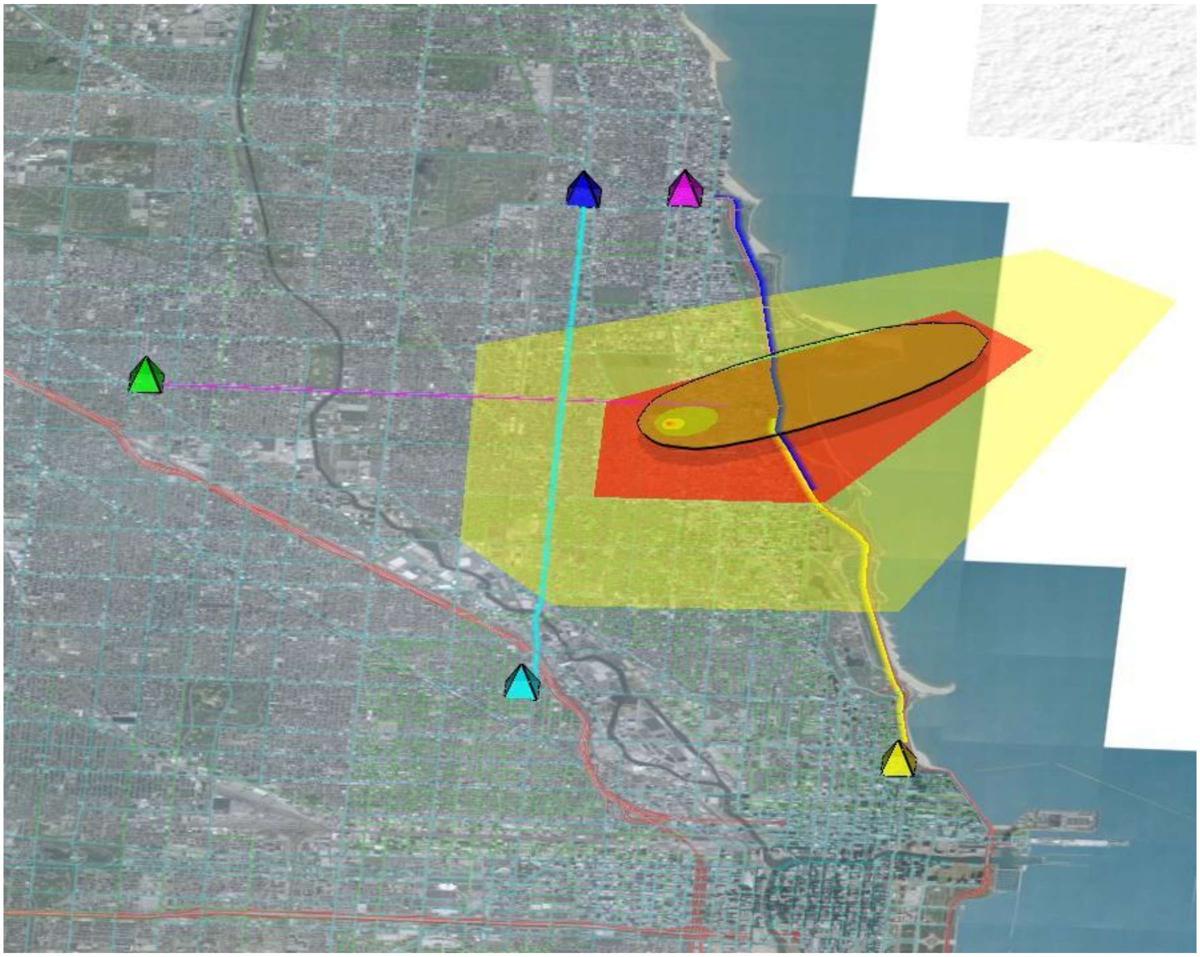


Figure 5.6: Evacuation Shelters for the Wrigley Field Stadium Scenario

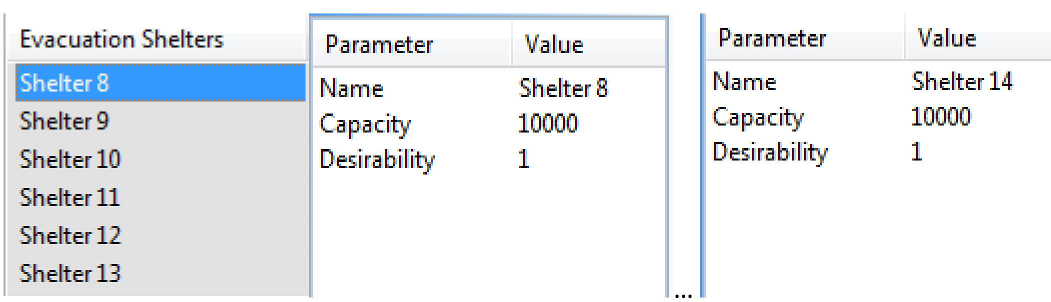


Figure 5.7 Parameters for Evacuation Shelters

Table 5.3 Evac_Shelters

LOCATION	CAPACITY	ATTRACTION	NAME
55641	10000	1	Shelter 8
55029	10000	1	Shelter 9
63945	10000	1	Shelter 10
66673	10000	1	Shelter 11
63545	10000	1	Shelter 12
93519	10000	1	Shelter 13
66196	10000	1	Shelter 14

Step 3: Define Evacuation Routes

There are a total of ten evacuation corridors defined for this scenario - eight highway evacuation corridors and two arterial evacuation corridors are used in the scenario as in Figure 5.8 and Figure 5.9.

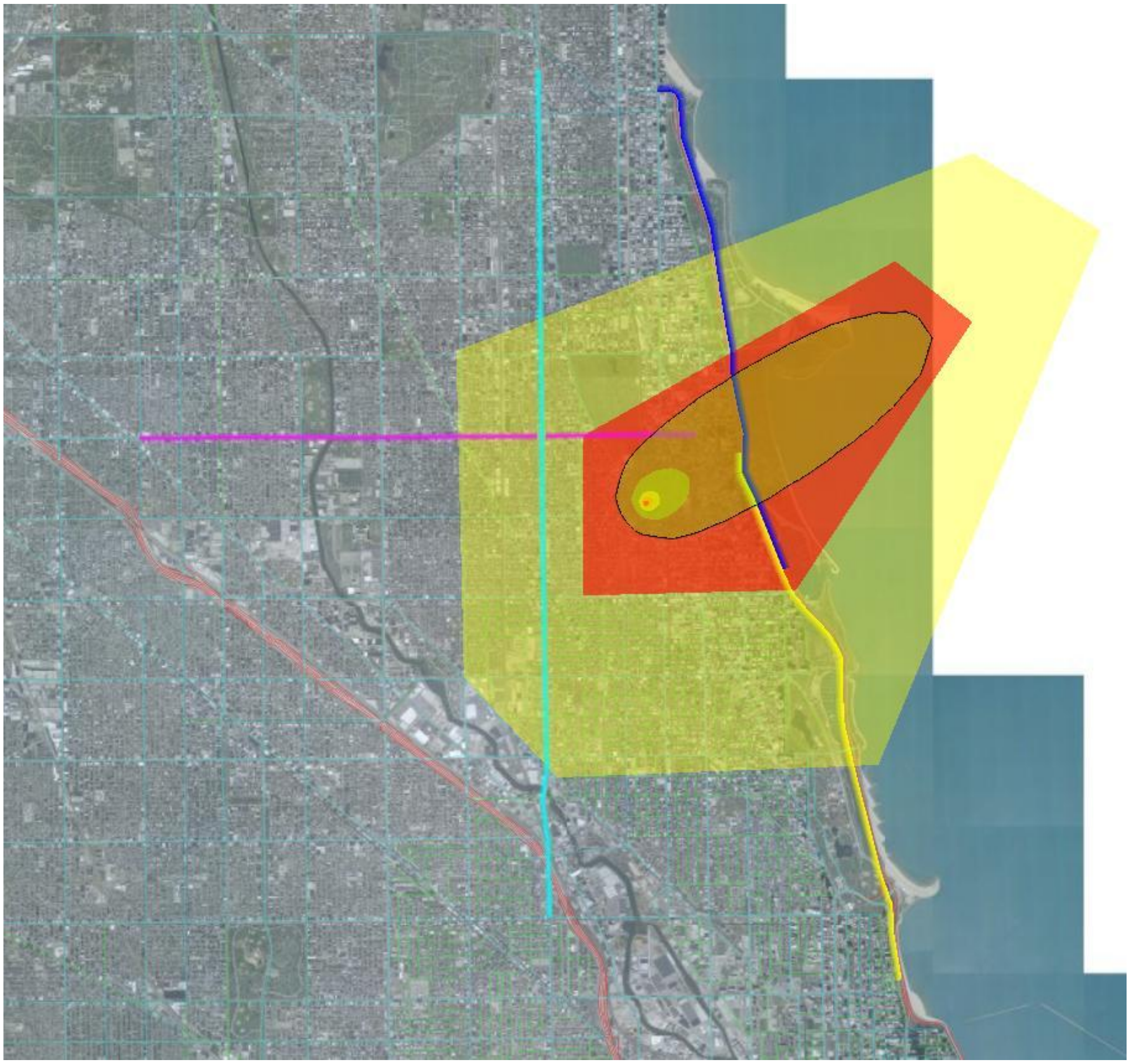


Figure 5.8: Evacuation Routes for the Wrigley Field Stadium Scenario

Table 5.4 Evacuation corridors for Wrigley Field Stadium Scenario

EVAC_CORRIDOR	EVAC_TYPE
I9094(NS)	EVAC_HIGHWAY
I9094(NS)	EVAC_HIGHWAY
41&LSD(NS)	EVAC_HIGHWAY
I94_N(SN)	EVAC_HIGHWAY
I9094(SN)	EVAC_HIGHWAY
41&LSD(SN)	EVAC_HIGHWAY
I290(EW)	EVAC_HIGHWAY
I55(NS)	EVAC_HIGHWAY
Ashland	EVAC_ARTERIAL
SRA308	EVAC_ARTERIAL

Step 4 Define Evacuation Dispersion Area

The dispersion area is defined in Figure 5.40. Different color filled contours indicates different risk levels.

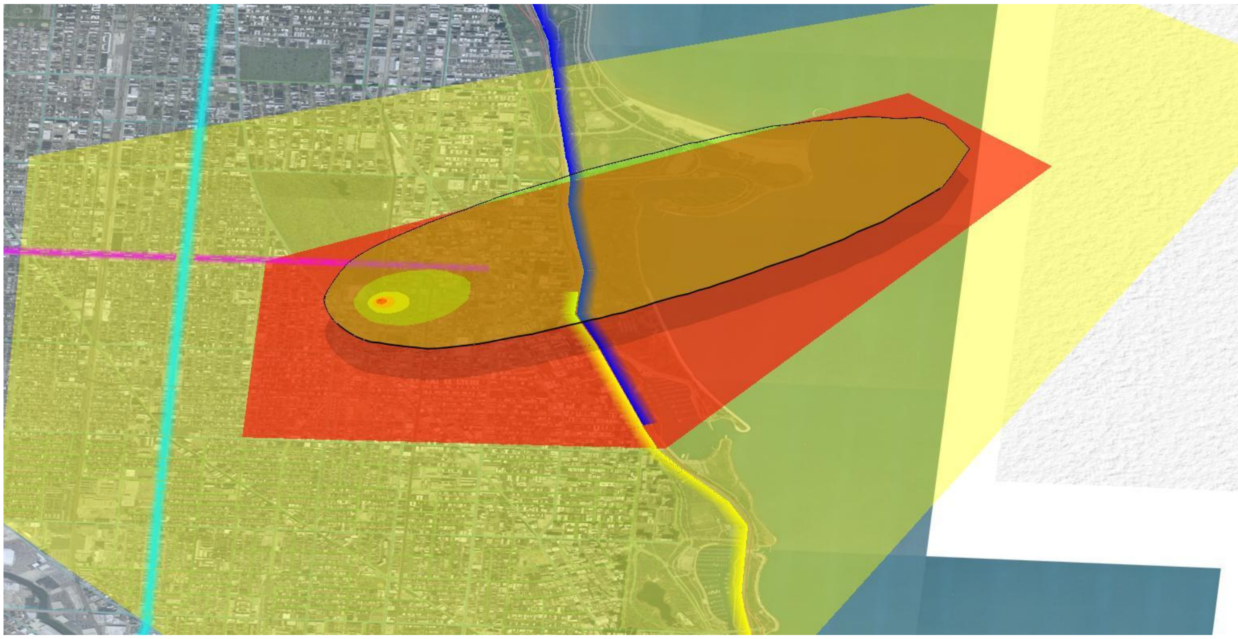


Figure 5.9: Evacuation Dispersion Area for the Wrigley Field Stadium Scenario

Step 5 Define Evacuation Start Time and Save Scenario

We define the evacuation start time as 12:00:00PM and then save the scenarios.

5.1.2.1. Scenario Analysis

Below is the picture which shows traffic distribution at 11:55am, right before a warning was issued. This particular traffic distribution is a result of so-called "normal day" model. This model predicts traffic patterns in the region on an average day. The normal day model was also developed as part of the RTSTEP tool. It was calibrated and validated against the observed traffic data.

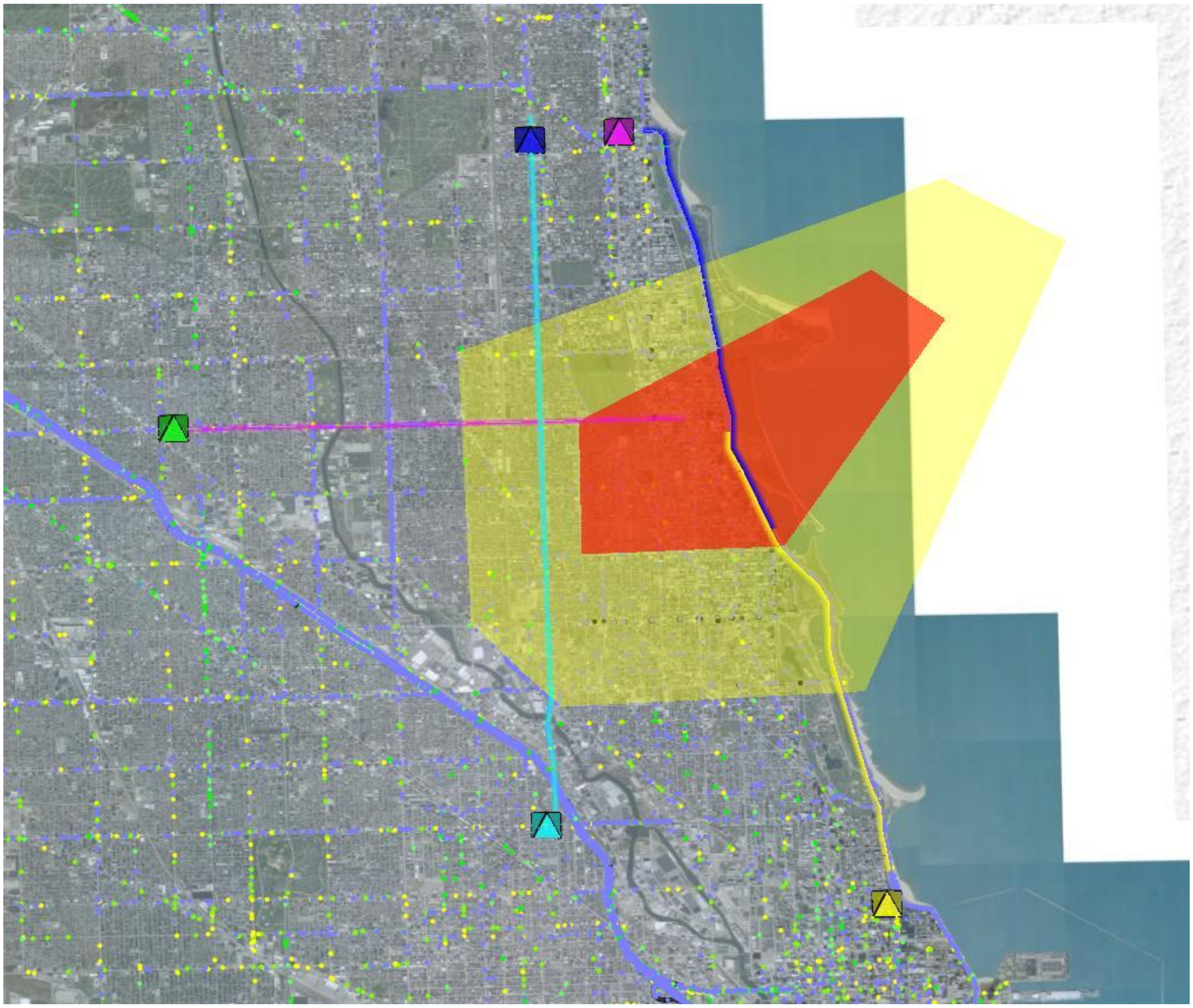


Figure 5.10: Traffic Distribution at 11:55am

Once the evacuation warning was issued, the hazard function is used to calculate the evacuation response delay for each of the travelers. Below is the curve which chows the cumulative evacuation percentage. In this scenario we assume that half of the population responds to the warning within one hour and after little more than four hours 90% reacted. Overall, it takes little more than five hours for the entire population to evacuate.

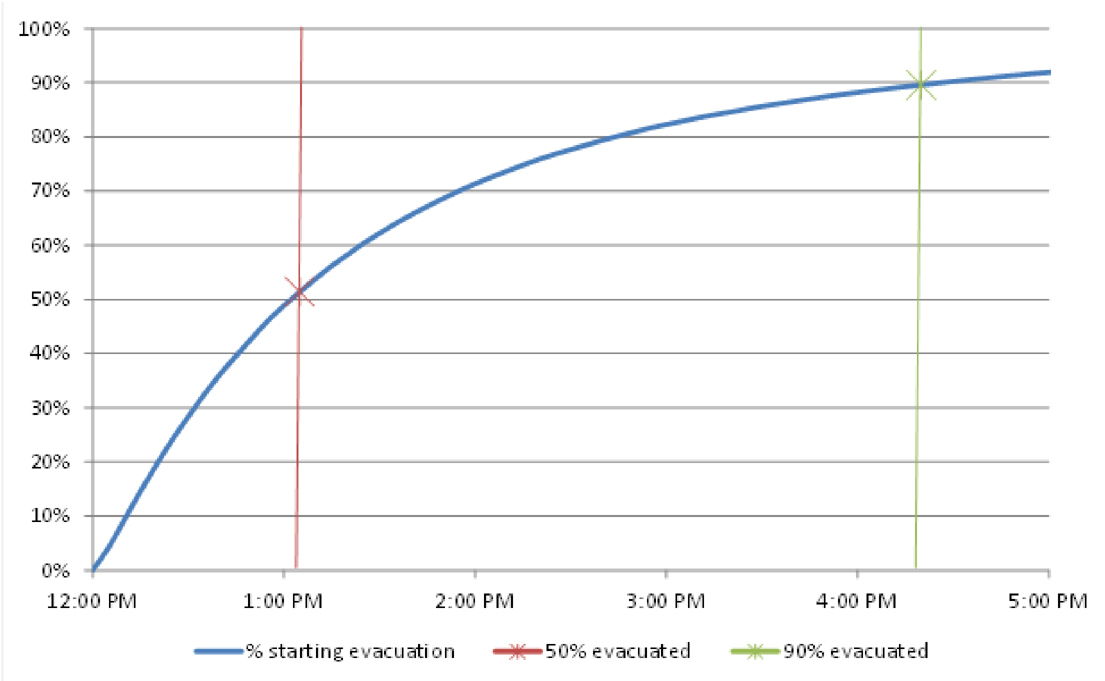


Figure 5.11: Cumulative evacuation demand curve

Below is more detailed information on the demand induced by the evacuation warnings issued by an authority. The table below shows distribution of trip types for scenario with planning applied and without. There are 45K trips which have shelter as the final destination and 274K trips were affected by the evacuation. By effected, we mean that part of the paths of those trips lies within the evacuation area. We assume that the traffic gets rerouted and does not enter evacuation zone.

Table 5.5: Wrigley Field Case Study

WRIGLEY FIELD CASE STUDY				
	No evacuation planning		**With evacuation planning**	
Evacuation Responses	**Count**	**%**	**Count**	**%**
Return home	467	0.4%	467	0.4%
Ignore evacuation	4,078	3.7%	4,204	3.9%
Shelter in place	29,588	27.1%	29,342	26.9%
Evacuate to shelter	–	–	45,864	42.0%
Evacuate - leave region	12,185	11.2%	12,192	11.2%
Evacuate - Go to friends/family/hotel	62,821	57.6%	17,070	15.6%
Total population @ start	109,139	100.0%	109,139	100.0%
Other impacted individuals				
Diverted trips, due to evacuation	160,022		160,022	
Cancelled trips	274,770		274,380	

Series of pictures below illustrates the network conditions after the evacuation warning was issued. The red dots illustrate evacuee's vehicle.

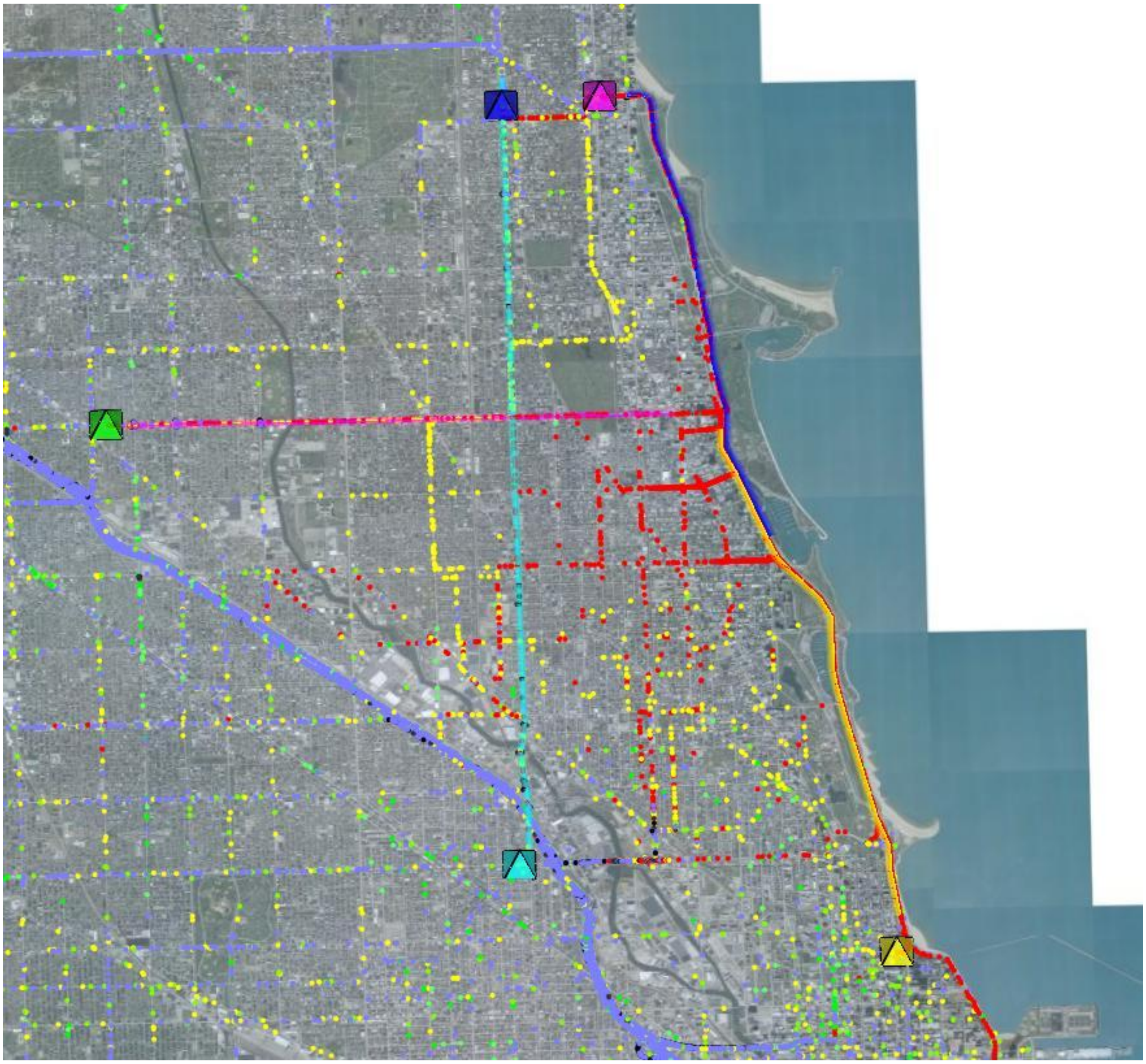


Figure 5.12: Traffic Distribution at 12:10pm

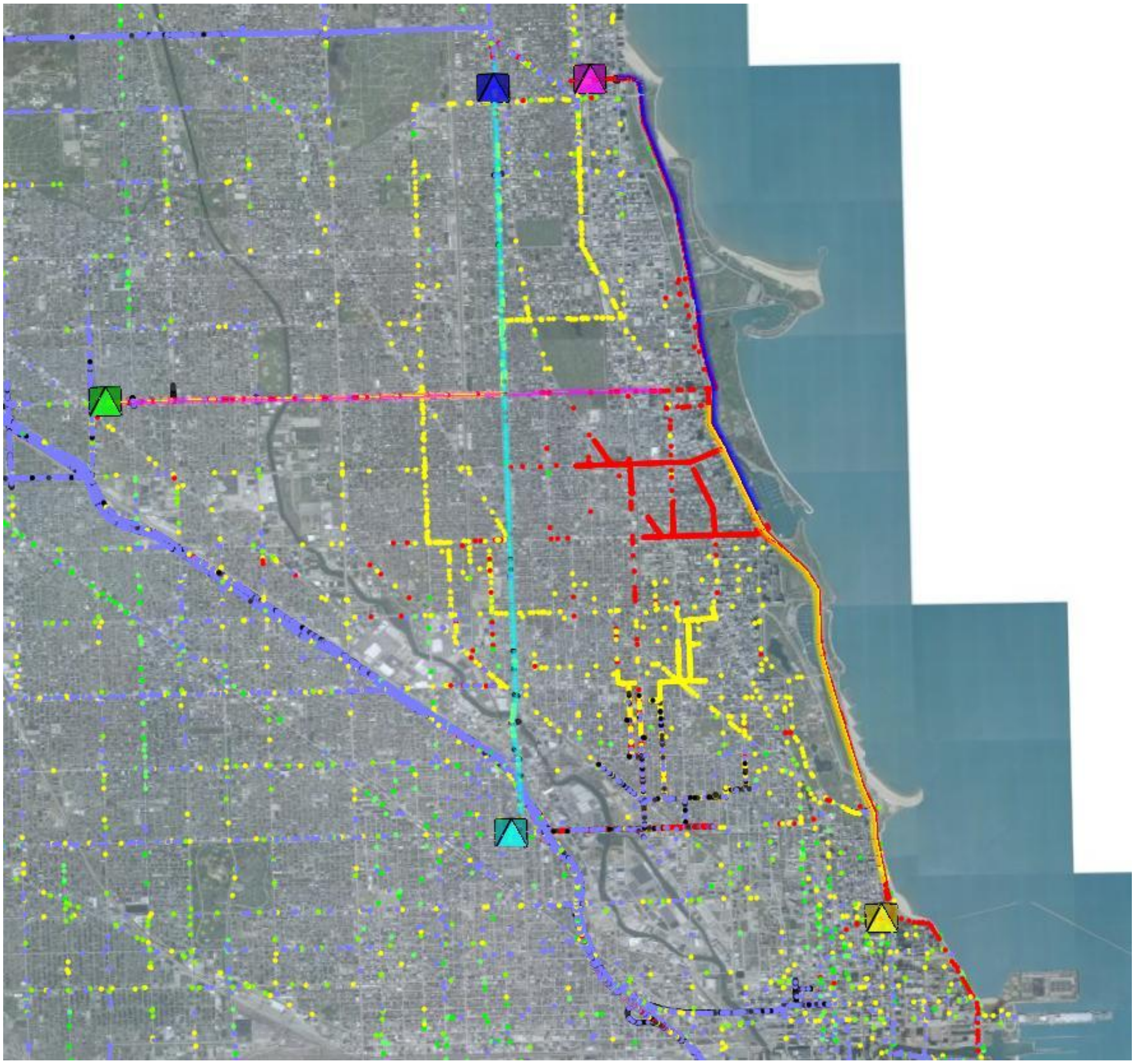


Figure 5.13: Traffic Distribution at 12:30pm

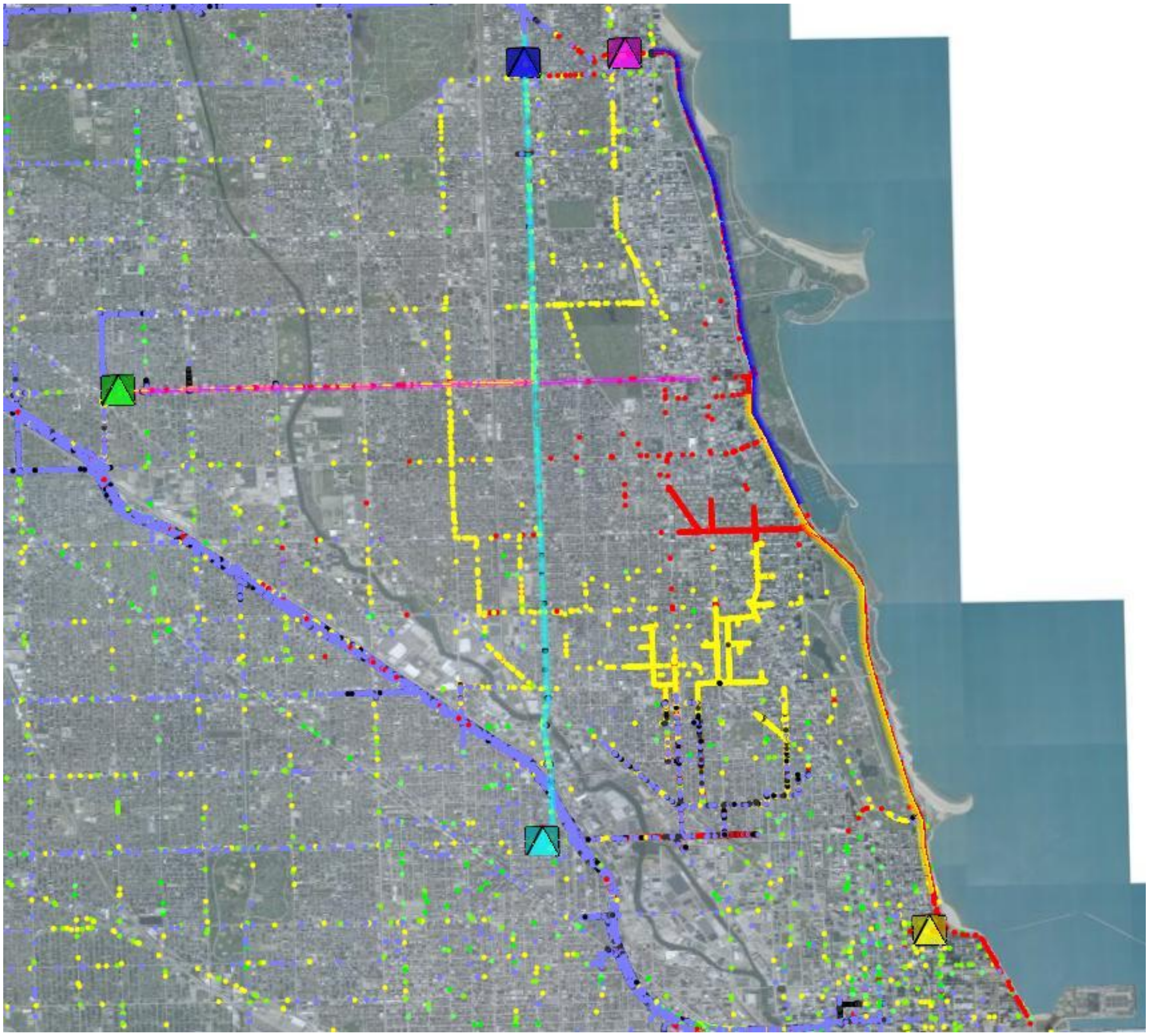


Figure 5.14: Traffic Distribution at 12:45pm

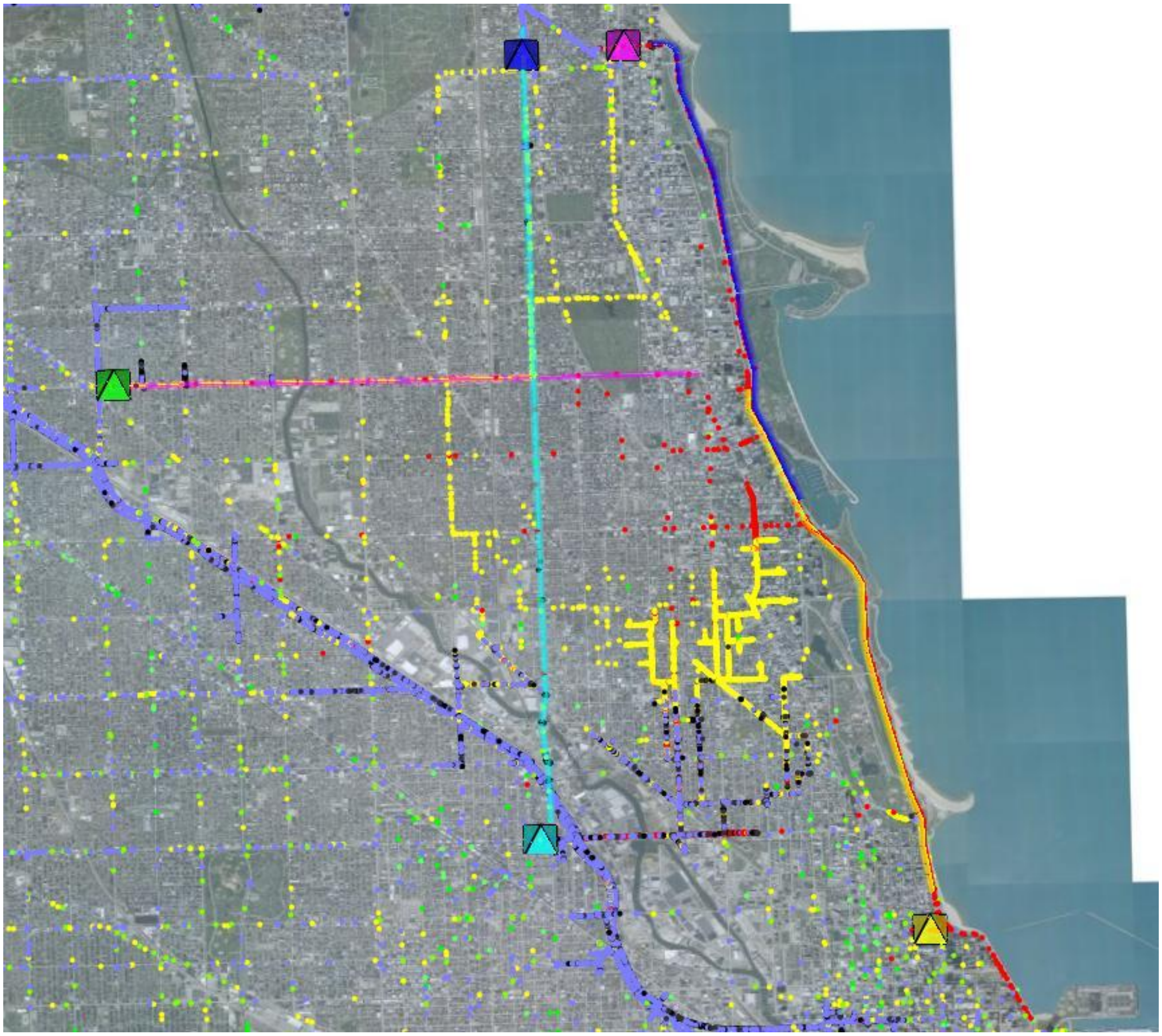


Figure 5.15: Traffic Distribution at 1:00pm

5.1.3. Analysis of the Evacuation of Wrigley Field

(More detailed documentation on dispersion can be found in section 8 of this report)

In order to have better understanding of the structure of Wrigley field, the work team went to a Chicago Cubs Game to look at the organization of the seats, number of rows, exits, and the general flow of the people inside the stadium.

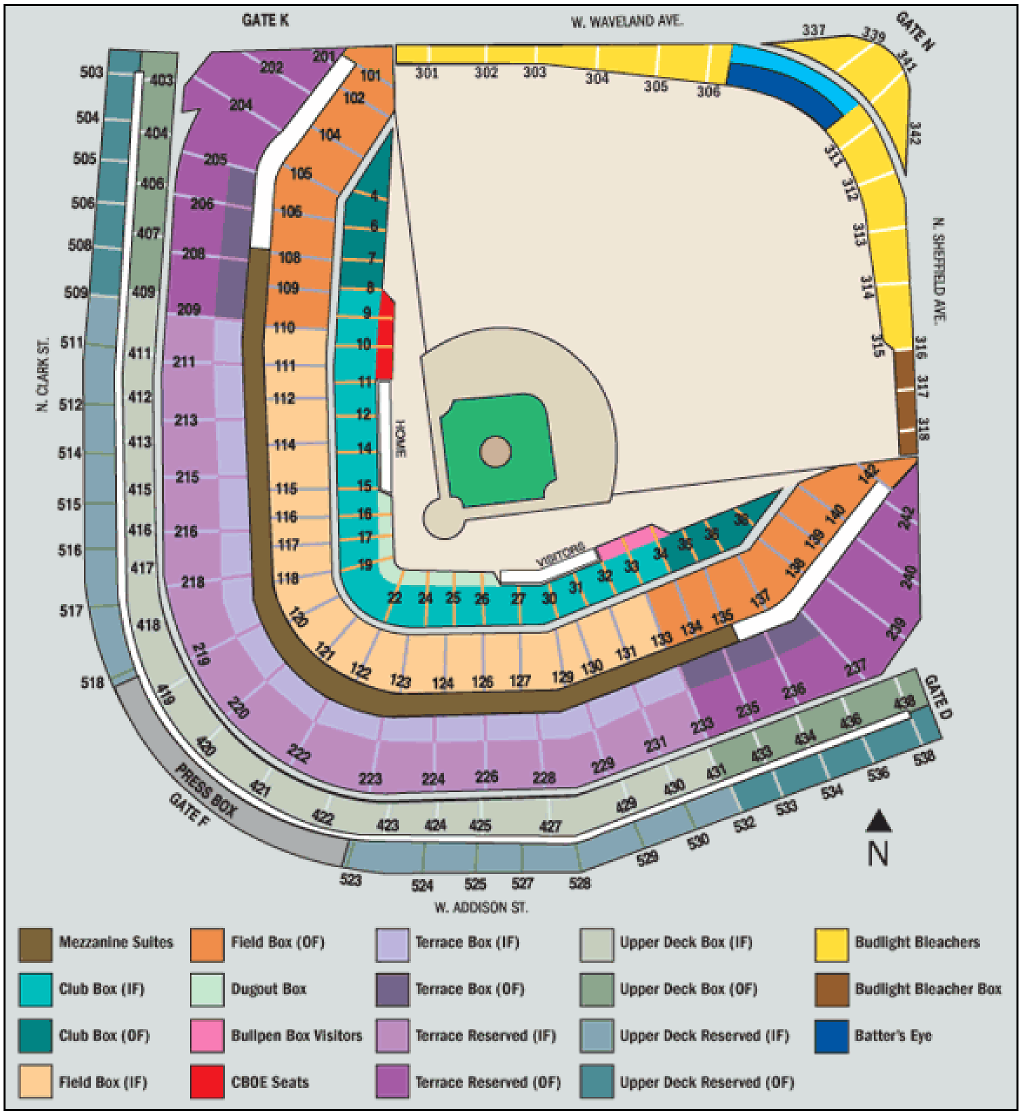


Figure 5.16: Wrigley Field

5.1.3.1. Gates

As we can see from the figure above, Wrigley Field has 4 gates: Gate D, Gate F, Gate K, and Gate N. The first three gates are connected to the main location, and Gate N is the only one leading to the Yellow seats. The total seating capacity of Wrigley Field is 41,160. In the following figures we can see the pictures of Gates D, F, and K respectively

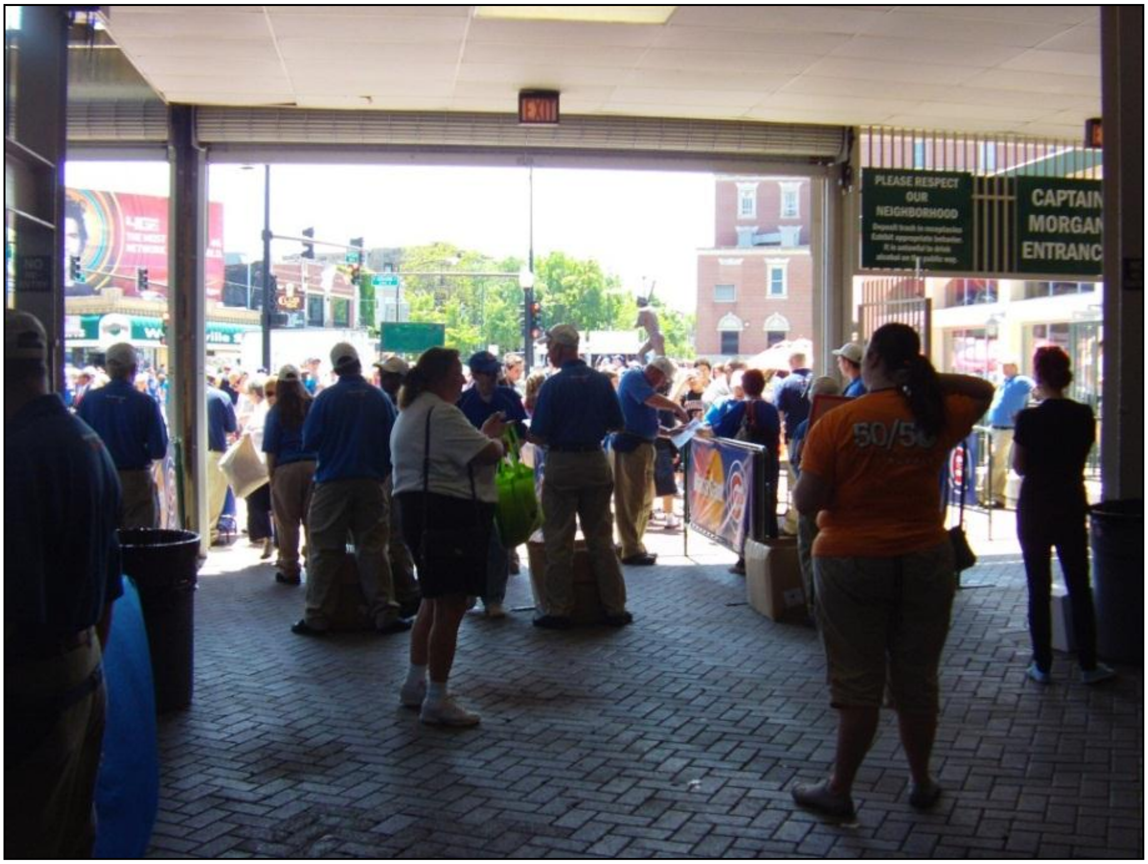


Figure 5.17: Gate D during the entrance to a game

We can see in Gate D how the entrance has been organized in a way that allows to for lines in order to check the tickets. We can also appreciate that the number of lanes allows avoiding having queues at the entrance given that people arrive at different times. At the moment of the exit, all the dividers are removed so the exit flow becomes free of obstacles.

Figure 5.18: Gate F during entrance to a game

Gate F is the largest one and in the same way as in gate D, the entrance is arranged in lanes in order to check the tickets. Once the game is over, the dividers are removed to allow an obstacle free exit.

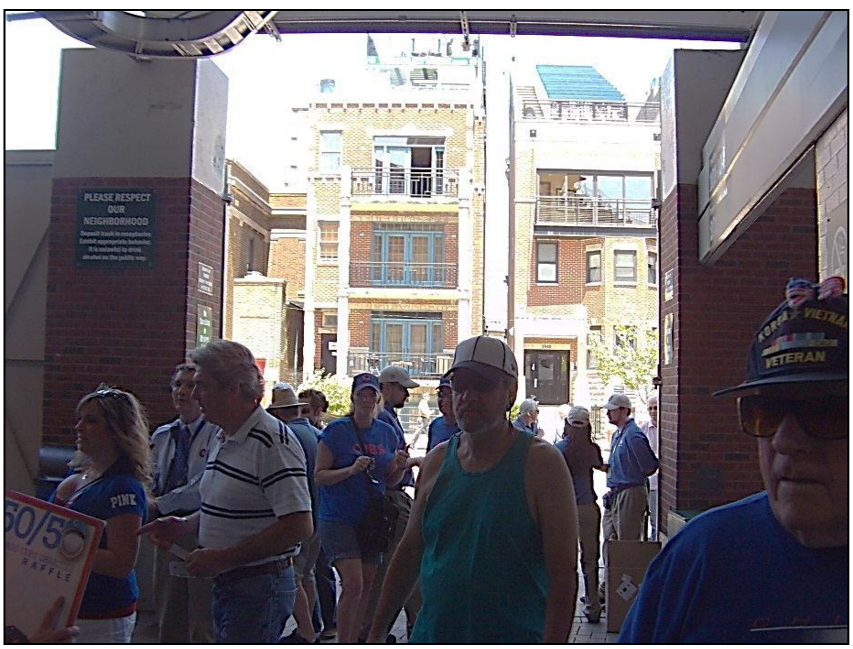


Figure 5.19: Gate K during entrance to a game

Gate K is the smallest of the three main gates, we can see in figure 6 how no divider is used during the entrance. Given the width of this gate, it was noticed that some queues were forming during the entrance to the game.

5.1.3.2. Seats

The distribution of the seats based on the number of rows and aisles are very important to determine the way in which the people in the stadium will proceed to leave once the game is over. The day of the game, there was 31,000 people at the game when the maximum capacity is 41,000, roughly a 75% of the full capacity.

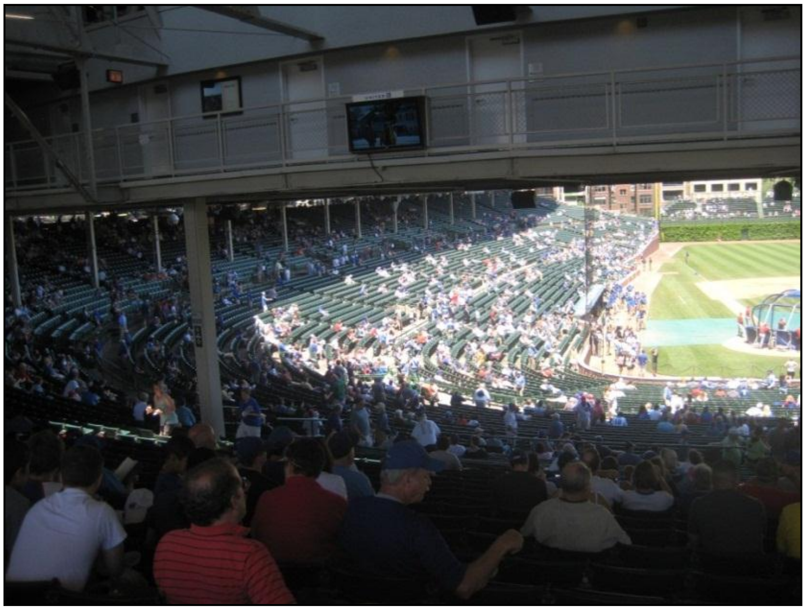


Figure 5.20: View of the 1st level

Figure 5.21: View of the two levels

In figures 7 and 8 the two levels of the stadium can be seen. The first level has three blocks (100's, 200's, and 300's) while the second level has two blocks (400's and 500's). This information will be used to determine an estimate of the number of seats on each block in order to create the simulation scenario for Wrigley Field using Legion. In figure 9 we can see an example of how the calculation of seats will be done. We can see in that block 24 seats per 10 rows for a total of 240 seats.

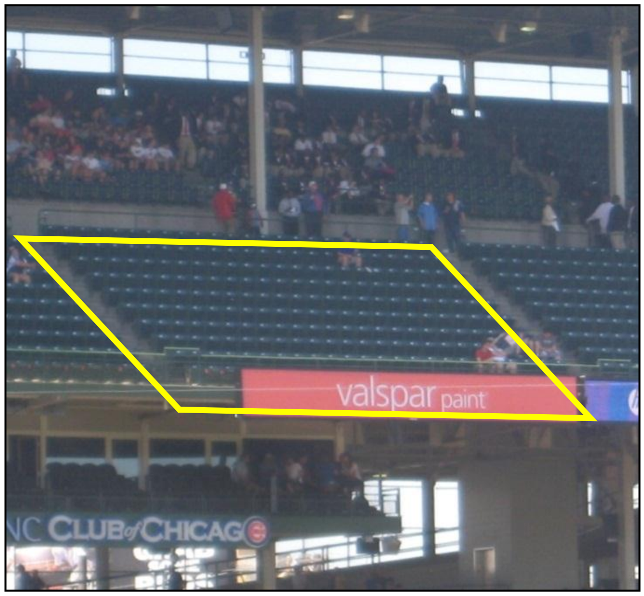


Figure 5.22: Number of seats per block

5.1.3.3. Legion Modeling

First we get the layout of the Wrigley Field in AutoCAD, and then import it into the LEGION software, as shown in Figure 10.

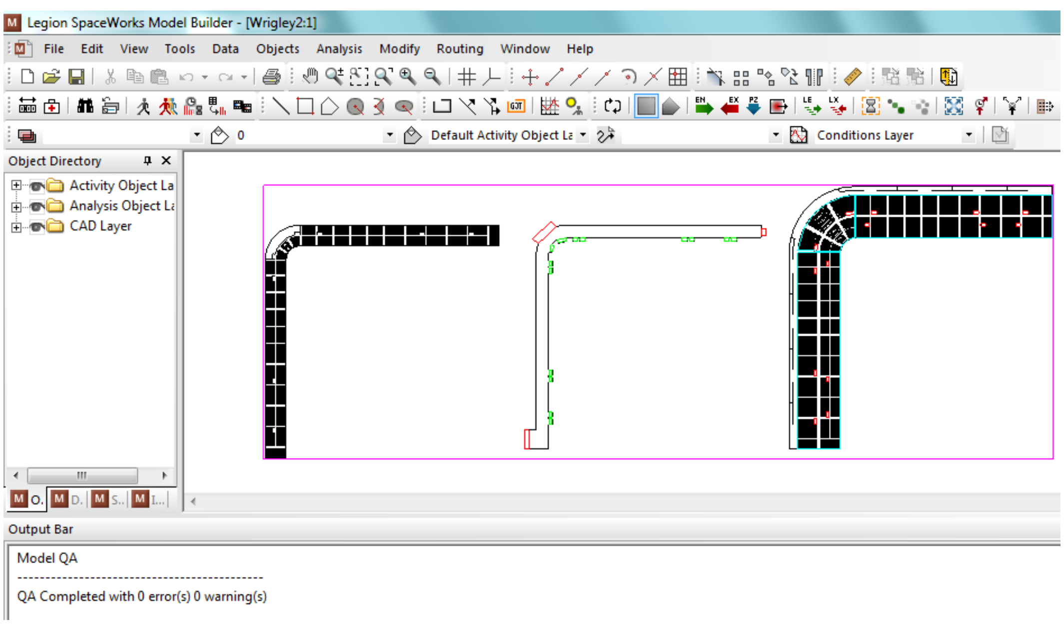


Figure 5.23: Wrigley Fields layout in Legion

After checking it with no errors, we continue to do our simulation and put parameters into the experiment. First we use the default speed defined by the legion itself as the normal speed for evacuees, as shown in figure 11. And then we input the population and percent of congestion in the legion system, as showed in figure 12 and figure 13 respectively.

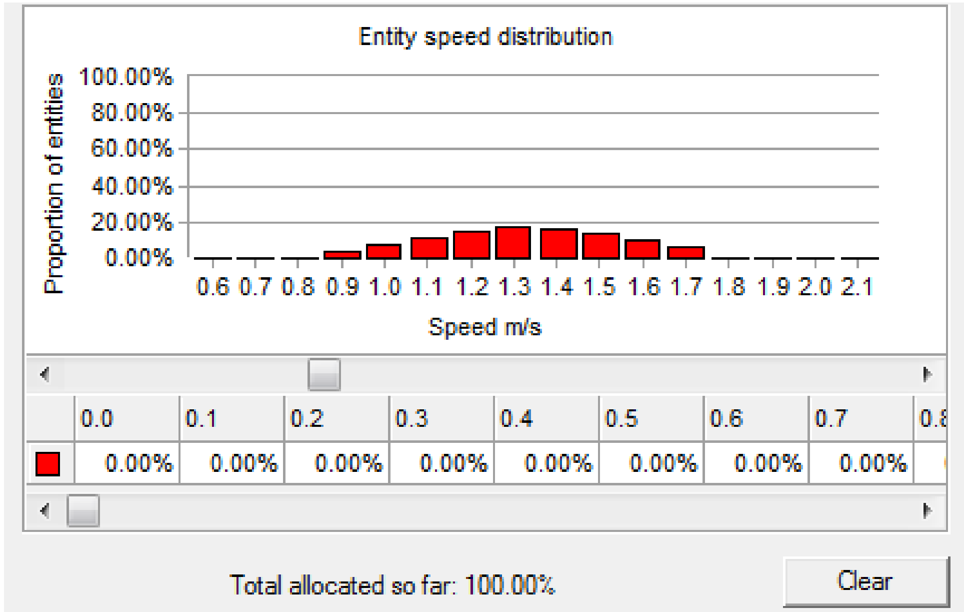


Figure 5.24: Normal Speed defined in Legion

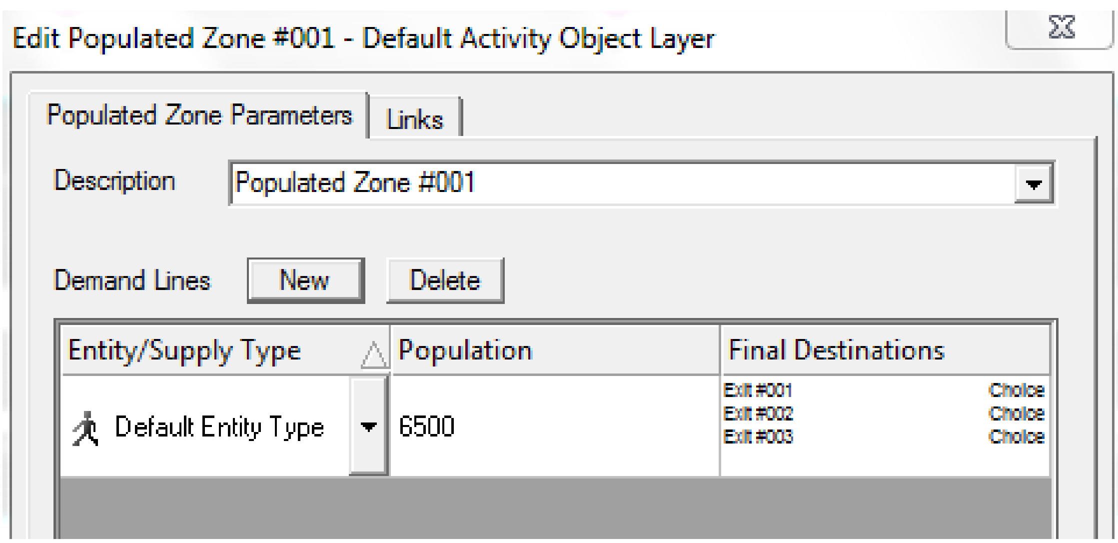


Figure 5.25: Simulated population defined in Legion

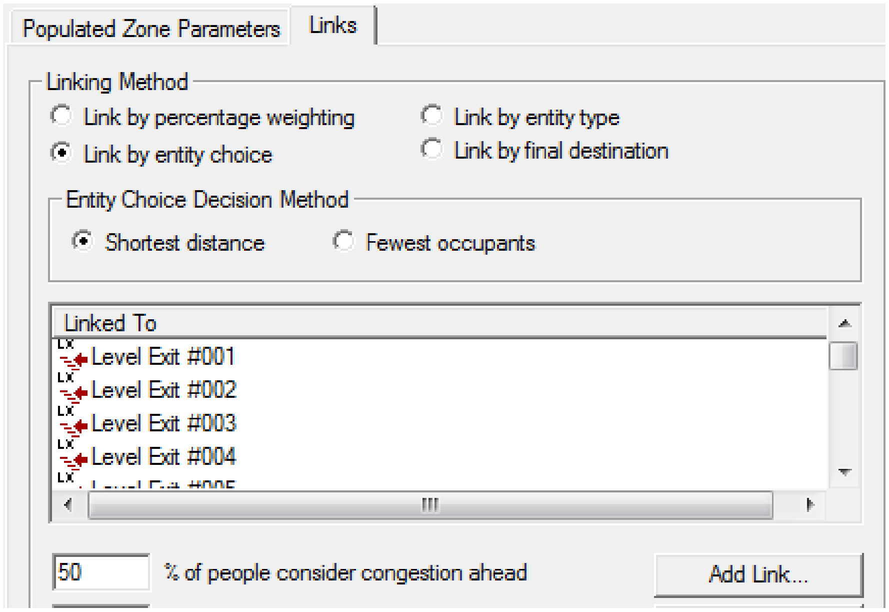


Figure 5.26: Percent of congestion considered in the Legion software

5.1.3.4. Design of Experiment

One of the objectives is to determine the importance of each factor and their interactions on the total evacuation time of each type of building. In order to calculate the impact of each factor on the total evacuation time, a two level (2*k*) factorial design of experiments will be performed. The values for the low level (-1) and high level (1) of each factor is presented in table 1.

Table 5.6: Values for the Wrigley Field Designed Experiments

Wrigley Field Designed Factors		
Levels	-1	1
Congestion	0%	50%
Speed	1.3m/s	2.6m/s
Population	12250	24500

The values for these three factors are determined based on the built-in function of Legion. In the case of the desired speed, multiple researches have concluded that 1.33 m/s is the average free speed. In the case of the high level, 2.66 m/s are a good estimation for a calm running (Kholshevnikov & Samoshin, 2010).

Legion is allowed to modify the values of the three parameters in a fast manner given that they determined the behavior of people in the model. The value of Congestion allows people to look ahead and change their destination if they see congestion ahead of them.

Given that the number of factors to use in the design of experiments is three (k = 3), the total amount of experiments to perform is 8 per replication. The combination of all the levels and factors is presented in table 2. Once all the experiments are performed, an ANOVA analysis will show us which factors have a greater influence on the total evacuation time.

Table 5.7: Factorial design for the Wrigley Field (k = 3)

Run	Congestion	Speed	Population
1	-	-	-
2	+	-	-
3	-	+	-
4	+	+	-
5	-	-	+
6	+	-	+
7	-	+	+
8	+	+	+

5.1.3.5. Analysis of the Simulated Results

Once the number of replications was calculated for each of the base scenarios, the same number of replications was run for all the other scenarios. Finally, the results of the Total Evacuation time were taken as the results in order to analyze the factorial design. The factorial design considered to have the number of replications calculated for the simulation in order to perform the analysis of variance for all the factors and their interactions. The initial model to be evaluated is:

$$\gamma = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 \dots \beta_{63} X_1 X_2 X_3 X_4 X_5 + \varepsilon$$

In the previous model, $\beta_n{}'s$ are the coefficients for each of the factors and the output, γ, corresponds to the total evacuation time.

After running all the eight scenarios, the results are imported in the Minitab to analyze the factorial design. An analysis of the variance is presented in the following table.

Table 5.8: Estimated effects and Coefficients for Wrigley Field

Term	Effect	Coef	SE Coef	*T*-value	*P*-value
Constant		411.7	4.503	91.43	0
Congestion	14.8	7.4	4.503	1.65	0.138
Speed	-429.3	-214.6	4.503	-47.67	0
Population	284.2	142.1	4.503	31.56	0
Congestion*Speed	22.8	11.4	4.503	2.53	0.035
Congestion*Population	-1.7	-0.8	4.503	-0.18	0.859
Speed*Population	-172.2	-86.1	4.503	-19.12	0
Congestion*Speed*Population	12.3	6.2	4.503	1.37	0.209

When a term has a *p*-value below a significance level of 0.05, it means that particular term does have an effect on the total evacuation time, which we say it is statistically significant. In table 3 we have more details regarding the significance of each of the factors and their interactions. The *p*-values for Speed (X_2), Population (X_3), and Speed*Population (X_2*X_3) are the lowest ones. The interaction Congestion*Speed (X_1*X_2) is also significant, but since Congestion is not, its interaction is left out of the model. Therefore, the model for the evacuation time can be reduced to those terms. The final model for the evacuation time of the Wrigley Field is:

$$\gamma = 411.7 - 214.6X_2 + 142.1X_3 - 86.1X_2X_3$$

This equation will be used with the non-stationary Poisson model in order to generate inter-exit evacuation times.

5.1.4. Detailed Dispersion Model for the Wrigley Field Area

(More detailed documentation on dispersion can be found in section 10 of this report)

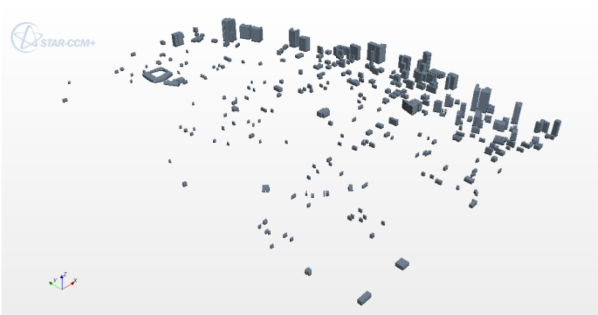


Figure 5.27: Wrigley area geometry automatically generated.

One of the areas of interest for the study was the Wrigley area. Using the python script, the buildings in the Wrigley field area of 3 or more stories were created. The goal of this part of the study was to examine the different ways to implement a plume into the geometry. Since the model was auto generated and not created in CAD program or module, using an inlet on the side of a building, like in the small scale and 145 building models, would be very hard to do. Instead, using shape parts created in STAR-CCM+ seemed to be the best option. The inlet location and size could now be completely user defined. The three shapes tested for the inlet were block, cylinder, and sphere. The block and cylinder shapes worked with no problems when placed on ground level. The sphere placed on ground level, would disappear from the model after meshing. This was assumed to be due to the combination of using the surface wrapper and the sphere only touching the ground at one point. Suspending the shapes in mid-air did not work. The parts would disappear after meshing, possibly due to the surface wrapper.

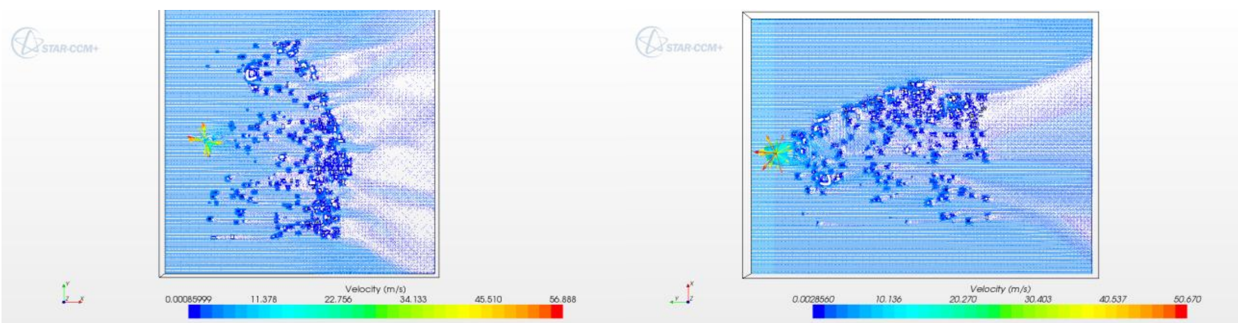


Figure 5.28: Comparison of Block plume inlet (left) and Cylinder plume inlet (right). The block inlet injects the plume at 90 degree angles. The cylinder injects the plume radially.

With many simulations ran in the Wrigley area, it's apparent that buildings in the area did not have a significant effect on the dispersion of the plume. Not many buildings in the area were taller than five stories. With this observation, it was decided that to make the most adaptable simulations for the areas of the project, no buildings should be used. This would allow the models to be applicable to any suburban areas.

5.2. Naperville

In this Chapter, we demonstrate case studies that highlight the methodologies developed in the RTSTEP project. The case studies demonstrate how to define an evacuation scenario, i.e. evacuation area definition, evacuation shelter choices, and evacuation route selection and management strategies, how to run TRANSIMS to obtain evacuation simulation results, how to visualize the results in TransimVis, and how to analyze the results. In addition, these case studies form the basis for training materials for potential users of this tool such as the emergency response planners.

There are two scenarios defined in the case studies: the first one is at Naperville Amtrak/Metra Station, the second one is at Wrigley Field Stadium.

5.2.1. Naperville Amtrak/Metra Station Scenario

5.2.1.1. Scenario Description

Naperville Amtrak/Metra station is an important station in the Chicago Metropolitan Area, which can be viewed as the west gate of the Chicago railway Hub. It consists of an Amtrak station (NPV) for national passenger rail services including three Amtrak routes and a Metra station for regional commuter rail services with one Metra route. Figure 5.29 shows the location of the Naperville Amtrak/Metra station in the Chicago Metropolitan Area. Figure 5.2 shows a satellite image of the Naperville Amtrak/Metra station including parking lots and waiting room.

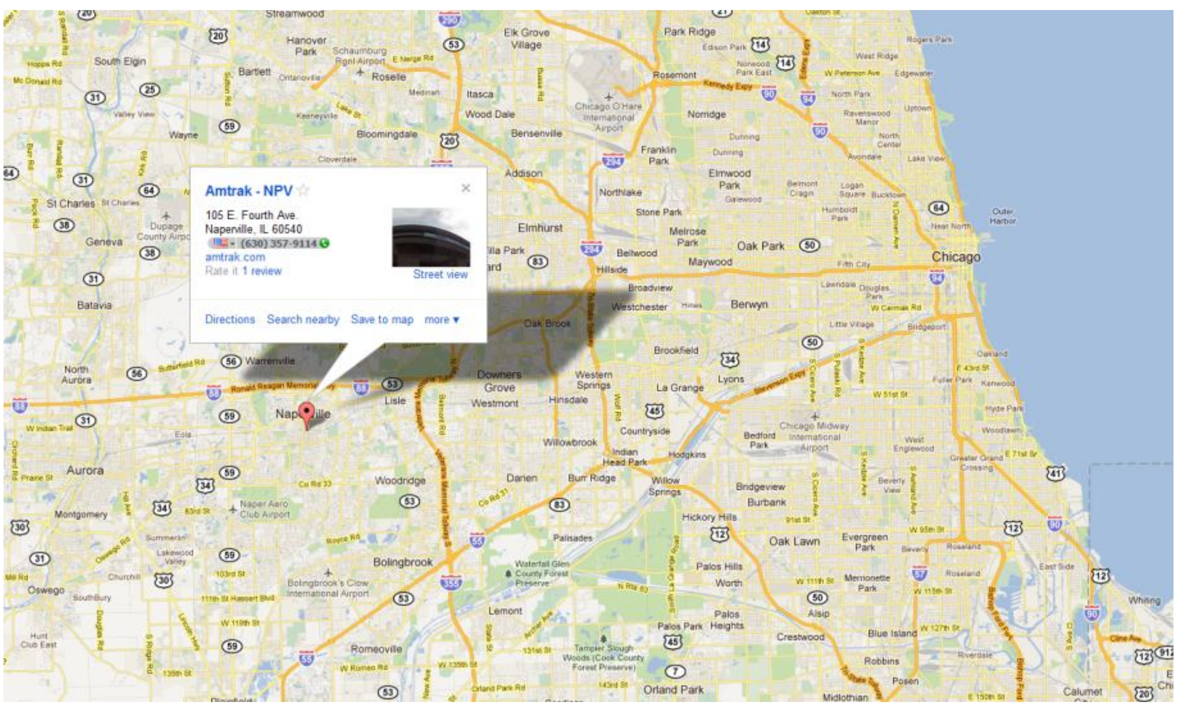


Figure 5.29: Naperville Amtrak/Metra Station

Figure 5.30 Satellite Image of the Naperville Amtrak/Metra Station

Naperville Amtrak Station (NPV) provides three Amtrak passenger rail services with two national passenger train services to California - Southwest Chief (from Chicago to Los Angeles in Figure 5.31) and California Zephyr (from Chicago to Emeryville in Figure 5.32), and one state passenger train service - Illinois Service (from Chicago to Quincy in Figure 5.33).

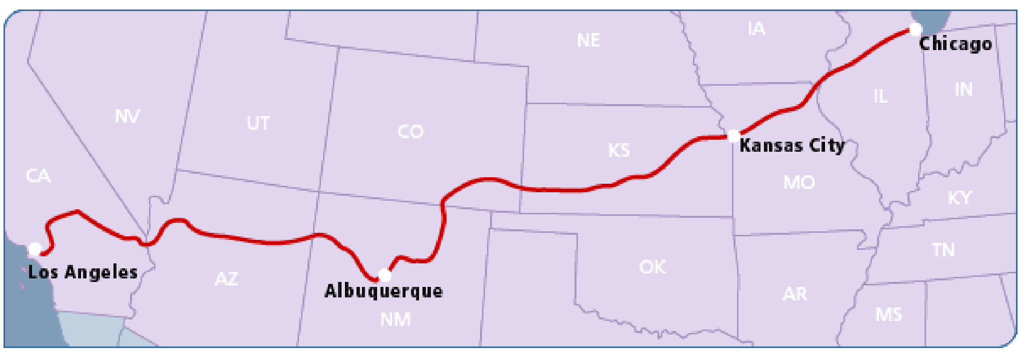


Figure 5.31 Southwest Chief (Chicago – Albuquerque-Los Angeles)

Figure 5.32 California Zephyr (Chicago-Denver-Emeryville)

Figure 5.33 Illinois Service (Chicago-Quincy)

Naperville Metra Station includes one Metra route operated by BNSF from Chicago to Aurora in Figure 5.3. The BNSF Railway Metra is a busy commuter line with average headway of 10 minutes in the peak hours and 60 minutes in the off-peak hours. Many commuters live in Aurora, Naperville, and Downers Groves utilize this metro from home to work trips to the downtown Chicago.

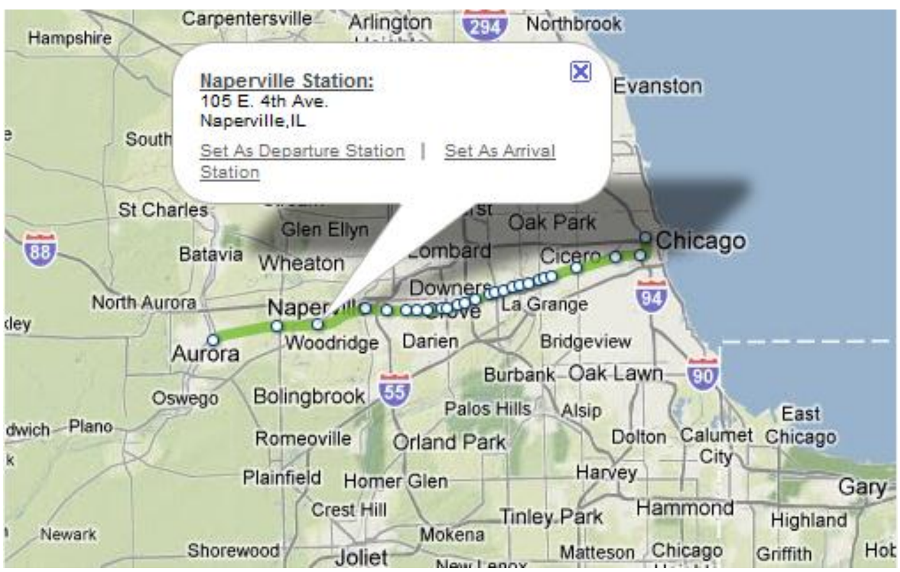


Figure 5.34 BNSF Railway (Chicago to Aurora)

We assume that an evacuation scenario is as follows. In noon, some terrorists attacked the Naperville Amtrak/Metra Station in order to destroy the commuter railway transportation from Chicago to the west suburban and the Amtrak rail services to California using bomb. The on-site radiation detectors are indicating noticeable levels of radiation. Emergency evacuation need to conduct to evacuate passengers waiting in the station and residents in the neighborhood of Naperville Amtrak/Metra Station.

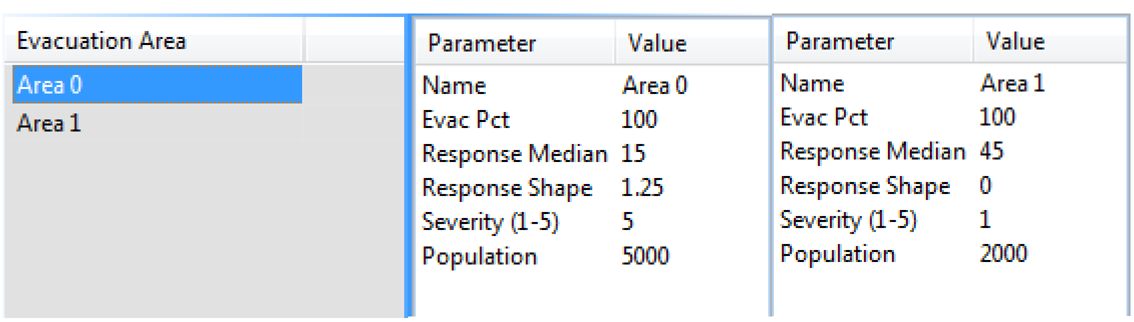
5.2.1.2. 6.1.2 Scenario Definition

Using the TransimVis tool, selecting the Evacuation Menu, we define the Naperville Station Scenario in the following steps. The TransimVis manual describes the details of the functions of the Evacuation Menu.

Step 1: Define Evacuation Area

We define two evacuation areas with different severity levels as in Figure 5.35 and the corresponding parameters of these two evacuation areas are in Figure 5.5. Based on these definitions, TransimVis will output two evacuation scenario files: evac_response in Table 5.9 and evac_zone in Table 5.10.

Figure 5.35 Evacuation Areas in the Naperville Station Scenario



Evacuation Area
Area 0
Area 1

Parameter	Value
Name	Area 0
Evac Pct	100
Response Median	15
Response Shape	1.25
Severity (1-5)	5
Population	5000

Parameter	Value
Name	Area 1
Evac Pct	100
Response Median	45
Response Shape	0
Severity (1-5)	1
Population	2000

Figure 5.36 Parameters of Evacuation Areas in the Naperville Station Scenario

Table 5.9 Evac_Responses

EVENT	LEVEL	DISTRIBUTION	COMPLIANCE	RESPONSE	EVAC_VEHICLE	NAME	POPULATION
1	5	LOG-LOGISTIC,15,1.25	100	0	95	Area 0	5000
1	1	LOG-LOGISTIC,45,1.5	100	0	91	Area 1	2000

Table 5.10 Evac_Zones

EVENT	ZONE	POP	LEVEL	START	END
1	1305	154	1	12:00	24:00:00
1	1306	154	1	12:00	24:00:00
1	1307	154	1	12:00	24:00:00
1	1308	833	5	12:00	24:00:00
1	1317	154	1	12:00	24:00:00
1	1318	833	5	12:00	24:00:00
1	1319	154	1	12:00	24:00:00
1	1320	154	1	12:00	24:00:00
1	1375	154	1	12:00	24:00:00
1	1376	154	1	12:00	24:00:00
1	1377	833	5	12:00	24:00:00
1	1378	833	5	12:00	24:00:00
1	1379	154	1	12:00	24:00:00
1	1380	154	1	12:00	24:00:00
1	1381	833	5	12:00	24:00:00
1	1382	154	1	12:00	24:00:00
1	1384	833	5	12:00	24:00:00
1	1385	154	1	12:00	24:00:00
1	1386	154	1	12:00	24:00:00

Step 2: Define Evacuation Shelters

We define eleven evacuation shelters for this scenario in Figure 5.37. The corresponding parameters are shown in Figure 5.7. Table 5.3 shows the output of the definitions of evacuation shelters.

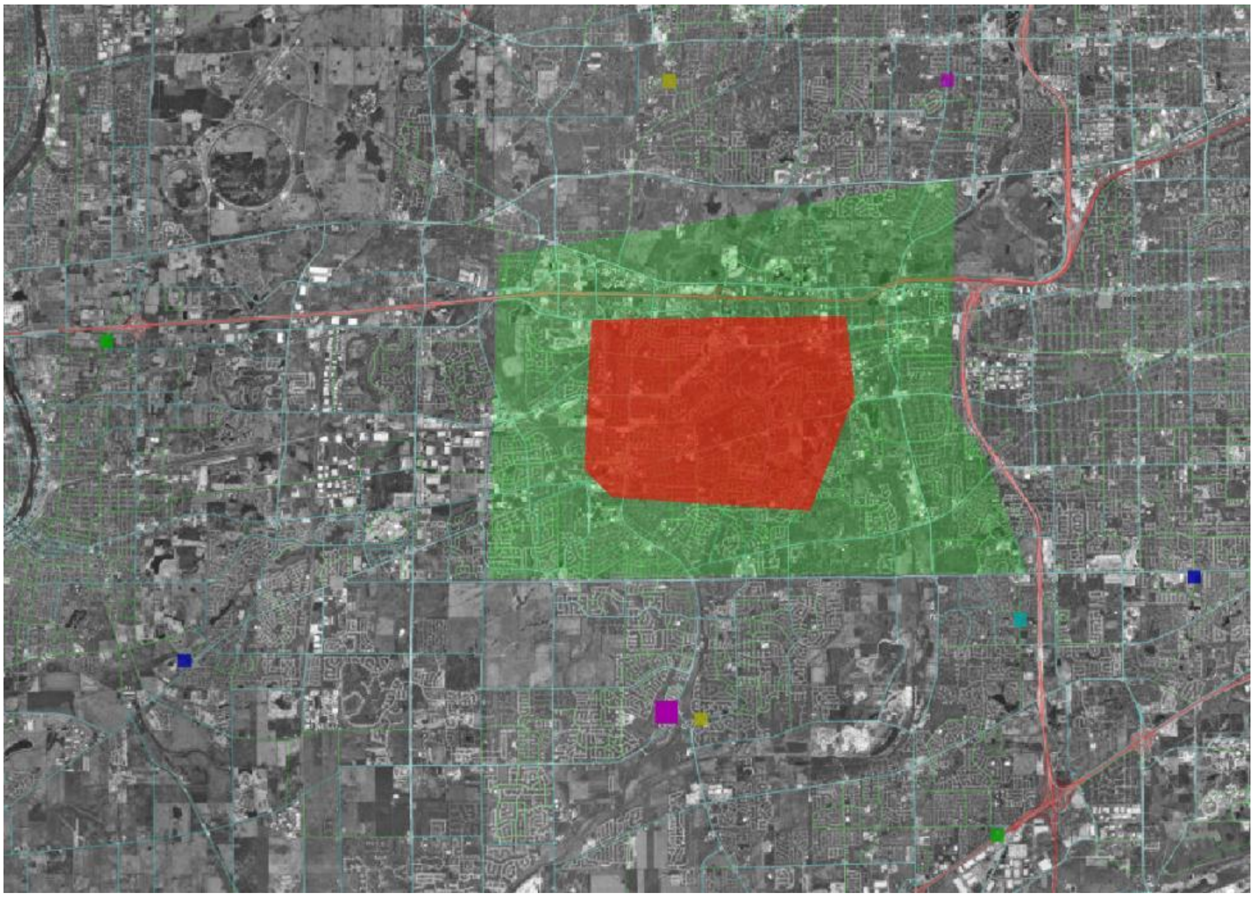


Figure 5.37 Evacuation Shelters for the Naperville Amtrak/Metra Station Scenario

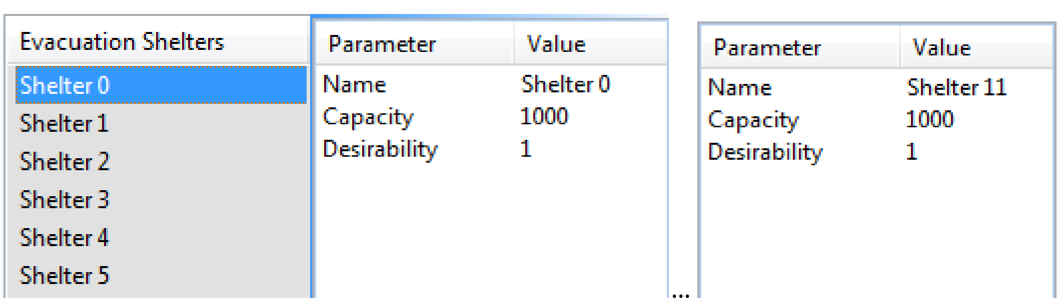


Figure 5.38 Parameters for Evacuation Shelters

Table 5.11 Evac_Shelters

LOCATION	CAPACITY	ATTRACTION	NAME
92389	1000	1	Shelter 0
26557	1000	1	Shelter 1
95558	1000	1	Shelter 2
31436	1000	1	Shelter 3
37373	1000	1	Shelter 4
35053	1000	1	Shelter 5
91060	1000	1	Shelter 6
90984	1000	1	Shelter 7
24648	1000	1	Shelter 8
17212	1000	1	Shelter 9
96099	1000	1	Shelter 10
20559	1000	1	Shelter 11

Step 3: Define Evacuation Routes

There are total six evacuation corridors defined for the Naperville Amtrak/Metra Station Scenario. Four highway evacuation corridors (I-88EW, I-88WE, I290/I355NS, I290/I355SN) and two arterial evacuation corridors (105 and SRA212) are used in the scenario as in Figure 5.39. The evac_routes file for this scenario is shown in Table 5.12.

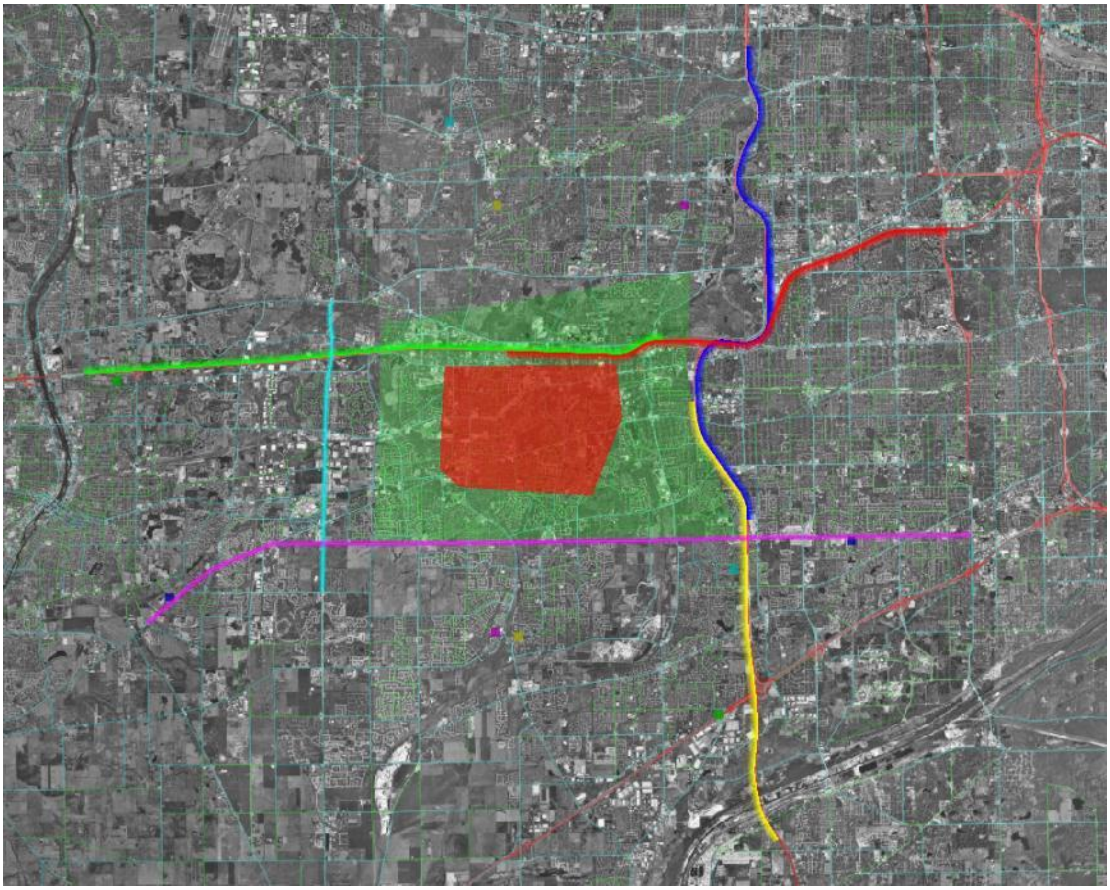


Figure 5.39 Evacuation Routes for Naperville Amtrak/Metra Station Scenario

Table 5.12 Evac_Routes for Naperville Amtrak/Metra Station Scenario

NODE	INLINK	OUTLINK	START	END	ACCESS_POINT	EVAC_PLAN	USE	EVAC_CORRIDOR	EVAC_SEGMENT	EVAC_TYPE
9702	7604	7366	12:00:00 PM	12:00:00 AM	1	1	ANY	53&I290&I355(SN)	I355&I55_I355&34(80597-9606)	EVAC_HIGHWAY
81259	7366	81949	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(SN)	I355&I55_I355&34(80597-9606)	EVAC_HIGHWAY
81178	81949	81843	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(SN)	I355&I55_I355&34(80597-9606)	EVAC_HIGHWAY
9610	81843	7221	12:00:00 PM	12:00:00 AM	1	1	ANY	53&I290&I355(SN)	I355&I55_I355&34(80597-9606)	EVAC_HIGHWAY
81185	7221	81855	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(SN)	I355&I55_I355&34(80597-9606)	EVAC_HIGHWAY
9606	81855	7213	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(SN)	I355&I55_I355&34(80597-9606)	EVAC_HIGHWAY
9607	7213	7216	12:00:00 PM	12:00:00 AM	1	1	ANY	53&I290&I355(SN)	I355&34-I290&I355(9606-10020)	EVAC_HIGHWAY
81183	7216	81852	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(SN)	I355&34-I290&I355(9606-10020)	EVAC_HIGHWAY
83740	81852	85895	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(SN)	I355&34-I290&I355(9606-10020)	EVAC_HIGHWAY
83740	81852	85894	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(SN)	I355&34-I290&I355(9606-10020)	EVAC_HIGHWAY

9747	85894	7434	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(SN)	I355&34-I290&I355(9606-10020)	EVAC_HIGHWAY
81195	7434	81868	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(SN)	I355&34-I290&I355(9606-10020)	EVAC_HIGHWAY
83738	81868	85891	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(SN)	I355&34-I290&I355(9606-10020)	EVAC_HIGHWAY
9965	85895	7761	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(SN)	I355&34-I290&I355(9606-10020)	EVAC_HIGHWAY
81261	7761	81951	12:00:00 PM	12:00:00 AM	1	1	ANY	53&I290&I355(SN)	I355&34-I290&I355(9606-10020)	EVAC_HIGHWAY
9800	81951	7516	12:00:00 PM	12:00:00 AM	1	1	ANY	53&I290&I355(SN)	I355&34-I290&I355(9606-10020)	EVAC_HIGHWAY
9846	7516	7585	12:00:00 PM	12:00:00 AM	1	1	ANY	53&I290&I355(SN)	I355&34-I290&I355(9606-10020)	EVAC_HIGHWAY
81232	5969	81912	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(WE)	I88&51_I88&I355(5032-9561)	EVAC_HIGHWAY
81175	81912	81840	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(WE)	I88&51_I88&I355(5032-9561)	EVAC_HIGHWAY
83673	81840	85760	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(WE)	I88&51_I88&I355(5032-9561)	EVAC_HIGHWAY
9433	85760	6936	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(WE)	I88&51_I88&I355(5032-9561)	EVAC_HIGHWAY
9561	6936	7149	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(WE)	I88&51_I88&I355(5032-9561)	EVAC_HIGHWAY
9772	7149	7473	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(WE)	I88&I355_I88&I294(9561-83757)	EVAC_HIGHWAY
81184	7473	81853	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(WE)	I88&I355_I88&I294(9561-83757)	EVAC_HIGHWAY
9845	81853	7584	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(WE)	I88&I355_I88&I294(9561-83757)	EVAC_HIGHWAY
10138	7584	8008	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(WE)	I88&I355_I88&I294(9561-83757)	EVAC_HIGHWAY
10288	8008	8234	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(WE)	I88&I355_I88&I294(9561-83757)	EVAC_HIGHWAY
19816	8234	22085	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(WE)	I88&I355_I88&I294(9561-83757)	EVAC_HIGHWAY
19819	22085	22086	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(WE)	I88&I355_I88&I294(9561-83757)	EVAC_HIGHWAY
10732	22086	8951	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(WE)	I88&I355_I88&I294(9561-83757)	EVAC_HIGHWAY
81233	8951	81913	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(WE)	I88&I355_I88&I294(9561-83757)	EVAC_HIGHWAY
10872	81913	9182	12:00:00 PM	12:00:00 AM	1	1	ANY	I88(WE)	I88&I355_I88&I294(9561-83757)	EVAC_HIGHWAY
81177	7197	81842	12:00:00 PM	12:00:00 AM	1	1	ANY	53&I290&I355(NS)	I355&34_I355&I55(9602-9923)	EVAC_HIGHWAY
81260	81842	81950	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(NS)	I355&34_I355&I55(9602-9923)	EVAC_HIGHWAY
9681	81950	7336	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(NS)	I355&34_I355&I55(9602-9923)	EVAC_HIGHWAY
9836	7336	7573	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(NS)	I355&34_I355&I55(9602-9923)	EVAC_HIGHWAY
9835	7573	7571	12:00:00	12:00:00	0	1	ANY	53&I290&I355(NS)	I355&34_I355&I55(9602-9923)	EVAC_HIGHWAY

			PM	AM						
9869	7571	7622	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(NS)	I355&34_I355&I55(9602-9923)	EVAC_HIGHWAY
9870	7622	7623	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(NS)	I355&34_I355&I55(9602-9923)	EVAC_HIGHWAY
9879	7623	7638	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(NS)	I355&34_I355&I55(9602-9923)	EVAC_HIGHWAY
81192	7638	81865	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(NS)	I355&34_I355&I55(9602-9923)	EVAC_HIGHWAY
9923	81865	7704	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(NS)	I355&34_I355&I55(9602-9923)	EVAC_HIGHWAY
81176	6937	81841	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(EW)	I88&I355_I88&I39(9821-5040)	EVAC_HIGHWAY
8846	81841	5970	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(EW)	I88&I355_I88&I39(9821-5040)	EVAC_HIGHWAY
81174	5970	81839	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(EW)	I88&I355_I88&I39(9821-5040)	EVAC_HIGHWAY
8416	81839	5288	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(EW)	I88&I355_I88&I39(9821-5040)	EVAC_HIGHWAY
8173	5288	4900	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(EW)	I88&I355_I88&I39(9821-5040)	EVAC_HIGHWAY
8111	4900	4802	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(EW)	I88&I355_I88&I39(9821-5040)	EVAC_HIGHWAY
7579	4802	3954	12:00:00 PM	12:00:00 AM	1	1	ANY	I88(EW)	I88&I355_I88&I39(9821-5040)	EVAC_HIGHWAY
81225	3954	81901	12:00:00 PM	12:00:00 AM	1	1	ANY	I88(EW)	I88&I355_I88&I39(9821-5040)	EVAC_HIGHWAY
81224	81901	81900	12:00:00 PM	12:00:00 AM	1	1	ANY	I88(EW)	I88&I355_I88&I39(9821-5040)	EVAC_HIGHWAY
7504	81900	3831	12:00:00 PM	12:00:00 AM	1	1	ANY	I88(EW)	I88&I355_I88&I39(9821-5040)	EVAC_HIGHWAY
7274	3831	3480	12:00:00 PM	12:00:00 AM	0	1	ANY	I88(EW)	I88&I355_I88&I39(9821-5040)	EVAC_HIGHWAY
80602	7704	80903	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(NS)	I355&I50_I355&I80(80602-10855)	EVAC_HIGHWAY
9970	80903	7769	12:00:00 PM	12:00:00 AM	0	1	ANY	53&I290&I355(NS)	I355&I50_I355&I80(80602-10855)	EVAC_HIGHWAY
83577	7769	85574	12:00:00 PM	12:00:00 AM	1	1	ANY	53&I290&I355(NS)	I355&I50_I355&I80(80602-10855)	EVAC_HIGHWAY
8117	4805	4810	12:00:00 PM	12:00:00 AM	1	1	ANY	105	105_01	EVAC_ARTERIAL
83214	4810	84992	12:00:00 PM	12:00:00 AM	0	1	ANY	105	105_01	EVAC_ARTERIAL
8118	84992	4812	12:00:00 PM	12:00:00 AM	0	1	ANY	105	105_01	EVAC_ARTERIAL
82511	4812	83893	12:00:00 PM	12:00:00 AM	0	1	ANY	105	105_01	EVAC_ARTERIAL
8125	83893	83885	12:00:00 PM	12:00:00 AM	0	1	ANY	105	105_01	EVAC_ARTERIAL
82506	83885	84428	12:00:00 PM	12:00:00 AM	0	1	ANY	105	105_01	EVAC_ARTERIAL
82851	84428	4815	12:00:00 PM	12:00:00 AM	0	1	ANY	105	105_01	EVAC_ARTERIAL

8119	4815	4814	12:00:00 PM	12:00:00 AM	0	1	ANY	105	105_01	EVAC_ARTERIAL
8120	4814	4817	12:00:00 PM	12:00:00 AM	0	1	ANY	105	105_01	EVAC_ARTERIAL
83211	4817	84987	12:00:00 PM	12:00:00 AM	0	1	ANY	105	105_01	EVAC_ARTERIAL
83033	84987	84711	12:00:00 PM	12:00:00 AM	0	1	ANY	105	105_01	EVAC_ARTERIAL
80287	84711	80474	12:00:00 PM	12:00:00 AM	0	1	ANY	105	105_01	EVAC_ARTERIAL
8123	80474	4822	12:00:00 PM	12:00:00 AM	0	1	ANY	105	105_01	EVAC_ARTERIAL
82306	4822	83576	12:00:00 PM	12:00:00 AM	0	1	ANY	105	105_01	EVAC_ARTERIAL
8124	83576	4825	12:00:00 PM	12:00:00 AM	0	1	ANY	105	105_01	EVAC_ARTERIAL
8133	4825	4837	12:00:00 PM	12:00:00 AM	0	1	ANY	105	105_01	EVAC_ARTERIAL
8138	4837	4845	12:00:00 PM	12:00:00 AM	1	1	ANY	105	105_01	EVAC_ARTERIAL
8141	4845	4853	12:00:00 PM	12:00:00 AM	1	1	ANY	105	105_02	EVAC_ARTERIAL
8142	4853	4847	12:00:00 PM	12:00:00 AM	0	1	ANY	105	105_02	EVAC_ARTERIAL
8139	4847	4848	12:00:00 PM	12:00:00 AM	1	1	ANY	105	105_02	EVAC_ARTERIAL
82523	4008	83912	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
7754	83912	4225	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
7793	4225	4291	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
7886	4291	4434	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
7944	4434	4524	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
7981	4524	4588	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
83212	4588	84989	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
8117	84989	4811	12:00:00 PM	12:00:00 AM	1	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
82495	4811	83868	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
8315	83868	5126	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
8458	5126	5352	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
82418	5352	83748	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
8518	83748	5443	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
8600	5443	5578	12:00:00	12:00:00	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL

			PM	AM						
82394	5578	83713	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
8763	83713	5840	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
8906	5840	6066	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
9046	6066	6301	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
9410	6301	6900	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
9517	6900	7081	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
9583	7081	7178	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
9647	7178	7288	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
9787	7288	7497	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
9810	7497	7530	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
9905	7530	7676	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
9963	7676	7759	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
83028	7759	84703	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
10213	84703	8123	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
83909	8123	86231	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
10364	86231	8363	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
10416	8363	8447	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
10497	8447	8567	12:00:00 PM	12:00:00 AM	1	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
10583	8567	8701	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
82192	8701	83400	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
10689	83400	8880	12:00:00 PM	12:00:00 AM	1	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
10756	8880	8989	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
82200	8989	83412	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
11013	83412	9378	12:00:00 PM	12:00:00 AM	0	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL
11119	9378	9542	12:00:00 PM	12:00:00 AM	1	1	ANY	SRA212	SRA12_02	EVAC_ARTERIAL

Step 4 Define Evacuation Dispersion Area

The dispersion area is defined in Figure 5.40. Different color filled contours indicates different risk levels.

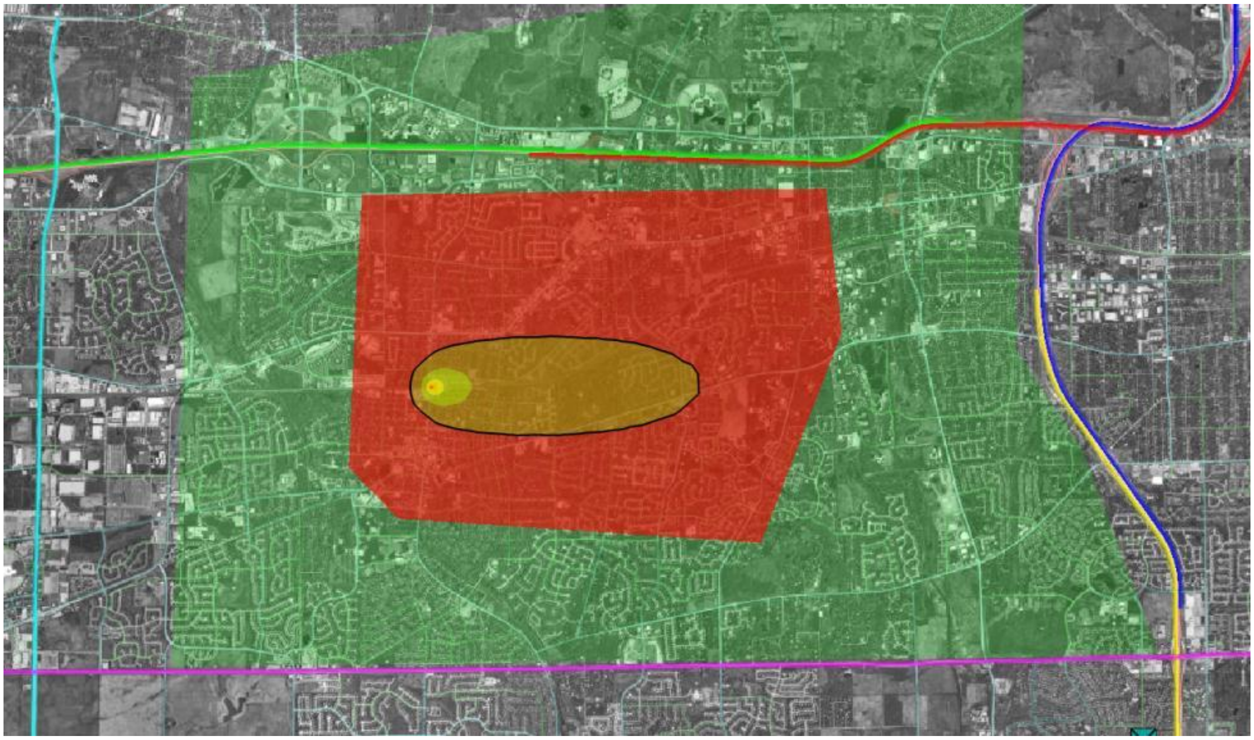


Figure 5.40 Evacuation Dispersion Area for the Naperville Amtrak/Metra Station Scenario

Step 5 Define Evacuation Start Time and Save Scenario

We define the evacuation start time as 12:00:00PM and then save the scenarios.

5.2.1.3. Scenario Analysis

In this section we provide an analysis of the modeled response of the population to the evacuation orders as well as the response of the transportation network to the demand induced by the evacuees. As mentioned above an evacuation warning message was issued at noon. The residents were informed about the location of the event and severity of the event. Note that assumption made in the model is that 100% of the population did receive the warning and did not "misinterpret" it. In other words everybody were aware about how risky it is to stay at their current location and whether they need to evacuate immediately or not. In the current scenario there are two types of zones. Population located in the red zone is warned to evacuate immediately, while population in the green zone is advised to evacuate rather then ordered. Below is the picture which shows traffic distribution at 11:55am, right before a warning was issued. This particular traffic distribution is a result of so-called "normal day" model. This model predicts traffic patterns in the region on an average day. The normal day model was also developed as part of the RTSTEP tool. It was calibrated and validated against the observed traffic data.

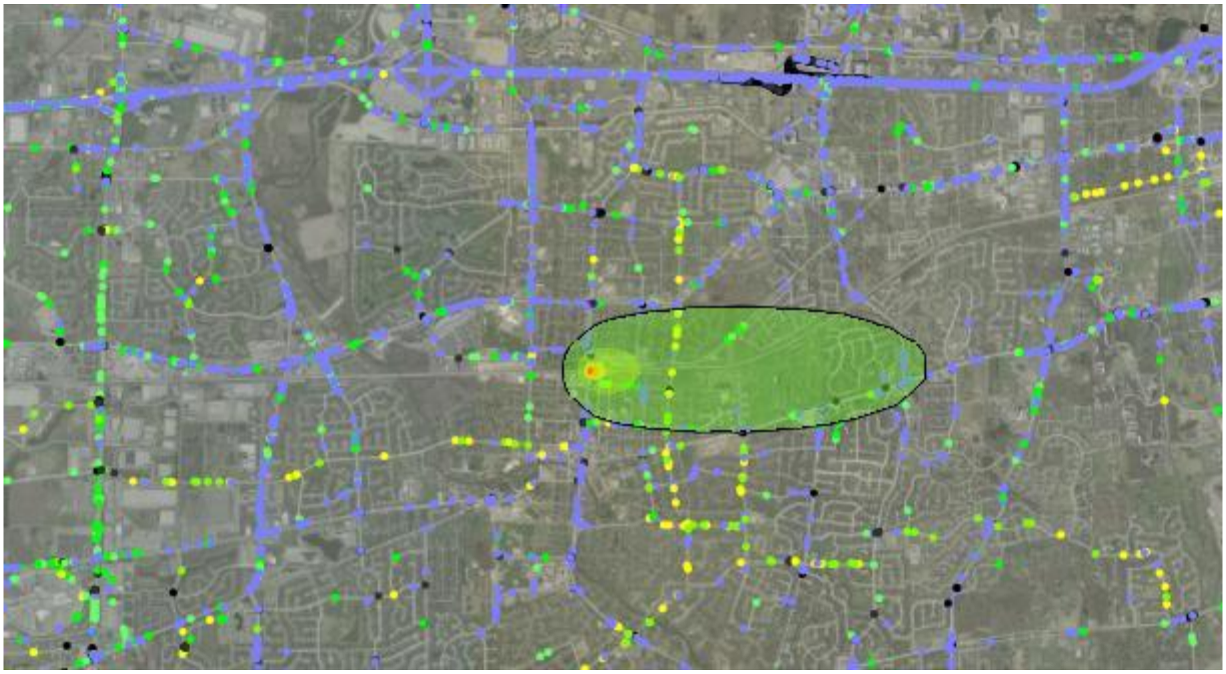


Figure 5.41: Traffic Distribution at 11:55am

Once the evacuation warning was issued, the hazard function is used to calculate the evacuation response delay for each of the travelers. Below is the curve which chows the cumulative evacuation percentage. In this scenario we assume that half of the population responds to the warning within one hour and after little more than four hours 90% reacted. Overall, it takes little more than five hours for the entire population to evacuate.

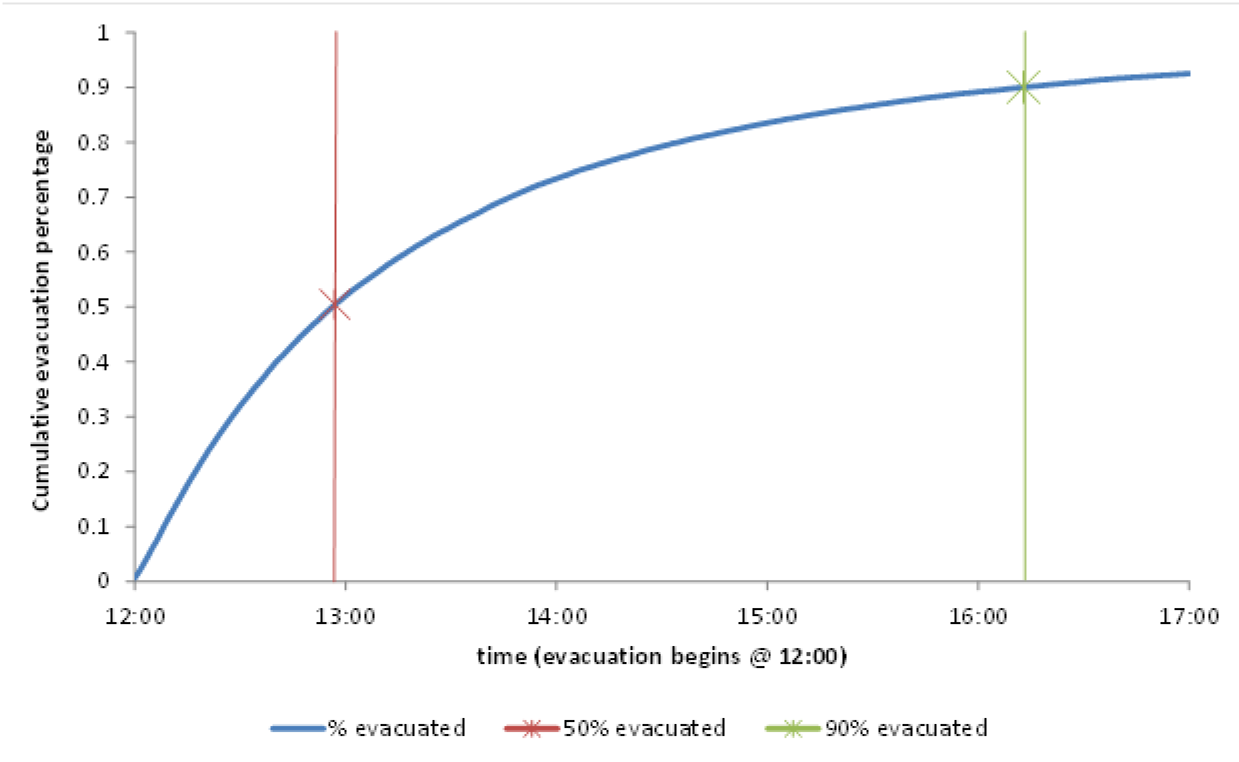


Figure 5.42: Cumulative evacuation demand curve

Below is more detailed information on the demand induced by the evacuation warnings issued by an authority. The table below shows distribution of trip types for scenario with planning applied and without. There are 26K trips which have shelter as the final destination and 223K trips were affected by the evacuation. By effected, we mean that part of the paths of those trips lies within the evacuation area. We assume that the traffic gets rerouted and does not enter evacuation zone.

Table 5.13: Naperville Case Study

NAPERVILLE CASE STUDY				
	No evacuation planning		**With evacuation planning**	
Evacuation Responses	**Count**	**%**	**Count**	**%**
Return home	2,700	3.6%	2,700	3.6%
Ignore evacuation	3,461	4.6%	3,385	4.5%
Shelter in place	14,567	19.2%	14,734	19.4%
Evacuate to shelter	–	–	26,586	35.0%
Evacuate - leave region	12,021	15.8%	12,067	15.9%
Evacuate - Go to friends/family/hotel	43,244	56.9%	16,521	21.7%
Total population @ start	75,993	100.0%	75,993	100.0%
Other impacted individuals				
Diverted trips, due to evacuation	233,871		233,872	
Cancelled trips	369,618		369,315	

5.2.1.4. Shelter utilization

The picture below shows the locations and identification numbers of all of the shelter locations specified for the case study. It is assumed that people are informed about the shelter locations and choose their destination according to the destination choice model described earlier in the report. The series of plots show the utilization for each individual shelter. The plots show number of trips which ended on the link associated with the shelter. Thus we do see certain number of trips ending on the associated link even before the evacuation starts. Note those trips are not evacuation trips but rather trips which happen to end on the corresponding link. Note that the time scale for cumulative curves are 1 second (40000 sec is approximately 11:06am).

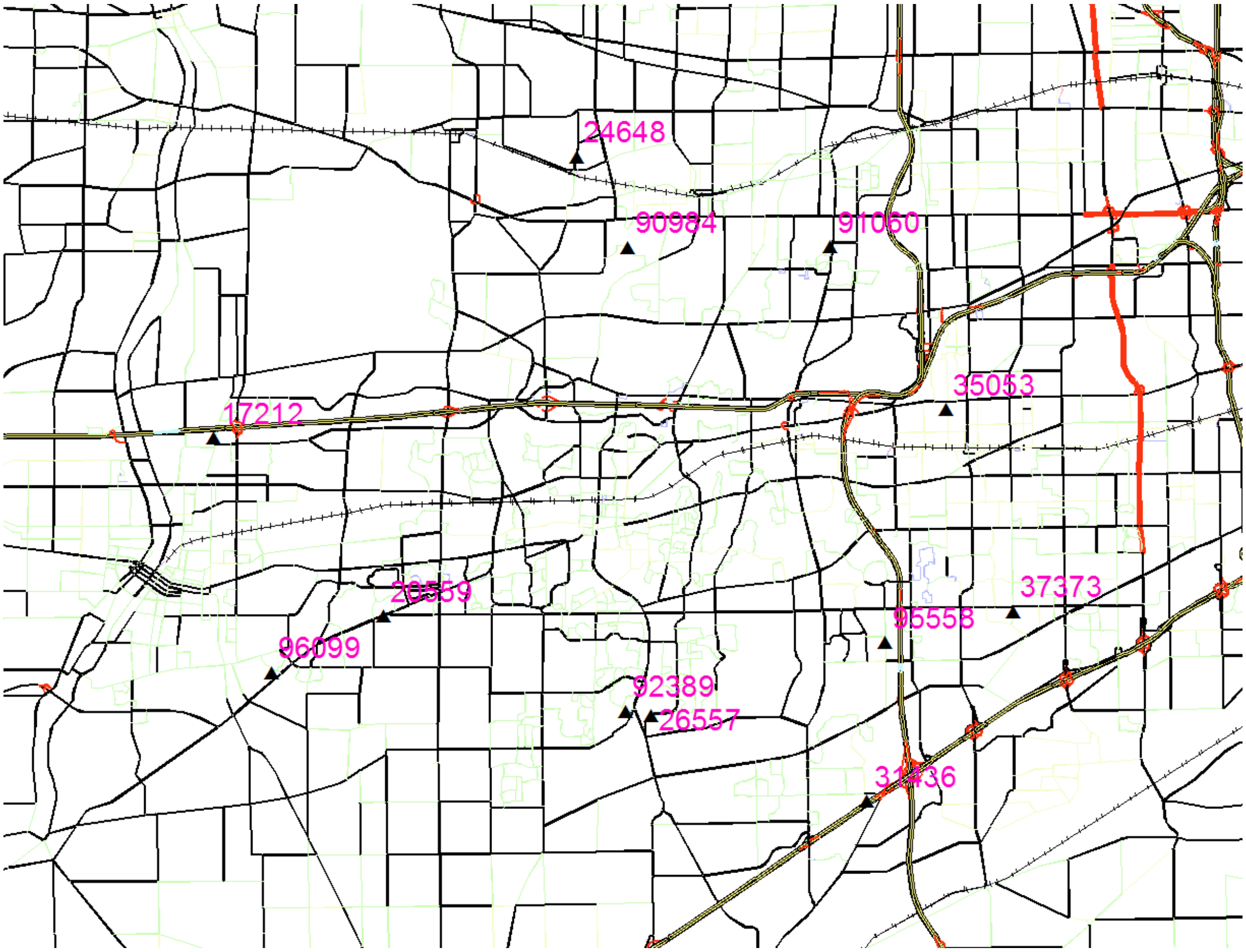


Figure 5.43: Shelter location and ids

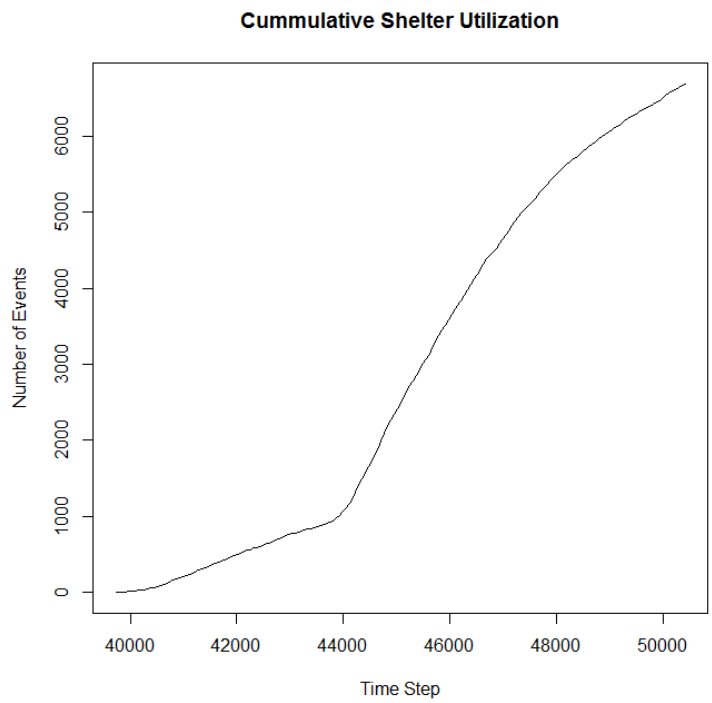


Figure 5.44: Cumulative Utilization of the Shelters

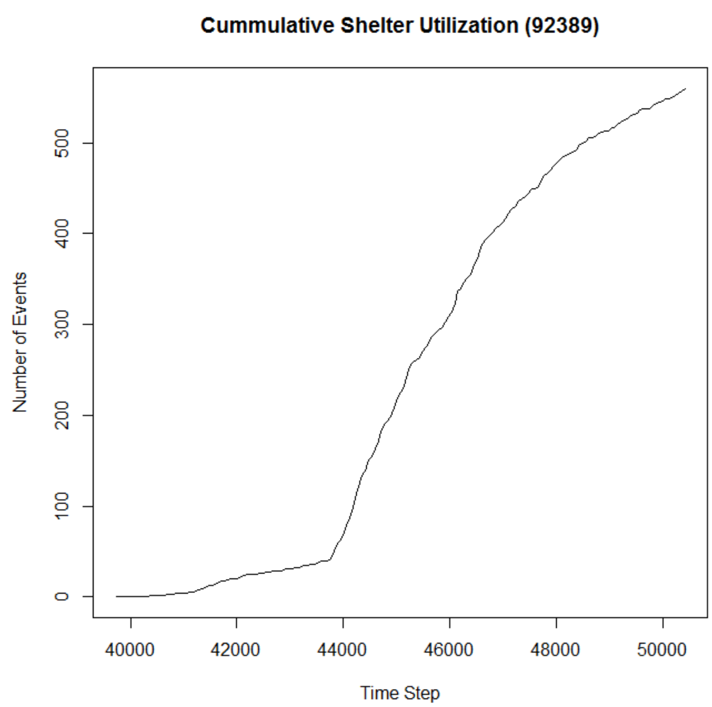
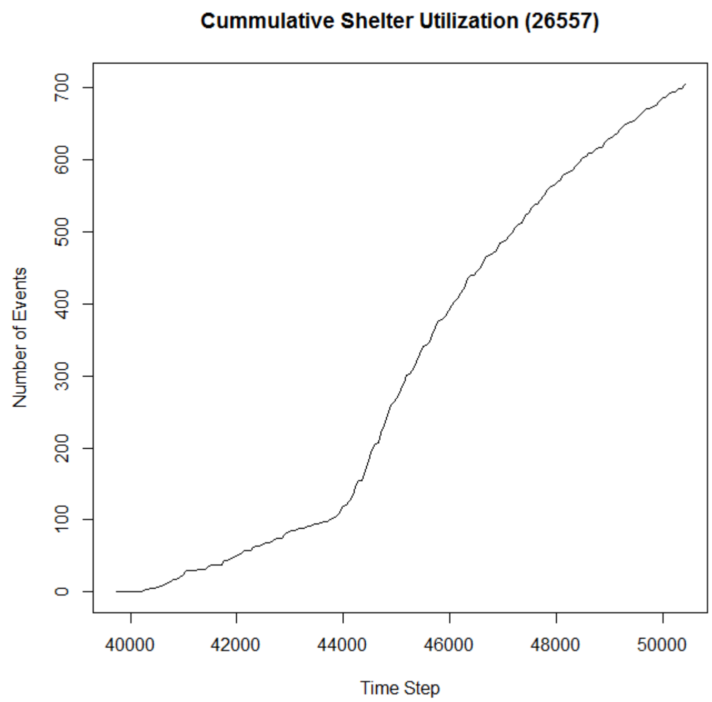
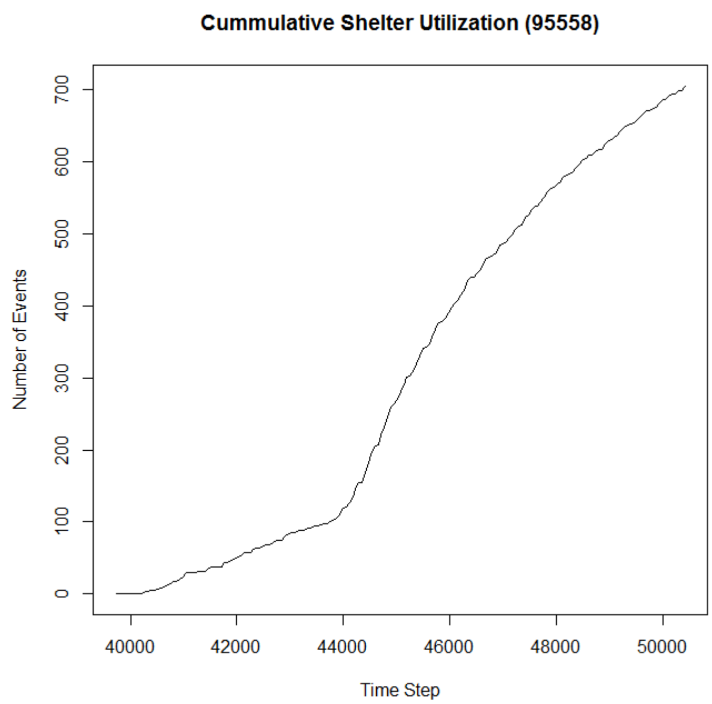
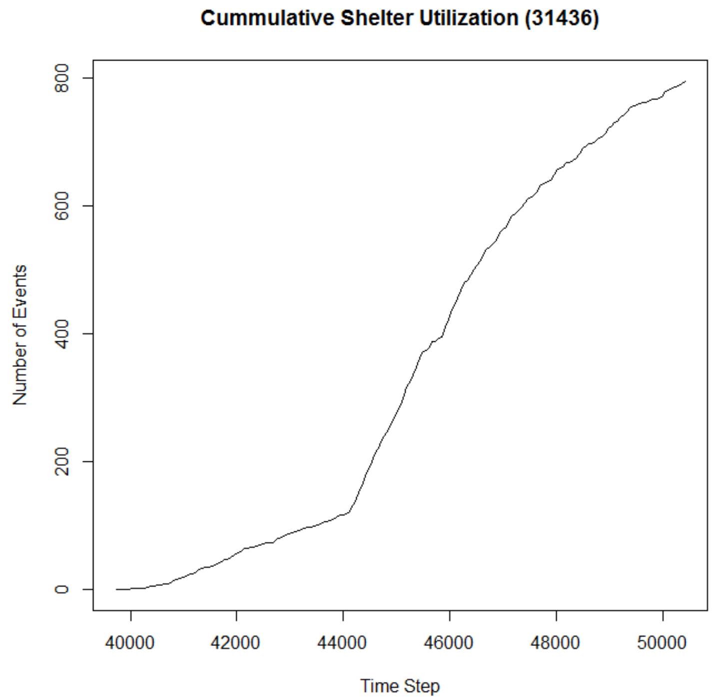
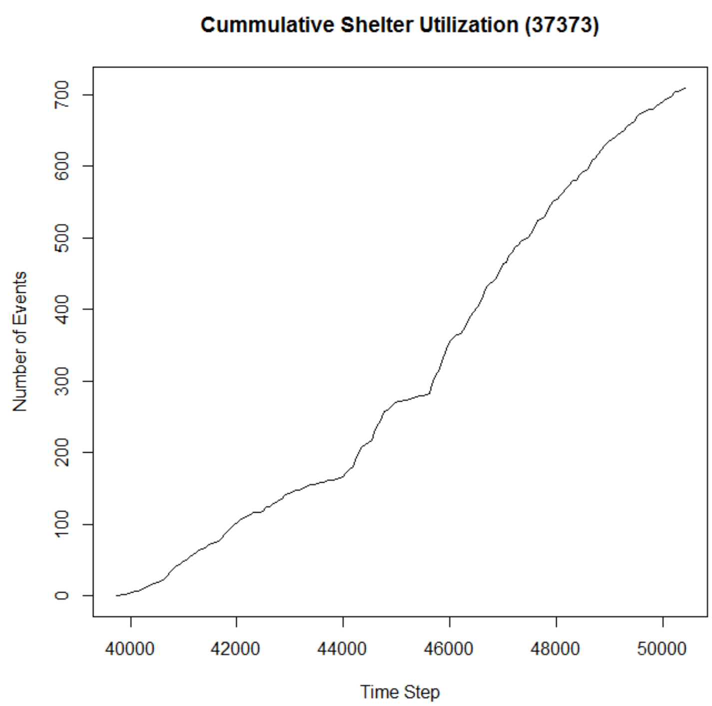


Figure 5.45: Shelter 92389 Utilization

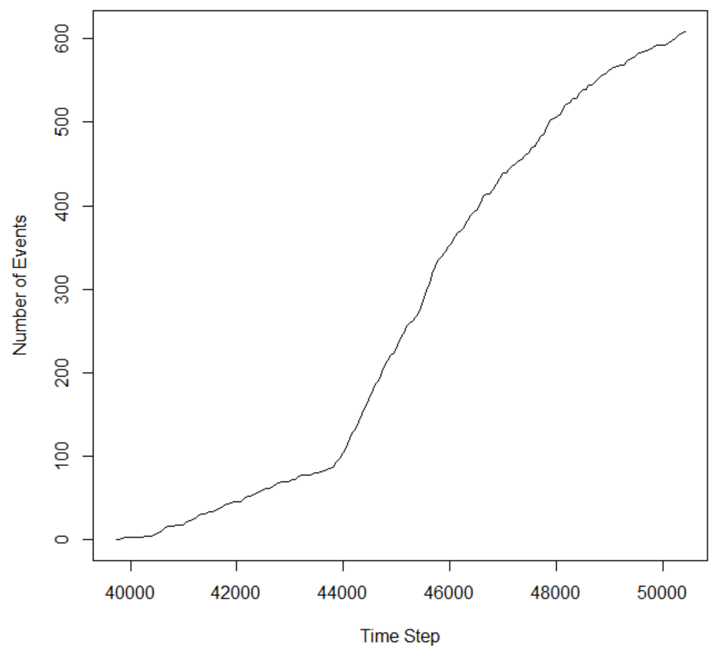

Cummulative Shelter Utilization (26557)
Number of Events
0
100
200
300
400
500
600
700
40000
42000
44000
46000
48000
50000
Time Step


Cummulative Shelter Utilization (95558)
Number of Events
0
100
200
300
400
500
600
700
40000
42000
44000
46000
48000
50000
Time Step

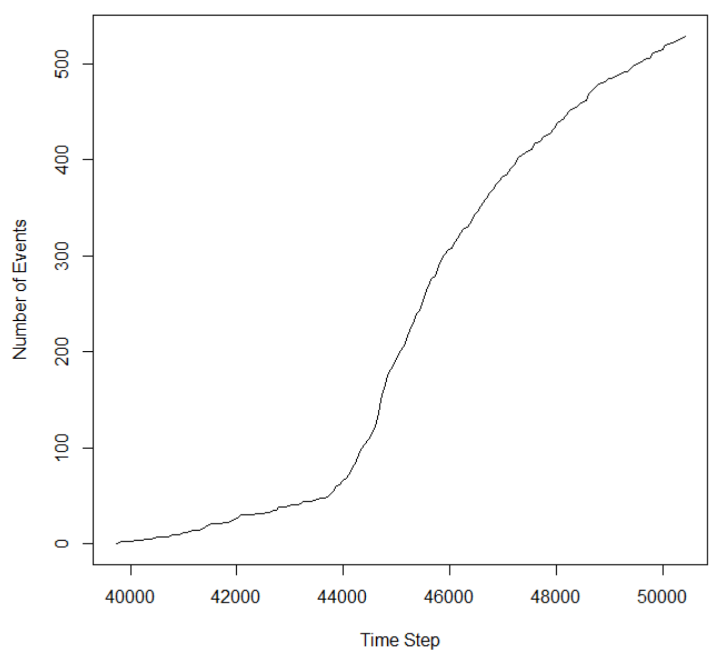

Cummulative Shelter Utilization (31436)
Number of Events
0
200
400
600
800
40000
42000
44000
46000
48000
50000
Time Step

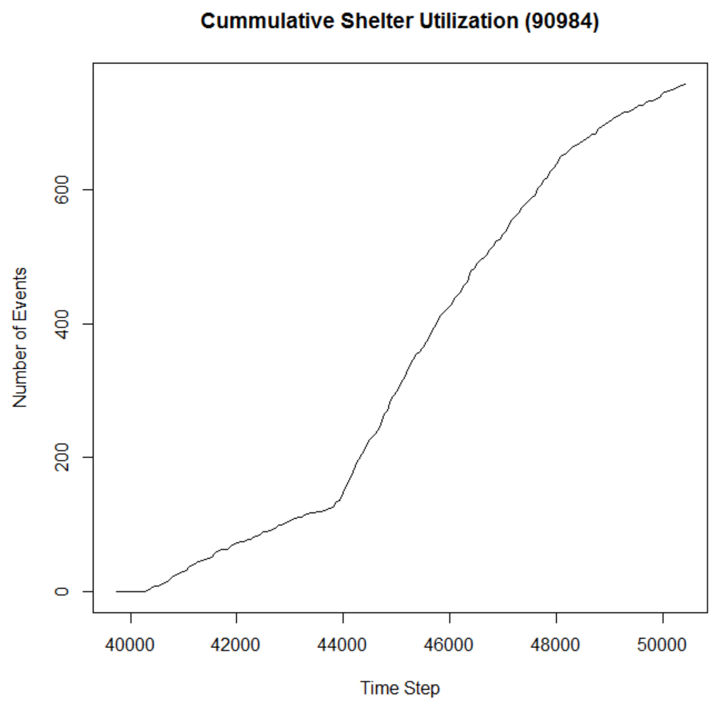

Cummulative Shelter Utilization (37373)
Number of Events
0
100
200
300
400
500
600
700
40000
42000
44000
46000
48000
50000
Time Step

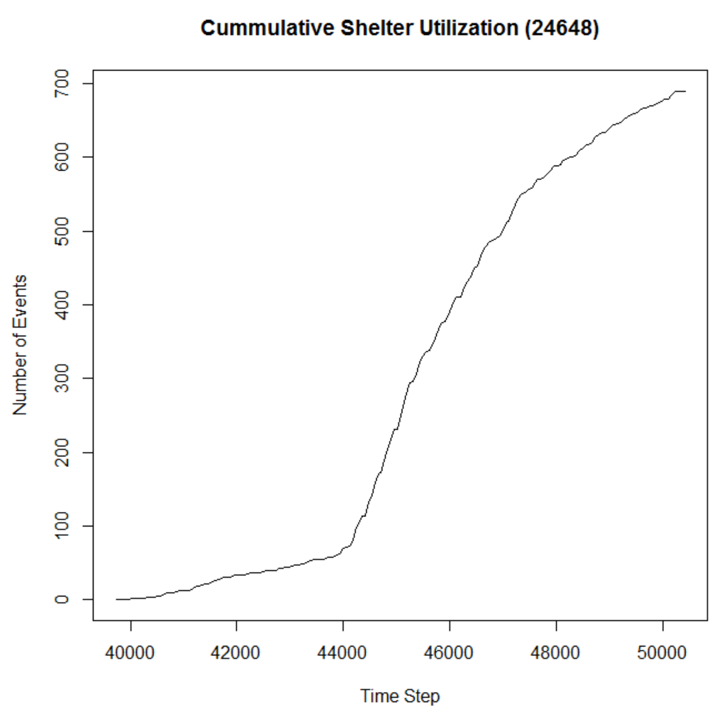
Cummulative Shelter Utilization (35053)

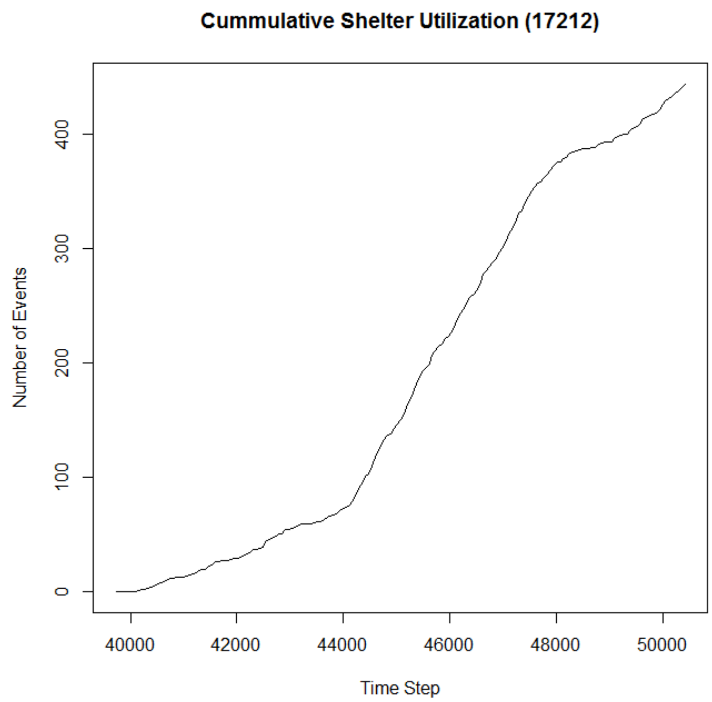


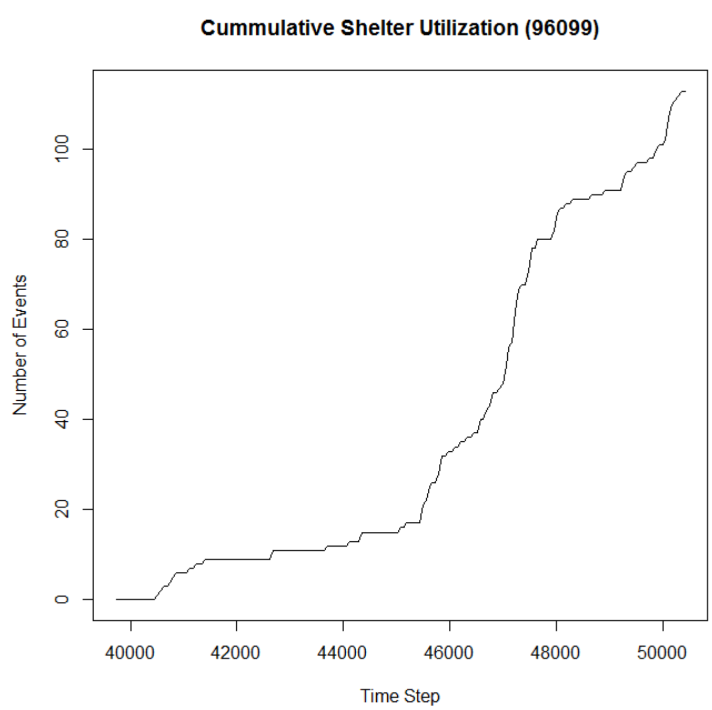
Cummulative Shelter Utilization (91060)

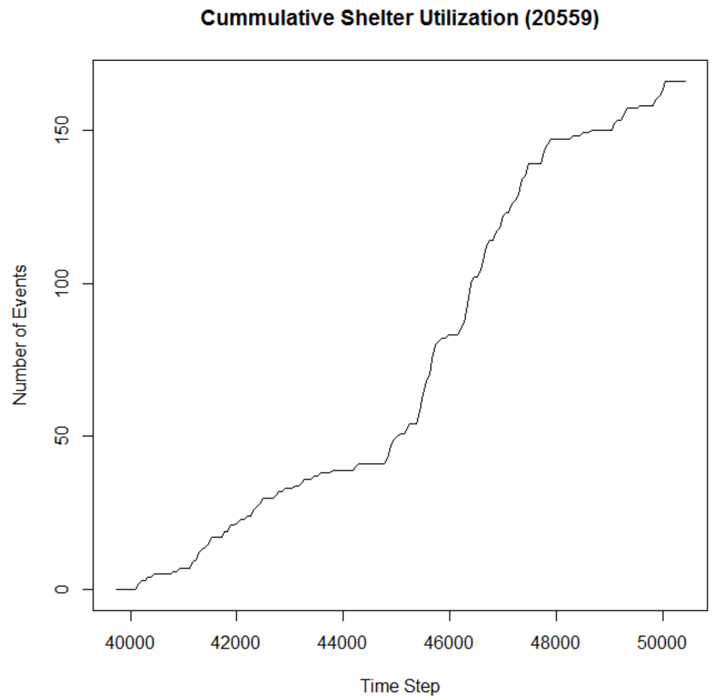



Cummulative Shelter Utilization (90984)
Number of Events
0
200
400
600
40000
42000
44000
46000
48000
50000
Time Step


Cummulative Shelter Utilization (24648)
Number of Events
0
100
200
300
400
500
600
700
40000
42000
44000
46000
48000
50000
Time Step


Cummulative Shelter Utilization (17212)
Number of Events
0
100
200
300
400
40000
42000
44000
46000
48000
50000
Time Step


Cummulative Shelter Utilization (96099)
Number of Events
0
20
40
60
80
100
40000
42000
44000
46000
48000
50000
Time Step



We can see that the population gets distributed to the shelters more or less uniformly, except for the locations located far from the epicenter and from major highways.

Series of pictures below illustrates the network conditions after the evacuation warning was issued. The red dots illustrate evacuee's vehicle. Figure 5.48 illustrates total volume of traffic on the network. We can see two distinct regions when the volume grows fast. The firs one correspond to the response of the population to the "immediate evacuation" warning. The second one corresponds to the response of the population located outside of the high risk area. This response is delayed compared to the response of the population from the high risk area.

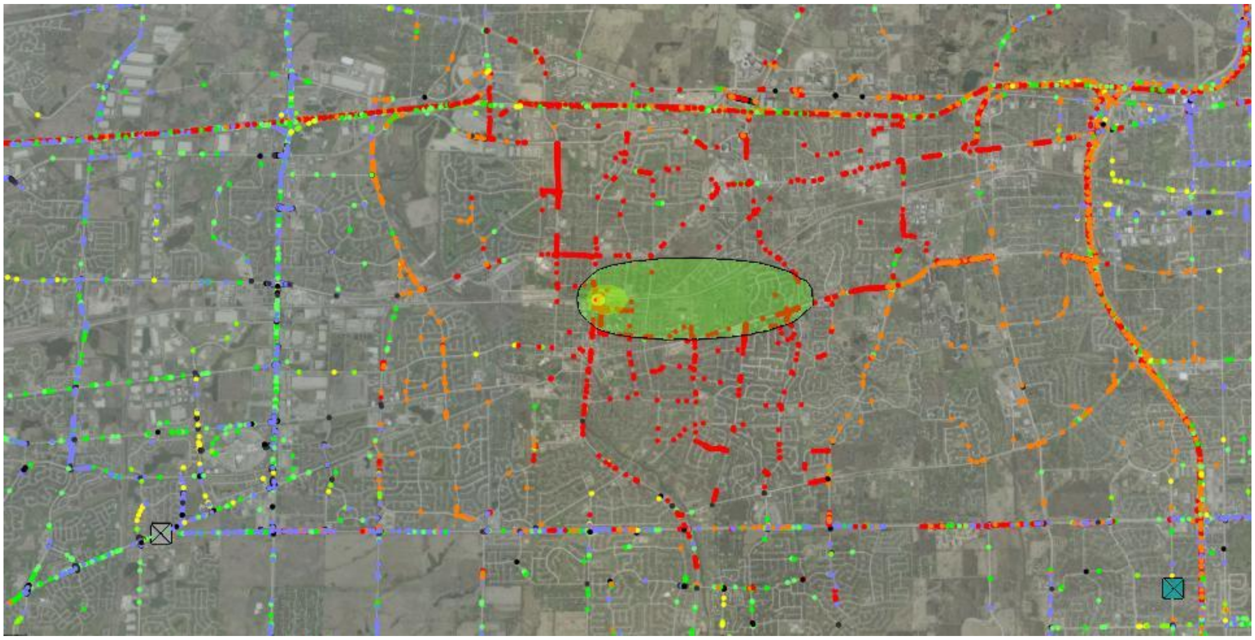


Figure 5.46: Traffic Distribution at 12:15pm

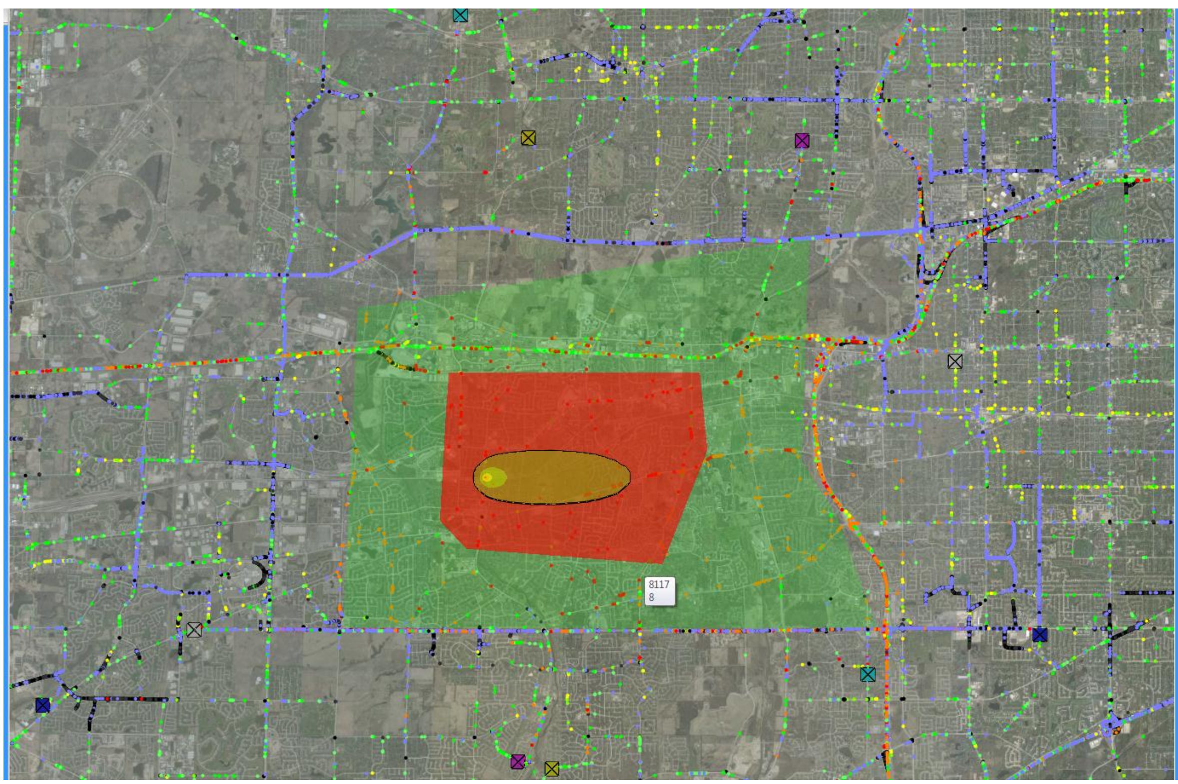


Figure 5.47: Traffic Distribution at 12:30pm

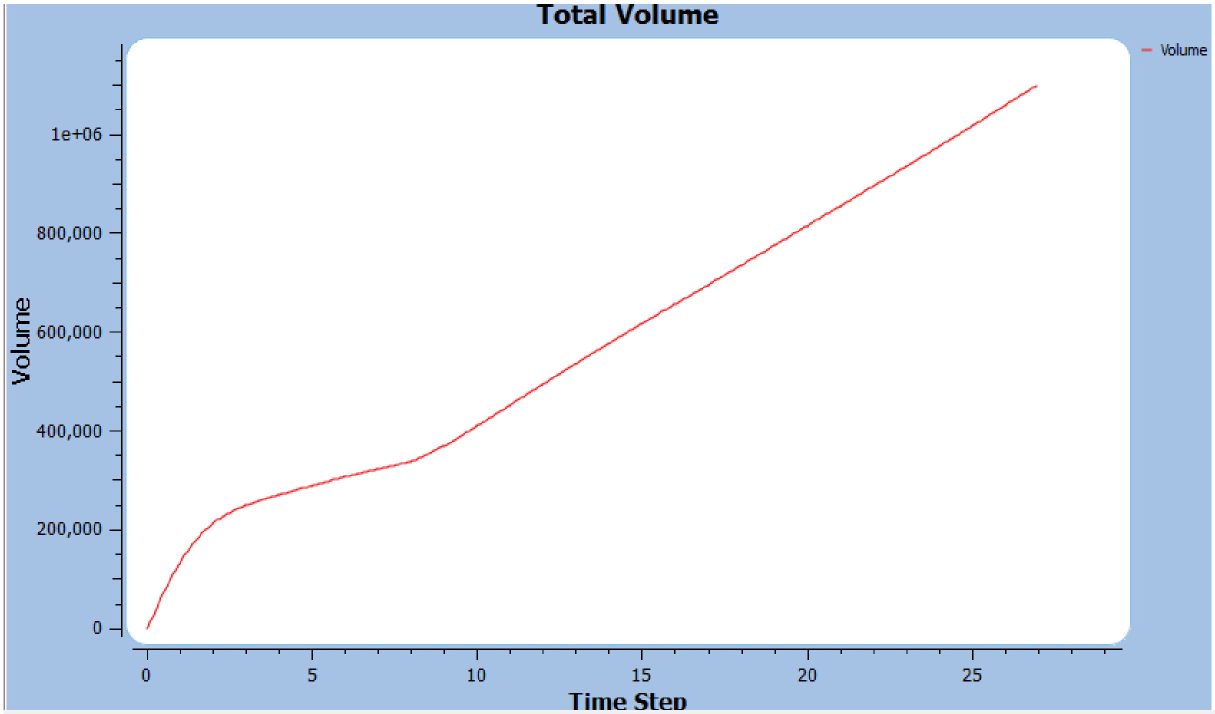


Figure 5.48: Total Volume on the network throughout the simulation period

5.3. Six Flags Great America

5.3.1. Analysis of the Evacuation of Six Flag Great America

(More detailed documentation on dispersion can be found in section 8 of this report)

The Six Flag Great America in Gurnee has two parking lots, which are the visitors' final destinations. The AutoCAD layout in considered is shown in the figure 14 below.

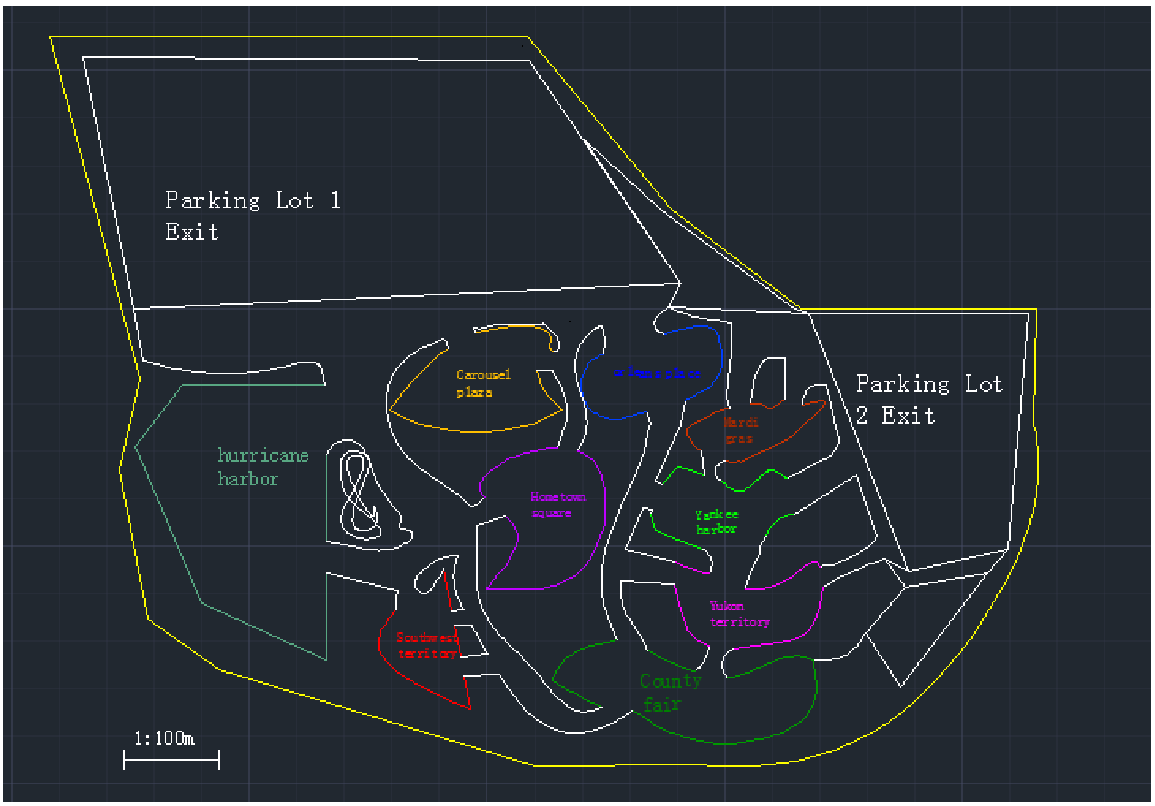


Figure 5.49: Six Flag Layout in AutoCAD

The Six Flags layout is imported to Legion model builder, and then we check whether there is any error in the model. The model builder display is shown in figure 15.

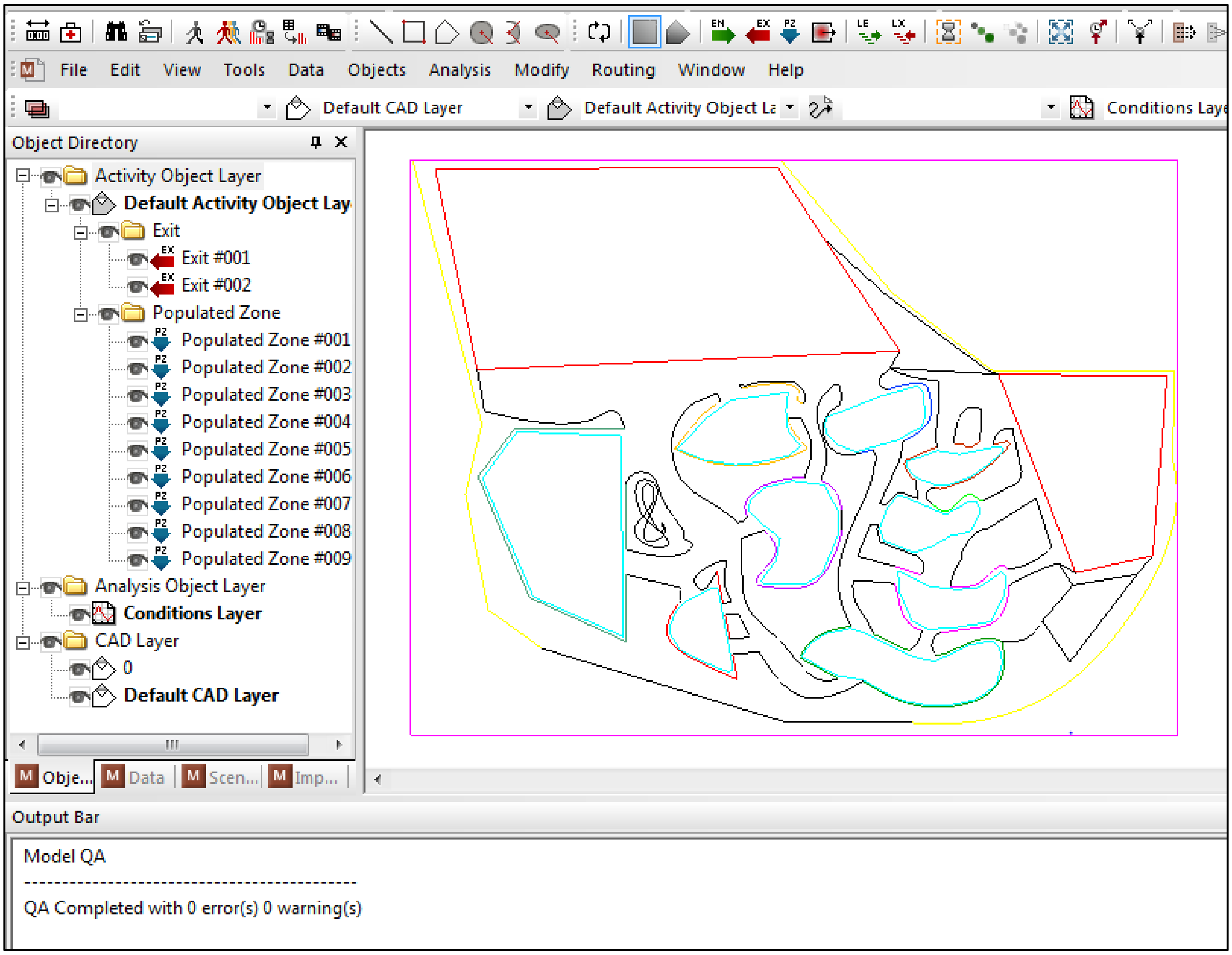


Figure 5.50: Six Flag in the Legion Model Builder

After entering the correct parameters for the above Six Flag Model, such as “Exit” and “Populated Zones”, Legion model builder check for errors and warnings. Then, the Legion model is imported to Legion Analyzer and run with different values but the same parameters.

5.3.1.1. Design of Experiment

In our case, three factors (congestion, speed and population) will be considered and the total scenarios are eight.

1. The congestion parameter indicates the percentage of the population that considers the blockage ahead of them and thus they can decide to move towards a different exit in order to avoid that congestion. The imitation parameter is also a percentage of the population that will follow the path of the majority of agents, this parameter represents those agents that are not familiar with the structure of the building and rely on the majority to find their way out.

2. The desired speed corresponds to the speed at which the agent will move if no obstruction on their way is found. The desired speed may not necessarily be reached due to the levels of people density and building structure, which in turns influences on the level of frustration of the

agents and on their effort function. Finally, the distance error is a parameter that represents the accuracy at which the entities calculate the distances between them and their objectives, this parameter is a percentage of the real distance.

3. Population is the number of visitors within simulated area.

In order to analyze the influence among each factor, a two level (2^k) factorial design of experiments is used in our case. The values for the low level (-1) and high level (1) of each factor is presented in table 4.

Table 5.14: Values for the Six Flag designed experiments

Six Flag Designed Factors		
Levels	-1	1
Congestion	0%	50%
Speed	1.3m/s	2.6m/s
Population	9000	18430

The values for these three factors are determined based on the built-in function of Legion. In the case of the desired speed, multiple researches have concluded that 1.33 m/s is the average free speed. In the case of the high level, 2.66 m/s are a good estimation for a calm running (Kholshevnikov & Samoshin, 2010).

Given that the number of factors to use in the design of experiments is three (k = 3), the total amount of experiments to perform is eight per replication. The combination of all the levels and factors is presented in table 5. Once all the experiments are performed, an ANOVA analysis will show us which factors have a greater influence on the total evacuation time.

Table 5.15: Factorial design for the Six Flags (k = 3)

Run	Congestion	Speed	Population
1	-	-	-
2	+	-	-
3	-	+	-
4	+	+	-
5	-	-	+
6	+	-	+

7	-	+	+
8	+	+	+

Table 5.16: Values for each scenario

Scenario	Congestion	Speed	Population
1	0	1.3	18430
2	0	1.3	9000
3	0	2.6	18430
4	0	2.6	9000
5	50%	1.3	18430
6	50%	1.3	9000
7	50%	2.6	18430
8	50%	2.6	9000

5.3.1.2. Analysis of the Simulated Results

Once the number of replications was calculated for each of the base scenarios, the same number of replications was run for all the other scenarios. Similar to the analysis done in the previous case study, the response is the total evacuation time:

$$\gamma = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 \dots \beta_{63} X_1 X_2 X_3 X_4 X_5 + \varepsilon$$

In the previous model, the β_n are the coefficients for each of the main and interaction factors and, and the output γ is the total evacuation time. After running all the eight scenarios, the results are imported to Minitab in order to analyze the factorial design. An analysis of the variance is presented in table 8.

Table 5.17: Estimated effects and Coefficients for Six Flag

Term	Effect	Coef	SE Coef	T	P
Constant		686.5	69.89	9.82	0
Congestion	19.2	9.6	69.89	0.14	0.894
Speed	-642.9	-321.4	69.89	-4.6	0.002

Population	295.5	147.7	69.89	2.11	0.067
Congestion*Speed	-139.1	-69.5	69.89	-0.99	0.349
Congestion*Population	-226.1	-113	69.89	-1.62	0.144
Speed*Population	14.9	7.4	69.89	0.11	0.918
Congestion*Speed*Population	-39.3	-19.6	69.89	-0.28	0.786

Table 8 provides details on the significance of each of the factors and their interactions. The *p*-values for Speed (X_2) and Population (X_3) are less than the significance level (0.05). Therefore, the model for the evacuation time can be reduced to this term. The final model for the evacuation time of the Six Flags is:

$$\gamma = 686.5 - 321.4X_2 + 147.7X_3$$

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6. TRANSIMS Version 5 Software Changes and Testing

6.1. Software Changes

The following sections describe the software enhancements implemented in Version 5 TRANSIMS SysLib

The software enhancements made to SysLib include:

- Vehicle Type – Subtype conversion was improved;
- A 'TRAVELER TYPE' field was added to trip and plan files;
- ArcView Draw Service keys were added;
- Partition range based processing was added to the command line;
- Logic to flatten nested files was added;
- 'Transit Route Nodes' file was included;
- 'Link Detail' file was included;
- Sqlite3 software version was updated;
- A USE type code "NONE" was added to simplify lane closures.;
- Previously, the vehicle type file was being processed after the lane-use and turn penalty files. This generated 'vehicle type not found' warnings. Software was updated to process the vehicle-type file before the lane-use and turn-penalty files; and
- Software was updated to generate turning movement data even if the input link delay file does not contain turning movement data.

6.1.1. NewFormat

The software enhancements made to NewFormat include:

- Transit route header and node file conversion from V4 to a nested V5 file;
- Node based plans conversion to link based plans;
- Thread based plan file conversion;
- A 'time format' key was added for trip and activity files;
- The option to flatten nested data files using information in the definition file was provided; and
- Version 4 snapshot files conversion to version 5 so that all version 4 snapshots can be used with the TransimsVIS software.

6.1.2. NetPrep

The software enhancements made to NetPrep include:

- The logic to split large loops was corrected;
- A new report to list freeway-arterial intersections was created;
- Link Detail file processing was added for intersection controls, approach lane distribution and time-of day lane use;
- Conversion from external to internal speed units was automated;

- Software was enhanced to update link lengths based on node coordinates and shape point coordinates;
- The COORDINATE_RESOLUTION key was added to control coordinate matching distance; and
- The INTERSECTION_TYPES report was added to summarize nodes by facility types and area types.

6.1.3. Arc Tools

The software enhancements made to TRANSIMS Arc toolset, which includes ArcNet, ArcPlan, and ArcSnapshot include:

- Common keys in the Draw Service were consolidated;
- ARCVIEW_DIRECTORY keys were replaced by file specific NEW_ARC_* keys;
- NEW_ARC_CENTERLINE_FILE key was added; and
- Problem-only output and plan selection by problem type was enabled.

6.1.4. TransimsNet

The software enhancements made to the TransimsNet module include:

- A USE type code "NONE" was added to simplify lane closures;
- Link detail processing was implemented. The data dictionary for the link detail file is presented in Table 3.1.

Table 6.1: Link detail file data dictionary

Field	Description
LINK	
DIR	
CONTROL	Signal/Sign
GROUP	Intersection group number
LM_LENGTH	Left merge pocket length
L_MERGE	Left merge lanes
LT_LENGTH	Left turn pocket length
LEFT	Left turn only lanes
LEFT_THRU	Shared left-thru lanes
THRU	Thru lanes
RIGHT_THRU	Shared right-thru lanes
RIGHT	Right turn only lanes
RT_LENGTH	Right turn pocket length
R_MERGE	Right merge lanes
RM_LENGTH	Right merge pocket length
USE	Vehicle use codes
LANES	Lane range affected by use code
PERIOD	Time period ranges for use restriction
NOTES	Text

6.1.5. Router

The software enhancements made to the Router module include:

- Facility based traveler behavior keys were changed to traveler type based traveler behavior keys;
- Facility bias factors were added;
- More traveler types were enabled and the use of a unique random number seed for each traveler was implemented;
- Software was enhanced to improve consistency between Router and PlanSum link delay files;
- The Lane Use data and file classes and read and write services were modified to include fields for minimum and maximum vehicle type codes and toll rate;
- Software was modified to apply the new lane-use constraints and cost components;
- Software was enhanced to output turning movement flows and LinkSum was enhanced to create a turning movement file from link delay data;
- The turning movement update logic was corrected;
- Tour processing logic was enhanced to allow tracking of destination parking lots. This is essential to route travelers in a selected time period;
- Logic was added to adjust trip schedules and activity durations between tour legs. In addition, departure times are adjusted and vehicle locations are updated if a subset of the tour file is rerouted;
- The memory buffer (size) was modified to overcome transfer and memory limitations;
- Random effects on the lane use delays were made consistent for a given trip. The lane use "apply" option was modified to ignore pocket lanes; and
- The exit check based on the maximum household number was removed when the input trip file is time sorted.

6.1.6. Plan and Trip Processing

The software enhancements made to the Plan and Trip Processing include:

- Reports to summarize and compare travel times and trip lengths were added;
- Logic was added to select plans that pass through a subarea polygon;
- 'DELETE' keys were activated to delete selected trips from input or merge trip files. TripPrep, PlanPrep, PlanSelect, PlanCompare, and Router can now be used to delete trips;
- Vehicle file keys were added to synchronize the management of vehicle files. It is now feasible to merge two vehicle files. The keys added were: VEHICLE_FILE, NEW_VEHICLE_FILE, MERGE_VEHICLE_FILE.

PlanSum was enhanced to:

- Implement V/C and trip time distribution reports,
- Implement a Message Passing Interface (MPI) based prototype using native MPI calls,
- Produce consolidate plan file statistics when using MPI; and
- Improve consistency between Router and PlanSum link delay files.

6.1.7. Simulator

The software enhancements made to the Simulator include

- The 'Microsimulator' program name was changed to 'Simulator';
- Facility based traveler behavior keys were changed to traveler type based traveler behavior keys;
- Facility bias factors were added;
- More traveler types were enabled;
- Use of a unique random number seed for each traveler was included;
- Plan following and look ahead logic was implemented;
- Subarea processing (unsimulated, macroscopic, mesoscopic, and microscopic) was implemented;
- Lane swapping logic was added;
- Data packaging routines for Simulator were enhanced;
- Calibration keys for facility type and traveler type controls were added. Driver behavior and data structures were improved;
- The simulator link class was restructured to permit different data items for mesoscopic and macroscopic processing method;
- An option was added to reload a vehicle that experienced a loading or waiting problem to the next link in the path so they can continue their trip. This option enables significantly more vehicles to complete their trip;
- A new compressed snapshot format was created. Conflicts between the snapshot processing module's read and write threads were resolved;
- Messages were added to the Simulator to inform the user when the plan file is not time sorted;
- The Simulator link class was restructured for macroscopic or queue based simulation;
- Random slowdown and reaction time keys were activated for the macroscopic simulation and passenger car equivalence calculations were included in volume-capacity comparisons;
- Lane assignments were improved in the macroscopic simulation for improved visualization;
- Vehicle lane use restrictions were added for mesoscopic simulation and logic was added to check the vehicle type ranges as well as the lane use type to remove vehicles on restricted links when all the lanes on the link are restricted and the end of the restriction is longer than the maximum wait time parameter;
- Logic was added to examine link restriction time ranges to determine if the restriction is scheduled to be removed in the next two minutes and if not, the vehicle is moved to the beginning of the next link in the path or to a lane that permits access;
- The selection of an entry lane for vehicles loading from an external station or a boundary link was randomized to avoid right lanes bias;
- Software was updated to ensure that a re-simulation using multiple threads produces identical results;
- Logic to simulate transit vehicles was added. Transit vehicles without any passengers can be simulated based on transit schedules with a minimum dwell at their scheduled stops; and

- Lane use restrictions with multiple criteria and "required" restriction types were improved. A unique random number was created for each combination of lane use record, lane number and vehicle to ensure that the random delay is the same each time a given link, lane, traveler, and time of day combination is probed or applied.

6.1.8. Relocate

Relocate software was created in order to:

- Convert activity locations and parking lots in trip, plan and vehicle files between networks based on spatial locations and/or link numbers;
- Rectify trip, plan and vehicle files after network edits;
- Rectify changes made by re-running TransimsNet; and
- Generate location/parking equivalence files and a list of travelers affected by the changes.

Relocate V5 can update node numbers in plan files but cannot yet update link numbers. Relocate V4 also included logic to redistribute trips within selected zones based on new location weights, but Relocate V5 is not yet capable of redistributing trips.

6.2. Testing

6.2.1. Linux Compilation and Testing

The TRANSIMS software Linux was compiled using GCC (GNU Compiler Collection: gcc/g++) and a custom perl script. This perl script was relatively easier to setup compared to the elaborate "make" process. The primary goal was to find and rectify software syntax and implementation issues to support both the Windows (using Visual C++ compiler) and Linux (using GCC) platforms. Several syntactical issues were identified and addressed.

The following are the details (from 'uname –a') of the Linux machine used for this purpose.

```
Linux Linuxws03 2.6.17-1.2157_FC5 #1 SMP Tue Jul 11 22:53:56 EDT 2006 x86_64 x86_64 x86_64 GNU/Linux
```

In order to conform to the latest standards in Linux compilation, the GCC was upgraded from 4.1.1 to 4.5.2 by building the source and its dependencies. Argonne National Laboratory's (ANL) message passing interface (MPICH2) implementation and related tools were also upgraded to the latest stable version 1.4. Boost libraries were also built for version 1.47.0. The following is a list of the various builds tested:

- Static programs (static-linking)
- Dynamic programs (runtime shared-libraries)
- Static programs with Boost libraries
- Dynamic programs with Boost libraries
- Static programs with Boost libraries and MPI enabled
- Dynamic programs with Boost libraries and MPI enabled

The various software builds were successful except dynamic programs with Boost and MPI (#6 as identified above). Further work is underway to resolve this issue. AECOM was also able to build software optimized for the TRACC compute nodes ('-march=amdfam10') for testing and is in the process of running the various builds on TRACC to ensure proper execution.

AECOM will share its experience regarding this process with the project team to help ease the Linux build process for other software components of the project such as TransimsVIS, EvacNet etc. and to aid in establishing an automated build process on TRACC (similar to the one existing for Version 4) for TRANSIMS Version 5.

6.2.1.1. TRACC Implementation

TRANSIMS Version 5 enhancements include Message Passing Interface (MPI) based applications that can utilize multiple machines simultaneously for high performance data processing. AECOM developed routines to automate the process of generating TRANSIMS control files and creating batch files or shell scripts to submit jobs to the TRACC queue. AECOM tested these scripts and several MPI-based applications on the TRACC cluster and observed that the use of MPI applications with multiple processing nodes (computers) and multiple parts per node (cores) significantly improves performance. AECOM applied the tools for Router calibration runs using 24 nodes and 8 threads per node. This setup reduced the processing time for an iteration of the calibration run from over 3 hours to about 30 minutes.

6.2.1.2. Linux Builds

As part of an effort to reduce the processing times for TRANSIMS Version 5 programs on the TRACC cluster, AECOM explored different compilers and optimization level flags in order to utilize latent optimizations during software compilation. TRACC cluster compute nodes use AMD microprocessors instead of the relatively widely used INTEL microprocessors. AMD and INTEL processors have relative advantages and disadvantages over each other. For example, AMD processors are considered to be more efficient for floating point operations whereas INTEL processors are considered to be more efficient for integer and logical operations.

TRANSIMS software fundamentally relies heavily on integer operations; it converts floating point operations into scaled-up and then scaled-down integer operations. This approach is more suitable to INTEL processors. Additionally, TRACC cluster is known for their powerful I/O, incredibly quick communications between machines and large number of available compute nodes; however each node is usually slower than relatively new in-house workstations. AECOM's past experience was one of the motivations to try to create faster code to run on TRACC without changing the software code itself.

Typically, TRANSIMS Version 4 and Version 5 software has been compiled using GCC. TRACC also has a license for the Pathscale compiler, which is known to generate superior code for 64-bit Linux based systems. Combinations of compilers (GCC and Pathscale) including different versions and optimization flags (O2, O3) were tested to build Router.

These quick tests produced counter-intuitive results. TRANSIMS software dependencies include mpich2 libraries, boost libraries etc. The final executable depends heavily on these dependencies and the optimization of the TRANSIMS code and not the libraries may not result in a better final executable. AECOM plans to conduct further tests based on these observations to see if any particular combination of flags helps produce a significantly faster code for TRACC – a benefit that would otherwise be lost. Table 3.2 presents the various software builds that were tested and their performance statistics.

Table 6.2: MPI Router Run Time Comparison

	MPICH2 (1.3.2p1)	BOOST (1.46.1)	TRANSIMS	Run Time
1	GCC 4.5.2 target<>TRACC O2	GCC 4.5.2 target<>TRACC O2	GCC 4.5.2 target=TRACC O2	9 minutes
2	GCC 4.3.2 target=TRACC O3	GCC 4.3.2 target=TRACC O3	GCC 4.3.2 target=TRACC O3	21 minutes
3	Pathscale 3.2.99 target=TRACC O3	Pathscale 3.2.99 target=TRACC O3	Pathscale 3.2.99 target=TRACC O3	32 minutes
4	GCC 4.5.2 target=TRACC O2	GCC 4.5.2 target=TRACC O2	GCC 4.5.2 target=TRACC O3	?
5	Pathscale 3.2.99 target=TRACC O2	Pathscale 3.2.99 target=TRACC O2	Pathscale 3.2.99 target=TRACC O3	?

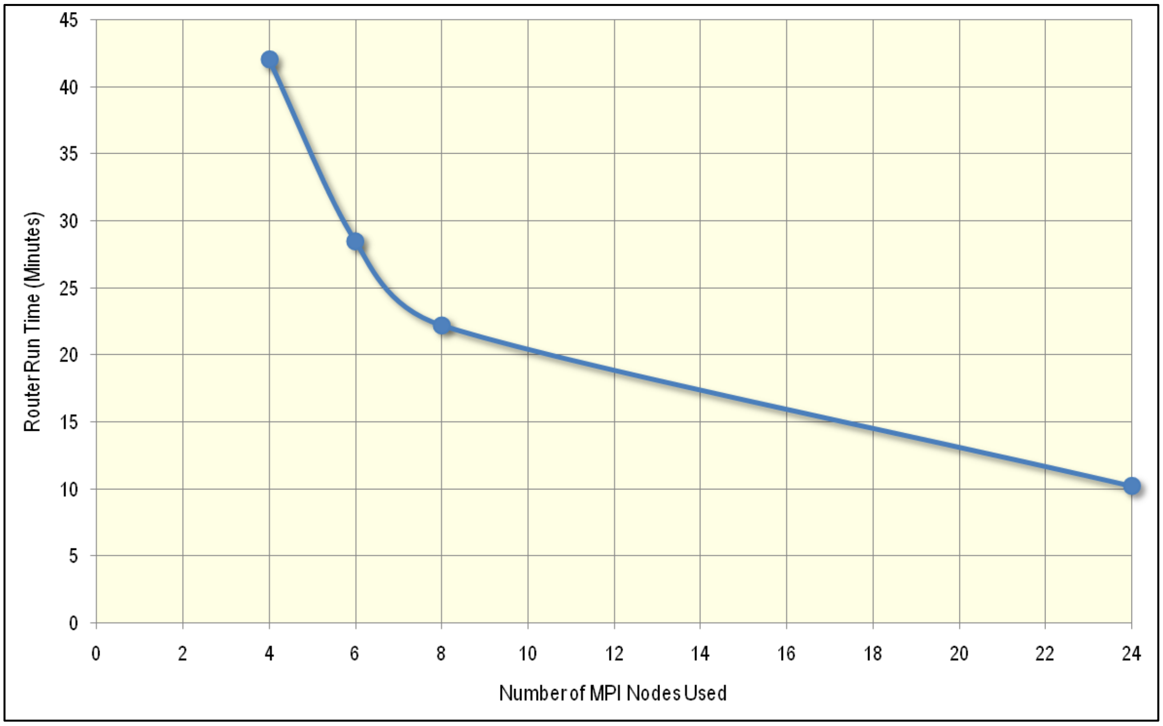
6.2.2. Parallel Computing and Threaded Software

6.2.2.1. MPI Performance

In order to better utilize the TRACC cluster and perform iterations quickly, MPI-based TRANSIMS programs are being used. Currently AECOM personnel's user accounts, the TRACC collaborator user (ac) account, are limited to the use of at most 24 computing nodes with 8 cores each. In order to utilize TRACC's full potential AECOM split the demand into 192 (24x8) parts for each iteration. Router stabilization runs are being conducted utilizing the MPI-based Router, PlanSum and PlanCompare programs. Previously, a Router iteration took 4 hours using 16 cores on AECOM's cluster, but now run time are reduced to 30 minutes using 192 cores on TRACC's cluster. AECOM performed MPI Router performance tests using 4, 6, 8, and 24 computing nodes. The results from these performance tests based on the MPI nodes utilized are presented in Figure 3.1. It was observed that the performance gain is not linear, however the use of 24 nodes does provide a performance gain.

Using 192 cores does provide some limitations on other TRACC users trying to use the cluster as 192 cores constitute almost 20% of the cluster and two normal day calibration applications running simultaneously use up almost 40% of available resources on the TRACC cluster. The benefits of using these resources when available are quite pronounced because calibration runs are much faster and the runs converge faster. Since the performance lost by reducing the computing nodes from 24 to 8 is only 50% i.e. run times double, AECOM used 8 nodes when running multiple case studies at the same time.

Figure 6.1: MPI Router Run Time Comparison



6.2.3. Version 5 Performance Testing

TRANSIMS Version 5 is capable of executing on multiple platforms (OS), architectures (32/64 bit), using threads and multiple machines. As part of performance testing for these various builds of the software, Simulator tests were performed on a 64 bit Windows 7 quad core machine with 12 GB of memory for the following:

- 32 bit, single threaded Simulator 4.0.79
- 32 bit, single threaded Simulator 5.0.5
- 64 bit, single threaded Simulator 5.0.5
- 64 bit, multiple threaded Simulator 5.0.5 (threads = 2-8)

Figure 3.2 presents run times, wait time problems, arrival time problems, and departure time problems for the various builds, Figure 3.3 presents average travel time and vehicle hours travelled for the various builds, and Figure 3.4 presents trips started and trips completed statistics for the various builds.

The Version 5 Simulator performs significantly better even as a single threaded application when compared to the Version 4. Additional performance increases can be achieved by adding processing threads. This performance increase asymptotes at four threads when using a four core processor. Wait time, arrival time, and departure time problems rise for Version 5 software when compared to Version 4, but these problems do not vary much when the number of threads is changed. The random number implementation is based on the machine's architecture and the differences in problem statistics could be attributed to the same. Almost all of the trips are started using the Version 5 software while only 95%

of the trips are started using the Version 4 software, but the Version 4 software enables more trips to be completed than Version 5.

Figure 6.2: Microsimulator Performance Testing – Problem Statistics

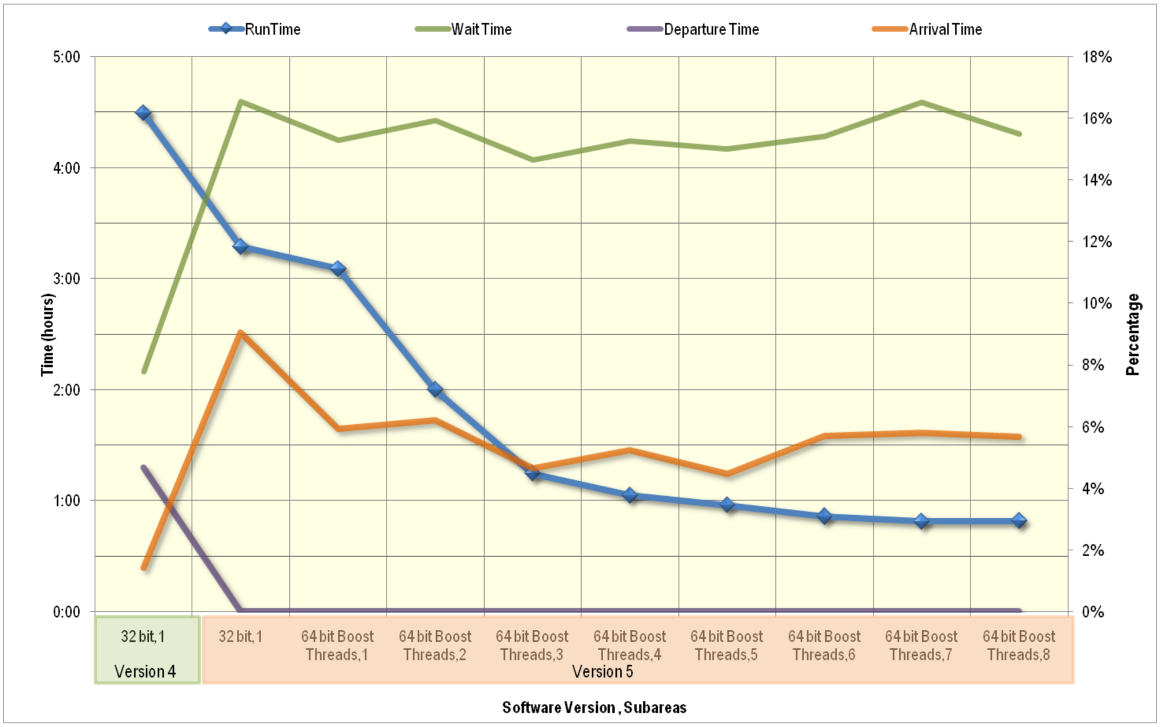


Figure 6.3: Microsimulator Performance Testing – Hours Traveled Statistcs

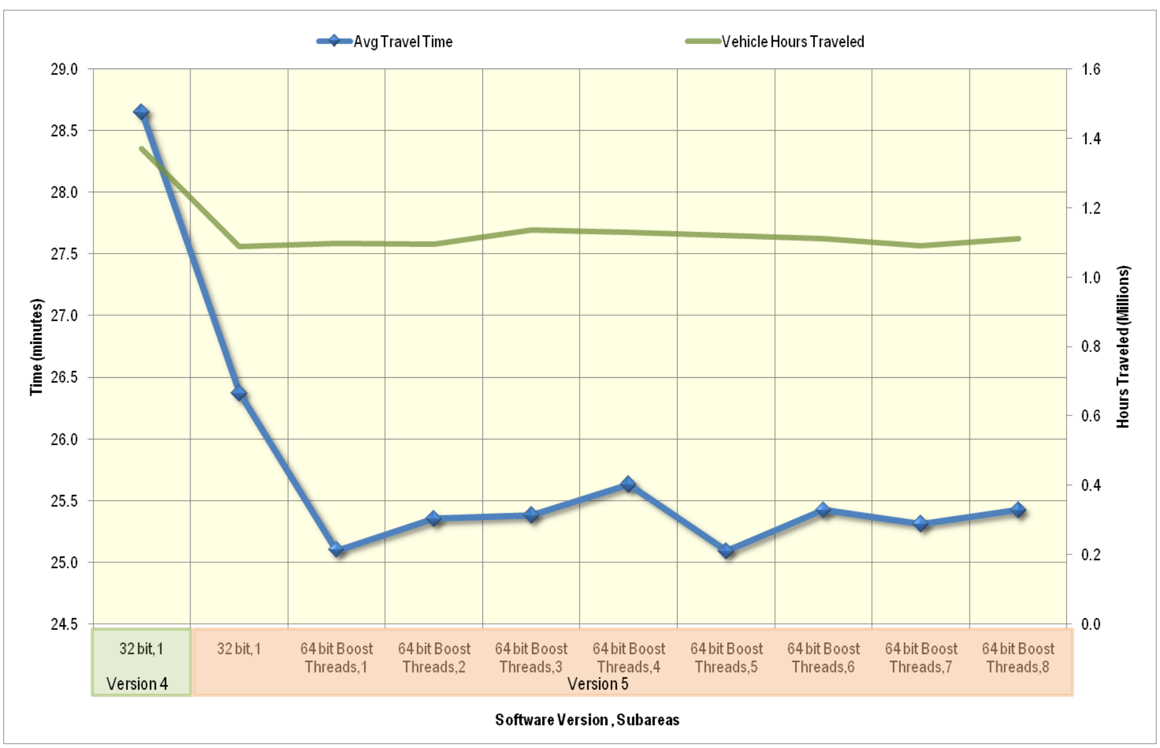
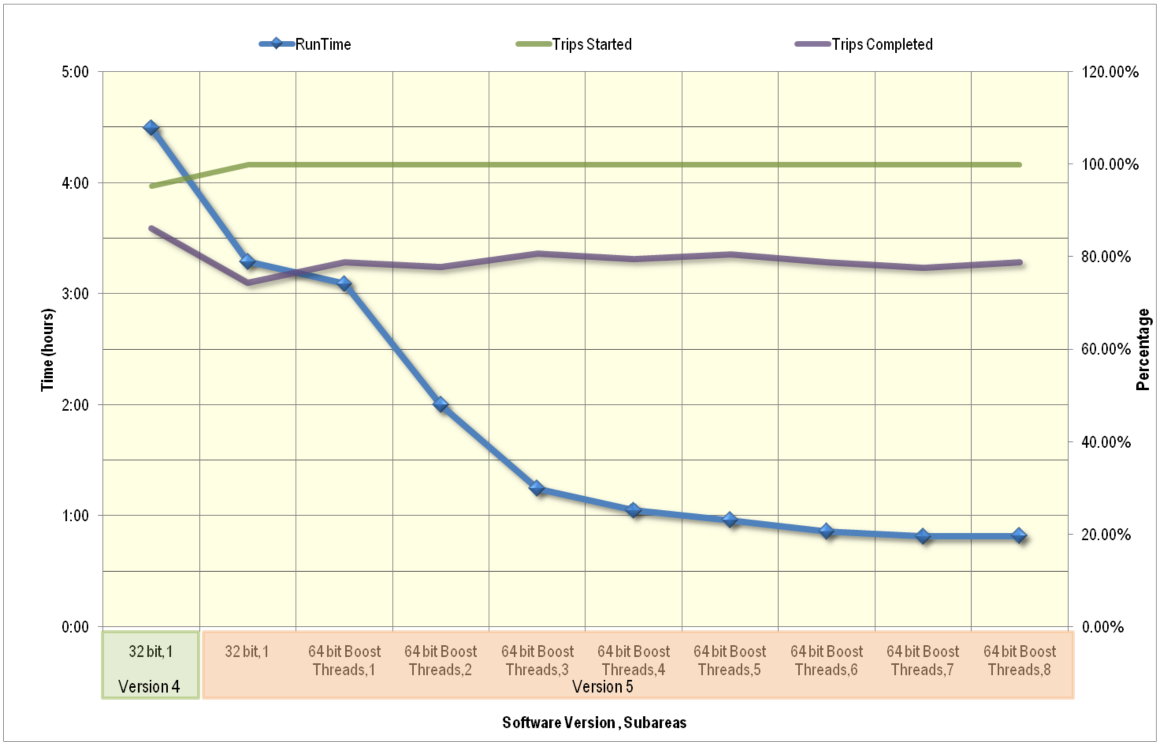


Figure 6.4: Microsimulator Performance Testing – Trip Statistics



6.2.4. MPI and Multi-threaded Simulator

AECOM conducted several tests to improve MPI-based and multi-threaded Simulator performance. These tests compared the performance measures from the MPI version of the Simulator to non-MPI versions. The initial MPI-based Simulator executions were much slower than the non-MPI Simulator executions. Other MPI-based TRANSIMS software such as the Router and plan processing are much faster as an MPI implementation. Since the Simulator needs to transport much larger datasets across machines when compared to the Router or plan processing software, a performance loss is expected and it occurs. This performance loss is partly due to bandwidth limitations, latency[1], application buffer limitations, synchronization delays, and message envelope[2] overhead. The Argonne MPI implementation for Windows, however, contains multiple MPI implementations. These implementations use different transport mechanism to communicate or pass data between different machines. While bandwidth limitations, latency, etc. cannot be overcome, each transport mechanism performs differently and a high performance transport mechanism can be chosen. In order to choose the best transport mechanism, AECOM tested the various implementations and observed that the use of the "thread safe" MPI implementation provides the best performance. The MPI-based Simulator is currently being refined to improve performance. In addition, AECOM is comparing performance statistics across the various builds of the software to ensure that they are consistent with each other. For example, the average speed for the transportation system across the various builds should be the same.

1 The time from the source sending a packet to the destination receiving it.
2 The overhead associated with sending a zero-byte message between two MPI machines.

As part of testing and debugging, AECOM executed several MPI-based and multi-threaded Simulator runs to compare performance statistics. The comparisons include:

- Run times for MPI-based multi-threaded Simulator when compared to
  - the single threaded Simulator, and
  - the multi-threaded Simulator.
- Performance statistics across various builds of the Simulator for the same scenario;
- Performance statistics for the same scenario and Simulator build executed twice to check if the results are replicated. The builds tested were:
  - the single threaded Simulator;
  - the multi-threaded Simulator; and
  - the MPI-based multi-threaded Simulator.

While the single threaded Simulator generated identical results and performance statistics when executed twice with the same random seed, the multi-threaded Simulator and the MPI-based multi-threaded Simulator did not replicate results and performance statistics. Though the performance statistics are similar, they are not identical. The differences occur because the partitions processed by different threads depend on data and results managed by other threads. If the operating system does not process the threads in the same order and with the same lock cycles, the conditions between partitions will not be the same which adds randomness to the results. During the Simulator execution, if the operating system requires additional processing power to receive an email or other application related task, then one of the Simulator threads will need to wait for the operating system to finish its task and release the processor back to the Simulator thread. The rest of the threads, however, do not need to wait for the operating system and they continue to simulate vehicles within the system. Since one of the threads has been delayed during this execution of the multi-threaded Simulator, the vehicles on the boundary links at that instant are processed differently for this execution when compared to an execution of the Simulator that is not interrupted by the operating system.

The Simulator has been modified to eliminate randomness during vehicle simulation and ensure that results and performance statistics are replicated. This modification involved processing or simulating the vehicles on the boundary links first using a two-pass procedure. During the first pass, each thread simulates the vehicles in its partition and shares the information with the other threads by writing the simulation details to shared memory. The threads are unaware of how other threads are processing vehicles until all the threads have finished their respective processing and have committed the simulation details to the shared memory. During the second pass the threads simulate all the other vehicles in the partition based on the knowledge gained from the first pass. This two-pass procedure ensures that the results, performance statistics and the simulation itself are identical when the same scenario is executed multiple times.

6.2.5. Simulator – Macroscopic vs. Mesoscopic

Macroscopic and mesoscopic simulation was developed and implemented by AECOM in the Simulator program. As opposed to mesoscopic simulation which encompasses car-following and lane changing information, macroscopic simulation is a queue-based approach to simulation. This approach is utilized for faster run times while generating comparable results to those from a mesoscopic simulation.

AECOM successfully completed executions of a macroscopic and mesoscopic simulation for the Chicago normal day model. When compared to mesoscopic simulation, the macroscopic simulation execution showed significant reduction in run time. While the mesoscopic method took nine hours, the macroscopic method took two hours and twenty minutes to complete a 24 hour simulation of the Chicago region. The faster macroscopic simulation vehicle speeds also lead to fewer problems meaning that the macroscopic simulation was not able to give an accurate picture of the normal day. Furthermore, tests revealed that a significant random slowdown was required to reduce the speeds to a reasonable level. Table 3.3 presents a comparison of macroscopic and mesoscopic simulation statistics.

Table 6.3: Comparison of Macroscopic and Mesoscopic Simulation statistics

Statistic	Macroscopic	Mesoscopic
Trips Removed	9,008	32,609
VHT	697,064	963,401
Average Travel Time	9.1 minutes	12.6 minutes
Wait Time Problems	9,006	27,326
Run time	27.85 minutes	54.75 minutes

6.2.6. Router – Time-Sorted Trips Assignment

Traditionally, Router has been used to update link delays dynamically to produce traffic assignments that are aware of time-of-day roadway capacities and speeds. This process has provided a better transition from routing to simulation than V/C-based Router iterations. Router link delay updates based on traveler sorted trip tables have not produced good results. Router link delay updates based on time sorted trip tables, however, are better since the trips are loaded chronologically and not randomly based on traveler ID. The routing of time sorted trip tables produces better capacity constrained assignments and also reduces the number of Router iterations.

Towards this end, four Router-based assignments were performed and validated with a time sorted trip table. These four tests are outlined below:

- All-or-nothing assignment: Router is not provided an input link delay and link delays are not updated. (Cold start without updates)
- Link delay updates only: Router is not provided an input link delay and link delays are updated after every 500 trips. (Cold start with updates)
- Input link delay and no updates: Router is provided an input link delay but the link delays are not updated (Warm start without updates)
- Input link delay and updates: Router is provided an input link delay and the link delays are updates after every 500 trips (Warm start with updates).

The runtimes and configurations for these runs using the threaded version of the Router were as follows:

- Cold start without updates: 0 partitions, 1 node, 8 threads, 0.1% prob., 03 hrs 06 min
- Cold start with updates (500 trips) 0 partitions, 1 node, 8 threads, 0.1% prob., 36 hrs 36 min
- Warm start without updates: 0 partitions, 1 node, 8 threads, 7.7% prob., 03 hrs 34 min
- Warm start with updates (500 trips) 0 partitions, 1 node, 8 threads, 2.1% prob., 30 hrs 12 min

The link delay file from the normal day model was used for the warm start Router tests. It is to be noted that it took several iterations to generate this link delay file and that it validates well. Figure 3.5 to Figure 3.8 present the validation reports for each of these test cases.

Figure 6.5: Cold Start – No Updates: Daily Validation

	Num.	--------VMT-------		---Difference---		--Abs.Error--		Std.	%
Facility Type	Obs.	Estimate	Observed	VMT	%	Avg.	%	Dev.	RMSE
FREEWAY	689	172037555	159758658	12278897	7.7	97371	42.0	171328	84.9
EXPRESSWAY	96	7823321	9210131	-1386810	-15.1	45646	47.6	48030	68.9
MAJOR	4406	136916554	151556162	-14639608	-9.7	15103	43.9	20045	73.0
MINOR	316	6619973	5755250	864723	15.0	9025	49.6	12266	83.5
COLLECTOR	150	1405239	1929489	-524250	-27.2	7110	55.3	8211	84.3
RAMP	71	1399999	1510280	-110281	-7.3	17035	80.1	32222	170.4
OTHER	44	1308655	1715232	-406577	-23.7	16128	41.4	20659	66.8
EXTERNAL	9	3612609	3005649	606960	20.2	67440	20.2	44059	23.7
TOTAL	5781	331123906	334440852	-3316947	-1.0	24989	43.2	67816	124.9

Figure 6.6: Cold Start –Updates @ 500 Trips: Daily Validation

	Num.	--------VMT-------		---Difference---		--Abs.Error--		Std.	%
Facility Type	Obs.	Estimate	Observed	VMT	%	Avg.	%	Dev.	RMSE
FREEWAY	689	172037555	159758658	12278897	7.7	97371	42.0	171328	84.9
EXPRESSWAY	96	7823321	9210131	-1386810	-15.1	45646	47.6	48030	68.9
MAJOR	4406	136916554	151556162	-14639608	-9.7	15103	43.9	20045	73.0
MINOR	316	6619973	5755250	864723	15.0	9025	49.6	12266	83.5
COLLECTOR	150	1405239	1929489	-524250	-27.2	7110	55.3	8211	84.3
RAMP	71	1399999	1510280	-110281	-7.3	17035	80.1	32222	170.4
OTHER	44	1308655	1715232	-406577	-23.7	16128	41.4	20659	66.8
EXTERNAL	9	3612609	3005649	606960	20.2	67440	20.2	44059	23.7
TOTAL	5781	331123906	334440852	-3316947	-1.0	24989	43.2	67816	124.9

Figure 6.7: Warm Start – No Updates: Daily Validation

	Num.	--------VMT-------		---Difference---		--Abs.Error--		Std.	%
Facility Type	Obs.	Estimate	Observed	VMT	%	Avg.	%	Dev.	RMSE
FREEWAY	689	166636951	159758658	6878293	4.3	89941	38.8	133767	69.5
EXPRESSWAY	96	9120925	9210131	-89206	-1.0	46051	48.0	62853	80.9
MAJOR	4406	145917823	151556162	-5638339	-3.7	13382	38.9	17019	62.9
MINOR	316	4974323	5755250	-780928	-13.6	8373	46.0	11195	76.7
COLLECTOR	150	1208119	1929489	-721370	-37.4	6635	51.6	8011	80.7
RAMP	71	1325337	1510280	-184943	-12.2	15472	72.7	29692	156.5
OTHER	44	1395925	1715232	-319307	-18.6	16157	41.4	20160	65.8
EXTERNAL	9	3558487	3005649	552838	18.4	63110	18.9	41334	22.2
TOTAL	5781	334137890	334440852	-302962	-0.1	22725	39.3	55460	103.6

Figure 6.8: Warm Start – Updates @ 500 Trips: Daily Validation

Facility Type	Num. Obs.	VMT Estimate	VMT Observed	Difference VMT	Difference %	Abs.Error Avg.	Abs.Error %	Std. Dev.	% RMSE
FREEWAY	689	171942475	159758658	12183817	7.6	91782	39.6	153509	77.1
EXPRESSWAY	96	8721637	9210131	-488494	-5.3	48411	50.5	58887	79.2
MAJOR	4406	144490844	151556162	-7065318	-4.7	13096	38.1	16563	61.4
MINOR	316	5749138	5755250	-6112	-0.1	7143	39.2	9815	66.6
COLLECTOR	150	1372296	1929489	-557193	-28.9	6805	52.9	8045	81.8
RAMP	71	1327729	1510280	-182551	-12.1	15573	73.2	29799	157.2
OTHER	44	1348431	1715232	-366801	-21.4	16097	41.3	20436	66.3
EXTERNAL	9	3596385	3005649	590735	19.7	65637	19.7	43860	23.2
TOTAL	5781	338548936	334440852	4108083	1.2	22707	39.2	61386	113.1

The comparison of validations for the four tests showing percent difference (observed – estimated) and percent RMSE is presented in Table 3.4.

Table 6.4: Router Tests Comparison

		Percentage Difference				% RMSE			
Functional Class	Num Obs.	Cold Start		Warm Start		Cold Start		Warm Start	
		No Updates	With Updates	No Updates	With Updates	No Updates	With Updates	No Updates	With Updates
FREEWAY	689	7.7	7.7	4.3	7.6	84.9	84.9	69.5	77.1
EXPRESSWAY	96	-15.1	-15.1	-1.0	-5.3	68.9	68.9	80.9	79.2
MAJOR	4,406	-9.7	-9.7	-3.7	-4.7	73.0	73.0	62.9	61.4
MINOR	316	15.0	15.0	-13.6	-0.1	83.5	83.5	76.7	66.6
COLLECTOR	150	-27.2	-27.2	-37.4	-28.9	84.3	84.3	80.7	81.8
RAMP	71	-7.3	-7.3	-12.2	-12.1	170.4	170.4	156.5	157.2
OTHER	44	-23.7	-23.7	-18.6	-21.4	66.8	66.8	65.8	66.3
EXTERNAL	9	20.2	20.2	18.4	19.7	23.7	23.7	22.2	23.2
TOTAL	5,781	-1.0	-1.0	-0.1	1.2	124.9	124.9	103.6	113.1

These tests were not part of the normal day model runs and hence a good validation is not expected; however, relative comparisons of these tests help in understanding the different processes used to build the link delay information which is used for routing travelers. It is observed that the warm-start runs validate better, and the warm-start run without updates provides the best validation. It is important to note that the link delay file used as an input to the warm start runs was generated as part of the normal day and it validates well. It should also be noted that a single cold-start application of the Router with link delay updates produces good results though the Router run time is very high and equivalent to a typical set of Router iterations required for the normal day model to stabilize. In addition, a single Router application produces a time dependent all-or-nothing traffic assignment while travelers' behavior in the real world has been observed to be stochastic. Router-PlanCompare iterations produce a stochastic assignment by limiting the number of travelers that are re-routed between iterations.

Evacuee behavior during an evacuation, however, is similar to a time dependent all-or-nothing traffic assignment. The aforementioned tests were conducted to lay the foundation for evacuation routing and subsequent simulation. This concept will be extended to the evacuation case studies to enable a cleaner evacuation simulation.

AECOM performed simulation test runs to evaluate each of the Router runs. Table 3.5 presents performance statistics for each of these simulation runs. The warm start run with updates has the least number of problems and less than half the wait time problems of any other run.

Table 6.5: Macro-Simulation Test Results

Scenario	Run Time	Input Trips	Total Prob.	Wait Prob.	Load Prob.	Arrival Prob.
Cold-NoUp	3:43:38	27,098,050	14,027,195	85,672	892	37,840
Cold-500Up	3:43:34	27,098,050	14,118,946	84,713	865	38,456
Warm-NoUp	3:31:26	25,032,071	14,011,770	154,816	4,577	26,618
Warm-500Up	3:36:05	26,563,299	7,946,453	34,133	58	7,599

7. Normal Day TRANSIMS Model

7.1. Model Conversion from Version 4 to Version 5

The existing Chicago TRANSIMS model (version 008) files from the Illinois Institute of Technology (IIT) study were converted to Version 5 using NewFormat. These converted model files were used as inputs to both Router and Microsimulator successfully. In addition, a subarea version of the model was created and tested with Router and Microsimulator. The main advantage of Version 5 is reduced run times when using the multi-threaded implementations. Performance tests using ten percent demand showed a reduction in run time from 3 hours to 0.6 hours when using ten subareas and four threads. With message passing interface (MPI) based software, the Chicago normal day model is capable of using multiple machines..

7.2. Model Unit Conversion from Metric to English

The Chicago TRANSIMS model was converted from Metric units to English units using NewFormat. Some initial issues were encountered during this conversion process that required NewFormat to be modified. Partial (10%) demand conversions were successful, but an updated version of NewFormat was required to successfully convert the 4GB, 27.1 million trip demand file. Table 4.1 presents a snapshot of the English and Metric versions of the Link file and Figure 4.1 presents part of the English and Metric versions of the Microsimulator control file. Once the demand and supply files were converted to English units, the control files were manually updated. It should be noted that the default unit system for UTM projection is metric so it is important to use UTM feet as the input coordinate system in order to ensure that the output shape files are projected correctly. The output shape files were projected using the NAD 1983 State Plane Illinois East (FIPS 1201) coordinate system.

Table 7.1: English and Metric Versions of the Link File

English

1	LINK	NODE_A	NODE_B	LENGTH	SETBACK_	SETBACK_	SPEED_AB	FSPD_AB	SPEED_BA	FSPD_BA
19	18	5001	5005	710.3	59.1	59.1	40.3	29.9	0	0
20	19	5001	80509	338.3	59.1	59.1	80.5	64.1	0	0
21	20	5002	5006	694.9	59.1	59.1	0	0	40.3	29.8

Metric

1	LINK	ANODE	BNODE	LENGTH	SETBACK_	SETBACK_	SPEED_AB	FSPD_AB	SPEED_BA	FSPD_BA
19	18	5001	5005	216.5	18	18	18	13.4	0	0
20	19	5001	80509	103.1	18	18	36	29.1	0	0
21	20	5002	5006	211.8	18	18	0	0	18	13.4

Figure 7.1: English and Metric Versions of the Control File

```
UNITS_OF_MEASURE                METRIC
CELL_SIZE                       6.0 meters
TIME_STEPS_PER_SECOND           1
TIME_OF_DAY_FORMAT              HOUR_CLOCK
SIMULATION_START_TIME           0:00
SIMULATION_END_TIME             27:00
SPEED_CALCULATION_METHOD        CELL-BASED

PLAN_FOLLOWING_DISTANCE         650 meters
LOOK_AHEAD_DISTANCE             260 meters
LOOK_AHEAD_LANE_FACTOR          4.0
LOOK_AHEAD_TIME_FACTOR          1.0
MAXIMUM_SWAPPING_SPEED          24 mps
MAXIMUM_SPEED_DIFFERENCE        6 mps
ENFORCE_PARKING_LANES           TRUE
```

→

```
UNITS_OF_MEASURE                ENGLISH
CELL_SIZE                       15 feet
TIME_STEPS_PER_SECOND           1
TIME_OF_DAY_FORMAT              HOUR_CLOCK
SIMULATION_START_TIME           0:00
SIMULATION_END_TIME             27:00
SPEED_CALCULATION_METHOD        CELL-BASED

PLAN_FOLLOWING_DISTANCE         1700 feet
LOOK_AHEAD_DISTANCE             850 feet
LOOK_AHEAD_TIME_FACTOR          1.0
LOOK_AHEAD_LANE_FACTOR          4.0
MAXIMUM_SWAPPING_SPEED          80 mph
MAXIMUM_SPEED_DIFFERENCE        15 mph
ENFORCE_PARKING_LANES           YES
```

There were no noted negative impacts of the unit conversion. The statistics from Router and Simulator were almost identical to statistics from the runs using metric units including vehicle problems and average travel time. The run times for the English unit runs for both programs were also comparable to the runs using Metric units.

7.3. Highway Network

AECOM reviewed the network and checked the freeway and ramp coding. Freeways closer to the CBD were checked first and then the search expanded outwards. Sections that needed to be edited were prioritized based on proximity to downtown and the proposed evacuation sites. A list of modifications was provided to ANL/IIT for implementation.

7.3.1. Freeway Network Edits

Some of the network details that were examined as part of the freeway edits are as follows:

- Freeway alignment when compared to satellite images
- Merge/diverge sections
- Ramp shapes (loop)
- Reversible links
- Ramp pocket lane length information
- Toll plazas
- Number of lanes (mainline & ramps)
- Turn restrictions

7.3.1.1. TRANSIMS Links Shapes

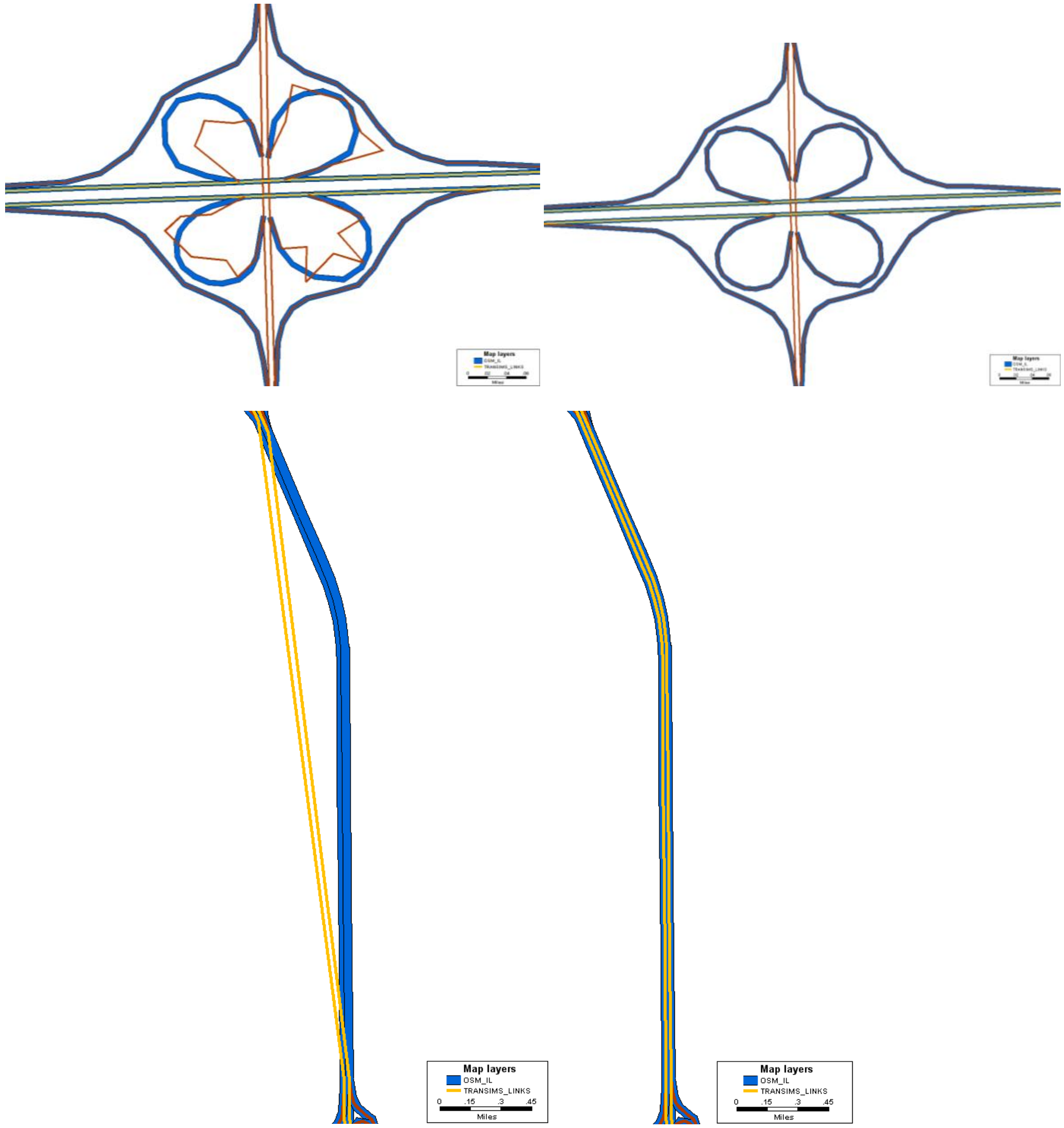
The decision was made to shape freeway and ramp links to help improve automatic lane connectivity and thus improve the simulation of traffic. This process is necessary to alleviate left versus right ramp connection problems and to remove acute and improbable turning connections. In addition, while shaping links throughout the network, missing links and ramps or awkward link configurations can be identified to be fixed by Argonne. The ability to identify problems as well as having a realistic network will make network maintenance easier and when visualizations are created, they will be much more realistic especially when used in conjunction with satellite imagery.

Rather than using a TRANSIMS program or ArcMap, TransCAD's conflation tool was used to reshape the links because of its ease of use. TRANSIMS links and OSM links were loaded into TransCAD and a one-to-one relationship between each TRANSIMS freeway/ramp link and its corresponding OSM link was established. OSM links were merged or split before processing to ensure a perfect match. A script was written based on TransCAD's conflation tool to automate the shaping process for multiple links.

Argonne spatially aligned OSM nodes with TRNAIMS nodes before this process was conducted. This process ensured that TRANSIMS node coordinates were preserved. Google Maps and Google Earth were used to check that links were correctly matching the real word.

Figure 4.2 shows two examples of the reshaping process. The first example shows ramps being identified as needing to be reshaped, then being selected for processing by the macro and then the final, shaped ramps. The second example shows a freeway link being shaped in the same process as the ramp links. The brown and yellow links are TRANSIMS links that were shaped to match the OSM links (shown in blue).

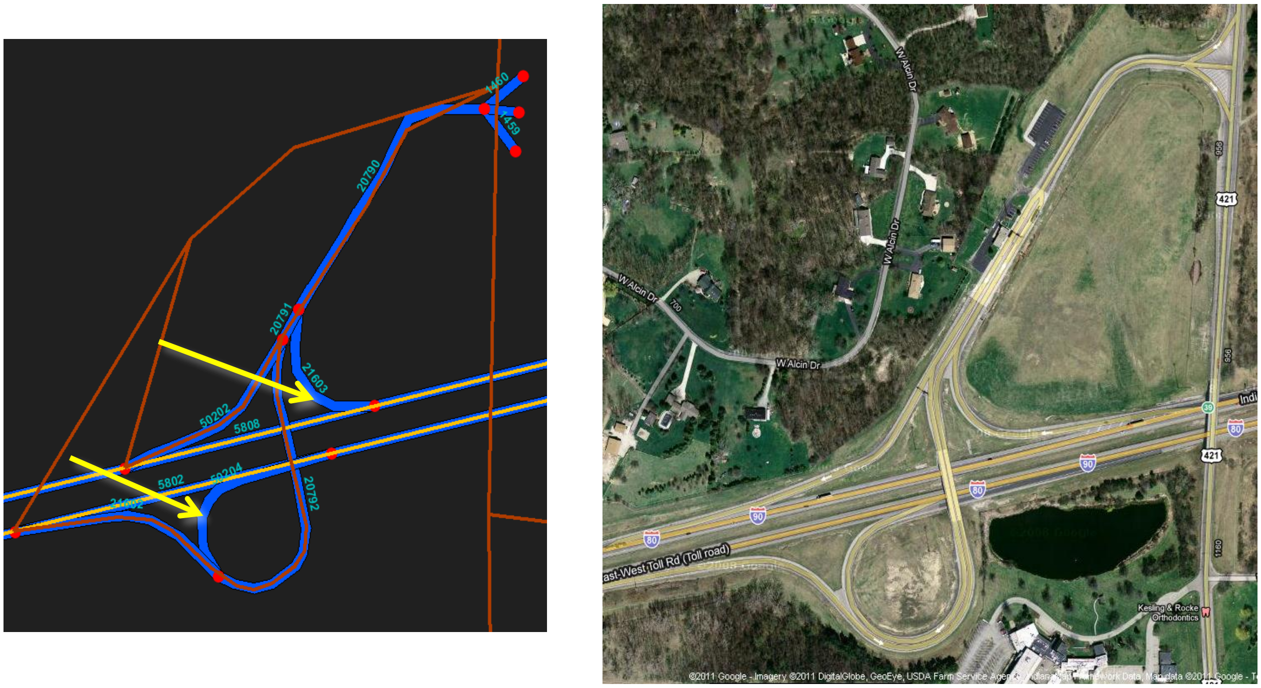
Figure 7.2: Link Reshaping Process



7.3.1.2. <u>Network Errors</u>

Throughout the reshaping process, network errors involving ramp and freeway links were identified. Over 30 network errors were identified and this information was shared with ARGONNE along with the shaped TRANSIMS files. TransimsEDT, the TRANSIMS network editor, was then used by ARGONNE to make the required edits. A sample for a network error is presented in Figure 4.3. Two ramps were coded to the incorrect BNODE, creating an improbable interchange that will impact traffic simulation.

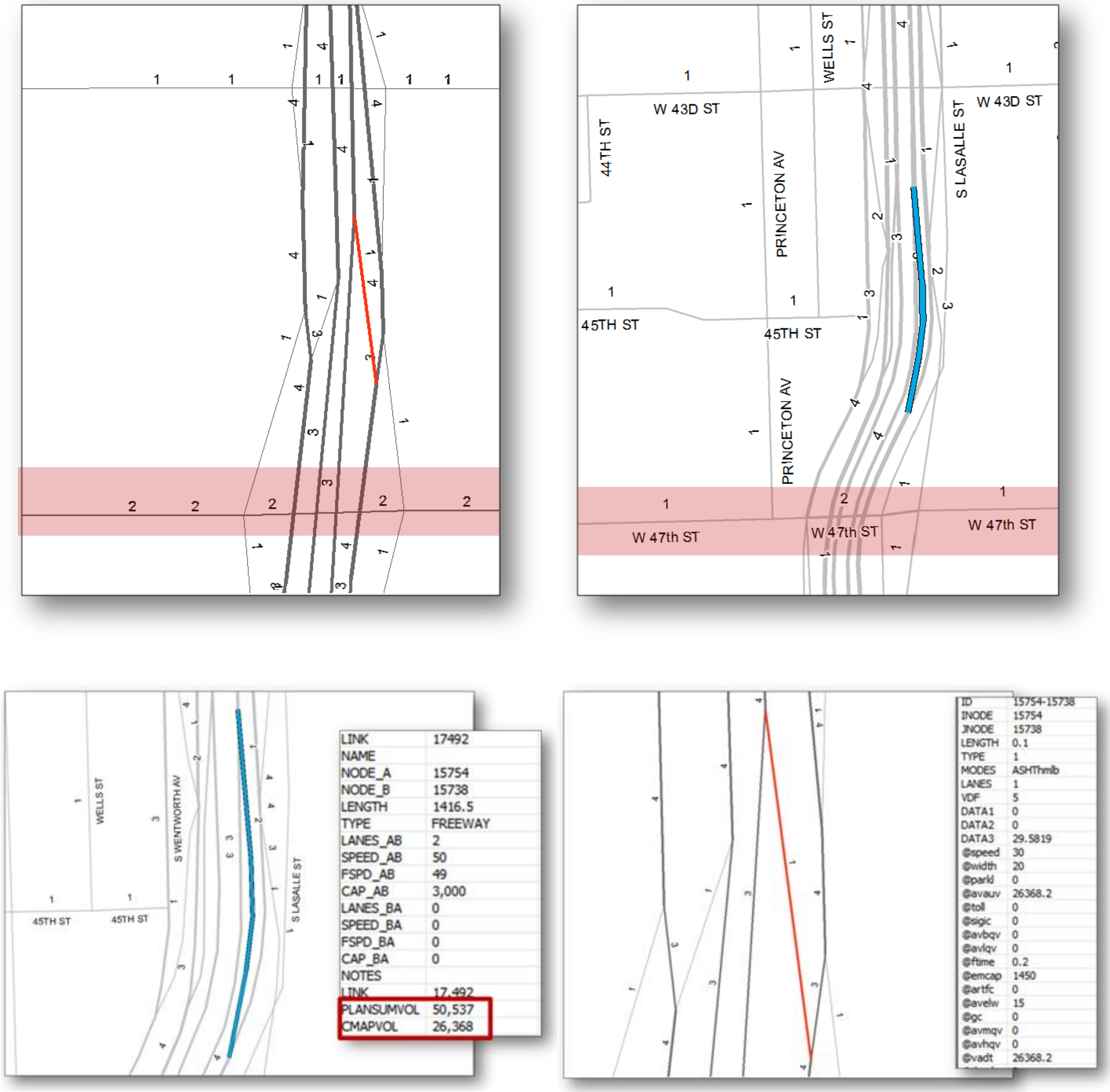
Figure 7.3: Network Errors



7.3.1.3. Network Differences

AECOM compared the CMAP EMME2 network link attributes to the TRANSIMS network link attributes and observed that the number of lanes coded in the EMME2 network is higher than the roadway travel lanes in the real world and the number of lanes coded in the TRANSIMS network. Since the EMME2 network does not include all the streets, it is believed that some of the links have been coded with a higher number of lanes to account for lost capacity. Figure 4.4 presents an example of such a network coding difference. Since capacity influences the amount of traffic that can be loaded on a link during traffic assignment, the EMME2 and TRANSIMS assignments produce different traffic volumes. The traffic volumes are different not only on the links with the differences but also on other links in the vicinity.

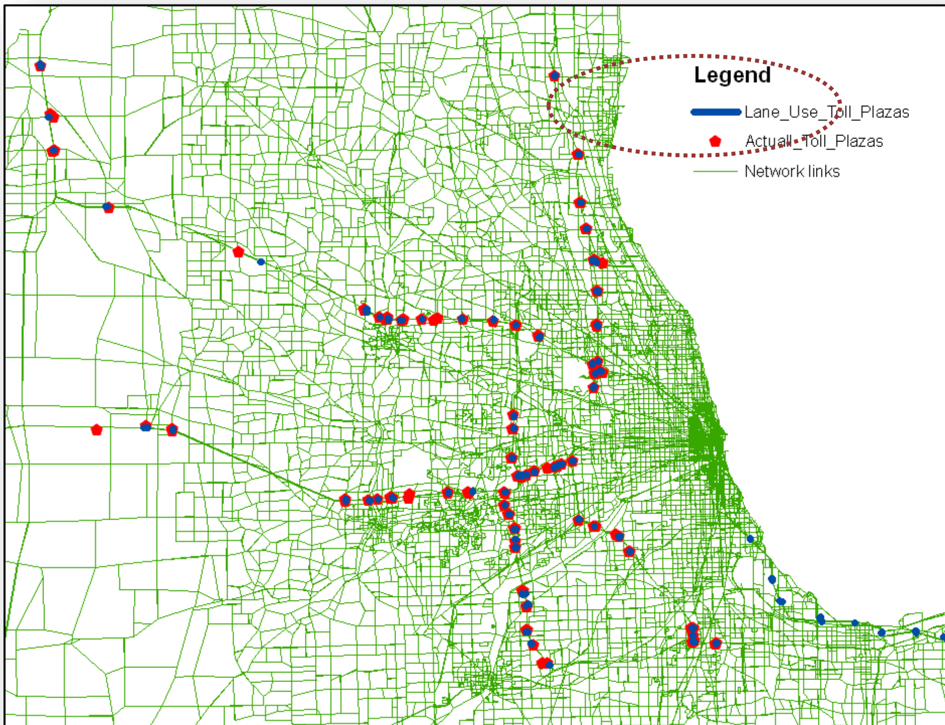
Figure 7.4: Network Differences – EMME2 v. TRANSIMS

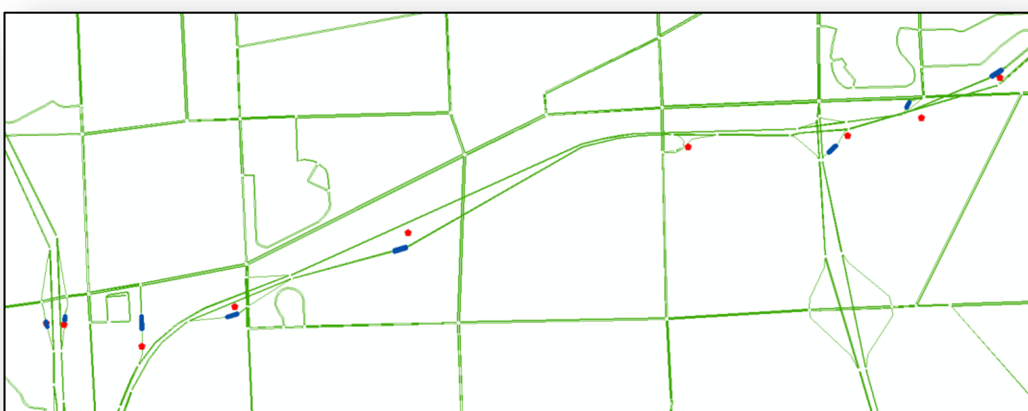


7.3.2. Toll Links

The Chicago region contains a number of toll roads and toll booths. It is essential to ensure that toll collection locations and toll fees are coded accurately into the network. Toll fees in Chicago vary by vehicle type (number of axles) and by type of collection (electronic or cash). The auxiliary files obtained from the Chicago Metropolitan Agency for Planning (CMAP) as part of the highway network contains toll collection location information along with toll information. This information was extracted and converted to a TRANSIMS lane use file. The accuracy of this lane use file was visually inspected using data available at www.illinoisvirtualtollway.com. A GIS layer was downloaded from this location which contained attribute information pertaining to toll plaza name, type (ramp, staffed ramp, or mainline), nearest milepost, direction, toll fees for passenger cars, trucks and tolls by payment type (cash or card). Figure 4.5: shows the location of toll plazas based on the lane use file and downloaded GIS layer. While most of the toll collection locations are accurate, the locations of a few toll booths need to be refined. AECOM edited the network to refine the locations of these toll booths.

Figure 7.5: Toll Plazas: Locations' Inspection

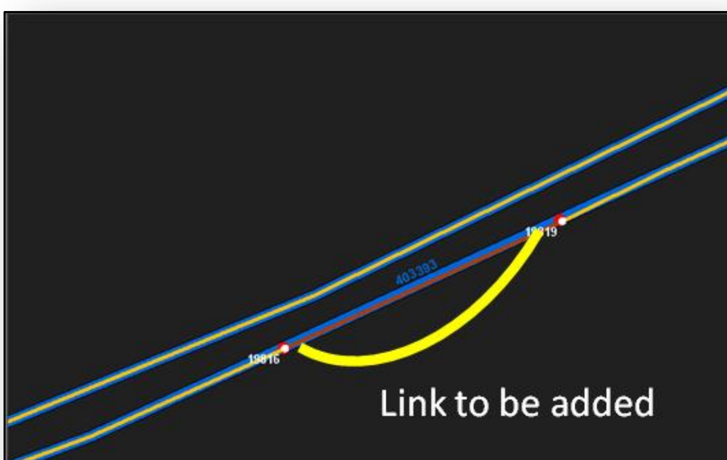




7.3.2.1. Cash Toll Booths

As part of the freeway and ramp network shaping process described in the previous section, AECOM identified that cash toll booths are to be coded as 'jug-handles' in order to ensure that the real world is replicated. Traffic simulation for these locations would be more realistic since the 'jug-handles' would allow for queues to build up for travelers paying tolls using cash without interfering with travelers paying tolls electronically. Figure 4.6 presents a Google maps satellite image of a cash toll booth location that is to be coded as a 'jug-handle' in the TRANSIMS network. Argonne refined the TRANSIMS network to include a more realistic representation of cash toll booth locations.

Figure 7.6: Cash Toll Both Network Edits



7.3.2.2. Lane Use File for Toll Information

Router builds paths based on impedance and tolls are an important part of the impedance calculation. Hence, it is important to correctly assign tolls links using the lane use file. The lane use file can also be used for other purposes, such as the management of reversible lanes. The CMAP EMME2 network contains toll information.

This section describes steps taken to create a new lane use file that correctly represents toll values by both vehicle type and payment type. Figure 4.7 presents a sample from this website showing tolls by vehicle type and payment type. Toll rates for truck vehicles, however, do not vary by payment type but vary by time of day. AECOM and Argonne rectified the network by classifying links as ‘cash’, ‘I-PASS’, or ‘both’ and added cash toll booth links to replicate the real world. Argonne performed most of the network edits while AECOM helped create the link attributes and the lane use file. Figure 4.8 presents a map showing toll links by payment type.

Figure 7.7: Toll Rates for Interstate 90

Jane Addams Memorial Tollway, Interstate 90

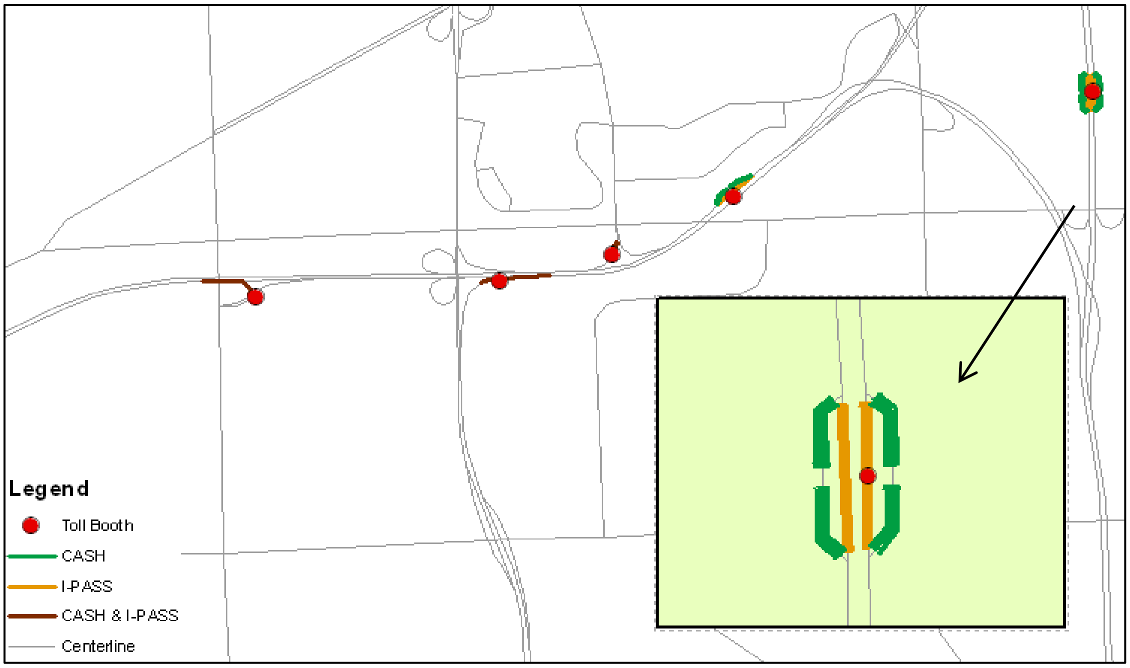
Toll Plaza Name	Plaza No.	Autos		Trucks					
		All Times (I-PASS)	All Times (Cash)	Daytime (Cash & I-PASS)			Overnight (Cash & I-PASS)		
				Small	Medium	Large	Small	Medium	Large
South Beloit Toll Plaza	1	$0.50	$1.00	$1.90	$2.85	$5.00	$1.25	$2.20	$3.75
East Riverside Blvd.	*2	$0.30	$0.60	$1.15	$1.70	$3.00	$0.75	$1.35	$2.25
Illinois 173	*4	$0.30	$0.60	$1.15	$1.70	$3.00	$0.75	$1.35	$2.25
Belvidere Toll Plaza	5	$0.80	$1.60	$3.00	$4.50	$8.00	$2.00	$3.50	$6.00
Marengo-Hampshire Toll Plaza	7	$0.80	$1.60	$3.00	$4.50	$8.00	$2.00	$3.50	$6.00
Randall Road	*8	$0.30	$0.60	$1.15	$1.70	$3.00	$0.75	$1.35	$2.25
Elgin Toll Plaza	9	$0.40	$0.80	$1.50	$2.25	$4.00	$1.00	$1.75	$3.00

*Unattended plazas - I-PASS, E-ZPASS, or exact coins only. No receipts.
Missed a Toll? Pay Online.
Bold lettering designates Mainline Toll Plazas.

Daytime and Overnight Hours

Daytime = 6:00 AM - 10:00 PM
Overnight = 10:00 PM - 6:00 AM

Figure 7.8: Toll Links by Payment Type



It should be noted that travelers have been split to cash or I-PASS travelers using a script during the demand conversion process with 80% (I-PASS) to 20% (cash). I-PASS travelers use vehicle type codes less than 60 and cash travelers use vehicle type codes greater than 60.

AECOM obtained a point shape file containing toll booth locations from www.illinoistollway.com. This file was overlaid on the TRANSIMS link shape file to develop a relationship between the toll booths the toll links in the TRANSIMS link database. A set of MS Access queries and scripts were used to generate toll lane use record for each vehicle type and payment type. Table 4.2 presents a partial snapshot of the lane use file generated using this process. The following enumerates I-PASS only or Cash only link lane use file records:

- One record for each auto vehicle type,
- One record for medium trucks for each of the three time periods;
- One record for heavy trucks for each of the three time periods; and
- One record to prohibit cash travelers from using I-PASS lanes and vice versa.

The following enumerates I-PASS and Cash only link lane use file records:

- One record for each auto vehicle and payment type,
- One record for medium trucks for each of the three time periods; and
- One record for heavy trucks for each of the three time period.

It is important to understand how TRANSIMS applies the lane use file records. The records are processed in the order they appear in the lane use file and the first record that matches the link, lane, use type, vehicle type, and time period is applied. If any of the subsequent records present a conflict, the information read from the first record is not overridden. For example, if the third lane use record prohibits all vehicles for all time periods, the information from the first records is kept and all other vehicle types that are not listed in the first two records are prohibited. In addition, vehicle types listed in the first two records for all other time periods that are not listed in the first two records are prohibited.

Table 7.2: Sample Records from the Final Lane Use File

LINK	DIR	LANES	TYPE	USE	MIN TYPE	MAX TYPE	START	END	LENGTH	OFFSET	TOLL	TOLL RATE	MIN DELAY	MAX DELAY	NOTES
108	0	0	APPLY	ANY	11	20	0:00:00	1@3:00	0	0	50	0	0	0	I-PASS
108	0	0	APPLY	ANY	21	22	0:00:00	6:00:00	0	0	220	0	0	0	I-PASS
108	0	0	APPLY	ANY	21	22	6:00:00	22:00:00	0	0	285	0	0	0	I-PASS
108	0	0	APPLY	ANY	21	22	22:00:00	1@3:00	0	0	220	0	0	0	I-PASS
108	0	0	APPLY	ANY	23	24	0:00:00	6:00:00	0	0	375	0	0	0	I-PASS
108	0	0	APPLY	ANY	23	24	6:00:00	22:00:00	0	0	500	0	0	0	I-PASS
108	0	0	APPLY	ANY	23	24	22:00:00	1@3:00	0	0	375	0	0	0	I-PASS
108	0	0	PROHIBIT	ANY	60	80	0:00:00	1@3:00	0	0	0	0	0	0	I-PASS
86127	0	0	APPLY	ANY	61	70	0:00:00	1@3:00	0	0	150	0	0	0	CASH
86127	0	0	APPLY	ANY	71	72	0:00:00	6:00:00	0	0	330	0	0	0	CASH
86127	0	0	APPLY	ANY	71	72	6:00:00	22:00:00	0	0	425	0	0	0	CASH
86127	0	0	APPLY	ANY	71	72	22:00:00	1@3:00	0	0	330	0	0	0	CASH
86127	0	0	APPLY	ANY	73	74	0:00:00	6:00:00	0	0	565	0	0	0	CASH
86127	0	0	APPLY	ANY	73	74	6:00:00	22:00:00	0	0	750	0	0	0	CASH
86127	0	0	APPLY	ANY	73	74	22:00:00	1@3:00	0	0	565	0	0	0	CASH
86127	0	0	PROHIBIT	ANY	10	30	0:00:00	1@3:00	0	0	0	0	0	0	CASH
170	0	0	APPLY	ANY	11	20	0:00:00	1@3:00	0	0	30	0	0	0	CASH & I-PASS
170	0	0	APPLY	ANY	21	22	0:00:00	6:00:00	0	0	135	0	0	0	CASH & I-PASS
170	0	0	APPLY	ANY	21	22	6:00:00	22:00:00	0	0	170	0	0	0	CASH & I-PASS
170	0	0	APPLY	ANY	21	22	22:00:00	1@3:00	0	0	135	0	0	0	CASH & I-PASS
170	0	0	APPLY	ANY	23	24	0:00:00	6:00:00	0	0	225	0	0	0	CASH & I-PASS
170	0	0	APPLY	ANY	23	24	6:00:00	22:00:00	0	0	300	0	0	0	CASH & I-PASS
170	0	0	APPLY	ANY	23	24	22:00:00	1@3:00	0	0	225	0	0	0	CASH & I-PASS
170	0	0	APPLY	ANY	61	70	0:00:00	1@3:00	0	0	60	0	0	0	CASH & I-PASS
170	0	0	APPLY	ANY	71	72	0:00:00	6:00:00	0	0	135	0	0	0	CASH & I-PASS

7.3.3. Link Detail Data

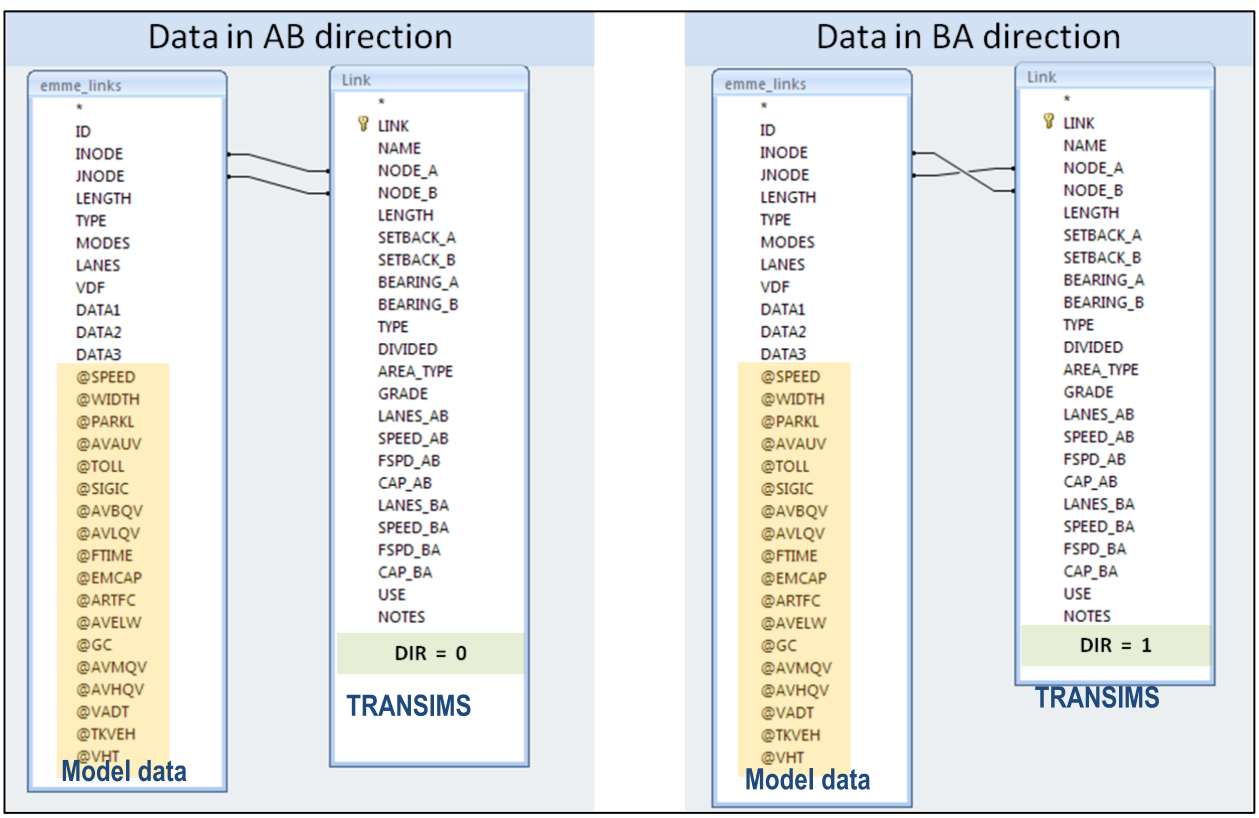
The Chicago Metropolitan Agency for Planning (CMAP) provided an EMME2 network containing ESRI shape files and DBASE files of loaded networks for the AM peak, PM peak and daily time periods. The daily time period files were used to aid in the creation of a link detail file. The CMAP model network files contain auxiliary items that are useful to build the TRANSIMS network. These data items include:

- Posted speed limit
- Lane widths
- Links where Parking is allowed
- De facto left turn lanes
- Toll (dollars)
- Signalized intersections
- Estimated volumes
- Observed volumes.

The link detail file stores auxiliary data items that are not included in the input link file. These data items are used by TransimsNet to create pocket lanes, parking restrictions, and signalized intersections.

The link detail file is used to create network details and reduce the amount of synthetic network details. Figure 4.9 presents a relational representation of the data extraction process used to create the link detail file.

Figure 7.9: CMAP Model Auxiliary Data Extraction Process



7.3.3.1. Pocket Lanes

Illinois Institute of Technology (IIT) coded pocket lane details for all the freeways and ramps in the Chicago region. This data was provided as excel spreadsheets. AECOM prepared automated routines to convert the pocket lane information into a lane use file format. Figure 4.10 presents this process. AECOM is also in the process of enhancing TransimsNet to process the link detail file.

Figure 7.10: Link Detail File Processing

LINK	DIR	CONTROL	LEFT CHECK	LEFT	LEFT THRU	THRU	RIGHT	RIGHT THRU	RIGHT CHECK
10277	1	0	C	0	0	2	1,T,10%	0	C
10479	0	0	C	0	0	5	1,T,50% ;1,M,50%	0	U

SQL

```
IIf(InStr([Right1],',')>0,Mid([right1],InStr([right1],',')+1,InStrRev([right1],',')-3)) as RightType1,
IIf(InStr([Right1],',')>0,Left([right1],1)) as RightLanes1,
IIf(InStr([Right1],',')>0,Right([right1], 1 + Len([right1]) - InStrRev([right1],',')-1)) as RightPercent1,
IIf(InStr([RIGHT],';') >0,Left([RIGHT],InStr([RIGHT],';')-1),) AS Right1,
```

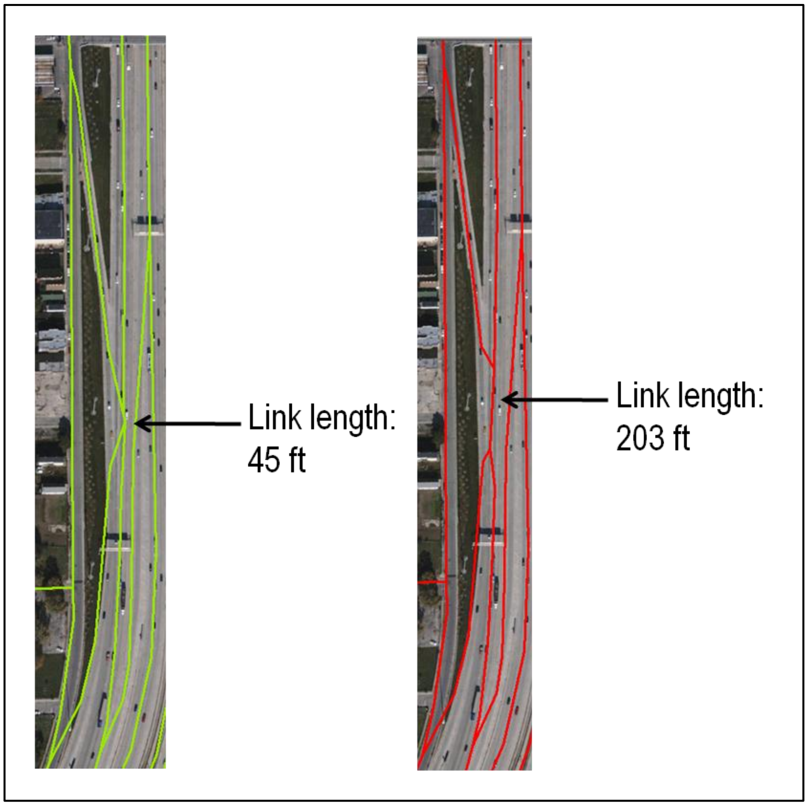
LINK	Dir	SIDE	POCKET	POCKET LANES	POCKET LANE PERCENT
10277	1	RIGHT	T	1	10%
10479	0	RIGHT	T	1	50%
10479	0	RIGHT	M	1	50%

7.3.4. Short Links

If the link lengths for a link do not match the true shape lengths, Simulator snapshot output will not be displayed correctly in the Visualizer. To overcome this issue, NetPrep was enhanced to update link lengths based on the true shape length. A new key MAXIMUM_LENGTH_TO_XY_RATIO was added to NetPrep to help update the link lengths. If the link length coded is less than the true shape length, the output length is set to the true shape length. If the ratio of the length coded and the true shape length is greater than the value specified by this key, NetPrep reduces the link length to the ratio times the true shape length. For example, if the length field indicates the link is 1.3 miles long, the straight-line distance between the nodes is 1.0 miles and the MAXIMUM_LENGTH_TO_XY_RATIO is set to 1.2, the program will reset the link length to 1.0 miles.

Links shorter than three mesoscopic simulator cell lengths cause problems in the Simulator. To reduce Simulator problems, AECOM analyzed the link file for short links, and identified about 30 such links. To correct for this, start or end nodes of the short links need to be either moved or collapsed. Argonne performed the necessary edits and provided AECOM with an updated network. Figure 4.11 shows an example of a short link before and after its length edited.

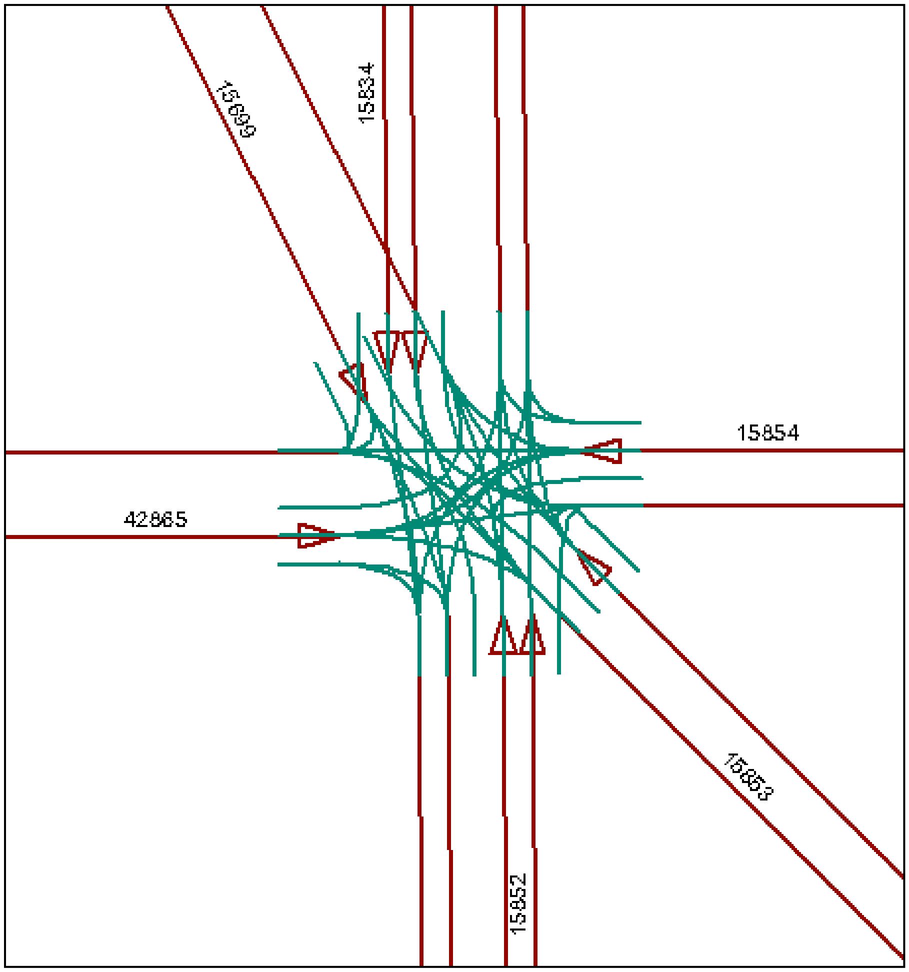
Figure 7.11: Short Link Before and After Edits.



7.3.5. Link Connectivity

The traffic controls preparation process revealed that there are missing connections between links. Missing connections were most frequently related to signals that were manually coded by Argonne. It was observed that link connections were typically missing for intersections with five or more legs. Network checks revealed that TransimsNet did not create connection links between many of these links because they were at an acute angle (135 degrees or more). To rectify the issue, TransimsNet was executed with the maximum connection angle key set to 160 degrees (previously set to 135 degrees). This modification enabled TransimsNet to create connections between links with acute angles. Figure 4.12 shows an example intersection with connection links created between link 15853 and 15854, and link 15699 and 42865. These connection links were missing prior to TransimsNet adjustment.

Figure 7.12: An example intersection with connection links created between all links.



7.3.6. Activity Locations

Activity locations or trip loading points are spatial locations that represent dwelling units, employment locations, social and recreational facilities, and shopping centers. These locations either produce or attract trips.

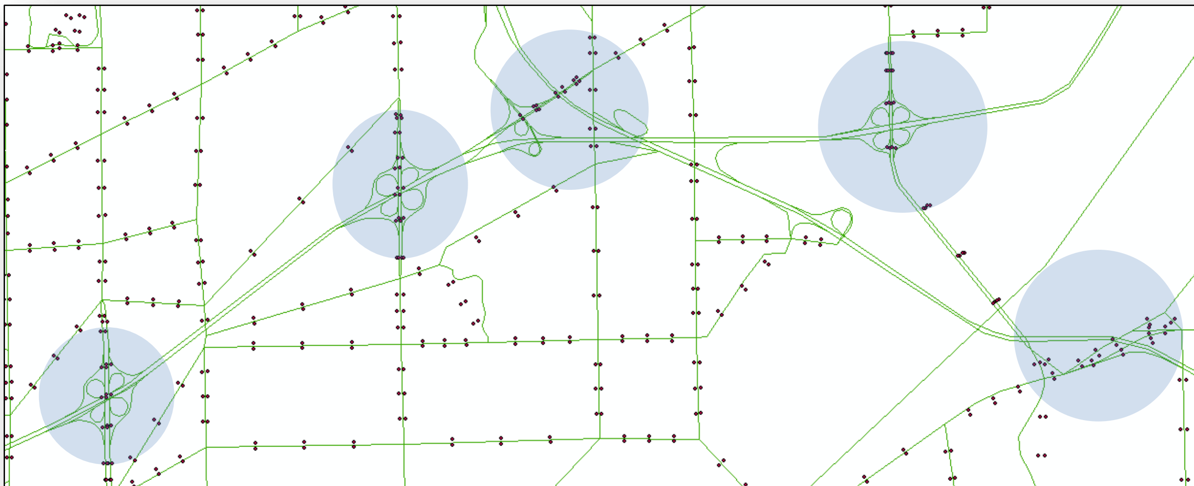
7.3.6.1. Synthetic Activity Locations

As it is not possible to obtain high fidelity location information, a set of synthetic activity locations were created using TransimsNet. Access warrants are used to control the number of activity locations that are placed along a link based on the link's facility type and area type. The following presents a sample TransimsNet key to generate activity locations along major collectors in area type 1 and 2.

```
FACILITY_ACCESS_WARRANT_1                    MAJOR..COLLECTOR, 1..2, 20, 50, 3
                                              #TYPE, AT, SETBACK meters, MIN_LEN meters, MAX_PTS
```

Synthetically generated activity locations are not a true representation of trip loading points in the real world and additional efforts are usually necessary to refine the positions of activity locations based on their relative spatial position. For example, activity locations should not be placed along bridges, overpasses/underpasses, and near ramps. Figure 4.13 shows spatial inaccuracies in synthetic activity locations.

Figure 7.13: Activity Locations: Completely Synthetic



7.3.6.2. Activity Location Refinements

The following selection criterion was used to select links that should not be allocated activity locations.

- Network links that intersected with rivers but were not explicitly coded as bridges, overpasses/underpasses or links that intersect freeways Short links near interchanges – links between two ramp nodes

Figure 4.14 presents roadway links that intersect rivers in the Chicago central business district and Figure 4.15 presents some of the selected overpasses, underpasses and links that intersect with freeways. These links were selected and activity locations were not allocated to along these links.

Figure 7.14: Activity Locations Refinement: Bridges

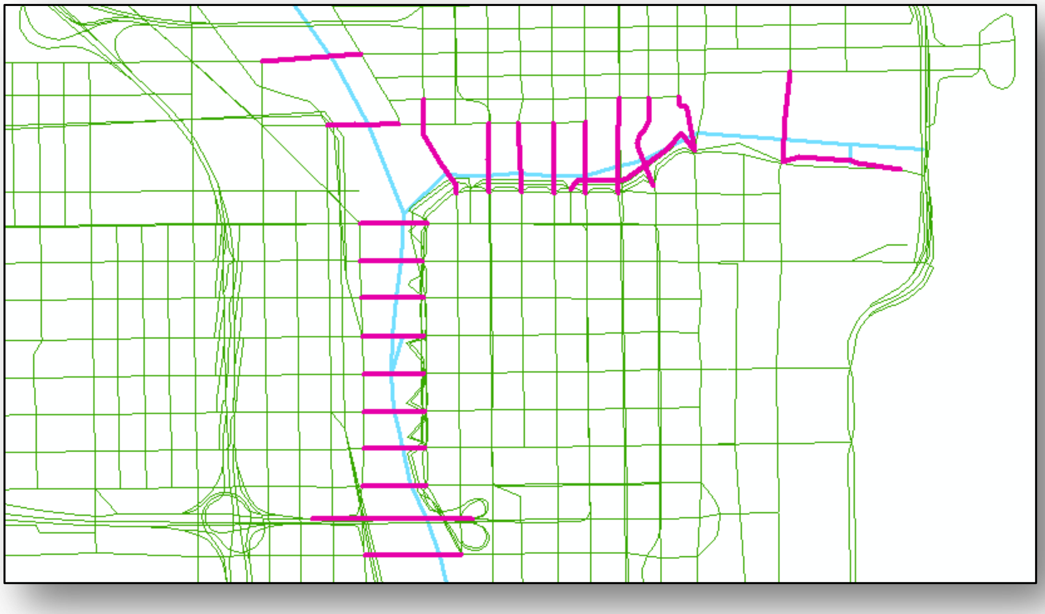
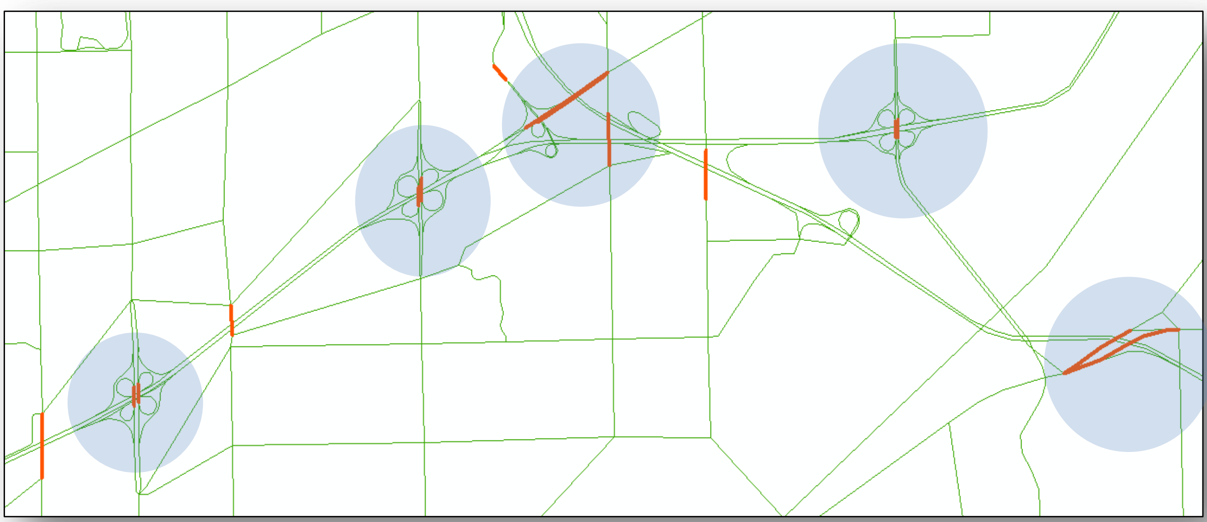
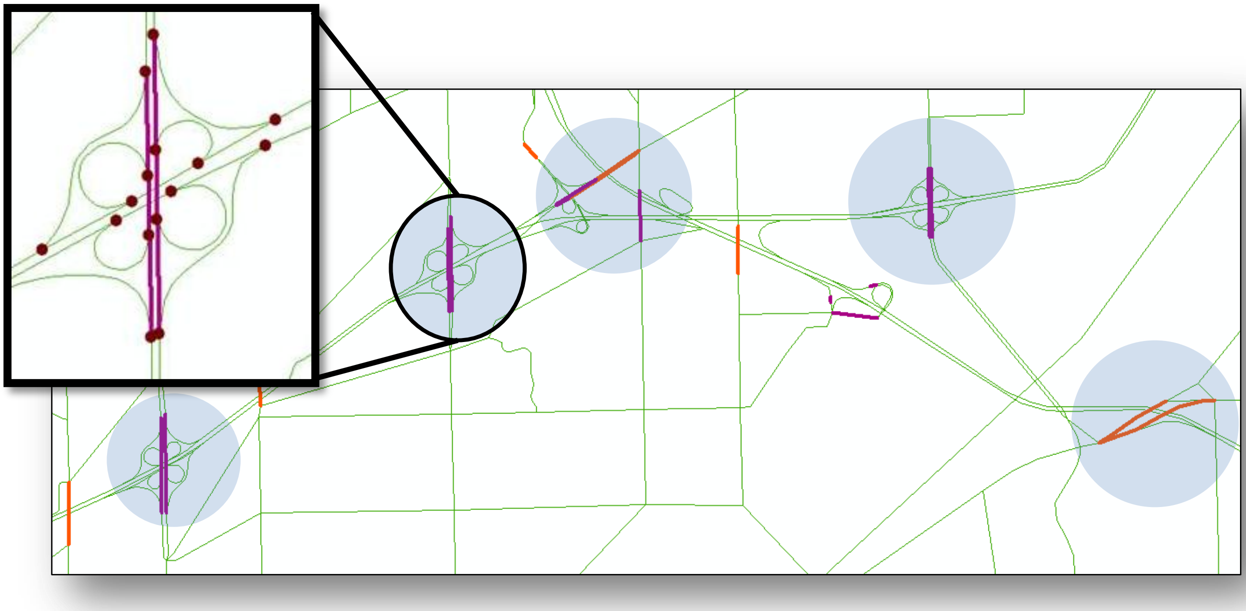


Figure 7.15: Activity Locations Refinement: Overpasses/Underpasses



AECOM observed that synthetic activity locations created by TransimsNet were on occasion within an interchange. Interchange geometry, especially clover leaf interchanges, consists of short links that are part of a major or minor highway and are connected to two ramp nodes as shown in Figure 4.16. An activity location allocated to such links would mean that the activity location is within the interchange. Since, activity locations are not present within interchanges in the real world, such links are to be selected and activity locations were not allocated to those links.

Figure 7.16: Activity Locations Refinement: Links between ramp nodes



This was accomplished by creating a database of ramp nodes and then using Microsoft Access to select short links (less than half a mile) that are connected to two ramp nodes. Figure 4.17 presents a graphical representation of the procedure used to select these links.

Figure 7.17: Activity Locations Refinement: Access Query for Selecting Links between Ramp Nodes

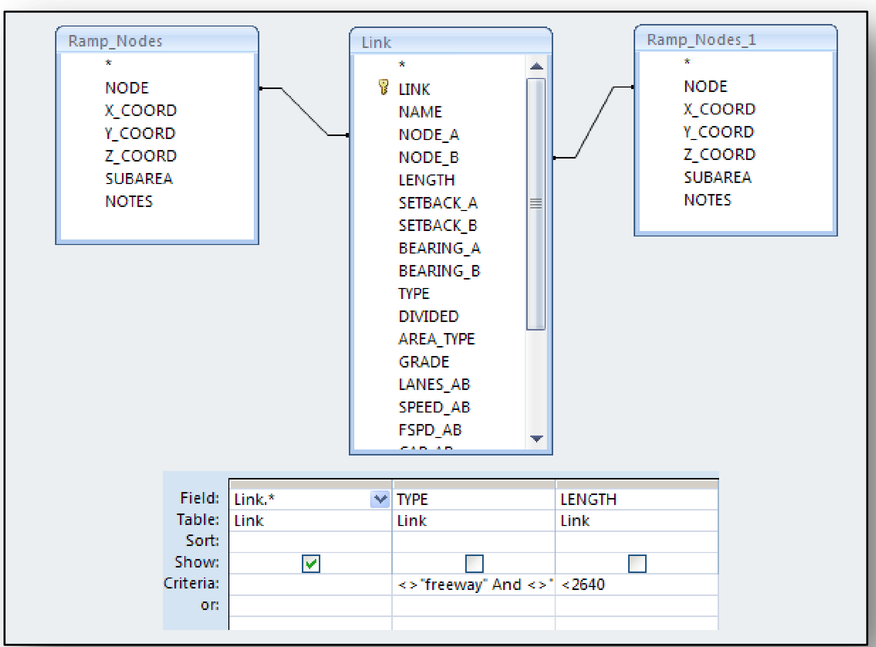
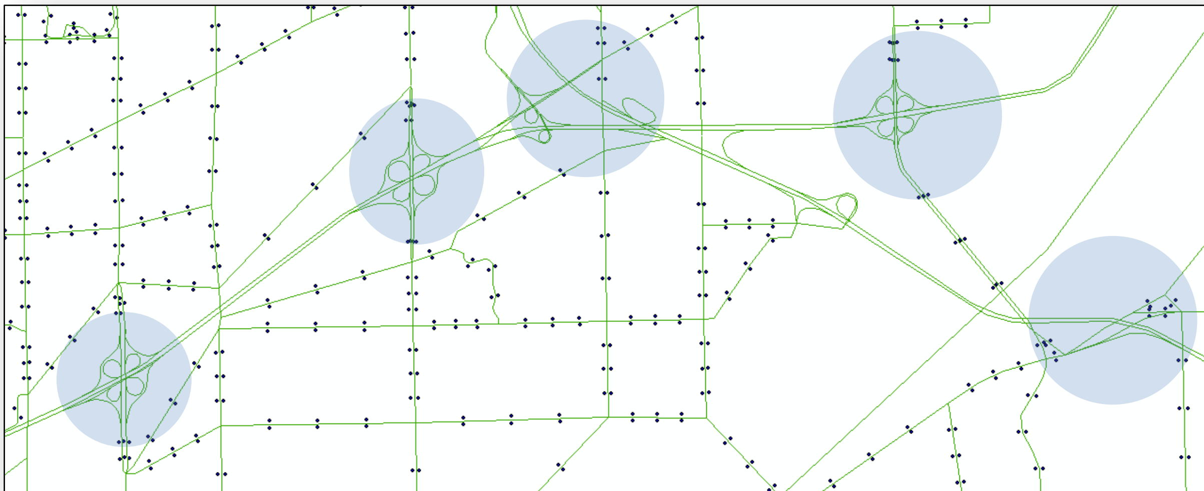


Figure 4.18 shows set of refined activity locations after activity locations associated with bridges, overpasses, underpasses, and links between interchange ramp nodes were removed.

Figure 7.18: Activity Locations: After Refinement



7.3.7. Traffic Control Devices

In order to achieve traffic flows that better match the observed flows on arterials, it is important to have a good representation of the real-world delays in the model. Ideally, the three thousand signals in the modeling area need to be coded with the real-world signal data. Collecting and coding such enormous amount of data, however, is impractical. Hence only the real-world signal data that is readily available and near the areas of interest (potential evacuation routes) is coded. In addition, about three hundred signals in the Chicago Central Business District (CBD) were initially coded by IIT. These signals were converted to Version 5 formats using the NewFormat program and manually rectified where needed by Argonne. AECOM guided them through this process.

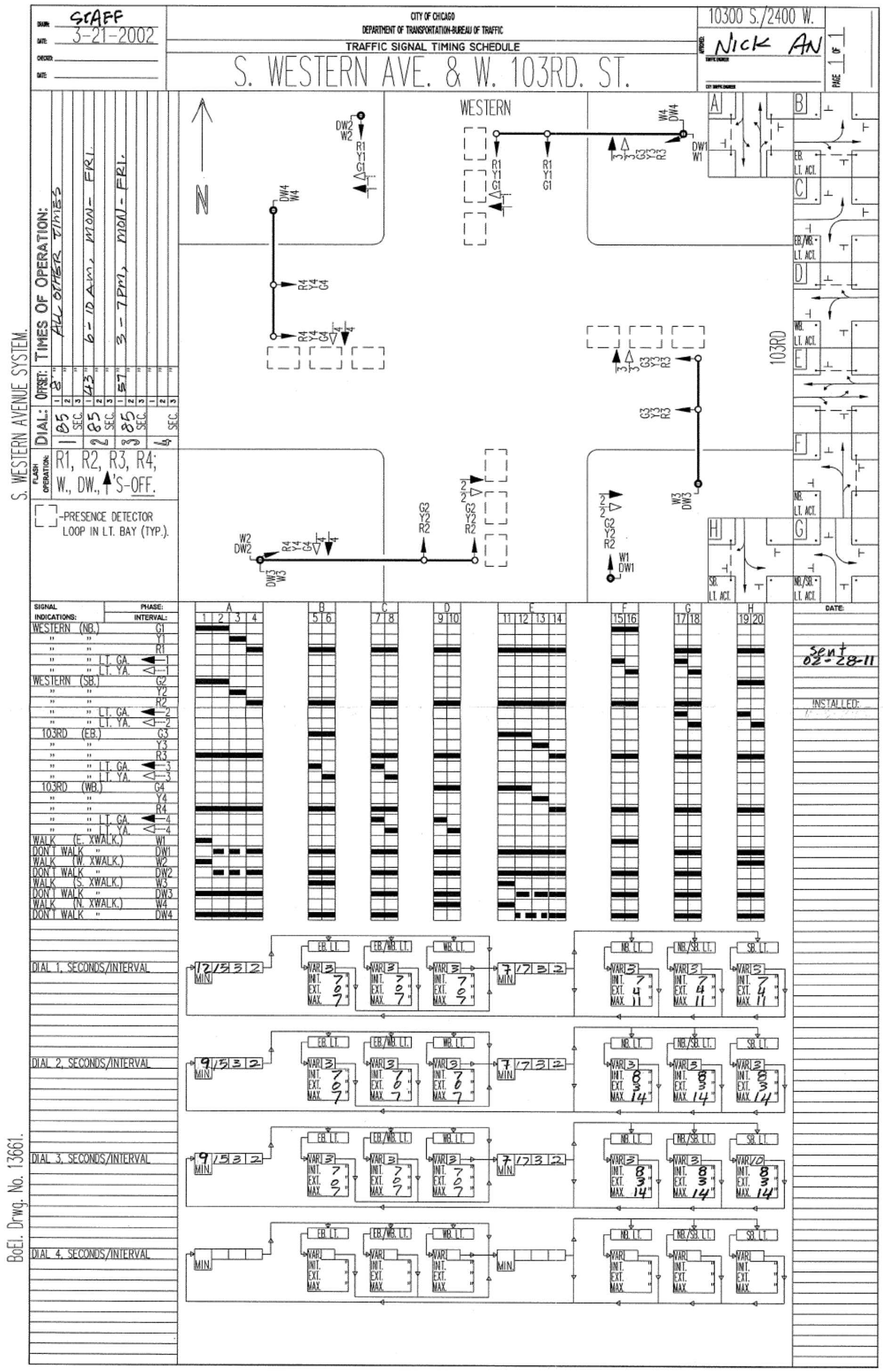
Argonne identified 128 critical signalized intersections along potential evacuation routes and obtained printed timing sheets for these signals from CDOT. CDOT does not maintain this information in signal database like SYNCHRO. Hence, manual interpretation and coding of these timing sheets into TRANSIMS Version 5 formats was required. Of these 128 signalized intersections, 59 are pre-timed and 69 are actuated. Argonne led the effort of converting this timing information to TRANSIMS network details. The pre-timed signals were easy to interpret and were manually coded by Argonne. Most of the actuated signals were identified along Cicero Avenue, Pulaski Road, Ashland Avenue, King Drive and Western Avenue and needed further processing before they could be manually coded in TRANSIMS.

The timing sheets indicated a signal controller (probably controller type LM90[3]) which cannot be directly translated into TRANSIMS signal formats. Therefore, the timing sheets needed to be converted into

3 Logic master traffic signal controller #90

equivalent National Electronic Manufacturer's Association (NEMA) phases (a phase for each movement) which can be readily coded into TRANSIMS. Figure 4.19 shows a sample CDOT signal timing sheet.

Figure 7.19: Sample Signal Timing Sheet



AECOM supported Argonne in this translation process and provided Argonne with a template for each typical timing sheet and shared the involved assumptions. Figure 4.20 through Figure 4.22 present an example for the translation of the CDOT timing information into equivalent NEMA phases.

Figure 7.20: Signal Timing Sheet Translation

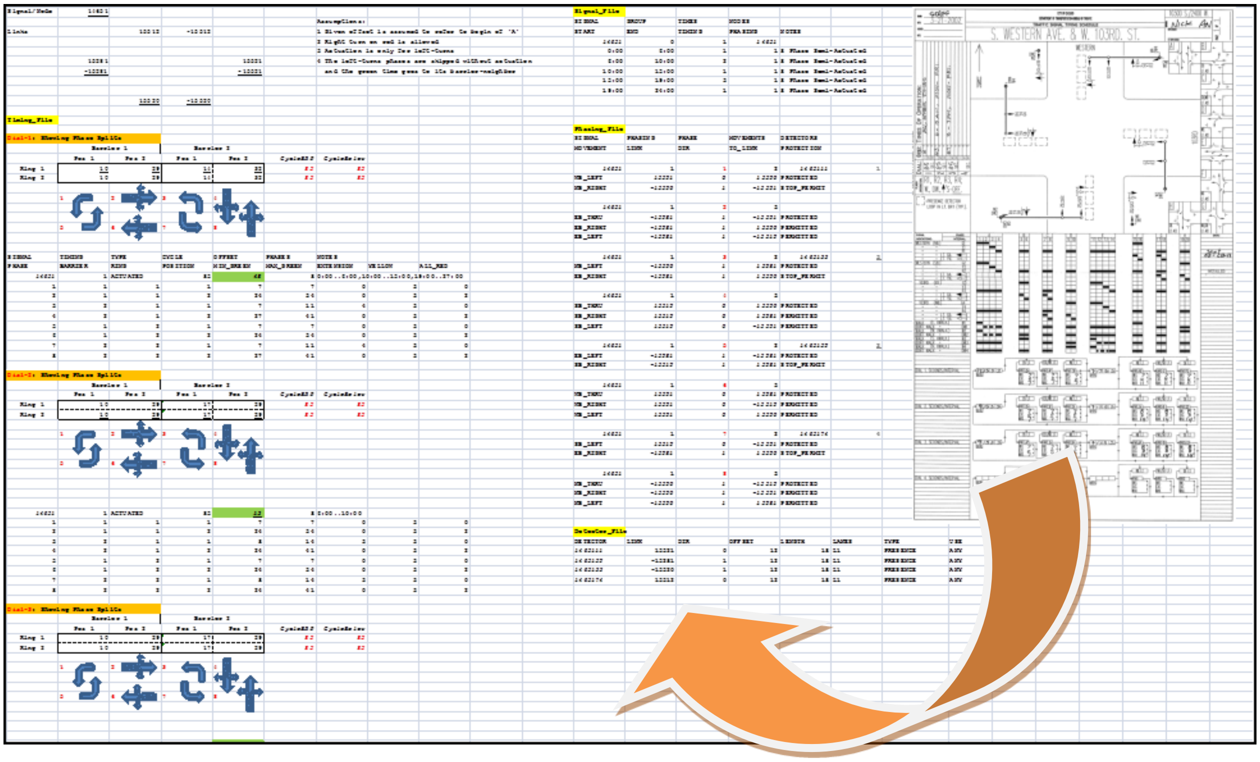
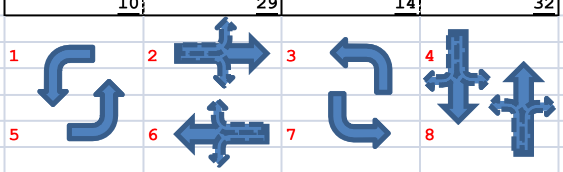


Figure 7.21: Translation to Equivalent NEMA 8-phase Barrier-ring Structure

Timing_File

Dial-1: Showing Phase Splits

	Barrier 1		Barrier 2			
	Pos 1	Pos 2	Pos 1	Pos 2	*CycleBRP*	*CycleBelow*
Ring 1	10	29	14	32	*85*	*85*
Ring 2	10	29	14	32	*85*	*85*



SIGNAL	TIMING	TYPE	CYCLE	OFFSET	PHASES	NOTES		
PHASE	BARRIER	RING	POSITION	MIN_GREEN	MAX_GREEN	EXTENSION	YELLOW	ALL_RED
14651	1	ACTUATED	85	*48*	8	0:00..6:00,10:00..15:00,19:00..27:00		
1	1	1	1	7	7	0	3	0
2	1	1	2	24	34	0	3	2
3	2	1	1	7	11	4	3	0
4	2	1	2	27	41	0	3	2
5	1	2	1	7	7	0	3	0
6	1	2	2	24	34	0	3	2
7	2	2	1	7	11	4	3	0
8	2	2	2	27	41	0	3	2

Figure 7.22: Translation of Phasing and Detector Information

Signal_File							
SIGNAL	GROUP	TIMES	NODES				
START	END	TIMING	PHASING	NOTES			
14651	0	1	14651				
0:00	6:00	1	1	8 Phase Semi-Actuated			
6:00	10:00	2	1	8 Phase Semi-Actuated			
10:00	15:00	1	1	8 Phase Semi-Actuated			
15:00	19:00	3	1	8 Phase Semi-Actuated			
19:00	24:00	1	1	8 Phase Semi-Actuated			
Phasing_File							
SIGNAL	PHASING	PHASE	MOVEMENTS	DETECTORS			
MOVEMENT	LINK	DIR	TO_LINK	PROTECTION			
14651	1	1	2	1465111	1		
WB_LEFT	15521	0	15520	PROTECTED			
NB_RIGHT	-15520	1	-15521	STOP_PERMIT			
14651	1	2	3				
EB_THRU	-15281	1	-15521	PROTECTED			
EB_RIGHT	-15281	1	15520	PERMITTED			
EB_LEFT	-15281	1	-15512	PERMITTED			
14651	1	3	2	1465133	3		
NB_LEFT	-15520	1	15281	PROTECTED			
EB_RIGHT	-15281	1	15520	STOP_PERMIT			
14651	1	4	3				
SB_THRU	15512	0	15520	PROTECTED			
SB_RIGHT	15512	0	15281	PERMITTED			
SB_LEFT	15512	0	-15521	PERMITTED			
14651	1	5	2	1465152	2		
EB_LEFT	-15281	1	-15281	PROTECTED			
SB_RIGHT	-15512	1	15281	STOP_PERMIT			
14651	1	6	3				
WB_THRU	15521	0	15281	PROTECTED			
WB_RIGHT	15521	0	-15512	PERMITTED			
WB_LEFT	15521	0	15520	PERMITTED			
14651	1	7	2	1465174	4		
SB_LEFT	15512	0	-15521	PROTECTED			
EB_RIGHT	-15281	1	15520	STOP_PERMIT			
14651	1	8	3				
NB_THRU	-15520	1	-15512	PROTECTED			
NB_RIGHT	-15520	1	-15521	PERMITTED			
NB_LEFT	-15520	1	15281	PERMITTED			
Detector_File							
DETECTOR	LINK	DIR	OFFSET	LENGTH	LANES	TYPE	USE
1465111	15521	0	12	18	L1	PRESENCE	ANY
1465152	-15281	1	12	18	L1	PRESENCE	ANY
1465133	-15520	1	12	18	L1	PRESENCE	ANY
1465174	15512	0	12	18	L1	PRESENCE	ANY

Although TRANSIMS is able to create synthetic signals for the whole region, it is desirable to maximize use of available signal data. Argonne coded 167 critical signalized intersections along potential evacuation routes and revised 300 signals in the Chicago CBD (previously coded by IIT). CDOT has also provided cycle lengths for 1,267 signals by time of day.

This project utilized the Argonne and CDOT signals in two ways:

- The data was used to create rules in order to assign either a signal or sign warrant to the intersection based on facility and area types.
- The data was also used to assign a group number to each signal. The group number is read by IntControl to set the cycle length and other signal attributes.

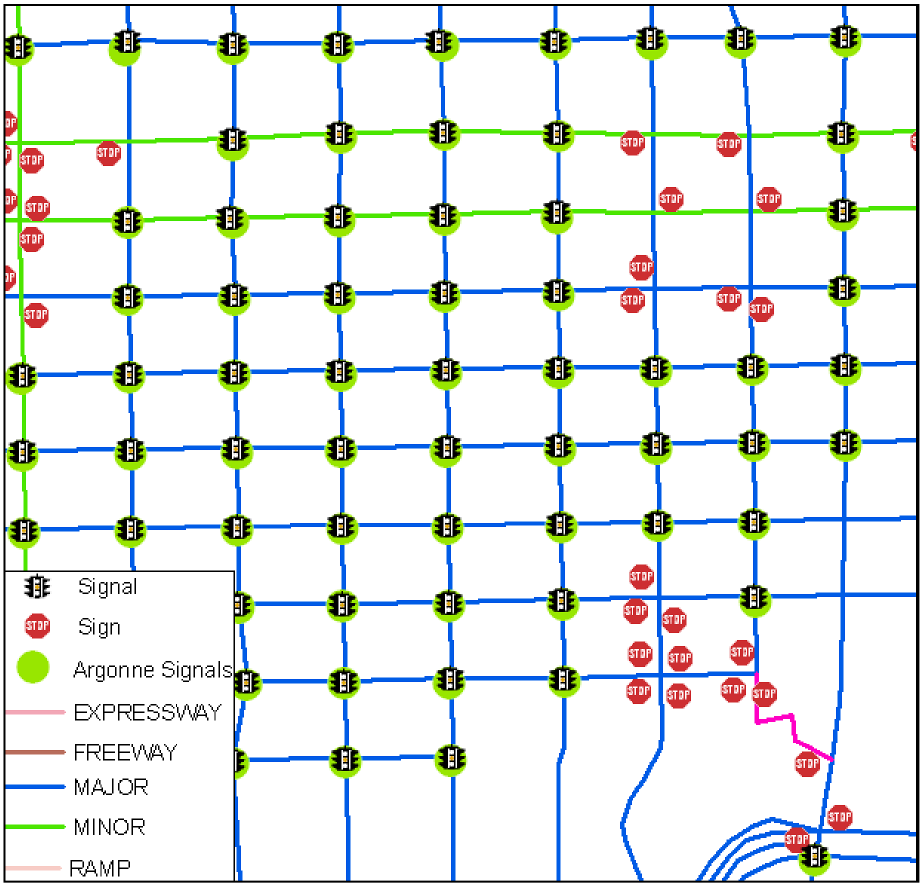
Figure 4.23 shows some of the rules that TransimsNet utilizes to generate signal and sign warrants.

Figure 7.23: TransimsNet Signal and Sign Warrants

```
TRAFFIC_CONTROL_WARRANT_1          EXPRESSWAY, MAJOR, 2..3, SIGNAL, 15, 1
TRAFFIC_CONTROL_WARRANT_2          EXPRESSWAY, MINOR..COLLECTOR, 1..8, TWO_WAY, 15, 4

TRAFFIC_CONTROL_WARRANT_3          MAJOR, MAJOR, 1..2, ALL_STOP, 15, 4
TRAFFIC_CONTROL_WARRANT_4          MAJOR, MAJOR, 3, SIGNAL, 15, 2
TRAFFIC_CONTROL_WARRANT_5          MAJOR, MAJOR, 4..8, SIGNAL, 15, 3

TRAFFIC_CONTROL_WARRANT_6          MAJOR, MINOR, 1..2, TWO_WAY, 12, 4
TRAFFIC_CONTROL_WARRANT_7          MAJOR, MINOR, 3..8, SIGNAL, 12, 3

TRAFFIC_CONTROL_WARRANT_8          MINOR, MINOR, 1..2, ALL_STOP, 12, 4
TRAFFIC_CONTROL_WARRANT_9          MINOR, MINOR, 3..8, ALL_STOP, 12, 4

TRAFFIC_CONTROL_WARRANT_10         MAJOR, LOCAL, 1..8, TWO_WAY, 12, 4
TRAFFIC_CONTROL_WARRANT_11         MAJOR, COLLECTOR, 3..8, TWO_WAY, 12, 4

TRAFFIC_CONTROL_WARRANT_12         MINOR, LOCAL, 1..8, TWO_WAY, 12, 4
TRAFFIC_CONTROL_WARRANT_13         MINOR, COLLECTOR, 1..8, TWO_Way, 12, 4

TRAFFIC_CONTROL_WARRANT_14         COLLECTOR, COLLECTOR, 1..8, ALL_STOP, 12, 4
TRAFFIC_CONTROL_WARRANT_15         COLLECTOR, LOCAL, 5..8, TWO_WAY, 12, 4

TRAFFIC_CONTROL_WARRANT_16         LOCAL, LOCAL, 1..8, ALL_STOP, 12, 4
```

It was not possible to create a set of rules to replicate real world signals and signs coded by Argonne for area types 1 and 2 since the real world traffic control devices do not follow any pattern. Figure 4.24 presents the current locations of the signals and signs coded by Argonne. Therefore, all the intersections in area type 1 and 2 are defined as unsignalized intersections and a separate procedure was created to modify the signal warrants generated by TransimsNet. This procedure merges the Argonne and CDOT signals with the signal warrants file. IntControl was then modified to overwrite sign warrants with signal warrants when a signal and a sign warrant exist for the same intersection. This made it possible to replicate the signals coded by Argonne for area types 1 and 2

Figure 7.24: An Example of Argonne Coded Signals and Signs in Area Type 1 & 2.



AECOM observed that the real world signals have different cycle lengths. An analysis of the signals by facility and area types showed that the signals could be classified into four basic groups. Table 4.3 shows the characteristics of these groups.

Table 7.3: Signal Cycle Lengths by Group

Facility Types	Area Type	Group	Cycle Length (sec)	Time Period
EXPRESSWAY, MAJOR	2, 3	1	100	00:00 to 24:00
MAJOR, MAJOR	3	2	85	00:00 to 24:00
MAJOR, MAJOR	4, 5, 6, 7, 8	3	75	00:00 to 24:00
MAJOR, MINOR	3, 4, 5, 6, 7, 8	3	75	00:00 to 24:00

Roadway intersections, in area type 1 and area type 2, where a major arterial crosses another arterial are not included in any of the signal groups presented in Figure 4.24. Since these signals are created from timing plans, phasing plans, and detector files provided by Argonne, the signal cycle length for these signals is constant throughout the day. Since the signal data obtained from CDOT contains signal cycle lengths by time of day, custom signal groups were created to apply the different cycle lengths.

AECOM created two sample custom groups and provided them to Argonne. Figure 4.25 presents a sample custom group that assigns different cycle lengths to different time periods.

Figure 7.25: Sample Custom Signal Group

```
SIGNAL_TYPE_CODE_16052                        TIMED
NUMBER_OF_RINGS_16052                         1
SIGNAL_TIME_BREAKS_16052                      6:00, 9:30, 16:00, 19:00
SIGNAL_CYCLE_LENGTH_16052                     85,105,85,105,85 seconds
MINIMUM_PHASE_TIME_16052                      5 seconds
YELLOW_PHASE_TIME_16052                       3 seconds
RED_CLEAR_PHASE_TIME_16052                    1 seconds
POCKET_LANE_FACTOR_16052                      0.5
SHARED_LANE_FACTOR_16052                      0.5
GENERAL_GREEN_FACTOR_16052                    0.7
EXTENDED_GREEN_FACTOR_16052                   0.6
MAXIMUM_GREEN_FACTOR_16052                    2.0
SIGNAL_DETECTOR_LENGTH_16052                  30 meters
SIGNAL_SPLIT_METHOD_16052                     CAPACITY
MINIMUM_LANE_CAPACITY_16052                   500
MAXIMUM_LANE_CAPACITY_16052                   2500
```

7.3.7.1. Signal Coding Assumptions

The conversion of the CDOT timing sheets required certain assumptions to be made in determining signal timing parameters such as minimum/maximum green times, phase splits and offset references. These assumptions are listed below:

- Standard dual ring 8-phase NEMA phasing scheme is assumed.
- Actuated phases are skipped when no vehicle calls are placed for the movement and the green time is assigned to the phase within the same ring-barrier. For example, if a left turn (Phase 3) at an approach is actuated and this movement has no vehicle calls, the left turn phase is skipped and the green time typically assigned to the left turn is now assigned to the through movement (Phase 4).
- Signal offsets contain two components: value or "offset" and the reference point in the cycle (typically, begin of green of a phase). This is used to identify the phase that a signal will show upon initiation. When a signal is initiated, the phase that allows the reference point in the cycle to show after the "offset" is shown by the controller. This requires back calculating from the end of the cycle. However, in TRANSIMS offset reference point is always the beginning of the cycle (first phase in ring & barrier 1) and the value refers the forward calculation into the cycle. So, in TRANSIMS offset directly identifies the position in the cycle which shows up when a signal is initiated instead of calculating this information as described earlier. In the conversion process, the reference for the CDOT timing sheets was not available and assumed to be the beginning of the cycle or Phase "A".
- All offsets are assumed to refer to a common master clock, i.e. '0' of one signal is equal to '0' of any other signal

7.3.7.2. CBD Signal Integration

The Chicago CBD signals were manually coded by IIT as part of their initial TRANSIMS application and were coded in TRANSIMS Version 4 formats. In order to incorporate these data into the regional network in TRANSIMS Version 5, the signals need to be upgraded to Version 5 and merged with the regional signals. AECOM provided Argonne with an extraction procedure that used IntControl to merge newly created signals with an existing signal file.

Version 5 signal formats use a "signal controller" to synchronize the timing and phasing plans at several nodes whereas Version 4 has a separate control for each individual signalized node. The Version 4 CBD signals were upgraded to Version 5 using NewFormat. This process created a separate signal controller for each node using the node ID.

The signal warrants generated from TransimsNet contained signal controller IDs in a sequential order meaning that the signal controller IDs did not match the node IDs. The signal controller IDs were reset to the corresponding node IDs. This change did not affect the modeling process because the signals are not grouped at this point. The CBD signals were identified in the signal warrants and removed. Version 5 IntControl was run with upgraded CBD signals and the refined signal warrants creating a merged signal system. Warning messages referencing missing link numbers appeared because network edits were performed after coding the CBD signals; these warnings were later addressed by Argonne.

7.4. Traffic Counts

Time of day traffic count data is useful to calibrate diurnal factors, and to validate the model. Traffic count datasets for the study area were obtained from various agencies. These datasets and the agencies that provided them include

- Count data from the IIT TRANSIMS Study
- GCM post processed count data for the year 2007
- Arterial intersections' post processed count data for the year 2007
- Gary-Chicago-Milwaukee (GCM) freeway count data for freeways for the years 2007, 2008, and 2009
- IDOT arterial count data for the years 2006 and 2007

The following sections describe AECOM efforts to process these databases for model calibration.

7.4.1. Count Datasets from the IIT Study

The GCM freeway and intersection traffic counts were processed by IIT to associate each count station to a TRANSIMS link. Figure 4.26 highlights freeways with hourly traffic data counts. AECOM performed quality checks to ensure that the traffic count stations have been associated to the correct links. It was observed that some freeway count stations had been incorrectly associated to rail links. Figure 4.27 illustrates one of these locations.

Figure 7.26: Freeway Links with Hourly Traffic Counts

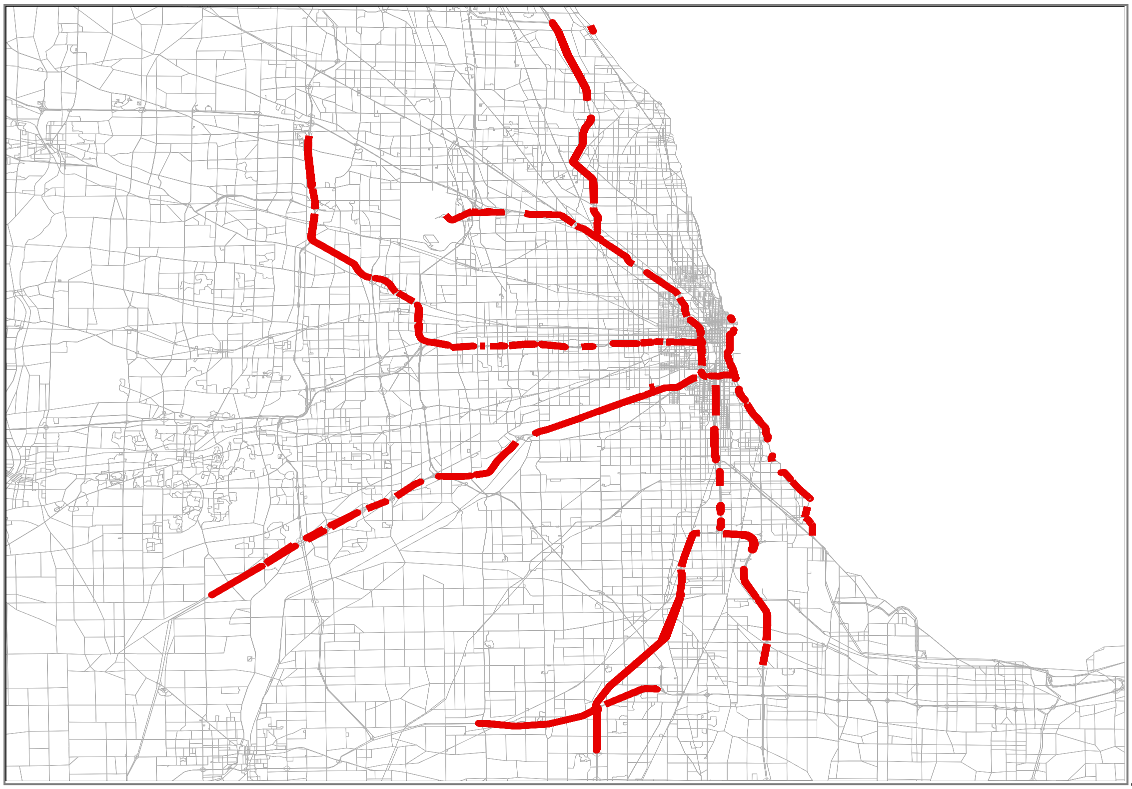
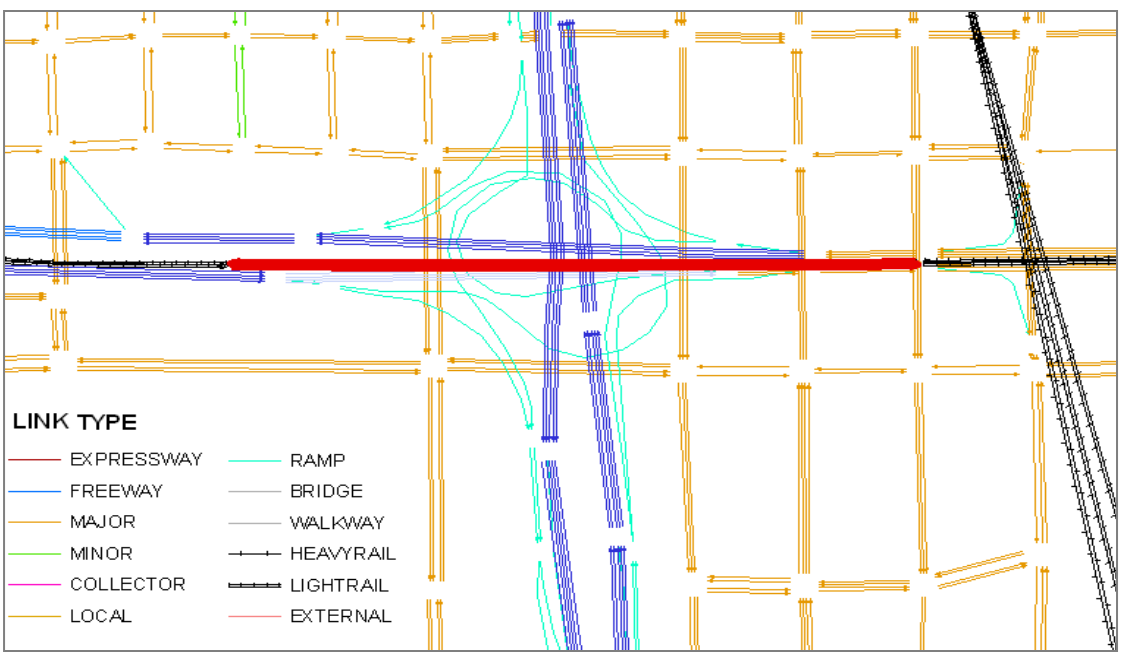


Figure 7.27: Freeway Counts Assigned to a Rail Link



It was also observed that, on occasion, multiple count stations have been assigned to a single link. Table 4.4 presents an example of this situation. The hourly traffic counts were different for these stations, so the average was calculated for each hour to be used for validation.

Table 7.4: Multiple Traffic Count Stations Assigned to One Link ID

Link	Route	Length	StationID	Direction	AB_000_100	AB_100_200	AB_200_300	AB_300_400
66	I-80	3400	5361	S	1042	946	1051	1279
66	I-80	3400	5363	S	1476	1107	1201	1449
5963	I-55	4890	5422	N	1279	876	696	731
5963	I-55	4890	5427	N	480	362	389	718
5963	I-55	4890	5428	N	857	657	702	1158
5963	I-55	4890	5429	N	852	652	697	1153
5963	I-55	4890	5431	N	798	615	670	1103
6979	I-55	5860	5423	N	1332	916	732	768
6979	I-55	5860	5424	N	1310	898	729	767
6979	I-55	5860	5425	N	1287	897	730	766
7030	I-55	2990	5432	N	839	653	709	1146
7030	I-55	2990	5433	N	703	571	577	879

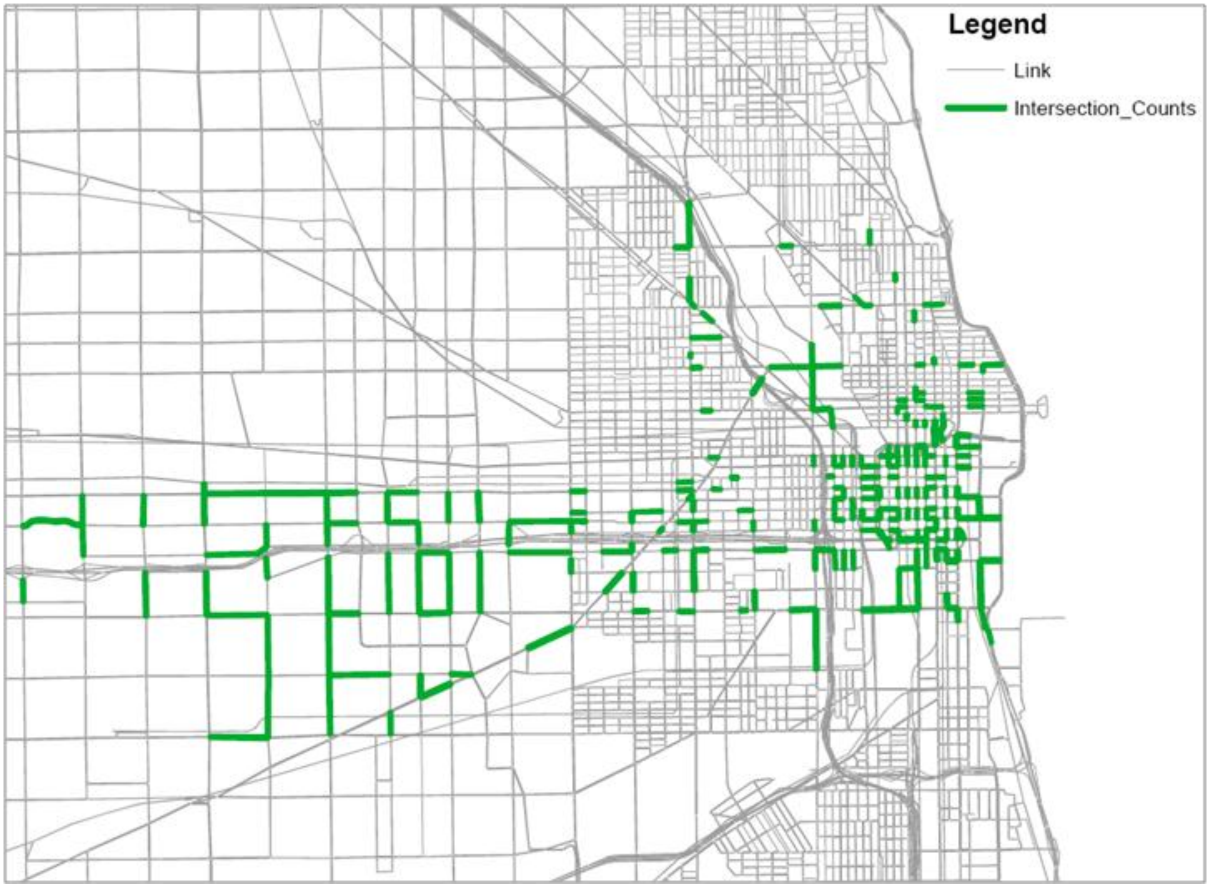
Table 4.5 presents an example of freeway links that have multiple traffic count stations associated with them. The 'direction' field in this dataset indicates that the count direction is different for each of the count records associated with the link. This presents a problem because freeway links are uni-directional and count stations cannot indicate multiple directions.

Table 7.5: Traffic Count Stations Assigned to Different Directions of a Freeway Link

Link	Direction	Length	AB_000_100	AB_100_200	AB_200_300	AB_300_400	AB_400_500
35051	N	1425	1179.62	678.76	441.08	415.4	781.48
35051	S	1425	955.79	561.41	379.82	348.78	605.33
Diff %			*18.97%*	*17.29%*	*13.89%*	*16.04%*	*22.54%*
81061	E	1405.1	1188.09	858.42	732.15	945.53	1924.23
81061	N	1405.1	730.17	448.05	324.43	431.98	1306.32
Diff %			*38.54%*	*47.81%*	*55.69%*	*54.31%*	*32.11%*
81442	E	3470	614.44	442.88	411.35	517.93	1133.86
81442	W	3470	551.95	406.62	364.92	474.27	945.38
Diff %			*10.17%*	*8.19%*	*11.29%*	*8.43%*	*16.62%*

The IIT TRANSIMS study also processed arterial counts. This count database contains multi-directional hourly traffic counts for at least one approach of an intersection. Figure 4.28 shows arterial traffic count locations. Most of these traffic count locations are in the CBD. Hence, additional arterial counts were obtained from IDOT. IDOT count data processing is described in the previous section.

Figure 7.28: Arterial Links with Hourly Traffic Count Data.



This dataset contains two identical records for the same link. These two records contain information collected at either end (intersection) of each link. AECOM condensed this dataset to contain only one record for each link.

Table 7.6: Identical Arterials Assigned to Different Intersection IDs

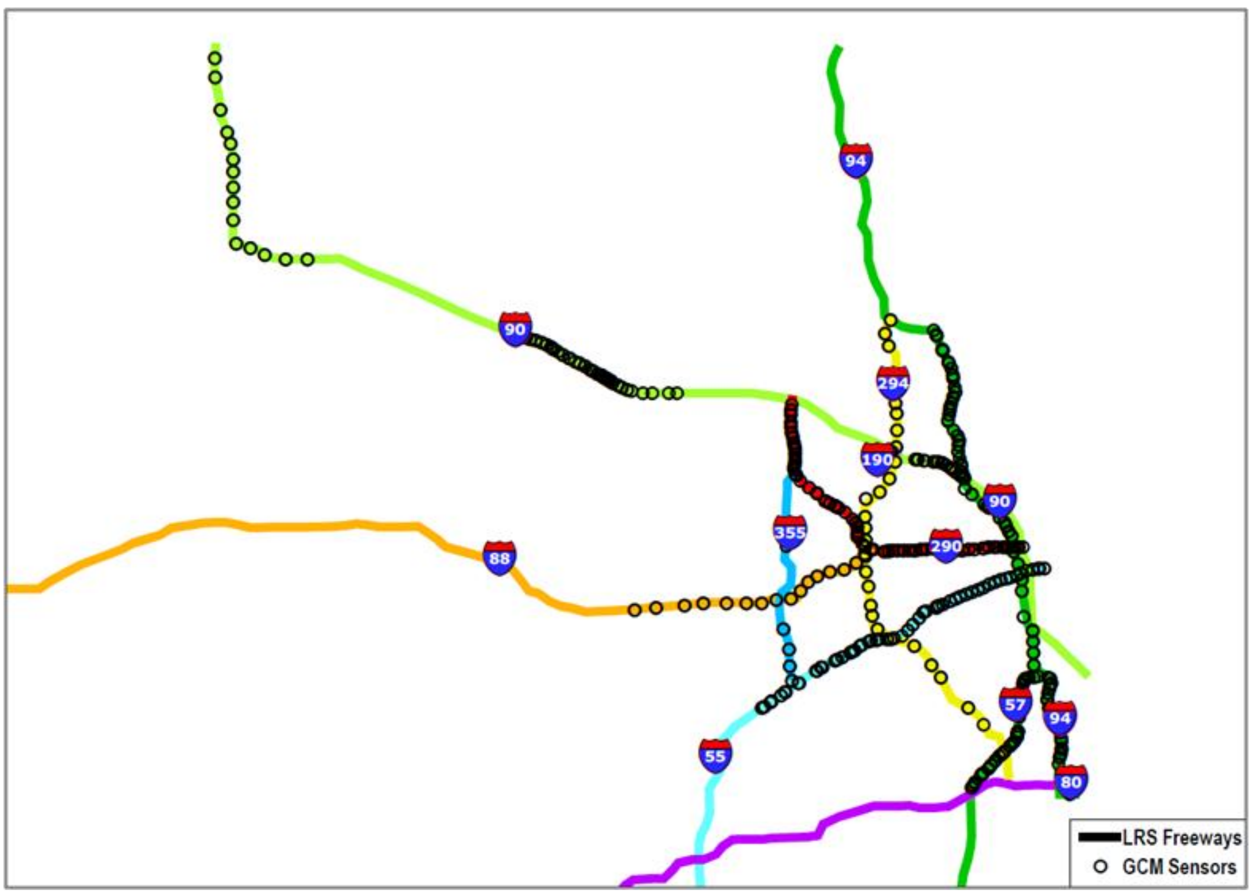
Intersection ID	Link ID	Anode	Bnode	AB_000_100	AB_100_200	AB_200_300
13376	13265	13376	81463	318	232	155
81463	13265	13376	81463	318	232	155
13378	13267	13378	13469	40	17	11
13469	13267	13378	13469	40	17	11
13469	13431	13469	13470	286	152	102
13470	13431	13469	13470	286	152	102
13469	13432	13469	13474	191	163	116
13474	13432	13469	13474	191	163	116

Intersection ID	Link ID	Anode	Bnode	AB_000_100	AB_100_200	AB_200_300
13597	13644	13597	13598	205	115	77
13598	13644	13597	13598	205	115	77

7.4.2. GCM Counts

The GCM count database contains traffic volume and speed information for each count station. The information contains five minute increments for every day of the year from 2007 to 2009. The GCM count stations are uniquely identified by the freeway route name and the mile point. The lack of actual coordinate information disallows the end-user from allocating these stations to links so that the traffic count information can be used for validation. A linear referencing system[4] (LRS) was created for all freeway routes in Illinois. This LRS was used to plot count locations along the freeway routes, but not for state routes due to the lack of information pertaining to the beginning (mile point 0) and end of each route. This information is critical to create an LRS. Figure 4.29 shows an example of the LRS created with routes and some of their associated count locations.

Figure 7.29: Linear referencing system for Illinois freeways with GCM sensor locations.



[4] A linear referencing system (LRS) is a geographic reference system which stores information using a measurement from a fixed reference point (mile point = 0.0) along a route instead of using geographic coordinates. The LRS returns a point interpolated along the route when mile point is input.

Once the routes were created, the count data was imported into SQL Server in order to extract the count information. The three years' worth of count information was provided in monthly text files. The average volume and average speed was summarized by date, time and station ID. The data was analyzed to gather statistics on the 85th percentile of data for Tuesday, Wednesday and Thursday. These three days were used in order to ensure that accurate and representative normal day data was used. This information was added to the routes and model links in order to calibrate and validate the TRANSIMS model with count data.

The GCM count database needed some processing before it could be used due to inconsistencies in the data. It was discovered that not all stations have data for all time periods, days or even months. A prevalent issue with the data was that count stations were missing data during the 1:10AM to 1:30AM time period. Even when narrowed down to Tuesdays, Wednesdays and Thursdays that are not holidays there were many stations that varied in the amount of data each device number or the station itself contained. One of the largest inconsistencies in the data was the way that device numbers were labeled (e.g. 1,2,1,2 v. 1,2,3,4). Some stations did not have data for some lanes signified by missing numbers in a set (e.g. 1,2,3,5,7,8). Without consistent data over multiple days or even a single day and inconsistent labeling, no rule or process can be developed for this count data to be used for TRANSIMS purposes. The team decided to not use this data set since a significant amount of data processing was required and the necessary resources were not available.

7.4.3. IDOT Arterial Count Data

IDOT provided hourly traffic counts and AADT for about 3,700 arterials in the Chicago region for the years 2006 and 2007. AECOM attempted to associate each count station to a TRANSIMS network link. Link IDs were successfully assigned to 2,200 count stations. However, TRANSIMS links lack true shape information so some of the count locations did not align with the TRANSIMS links. However, these count stations aligned perfectly on a street map or a satellite image. Figure 4.31 shows an example of TRANSIMS links without true shape.

Figure 7.30: IDOT traffic count sensors location

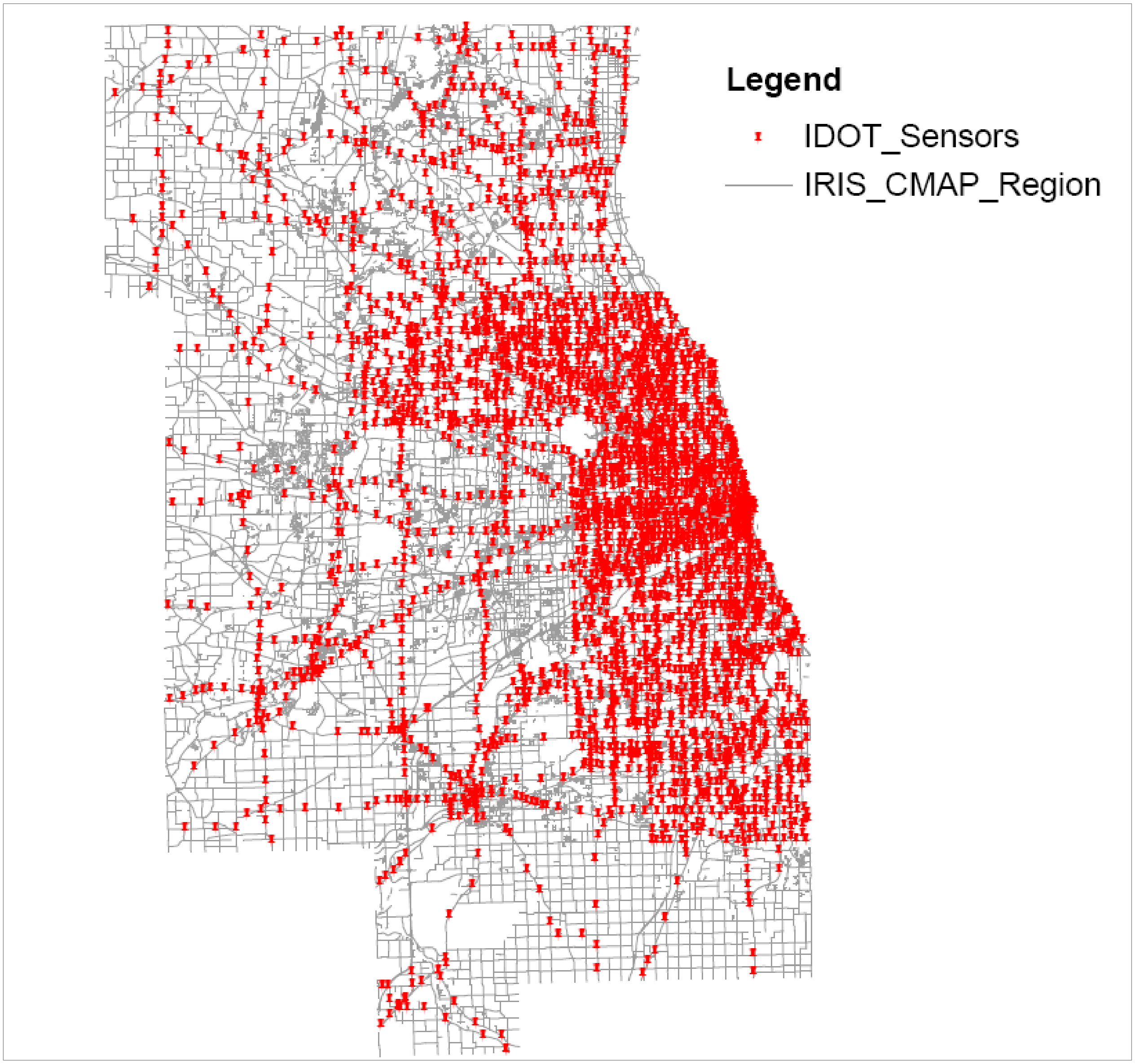
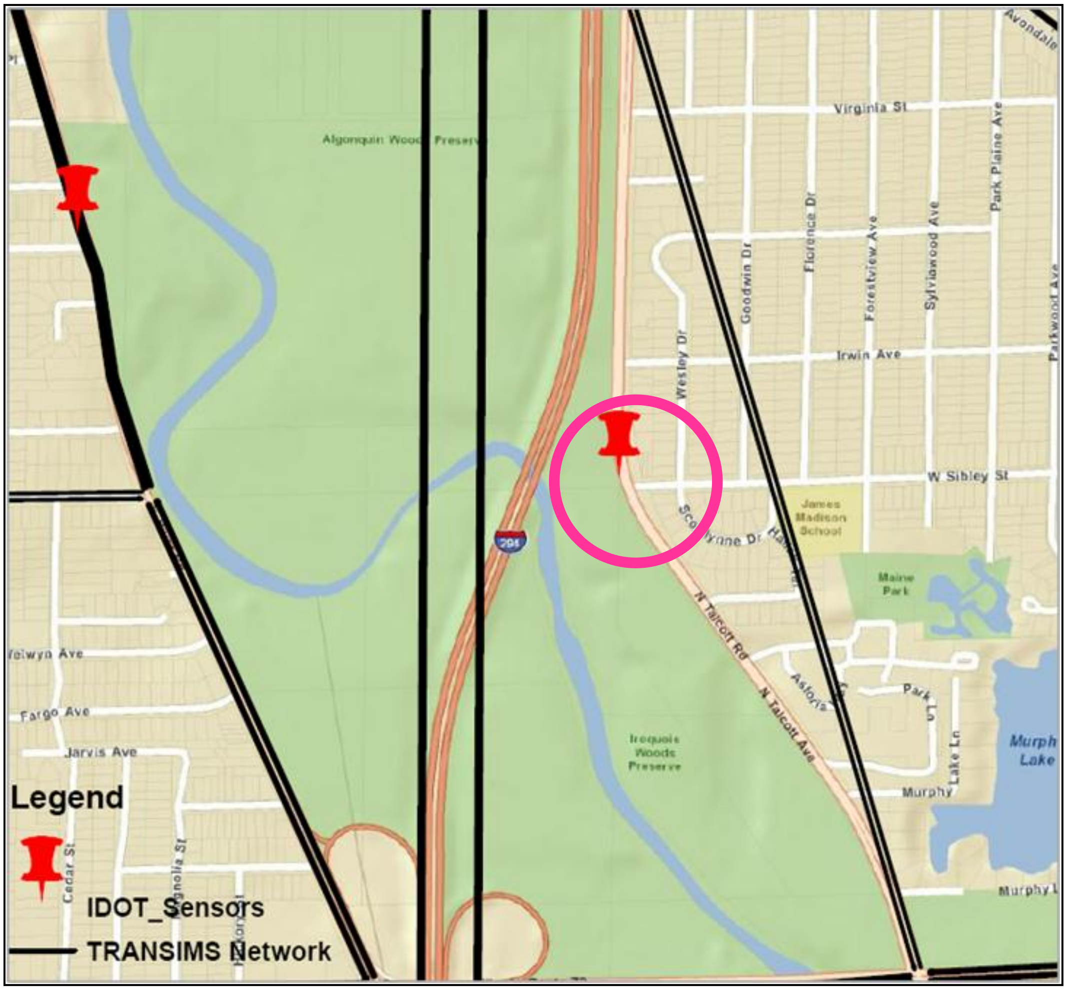


Figure 7.31: A Sample of Incorrect TRANSIMS Link Shape

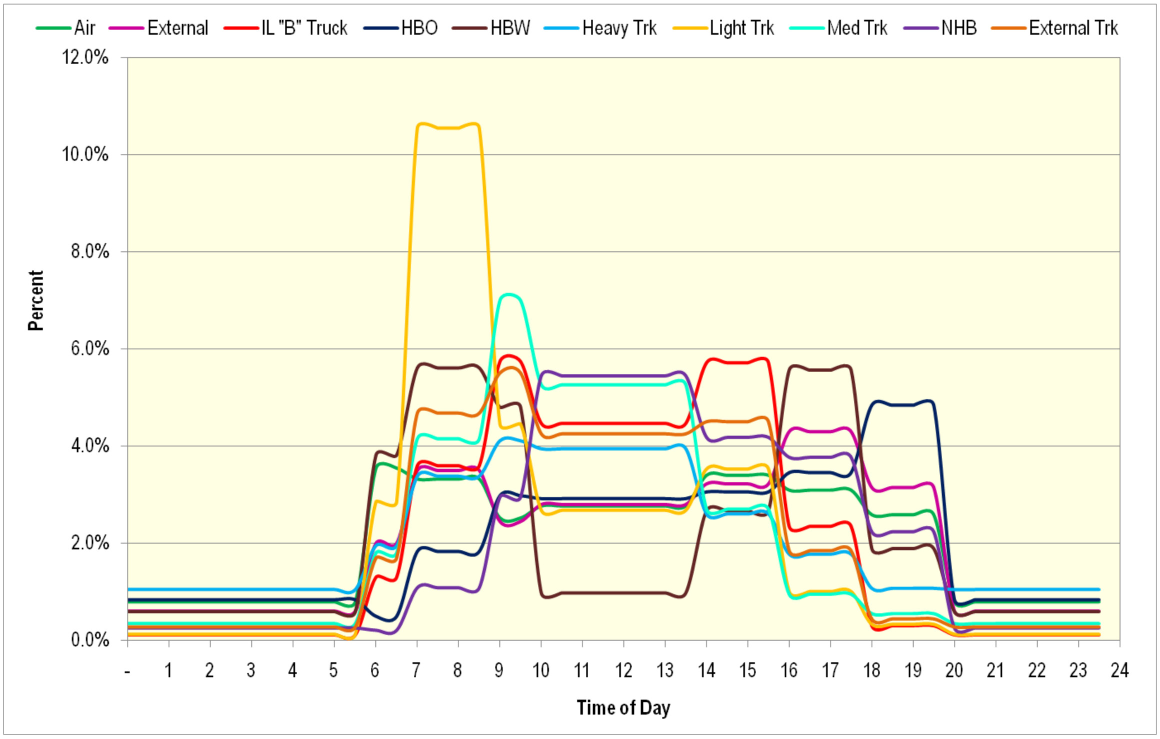


7.5. Demand

7.5.1. Diurnal Refinement

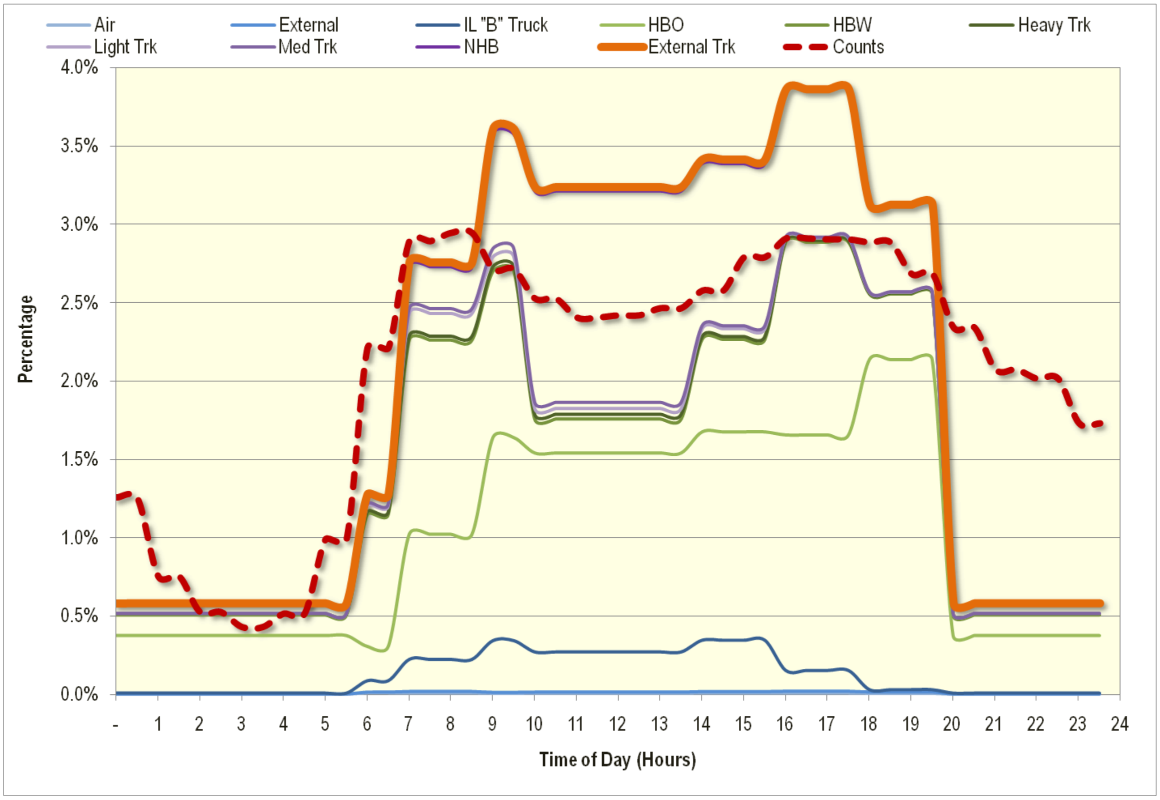
AECOM used the traffic count data sets described in the previous section to refine the 30 minute diurnal factors used in the CMAP model. The CMAP model is a static, multi-period model and uses the same diurnal factor for every hour in a time period. Figure 4.32 presents these diurnals by trip purpose. Unlike the CMAP static model, the Chicago TRANSIMS model has a very high temporal fidelity and the use of diurnals that remain constant for any given time period is not recommended.

Figure 7.32: Input Diurnals by Trip Purpose



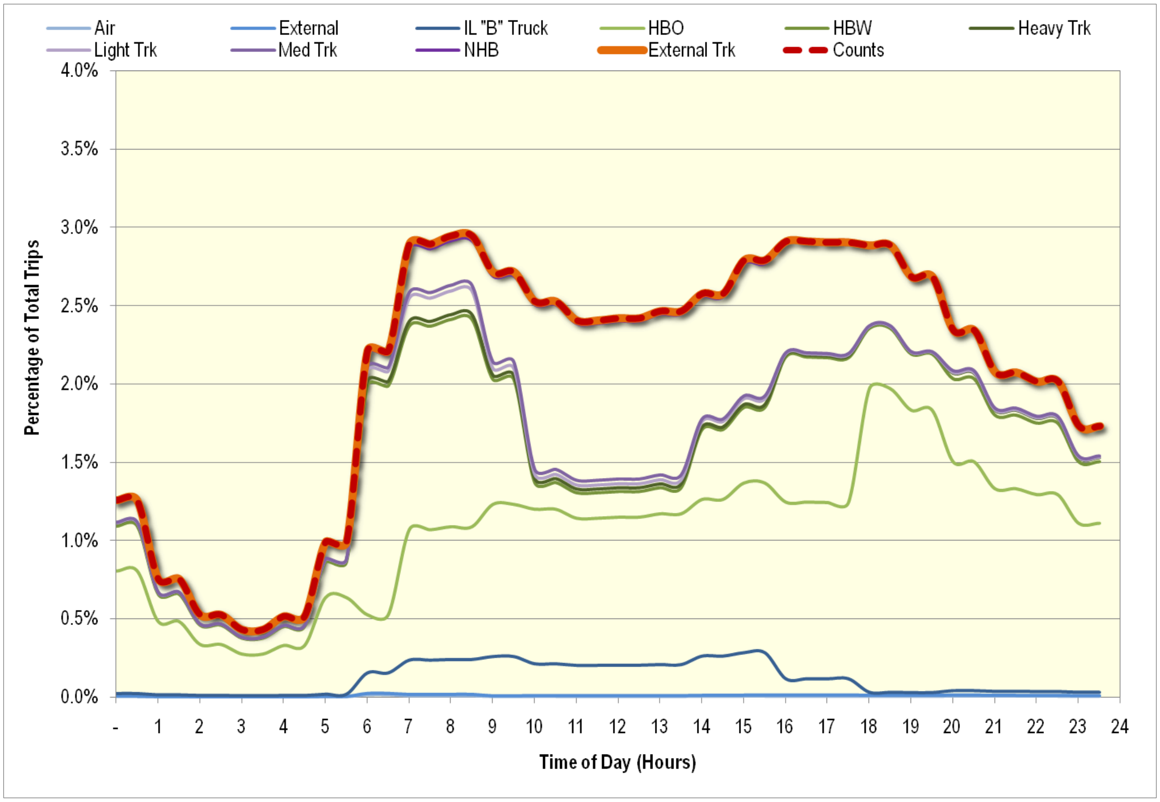
The diurnals for each trip purpose were used to create a composite diurnal for all trip purposes. Figure 4.33 presents the diurnals incrementally stacked on each other to create the diurnal for all trip purposes plotted against 30 minute cumulative counts. It was observed that the shape of the composite trips diurnal is not similar to the shape of count diurnal.

Figure 7.33: Diurnals (Accumulated by Trip Purpose) versus Cumulative Counts



The count diurnal was used to adjust the composite trips diurnal, which was subsequently used to adjust the rest of the incrementally stacked diurnals. Figure 4.34 presents the output of these adjustments.

Figure 7.34: Adjusted Diurnals (Accumulated by Trip Purpose) versus Cumulative Counts



A 3-point moving average smoothing procedure was applied to these diurnals in order to soften the curves. Figure 4.35 presents the output of this procedure and Figure 4.36 presents the smoothed, adjusted diurnals by trip purpose. The GCM count data described in the previous section contains counts for every five minutes of the day. AECOM used this data to create and refine fifteen minute diurnals. These diurnals were used to distribute trips by purpose.

Figure 7.35: Adjusted Smoothed Diurnals (Accumulated by Trip Purpose) versus Cumulative Counts

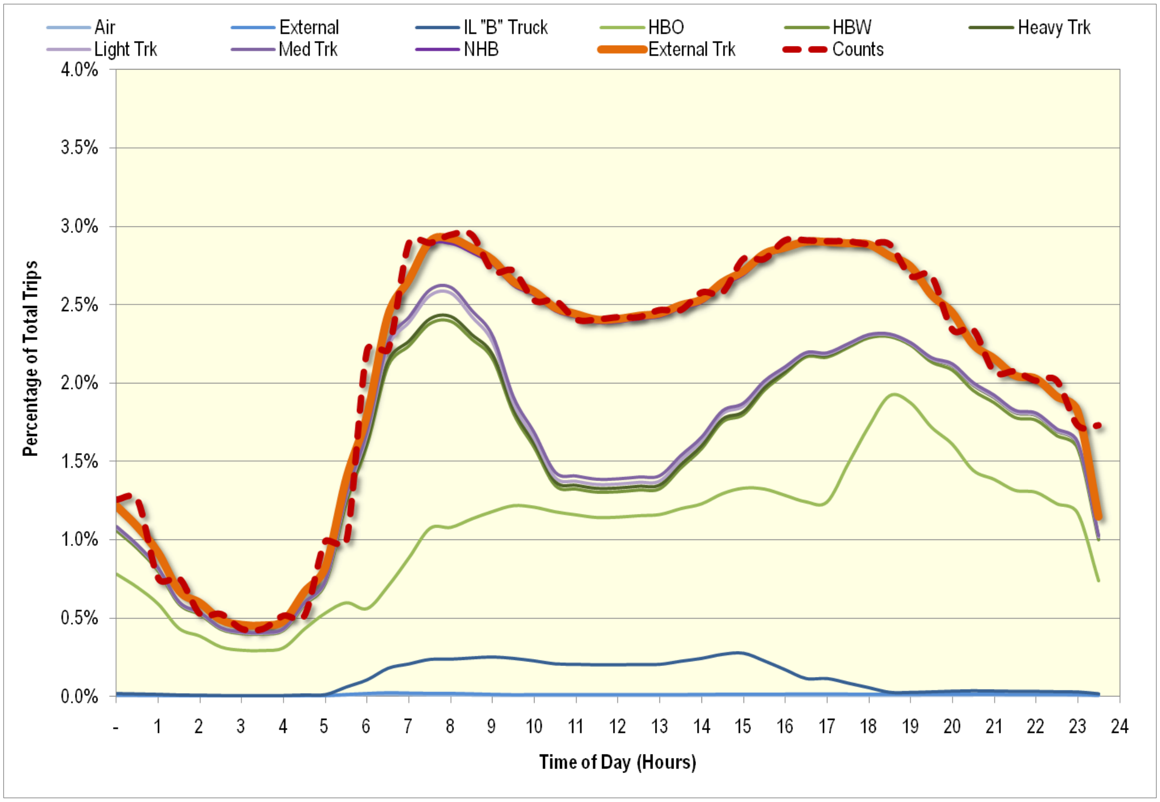
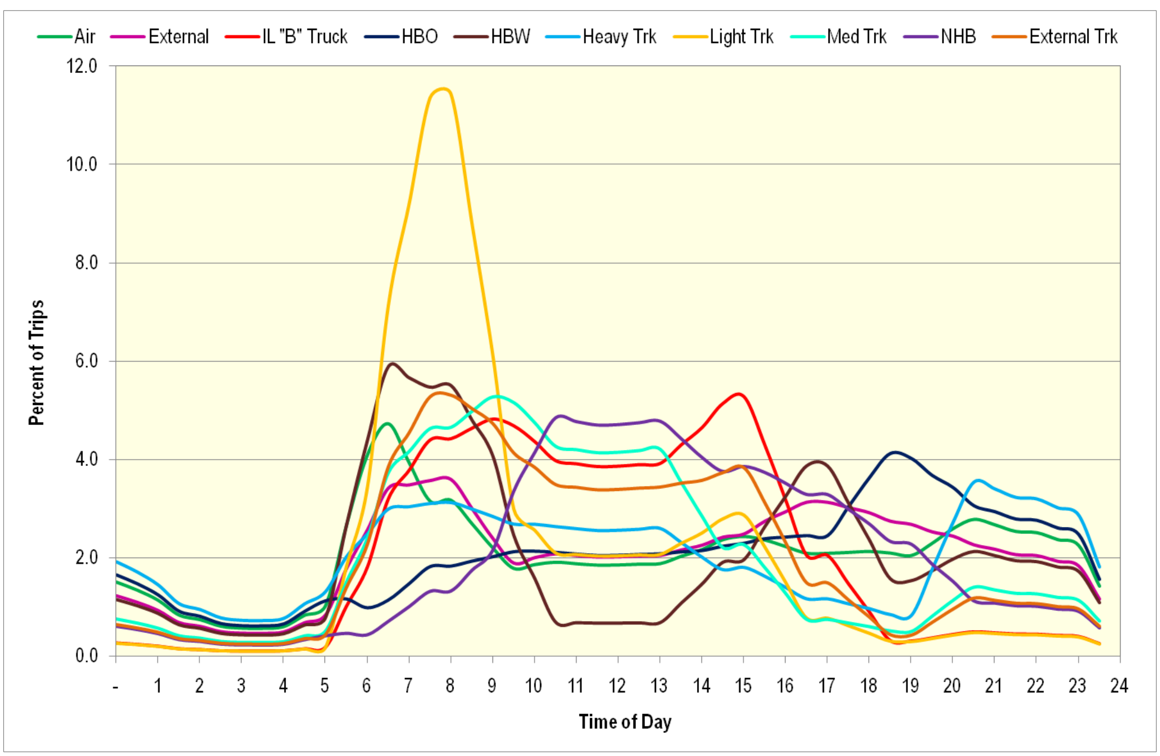


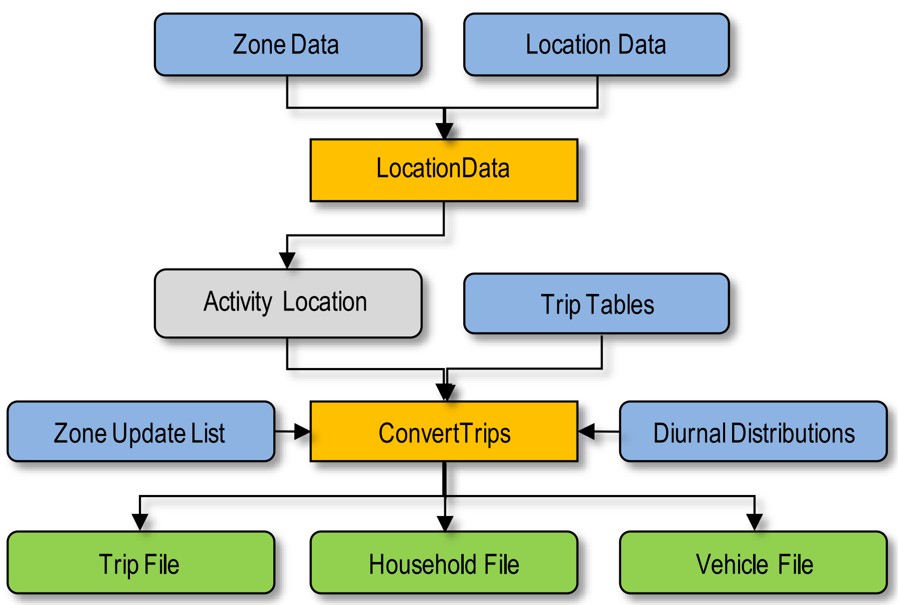
Figure 7.36: Adjusted Smoothed Diurnals by Trip Purpose



7.5.2. Trip Table Conversion

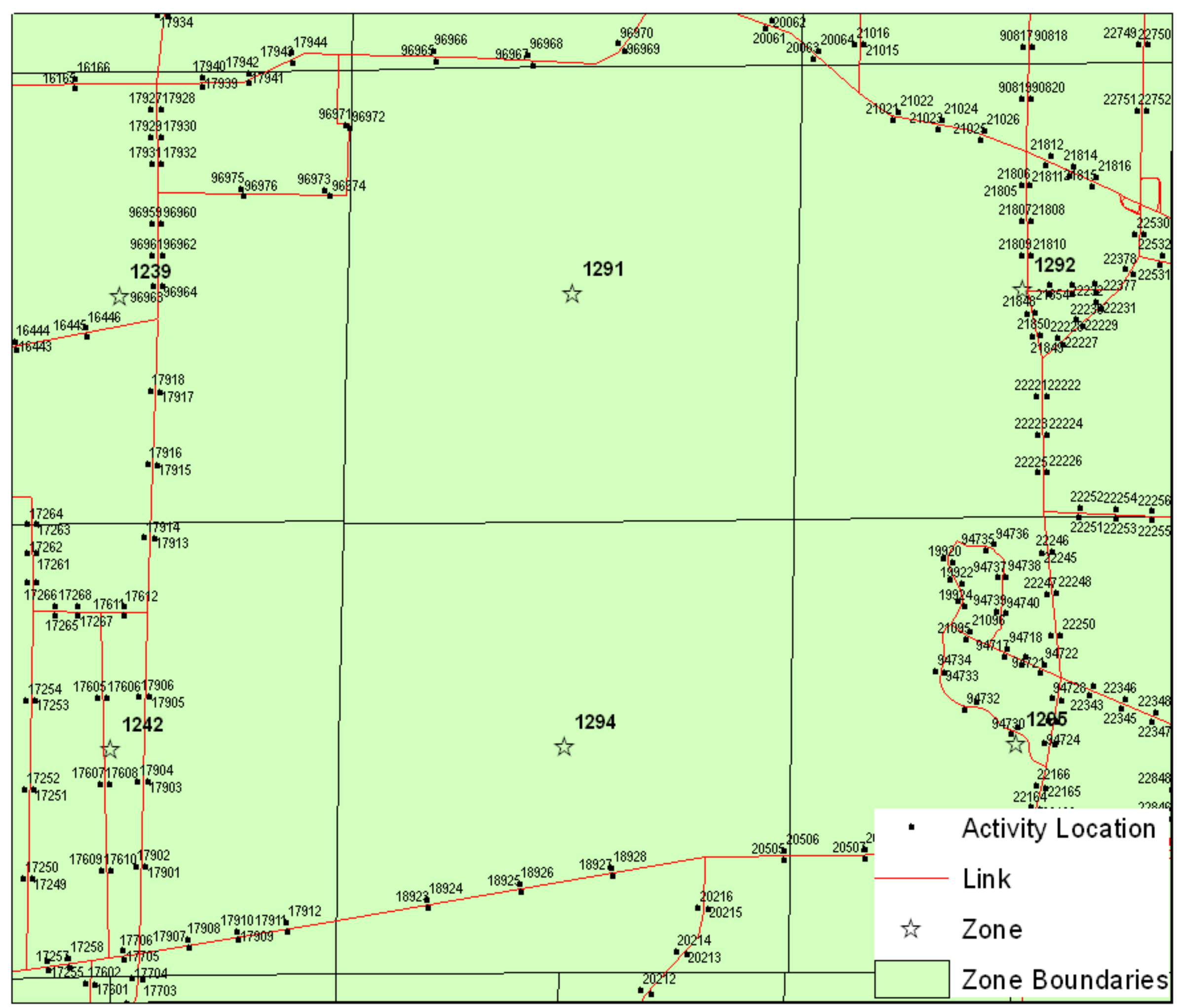
AECOM, as part of the normal day TRANSIMS model creation, converted the Chicago Metropolitan Agency for Planning (CMAP) EMME2 trip tables to a TRANSIMS trip file. While the CMAP EMME2 trip tables define trips between zones by time period and mode of travel, the TRANSIMS trip file define trips between specific activity locations, at specific times of day, using a specific mode. The diurnal distribution information extracted from time-of-day freeway counts was used to distribute the static multi-period CMAP trip tables to a TRANSIMS trip file with a high temporal fidelity. For this trip-based application, a separate household and vehicle is generated for each trip. The vehicle starts the day in a parking lot near the activity location of the trip origin. During this trip table conversion process, AECOM allocated traveler types and vehicle types by trip purpose and the type of traveler: Travelers who pay tolls using cash or travelers who use iPass, the electronic toll pass. About 20% of the travelers in the Chicago area pay tolls using cash. A ConvertTrips traveler script was created to randomly allocate a traveler type to each traveler. Figure 4.37 shows the TRANSIMS demand conversion process used in this project.

Figure 7.37: TRANSIMS Demand Conversion Process



The first step in the trip table conversion process is the preparation of the activity location file generated by TransimsNet. LocationData is used to add attributes to the activity location file. These attributes include: trip distribution flags based on use codes of activity location links and zone numbers based on point-in-polygon (activity location in zone) equivalence. If there are no links inside a zone, the zone would not contain any activity locations. The trips from or to this zone in such cases would be lost during the trip table conversion process. Figure 4.38 presents an example of a zone (1291) without any activity locations within its boundaries. In order to ensure that trips are not lost during the conversion process, a zone update list was created to manually assign activity locations from neighboring zones to the zones without any activity locations.

Figure 7.38: An Example of a Zone without Activity Locations



Once the activity location file is updated and every zone has at least two activity locations, ConvertTrips is used to convert the EMME2 trip tables to TRANSIMS trip tables. Figure 4.39 and Figure 4.40 present the ConvertTrips control file and the traveler type script file respectively.

Figure 7.39: Convert Trips Control File

```
#---- airport trips ----

TRIP_TABLE_FILE_1                    inputs/trips/Input_Trips.airpoe
TIME_DISTRIBUTION_FILE_1             inputs/trips/diurnal.airpoe
TRIP_SCALING_FACTOR_1                1
TIME_DISTRIBUTION_TYPE_1             MID-TRIP
ORIGIN_WEIGHT_FIELD_1                AUTO_ORG
DESTINATION_WEIGHT_FIELD_1           AUTO_DES
TRIP_PURPOSE_CODE_1                  1
TRAVEL_MODE_CODE_1                   DRIVE
AVERAGE_TRAVEL_SPEED_1               10 mps
VEHICLE_TYPE_CODE_1                  16

#---- external trips ----

TRIP_TABLE_FILE_2                    inputs/trips/Input_Trips.autopoe
TIME_DISTRIBUTION_FILE_2             inputs/trips/diurnal.autopoe
TRIP_SCALING_FACTOR_2                1
TIME_DISTRIBUTION_TYPE_2             MID-TRIP
ORIGIN_WEIGHT_FIELD_2                AUTO_ORG
DESTINATION_WEIGHT_FIELD_2           AUTO_DES
TRIP_PURPOSE_CODE_2                  2
TRAVEL_MODE_CODE_2                   DRIVE
AVERAGE_TRAVEL_SPEED_2               10 mps
VEHICLE_TYPE_CODE_2                  17
```

Figure 7.40: Convert Trips Traveler Type Script

```
REAL PROB ENDDEF
PROB = RANDOM ()

IF (Traveler.Veh_Type > 10 && Traveler.Veh_Type < 20) THEN
     IF (PROB > 0.80) THEN   //Cash Type
          Traveler.Type = Traveler.Veh_Type + 50
          Traveler.Veh_Type = Traveler.Veh_Type  + 50
     ELSE          //Card Type
          Traveler.Type = Traveler.Veh_Type
     ENDIF
ELSE
     Traveler.Type = Traveler.Veh_Type
ENDIF
```

7.6. Normal Day Traveler Routing

Router and PlanCompare iterations were run to calibrate the TRANSIMS Chicago normal day model. These iterations are run before simulation so that traffic volumes on links can reach equilibrium and replicate observed traffic patterns. Traveler paths are refined throughout the iteration process to ease congestion and reduce vehicle problems.

The PlanCompare program selects a certain number of travelers whose impedance has changed significantly enough from their impedance in the previous iteration based on user defined parameters. These selected travelers are re-routed and their new plans are merged with the overall plan files. These merged plans are then used to create link delays.

The LinkDelay program is used for faster convergence and to average link delays across iterations in order to ensure that link delays across two consecutive iterations are not volatile. The weighted average method was used meaning that a previous link delay has a user defined weight when producing the averaged LinkDelay file. For example, if that weight is set to 7, then the previous iteration's averaged LinkDelay file will be weighted 7 times as much as the current iteration's router link delay.

```
CURRENT AVG LINK DELAY  =   7/8 *(PREV AVG LINK DELAY)   +   1/8 * (CURRENT ROUTER LINK DELAY)
```

To improve the overall performance of the Router and more accurately replicate observed traffic counts, the following Router parameters were adjusted:

- BPR coefficients
- Facility bias factors
- Local facility type
- Local access distance
- Distance value

The Link Delay functions and coefficients presented in Figure 4.41 replicated the CMAP model routing well and were chosen.

Figure 7.41: Link Delay Functions and Coefficients

```
EQUATION_PARAMETERS_1    BPR+, 0.06, 4.0, 0.75, 1       Freeway
EQUATION_PARAMETERS_2    BPR+, 0.06, 4.0, 0.75, 1       Expressway
EQUATION_PARAMETERS_4    BPR+, 0.50, 5, 0.75, 1         Major Arterial
EQUATION_PARAMETERS_5    BPR+, 0.40, 5, 0.75, 1         Minor Arterial
EQUATION_PARAMETERS_6    BPR+, 0.15, 4.0, 0.75, 1       Collector
EQUATION_PARAMETERS_7    BPR+, 0.15, 4.0, 0.75, 1       Local
EQUATION_PARAMETERS_9    BPR+, 0.15, 4.0, 0.75, 1       Ramp
EQUATION_PARAMETERS_10   BPR+, 0.45, 3.3, 1.00, 1       Bridge/Other
```

The facility bias factors presented in Figure 4.42 replicated the CMAP model routing well and were chosen.

Figure 7.42: Facility Bias Factors

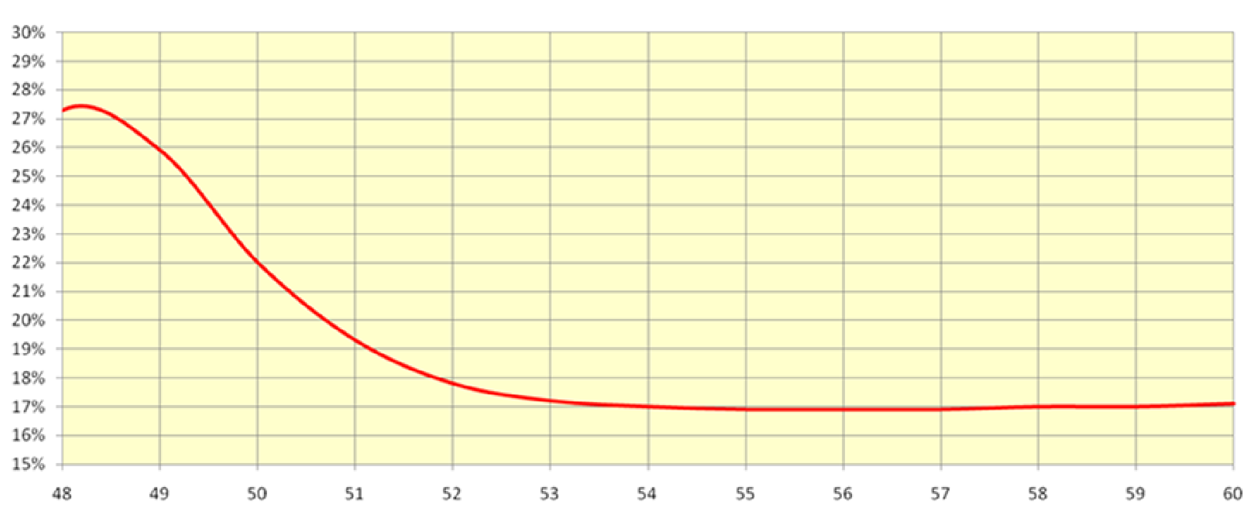
```
FACILITY_BIAS_FACTORS_1      0.5            Freeway
FACILITY_BIAS_FACTORS_2      0.5            Expressway
FACILITY_BIAS_FACTORS_4      1.5            Major Arterial
FACILITY_BIAS_FACTORS_5      1.5            Minor Arterial
FACILITY_BIAS_FACTORS_10     0.5            Bridge/Other
```

The current Chicago TRANSIMS model network does not include local streets so collectors were designated as local access facilities. The local access distance was limited to 2.5 miles and the distance value or the contribution of distance to impedance was set to ‘0’ (i.e. distance does not contribute to impedance). Additional parameter combinations including changes to facility bias factors for arterials from 1.5 to 2.0 and a change to the distance value from 0.0 to 0.5 were tested.

7.7. Traveler Selection Criteria for Rerouting

The PlanCompare program is used in conjunction with Router to ensure that traffic assigned to the network is not volatile across iterations. In other words, if Router’s path for the current iteration picks a route, that particular route would be congested and thus the next iteration of Router which is built on the current iteration’s link delays may avoid that particular route. This process would cause fluctuations in traffic volumes on parallel roadways and unless these fluctuations are dampened, the amount of time required for traffic volumes on roadways to stabilize would be very high. In order to dampen the fluctuations, not all travelers are to be routed using the same link delay. This is accomplished by selecting travelers to be routed using the latest link delay and replacing these travelers’ plans in the existing plan set. The specific selection criterion includes at least a 3% difference in impedance and at least a 2 minute difference in time. No more than 50% of these travelers are selected. The percentage of travelers selected reduces as iterations progress demonstrating stability. Figure 4.43 shows how many travelers are selected each iteration and how it reduces until it converges around 17%.

Figure 7.43: PlanCompare Selection Percentage by iteration



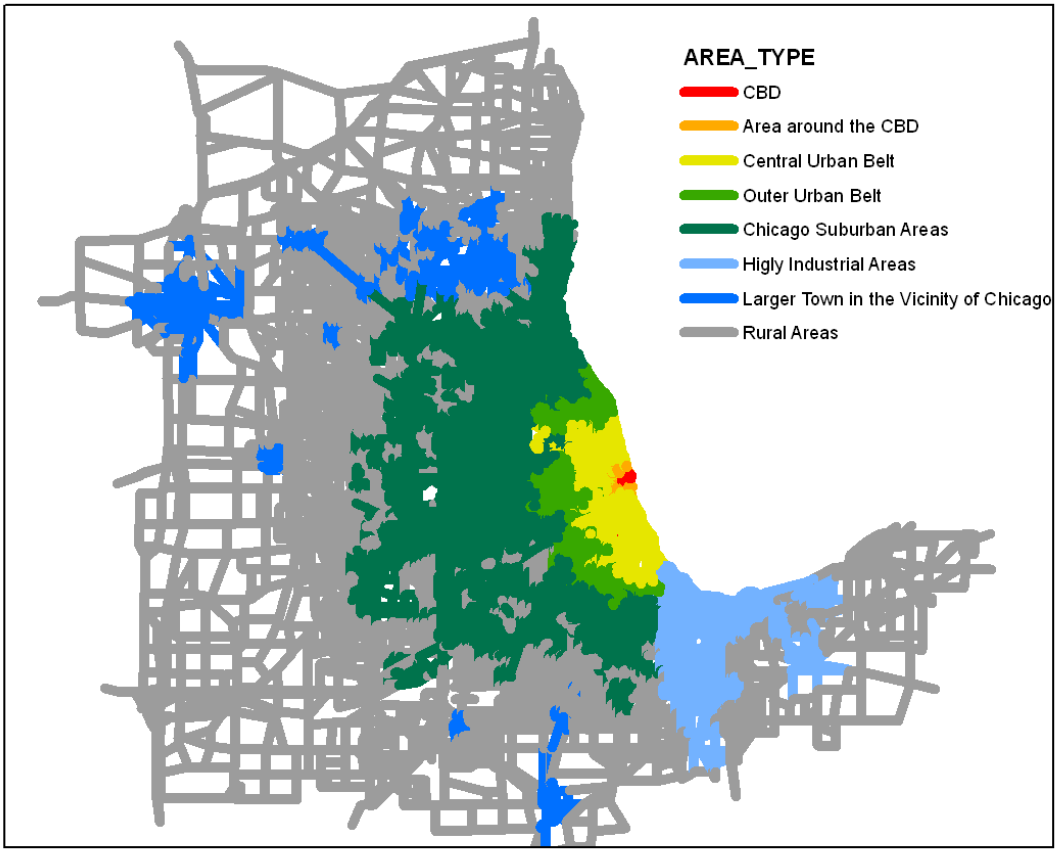
7.7.1. Next Steps

AECOM has started Router-Simulator iterations for the Chicago normal day model; however, there were not enough resources to complete this process as part of this task order. AECOM has provided Argonne the Router-Simulator iteration setups on TRACC and Argonne plans to continue the iterations. In addition, AECOM has tested transit vehicle simulation and provided Argonne transit network files, and control files required to simulate transit vehicles. TRANSIMS version 5 Router is not capable of routing transit travelers yet. Once the software is developed, the transit travelers need to be added to the Router-Simulator iterations.

7.8. Model Validation

A travel demand model is validated by comparing model traffic volume estimates to observed traffic counts and speeds. The Chicago TRANSIMS model is in a very primitive state, but a model validation was performed on the initial results. The following sections discuss the current model state and validation results. Validation results are reported by both area type and by functional class. Figure 4.44 presents the area types in the Chicago region.

Figure 7.44: Area Types



7.8.1. CMAP Model Validation

AECOM extracted the existing CMAP model estimated traffic volumes and compared them to observed traffic volumes. The following section presents the results of this analysis as scatter plots and maps. Figure 4.45 presents a comparison of CMAP model estimated volumes plotted against observed volumes while Figure 4.46 presents CMAP model observed volumes plotted against percentage deviation of estimated volumes from the observed volumes.

Figure 7.45: CMAP Model - Observed v. Estimated

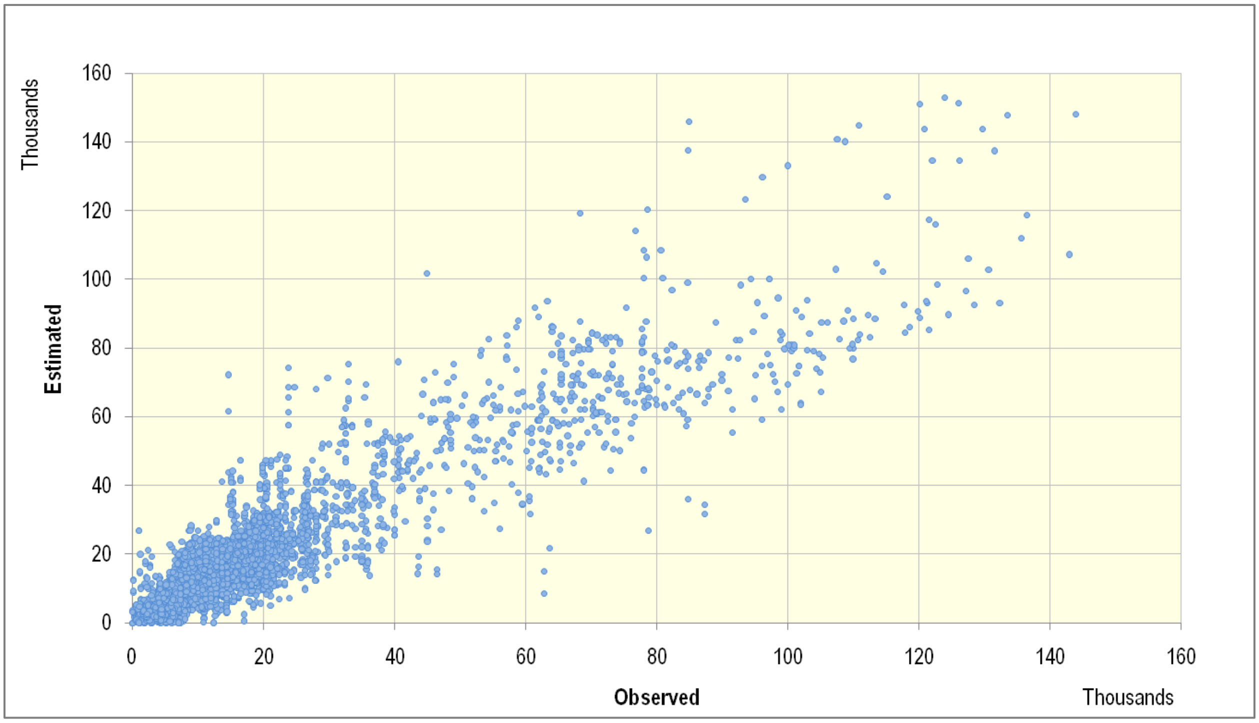


Figure 7.46: CMAP Model - Observed v. Percentage Deviation of Estimated from Observed

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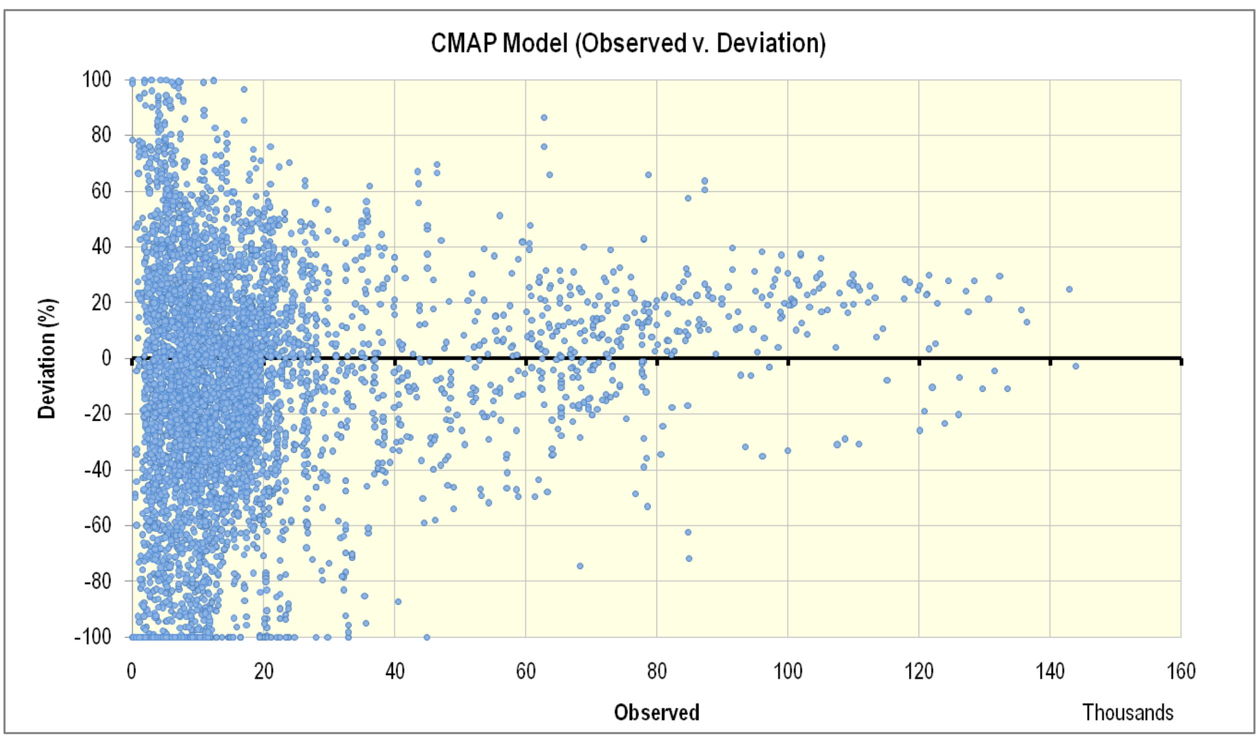


Figure 4.47 presents a map showing differences between CMAP model estimated volumes and observed volumes.

Figure 7.47: CMAP Model Estimated v. Observed

7.8.2. Router Validation

The following section presents comparisons of Router estimated volumes with observed volumes and with CMAP estimated volumes. The entire set of estimated volumes and observed traffic volumes obtained from CMAP could not be attributed to TRANSIMS links correctly since some of the CMAP EMME2 network links were either split, removed, or moved. In an effort to continue Router parameter calibration efforts AECOM identified a set of estimated and observed volume locations that match TRANSIMS link locations and used these filtered locations for comparison. Figure 4.48 and Figure 4.49 present TRANSIMS Validate reports for comparisons of Router estimated volumes with CMAP EMME2 estimated volumes and observed traffic volumes respectively. These exhibits present a comparison for all the locations and the filtered locations. It is observed that Router parameters have been well calibrated and the plans from Router can be simulated.

Figure 7.48: Validation – Router Estimated Volumes v. EMME2 Estimated Volumes

Facility Type	Num. Obs.	VMT Estimate	VMT Observed	Difference VMT	Difference %	Abs.Error Avg.	Abs.Error %	Std. Dev.	% RMSE	R Sq.
ALL										
FREEWAY	776	192693400	197039041	-4345641	-2.2	60263	23.7	157273	66.3	0.703
EXPRESSWAY	118	12360410	12328803	31607	0.3	25014	23.9	31702	38.5	0.837
MAJOR	22369	575919719	581317220	-5397501	-0.9	9057	34.9	16956	74.0	0.670
MINOR	6173	114047623	67857703	46189920	68.1	9841	89.5	15911	170.2	0.423
COLLECTOR	2883	39870382	17485613	22384768	128.0	9449	155.8	10309	230.5	0.289
RAMP	960	12932736	11755571	1177165	10.0	6512	53.2	10427	100.4	0.411
OTHER	117	967412	2426477	-1459064	-60.1	14663	70.7	27779	151.0	0.249
EXTERNAL	9	3624881	3705327	-80446	-2.2	8938	2.2	8570	2.9	0.998
TOTAL	33405	952416563	893915755	58500808	6.5	10428	39.0	29867	118.2	0.772
FILTERED										
FREEWAY	389	91155241	94740298	-3585057	-3.8	28760	11.8	40927	20.5	0.963
EXPRESSWAY	53	6069942	5675335	394607	7.0	12548	11.7	13095	16.9	0.976
MAJOR	12644	303508856	319544166	-16035310	-5.0	6460	25.6	10226	47.9	0.821
MINOR	4026	67371956	35923740	31448216	87.5	8688	97.4	14477	189.2	0.504
COLLECTOR	1896	24791431	9446089	15345342	162.5	8771	176.1	9727	262.9	0.285
RAMP	458	5754660	5100919	653741	12.8	4049	36.4	4484	54.2	0.769
OTHER	41	355578	391414	-35836	-9.2	1348	14.1	2904	33.2	0.991
EXTERNAL	9	3624881	3705327	-80446	-2.2	8938	2.2	8570	2.9	0.998
TOTAL	19516	502632544	474527287	28105257	5.9	7539	31.0	12846	61.3	0.927

Figure 7.49: Validation – Router Estimated Volumes v. Observed Volumes

Facility Type	Num. Obs.	VMT Estimate	VMT Observed	Difference VMT	Difference %	Abs.Error Avg.	Abs.Error %	Std. Dev.	% RMSE	R Sq.
ALL										
FREEWAY	690	176026289	159709958	16316331	10.2	93678	40.5	134263	70.7	0.699
EXPRESSWAY	96	8804461	9210131	-405671	-4.4	47042	49.0	50879	72.0	0.451
MAJOR	4410	145507796	151565598	-6057802	-4.0	11456	33.3	15555	56.2	0.645
MINOR	316	5725423	5755250	-29827	-0.5	6157	33.8	7574	53.5	0.753
COLLECTOR	150	1297888	1929489	-631602	-32.7	6727	52.3	7848	80.2	0.327
RAMP	71	1368296	1508513	-140217	-9.3	15583	73.3	29639	156.7	0.099
OTHER	43	552897	1642861	-1089964	-66.3	34055	89.1	29638	117.6	0.128
EXTERNAL	9	3624881	3005649	619231	20.6	68803	20.6	45972	24.3	0.989
TOTAL	5785	342907931	334327451	8580480	2.6	21749	37.6	55962	103.9	0.785
FILTERED										
FREEWAY	218	51177362	52717154	-1539792	-2.9	34909	14.4	53698	26.4	0.946
EXPRESSWAY	22	2404122	2483492	-79370	-3.2	32972	29.2	35537	42.4	0.698
MAJOR	2041	60534536	67023276	-6488739	-9.7	7071	21.5	8697	34.1	0.853
MINOR	170	3040957	2839767	201190	7.1	4059	24.3	5877	42.7	0.891
COLLECTOR	58	490939	458753	32186	7.0	2479	31.3	3745	56.4	0.627
RAMP	20	420622	370677	49945	13.5	6554	35.4	6371	48.7	0.735
OTHER	2	17405	14349	3056	21.3	1714	23.9	2161	32.0	1.000
EXTERNAL	9	3624881	3005649	619231	20.6	68803	20.6	45972	24.3	0.989
TOTAL	2540	121710825	128913118	-7202293	-5.6	9589	18.9	20196	44.0	0.955

7.9. Modeling Procedure and Algorithms

TRANSIMS network and demand are typically created from highway/transit network and demand from a traditional four step modeling package. The networks and demand from these packages are then post-processed to create inputs to TRANSIMS modeling process. The following sections explain how to convert the network and demand. In addition, this document presents the process to execute Router-Simulator iterations.

7.9.1. Network Conversion Process

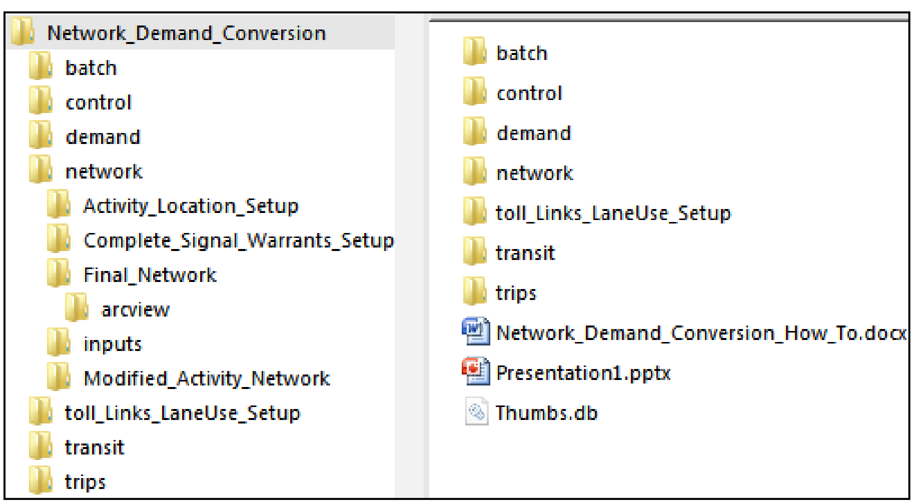
7.9.1.1. Highway Network

The CMAP EMME2 network is the basis for the Chicago normal day model. Argonne processed the EMME2 network to create an input link, node, zone, and shape file. AECOM processed these inputs and created the TRANSIMS highway network. The network conversion process includes four main tasks. They are:

1. producing a temporary network (original network),
2. modifying activity locations,
3. modifying signal warrants, and
4. generating traffic control files.

These steps should be followed sequentially in order to create the final network. AECOM created separate setups for each of these tasks in order to simplify the network conversion process. Figure 4.50: shows the structure that needs to be in place in order for a user to follow the steps explained in this How-To and successfully create the TRANSIMS network and demand. If a different structure is used, the control files would need to be modified accordingly.

Figure 7.50: Network and demand conversion process folder structure



The following steps are used to create the TRANSIMS network for Chicago.

STEP 1 Go to the ***batch*** folder and run "***Network_Conversion_Step1.bat***". This batch file executes NetPrep and TransimsNet using "***Chicago.NetPrep.ctl***" and "***Chicago.TransimsNet.Temp_Network.ctl***" control files respectively. These files are located in the control folder. This step generates "Original Network" and is placed in the network folder.

STEP 2 Go to the ***network\Complete_Signal_Warrants_Setup*** and run "***Modify_Signal_Warrants.bat***". This setup modifies the ***Signal_Warrants*** file created in the first step to maximize the use of available signal data. This ensures that the 167 critical signalized intersections along potential evacuation routes, the 300 signals in the Chicago Central Business District, the CDOT signal locations and the 1,267 signals throughout the study area are effectively incorporated in the network conversion process.

STEP 3 Go to the ***network\Activity_Location_Setup*** and complete the following steps.

1. Run "***Get_Original_Link_File.bat***". This batch file automatically creates a copy of the ***Link_Original*** file created in Step 1.
2. Open ***Create_Updated_Link_File.accdb***
3. Run the macro "***ProcessData***".

The main objective of this setup is to change the type field of preselected links to "***Other***". The preselected links include overpasses, underpasses, bridges, and links within interchange perimeters.

STEP 4 Go to the ***batch*** folder and run "***Network_Conversion_Step2.bat***". This batch executes TransimsNet using "***Chicago.TransimsNet.Act.ctl***" located in the control folder. This control file is similar to "Chicago.TransimsNet.Temp_Network.ctl" but will not generate activity locations for links with type "Other". Although after this step a complete set of network files are generated and placed in the "***Modified_Activity_Network***" folder, only ***Locations_Act***, ***Parking_Act***, and ***Access_Link_Act*** files will be used as part of the final network. The rest of the files will be ignored.

STEP 5 Go to ***Final_Network*** folder and run Build_Network_Best.bat. This batch file fills the ***Final_Network*** folder with files from ***Network***, ***Complete_Signal_Warrants_Setup***, and ***Modified_Activity_Network*** folders.

STEP 6 Go to the ***batch*** folder and run "***Network_Conversion_Step3.bat***". This batch file executes IntControl using "***Chicago.IntControl.ANL.ctl***" located in the control folder. IntControl creates traffic signal and sign files and places them in the ***Final_Network*** folder. The batch file also executes ArcNet using "***Chicago.ArcNet_BestNetwork.ctl***" located in the control folder. ArcNet creates Arcview shapefiles for the files placed in the ***Final_Network*** folder. The shapefiles are placed in the arcview folder under ***Final_Network*** folder, "***network\Network_Best\arcview***".

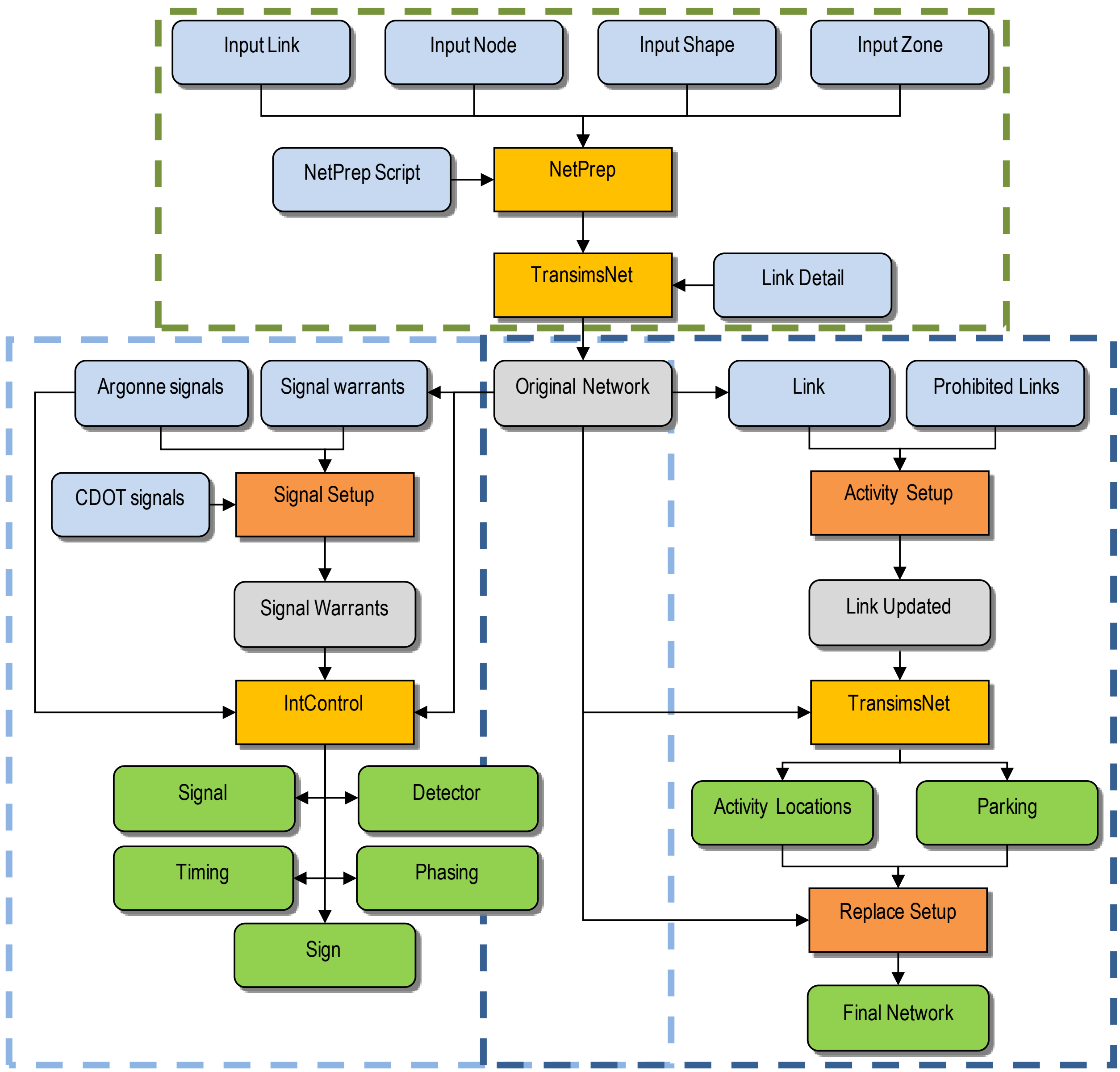
Figure 4.51 shows the TRANSIMS highway network conversion process used in this project.

7.9.1.2. Transit Network

Transit network conversion only includes the rail network at this point.

STEP 1 Go to the ***batch*** folder and run ***Transit_Conversion.bat***. This batch file executes TransitNet using "***Chicago.TransitNet.ctl***" located in the control folder. The results will be placed in the transit folder.

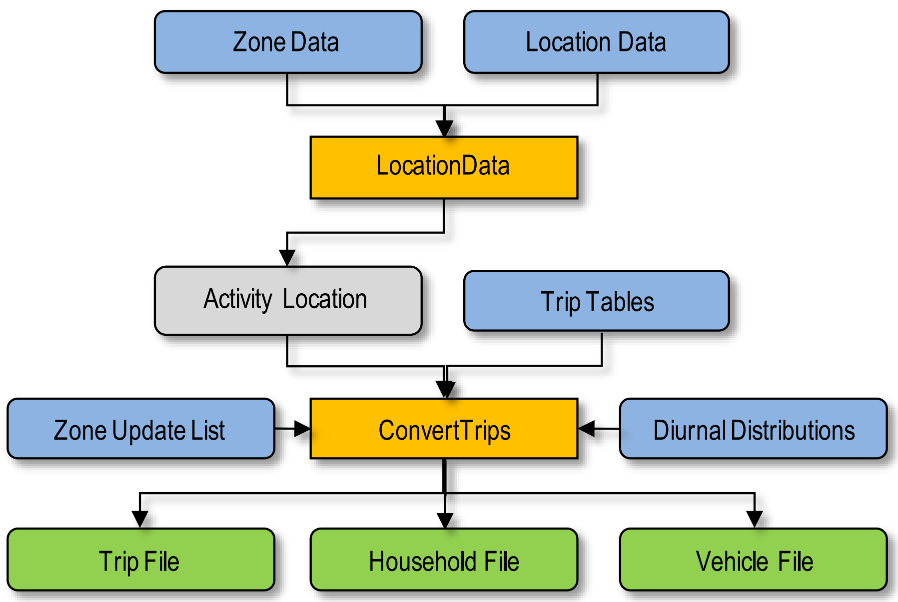
Figure 7.51: Chicago's highway network conversion process



7.9.2. Demand Conversion Process

As part of the normal day TRANSIMS model, AECOM converted the Chicago Metropolitan Agency for Planning (CMAP) EMME2 trip tables to TRANSIMS trip table data. While the CMAP EMME2 trip tables define trips between zones by time period and mode of travel, the TRANSIMS trip file define trips between specific activity locations, at specific times of day, using a specific mode. The diurnal distribution information extracted from time-of-day freeway counts was used to distribute the static multi-period CMAP trip tables to a TRANSIMS trip file with high temporal fidelity. For this trip-based application, a separate household and vehicle is generated for each trip. The vehicle starts the day in a parking lot near the activity location of the trip origin. During this trip table conversion process, AECOM allocated traveler types and vehicle types by trip purpose and the type of traveler – travelers who pay tolls using cash or travelers who use iPass, the electronic toll pass. About 20% of the travelers in the Chicago area pay tolls using cash. A ConvertTrips traveler script was created to randomly allocate a traveler type to each traveler. Figure 4.52: shows the TRANSIMS demand conversion process used in this project.

Figure 7.52: TRANSIMS demand conversion process



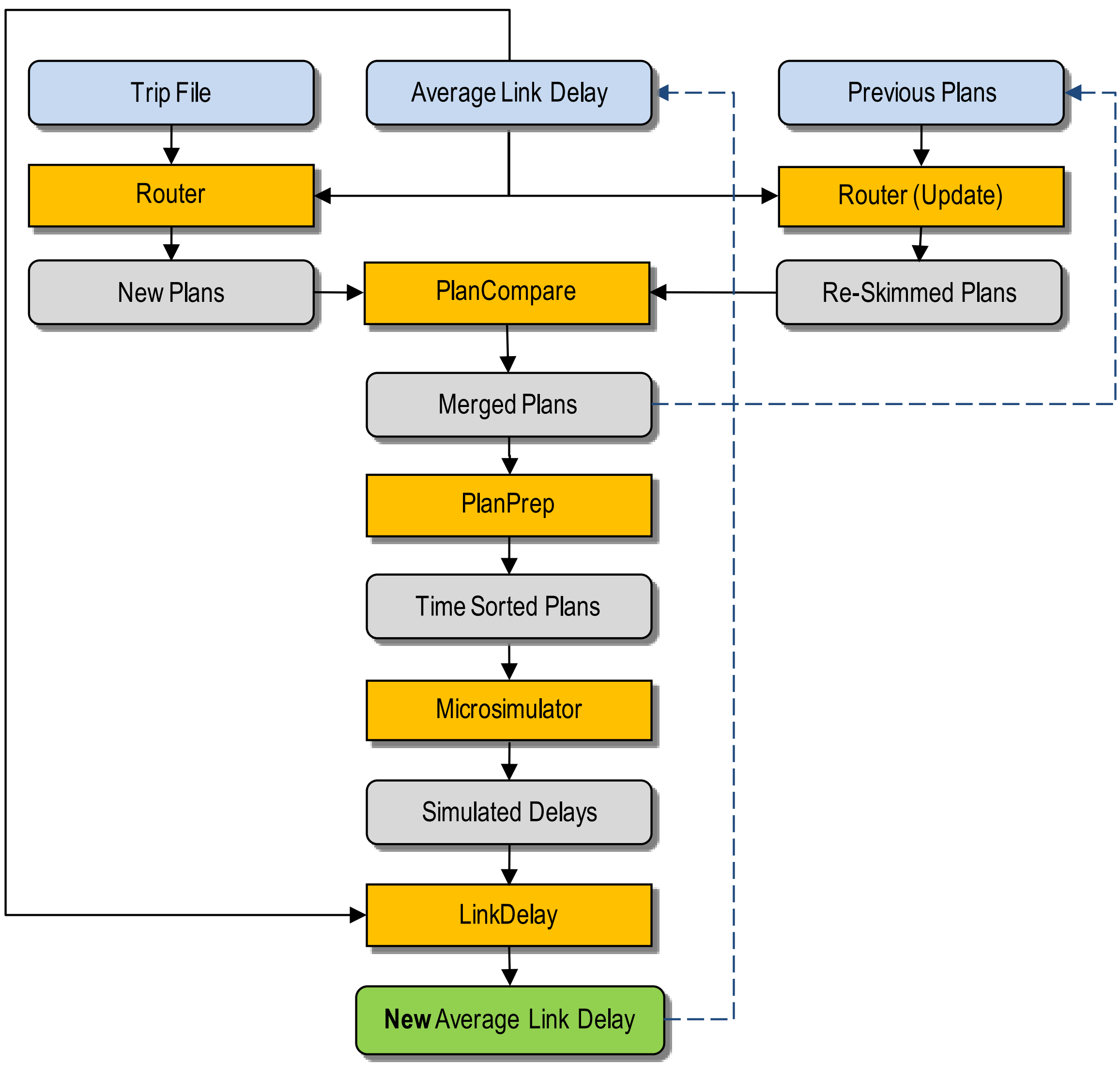
The demand conversion process is a one step process as follows:

STEP 1 Go to the ***batch*** folder and run "***Demand_Conversion.bat***". This batch file executes LocationData and ConvertTrips using ***Chicago.LocationData.ANL.ctl*** and ***Chicago.ConvertTrips.ANL.ctl*** control files, respectively. These files are located in the control folder. LocationData post processes the activity location file (originally generated by TransimsNet) to add attributes to the activity location file. These attributes include trip distribution flags based on use codes of activity location links and zone numbers based on point-in-polygon (activity location in zone) equivalence. If there are no links inside a zone, the zone would not contain any activity locations. The trips from or to this zone in such cases would be lost during the trip table conversion process. In order to ensure that trips are not lost during the conversion process, a zone update list was created to manually assign activity locations from neighboring zones to the zones without any activity locations. Once the activity location file is updated and every zone has at least two activity locations, ConvertTrips is used to convert the EMME2 trip tables to a TRANSIMS trip file. The results of this step are placed in the demand folder.

7.9.3. Router-Simulator Iterations

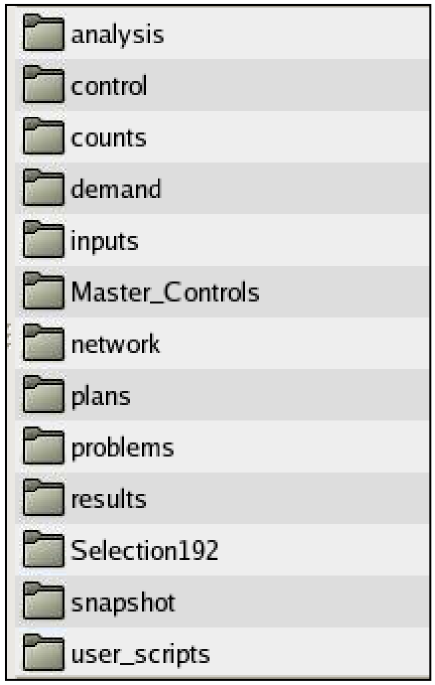
A series of feedback iterations between the Router and the Simulator are typically employed to achieve user equilibrium convergence of the travel paths. Figure presents the Router-Simulator feedback process. AECOM developed procedures to create control files and shell scripts on the Transportation Research and Analysis Computing Center (TRACC). This section describes the procedure for creating these control files.

Figure 7.53: Router-Simulation iterations



The Router-Simulator runs folder structure on TRACC is presented in Figure .

Figure 7.54: Router-Simulator runs folder structure



The control files and the shell scripts to run the Router-Simulator iterations are created using a python script located in the ***user_scripts*** folder. This python script, ***CreateBatchControlFiles.py***, reads the Router-Simulator iteration setup control file, ***m.files.Router_Simulator.ctl***, presented in Figure , which contains a list of the number of TRACC nodes to be used, the TRANSIMS program to be used, the file name of the master control file, and an enumeration of the iteration numbers. If the number of nodes to be used is one, MPI-based executables are not used. If a UNIX shell command is to be used instead of a TRANSIMS program, the number of nodes is to be set to zero. This is useful to delete large plan files from previous iterations. It is advised that the last three iterations' plan files be saved.

Figure 7.55: Sample Router-Simulator Iterations setup control file

```
24,m.Router.RouterUpdatePlans.ctl,1..15
24,m.Router.Router.ctl,1..15
24,m.PlanCompare.PlanCompare.ctl,1..15
24,m.PlanPrep.PlanPrep.ctl,1..15
1,m.Simulator.Sim.ctl,1..15
1,m.LinkDelay.LinkDelay.ctl,1..15
0,m.rm.delPlans.sh,0..3
0,m.rm.delPlans.sh,6..13
0,m.rm.delPlans.sh,15..23
0,m.rm.delPlans.sh,25
```

The setup to create the control files is located under the ***user_scripts*** folder in the project directory. To create the control files and the shell scripts:

STEP 1 Go to the ***Master_Controls*** folder and update the master control files as needed. The master control files contain the following parameters

- @run@ current iteration number
- @prev@ previous iteration number
- @project@ project directory
- @del@ iteration number for the plan to be deleted

STEP 2 Go to the ***user_scripts*** folder and modify ***m.files.Router_Simularor.ctl*** to use the correct number of nodes and to create and setup control files for the required number of iterations.

STEP 3 Go to the ***user_scripts*** folder and run ***create_controls.sh***. The control files will be created in the ***control*** folder and the ***RunBatch.sh*** shell script in created in the ***control*** folder.

STEP 4 Go to the ***control*** folder and execute ***Submit_Router_Simulator_Runs.csh***. Before executing, please change TRACC queue parameters such as wall-time as needed.

8. Research on Stadium and Building Evacuation Modeling

- Raul Alvarez, NIU Graduate Student
- Quan Zhang, NIU Graduate Student
- Reinaldo Moraga, NIU Faculty

8.1. Literature Review

Emergencies are likely to happen all over the world, it could be in a particular building, stadium or it could involve a larger area such a neighborhood. Given this situation, proper planning is required in order to proceed with the evacuation of the people involve. It is important to notice that the evacuation is a complex process due to the large number of people, their interactions, and external factors such as the building design or the actual threat (Schadschneider, Klingsch, Klüpfel, Kretz, Rogsch, & Seyfried, 2009).

A large amount of work can be found in the literature related to pedestrians. Most of the research work focuses on different aspects of pedestrian behavior: modeling approaches, empirical data, behavior under normal conditions, behavior in emergencies, building evacuation, stadium evacuation, neighborhood evacuation, among others. It is important to have an idea of what each one of these aspects represent in order to have a whole perspective of how pedestrians behave and which approach is the right one to use in order to solve a problem.

Given the complexity of an emergency situation, the use of simulation tools is very helpful in order to understand the dynamics of the evacuation process and how to improve it. In order to make a simulation model more realistic, it is necessary to take into account all the different transportations modes: people walking, cars, and public transportation. However, is very common to make the assumption of having the cars or pedestrians entering into the traffic network flow directly without taking into account the actual movement time (Rossetti & Ni, 2010).

In the case of Chicago's evacuation TRANSIMS model, it is required to improve the actual egress time from the buildings. In the current model, the pedestrians are leaving the building without taking into account this factor which has a great importance. The purpose of the present literature review is to explore different investigations done in pedestrian evacuation in order to understand the dynamics of pedestrian movement and evacuation. We will discuss findings related to evacuation times, and simulation approaches.

8.1.1. Evacuation Time

According to Sorensen (1991), people do not evacuate at the same time given variations on two main parts: when they receive the information and the time they spend deciding what to do (reaction time), and the second is the actual time to leave their location (egress time). The sum of these two times will give us the actual evacuation time of a single person. We also need to notice that there are multiple factors that can affect these times, and it has been difficult to identify the significance of them due to the lack of proper data.

Rogers and Sorensen (1991) did a research in order to understand how different warning systems impacted the evacuation times based on empirical data. Sorensen (1991) also used empirical data in order to find the significance of factors such as age, family size, location, among others. Both studies show that the lack of proper data is an issue, however based on the data available several findings were found such as how providing information in person helps people to get a better understanding of the situation.

When it comes to evacuation simulation models, it was found that the evacuation time tends to be simplify by assuming that the egress time is the total evacuation time without considering the reaction time. We can find examples of models doing this simplification in Rossetti and Ni (2010), and Cova and Johnson (2002).

8.1.2. Simulation Approaches

Simulation approaches can be identified among three types: micro-simulation, meso-simulation and macro-simulation (Rossetti & Ni, 2010). It is found that the trend is to migrate from macro-simulation models to micro-simulation agent-based models using discrete or continuous space (Berrou, Beecham, Quaglia, Kagarlis, & Gerodimos, 2007).

Macro-simulation models tend to model the pedestrian crowds as a fluid or lattice gas, even queuing methods are used. The common point of view among these approaches is that they don't look into the detail of each person, but look at the whole group in order to model its behavior.

Hamacher and Tjandra (2002) present several mathematical models used in order to model evacuations. Among these models we have static networks, discrete time dynamic networks, and continuous time dynamic networks. Casadesus Pursals and Garriga Garzon (2007) presented a model that incorporates evacuation routes and the relation between flow and occupation density to optimize the building evacuation time. In the case of the work presented by Talebi and Smith (1985), a stochastic network was presented for a hospital and solve through the use of queuing network.

Micro-simulation models have the capability of representing each pedestrian, their interactions with other pedestrians as well as the interaction with their environment. The reason of the increasing use of micro-simulation models in evacuation is the complexity of it. Pedestrian evacuation presents a different level of difficulty given factors such as panic and danger perception (Izquierdo, Montalvo, Perez, & Fuertes, 2009).

Schadschneider (2002) presents the theory of how to use micro-simulation by discretizing the space in which the agents (pedestrians) are moving, this approach is called Cellular Automata. The use of Cellular Automata is presented by multiple works: Burstedde, *et al.* (2002) show how behavior presented in large crowds can be model by using cellular automata with the implementation of simple rules. Gwynne, *et al.* (2005) presented a comparison of the results of experimental data versus the results obtained using buildingEXODUS which uses cellular automata.

Another approach for micro-simulation is the used of continuous space. Helbing, *et al.* (2002) discuss the use of the Social Forces Concept in order to model the behavior of pedestrians under normal and panic situations. The Social Forces take into account the desire speed at which the pedestrians want to move, the tendency of keeping a distance from other pedestrians, and physical forces coming from interactions with other pedestrians.

Izquierdo, *et al.* (2009) also used agent-based simulation in a continuous space but instead of the Social Forces concept, they used the Particle Swarm Optimization. Finally we have another approach based on the Least-Effort, in which the agents want to reach their objective by minimizing the amount of energy utilized (Guy, Chhugani, Curtis, Dubey, Lin, & Manocha, 2010).

In the case of the pedestrian simulation software LEGION, we have that the agents also seek to minimize a cost function, however is not based on the energy but on three aspects: inconvenience, frustration, and discomfort. The cost function is a weighted sum of the previous factors, and the entities are represented using several parameters that depend on the population profiles (Berrou, *et al.,* 2007). LEGION has been calibrated using empirical data obtained from multiple scenarios such as metro stations and stadiums.

8.1.3. Poisson Process Superimposition

The main assumption for the inter-exit evacuation times comes from the idea of superposition of renewal processes. It has been shown that when the arrival process to a queue is the superposition of many independent processes, the Poisson distribution can be used to model the arrivals (Lam & Lehoczky, 1991). Given that the individuals come from different parts of the building and each one has its own reaction time, the assumption of independency among them can be stated. A representation of the superposition of processes is shown in figure 1.

The basic idea is that the superposition of two renewal processes is a Poisson process if and only if the initial renewal process is Poisson (Cox & Isham, 1980). Other authors have worked on relaxing the main assumption that the initial processes have to be Poisson. The work of Cinlar & Agnew (1968) shows how the superposition of a large number of uniformly sparse processes is approximately a Poisson process.

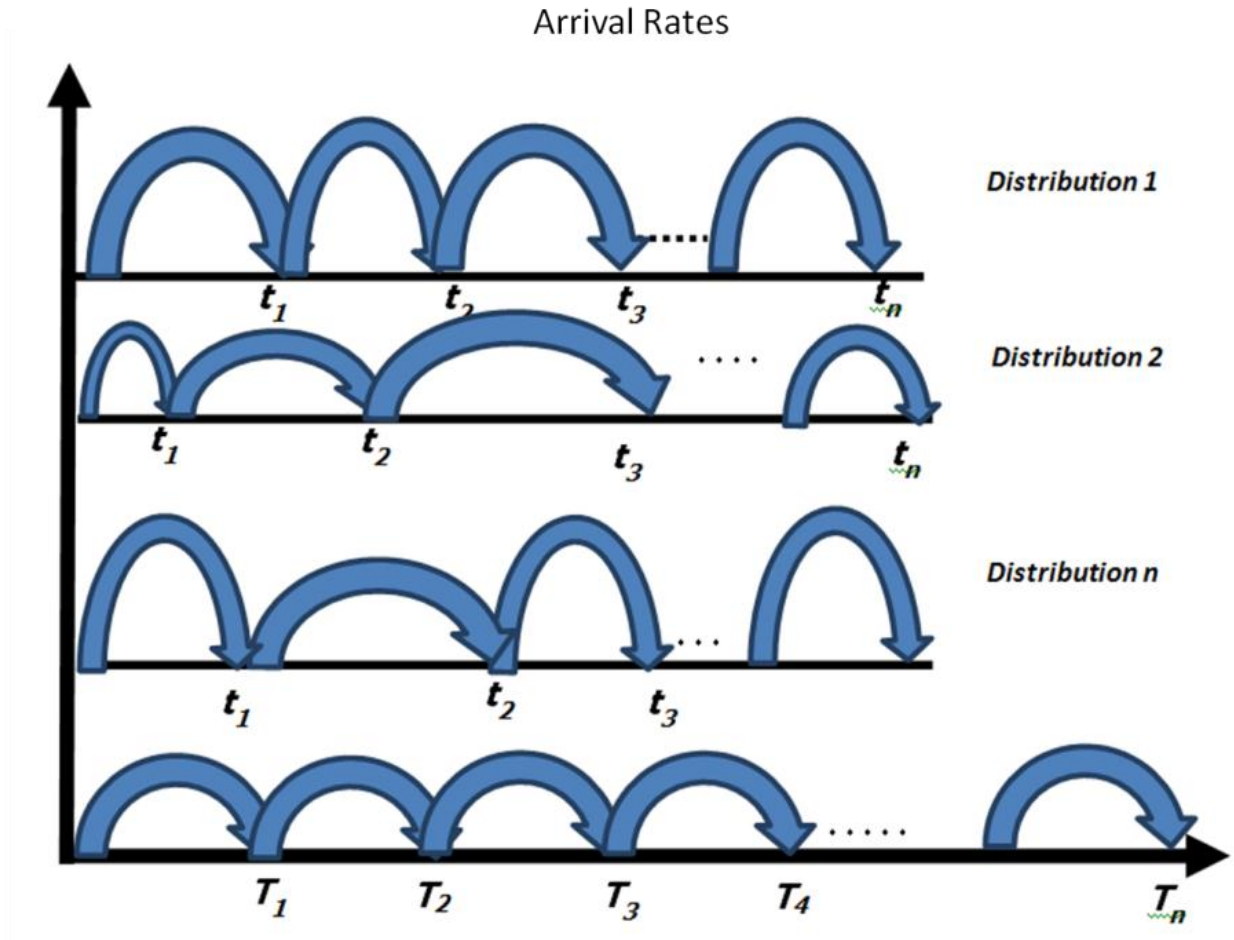


Figure 8.1: Process superposition

Based on the assumption that the results of the simulation can be represented as a superposition of different distribution given that the entities come from different parts of the building, the final results can be fitted using a Non-Stationary Poisson Process (NSPP).

In a Non-Stationary Poisson Process the instantaneous rate function is $\lambda(\tau) \geq 0$ for all continuous times τ, and the cumulative rate function $\Lambda(\tau)$ = $\int_0^\tau \lambda(s)ds$. The number of events in the interval [τ1, τ2] then follows a Poisson distribution with mean $\int_{\tau 2}^{\tau 1} \lambda(s)ds.$ = $\Lambda(\tau 2)$ - $\Lambda(\tau 1)$. Figure 7 shows an example of a continuous and piecewise cumulative rate function, where rk represents the arrival rate at segment k.

At least three methods of NSPP generation are found in the literature: inversion of the cumulative rate function, thinning, and composition. In the case of building evacuation, the inversion method will be proposed because it is intuitive and the more efficient when the cumulative exit rate function can be defined.

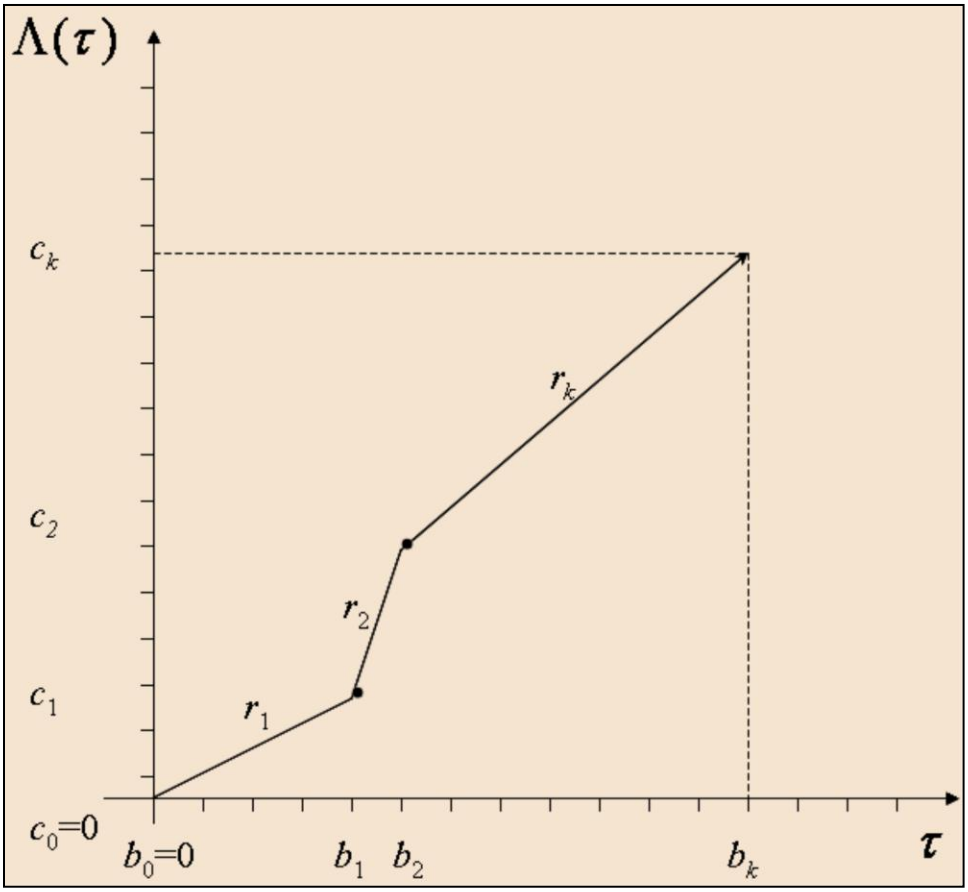


Figure 8.2: Cumulative functions for a NSPP

8.1.4. Legion Software Description

Before describing the case studies in detail, it is important to provide a brief description of the simulation software that is used for the present work. The software is Legion, which is a pedestrian agent-based simulation software.

The main advantage of using Legion is that it is specialized on pedestrian simulation. It was mentioned before that the entities in Legion follow the least-effort algorithm to determine their path towards the exits. Legion allows modifying several parameters regarding the way which the entities will behave. By modifying those parameters we can alter the final evacuation time of each scenario. In the present thesis the following parameters will be taken into account: Congestion Ahead, Imitation, Desired Speed, and Distance Error.

The congestion ahead is a percentage of the population that will consider the congestion ahead of them, and therefore can decide to move towards a different exit in order to avoid that congestion. The imitation parameter is also a percentage of the population that will follow the path that the majority of entities, this parameter represent those entities that are not familiar with the structure of the building and rely on the majority to find their way out.

The desired speed is the speed at which the entity will like to move if no obstruction on their way is found. The desired speed is not necessarily reach given the levels of people density and building structure, and therefore influence on the level of frustration of the entities, and therefore on their effort function. Finally, the distance error is a parameter that represent the accuracy at which the entities calculate the distances between them and their objectives, this parameter is a percentage of the real distance.

In order to work with Legion, the software requires the input of the structure drawings that can be done on AutoCAD or in Legion itself. Once the drawings are completed and the environment on which the entities will be moving is determined, the next step is to define the location of the initial population as well as the exits that they will use to evacuate. In the same manner other structures details have to be determine in Legion such as stair, escalators, level changes, and others. Once all the components are included, the simulations are ready to be run.

8.2. Methodology

8.2.1. Wrigley Field Detailed Analysis

In order to have better understanding of the structure of Wrigley field, the work team went to a Chicago Cubs Game to look at the organization of the seats, number of rows, exits, and the general flow of the people inside the stadium.

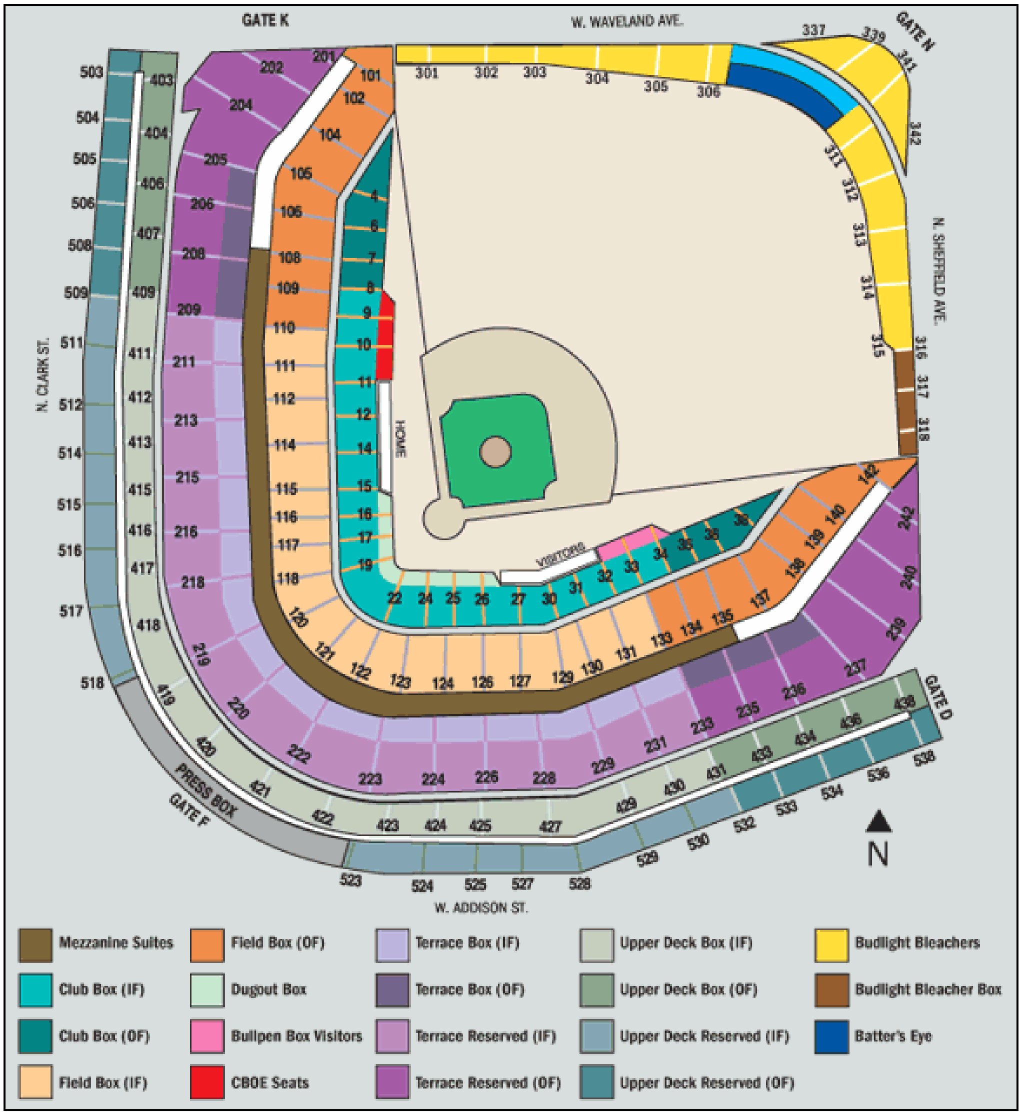


Figure 8.3: Wrigley Field

8.2.1.1. <u>Gates</u>

As we can see from figure 3, Wrigley Field has 4 gates: Gate D, Gate F, Gate K, and Gate N. The first three gates are connected to the main location, and Gate N is the only one leading to the Yellow seats. The total seating capacity of Wrigley Field is 41,160. In figures 4, 5, and 6 we can see the pictures of Gates D, F, and K.

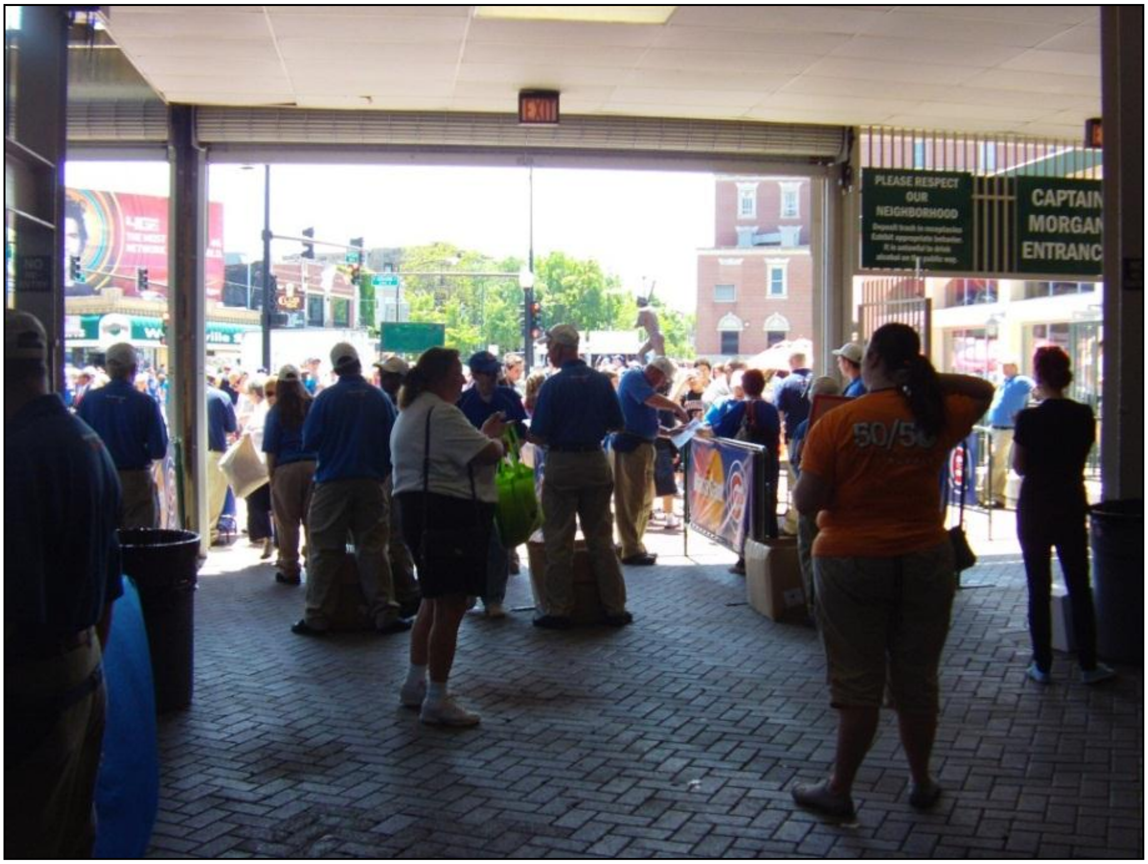


Figure 8.4: Gate D during the entrance to a game

We can see in Gate D how the entrance has been organized in a way that allows to for lines in order to check the tickets. We can also appreciate that the number of lanes allows avoiding having queues at the entrance given that people arrive at different times. At the moment of the exit, all the dividers are removed so the exit flow becomes free of obstacles.

Figure 8.5: Gate F during entrance to a game

Gate F is the largest one and in the same way as in gate D, the entrance is arranged in lanes in order to check the tickets. Once the game is over, the dividers are removed to allow an obstacle free exit.

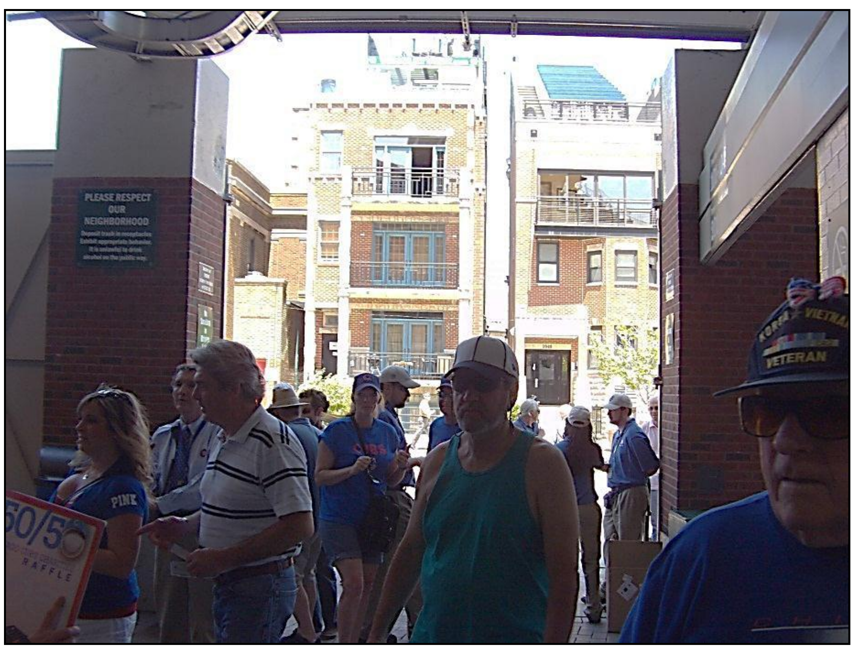


Figure 8.6: Gate K during entrance to a game

Gate K is the smallest of the three main gates, we can see in figure 6 how no divider is used during the entrance. Given the width of this gate, it was noticed that some queues were forming during the entrance to the game.

8.2.1.2. Seats

The distribution of the seats based on the number of rows and aisles are very important to determine the way in which the people in the stadium will proceed to leave once the game is over. The day of the game, there was 31,000 people at the game when the maximum capacity is 41,000, roughly a 75% of the full capacity.

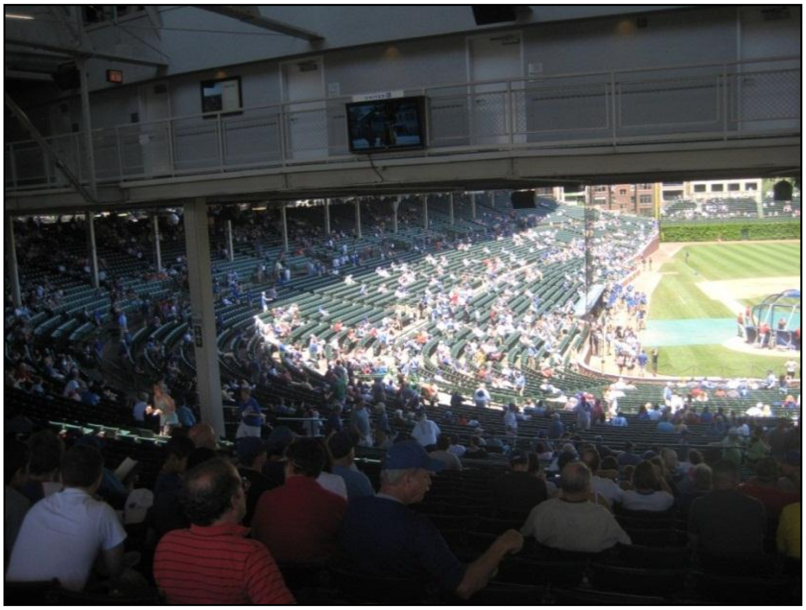


Figure 8.7: View of the 1st level

Figure 8.8: View of the two levels

In figures 7 and 8 the two levels of the stadium can be seen. The first level has three blocks (100's, 200's, and 300's) while the second level has two blocks (400's and 500's). This information will be used to determine an estimate of the number of seats on each block in order to create the simulation scenario for Wrigley Field using Legion. In figure 9 we can see an example of how the calculation of seats will be done. We can see in that block 24 seats per 10 rows for a total of 240 seats.

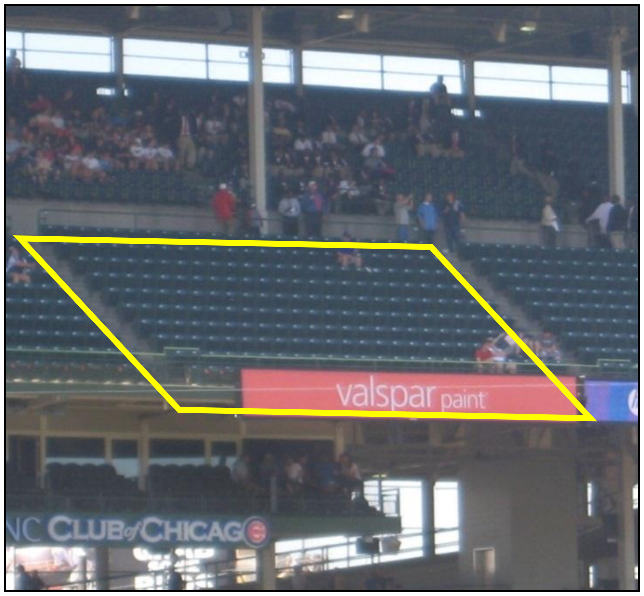


Figure 8.9: Number of seats per block

8.2.1.3. Legion Modeling

First we get the layout of the Wrigley Field in AutoCAD, and then import it into the LEGION software, as shown in Figure 10.

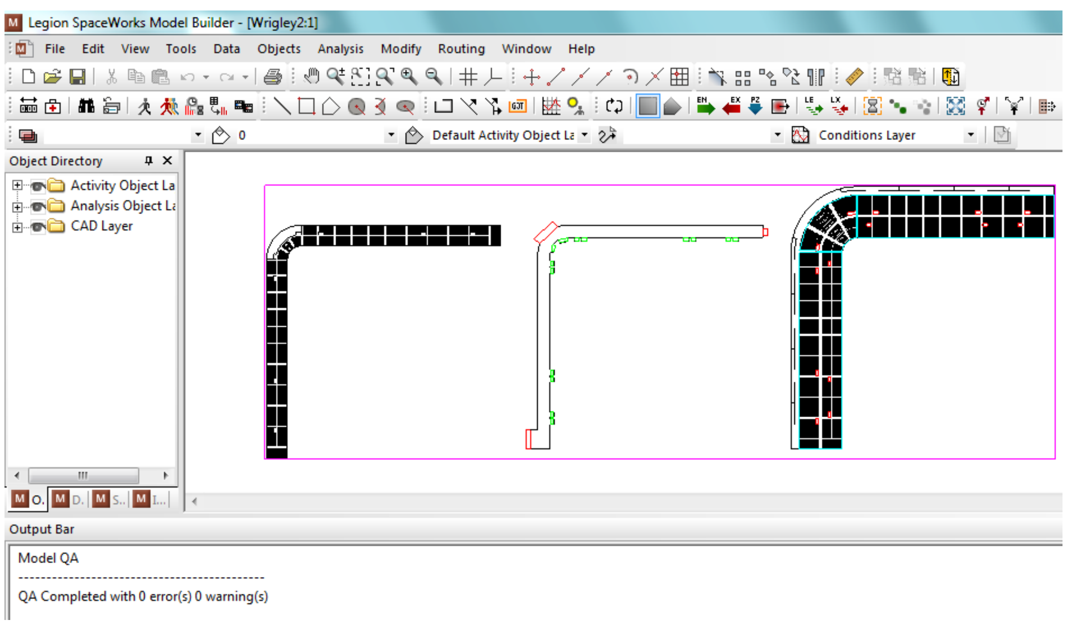


Figure 8.10: Wrigley Fields layout in Legion

After checking it with no errors, we continue to do our simulation and put parameters into the experiment. First we use the default speed defined by the legion itself as the normal speed for evacuees, as shown in figure 11. And then we input the population and percent of congestion in the legion system, as showed in figure 12 and figure 13 respectively.

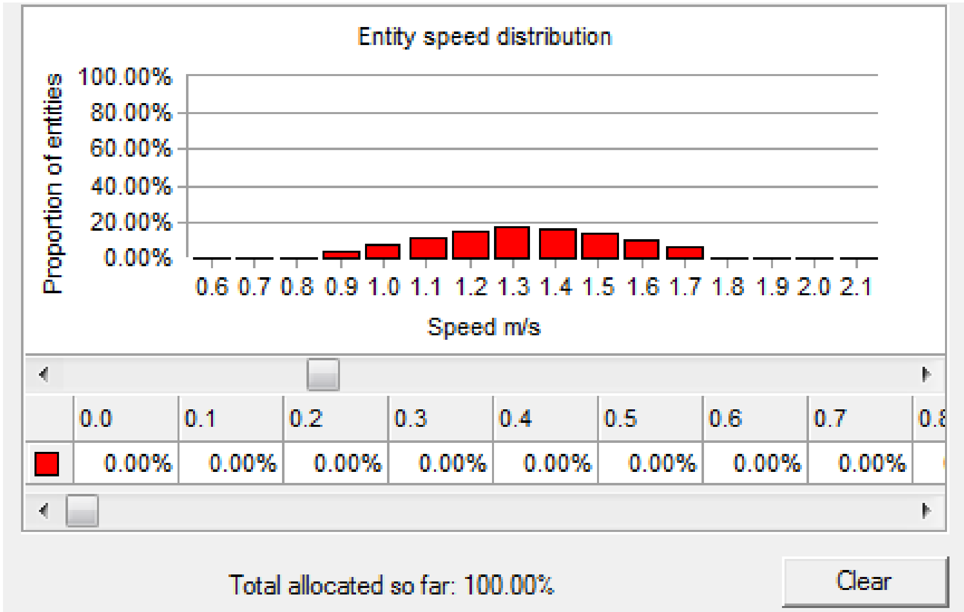


Figure 8.11: Normal Speed defined in Legion

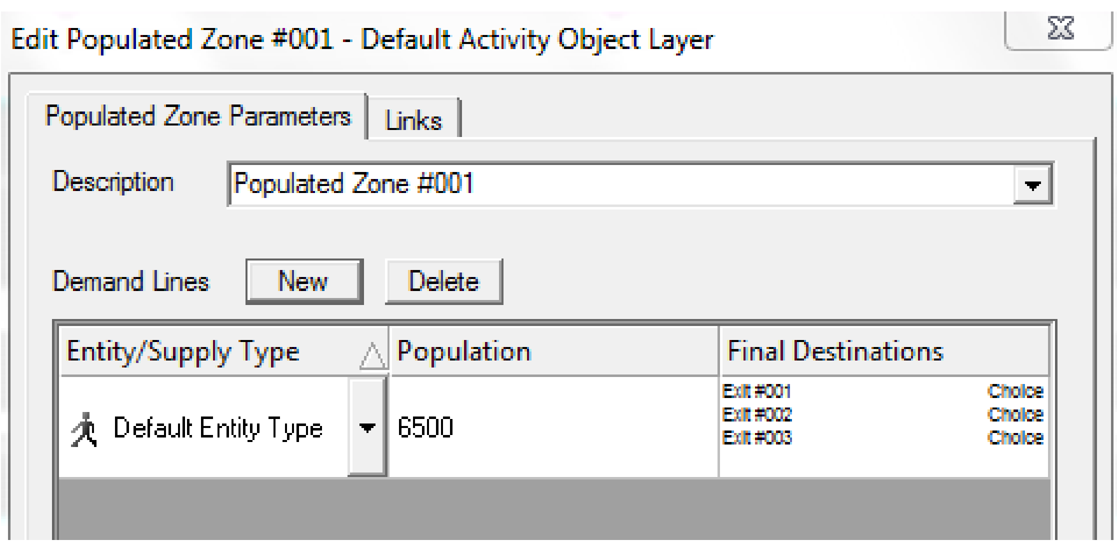


Figure 8.12: Simulated population defined in Legion

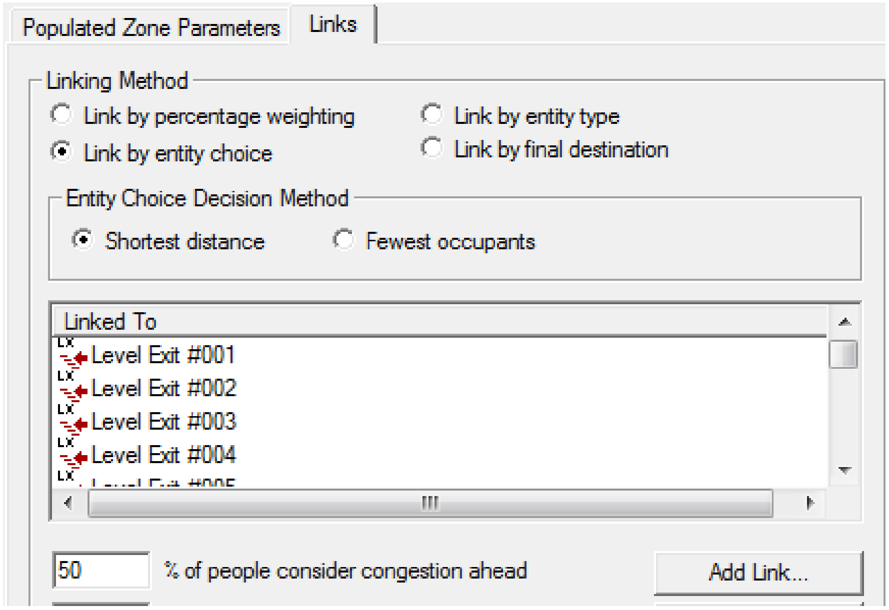


Figure 8.13: Percent of congestion considered in the Legion software

8.2.1.4. Design of Experiment

One of the objectives is to determine the importance of each factor and their interactions on the total evacuation time of each type of building. In order to calculate the impact of each factor on the total evacuation time, a two level (2*k*) factorial design of experiments will be performed. The values for the low level (-1) and high level (1) of each factor is presented in table 1.

Table 8.1: Values for the Wrigley Field Designed Experiments

Wrigley Field Designed Factors		
Levels	-1	1
Congestion	0%	50%
Speed	1.3m/s	2.6m/s
Population	12250	24500

The values for these three factors are determined based on the built-in function of Legion. In the case of the desired speed, multiple researches have concluded that 1.33 m/s is the average free speed. In the case of the high level, 2.66 m/s are a good estimation for a calm running (Kholshevnikov & Samoshin, 2010).

Legion is allowed to modify the values of the three parameters in a fast manner given that they determined the behavior of people in the model. The value of Congestion allows people to look ahead and change their destination if they see congestion ahead of them.

Given that the number of factors to use in the design of experiments is three (*k* = 3), the total amount of experiments to perform is 8 per replication. The combination of all the levels and factors is presented in table 2. Once all the experiments are performed, an ANOVA analysis will show us which factors have a greater influence on the total evacuation time.

Table 8.2: Factorial design for the Wrigley Field (k = 3)

Run	Congestion	Speed	Population
1	-	-	-
2	+	-	-
3	-	+	-
4	+	+	-
5	-	-	+
6	+	-	+
7	-	+	+
8	+	+	+

8.2.1.5. Analysis of the Simulated Results

Once the number of replications was calculated for each of the base scenarios, the same number of replications was run for all the other scenarios. Finally, the results of the Total Evacuation time were taken as the results in order to analyze the factorial design. The factorial design considered to have the number of replications calculated for the simulation in order to perform the analysis of variance for all the factors and their interactions. The initial model to be evaluated is:

$$\gamma = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 \ldots \beta_{63} X_1 X_2 X_3 X_4 X_5 + \varepsilon$$

In the previous model, $\beta_n{}'s$ are the coefficients for each of the factors and the output, γ, corresponds to the total evacuation time.

After running all the eight scenarios, the results are imported in the Minitab to analyze the factorial design. An analysis of the variance is presented in the following table.

Table 8.3: Estimated effects and Coefficients for Wrigley Field

Term	Effect	Coef	SE Coef	*T*-value	*P*-value
Constant		411.7	4.503	91.43	0
Congestion	14.8	7.4	4.503	1.65	0.138
Speed	-429.3	-214.6	4.503	-47.67	0
Population	284.2	142.1	4.503	31.56	0
Congestion*Speed	22.8	11.4	4.503	2.53	0.035
Congestion*Population	-1.7	-0.8	4.503	-0.18	0.859
Speed*Population	-172.2	-86.1	4.503	-19.12	0
Congestion*Speed*Population	12.3	6.2	4.503	1.37	0.209

When a term has a *p*-value below a significance level of 0.05, it means that particular term does have an effect on the total evacuation time, which we say it is statistically significant. In table 3 we have more details regarding the significance of each of the factors and their interactions. The *p*-values for Speed (X_2), Population (X_3), and Speed*Population (X_2*X_3) are the lowest ones. The interaction Congestion*Speed (X_1*X_2) is also significant, but since Congestion is not, its interaction is left out of the model. Therefore, the model for the evacuation time can be reduced to those terms. The final model for the evacuation time of the Wrigley Field is:

$$\gamma \ = \ 411.7 - 214.6X_2 + 142.1X_3 - 86.1X_2X_3$$

This equation will be used with the non-stationary Poisson model in order to generate inter-exit evacuation times.

8.2.2. Analysis of Six Flag Great America

The Six Flag Great America in Gurnee has two parking lots, which are the visitors' final destinations. The AutoCAD layout in considered is shown in the figure 14 below.

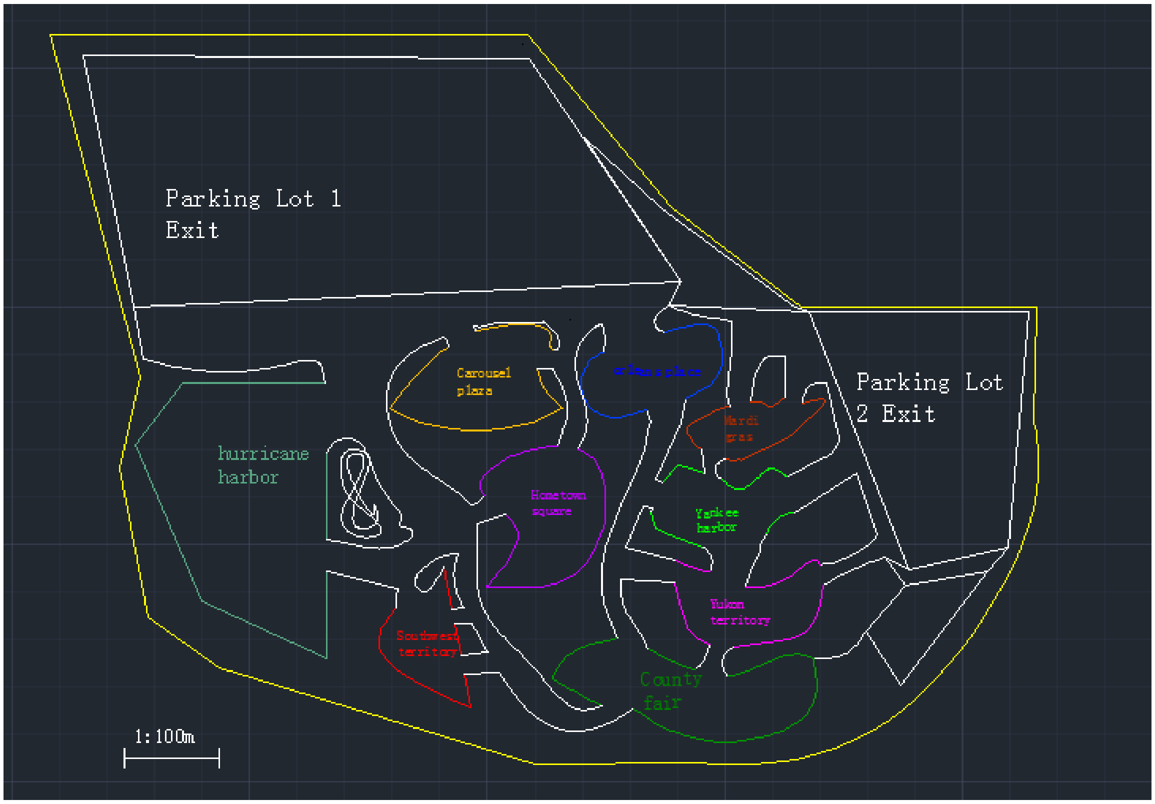


Figure 8.14: Six Flag Layout in AutoCAD

The Six Flags layout is imported to Legion model builder, and then we check whether there is any error in the model. The model builder display is shown in figure 15.

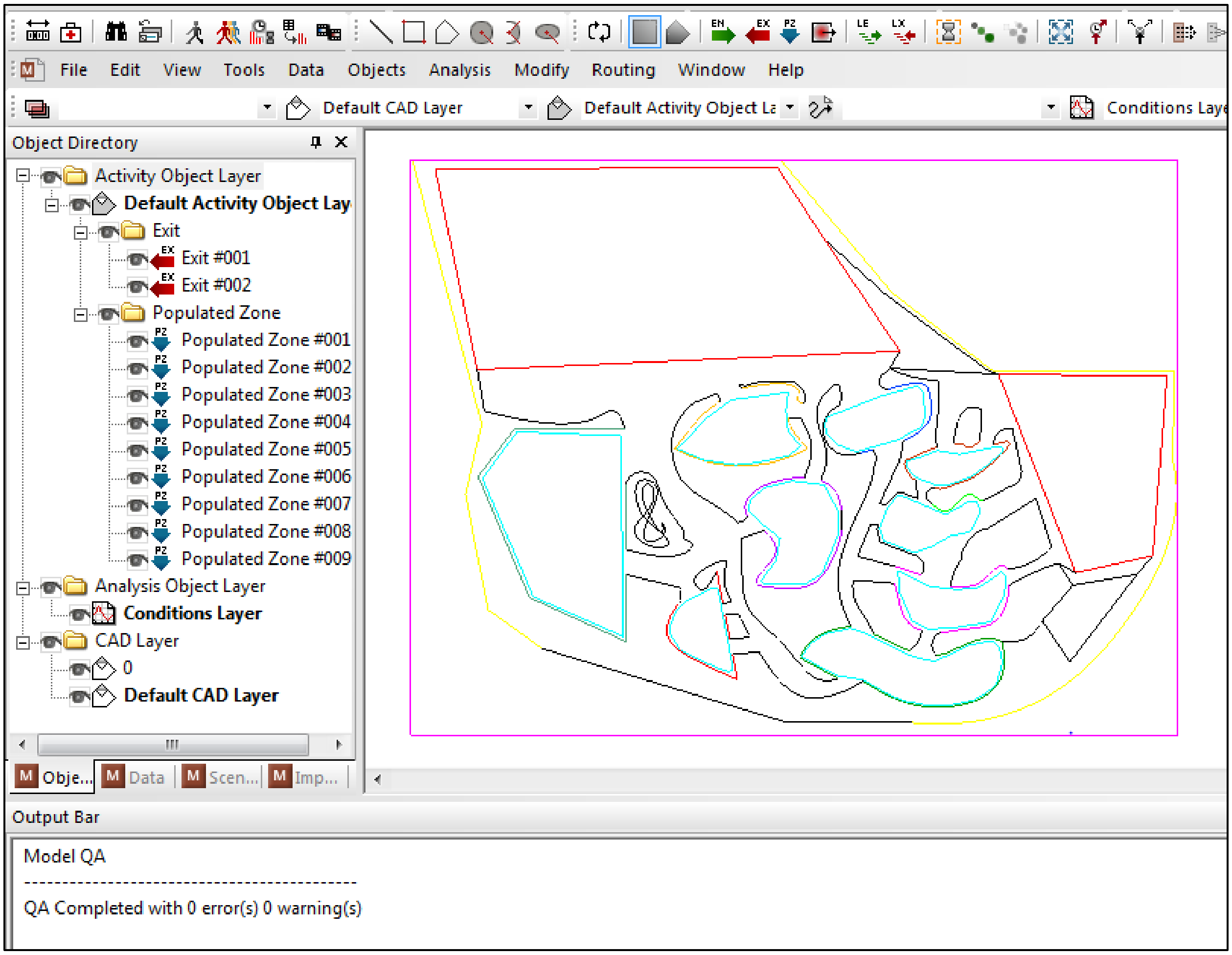


Figure 8.15: Six Flag in the Legion Model Builder

After entering the correct parameters for the above Six Flag Model, such as "Exit" and "Populated Zones", Legion model builder check for errors and warnings. Then, the Legion model is imported to Legion Analyzer and run with different values but the same parameters.

8.2.2.1. Design of Experiment

In our case, three factors (congestion, speed and population) will be considered and the total scenarios are eight.

4. The congestion parameter indicates the percentage of the population that considers the blockage ahead of them and thus they can decide to move towards a different exit in order to avoid that congestion. The imitation parameter is also a percentage of the population that will follow the path of the majority of agents, this parameter represents those agents that are not familiar with the structure of the building and rely on the majority to find their way out.

5. The desired speed corresponds to the speed at which the agent will move if no obstruction on their way is found. The desired speed may not necessarily be reached due to the levels of people density and building structure, which in turns influences on the level of frustration of the

agents and on their effort function. Finally, the distance error is a parameter that represents the accuracy at which the entities calculate the distances between them and their objectives, this parameter is a percentage of the real distance.

6. Population is the number of visitors within simulated area.

In order to analyze the influence among each factor, a two level (2^k) factorial design of experiments is used in our case. The values for the low level (-1) and high level (1) of each factor is presented in table 4.

Table 8.4: Values for the Six Flag designed experiments

Six Flag Designed Factors		
Levels	-1	1
Congestion	0%	50%
Speed	1.3m/s	2.6m/s
Population	9000	18430

The values for these three factors are determined based on the built-in function of Legion. In the case of the desired speed, multiple researches have concluded that 1.33 m/s is the average free speed. In the case of the high level, 2.66 m/s are a good estimation for a calm running (Kholshevnikov & Samoshin, 2010).

Given that the number of factors to use in the design of experiments is three (k = 3), the total amount of experiments to perform is eight per replication. The combination of all the levels and factors is presented in table 5. Once all the experiments are performed, an ANOVA analysis will show us which factors have a greater influence on the total evacuation time.

Table 8.5: Factorial design for the Six Flags (k = 3)

Run	Congestion	Speed	Population
1	-	-	-
2	+	-	-
3	-	+	-
4	+	+	-
5	-	-	+
6	+	-	+

7	-	+	+
8	+	+	+

Table 8.6: Values for each scenario

Scenario	Congestion	Speed	Population
1	0	1.3	18430
2	0	1.3	9000
3	0	2.6	18430
4	0	2.6	9000
5	50%	1.3	18430
6	50%	1.3	9000
7	50%	2.6	18430
8	50%	2.6	9000

8.2.2.2. Analysis of the Simulated Results

Once the number of replications was calculated for each of the base scenarios, the same number of replications was run for all the other scenarios. Similar to the analysis done in the previous case study, the response is the total evacuation time:

$$\gamma = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 \ldots \beta_{63} X_1 X_2 X_3 X_4 X_5 + \varepsilon$$

In the previous model, the β_n are the coefficients for each of the main and interaction factors and, and the output γ is the total evacuation time. After running all the eight scenarios, the results are imported to Minitab in order to analyze the factorial design. An analysis of the variance is presented in table 8.

Table 8.7: Estimated effects and Coefficients for Six Flag

Term	Effect	Coef	SE Coef	T	P
Constant		686.5	69.89	9.82	0
Congestion	19.2	9.6	69.89	0.14	0.894
Speed	-642.9	-321.4	69.89	-4.6	0.002

Population	295.5	147.7	69.89	2.11	0.067
Congestion*Speed	-139.1	-69.5	69.89	-0.99	0.349
Congestion*Population	-226.1	-113	69.89	-1.62	0.144
Speed*Population	14.9	7.4	69.89	0.11	0.918
Congestion*Speed*Population	-39.3	-19.6	69.89	-0.28	0.786

Table 8 provides details on the significance of each of the factors and their interactions. The *p*-values for Speed (X_2) and Population (X_3) are less than the significance level (0.05). Therefore, the model for the evacuation time can be reduced to this term. The final model for the evacuation time of the Six Flags is:

$$\gamma = 686.5 - 321.4X_2 + 147.7X_3$$

8.2.3. Apartment Complex Analysis

After running the five replications for the apartment complex, the average evacuation time was 92.16 seconds and the standard deviation was 6.97 seconds. Given the results from this simulation, the total number of replications for a half width of one second is approximately four replications. This means that no more replications than the preliminary five are required. In order to maintain the variation, five replications will be used for all the scenarios. A snapshot of the entities moving from their apartments towards the stairs and final exit is shown in figure 16.

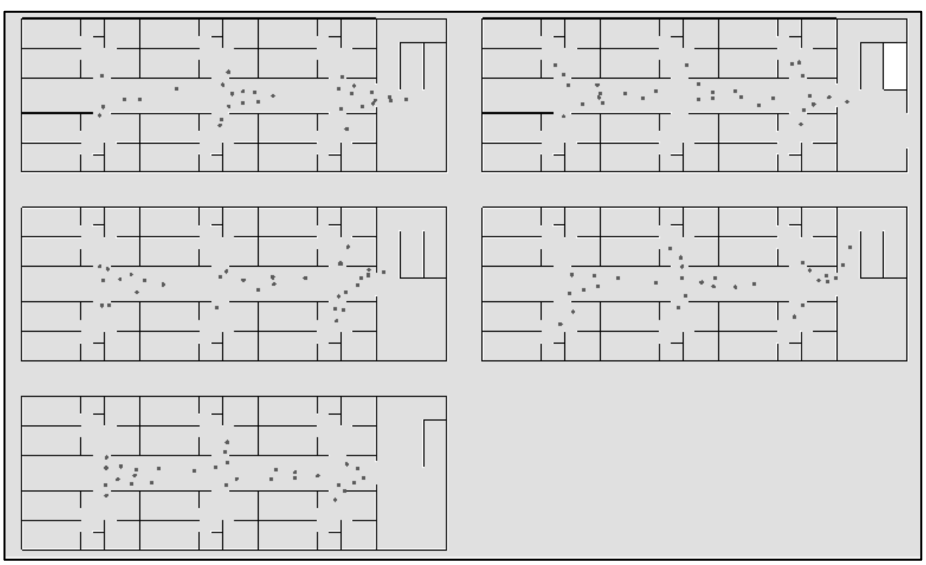


Figure 8.16: Apartment complex simulation

After running all the 32 scenarios, each scenario with five replications, the results were introduced in Minitab to analyze the factorial design. An analysis of variance using a Fisher test and the estimation of the coefficients were calculated and presented in table 9 and table 10.

Table 8.8: Analysis of variance for apartment complex

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Main Effects	5	53763.800	53763.800	10752.800	1271.520	0.000
2-Way Interactions	10	65.900	65.900	6.600	0.780	0.649
3-Way Interactions	10	119.300	119.300	11.900	1.410	0.183
4-Way Interactions	5	20.800	20.800	4.200	0.490	0.782
5-Way Interactions	1	1.400	1.400	1.400	0.170	0.684
Residual Error	128	1082.400	1082.400	8.500		
Pure Error	128	1082.400	1082.400	8.500		
Total	159	55053.600				

Table 8.9: Estimated effects and Coefficients for apartment complex

Term	Effect	Coef	SE Coef	T	P
Constant		72.386	0.230	314.860	0.000
Congestion	0.923	0.461	0.230	2.010	0.047
Imitation	-0.083	-0.041	0.230	-0.180	0.858
Desired Speed	-3.938	-1.969	0.230	-8.560	0.000
Distance Error	0.877	0.439	0.230	1.910	0.059
Floors/Population	36.428	18.214	0.230	79.220	0.000
Congestion*Imitation	0.518	0.259	0.230	1.130	0.262
Congestion*Desired Speed	0.353	0.176	0.230	0.770	0.445
Congestion*Distance Error	0.458	0.229	0.230	0.990	0.322
Congestion*Floors/Population	-0.083	-0.041	0.230	-0.180	0.858
Imitation*Desired Speed	-0.593	-0.296	0.230	-1.290	0.200
Imitation*Distance Error	-0.097	-0.049	0.230	-0.210	0.832
Imitation*Floors/Population	-0.397	-0.199	0.230	-0.860	0.389
Desired Speed*Distance Error	-0.202	-0.101	0.230	-0.440	0.660
Desired Speed*Floors/Population	0.578	0.289	0.230	1.260	0.211
Distance Error*Floors/Population	0.383	0.191	0.230	0.830	0.407
Congestion*Imitation*Desired Speed	0.188	0.094	0.230	0.410	0.684
Congestion*Imitation*Distance Error	-0.248	-0.124	0.230	-0.540	0.591
Congestion*Imitation*Floors/Population	-0.698	-0.349	0.230	-1.520	0.132
Congestion*Desired Speed*Distance Error	0.517	0.259	0.230	1.130	0.262
Congestion*Desired Speed*Floors/Population	-0.053	-0.026	0.230	-0.110	0.909
Congestion*Distance Error*Floors/Population	0.862	0.431	0.230	1.880	0.063
Imitation*Desired Speed*Distance Error	0.202	0.101	0.230	0.440	0.660
Imitation*Desired Speed*Floors/Population	-0.667	-0.334	0.230	-1.450	0.149
Imitation*Distance Error*Floors/Population	0.217	0.109	0.230	0.470	0.637
Desired Speed*Distance Error*Floors/Population	0.923	0.461	0.230	2.010	0.047
Congestion*Imitation*Desired Speed*Distance Error	0.472	0.236	0.230	1.030	0.306
Congestion*Imitation*Desired Speed*Floors/Population	-0.248	-0.124	0.230	-0.540	0.591
Congestion*Imitation*Distance Error*Floors/Population	-0.353	-0.176	0.230	-0.770	0.445
Congestion*Desired Speed*Distance Error*Floors/Population	0.323	0.161	0.230	0.700	0.484
Imitation*Desired Speed*Distance Error*Floors/Population	-0.083	-0.041	0.230	-0.180	0.858
Congestion*Imitation*Desired Speed*Distance Error*Floors/Population	0.187	0.094	0.230	0.410	0.684

Looking at the results from Table 9, the *p*-value for higher order interactions shows they are not statistically significant terms. Since *p*-values for the main effects are below the significance level they have an impact on the total evacuation time. In figure 17 shows the evacuation time has a higher change when the number of Floors and the Desired Speed change their level. On the other side, the Imitation factor has a smaller impact on the modification of the total evacuation time.

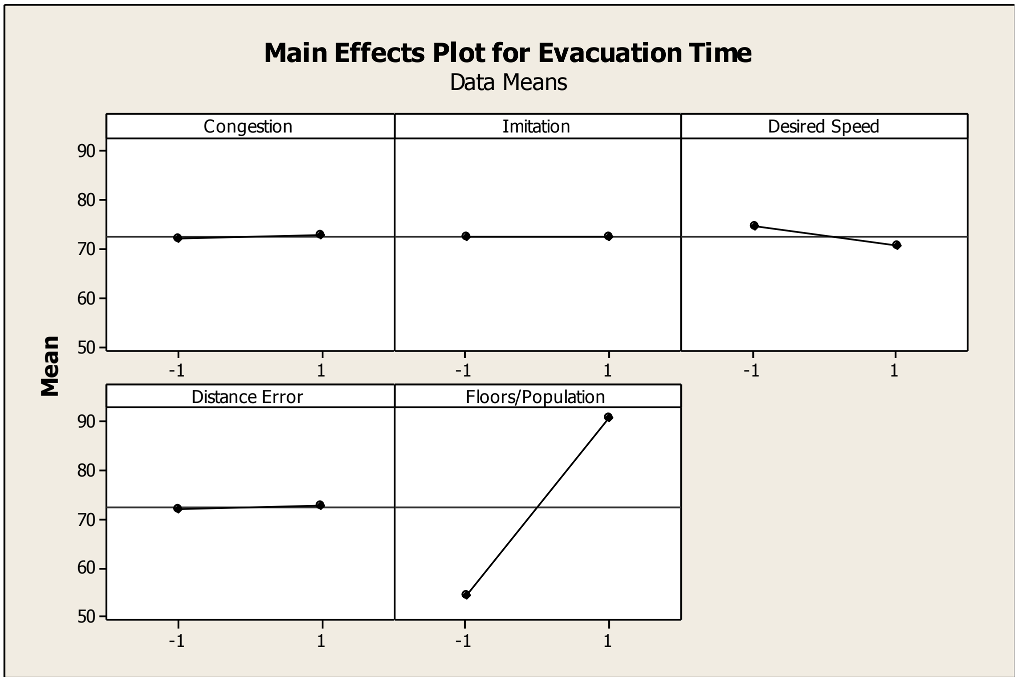


Figure 8.17: Main effects plot for evacuation time of apartment complex

In table 10, there is more details regarding the significance of each of the factors and their interactions. The *p*-values for Congestion (X_1), Desired Speed (X_3), Distance Error(X_4), Floors (X_5), and the interaction of Desired Speed*Distance Error*Floors ($X_3X_4X_5$) are the lowest ones. Since both Desired Speed and Floors (population) are significant, and three-way interaction of this two variables with the Distance Error is significant also, the main effect Distance Error is included in the model. Therefore, the model for the evacuation time is explained by those terms, this model allows to explain the 97% of the variance according to the R-square analysis. The final model for the evacuation time of the apartment complex is:

$$\gamma = 72.386 + 0.46X_1 - 1.97X_3 + 0.44X_4 + 18.21X_5 + 0.46X_1X_4X_5$$

8.2.4. Commercial Mall Analysis

The average evacuation time of the five replications was 133.44 seconds and the standard deviation 2.64 seconds. For a half width of one second, the number of replications needed is three (2.27) replications. In the same way as in the apartment complex, the original number of five replications is higher than the required number of the calculation. A snapshot of the commercial mall simulation is presented in figure 18.

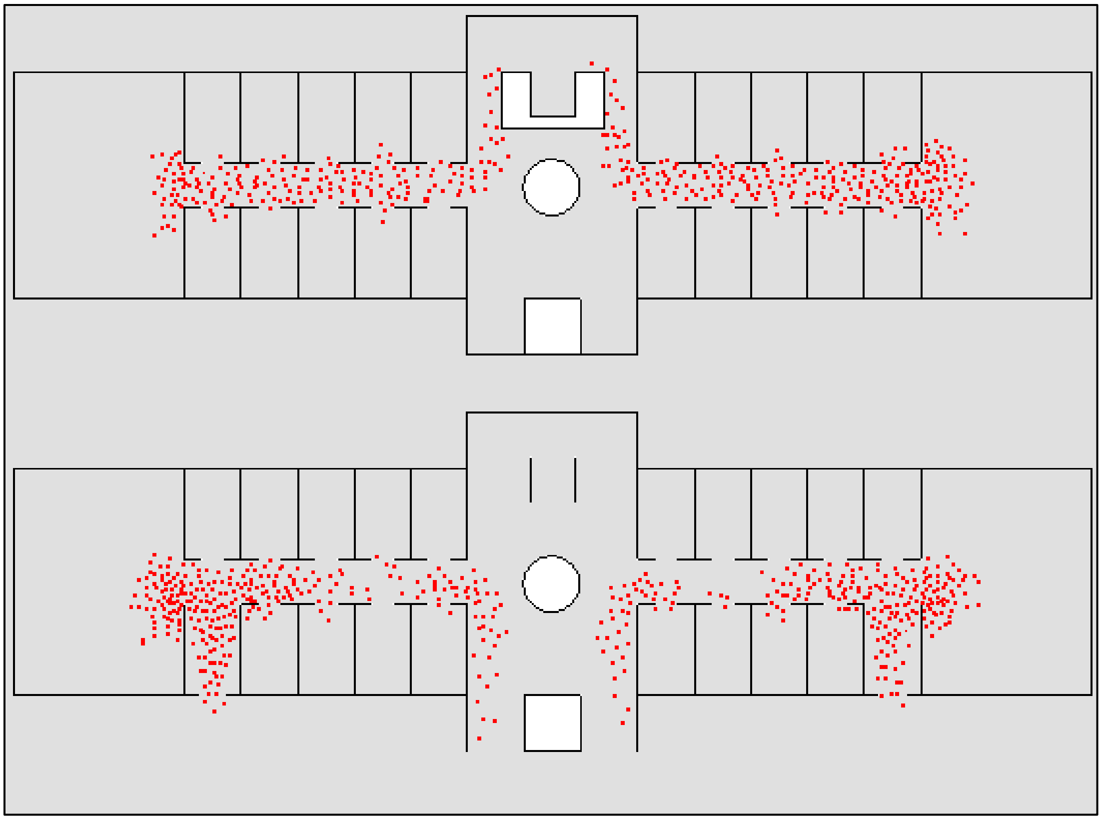


Figure 8.18: Commercial mall simulation

The results of the simulation were inputted to Minitab for their analysis. The analysis of variances is presented in table 11, and the estimation of the coefficients is shown in table 12.

Table 8.10: Analysis of variances for commercial mall

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Main Effects	5	100794.000	100794.000	20158.800	2036.010	0.000
2-Way Interactions	10	120.000	120.000	12.000	1.220	0.286
3-Way Interactions	10	55.000	55.000	5.500	0.560	0.845
4-Way Interactions	5	38.000	38.000	7.700	0.780	0.569
5-Way Interactions	1	1.000	1.000	0.500	0.050	0.821
Residual Error	128	1267.000	1267.000	9.900		
Pure Error	128	1267.000	1267.000	9.900		
Total	159	102276.000				

Looking at the results from table 11, the *p*-value for higher order interactions shows they are not statistically significant for the model. The *p*-value for the main effects is very low which means that they do have an impact on the total evacuation time.

Table 8.11: Estimated effects and Coefficients for commercial mall

Term	Effect	Coef	SE Coef	T	P
Constant		105.326	0.249	423.400	0.000
Congestion	0.112	0.056	0.249	0.230	0.821
Imitation	-0.518	-0.259	0.249	-1.040	0.300
Desired Speed	-5.573	-2.786	0.249	-11.200	0.000
Distance Error	0.503	0.251	0.249	1.010	0.314
Floors/Population	49.883	24.941	0.249	100.260	0.000
Congestion*Imitation	-0.578	-0.289	0.249	-1.160	0.248
Congestion*Desired Speed	0.367	0.184	0.249	0.740	0.461
Congestion*Distance Error	-0.847	-0.424	0.249	-1.700	0.091
Congestion*Floors/Population	0.112	0.056	0.249	0.230	0.821
Imitation*Desired Speed	0.338	0.169	0.249	0.680	0.499
Imitation*Distance Error	0.533	0.266	0.249	1.070	0.286
Imitation*Floors/Population	0.653	0.326	0.249	1.310	0.192
Desired Speed*Distance Error	0.098	0.049	0.249	0.200	0.845
Desired Speed*Floors/Population	0.428	0.214	0.249	0.860	0.392
Distance Error*Floors/Population	0.893	0.446	0.249	1.790	0.075
Congestion*Imitation*Desired Speed	-0.563	-0.281	0.249	-1.130	0.260
Congestion*Imitation*Distance Error	0.022	0.011	0.249	0.050	0.964
Congestion*Imitation*Floors/Population	-0.037	-0.019	0.249	-0.080	0.940
Congestion*Desired Speed*Distance Error	-0.233	-0.116	0.249	-0.470	0.641
Congestion*Desired Speed*Floors/Population	0.218	0.109	0.249	0.440	0.663
Congestion*Distance Error*Floors/Population	0.473	0.236	0.249	0.950	0.344
Imitation*Desired Speed*Distance Error	-0.052	-0.026	0.249	-0.110	0.916
Imitation*Desired Speed*Floors/Population	0.218	0.109	0.249	0.440	0.663
Imitation*Distance Error*Floors/Population	-0.337	-0.169	0.249	-0.680	0.499
Desired Speed*Distance Error*Floors/Population	0.758	0.379	0.249	1.520	0.130
Congestion*Imitation*Desired Speed*Distance Error	0.337	0.169	0.249	0.680	0.499
Congestion*Imitation*Desired Speed*Floors/Population	0.247	0.124	0.249	0.500	0.620
Congestion*Imitation*Distance Error*Floors/Population	-0.637	-0.319	0.249	-1.280	0.202
Congestion*Desired Speed*Distance Error*Floors/Population	-0.563	-0.281	0.249	-1.130	0.260
Imitation*Desired Speed*Distance Error*Floors/Population	0.247	0.124	0.249	0.500	0.620
Congestion*Imitation*Desired Speed*Distance Error*Floors/Population	-0.112	-0.056	0.249	-0.230	0.821

In table 12, more details is presented with regard to the significance of each of the factors and their interactions. The *p*-values for Desired Speed (X_3), Population (X_5), and the interaction of Distance Error*Population ($\mathrm{X}_4\mathrm{X}_5$), are the lowest ones. Therefore, the model for the evacuation time can be expressed as a function of those terms and it explains the 98% of the variance. The final model for the evacuation time of the apartment complex is:

$$\gamma = 105.32 - 2.79X_3 + 0.25X_4 + 24.94X_5 + 0.45X_4X_5$$

In figure 19, the evacuation time has a higher change when the Desired Speed changes. On the other side, the Imitation factor and for the Congestion factor have a smaller impact on the modification of the total evacuation time.

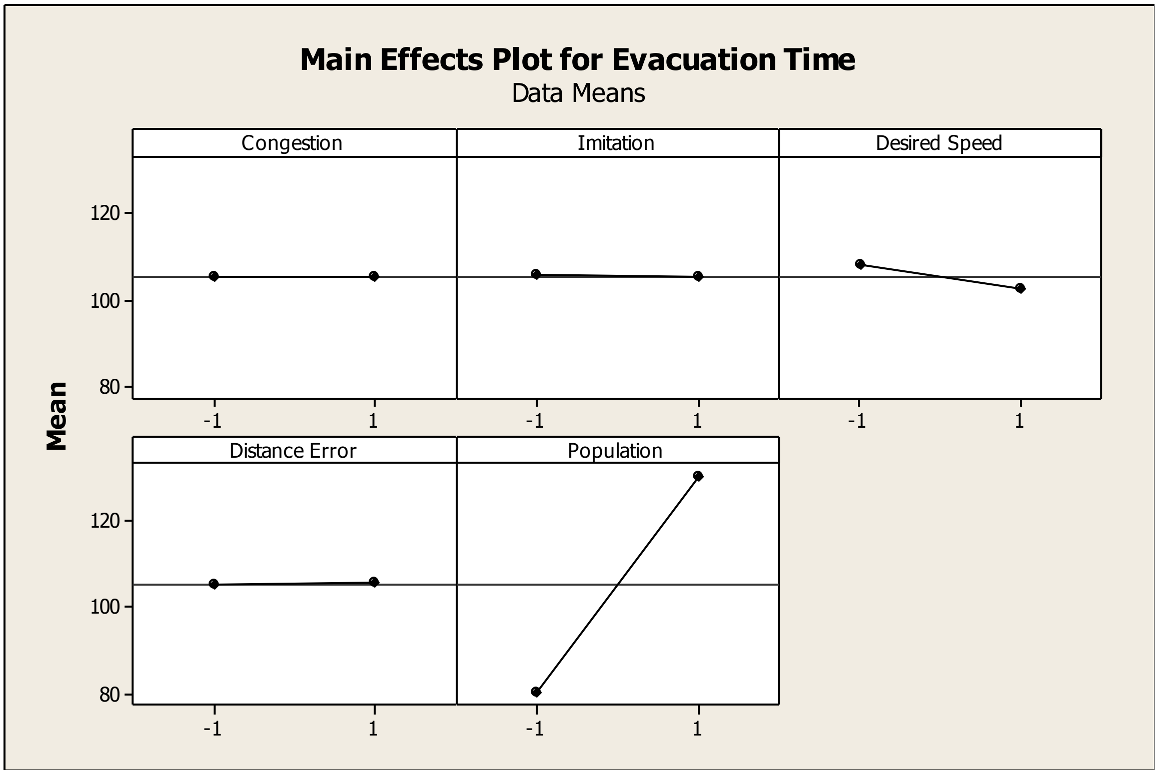


Figure 8.19 : Main Effects plot for evacuation time of commercial mall

8.2.5. Validation of Legion Model Using Wrigley Field

Given that Legion is software specialized on pedestrian simulation, it represents a great advantage when it comes to the validation of the simulation models. Great effort has been done in order to calibrate and validate the software and the way through which it represents the movement of pedestrians. One of the validation efforts has already been presented on the literature review.

Several difficulties come into place when it comes to the validation of simulation models of pedestrian evacuation. The main difficulties are related to the lack of good empirical data.

A qualitative validation of a baseball stadium is introduced ahead. The drawings of the stadium presented before were introduced in Legion and all the entrances, exits, and initial population were defined. The result of the simulation is compared to the data collected after a real baseball game. The qualitative analysis is done by comparing the total exit time of the stadium and also by comparing pictures of the stadium with snapshots of the simulation.

In figure 20, a part of the stadium drawing is presented after it has been populated with agents by the Legion software and the people have started to move towards the exits. In the simulation is clear how people tend to crowd around the exit the same way as in the real stadium, this can be seen in figure 21.

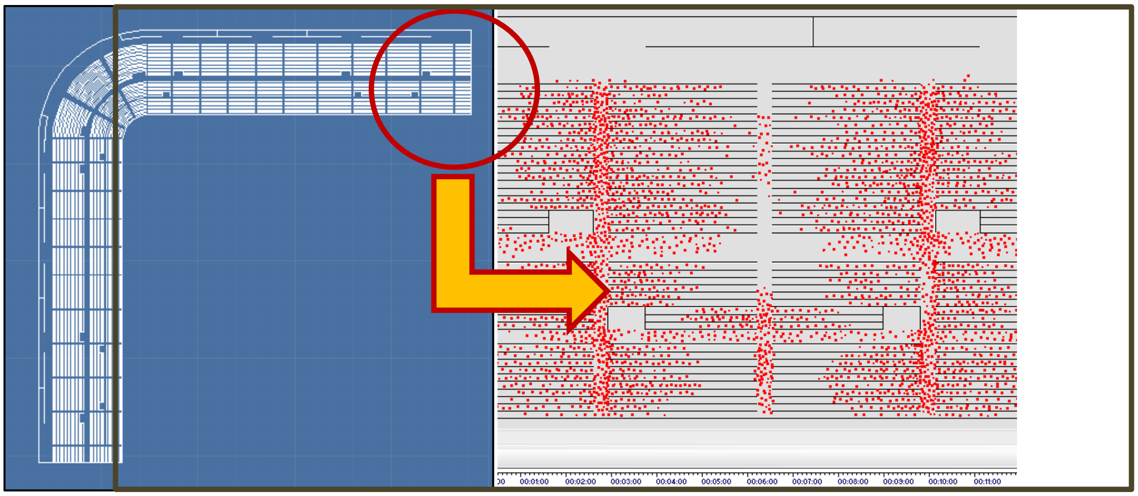


Figure 8.20: Detail of the simulation of the stadium in legion

Figure 8.21: Crowd density around exits

The same behavior is shown at the simulation. Once people start leaving their seats, the crowd density starts to increase next to the exits and some queues start to build up. This behavior can be seen in figure 22, where the entities are moving towards the exits and the density starts to increase in those areas.

Figure 8.22: High density of entities next to exits in the simulation in Legion

There were 30,000 people during the baseball game; however several of them left before the game ended. Therefore, a rough estimation is that 24,500 people were left at the moment the game was over. The total time that took people to leave the stadium from the end of the game until the last person left was about 15 minutes. In table 13 a comparison between the real data and the simulation is presented. We can see how both results are very close to each other by a total difference of 0.6 minutes.

Table 8.12: Comparison of results from empirical data and simulation results

	Empirical Data	Simulation
Population	24,000 - 25,000	24,500
Exits	3	3
Exit time	15 minutes	14.4 minutes

8.3. Inter-Exit Generators

The inter-exit generator will be based on a Non-Stationary Poisson Process. The method to generate the NSPP is going to be the inversion of the cumulative function. In order to do this, the cumulative function $\Lambda(\tau)$ versus time for the total amount of entities leaving the building versus the percentage of time (τ) is calculated for each case. $\Lambda(\tau)$ is a function defined by pieces, where each piece is defined by a set of points (c_k, b_k) and the slope r_k, as it is shown in figure 2—which reproduced in this section. The cumulative functions will be calculated by adjusting the cumulative function with 4 segments. Each of the segments will be determined at the quartiles (25%, 50%, and 75%).

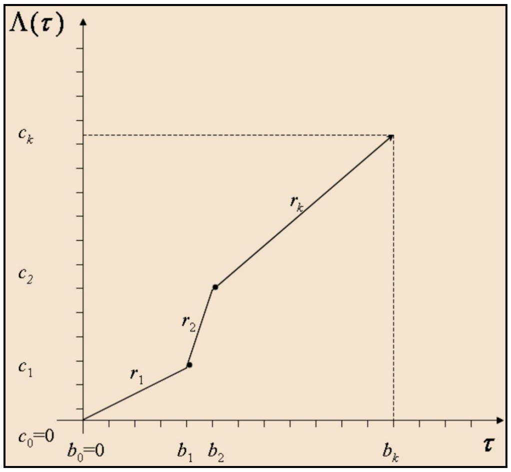
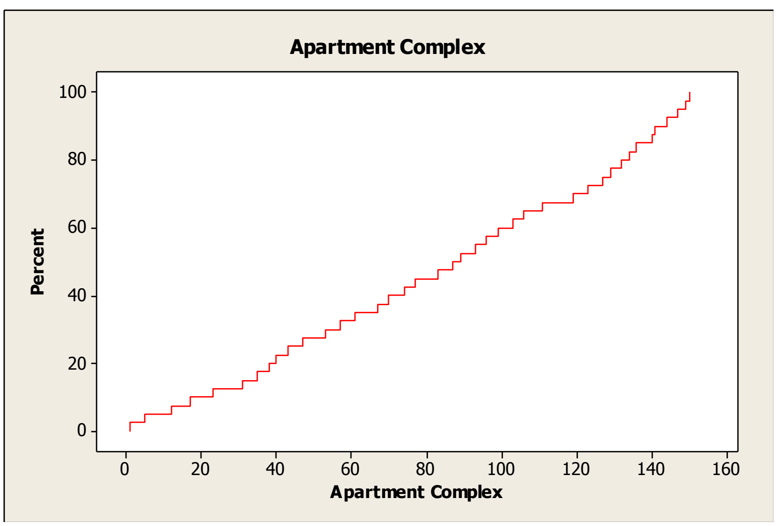


Figure 8.23: Cumulative functions for a NSPP

8.3.1. Apartment Complex Cumulative Function

The results from the apartment complex gave a cumulative function that had very similar exit rates throughout the whole simulation time. Figure 23 shows the plot of the cumulative function of the apartment complex for 150 entities.



Time (s)

Figure 8.24: Cumulative function of the apartment complex

The values of r_k were calculated using the values from of c_k and b_k, and are presented in table 14. Using these values, the cumulative function of the apartment complex was finally constructed.

Table 8.13: Values of ck, bk, and rk for the apartment complex

Segment	c_k	b_k	r_k
1	0.25	0.20	1.28

2	0.50	0.46	0.94
3	0.75	0.68	1.13
4	1.00	1.00	0.79

$$\Lambda(\tau) = \begin{cases} 1.28\tau \quad , & 0.00 \leq \tau \leq 0.20 \\ 0.94\tau + 0.068 , & 0.20 \leq \tau \leq 0.46 \\ 1.13\tau - 0.019 , & 0.46 \leq \tau \leq 0.68 \\ 0.79\tau + 0.210, & 0.68 \leq \tau \leq 1.00 \end{cases}$$

Where the total evacuation time is given by the following model, as shown in the previous section:

$$\gamma = 72.386 + 0.46X_1 - 1.97X_3 + 0.44X_4 + 18.21X_5 + 0.46X_1X_4X_5$$

8.3.2. Commercial Mall Cumulative Function

The results from the commercial mall gave a cumulative function that had some clear changes on the value of exit rates at certain intervals. Figure 24 shows the plot of the cumulative function of the commercial mall complex for 1,000 agents.

The values of r_k were calculated using the values from of c_k and b_k, and are presented in table 15. Using these values, the cumulative function of the apartment complex was finally constructed.

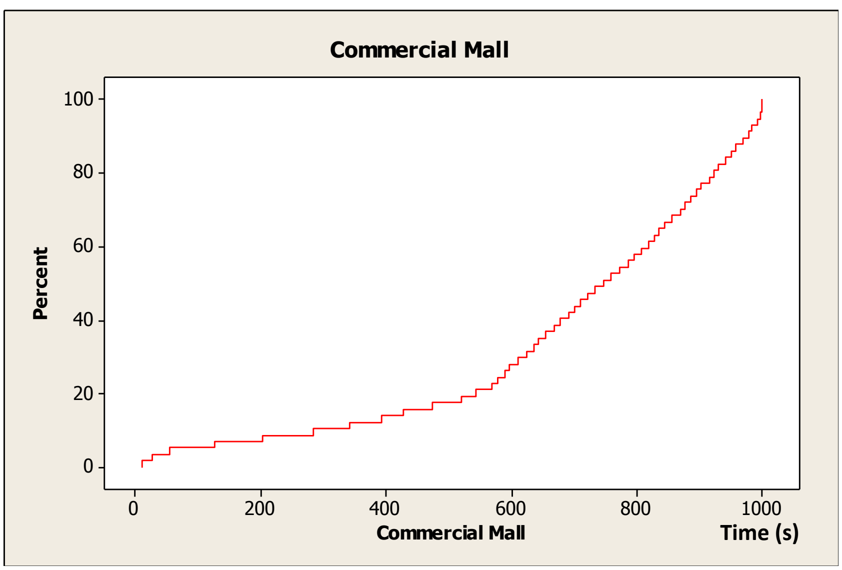


Figure 8.25: Cumulative function of the commercial mall

Table 8.14: Values of ck, bk, and rk for the commercial mall

Segment	c_k	b_k	r_k

1	0.25	0.11	2.38
2	0.50	0.19	2.85
3	0.75	0.53	0.75
4	1.00	1.00	0.53

$$\Lambda(\tau) = \begin{cases} 2.38\tau & , \quad 0.00 \leq \tau \leq 0.11 \\ 2.85\tau - 0.064 , & 0.11 \leq \tau \leq 0.19 \\ 0.75\tau + 0.358 , & 0.19 \leq \tau \leq 0.53 \\ 0.53\tau + 0.469 , & 0.53 \leq \tau \leq 1.00 \end{cases}$$

where the total evacuation time is given by the following model, as shown in the previous section:

$$\gamma = 105.32 - 2.79X_3 + 0.25X_4 + 24.94X_5 + 0.45X_4X_5$$

8.3.3. Wrigley Field Cumulative Function

Using the same procedure as in the previous cases, the following set of equations was obtained for the case of Wrigley Field. The values for c_k, b_k, and r_k are shown in table 16, which were used to get the function $\Lambda(\tau)$.

Table 8.15: Values of ck, bk, and rk for Wrigley Field

Segment	c_k	b_k	r_k
1	0.25	0.22	1.14
2	0.50	0.44	1.14
3	0.75	0.65	1.19
4	1.00	1.00	0.71

$$\Lambda(\tau) = \begin{cases} 1.14\tau & , \quad 0.00 \leq \tau \leq 0.22 \\ 1.14\tau & , \quad 0.22 \leq \tau \leq 0.44 \\ 1.19\tau - 0.024 , & 0.44 \leq \tau \leq 0.65 \\ 0.71\tau + 0.286 , & 0.65 \leq \tau \leq 1.00 \end{cases}$$

where the total evacuation time is given by the following model, as shown in the previous section:

$$\gamma = 411.7 - 214.6X_2 + 142.1X_3 - 86.1X_2X_3$$

8.3.4. Six Flags Cumulative Function

As well as in the previous cases, the following set of equations was obtained for the case of Six Flags. The values for c_k, b_k, and r_k are shown in table 16, which were used to get the function $\Lambda(\tau)$.

Table 8.16: Values of ck, bk, and rk for Six Flags

Segment	Ck	bk	Rk
1	0.25	0.08	3.13
2	0.50	0.15	3.52
3	0.75	0.25	2.50
4	1.00	1.00	0.33

$$\Lambda(\tau) = \begin{Bmatrix} 3.13\tau & ,0.00 \leq \tau \leq 0.08 \\ 3.52\tau - 0.0316 & ,0.08 \leq \tau \leq 0.15 \\ 2.50\tau + 0.125 & ,0.15 \leq \tau \leq 0.25 \\ 0.33\tau + 0.6675 & ,0.25 \leq \tau \leq 1.00 \end{Bmatrix}$$

where the total evacuation time is given by the following model, as shown in the previous section:

$$\gamma = 686.5 - 321.4X_2 + 147.7X_3$$

8.3.5. 3.5 Non-stationary Poisson Algorithm for Inter-Exit Times

The inter-exit generator requires using the cumulative distribution function ($\Lambda(\tau)$) to determine the inter-exit times for the respective facility (building, stadium, park, etc.) In addition, it is needed to calculate the total evacuation time (γ) for each facility, using the models from the factorial design.

The generation of inter-exit times can be performed by using a direct algorithm (Harrold & Kelton, 2006) with a very slight modification. The algorithm starts by setting the values of the factors for each type of facility (cases), and then the γ-value is determined. Depending on the number of people inside of each facility, a loop has to be performed in order to generate an equal number of exit events. A random number (u) is generated and a time between events ($a(i)$, where i is the index of each event) is calculated using a stationary rate 1 Poisson process standardized by the number of people or agents that needs to be evacuated from the facility under consideration.

The pseudo-code for each case is given as follows:

8.3.5.1. A. Pseudo Code for Wrigley Field

1 Set X_2; X_2 represents the speed (meter per seconds)

Set X_3;	X_3 represents the total number of people in the stadium
Compute $\gamma = f(X_2, X_3)$;	Total evacuation time for Wringley Field case Study
For *i* =1: X_3,	For a desired number of exit events X_3 to be generated.
u = rand(0,1);	A random number is generated from a uniform(0,1).
$a(i) = -\ln(u)/X_3$;	An inter-event time is calculated using a stationary rate 1 Poisson process standardized by X_3—the population that needs to be evacuated from the stadium.
$y(i) = y(i-1) + a(i)$;	Calculate the moment at which next evacuation event is going to occur.
$\tau(i) = \Lambda^{-1}(y(i))$;	Calculate the exit time of agent *i* as a percentage of the total evacuation time.
$t(i) = \tau(i)\ \gamma$;	Calculate the actual exit time of agent *i*.
End	
Report *t*	

8.3.5.2. B. Pseudo Code for Six Flags

Set X_2;	X_2 represents the speed (meter per seconds)
Set X_3;	X_3 represents the total number of people in a particular day
Compute $\gamma = f(X_2, X_3)$;	Total evacuation time for Six Flags Case Study
For *i* =1: X_3,	For a desired number of exit events X_3 to be generated.
u = rand(0,1);	A random number is generated from a uniform(0,1).
$a(i) = -\ln(u)/X_3$;	An inter-event time is calculated using a stationary rate 1 Poisson process standardized by X_3—the population that needs to be evacuated from the Six Flags.
$y(i) = y(i-1) + a(i)$;	Calculate the moment at which next evacuation event is going to occur.
$\tau(i) = \Lambda^{-1}(y(i))$;	Calculate the exit time of agent *i* as a percentage of the total evacuation time.

$t(i) = \tau(i)\,\gamma$;	Calculate the actual exit time of agent *i*.
End	
Report *t*	

8.3.5.3. C. Pseudo Code for Buildings

Set X_1;	X_1 represents the congestion (%)
Set X_3;	X_3 represents the desired speed (meter per seconds)
Set X_4;	X_4 represents the distance error
Set X_5;=30*n_f	X_5 represents the total number of people in the building, assuming 30 people per floor (n_f).
Compute $\gamma = f(X_1, X_3, X_4, X_5)$;	Total evacuation time for an Apartment Building Case Study
For *i* =1: X_5,	For a desired number of exit events X_5 to be generated.
u = rand(0,1);	A random number is generated from a uniform(0,1).
$a(i) = -\ln(u)/X_5$;	An inter-event time is calculated using a stationary rate 1 Poisson process standardized by X_3—the population that needs to be evacuated from the Six Flags.
$y(i) = y(i-1) + a(i)$;	Calculate the moment at which next evacuation event is going to occur.
$\tau(i) = \Lambda^{-1}(y(i))$;	Calculate the exit time of agent *i* as a percentage of the total evacuation time.
$t(i) = \tau(i)\,\gamma$;	Calculate the actual exit time of agent *i*.
End	
Report *t*	

8.3.5.4. D. Pseudo Code for Malls

Set X_4;	X_4 represents the distance error
Set X_5;	X_5 represents the total number of people in the mall

3	Compute $\gamma = f(X_4, X_5)$;	Total evacuation time for an commercial mall Case Study
4	For *i* =1: X_5,	For a desired number of exit events X_5 to be generated.
5	*u* = rand(0,1);	A random number is generated from a uniform(0,1).
6	$a(i) = -\ln(u)/X_5$;	An inter-event time is calculated using a stationary rate 1 Poisson process standardized by X_3—the population that needs to be evacuated from the Six Flags.
7	$y(i) = y(i\text{-}1) + a(i)$;	Calculate the moment at which next evacuation event is going to occur.
8	$\tau(i) = \Lambda^{-1}(y(i))$;	Calculate the exit time of agent *i* as a percentage of the total evacuation time.
9	$t(i) = \tau(i)\ \gamma$;	Calculate the actual exit time of agent *i*.
10	End	
11	Report *t*	

The algorithm was implemented using a spreadsheet in Excel in order to verify that the algorithm generates similar data as the one generated by the simulation. After generating the data with the algorithm for certain conditions, it was plotted against the original data obtained from the simulation under the same conditions. We can see in figure 27 and 28 the graphs of the apartment complex and the commercial mall. Both graphs show that the algorithm is generating data that represents the results obtained from the simulation.

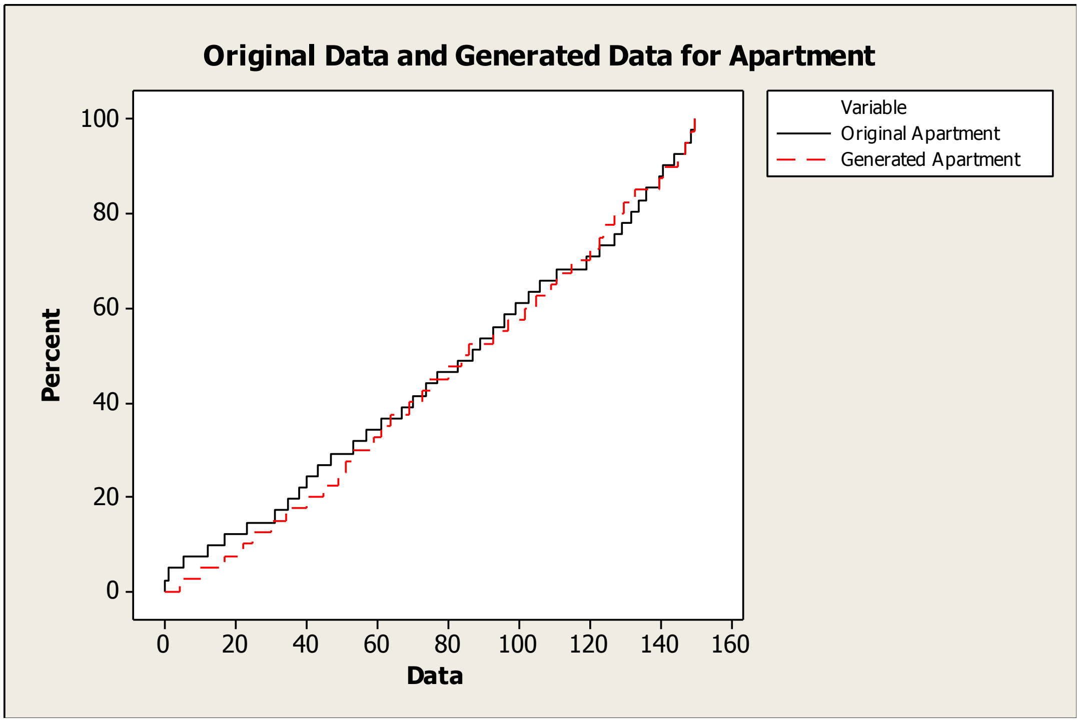


Figure 8.26: Graph of original and generated data for apartment complex

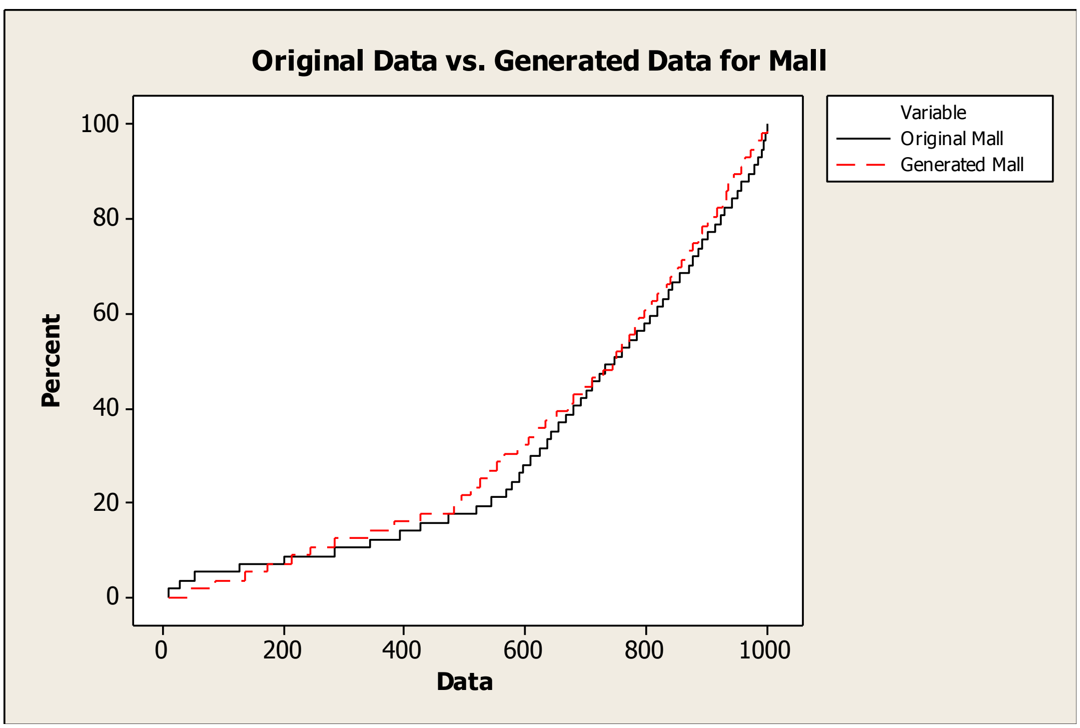


Figure28. Graph of original and generated data for commercial mall

8.4. Conclusions and Recommendations for Future Research

In this work, simulation models of the evacuation of four different facilities were modeled. These facilities are an apartment complex, a commercial mall, a baseball stadium and an amusement park. A factorial design was performed in each case in order to analyze the factors that had a large impact on the total evacuation time. The baseball stadium simulation was used also to perform a qualitative validation of the simulation software used.

An important conclusion of the present work is that the Poisson process is a good assumption to generate the inter-exit times. This is because the different sections/floors of a facility can be considered to be independent between each other given that they do not interact among each other. Therefore, the final evacuation process can be considered as the superposition of all the sections/floors evacuations and the Poisson process can be used to model this superposition. Ideally, the more sections/floors you have, the assumption of using the Poisson will become stronger. The inter-exit generators were developed using a Non-Stationary Poisson Process (NSPP). The generators were able to represent the results obtained from the simulation in a very close way. This is a great advantage given that using the generators allows getting results of an evacuation in a faster way. The generators can be used in large-scale evacuation simulation to obtain the inter-exit times from buildings in a fast manner without a computational burden.

The factors under study on this work were Congestion, Imitation, Desired Speed, and Distance Error. In a future research, the size of the space occupied for each entity should be investigated as well. This would help to understand the changes on the total evacuation time under a scenario where people have luggage with them as in an airport for example.

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9. Demand Modeling and Evacuation Survey

9.1. Development of the EvacDemand Module for TRANSIMS

EvacDemand.exe is a new module in the TRANSIMS software system which allows evacuation analysts to input evacuation scenario information and baseline travel information and which then modifies the baseline travel information to respond to the evacuation scenario specified. The software is flexible to allow the analyst to input any variety of evacuation type. Evacuation scenarios are created (as documented in the TransimsVIS user manual) which determine the size, timing and extent of the emergency, the degree of severity or risk level, the location of any shelters or collection points and the provision of evacuation routes to evacuees, through a variety of input files. EvacDemand then combines these scenario files with the average day TRANSIMS model results to estimate a new set of trips impacted, either directly or indirectly, by the evacuation. The determination of new evacuation trips is handled through a series of user-configurable logical rules and behavioral models, through a set of configuration parameters in the EvacDemand control file. This report documents the development and usage of the EvacDemand executable.

9.1.1. Development of evacdemand.exe project

After the inputs needed for the evacuation scenario were determined, the development of the EvacDemand.exe project was undertaken. The first step in the development of the EvacDemand executable was to create a new tool in the TRANSIMS toolbox. The EvacDemand.exe project has been created with its own set of control keys and currently compiles under the releaseboost configuration. The EvacDemand.exe project is capable of reading three input files which contain the data described above using three new control keywords, into separate data arrays comprised of new classes (EvacZone_Data, Evac_Response_Data and Evac_Shelter_Data).

- EVAC_ZONE_FILE to read the evacuation zone file into the internal array of EvacZone_Data items
- EVAC_SHELTER_FILE to read the shelter locations into array of Evac_Shelter_Data items
- EVAC_RESPONSE_FILE to read the response file into array of Evac_Response_Data items

The program also reads in the existing network files (NODE, LINK, ZONE, etc.) as requirements as well as an existing trip file using the control keyword TRIP_FILE_IN.

The project then processes the trip file and generates a new trip file in response to the evacuation scenario. The new trip file includes all trips which were unaffected by the evacuation scenario, trips whose destinations were modified because they were originally within an evacuation zone during the evacuation time, and newly generated trips originating within the evacuation zones as individuals begin responding to the evacuation scenario. These generated evacuation trips are determined by tracking the flows into and out of each evacuation zone prior to the evacuation along with the initial population. In this way the exact population of the zone at the start of the evacuation is known. Additionally, the origin zones of trips flowing into an evacuation zone are saved, so that trips can be routed out of the evacuation zone to the origin zone (simulating evacuees returning home) as long as the origin zone was not also an evacuation zone. Individuals within the evacuation zone not originally from another zone are simply routed to the nearest evacuation shelter. All new trips and unmodified original trips are then output to a new trip file defined by the NEW_TRIP_FILE keyword.

9.1.2. EvacDemand.exe program structure

The overall program structure and how the program interacts with other TRANSIMS executables is shown in Figure 6.1 below. The EvacDemand.exe demand modification program is currently a trip-based model, where the trips are estimated using ConvertTrips.exe from aggregate zone-to-zone flow data, representing the average day traffic. The zone flows are disaggregated using estimated diurnal distributions and randomly assigned to activity locations within zones to produce the average day trip table. This table is read in to the EvacDemand.exe program using the ReadTrips() function and is then modified to produce the evacuation demand. The average day trips are used with a flow-based process to estimate the potential demand for evacuation trips, where trips flowing into and out of evacuation zones are tracked until the start of the evacuation process to estimate the current number of individuals in the zone when the evacuation is to begin. These zonal population count estimates are then combined with the updated evacuation network, and the evacuation shelters and other zonal data and used in the evacuation response model which has yet to be developed. Finally, the modified and unmodified trips are written to a new trip file defined by the NEW_TRIP_FILE control.

The EvacDemand.exe program relies on a variety of inputs defining both the current evacuation scenario as well as information regarding the land-use, household characteristics and location of significant structures such as schools, hospitals and emergency response facilities. The control keys and file descriptions associated with these inputs (excluding the system files such as LOCATION_FILE, LINK_FILE, etc.) are discussed in the next section.

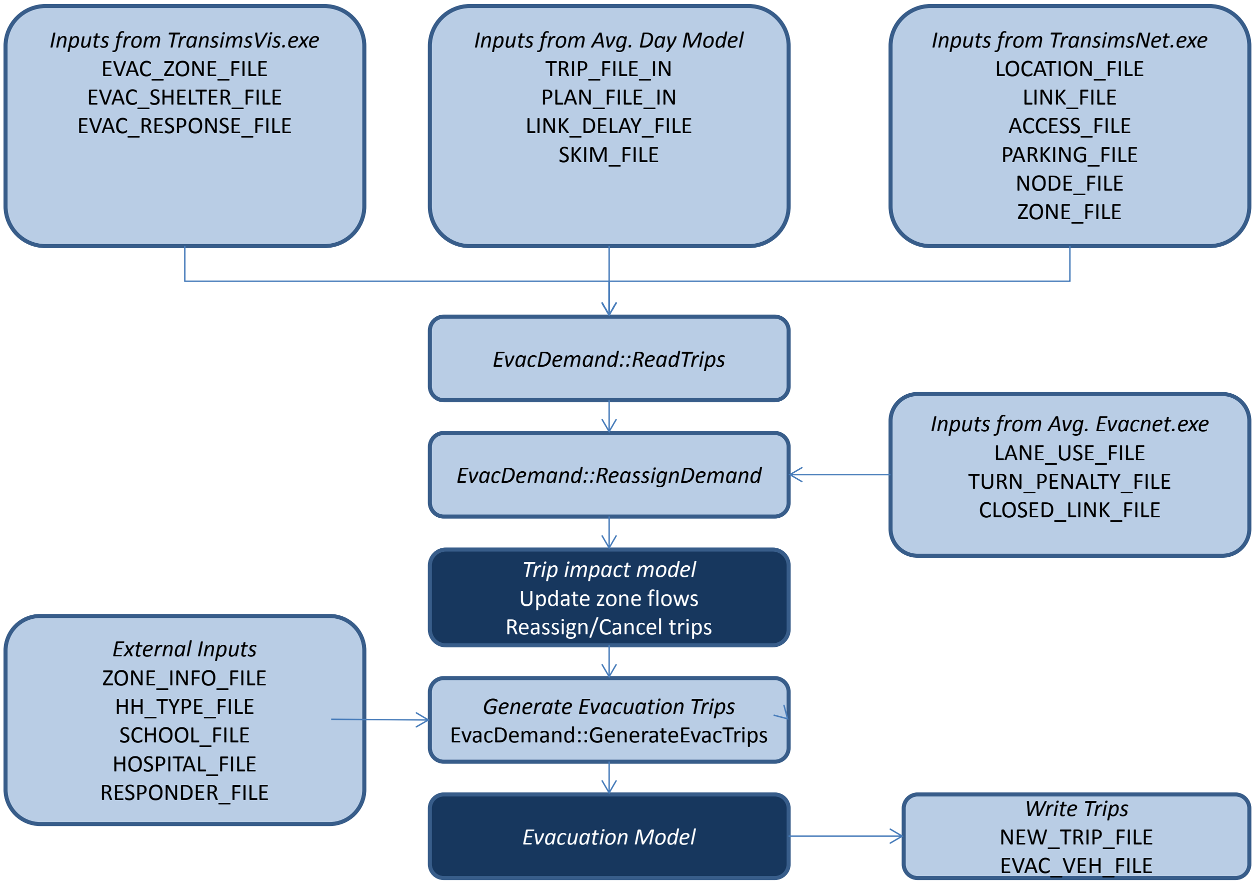


Figure 9.1: EvacDemand.exe Program Flow

9.1.2.1. EvacDemand Pseudo-Code

The process of estimating the evacuation demand, given these inputs and based on the program flow shown in Figure 6.1 is shown below.

```
Read Input Files()
Read_Trips()
      If trip.origin == evaczone
            if trip.start < evaczone.Start
                  evaczone.currentpop--
                  write trip(trip)
            else cancel trip
      Else If trip.destination == evaczone
            if trip.start < evaczone.Start
                  evaczone.currentpop++
                  write trip(trip)
            else replan_trip(trip)
      Else If trip.Evac_TTime > trip.TTime*TTime_Threshold
            replan_trip(trip)
      Else If Closed_Links.Contains(Trip.LegID)
            Reroute_trip(trip)
      Else write_trip(trip)
```

```
End

Generate_Evacuation_Trips()
      Foreach evaczone in evac_zone_array
            while (evaczone.currentpop>0)
                  HH = Get_Random_HH_Type()
                  trips = Evac_Response_Model(HH, zone, network)
                  trips.start += Egress_Model(HH,location,zone)
                  write_trip(trips)
                  evaczone.currentpop -= HH_EVAC_VEH_OCC
            End
      End
End
```

The pseudo-code shows the process of first reading in the existing average day trips to develop the evacuation zone inflows/outflows which is combined with the existing population in the zone to estimate the current population as the evacuation begins. If the travel happens before the evacuation starts, the trip merely changes the population in the origin and destination zones. If the trip happens then, for each evacuation zone, evacuation trips are generated until no population remains in the zone (other than individuals choosing to shelter-in-place). The main routine in this section of the program is the Evac_Response_Model which will be discussed in Section 5.

The next section documents the control keys and input files used to run the EvacDemand executable. Then, the following sections document the underlying models used to generate the evacuation demand.

9.1.3. Control Key Descriptions

The following control keys are available in the EvacDemand executable to control the inputs and settings used to generate the evacuation case. The keys below include TRANSIMS system keys and system file keys, as well as keys specific to EvacDemand only. The keys shown can be either optional or required and most EvacDemand-specific keys have default values which enables the program to be run without explicitly defining the control values. This is important to note fort the response model parameters. The parameters are defaulted to values estimated as discussed in following sections, and do not need to be defined for an evacuation case unless contrary evidence or need exists for other parameter values. Changing these values can be done through the control keys to represent other types of emergency evacuation scenarios than those tested during the development of EvacDemand.

Table 9.1: EvacDemand Control Keys

Control Key	Note	Required	Default	Range
Basic Keys				
TITLE		N		Control Keys
REPORT_FILE		N		filename[_partition][.prn]
REPORT_FLAG		N	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
PROJECT_DIRECTORY		N		
DEFAULT_FILE_FORMAT		N	TAB_DELIMITED	TEXT, BINARY, TAB_DELIMITED…
TIME_OF_DAY_FORMAT		N	DAY_TIME	HOUR_CLOCK, DAY_TIME, etc.
MODEL_START_TIME		N	0:00	>= 0 [seconds], 0.0 [hours], 0:00
MODEL_END_TIME		N	24:00:00	> [model_start_time]
UNITS_OF_MEASURE		N	METRIC	METRIC, ENGLISH
RANDOM_NUMBER_SEED		N	0	0 = computer clock, > 0 = fixed
MAX_WARNING_MESSAGES		N	100000	>= 0
MAX_WARNING_EXIT_FLAG		N	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
MAX_PROBLEM_COUNT		N	0	>= 0
NUMBER_OF_THREADS		N	1	1..12
#---- System File Keys ----				
NODE_FILE		Yes		[project_directory]filename
ZONE_FILE		Yes		[project_directory]filename
LINK_FILE		Yes		[project_directory]filename
POCKET_FILE		Yes		[project_directory]filename
LOCATION_FILE		Yes		[project_directory]filename
ACCESS_FILE		Yes		[project_directory]filename
NEW_TRIP_FILE		Yes		[project_directory]filename.*
NEW_VEHICLE_FILE		Yes		[project_directory]filename.*
LANE_USE_FILE	[1]	Yes		[project_directory]filename
VEHICLE_TYPE_FILE	[12]	Yes		[project_directory]filename
SKIM_FILE	[2]	Yes		[project_directory]filename.*
VEHICLE_FILE	[2]	Yes		[project_directory]filename.*
HOUSEHOLD_FILE	[2]	N		[project_directory]filename.*
PARKING_FILE		N		[project_directory]filename
NOTES_AND_NAME_FIELDS		N	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
FLOW_UNITS		N	VEHICLES	VEHICLES, PERSONS, ETC.
SKIM_TOTAL_TIME_FLAG		N	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Control Key	Note	Required	Default	Range
#---- EvacDemand File Keys ----				
TRIP_FILE_IN	[2]	Y		[project_directory]filename
PLAN_FILE_IN	[2]	Y		[project_directory]filename
EVAC_VEHICLE_FILE	[3]	Y		[project_directory]filename
EVAC_ZONE_FILE	[4]	Y		[project_directory]filename
CLOSED_LINK_FILE	[1]	Y		[project_directory]filename
ZONE_INFO_FILE		Y		[project_directory]filename
EVAC_SHELTER_FILE	[4]	Y		[project_directory]filename
EVAC_RESPONSE_FILE	[4]	Y		[project_directory]filename
HH_TYPE_FILE		Y		[project_directory]filename
EVAC_SKIM_FILE	[5]	N		[project_directory]filename
#---- EvacDemand Keys ----				
HB_PURPOSE_CODES	[6]	Yes		0,1..100
NUM_HH_TYPES	[7]	Yes	448	0..1000
TRIP_SCALING_FACTOR		Yes	1	0.001..1.0
TTIME_THRESHOLD	[8]	Yes	0.75	0.0..1.0
DIVERT_VEH_TYPE	[9]	Yes	99	1..100
SCHOOL_FILE		N		[project_directory]filename
HOSPITAL_FILE		N		[project_directory]filename
RESPONDER_FILE		N		[project_directory]filename
UTILITY_THRESHOLD	[10]	N	0	0.0..1.0
HOSPITAL_EVAC_VEH_OCC	[11]	N	1	1..200
SCHOOL_EVAC_VEH_OCC	[11]	N	1	1..200
HH_EVAC_VEH_OCC	[11]	N	1	1.0..100.0
MAX_RESPONSE_TIME		N	0	>= 0 [seconds]
#---- EvacDemand Choice Model Keys ----				
DEST_CHOICE_SET_SIZE	[13]	Yes	50	0..100
PAR_SHELTER_CAP	[14]	N	0.1	0.0..100.0
PAR_IGNORE_HIRISK	[14]	N	-0.805	-100.0..100.0
PAR_IGNORE_CHILD	[14]	N	-0.575	-100.0..100.0
PAR_SHELTER	[14]	N	1.849	-100.0..100.0
PAR_SHELTER_VEHACC	[14]	N	-0.678	-100.0..100.0
PAR_SHELTER_MEDRISK	[14]	N	0..382	-100.0..100.0
PAR_CHILD	[14]	N	-0.761	-100.0..100.0
PAR_EVAC	[14]	N	0.397	-100.0..100.0
PAR_EVAC_ORDER	[14]	N	1.431	-100.0..100.0
PAR_EVAC_SHLTR_MEDRISK	[14]	N	0.531	-100.0..100.0
PAR_EVAC_SHLTR_CHILD	[14]	N	-0.639	-100.0..100.0
PAR_EVAC_EXTERN	[14]	N	-1.235	-100.0..100.0
PAR_EVAC_EXTERN_EDIST	[14]	N	0.0167	-100.0..100.0
PAR_EVAC_ZONE	[14]	N	-0.9001	-100.0..100.0
PAR_EVAC_ZONE_EDIST	[14]	N	-0.012	-100.0..100.0
PAR_EVAC_ZONE_IV	[14]	N	0.436	0.0..1.0
PAR_TTIME	[14]	N	-0.0158	-100.0..100.0
PAR_POP_PER	[14]	N	0.896	-100.0..100.0
PAR_POP_DEN	[14]	N	-1.018	-100.0..100.0
PAR_AREA_RES	[14]	N	-0.442	-100.0..100.0
PAR_NUMADULT	[14]	N	0	-100.0..100.0

Control Key	Note	Required	Default	Range
#---- EvacDemand Choice Model Keys(Continued)				
PAR_NUMVEH	[14]	N	0	-100.0..100.0
PAR_NUMWORK	[14]	N	0	-100.0..100.0
PAR_CHILDREN	[14]	N	0	-100.0..100.0
PAR_AREA	[14]	N	0	-100.0..100.0
PAR_RES_LOW	[14]	N	0	-100.0..100.0
PAR_RES_HIGH	[14]	N	0	-100.0..100.0
PAR_COMM	[14]	N	0	-100.0..100.0
PAR_IND	[14]	N	0	-100.0..100.0
PAR_EMP_TOT	[14]	N	0	-100.0..100.0
PAR_EMP_RET	[14]	N	0	-100.0..100.0
PAR_POP_HH	[14]	N	0	-100.0..100.0
PAR_POP_GQ	[14]	N	0	-100.0..100.0

NOTES	
[1]	Generated from EvacNET.exe. Represents evacuated network conditions
[2]	From average day model results - used as input
[3]	Used when routing evacuee/replanned trips
[4]	Generated using TransimsVIS configuration mode
[5]	Generated from Pathskim.exe, using evacuated network results
[6]	Trip purposes which represent home based travel.
[7]	Number of household type categories in ZONE_INFO_FILE
[8]	Threshold for trip replanning. If avg day time / evacuated time < threshold, the trip gets replanned
[9]	If utility of new destination < utility of original - threshold, new destination is not considered
[10]	Vehicle type code for diverted vehicles, should be greater than maximum evacuated vehicle type
[11]	Average expected occupancy for evacuated vehicles
[12]	Vehicle types 91-95 required for evacuation vehicles. Generated in zones with severity 1-5 respectively
[13]	Number of alternative zones to consider when replanning a trip or generating a new evacuation trip
[14]	Zone choice model parameters. See EvacDemand technical documentation for details. Default values are set based on 2011 Chicago Evacuation Survey.

9.1.4. EvacDemand.exe Input File Descriptions

The EvacDemand.exe project currently uses a number of required system file controls, required and optional input file controls and various control parameters in estimated evacuation demand. The current list of control keys is shown in Table 6.1. This list does not show the required system file keys, which are LOCATION_FILE, LINK_FILE, ACCESS_FILE, PARKING_FILE, NODE_FILE and ZONE_FILE. Each file-type control key has an associated data object, data map and data array within the EvacDemand.exe project. For example, the SCHOOL_FILE control key is associated with a *School_File* object, which is read and fills the *School_Array* data structure with *School_Data* data items, and fills the *School_Map* with a pair linking the *School_Data* ID to its index in the *School_Array*. A similar convention is used for all other objects read in by the project, except for TRIP_FILE_IN and NEW_TRIP_FILE, which use existing methods in SysLib. The non-file control keys define various parameters used within the model as described in the table.

Each of the file control keys above (excluding the TRIP_FILE_IN and NEW_TRIP_FILE) is associated with a new file type which are described in detail in the following tables. First is the EVAC_ZONE_FILE control, which creates the Evac_Zone_File object in the project. This file is described in Table 6.2.

Table 9.2: EVAC_ZONE_FILE Description

EVAC_ZONE_FILE		Evacuation zone description file	
Field	**Type**	**Description**	**Units**
EVENT	Integer (10)	Event ID for zone	
ZONE	String (128)	Evacuation Zone Range (Begin:End) or (Zone)	
POP	Integer (10)	Population of the zone	
LEVEL	Integer (10)	Link to a response type in EVAC_RESPONSE_FILE	
START	Time (10)	Beginning of evacuation in zone(s)	Hour
END	Time (10)	End of evacuation in zone(s)	Hour

The EVAC_ZONE_FILE is created either manually or as an output from TransimsVIS and describes the emergency/evacuation spatio-temporally and in terms of the response through the LEVEL field. The file includes the ZONE filed which is either a single zone or a range of zones with a starting and ending zone ID separated by a colon (i.e. “1561:1579”). The LEVEL field links to the next input file EVAC_RESPONSE_FILE, and describes the evacuation response characteristics for each zone. Note that each evacuation zone must have a valid LEVEL found in the EVAC_RESPONSE_FILE. This file is described in Table 6.3

Table 9.3: EVAC_RESPONSE_FILE Description

EVAC_RESPONSE_FILE		Evacuation response description file	
Field	**Type**	**Description**	**Units**
EVENT	Integer (10)	Event ID	
LEVEL	Integer (10)	Response level ID	
DIST	String (128)	Response time distribution and parameters <WEIBULL, LOG-LOGISTIC, GAMMA>:Param1:Param2…	
COMPLIANCE	Double (10)	Evacuation compliance rate	
RESPONSE	Integer (10)	Emergency response type ID	
EVAC_VEH_ID	Integer (10)	ID of evacuation vehicle type generated in level	

Again, the level parameter is used to link the various response types described in this file to the evacuation zones. There can be and individual response for each zone, several responses for different groups of zones, or one response for all evacuation zones, depending on the problem requirements. The response file also includes the DIST field, which describes the evacuation response in terms of the response time distributions. Three distributions are available for use here, including log-logistic, weibull and Gamma distributions. The DIST field for the response level should include the distribution name and parameter values separated by colons. The compliance parameter determines what percentage of individuals in the zone respond to the evacuation order, and the RESPONSE, parameter will be used to determine how emergency responders react to the evacuation/emergency in the zone. The next input is the EVAC_SHELTER_FILE, which simply determines the locations of evacuation shelters and their capacities, for evacuating individuals to route to. The file description is shown in Table 6.4

Table 9.4: EVAC_SHELTER_FILE Description

EVAC_SHELTER_FILE		Evacuation shelter description file	
Field	**Type**	**Description**	**Units**
LOCATION	Integer (10)	Activity location ID, link to LOCATION_FILE	
CAPACITY	Integer (10)	Capacity of the shelter	
ATTRACTION	Integer (10)	1= Available, 0 = unavailable	
NAME	String (20)	Name of shelter – set by TransimsVIS	

The next two input files are closely linked and describe the basic land use and demographic characteristics of the zones. This data will be used in the behavioral evacuation decision models, the egress time models, and in the trip flow calculations. The first file is the zone info file shown in Table 6.5

below. This file describes the land use and population characteristics of the zone. These characteristics are important in determining destination choice, egress rates (different models based on land use types), and for determining how the zones evacuate (using the distributions of different household types). For example, zones with higher percentages of households with children will likely make more secondary trips than zones with high percentages of single individual households, etc. This file includes a field HHTYPECOUNT which is a comma-separates list of the counts of household types defined in the next file, the HH_TYPE_FILE.

Table 9.5: ZONE_INFO_FILE Description.

ZONE_INFO_FILE		Evacuation response description file	
Field	**Type**	**Description**	**Units**
INTERNAL	Integer (10)	1= internal zone, 0 = external to region	
ZONE	Integer (10)	Zone ID – link to ZONE_FILE	
AREA	Integer (10)	Zone Area	Sq feet
AREA_RES_LOW	Integer (10)	Area of low density residential land use	Sq feet
AREA_RES_HI	Integer (10)	Area of high density residential land use	Sq feet
AREA_COMM	Integer (10)	Area of commercial land use	Sq feet
AREA_IND	Integer (10)	Area of industrial land use	Sq feet
POP_HH	Integer (10)	Total households in zone	
POP_PER	Integer (10)	Total persons in zone	
POP_GQ	Integer (10)	Total persons living in group quarters	
EMP_TOT	Integer (10)	Total employment	
EMP_RET	Integer (10)	Retail employment	
HHTYPECOUNT	String (1200)	Comma separated List of HH counts for each HHTYPE**	
** Important: the counts in HHTYPECOUNT must be in same order as HH_TYPE_FILE			

The household type file simply describes each household type in terms of the variables shown in Table 6.6 below. This basic demographic information is used in place of the more detailed demographics which are available with a full synthetic population, to do basic behavioral modeling. It is important that the number of household types defined in this file exactly matches the size of the HHTYPECOUNT list in the ZONE_INFO_FILE and the NUM_HH_TYPES control key, otherwise an error will occur and execution will stop.

Table 9.6: HH_TYPE_FILE Description

HH_TYPE_FILE		Household Type description file	
Field	**Type**	**Description**	**Units**
TYPE	Integer (10)	Household type number	
NUMADULT	Integer (10)	Number of adults in type	
NUMWORKER	Integer (10)	Number of workers in type	
NUMVEH	Integer (10)	Number of vehicles in type	
CHILDREN	Integer (10)	1=children present, 0 = no children	

The final two files are described in Table 6.7 and

Table 6.8 below. These are the school and hospital location input files. Each file links the building to an existing TRANSIMS activity location through the LOCATION field, and provides some measure of the size/capacity of the building (ENRLMNT_NUM or BEDS). Note that two additional files similar in nature to these files are expected to be added to the project, including and emergency responder location file and a large structures file, but are not currently completed.

Table 9.7: SCHOOL_FILE Description

SCHOOL_FILE		School location description file	
Field	**Type**	**Description**	**Units**
SCHOOL	Integer (10)	School ID number	
LOCATION	Integer (10)	School Location ID, link to LOCATION_FILE	
ZONE	Integer (10)	Zone ID, link to ZONE_FILE	
ACCESS_DIS_FT	Integer (10)	Distance that actual school location was shifted to coincide with and Activity location (NOT USED)	Feet
PUBLIC_SCH	Integer (10)	1=yes, 0 = no	
ENRLMT_NUM	Integer (10)	Current enrollment at the school	
GRADE_MIN	Integer (10)	Minimum grade served at school Preschool = -1, K=0,…College = 13	
GRADE_MAX	Integer (10)	Maximum grade served at school Preschool = -1, K=0,…College = 13	

Table 9.8: HOSPITAL_FILE Description

HOSPITAL_FILE		Hospital location description file	
Field	**Type**	**Description**	**Units**
HOSPITAL	Integer (10)	Hospital ID number	
LOCATION	Integer (10)	Hospital Location ID, link to LOCATION_FILE	
ZONE	Integer (10)	Zone ID, link to ZONE_FILE	
ACCESS_DIS_FT	Integer (10)	Distance that actual hospital location was shifted to coincide with and Activity location (NOT USED)	Feet
AREA	Integer (10)	Size of hospital grounds	Sq ft
BEDS	Integer (10)	Hospital size in terms of beds	
NOTES	String (128)	Hospital name	

9.1.5. Data Sources

The development of the Evacuation Demand model and software drew from a variety of data sources. Primarily, these included average day trip files and network files from the Chicago Metropolitan Agency for Planning (CMAP) regional travel model, and other input files needed to run the TRANSIMS software. Additionally, however, a source of data regarding evacuation demand behavior was needed to estimate and calibrate the evacuation response model, which forms the core of the EvacDemand program.

9.1.5.1. Evacuation Survey

The survey is designed to collect information on a typical weekday for a household and then to develop two no-notice emergency evacuation events which would impact the household on the given day. The respondents then determine how they would respond to the event in terms of evacuation likelihood, response time, additional trips they would make (i.e. picking up children, meeting with others, etc.) and final destination.

The survey has been implemented as an internet based, self-guided survey, using third-party survey software, Google Maps API and significant Javascript customization. The survey is conducted in three parts starting with the collection of basic demographics and average day location and vehicle use information. Following this, the respondents are presented with two randomly generated emergency evacuation scenarios. These scenarios are generated based on a combination of randomly selected factors including:

- Time of the event
- Location of the event (who does the event occur near)
- Severity of the event (at household member's location)
- Event radius
- Government recommendation for individuals in the area

These factors are varied for each respondent and for each scenario. The respondents then answer a series of questions related to how they would react in the given scenario. The survey instrument is described in detail in the RTSTEP Evacuation Survey Technical Report.

The survey was implemented using KeySurvey internet-surveying software and was collected on a sample of 205 households containing 533 individuals who responded to a total of 347 different evacuation scenarios. The data was collected in the Chicago Metropolitan Area in during July and August 2011. The characteristics of the survey sample matched observed population characteristics for the region according to Census 2010 data. A description of the survey sample is shown in Table 2.

Table 9.9: Survey Sample Characteristics

Household-level

HH Size	Survey	Census
1	20%	26%
2	33%	33%
3	20%	16%
4+	27%	25%

Income	Survey	Census
<25	9%	29%
25-50	17%	29%
50-75	15%	19%
75-100	20%	10%
>100	27%	12%
blank	17%	–

Tenure	Survey	Census
Own	72%	66%
Rent	25%	34%
blank	3%	–

Children	Survey	Census
Yes	32%	36%
No	68%	64%

Total Sample Size	
HH	205

Person-level

Age	Survey	Census
<15	17%	21%
16-25	9%	14%
26-35	16%	14%
36-45	13%	14%
46-55	18%	15%
56-65	20%	11%
66+	7%	11%

Gender	Survey	Census
Female	49%	51%
Male	51%	49%
blank	1%	–

Employment	Survey	Census
Employed	64%	59%
Unemployed	7%	8%
Not in labor force	29%	32%

Education	Survey	Census
HS or less	14%	39%
Some College	25%	21%
Associate / Bachelor	29%	28%
Graduate / Prof.	32%	13%
blank	1%	–

Total Sample Size	
Adult	427
Child	106

9.1.5.2. Data Cleaning and Processing

The total data sample was cleaned to remove entries considered to be unreliable due to high item non-response, quitting the survey before responding to an evacuation scenario, giving inconsistent responses to evacuation behavior, etc. From a total of 303 households who completed some portion of the survey, the final sample of 205 valid households was extracted.

The data was then processed so that it was in a usable format for the choice model analysis described in Section 6. This mainly involves converting discrete values in the survey (i.e. education level, employment category, etc.) into indicator variables. In addition, significant processing of the geocoded data retrieved from the Google Maps interface was required. The selected individual activity and evacuation locations were converted to data points and connected to zonal data, either TAZ level in the Chicago region, or County level outside of Chicago. Evacuated distances were also calculated using straight line distance between starting and ending points. Finally, the user reported evacuation likelihood ratings were converted into probabilities by setting a rating of 1 equal to a probability of 0% and a rating of 5 equal to a probability of 100%, and setting the rest of the rating probabilities accordingly. The evacuation probability was estimated using a weighted combination of the three different evacuation probabilities recorded. This was then combined with the estimated destination type under the evacuation responses (i.e. shelter, hotel, residence, etc.) and the location of those destination to give the final set of 5 evacuation outcomes which were modeled. These include:

- P_IGNORE: Ignoring the government order
- P_SHELTER: Sheltering in place
- P_EVAC_SHELTER: Evacuating to a public evacuation shelter
- P_EVAC_EXTERNAL: Evacuating outside of the Chicago region (hotel or residence)
- P_EVAC_ZONE: Evacuating to a zone inside the Chicago region (hotel or residence)

The final set of variables is shown in Table 3. Note that these variables also include a selection of zone-level variables for the Chicago region extracted from CMAP data.

Table 9.10: Model Variables

Variable	Avg.	St. Dev.	Min	Max
Continuous Variables				
Num. Adults	2.08	0.93	1	5
Num Children	0.63	1.06	0	5
Distance from epicenter (mi)	16.23	14.59	0.70	156.38
Evacuated area size (mi)	23.95	15.88	5	60
Zonal Variables				
Travel time to zone (min)	28.54	16.87	0.56	109.72
Log of Residential Area (sqft)	14.06	5.63	0.69	18.47
Log of Population	6.87	3.02	0.00	10.67
Indicator Variables				
Vehicle Access	0.90	0.31	0	1

College Degree	0.69	0.46	0	1
Medium Risk	0.35	0.48	0	1
High Risk	0.37	0.48	0	1
Evacuation Order issued	0.63	0.48	0	1
Medium Income	0.37	0.48	0	1
High Income	0.28	0.45	0	1
Dependent Variables				
P_IGNORE	0.06	0.15	0	1
P_SHELTER	0.31	0.31	0	1
P_EVAC_SHELTER	0.34	0.40	0	1
P_EVAC_ZONE	0.18	0.34	0	1
P_EVAC_EXTERN	0.12	0.29	0	1

9.1.6. Evacuation Model

The evacuation model in the EvacDemad executable occurs in two primary stages – the trip impact model and the evacuation behavioral response model – as shown in Figure 6.1. These models are run as the existing average day trip file is parsed. The trip impact model determines any changes necessary to existing trips, i.e. rerouting, replanning or canceling of trips, and the behavioral response model estimates the generation of new evacuation trips. Each model is discussed in detail below.

9.1.6.1. Trip Impact Model

The trip impact model operates on the average day trip file and determines any impacts on the existing trips from the specified evacuation scenario. The trip impact model makes modifications to any trips as necessary and also tracks changes in zonal populations due to average day trips, so the existing population in each zone at the time of the evacuation is known. The trip impact model is implemented as a series of logical rules to determine any necessary responses on different classes of trips, and operates on the following classes of trips:

1. Trips originating in an evacuation zone
2. Trips destined for an evacuation zone
3. Trips whose travel time is altered by the evacuation network
4. Trips traveling through an evacuation zone

The first set of rules looks at the origin and destination of the trip in the average day file. If the origin is in an evacuation zone, i.e. a type 1 trip, the timing is next checked. Trips originating before the evacuation starts are unchanged, and are merely used to update the zonal population, as discussed in a later section. Trips originating after the evacuation starts are cancelled, as it is assumed that individuals would evacuate or alter average day trips in response to the emergency, as discussed in the behavioral response model section.

For type 2 trips which are destined for an evacuation zone, if the end time of the trip is prior to the start of the evacuation, the trip is unchanged and is used to increment the zonal population. However, if the end time of the trip is after the trip, the trip needs to be replanned, as it is not expected individuals will enter an evacuation area for discretionary trips. The replanning occurs using a utility based choice model, where individuals attempt to choose a zone from a randomly selected choice set of a size set by the CHOICE_SET_SIZE which maintains some percentage of the utility of the original location choice, as determined by the UTILITY_THRESHOLD control key. If no suitable replacement zones are found, the trip is instead canceled. If a suitable set of zones is found, a new zone is probabilistically selected and the trip is rerouted to a random location within the zone.

The type 3 trips are closely related to Type 2 trips and have a similar response in the model. Type 3 trips are identified by looking at network skim travel times on the average day and evacuation day networks, to determine if the expected travel time for the trip as planned will be increased beyond a reasonable level, as determined using the TTIME_THRESHOLD control key. If the trip is identified as being affected, the trip end is replanned or cancelled as in Type 2 trips.

Finally, type 4 trips are identified by looking at the average day plan file and determining if any of the links used by the trip are within the evacuation area as defined by the CLOSED_LINK_FILE. If the trip does pass through the evacuated area, it is simply rerouted.

For the type 1 and type 2 trips described above, the model also tracks how the trips change the population in the set of evacuated zones, so the exact number of individuals remaining within the zone can be used to generate evacuation trips when the evacuation begins. Each zone starts with an initial population, as set in the ZONE_INFO_FILE, as well as any special generator population given in the EVAC_ZONE_FILE to represent non-average day additional population in the zone. Then, for each trip leaving or entering the zone, the zone population is decremented or incremented, respectively, and the respective destination/origin of the trip is recorded. Each evacuation zone, then, also contains a vector of where each current individual entering the zone has arrived from. For example, if Zone 1 is an evacuation zone, and two trips from Zone 2 enter Zone 1, and one trip leaves Zone 1 for Zone 2, there will be an entry in the Zone 1 trip list stating that one individual from Zone 2 is still in Zone 1 at the start of the evacuation. This information is then used when evacuation trips are generated, as it is assumed that individuals, who have arrived in an evacuation zone from somewhere else, will return to their original locations, rather than evacuating to other locations.

9.1.6.2. Behavioral Evacuation Response Model

The evacuation response model is accomplished in two phases. The first involves the individuals in the zone who have arrived from another zone, as described above. In the evacuation generation phase, these individuals generate new trips destined for their original locations, providing that the original location is not also an evacuation zone. If the original location is in an evacuation zone, the individuals are handled in the same manner as other individuals in the second generation phase. For every trip generated in the first phase, the current population in the evacuation zone is decremented, as is the number of trips in the origin zone vector for each evacuation zone. Once all trips in the origin zone vector have been generated (representing individuals returning home from the evacuation zone), the second phase of the evacuation is started. This phase involves generating new evacuation trips according to the behavioral evacuation response model, described in this section.

The idea for the behavioral response model is to develop a multi-level nested-logit model which determines how the individuals (or household aggregates in the case of the trip-based model) will react to the evacuation order. The nested logit model is combined with a hazard-based model to determine how long it will take the individuals to react to the evacuation order, and an egress model based on land-use and building characteristics to determine how long it takes the individuals to leave their location once they have decided to act. The core of the model is the nested logit behavioral discrete choice model which determines the household reaction type based on household, zone and emergency/evacuation characteristics, show in Figure 9.2. The household decision consists of a top level choice between ignoring the order, sheltering in place or evacuating. Beneath this level there is a secondary decision level of whether to evacuate to a shelter, another zone (i.e. friends/family/hotel,etc.) or to an external location. The final layer of the decision model is the actual choice of specific zone to evacuate to.

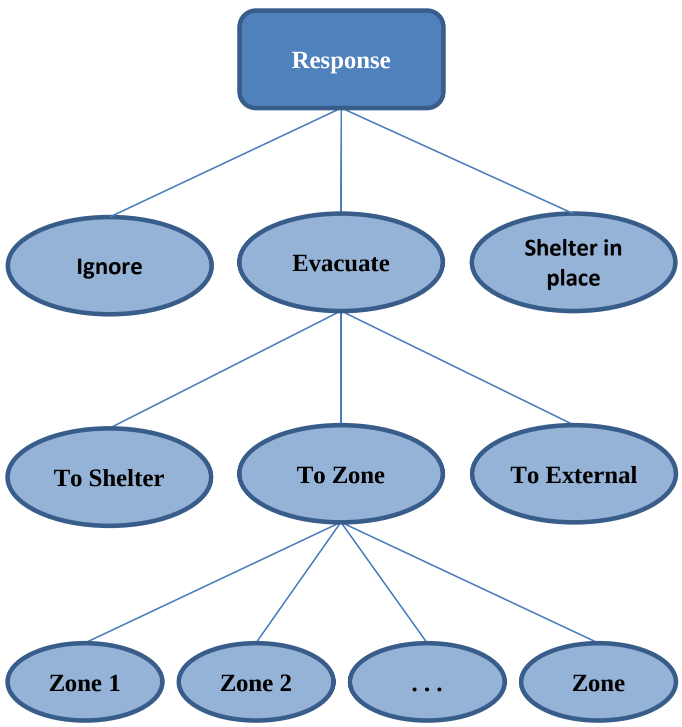


Figure 9.2: Initial Nested-Logit Evacuation Decision Model Framework

This model is used for all individuals remaining in the evacuation zones after returning all trips to originating zones. This model represents how individuals living in an evacuated zone would respond under emergency evacuation conditions. The model is formulated as a discrete choice model, where the evacuating individuals choose from a set of potential behavioral response, including ignoring the evacuation, sheltering-in-place, or evacuating. If the individuals choose to evacuate, there is also a decision of whether to evacuate to a shelter, other zone or external collection point. Finally, if the individuals choose to evacuate to a zone within the modeled region, there is a choice of which zone to evacuate to, from a random selection of non-evacuated zones in the region, again defined by CHOICE_SET_SIZE. There could potentially also be lower level models for which shelter or external zone to choice, but these choices are simply made as gravity models based on travel distance, as no other attributes of shelters or zones where available in the survey data on which the model is based. It is important to note that in the framework above, the quality of zones to evacuate to impacts the probability of evacuating to a zone, and the quality of evacuation options impacts the probability of evacuating. This characteristic derives from the use of the Nested Logit discrete choice model framework as described below.

The behavioral model is formulated as a nested logit model, implying that certain responses are correlated, unlike in the standard Multinomial Logit model, in which all responses are independently distributed. The basic nested logit selection probability for an alternative *i,* in a nest *n* from a set of nests *N* is:

$$P(i|n) = \frac{e^{V_i}}{\sum_{j \in n} e^{V_j}} \tag{1}$$

$$IV_n = \ln\left(\sum_{j \in n} e^{V_j}\right) \tag{2}$$

$$P(n) = \frac{e^{W_n + \tau_n IV_n}}{\sum_{k \in N} e^{W_k + \tau_k IV_k}} \tag{3}$$

$$P(i) = P(i|n) * P(n) \tag{4}$$

Where,

P(i|n) = conditional probability of choosing alternative *i* given nest *n* has been selected

V_i = utility of choosing alternative *i* given nest *n*

IV_n **=** inclusive value, or logged sum of utilities of alternatives in nest *n*

P(n) **=** probability of choosing nest *n*

W_n = utility of choosing nest *n*

P(i) **=** probability of choosing alternative *i*

The alternatives in the case of this model are the evacuation response type and location as shown in Figure 6. The probability shown above can be combined with observed data to formulate a likelihood function to estimate the model parameters.

The utility functions for each nest/alternative are shown below:

$$U(ignore) = \beta_{hirisk} HiRisk + \beta_{child} HasChildren \tag{5}$$

$$U(s.i.p.) = \beta_{const} + \beta_{vehacc} VehAccess + \beta_{medrisk} MedRisk + \beta_{child} HasChildren \tag{6}$$

$$U(evacuate) = \beta_{const} + \beta_{evac} EvacOrder \tag{7}$$

$$U(evac\ shelter) = \beta_{medrisk} MedRisk + \beta_{child} * HasChildren \tag{8}$$

$$U(evac\ extern) = \beta_{const} \tag{9}$$

$$U(evac\ zone) = \beta_{const} + \tau_{evac\_zone} IV_{evac\_zone} \tag{10}$$

$$U(zone) = \beta_{ttime} TTime + \beta_{pop} Population + \beta_{popden} PopDensity + \beta_{resarea} ResArea \tag{11}$$

Table 9.11: Model Parameter Estimates

Parameter	Value	t-stat
Ignore		
High risk level	-0.825	-1.536
Has children	-0.567	-1.115
Shelter in Place		
Constant	1.828	3.767
Vehicle Access	-0.678	-1.780
Medium risk level	0.425	1.390
Has children	-0.752	-2.304
Evacuate		
Constant	0.387	0.998
Evacuation order given	1.421	5.678
Inclusive Value	1.000	–
Evacuate - to shelter		
Medium risk level	0.571	2.027
Has children	-0.626	-2.092
Evacuate - to external		
Constant	-1.046	-4.496
Evacuate - to zone		
Constant	-3.035	-1.076
Inclusive Value	0.517	0.845
Zone Selection		
Travel time	-0.015	-2.887
ln(Population)	0.251	1.612
ln(Pop. density)	0.225	2.650
ln(Residential area)	-0.140	-1.591

Goodness of fit results

LLc	-763.18
LLf	-611.19
R-square	0.199

9.1.6.3. Model Discussion

The model described above, used to determine the evacuation response of individuals remaining in evacuation zones, has an acceptable goodness-of-fit and shows statistical significance according to chi-square tests when explaining the observed evacuation responses in the evacuation survey data. The parameters shown in general have statistical significance at the 0.1-level, except where kept in for modeling purposes, such as the *Has Children* parameter in the *ignore evacuation* utility, etc. The parameters in the model have reasonable levels and signs, with individuals increasingly likely to evacuate when an evacuation order is given, when risk levels increase, when children are present, and when vehicles are available for use. Individuals who evacuate to home or hotels in the region are more likely to target zones which are easier to get to and have higher population and population density, since they or their friends and family are more likely to live in such zones.

The model as described is implemented in the EvacDemand executable, with all parameters described in the Control Keys section set to the above default values. This model is executed for every remaining individual in the evacuated zones. If any alternative other than shelter-in-place or ignore is selected, a new evacuation trip is generated and output to the NEW_TRIP_FILE and EVAC_VEH_FILE, where the trip is destined for either a random location in a zone, a shelter location, or an external location, according to the model results.

9.1.6.4. Evacuation Trip Start Time

After the new evacuation trips are generated, the start time model is called to determine when the individual will actually begin to evacuate. The evacuation start time model represents the delay in evacuation before individuals hear about and begin to respond to evacuation orders. The delay is modeled as a log-logistic distribution, where individual delay times are randomly drawn from the cumulative probability function determined by the DIST field of the response file for the current evacuation zone. If the default LOG_LOGISTIC distribution is used, the cumulative distribution is:

$$F(t) = \frac{1}{1 + \left({}^{t}/_{\alpha}\right)^{-\beta}}$$

Where α and β are the scale and shape parameters of the distribution, respectively. The scale parameter determines for this distribution is the median response time in minutes, while the shape parameter determines how tightly clustered about the median the evacuation response times are. These parameters are also set in the DIST field of the response file. Similar cumulative distribution functions can be determined for the other distribution types. This distribution is then inverted and evaluated at a random uniform probability draw to determine evacuation start times for each evacuation trip. This time is then added to the zonal evacuation start time when writing to the trip file. The figure below shows how different values of the parameter impact the start time distributions:

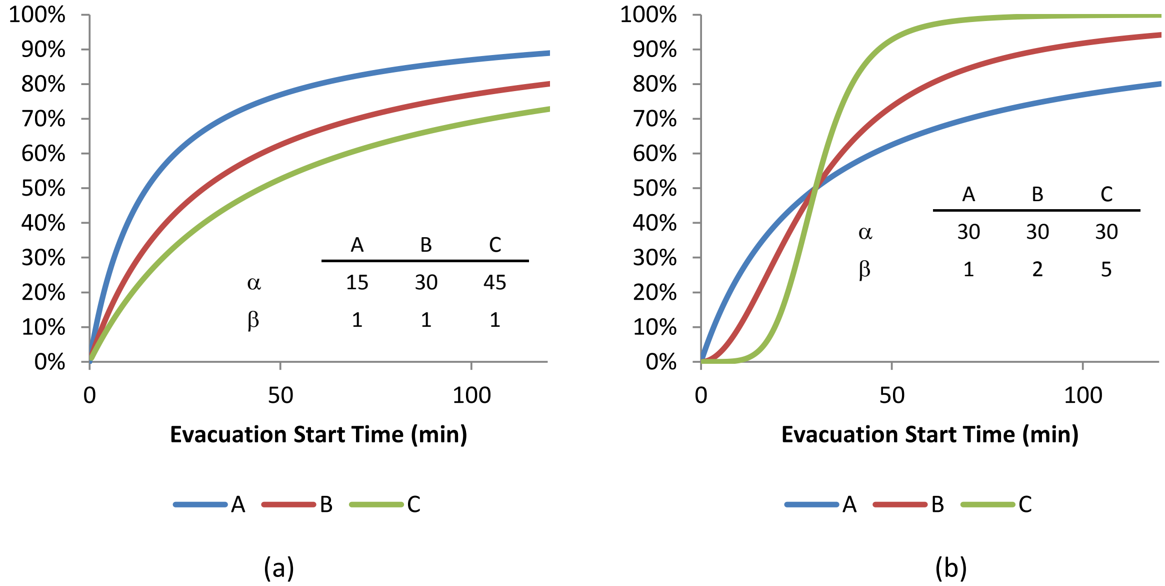


Figure 9.3: Evacuation time distributions for various (a) scale and (b) shape values

9.1.6.5. Evacuation Model Output.

The results of the EvacDemand executable are the NEW_TRIP_FILE and EVAC_VEH_FILE, which contain all the trips which have been either rerouted, replanned, deleted, or newly generated. Each trip is tagged with an appropriate trip purpose for later use in other executables or for analysis purposes.

In the trip file, the following purpose codes are used:

- 89: rerouted trip
- 90: replanned trip (destination in evac zone)
- 91: replanned trip (travel time increase over threshold)
- 92: return to original origin location
- 93: reroute to evac shelter
- 94: reroute to evac shelter after picking up children
- 96: new trip to evac shelter
- 97: new trip to external zone
- 98: new trip to internal zone
- 99: delete trip (used in plan prep to remove trip from average day file)

In the vehicle file, the following vehicle codes are used:

- DIVERT_VEH_TYPE: vehicles diverted due to travel time changes, closed links, etc.
- PERMIT_VEH_TYPE: vehicles allowed to drive in evac network at start of evacuation
- 91-95: vehicles generated in evacuation severity levels 1-5

The files are written in the specified project directory and are used in combination with the evacuation network files output by EvacNet executable as input to the TRANSIMS router. This generates the evacuation plans which are then integrated with the average day plans to give the final evacuation output for use in the TRANSIMS Microsimulator.

9.2. The RTSTEP Evacuation Survey

Large-scale evacuations from major cities during no-notice events – such as chemical or radiological attacks, hazardous material spills, or earthquakes – have an obvious impact on large regions rather than on just the directly affected area. The scope of the impact includes the accommodation of emergency evacuation traffic throughout a very large area and the planning of resources to respond appropriately to the needs of the affected population. Compared to events with advance notice, such as evacuations based on hurricanes approaching an affected area, the response to no-notice events relies exclusively on pre-planning and general regional emergency preparedness. In this paper we present the design, methodology and results of a survey which was conducted in order to obtain empirical data on individuals' responses to no-notice evacuation which can be used to calibrate an evacuee behavior model for planning purposes. The results of the survey show that people are more likely to evacuate if they see others evacuating and whether the evacuation ordered or recommended making little difference. When the event risk is moderate evacuees are more likely to go evacuate to a shelter then when the risk is high, in this case people are more likely to evacuate to friends or family house and hotels. The area covered in the sample mostly includes the Chicago Metropolitan Area. However, we argue that the regional differences in the response to a no-notice evacuation are likely to be negligible, in contrast to advanced-notice evacuations where conditioning may occur. Thus, the results of the survey could be applicable nation-wide.

9.2.1. Introduction and Literature Review

9.2.1.1. Project Background

Much attention has recently focused on efforts to model responses to advance-notice emergency evacuation events, such as those precipitated by hurricanes, tsunamis and other natural disasters. However, comparatively little work has been done on analyzing responses to no-notice emergency evacuations from events such as terrorist attacks, industrial accidents, earthquakes and others were advanced warning is not possible. To address this a new no-notice emergency evacuation transportation model is being developed at Argonne National Laboratory. The aim of the model is to predict a response of the transportation network to the demand induced by certain types of evacuation warnings issued by the government. The model was built upon a "normal day" forecast model developed by Chicago Metropolitan Agency for Planning and Argonne. The model consists of several components. The network component allows a modeler to specify the evacuation routes and calculates sub-optimal control strategies for the intersections. The demand component calculates the reaction time of an evacuee to a government warning, the tips taken by an evacuee and a mode of transportation used. The dispersion component of the model allows predicting the area affected by an event based on the material dispersed and the meteorological conditions. In this paper we discuss an online based survey on the intended reaction to an evacuation warning. The results of the survey are to be used to calibrate the evacuee's behavioral model.

The evacuee behavioral response model is to conceived as a multi-level nested-logit model which determines how the individuals will react to the evacuation recommendations under various conditions. The nested logit model will be combined with a hazard-based model to determine how long it will take the individuals to react to the evacuation order, and an egress model based on land-use and building characteristics to determine how long it takes the individuals to leave their location once they have decided to act. The core of the model is the nested logit behavioral discrete choice model which determines the household reaction type based on household, zone and emergency/evacuation characteristics, show in Figure 1. The household decision consists of a top level choice between ignoring the order, sheltering in place or evacuating. Beneath this level there is a secondary decision level if evacuation is chosen to either evacuate directly, or make 1 or 2 stops first, and these decisions are in turn followed by a lower level decision of whether to evacuate to a shelter, another zone (i.e. friends/family/hotel, etc.) or to an external location. The final layer of the decision model is the actual choice of specific shelter, zone or external location. In order to estimate this model, however, extensive data on individual reactions to evacuation scenarios are needed, which do not currently exist. Therefore a new survey is needed to assess how individuals are likely to react to no-notice evacuations.

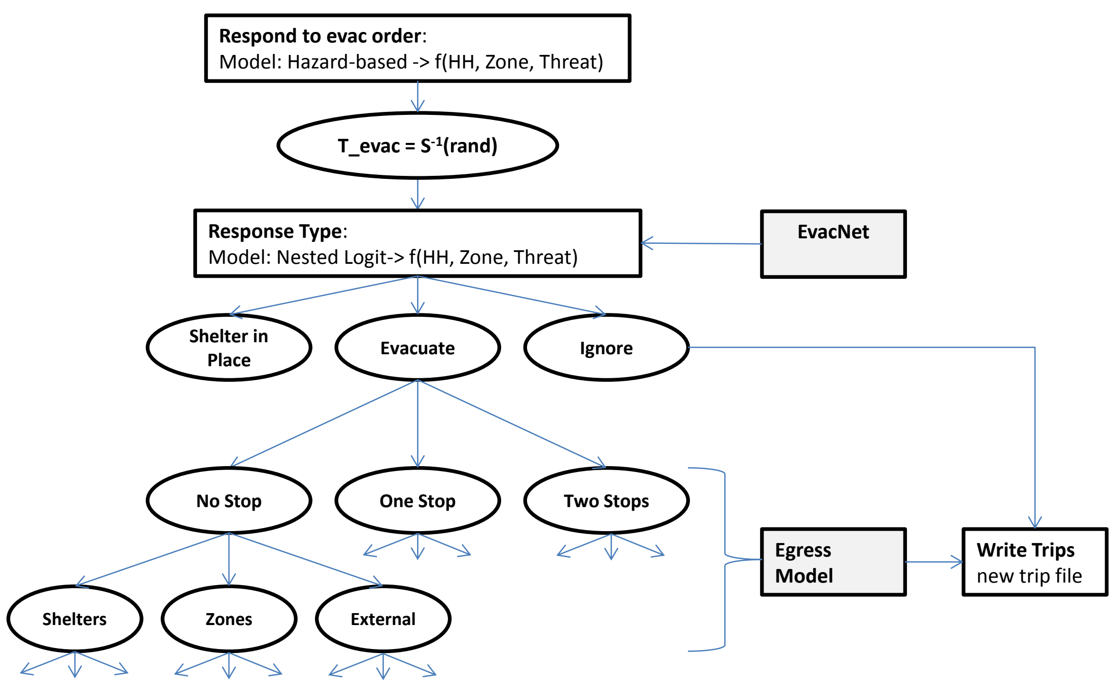


Figure 9.4: Evacuation Response Model

9.2.2. Previous Work in Evacuation Response Surveying

Most of the previous research on intended evacuation response behavior considered natural disaster scenarios. A good overview on the hurricane evacuation behavior is available at (Baker, 1991). The paper provides an overview of twelve sample surveys conducted between 1961 and 1989 in different states, from Texas to Massachusetts. There is work done in the area of no-notice events, such as terrorism attacks (Meit, et al., 2011), accidents (Zeigler and Johnson, 2005) and chemical accidents (Vogt, 1999). Data for evacuation research has been collected using a variety of modes (online, mail, and telephone surveys), and with a variety of differing methods (hypothetical report, single event, or a combination). Additionally, a portion of this research has specifically examined responses related to government warning or direction (Pfister, 2002; Dash and Morrow, 2000; Kang et al, 2007).

This survey builds on the previous research and focuses specifically on responses to government recommendations to no-notice evacuation scenarios. While other research related to evacuation response is prompted by a particular event (or threat of event) such as a hurricane, or nuclear disaster, this survey is intended to collect information about respondent's evacuation patterns in general. Furthermore, the survey randomizes threat levels related to the general threat; some respondents are asked to report their evacuation behavior to localized, low-risk scenarios all the way up to region-level high severity scenarios. Finally, a Likert-type scale is used to collect data on respondents' evacuation responses. The use of a scales, rather than dichotomous choices variables, will allow both insight into the validity of the data (through the examination of response patterns), as well as additional data analysis options when data have been collected.

9.2.3. Stated Response Survey Methodology

The Chicago-Area no-notice emergency evacuation response survey has been developed as a stated (intended)-response survey and will be conducted on a random sample of individuals in the Chicago area

9.2.3.1. Sample and list

To obtain a target sample of 500 individuals, a list of 20,000 Chicago area emails was purchased from a third-party vendor. Although this method is not ideal, it provides better coverage than other non-random sampling methods such as snowball or convenience sampling.

9.2.3.2. Online Surveys

The survey was conducted online through a survey implemented using KeySurvey software. While online surveys are gaining in popularity, there are methodological concerns with this approach. Because there is a disparity in the access and use of computer and internet technology, online surveys increase coverage error. However, the specificity required in this survey necessitates something like the Google Maps technology – which is only available online. Utilizing another survey methodology, such as print maps in a mail survey, would reduce the coverage bias introduced by the online component, but may increase measurement error – a critical aspect of this study.

Additionally, considerable steps were taken to ensure survey best practices were followed. Sent with the link to the survey is an email invitation developed from previous research on online survey methodology (Dillman et al, 2008). Because the survey contains many web-pages, the progress bar is not included (Yan et. al, 2011). The highly respected sponsoring organizations are featured on the landing page of the survey (Lehmann et al, 1998).

9.2.3.3. Intended Response Survey

The study used a hypothetical methodology to collect data about evacuation behavior. While this approach may be problematic in that it relies on the respondent to report their intended behavior given an emergency situation, it is a frequently used method in transportation studies (Carnegie and Deka, 2010), and there is research that suggests a correlation between intent and behavior in transportation (Sheskin, 1991; Kang et al., 2007). Social psychology research, such as the theory of planned behavior (Ajzen and Fishbein, 1980) also indicates a relationship between behavior intent and actual behavior, indicating that while responses to a hypothetical emergent situation may not always perfectly reflect actual behavior in such situations, there is a strong relationship between intended and actual behavior, making the use of intended response surveys a valid alternative.

9.2.4. Survey Design and Implementation

The survey is designed to collect information on a typical weekday for a household and then to develop two no-notice emergency evacuation events which would impact the household on the given day. The respondents then determine how they would respond to the event in terms of evacuation likelihood, response time, additional trips they would make (i.e. picking up children, meeting with others, etc.) and final destination.

The survey has been implemented as an internet based, self-guided survey, using third-party survey software, Google Maps API and significant Javascript customization. The survey is conducted in three parts starting with the collection of basic demographics and average day location and vehicle use information. Following this, the respondents are presented with two randomly generated emergency evacuation scenarios. These scenarios are generated based on a combination of randomly selected factors including:

- Time of the event
- Location of the event (who does the event occur near)
- Severity of the event (at household member's location)
- Event radius
- Government recommendation for individuals in the area

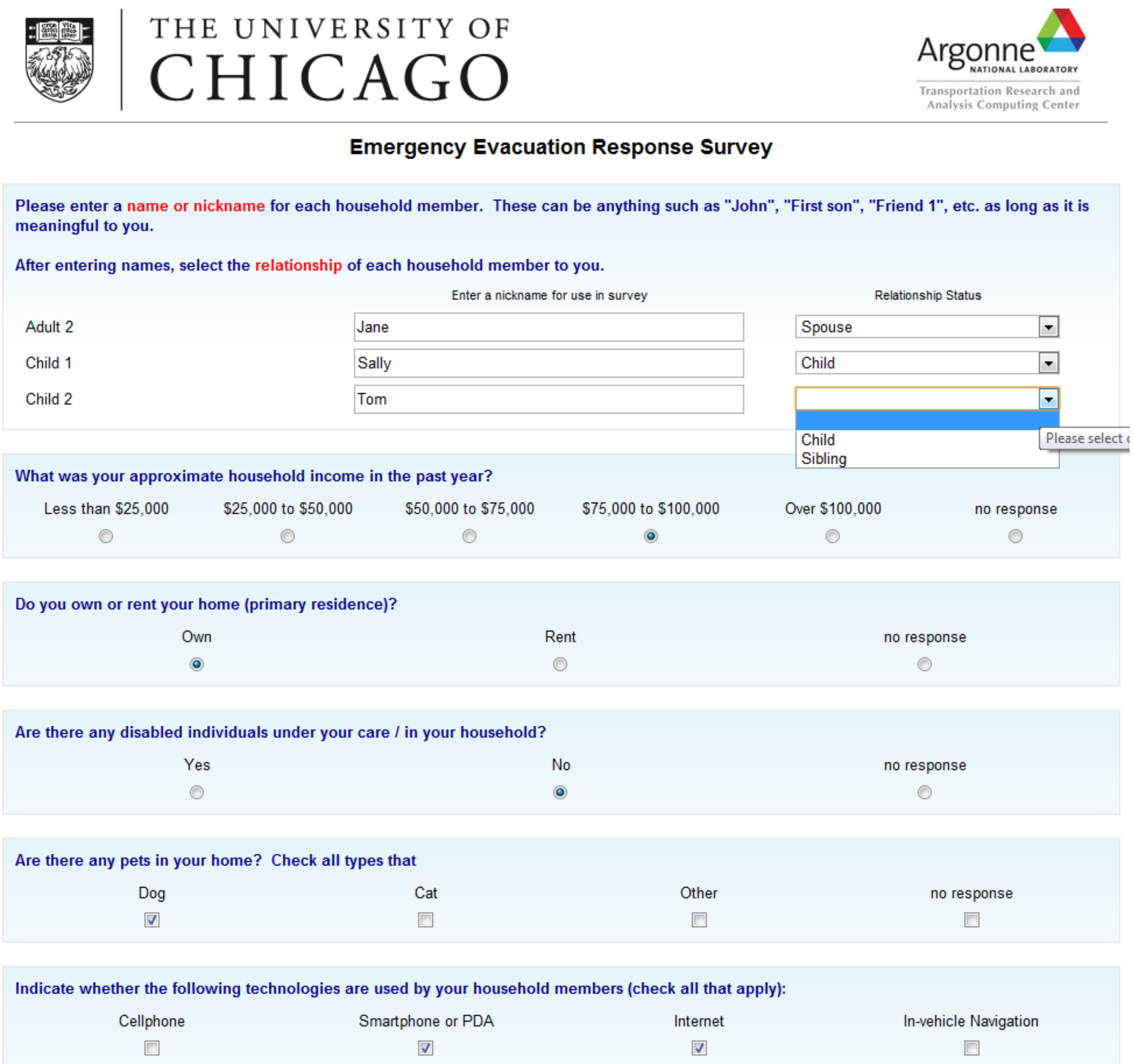
These factors are varied for each respondent and for each scenario. The respondents then answer a series of questions related to how they would react in the given scenario. The survey instrument is described in detail below.

9.2.4.1. Household Demographics and Average Day Information Forms

The survey starts with a short introductory message to the respondent stating the purpose of the survey and stressing that the answers are confidential, and that no personally identifiable information is collected. After viewing the introductory message, the respondents press a "Begin" button giving affirmative consent to participate in the survey. Pressing the button begins the survey process.

The individual then answers two questions about the household composition by providing the number of adults and children under 18 years old in the household. These responses are used to generate the questions in the following pages and implement show/hide logic on certain questions and answer responses. For example, if no children are present in the household, later questions about school attendance will not be asked

Following the household size input, the individuals fill in two further household demographics forms. In the first page, shown in the figure, the respondents provide relationship status and a convenient alias for each household member specified on the first page. The aliases are used throughout the rest of the survey when questions or answer choices refer to specific household individuals. In addition, questions regarding household income ranges, home ownership, presence of disable individuals, presence of pets and information and communication technology usage are shown in this page. On the following page the household members' education level, employment status, school attendance, age and gender are collected. An example of the first form is shown in Figure 2.



THE UNIVERSITY OF CHICAGO

Argonne NATIONAL LABORATORY
Transportation Research and Analysis Computing Center

Emergency Evacuation Response Survey

Please enter a name or nickname for each household member. These can be anything such as "John", "First son", "Friend 1", etc. as long as it is meaningful to you.

After entering names, select the relationship of each household member to you.

	Enter a nickname for use in survey	Relationship Status
Adult 2	Jane	Spouse
Child 1	Sally	Child
Child 2	Tom	

Child
Sibling
Please select

What was your approximate household income in the past year?

Less than $25,000 | $25,000 to $50,000 | $50,000 to $75,000 | $75,000 to $100,000 | Over $100,000 | no response

Do you own or rent your home (primary residence)?

Own | Rent | no response

Are there any disabled individuals under your care / in your household?

Yes | No | no response

Are there any pets in your home? Check all types that

Dog | Cat | Other | no response

Indicate whether the following technologies are used by your household members (check all that apply):

Cellphone | Smartphone or PDA | Internet | In-vehicle Navigation

Figure 9.5: Household Demographics Form (Page 1)

Following the household demographic information input, the respondents answer a series of questions about where the household members were located during three time periods (9AM, 2PM and 7PM) on the previous days. These locations are used in the development of the evacuation scenarios, to determine where all of the individuals are in relation to each other as the emergency event is occurring. The respondents are instructed to enter the locations at the approximate times (i.e. if they were traveling at 9AM the destination location is used) for each period through the Google Maps interface shown in Figure 3 below. In this form, the respondent selects each time period, and a map is shown of the current household individual locations. The respondent can then either enter an address in the input boxes above the map and press the associated search buttons, or simply drag the marker to the appropriate location. The respondents are instructed to place the location pins as accurately as possible. Once all of the location markers have been set, the respondent can proceed to the next form which asks for the availability of motorized vehicles for household members at each time.

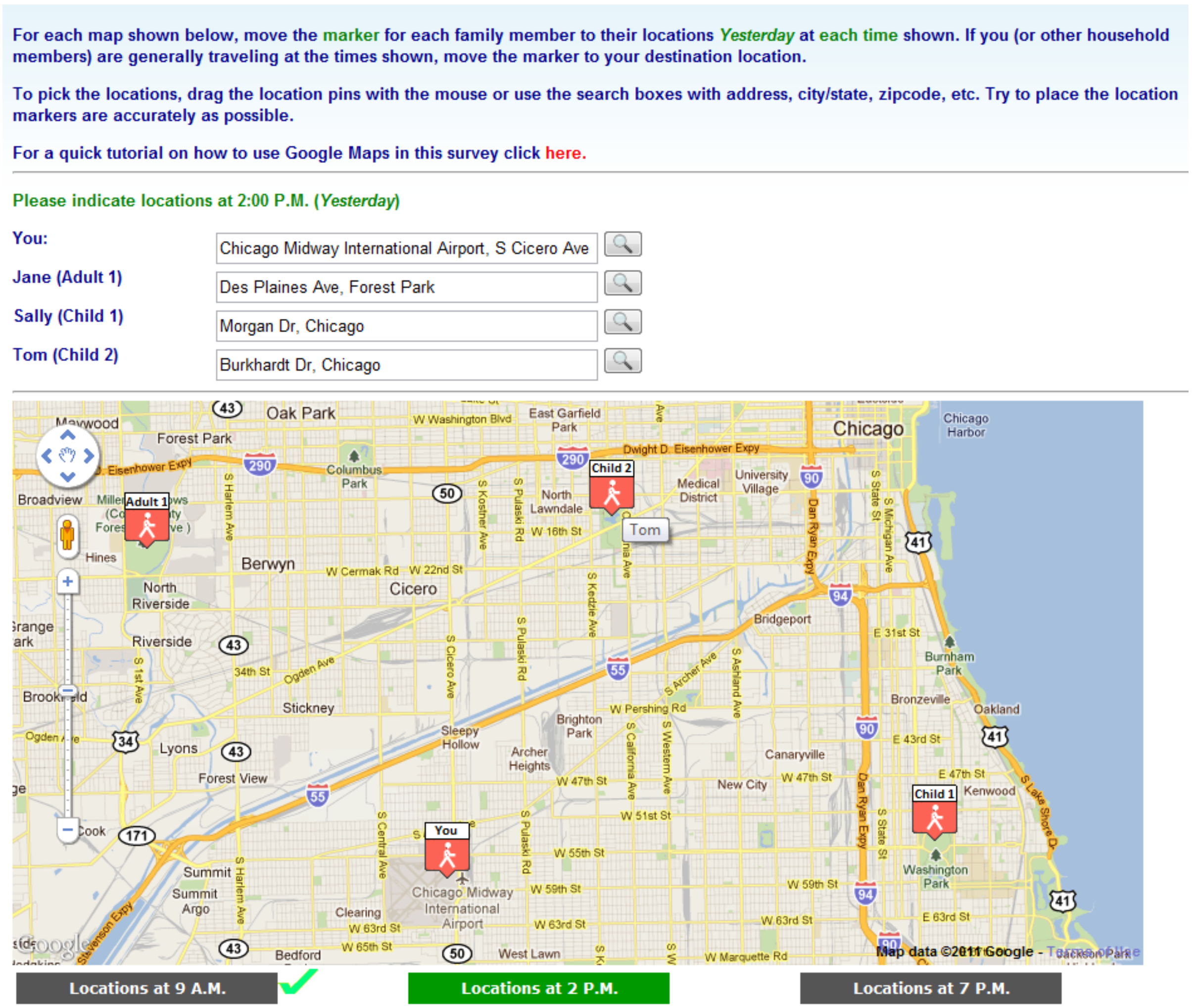


Figure 9.6: Household Member Location Inputs

9.2.4.2. Emergency Scenario and Response Forms

After the basic demographic information and the average day information for the household has been entered, the emergency scenarios are generated and displayed to the respondents. The data entered in the introductory forms are combined with the randomly assigned emergency characteristics described above to generate an evacuation scenario. An example of the scenario form is shown in Figure 4 below.

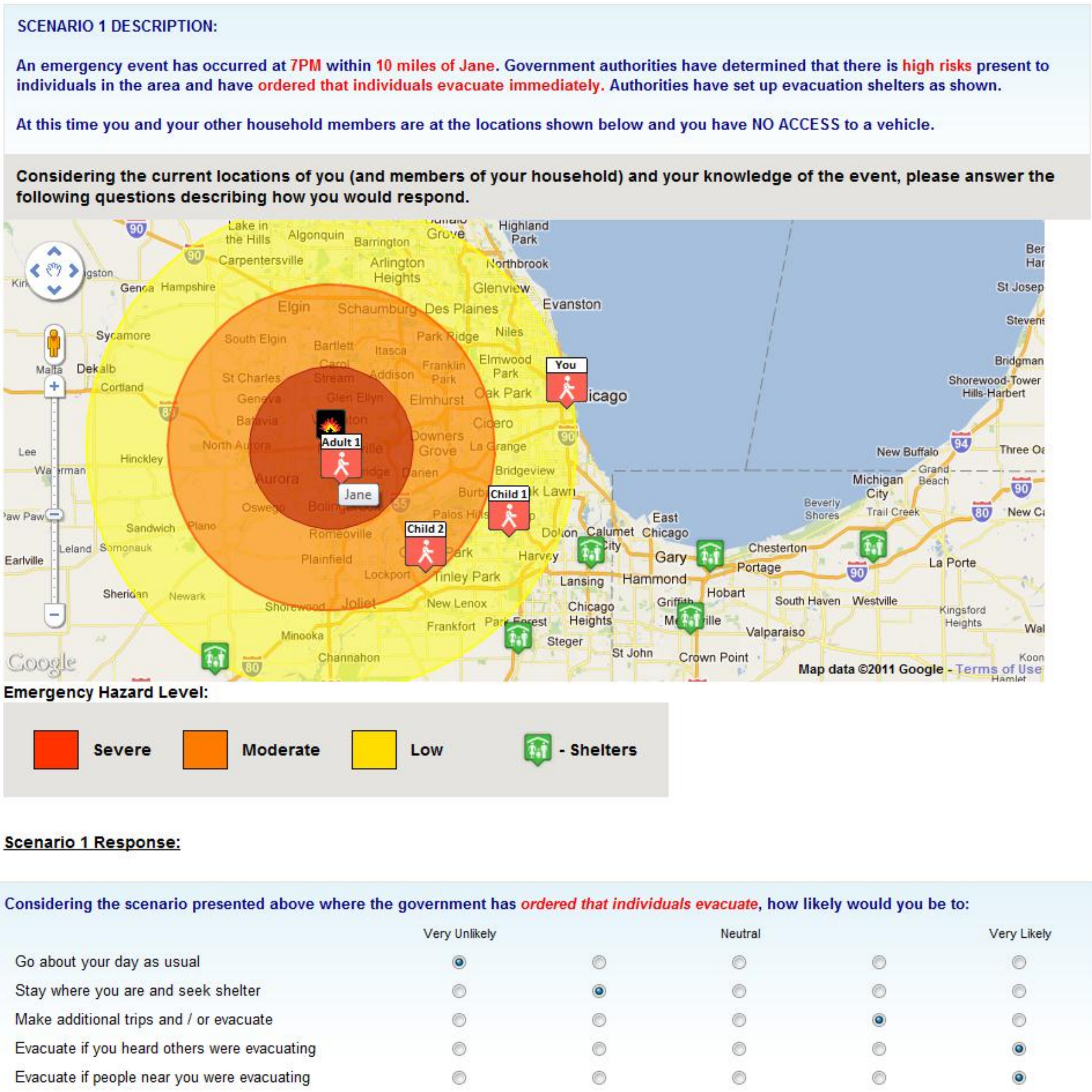


FIGURE 4. Emergency Evacuation Scenario Example

The randomly assigned scenario characteristics are shown highlighted in red in the paragraph describing the scenario for the respondent. The randomly assigned scenario location (i.e. 10 miles from Jane in this example) and risk level (high) is combined with the entered location for the household member at the randomly assigned time (7pm) to locate the epicenter of the emergency which is then placed the specified distance away from the person along a randomly generated heading. The respondent is also told whether a vehicle is available to them based on the vehicle availability responses. The emergency event, the locations of the other household members, and a set of available emergency shelters from a predefined list are then shown to the respondent to completely define the scenario. The individuals then determine how they would react to the given scenario by estimating the likelihood of taking various actions as shown in the figure. Regardless of the likelihood of evacuation estimated in this response question, the respondents are instructed to answer the remainder of the survey as if they would either evacuate or make additional trips in regards to the presented scenario. Following the scenario definition and response likelihood form, the respondent then enters an estimate of how long they would wait before traveling, and the mode they would use during travel. Then, another form, shown in Figure 5, collects the stops the individual makes before reaching the final destination.

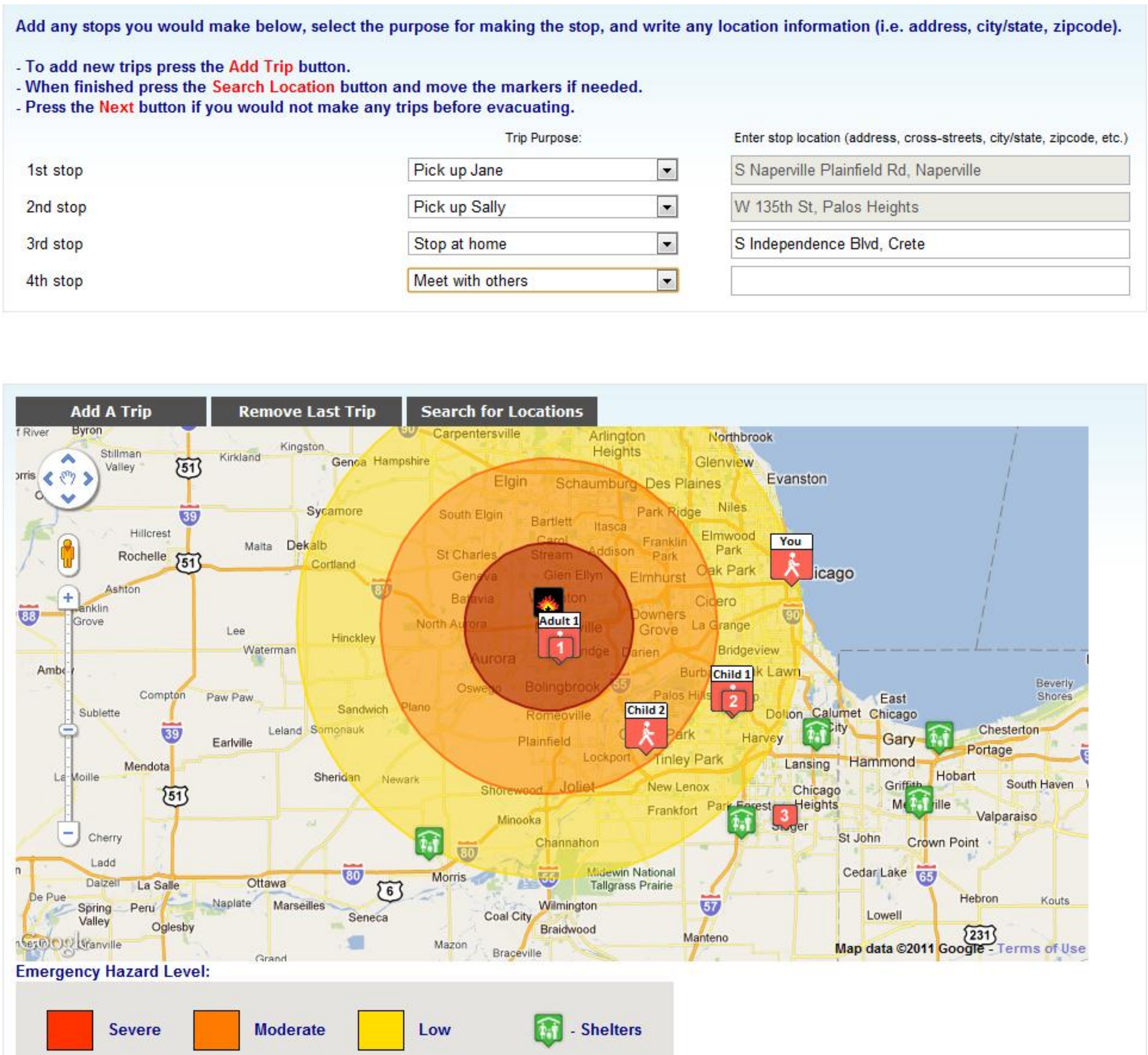


Figure 9.7: Stops Made Prior to Reaching Final Destination

This form allows the respondents to add trips which they would make prior to reaching the final evacuation destination (or before returning home). The trip purpose options include picking up other household members, meeting others, returning home, or an "other trip" category. The stops are added to the evacuation plan in the order they would be conducted. The respondent first adds a stop to the itinerary then specifies the purpose of the stop. Finally, location information for the stop is entered, unless the stop purpose is picking up household member as their locations are already known and shown on the map, along with the emergency event, to inform decision-making. After the stops are added, the "search for locations" button is used, which geocodes the location information and adds markers for each stop. The respondent then has the option to drag the markers to more accurate locations.

Finally, after any prior stops have been entered, the survey respondents are asked to input the final destination for the evacuation trip or the home location if the individual would return home. The final destination type is first entered through a drop-down list, where the types include evacuation shelters, staying with friends or family, going to a hotel or motel, or returning home. After the type is specified, the location information is entered and a marker placed as before. Additionally the respondents have the option of simply clicking on one of the evacuation shelters provided. After the type and location are entered the scenario response is finished.

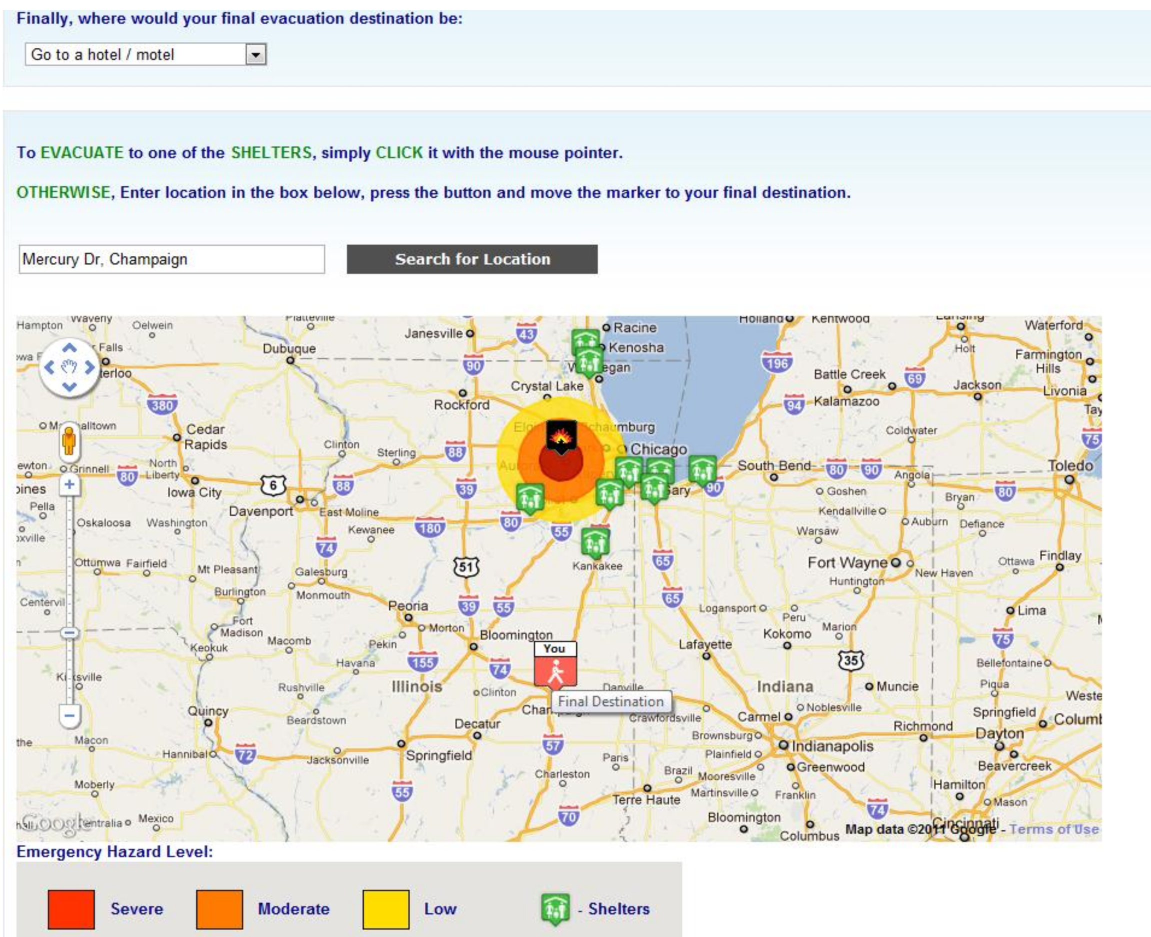


Figure 9.8: Final Destination for Emergency Evacuation

The responses for two evacuation scenarios as described above are collected for each respondent, to complete the survey. The data from the respondents is stored on a secured server operated by the survey website vendor. After the survey was designed and implemented, extensive pre-pilot testing was performed to improve the survey design. Several rounds of testing led to the final survey design described above. After testing was completed, the survey was conducted, the results of which are described in the following section.

9.2.5. Results from Survey

Data from a sample of 302 respondents covering 526 emergency evacuation scenarios have been collected in the survey. The respondents in the current sample were drawn from the random email sample described above. From the sample of 302 respondents who had completed at least one response scenario, 205 respondents providing data regarding 347 emergency response scenarios were deemed reliable for further analysis. The criteria used to determine data reliability included the percentage of item non-response and the consistency of response type answers to the question shown in Figure 4, i.e. individuals who listed a high probability of both ignoring the evacuation and also evacuating, or similar were removed from the sample. Some basic respondent characteristics of the final sample are shown in Table 1.

Table 9.12: Survey Sample Characteristics

Household-level			Person-level		
HH Size	**Survey**	**Census**	**Age**	**Survey**	**Census**
1	20%	26%	<15	17%	21%
2	33%	33%	16-25	9%	14%
3	20%	16%	26-35	16%	14%
4+	27%	25%	36-45	13%	14%
			46-55	18%	15%
Income	**Survey**	**Census**	56-65	20%	11%
<25	9%	29%	66+	7%	11%
25-50	17%	29%			
50-75	15%	19%	**Gender**	**Survey**	**Census**
75-100	20%	10%	Female	49%	51%
>100	27%	12%	Male	51%	49%
blank	17%	–	blank	1%	–
Tenure	**Survey**	**Census**	**Employment**	**Survey**	**Census**
Own	72%	66%	Employed	64%	59%

Rent	25%	34%	Unemployed	7%	8%
blank	3%	–	Not in labor force	29%	32%

Children	**Survey**	**Census**
Yes	32%	36%
No	68%	64%

Total Sample Size		
HH	205	

Education	**Survey**	**Census**
HS or less	14%	39%
Some College	25%	21%
Associate / Bachelor	29%	28%
Graduate / Prof.	32%	13%
blank	1%	–

Total Sample Size		
Adult	427	
Child	106	

The basic characteristics of the survey sample collected during the study shown in Table 2 were compared to Census 2010 distributions for the population in the Chicago MSA. While it was expected that the study would not be a highly representative sample due to the sampling procedure used and small sample size, the characteristics of the sample are still compared to the Census characteristics to put the resulting survey data in context. The distributions shown in the table for both the household and person level characteristics matched fairly closely to what was expected to be found. The sample is somewhat wealthier and more highly educated than the actual population, with individuals with graduate degrees especially highly overrepresented. Other aspects of the sample match more closely to the census distributions, such as the household size, age distribution, employment and presence of children. Overall, it is important to consider these characteristics as the evacuation responses of the sample are considered.

The characteristics of the randomly generated scenarios are shown in Table 2. The risks and occurrence time of the event are approximately evenly distributed, with the high risk event slightly oversampled. Also, the notice that evacuation scenarios are represented at a 2:1 ratio to the shelter-in-place recommendation scenarios, as the evacuation recommendations are the primary scenario of interest. The event location is approximately uniformly distributed with respect to event radius, but the scenarios tend to occur mostly near the respondent with 59% of emergencies occurring near the responding individual due to 21% of households consisting of single individuals.

Table 9.13: Distribution of Scenario Characteristics

Government Response:	
Order evacuation	23%
Recommend evacuation	22%
Suggest evacuation	18%
Order shelter-in-place	14%
Recommend shelter-in-place	13%
Suggest shelter-in-place	11%
Total	347

Time of event	
2PM	33%
7PM	34%
9AM	33%

Risk of event	
high	41%
low	29%
moderate	29%

Event Location:	5 mi	10 mi	20 mi	Total
Respondent	16%	20%	22%	59%
1st Child	2%	2%	2%	7%
2nd Child	2%	2%	1%	5%
Adult1	9%	11%	4%	24%
Adult2	0%	2%	4%	7%
Total	28%	38%	33%	100%

The responses of the sample respondents to the above described emergency scenarios are next analyzed in terms of compliance to the government order/recommendation/suggestion, the number and type of additional stops made while completing an evacuation, and the distance and location type of the final evacuation destinations.

The compliance rates for individuals under the various scenarios are first analyzed. The order from public officials appears to be the best predictor of evacuation rates. Typically residents would react differently depending on a warning level issued by the government and on how others react (neighbors, co-workers, and family members). Figure 7 below illustrates that respondents believing they were told to evacuate are very likely to do so regardless of what the others do. In the case when residents learn that government ordered the evacuation an average evacuation likelihood of 4.3 out of a 5 point scale was given by individuals. This likelihood is increased substantially if the government recommendation is combined with the observation of others evacuating, increasing to 4.5. Similar distributions are observed for the suggested and recommended evacuations. The distinction in response to ordered and recommended evacuation warnings are not that large. In (Baker, 1991) the author reports similar findings based on the hurricane evacuation after-fact survey data.

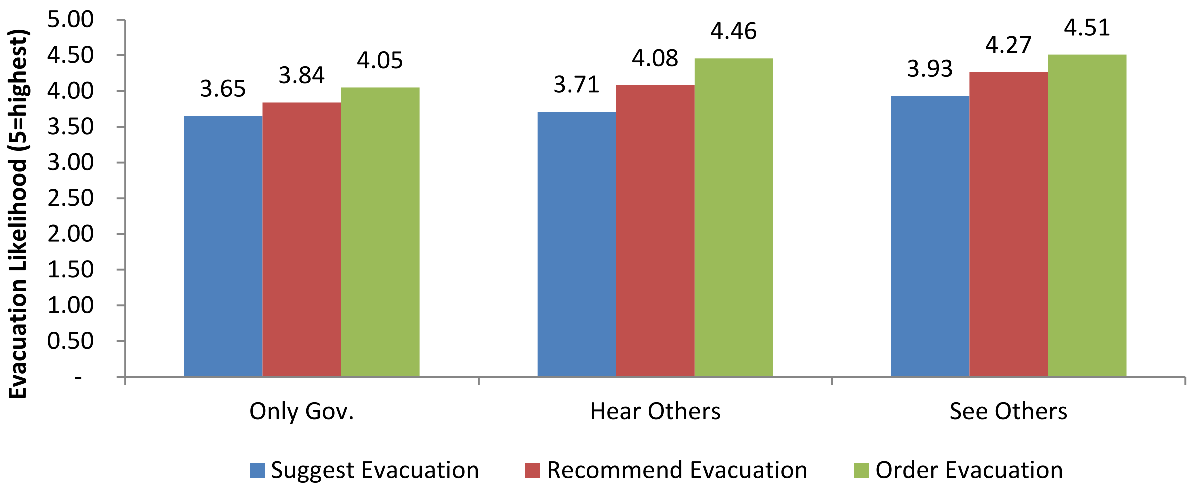
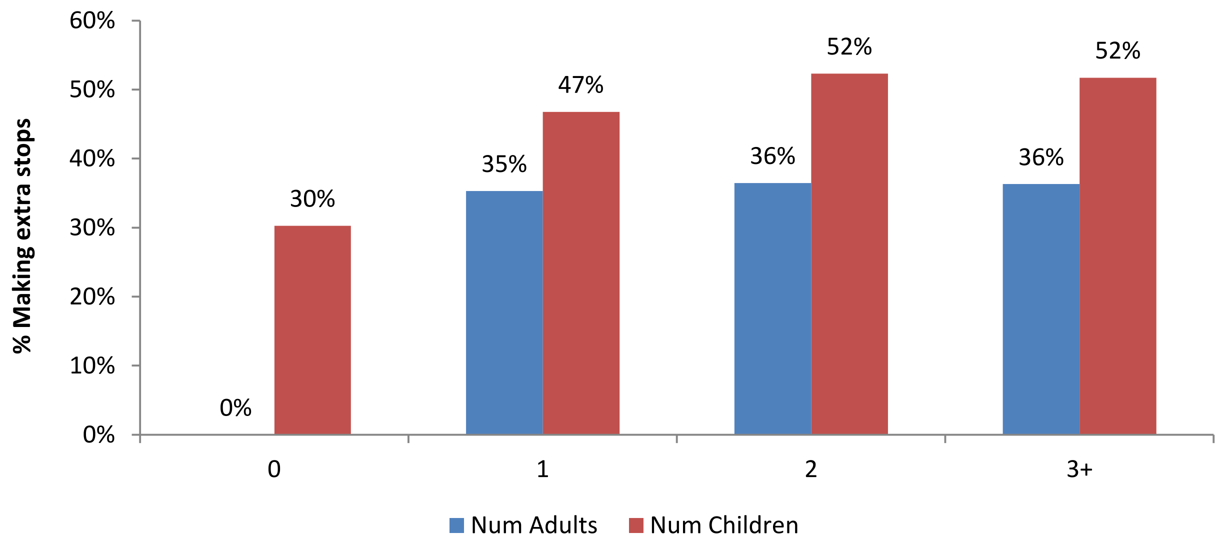
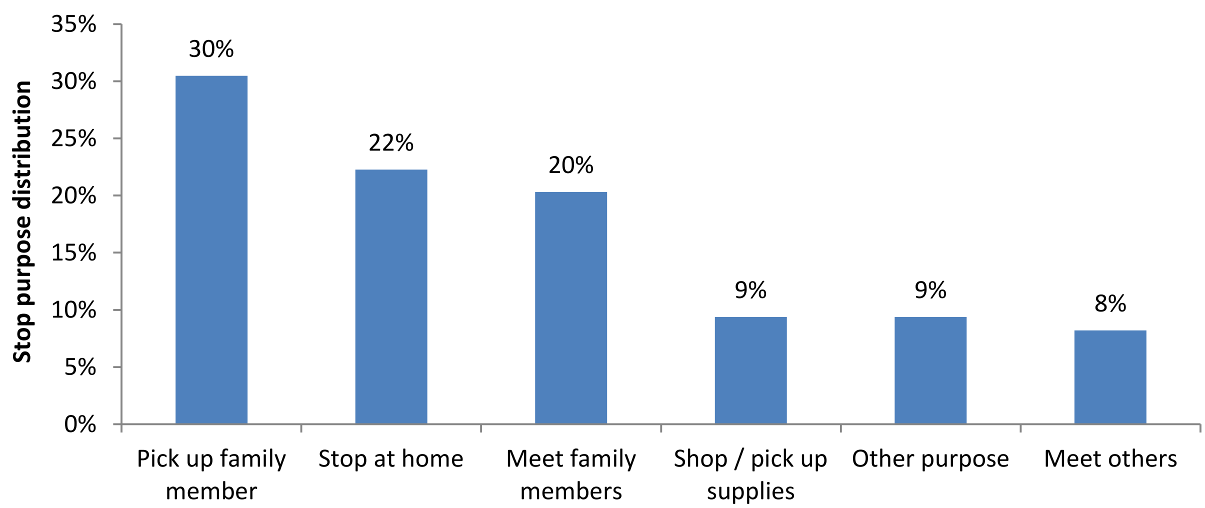


Figure 9.9: Likelihood of Evacuation by Government Recommendation

The next analysis concerns the stops that individuals intend on making before reaching the final evacuation destination. Figure 8 below illustrates an intuitively obvious result. Adults with one or more children in the household are much more likely to make a prior stop compare to those who have no children. On the other hand, the correlation between number of adults in the household and probability of making extra stops is minimal. This is likely due to the fact that other household adults are capable of evacuating independently, and there is even a division of labor effect, where the percentage of individuals making extra stops goes down as the number of adults increases as the respondent is less likely to have to make stops to pick up children or secure property, etc. as other adults in the household can complete those tasks. The distribution of prior stop types shows that most of the additional stops prior to evacuating occur with individuals picking up other family members, which occurs in over 30% of cases. Many additional stops also involve stopping at home, or meeting family members at another location. A small percentage of stops involved shopping or picking up supplies, at 9% of cases. Encouragingly, only 9% of stops are for an “other” purpose, indicating that the options provided sufficiently cover the needed trip purposes.



(a)

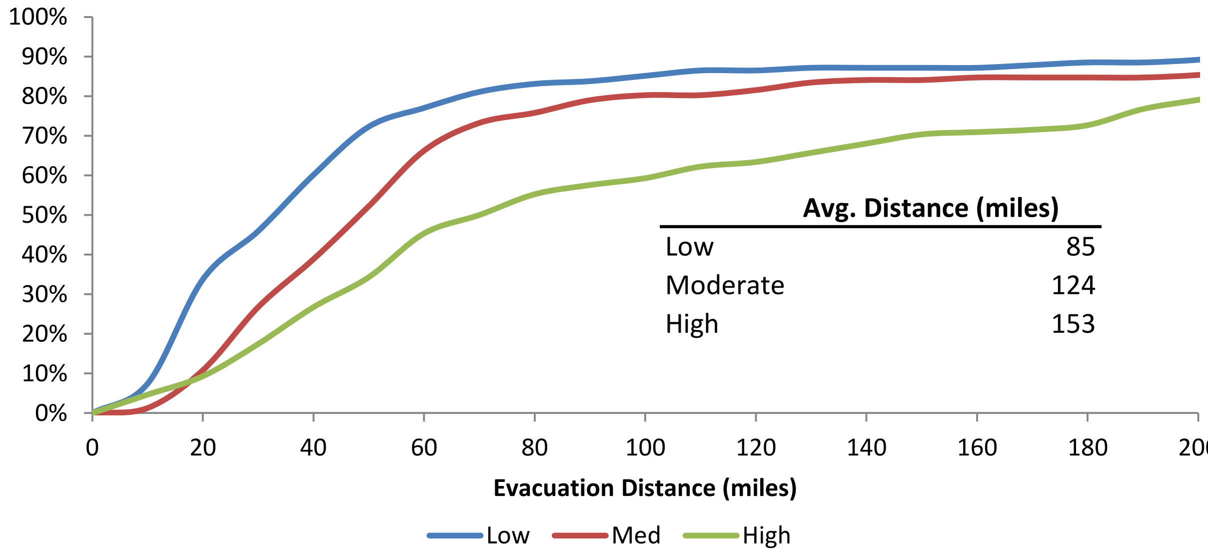


(b)

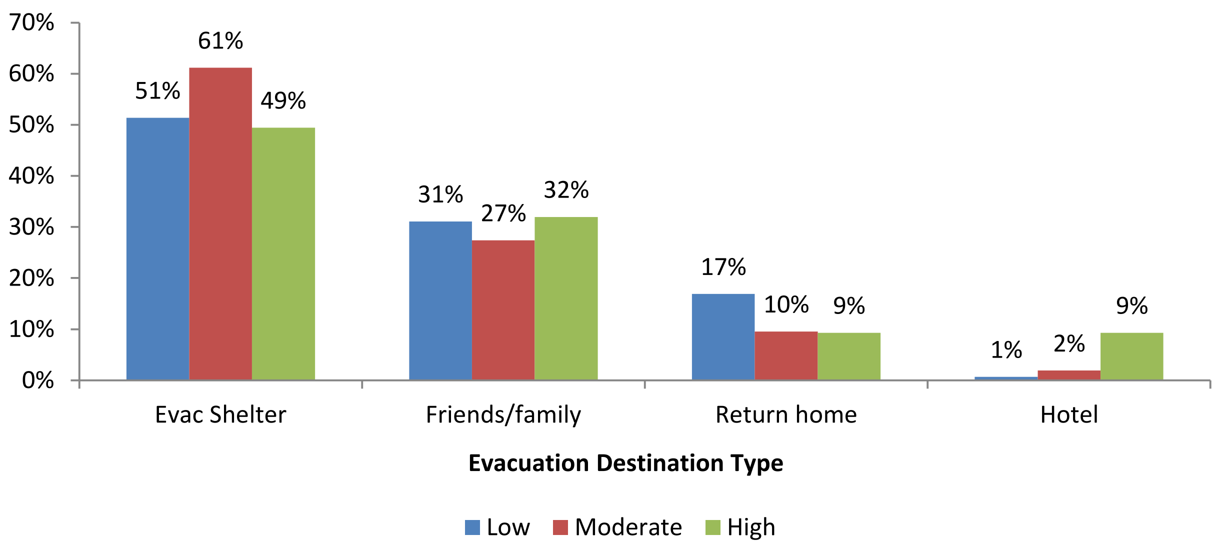
Figure 9.10: Prior Stop Characteristics (a) Count by HH Size (b) Stop Purpose Distribution

Finally, the characteristics of the final evacuation destination are analyzed as shown in Figure 9. Part (a) of the figure shows the cumulative distribution of distance people intend to travel depending on the risk level identified by the government. Even though the level of risk is very subjective and a hypothetical measure, people tend to react differently. It appears that when the threat level was identified "high" in the evacuation notice residents tend to travel further from the epicenter. In reality, a no-notice event usually does not affect a very large geographical area. For example, a radius of the zone affected by a

Radiological Dispersion Device is typically less than 10 miles. From this we can conclude, that the wording of the notice is an important factor. Interestingly, even for low impact scenarios, individuals have an average evacuation distance of 85 miles which would be well outside a typical metropolitan region.



(a)



(b)

Figure 9.11: Final Destination Characteristics: (a) Distance from event (b) Location Type

Part (b) of the figure illustrates that residents are more likely to evacuate to a shelter provided that the event severity is moderate. In case of a high severity effect the likelihood of evacuees going to a friend's/family house or a hotel is heightened. It probably could be explained by the fact that residents associate an event of moderate level with a short term evacuation and feel appropriate to stay in a shelter that period. On the other hand, a long-term evacuation associate with an event of high level make respondents uncomfortable staying in a shelter and they would prefer to stay in a more comfortable environment, like someone else's house. Also, the shelters specified in the survey tend to vary between a distance of 1-3 times the event radius outside of the emergency zone. With an average evacuation distance of 122 miles for high severity events, this may have put the shelters in an area many evacuees felt was too close to the emergency event.

9.2.6. Conclusions

It was observed that there exists a lack of research in the area of the responses to a no-notice event, like radiological dispersal device explosion, hazardous material spills, etc. Many studies have focused on post hurricane evacuations and they provide enough statistical data to get some understanding of the residents' behavior. However, the amount of data that has been collected for other hazards is much smaller. To address this, a new stated response survey has been developed and implemented. The survey collects responses to hypothetical generic emergencies which vary in terms of size, hazard level, time of day, etc. The survey collects information on individuals intended responses to these hypothetical scenarios.

The stated response survey provides insight into which factors do affect evacuation rates and which do not. The results of the survey show that the best predictors of the evacuation rate are:

- Threat level identified by the government notice
- Whether evolution is Ordered/Recommended or suggested
- Engagement of the neighborhood members, co-workers, and family members in the behavior.

It is clear that the data obtained in such a survey is not necessarily indicative of how individuals would actually behave under emergency scenarios, where existential threats and extreme pressures on individual decision making may exist. However, data of this type provides a valuable start to understanding no-notice evacuation behavior. Further research is to understand the difference in intended and actual responses to an evacuation order to a no notice event, although previous work makes clear that correlations between intended and actual behavior in different contexts are strong.

The study was used to quantify such a difference and to build a general model of evacuation behavior which can be sensitive to all of the predictors of an actual evacuation response. The use of the data in model development is detailed in the RTSTEP EvacDemand Technical Report.

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10. Dispersion Research and Integration with TRANSIMS

Emergency preparedness has become increasingly important in the recent decade due to the threat of terrorism. The ability to accurately predict the outcomes of hypothetical attack situations can be a crucial tool for ensuring the safety of huge populations. There has been much prediction and speculation about the effects of a radiological, chemical, or biological attack on large areas and, more important, on cities. For example, high fidelity traffic simulation model may be developed in response to hypothetical terrorism of radiological dispersal (RDD) event. In this regard, it is necessary to develop a detailed model of plume dispersion as well as traffic model. Upon integration of dispersion model with TRANSIMS, it may be possible to radiological exposures to individual level.

The vast scale of areas and models of interest has made the feat of predicting outcomes with accuracy nearly impossible. Recently, modern computational fluid dynamics (CFD) has emerged as a means of making these predictions. CFD software packages provide an interface that allows the selection, manipulation, and visualization of physics models and parameters for user-defined fluid volumes. CFD operates by generating surface and volume meshes of the fluid volume, then applying the parameters, models, and solvers desired. The software can output various data sets, depending on the desired direction of the study.

For purposes of this study, CFD was used to model the dispersion of a plume of radiological and/or harmful gas in areas near Chicago. Building footprint shape files were used to generate the areas' building geometries. Based on three-dimensional building models, air volumes were created. Multi-component and multi-phase flows are being modeled using K-epsilon turbulent, gravity, ideal gas, and both steady-state and transient models. Various wind directions and speeds will be used to simulate plume dispersion for different cases. While no results have been produced to date, multiple simulations for various theoretical situations are being run. The simulation data will be used specifically in conjunction with evacuation planning and traffic simulation in order to minimize evacuation time, as well as harmful exposure, and other dangers. The results of the study will provide useful data and visualization for emergency planning and preparedness. With the success of the study, other metropolitan areas will pursue similar CFD modeling to improve the emergency preparedness.

10.1. The Star-CCM+ CFD Modeling Tool

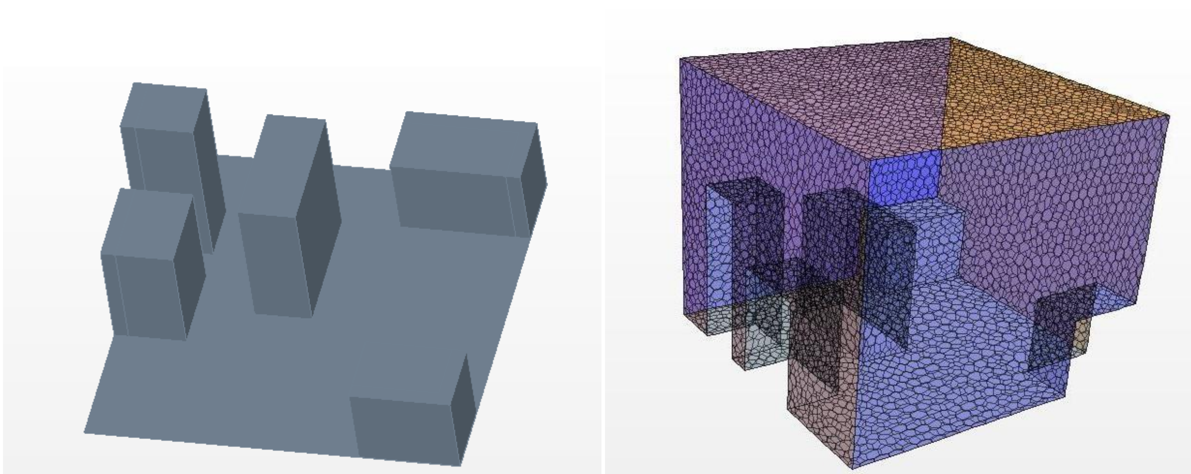
STAR-CCM+ is CD-adapco´s newest CFD software package for modeling of fluid flow problems. (The name STAR stands for "Simulation of Turbulent flow in Arbitrary Regions".) The STAR-CCM+ package can be applied to a wide range of problems such as

- Aerospace Engineering
- Turbo Machinery
- Chemical Process Engineering
- Automotive Engineering
- Building and Environment Engineering

STAR-CCM+ uses the well-established CFD solver technologies available in STAR-CD, and it employs new client-server architecture and object oriented user interface to provide a highly integrated and powerful CFD analysis environment to users. This environment includes advanced pre and post-processing tools, including CAD import geometry surface analysis, automated surface repair, tools for identification and hand repair of small numbers of surface defects, tunable surface wrapping to retain the amount of surface detail required for CFD analysis, advanced automated meshing that yields polyhedral, hexahedral, or tetrahedral volume meshes, pre-simulation post processing visualization setup that can be used to monitor the progress of a simulation during solution, and a variety of other tools to ease the work of CFD analysts, such as the ability to copy and paste model components between models. With its new graphical user interface including many automated tools for meshing, solution monitoring, and post processing visualization, and plotting of primary variables and derived quantities, STAR-CCM+ is a full featured CFD software package adequate for our problem case of urban dispersion analysis.

10.2. Small Scale Urban Dispersion Models

Developing a CFD model of urban air flow and dispersion is a computationally intensive task mainly due to the large scale of the simulation volume. To address such computational challenges, CFD model is first developed with small urban area model. This will help develop and verify various modeling methods and capabilities. Figure 1 show an urban area with building geometries and the fluid (air) volume mesh surrounding the buildings, which is used in the analysis. The volume of the fluid is 120m x 120m x 100m (height).



Urban building geometry **(b) Surrounding fluid volume mesh**

Figure 10.1. Geometry of a Small-scale Urban Area

The flume volume has six bounding faces. As shown in Figure 2, they are namely west (shown in red), east, south (blue), and north, top (yellow), and bottom boundaries. Boundary conditions are defined at the bounding faces of the continuum volume for the analysis.

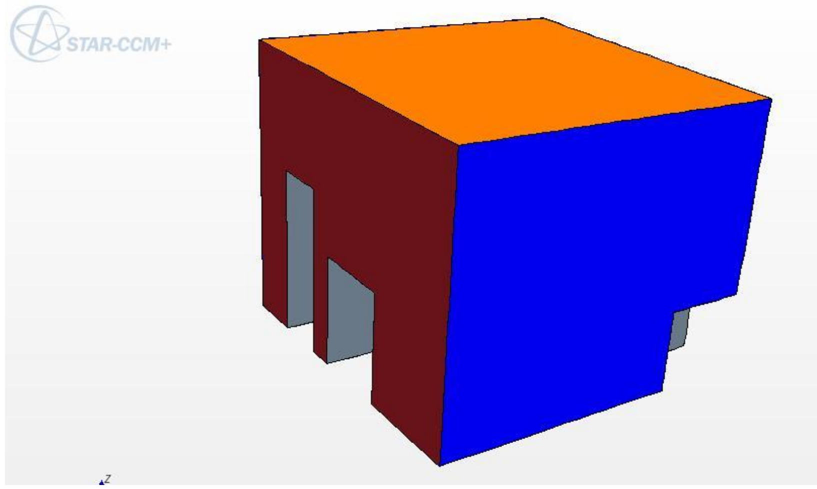


Figure 10.2. Bounding faces of the fluid continuum: west (red), south (blue), top (orange)

10.2.1. Steady-State Urban Air Flow Model

First the steady-state air flow model is developed, which will serve to provide the initial condition for the subsequent plume dispersion model.

The physical model of the fluid continuum is defined by the following physical parameters:

- Ideal Gas (Air)
- Segregated flow
- Constant density
- Turbulent (k-omega model)
- Steady state

The following initial conditions are used:

- Pressure: 1 atm
- Turbulent Intensity: 0.01
- Turbulent Velocity Scale: 1.0 m/sec
- Turbulent Viscosity Ratio: 10
- Ambient Velocity: [0, 0, 0] m/sec

Boundary conditions define the conditions at the bounding faces of the continuum volume under analysis. Figure 2 shows the bounding faces whereas the west face shown in red is the flow inlet boundary, whereas south boundary is shown in blue, and top boundary is shown in yellow.

- West boundary: Velocity inlet (5 m/s eastward)
- East/Top boundary: Pressure outlet (1 atm)
- North/South boundary: Symmetric or Pressure
- Bottom boundary: Wall

The simulation model is solved numerically. Figure 3 shows the simulation model obtained by the solution for the boundary conditions (East, Top = pressure outlet, North, South = symmetry outlet). Figure 3(a) shows the streamlines of the air flow, and Figure 3(b) shows the magnitude of the flow velocity at a horizontal plane at 10 m height from the ground. In both plots, flow velocity is color coded. Figure 4 shows the various residuals of the steady-state model at each iteration step. The solution converged to a solution with small overall error.

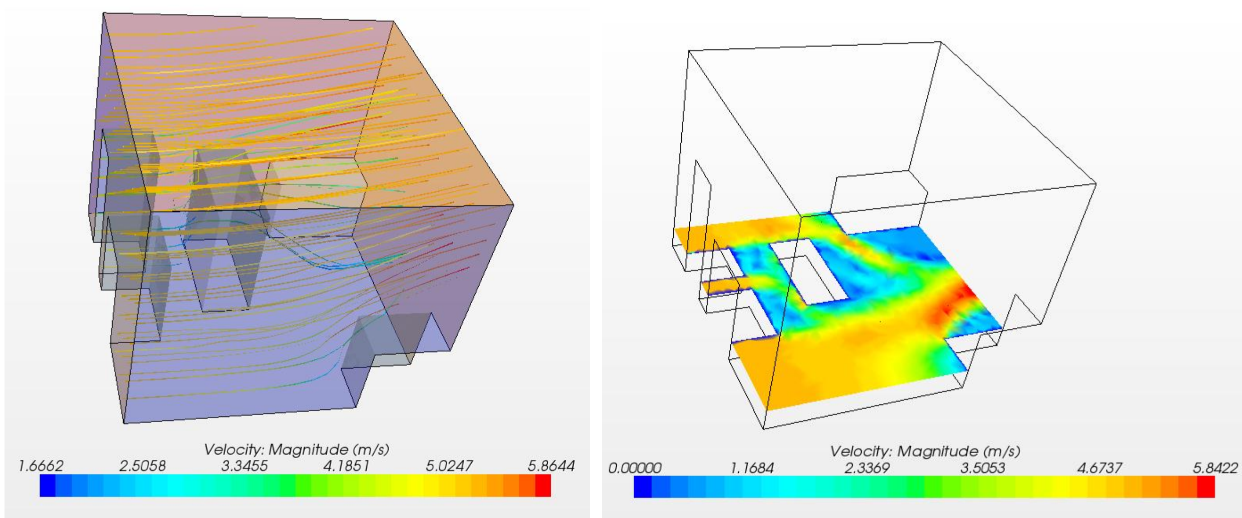


Figure 10.3. Urban Air Flow Predicted by the Model: Boundary Condition: (East, Top = pressure outlet, North, South = symmetry outlet)

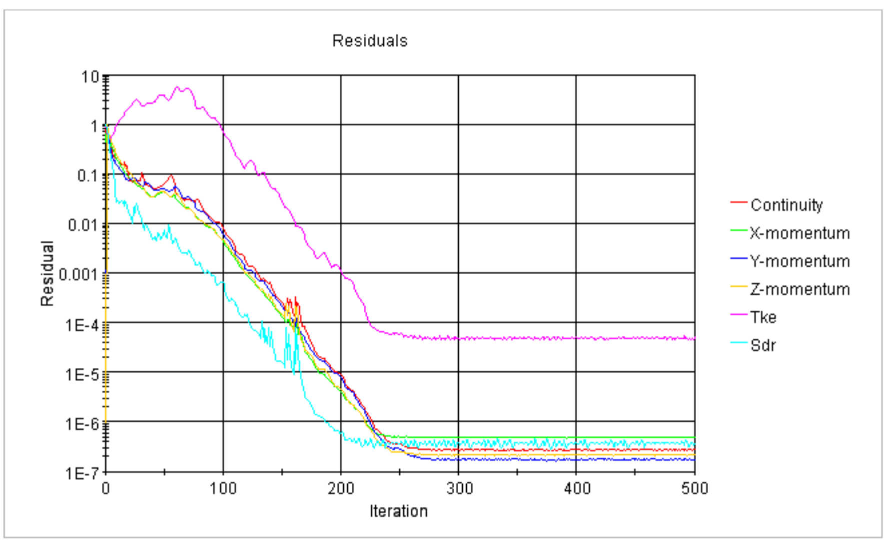


Figure 10.4. Residual Plot Showing Convergence of the Steady Air Flow Solution

Another simulation model was developed with a different boundary condition (East, Top = pressure outlet, North, South = symmetry outlet). Figure 5 shows the steady-state flow pattern predicted by the model.

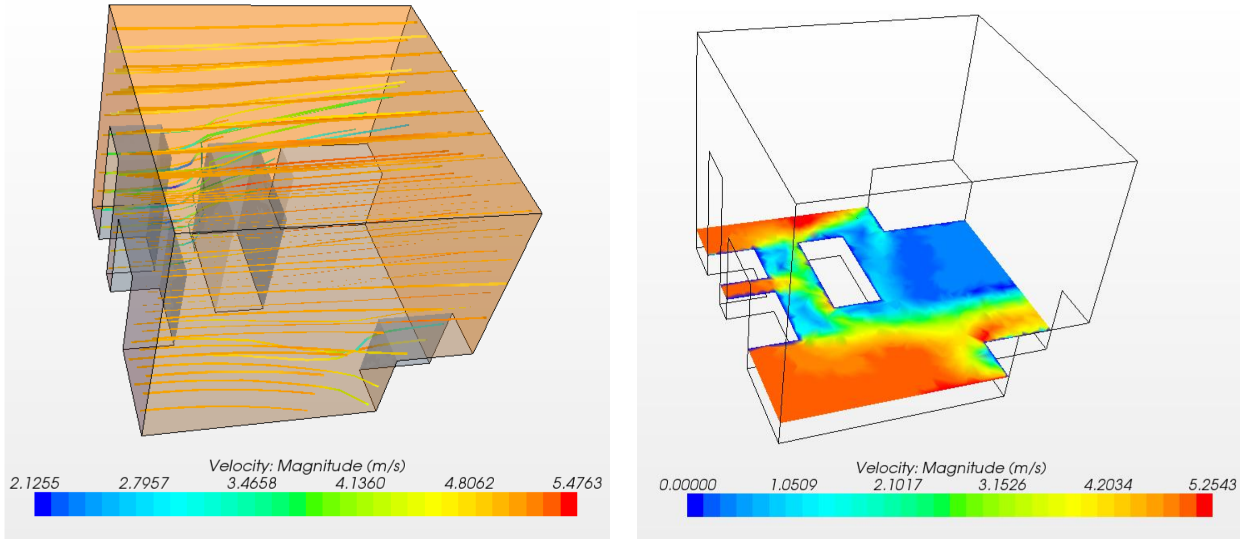


Figure 10.5. Urban Air Flow Predicted by the Model: Boundary Condition: (East, Top, North, South = pressure outlet)

10.2.2. Plume/Explosion: Multiple Component Gas Model

Since the plume generation is expected to vary in time, it is necessary to develop an unsteady flow model and perform transient analysis. This is accomplished by Star-CCM+ by redefining the model as unsteady flow model, and associating the boundary condition with a user function for time varying flow speed at the plume inlet. Figure 6 shows the velocity profile of the plume flow, which starts with 50 m/sec at 5 seconds and decreases to 10 m/sec at 30 second.

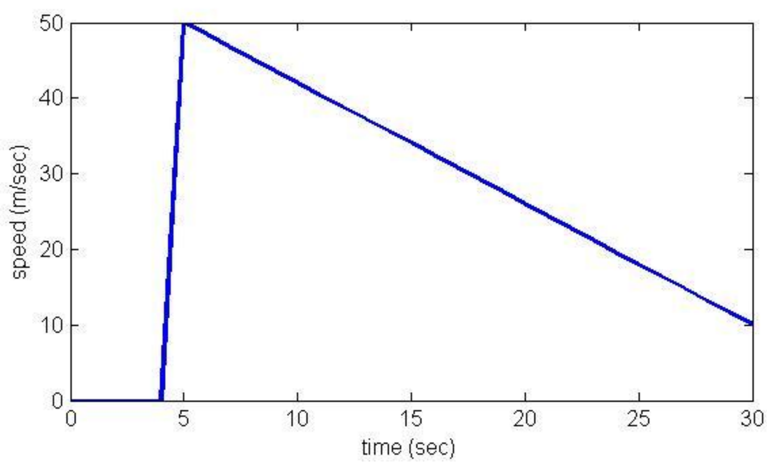


Figure 10.6. Velocity Profile of the Plume Flow

The numerical solution of the unsteady solution results in transient flow development. Figure 7 shows the transient development of the plume dispersion which is represented by the mass fraction of methane.

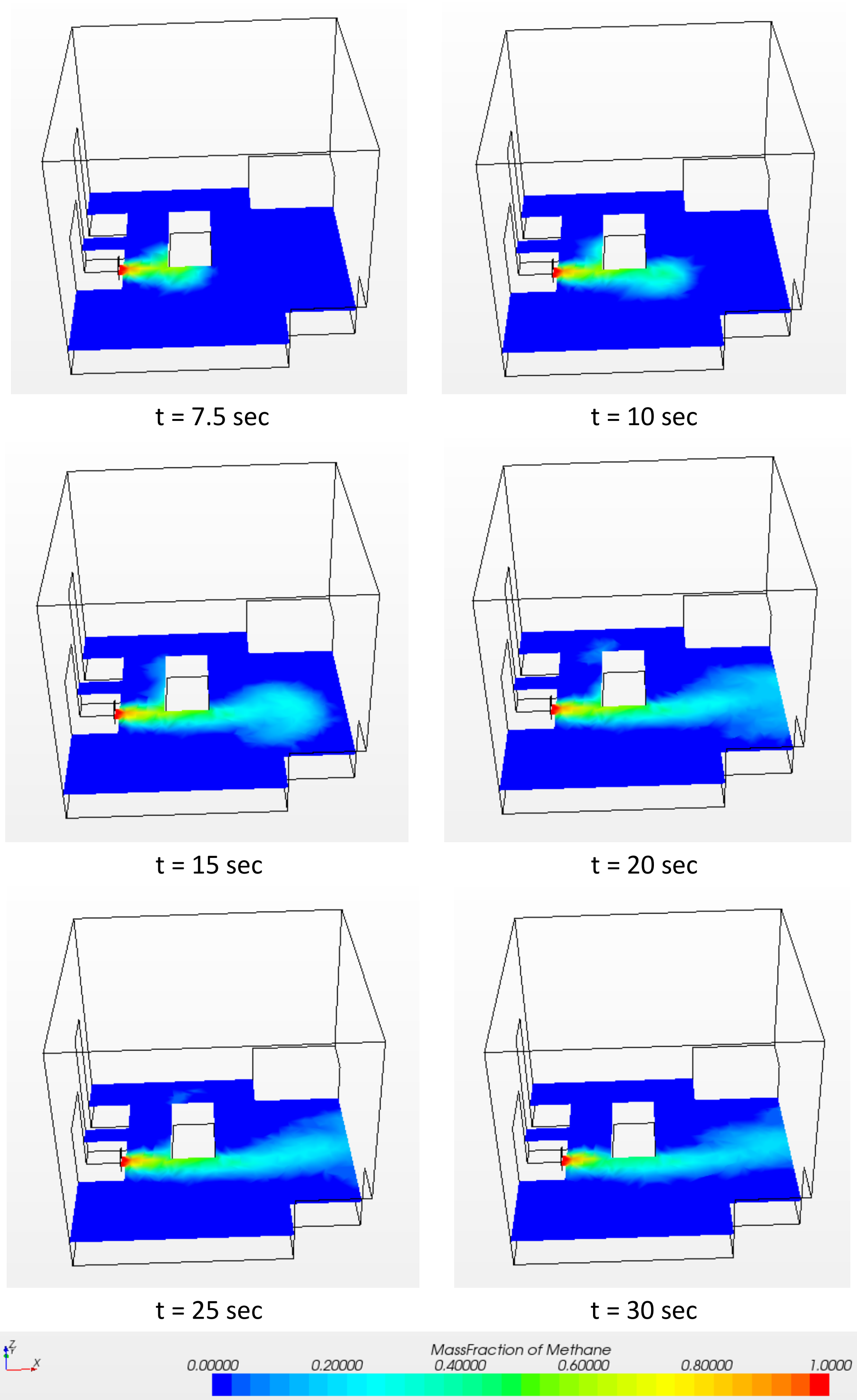


Figure 10.7. Transient Plume Dispersion (Mass Fraction of Methane) Predicted by Multi-Component Flow Model (Plume discharge starts 50 m/sec at t=5 sec, and decreases to 10 m/sec at t=30 sec)

10.2.3. Suspension of Radioactive Contaminant: Multiple Phase Model

In a real radioactive dispersion event, the plume is expected to be composed of not only the multi-component gases but also multiple phase particles. Therefore a multi-phase flow model is added to the plume model. This is accomplished by Star-CCM+ by redefining the model with addition of Lagrangian multiphase component. For the purpose of demonstrating the modeling capability, solid particles of Aluminum was added with the following properties:

- Density: 1200 kg/m3
- Diameter: 4 x 10-5 m
- Initial velocity: (10, 0, 0) m/sec

This particle was injected into the pollutant gas (methane) at the inlet with the following conditions:

- Volume loading of particle in pollutant = 0.01%
- Volume particle flow rate = 6.4516 x 10-5 m/sec

In this model, the particles are assumed to rebound with perfect restitution (normal and tangential restitution factor = 1.0).

With the addition of the particle component and the previous multi-component model, the simulation model was solved in unsteady state mode. Figure 8 shows the development of the plume dispersion which is represented by the mass fraction of methane.

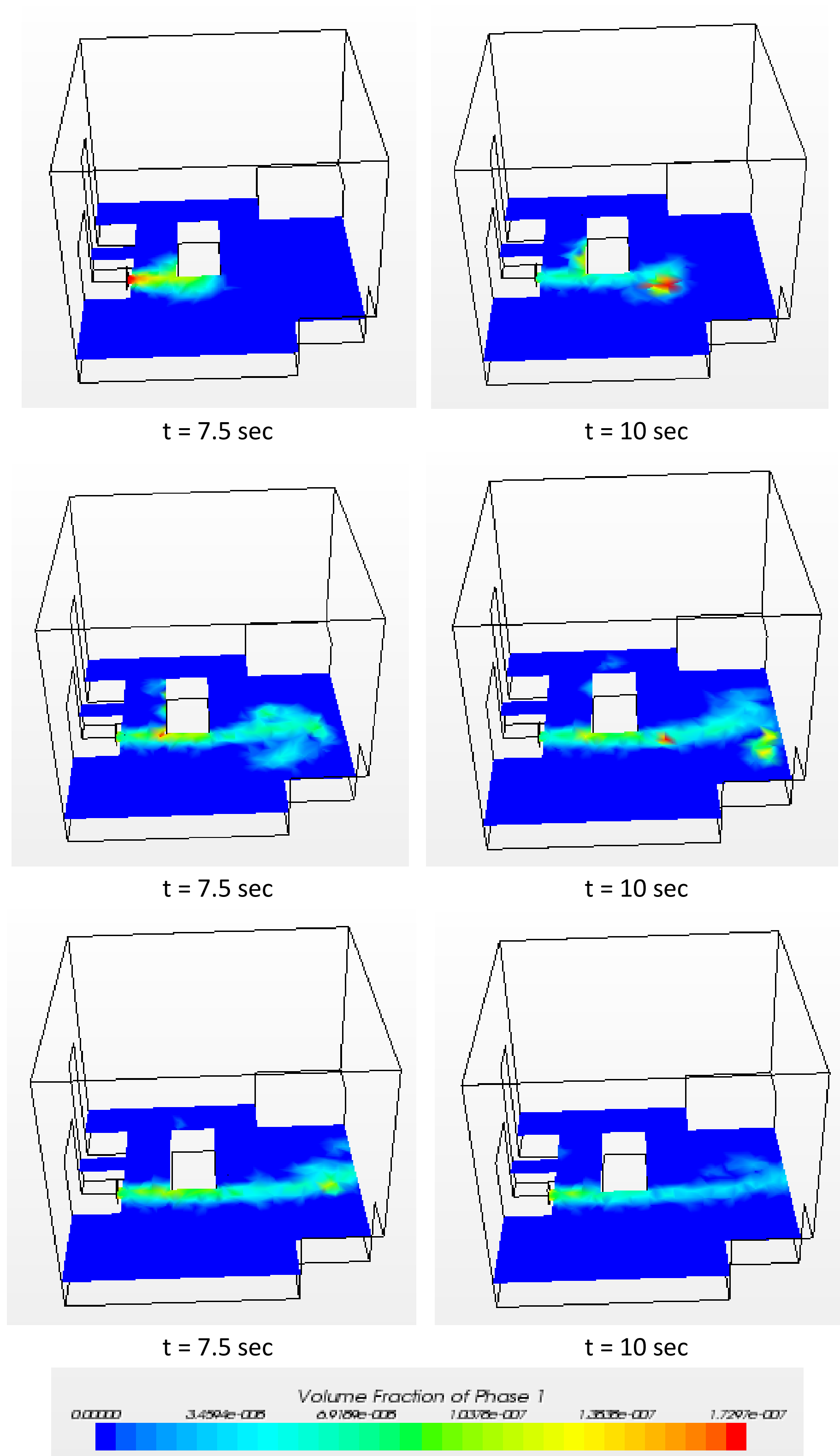


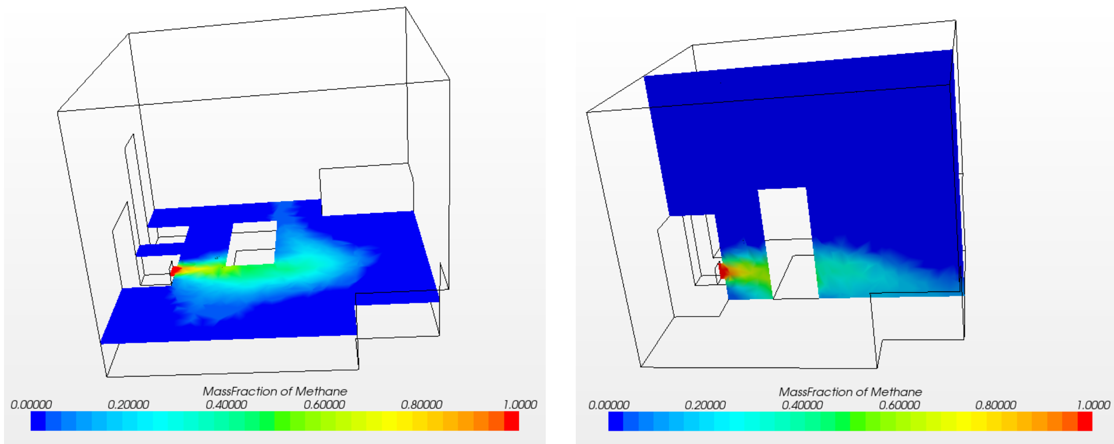
Figure 10.8. Transient Plume Dispersion (Mass Fraction of Methane) Predicted by Multi-Component, Multi-Phase Flow Model

10.2.4. Model Improvements

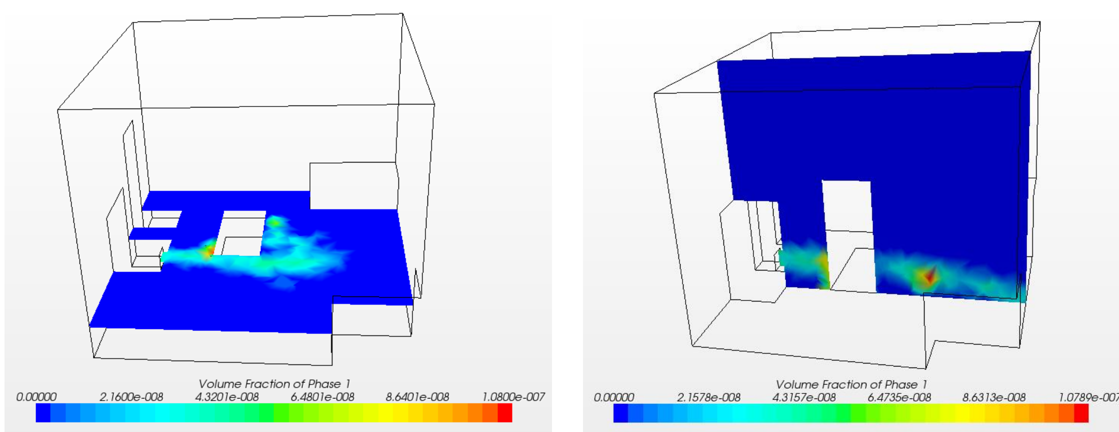
The multi-component, multi-phase dispersion model was further refined in this month by including the effects of gravity, earth boundary layer, and particulate restitution factors.

Gravity

First model enhancement is addressed by inclusion of gravity effect. This is accomplished in StarCCM+ code by adding gravity term in the model physics. Fig. 9 shows the model predicted dispersion of the gaseous and particulate phase. Compared to the case of Fig. 8, both phases of the plume settled down to the bottom floor and spreads quickly since both substances are heavier than air. Fig. 10 shows the predicted dispersion of plume with smaller particle size (40 μm). In this case, the particulate phase travels further as shown in Fig. 10(b) whereas the gaseous phase disperses in a similar pattern as 100 μm case.

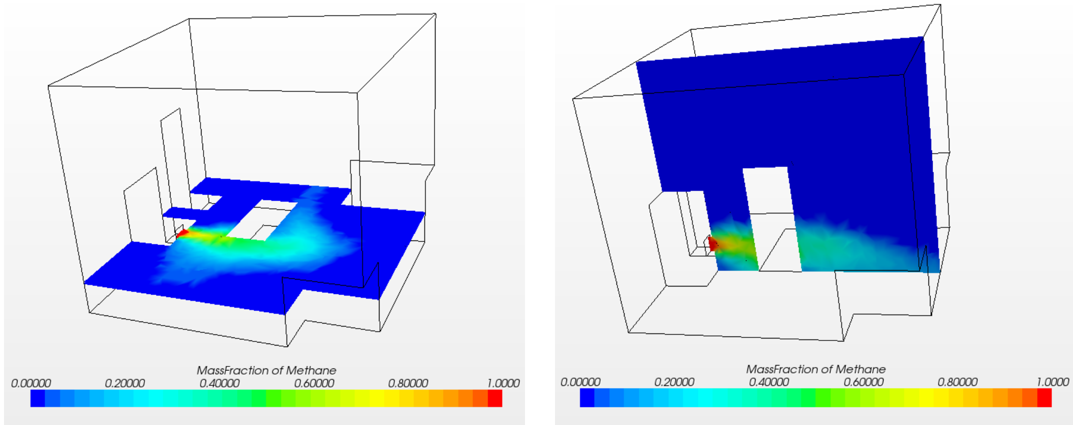


a) Mass Fraction of Gaseous Component

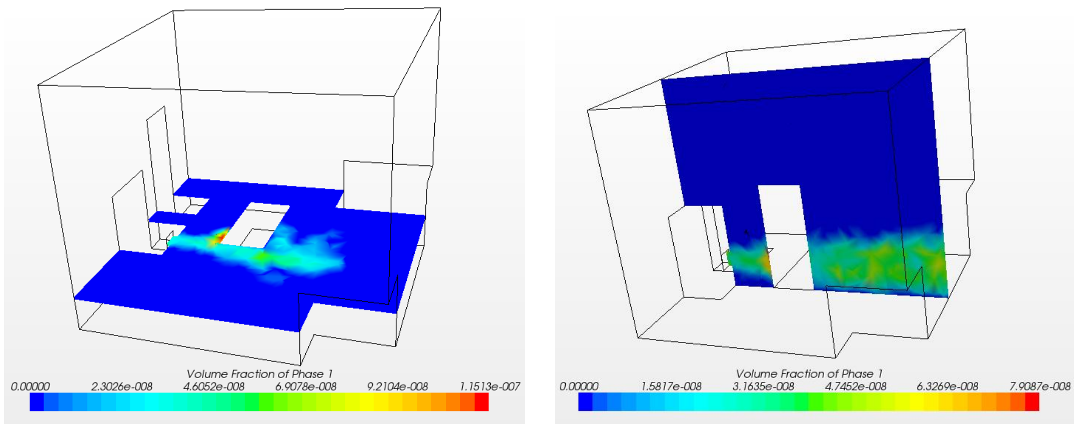


b) Volume Fraction of Solid Particle

Figure 10.9. Steady State Plume Dispersion upon Gravity Effect (particle size: 100 μm)



a) Mass Fraction of Gaseous Component



b) Volume Fraction of Solid Particle

Figure 10.10. Steady State Plume Dispersion upon Gravity Effect (particle size: 40 μm)

<u>Earth Boundary Layer</u>

Another refinement of the model is made to address atmospheric boundary conditions. The atmospheric boundary layer is defined as the lower part of the earth atmosphere directly influenced by its contact with a planetary surface. In this layer, physical interactions of flow velocity, temperature, moisture display turbulence and vertical mixing is strong. It is envisioned that most plume dispersion interaction will occur in the atmospheric boundary. Within the atmospheric boundary layer, due to aerodynamic drag, there is a gradient in the wind flow. Wind speed increases with increasing height above the ground, starting from zero due to the no-slip condition. The wind gradient is a function of surface roughness, which can be modeled as

$$\frac{u}{u^*} = \frac{1}{k}\ln\left(\frac{y}{y^*}\right)$$

where u is the wind speed, u^* is a reference velocity, y is height, and y^* is a factor depending on surface kinematic viscosity. The scale factor k is empirically set to 0.42. The effect of the surface drag is incorporated in the StarCCM+ physics model. The velocity boundary condition of the air inlet is changed according to the gradient model, as shown in Fig. 11. Simulation results are shown in Fig. 12. Due to the lower velocity at the bottom region, both phases of the plume settle quickly and spread further to the sides.

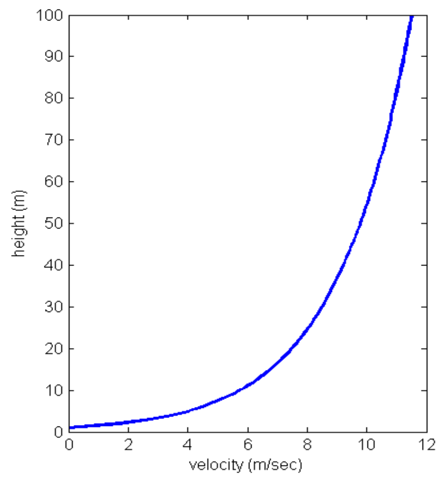
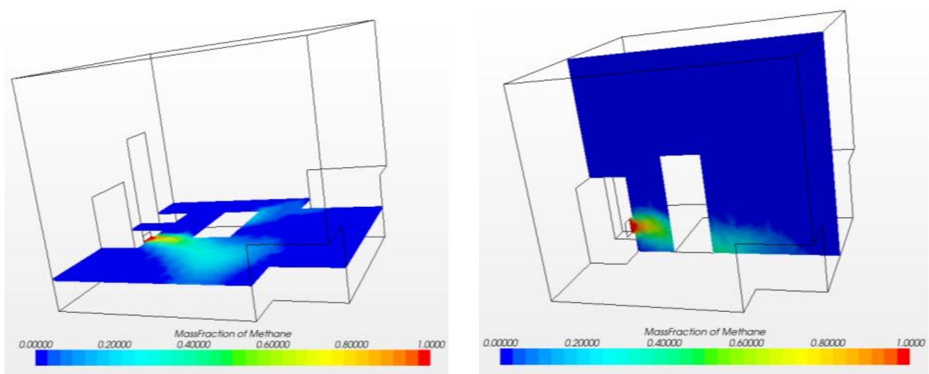
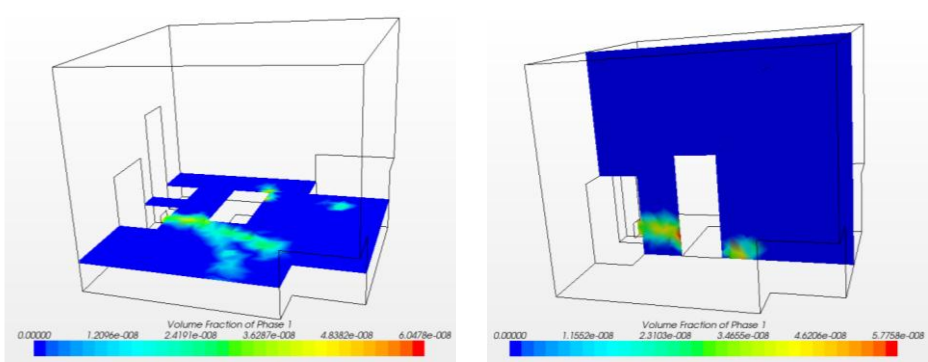


Figure 10.11. Inlet Air Velocity Profile



Mass Fraction of Gaseous Component



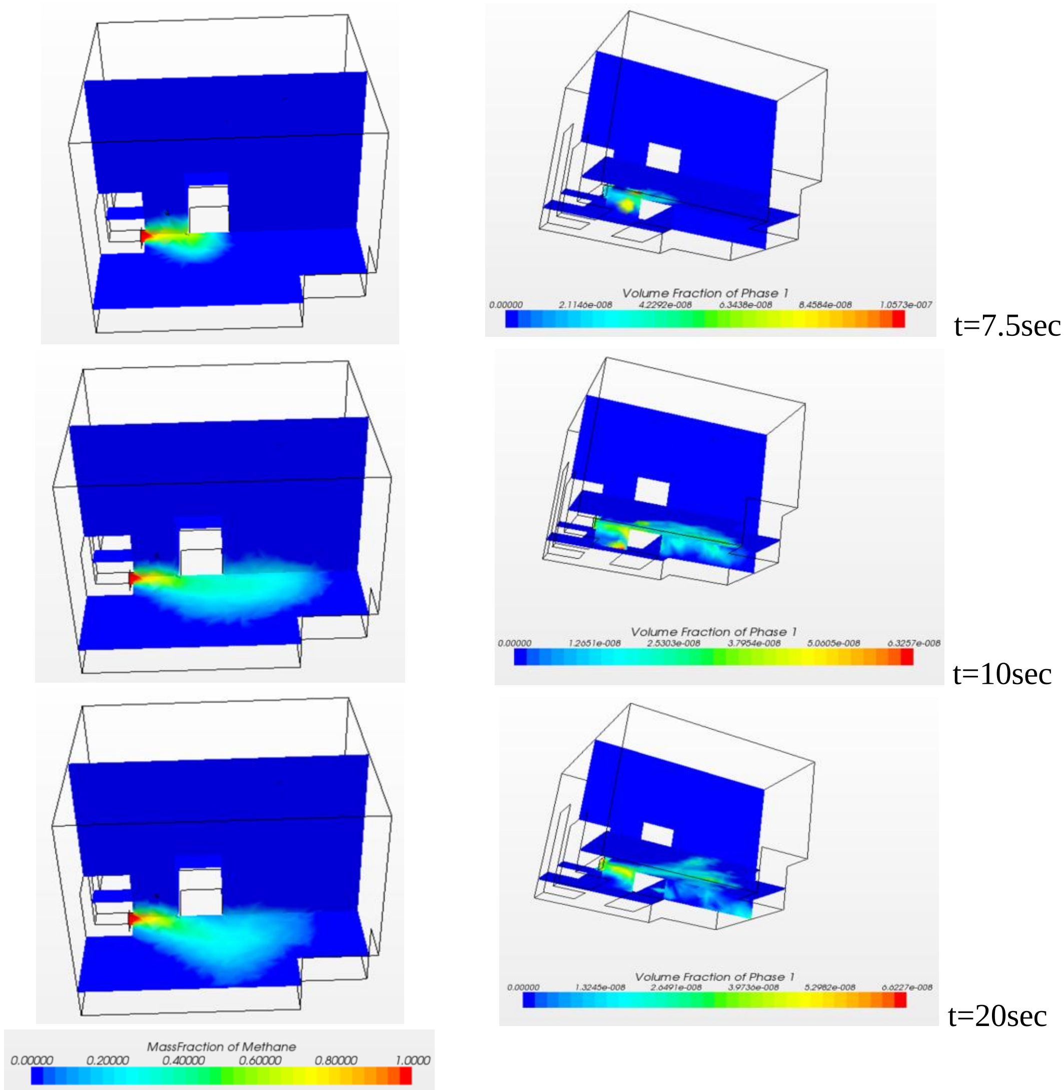
Volume Fraction of Solid Particle

Figure 10.12. Plume Dispersion with Earth Boundary Layer Wind Gradient (particle size: 100 μm)

Particle Deposition Model

To estimate the dispersion of radioactive material, it is necessary to model the deposition of solid particles upon contact with the environment. In this regard, StarCCM+ offers various modes of interaction of solid particles with walls. Two different approaches are taken by adopting rebound mode and stick mode.

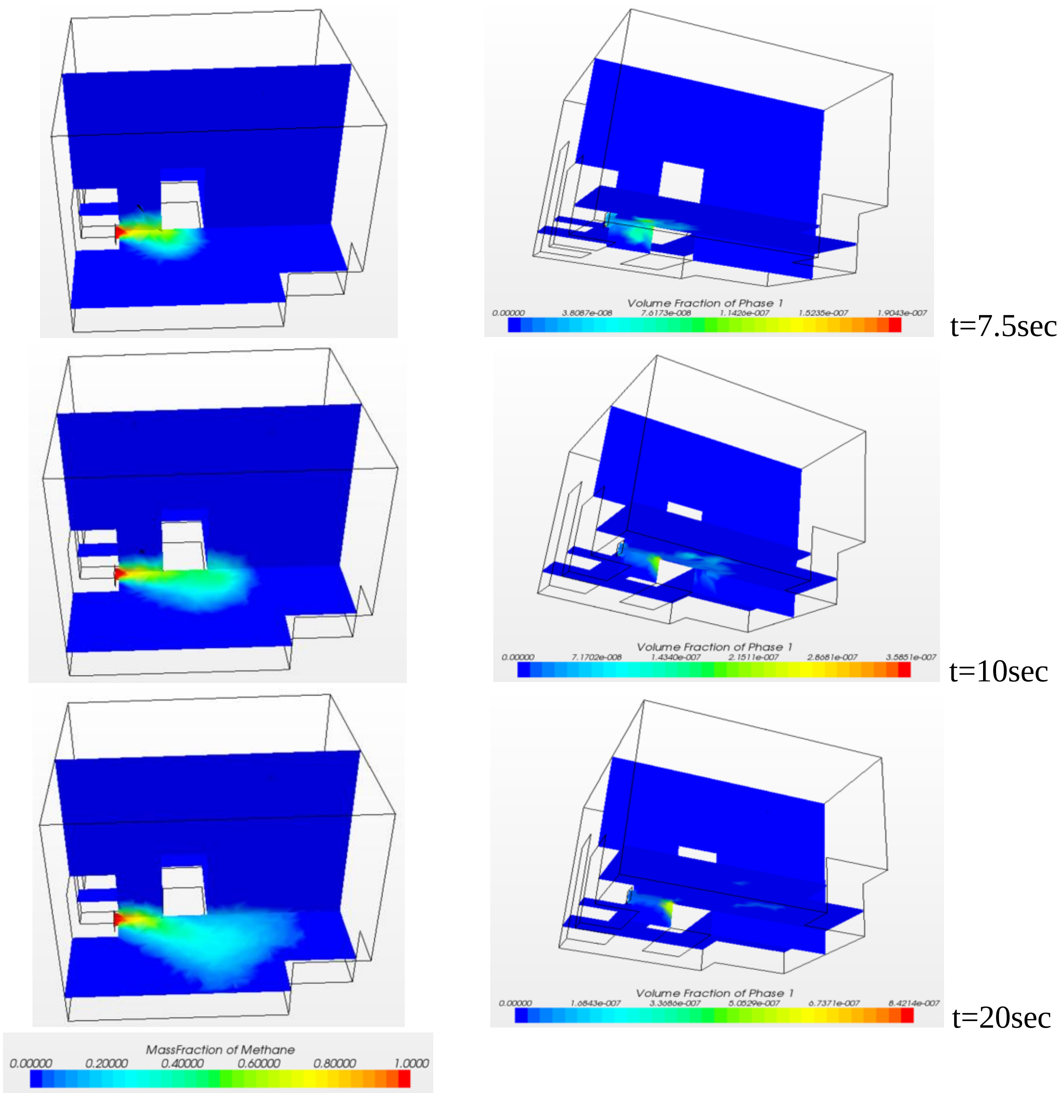
In rebound mode, the particles are allowed to rebound upon contact with wall surfaces. The rebound speed at each time is determined by restitution factor. Our model is based on the reasoning that the particle will lose its speed eventually upon repeated interaction with the walls. Fig. 13 shows a non-steady state simulation results with restitution factor of 0.8. Particle deposit was observed early parts of dispersion, e.g. at 10 sec.



(a) Mass Fraction of Gaseous component (b) Volume Fraction of Solid Particle Phase

Figure 13. Non-Steady State Simulation of Plume Dispersion with Particle Rebound

Stick mode is available only in unsteady flows. Particles are stuck to the boundary face at the location of contact. Stick mode is invoked by defining the particle physics model accordingly. Figure 14 shows the predicted plume dispersion by non-steady state model. Compared to the rebound model, the stick mode simulation predicts more rapid settling of particle phase.



(a) Mass Fraction of Gaseous component (b) Volume Fraction of Solid Particle Phase

Figure 10.13. Non-Steady State Simulation of Plume Dispersion with Particle Stiction

10.3. Large Scale Urban Dispersion Models

10.3.1. Air Flow Model: Resolving Scaling-up Issues

With a complete understanding of the simulation process and a definitive list of physics models and solvers to include, a large scale simulation was the next task. The area of interest was a section of downtown Chicago. Using ArcGIS to view data and locations of buildings, a model of 145 buildings was constructed using the integrated CAD module in STAR-CCM+, as shown Figure 15. The model was constructed at 1/100 of the actual size due to the size limitations of the CAD module. Once imported as a region, the model was scaled by 100. The total volume of the geometry was originally about 2.5 km by 2.5 km by 0.7 km. Further into the progression, the volume was extended to be about 3 km by 3.5 km by 1.5 km.

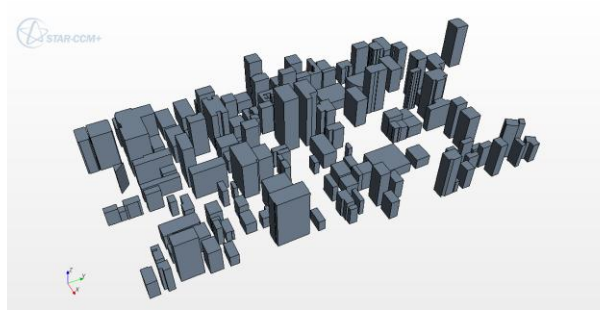


Figure 10.14. 145 building model.

10.3.1.1. Initial Run

Once constructed and imported as a region in the STAR-CCM+ interface, the first step was to successfully run an airflow simulation. The simulation immediately diverged with or without gravity. At first, the large mesh size was thought to be the problem, but with increasingly small cell sizes, the simulation was showing no improvement. To resolve the problem, simulations ranging from simple to complex were set up on the large scale in an attempt to solve the problems with the 145 building model.

10.3.1.2. Empty Area

The starting point was an air volume with no buildings 10 km by 10 km by 4 km. The airflow simulation in this geometry converged immediately. Figure 16 shows how the air enters at 5 m/s and, due to viscous effects, exits at around 3 m/s.

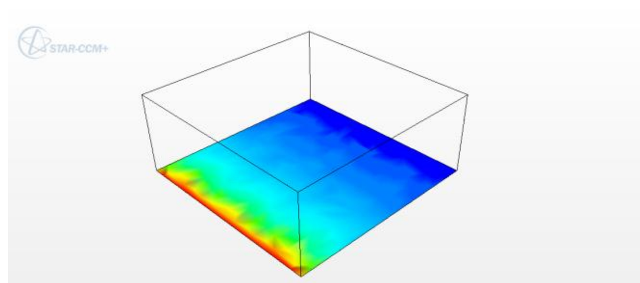


Figure 10.15: Velocity magnitude near ground in empty volume.

10.3.1.3. Single Building Model

With no answers to the large scale divergence issue from the empty volume, a single building model was constructed. The volume was about 1.5 km by 1 km by 0.6 km, with a single square-based building. The airflow simulation diverged for this geometry. Shear stress, Y+, pressure, and velocity magnitudes were all examined in an attempt to resolve the divergence on the large scale. One theory presented was related

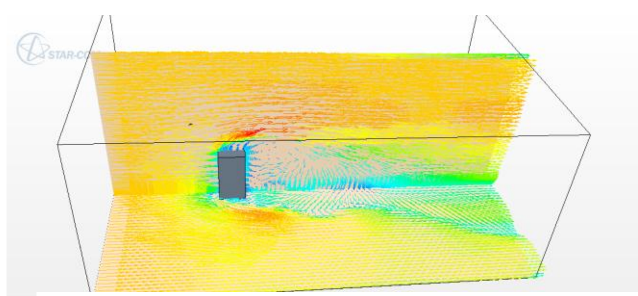


Figure 10.16: Flow pattern without gravity of single building.

to shear stress and viscosity. With such a large volume, to run the simulations in a practical amount of time, the mesh size had to be quite large, in the range of 10 m to 100 m. The large cells along the floor and building would be inadequate for accurately computing the shear stresses, causing the simulation to diverge. To test this theory, the inclusion of prism layers in the mesh was used. The prism layers would greatly decrease the cell size near the ground and building, effectively increasing the accuracy of computing the shear stresses. Figure 17 shows the simulation result. The prism layers were a success, the airflow simulation converged with a single building.

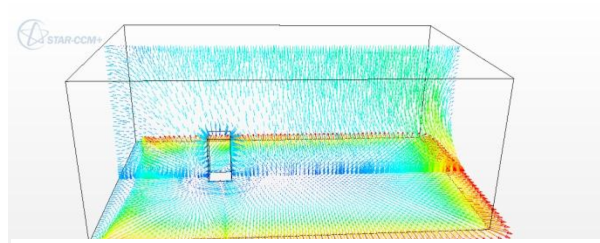


Figure 10.17: Unusual flow pattern with gravity.

Subsequently, the single building geometry was also tested with gravity. The simulation converged, but just as in the small scale, the flow was unusual, as shown in Figure 18.

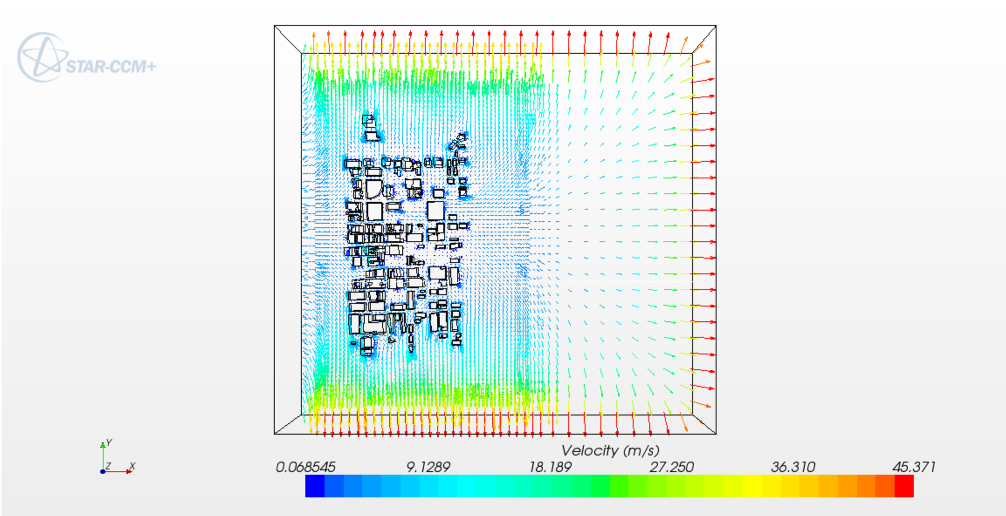
10.3.1.4. 12 Buildings Model

Although prism layers seemed to be a viable solution for use in the 145 building model, showing success with a single building was not enough. A 12 building model was constructed (Figure 19) to observe how the simulation would react with more buildings added to the model. The simulation successfully converged. Implementation of prism layers to the 145 building model was ready to begin, and hopefully a working simulation would come of it.

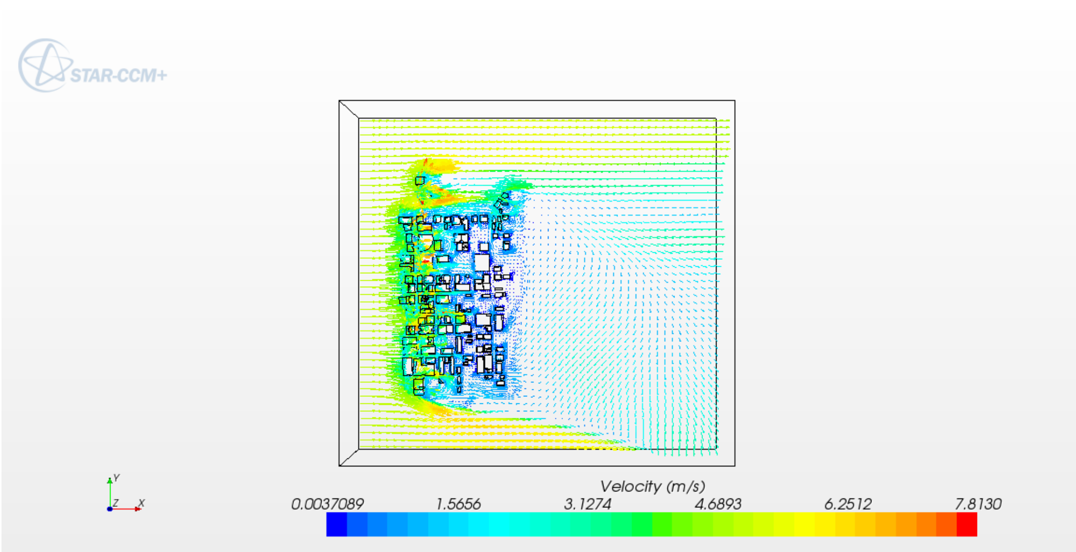
Figure 10.18. 12 building model.

10.3.1.5. 145 Building Revisited

With prism layers added to the mesh of the 145 building model, the airflow simulation converged. With gravity on, though, the airflow simulation would not converge. The velocity vector field showed glaring problems with the simulation. Finer mesh and more prism layers were implemented as a possible solution, but the simulation still did not converge. Examining the vector fields on different planes in the volume showed the fluid in the upper region “falling” down to the floor. A pressure plot revealed negative pressure gradients at the pressure boundaries, effectively causing the air to accelerate out of the volume through the closest pressure boundary. The air near the top of the volume would then move down to fill the void. With no knowledge of the cause of the negative pressure gradients, other types of boundaries needed to be considered. In the end, the consensus was to combine all the lateral boundaries, excluding the wind boundary, into a single flow-split outlet. A flow-split outlet requires a defined ratio of the fluid exiting each boundary, but with all the outlets combined as one, the ratio was simply one. The top boundary was now a symmetry plane, which would only work if the boundary was far enough away from changing flow patterns. The new boundary types solved the gradient problems. The airflow simulation with gravity now converged with a flow field that seemed reasonable. Figure 20 depicts a comparison of the vector fields with pressure outlets and flow-split outlets. The pressure outlet vector field shows the air accelerating out of the nearest boundary, while the flow-split outlet vector field shows the flow as expected.



Pressure boundary condition



Flow-Split boundary condition

Figure 10.19: Comparison of vector field with different outlet types.

10.3.2. Plume Dispersion Simulation Studies

The model was now ready for multi-component and multi-component/multi-phase plume implementation. Although the study did not include areas of downtown Chicago for plume events, the success of these plume simulations would prove that this study could be done using large scale areas with buildings as the model, making the study applicable to any city. There were four final simulations ran for the 145 building model. The simulations were both steady state and transient for multi-component (MC) and multi-component/multi-phase (MC/MP).

10.3.2.1. Steady State (MC, MC/MP)

The steady state simulations were not much different than the ones ran during the debugging. The simulations were meant to be a final, good run of the plume models in the 145 building model. A slightly finer mesh was used to get more accurate results. Both MC and MC/MP simulations converged successfully as shown in Figure 21.

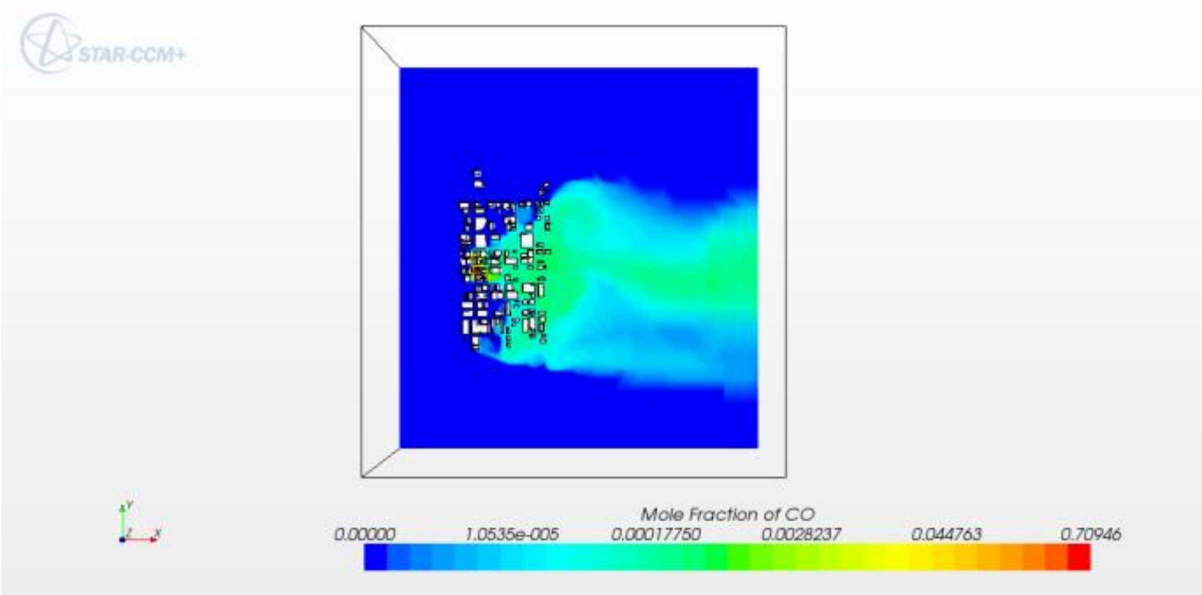


Figure 10.20: Steady state plume in 145 building model.

10.3.2.2. Transient (MC, MC/MP)

Unlike the steady state simulations, transient simulations tend to be divergent. Comparing the steady state to the transient, the only difference was the time dependence. Intuitively, this would infer a problem with the time step. Originally the time step was set to one second. Using a smaller time step did not improve the simulation. Using a two second step allowed the simulation to run longer before diverging. After trial and error with different time steps, a four second step came out to be the smallest for convergence. The reason for need of such a large time step is may be due to the large mesh size for the time step. Since the mesh size was so large, ~20 m, and majority of the fluid in the volume was moving at 5 m/s, there's the possibility that transient simulations require the fluid to traverse approximately one cell in a time step. Although proof of this theory is not absolute, the transient simulations converged with the new time step, but attempts to run with smaller time steps would take unmanageable computing time with the computer cluster. This means that higher capacity computer cluster would be adequate for such a large-scale transient simulation.

10.3.3. Automated Building Extrusion (Chicago Loop Area)

With successful transient simulations in the 145 building model, the study could be applicable to many other cities. The only thing lacking was an efficient and accurate method of constructing the building geometries for use in STAR-CCM+. The manual generation method is impractical for use in replicating the study in other cities. A method of translating the building shape file data into a CAD model would solve this problem.

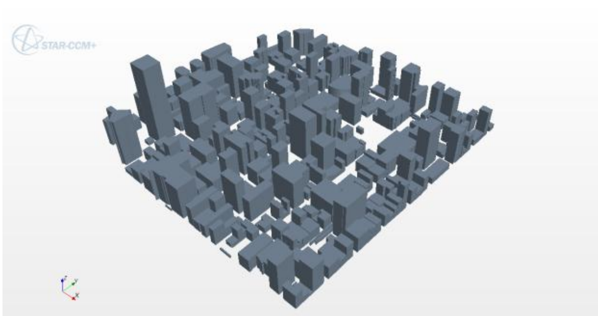


Figure 10.21: Automatically generated buildings in Loop.

The TRACC department head, Hubert Ley, was able to write a python script to resolve the issue. The script would read a building shape file, create each buildings footprint, and extrude the footprints up to the corresponding number of stories. The geometry would be saved as a .stl file, which can be imported into STAR-CCM+. This script could be used for any shape file as long as the file contained the relative data. Since 145 buildings was only a portion of Chicago's Loop, the geometry generated was the full Loop area.

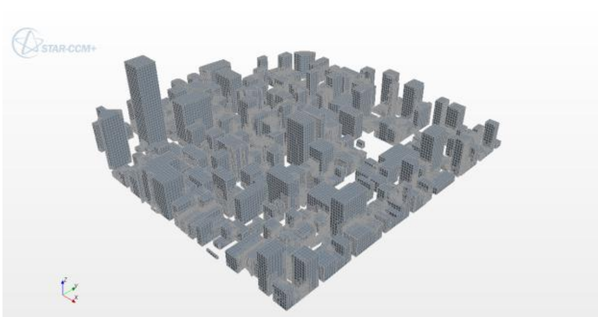


Figure 10.22: Surface mesh after surface wrapper.

The building geometries would now have to be used in successful simulations to prove the script's usefulness in the study. The buildings imported into STAR-CCM+ fine, and using a block shape part, the air volume around the buildings was defined. The surface mesh had many flaws such as holes and self-intersections. To correct the surface, STAR-CCM+ has a surface wrapper meshing option. This option "shrink wraps" the geometry, making it manifold. The wrapper takes care of self-intersections and also closes gaps up to a user-defined distance.

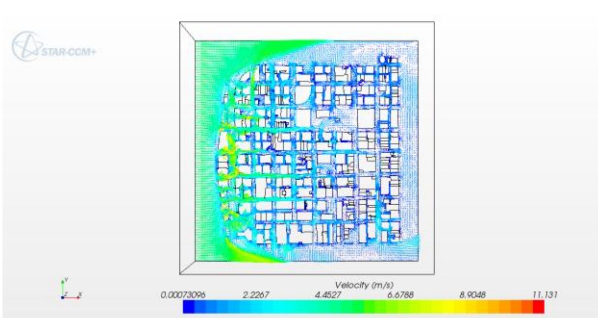


Figure 10.23: Vector field through Loop geometry.

Running a successful airflow simulation would verify the ability of extending this type of study to other cities. The Loop buildings were enclosed in a volume about 1.3 km by 1.3 km by 0.5 km. The boundaries were not made to be extensive because capturing the full flow behavior was not of interest. Only a converging simulation with the automatic building generation was needed. With the simulation ready, it converged immediately.

10.4. Case Studies

10.4.1. Wrigley Field Area

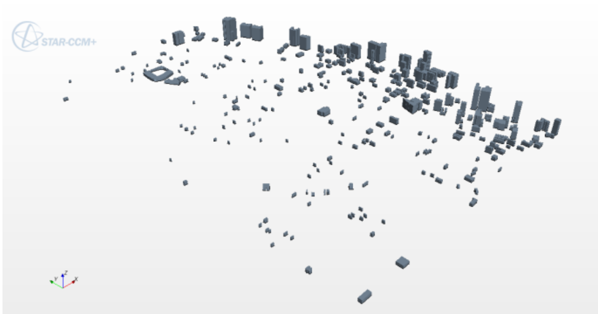


Figure 10.24: Wrigley area geometry automatically generated.

One of the areas of interest for the study was the Wrigley area. Using the python script, the buildings in the Wrigley field area of 3 or more stories were created. The goal of this part of the study was to examine the different ways to implement a plume into the geometry. Since the model was auto generated and not created in CAD program or module, using an inlet on the side of a building, like in the small scale and 145 building models, would be very hard to do. Instead, using shape parts created in STAR-CCM+ seemed to be the best option. The inlet location and size could now be completely user defined. The three shapes tested for the inlet were block, cylinder, and sphere. The block and cylinder shapes worked with no problems when placed on ground level. The sphere placed on ground level, would disappear from the model after meshing. This was assumed to be due to the combination of using the surface wrapper and the sphere only touching the ground at one point. Suspending the shapes in mid-air did not work. The parts would disappear after meshing, possibly due to the surface wrapper.

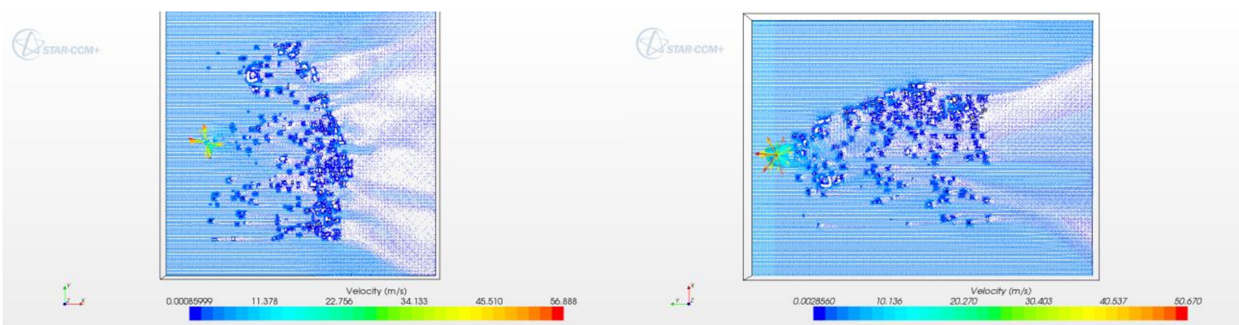


Figure 10.25: Comparison of Block plume inlet (left) and Cylinder plume inlet (right). The block inlet injects the plume at 90 degree angles. The cylinder injects the plume radially.

With many simulations ran in the Wrigley area, it's apparent that buildings in the area did not have a significant effect on the dispersion of the plume. Not many buildings in the area were taller than five stories. With this observation, it was decided that to make the most adaptable simulations for the areas of the project, no buildings should be used. This would allow the models to be applicable to any suburban areas.

10.4.2. Reference Models

For the application to suburban areas, a volume measuring 3.2 km by 3.2 km by 2 km was created with no buildings. The plume inlet was centered 200 m from the wind inlet. Originally, the inlet was a cylinder due to the problems with the sphere inlet in the Wrigley simulations. With no buildings in this model, the surface wrapper was no longer necessary. The inlet was switched to be a sphere, radius of 2.5 m, since meshing no longer rid the model of the shape part. A sphere would be a more accurate representation of an explosion as well. To better model an explosive, the plume composition was changed from methane or carbon monoxide to the actual products, in correct ratios, of TNT. Now that the plume inlet was dependent on a set amount of mass to inject into the volume, the type was changed to a mass-flow inlet. The function for the mass flow rate was elected to be a Gaussian distribution with duration of thirty seconds.

An example of the function, in (kg/s), for 2000 kg of TNT: $\dot{m} = (198.72)e^{-\frac{t^2}{100}}$.

As for the radioactive solid phase, the density was defined to be identical to that of cesium oxide, the product of burning cesium. The mass flow function was a Gaussian distribution defined for thirty seconds and 2500 Curies of cesium. The velocity function for injecting the cesium oxide was set to be the velocity of the plume being injected. Particle diameter was 100 microns. These final simulations were set up with three variables: amount of TNT, wind speed, and plume inlet height. Heights used were ground level, five stories, and fifty stories. Amounts of TNT were 2000 kg and 10,000 kg. Wind speeds were 5 m/s and 20 m/s. Every possible combination of these variables was used for a total of twelve simulations. These combinations were designed to cover a "subtle" event up to an extreme event. All six of the simulations using 2000 kg of TNT ran and converged with no problems. All of the 10,000 kg TNT simulations diverge instantly with overflow errors. Troubleshooting this problem has involved both courser and finer meshes, with no real results. Varying the time step was able to warrant a response. Problem is a time step of 0.1 seconds was required to keep the simulation running. To run the simulation out to a usable duration (the others ran to 1000 seconds), would require weeks of computing time.

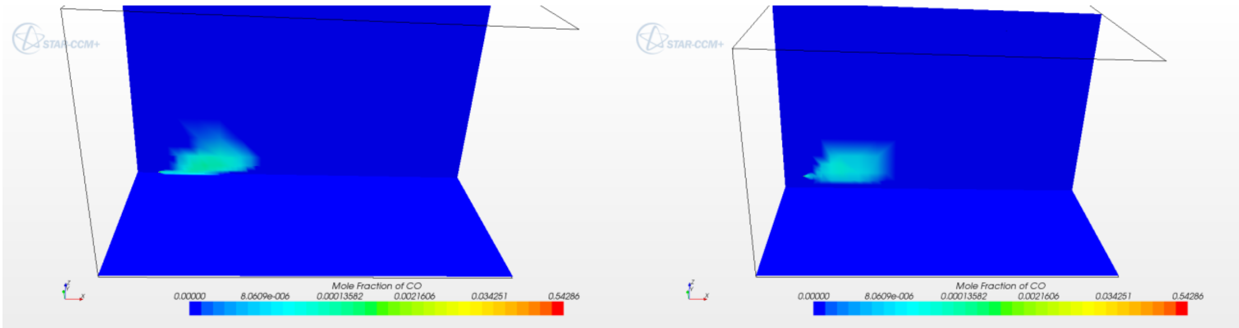


Figure 10.26: Comparison of 5 story inlet (left) and 50 story inlet (right) with 2000 kg TNT and 5 m/s wind.

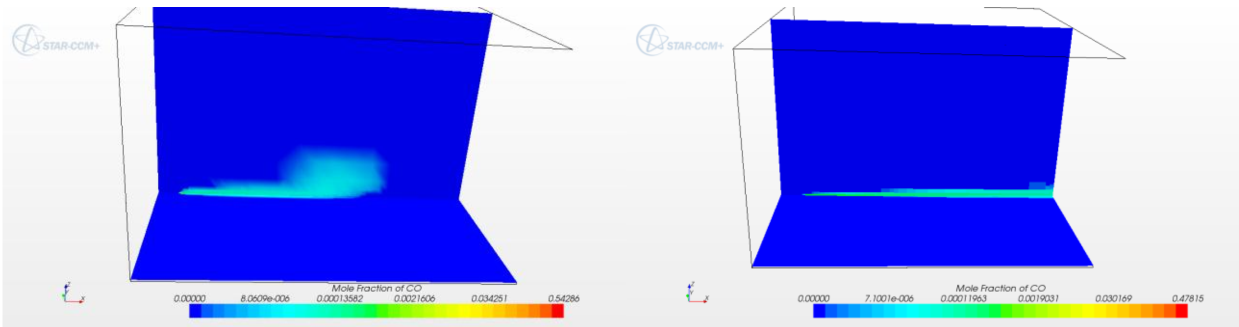


Figure 10.27: Comparison of ground level inlet with 2000 kg TNT. 5 m/s wind (left) and 20 m/s wind (right).

10.5. HPAC

The HPAC software package is another tool made available for this project to help provide atmospheric transport and dispersion predictions in the event of hazardous atmospheric releases. Developed by the Defense Threat Reduction Agency (DTRA), HPAC is a suite of models that allows for various modes of release of radiological, chemical and biological agents, generates interpolated meteorological data fields based on inputted meteorology, and transports the material using a tested transport and diffusion model. Rather than giving continuous spatial distribution of dispersion, HPAC outputs discrete probabilistic ranges of distribution. Also it does not take into consideration of urban area with buildings. However, since most of our simulation areas are non-urban areas, atmospheric simulation by HPAC may be adequate for the purpose.

10.5.1. Hazard Prediction and Assessment Capability (HPAC)

HPAC's Radiological weapon incident module, or RWPN, computes and interpolates the explosive dispersal of radiological materials. The source characteristics in our incident models are based on Sandia National Laboratory characterization. As the user, we must define the weapon characteristics (mass/activity of radiological materials and high explosives).

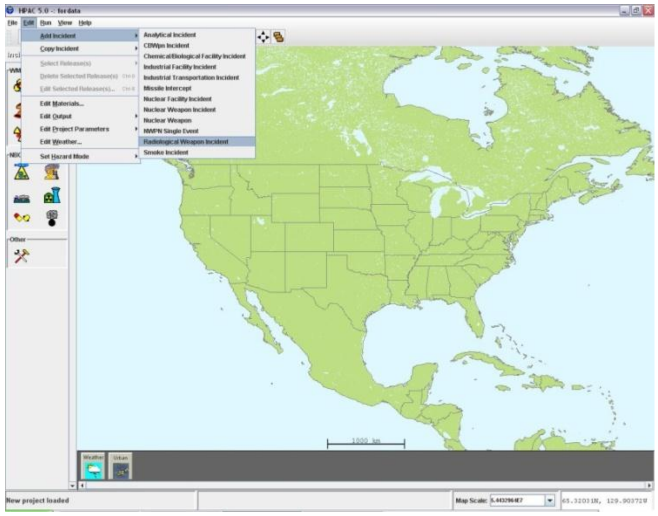


Figure 10.28: HPAC - Add RDD

First we need to select the RWPN incident. Right away we are prompted to fill out all the necessary user-defined data about the incident before HPAC can compute the results and plot the data. The "Where" dialog box seen below allows us to define a single geographic location for our RWPN incident and will represent the epicenter for our model.

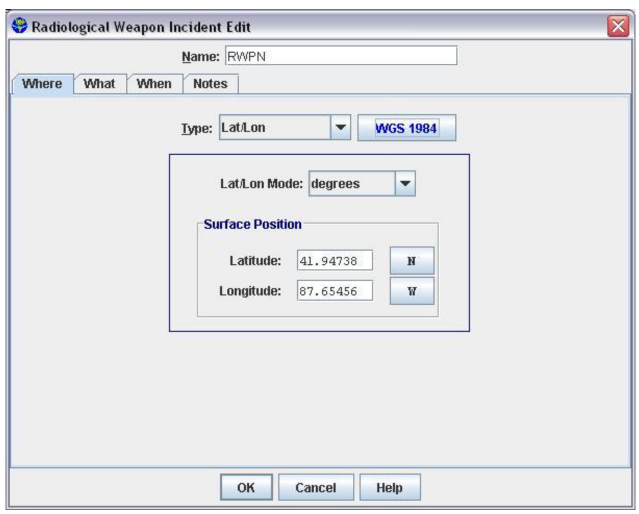


Figure 10.29: HPAC - Location Dialog

Using Google Earth, we are able to retrieve the latitude and longitude of our desired location in decimal degrees. For our scenario, we will specify the location near Wrigley Field at the intersection of N Sheffield Ave. and W Addison St. in Chicago, IL. (41.947383 N, 87.654556 W). Being mindful of the hemisphere button is important at this step. The hemisphere button defaults to the value which will result in a non-negative latitude/longitude.

After defining our location we need to describe the details of the weapon itself. The “What” tab of the Radiological Weapon Incident Edit dialog displays a panel that is used to set technical parameters for our Radiological Weapon Incident. Right away, we chose the Explosive RDD incident from the dropdown menu. With the Explosive RDD incident enabled as our Dispersal Device, the middle of the "What" tab of the Radiological Weapon Incident Edit dialog will activate a panel where we can set the technical parameters for our explosive RDD.

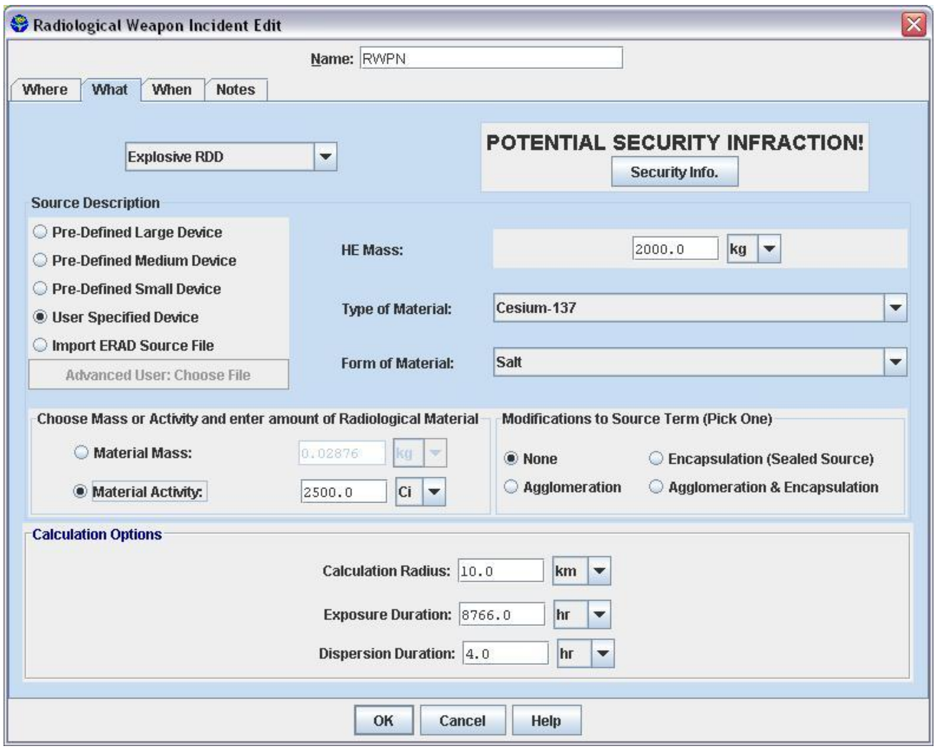


Figure 10.30: HPAC - Radiological Weapon Incident Edit Dialog

We know that in a past event a perpetrator used approximately 2000kg of high explosives for their device. We want our device to mimic historical events so we can have a point of reference. Although there are some pre-defined devices that we can choose from, none of them have the High Explosive (HE) capacity that we are looking for. So, we will choose the User Specified Device option. This will allow us to input the mass of 2000kg of HE. After specifying the HE mass, we will choose Cs-137 as our material and Salt as the form of material.

With Cs-137 selected as our material, HPAC requires us to define the material’s mass or the material’s activity. Since the mass of our material is so small we are going to define the activity at 2,500 Curies(Ci). After the Ci amount is defined and clicking elsewhere, HPAC automatically calculates the corresponding mass for the activity. Before moving on to the calculation options, we selected "None" for the Source Term for our RDD.

The calculation options for our model deal less with what HPAC calculates and more with how HPAC calculates. Changes here will affect how precise our model is which will relate to how long our model takes to render. For our model we chose 10km for our calculation radius, One year (8760 hours) for the exposure duration, and 4 hours for the Dispersion duration. The When and Notes tab for this model were deemed unnecessary, so our next step was to complete the weather data that is needed to compute our RDD model.

The environmental data used in HPAC includes weather and terrain. Our HPAC project has to include weather data of some sort. If we tried to compute results without specifying weather, HPAC would prompt us to edit the weather definition. We will use the Weather button to define environmental data for your HPAC project.

In HPAC, we want to define environment after we have created our incident. HPAC automatically estimates the spatial domains of a project each time we place an incident on the map. These domains are prerequisites in obtaining the most accurate environmental data. When right-clicking on the weather button and choosing the edit option, we can start defining our environmental data.

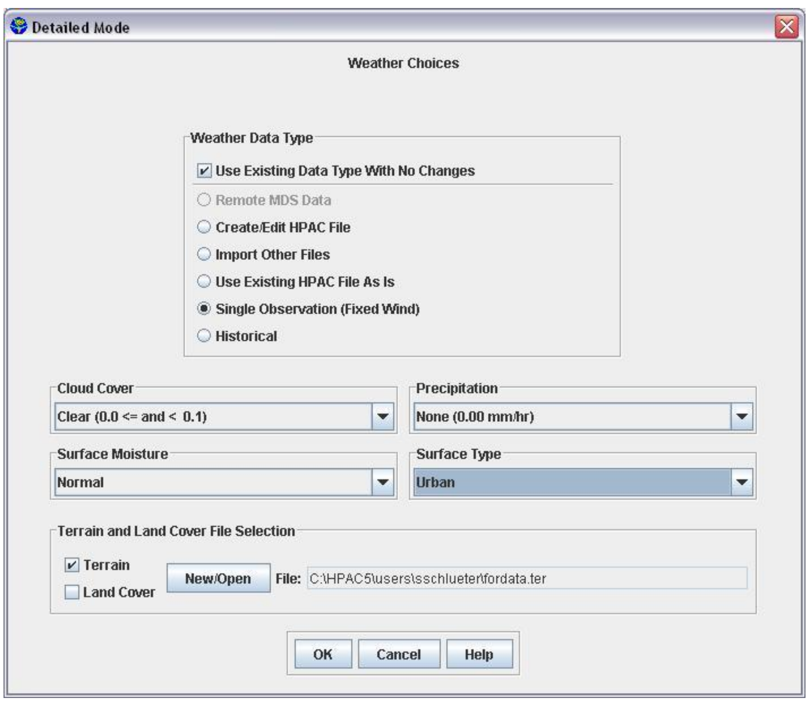


Figure 10.31: HPAC - Weather Choices Dialog

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For our model we are going to select the Single Observation data type. We use this option to manually enter a Fixed Wind observation (i.e., wind speed and direction). HPAC assumes that this wind speed and direction apply to the entire spatial domain and time of interest. We want to have the clearest conditions for our event so we must choose Clear for the cloud cover, None for precipitation and Normal for Surface Moisture.

In our Single Observation data type method, we need to have a corresponding terrain file to calculate our model. Click the terrain checkbox and selected the New/Open button to create a new terrain file and name the file the same as the HPAC project itself to maintain consistency. At this point, clicked the OK button and you will be prompted by the Single Observation (Fixed Wind) dialog box to complete magnitude of our fixed wind. For our model, we wanted the direction to be 270°(Eastbound) at 20 mph.

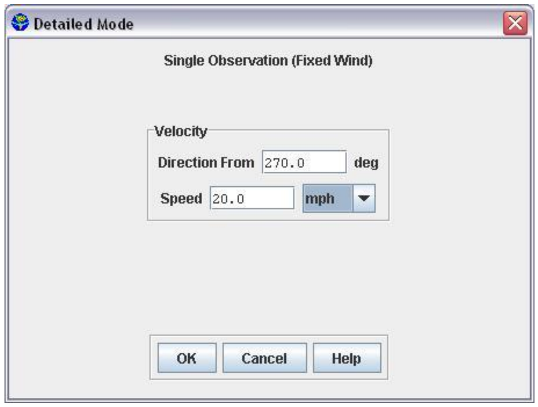


Figure 10.32: HPAC - Fixed Wind Dialog

Finally, in order to generate the models from our incident we need HPAC to compute all the numbers necessary to produce the model. By clicking Run > Compute Results (or Control+ M), HPAC will process all of the data we have entered into our incident. When this process is complete, the output button on the lower toolbar will be available for us to use.

Figure 10.33: HPAC - Output Button

The output button allows us to display plots, export data, import plots that have been exported from other projects and generate a series of images. If we click on the output button the default model plume of TEDE, which represents dosage accumulation received over 4 hours. Instead, however, we are going to right-click the output button to plot a different kind of model. We want the Material Disposition model which will give us the material (Cs-137) mass disposition around the incident epicenter. In our output models we can see that the further away from the epicenter we go, the less material and activity there is. We can also see that the wind pushes the material to the east, which has a significant effect on the way RDD plume model is shaped. This output and plotting process can be altered quickly by changing the activity amount and wind speeds. Each time requires us to compute the results before we can plot the models.

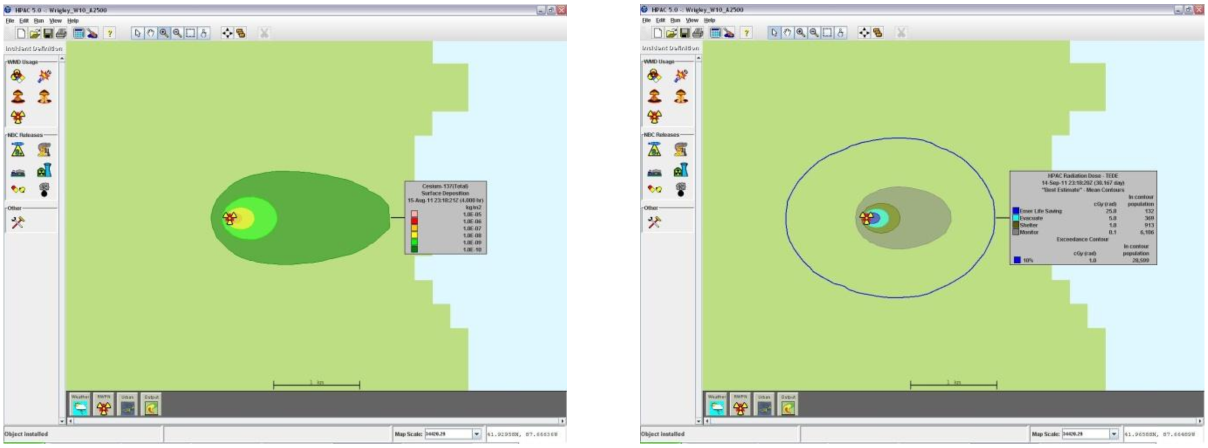


Figure 10.34: Surface Deposition and Dose Rate (TEDE)

The models displayed in HPAC are nice, but they don't really portray a quality representation of how the incident will affect the surroundings of its environment. To remedy this, we will export the existing model as an ESRI shape file (.shp) and import it to ArcMap.

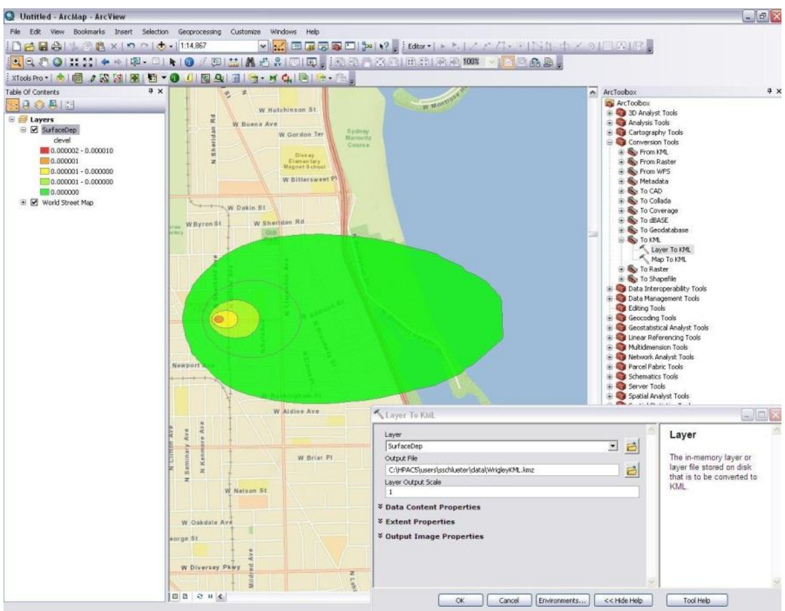


Figure 10.35: ArcMap Conversion to KML

Once in ArcMap we can use the file conversion toolbox to convert our shape file to a .KML file which will allow us to view our model in Google Earth. Once we can see the visual representation in Google Earth, we can easily grasp how our RDD incident will spread throughout the city with our given specifications.

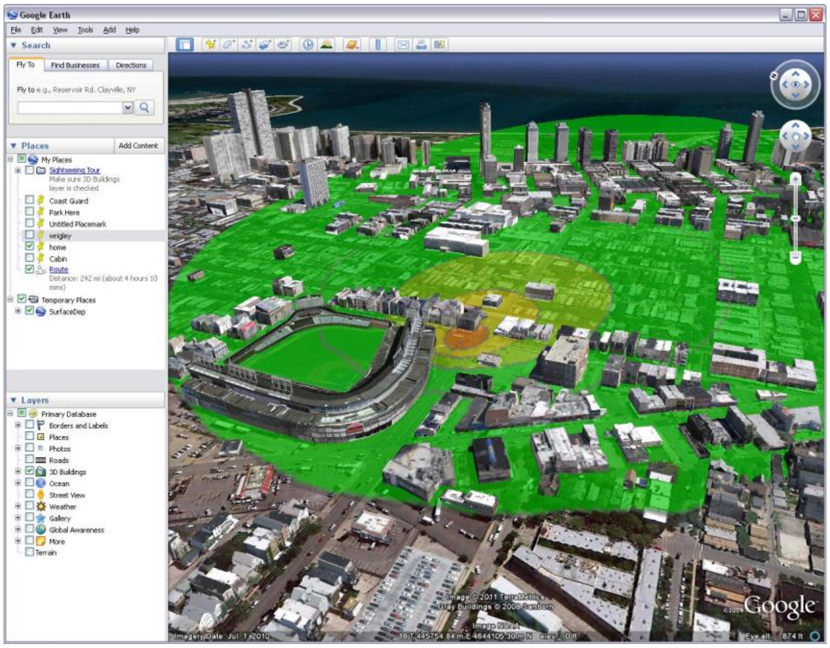


Figure 10.36: Google Earth Model of the Incident

11. Evacuation Network Tools and Modeling

11.1. Evacuation Routes

Modeling evacuation routes is an important supply management strategy for the RTSTEP project. The work includes a development of a tool, namely EvacNet.exe, which allows emergency planner to define a set of evacuation routes and corresponding intersection management plans. In addition, this work also define a set of candidate evacuation routes for the Chicago Metropolitan Area and corresponding design guideline that can be utilized in other cities as well.

The structure of this chapter is as follows. The next section presents the candidate evacuation route setup and the procedure of defining the Chicago Candidate Evacuation Route Set. Then, the development of evacuation network tool - EvacNet.exe is presented, and followed by a software quick reference and a sample scenario design and corresponding scenario design procedures.

11.1.1. Candidate Evacuation Routes Setup

Since it is not realistic to manage every link and intersection for emergency evacuation management in practice, especially for a regional transportation network in this study considering resources and budget, this study defines a concept of candidate evacuation routes set. Those links and intersections in the candidate evacuation route set are the decision variables for functioning as evacuation routes during an emergency evacuation event. In light of literature and practical projects for hurricane evacuation plans, criteria for defining a candidate evacuation routes set are as follows.

- Freeways and expressways
- Major Arterials
    - High-volume, long-distance, multiple lanes arterials
    - Close to shelters, schools, and hospitals
    - Better road devices and facilities

In this study, we take the advantage of the exiting Chicago Strategic Regional Arterial (SRA) System as a start point of the candidate evacuation route set design, since the SRA system includes the key criteria of the evacuation routes and has further improvement plan with more advanced traffic control technologies and devices along those routes, which can be utilized to develop more advanced evacuation route guide systems in the Intelligent Transportation Systems (ITS) framework.

11.1.1.1. Chicago Strategic Regional Arterials

The concept of the Strategic Regional Arterial (SRA) System is developed from approximately 1998. It is a 1340 mile network of existing roads in Northeastern Illinois, including 146 route segments in Cook, DuPage, Kane, Lake, McHenry and Will Counties. As part of the 2010 Transportation System Development plan, the SRA system is aimed to supplement the existing and proposed expressway facilities by accommodating a large portion of long-distance, high-volume automobile and commercial vehicle traffic in the region. The SRA system is nothing but a result of recognizing the need for a comprehensive network of routes one step below the expressway system to handle long-distance regional traffic. Figure 11.1 shows the vision plan of the SRA system.

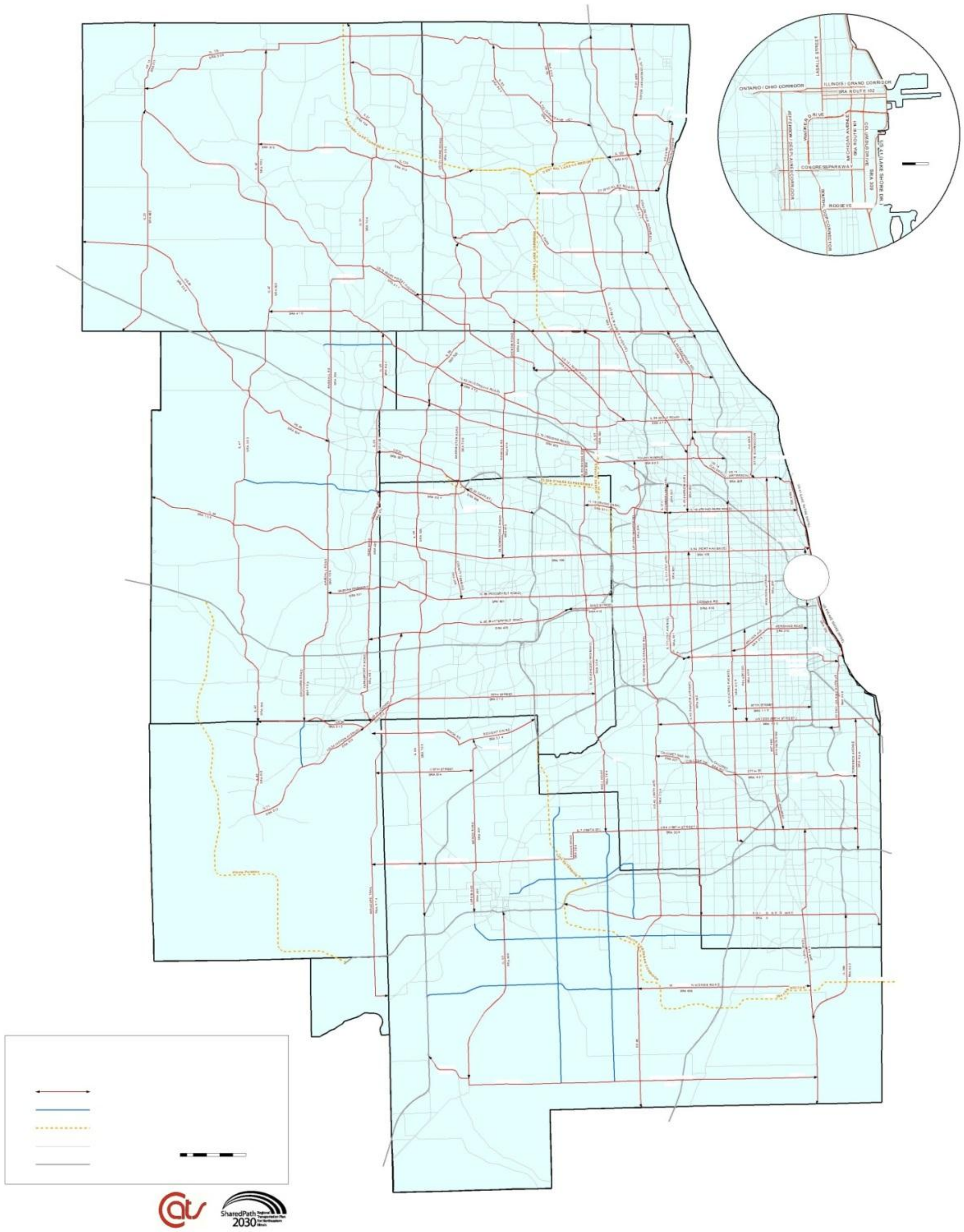


Figure 11.1: Chicago Strategic Regional Arterial (SRA) System

The SRA system is expected to accomplish following purposes and goals within the overall regional transportation system: i) improve regional mobility; ii) complement the region's major transit and highway facilities by providing access for regional trips on these facilities; and iii) provide for long-distance travel to supplement the regional expressway system.

Significant differences in the roadway environment can be identified within the overall SRA networks, and based on these differences, three types of SRA routes have been designates as follows:

- Urban Routes: Densities > 5.0 HH/acre by 2010
- Suburban Routes: Densities > 0.5 & < 5.0 HH/acre by 2010
- Rural Routes: Densities < 0.5 HH/acre by 2010

Typical roadway environment for each type of route are shown below.

Table 11.1: Road Conditions of the SRA

Urban Route	Suburban Route	Rural Route
Right-of-Way		
60-100 Ft	100 Ft	>100 Ft
Developed Roadway		
4-6 Lanes 10-12' each Cross Streets 8-20/mile Occasional Center Lane or Left Turn Lane On-Street Parking & Loading Traffic Signals 4-8/mile Sidewalk	4 lanes 12' each Cross Streets 2-10/mile Continuous No Median, Center Lane, or Median with Turn Bays No Parking, Loading, Off-Street Required Traffic Signals 1-5/mile Discontinuous Sidewalk	2-4 lanes 12-14' each Cross Street <=1/mile Few Median or Turn Bays No Parking, Loading Traffic Signals around 1-2/mile apart No Sidewalk
Surrounding Uses		
No or Limited Setback Building/Land Ratio > 1.5/1.0	20-35' Building Setback Building/Land Ratio = 0.2-1.0/1.0	Large Setback Building/Land Ratio < 0.01/1.0
Speed Limit & Volume		
25-35 mph 25,000 -65,000 V/day	35-50 mph 15,000-55,000 V/day	55 mph 5,000-15,000 V/day

The SRA system is designed as a start point of the arterial candidate evacuation routes set in this study, since the Strategic Regional Arterials (SRA) planning project sponsored by the Illinois Department of Transportation plans to improve the major arterials in the regional level for network throughput in the near future. These SRAs have key attributes for being potential as candidate evacuation routes since the selection criteria of them are similar to the evacuation routes, which are high-volume and long-distance. In addition, these SRAs are designed as a network other than individual corridors, which also provides reliable connectivity and robustness in the case of extreme events.

11.1.1.2. Chicago Candidate Evacuation Route Set

From the existing literatures of evacuation planning and related topics, we have defined four primary criteria, that are mobility, connectivity, interstate connectivity, and interstate reliever, and three other criteria, that are ITS, work zones, and roadside hazards. Considering the first criterion, mobility, similar to the other existing evacuation routes, in this project, the entire Freeway and Expressway systems within Chicago Regional Area are selected as the candidate evacuation corridors. This part of candidate evacuation corridors of Chicago regional area is label as "EVAC_HIGHWAY" in the evacuation routes input file. Then, the arterial part of candidate evacuation routes should be developed to be the supplement and reliever of the highway part of routes. Only if combined both highway part and arterial part of evacuation corridors, the candidate evacuation roadway network is complete. The concept of the Strategic Regional Arterial (SRA) System is employed as the basis of the arterial evacuation corridor selection. Main reason for not developing the total arterial routes ourselves based on selecting criteria that we mentioned before is the lack of time and row data. While, on the other hand, the concept of the Strategic Regional Arterial (SRA) System is applicable for evacuation corridors in that corridors in SRA System have a higher level of mobility than other arterial. Therefore, based on the Strategic Regional Arterial (SRA) System and other criteria, the arterial part of candidate evacuation corridors of Chicago regional area is developed and label as "EVAC_ARTERIAL" in the evacuation routes input file.

Figure 11.2 shows the Chicago candidate evacuation routes set, which includes all the freeway and expressway systems and selected arterials in light of the SRA system in the Chicago Metropolitan Area. The details of the arterial evacuation routes are in Table 11.2. Along these candidate arterial evacuation routes, signal timing plans have been enhanced in light of real world data.

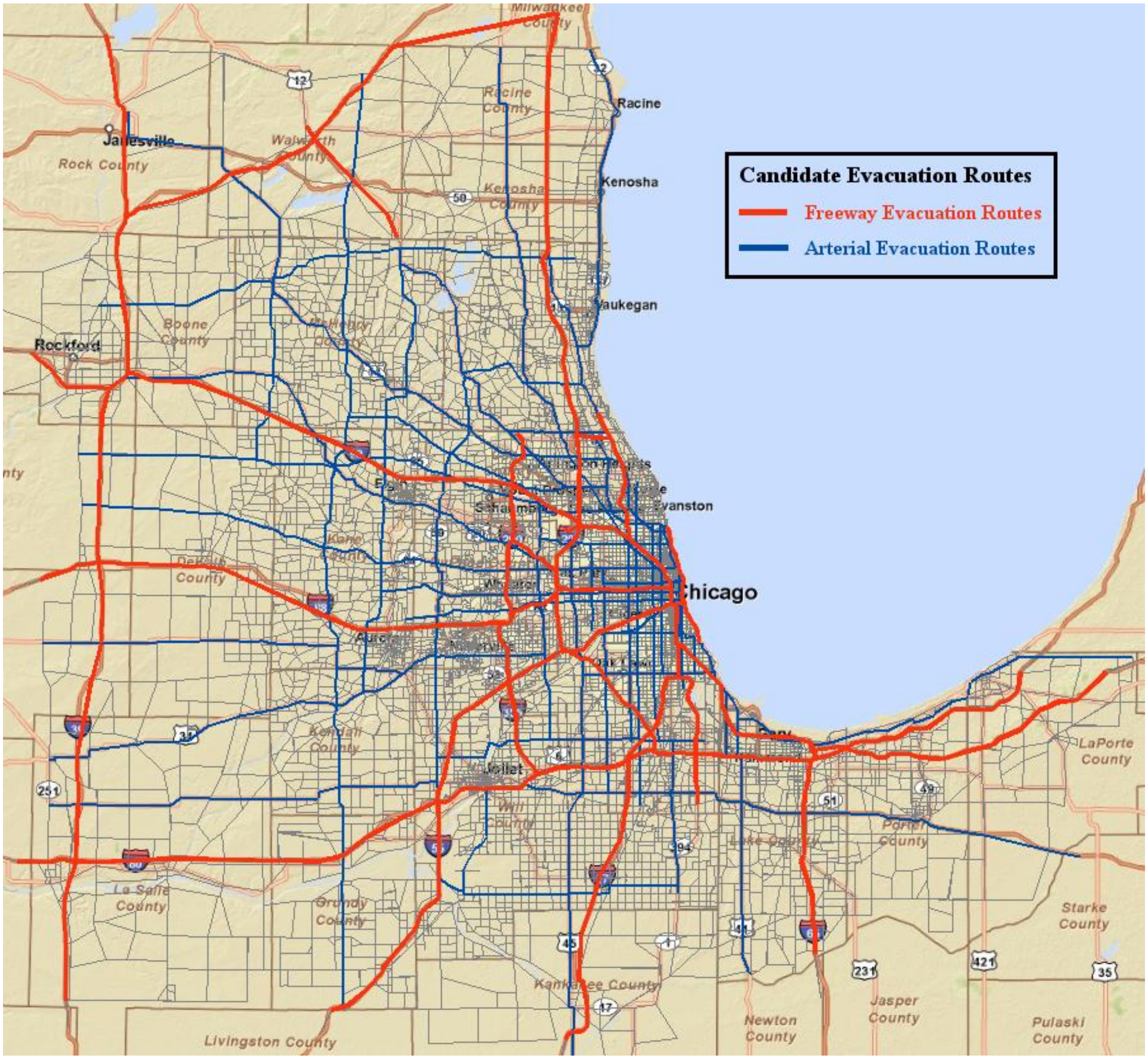


Figure 11.2: Chicago Candidate Evacuation Routes – freeways and arterials

Table 11.2: Arterial Candidate Evacuation Routes Set Table

SRA #	STREET	O-NODE(EAST)	D-NODE(WEST)	NOTES
305	IL-173 from IL-131 to US-14	11806	5577	all route 2-lane
512	IL-60 from US-41 to IL-176	12148	9758	part of route 2-lane
	IL-176 from IL-60 to US-12	9758	8544	
108	Lake Cook Rd. from US-41 to US-12	13029	9789	all route multi-lane

107	Willow Rd. from I-94 to IL-21	13405	11735	part of route 2-lane
	Palatine Rd. from IL-21 to US-12	11735	9864	
211	US-14 from Palatine Rd. to WI&IL line	9864	5656	part of route 2-lane
410	IL-58 from IL-43 to IL-62	13066	10467	part of route 2-lane
	IL-62 from IL-58 to W Algonquin Rd.	10467	7426	
	W Algonquin Rd. from IL-62 to IL-47	7426	6536	
503	Touhy Ave. from I-94 to IL-72	13599	11713	all route multi-lane
	IL-72 from Touhy Ave. to IL-25	11713	7765	
308	US-14 from W Peterson Ave. and N Ridge Ave. to IL-43	14760	13073	all route multi-lane
209	IL-19 (Irving Park Rd.) from US-41 to IL-171	50022	12593	part of route 2-lane
511	IL-19 (Irving Park Rd.) from IL-171 to IL-83	12593	10933	
109	La Salle Dr. from US-14 to IL-64	50009	15568	part of route 2-lane
	IL-64 from La Salle Dr. to W County line Rd.	15568	5634	
501(404)	Roosevelt Rd. (IL-38) from US-14 to Fabyan Parkway	16042	7878	all route multi-lane
	Fabyan Parkway from IL-38 to Randall Rd.	7878	6989	
405	IL-56 from 22nd St. to Kirk Rd.	10567	7567	part of route 2-lane
416	22nd St. (Cermak Rd.) from IL-50 to IL-56	13755	10567	all route multi-lane
408	Midway Plaisance to Payne Dr. to Morgan Dr.	16301	16103	part of route 2-lane
	Garfield Blvd. from Morgan Dr. to 55th St.	16103	14609	
	55th St. from Garfield Blvd. to Archer Ave.	14609	13294	
	Archer Ave. from 55th St. to IL-171	13294	12942	
212	75th St. from IL-83 to US-34	11119	7981	part of route 2-lane
	US-34 from 75th St. to US-30	7981	7480	
	US-30 from US-34 to IL-47	7480	6389	
110	US-12/20 from 106th St. to US-45	16578	12337	all route multi-lane
306(ad)	US-6 from US-83 to US-7	16474	11884	part of route 2-lane
	US-7 from US-6 to Caton Farm Rd.	11884	9243	
	Caton Farm Rd. from US-7 to IL-59	9243	8184	
103	US-30 from Sauk Trail to I-80	16589	10551	part of route 2-lane
406(ad)	Co Hwy 24 from IL-1 to IL-50	16088	13297	part of route 2-lane
	IL-50 from Co Hwy 24 to Peotone/Wilmington Rd.	13297	13227	
	Peotone/Wilmington Rd. from IL-50 to IL-53	13227	8751	
	IL-53 from Peotone/Wilmington Rd. to River Rd.	8751	8747	

	River Rd. from IL-53 to I-55	8747	8279	
202	US-12 from IL-58 to IL-31	11662	7309	part of route 2-lane
CSA 01	Randolph St. from Michigan Ave. to Washington Blvd.	15878	14870	part of route 2-lane
	Washington Blvd. from Randolph St. to IL-43	14870	13008	
CSA 02	Cermak Rd. from King Dr. to IL-50	61461	13755	part of route 2-lane
CSA 03	Archer Ave. from Cermak Rd. to 55th St.	15539	13294	all route multi-lane
109(EX)	IL-64 from W County line Rd. to IL-251	5634	19665	all route 2-lane
CSA 04	IL-173 from US-14 to IL-251	5576	19566	all route 2-lane
103(EX)	US-30 from out to Sauk Trail	1957	16589	part of route 2-lane
SRA #	STREET	O-NODE(NORHT)	D-NODE(SOUTH)	NOTES
502	IL1(HALSTED) From US5(159TH STREET) to 311 th ST	15563	16087	part of route 2-lane
204	US54 From IL19(IRVING PARK)to WILIMINGTON-PEOTONE-RD	11816	11922	part of route 2-lane
508	IL53 From Peotone Road to interstate 80	9314	8751	all route 2-lane
208	Western AV From US41(Clincon Ave) to US5(159th St)	14488	14891	all route 2-lane
509	IL50(Cicero AV)From US41(Clincon Ave)toUS5(159th St)	13664	83062	all route multi-lane
309	Stony Island AV from 67 th St to 95th St	16300	16313	all route multi-lane
302	IL 43(Harlem AV)From IL 64(North AV)to US30(Lioncon Highway)	12982	13213	all route 2-lane
301	IL171(1th AV)From IL19(IRVING PARK ROAD)to Archer Ave	15293	12666	all route 2-lane
304	IL(Busse Road) From IL72(Higging Road)toUS5(159th St)	10846	11325	Include 1 2 3 lanes
302__	IL43(Waukgan Road) From Lake Cook Road to US14(Peterson)	12577	13664	all route 2-lane
201	US41(Skokie Highway) From IL173 to IL50(Townline Road)	11898	12727	all route 2-lane
202	US12(Rand Road) From IL 176 to IL58 (GOLF Road)	7309	11662	part of route 2-lane
105	IL59From IL 176 to Caton Farm Road	8610	8385	Include 1 2 3 lanes
104	IL31 and Randall Road From IL173 to US 34 (Ogden Avenue)	7303	6789	part of route 2-lane
303	IL 47 From IL 173 to IL 71	6490	6362	part of route 2-lane
402	IL 23 From US14 to US 20	5642	5464	route of 1 lanes
505	IL59from IL 62 toIL72	8385	8195	route of 1 lanes
N/A	Ashland from W. Elmdale ave to W 103rd st	14799	15103	all route multi-lane

N/A	Pulasik From Central St to US 30	13920	14204	Include 1 2 3 lanes
N/A	King JR From East Cermak road to East 111th st	13920	16133	Include 1 2 4 lanes
N/A	Wacker from Lake Shore Dr to Congress St	15504	16044	Include 1 2 3 lanes
N/A	Michigan Ave from E Chicago to E 63th St	15888	15972	Include 1 2 3 lanes

11.1.1.3. Chicago Evacuation Candidate Routes Data Preparation Procedure

The input file of the EvacNet.exe is designed as a single file that can recognize the relationship of evacuation corridor and corresponding node/link sequence in order to providing a format for a flexible evacuation route scenario design. The original Link file in TRANSIMS has a bi-directional link format to store the relationships of links and nodes. Links are identified by a field named LINK for each line of data with two nodes that are adjacent to that link are labeled as NODE_A and NODE_B, and corresponding two fields for number of lanes, namely LANES_AB and LANES_BA. This network representation is derived from the static network analysis. However, it does not explicitly indicate the upstream and downstream node of a link. Therefore, it is not easy to implement evacuation operations in a corridor (i.e. a path consists of a sequence of links or nodes). For instance, the only way to find out one link's direction is to check the lane number from A to B or B to A of this link is zero or not, and if it is zero, no traffic can travel on this direction. The original link data format can be shown as an example below.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	LINK	NAME	NODE_A	NODE_B	LENGTH	SETBACK_A	SETBACK_B	BEARING_A	BEARING_B	TYPE	DIVIDED	AREA_TYPE	GRADE	LANES_AB	SPEED_AB	FSPD_AB	CAP_AB	LANES_BA	SPEED
2	19		5001	80509	103	12	12	110	92	FREEWAY	0	8	0	2	135	106	4000	0	
3	21		5002	19524	2719	12	12	291	274	FREEWAY	0	8	0	2	135	115	4000	0	
4	22		5004	80493	334	12	12	177	177	FREEWAY	0	8	0	2	135	111	4000	0	
5	24		5005	19512	3669	12	12	187	204	FREEWAY	0	8	0	2	135	115	4000	0	
6	25		5006	80512	135	12	12	186	187	FREEWAY	0	8	0	2	135	108	4000	0	
7	26		5007	80498	15892	12	12	357	49	FREEWAY	0	8	0	2	135	115	4000	0	
8	28		5009	80516	126	12	12	6	6	FREEWAY	0	8	0	2	135	108	4000	0	
9	31		5010	80496	11104	12	12	7	359	FREEWAY	0	8	0	2	135	115	4000	0	
10	35		5012	80514	110	12	12	271	271	FREEWAY	0	8	0	2	135	104	4000	0	
11	36		5013	19532	3580	12	12	92	91	FREEWAY	0	8	0	2	135	115	4000	0	
12	37		5014	80495	347	12	12	184	182	FREEWAY	0	8	0	2	135	113	4000	0	
13	38		5015	80494	8894	12	12	6	357	FREEWAY	0	8	0	2	135	115	4000	0	
14	44		5018	80497	203	12	12	229	229	FREEWAY	0	8	0	2	135	109	4000	0	
15	46		5019	80506	6966	12	12	49	0	FREEWAY	0	8	0	2	135	115	4000	0	
16	54		5023	80501	222	12	12	181	181	FREEWAY	0	8	0	2	135	111	4000	0	
17	55		5024	80499	286	12	12	181	181	FREEWAY	0	8	0	2	135	112	4000	0	
18	56		5025	80500	7123	12	12	1	1	FREEWAY	0	8	0	2	135	115	4000	0	
19	62		5027	80504	10024	12	12	1	1	FREEWAY	0	8	0	2	135	115	4000	0	
20	64		5029	80503	403	12	12	181	181	FREEWAY	0	8	0	2	135	113	4000	0	
21	66		5030	80812	3395	12	12	260	271	FREEWAY	0	8	0	2	135	115	4000	0	
22	69		5032	80508	121	12	12	80	89	FREEWAY	0	8	0	2	135	109	4000	0	
23	71		5033	81071	6680	12	12	1	1	FREEWAY	0	8	0	2	135	115	4000	0	
24	72		5034	81161	102	12	12	171	164	FREEWAY	0	8	0	2	135	105	4000	0	
25	73		5035	5044	6210	12	12	158	181	FREEWAY	0	8	0	2	135	115	4000	0	
26	74		5036	80502	3086	12	12	350	1	FREEWAY	0	8	0	2	135	115	4000	0	

Figure 11.3: Original Link Data

Since during evacuations, only outbound direction of traffic demand would has a big jump, that means only one direction of the roadway network would be focused. So directions of corridors need to be identified simply. Besides, transportation control operations most deal with intersections so that evacuation operations status should be defines in the input file one-to-one with nodes. Thus, node ID is employed as the ID for each line of data in Evac_Routes file to define the candidate evacuation corridors, and this format can be shown as an example below.

NODE	INLINK	OUTLINK	START	END	ACCESS_POINT	USE	EVAC_PLAN	EVAC_CORRIDOR	EVAC_SEGMENT	EVAC_TYPE	NOTES
19601	21882	21888	12:00	24:00:00	1	ANY	0	20 Westest(WE)	20&WS_20&I39&51(19601-5109)	EVAC_HIGHWAY	
19607	21888	21900	12:00	24:00:00	0	ANY	0	20 Westest(WE)	20&WS_20&I39&51(19601-5109)	EVAC_HIGHWAY	
81060	21900	81638	12:00	24:00:00	0	ANY	0	20 Westest(WE)	20&WS_20&I39&51(19601-5109)	EVAC_HIGHWAY	
19621	81638	21925	12:00	24:00:00	0	ANY	0	20 Westest(WE)	20&WS_20&I39&51(19601-5109)	EVAC_HIGHWAY	
81062	21925	81642	12:00	24:00:00	0	ANY	0	20 Westest(WE)	20&WS_20&I39&51(19601-5109)	EVAC_HIGHWAY	
19637	81642	21951	12:00	24:00:00	0	ANY	0	20 Westest(WE)	20&WS_20&I39&51(19601-5109)	EVAC_HIGHWAY	
81066	21951	81650	12:00	24:00:00	0	ANY	0	20 Westest(WE)	20&WS_20&I39&51(19601-5109)	EVAC_HIGHWAY	
81068	81650	81654	12:00	24:00:00	0	ANY	0	20 Westest(WE)	20&WS_20&I39&51(19601-5109)	EVAC_HIGHWAY	
19638	81654	21953	12:00	24:00:00	0	ANY	0	20 Westest(WE)	20&WS_20&I39&51(19601-5109)	EVAC_HIGHWAY	
19636	21953	21949	12:00	24:00:00	0	ANY	0	20 Westest(WE)	20&WS_20&I39&51(19601-5109)	EVAC_HIGHWAY	
81065	21949	81647	12:00	24:00:00	0	ANY	0	20 Westest(WE)	20&WS_20&I39&51(19601-5109)	EVAC_HIGHWAY	
5109	81647	191	12:00	24:00:00	0	ANY	0	20 Westest(WE)	20&WS_20&I39&51(19601-5109)	EVAC_HIGHWAY	
5109	81647	192	12:00	24:00:00	1	ANY	0	20 Westest(WE)	I39&20_I90&51(5109-5117)	EVAC_HIGHWAY	
19250	192	21467	12:00	24:00:00	0	ANY	0	20 Westest(WE)	I39&20_I90&51(5109-5117)	EVAC_HIGHWAY	
50047	4	35077	12:00	24:00:00	1	ANY	0	I39(NS)	I90&I39&LD_I90&I43&I39(50047-83709)	EVAC_HIGHWAY	
50075	35077	35108	12:00	24:00:00	0	ANY	0	I39(NS)	I90&I39&LD_I90&I43&I39(50047-83709)	EVAC_HIGHWAY	
5050	35108	97	12:00	24:00:00	0	ANY	0	I39(NS)	I90&I39&LD_I90&I43&I39(50047-83709)	EVAC_HIGHWAY	
5063	97	118	12:00	24:00:00	0	ANY	0	I39(NS)	I90&I39&LD_I90&I43&I39(50047-83709)	EVAC_HIGHWAY	
50078	118	35113	12:00	24:00:00	0	ANY	0	I39(NS)	I90&I39&LD_I90&I43&I39(50047-83709)	EVAC_HIGHWAY	
5064	35113	119	12:00	24:00:00	0	ANY	0	I39(NS)	I90&I39&LD_I90&I43&I39(50047-83709)	EVAC_HIGHWAY	
5068	119	126	12:00	24:00:00	0	ANY	0	I39(NS)	I90&I39&LD_I90&I43&I39(50047-83709)	EVAC_HIGHWAY	
5069	126	127	12:00	24:00:00	0	ANY	0	I39(NS)	I90&I39&LD_I90&I43&I39(50047-83709)	EVAC_HIGHWAY	
5073	127	133	12:00	24:00:00	0	ANY	0	I39(NS)	I90&I39&LD_I90&I43&I39(50047-83709)	EVAC_HIGHWAY	
50088	133	35126	12:00	24:00:00	0	ANY	0	I39(NS)	I90&I39&LD_I90&I43&I39(50047-83709)	EVAC_HIGHWAY	
50087	35126	35125	12:00	24:00:00	0	ANY	0	I39(NS)	I90&I39&LD_I90&I43&I39(50047-83709)	EVAC_HIGHWAY	

Figure 11.4: Evac_Routes Data

11.1.1.3.1. Network Selection from Shape File

To select the Chicago regional area evacuation candidate routes, or in other words, to create the Evac_Routes input file, the primary task is to pick out the links that belongs to the selected candidate routes from original Link shape file manually. For most of links in original Link file we had of Chicago regional area, there is no street name information available, so manually select is the only way in this case. To do so, Geographic Information System software Esri ArcGIS is employed. From the attribute table of the selected network, link data can be exported and opened in Excel.

11.1.1.3.2. Data Format Conversion and Sorting

After picking out links data of evacuation corridors from the original Link shape file, what we have so far is disordering link data in original data format. Therefore, a data format conversion from link related to node related and data sorting by direction should be done. As the project progresses, several versions of Evac_Routes file are developed. In the very beginning, the first version is prepared and checked corridor-by-corridor manually by using MS Excel. First, for the corridor we are dealing with, find out the starting link of the corridor and put this link ID in the first cell of line of a new sheet. Second, put the tail node and head node ID of this link next. Then, do the same until we finish this corridor. An example is shown below.

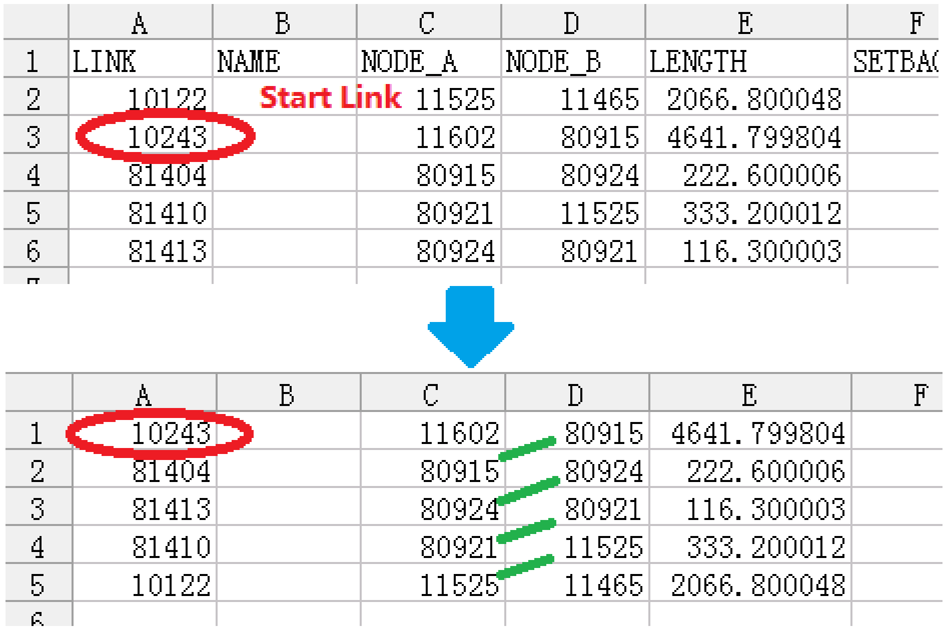


Figure 11.5: Link Data Sorting

We have sorted the data by link, while as the last step of work, link sorted format should be converted to node based format. INLINK of the first node and OUTLINK of the last node would be complete. This can be shown in below.

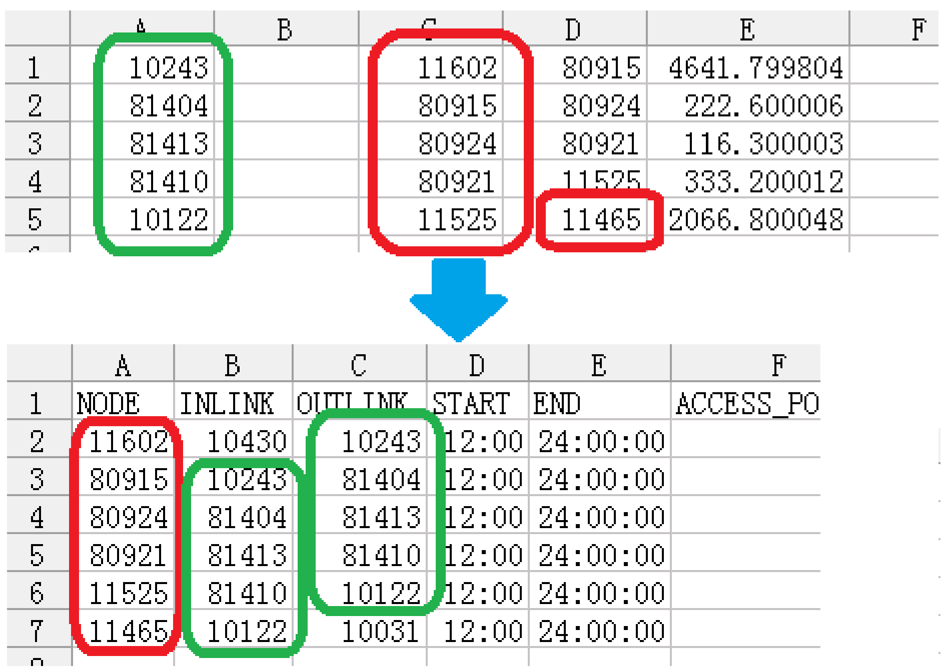


Figure 11.6: Link Base Data to Node Base Data

When finishing data conversion and sorting for all selected candidate corridor in separate sheet, the Evac_Routes input file can be created by join all sheet in one.

11.2. EvacNet

11.2.1. Structure of EvacNet

The EvacNet.exe is designed to include the following features turn prohibition, lane use restriction, evacuation route definition, and signal retiming specification. As a result, the EvacNet includes four main functions: Evac_Lane_Use, Evac_Turn_Penalty, Evac_Routes, and Evac_Area_Lane_Restriction. Evac_Lane_Use is designed to change a set of user specified lane use restrictions during evacuation period. Evac_Turn_Penalty is designed to change a set of user specified turn penalties during evacuation period. Evac_Routes is the core functions of the EvacNet tool, which is designed to change the turn prohibitions, signal timing plans, and phasing plans along a user specified evacuation corridor. Evac_Area_Lane_Restriction is designed to change the lane user restrictions in the emergency event sites in light of different risk levels. The module files of the EvacNet is shown in Table 11.3. And program controls and execution procedure is shown in Table 11.4.

Table 11.3: Module files

Module	Evac_Lane_Use	Evac_Turn_Pentalty	Evac_Routes	Evac_Area_Lane_Restriction
Data Class	Evac_Lane_Use_Data.hpp	Evac_Turn_Penalty_Data.hpp	Evac_Routes_Data.hpp	Evac_Zone_Data.hpp Evac_Response_Data.hpp
File Class	Evac_Lane_Use_File.hpp	Evac_Turn_Penalty_File.hpp	Evac_Routes_File.hpp	Evac_Zone_File.hpp Evac_Response_File.hpp
File implementation	Evac_Lane_Use_File.cpp	Evac_Turn_Penalty_File.cpp	Evac_Routes_File.cpp	Evac_Zone_Data.cpp Evac_Zone_File.cpp Evac_Response_File.cpp
Read function	Read_Evac_Lane_Use.cpp	Read_Evac_Turn_Penalty.cpp	Read_Evac_Routes.cpp	Read_Evac_Data.cpp

Table 11.4: Program controls and execution procedure

Module	File	Notes
Execution Class	EvacNet.hpp	EvacNet execution class definition
Evacuation Control	EvacNet.cpp	Process the evacuation control parameters
Program Control	Control.cpp	process the control parameters

Execution Implementation	Execute.cpp	main execution procedure

Algorithmic Procedures of these functions are as in the following.

11.2.1.1. Evacuation Lane Use Plan Definition Procedure (Evac_Lane_Use):

- **Step 1**: Read evac_lane_use table to evac_lane_use_array.
- **Step 2**: For an evac_lane_use_data in evac_lane_use_array.
- **Step 2.1** Find this lane data in the lane_use_array.
- **Step 2.2** Change the lane_use_data in the lane_use_array.
- **Step 3**. If it reaches the end of evac_lane_array, then output lane_use file and stop, else go to step 2.

11.2.1.2. Evacuation Route Plan Definition Procedure (Evac_Turn_Penalty):

- **Step 1**: Read evac_turn_penalty table to evac_turn_penalty_array.
- **Step 2**: For an evac_turn_penalty _data in evac_turn_penalty_array.
- **Step 2.1**: Find this turn penalty data in the turn_penalty_array.
- **Step 2.2:** Change the turn_penalty_data in the turn_penalty_array
- **Step 3**. If it reaches the end of evac_turn_penalty_array, then output files of turn_penalty and stop, else go to step 2.

11.2.1.3. Evacuation Route Plan Definition Procedure (Evac_Routes):

- **Step 1**: Read evac_route table to evac_route_array.
- **Step 2**: For an evac_route_data in evac_route_array.
- **Step 2.1** If evac_route_data.evac_plan_flag == 0, then go to Step 2; else go to Step 2.2.
- **Step 2.2** If evac_route_data.node_access == 0, then go to Step 2.3, else go to Step 2.
- **Step 2.3** If evac_route_data.node is a signal node, then change signal timing and phases that includes movements from evac_route_data.inlink to evac_route_data.outlink to full green, and other movements to all red. In the meantime, a prohibition for those movements with red signal timing is also defined for router to find a correct route. This step will change signal_array, timing_plan_array, phasing_plan_array, and turn_penalty_array.
- **Step 2.4** If evac_route_data.node is a non-signal node, then turn prohibitions will apply to all other movements that have conflict to the movement from evac_route_data.inlink to evac_route_data.outlink. This step will change the turn_penalty_array.
- **Step 3**. If it reaches the end of evac_route_array, then output files of signal, timing_plan, phasing_plan, and turn_penalty and stop, else go to step 2.

11.2.1.4. Evacuation Area Lane Restriction Plan Definition Procedure (Evac_Area_Lane_Restriction):

- **Step 1**: Read Response File.
- **Step 2**: Read Evacuation Zone File

- **Step 3**: Read Zone Boundary File
- **Step 4**: Find closed links using the coordinate of the boundary information of evacuation zones and links and feed these links into the evac_lane_use array.
- **Step 5**: For an evac_lane_use_data in evac_lane_use_array.
- **Step 5.1** Find this lane data in the lane_use_array.
- **Step 5.2** Change the lane_use_data in the lane_use_array.
- **Step 6**. If it reaches the end of evac_lane_array, then output lane_use file and stop, else go to step 5.

11.2.2. Signal redefining in Evac_Routes

The Evac_Route procedure considers signal timing and phasing plan redefining for managed intersections. The signal redefining problem is to update signal timing and phasing plans for intersections with prohibited turns under evacuation situations. The current method is to add a new timing plan with new green time allocation for evacuation periods, and new phasing plan with new phase definition that only includes evac_route movements for evacuation periods. The signal redefining strategies are as follows.

- *Intersections between evacuation routes and non-evacuation routes*: adding a new phasing plan and timing plan with one phase to allow both directions of movement along evacuation routes.
- *Intersections between two evacuation routes*: adding a new phasing plan and timing plan with two phases to allow movements along both directions of each evacuation route, and redefining green, yellow, and all-red times for each phase (currently, we give the same green time to each evacuation route).

An example for signal redefining of an intersection between evacuation route and non-evacuation route is showed in Figure 11.7. In this case, EvacNet will add a new timing plan 6 with all green to the evac_route and a new phasing plan 6 with one phase that only allows movements along evac_route during evacuation period 18:00pm – 24:00pm. Currently, the signal redefining function is under testing using TRANSIMS simulator.

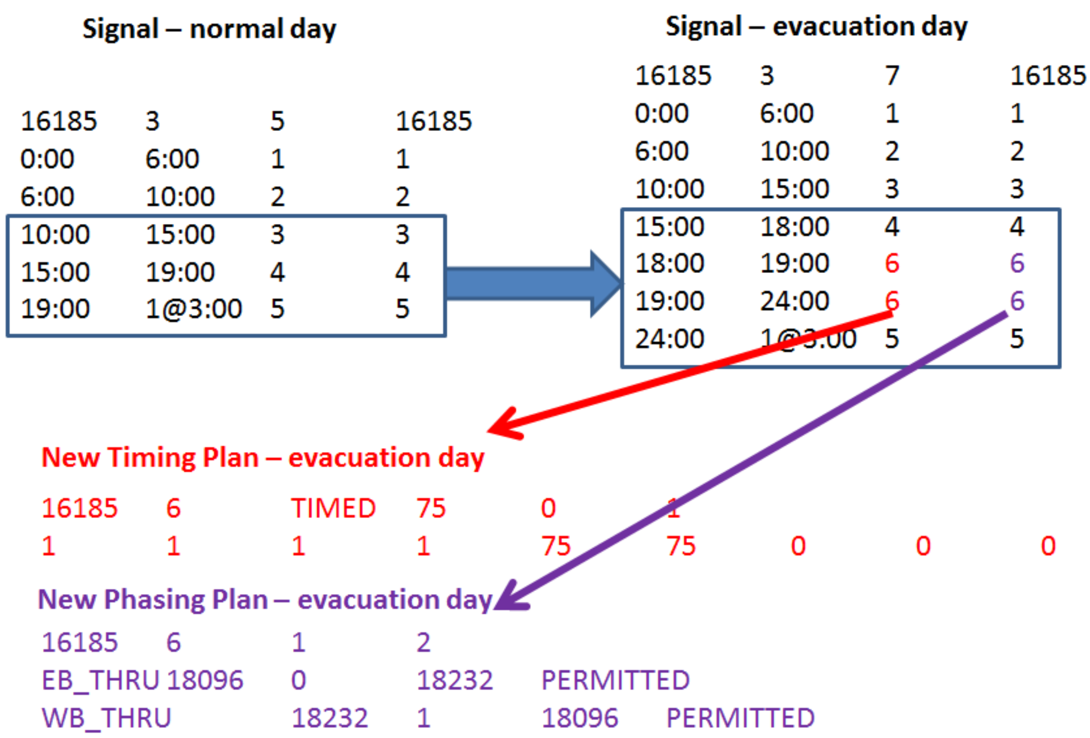


Figure 11.7: Example of signal redefining at an intersection between evacuation route and non-evacuation route

11.2.3. Inputs and Outputs of EvacNet

Based on the control file of the EvacNet, there are two categories of input files to EvacNet: normal day network and evacuation related files. The normal day network files are detailed in the TRANSIMS software tool. The evacuation demand and zone files are detailed in the EvacDemand software tool. This section only presents three input files of EvacNet, namely Evac_Route in Table 11.5, Evac_Turn_Penalty in Table 11.6, and Evac_Lane_Use in Table 11.7.

Table 11.5: Evac_Route file

Evac_Route_File		Network Evacuation Route File Class	
Field Name	**Data Type**	**Description**	**Units**
NODE	Integer (10)	Node ID number	
INLINK	Integer (10)	Inbound Link ID number	
OUTLINK	Integer (10)	Outbound Link ID number	
START	Time(16)	Start time of the use restriction	Time Code
END	Time(16)	End time of the use restriction	Time Code
USE	Text (128)	List of vehicle types permitted on the turn	Use Code
ACCESS_POINT	Integer(2)	Accessibility for other inbound and outbound links	0 no; 1 yes.
EVAC_PLAN	Integer(2)	Availability for the evacuation plan	0 no; 1 yes.
EVAC_CORRIDOR	Text(64)	Corridor name	
EVAC_SEGMENT	Text(64)	Segment name	
EVAC_TYPE	Text(16)	corridor type, Highway or Arterial	
NOTES	Text (128)	A character string for user annotations	

Table 11.6: Evac_Turn_Penalty File

Evac_Turn_Penalty_File		Network Evacuation Turning Penalty File Class	
Field Name	**Data Type**	**Description**	**Units**
LINK	Integer (10)	Link ID number of the approach link	
DIR	Integer (1)	Link direction code (0 = AB, 1 = BA)	
TO_LINK	Integer (10)	Link ID number of the destination link	
START	Time(16)	Start time of the trip	Time Code
END	Time(16)	End time of the trip	Time Code
USE	Text (128)	List of vehicle types permitted on the turn	Use Code
PENALTY	Integer (5)	Delay for making the turn	Impedance
NOTES	Text (128)	A character string for user annotations	

Table 11.7: Evac_Lane_Use File

Evac_Lane_Use_File		Network Evacuation Lane Use File Class	
Field Name	**Data Type**	**Description**	**Units**
LINK	Integer (10)	Link ID number	
DIR	Integer (1)	Link direction code (0 = AB, 1 = BA)	
LANES	Integer (8)	Lane code or range of lane codes (e.g., 2..L)	Lane Range Code
TYPE	Text (12)	Lane use restriction type	Restrict Code
USE	Text (128)	List of vehicle types permitted on the lanes	Use Code
START	Time(16)	Start time of the use restriction	Time Code
END	Time(16)	End time of the use restriction	Time Code
LENGTH	Decimal (8.1)	Length of the lane-use restriction	Feet (Meters)
OFFSET	Decimal (8.1)	Starting offset from the beginning of link	Feet (Meters)
TOLL	Integer (5)	Toll cost	Cents
FIXED	Decimal (8.1)	Fixed time delay per vehicle	Seconds
VARIABLE	Decimal (8.1)	Variable/random time delay per vehicle	Seconds
NOTES	Text (128)	A character string for user annotations	

11.3. Software Quick Reference and How To's

11.3.1. Keys in EvacNet.ctl

The keys in EvacNet.ctl define parameters, inputs, and outputs of EvacNet. These keys can be grouped in five categories in Table 11.8 that includes general keys, input file keys, evacuation file keys, output file keys, and projection file keys. The general keys define project directory and units of measure. The input file keys define input file directories. The evacuation file keys define the evacuation network scenario definition input file locations. The output file keys define the evacuation network scenario output file locations. And the projection file keys define the coordinate system for closing links in the evacuation areas.

Table 11.8: Keys in EvacNet.ctl

KEY	Descriptions
#---- General keys ----	
TITLE	Project time
PROJECT_DIRECTORY	Project directory
UNITS_OF_MEASURE	Unit of measure, e.g. METRIC
#---- Input File Keys ----	
NODE_FILE	Node file
LINK_FILE	Link file
SHAPE_FILE	Shape file
CONNECTION_FILE	Connection file
LOCATION_FILE	Location file
ZONE_FILE	Zone file
PARKING_FILE	Parking file
ACCESS_FILE	Access file
POCKET_FILE	Pocket file
DETECTOR_FILE	Detector file
LANE_USE_FILE	Lane use file
TURN_PENALTY_FILE	Turn penalty file
SIGNAL_FILE	Signal file
SIGN_FILE	Sign file
PHASING_PLAN_FILE	Phasing plan file
TIMING_PLAN_FILE	Timing plan file
VEHICLE_TYPE_FILE	Vehicle type file
#--- Evacuation File Keys ----	
EVAC_ROUTES_FILE	Evacuation route scenario file
EVAC_TURN_PENALTY_FILE	Evacuation turn penalty file
EVAC_LANE_USE_FILE	Evacuation lane use file
EVAC_ZONE_FILE	Evacuation zone file
EVAC_SHELTER_FILE	Evacuation shelter file
EVAC_RESPONSE_FILE	Evacuation response level file
ZONE_INFO_FILE	Zone information file
ZONE_BOUNDARY_FILE	Zone boundary file
ZONE_FIELD_NAME	Zone field name
#---- Output File Keys ----	
NEW_SIGN_FILE	Evacuation sign output file
NEW_SIGNAL_FILE	Evacuation signal output file
NEW_PHASING_PLAN_FILE	Evacuation phasing plan output file
NEW_TIMING_PLAN_FILE	Evacuation timing plan output file
NEW_LANE_USE_FILE	Evacuation lane use output file
NEW_TURN_PENALTY_FILE	Evacuation turn penalty output file
NEW_CLOSED_LINK_FILE_NAME	Evacuation closed link output file
#---- Projection File keys ----	
INPUT_COORDINATE_SYSTEM	Input coordinate system, e.g. STATEPLANE, 1201, FEET
INPUT_COORDINATE_ADJUSTMENT	Input coordinate adjustment, e.g. 0.0, 0.0, 1.0, 1.0
OUTPUT_COORDINATE_SYSTEM	Output coordinate system, e.g. UTM, 16N, METERS
OUTPUT_COORDINATE_ADJUSTMENT	Output coordinate adjustment, e.g. 0.0, 0.0, 10.0, 10.0

11.3.2. Defining Evacuation Scenarios

11.3.2.1. Manually Defining Scenario

To create a scenario based on the ***Evac_Routes*** input form and GIS tool, the following steps and preparations are needed. Here, Microsoft Excel and ESRI Arcmap are employed as the data processing tool and GIS platform.

STEP 1 Preparation

In this case, it is assumed that information of hazardous event impact area, shelters location, and evacuation corridors needed for this scenario has already been provided or decided. Therefore, planner can find out the information like Link or Node ID that they need during processes by using GIS tool.

In addition, a default Evac_Routes input file is needed with values in field EVAC_PLAN and field ACCESS_POINT equal to 0 as initialization.

STEP 2 Define Evacuation Routes

For each evacuation route needed to be defined in the ***Evac_Routes*** file, go to Arcmap, join the ***Evac_Routes*** table with ***Link.shp*** by INLINK field and LINK field, and then use "Selection By Attributes" to highlight the candidate evacuation routes. After that, use Identify function key on the end-links of the evacuation route to figure out the EVAC_CORRIDOR, EVAC_SEGMENT, and NODE ID of the two end-nodes.

Go to Excel, the ***Evac_Routes*** input form. Filter the form by EVAC_CORRIDOR, and locate the two end-nodes of the evacuation route by NODE ID with the help of EVAC_SEGMENT. Change the values of EVAC_PLAN of all nodes between and including the two end-nodes to 1.

The following figures show the processes of Step 2.

STEP 3 Define Accessibility

For all intersections on evacuation routes, default evacuation operation in EvacNet.exe suppose that the evacuation routes would not allow the non-evacuees access when evacuation is under way.

Thus, if for some reasons, some nodes on the evacuation routes are required to with accessibility for non-evacuees as in normal situation, values of ACCESS_POINT of these nodes should be manually changed to 1.

To do so, similar to processes in step 2, figure out the NODE ID and other information if needed of these nodes by the Identify function key in Arcmap. Then go to Excel, change the values of ACCESS_POINT of these nodes to 1, as shown below.

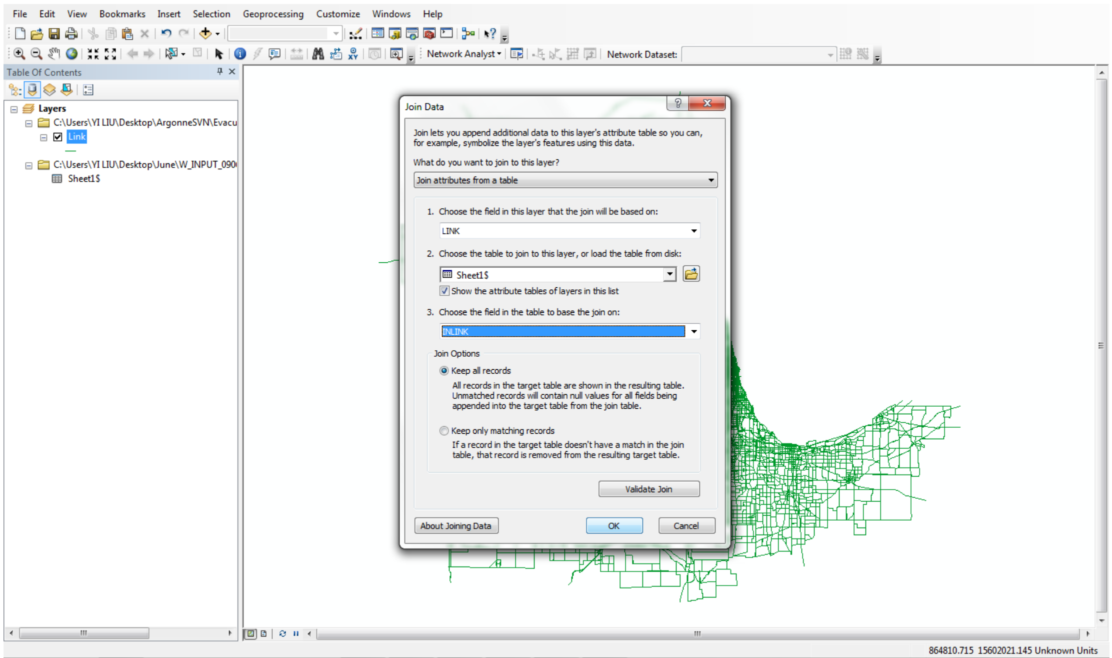


Figure 11.8: Join Data

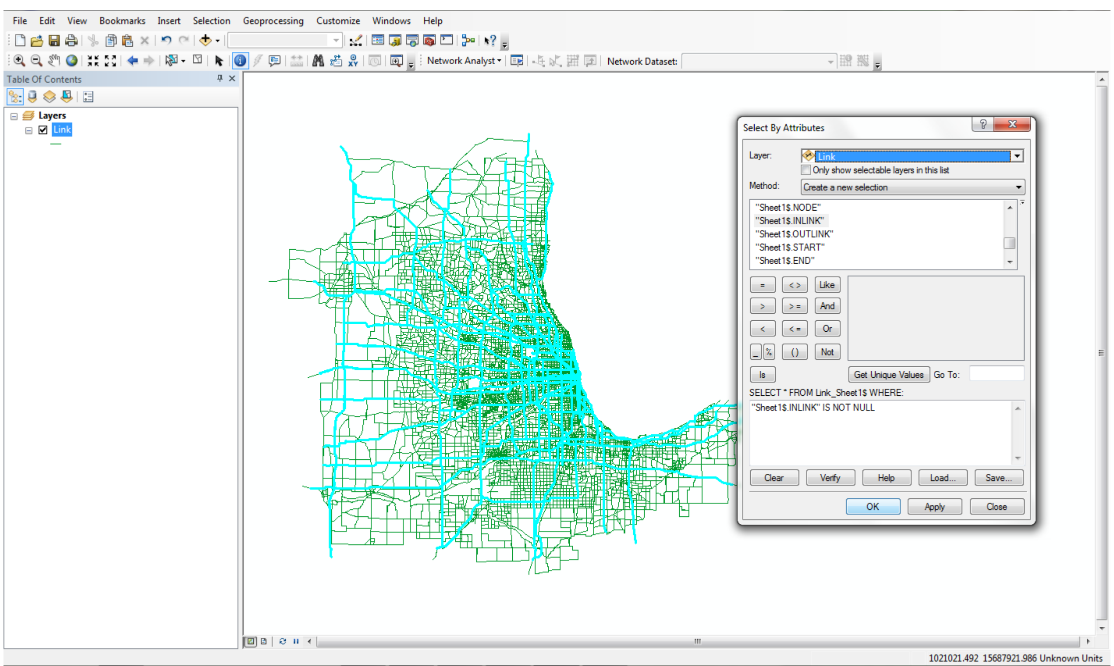


Figure 11.9: Highlight Candidate Corridors

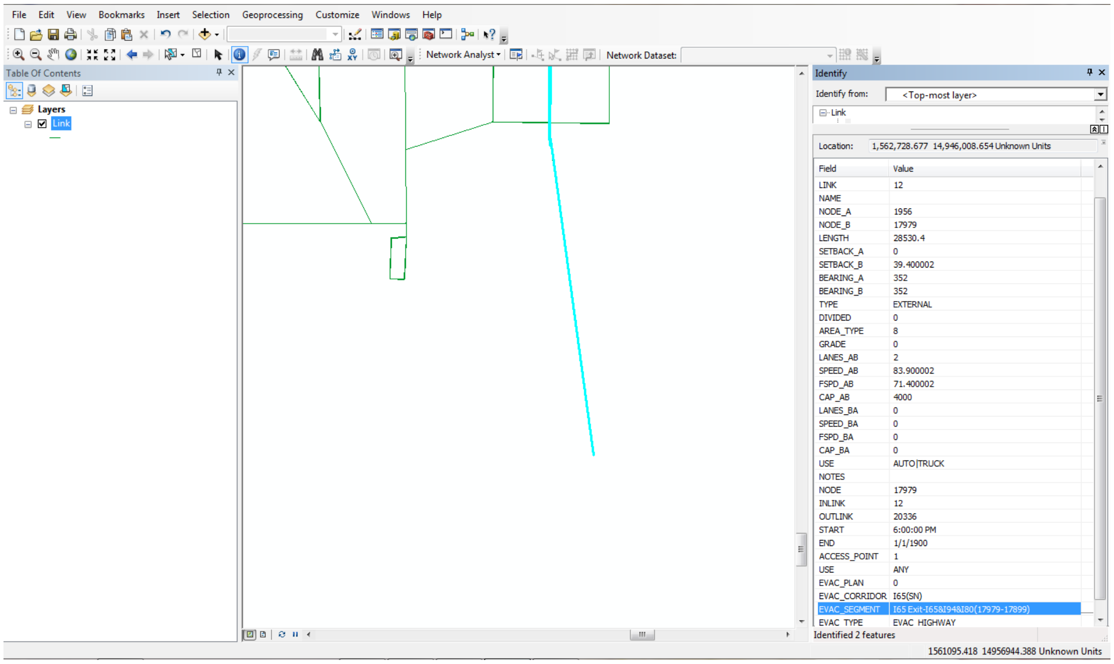


Figure 11.10: Identify End-Link and End Node

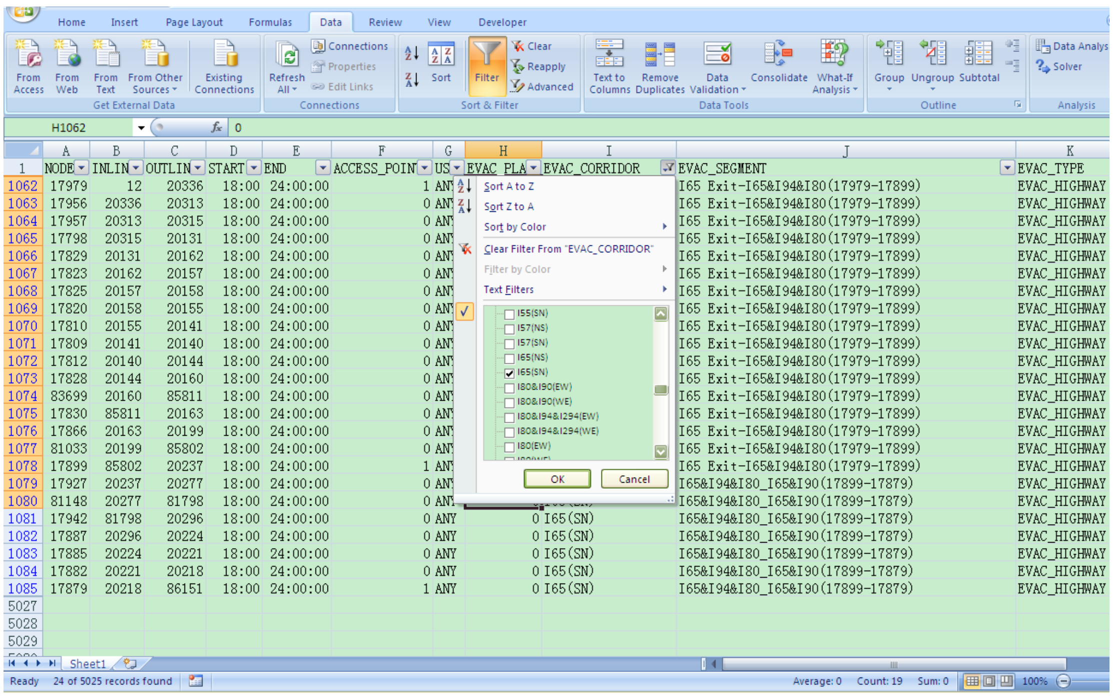


Figure 11.11: Filter a Corridor

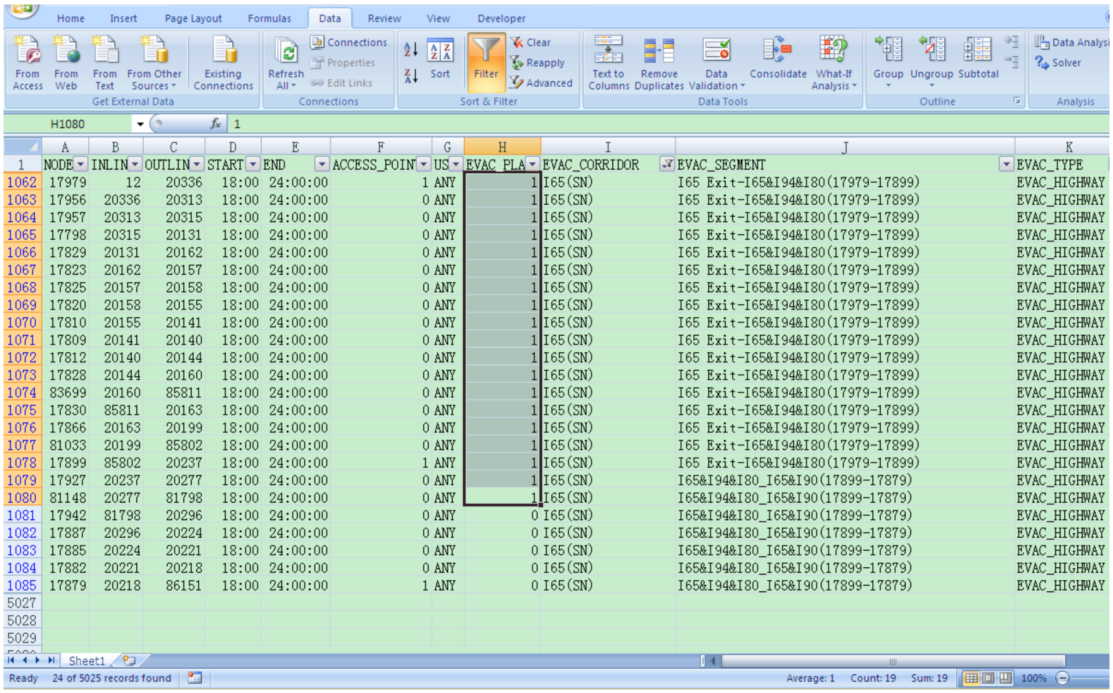


Figure 11.12: Change values of EVAC_PLAN

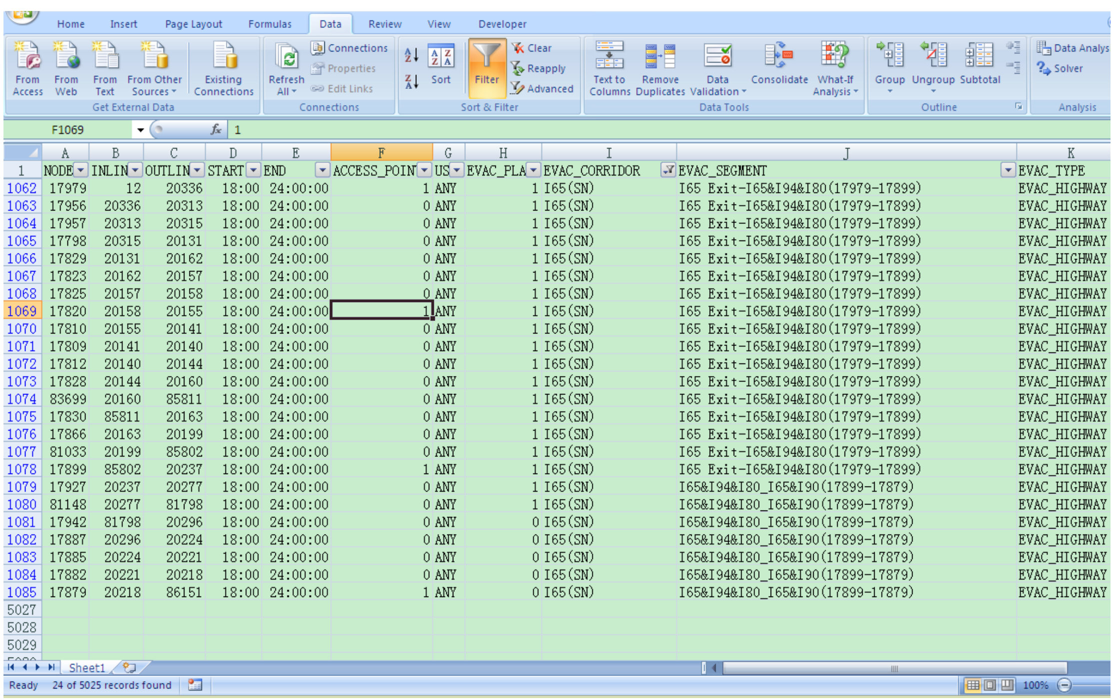


Figure 11.13: Change values of ACCESS_POINT

A sample scenario using the manually defining method is shown as follows. The figure below shows an arterial and highway evacuation routes plan for a high evacuation scenario, and corresponding covered shelters, fire stations, hospitals, and schools are shown in the table below. This definition will provide an input file for evac_route, which can be taken by EvacNet.exe.

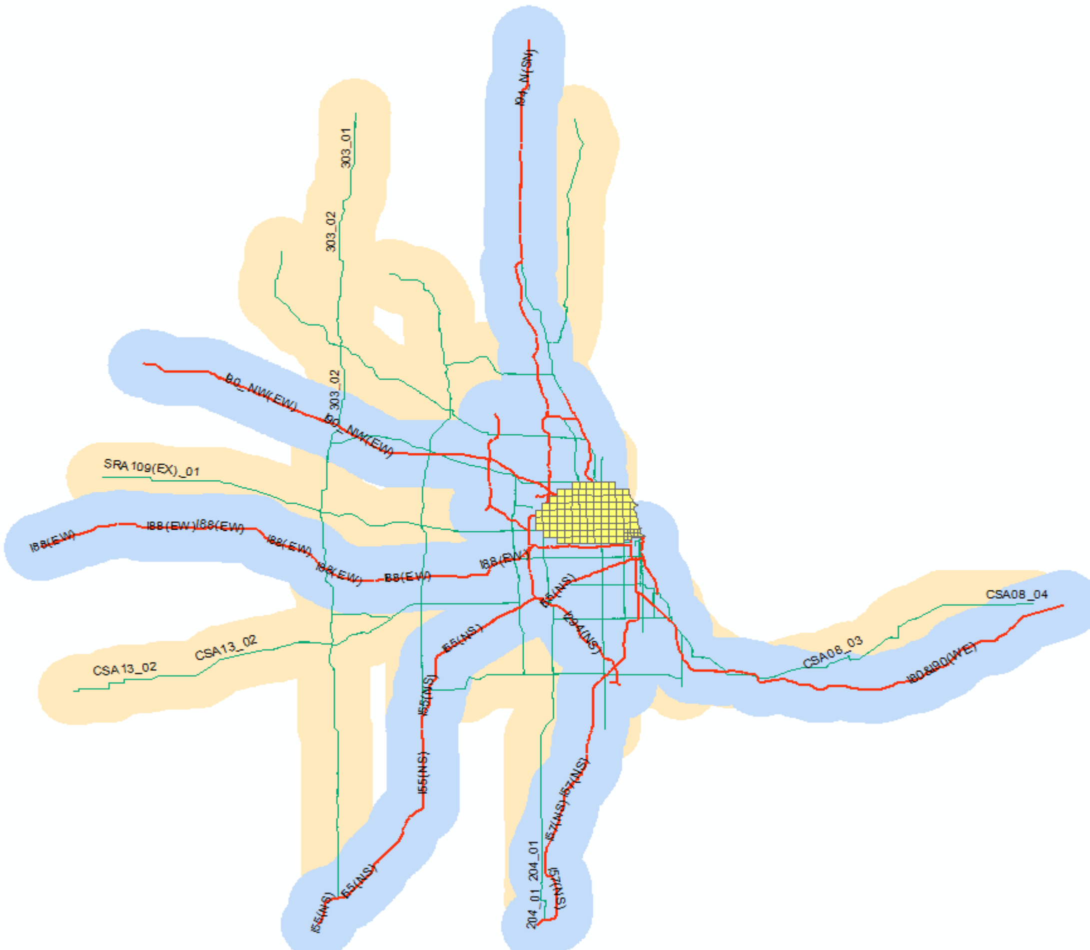


Figure 11.14: Arterial & Highway Evacuation Routes Plan for High Evacuation Scenario

Table 11.9: Arterial & Highway Evacuation Routes Plan for High Demand Scenario

Facility	# Covered	# of Total	% of Total
Shelter	75.00	89.00	84.27
Fire Station	92.00	92.00	100.00
Hospital	101.00	102.00	99.02
School	3423.00	3514.00	97.41

11.3.2.2. Using TransimVis GUI to Design Evacuation Route Plan

Candidate evacuation route set is also integrated into the TransimVis GUI. Users also can use TransimVis to design evacuation route plan. In the Configuration mode of TransimVis, e.g. VISUALIZER_MODE = CONFIGURATION, users can use mouse click to select evacuation routes, trim evacuation corridors, and define access points. This description of TransimVis Evacuation Menu Secion is detailed in the TransimVis Manual. We present a sequence of steps here by highlighting an evacuation route plan design process in the following.

STEP 1 Defining Evacuation Areas

This step is to define a set of a set of evacuation areas with different levels of risk. Users can use mouse to define evacuation areas and specify parameters.

STEP 2 Defining Evacuation Shelters

This step is to define a set of evacuation shelters that serve for the evacuation areas. Users can use mouse to click the map and create shelters.

STEP 3 Defining Evacuation Routes

This step is to define a set of evacuation routes based on the location of evacuation areas, shelters, and candidate evacuation routes. Users can also use mouse to change state of an access point. After the Adding Evacuation Route Button is clicked, users can add evacuation routes to the evacuation route scenario. Users can also define corresponding attributes for the selected evacuation route using mouse. By clicking the Editing Evacuation Route Button, users can trim the selected evacuation route, which is shown on the right, where colored links are used to distinguish different links along the evacuation route; by clicking the Editing Critical Intersection Button, users can add/delete a critical intersession along the selected evacuation route, which is shown in on the right, where the green nodes are critical intersections and red nodes are managed intersections.

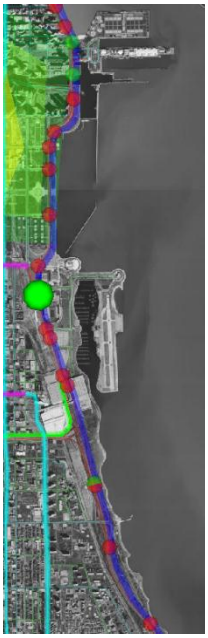


Figure 11.16: Editing Critical Intersection Mode

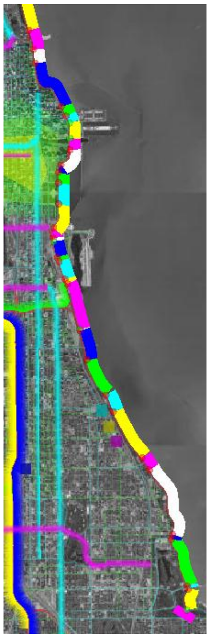


Figure 11.15: Editing Evacuation Route Mode

STEP 4 Defining Evacuation Dispersion Area

This step is to define a dispersion area in the map.

STEP 5 Defining Evacuation Start Time and Scenario Saving

This step is to define evacuation start time and save scenario definitions to EvacNet.ctl, Evac_Responses, Evac_Shelters, Evac_Zones, and evac_routes_selected files.

EvacNet.exe can take these input files and produce an evacuation network by restricting lane usages in the evacuation areas and managing access points along evacuation corridors through prohibiting turns and signal retiming and phasing redesigning.

12. Network Editing and Model Development

In the month of July, the focus was on developing the average day plan file and the link delay file for the refined network. The refinement and extension of the existing road includes rectifying one-way links directions, editing light rail links, and updating lane use file.

12.1. Network Refinement

In the TRANSIMS network, many one-way links were found with incorrect directions. These were mostly ramp links. All the attributes of those links in AB directions were changed to BA directions, and vice versa. Some other links were edited because of incorrect intersection connections. To simply rectify this type of error (instead of redrawing link in TransimsEDT), changing ANODE or BNODE of the link to the right node was the better option. There are some links that had offline shape points according to ArcView shape file; these were edited by removing those shape points. Some links were intersected with a very small angle causing missing connections for the intersection; these were reshaped properly. Toll links were categorized in CASH and IPASS in notes attribute of link table. Table 9.1 presents the list of the edited links IDs.

Table 12.1: Editing Link List

Links	Notes
10618	Link with wrong direction
10605	Link with wrong direction
10574	Link with wrong direction
86011	Link with wrong direction
86010	Link with wrong direction
85996	Link with wrong direction
85994	Link with wrong direction
10626	Link with wrong direction
81954	Link with wrong direction
81953	Link with wrong direction
7540	Link with wrong direction
7523	Link with wrong direction
9184	Link with wrong direction
9238	Link with wrong direction
9152	Link with wrong direction
12567	Link with wrong direction
85618	Link with wrong direction
81537	Link with wrong direction
13572	Link with wrong direction
13470	Link with wrong direction
85171	Link with wrong direction
11827	Link with wrong direction
85934	Link with wrong direction
18314	Wrong connection, change ANODE to 16336

18485	Wrong connection, change ANODE to 83596
86111	Link with wrong shapes
86113	Link with wrong shapes
4981	Link with wrong shapes
11078	CASH toll
15694	CASH toll
85850	CASH toll
85950	Type is OTHER, IPASS toll
85953	IPASS toll

12.2. Lane Use Update

The reversible Kennedy Expressway generally switches directions twice a day Monday through Friday. It is switched from inbound to outbound sometime between 11:00 am and 1:00 pm, and switched back from outbound to inbound sometime between 11:00 pm and 1:00 am. The switch time varies according to traffic congestion, major incidents or accidents, maintenance activities, and storm alerts etc. Additional switches for weekends and holidays may happen during the day. In TRANSIMS modeling, the reversible expressway is expressed as several 4-lane two-way links in the middle and 2-lane two-way links in the inbound and outbound. There are also 1-lane one-way on-ramp and off-ramp links in some access points and inbound and outbound as shown in Figure 9.1.

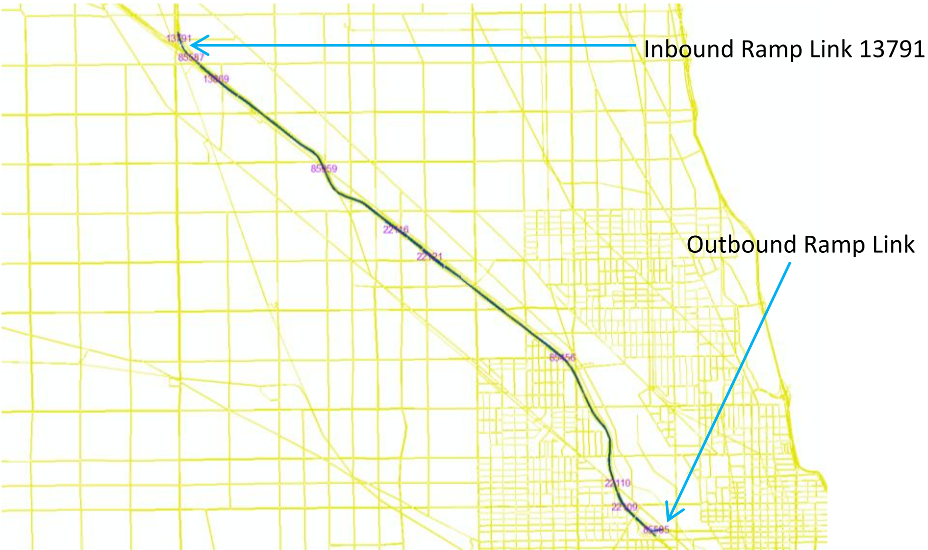


Figure 12.1: Reversible Kennedy Expressway in ArcGIS

Lane use file is utilized to define the restricted use directions of the reversible links as Table 9.2 indicated. As seen in the table, one hour (between 11:30AM to 12:30PM) time gap is adopted which means vehicles already on the reversible way have one hour time to drive out before the switch starts.

Table 12.2: Lane Use Table for Reversible Kennedy Expressway

LINK	Dir	LANES	TYPE	USE	MIN_ TYPE	MAX_ TYPE	START	END	LENG TH	OFFSET	TOLL	TOLL_ RATE	MIN_D ELAY	MAX_D ELAY
13791	0	0	PROHIBIT	ANY			11:30:00	1@3:00	0	0	0	0	0	0
85585	0	0	PROHIBIT	ANY			0:00:00	12:30:00	0	0	0	0	0	0
85588	0	0	PROHIBIT	ANY			0:00:00	12:30:00	0	0	0	0	0	0
85587	0	0	PROHIBIT	ANY			12:30:00	1@3:00	0	0	0	0	0	0
85587	0	0	PROHIBIT	ANY			11:30:00	12:30:00	0	0	0	0	0	0
85587	1	0	PROHIBIT	ANY			11:30:00	12:30:00	0	0	0	0	0	0
85587	1	0	PROHIBIT	ANY			0:00:00	11:30:00	0	0	0	0	0	0
13734	0	0	PROHIBIT	ANY			11:30:00	1@3:00	0	0	0	0	0	0
13869	0	0	PROHIBIT	ANY			12:30:00	1@3:00	0	0	0	0	0	0
13869	0	0	PROHIBIT	ANY			11:30:00	12:30:00	0	0	0	0	0	0
13869	1	0	PROHIBIT	ANY			11:30:00	12:30:00	0	0	0	0	0	0
13869	1	0	PROHIBIT	ANY			0:00:00	11:30:00	0	0	0	0	0	0
85961	0	0	PROHIBIT	ANY			0:00:00	11:30:00	0	0	0	0	0	0
85959	0	0	PROHIBIT	ANY			12:30:00	1@3:00	0	0	0	0	0	0
85959	0	0	PROHIBIT	ANY			11:30:00	12:30:00	0	0	0	0	0	0
85959	1	0	PROHIBIT	ANY			11:30:00	12:30:00	0	0	0	0	0	0
85959	1	0	PROHIBIT	ANY			0:00:00	11:30:00	0	0	0	0	0	0
22116	0	0	PROHIBIT	ANY			11:30:00	1@3:00	0	0	0	0	0	0
22117	0	0	PROHIBIT	ANY			12:30:00	1@3:00	0	0	0	0	0	0
22117	0	0	PROHIBIT	ANY			11:30:00	12:30:00	0	0	0	0	0	0
22117	1	0	PROHIBIT	ANY			11:30:00	12:30:00	0	0	0	0	0	0
22117	1	0	PROHIBIT	ANY			0:00:00	11:30:00	0	0	0	0	0	
85454	0	0	PROHIBIT	ANY			0:00:00	11:30:00	0	0	0	0	0	0
22121	0	0	PROHIBIT	ANY			11:30:00	1@3:00	0	0	0	0	0	0
22120	0	0	PROHIBIT	ANY			12:30:00	1@3:00	0	0	0	0	0	0
22120	0	0	PROHIBIT	ANY			11:30:00	12:30:00	0	0	0	0	0	0
22120	1	0	PROHIBIT	ANY			11:30:00	12:30:00	0	0	0	0	0	0
22120	1	0	PROHIBIT	ANY			0:00:00	11:30:00	0	0	0	0	0	
22125	0	0	PROHIBIT	ANY			0:00:00	12:30:00	0	0	0	0	0	0
85456	0	0	PROHIBIT	ANY			12:30:00	1@3:00	0	0	0	0	0	0
85456	0	0	PROHIBIT	ANY			11:30:00	12:30:00	0	0	0	0	0	0
85456	1	0	PROHIBIT	ANY			11:30:00	12:30:00	0	0	0	0	0	0
85456	1	0	PROHIBIT	ANY			0:00:00	11:30:00	0	0	0	0	0	
22109	0	0	PROHIBIT	ANY			12:30:00	1@3:00	0	0	0	0	0	0
22109	0	0	PROHIBIT	ANY			11:30:00	12:30:00	0	0	0	0	0	0
22109	1	0	PROHIBIT	ANY			11:30:00	12:30:00	0	0	0	0	0	0
22109	1	0	PROHIBIT	ANY			0:00:00	11:30:00	0	0	0	0	0	
22110	0	0	PROHIBIT	ANY			11:30:00	1@3:00	0	0	0	0	0	0
85584	0	0	PROHIBIT	ANY			0:00:00	12:30:00	0	0	0	0	0	0

85582	1	0	PROHIBIT	ANY			12:30:00	1@3:00	0	0	0	0	0	0
85582	1	0	PROHIBIT	ANY			11:30:00	12:30:00	0	0	0	0	0	0
85582	0	0	PROHIBIT	ANY			11:30:00	12:30:00	0	0	0	0	0	0
85582	0	0	PROHIBIT	ANY			0:00:00	11:30:00	0	0	0	0	0	
85586	0	0	PROHIBIT	ANY			11:30:00	12:30:00	0	0	0	0	0	0

12.3. Average Day Plan Update

Because of the network change, the average day plan file and the link delay file needed to be updated correspondingly. AECOM has provided those files for the previous version of network. Since only few links have been changed this time, the previous link delay file was used to input to the router initialization for new network plan file generation. In router initialization, incremental demand loading was used which expedites router stabilization procedure. This is the first time using the AECOM adjusted diurnal tables to convert regional trips. Figure 9.2 shows the new input diurnals have dramatic difference from the old diurnals. For example, new diurnal traffic flow in the day time is lower than that of old diurnal, and is higher during evening time.

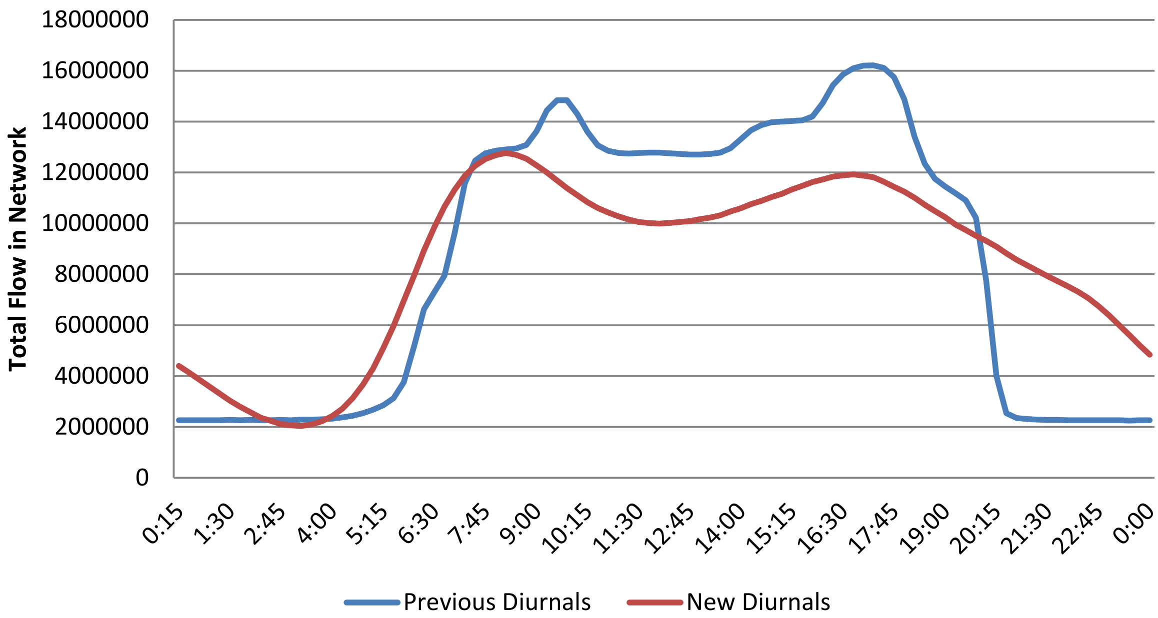


Figure 12.2 Comparison of Total Flow in the Network VS. Time

Figure 9.3 presents the process of router based iterations, which provides the appropriate link travel times and travel plans. In the beginning, new network, new converted trip table, and old link delay were inputted to router initialization, and generated updated plans and link delay file. To decrease number of iterations in the router initialization, incremental demand loading was adopted. The entire house list was partitioned for reducing the computing process time. In each of iteration, average day link travel times were calculated and average day plans were compared and merged.

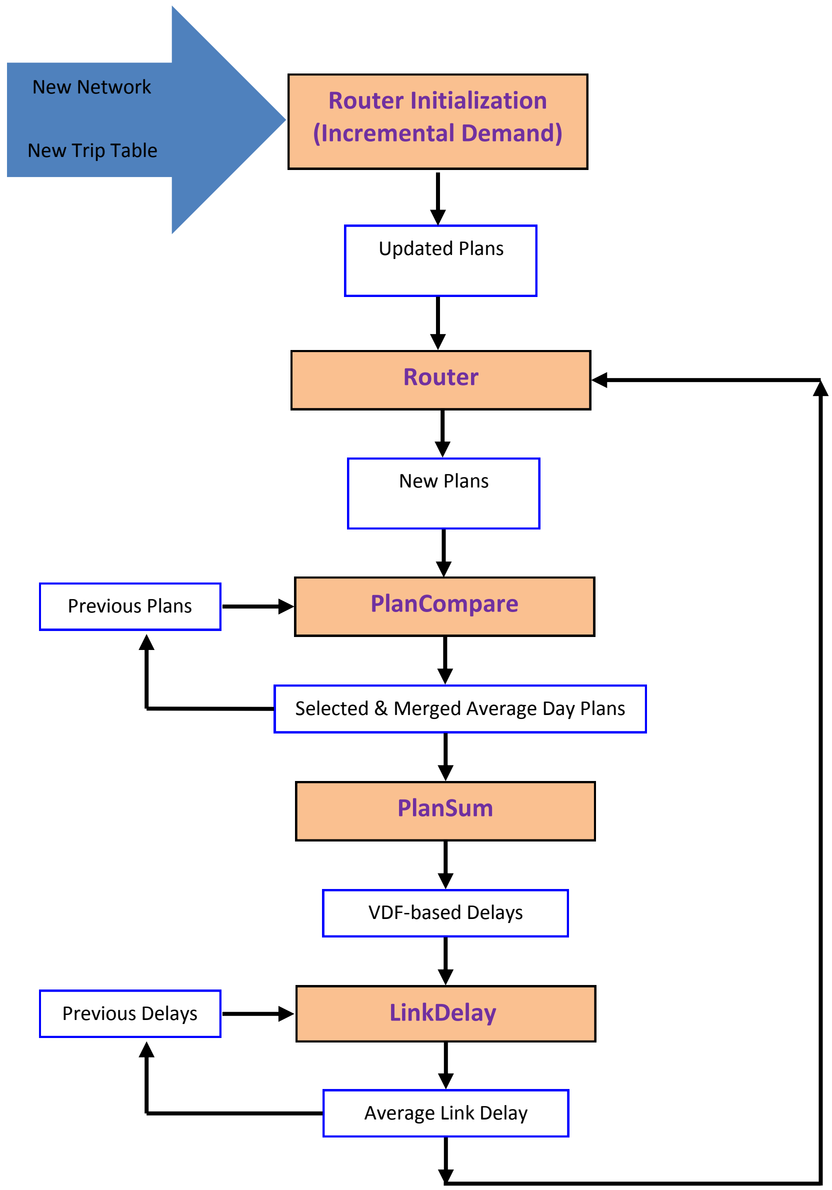


Figure 12.3 Average Day Router Iteration

In the Router.ctl file, parameter keys were defined as below.

```
FACILITY_BIAS_FACTORS_1          1.0
FACILITY_BIAS_FACTORS_2          1.2, 1.0
FACILITY_BIAS_FACTORS_4          2.0, 1.5,
FACILITY_BIAS_FACTORS_6          1.0, 1.0, 1.0
FACILITY_BIAS_FACTORS_9          1.0
FACILITY_BIAS_FACTORS_10         1.0
EQUATION_PARAMETERS_1       BPR+, 0.06, 4.0, 0.75, 1    #---  1 = Freeway ---
EQUATION_PARAMETERS_2       BPR+, 0.06, 4.0, 0.75, 1    #---  2 = Expressway ---
EQUATION_PARAMETERS_4       BPR+, 0.50, 5, 0.75, 1      #---  4 = Major Arterial ---
EQUATION_PARAMETERS_5       BPR+, 0.40, 5, 0.75, 1      #---  5 = Minor Arterial ---
```

```
EQUATION_PARAMETERS_6          BPR+, 0.15, 4.0, 0.75, 1    #---  6 = Collector ---
EQUATION_PARAMETERS_7          BPR+, 0.15, 4.0, 0.75, 1    #---  7 = Local ---
EQUATION_PARAMETERS_9          BPR+, 0.15, 4.0, 0.75, 1    #---  9 = Ramp  ---
EQUATION_PARAMETERS_10         BPR+, 0.45, 3.3, 1.00, 1    #--- 10 = Bridge/Other ---
UPDATE_FLOW_RATES                    YES
CLEAR_INPUT_FLOW_RATES               YES
UPDATE_TRAVEL_TIMES                  YES
WALK_PATH_DETAILS                TRUE
LIMIT_PARKING_ACCESS             FALSE
IGNORE_TIME_CONSTRAINTS          TRUE
WALK_SPEED                     1.0 mps
BICYCLE_SPEED                  4.0 mps
WALK_TIME_VALUES               20.0 impedance/second
BICYCLE_TIME_VALUES            15.0 impedance/second
FIRST_WAIT_VALUES              20.0 impedance/second
VEHICLE_TIME_VALUES            10.0 impedance/second
DISTANCE_VALUES                0.5 impedance/meter
COST_VALUES                    30.0 impedance/cent
LEFT_TURN_PENALTIES            300 impedance
U_TURN_PENALTIES               5000 impedance
MAX_WALK_DISTANCES             2000 meters
MAX_BICYCLE_DISTANCES          10000 meters
MAX_WAIT_TIMES                 60 minutes
MIN_WAIT_TIMES                 60 seconds
LOCAL_ACCESS_DISTANCE          4000 meters
LOCAL_FACILITY_TYPE            Collector
MAX_CIRCUITY_RATIO             5.0
MIN_CIRCUITY_DISTANCE          2000
MAX_CIRCUITY_DISTANCE          20000
```

The following gives the values of control keys in PlanCompare.ctl. SELECTION_PERCENTAGE and MAXIMUM_PERCENT_SELECTED were defined to 20 percent in the first 4 iterations, and changed to 10 percent for the rest of 3 iterations.

```
COMPARE_GENERALIZED_COSTS      TRUE
PERCENT_COST_DIFFERENCE        2.0 percent
MINIMUM_COST_DIFFERENCE        10 impedance
MAXIMUM_COST_DIFFERENCE        100 impedance
SELECTION_PERCENTAGE           20.0 percent
MAXIMUM_PERCENT_SELECTED       20.0 percent
SELECTION_METHOD               PERCENT_DIFFERENCE
DAILY_WRAP_FLAG                TRUE
SUMMARY_TIME_RANGES            ALL
SUMMARY_TIME_INCREMENT         0 minutes
PERIOD_CONTROL_POINT           MID-TRIP
```

At the end of seven iterations, Router and PlanCompare print out files indicate the iteration results shown below.

- Router.prn

  Total Number of Problems = 15263 (0.1%)

  Number of Path Circuity (#5) Problems = 8113 (53.2%)

  Number of Access Restriction (#25) Problems = 7150 (46.8%)

- PlanCompare.prn

Time Period Summary (Dollars)

	Number	--Travel Cost	------------------	Cost Difference	----------------------		85% Range --	
Time Period	Trips	Current	Base	Average	Percent	Absolute Percent	Low	High
0:00..24:00	27113595	448.39	451.41	-3.02	-0.67	24.11 5.34	-34.06	21.03
Total	27113595	448.39	451.41	-3.02	-0.67	24.11 5.34	-34.06	21.03

Trip Gap Report (Minutes)

	Number	---------- Travel Time (minutes) ----------			
Time Period	Trips	Input	Compare	Difference	Trip Gap
0:00..24:00	27113595	431248028	436566550	58768167	0.134614
Total	27113595	431248028	436566550	58768167	0.134614

Trip Gap Report (Dollars)

	Number	---------- Travel Cost (dollars) ----------			
Time Period	Trips	Input	Compare	Difference	Trip Gap
0:00..24:00	27113595	12157456675	12239464058	653779900	0.053416
Total	27113595	12157456675	12239464058	653779900	0.053416

The results show trip differences in time and money costs between the last two iterations are a little bit high. Thus, in the next step, more router iterations will be processed.

12.4. Short Links Adjustment

TRANSIMS links shorter than 18m cannot be interpolated correctly by multiple cells (size = 6m) that do not allow vehicles moving on them second by second. To solve this problem, many network input file modifications have been conducted by TRACC based on the version of the network updated on June 3, 2011.Table 9.3 lists all the modifications.

Table 12.3: Short Links Editing List

LINK	NAME	NODE_A	NODE_B	LENGTH	TYPE	Modification
3403	Douglas Rd	7221	7234	3.7	MAJOR	change link 3421 ANODE to 7221; delete link 3403 and node 7234; link 84929 (ANODE:BNODE -> 83172:7234) changes to link 86373(ANODE:BNODE -> 83172:7221)
8861	N 12000W Rd	10679	10695	3.9	MAJOR	change link 8544 BNODE to 10695; change link 8857 BNODE to 10695; delete link 8861 and node 10679
4182		7725	83640	11.9	MAJOR	change link 85703 BNODE to 7725; change link 85701 ANODE to 7725; delete link 4182 and node 83640
4645		8019	8020	10.6	MAJOR	change link 4647 ANODE to 8019; delete link 4645 and node 8020

4842	Arbor Ave	8135	8151	16.1	MAJOR	change link 4865 BNODE to 8135; change link 4871 ANODE to 8135; delete link 4842 and node 8151
5228		8380	8381	9.1	MINOR	change link 5229 ANODE to 8381; delete link 5228 and node 8380
6675		9273	9320	9.7	MAJOR	change link 6674 ANODE to 9320; change link 6678 BNODE to 9320; delete link 6675 and node 9273
6839		9375	81104	17.8	MAJOR	change link 81719 ANODE to 9375; change link 81717 ANODE to 9375; delete link 6839 and node 81104
7896		10066	83651	13.7	MAJOR	change link 85722 BNODE to 10066; change link 85723 ANODE to 10066; delete link 7896 and node 83651
8387		82060	80102	9.4	LOCAL	move node 42278 further
10530		11781	42670	15.3	MAJOR	change link 10529 ANODE to 42670; change link 85158 BNODE to 42670; delete link 10530 and node 11781
12627		13013	83679	13.4	MAJOR	change link 85776 ANODE to 13013; change link 85774 BNODE to 13013; change link 85775 ANODE to 13013; delete link 12627 and node 83679
13264		13376	13377	9	MAJOR	change link 85941 BNODE to 13376; change link 13206 BNODE to 13376; change link 13266 ANODE to 13376; delete link 13264 and node 13377
16084	MILWAUKEE AV	14955	42607	10.7	MAJOR	move node 42607 further (involve CBD signals)
16132	KENNEDY /I-90/94	14982	42605	17.2	FREEWAY	move node 14982 and node 42605 further
16682	KENNEDY /I-90/94	15285	42596	16.1	FREEWAY	move node 15285 and node 42596 further (open ESRI overlay once coding)
16684	KENNEDY /I-90/94	15288	42602	5.3	FREEWAY	move node 15288 and node 42602 further
16768		15337	42554	17.3	MAJOR	move node 42554 further (involve CBD signals)
17360		15671	15672	4.8	FREEWAY	move node 15671 and node 15672 further
17496		15756	15755	9.9	FREEWAY	move node 15756 and node 15755 further
17937		16011	15789	14.1	FREEWAY	move node 15789 and node 16011 further
20484		18128	18132	15.8	MAJOR	move node 18132 further
20490		18132	18135	14.1	MAJOR	move node 18132 further
30064	KENNEDY /I-90/94 Local	42616	42619	8.6	FREEWAY	move node 42616 and node 42619 further
40399	HALSTED AV	60225	60221	11.9	MINOR	change link 40403 BNODE to 60221; change link 40402 BNODE to 60221; delete link 40399 and node 60225
41251	DIVISION AV	60721	60652	17.7	MAJOR	move node 60721 further
41572	WABANSIA AV	60904	60899	14.5	MINOR	move node 60904 and node 60899 further
80454	N RIVER RD	80267	42646	13.4	MAJOR	change link 11176 ANODE to 42646; change link 30092 BNODE to 42646; delete link 80454 and noe 80267
81714		81102	8246	17.6	MAJOR	change link 81715 ANODE to 8246; change link 81711 BNODE to 8246; delete link 81714 and node 81102
85342		83443	83442	14.5	MAJOR	move nodes; break link 85343 to two links and reshape links
85343		83442	83443	14.5	MINOR	
82053	W 69th St	81327	81329	814.6	MINOR	change ANODE to 81328

Two types of modifications are involved, which are deleting incorrect connected short links as seen in Figure 9.4 and moving end points of short links in Figure 9.5. In the two figures, red lines represent old network links and blue lines represent modified and updated network links. The first type of modifications were conducted by changing ANODE or BNODE of longer links to those of short links and deleting short links and unused node records in the link and node input files, adequately keeping old link IDs for future network validation. The second type of modification involved moving ANODE and BNODE locations to extend short links lengths, which is easy to do in TRANSIMS Editor tool.

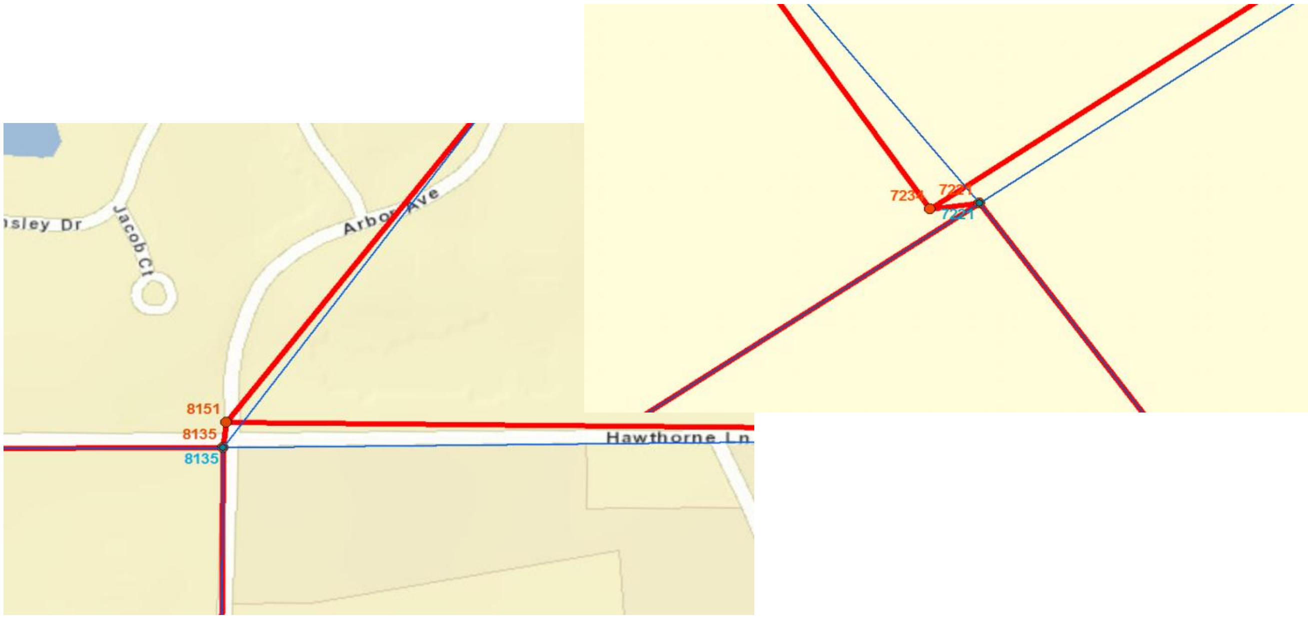


Figure 12.4: Incorrectly Connected Short Links in ArcGIS

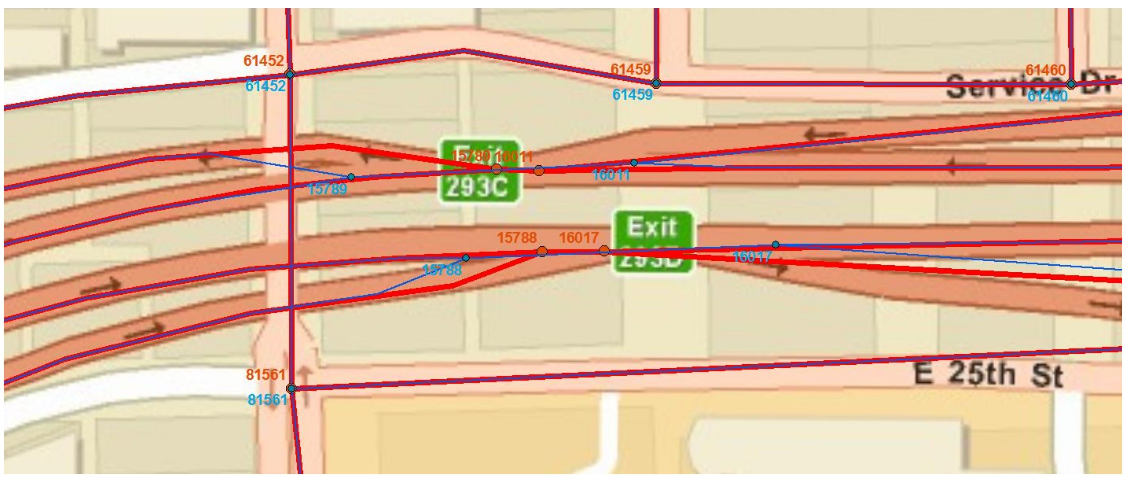


Figure 12.5: Freeway Short Waving Links in ArcGIS

Although the network links and nodes were reshaped according to the actual layout map, lengths of all links have not been updated geographically, which means lengths in the input link file Table 9.4) are either shorter or longer than those in the actual condition. To update the links length to the actual values, the key MAXIMUM_LENGTH_TO_XY_RATIO in NetPrep.ctl should be set to 1.0, for which NetPrep.exe recalculates links length based on the sum up of distances of link shape points. Table 9.5 gives the example of the link table indicating links' lengths were updated properly by NetPrep.exe.

Table 12.4: Input Link Table of NetPrep

LINK	STREET	ANODE	BNODE	LENGTH	TYPE
21		5002	19524	2718.7	FREEWAY
22		5004	80493	333.8	FREEWAY
23		5004	19366	187.8	RAMP
24		5005	19512	3669.3	FREEWAY
25		5006	80512	134.9	FREEWAY
26		5007	80498	15892.2	FREEWAY

Table 12.5: Output Link Table of NetPrep

LINK	NAME	NODE_A	NODE_B	LENGTH	SETBACK_A	SETBACK_B	BEARING_A	BEARING_B	TYPE
21		5002	19524	1971	0	0	291	274	FREEWAY
22		5004	80493	951.3	0	0	177	177	FREEWAY
23		5004	19366	562.9	0	0	181	188	RAMP
24		5005	19512	2508.7	0	0	187	204	FREEWAY
25		5006	80512	645.1	0	0	186	187	FREEWAY
26		5007	80498	15885.9	0	0	357	49	FREEWAY

12.5. Signal Timing and Phasing Plan Updates for the Regional Network

As of June, 2011, IIT manually coded and tested 344 signal phasing and timing plans in central business district (CBD) of Chicago Metropolitan Area. , Many rectifications have been conducted after converting those plans to version 5 format, according to network changing. Rectifications also included correcting the previous miscoding, editing 8-phase actuated signals to standard NEMA dual-ring and barrier structure, and adding associated detectors for them.

Supplying traffic controls for the access point (critical intersection) of evacuation routes, 128 signal timing and phasing plans for critical intersections on the evacuation candidate routes in the City of Chicago area manually coded by TRACC, have been completed. Based on TRACC geocoded city signals with cycle length data, AECOM has created close signal warrants for TransimsNet. Then, 128 critical intersection signals and 344 CBD intersection signals were combined and merged into IntControl signal output files (4 CBD signal plans were removed due to duplications records in critical signal plans). Herein, a total of 9,823 signal controlled intersections in the entire region are shown in Figure 9.6. Green symbols are signal lights and red symbols are stop signs.

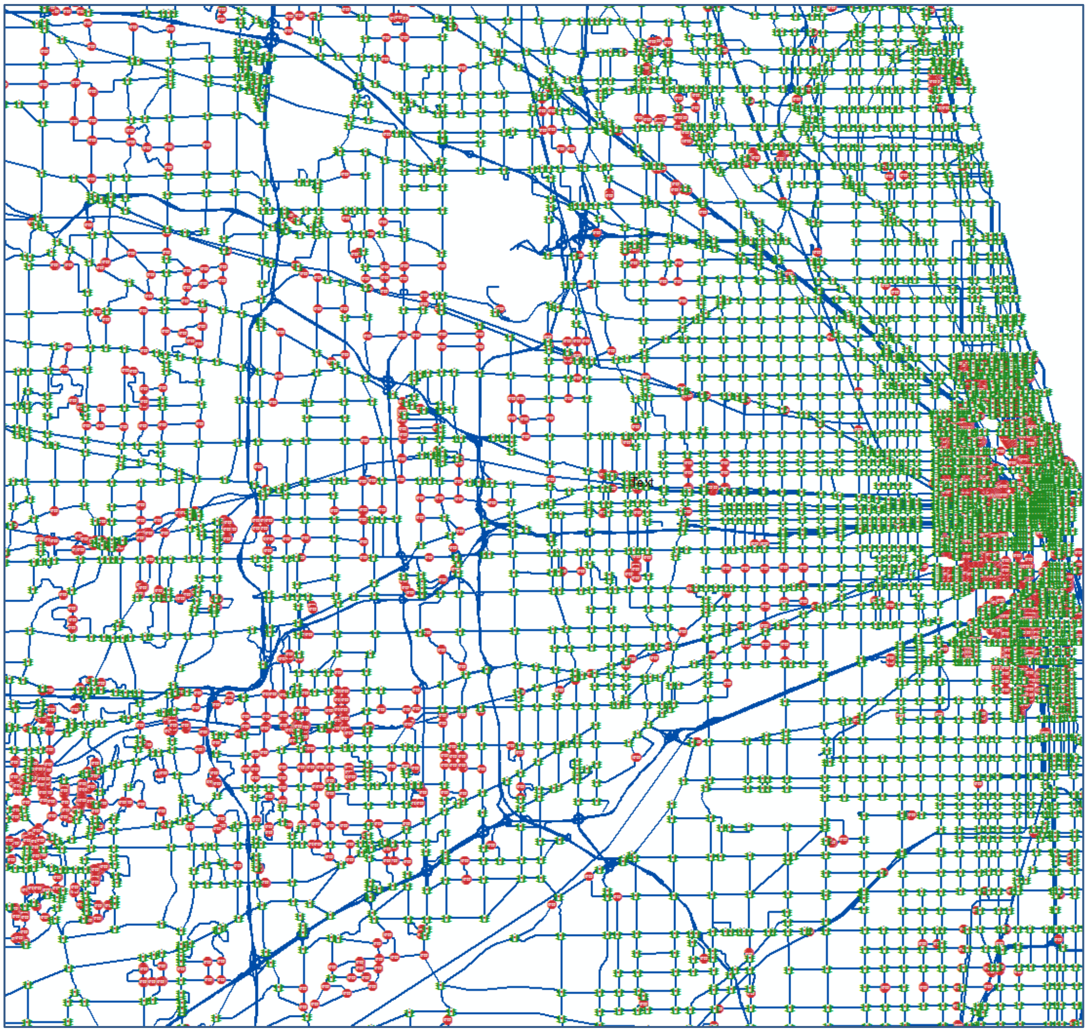


Figure 12.6: Intersection Control Layout

Since many signalized intersections are very skew intersected, connections for turning movements were not generated properly by TransimsNet. To solve this, the key MAXIMUM_CONNECTION_ANGLE in TransimsNet.ctl was changed from 120 degrees to 160 degrees.

12.6. Preliminary Case Studies

With the RTSTEP project nearing final delivery, some preliminary case studies were conducted in this month to test TRACC evacuation demand and evacuation routes strategies. In parallel, some auxiliary work was done, such as updating evacuation shelter input files, creating normal day time sorted and traveler sorted plan files, and updating normal day plan files for new network, etc.

Case studies include testing Wrigley Field evacuation scenarios with evacuation routes and without evacuation routes. In the case with evacuation routes,EvacNet generated lane use and turn penalty areused as inputs to EvacDemand. Lane use defines all types of vehicles outside the evacuation area during evacuation time that cannot have access to the evacuation area. Turn penalty specifies restricted turning movements for all vehicles on the evacuation routes including highways and major arterials.

The case without evacuation routes only requires lane use file as input. Both cases run EvacDemand first to generate evacuation trips. Once evacuation is active, then the Router is run to create trip plans for evacuation trips. The next step is running PlanPrep three times: merging evacuation trip plans with normal day plans, then sorting combined plans by time, and finally, deleting plans of trips which arrive at the impact area after evacuation has started. The final two steps run the Microsimulator to the creating snapshot result and for observing it in TransimsVIS.

Figure 9.7 gives the snapshot images of cases without evacuation routes (left) and with evacuation routes (right). Both evacuations start at 12:00PM under high impact level. The blue dots represent evacuation vehicles and they are driven to different shelters outside the impact area. The following steps will be using different values of keys and different times of day to run multiple cases, and making lateral comparison for the results.

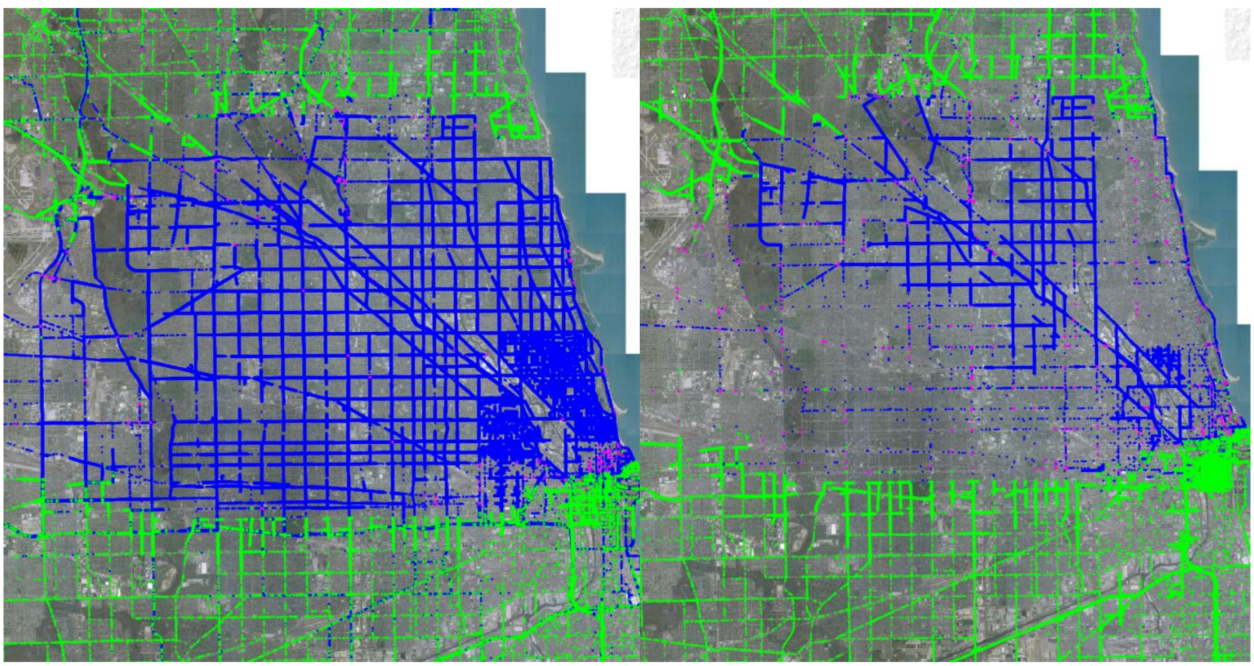


Figure 12.7: Comparison of Two Scenario Cases

12.7. Pace Transit Route Editing

Pace is one of the suburban transit systems in the Chicago Metropolitan Area. Unlike the CTA, Pace has longer headways (20 ~ 60 min) which serve larger geographic areas including Cook, Lake, Will, Kane, McHenry and DuPage counties. The extension of the Pace transit network for the Chicago Metropolitan Area is necessary to support regional evacuation planning in the predefined affected area. The data about routes, stops, and time schedules of Pace transit was downloaded from Google Transit Data Feed. Stops data includes stop IDs, geographic locations, and the names of stops, which can be geocoded in ArcGIS and matched to the TRANSIMS network. Since the TRANSIMS network in suburban areas was not accurately reshaped to the actual road curvature, some geocoded Pace stops have larger distances to the TRANSIMS network links. Two types of network editing were conducted to solve this issue. Type A editing adds local TRANSIMS links that the Pace routes cover. Type B editing reshapes the TRANSIM link shape file to the actual road curvature that Pace stops can be matched to the network. Figure 9.8 shows the Pace transit network editing result. Green dots represent Pace stops and blue lines represent the TRANSIMS network.

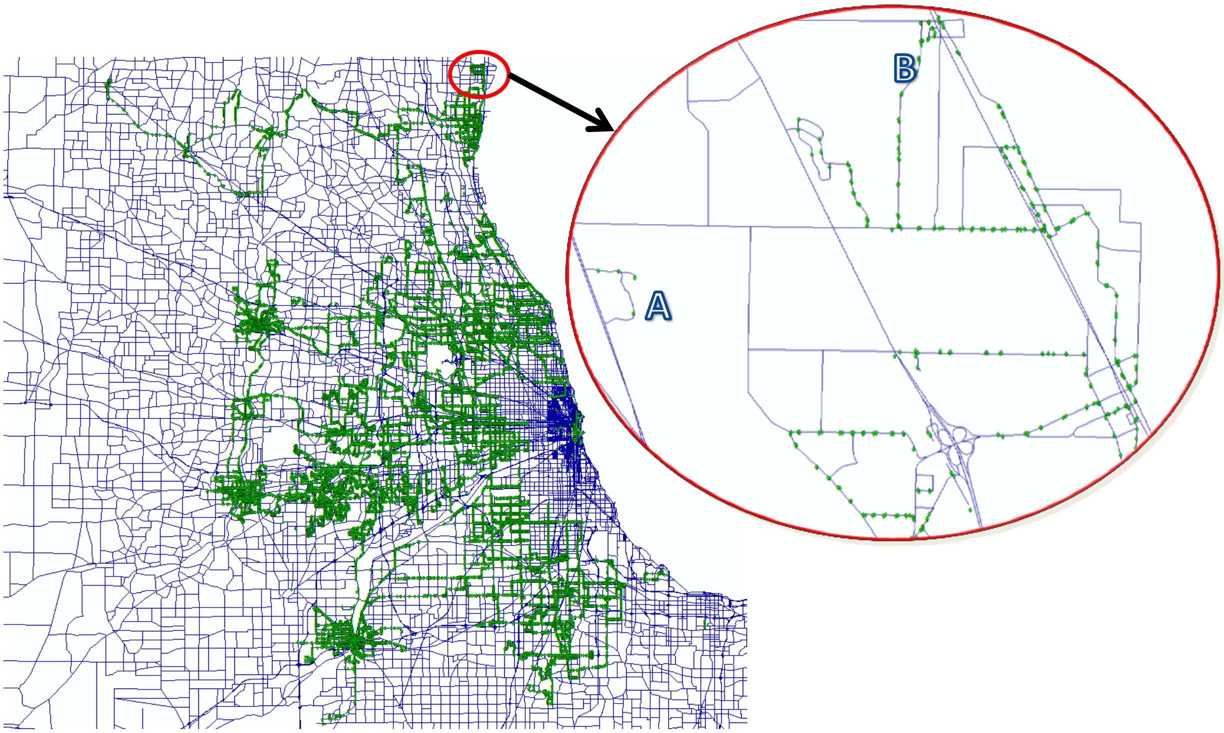


Figure 12.8 Pace Stops Geocoding Result in ArcGIS

12.8. City of Chicago Signals Geocoding

CDOT provided cycle length data of all signals in the City of Chicago (2899 in total). The data would help modeling intersection delays more accurately than just using predefined traffic warrants in TransimsNet. All of the signals were geocoded in ArcGIS based on their geographical locations downloaded from the CDOT website. Then according to the requirement of distance between signal and TRANSIMS node is less than 12 meters, 1938 city signals out of all city signals were matched to TRANSIMS network. Figure 9.9 represents city signals geocoding results.

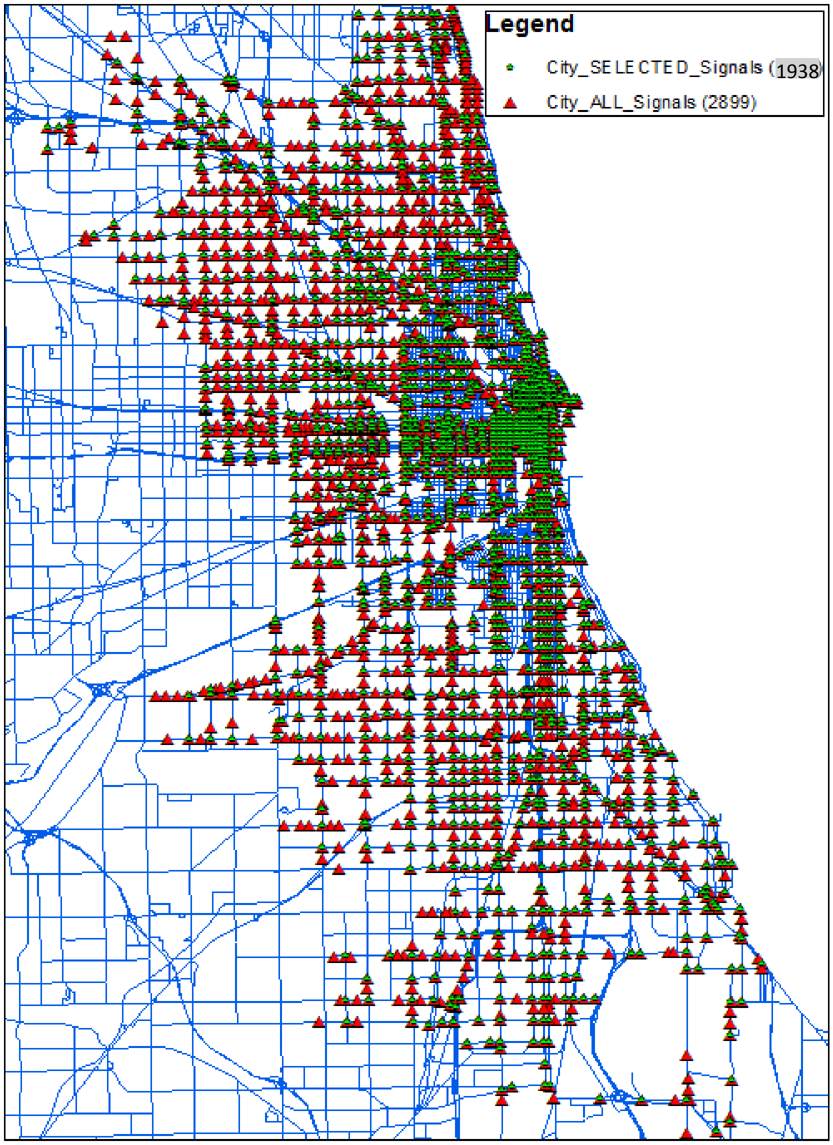


Figure 12.9 City of Chicago Signals Geocoding Result in ArcGIS

Table 9.6 indicates the list of TRANSIMS nodes representing city signals associated with their cycle lengths, all red times, and yellow times. Signals in the city are generally operated in different timing periods, which are C2 (6:00AM-10:00AM), C3 (3:00PM-7:00PM), and C1 (all the other times). Few signals have C4 (7:00 PM – 6:00AM) timing period. Thus, on a daily basis, five timing periods 0:00-6:00, 6:00-10:00, 10:00-15:00, 15:00-19:00, 19:00-24:00 are coded in signal timing table, and 0:00-6:00. 10:00-15:00, 19:00-24:00 are in the same timing plan.

Table 12.6 City Signal Cycle Length Data Set

TRANSIMS_NODE	BOE_NUM	Key_Letter	SIGNAL_NAM	C1__All_Ot	C2__6am_10am	C3__3pm_7pm	C4__7pm_6am	All_Red_NS	All_Red_EW	All_Red_Dia	Yellow_NS	Yellow_EW	Yellow_Dia	lat_cdot	lng_cdot
13321	14950	A	AUSTIN-LAWRENCE-MASON-GUNNISON	85	0	0	0	0	1		3	3		4646476	435596
13325	14952	A	AUSTIN-HIGGINS	75	0	0	0	2	2		3	3		4647090	435521
13326	22499	A	AUSTIN-FOSTER	75	75	75	0	1	1		3	3		4647368	435528
13328	22287	A	AUSTIN-NORTHWEST HIGHWAY	90	0	0	0	0	0	0	4	0	4	4647913	435541
13330	22276	A	AUSTIN-ARDMORE-MILWAUKEE	130	130	0	0	2	2	2	3	3	3	4648577	435557
13331	22212	A	AUSTIN-ELSTON	65	0	0	0	1	0	1	3	0	3	4648954	435566
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
14639	22373	A	KENNEDY-FULLERTON-KENNEDY	85	85	85	0	1	1		3	3		4641670	443361
14564	22373	B	KENNEDY-FULLERTON	85	85	85	0	1	1		3	3		4641670	443361

Signals with the same BOE_NUM value should be controlled in one group. For example, intersections of Fullerton Ave with Kennedy Expressway NB and SB ramps as shown on the left of Figure 9.10, signal node 14639 and 14564 should be in one signal controlling group. The right image of Figure 9.10 shows another condition that three signal nodes geographically locate in the vertices of a small right triangular are controlled in one group.

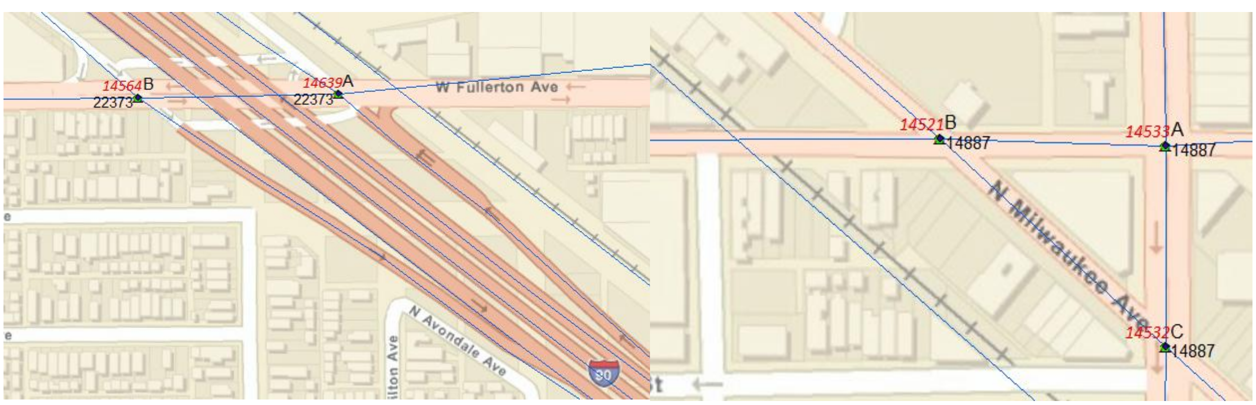


Figure 12.10 Group Controlled Signals

12.9. Signal Timing and Phasing Updates of Critical Intersections in the Central Business District

Supplying traffic controls for the access point (critical intersection) of evacuation routes, all signals (128 in total) timing and phasing plans for the pre-selected critical intersections inside the City boundary were coded. 63 signals among them are actuated controlled, which were coded with their detectors as well. Figure 9.11 shows the photocopy of signal plan file for the Western Ave. and Chicago Ave. intersection.

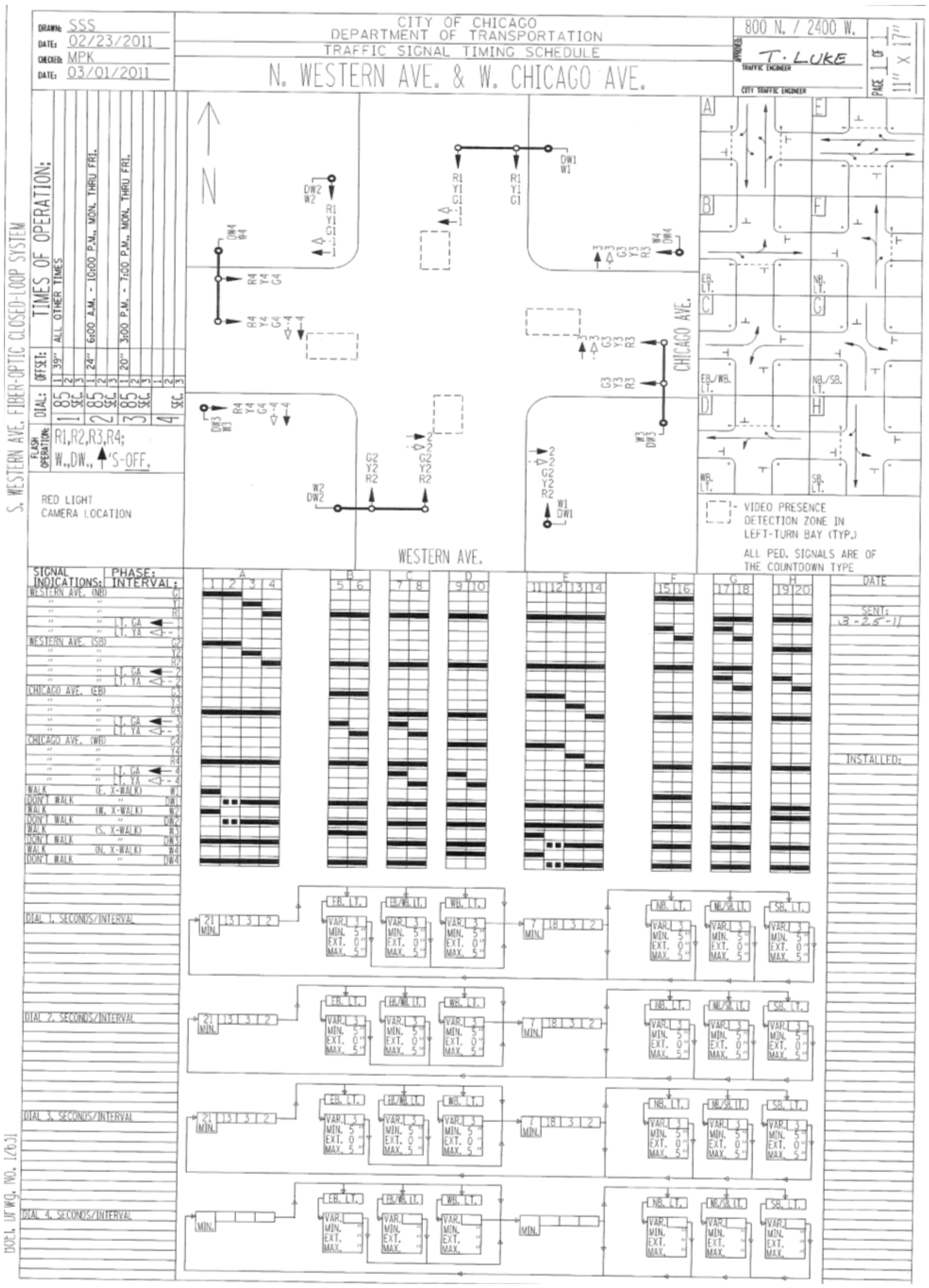


Figure 12.11 Traffic Signal Timing Schedule for Intersection Western Ave and Chicago Ave

It has three timing plans indicated by Dial 1, Dial 2, and Dial 3, and one phasing plan. Table 9.7 demonstrates three timings divided by 5 timing periods per day for this intersection.

Table 12.7 Signal Plan for Intersection Western Ave and Chicago Ave

SIGNAL START	GROUP END	TIMES TIMING	NODES PHASING	NOTES
14540	1	5	*14540*	
0:00	6:00	1	1	8 Phase Semi-Actuated
6:00	10:00	2	1	8 Phase Semi-Actuated
10:00	15:00	1	1	8 Phase Semi-Actuated
15:00	19:00	3	1	8 Phase Semi-Actuated
19:00	24:00:00	1	1	8 Phase Semi-Actuated

The phasing plan for this intersection consists of eight phases: A, B, C, D, E, F, G, H. B, C, and D are East-West bound actuated phases. F, G, and H are North-South bound actuated phases. Since TRANSIMS Version 5 uses the standard NEMA ring-and-barrier structure for signal control, A, B, C, D, E, F, G, H phases need to be translated into ring-and-barrier structure. Table 9.8 shows turning movements in A, B, C, D, E, F, G, H phases were translated to 1, 2, 3, 4, 5, 6, 7, 8 phases in dual-ring two barriers structure.

Table 12.8 Phasing Plan for Intersection Western Ave and Chicago Ave

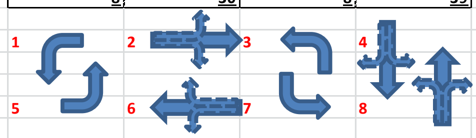
SIGNAL MOVEMENT	PHASING LINK	PHASE DIR	MOVEMENTS TO_LINK	DETECTORS PROTECTION
14540	1	**1**	2	*1454011*
WB_LEFT	*15340*	*1*	*15339*	PROTECTED
NB_RIGHT	*15339*	*1*	*15340*	STOP_PERMIT
14540	1	**2**	3	
EB_THRU	*15091*	*0*	*15340*	PROTECTED
EB_RIGHT	*15091*	*0*	*15339*	PERMITTED
EB_LEFT	*15091*	*0*	*41446*	PERMITTED
14540	1	**3**	2	*1454033*
NB_LEFT	*15339*	*1*	*15091*	PROTECTED
EB_RIGHT	*15091*	*0*	*15339*	STOP_PERMIT
14540	1	**4**	3	
SB_THRU	*41446*	*0*	*15339*	PROTECTED
SB_RIGHT	*41446*	*0*	*15091*	PERMITTED
SB_LEFT	*41446*	*0*	*15340*	PERMITTED
14540	1	**5**	2	*1454052*
EB_LEFT	*15091*	*0*	*41446*	PROTECTED
SB_RIGHT	*41446*	*0*	*15091*	STOP_PERMIT
14540	1	**6**	3	
WB_THRU	*15340*	*1*	*15091*	PROTECTED
WB_RIGHT	*15340*	*1*	*41446*	PERMITTED
WB_LEFT	*15340*	*1*	*15339*	PERMITTED
14540	1	**7**	2	*1454074*
SB_LEFT	*41446*	*0*	*15340*	PROTECTED
WB_RIGHT	*15340*	*1*	*15339*	STOP_PERMIT
14540	1	**8**	3	
NB_THRU	*15339*	*1*	*41446*	PROTECTED
NB_RIGHT	*15339*	*1*	*15340*	PERMITTED
NB_LEFT	*15339*	*1*	*15091*	PERMITTED

Table 9.9 shows the coding result for three timing plans according to the signal timing schedule shown in Figure 9.11.

Table 12.9 Timing Plan for Intersection Western Ave and Chicago Ave

Dial-1: Showing Phase Splits

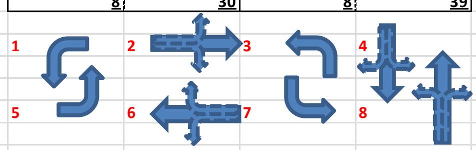
	Barrier 1		Barrier 2			
	Pos 1	Pos 2	Pos 1	Pos 2	*CycleBRP*	*CycleBelow*
Ring 1	8	30	8	39	*85*	*85*
Ring 2	8	30	8	39	*85*	*85*



SIGNAL PHASE	TIMING BARRIER	TYPE RING	CYCLE POSITION	OFFSET MIN_GREEN	PHASES MAX_GREEN	NOTES EXTENSION	YELLOW	ALL_RED
14540	1	ACTUATED	85	7	8	0:00..6:00,10:00..15:00,19:00..24:00		
1	1	1	1	5	5	0	3	0
2	1	1	2	25	33	0	3	2
3	2	1	1	5	5	0	3	0
4	2	1	2	34	42	0	3	2
5	1	2	1	5	5	0	3	0
6	1	2	2	25	33	0	3	2
7	2	2	1	5	5	0	3	0
8	2	2	2	34	42	0	3	2

Dial-2: Showing Phase Splits

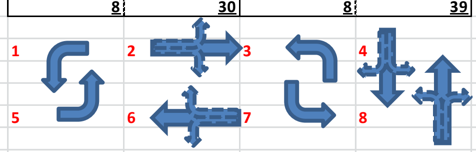
	Barrier 1		Barrier 2			
	Pos 1	Pos 2	Pos 1	Pos 2	*CycleBRP*	*CycleBelow*
Ring 1	8	30	8	39	*85*	*85*
Ring 2	8	30	8	39	*85*	*85*



SIGNAL PHASE	TIMING BARRIER	TYPE RING	CYCLE POSITION	OFFSET MIN_GREEN	PHASES MAX_GREEN	NOTES EXTENSION	YELLOW	ALL_RED
14540	2	ACTUATED	85	22	8	6:00..10:00		
1	1	1	1	5	5	0	3	0
2	1	1	2	25	33	0	3	2
3	2	1	1	5	5	0	3	0
4	2	1	2	34	42	0	3	2
5	1	2	1	5	5	0	3	0
6	1	2	2	25	33	0	3	2
7	2	2	1	5	5	0	3	0
8	2	2	2	34	42	0	3	2

Dial-3: Showing Phase Splits

	Barrier 1		Barrier 2			
	Pos 1	Pos 2	Pos 1	Pos 2	*CycleBRP*	*CycleBelow*
Ring 1	8	30	8	39	*85*	*85*
Ring 2	8	30	8	39	*85*	*85*



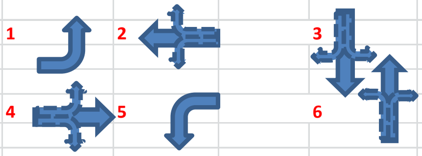
SIGNAL PHASE	TIMING BARRIER	TYPE RING	CYCLE POSITION	OFFSET MIN_GREEN	PHASES MAX_GREEN	NOTES EXTENSION	YELLOW	ALL_RED
14540	3	ACTUATED	85	26	8	15:00..19:00		
1	1	1	1	5	5	0	3	0
2	1	1	2	25	33	0	3	2
3	2	1	1	5	5	0	3	0
4	2	1	2	34	42	0	3	2
5	1	2	1	5	5	0	3	0
6	1	2	2	25	33	0	3	2
7	2	2	1	5	5	0	3	0
8	2	2	2	34	42	0	3	2

Because movements of the starting position in NEMA structure are different from those of phase A in actual conditions, offsets need to be reset according to NEMA structure. For instance, offset for Dial 1 is actually 39 sec, so the starting position is one of B, C, and D phases once the timing plan gets started, and there is a 7 sec offset in this phase. Considering B, C, and D are translated to ring 1 and ring 2 in the first position of barrier 1, the recalculated offset is 7 sec. Offsets in Dial 2 and Dial 3 were calculated in the same way.

The above paragraphs describe the method to code 8-phase intersection traffic signals with detected left turn control for all approaches. For translating phasing plans into NEMA structure, some assumptions are made based on geometries and phasing plans of signals. Figure 9.12, Figure 9.13, and Figure 9.14 represent three examples of translating one detector, two detectors, and three detectors signals.

Dial-1: Showing Phase Splits

	Barrier 1		Barrier 2			
	Pos 1	Pos 2	Pos 1	Pos 2	*CycleBRP*	*CycleBelow*
Ring 1	**9**	**45**	**36**		*90*	*90*
Ring 2	**44**	**10**	**36**		*90*	*90*



SIGNAL	TIMING	TYPE	CYCLE	OFFSET	PHASES	NOTES		
PHASE	BARRIER	RING	POSITION	MIN_GREEN	MAX_GREEN	EXTENSION	YELLOW	ALL_RED
14585	1	ACTUATED	90	*46*	6	0:00..6:00,10:00..15:00,19:00..27		
1	1	1	1	6	6	0	3	0
2	1	1	2	40	49	0	3	2
3	2	1	1	31	31	0	3	2
4	1	2	1	32	41	0	3	0
5	1	2	1	5	5	0	3	2
6	2	2	1	31	31	0	3	2

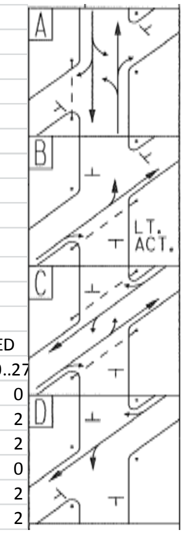
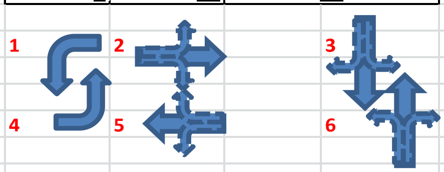


Figure 12.12 One Detector Signal NEMA Phasing

Dial-1: Showing Phase Splits

	Barrier 1		Barrier 2			
	Pos 1	Pos 2	Pos 1	Pos 2	*CycleBRP*	*CycleBelow*
Ring 1	**9**	**38**	**53**		*100*	*100*
Ring 2	**9**	**38**	**53**		*100*	*100*



SIGNAL	TIMING	TYPE	CYCLE	OFFSET	PHASES	NOTES		
PHASE	BARRIER	RING	POSITION	MIN_GREEN	MAX_GREEN	EXTENSION	YELLOW	ALL_RED
14904	1	ACTUATED	100	*37*	6	0:00..6:00,10:00..15:00,19:00..		
1	1	1	1	6	6	0	3	0
2	1	1	2	33	42	0	3	2
3	2	1	1	49	49	0	3	1
4	1	2	1	6	6	0	3	0
5	1	2	2	33	42	0	3	2
6	2	2	1	49	49	0	3	1

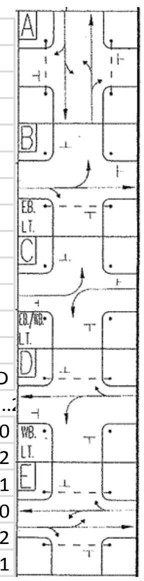
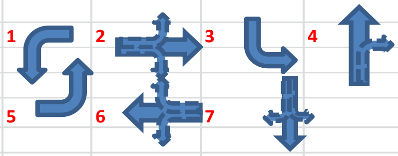


Figure 12.13 Two Detectors Signal NEMA Phasing

Dial-1: Showing Phase Splits								
	Barrier 1		Barrier 2					
	Pos 1	Pos 2	Pos 1	Pos 2	CycleBRP	CycleBelow		
Ring 1	9	47	9	65	130	130		
Ring 2	9	47	74		130	130		



SIGNAL	TIMING	TYPE	CYCLE	OFFSET	PHASES	NOTES		
PHASE	BARRIER	RING	POSITION	MIN_GREEN	MAX_GREEN	EXTENSION	YELLOW	ALL_RED
14842	1	ACTUATED	130	0	7	0:00..24:00		
1	1	1	1	6	6	0	3	0
2	1	1	2	42	51	0	3	2
3	2	1	1	6	6	0	3	0
4	2	1	2	60	69	0	3	2
5	1	2	1	6	6	0	3	0
6	1	2	2	42	51	0	3	2
7	2	2	1	69	69	0	3	2

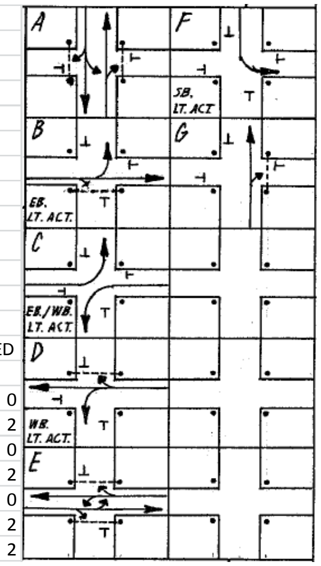


Figure 12.14 Three Detectors Signal NEMA Phasing

Due to the latest network revising, signals phasing and timing plan files in Center Business District of Chicago Metropolitan Area coded by IIT have been rectified accordingly. In addition, detectors for actuated signals were coded.

On the selected evacuation route candidates, IIT has identified 128 critical signalized intersections beyond CBD area in the City of Chicago according the following selection criterion. Those signalized intersections will be tested later as evacuation access points.

- Select all signalized intersections crossed by evacuation route candidates.
- Based upon criteria 1, select intersections crossed by major roads with about 3 miles between each other in urban area and 5 miles for suburban.
- Select intersections close to freeway enter/exit without very changing of number of lanes.

Table 9.10 presents the list of signal nodes being selected with intersection names coded by CDOT.

Table 12.10 Signal Lists of Critical Intersection

CDOT_Intersection_Name	TRANSIMS_Node
CICERO-IRVING PARK-MILWAUKEE	13696
CICERO-BELMONT	13700
CICERO-FULLERTON	13708
CICERO-NORTH	13713
CICERO-CHICAGO	13715
CICERO-WASHINGTON	13723
CICERO-JACKSON	13721
CICERO-FLOURNOY	13729
CICERO-LEXINGTON	13728
PULASKI-PETERSON	13915

PULASKI-LAWRENCE	13938
PULASKI-IRVING PARK	13935
PULASKI-KENNEDY	13939
PULASKI-KENNEDY	13943
....	….

All the signal plan data was extracted from the CDOT computer machine in the format of photocopies of signal plan sheets. Most of the signals use either one timing plan or three timing plans. Three timing plans are the periods of 6:00 AM to 10:00AM, 3:00PM to 7:00PM, and all other times, which divide one day to five timing periods. The selected signals include actuated signals and coordinated signals that are controlled by extension values and offsets. Some intersections are complicated in real condition, intersection of King Dr. & Pershing Rd.; for instance, SB Service Dr. and NB Service Dr. were not coded in TRANSIMS network as demonstrated in Figure 9.15. In this case, new links (red) should be added to complete all movements for this intersection. Updating signal timing/phasing plan data for all selected critical intersections has been processed in the format of TRANSIMS version 5.

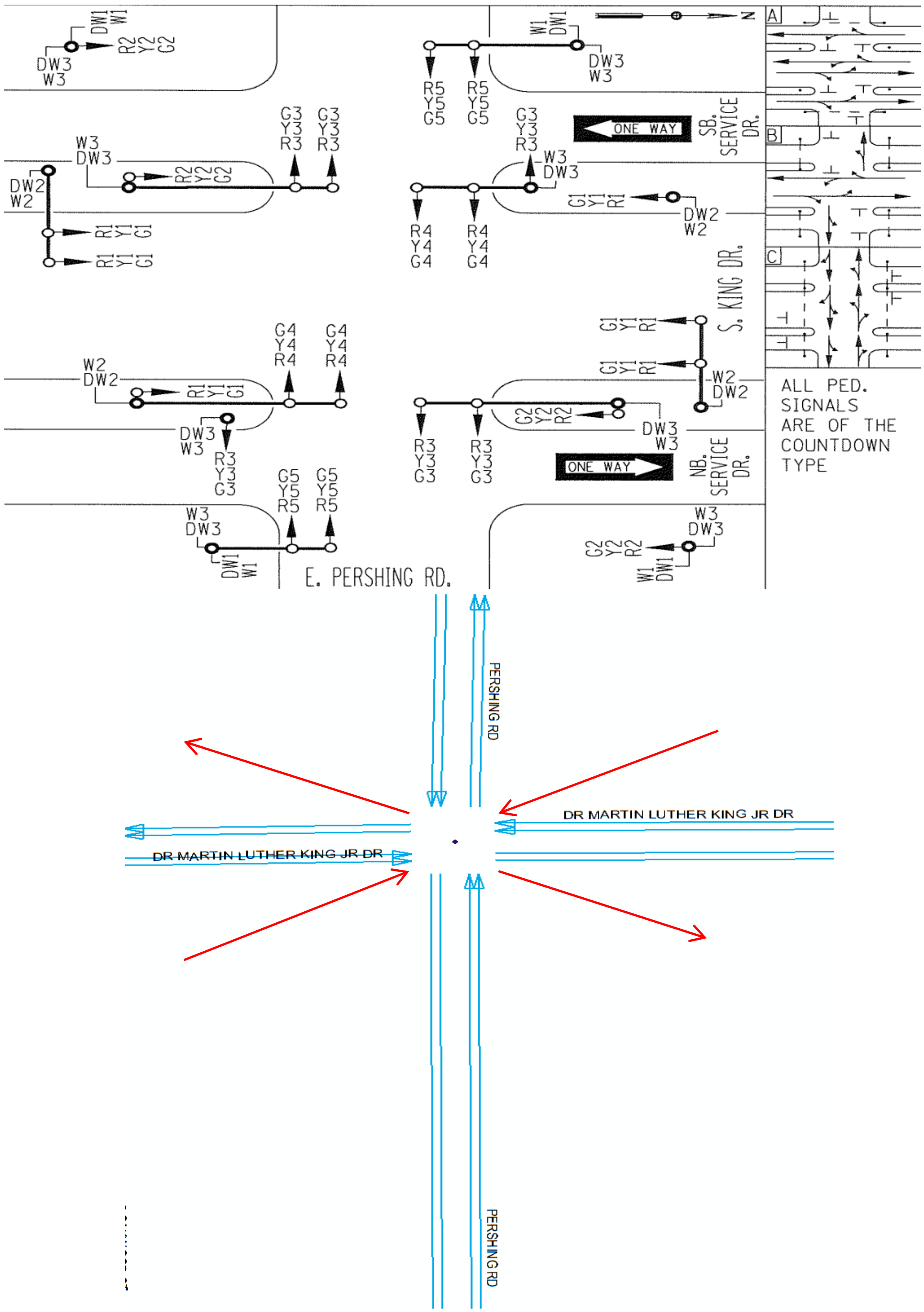


Figure 12.15 Intersection Geometries in Signal Plan and TRANSIMS Network

12.10. Intersection Node Adjustment

The modification of intersection nodes, including arterial intersections, ramp entrances and exits locations, were edited in ArcGIS. This is a very necessary step to refine Chicago regional TRANSIMS network such that it matches the actual highway network. Open Street Map (OSM) was adopted as the layout map herein. OSM is an extensively used data source for transportation network modeling because of its ease in acquisition and its accuracy as well.

Since Chicago regional network covers state of Illinois, and partial areas of Indiana, and Wisconsin, three OSM highway transportation map data files were downloaded from the CloudMade website (http://downloads.cloudmade.com/americas/northern_america/united_states#downloads_breadcrumbs). Those files include "illinois.osm.highway.bz2," "indiana.osm.highway.bz2," and "wisconsin.osm.highway.bz2." Each map file was converted to TRANSIMS network input files; also created node and link shapefiles. New keys INPUT_OSM_FILE and OSM_CROP_BOX were developed in NetPrep for processing this conversion. INPUT_OSM_FILE is the key to indicate the downloaded OSM map file mentioned above. OSM_CROP_BOX presents the extension area of Chicago regional network, which is a serial numbers of Top, Bottom, Left, and Right as demonstrated in Figure 9.16.

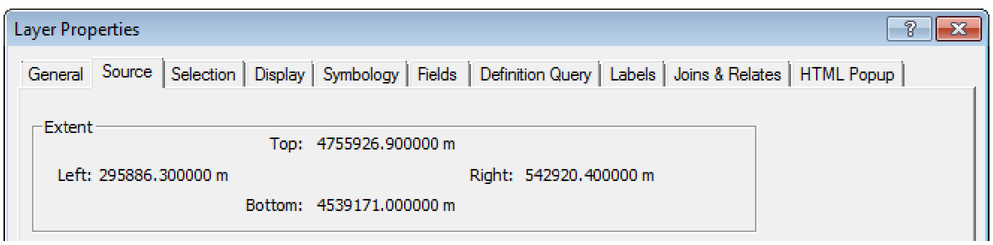


Figure 12.16 Extension Area of Chicago Regional Network

In the ArcMap application of ArcGIS, Chicago regional network shapefiles are overlaid on the top of link and node shapefiles of OSM map. The left image of Figure 9.17 represents the TRANSIMS nodes (red) that do not match OSM node (blue) locations and need to be reshaped.

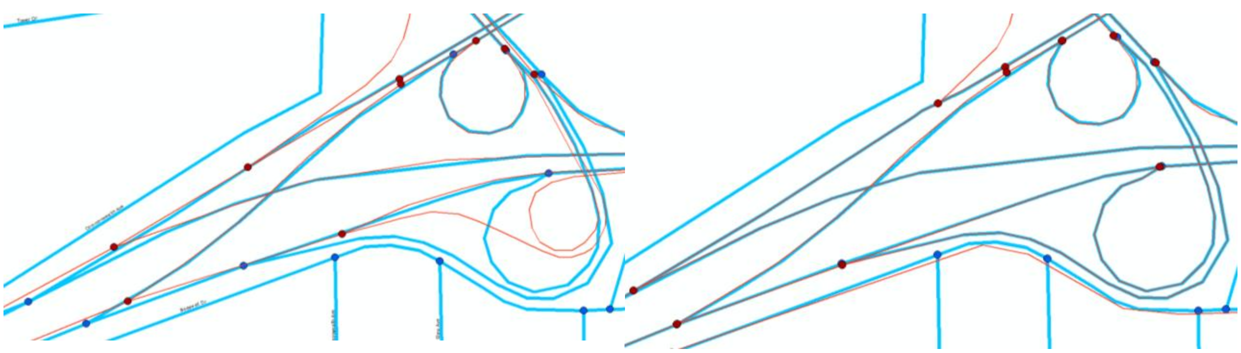


Figure 12.17 TRANSIMS Node Editing in ArcMap

Using the pointing tool of "Editor" Toolbar, arterial intersection nodes and freeway/ramp connections nodes in TRANSIMS network were reshaped by moving them to the corresponding OSM nodes' locations. The right image of Figure 9.17 shows the final modification with all ramp nodes properly reshaped. After manually reshaping those nodes, their spatial coordinates X and Y were added in the node attribute table. The original X_COORD and Y_COORD attributes were replaced by X and Y values, and the TRANSIMS node file revision was completed.

12.11. Freeway and Ramp Errors Revision

The freeway links were reshaped by AECOM based on TRACC provided OSM map shapefiles. Many freeway/ramp errors were observed during the process. An efficient method to modify those errors would be using TRANSIMS Studio Network Editor. Again, the OSM was employed as layout map in this process. Since the OSM layout network for Illinois is too detailed to be refreshed quickly in the Network Editor, the network was cropped to six subareas as shown in Figure 9.18.

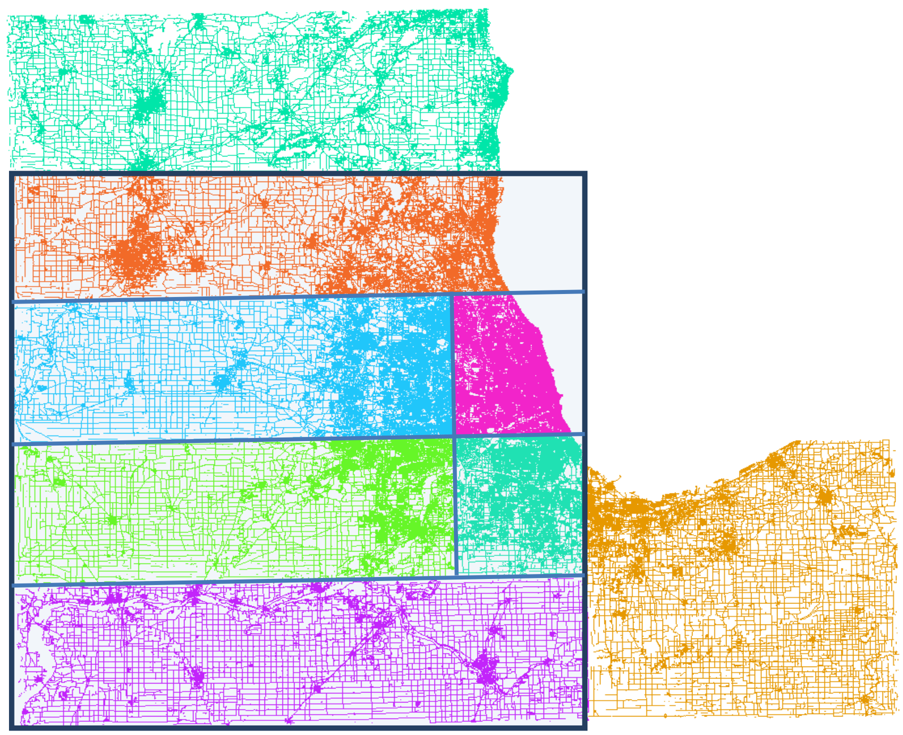


Figure 12.18 OSM TRANSIMS Network

Generally, freeway/ramp errors can be categorized by three types, missing freeway/ramp link, missing separated toll link, and incorrect connection location. As seen in Figure 9.19, Figure 9.20, and Figure 9.21, three typical error examples, blue color lines present OSM network and red lines overlaid present Chicago regional network. Figure 9.19 left map shows the previous network had one through freeway link missing. So one freeway link was added and the NB old freeway link was changed to ramp as shown in the right map.

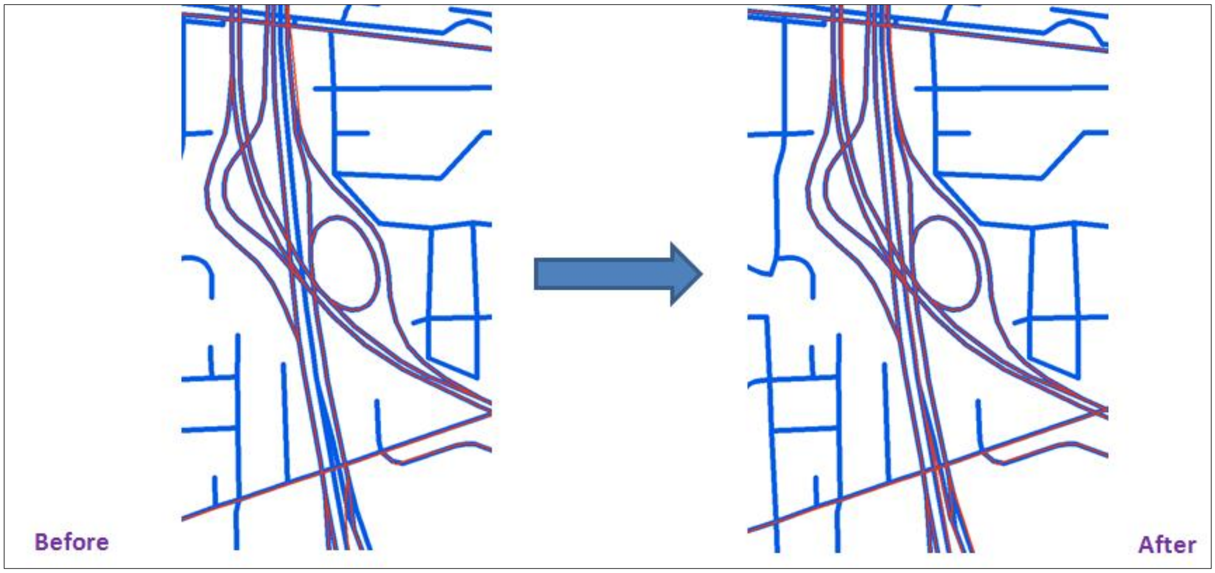


Figure 12.19 Type I Freeway/Ramp Errors

The right map in Figure 9.20 indicates that two cash toll links (green) for both bounds was added based on Google satellite map, and the toll links on the main freeways should be IPASS with the same free flow speed (FSPD) as the approaching freeway links.

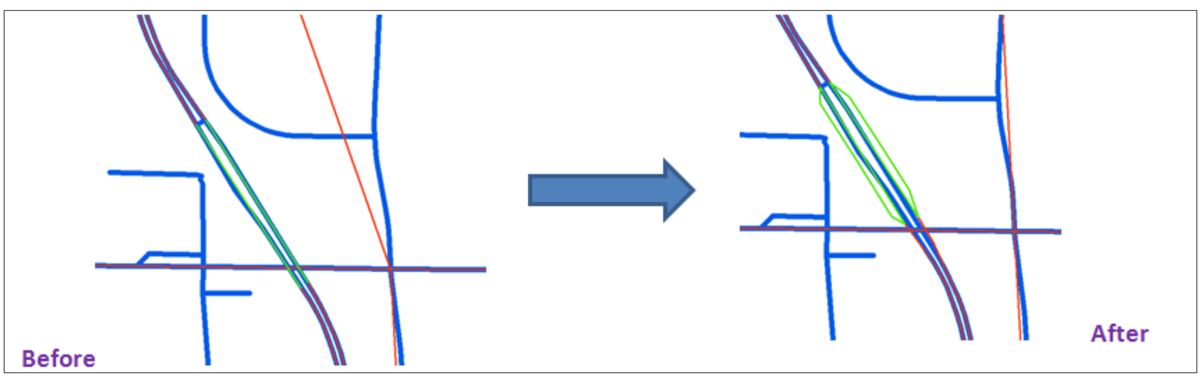


Figure 12.20 Type II Freeway/Ramp Errors

Figure 9.21 shows two ramps were incorrectly connected in the previous network (left). The error was rectified by deleting incorrect links and adding correct ones.

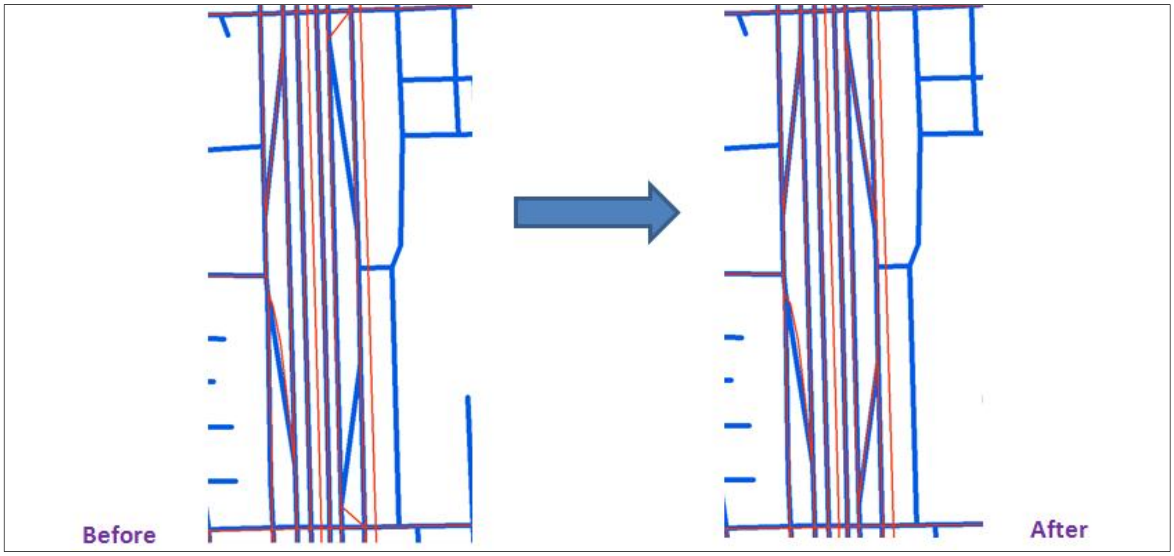


Figure 12.21: Type III Freeway/Ramp Errors

Some link directional errors were also rectified, such as changing W Congress Pkwy from two-way to one-way link, and combining two divided one-way Reversible I-94 Kennedy Expressway links into one two-way link, etc. The link type of lower N Wacker Dr. was changed from “Expressway” to “Major,” and activity locations associated to this road will be post processed and deleted. In addition, all the major roads links were reshaped approximately based on the OSM map layout.

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13. Visualization Tool Development

13.1. Motivations for A RTSTEP Visualization Tool: TransimsVIS 2.0

RTSTEP has outlined the need for both a tool which can be used to configure transportation management options for evacuations as well as a tool which can visualize the results of the evacuation case studies.

The original TransimsVIS software was developed by TRACC to aid in the visualization of TRANSIMS results. The tool was pseudo-3D, python-based, and semi-interactive – it included many features including visualizations of: vehicle trajectory, regional congestion, regional signal patterns, transit ridership, vehicle paths, car following, vehicle speeds, and more. It also included features such as movie creation, waypoint selection for cinematic camera movements, and side-by-side comparisons.

There were many motivations to re-code a new version of the visualizer for use in the RTSTEP project:

1. The extensive opportunities presented by working in a fully 3D programming environment via OpenGL – much visualization can be made much more effective if able to take advantage of a third spatial dimension.
2. The conclusion of the Metropolis (another 3D visualization software produced at TRACC) project leaves a gap in the ability of TRANSIMS to perform visualization with a high level of interactivity.
3. The original TransimsVIS had some serious performance problems in several areas. Utilizing the C++ programming language enables the programmer to attain far superior performance to that available with Python.
4. TRANSIMS is undergoing an upgrade as well from version 4 to version 5 which would have required numerous changes to the original TransimsVIS.
5. Several framework choices for the original TransimsVIS hamstrung several avenues of future development – specifically direct integration with the core TRANSIMS libraries.
6. The original TransimsVIS had poor in-code documentation and structure.

13.2. TRANSIMS Integration and Program Framework

There was an early expression of the value to integrate the visualizer directly with the TRANSIMS code base. The potential advantages of this merge include: eliminating the need to implement an independent file I/O system, gaining access to TRANSIMS SysLib’s extensive set of utility functions, active compatibility with TRANSIMS development, the potential for direct integration with TRANSIMS (for instance, an interactive Microsimulator), and a stronger distribution strategy to ensure TransimsVIS is available with all releases of TRANSIMS. This integration required a preliminary conversion of the Chicago network to version 5 of TRANSIMS for use in testing the visualizer.

There are many similarities to the original TransimsVIS structure, however the sovereignty of individual classes is much better respected and in-code documentation is plentiful.

13.3. Visibility Testing and Navigation Frameworks

The nature of 3D programming implies that both visibility testing and navigation become an order of magnitude more difficult and more valuable. Visibility testing essentially means understanding what is in the viewing volume (what the user sees) and what the user is talking about when they click somewhere. OpenGL provides a function called gluUnProject which will reverse the modelview and perspective transformations when given an X, Y, and Z in window coordinates. In this case X and Y are easy to obtain, however Z is much less simple as the user is only able to move the mouse in 2D - so any position necessarily corresponds with a ray of Z candidate selections. Fortunately for transportation visualization, the core data is essentially on a 2D plane, so the point you are interested in is simply the intersection of this ray with the 2D plane. There are two ways of performing this intersection: use of the OpenGL depth buffer to approximate the distance or using geometry to mathematically compute the distance. As the former is much simpler than the latter, it was the method initially used for the computation. The relative slowness of the operation, however, implores a replacement in the future.

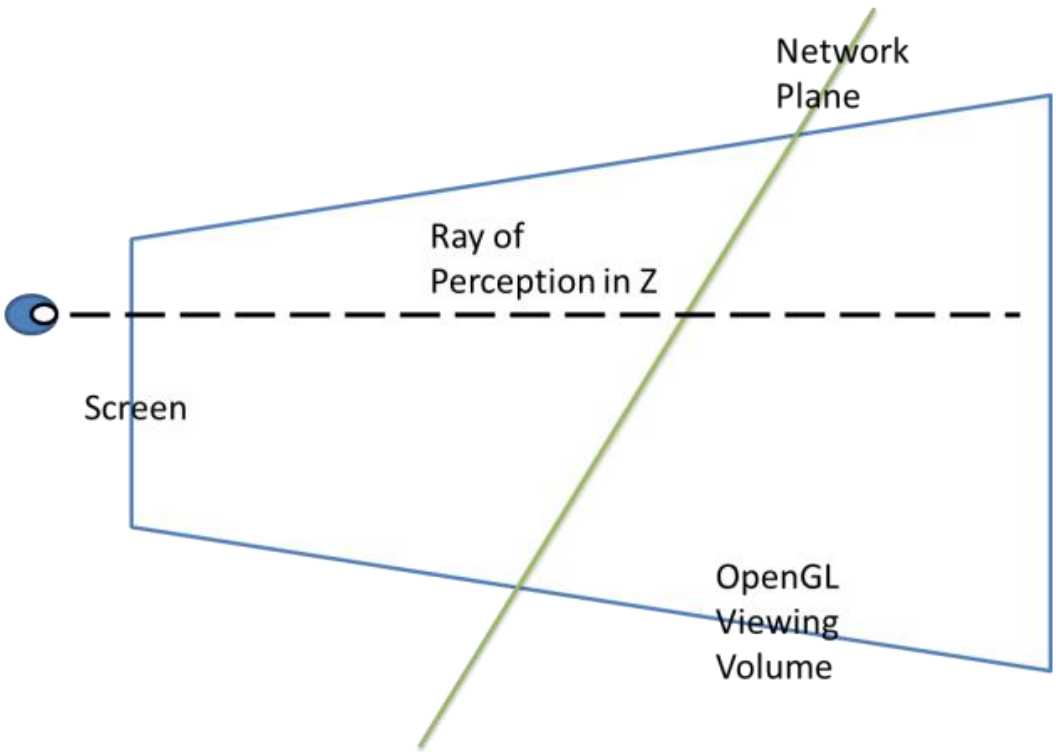

Figure 13.1: Illustration of the Eye's Perception and Interaction with the OpenGL Network Plane

Navigation is closely intertwined with visibility testing, if one can discern the point that the user is clicking on and moving to, the 2D plane can easily be adjusted to correspond with that new position by performing the necessary translation and rotation operations. Zooming has been handled initially with the mouse wheel (+/-), keys will be used as well eventually. To make the approach feel smoother and resemble an application like Google Earth more closely, the zoom is done in many tiny steps which are hooked up to the system idle process. This means that the zoom happens fluidly as the processor is able to handle it.

13.4. Network Drawing Algorithm

Arguably one of the most important drawn elements of a transportation visualizer is the road network. Style and performance are both issues when drawing a network as large as the Chicago Metropolitan Network. The drawing algorithm uses two tiers of detail to ensure that the network can always be drawn as fast as possible. The basic tier which is used when visualizing on a regional level works fairly simply. All of the link vertices are cached in advance as a vertex array, during the render cycle the OpenGL DrawArrays command is used to draw all of the lines with very fast speed.

Once the zoom is sufficiently localized, a different approach becomes necessary to begin displaying all of the details. In preparation for this type of visualization, links need to have their bounding boxes constructed and trigonometric functions based on their bearing angles need to be cached. The first step is to loop over all the links and determine which are within the viewing volume; these are collected into a fast iterating hash set for the purposes of determining visibility of other objects later. Next, there is a loop over the links for each visible element to ensure that they are properly drawn from bottom to top so as not to confuse the depth buffer. First there is a grey carpet polygon layer which accentuates the shoulders and full extent of the roadway. Second, there is a drawing of the permanent block of lanes. Third, there is a drawing of the pocket lanes. Fourth, the dashed lane delimiters for the permanent lanes are drawn. Fifth, the dashed lane delimiters for the pocket lanes are drawn. Sixth, the thick yellow centerline is drawn for two-way links. Finally, the intersection disks are drawn on top of each intersection to illustrate the setback of an intersection. Throughout the drawing algorithm the line widths are varied to seamlessly change with the level of zoom.

Figure 13.2: High Quality Road Network Drawing Algorithm

13.5. Satellite Imagery Acquisition Algorithm

One of the most important ways to associate a model's data with the real world it models is by satellite imagery. The success of the algorithm used in TransimsEDT (a network editor developed at TRACC) implored a port to the new TransimsVIS. One of the main drawbacks of the original TransimsVIS was the incredibly slow display of satellite images. The difficulty of displaying satellite imagery at a fast render speed even in C++ required a sophisticated algorithm which had to utilize multithreading.

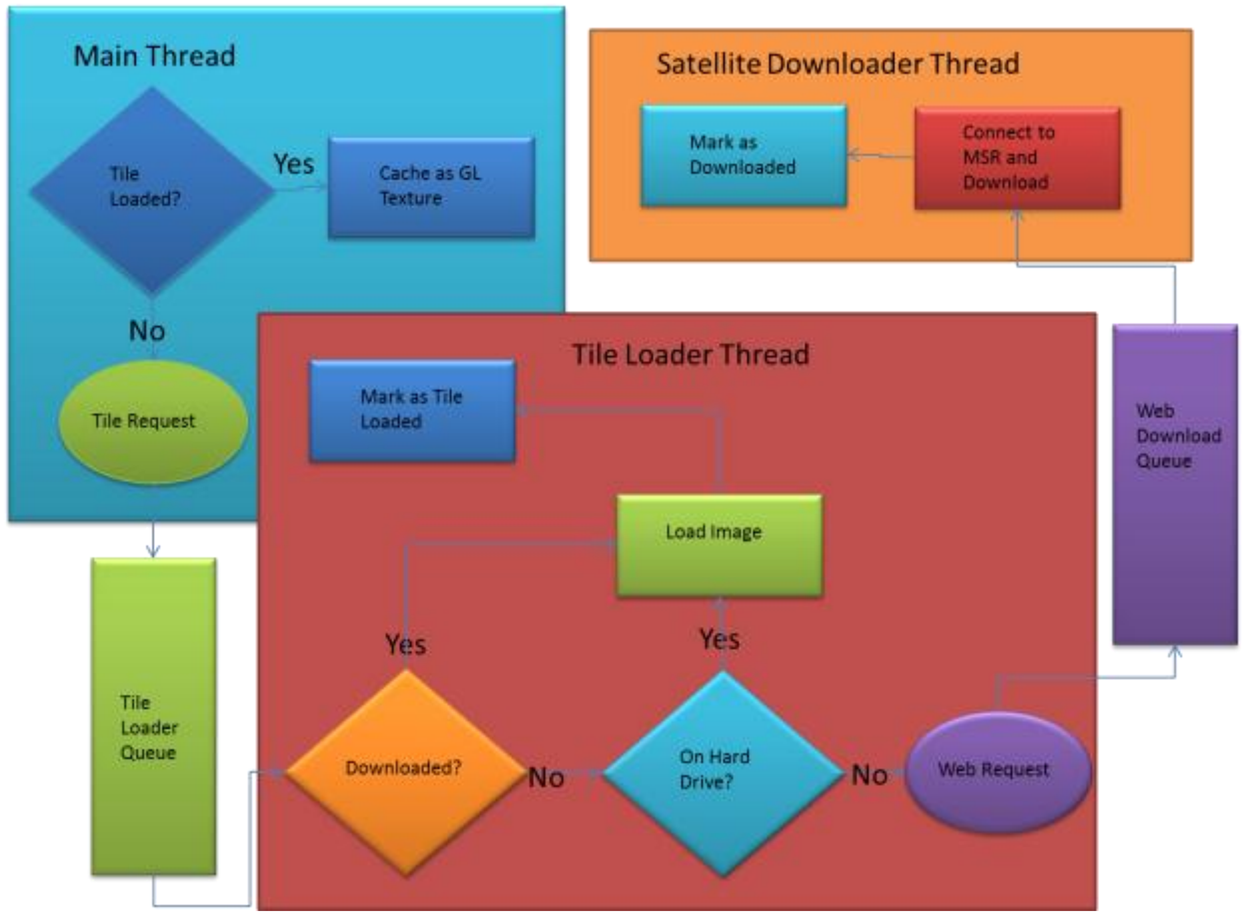

Figure 13.3: Satellite Loading Algorithm

By making generous use of multithreading, the "hard work" of the satellite imagery is handled outside of the main thread. The only responsibilities which rest with the main thread are to submit the tiles for loading if necessary, caching new tiles as OpenGL textures, and finally drawing all available tile textures which are applicable.

In addition to the loading algorithm, there are also several algorithms which manage the queues and memory. The loader queues are designed as LIFO (Last in First Out), because of this a stale collection of records can build up at the end of the queue which periodically needs to be cleaned up. Similarly, caching every satellite image at every level of resolution for the entire regional area would require more memory than is available on most desktop machines. Therefore, periodically the oldest satellite images are cleared from memory (but not from the hard drive); these can be reloaded when needed again.

Figure 13.4: Satellite Imagery for O'Hare Airport

13.6. Vehicle Compression Algorithm

A consistent problem with visualizing a regional group of travelers is that the file which specifies these traveler's positions is relatively large and thus slow to read and write. The algorithm for the previous version of TransimsVIS was somewhat limited by the python programming language such that a bit-level of compression could not be obtained, so an alternative method which utilized making frames dependent on previous frames was necessary to achieve an acceptable level of compression. Additionally the previous version of the compression did not include a few critical data elements, namely the direction, lane, and link the vehicle occupied as well as limiting the total number of passengers – these shortcomings hampered the potential to make a correlation with a plan file or network data.

```
struct Raw_Vehicle_Attributes
{
    unsigned int id:28;
    unsigned int lane:4;
    unsigned int link:20;
    unsigned int passengers:12;
    unsigned int speed:8;
    unsigned int offset:23;
    unsigned int dir:1;
};
```

Figure 13.5: Vehicle Compression Scheme

This is a special kind of C++ structure which utilizes bit-level memory allocations. The way it reads is that for a given record: id fits into 28 bits, lane into 4 bits, link into 20 bits, etc… The advantage here is that only the memory needed is used, the entire record is only 12 bytes (the equivalent of storing one 12 letter word to describe all listed aspects of a vehicle's time step). In addition to recording all of the data in this format, an index is also created at the beginning of the file, this index specifies where in the file the different data elements are for each second of the snapshot. As time steps are no longer dependent on the previous one, navigation through the file becomes much more flexible, the key frames (to a user the ticks on the time slider) can now be whichever length the user feels is necessary. The final improvement over the previous compression is that the TRANSIMS version 5 Microsimulator will support this format and be able to output it directly. The format no longer requires a pre-computation of x and y for the vehicle, this means that no additional processing through ArcSnapshot is necessary.

13.7. Snapshot Buffering and Management

One of the most challenging aspects of snapshot visualization for a large area is the loading of the snapshot. Many of these regional snapshots are too large to fit into memory, for a moderately sized region over a 15 minute interval only - the compressed file can approach half a gigabyte. Therefore, similar to the previous visualizer, the decision was made to read only the necessary portion of the snapshot file on-the-fly. However, unlike the previous visualizer there was not nearly enough time to do this in the main loop, instantiating only time step at a time. Therefore, the process was threaded to behave somewhat like a web-buffered video.

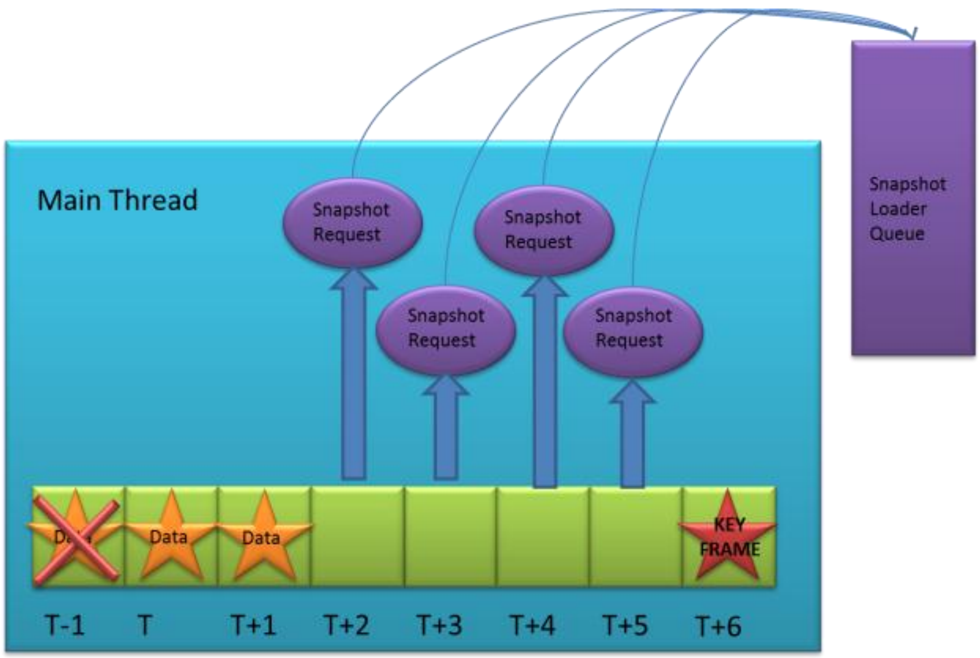

Figure 13.6: Snapshot Buffering Algorithm

Only a fixed sized buffer of time steps (and all key frames) is kept in memory at a given time. The remaining steps are erased step-by-step and future steps are requested if applicable. When the time control is used to switch to a new key frame, all data is cleared.

13.8. Vehicle Loading and Visualization

Similar to many other processes in the visualization, the physical loading of a snapshot file is computationally expensive, so it is done across a series of snapshot loader threads. These threads not only extract the data from the hard drive, but do a good chunk of pre-rendering to get the vehicles ready to be visualized. The basic process is shown below:

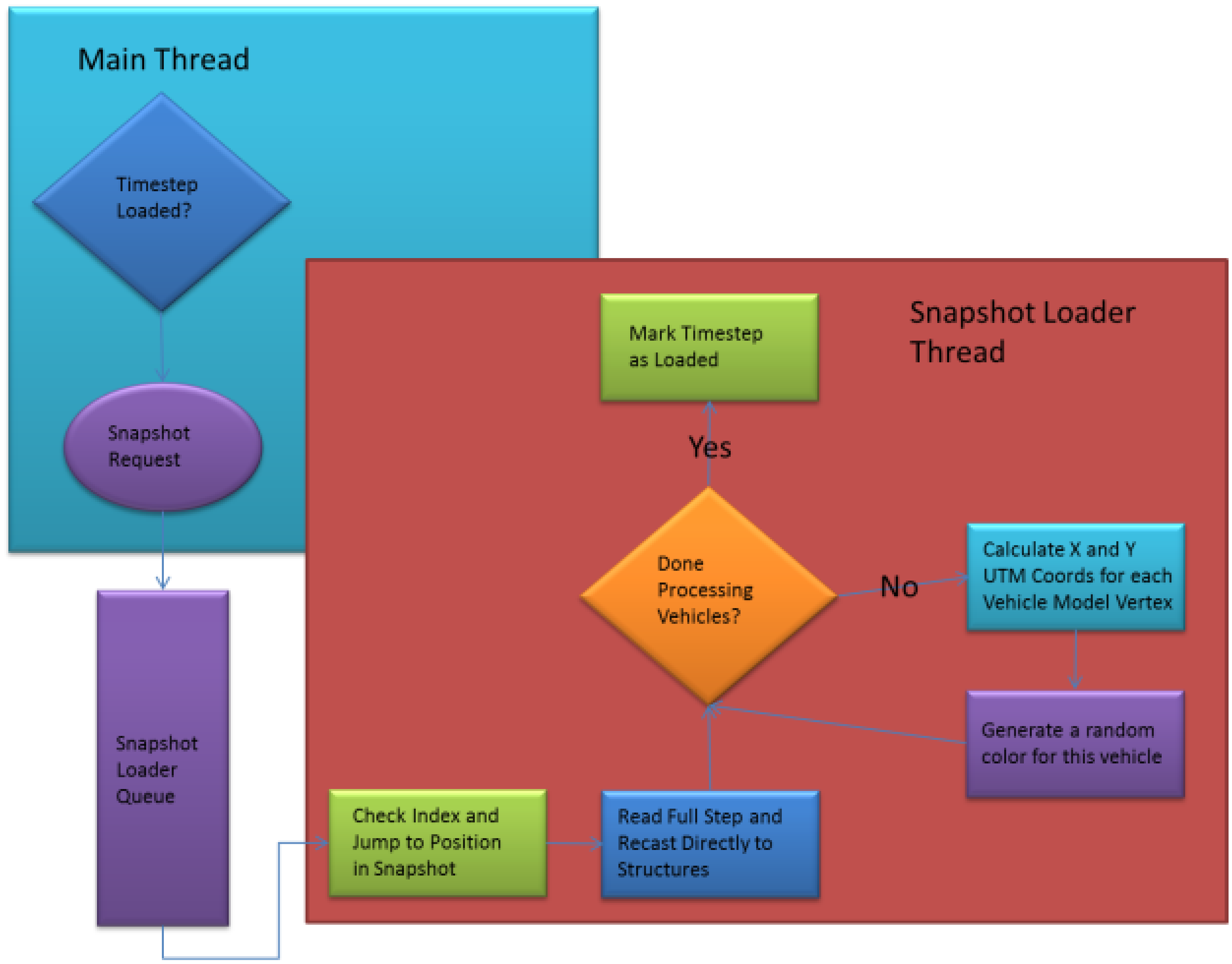

Figure 13.7: Vehicle Loading Algorithm

Two different draw methods are employed for visualizing the vehicles. If working at a regional level, the very fast DrawArrays command will draw only the basic "footprint" of each vehicle without lighting or coloration calls to slow it down. If zoomed in to a local area; after the vertices have been calculated for all the vehicles, the only processing which is necessary during a rendering loop is to determine which vehicles are visible for that viewing volume and to generate a list of the indices of these vehicles. The visibility testing is very easy as at this point in the rendering loop it is already understood which links are within the viewing volume and which are not, requiring only a simple hash set membership test. The final draw commands are handled with an efficient set of calls in OpenGL "immediate" mode rendering the vehicles with coloring and transparency.

13.9. Data Plot Visualization

One of the most critical elements of a visualization tool like this is being able to aggregate data on a regional level and displays it dynamically. The solution proposed is that of a generalized data plot. The concept is that the region gets subdivided into many tiny squares, each of which can hold some quantity of data. Over time, the data can accumulate in the squares and similar to heat, will spread to surrounding squares. Squares with lots of data are "hotter" and will dissipate more heat farther. The end result displayed is to draw each square as a vertex at the center of the square, its height, color, and transparency correlates with the current amount of data within the cell. This routine is extremely expensive to handle second-by-second, so the algorithm is extremely efficient and makes full use of parallel processing.

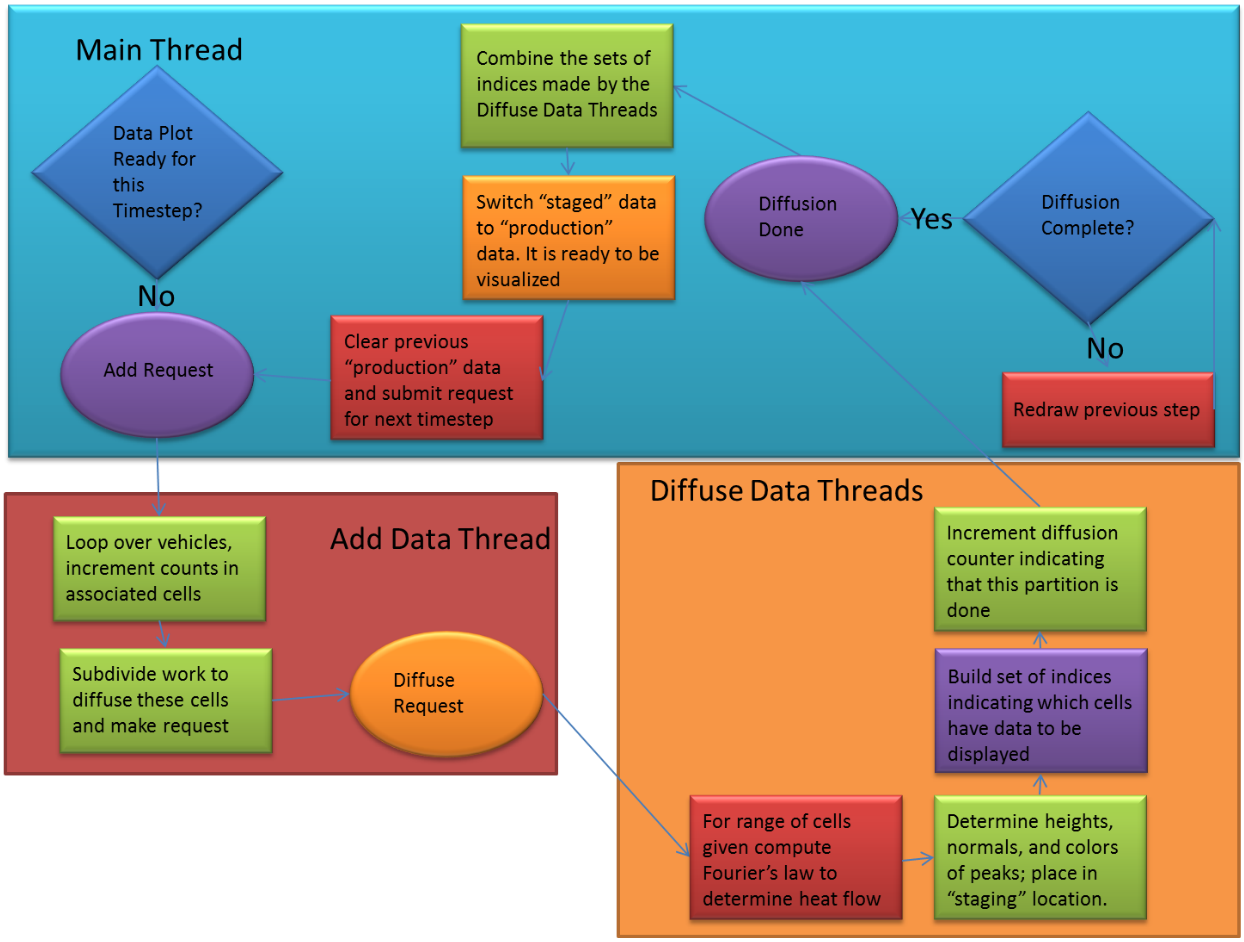

Figure 13.8: Data Plot Algorithm

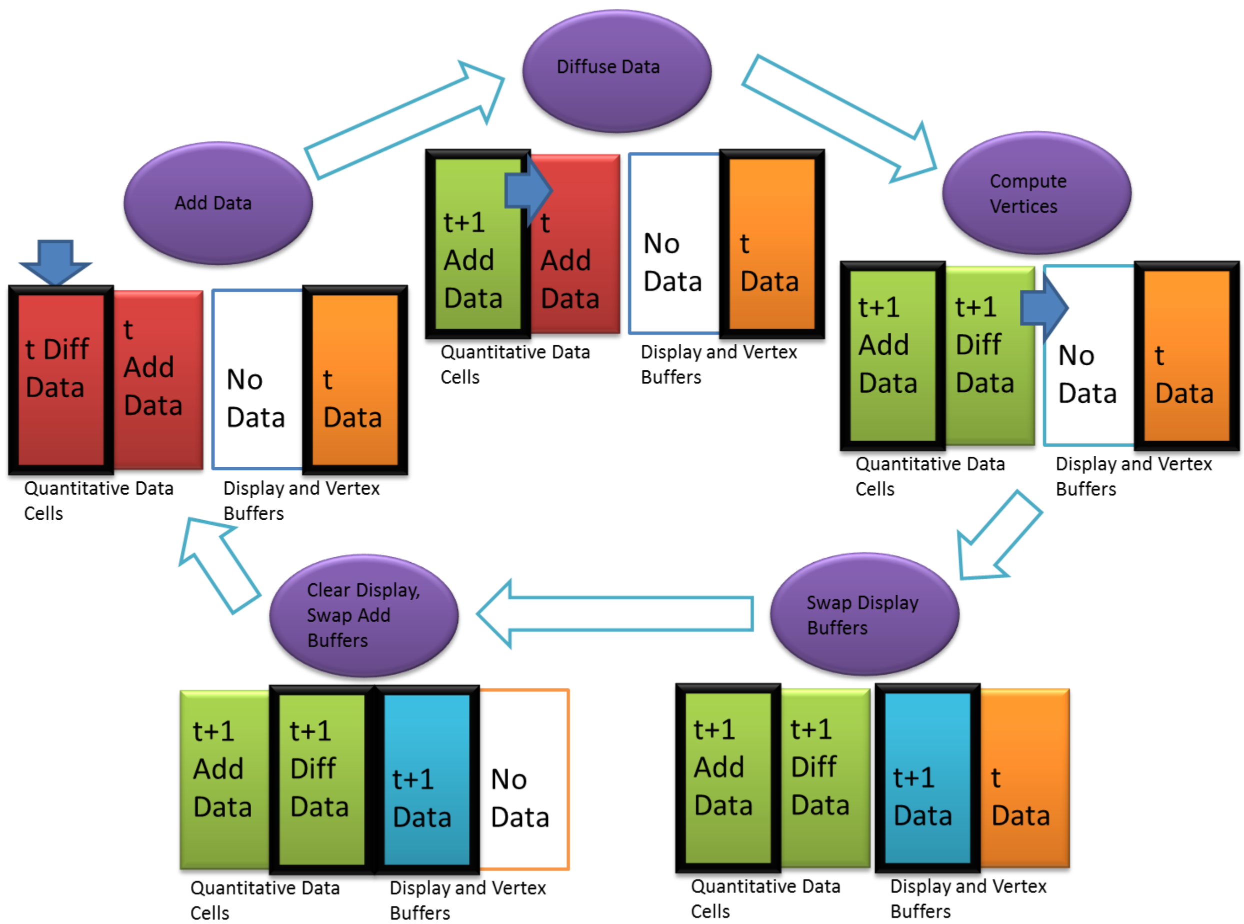

Figure 13.9: Data Plot Memory Flowchart

Currently this generalized algorithm is used to display vehicle congestion values. The more vehicles in one area, the higher the data plot in that region. As cars move out of the area, the data plot dissipates showing a very nice ebb and flow in the system.

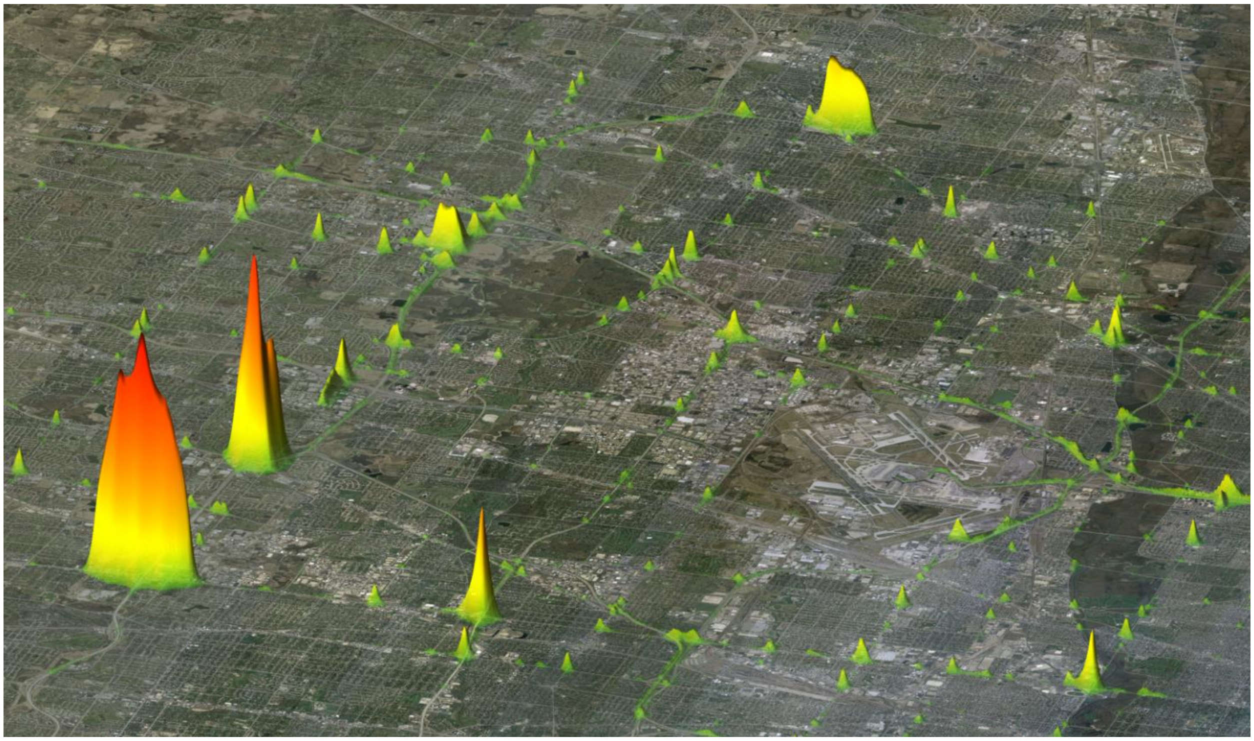

Figure 13.10: Regional Data Plot

13.10. Regional Vehicle Visualization Algorithm

One of the major challenges in visualizing vehicle traffic in a large region such as Chicago is to find an effective balance of vehicle display quality versus performance. In the February report a vehicle loading algorithm was described, this has now been upgraded to handle the regional case. The primary difference is that an extra step has been added to the pipeline. Previously the processing (computation of vertices) was done at the same time the reading was done; now this processing is split up into parts and performed in parallel.

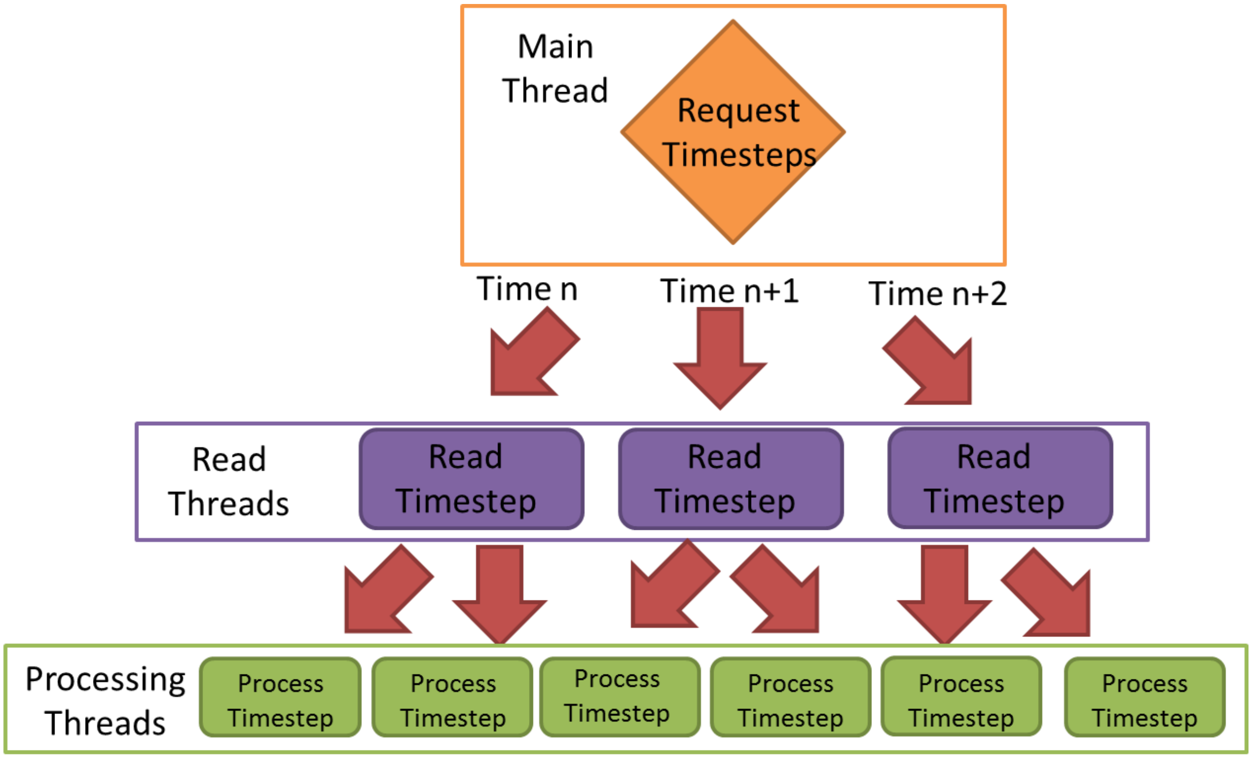

Figure 13.11: Regional Snapshot Reading Pipeline

One other fine point which was enabled by dividing the reading into two pipe segments is that vehicle design became much more flexible. The read algorithm now computes the memory requirements of all the vehicle vertices in the time step which means that vehicles can now deviate from the previous limitation of having only 12 vertices. This will be invaluable as work progresses to develop differentiated vehicle models by vehicle type. They are designed to be simple in order to be visualized quickly, yet complex enough to indicate the vehicle type.

Figure 13.12: Basic 3D Car Design

13.11. Regional Data Plot Algorithm

Visualizing the data plot over a large region on the fly is a challenge on the same order as that of loading and visualizing vehicles over the region. In the February report an algorithm to compute the data plot was also shown. In similar fashion to the vehicle loading procedure, an additional part of the pipeline was parallelized to compute the data plot for the subsequent time step. In short, the thread which previously accumulated the data from vehicles for the current time step now does so in a parallel manner allowing it to cross vast tracks of the vehicle array in a time-efficient manner.

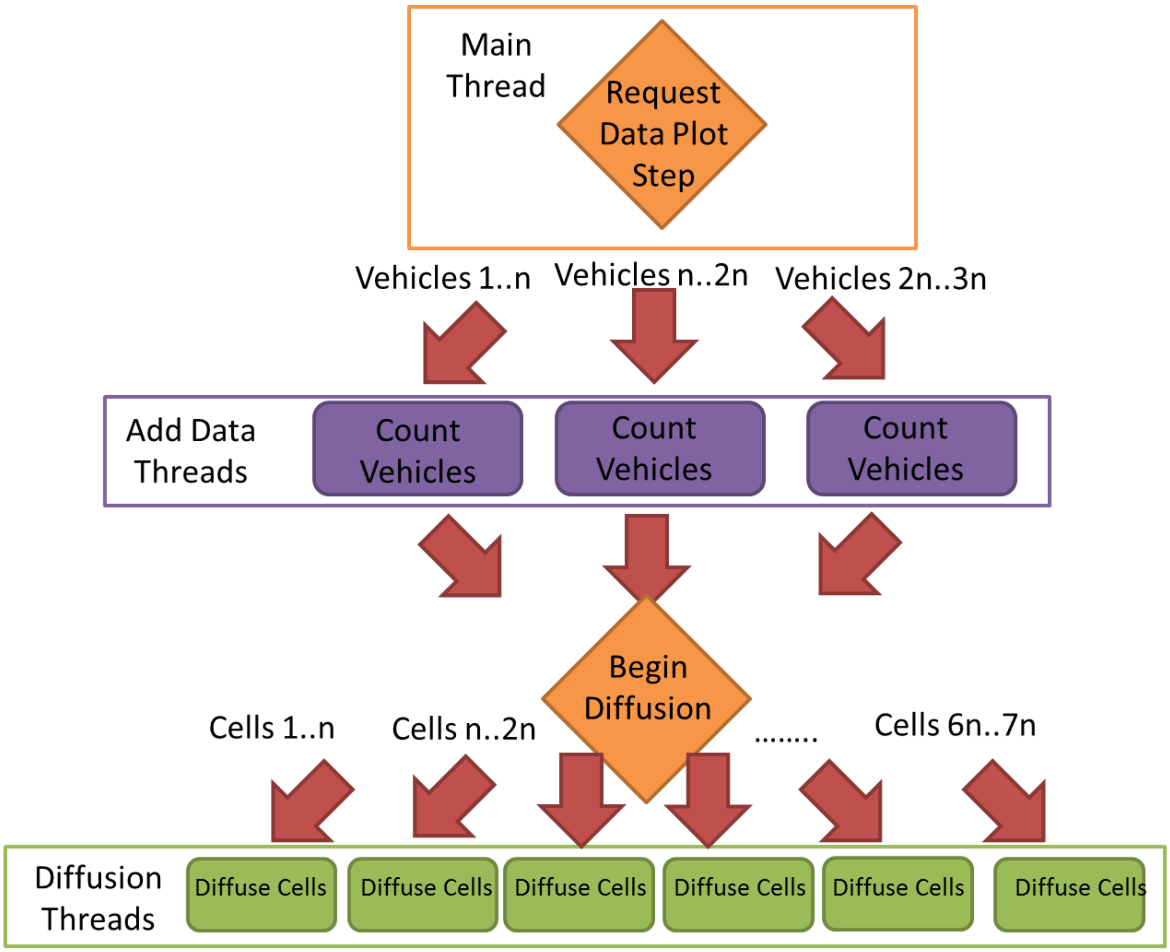

Figure 13.13: Regional Data Plot Pipeline

Added to this improved algorithm is a tool that allows the user to select the region they wish to see plotted. By enforcing this restriction, the algorithm can intelligently compute a data cell size which is balances perfectly computational efficiency versus visual appearance for that region. Additionally, as the data plot is an adaptive algorithm, it allows the user to eliminate regions which would "skew" the data.

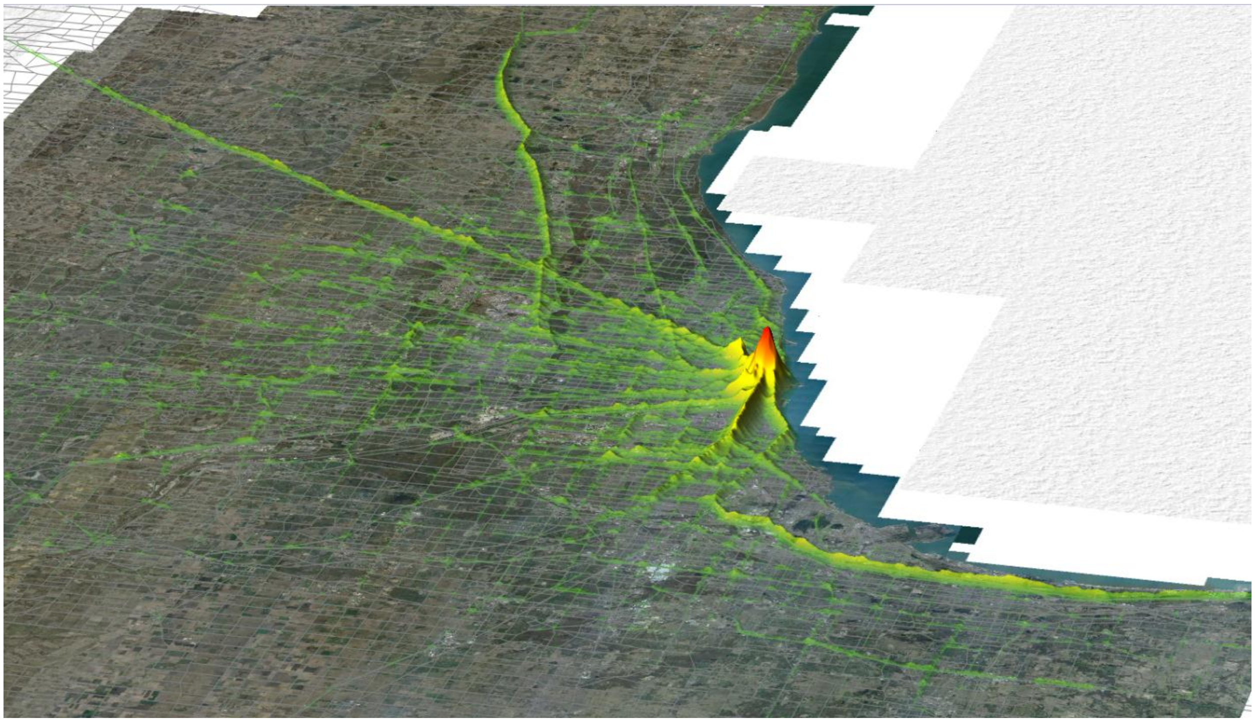

Figure 13.14: Regional Data Plot

13.12. Regional Satellite Algorithm

Another challenge which occurs when visualize the software over a large region is that of managing the satellite imagery. The algorithm was overhauled to be far less error-prone and much higher performance. In addition a certain amount of intelligence was added in to select the correct resolution of tile (thus keeping performance and resolution much better balanced).

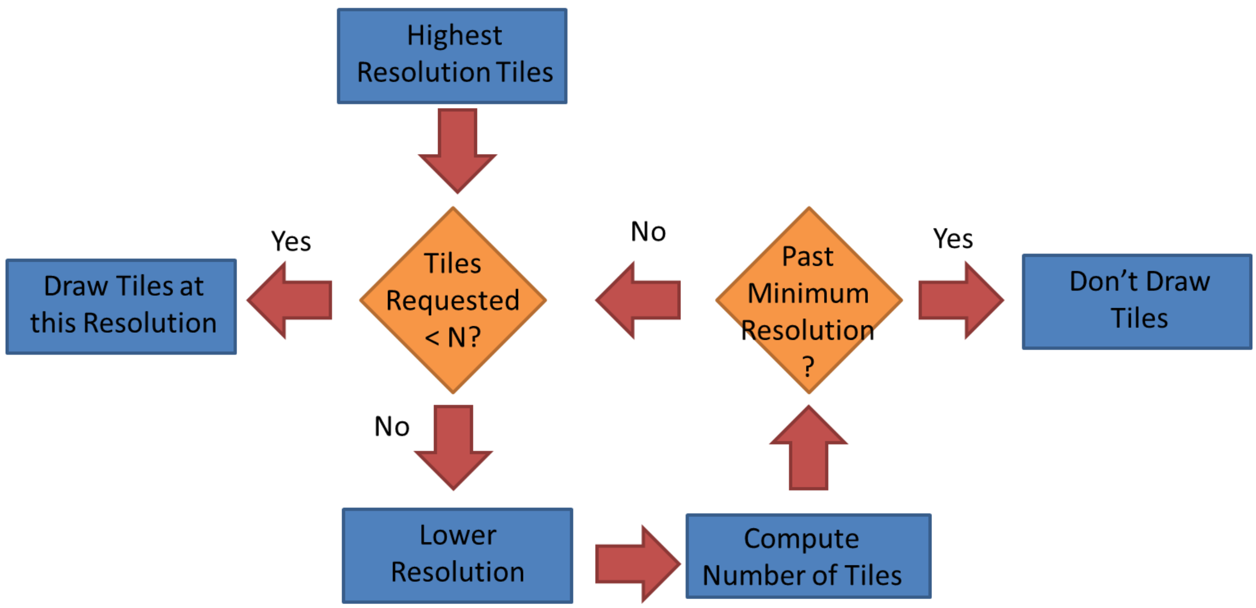

Figure 13.15: Regional Satellite Resolution Choice

13.13. Improved Time Control

A small but important feature which compliments the revision of the snapshot loading feature is that of an improved time navigation control. The previous control would automatically size to where snapshot data was available. However, many of the things RTSTEP would like to visualize are not concurrent with the snapshot. Therefore, a more general 24-hour time control was developed with an hour and a minute slider along with a large easy-to-read digital clock. In addition, the display denotes where snapshot data (or other temporal data) is available using green bar segments. In this example data is available from 8:00:00 to 8:05:00, from 12:00:00 to 12:05:00 and from 17:00:00 to 17:05:00.

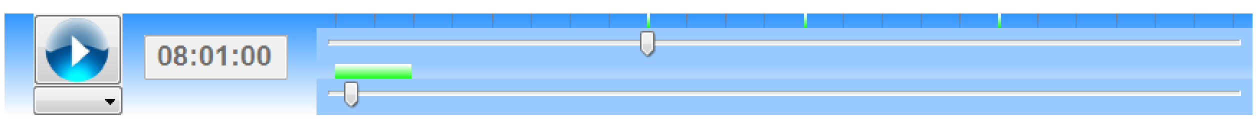

Figure 13.16: Improved Time Control

13.14. Link and Node Selection Feature

In any effective spatial analytical tool, there must be some way to drill down to the underlying data through element selection and attribute display. Fortunately TRANSIMS comes pre-equipped with libraries which can identify whether a point is inside a complex polygon or not. This means that to identify links: the only thing TransimsVIS needs to communicate is the projection of the cursor onto the x,y plane and provide a list of candidate polygons in the viewing area. For nodes, it is simpler; all that is required is a distance check from the projection of the cursor to each visible node with the minimum distance within a certain tolerance being the identified node. A pleasant feature which was designed in TransimsEDT was to "drive" over the links and highlight them as they are identified. This was augmented by displaying the attribute table on the fly in a right-hand information panel. The tooltip is also configured to display the ID of the link or node as it is driven over.

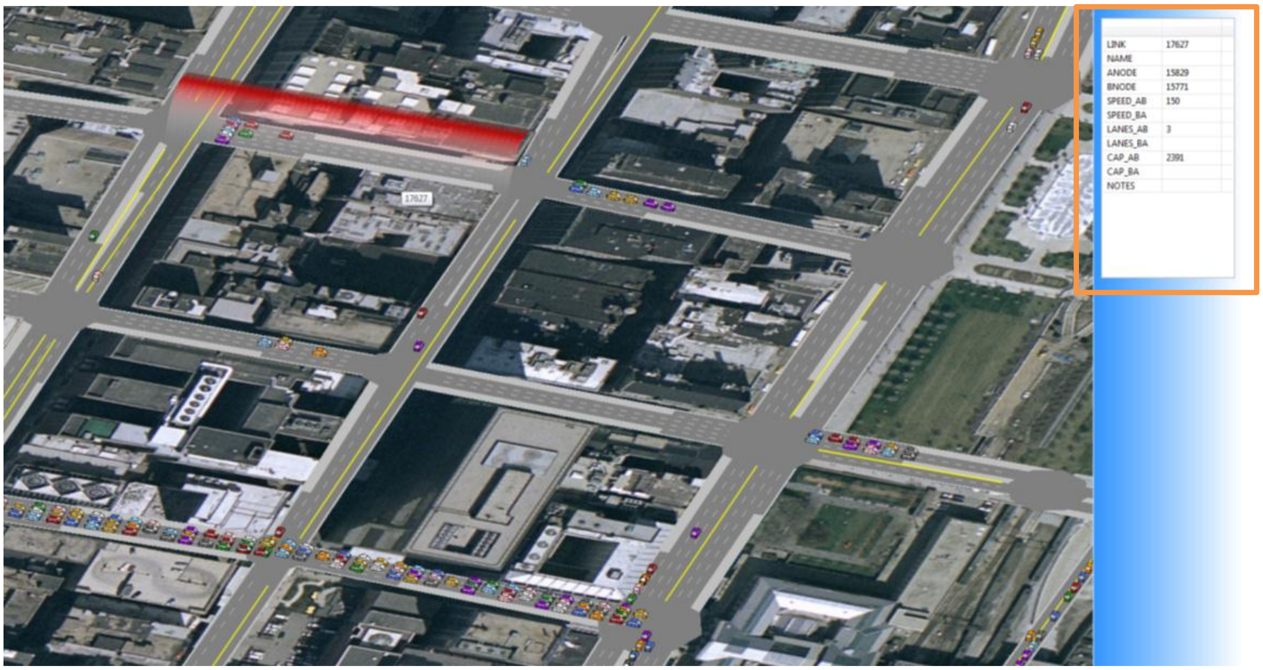

Figure 13.17: Link and Node Selection

13.15. Distribution for Testing

One vital practice in developing new software is to ensure it is properly tested. One of the goals was to make the software available to others on the RTSTEP team. In order to do this several things had to be done. First, the project had to be updated to the latest version of the TRANSIMS version 5.0 trunk. Second, the software needed a control file designed for it (the input file language TRANSIMS uses) with appropriate control keys. Third, the software needed to be more tightly integrated with the TRANSIMS version 5 Microsimulator so that the simulator could output a compressed vehicle snapshot file that the visualizer could make use of. TRACC worked with AECOM to update the Microsimulator to output such a compressed snapshot. Fourth, the software had to be committed to a central archive. For this, TRACC established a new branch of TRANSIMS which will be used for updating all RTSTEP-related utilities. All of these goals were accomplished in March and copies of the visualizer are now available to all team members.

Figure 13.18: Visualization of Alexandria, VA

```
TITLE                                   Simulate the Trips for Chicago
DEFAULT_FILE_FORMAT                     TAB_DELIMITED
PROJECT_DIRECTORY                       C:\Users\hope\Desktop\Transims50_T

MODEL_START_TIME                         0:00                    //---- >=
MODEL_END_TIME                           9:00                   //---- > [
UNITS_OF_MEASURE                         METRIC                  //---- ME
RANDOM_NUMBER_SEED                       0                       //---- 0
MAX_WARNING_MESSAGES                     100000                  //---- >=
MAX_WARNING_EXIT_FLAG                    TRUE                    //---- TR
MAX_PROBLEM_COUNT                        0                       //---- >=
NUMBER_OF_THREADS                        6                       //---- 1.

NODE_FILE                               network/subarea_node
LINK_FILE                               network/Link
POCKET_FILE                             network/Pocket
PARKING_FILE                            network/Parking
CONNECTION_FILE                         network/Connection
LOCATION_FILE                           network/Location
ACCESS_FILE                             network/Access_Link
SIGN_FILE                               network/Sign
SIGNAL_FILE                             network/Signal
TIMING_PLAN_FILE                        network/Timing_Plan
PHASING_PLAN_FILE                       network/Phasing_Plan
DETECTOR_FILE                           network/Detector
VEHICLE_FILE                            demand/regional_vehicle
VEHICLE_TYPE_FILE                       inputs/vehicle_type_V5
PLAN_FILE                               demand/regional_trips_TimePlan1.*
HOUSEHOLD_FILE                          demand/regional_household     //--

NEW_SNAPSHOT_FILE_1                    results/regional_trips_Snapshots
NEW_SNAPSHOT_FORMAT_1                  BINARY
NEW_SNAPSHOT_INCREMENT_1               1 seconds
NEW_SNAPSHOT_TIME_RANGE_1              8:00..8:05
NEW_SNAPSHOT_COMPRESSION_1             TRUE                    //---- TRUE/
```

Figure 13.19: Microsimulator Control File with the Snapshot Compression Key

13.16. Cinematic Waypoints

When examining cases, it is often helpful to have a set of visual positions you can quickly jump between. Similarly, when creating visualization videos or watching dynamic effects; it is helpful to move between positions over time. For this purpose, a waypoint system was created in the TransimsVIS software. It allows users to catalogue interesting spatial positions and jump back to them on demand. The user can also click on a set of time-position combinations and add them to a "playlist" of points which they would like to watch visualized.

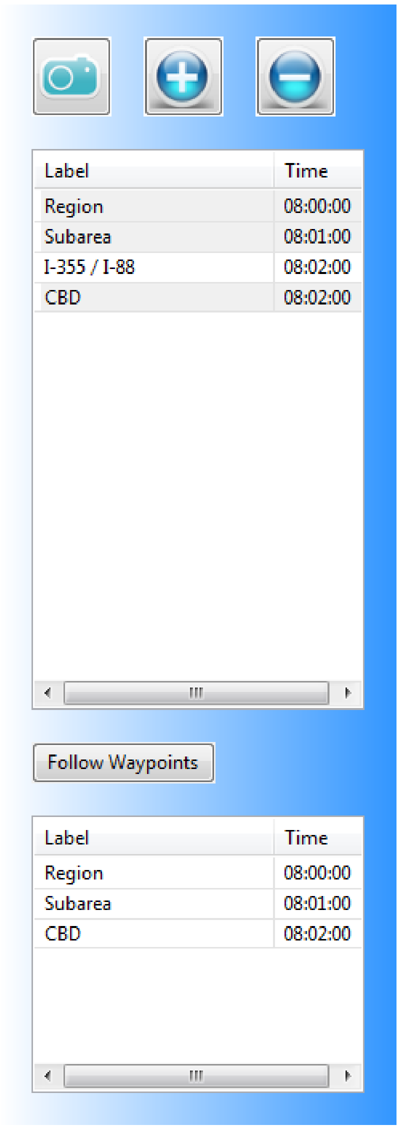

Figure 13.20: Waypoint Control Panel

13.17. Interpolation

In order to achieve the effect of very smooth vehicle trajectories (and other visualizations such as the waypoint feature), interpolation is very important. Interpolation generally means that given two full timesteps, the intermediate steps can be computed as weighted combinations of similar members in each set. Given the nature of the snapshot loading algorithm, implementing interpolation is not that straightforward. The loading algorithm must buffer some number of timesteps ahead in order to maintain high performance. When these two concepts are put together, they require that the buffering order must be specific to some degree.

As an example, consider the situation where you have a second-by-second snapshot from 8:00:01 to 8:00:03 and you want to interpolate by 5 and buffer 10 timesteps. Instead of buffering the next 10 timesteps in any order, you must request roughly in this order:

1) 8:00:01 and 8:00:02
2) Steps between 8:00:01 and 8:00:02
3) 8:00:03
4) Steps between 8:00:02 and 8:00:03

The other major advantage of interpolation is that lower resolution snapshots (2 second by 2 second) may be used and still appear very fluid during visualization. These snapshots are necessarily half or less the size of a full resolution one. Notice the partial lane changes and non-cell-length positions of vehicles.

Figure 13.21: Spatial Interpolation

13.18. Restructuring

As the TransimsVIS program grows, it becomes more important to have strong code structure so that all of the complexities can be neatly handled. The first such restructuring effort is designed to lay the foundation for the rest of the visual paradigms and interfaces to be delivered as part of RTSTEP. The complexity of a multi-threaded event-driven program such as the visualizer comes from the following set of issues:

- Is my data available (from file) for a given timestep?
- Has my data been processed for this timestep such that it can be displayed?
- If I depend on multiple data sources, how do I check whether they are available for a given timestep and whether I can begin processing?
- If my data "evolves" over time and depends on previous timesteps, how do I check whether I can begin processing a new timestep?
- How can I conserve memory, gpu, and cpu cycles wherever possible?
    - What is the optimal configuration of data for the gpu to render as fast as possible
    - How can every process which would benefit from multithreading be parallelized
    - Can I pre-allocate memory and manage it myself to save on dynamic memory allocations

The solution to begin to solve these problems came through using a very general base class called the "Dynamic_Dataset." This base class is aimed to accommodate the following present (and future) dynamic data structures: data plot, vehicle trajectories, link wall plots, signal systems, dispersion patterns, evacuation routes, evacuation areas, evacuation tracking, transit ridership, and more. The functional content is roughly described below:

- Request, process, and store upcoming timesteps in parallel using generalized functions and data structures.
- Cache sets of vertices in a configuration for optimal display speed (for a 4x or greater speed increase compared to indexing vertices).
- Manage layers and dependencies among dynamic datasets.
- Generalize the processing and tracking multithreaded pipeline.
- Coordinate all parallel processes, get a visualization's processing status / availability for a given time.
- Pause threads, clear data, or erase data with generalized functions.

- Develop generalized buffers and thread safe versions of STL structures for parallel reading and writing as well as memory conservation.

Using the Dynamic Dataset, the generalized pipeline to coordinate multiple dynamic datasets becomes much more structured. In this example image there are four active visualizations: vehicle trajectories, data plot, link wall plot, and transit ridership plot. These visualizations depend on snapshot, trajectories, problems, and snapshot respectively. While timestep, ***t*** is being visualized, the next ***t+N*** steps are requested in parallel. First the sub-pipeline for each of the file-dependent data structures are evaluated. Once these are complete, it waterfalls to the ones which depend on those. The datasets which evolve over time (such as the data plot) wait for the previous step's data plot to complete.

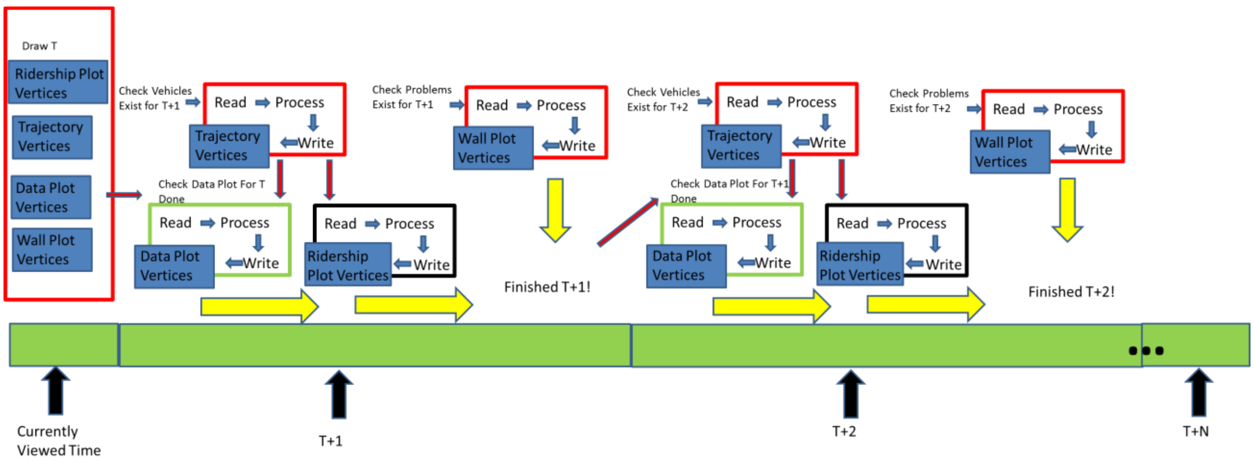

Figure 13.22: The generalized processing pipeline

Aside from the obvious increase in structural cogency, re-working the vehicle trajectories and data plot with an added step in the pipeline (write) provided the opportunity to double graphical performance. Instead of having to put data into a sparse array and only using elements of it, the vertices can be pushed together into a contiguous array that can be drawn without going through indices as middlemen. This condensed array also conserves memory, which would have otherwise been useless.

13.19. Probe Vehicles

One feature driven more by users than developers was the necessity of adding probe vehicles to the mix. A probe vehicle is some caricature of a real vehicle drawn in such a way that it is visible or relevant at the regional level. Given the regional nature of the simulation and visualization something very quick had to be chosen. The OpenGL point primitive is such a quick operation, the point is what is called a "sprite" which means that it is a pre-rendered picture which can be dropped into the scene very quickly. The next consideration was coloration; for this, some measure of the vehicle's speed was the obvious contender. The current version stresses the vehicle's speed ratio, that is the ratio of the vehicle's current speed to the road's speed limit; depending on the disparity between the two numbers the vehicles are colored from black (stopped), to red (slow), to yellow (medium), to green (fast), to white (full speed). In addition, the probes which are stopped needed to be accented so they could be seen at a more regional level. To fulfill this purpose, they are drawn at a higher size level and drawn in a second pass after the first set to ensure they lay on top of the faster moving vehicles.

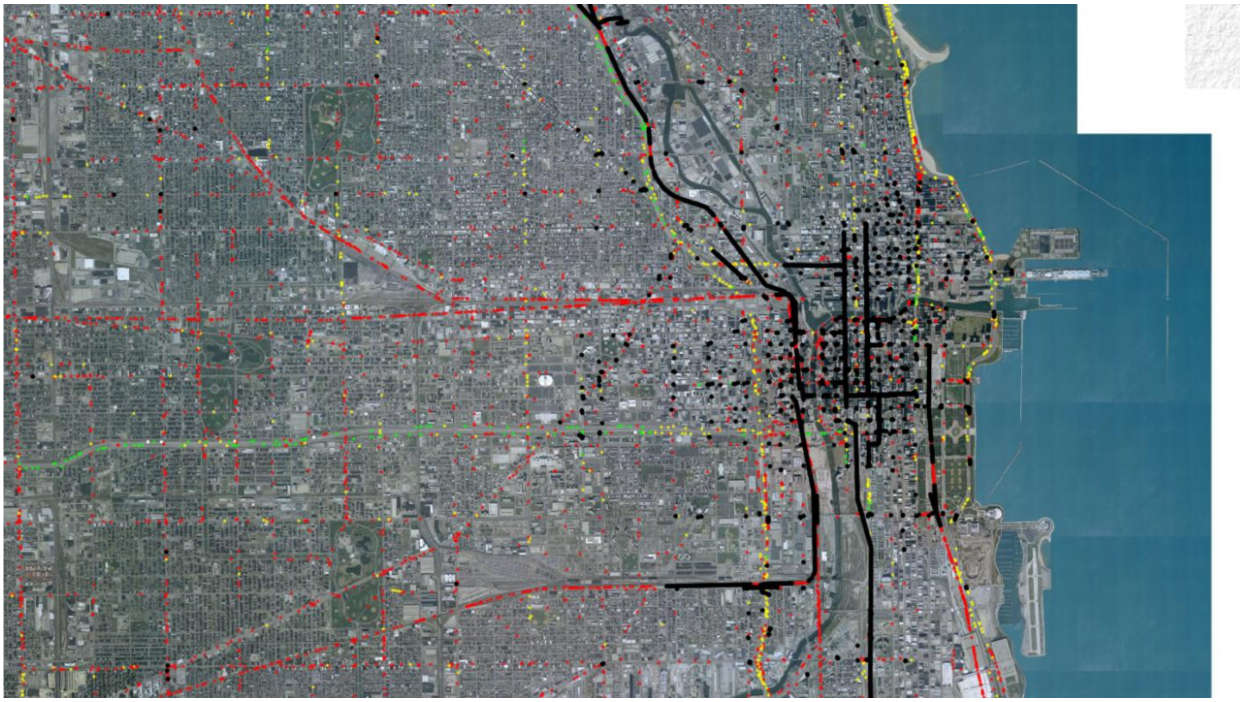

Figure 13.23: The Probe Vehicle Feature

A couple of aesthetic elements related to size and selection had to be added. In order to determine the ideal pixel size at each level of zoom, a manual assessment was done at each level of zoom to determine what the correct size for the probes were. These measurements were aggregated and regression was used to dynamically compute the correct size for a given screen and level of zoom. The second feature related to probe vehicles is that of the selection percentage, often seeing 100% of probe vehicles is not helpful at a very high level of zoom, therefore a simple selection was added to allow the user to select only a percentage of the probes to be displayed. The selection is based on a static "probe value" the vehicle is granted on creation, so the same vehicles are seen from second to second.

13.20. Improved Data Plot Intelligence

The data plot feature has proved very popular to showcase the tool's power and capabilities to non-modelers, however in terms of usefulness for analysis it needed improvement. Namely, this was due to the fact that the heat added by vehicles in the data plot was unbiased. This meant that in an area which was crowded with many streets (such as downtown Chicago), the data plot would always show a higher peak whether it was congested or not simply because there were many more vehicles there than in the outlying areas. Additionally, highways would show up as having a high peak because they contained many vehicles even if the highway was not congested. Therefore, the heat contribution was altered in a couple ways. First, the heat contribution is divided by vehicle speed; that is, the slower moving vehicles contribute more heat than the faster vehicles – stopped vehicle contribute the most by far. Second, the vehicle now takes into consideration what type of link they are on, specifically what the capacity of the link is (which is a stand-in for an aggregate assessment of the link's speed limit and number of lanes). If a vehicle is on a higher capacity link, it will contribute less heat. This mitigates the observed effect of areas with many roadways attaining much higher peak levels simply because there are more vehicles in the area.

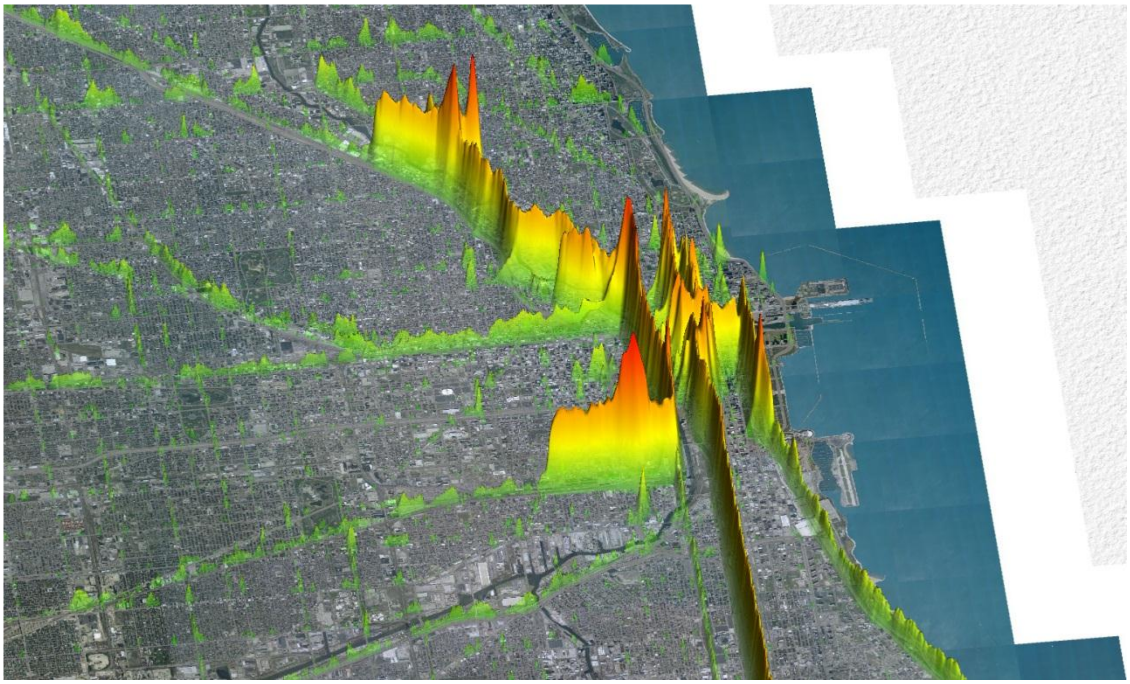

Figure 13.24: Data Plot with Improved Intelligence

In addition to these heat contribution improvements, the plot was also modified for computational and aesthetic purposes. The primary idea here was that, based on the area that the user selects, they are interested in a different level of data aggregation. When a small region is selected, they want a more precise idea of what areas are congested then when they select a larger region. Therefore, an algorithm was added which determines the grid size for the data plot based on area size as well as the height of the plot based on area size. The effect is that small regions have precise, short peaks, whereas large regions have prominent, tall peaks. This algorithm also takes into account the computational complexity of the area and will ensure that regardless of the area selected, the memory requirement will be below 600 megabytes of RAM.

13.21. 3D Vehicle Models

One important aspect of model examination when at a high level of zoom is to track how different vehicles types are behaving and to determine what certain special vehicle types (such as emergency vehicles or transit) are doing. In order to acquire this effect, it is necessary to have different 3D vehicle models for each relevant vehicle type. The vehicles are implemented in a fairly straightforward process. First, the models which need to be implemented are identified. Second, a rough idea of the design is discussed. The design is sketched out and coding begins it in a separate visualization program which is designed to accept vehicle vertices and has a simple navigation system to examine them. Once the vehicle model is completed in this program, it goes for final approval. Next, the vertices are indexed, renumbered, and codified in the TransimsVIS source.

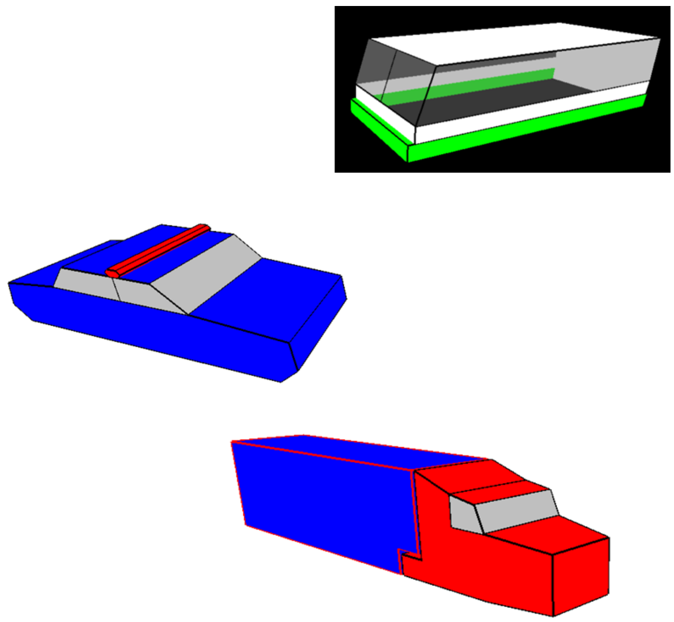

Figure 13.25: Sampling of 3D Vehicle Models

13.22. Black and White Satellite Imagery

A more minor feature addition is that of Black and White satellite imagery. This imagery is useful for Chicagoland because it has a wider coverage than the color pictures and the grey images are draw with higher performance than the color images. In addition for most non-Chicago regions, the grey satellite imagery is the only type available from MSR maps. The alternate imagery is toggled using the "SATELLITE_THEME" key in the control file.

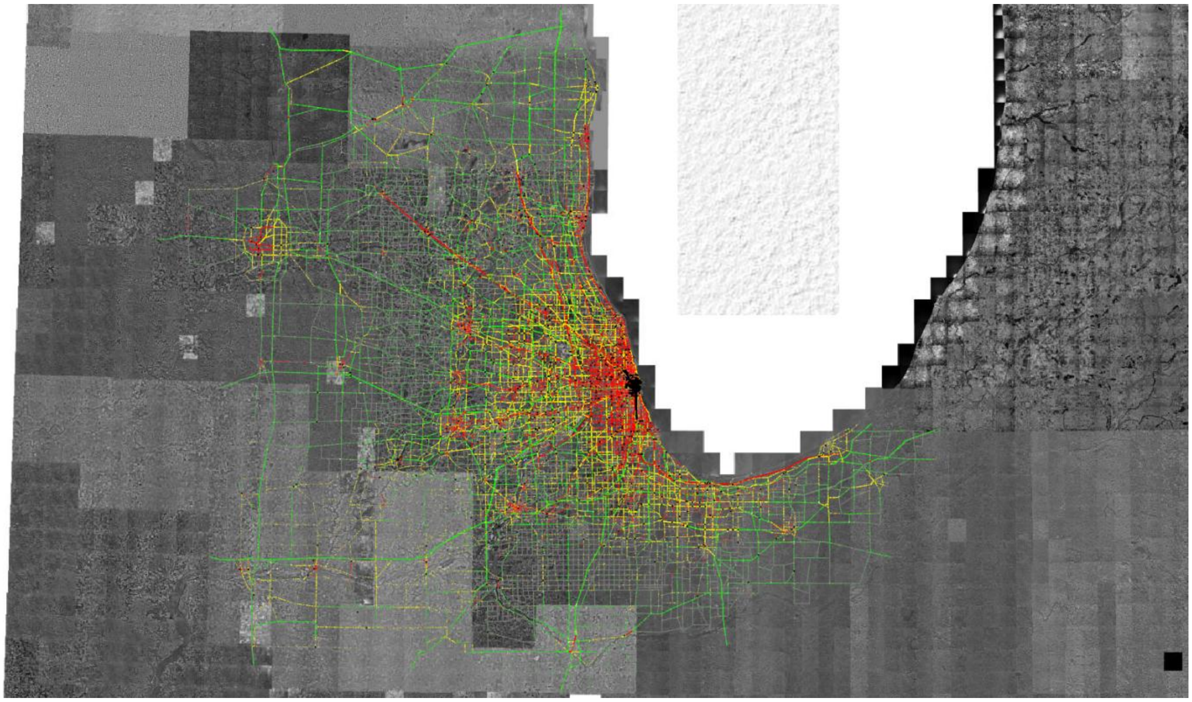

Figure 13.26: Black and White Satellite Imagery

13.23. Link Plot

The link plot is designed as a mesoscopic visualization which highlights various traffic statistics at the link level. This is accomplished by dividing the link into a set of cells. If a vehicle or other piece of data is shown to be localized within that cell, it accumulates “heat” (similar to the way the data plot gains “heat”). However, unlike the data plot, this heat isn’t fully retained and thus doesn’t spread out and become uniform across an area – this allows it to indicate more precisely in a region on a link where the relevant information is. Also similar to the data plot, the link plot is administered using a multi-threaded algorithm based on the dynamic dataset class which basically eliminates the processing load on the main thread, so it is very quick. It also utilizes the managed memory structures (as does the data plot and vehicle visualization) which allow it to not create a delay when it is necessary to allocate/de-allocate memory.

Visually, the link plot fades from opaque to transparent as the section gets closer to the ground. The top of the plot is ridged with a dark line to accent where the peaks are. The plot runs both ways on a link if it is a two-way link, or just one way on the link if it is a one-way link. The plot is also colorized by link direction to help orient the user to the data: blue for northbound links, yellow for southbound links, red for eastbound links, and green for westbound links. Also similar to the data plot, the link plot is created by selecting an area – the size of the area selected determines the height of the peaks and the length of the cells.

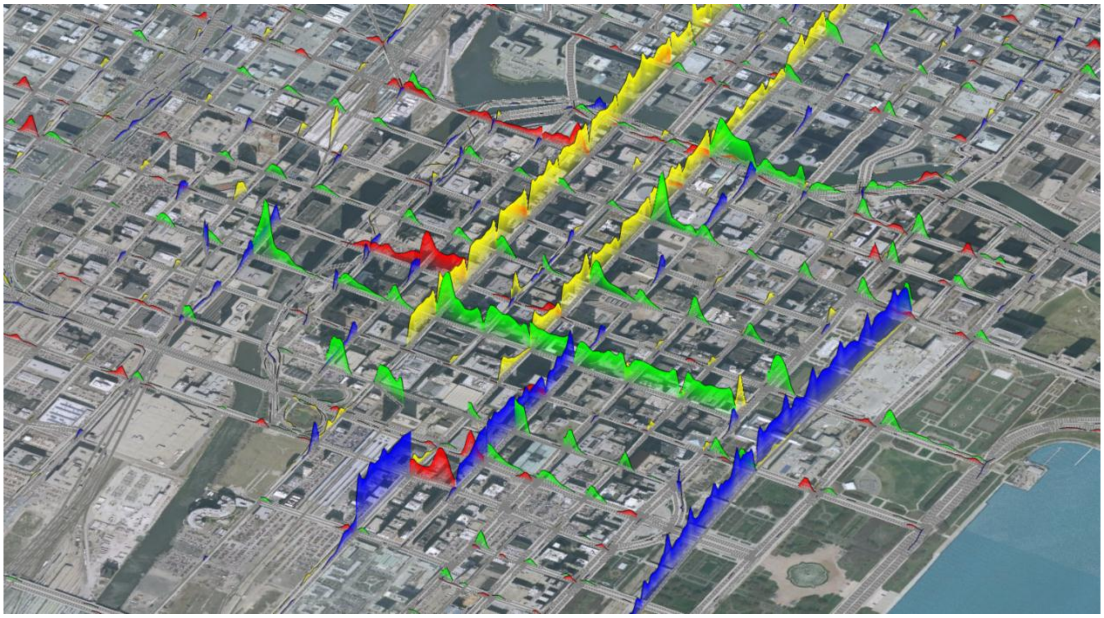

Figure 13.27: Link plot covering the Chicago Loop Area

13.24. 3D Vehicle Models

The first step of incorporating the different vehicle types into the TRANSIMS Visualizer was accomplished by Joe Reitzer. Joe created the vertices and indices needed to portray a three dimensional model of the intended vehicles including a train engine, train car, suv, pickup truck, and an ambulance. These sets of vertices and indices were then passed on to Justin Holifield who implemented them into C++ code for use in the visualizer. Most of the vehicles were normal with exception to the ambulance. Justin created a flashing effect on the ambulance's lights as it moves down the road thus, giving it a more lifelike appearance. There were a few challenges throughout the implementation process. One main issue that was overcome occurred when pointers were not pointing to the correct slot. When the visualizer tried to render these vehicles with incorrect pointers, the vehicles ended up appearing as a mangled mess. After close inspection of the code however, this problem was quickly solved

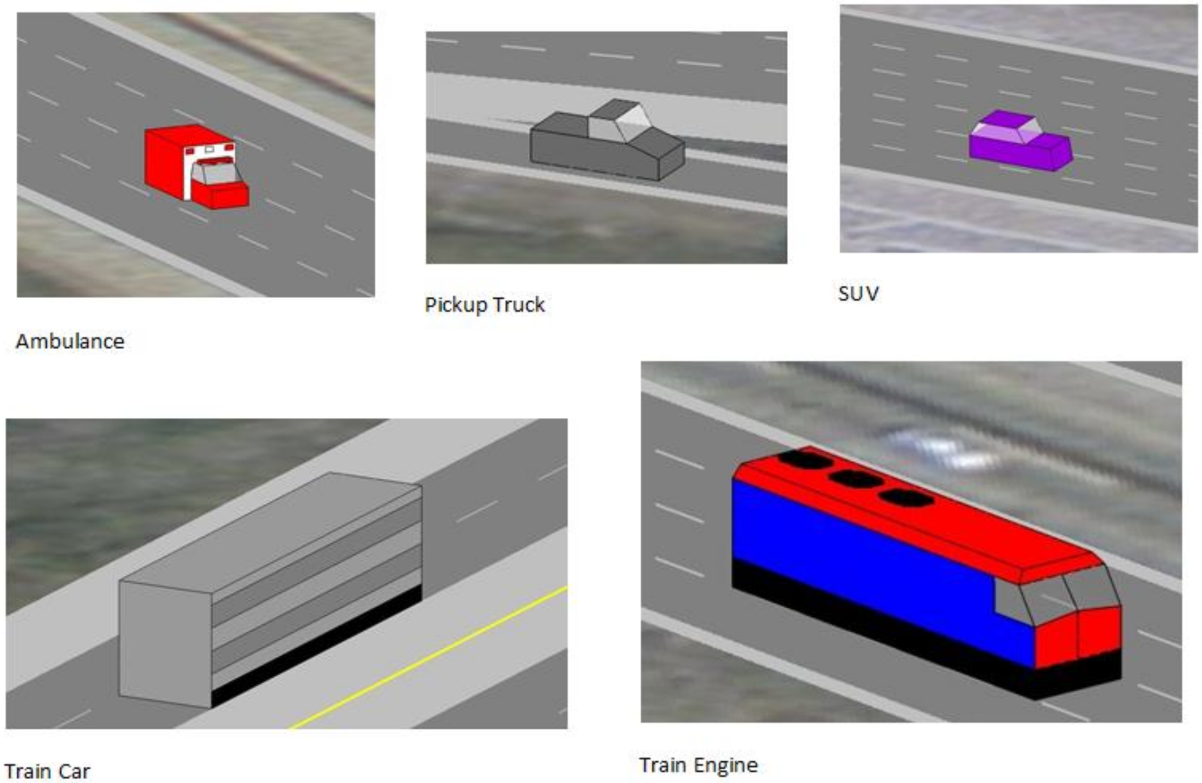

Figure 13.28: Three-dimensional Vehicle Models

13.25. 3D Building Models

In order to increase the level of realism and to better orient the user, 3D building models for the city of Chicago were explored. The process involved four primary phases. First, interpret the building footprint data provided by OEMC as a polygon and record the number of stories. Second, triangulate the polygon and write the triangles out in a specialized binary format which indicates when the buildings start and end, whether the triangles are for the roof or sides, and additional information such as building name or number of stories. Third, read the file into the visualizer, unpack it, and then store the triangles in memory for fast re-display later. Finally, differentiate the building colors, and make them semi-transparent.

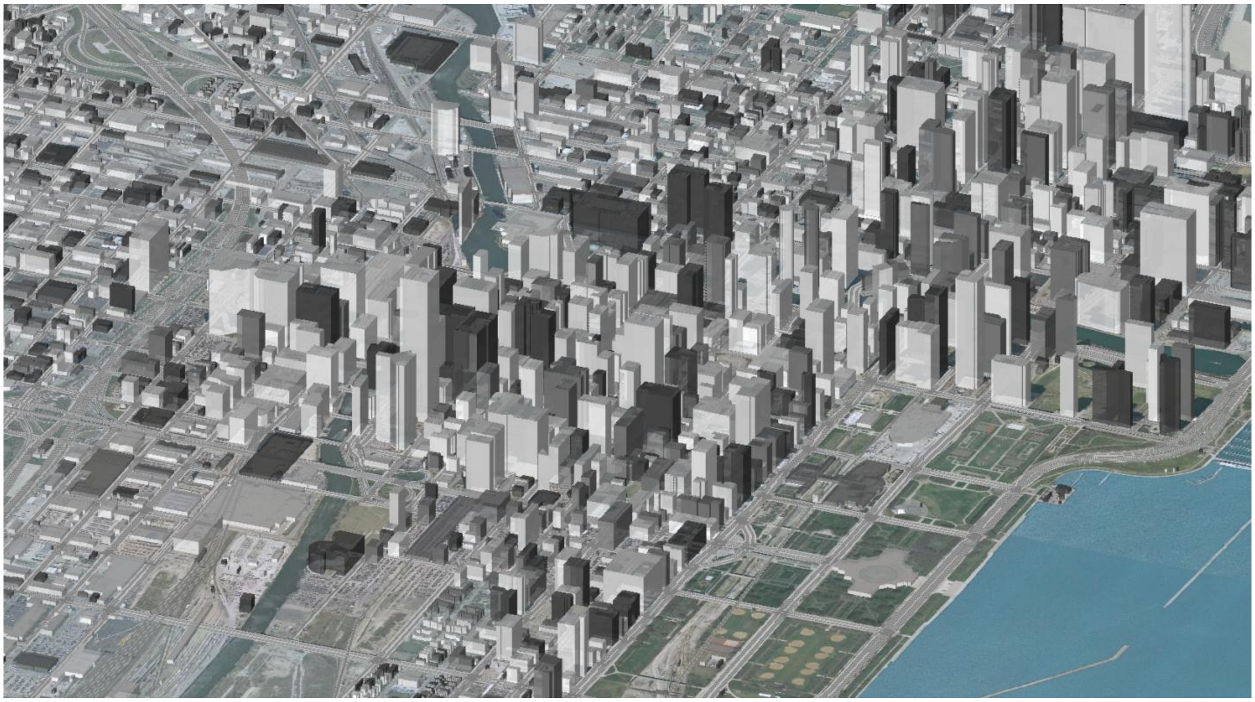

Figure 13.29: 3D Building Models

13.26. Strategic Routes Visualization

These routes are visualized at two levels, in line diagrams when at a high level of zoom and in polygons at a low level of zoom. In addition they are split into two categories, arterials and highways. The arterials are drawn in blue and the highways are drawn in red.

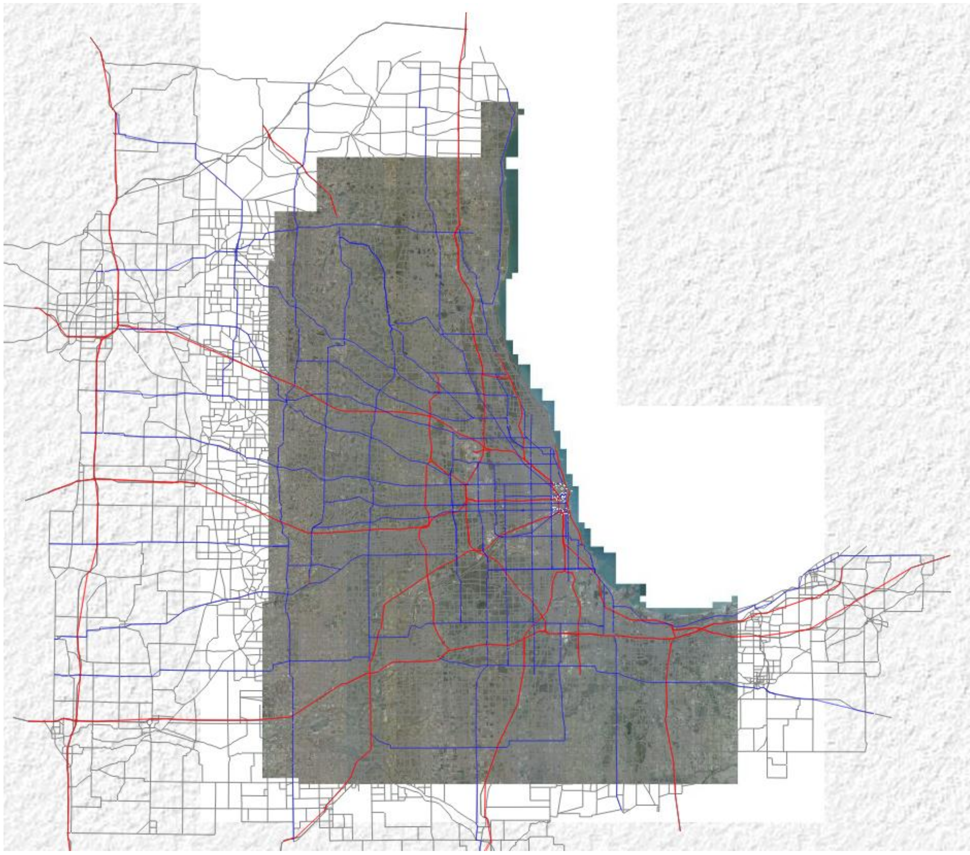

Figure 13.30: Evacuation Routes

13.27. Evacuation Area Visualization

These areas are visualized in three categories: high, medium, and low severity. The highly affected areas are red, the medium affected areas are yellow, and the low affected areas are green. In addition, three different cases were read in and visualized: high, medium, and low severity – each higher level of severity covers a larger area. A primitive polygon triangulation was necessary to convert the zone polygons into OpenGL triangles.

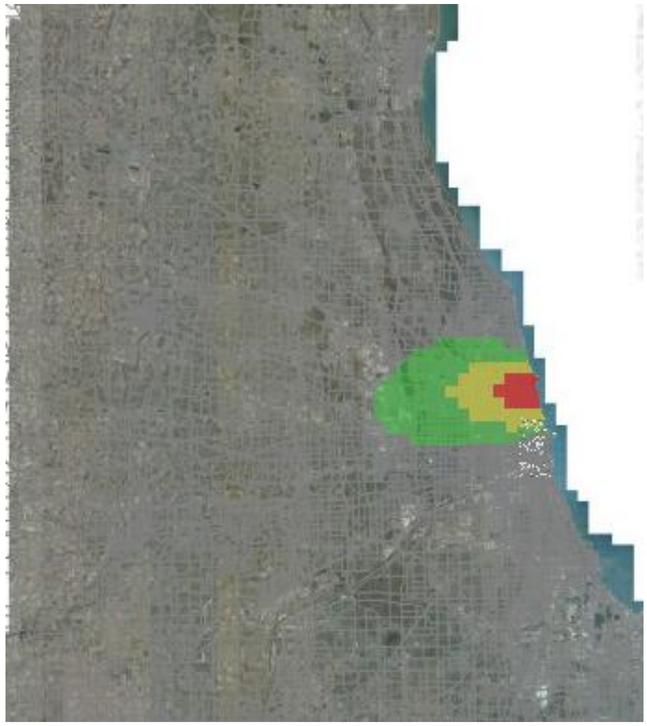

Figure 13.31: Evacuation Areas

13.28. Demo Version

At the request of OEMC, rapid development of a demo version of the visualizer was undertaken. The aim of this product was to provide a simplified interface to highlight one evacuation case very well. A number of temporary changes were implemented to support this goal. First, the interface was re-worked so that it auto-scaled to the size of the 6 panel system and used a series of 5 toggle-buttons to enable/disable all of the features. Additionally, the time control was simplified to reduce the speed selection to three categories: low, medium, and high.

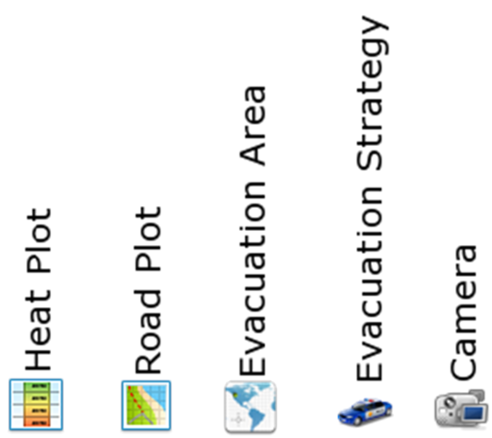

Figure 13.32: Buttons for Demo Version

A special evacuation snapshot with 100% regional demand was included to illustrate a regional evacuation. A restart button was added to bring the simulation back to the 11:45 mark (the data ran from 11:45 until the early afternoon). The camera button used a series of pre-defined waypoints to take the user through the evacuation from 11:45 to 12:15. Finally, numerous tiny bug fixes and user interaction tweaks (such as navigation) were undertaken to improve reliability and user operation.

13.29. Vehicle Plan Visualization

One important feature for the purposes of examining evacuation cases is the ability to get inside the driver's head and determine who they are and where they intend to go. This is easier said than done due to the immense size of the TRANSIMS plan file (which holds all routes and most of the pertinent driver information). The first necessary task was to write an efficient plan indexing scheme which can index the plan file very quickly. This was completed making use of Windows API file functions and utilizing a chunk-based reading/writing system for rapid scanning of the file and low latency writing.

Figure 13.33: Plan Visualization

Internally, the indexing allows the traveler's path to be retrieved very quickly through what is called a "hash map." Pre-allocated memory and pre-rendered link geometry values allow the plan to be assembled into a visual path on the fly. Similar to the link plot, the links are color coded to indicate directionality of the plan.

13.30. Improved Identification System

This system allows the user to identify and select links, nodes, and vehicles dynamically and display those attributes in an information table on the right hand side of the visualizer. The selection/deselection process was streamlined to increase ease of use, the highlighting was made much more evident, and the identification is now broken down by category to increase accuracy.

HHOLD	14467989
SPEED	28
PASSENGERS	0
HEAT_VALUE	0
WAIT	0
DIFF	644
USER	0
ORIGIN	55153
DESTINATI...	61995
START	410130
END	422850

Figure 13.34: Traveler/Driver Identification Information

13.31. Satellite Source Investigation

At the request of OEMC, satellite sources were identified to replace the outdated MSR Maps images. The strongest candidate appears to be a pipeline available directly through USGS which has up-to-date images for Chicago and an API for applications to access the data.

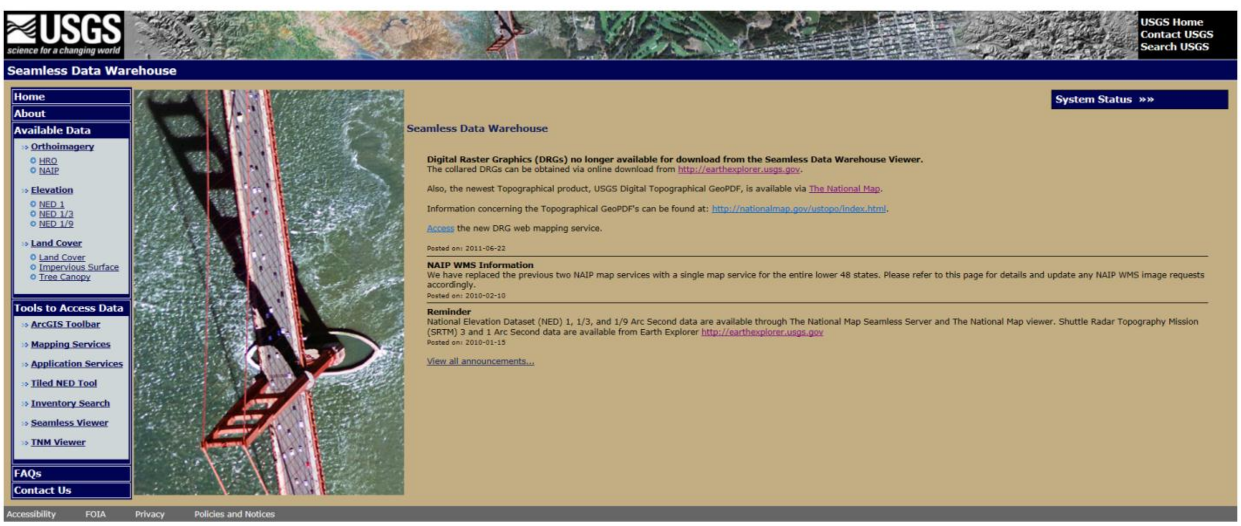

Figure 13.35: USGS Seamless Data Warehouse Site

13.32. Evacuation Specific Modes

The TransimsVIS software has three primary modes of operation, two of which are related to evacuation. In the CONFIGURATION mode, the visualizer turns on only functionality related to configuring and exporting an evacuation case. In the EVACUATION mode, the visualizer enables functionality related to viewing an evacuation case, but disables functionality related to configuring an evacuation case. If no mode is specified, then the software functions without evacuation capbilities.

Figure 13.36: Evacuation Configuration Menu

13.33. Evacuation Area Selection

The visualizer has multiple evacuation configuration capabilities. The first of these allows a user to select a nested set of areas which define where the evacuation will take place. The usage is quite simple, activate the add area button and click to describe a polygon on the screen. Once the polygon is finished, it will appear in a list below. When selected, the area will become more prominent and a panel will be exposed on the right hand side which will enable configuration of the area. A few technical items at play with this feature include functions which ensure that the user cannot draw a complex polygon or a concave polygon which OpenGL cannot draw with a GL_POLYGON call (which is limited to convex and some concave polygons). Additionally, the layering is achieved by ordering the areas in a map based on their severity which is dynamically re-assessed when any changes are made.

Figure 13.37: Evacuation Area Selection

13.34. Evacuation Shelter Selection

Another feature related to evacuation configuration is the shelter selection feature. This allows the user to place shelters at locations which would serve as strong collection points for the region. The usage is once again quite simple, activate the add shelter button to put a pyramid-shaped shelter on the cursor. When the user double clicks on the screen, the shelter will be placed and snapped to the nearest TRANSIMS location to it, it will appear in a list below. Similarly to the area, when selected the shelter will become more prominent and a panel will be exposed on the right hand side which enables configuraiton of the shelter. The main technical item at play is the fast re-construction of shelter geometry at each cursor update.

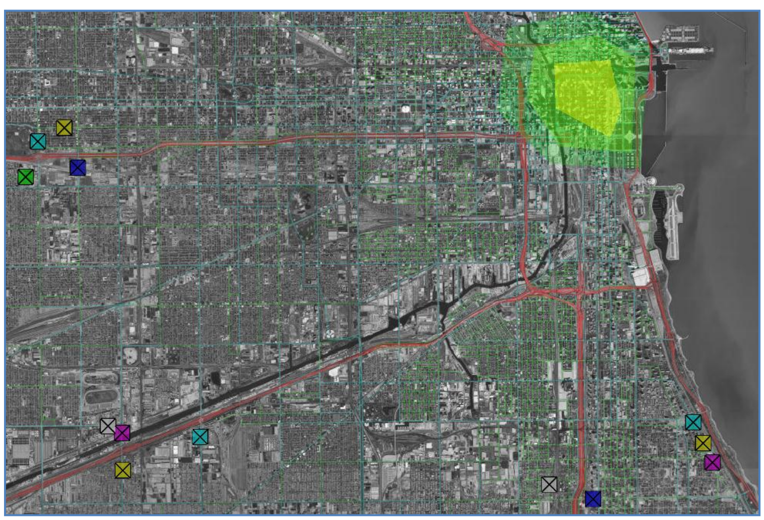

Figure 13.38: Evacuation Shelter Selection

13.35. Evacuation Route Selection

A slightly more intricate evacuation configuration option is that of evacuation route selection for EvacNet. When the button to select routes is depressed, all major evacuation route candidates will be highlighted (based on a set of strategic arterials). As the cursor moves, it will highlight each candidate route, double clicking on the route will change the color to white and add it to the list below. Once routes are chosen, they may be selected in the list – this will accent the route. Two further operations may be performed on the evacuation routes. First, the route may be trimmed: once the route is selected for trimming, a start of the trimmed region may be selected, as the cursor moves along the link more sections hilight. Double clicking will trim the route to the section selected. Second, the access points may be configured for the route: once the route is selected for access point adjustment, moving the cursor over an intersection will make the access point more visible, double clicking the point will change its color to red (if green) or to green (if red) to switch the outside access to the route. Some technical elements at play include triangle-based drawing of the access hemispheres at alternative numbers of stacks and slices to save memory. Another is the modular storage of routes in terms of route, segment, and link to allow route-wide changes as well as section changes (trimming). Finally, the storage of alternate geometries to indicate routes in various forms of selection as well as a visually appealing fade effect for horizontally drawn routes.

Figure 13.39: Evacuation Route Selection

13.36. Evacuation Plume Selection

A final evacuation configuration feature is that of the dispersion plume. The user selects either 1000 or 2500 curies of radioactive cesium in the explosion. Next, the user selects the epicenter. Once the epicenter is selected, an arrow appears which can be sized and directed to indicate the dynamics of the wind. Upon wind selection, the plume will appear indicating the concentration of radiation at various topographical points. The data is derived from a pre-computed run of such an explosion from the HPAC software. The technical elements at play include proper rotation, layering, and triangulation of plume geometries from source point data.

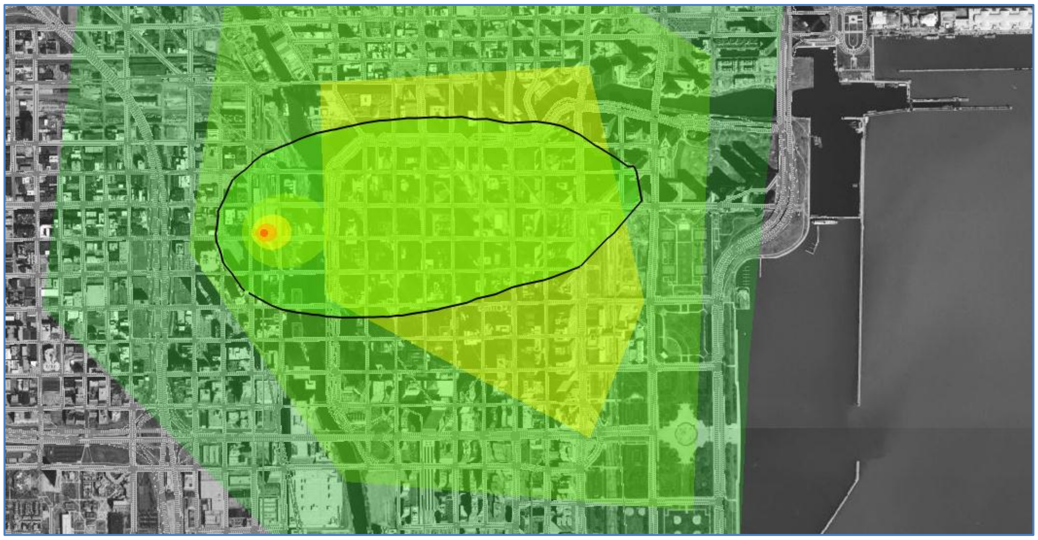

Figure 13.40: Evacuation Plume Selection

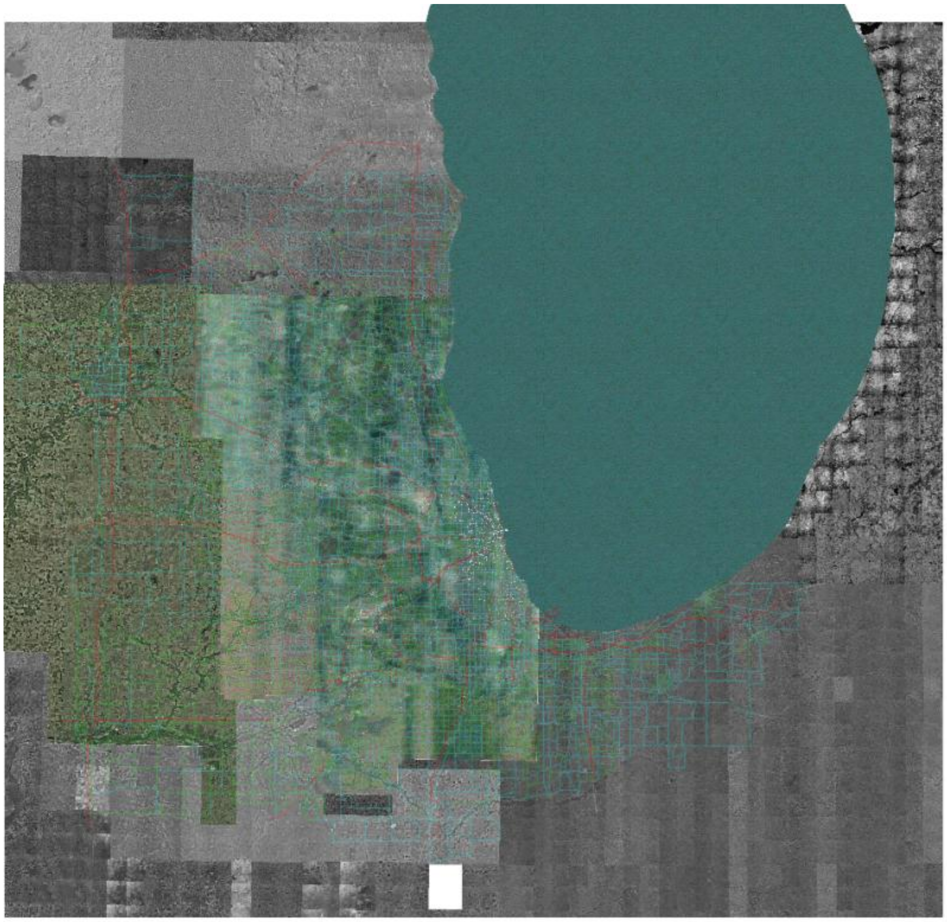

Figure 13.41: Coverage of Improved Satellite Imagery

13.37. Pre-Loaded Satellite Imagery

A very useful feature for platforms which are embedded with TransimsVIS is the pre-loaded satellite imagery. This imagery is derived from the most up to date USGS satellite imagery, 2008 for Chicagoland. In contrast to the automatically downloaded imagery, the new imagery: covers a much larger area, has a higher percentage of colored images, texturing for Lake Michigan, and better detail in the high resolution images. The images underwent a significant degree of processing to ensure that they were tiled and laid out in files to optimize both appearance and loading performance.

One change in the repository layout was to group multiple tiles into a single file, as opposed to having one file per tile. This helps significantly both from a tile loading as well as a repository transferring perspective. Another change designed to help boost performance and minimize storage space is to store the tiles in a native OpenGL compressed texture format. This allows direct conversion from tile to texture as well as decreasing the amount of graphics memory which must be used to store the tile on the graphics card (allowing more total tiles to be stored).

In addition to format changes, the loading procedure was heavily optimized. First, a minimum number of threads were used to ensure optimal drive access. Second, most parts of the routine now entirely avoid dynamic allocation/deallocation of memory and the storage requirements have been minimized. Next, geometric checks are done to ensure that only the tiles which are required to fill the screen are actually loaded. Additionally, routines ensure that the number of tiles loaded at a resolution never exceeds a given threshold; this eliminates the situation where the wrong viewing angle will overload a frame with too many tiles. Finally, usage is tracked much more diligently to ensure that only the least used tiles are cleared from memory.

Finally, to improve user experience, a timing routine was added which will continue refreshing the screen until all tiles have been loaded. The result of all optimizations is an extremely seamless satellite viewing experience.

13.38. ESRI Shape File Display Capabilities

A capability which bridges much of the gap with existing GIS applications is a limited capability to display ESRI shape files. There are a few restrictions currently: layers must be either polyline or point, they must be pre-projected in UTM (meters) in order to be loaded correctly, and the .dbf file format must be either Xbase or dBase 3.

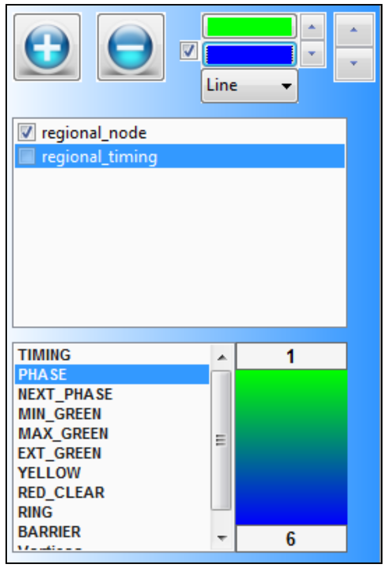

Figure 13.42: Shape Layer Control

Usage is fairly straightforward, clicking on the add button will allow the user to select a shapefile from a file browsing prompt. Once added, the file will be appended to the list of shape files currently loaded. Each layer has a checkbox which allows it to be hidden or shown easily. A number of features allow the user to enhance the appearance of a layer. First, a symbol may be selected for the layer: point layers allow 2D point sprites, pyramids, or cubes; line layers allow walls, or 2D line sprites. Next, the layer may be colored in a single tone or the opacity may be adjusted. Finally, the size of the layer can be changed to make it more or less visible. When a layer is selected, the user can see the list of attributes within that layer below. When an attribute is selected, the minimum and maximum values are displayed to the right. Additionally, the layers may be automatically colored on a gradient which the user can select upper and lower bounds for.

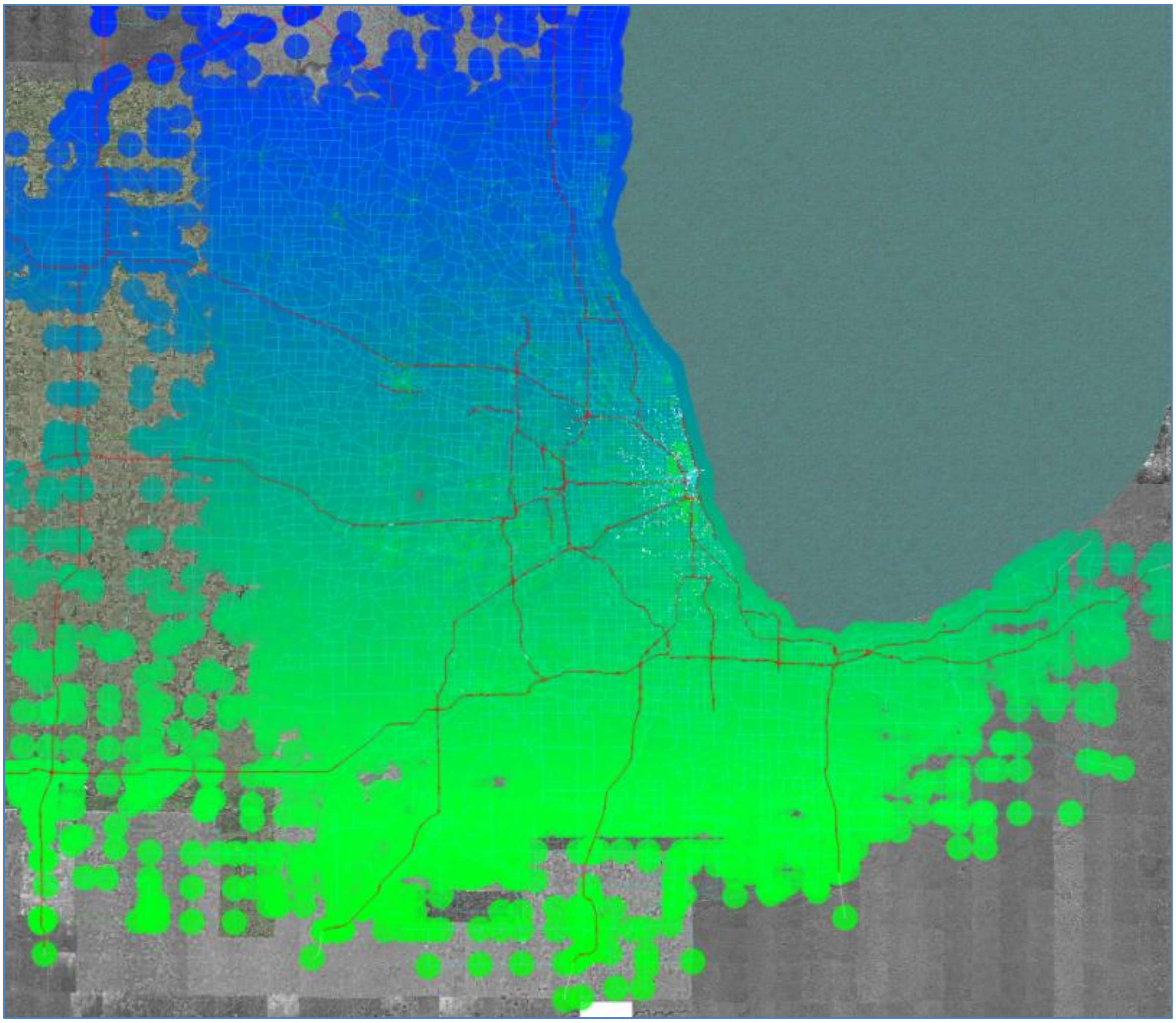

Figure 13.43: Point Layers Loaded and Colored by Auto Gradient

Layers may also be identified. This is done by selecting the identify current shape layer option from the identify choice menu. Once this done, as the user moves the cursor, the individual layer elements will become accented and the attributes for that element will show up in a panel which is revealed on the right hand side.

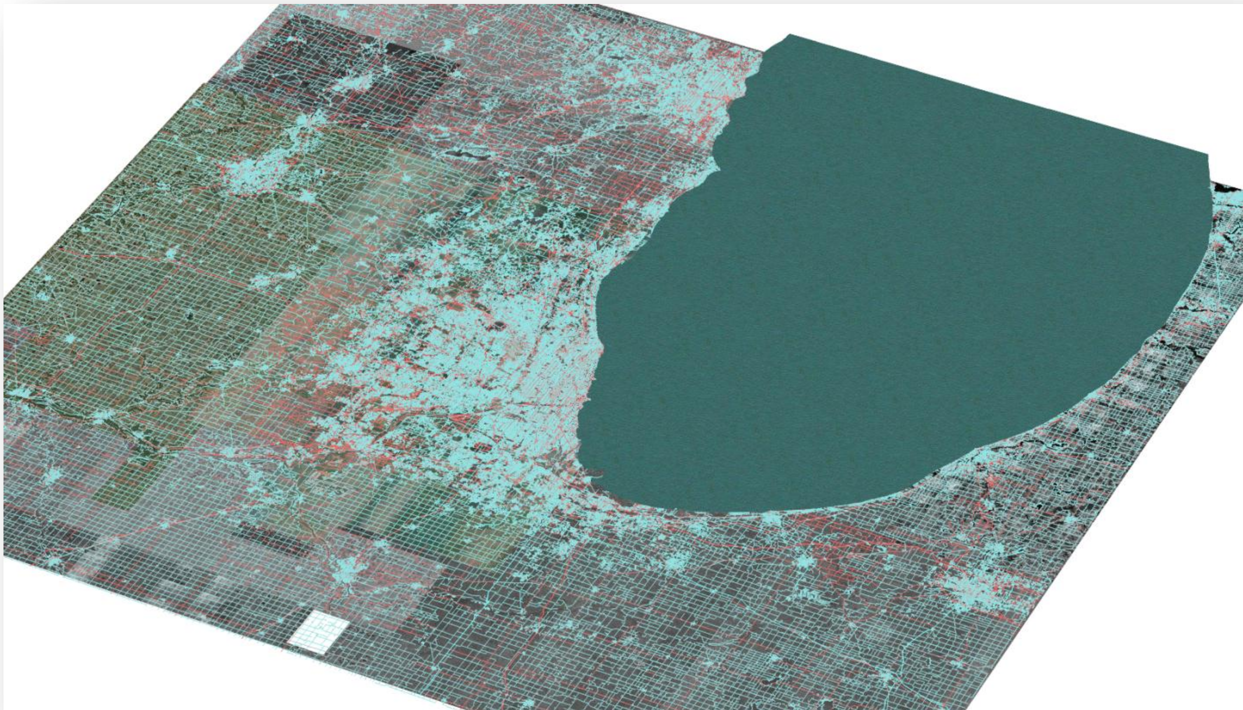

Figure 13.44: OSM Streets Shape Layer

Many advanced techniques are utilized to make this feature operate seamlessly. First, shape loading is done with an extremely fast read routine, even so loading the attribute table (which is much of the overall load time) is roughly bottlenecked by disk speed. To combat this unavoidable delay, a progress bar is added to show the user that the software is continuing to work properly. However, the other routines on load operate extremely quickly. One of the challenges when it comes to storing attribute data is due to the fact that the dimensionality and characteristics of a given table is only known at run time. Therefore, a special structure which makes heavy use of templating and type-less memory operations is used to seamlessly store and extract attributes in a very compact profile, of course special destruction techniques are also necessary. An added benefit of this approach is the verticalization of attribute data. As it is usually of interest to access entire swathes of attribute data in a given field, it makes more sense to localize that memory and de-localize the attribute data across a record. This allows for extremely fast gradient computations. Another advanced technique is that of fast geometry re-construction when size or gradient properties are changed. Loops are unrolled as far as possible for a given 3D symbol and memory is accessed purely with pointers rather than through an intermediate access index. Normal computation, gradient color computation, and certain coordinate calculations are all minimized. In order to display layers very quickly a specialized OpenGL function called a Display List is used which locates static geometry information on the gpu for extremely fast re-display. The find routine for lines has been greatly improved over prior iterations. Central to the calculation is a projection function which computes the true distance from point to line segment or set of line segments, this allows the truest judgment of what line the cursor is closest to. A well organized set of management routines are necessary to ensure the GUI does not crack when various controls such as layer removal, selection, and addition are used.

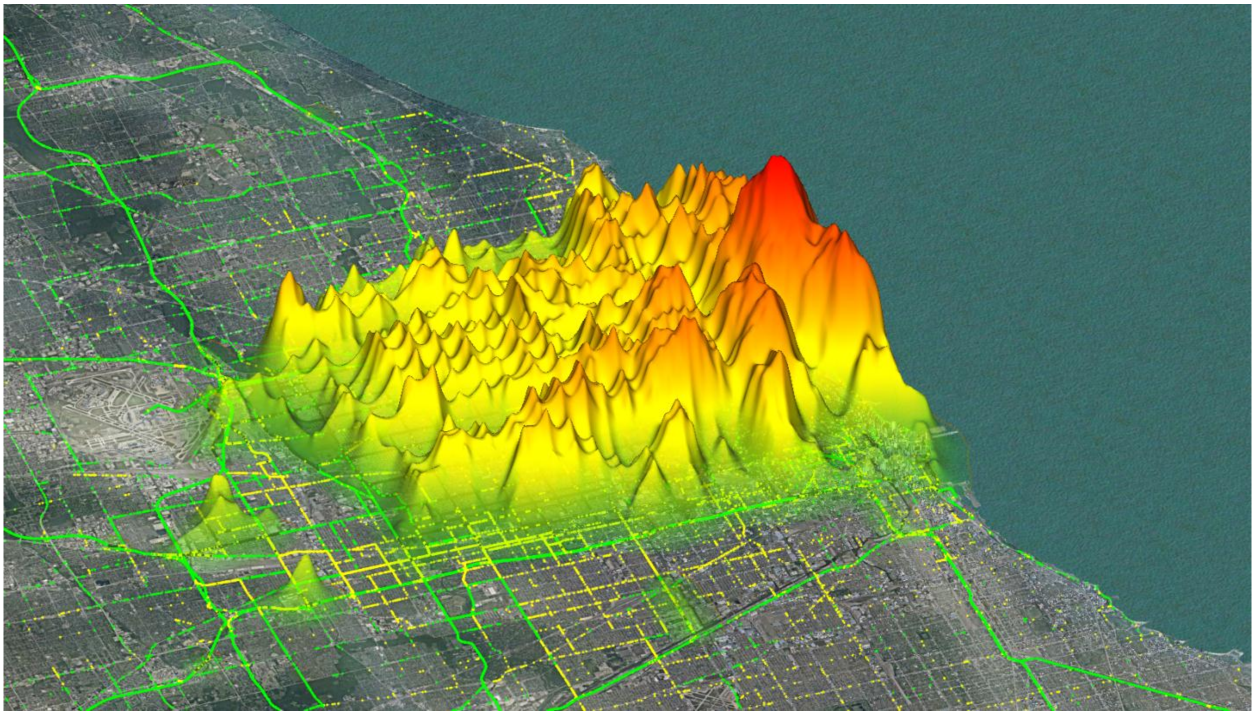

Figure 13.45: Data Plot with Improved Normals and Lighting

13.39. Miscellaneous Feature Improvements

A number of miscellaneous improvements were made; the most significant of these was the proper layering of the road network in 3D. In order to ensure the depth buffer was sensitive to these relatively minute height adjustments, the frustrum had to be painstakingly tuned. This change ensures that the majority of layers are actually depth tested and any future effects can be properly placed in Z. Another improvement was that of data plot normals, the previous routine left some sides of the plot appearing overly dark. Through using an averaging technique, the dark sections were not only removed, but the entire plot smoothed and improved in appearance. OpenGL vertex and fragment shaders were experimented with to improve layering of probe vehicles, however they currently remain disabled due to unknown compatibility on certain platforms.

Due to emerging memory limitations in very large cases and the general TRANSIMS development trending toward 64-bit, the visualizer was updated to a 64-bit configuration. This was performed by updating the boost and WxWidgets component libraries and reconfiguring certain OpenGL parameters. The 64bit configuration also improves performance slightly by speeding memory allocation.

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14. Acquisition of Orthorectified Imagery for the Visualizer

The visualization software benefits significantly from high-resolution orthorectified imagery. As an open source project, all possible freely available data sources have been researched, and appropriate high resolution datasets have been obtain and processed to be readily available within the user interface.

All imagery obtained for this project is freely available from the US Geological Survey (USGS). If needed, this imagery can be provided to RCPG for use in other GIS applications, although a proper data format needs to be devised to support the enormous amounts of data. The final imagery for the RTSTEP project has been composed of the following individual data sets:

14.1. USGS Digital Raster Graphics – DOQ

This is a layer from USGS that contains imagery at a resolution of about 1 meter per pixel in a grayscale (black and white) format only. These images can be easily found as part of the TerraServer USA project by Microsoft. This project was renamed to MSRMAPS (Microsoft Research Maps) a few years ago, and the servers allow access to tiles of 200x200 pixels in UTM coordinates at 1 meter per pixel maximum resolution.

The visualizer can use this remote database directly, although the necessary download of a large number of tiles is cumbersome. Therefore, the layer has been completely downloaded for the area of interest to RTSTEP and forms the largest coverage in the overall mosaic of data sources.

Detailed information can be found at "http://nationalmap.gov/digitalbackyard/doqbkyd.html". An excerpt from this page should provide sufficient background for the purpose of this documentation:

> ***Introduction***
>
> *A digital orthophoto quadrangle (DOQ) is a computer-generated image of an aerial photograph. It has been orthorectified--altered so that it has the geometric properties of a map; DOQ's in fact meet National Map Accuracy Standards. Thus the user can measure distances accurately on a DOQ.*
>
> *The standard DOQ from the U.S. Geological Survey is a black-and-white (gray-scale) or color-infrared image covering 3.75 minutes of latitude by 3.75 minutes of longitude. Thus, four such photos can be combined, or mosaicked, to cover the area represented by a standard USGS 7.5-minute, 1:24,000-scale topographic map. Mosaicking is facilitated by the fact that the images overlap. The DOQ's are referenced to the North American Datum of 1983 and use the Universal Transverse Mercator projection. Their resolution is such that each pixel represents a square meter.*
>
> *The standard gray-scale DOQ includes an ASCII keyword header followed by a series of 8-bit binary image lines. The average file size for a black-and-white DOQ is 55 megabytes . Header information includes photographic source type, date, production software, and date of the digital elevation model metadata used in orthorectification. Also, primary and secondary datum coordinates for the upper left pixel are included to assist in referencing other digital geospatial data. To view or manipulate one of these images, the user must extract the header information from the image and be equipped with editing software designed to handle large image files.*
>
> *A minority of the DOQ's are not gray scale, but color-infrared, a false-color scheme used for certain scientific and analytic purposes. These files average about 150 megabytes and are stored in band-interleaved-by-pixel, or BIP, format.*
>
> ***DOQ Applications and Uses***

DOQ applications include land and timber management, routing and habitat analysis, environmental impact assessment, evacuation planning, flood analysis, soil erosion assessment, facility management, and groundwater and watershed analysis. The accuracy and extraordinary detail of DOQ's allow users to evaluate their data for accuracy and thoroughness, to modify their data promptly, and even to generate new files.

A DOQ can be used in a wide variety of geographic information systems and is an excellent cartographic base on which to overlay any number of associated thematic layers for displaying, generating, and modifiying planimetric data or associated data files.

Producing DOQ's

DOQ production begins with an [aerial photograph] and requires four elements: (1) at least three ground positions that can be identified within the photograph; (2) camera calibration specifications, such as focal length; (3) a digital elevation model (DEM) of the area covered by the photograph; (4) and a high-resolution digital image of the photograph, produced by scanning. The photograph is processed pixel by pixel to produce an image with features in true geographic positions.

Accuracy Standards

USGS DOQ's meet National Map Accuracy Standards at 1:12,000 scale for 3.75-minute quarter quadrangles and at 1:24,000 scale for 7.5-minute quadrangles (corresponding to standard, 7.5-minute USGS topographic maps).

Distribution

DOQ's are distributed mostly on compact disc-recordables but are also available on 8-mm tape and by file transfer protocol download, all in uncompressed form. DOQ's are not available for all areas of the United States; however, a few counties are covered by JPEG-compressed CD-ROM's, each containing decompression software for DG-Unix and MS-DOS users and C-language makefiles that can be compiled for use on other systems.

From the TerraServer TerraServer Web site, users can view and download web-compatible version of USGS DOQ's. Because these images have been converted to JPEG format so they can be viewed with a web browser, the sharpness and quality is not as good as the source DOQ's from which they were created.

To Obtain DOQ's

USGS DOQ's may be obtained from a selected list of USGS Business Partners.

DOQ's can also be ordered online via EarthExplorer.

Information

Additional information about DOQ's is available at http://wmc.wr.usgs.gov/orthophoto_basic.html.

14.2. USGS High Resolution Orthoimagery – Urban Area

This is a layer from USGS that contains imagery at a resolution of about 0.25 meter per pixel in a color format dated to about 2002. These images can also be easily found as part of the TerraServer USA project by Microsoft. As mentioned above, this project was renamed to MSRMAPS (Microsoft Research Maps) a few years ago, and the servers allow access to tiles of 200x200 pixels in UTM coordinates at 0.25 meter per pixel maximum resolution.

The visualizer can also use this remote database directly, although the necessary download of a large number of tiles is cumbersome. Therefore, the layer has been completely downloaded, but is currently not being used due to the fact that much more current data is available (see below).

Detailed information can be found at:

“http://www.isgs.uiuc.edu/nsdihome/webdocs/cua05/cua05_meta.html”.

An excerpt from this page should provide sufficient background for the purpose of this documentation:

> ***Abstract:***
>
> *An orthoimage is remotely sensed image data in which displacement of features in the image caused by terrain relief and sensor orientation have been mathematically removed. Orthoimagery combines the image characteristics of a photograph with the geometric qualities of a map. The projected coordinate system is UTM with a NAD83 datum. There is no image overlap between adjacent files.*
>
> ***Purpose:***
>
> *These data have been created as a result of the need for having geospatial data immediately available and easily accessible in order to provide geographic reference for Federal, State, and local emergency responders, as well as for homeland security efforts. Orthoimages also serve a variety of purposes, from interim maps to field references for earth science investigations and analysis. The digital orthoimage is useful as a layer of a geographic information system. These data can be used to provide reference information for Web browsers and for map applications at a scale of 1:100,000 or smaller. Larger scale orthoimagery such as digital orthophoto quadrangles will be more accurate, but often at the expense of timely updates.*
>
> ***Supplemental_Information:***
>
> *The data obtained through The Seamless Server is considered to be the "best available" data from USGS. Historical data and other data may be obtained by contacting Customer Services, Center for Earth Resources Observation & Science, at 1-800-252-4547. Information in quotation marks, initial processing steps, accuracy reports, and source information is taken directly from the original metadata. Spatial-specific information not available*

14.3. USGS High Resolution Orthoimagery – HRO

This is a set of layers from USGS that contains imagery at a resolution of about 0.25 meter per pixel (or similar) in a color format. All datasets for Cook County and the Collar Counties (as well as a large medium resolution set for Rockford) have been downloaded for this project. The final version of the RTSTEP mosaic is the data from May 2008 (and Rockford from 2006). The data from March 2005 is available in form of large downloaded tile files if needed, as well as the 2002 data.

These images cannot be downloaded easily, and a Python script was written that extracts the imagery in a format suitable for RTSTEP. The scripts had to execute for several weeks to download and process the information, resulting in approximately 150GB of highly compressed imagery files.

The visualizer can use this imagery directly as part of the orthorectified imagery provided with RTSTEP.

Detailed information can be found at “http://seamless.usgs.gov/hro.php”. The following datasets form the basis for the colored parts of the RTSTEP mosaic.

Illinois							
IL	Chicago	Apr 2002	0.30 meter	UTM	Color	Public Domain	Tiled
IL	Chicago	Mar 2005	0.30 meter	UTM	Color	Public Domain	Tiled
IL	Cook County	May 2008	0.5 foot	State Plane	Color	Public Domain	Seamless
IL	Dupage County	May 2008	0.5 foot	State Plane	Color	Public Domain	Seamless
IL	Kane County	May 2008	0.5 foot	State Plane	Color	Public Domain	Seamless
IL	Kendall County	May 2008	0.5 foot	State Plane	Color	Public Domain	Seamless
IL	Lake County	May 2008	0.5 foot	State Plane	Color	Public Domain	Seamless
IL	McHenry County	May 2008	0.5 foot	State Plane	Color	Public Domain	Seamless
IL	Rockford	Apr 2006	0.3048 meter	UTM	Color	Public Domain	Seamless

14.4. Data Conversion and the Visualizer TILES File Format

The downloading and conversion of these tile sets is a very complex process requiring significant CPU time, network volume, and image processing. The following documentation provides basic insight into the process employed to accomplish this particular task.

Some of the sets (listed above as tiled) have been available in UTM Zone 18 format. The UTM (Universal Transverse Mercator Projection) is a worldwide standard to reach maximum accuracy on large swaths of the globe. The globe is subdivided into 60 zones around the equator, and then subdivided furthermore towards north and south. The details are complex, but allow for the whole Chicagoland region to be expressed in a Cartesian coordinate system with minimal perspective errors at the boundaries of a zone that extends for around 250 to 300 miles in each direction. This is also the coordinate system that TRANSIMS uses internally.

The imagery not available in UTM format comes in a format called EPSG:4326. The scripts use a utility called “gdaltransform” to determine the image area covering the requested tile in this projection based on knowing the requested UTM bounding box. The slightly larger image in EPSG:4326 is then downloaded and reprojected to UTM 18 using the “gdalwarp” utility. The download is based on forming an appropriate WMS request for an image that after warping becomes exactly 1024x1024 pixels in size.

Once the image is downloaded and converted, it is cut into 16 256x256 pixel tiles. 10,000 of these 256x256 pixel tiles are stored in each tiles file in form of highly compressed JPEG images, together with masks that indicate the transparency based on the area covered by the tile. Each 256x256 tile covers a specific physical area, indicated by the number of meters per pixel. The highest resolution tiles in this scheme cover 100x100 meters precisely, at a pixel resolution of 0.390625 meters per pixel. These values were chosen because they are highly effective in a binary system as opposed to a decimal system. For example, images at 256x256 pixel resolution are ideal for an OpenGL application.

The tile files are written in a tagged image format that provides an integer index for the starting offset for each subsequent image in the file. This allows access to individual tiles that require in the final software a single seek operation within the file, and thus provide rapid access for effective imaging.

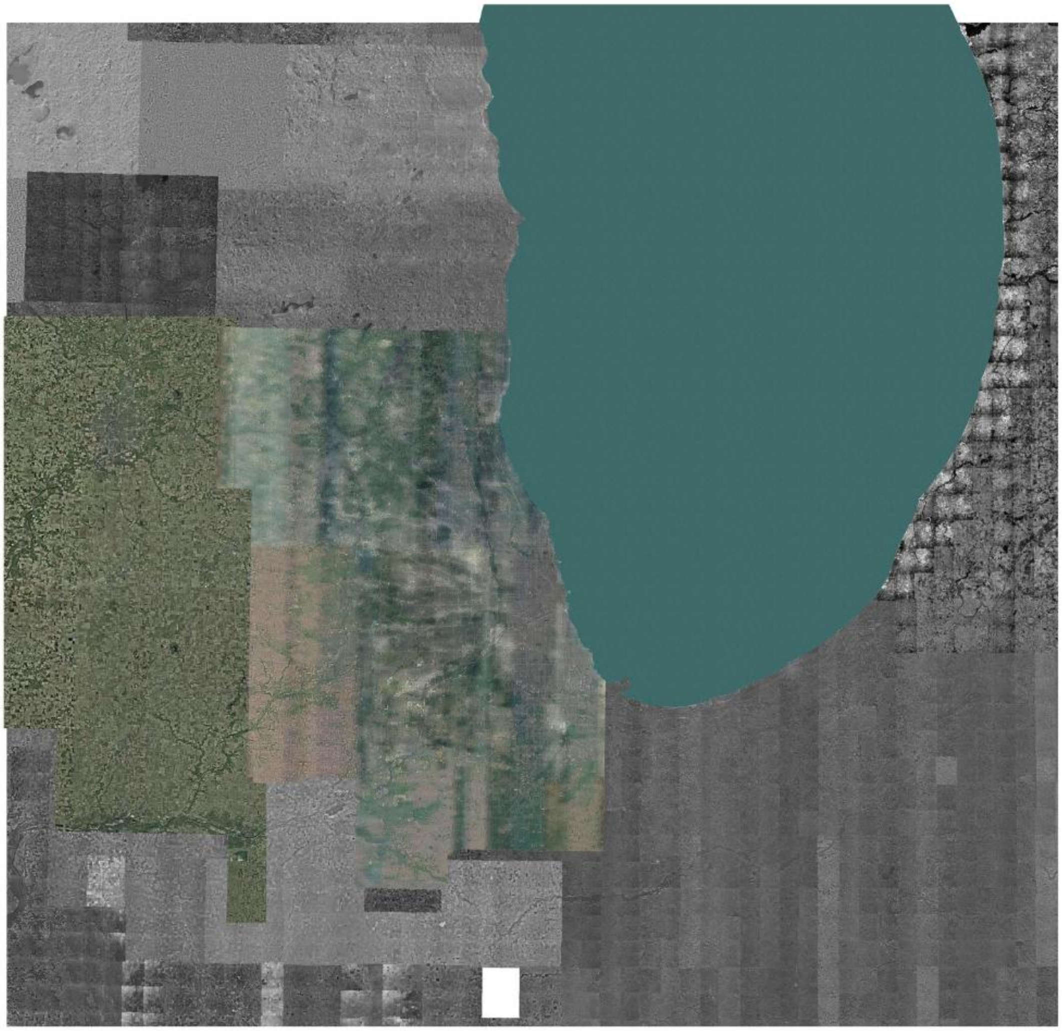

Figure 14.1: Final Orthoimagery Canvas for the RTSTEP CMA

After all imagery had been downloaded, a secondary procedure was used to assemble a complete mosaic from the complete set of images. To do so, a script was written to iterate over all individual tiles in all of the source files, and overlaying them including proper masking to avoid unnecessary striping artifacts. To determine, for example, white borders around some of the imagery, an image processing sequence was created that surrounds the image first with a white boundary, the flood-fills the white portion of the image with pure black, and then turns pure black into transparency in form of a mask. Additional logic was used to increase the fidelity of this image processing approach, such as requiring minimal flood filling before assuming a white border, and counting the white edges of an image.

The superimposition was also enhanced with a masking algorithm that considers the outline of lake Michigan in form of an ESRI shape file. This outline was drawn on the appropriate tiles to "dra" the lake as a graphic image. The lake's area was then approximated with a continuous tile image of water that is masked upon the top of the highest superimposition tile. The resulting tile set provides marginal artifacts and provides the highest possible resolution across the entire area.

The preprocessed tile files were then furthermore converted into a special OpenGL texture format that requires no further conversion when loaded into the visualizer. This procedure allow for the extremely efficient and smooth display of continuous Orthoimagery as part of the visualizer.

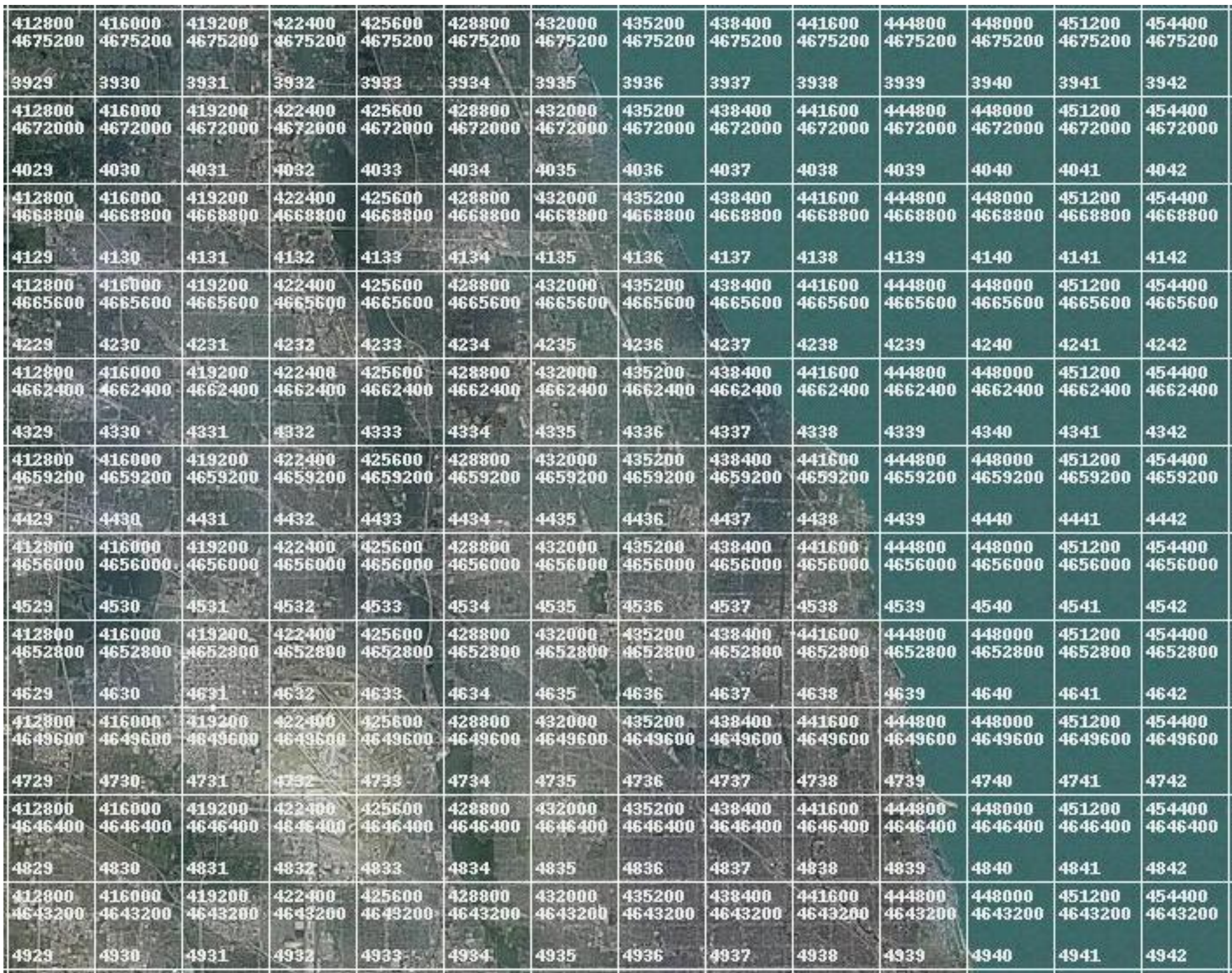

Figure 14.2: Map of a 100x100 pixel tile file with UTM Coordinates and Tile Indices

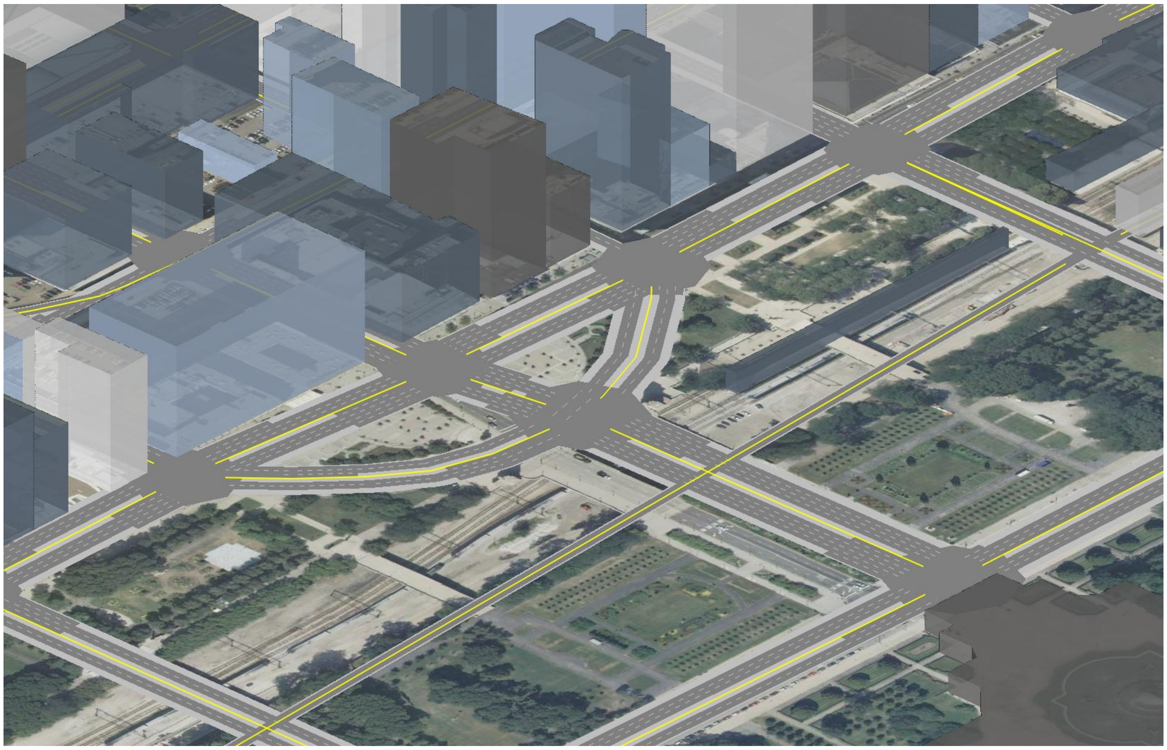

Figure 14.3: Orthoimagery as Used in the RTSTEP TransimsVIS Model for Chicago

Figure 14.4: Orthoimagery Covering Large Area (with Lake Michigan Water Texture)

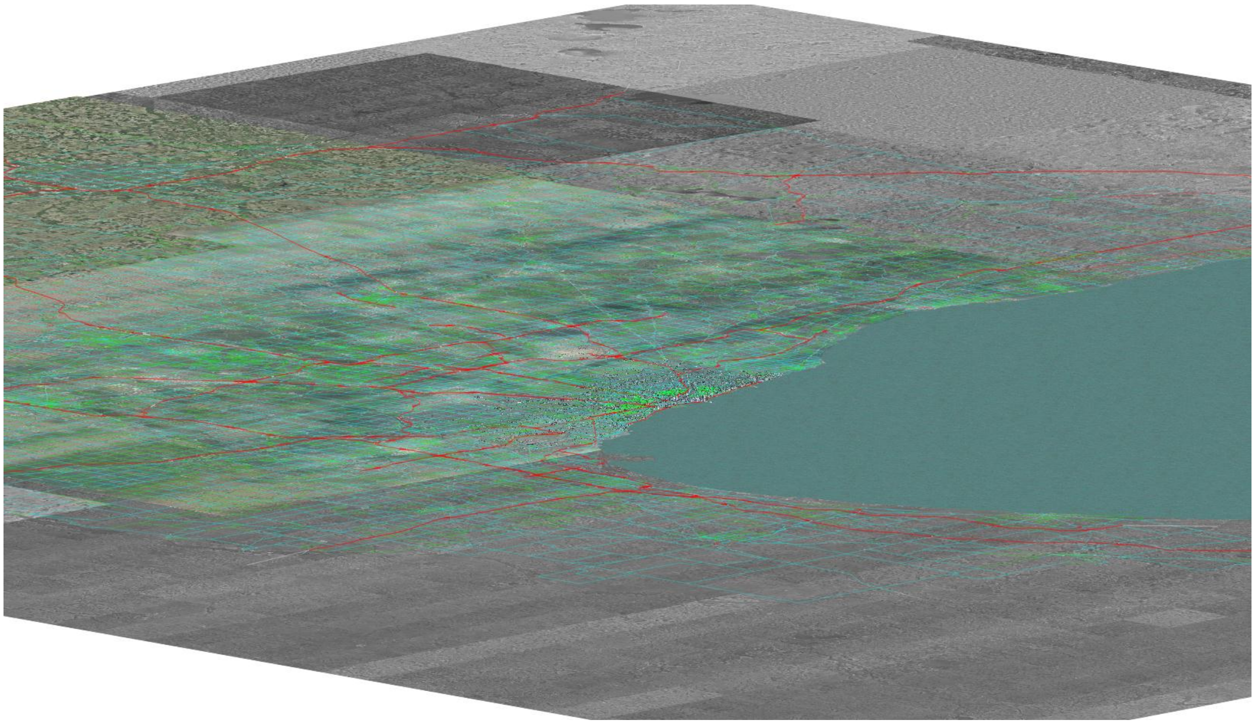

Figure 14.5: Full View of the Metropolitan Area

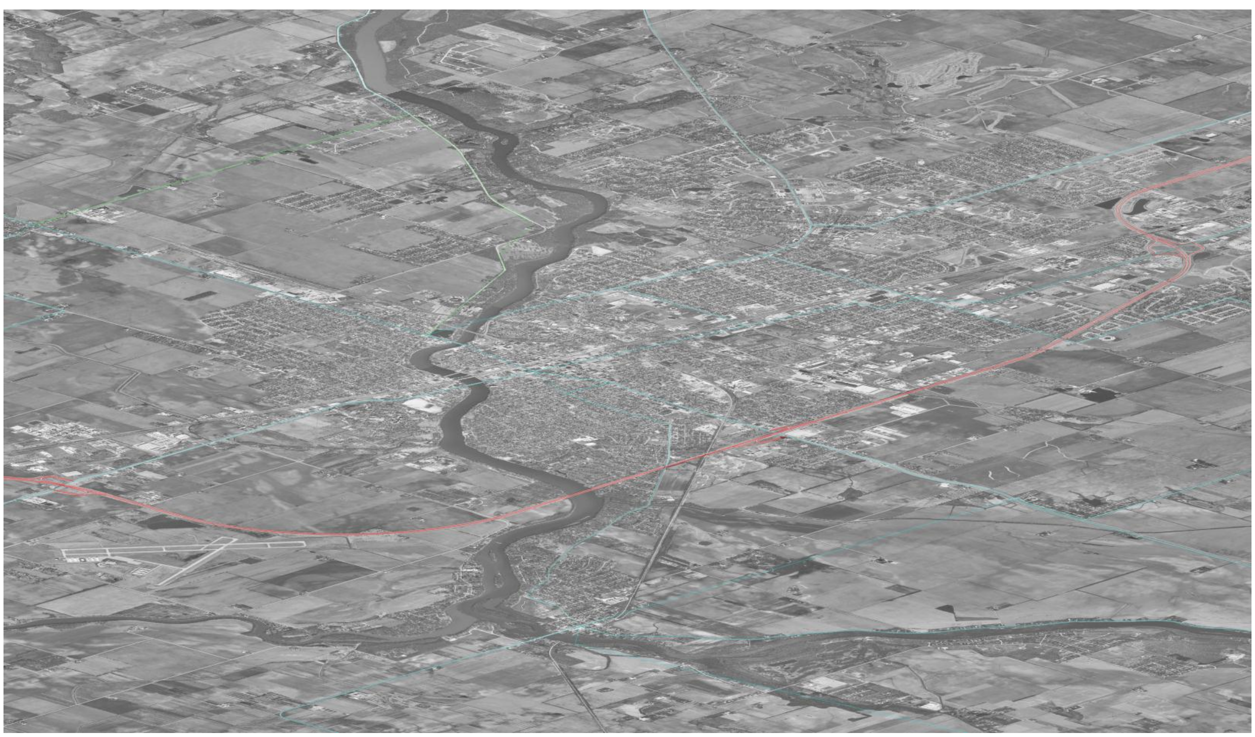

Figure 14.6: View of Kankakee from the Same Perspective, based on DOQ Imagery from USGS

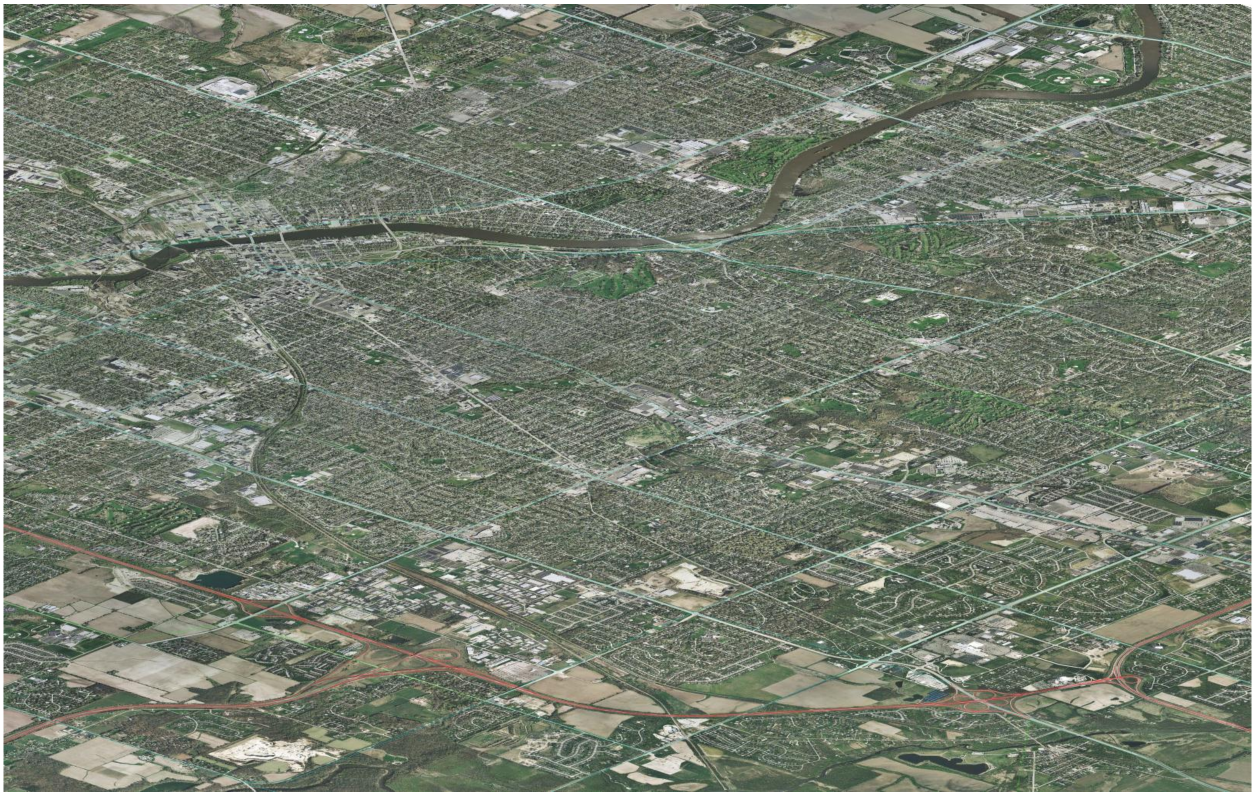

Figure 14.7: View of Rockford (Source Tiles from the 2006 Rockford Dataset of USGS)

Figure 14.8: Illustration of the High Resolution Dataset for Cook County and the Collar Counties (as of May 2008)

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15. Appendix A: RCPT 2009 Summit Scenarios

Scenario Background

- It is early July, 2009.
- Mayor Daley and the Chicago 2016 Organizing Committee have continued to push for broad local support for the effort to bring the Summer Olympics to Chicago in 2016, even though several local groups have been outspoken in their criticism of these efforts.
- A group of passionate anti-government radicals have become increasingly critical of Chicago's Olympic bid. While no group members have directly advocated any violence, their rhetoric has become a lightning rod for many who are disheartened by perceived excesses of government.

FEMA 7

Day One: The First Event

- Saturday, July 11, 2009, 3:14 p.m., Whiting, IN
- In June, British Petroleum (BP) temporarily shut down a distillate desulfurization unit at its Whiting, Indiana, refinery due to a leak in an associated compressor.
- In the mid-afternoon, several blasts rock that same refinery and the surrounding area. Local residents can see flames leaping skyward.
- Local fire crews arrive quickly on the scene. While sensitive to a possible terrorist connection, they find no evidence to that effect.
- No one is injured, but 12 people report to a nearby hospital, complaining of exposure.
- A decontamination area is set up, and nearby plants are told to evacuate as a precaution.

FEMA 8

Day One: The Second Event

- Saturday, July 11, 2009, 4:10 p.m., Pleasant Prairie, Wisconsin
- Three armed robbers enter a store at Prime Outlets in Pleasant Prairie. A getaway driver waits in a van parked in the fire zone.
- An onsite security guard attempts to foil the robbery and is shot. One robber runs to the getaway van and flees the scene in a panic.
- The two robbers left at the scene realize that they don't have a way out and take several customers and store clerks hostage.
- The getaway van is last seen heading south toward Chicago on I-94.

FEMA

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Day One: The Third Event

- Saturday, July 11, 2009, 6:07 p.m., Chicago, IL
- The Chicago Cubs have just defeated the St. Louis Cardinals in extra innings at Wrigley Field.
- As fans exit the stadium and begin making their way to the parking lot, there is a deafening noise from just beyond the northeast corner of the stadium.
- People in the vicinity of the stadium are experiencing significant breathing trouble, as acrid smoke and dust swirls into the air above the Lakeview neighborhood.
- As the first fire engine pulls through the gates, the crew is startled by an alarm they've never heard, coming from a new "radiation detector" provided to responders by the Illinois Terrorism Task Force and mounted on the dashboard of their apparatus…

FEMA

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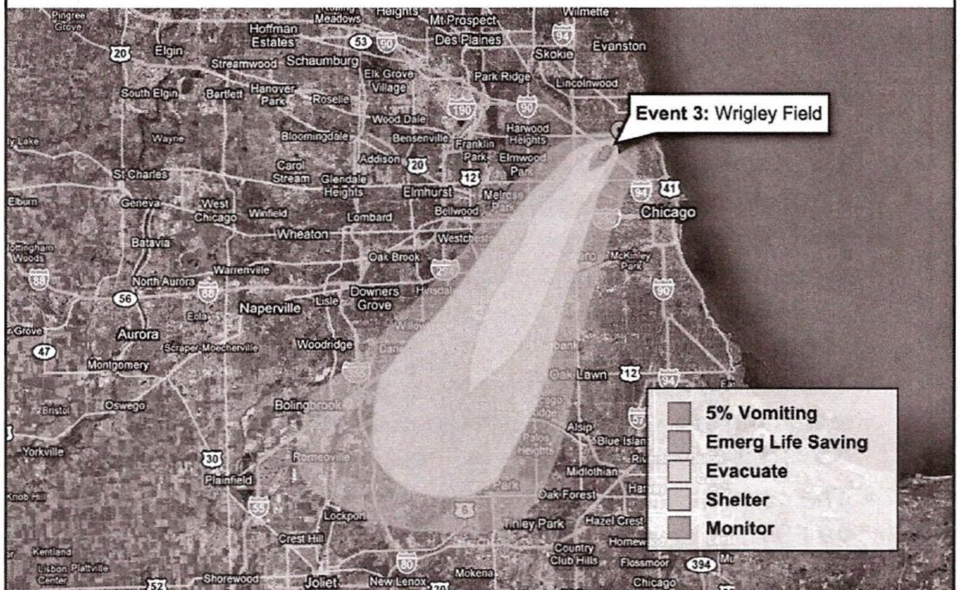

Day One: The Fourth Event

- Saturday, July 11, 2009, 6:38 p.m., Gurnee, IL
- A mid-sized U-Haul truck turns into the back road entrance to Six Flags off of Washington Street.
- As the truck pulls adjacent to the water park, which is less than a hundred yards away, there is a deafening explosion. Many adults and children are injured in the blast, and some are killed. The truck is reduced to a twisted pile of metal. A column of smoke, dust, and debris rises from the explosion site and drifts on the breeze from the northeast over the Illinois Tollway.
- The initial responders, aware of the incident at Wrigley Field, bring HazMat resources to the scene. A radiation technician takes a reading and reports a higher-than-background level of radiation.

FEMA

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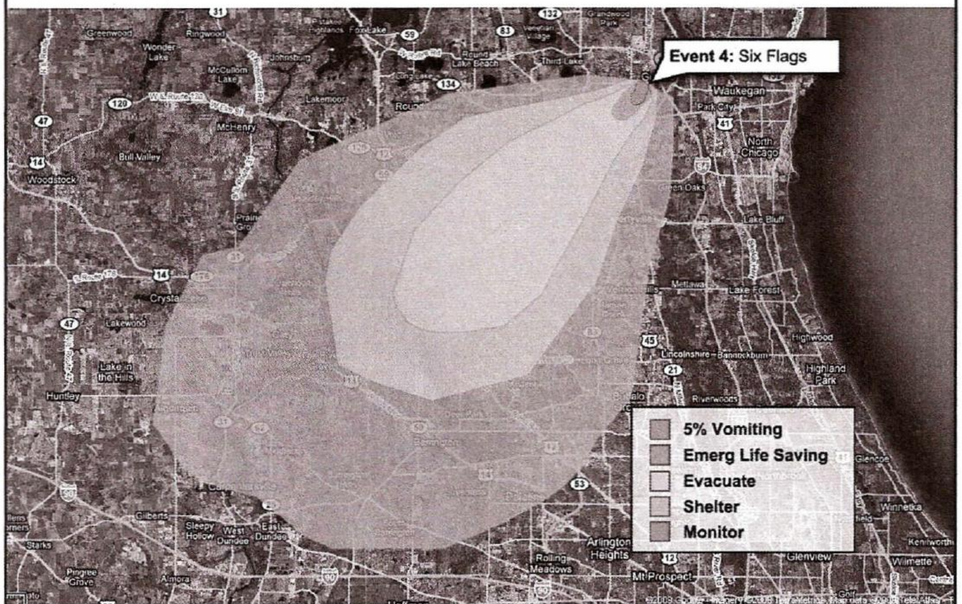

Day One: The Fifth Event

- Saturday, July 11, 2009, 6:52 p.m., Joliet, IL
- A boisterous crowd fills the Chicagoland Speedway in Joliet to its maximum seating capacity of 75,000 fans, while hundreds more fans are sitting and standing on the roofs of their RVs inside and outside the track.
- As a group of cars follows the pace car into turn four, there is a deafening "ka-boom," and a fireball erupts from one of the large RVs parked in the infield near the turn. Bodies are thrown from the tops of adjacent RVs, and pieces of the demolished motor home and other debris shower down on the closest grandstands. Smoke and dust from the explosion is driven southwest into the crowd by the light winds from the northeast.
- Two on-scene fire units, one in the infield and one at the north end of the grandstand, report by radio to their operations chief that their on-unit radiation detectors are indicating noticeable levels of radiation.

FEMA

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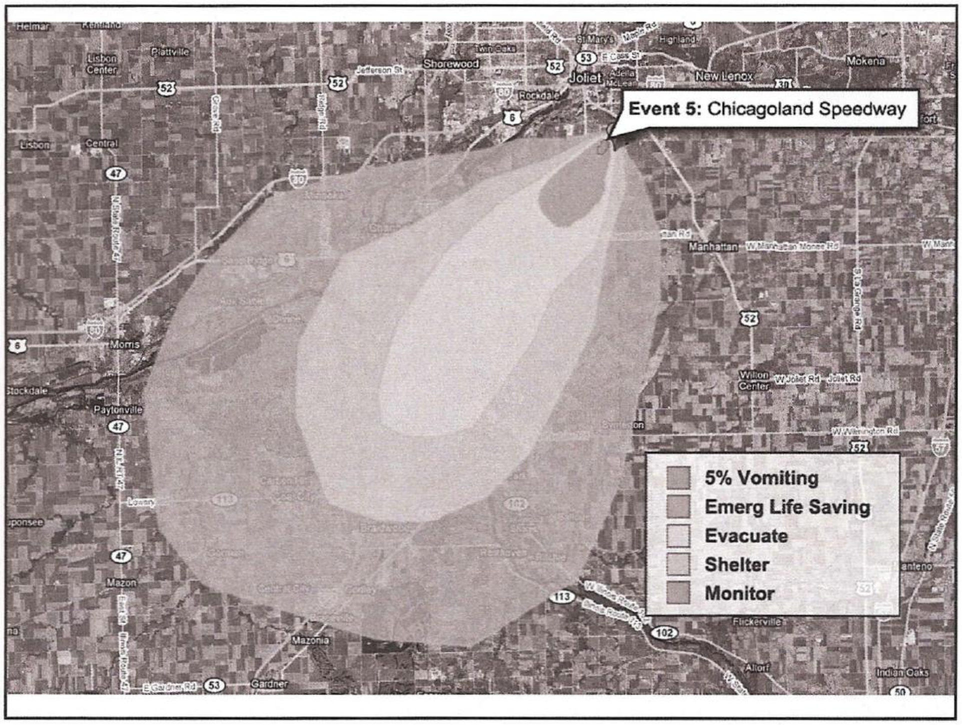

Day One: The Media

- Saturday, July 11, 2009, 7:45 p.m., Chicago area
- Chicago-area media outlets receive a statement that says, "Since officials in the Chicago Area cannot protect you (the public) from weapons of mass destruction during routine events, they should open their eyes to the international threats that would come with the Olympic games. Officials need to move quickly to remove Chicago from consideration as a host for the 2016 Olympic games, so that our government will stop wasting public resources on such an expensive and wasteful fiasco."
- Television pundits begin broadcasting anything they find without regard for accuracy.

FEMA

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Day Two: The Evacuation

- Sunday, July 12, 2009, 11:00 a.m., Chicago, IL
- Mayor Daley says it appears that the terrorists obtained some form of radioactive metal and ground it into a relatively fine dust.
- Initial estimates indicate that thirty pounds of radioactive material were released across the three attack sites, but because of the fineness of the powder and the dispersion of the explosions and wind, significant areas have been contaminated and are now off limits until they can be cleaned. The BP plant and Pilot Outlets robbery are not thought to be connected.
- The Mayor attempts to reassure the public that they are safe, but then announces that an evacuation is strongly recommended and creates exclusion zones that encompass most of Lakeview and the other affected neighborhoods "just to be on the safe side."

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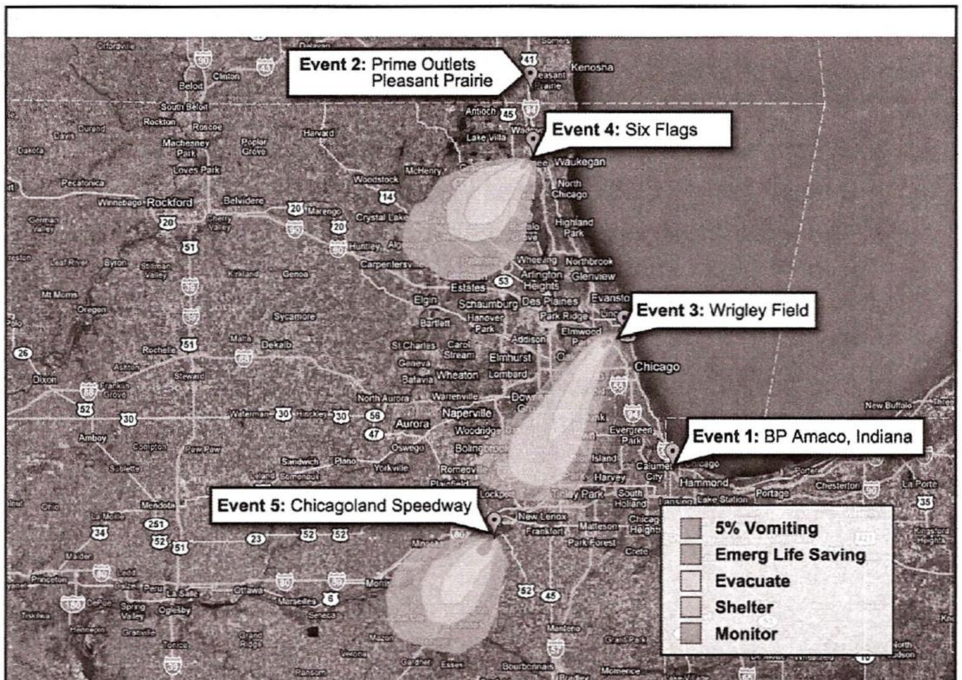

Scenario Assumptions

- The evacuation is based on the detonation of a Radiological Dispersal Device (RDD), with no notice.
- An evacuation of the area is "strongly recommended" by both the Mayor and Governor.
- One million people will be evacuated from the city.
- Of those one million people, one hundred thousand will require shelter for a period of 30 days.
- 170 people will be killed, 1,800 will suffer serious injuries, and 140,000 are thought to have been exposed to radioactive dust.

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Scenario Assumptions Continued

- Evacuees will be self-sufficient for a 72-hour period.
- Evacuation will be completed in a period of 72 hours.
- The mass transportation and highway systems will be functional, with no direct impact by the RDD.
- Evacuees may be displaced as far as 200 miles from the City of Chicago.
- The cellular communications system IS NOT working due to tower failure and system overload.

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16. Appendix B: Evacuation Behavior Survey

THE UNIVERSITY OF CHICAGO

Argonne NATIONAL LABORATORY
Transportation Research and Analysis Computing Center

Emergency Evacuation Response Survey

We thank you in advance for your help. We are conducting this survey to find out how people would react in the event of an emergency evacuation. Your answers are very important for planning and scientific research.

The survey is completely anonymous and will not take too long to complete. We will ask you for demographic information of you and other household members. Importantly, we will ask you about the decisions that you would make in the event of a city emergency.

Please answer the best you can, as your responses are extremely valuable for the successful completion of this study. Please begin now.

For more information about about the Transportation Research and Analysis Computing Center (TRACC) at Argonne National Laboratory, please visit our website at www.tracc.anl.gov

Please press 'Begin' to start the survey:

Begin

Section 1: Demographics

How many adults (18 years and older) are in your household, including you?

2

How many children (under 18 years old) are in your household?

2

THE UNIVERSITY OF CHICAGO

Argonne NATIONAL LABORATORY
Transportation Research and Analysis Computing Center

Emergency Evacuation Response Survey

Please enter a name or nickname for each household member. These can be anything such as "John", "First son", "Friend 1", etc. as long as it is meaningful to you.

After entering names, select the relationship of each household member to you.

	Enter a nickname for use in survey	Relationship Status
Adult 2	Jane	Spouse
Child 1	Sally	Child
Child 2	Tom	

Child
Sibling
Please select

What was your approximate household income in the past year?

Less than $25,000	$25,000 to $50,000	$50,000 to $75,000	$75,000 to $100,000	Over $100,000	no response
○	○	○	◉	○	○

Do you own or rent your home (primary residence)?

Own	Rent	no response
◉	○	○

Are there any disabled individuals under your care / in your household?

Yes	No	no response
○	◉	○

Are there any pets in your home? Check all types that

Dog	Cat	Other	no response
☑	☐	☐	☐

Indicate whether the following technologies are used by your household members (check all that apply):

Cellphone	Smartphone or PDA	Internet	In-vehicle Navigation
☐	☑	☑	☐

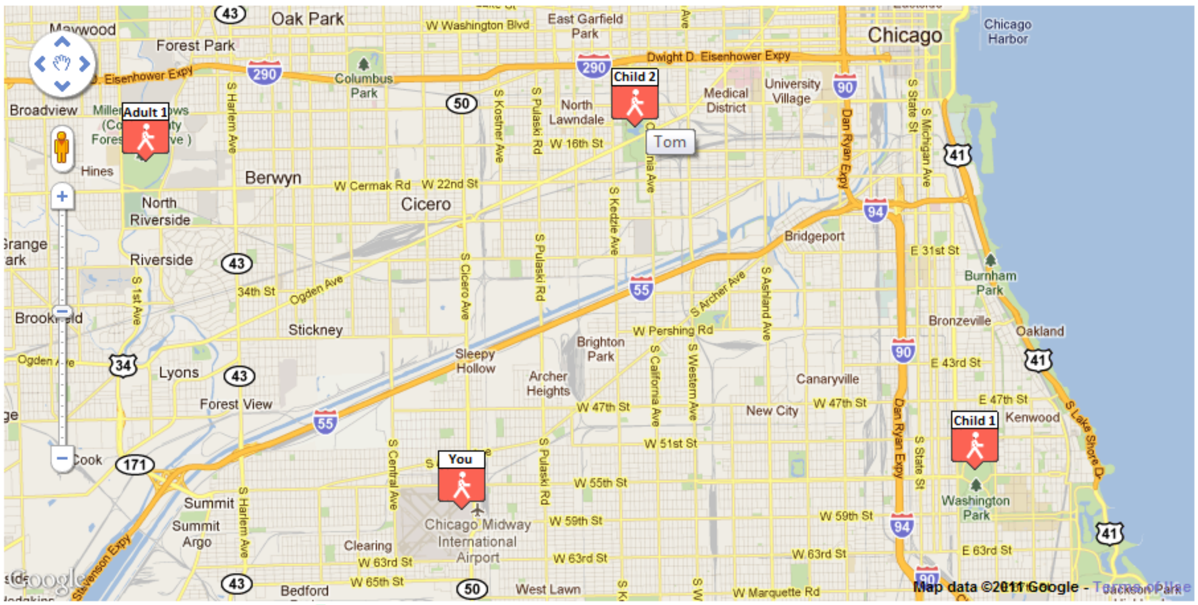
For each map shown below, move the marker for each family member to their locations *Yesterday* at each time shown. If you (or other household members) are generally traveling at the times shown, move the marker to your destination location.

To pick the locations, drag the location pins with the mouse or use the search boxes with address, city/state, zipcode, etc. Try to place the location markers are accurately as possible.

For a quick tutorial on how to use Google Maps in this survey click here.

Please indicate locations at 2:00 P.M. (*Yesterday*)

You:	Chicago Midway International Airport, S Cicero Ave
Jane (Adult 1)	Des Plaines Ave, Forest Park
Sally (Child 1)	Morgan Dr, Chicago
Tom (Child 2)	Burkhardt Dr, Chicago



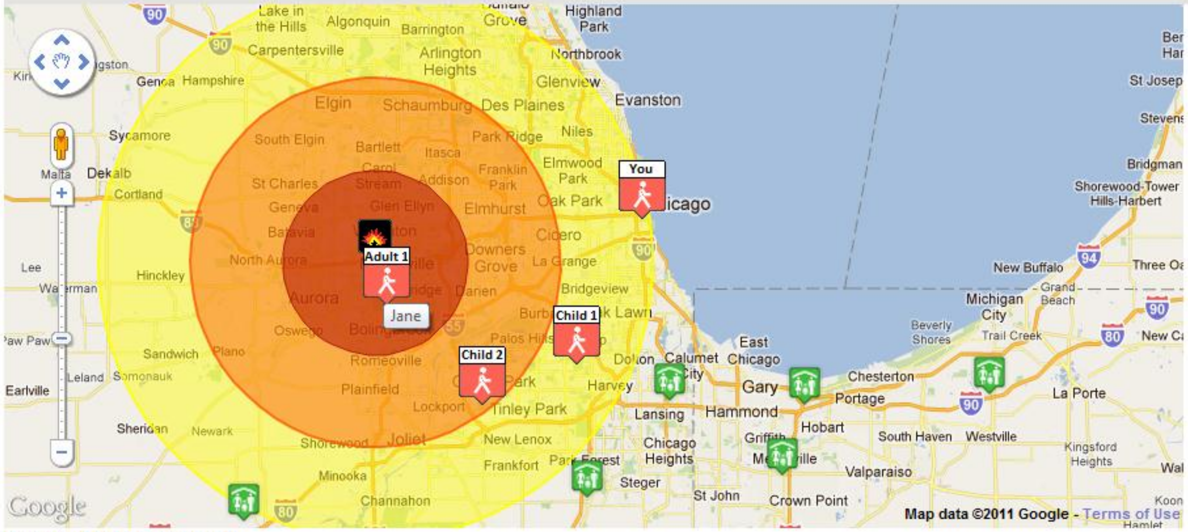
Locations at 9 A.M. ✓ **Locations at 2 P.M.** **Locations at 7 P.M.**

SCENARIO 1 DESCRIPTION:

An emergency event has occurred at 7PM within 10 miles of Jane. Government authorities have determined that there is high risks present to individuals in the area and have ordered that individuals evacuate immediately. Authorities have set up evacuation shelters as shown.

At this time you and your other household members are at the locations shown below and you have NO ACCESS to a vehicle.

Considering the current locations of you (and members of your household) and your knowledge of the event, please answer the following questions describing how you would respond.



Emergency Hazard Level:

Severe | Moderate | Low | - Shelters

Scenario 1 Response:

Considering the scenario presented above where the government has *ordered that individuals evacuate*, how likely would you be to:

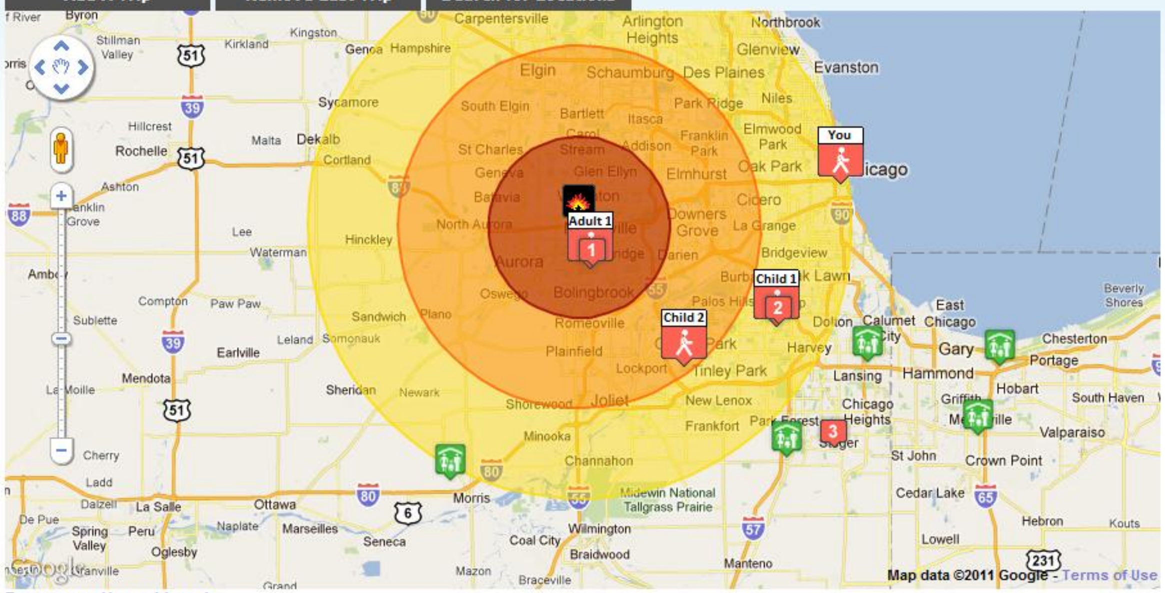
	Very Unlikely		Neutral		Very Likely
Go about your day as usual	●	○	○	○	○
Stay where you are and seek shelter	○	●	○	○	○
Make additional trips and / or evacuate	○	○	○	●	○
Evacuate if you heard others were evacuating	○	○	○	○	●
Evacuate if people near you were evacuating	○	○	○	○	●

Add any stops you would make below, select the purpose for making the stop, and write any location information (i.e. address, city/state, zipcode).

- To add new trips press the Add Trip button.
- When finished press the Search Location button and move the markers if needed.
- Press the Next button if you would not make any trips before evacuating.

	Trip Purpose:	Enter stop location (address, cross-streets, city/state, zipcode, etc.)
1st stop	Pick up Jane	S Naperville Plainfield Rd, Naperville
2nd stop	Pick up Sally	W 135th St, Palos Heights
3rd stop	Stop at home	S Independence Blvd, Crete
4th stop	Meet with others	

Add A Trip | Remove Last Trip | Search for Locations



Emergency Hazard Level:

Severe | Moderate | Low | - Shelters

Finally, where would your final evacuation destination be:

Go to a hotel / motel

To EVACUATE to one of the SHELTERS, simply CLICK it with the mouse pointer.

OTHERWISE, Enter location in the box below, press the button and move the marker to your final destination.

Mercury Dr, Champaign

Search for Location

Emergency Hazard Level:

Severe | Moderate | Low | - Shelters

17. Appendix C: TRANSIMS V5 Documentation

17.1. EvacDemand Quick Reference

Version 5.0

Revision History
11/22/2011 Edited By Argonne National Laboratory - TRACC

Purpose:

1. Generate evacuation trips for emergency case studies, given input files defining the emergency event, the available network during the evacuation (including any network management effects) and an average day model determining travel conditions prior to evacuation.

Control Key	Note	Required	Default	Range
Basic Keys				
TITLE		N		Control Keys
REPORT_FILE		N		filename[_partition][.prn]
REPORT_FLAG		N	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
PROJECT_DIRECTORY		N		
DEFAULT_FILE_FORMAT		N	TAB_DELIMITED	TEXT, BINARY, TAB_DELIMITED, CSV_DELIMITED, etc.
TIME_OF_DAY_FORMAT		N	DAY_TIME	SECONDS, MINUTES, HOURS, HOUR_CLOCK, DAY_TIME
MODEL_START_TIME		N	0:00	>= 0 [seconds], 0.0 [hours], 0:00
MODEL_END_TIME		N	24:00:00	> [model_start_time]
UNITS_OF_MEASURE		N	METRIC	METRIC, ENGLISH
RANDOM_NUMBER_SEED		N	0	0 = computer clock, > 0 = fixed

MAX_WARNING_MESSAGES		N	100000	>= 0
MAX_WARNING_EXIT_FLAG		N	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
MAX_PROBLEM_COUNT		N	0	>= 0
NUMBER_OF_THREADS		N	1	1..12
#---- System File Keys ----				
NODE_FILE		Yes		[project_directory]filename
ZONE_FILE		Yes		[project_directory]filename
LINK_FILE		Yes		[project_directory]filename
POCKET_FILE		Yes		[project_directory]filename
LOCATION_FILE		Yes		[project_directory]filename
ACCESS_FILE		Yes		[project_directory]filename
NEW_TRIP_FILE		Yes		[project_directory]filename.*
NEW_VEHICLE_FILE		Yes		[project_directory]filename.*
LANE_USE_FILE	[1]	Yes		[project_directory]filename
VEHICLE_TYPE_FILE	[12]	Yes		[project_directory]filename
SKIM_FILE	[2]	Yes		[project_directory]filename.*
VEHICLE_FILE	[2]	Yes		[project_directory]filename.*
HOUSEHOLD_FILE	[2]	N		[project_directory]filename.*
PARKING_FILE		N		[project_directory]filename
NOTES_AND_NAME_FIELDS		N	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
FLOW_UNITS		N	VEHICLES	VEHICLES, CAR_EQUIV/PCE, PERSONS
SKIM_TOTAL_TIME_FLAG		N	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
#---- EvacDemand File Keys ----				
TRIP_FILE_IN	[2]	Y		[project_directory]filename
PLAN_FILE_IN	[2]	Y		[project_directory]filename
EVAC_VEHICLE_FILE	[3]	Y		[project_directory]filename
EVAC_ZONE_FILE	[4]	Y		[project_directory]filename
CLOSED_LINK_FILE	[1]	Y		[project_directory]filename
ZONE_INFO_FILE		Y		[project_directory]filename

EVAC_SHELTER_FILE	[4]	Y		[project_directory]filename
EVAC_RESPONSE_FILE	[4]	Y		[project_directory]filename
HH_TYPE_FILE		Y		[project_directory]filename
EVAC_SKIM_FILE	[5]	N		[project_directory]filename
#---- EvacDemand Keys ----				
HB_PURPOSE_CODES	[6]	Yes		0,1..100
NUM_HH_TYPES	[7]	Yes	448	0..1000
TRIP_SCALING_FACTOR		Yes	1	0.001..1.0
TTIME_THRESHOLD	[8]	Yes	0.75	0.0..1.0
DIVERT_VEH_TYPE	[9]	Yes	99	1..100
SCHOOL_FILE		N		[project_directory]filename
HOSPITAL_FILE		N		[project_directory]filename
RESPONDER_FILE		N		[project_directory]filename
UTILITY_THRESHOLD	[10]	N	0	0.0..1.0
HOSPITAL_EVAC_VEH_OCC	[11]	N	1	1..200
SCHOOL_EVAC_VEH_OCC	[11]	N	1	1..200
HH_EVAC_VEH_OCC	[11]	N	1	1.0..100.0
MAX_RESPONSE_TIME		N	0	>= 0 [seconds]
#---- EvacDemand Choice Model Keys ----				
DEST_CHOICE_SET_SIZE	[13]	Yes	50	0..100
PAR_SHELTER_CAP	[14]	N	0.1	0.0..100.0
PAR_IGNORE_HIRISK	[14]	N	-0.805	-100.0..100.0
PAR_IGNORE_CHILD	[14]	N	-0.575	-100.0..100.0
PAR_SHELTER	[14]	N	1.849	-100.0..100.0
PAR_SHELTER_VEHACC	[14]	N	-0.678	-100.0..100.0
PAR_SHELTER_MEDRISK	[14]	N	0..382	-100.0..100.0
PAR_CHILD	[14]	N	-0.761	-100.0..100.0
PAR_EVAC	[14]	N	0.397	-100.0..100.0
PAR_EVAC_ORDER	[14]	N	1.431	-100.0..100.0

PAR_EVAC_SHLTR_MEDRISK	[14]	N	0.531	-100.0..100.0
PAR_EVAC_SHLTR_CHILD	[14]	N	-0.639	-100.0..100.0
PAR_EVAC_EXTERN	[14]	N	-1.235	-100.0..100.0
PAR_EVAC_EXTERN_EDIST	[14]	N	0.0167	-100.0..100.0
PAR_EVAC_ZONE	[14]	N	-0.9001	-100.0..100.0
PAR_EVAC_ZONE_EDIST	[14]	N	-0.012	-100.0..100.0
PAR_EVAC_ZONE_IV	[14]	N	0.436	0.0..1.0
PAR_TTIME	[14]	N	-0.0158	-100.0..100.0
PAR_POP_PER	[14]	N	0.896	-100.0..100.0
PAR_POP_DEN	[14]	N	-1.018	-100.0..100.0
PAR_AREA_RES	[14]	N	-0.442	-100.0..100.0
PAR_NUMADULT	[14]	N	0	-100.0..100.0
PAR_NUMVEH	[14]	N	0	-100.0..100.0
PAR_NUMWORK	[14]	N	0	-100.0..100.0
PAR_CHILDREN	[14]	N	0	-100.0..100.0
PAR_AREA	[14]	N	0	-100.0..100.0
PAR_RES_LOW	[14]	N	0	-100.0..100.0
PAR_RES_HIGH	[14]	N	0	-100.0..100.0
PAR_COMM	[14]	N	0	-100.0..100.0
PAR_IND	[14]	N	0	-100.0..100.0
PAR_EMP_TOT	[14]	N	0	-100.0..100.0
PAR_EMP_RET	[14]	N	0	-100.0..100.0
PAR_POP_HH	[14]	N	0	-100.0..100.0
PAR_POP_GQ	[14]	N	0	-100.0..100.0

NOTES

[1]	Generated from EvacNET.exe. Represents evacuated network conditions
[2]	From average day model results - used as input
[3]	Used when routing evacuee trips only, while NEW_VEHICLE_FILE contains vehicle records for both evacuees and
[4]	Generated using TransimsVIS configuration mode

[5]	Generated from Pathskim.exe, using evacuated network results
[6]	Trip purposes which represent home based travel.
[7]	Number of household type categories in ZONE_INFO_FILE
[8]	Threshold for trip replanning. If avg day time / evacuated time < threshold, the trip destination gets replanned
[9]	Threshold for acceptable destination utility during replanning. If utility of new destination < utility of original - threshold, new destination is not considered
[10]	Vehicle type code for diverted vehicles, should be greater than maximum evacuated vehicle type
[11]	Average expected occupancy for evacuated vehicles
[12]	Make sure vehicle type file has vehicle types 91-95 defined for evacuation vehicles. These types represent vehicles generated in zones with severity 1-5 respectively
[13]	Number of alternative zones to consider when replanning a trip or generating a new evacuation trip to a zone, rather than a shelter.
[14]	Zone choice model parameters. See Evacdemand technical documentation for details. Default values are set based on 2011 Chicago Evacuation Survey.

17.2. ArcNet - Quick Reference

Version 5.0.5

Usage

ArcNet [-flag] [control_file]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Create ArcView shapefiles from TRANSIMS nodes, links, shape, lane-use, activity locations, parking, process links, pocket lanes, lane connectivity, turn prohibition, unsignalized nodes, signalized nodes, detector, transit routes, transit stop, transit driver, route header, and route nodes files.
2. Draw links and link-related attributes using individual lanes.
3. Draw transit routes using a different offset for each route.
4. Draw the network attributes associates with a specific time period.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	MAX_PROBLEM_COUNT	Int.	0	>= 0
	NUMBER_OF_THREADS	Int.	1	1..24

System File Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	NODE_FILE	File		[project_directory]filename
	ZONE_FILE	File		[project_directory]filename
	SHAPE_FILE	File		[project_directory]filename
	LINK_FILE	File		[project_directory]filename
	POCKET_FILE	File		[project_directory]filename
	LANE_USE_FILE	File		[project_directory]filename
	CONNECTION_FILE	File		[project_directory]filename

TURN_PENALTY_FILE	File		[project_directory]filename
PARKING_FILE	File		[project_directory]filename
LOCATION_FILE	File		[project_directory]filename
ACCESS_FILE	File		[project_directory]filename
SIGN_FILE	File		[project_directory]filename
SIGNAL_FILE	File		[project_directory]filename
PHASING_PLAN_FILE	File		[project_directory]filename
TIMING_PLAN_FILE	File		[project_directory]filename
DETECTOR_FILE	File		[project_directory]filename
TRANSIT_STOP_FILE	File		[project_directory]filename
TRANSIT_ROUTE_FILE	File		[project_directory]filename
TRANSIT_SCHEDULE_FILE	File		[project_directory]filename
TRANSIT_DRIVER_FILE	File		[project_directory]filename
ROUTE_NODES_FILE	File		[project_directory]filename
VEHICLE_TYPE_FILE	File		[project_directory]filename

File Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
NOTES_AND_NAME_FIELDS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Draw Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
DRAW_NETWORK_LANES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
LANE_WIDTH	Dec.	3.5 meters	0..40 meters
CENTER_ONEWAY_LINKS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
LINK_DIRECTION_OFFSET	Dec.	0.0 meters	0..50 meters
DRAW_AB_DIRECTION	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
POCKET_SIDE_OFFSET	Dec.	2.0 meters	0..82 meters
PARKING_SIDE_OFFSET	Dec.	3.0 meters	0..164 meters
LOCATION_SIDE_OFFSET	Dec.	10.0 meters	0..328 meters
SIGN_SIDE_OFFSET	Dec.	2.0 meters	0..164 meters
SIGN_SETBACK	Dec.	2.0 meters	0..328 meters

TRANSIT_STOP_SIDE_OFFSET	Dec.	2.0 meters	0..164 meters
TRANSIT_DIRECTION_OFFSET	Dec.	0.0 meters	0..50 meters
TRANSIT_OVERLAP_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
DRAW_ONEWAY_ARROWS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
ONEWAY_ARROW_LENGTH	Dec.	7.0 meters	0.1..656 meters
ONEWAY_ARROW_SIDE_OFFSET	Dec.	1.75 meters	0.1..164 meters
CURVED_CONNECTION_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Projection, Smooth Data, Difference Data Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
INPUT_COORDINATE_SYSTEM	List		LATLONG, DEGREES/MILLION_DEGREES or STATEPLANE/UTM, code, FEET/METERS/MILES/KILOMETERS
INPUT_COORDINATE_ADJUSTMENT	List		X Offset, Y Offset, X Factor, Y Factor
OUTPUT_COORDINATE_SYSTEM	List		LATLONG, DEGREES/MILLION_DEGREES or STATEPLANE/UTM, code, FEET/METERS/MILES/KILOMETERS
OUTPUT_COORDINATE_ADJUSTMENT	List		X Offset, Y Offset, X Factor, Y Factor
OUTPUT_XYZ_SHAPES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
OUTPUT_XYM_SHAPES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Control Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
SUBZONE_DATA_FILE	File		[project_directory]filename
NEW_ARC_NODE_FILE	File		[project_directory]filename
NEW_ARC_ZONE_FILE	File		[project_directory]filename
NEW_ARC_LINK_FILE	File		[project_directory]filename
NEW_ARC_CENTERLINE_FILE	File		[project_directory]filename
NEW_ARC_POCKET_FILE	File		[project_directory]filename
NEW_ARC_LANE_USE_FILE	File		[project_directory]filename
NEW_ARC_LOCATION_FILE	File		[project_directory]filename
NEW_ARC_PARKING_FILE	File		[project_directory]filename
NEW_ARC_ACCESS_FILE	File		[project_directory]filename
NEW_ARC_CONNECTION_FILE	File		[project_directory]filename
NEW_ARC_TURN_PENALTY_FILE	File		[project_directory]filename

NEW_ARC_SIGN_FILE	File		[project_directory]filename
NEW_ARC_SIGNAL_FILE	File		[project_directory]filename
NEW_ARC_TIMING_PLAN_FILE	File		[project_directory]filename
NEW_ARC_PHASING_PLAN_FILE	File		[project_directory]filename
NEW_ARC_DETECTOR_FILE	File		[project_directory]filename
NEW_ARC_TRANSIT_STOP_FILE	File		[project_directory]filename
NEW_ARC_TRANSIT_ROUTE_FILE	File		[project_directory]filename
NEW_ARC_TRANSIT_DRIVER_FILE	File		[project_directory]filename
NEW_ARC_ROUTE_NODES_FILE	File		[project_directory]filename
NEW_ARC_SUBZONE_DATA_FILE	File		[project_directory]filename
SELECT_TIME	Time	0:00	0:00..24:00
TRANSIT_TIME_PERIODS	Text	0:00	0:00..24:00

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.3. ArcPlan - Quick Reference

Version 5.0.7

Usage

ArcPlan [-flag] [control_file] [partition]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Create ArcView shapefiles showing the paths from selected records in TRANSIMS plan files.
2. Use the Simulator problem file to select problem plans and draw ArcView shapefiles for the problem locations.
3. Create ArcView shapefiles showing the vehicle demand on links from selected plans as a bandwidth plot.
4. Create ArcView shapefiles showing travel time contours from a given origin to all destinations.
5. Create ArcView shapefiles showing trip length contours from a given origin to all destinations.
6. Create ArcView shapefiles showing the travel time and trip distance from a given origin to all activity locations.
7. Create ArcView shapefiles summarizing the transit ridership on network link segments as polylines or ridership bandwidths.
8. Create ArcView shapefiles summarizing the transit boardings and alightings at selected transit stops.
9. Create ArcView shapefiles aggregating the transit boardings and alightings from groups of transit stops.
10. Create ArcView shapefiles summarizing the vehicle arrivals and departures at selected parking lots.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	MAX_PROBLEM_COUNT	Int.	0	>= 0
	NUMBER_OF_THREADS	Int.	1	1..24
	ARCPLAN_REPORT_*	Text		program report name

System File Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	NODE_FILE	File		[project_directory]filename
YES	LINK_FILE	File		[project_directory]filename

YES	PARKING_FILE	File		[project_directory]filename
YES	LOCATION_FILE	File		[project_directory]filename
	SHAPE_FILE	File		[project_directory]filename
	POCKET_FILE	File		[project_directory]filename
	CONNECTION_FILE	File		[project_directory]filename
	ACCESS_FILE	File		[project_directory]filename
	TRANSIT_STOP_FILE	File		[project_directory]filename
	TRANSIT_ROUTE_FILE	File		[project_directory]filename
	TRANSIT_DRIVER_FILE	File		[project_directory]filename
	SELECTION_FILE	File		[project_directory]filename.*
	LINK_DELAY_FILE	File		[project_directory]filename
	PERFORMANCE_FILE	File		[project_directory]filename
	VEHICLE_TYPE_FILE	File		[project_directory]filename
	PROBLEM_FILE	File		[project_directory]filename.*
	PLAN_FILE	File		[project_directory]filename.*

File Service Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	NOTES_AND_NAME_FIELDS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	STOP_EQUIVALENCE_FILE	File		[project_directory]filename

Select Service Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	SELECT_HOUSEHOLDS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
	SELECT_MODES	List	ALL	e.g., ALL or 1, 12..14 or WALK, HOV2..HOV4
	SELECT_PURPOSES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
	SELECT_START_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
	SELECT_END_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
	SELECT_ORIGINS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
	SELECT_DESTINATIONS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
	SELECT_TRAVELER_TYPES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
	SELECT_FACILITY_TYPES	List	ALL	FREEWAY..EXTERNAL

SELECT_PROBLEM_TYPES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_LINKS_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_NODES_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_SUBAREA_POLYGON	File		[project_directory]filename
SELECT_ORIGIN_ZONES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_DESTINATION_ZONES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECTION_PERCENTAGE	Dec.	100.0 percent	0.01..100.0 percent

Draw Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
DRAW_NETWORK_LANES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
LANE_WIDTH	Dec.	3.5 meters	0..40 meters
CENTER_ONEWAY_LINKS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
LINK_DIRECTION_OFFSET	Dec.	0.0 meters	0..50 meters
PARKING_SIDE_OFFSET	Dec.	3.0 meters	0..164 meters
LOCATION_SIDE_OFFSET	Dec.	10.0 meters	0..328 meters
TRANSIT_STOP_SIDE_OFFSET	Dec.	2.0 meters	0..164 meters
TRANSIT_DIRECTION_OFFSET	Dec.	0.0 meters	0..50 meters
BANDWIDTH_SCALING_FACTOR	Dec.	1.0 units/meter	0.01..100000 units/meter
MINIMUM_BANDWIDTH_VALUE	Dec.	0	0..100000
MINIMUM_BANDWIDTH_SIZE	Dec.	1.0 meters	0.001..10 meters
MAXIMUM_BANDWIDTH_SIZE	Dec.	1000.0 meters	1..10000 meters

Projection, Smooth Data, Difference Data Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
INPUT_COORDINATE_SYSTEM	List		LATLONG, DEGREES/MILLION_DEGREES or STATEPLANE/UTM, code, FEET/METERS/MILES/KILOMETERS
INPUT_COORDINATE_ADJUSTMENT	List		X Offset, Y Offset, X Factor, Y Factor
OUTPUT_COORDINATE_SYSTEM	List		LATLONG, DEGREES/MILLION_DEGREES or STATEPLANE/UTM, code, FEET/METERS/MILES/KILOMETERS
OUTPUT_COORDINATE_ADJUSTMENT	List		X Offset, Y Offset, X Factor, Y Factor
OUTPUT_XYZ_SHAPES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
OUTPUT_XYM_SHAPES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Control Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	NEW_ARC_PLAN_FILE	File		[project_directory]filename
	NEW_ARC_PROBLEM_FILE	File		[project_directory]filename
	NEW_ARC_BANDWIDTH_FILE	File		[project_directory]filename
	NEW_ARC_TIME_CONTOUR_FILE	File		[project_directory]filename
	NEW_ARC_DISTANCE_CONTOUR_FILE	File		[project_directory]filename
	NEW_ARC_ACCESSIBILITY_FILE	File		[project_directory]filename
	NEW_ARC_RIDERSHIP_FILE	File		[project_directory]filename
	NEW_ARC_STOP_DEMAND_FILE	File		[project_directory]filename
	NEW_ARC_STOP_GROUP_FILE	File		[project_directory]filename
	NEW_ARC_PARKING_DEMAND_FILE	File		[project_directory]filename
	MAXIMUM_SHAPE_ANGLE	Dec.	0.0 meters	0..50 meters
	MINIMUM_SHAPE_LENGTH	Dec.	0.0 meters	0..50 meters
	CONTOUR_TIME_INCREMENTS	Dec.	0.0 meters	0..50 meters
	CONTOUR_DISTANCE_INCREMENTS	Dec.	0.0 meters	0..50 meters
	RIDERSHIP_SCALING_FACTOR	Dec.	0.0 meters	0..50 meters
	MINIMUM_RIDERSHIP_VALUE	Dec.	0.0 meters	0..50 meters
	MINIMUM_RIDERSHIP_SIZE	Dec.	0.0 meters	0..50 meters
	MAXIMUM_RIDERSHIP_SIZE	Dec.	0.0 meters	0..50 meters

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.4. ArcSnapshot - Quick Reference

Version 5.0.4

Usage

ArcSnapshot [-flag] [control_file]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Create ArcView shapefiles from selected records in TRANSIMS snapshot files.
2. Create ArcView shapefiles from selected records in TRANSIMS occupancy files.
3. Vehicle lane-offset locations can be drawn as polygons or points layers.
4. Output new snapshot files with X, Y, and bearing data updated based on the lane shape.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

MAX_PROBLEM_COUNT	Int.	0	>= 0
NUMBER_OF_THREADS	Int.	1	1..24

System File Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
YES NODE_FILE	File		[project_directory]filename
YES LINK_FILE	File		[project_directory]filename
YES POCKET_FILE	File		[project_directory]filename
YES VEHICLE_TYPE_FILE	File		[project_directory]filename
SHAPE_FILE	File		[project_directory]filename
CONNECTION_FILE	File		[project_directory]filename

File Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
NOTES_AND_NAME_FIELDS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Data Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
SUMMARY_TIME_RANGES	Text	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SUMMARY_TIME_INCREMENT	Time	15 minutes	0, 2..240 minutes

Select Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
SELECT_VEHICLE_TYPES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_SUBAREA_POLYGON	File		[project_directory]filename

Draw Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
LANE_WIDTH	Dec.	3.5 meters	0..40 meters
CENTER_ONEWAY_LINKS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
DRAW_VEHICLE_SHAPES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Projection, Smooth Data, Difference Data Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
INPUT_COORDINATE_SYSTEM	List		LATLONG, DEGREES/MILLION_DEGREES or STATEPLANE/UTM, code, FEET/METERS/MILES/KILOMETERS
INPUT_COORDINATE_ADJUSTMENT	List		X Offset, Y Offset, X Factor, Y Factor
OUTPUT_COORDINATE_SYSTEM	List		LATLONG, DEGREES/MILLION_DEGREES or STATEPLANE/UTM, code, FEET/METERS/MILES/KILOMETERS
OUTPUT_COORDINATE_ADJUSTMENT	List		X Offset, Y Offset, X Factor, Y Factor
OUTPUT_XYZ_SHAPES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
OUTPUT_XYM_SHAPES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Control Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
SNAPSHOT_FILE	File		[project_directory]filename
OCCUPANCY_FILE	File		[project_directory]filename
NEW_ARC_SNAPSHOT_FILE	File		[project_directory]filename
CELL_SIZE	Dec.	0.0 meters	0, 3..10 meters
ADD_PASSENGER_CIRCLE_SIZE	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
ADD_PASSENGER_SQUARE_SIZE	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
PAD_FILE_TIME_LABEL	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
TIME_PROCESSING_METHOD	Text	AT_INCREMENT	AT_INCREMENT, TOTAL, MAXIMUM
NEW_SNAPSHOT_FILE	File		[project_directory]filename
NEW_LINK_SUMMARY_FILE	File		[project_directory]filename

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.5. ConvertTrips - Quick Reference

Version 5.0.4

Usage

ConvertTrips [-flag] [control_file]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Convert multiple zone-to-zone trip tables to trip, vehicle, household, and population files.
2. Assign each trip table to a different trip purpose and vehicle type.
3. Apply different diurnal distribution curves to each trip table or zone range.
4. Apply district-to-district correction factors to the input trips by trip purpose.
5. Append additional trips to existing trip, vehicle, household, and population files.
6. A period field can be included in the input trip tables to limit the time-of-day distribution of the trips.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed

MAX_WARNING_MESSAGES	Int.	100000	>= 0
MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
MAX_PROBLEM_COUNT	Int.	0	>= 0
NUMBER_OF_THREADS	Int.	1	1..24
CONVERTTRIPS_REPORT_*	Text		program report name

System File Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	NODE_FILE	File		[project_directory]filename
YES	ZONE_FILE	File		[project_directory]filename
YES	LINK_FILE	File		[project_directory]filename
YES	PARKING_FILE	File		[project_directory]filename
YES	LOCATION_FILE	File		[project_directory]filename
YES	VEHICLE_TYPE_FILE	File		[project_directory]filename
YES	NEW_HOUSEHOLD_FILE	File		[project_directory]filename.*
YES	NEW_VEHICLE_FILE	File		[project_directory]filename.*
YES	NEW_TRIP_FILE	File		[project_directory]filename.*
	SHAPE_FILE	File		[project_directory]filename
	ACCESS_FILE	File		[project_directory]filename
	HOUSEHOLD_FILE	File		[project_directory]filename.*
	VEHICLE_FILE	File		[project_directory]filename.*
	TRIP_FILE	File		[project_directory]filename.*
	SKIM_FILE	File		[project_directory]filename.*

File Service Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	NOTES_AND_NAME_FIELDS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	ZONE_EQUIVALENCE_FILE	File		[project_directory]filename
	ZONE_LOCATION_MAP_FILE	File		[project_directory]filename

Control Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	TRIP_TABLE_FILE_*	File		[project_directory]filename
YES	TIME_DISTRIBUTION_FILE_*	File		[project_directory]filename
	FIRST_HOUSEHOLD_NUMBER	Int.	1	1..1000000000
	ADDITIONAL_TRAVEL_TIME	Time	0 minutes	0..30 minutes
	TRIP_SCALING_FACTOR_*	Dec.	1.0	0.001..100.0
	TIME_DISTRIBUTION_SCRIPT_*	File		[project_directory]filename
	TIME_DISTRIBUTION_FIELD_*	Text		
	TIME_DISTRIBUTION_TYPE_*	Text	TRIP_START	TRIP_START, TRIP_END, MID_TRIP
	TIME_PERIOD_RANGE_*	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
	TIME_SCHEDULE_CONSTRAINT_*	Text	START_TIME	NONE, START, ARRIVE, FIXED, DURATION, PASSENGER
	ORIGIN_WEIGHT_FIELD_*	Text		
	DESTINATION_WEIGHT_FIELD_*	Text		
	DISTANCE_WEIGHT_FLAG_*	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	TRAVELER_TYPE_SCRIPT_*	File		[project_directory]filename
	TRAVELER_TYPE_CODE_*	Int.	0	0..100
	TRIP_PURPOSE_CODE_*	Int.	0	0..100
	TRAVEL_MODE_CODE_*	Text	DRIVE	WALK, BIKE, DRIVE, RIDE, TRANSIT, PNR_OUT, PNR_IN, KNR_OUT, KNR_IN, TAXI, OTHER, HOV2, HOV3, HOV4
	RETURN_TRIP_FLAG_*	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	ACTIVITY_DURATION_*	Time	0.0 hours	0.0, 0.25..24.0 hours
	TRIP_PRIORITY_CODE_*	Text	MEDIUM	LOW, MEDIUM, HIGH, CRITICAL
	VEHICLE_TYPE_CODE_*	Int.	1	0..100
	VEHICLE_PASSENGERS_*	Int.	0	0..500
	AVERAGE_TRAVEL_SPEED_*	Dec.	30.0 kph	3.0..100.0 kph
	TRIP_FACTOR_FILE_*	File		[project_directory]filename

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.6. FileFormat - Quick Reference

Version 5.0.0

Usage

FileFormat [-flag] [control_file]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	MAX_PROBLEM_COUNT	Int.	0	>= 0
	NUMBER_OF_THREADS	Int.	1	1..24

Control Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	DATA_FILE_*	File		[project_directory]filename
YES	NEW_DATA_FILE_*	File		[project_directory]filename

Notes

File Formats:
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.7. IntControl - Quick Reference

Version 5.0.1

Usage

IntControl [-flag] [control_file]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Synthesize TRANSIMS sign and signal data from location lists.
2. Delete signs or signal records from an existing set of TRANSIMS traffic control files.
3. Append new signs and signals to an existing set of TRANSIMS traffic control files.
4. Update the signal timing plans for selected locations and time periods based on turning movements or link delay data.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	MAX_PROBLEM_COUNT	Int.	0	>= 0
	NUMBER_OF_THREADS	Int.	1	1..24
	INTCONTROL_REPORT_*	Text		program report name

System File Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	NODE_FILE	File		[project_directory]filename
YES	LINK_FILE	File		[project_directory]filename
YES	POCKET_FILE	File		[project_directory]filename
YES	CONNECTION_FILE	File		[project_directory]filename
	SHAPE_FILE	File		[project_directory]filename
	LANE_USE_FILE	File		[project_directory]filename
	SIGN_FILE	File		[project_directory]filename
	SIGNAL_FILE	File		[project_directory]filename
	PHASING_PLAN_FILE	File		[project_directory]filename
	TIMING_PLAN_FILE	File		[project_directory]filename
	DETECTOR_FILE	File		[project_directory]filename
	LINK_DELAY_FILE	File		[project_directory]filename
	NEW_SIGN_FILE	File		[project_directory]filename
	NEW_SIGNAL_FILE	File		[project_directory]filename

NEW_PHASING_PLAN_FILE	File		[project_directory]filename
NEW_TIMING_PLAN_FILE	File		[project_directory]filename
NEW_DETECTOR_FILE	File		[project_directory]filename

File Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
NOTES_AND_NAME_FIELDS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Data Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
DAILY_WRAP_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
SUMMARY_TIME_RANGES	Text	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SUMMARY_TIME_INCREMENT	Time	15 minutes	0, 2..240 minutes

Control Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
INPUT_SIGN_FILE	File		[project_directory]filename
INPUT_SIGNAL_FILE	File		[project_directory]filename
DELETE_NODE_CONTROL_FILE	File		[project_directory]filename
PRINT_SIGN_WARNINGS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
PRINT_MERGE_WARNINGS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
SIGNAL_TYPE_CODE_*	List	TIMED	TIMED or ACTUATED
NUMBER_OF_RINGS_*	List	1	1..4
SIGNAL_TIME_BREAKS_*	List	NONE	e.g., NONE, 6:00, 10:00, 16:00
SIGNAL_CYCLE_LENGTH_*	List	60 seconds	30..360 seconds
MINIMUM_PHASE_TIME_*	List	5 seconds	0..30 seconds
YELLOW_PHASE_TIME_*	List	3 seconds	0..6 seconds
RED_CLEAR_PHASE_TIME_*	List	0 seconds	0..4 seconds
SIGNAL_DETECTOR_LENGTH_*	Dec.	20 meters	5..50 meters
POCKET_LANE_FACTOR_*	List	0.5	0.2..1.0
SHARED_LANE_FACTOR_*	List	0.5	0.2..1.0
TURN_MOVEMENT_FACTOR_*	List	0.9	0.2..1.0

PERMITTED_LEFT_FACTOR_*	List	0.5	0.2..1.0
GENERAL_GREEN_FACTOR_*	List	1.0	0.7..1.0
EXTENDED_GREEN_FACTOR_*	List	0.5	0.1..1.0
MAXIMUM_GREEN_FACTOR_*	List	2.0	0.2..10.0
SIGNAL_SPLIT_METHOD_*	List	CAPACITY	LANES, CAPACITY, VOLUME, UPDATE
MINIMUM_LANE_CAPACITY_*	Int.	500	0..1000 vphpl
MAXIMUM_LANE_CAPACITY_*	Int.	1500	100..3000 vphpl
TURN_VOLUME_FILE	File		[project_directory]filename

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.8. LinkData - Quick Reference

Version 5.0.1

Usage

LinkData [-flag] [control_file]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	MAX_PROBLEM_COUNT	Int.	0	>= 0
	NUMBER_OF_THREADS	Int.	1	1..24

Data Service Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	SUMMARY_TIME_RANGES	Text	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
	SUMMARY_TIME_INCREMENT	Time	15 minutes	0, 2..240 minutes

Control Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	LINK_NODE_LIST_FILE	File		[project_directory]filename
YES	DIRECTIONAL_DATA_FILE	File		[project_directory]filename
	FROM_NODE_FIELD_NAME	Text	ANODE	NODE_A, A_NODE, A, NODEA, ANODE
	TO_NODE_FIELD_NAME	Text	BNODE	NODE_B, B_NODE, B, NODEB, BNODE
	VOLUME_DATA_FIELD_NAME	Text		
	SPEED_DATA_FIELD_NAME	Text		
	AB_VOLUME_FIELD_NAME	Text		
	BA_VOLUME_FIELD_NAME	Text		
	BA_SPEED_FIELD_NAME	Text		
	AB_SPEED_FIELD_NAME	Text		
	NEW_LINK_DATA_FILE	File		[project_directory]filename
	NEW_AB_VOLUME_FIELD_NAME	Text	AB_VOLUME	
	NEW_BA_VOLUME_FIELD_NAME	Text	BA_VOLUME	
	NEW_AB_SPEED_FIELD_NAME	Text	AB_SPEED	
	NEW_BA_SPEED_FIELD_NAME	Text	BA_SPEED	
	NEW_DIRECTIONAL_DATA_FILE	File		[project_directory]filename

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.9. LinkDelay - Quick Reference

Version 5.0.1

Usage

LinkDelay [-flag] [control_file]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Merge, average, and/or convert Link Delay files.
2. Smooth the link delays between time increments.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	MAX_PROBLEM_COUNT	Int.	0	>= 0
	NUMBER_OF_THREADS	Int.	1	1..24

System File Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	NODE_FILE	File		[project_directory]filename
YES	LINK_FILE	File		[project_directory]filename
YES	LINK_DELAY_FILE	File		[project_directory]filename
YES	NEW_LINK_DELAY_FILE	File		[project_directory]filename
	CONNECTION_FILE	File		[project_directory]filename

Data Service Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	DAILY_WRAP_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	SUMMARY_TIME_RANGES	Text	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
	SUMMARY_TIME_INCREMENT	Time	15 minutes	0, 2..240 minutes

Projection, Smooth Data, Difference Data Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	SMOOTH_GROUP_SIZE	Int.	3	0, >= 3
	PERCENT_MOVED_FORWARD	Dec.	20	> 0.0
	PERCENT_MOVED_BACKWARD	Dec.	20	> 0.0
	NUMBER_OF_ITERATIONS	Int.	3	> 0
	CIRCULAR_GROUP_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Control Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	MERGE_LINK_DELAY_FILE	File		[project_directory]filename
	PROCESSING_METHOD	Text	SIMPLE_AVERAGE	REPLACE_LINKS, SIMPLE_AVERAGE, WEIGHTED_AVERAGE, REPLACE_OR_AVERAGE
	MERGE_WEIGHTING_FACTOR	Dec.	1.0	0.0, >= 0.5
	MAX_TRAVEL_TIME_RATIO	Dec.	0.0	0.0, > 1.0

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.

TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.10. LinkSum - Quick Reference

Version 5.0.7

Usage

LinkSum [-flag] [control_file]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Generate link data files of volumes, speeds, travel times, V/C ratios, travel time ratios, delay, average density, maximum density, average queue, maximum queue, and cycle failures summarized by time of day.
2. Summarize data within a subarea polygon or for specified facility types.
3. Summarize link data by zone or zone group found in the activity location file.
4. Summarize activity location data fields by link direction.
5. Report the links with the top 100 link volumes, lane volumes, period volumes, speed reductions, V/C ratios, travel time ratios, volume changes, or travel time changes.
6. Report the link groups with total volumes greater than user specified values.
7. Report the distribution of travel time, V/C ratio, travel time change, and volume change by lane kilometer and time period.
8. Select links to output using a link equivalence file.
9. Calculate congestion duration-based measures by aggregating time periods with time ratios greater than a specified value.

10. Report various network performance statistics.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	MAX_PROBLEM_COUNT	Int.	0	>= 0
	NUMBER_OF_THREADS	Int.	1	1..24
	LINKSUM_REPORT_*	Text		program report name

System File Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	NODE_FILE	File		[project_directory]filename
YES	LINK_FILE	File		[project_directory]filename
YES	PERFORMANCE_FILE	File		[project_directory]filename
	LANE_USE_FILE	File		[project_directory]filename
	CONNECTION_FILE	File		[project_directory]filename
	LOCATION_FILE	File		[project_directory]filename

File Service Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	ZONE_EQUIVALENCE_FILE	File		[project_directory]filename
	LINK_EQUIVALENCE_FILE	File		[project_directory]filename

Data Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
DAILY_WRAP_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
SUMMARY_TIME_RANGES	Text	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SUMMARY_TIME_INCREMENT	Time	15 minutes	0, 2..240 minutes

Select Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
SELECT_FACILITY_TYPES	List	ALL	FREEWAY..EXTERNAL
SELECT_SUBAREA_POLYGON	File		[project_directory]filename

Control Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
COMPARE_PERFORMANCE_FILE	File		[project_directory]filename
MINIMUM_LINK_FLOW	Dec.	2.0	>= 0
SELECT_BY_LINK_GROUP	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
NEW_LINK_ACTIVITY_FILE	File		[project_directory]filename
COPY_LOCATION_FIELDS	Text		
NEW_ZONE_TRAVEL_FILE	File		[project_directory]filename
NEW_GROUP_TRAVEL_FILE	File		[project_directory]filename
NEW_LINK_DIRECTION_FILE_*	File		[project_directory]filename
NEW_LINK_DIRECTION_FIELD_*	Text		FLOW, TRAVEL_TIME, VC_RATIO, TIME_RATIO, SPEED, DELAY, DENSITY, MAX_DENSITY, QUEUE, MAX_QUEUE, CYCLE_FAILURE, VMT, V
NEW_LINK_DIRECTION_INDEX_*	Bool		TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
NEW_LINK_DATA_FILE_*	File		[project_directory]filename
NEW_LINK_DATA_FIELD_*	Text		FLOW, TRAVEL_TIME, VC_RATIO, TIME_RATIO, SPEED, DELAY, DENSITY, MAX_DENSITY, QUEUE, MAX_QUEUE, CYCLE_FAILURE, VMT, V
NEW_PERFORMANCE_DATA_FILE	File		[project_directory]filename
NEW_TURN_VOLUME_FILE	File		[project_directory]filename
TURN_NODE_RANGE	List	ALL	e.g., 1, 2, 4..10, 100..200, 300

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.

TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.11. LocationData - Quick Reference

Version 5.0.3

Usage

LocationData [-flag] [control_file]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Create or update fields in the activity location file.
2. Assign activity locations to a zone number based on the point-in-polygon equivalence to an ArcView zone boundary file.
3. Create transit accessibility weights based on the number of transit runs within a specified distance of each activity location.
4. Create trip distribution flags based on the use codes of the link attached to the activity location.
5. Create trip distribution weights based on the location of subzone centroids and a subzone data field.
6. Copy data fields from a zone file based on a zone number in the activity location file.
7. Apply custom data processing scripts to manipulate and calculate fields in the activity location file based on inputs from several related files.
8. Access fields in an ArcView polygon boundary file based on a point-in-polygon match to the activity location coordinates.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	MAX_PROBLEM_COUNT	Int.	0	>= 0
	NUMBER_OF_THREADS	Int.	1	1..24
	LOCATIONDATA_REPORT_*	Text		program report name

System File Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	NODE_FILE	File		[project_directory]filename
YES	LINK_FILE	File		[project_directory]filename
YES	LOCATION_FILE	File		[project_directory]filename
YES	NEW_LOCATION_FILE	File		[project_directory]filename
	ZONE_FILE	File		[project_directory]filename
	SHAPE_FILE	File		[project_directory]filename
	ACCESS_FILE	File		[project_directory]filename
	TRANSIT_STOP_FILE	File		[project_directory]filename
	TRANSIT_ROUTE_FILE	File		[project_directory]filename
	TRANSIT_SCHEDULE_FILE	File		[project_directory]filename

File Service Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	NOTES_AND_NAME_FIELDS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Projection, Smooth Data, Difference Data Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
INPUT_COORDINATE_SYSTEM	List		LATLONG, DEGREES/MILLION_DEGREES or STATEPLANE/UTM, code, FEET/METERS/MILES/KILOMETERS
INPUT_COORDINATE_ADJUSTMENT	List		X Offset, Y Offset, X Factor, Y Factor
OUTPUT_COORDINATE_SYSTEM	List		LATLONG, DEGREES/MILLION_DEGREES or STATEPLANE/UTM, code, FEET/METERS/MILES/KILOMETERS
OUTPUT_COORDINATE_ADJUSTMENT	List		X Offset, Y Offset, X Factor, Y Factor
OUTPUT_XYZ_SHAPES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
OUTPUT_XYM_SHAPES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Control Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
COPY_EXISTING_FIELDS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
NEW_WALK_ACCESS_FIELD	Text		
MAX_WALK_DISTANCE	Int.	1000 meters	10..3000 meters
WALK_ACCESS_TIME_RANGE	Text		
NEW_USE_FLAG_FIELD_*	Text		
LINK_USE_FLAG_TYPES_*	Text		
SUBZONE_ZONE_FACTOR_FILE	File		[project_directory]filename
NEW_SUBZONE_FIELD_*	Text		NAME, INTEGER, 10
MAX_SUBZONE_DISTANCE_*	Int.	1000 meters	0, 10..10000 meters
SUBZONE_DATA_FILE_*	File		[project_directory]filename
SUBZONE_DATA_FIELD_*	Text		
SUBZONE_ZONE_FIELD_*	Text		
NEW_LOCATION_FIELD_*	Text		NAME, INTEGER, 10
CONVERSION_SCRIPT	File		[project_directory]filename
DATA_FILE_*	File		[project_directory]filename
DATA_JOIN_FIELD_*	Text		
LOCATION_JOIN_FIELD_*	Text		
BOUNDARY_POLYGON_FILE_*	File		[project_directory]filename
NEW_ZONE_LOCATION_MAP_FILE	File		[project_directory]filename
MINIMUM_ZONE_LOCATIONS	Int.	4	2..20

ZONE_BOUNDARY_FILE	File		[project_directory]filename
ZONE_FIELD_NAME	Text		
ZONE_UPDATE_RANGE	List	ALL	e.g., 1, 2, 4..10, 100..200, 300

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.12. NetPrep - Quick Reference

Version 5.0.9

Usage

NetPrep [-flag] [control_file]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	MAX_PROBLEM_COUNT	Int.	0	>= 0
	NUMBER_OF_THREADS	Int.	1	1..24

NETPREP_REPORT_*	Text		program report name

System File Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
NODE_FILE	File		[project_directory]filename
ZONE_FILE	File		[project_directory]filename
SHAPE_FILE	File		[project_directory]filename
LINK_FILE	File		[project_directory]filename
NEW_NODE_FILE	File		[project_directory]filename
NEW_ZONE_FILE	File		[project_directory]filename
NEW_SHAPE_FILE	File		[project_directory]filename
NEW_LINK_FILE	File		[project_directory]filename

File Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
NOTES_AND_NAME_FIELDS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Projection, Smooth Data, Difference Data Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
INPUT_COORDINATE_SYSTEM	List		LATLONG, DEGREES/MILLION_DEGREES or STATEPLANE/UTM, code, FEET/METERS/MILES/KILOMETERS
INPUT_COORDINATE_ADJUSTMENT	List		X Offset, Y Offset, X Factor, Y Factor
OUTPUT_COORDINATE_SYSTEM	List		LATLONG, DEGREES/MILLION_DEGREES or STATEPLANE/UTM, code, FEET/METERS/MILES/KILOMETERS
OUTPUT_COORDINATE_ADJUSTMENT	List		X Offset, Y Offset, X Factor, Y Factor
OUTPUT_XYZ_SHAPES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
OUTPUT_XYM_SHAPES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Control Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
INPUT_LINK_FILE	File		[project_directory]filename
INPUT_NODE_FILE	File		[project_directory]filename
INPUT_ZONE_FILE	File		[project_directory]filename

INPUT_SPDCAP_FILE	File		[project_directory]filename
INPUT_UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
FACILITY_INDEX_FIELD	Text		
AREA_TYPE_INDEX_FIELD	Text		
CONVERSION_SCRIPT	File		[project_directory]filename
INTERNAL_ZONE_RANGE	List	0	0..10000
KEEP_ZONE_CONNECTORS_AS_LOCALS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
FIRST_NODE_NUMBER	Int.	1	1..1000000000
FIRST_LINK_NUMBER	Int.	1	1..1000000000
SPEED_FACTOR_BY_FACILITY	List	1.0	1.0..2.0
SPEED_ROUNDING_INCREMENT	Dec.	0.0 mps	0.0..10.0 mps
COORDINATE_RESOLUTION	Dec.	1.0 meters	0..30 meters
MAXIMUM_LENGTH_TO_XY_RATIO	Dec.	0.0	0.0, 1.0..3.0
MAXIMUM_SHAPE_ANGLE	Int.	90 degrees	10..160 degrees
MINIMUM_SHAPE_LENGTH	Int.	10 meters	0..200 meters
DROP_DEAD_END_LINKS	Int.	0 meters	0..2000 meters
DROP_SHORT_LINKS	Dec.	0 meters	0..200 meters
SPLIT_LARGE_LOOPS	Int.	0 meters	0, 100..4000 meters
COLLAPSE_SHAPE_NODES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
COLLAPSE_DIVIDED_ARTERIALS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
LOCAL_THRU_SEGMENT_LENGTHS_*	List	0 meters	0, 500..10000 meters
LOCAL_SELECTION_SPACING_*	List	0 meters	0, 50..10000 meters
KEEP_NODE_RANGE	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
KEEP_NODE_FILE	File		[project_directory]filename
KEEP_LINK_RANGE	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
KEEP_LINK_FILE	File		[project_directory]filename
DELETE_NODE_RANGE	List	NONE	e.g., 1, 2, 4..10, 100..200, 300
DELETE_NODE_FILE	File		[project_directory]filename
DELETE_LINK_RANGE	List	NONE	e.g., 1, 2, 4..10, 100..200, 300
DELETE_LINK_FILE	File		[project_directory]filename
NEW_LINK_DETAIL_FILE	File		[project_directory]filename
NEW_LINK_NODE_LIST_FILE	File		[project_directory]filename

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.13. NewFormat - Quick Reference

Version 5.0.17

Usage

NewFormat [-flag] [control_file]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Converts Version 4 transit driver plans to a Version 5 transit driver file.
2. Converts a Version 4 population file to a Version 5 household and population file
3. Converts a Version 4 activity file to a Version 5 activity file
4. Converts a Version 4 survey activity file to a Version 5 survey activity file
5. Convert the X-Y coordinates in a survey activity file to the TRANSIMS coordinate system and then match the location to the nearest activity location.
6. Estimates locations for activities without coordinates based on the prior and following activity locations and excluded households located outside the modeling region.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	MAX_PROBLEM_COUNT	Int.	0	>= 0
	NUMBER_OF_THREADS	Int.	1	1..24

System File Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	NODE_FILE	File		[project_directory]filename
	ZONE_FILE	File		[project_directory]filename
	SHAPE_FILE	File		[project_directory]filename
	LINK_FILE	File		[project_directory]filename
	POCKET_FILE	File		[project_directory]filename
	LANE_USE_FILE	File		[project_directory]filename
	CONNECTION_FILE	File		[project_directory]filename
	TURN_PENALTY_FILE	File		[project_directory]filename
	PARKING_FILE	File		[project_directory]filename
	LOCATION_FILE	File		[project_directory]filename
	ACCESS_FILE	File		[project_directory]filename
	SIGN_FILE	File		[project_directory]filename
	SIGNAL_FILE	File		[project_directory]filename
	PHASING_PLAN_FILE	File		[project_directory]filename
	TIMING_PLAN_FILE	File		[project_directory]filename

DETECTOR_FILE	File	[project_directory]filename
TRANSIT_STOP_FILE	File	[project_directory]filename
TRANSIT_FARE_FILE	File	[project_directory]filename
TRANSIT_ROUTE_FILE	File	[project_directory]filename
TRANSIT_SCHEDULE_FILE	File	[project_directory]filename
TRANSIT_DRIVER_FILE	File	[project_directory]filename
SELECTION_FILE	File	[project_directory]filename.*
HOUSEHOLD_FILE	File	[project_directory]filename.*
LINK_DELAY_FILE	File	[project_directory]filename
PERFORMANCE_FILE	File	[project_directory]filename
RIDERSHIP_FILE	File	[project_directory]filename
VEHICLE_TYPE_FILE	File	[project_directory]filename
VEHICLE_FILE	File	[project_directory]filename.*
TRIP_FILE	File	[project_directory]filename.*
PROBLEM_FILE	File	[project_directory]filename.*
PLAN_FILE	File	[project_directory]filename.*
SKIM_FILE	File	[project_directory]filename.*
NEW_NODE_FILE	File	[project_directory]filename
NEW_ZONE_FILE	File	[project_directory]filename
NEW_SHAPE_FILE	File	[project_directory]filename
NEW_LINK_FILE	File	[project_directory]filename
NEW_POCKET_FILE	File	[project_directory]filename
NEW_LANE_USE_FILE	File	[project_directory]filename
NEW_CONNECTION_FILE	File	[project_directory]filename
NEW_TURN_PENALTY_FILE	File	[project_directory]filename
NEW_PARKING_FILE	File	[project_directory]filename
NEW_LOCATION_FILE	File	[project_directory]filename
NEW_ACCESS_FILE	File	[project_directory]filename
NEW_SIGN_FILE	File	[project_directory]filename
NEW_SIGNAL_FILE	File	[project_directory]filename
NEW_PHASING_PLAN_FILE	File	[project_directory]filename
NEW_TIMING_PLAN_FILE	File	[project_directory]filename
NEW_DETECTOR_FILE	File	[project_directory]filename

NEW_TRANSIT_STOP_FILE	File		[project_directory]filename
NEW_TRANSIT_FARE_FILE	File		[project_directory]filename
NEW_TRANSIT_ROUTE_FILE	File		[project_directory]filename
NEW_TRANSIT_SCHEDULE_FILE	File		[project_directory]filename
NEW_TRANSIT_DRIVER_FILE	File		[project_directory]filename
NEW_ROUTE_NODES_FILE	File		[project_directory]filename
NEW_SELECTION_FILE	File		[project_directory]filename.*
NEW_HOUSEHOLD_FILE	File		[project_directory]filename.*
NEW_LINK_DELAY_FILE	File		[project_directory]filename
NEW_PERFORMANCE_FILE	File		[project_directory]filename
NEW_RIDERSHIP_FILE	File		[project_directory]filename
NEW_VEHICLE_TYPE_FILE	File		[project_directory]filename
NEW_VEHICLE_FILE	File		[project_directory]filename.*
NEW_TRIP_FILE	File		[project_directory]filename.*
NEW_PROBLEM_FILE	File		[project_directory]filename.*
NEW_PLAN_FILE	File		[project_directory]filename.*
NEW_SKIM_FILE	File		[project_directory]filename.*

File Service Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	NOTES_AND_NAME_FIELDS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	FLOW_UNITS	Text	VEHICLES	VEHICLES, CAR_EQUIV/PCE, PERSONS
	SKIM_TOTAL_TIME_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Data Service Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	DAILY_WRAP_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	SUMMARY_TIME_RANGES	Text	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
	SUMMARY_TIME_INCREMENT	Time	15 minutes	0, 2..240 minutes
	CONGESTED_TIME_RATIO	Dec.	3.0	1.0..5.0
	TRIP_SORT_TYPE	Text	DO_NOT_SORT	DO_NOT_SORT, TRAVELER_SORT, TIME_SORT

Control Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	FLATTEN_OUTPUT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	TOLL_FILE	File		[project_directory]Version_4_filename
	ACTIVITY_FILE	File		[project_directory]Version_4_filename
	PERSON_FILE	File		[project_directory]Version_4_filename
	SNAPSHOT_FILE	File		[project_directory]filename
	NEW_SNAPSHOT_FILE	File		[project_directory]filename
	NEW_SNAPSHOT_COMPRESSION	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	VERSION4_PLAN_FILE	File		[project_directory]Version_4_filename.*
	NODE_LIST_PATHS	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	TRAVELER_SCALING_FACTOR	Int.	100	1..100
	VERSION4_ROUTE_HEADER	File		[project_directory]Version_4_filename
	VERSION4_ROUTE_NODES	File		[project_directory]Version_4_filename

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.14. PathSkim - Quick Reference

Version 5.0.12

Usage

PathSkim [-flag] [control_file] [partition]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	MAX_PROBLEM_COUNT	Int.	0	>= 0
	NUMBER_OF_THREADS	Int.	1	1..24

	PATHSKIM_REPORT_*	Text		program report name

System File Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	NODE_FILE	File		[project_directory]filename
YES	LINK_FILE	File		[project_directory]filename
YES	CONNECTION_FILE	File		[project_directory]filename
YES	LOCATION_FILE	File		[project_directory]filename
	ZONE_FILE	File		[project_directory]filename
	POCKET_FILE	File		[project_directory]filename
	LANE_USE_FILE	File		[project_directory]filename
	TURN_PENALTY_FILE	File		[project_directory]filename
	PARKING_FILE	File		[project_directory]filename
	ACCESS_FILE	File		[project_directory]filename
	TRANSIT_STOP_FILE	File		[project_directory]filename
	TRANSIT_FARE_FILE	File		[project_directory]filename
	TRANSIT_ROUTE_FILE	File		[project_directory]filename
	TRANSIT_SCHEDULE_FILE	File		[project_directory]filename
	SELECTION_FILE	File		[project_directory]filename.*
	HOUSEHOLD_FILE	File		[project_directory]filename.*
	LINK_DELAY_FILE	File		[project_directory]filename
	VEHICLE_TYPE_FILE	File		[project_directory]filename
	VEHICLE_FILE	File		[project_directory]filename.*
	NEW_LINK_DELAY_FILE	File		[project_directory]filename
	NEW_PROBLEM_FILE	File		[project_directory]filename.*
	NEW_PLAN_FILE	File		[project_directory]filename.*
	NEW_SKIM_FILE	File		[project_directory]filename.*

File Service Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	NOTES_AND_NAME_FIELDS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	SKIM_OD_UNITS	Text	ZONES	DISTRICTS, ZONES, LOCATIONS

SKIM_TIME_PERIODS	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SKIM_TIME_INCREMENT	Time	0 minutes	0, 2..240 minutes
SKIM_TOTAL_TIME_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
NEAREST_NEIGHBOR_FACTOR	Dec.	0.0	0.0..1.0
MERGE_TIME_PERIODS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
ZONE_EQUIVALENCE_FILE	File		[project_directory]filename
ZONE_LOCATION_MAP_FILE	File		[project_directory]filename

Data Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
DAILY_WRAP_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
SUMMARY_TIME_RANGES	Text	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SUMMARY_TIME_INCREMENT	Time	15 minutes	0, 2..240 minutes

Flow, Time Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
UPDATE_FLOW_RATES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
UPDATE_TURNING_MOVEMENTS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
CLEAR_INPUT_FLOW_RATES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
UPDATE_TRAVEL_TIMES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
LINK_DELAY_UPDATE_RATE	Int.	0	-1..5000
LINK_DELAY_FLOW_FACTOR	Dec.	1.0	1..100000
EQUATION_PARAMETERS_*	List	BPR, 0.15, 4.0, 0.75	BPR, 0.15, 4.0, 0.75

Router Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
IMPEDANCE_SORT_METHOD	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
SAVE_ONLY_SKIMS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
WALK_PATH_DETAILS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
IGNORE_VEHICLE_ID	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
LIMIT_PARKING_ACCESS	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
IGNORE_TIME_CONSTRAINTS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

END_TIME_CONSTRAINT	Time	0 minutes	0..360 minutes
IGNORE_ROUTING_PROBLEMS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
PERCENT_RANDOM_IMPEDANCE	Dec.	0.0 percent	0.0..100.0 percent
HOUSEHOLD_TYPE_SCRIPT	File		[project_directory]filename
WALK_SPEED	Dec.	1.0 mps	0.5..4.0 mps
BICYCLE_SPEED	Dec.	4.0 mps	1.0..10.0 mps
WALK_TIME_VALUES_*	List	20.0 impedance/second	0..1000.0
BICYCLE_TIME_VALUES_*	List	15.0 impedance/second	0..1000.0
FIRST_WAIT_VALUES_*	List	20.0 impedance/second	0..1000.0
TRANSFER_WAIT_VALUES_*	List	20.0 impedance/second	0..1000.0
PARKING_TIME_VALUES_*	List	0.0 impedance/second	0.0..1000.0
VEHICLE_TIME_VALUES_*	List	10.0 impedance/second	0..1000.0
DISTANCE_VALUES_*	List	0.0 impedance/meter	0.0..1000.0
COST_VALUES_*	List	0.0 impedance/cent	0.0..1000.0
FACILITY_BIAS_FACTORS_*	List	1.0	0.5..2.0
LEFT_TURN_PENALTIES_*	List	0 impedance	0..10000
RIGHT_TURN_PENALTIES_*	List	0 impedance	0..10000
U_TURN_PENALTIES_*	List	0 impedance	0..10000
PARKING_PENALTY_FILE	File		[project_directory]filename
TRANSIT_PENALTY_FILE	File		[project_directory]filename
TRANSFER_PENALTIES_*	List	0 impedance	0..100000
STOP_WAITING_PENALTIES_*	List	0 impedance	0..100000
STATION_WAITING_PENALTIES_*	List	0 impedance	0..100000
BUS_BIAS_FACTORS_*	List	1.0	1.0..3.0
BUS_BIAS_CONSTANTS_*	List	0 impedance	0..10000
RAIL_BIAS_FACTORS_*	List	1.0	0.1..1.0
RAIL_BIAS_CONSTANTS_*	List	0 impedance	-1000..0
MAX_WALK_DISTANCES_*	List	2000 meters	100..20000 meters
WALK_PENALTY_DISTANCES_*	List	2000 meters	100..10000 meters
WALK_PENALTY_FACTOR	Dec.	0.0	0.0..25.0
MAX_BICYCLE_DISTANCES_*	List	10000 meters	1000..40000 meters
BIKE_PENALTY_DISTANCES_*	List	10000 meters	1000..20000 meters
BIKE_PENALTY_FACTOR	Dec.	0.0	0.0..25.0

MAX_WAIT_TIMES_*	List	60 minutes	5..400 minutes
WAIT_PENALTY_TIMES_*	List	60 minutes	5..200 minutes
WAIT_PENALTY_FACTOR	Dec.	0.0	0.0..25.0
MIN_WAIT_TIMES_*	List	0 seconds	0..3600 seconds
MAX_NUMBER_OF_TRANSFERS_*	Int.	3	0..10
MAX_NUMBER_OF_PATHS_*	Int.	4	1..10
MAX_PARK_RIDE_PERCENTAGE_*	Int.	50 percent	1..100 percent
MAX_KISS_RIDE_PERCENTAGE_*	Int.	35 percent	1..100 percent
KISS_RIDE_TIME_FACTOR_*	Dec.	2.5	1.0..4.4
KISS_RIDE_STOP_TYPES	Text	EXTERNAL	
MAX_KISS_RIDE_DROPOFF_WALK	Dec.	100 meters	10..500 meters
MAX_LEGS_PER_PATH	Int.	1000	10..10000
FARE_CLASS_DISTRIBUTION	List	0	
DEFAULT_PARKING_DURATION	List	0.0 hours	0.0..24.0 hours
LOCAL_ACCESS_DISTANCE	Dec.	2000 meters	100..7500 meters
LOCAL_FACILITY_TYPE	Text	EXTERNAL	MAJOR..LOCAL, EXTERNAL
LOCAL_IMPEDANCE_FACTOR	Dec.	0.0	0.0..25.0
MAX_CIRCUITY_RATIO	Dec.	0.0	0.0..10.0
MIN_CIRCUITY_DISTANCE	Dec.	2000 meters	0..10000 meters
MAX_CIRCUITY_DISTANCE	Dec.	20000 meters	0..100000 meters
MIN_DURATION_FACTORS	List	0.1, 0.5, 0.8, 1.0	0.0..1.0

Control Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
ROUTE_FROM_SPECIFIED_LOCATIONS	List	ALL	
ROUTE_TO_SPECIFIED_LOCATIONS	List	ALL	
ROUTE_AT_SPECIFIED_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
ROUTE_BY_TIME_INCREMENT	Time	0 minutes	0, 2..240 minutes
ROUTE_WITH_TIME_CONSTRAINT	Text	START_TIME	NONE, START, ARRIVE, FIXED, DURATION, PASSENGER
ROUTE_WITH_SPECIFIED_MODE	Text	DRIVE	WALK, BIKE, DRIVE, RIDE, TRANSIT, PNR_OUT, PNR_IN, KNR_OUT, KNR_IN, TAXI, OTHER, HOV2, HOV3, HOV4
ROUTE_WITH_SPECIFIED_USE_TYPE	Text	CAR	ANY, WALK, BIKE, CAR, TRUCK, BUS, RAIL, SOV, HOV2, HOV3, HOV4, LIGHTTRUCK, HEAVYTRUCK, TAXI, RESTRICTED, NONE

ROUTE_FROM_SPECIFIED_ZONES	List	ALL	
ROUTE_TO_SPECIFIED_ZONES	List	ALL	
ORIGIN_LOCATIONS_PER_ZONE	Int.	0	0..100
DESTINATION_LOCATIONS_PER_ZONE	Int.	0	0..100
LOCATION_SELECTION_METHOD	Text	RANDOM	USER, RANDOM, CENTROID, DISTRIBUTED
ORIGIN_ZONE_FILE	File		[project_directory]filename
DESTINATION_ZONE_FILE	File		[project_directory]filename
ORIGIN_LOCATION_FILE	File		[project_directory]filename
DESTINATION_LOCATION_FILE	File		[project_directory]filename
NEW_ORIGIN_LOCATION_FILE	File		[project_directory]filename
NEW_DESTINATION_LOCATION_FILE	File		[project_directory]filename

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.15. PlanCompare - Quick Reference

Version 5.0.12

Usage

PlanCompare [-flag] [control_file] [partition]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Compares two plan files and selects plans that have significantly different travel times.
2. Generate convergence statistics and distribution charts by time of day.
3. Includes walk and wait time in the transit travel time comparisons.
4. Includes options to only compare drive legs.
5. Compares plan files generated on different networks.
6. Compares plan files for specified time periods.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed

MAX_WARNING_MESSAGES	Int.	100000	>= 0
MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
MAX_PROBLEM_COUNT	Int.	0	>= 0
NUMBER_OF_THREADS	Int.	1	1..24
PLANCOMPARE_REPORT_*	Text		program report name

System File Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	PLAN_FILE	File		[project_directory]filename.*
	SELECTION_FILE	File		[project_directory]filename.*
	NEW_SELECTION_FILE	File		[project_directory]filename.*
	NEW_PLAN_FILE	File		[project_directory]filename.*

Data Service Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	DAILY_WRAP_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	SUMMARY_TIME_RANGES	Text	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
	SUMMARY_TIME_INCREMENT	Time	15 minutes	0, 2..240 minutes
	PERIOD_CONTROL_POINT	Text	MID-TRIP	START, END, MID-TRIP

Select Service Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	SELECT_HOUSEHOLDS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
	SELECT_MODES	List	ALL	e.g., ALL or 1, 12..14 or WALK, HOV2..HOV4
	SELECT_PURPOSES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
	SELECT_START_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
	SELECT_END_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
	SELECT_ORIGINS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
	SELECT_DESTINATIONS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
	SELECT_TRAVELER_TYPES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
	SELECT_LINKS_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
	SELECT_NODES_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300

SELECT_SUBAREA_POLYGON	File		[project_directory]filename
PERCENT_TIME_DIFFERENCE	Dec.	0.0 percent	0.0..100.0 percent
MINIMUM_TIME_DIFFERENCE	Time	1 minutes	0..120 minutes
MAXIMUM_TIME_DIFFERENCE	Time	60 minutes	0..1440 minutes
PERCENT_COST_DIFFERENCE	Dec.	0.0 percent	0.0..100.0 percent
MINIMUM_COST_DIFFERENCE	Dec.	10 impedance	0..500 impedance
MAXIMUM_COST_DIFFERENCE	Dec.	1000 impedance	0..10000 impedance
SELECTION_PERCENTAGE	Dec.	100.0 percent	0.01..100.0 percent
MAXIMUM_PERCENT_SELECTED	Dec.	100.0 percent	0.1..100.0 percent
DELETION_FILE	File		[project_directory]filename
DELETE_HOUSEHOLDS	List	NONE	e.g., 1, 2, 4..10, 100..200, 300
DELETE_MODES	List	NONE	e.g., ALL or 1, 12..14 or WALK, HOV2..HOV4
DELETE_TRAVELER_TYPES	List	NONE	e.g., 1, 2, 4..10, 100..200, 300

Control Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	COMPARE_PLAN_FILE	File		[project_directory]filename.*
	COMPARE_GENERALIZED_COSTS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	SELECTION_METHOD	Text	RANDOM	RANDOM, PERCENT_DIFFERENCE, RELATIVE_GAP
	MERGE_PLAN_FILES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	NEW_TIME_DISTRIBUTION_FILE	File		[project_directory]filename
	NEW_COST_DISTRIBUTION_FILE	File		[project_directory]filename
	NEW_TRIP_TIME_GAP_FILE	File		[project_directory]filename
	NEW_TRIP_COST_GAP_FILE	File		[project_directory]filename

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.16. PlanPrep - Quick Reference

Version 5.0.9

Usage

PlanPrep [-flag] [control_file] [partition]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Merge, sort, select, and combine plan files.
2. Reintegrate subarea plans with regional plan files.
3. Create and check plan partitions.
4. Generate distribution reports of path and travel time changes.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

MAX_PROBLEM_COUNT	Int.	0	>= 0
NUMBER_OF_THREADS	Int.	1	1..24

System File Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
YES PLAN_FILE	File		[project_directory]filename.*
SELECTION_FILE	File		[project_directory]filename.*
NEW_PLAN_FILE	File		[project_directory]filename.*

Data Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
TRIP_SORT_TYPE	Text	DO_NOT_SORT	DO_NOT_SORT, TRAVELER_SORT, TIME_SORT
PLAN_SORT_TYPE	Text	DO_NOT_SORT	DO_NOT_SORT, TRAVELER_SORT, TIME_SORT

Select Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
SELECT_HOUSEHOLDS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_MODES	List	ALL	e.g., ALL or 1, 12..14 or WALK, HOV2..HOV4
SELECT_PURPOSES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_START_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SELECT_END_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SELECT_ORIGINS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_DESTINATIONS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_TRAVELER_TYPES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_LINKS_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_NODES_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_SUBAREA_POLYGON	File		[project_directory]filename
SELECTION_PERCENTAGE	Dec.	100.0 percent	0.01..100.0 percent
DELETION_FILE	File		[project_directory]filename
DELETE_HOUSEHOLDS	List	NONE	e.g., 1, 2, 4..10, 100..200, 300
DELETE_MODES	List	NONE	e.g., ALL or 1, 12..14 or WALK, HOV2..HOV4
DELETE_TRAVELER_TYPES	List	NONE	e.g., 1, 2, 4..10, 100..200, 300

Control Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
MERGE_PLAN_FILE	File		[project_directory]filename.*
MAXIMUM_SORT_SIZE	Int.	0	0, >=100000 trips

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.17. PlanSelect - Quick Reference

Version 5.0.10

Usage

PlanSelect [-flag] [control_file] [partition]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Create a set of household ID files that can be used as input to the Router;
2. Select plans based on traveler ID, time of day, activity location, parking lot, transit stop, transit route, V/C ratio, travel time ratio, coordinates, vehicle types, subarea polygon, and path node sequence; and
3. Use link delay information to select plans where the plan duration and the current travel time for the plan path are significantly different.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

MAX_PROBLEM_COUNT	Int.	0	>= 0
NUMBER_OF_THREADS	Int.	1	1..24

System File Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
YES PLAN_FILE	File		[project_directory]filename.*
YES NEW_SELECTION_FILE	File		[project_directory]filename.*
NODE_FILE	File		[project_directory]filename
LINK_FILE	File		[project_directory]filename
LANE_USE_FILE	File		[project_directory]filename
CONNECTION_FILE	File		[project_directory]filename
LOCATION_FILE	File		[project_directory]filename
LINK_DELAY_FILE	File		[project_directory]filename
VEHICLE_TYPE_FILE	File		[project_directory]filename
NEW_PLAN_FILE	File		[project_directory]filename.*

Data Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
DAILY_WRAP_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
SUMMARY_TIME_RANGES	Text	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SUMMARY_TIME_INCREMENT	Time	15 minutes	0, 2..240 minutes

Select Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
SELECT_HOUSEHOLDS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_MODES	List	ALL	e.g., ALL or 1, 12..14 or WALK, HOV2..HOV4
SELECT_PURPOSES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_START_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SELECT_END_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SELECT_ORIGINS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_DESTINATIONS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_TRAVELER_TYPES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300

SELECT_FACILITY_TYPES	List	ALL	FREEWAY..EXTERNAL
SELECT_LINKS_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_NODES_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_SUBAREA_POLYGON	File		[project_directory]filename
SELECT_ORIGIN_ZONES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_DESTINATION_ZONES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
PERCENT_TIME_DIFFERENCE	Dec.	0.0 percent	0.0..100.0 percent
MINIMUM_TIME_DIFFERENCE	Time	1 minutes	0..120 minutes
MAXIMUM_TIME_DIFFERENCE	Time	60 minutes	0..1440 minutes
SELECTION_PERCENTAGE	Dec.	100.0 percent	0.01..100.0 percent
MAXIMUM_PERCENT_SELECTED	Dec.	100.0 percent	0.1..100.0 percent
DELETION_FILE	File		[project_directory]filename
DELETE_HOUSEHOLDS	List	NONE	e.g., 1, 2, 4..10, 100..200, 300
DELETE_MODES	List	NONE	e.g., ALL or 1, 12..14 or WALK, HOV2..HOV4
DELETE_TRAVELER_TYPES	List	NONE	e.g., 1, 2, 4..10, 100..200, 300

Control Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
SELECT_PARKING_LOTS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_VC_RATIOS	Dec.	0.0	0.0, >1.0
SELECT_TIME_RATIOS	Dec.	0.0	0.0, >1.0

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.18. PlanSum - Quick Reference

Version 5.0.16

Usage

PlanSum [-flag] [control_file] [partition]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Summarize the link demands generated by the Router.
2. Apply volume-delay equations to estimate link travel times.
3. Produce link volume, link delay, and turning movement files by time of day.
4. Produce zone or district trip tables and skim files by mode and time of day.
5. Summarize transit ridership demand by transit route, run, and stop.
6. Generate V/C ratio reports by link and link groups by time of day.
7. Create diurnal distributions of the start, end, and mid-trip times of each plan.
8. Expand travel statistics from survey plans to the total population.
9. Summarize transit transfer details.
10. Calculate intrazonal skim values based on a nearest neighbor factor.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		

MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
MODEL_END_TIME	Time	24:00	> [model_start_time]
UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
MAX_WARNING_MESSAGES	Int.	100000	>= 0
MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
MAX_PROBLEM_COUNT	Int.	0	>= 0
NUMBER_OF_THREADS	Int.	1	1..24
PLANSUM_REPORT_*	Text		program report name

System File Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	PLAN_FILE	File		[project_directory]filename.*
	NODE_FILE	File		[project_directory]filename
	LINK_FILE	File		[project_directory]filename
	LANE_USE_FILE	File		[project_directory]filename
	CONNECTION_FILE	File		[project_directory]filename
	SELECTION_FILE	File		[project_directory]filename.*
	LINK_DELAY_FILE	File		[project_directory]filename
	VEHICLE_TYPE_FILE	File		[project_directory]filename
	NEW_LINK_DELAY_FILE	File		[project_directory]filename

File Service Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	ZONE_EQUIVALENCE_FILE	File		[project_directory]filename
	LINK_EQUIVALENCE_FILE	File		[project_directory]filename
	STOP_EQUIVALENCE_FILE	File		[project_directory]filename

Data Service Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	DAILY_WRAP_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	SUMMARY_TIME_RANGES	Text	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00

SUMMARY_TIME_INCREMENT	Time	15 minutes	0, 2..240 minutes
PERIOD_CONTROL_POINT	Text	MID-TRIP	START, END, MID-TRIP

Select Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
SELECT_HOUSEHOLDS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_MODES	List	ALL	e.g., ALL or 1, 12..14 or WALK, HOV2..HOV4
SELECT_PURPOSES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_START_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SELECT_END_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SELECT_ORIGINS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_DESTINATIONS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_TRAVELER_TYPES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_LINKS_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_NODES_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_SUBAREA_POLYGON	File		[project_directory]filename
SELECTION_PERCENTAGE	Dec.	100.0 percent	0.01..100.0 percent

Flow, Time Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
UPDATE_FLOW_RATES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
UPDATE_TURNING_MOVEMENTS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
CLEAR_INPUT_FLOW_RATES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
UPDATE_TRAVEL_TIMES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
LINK_DELAY_FLOW_FACTOR	Dec.	1.0	1..100000
EQUATION_PARAMETERS_*	List	BPR, 0.15, 4.0, 0.75	BPR, 0.15, 4.0, 0.75

Control Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
NEW_TRIP_TIME_FILE	File		[project_directory]filename
NEW_LINK_VOLUME_FILE	File		[project_directory]filename

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.19. ProblemSelect - Quick Reference

Version 5.0.0

Usage

ProblemSelect [-flag] [control_file] [partition]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Create a set of household ID files that can be used as input to the Router.
2. Select problems based on time of day, problem link, and/or problem type.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	MAX_PROBLEM_COUNT	Int.	0	>= 0
	NUMBER_OF_THREADS	Int.	1	1..24

System File Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	NODE_FILE	File		[project_directory]filename
YES	LINK_FILE	File		[project_directory]filename
YES	LOCATION_FILE	File		[project_directory]filename
YES	PROBLEM_FILE	File		[project_directory]filename.*
YES	NEW_SELECTION_FILE	File		[project_directory]filename.*
	SELECTION_FILE	File		[project_directory]filename.*

Select Service Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	SELECT_HOUSEHOLDS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
	SELECT_MODES	List	ALL	e.g., ALL or 1, 12..14 or WALK, HOV2..HOV4
	SELECT_PURPOSES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
	SELECT_START_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
	SELECT_END_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
	SELECT_ORIGINS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
	SELECT_DESTINATIONS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300

SELECT_TRAVELER_TYPES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_FACILITY_TYPES	List	ALL	FREEWAY..EXTERNAL
SELECT_PROBLEM_TYPES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_ORIGIN_ZONES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_DESTINATION_ZONES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECTION_PERCENTAGE	Dec.	100.0 percent	0.01..100.0 percent
MAXIMUM_PERCENT_SELECTED	Dec.	100.0 percent	0.1..100.0 percent

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.20. RandomSelect - Quick Reference

Version 5.0.1

Usage

RandomSelect [-flag] [control_file]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	MAX_PROBLEM_COUNT	Int.	0	>= 0
	NUMBER_OF_THREADS	Int.	1	1..24

System File Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	NEW_SELECTION_FILE	File		[project_directory]filename.*
	HOUSEHOLD_FILE	File		[project_directory]filename.*
	TRIP_FILE	File		[project_directory]filename.*

Select Service Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	SELECT_HOUSEHOLDS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
	SELECTION_PERCENTAGE	Dec.	100.0 percent	0.01..100.0 percent

Control Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	NUMBER_OF_PARTITIONS	Int.	8	1..999

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION33

17.21. Relocate - Quick Reference

Version 5.0.0

Usage

Relocate [-flag] [control_file] [partition]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Convert trip, activity, plan, and/or vehicle files from an "old" network to the current network.
2. Map "old" activity locations to current activity locations based on the closest coordinate distance. This can be used to move or consolidate trip ends.
3. In converting plan files, the "old" node, link, parking, and processing link values are converted to the current network. This includes an expansion or deletion of links and nodes based on minimum distance paths between the common points in the two networks. This can be used to update or repair plan files after network edits add or remove nodes.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0

MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
MAX_PROBLEM_COUNT	Int.	0	>= 0
NUMBER_OF_THREADS	Int.	1	1..24

System File Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
YES NODE_FILE	File		[project_directory]filename
YES LINK_FILE	File		[project_directory]filename
YES PARKING_FILE	File		[project_directory]filename
YES LOCATION_FILE	File		[project_directory]filename
SHAPE_FILE	File		[project_directory]filename
ACCESS_FILE	File		[project_directory]filename
VEHICLE_FILE	File		[project_directory]filename.*
TRIP_FILE	File		[project_directory]filename.*
PLAN_FILE	File		[project_directory]filename.*
NEW_SELECTION_FILE	File		[project_directory]filename.*
NEW_VEHICLE_FILE	File		[project_directory]filename.*
NEW_TRIP_FILE	File		[project_directory]filename.*
NEW_PLAN_FILE	File		[project_directory]filename.*

Control Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
YES OLD_NODE_FILE	File		[project_directory]filename
YES OLD_LINK_FILE	File		[project_directory]filename
YES OLD_LOCATION_FILE	File		[project_directory]filename
YES OLD_PARKING_FILE	File		[project_directory]filename
OLD_SHAPE_FILE	File		[project_directory]filename
OLD_ACCESS_FILE	File		[project_directory]filename
NEW_LOCATION_MAP_FILE	File		[project_directory]filename
NEW_PARKING_MAP_FILE	File		[project_directory]filename

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.22. Router - Quick Reference

Version 5.0.30

Usage

Router [-flag] [control_file] [partition]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Generate travel plans for household activities that are connected by walk, drive, transit, park-&-ride, kiss-&-ride, bicycle, and magic move modes.
2. Generate travel plans for household and itinerant trips by walk, drive, transit, park-&-ride, kiss-&-ride, bicycle, and magic move modes.
3. Build travel plans from specified origins to specified destinations at specified times of day using a specified travel mode.
4. Selectively route activities or trips from specified origins, to specified destinations, at specified times of day, and/or by specified modes.
5. Generate problem files for those activities or trips that could not be routed for specific reasons.
6. Implement an incremental capacity restrained assignment algorithm.
7. Build travel plans for select household, person, and trip records.
8. Update an existing plan file.
9. Dump out an ArcView shapefile showing the links reached by a path building task that experienced problems of a selected type.

10. Routing by selected trip purposes.
11. A vehicle file is optional for plans that are not simulated.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	MODEL_TIME_INCREMENT	Time	15 minutes	0, 2..240 minutes
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	MAX_PROBLEM_COUNT	Int.	0	>= 0
	NUMBER_OF_THREADS	Int.	1	1..24
	ROUTER_REPORT_*	Text		program report name

System File Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	NODE_FILE	File		[project_directory]filename
YES	LINK_FILE	File		[project_directory]filename
YES	CONNECTION_FILE	File		[project_directory]filename
YES	LOCATION_FILE	File		[project_directory]filename
	POCKET_FILE	File		[project_directory]filename
	LANE_USE_FILE	File		[project_directory]filename
	TURN_PENALTY_FILE	File		[project_directory]filename
	PARKING_FILE	File		[project_directory]filename
	ACCESS_FILE	File		[project_directory]filename

TRANSIT_STOP_FILE	File		[project_directory]filename
TRANSIT_FARE_FILE	File		[project_directory]filename
TRANSIT_ROUTE_FILE	File		[project_directory]filename
TRANSIT_SCHEDULE_FILE	File		[project_directory]filename
TRANSIT_DRIVER_FILE	File		[project_directory]filename
SELECTION_FILE	File		[project_directory]filename.*
HOUSEHOLD_FILE	File		[project_directory]filename.*
LINK_DELAY_FILE	File		[project_directory]filename
VEHICLE_TYPE_FILE	File		[project_directory]filename
VEHICLE_FILE	File		[project_directory]filename.*
TRIP_FILE	File		[project_directory]filename.*
PLAN_FILE	File		[project_directory]filename.*
NEW_LINK_DELAY_FILE	File		[project_directory]filename
NEW_PROBLEM_FILE	File		[project_directory]filename.*
NEW_PLAN_FILE	File		[project_directory]filename.*

File Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
NOTES_AND_NAME_FIELDS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Data Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
DAILY_WRAP_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
SUMMARY_TIME_RANGES	Text	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SUMMARY_TIME_INCREMENT	Time	15 minutes	0, 2..240 minutes

Select Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
SELECT_HOUSEHOLDS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_MODES	List	ALL	e.g., ALL or 1, 12..14 or WALK, HOV2..HOV4
SELECT_PURPOSES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_START_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00

SELECT_END_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SELECT_ORIGINS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_DESTINATIONS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_TRAVELER_TYPES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_ORIGIN_ZONES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_DESTINATION_ZONES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECTION_PERCENTAGE	Dec.	100.0 percent	0.01..100.0 percent
DELETION_FILE	File		[project_directory]filename
DELETE_HOUSEHOLDS	List	NONE	e.g., 1, 2, 4..10, 100..200, 300
DELETE_MODES	List	NONE	e.g., ALL or 1, 12..14 or WALK, HOV2..HOV4
DELETE_TRAVELER_TYPES	List	NONE	e.g., 1, 2, 4..10, 100..200, 300

Flow, Time Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
UPDATE_FLOW_RATES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
UPDATE_TURNING_MOVEMENTS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
CLEAR_INPUT_FLOW_RATES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
UPDATE_TRAVEL_TIMES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
LINK_DELAY_UPDATE_RATE	Int.	0	-1..5000
LINK_DELAY_FLOW_FACTOR	Dec.	1.0	1..100000
EQUATION_PARAMETERS_*	List	BPR, 0.15, 4.0, 0.75	BPR, 0.15, 4.0, 0.75

Router Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
IMPEDANCE_SORT_METHOD	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
SAVE_ONLY_SKIMS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
WALK_PATH_DETAILS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
IGNORE_VEHICLE_ID	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
LIMIT_PARKING_ACCESS	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
IGNORE_TIME_CONSTRAINTS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
END_TIME_CONSTRAINT	Time	0 minutes	0..360 minutes
IGNORE_ROUTING_PROBLEMS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

PERCENT_RANDOM_IMPEDANCE	Dec.	0.0 percent	0.0..100.0 percent
HOUSEHOLD_TYPE_SCRIPT	File		[project_directory]filename
WALK_SPEED	Dec.	1.0 mps	0.5..4.0 mps
BICYCLE_SPEED	Dec.	4.0 mps	1.0..10.0 mps
WALK_TIME_VALUES_*	List	20.0 impedance/second	0..1000.0
BICYCLE_TIME_VALUES_*	List	15.0 impedance/second	0..1000.0
FIRST_WAIT_VALUES_*	List	20.0 impedance/second	0..1000.0
TRANSFER_WAIT_VALUES_*	List	20.0 impedance/second	0..1000.0
PARKING_TIME_VALUES_*	List	0.0 impedance/second	0.0..1000.0
VEHICLE_TIME_VALUES_*	List	10.0 impedance/second	0..1000.0
DISTANCE_VALUES_*	List	0.0 impedance/meter	0.0..1000.0
COST_VALUES_*	List	0.0 impedance/cent	0.0..1000.0
FACILITY_BIAS_FACTORS_*	List	1.0	0.5..2.0
LEFT_TURN_PENALTIES_*	List	0 impedance	0..10000
RIGHT_TURN_PENALTIES_*	List	0 impedance	0..10000
U_TURN_PENALTIES_*	List	0 impedance	0..10000
PARKING_PENALTY_FILE	File		[project_directory]filename
TRANSIT_PENALTY_FILE	File		[project_directory]filename
TRANSFER_PENALTIES_*	List	0 impedance	0..100000
STOP_WAITING_PENALTIES_*	List	0 impedance	0..100000
STATION_WAITING_PENALTIES_*	List	0 impedance	0..100000
BUS_BIAS_FACTORS_*	List	1.0	1.0..3.0
BUS_BIAS_CONSTANTS_*	List	0 impedance	0..10000
RAIL_BIAS_FACTORS_*	List	1.0	0.1..1.0
RAIL_BIAS_CONSTANTS_*	List	0 impedance	-1000..0
MAX_WALK_DISTANCES_*	List	2000 meters	100..20000 meters
WALK_PENALTY_DISTANCES_*	List	2000 meters	100..10000 meters
WALK_PENALTY_FACTOR	Dec.	0.0	0.0..25.0
MAX_BICYCLE_DISTANCES_*	List	10000 meters	1000..40000 meters
BIKE_PENALTY_DISTANCES_*	List	10000 meters	1000..20000 meters
BIKE_PENALTY_FACTOR	Dec.	0.0	0.0..25.0
MAX_WAIT_TIMES_*	List	60 minutes	5..400 minutes
WAIT_PENALTY_TIMES_*	List	60 minutes	5..200 minutes

WAIT_PENALTY_FACTOR	Dec.	0.0	0.0..25.0
MIN_WAIT_TIMES_*	List	0 seconds	0..3600 seconds
MAX_NUMBER_OF_TRANSFERS_*	Int.	3	0..10
MAX_NUMBER_OF_PATHS_*	Int.	4	1..10
MAX_PARK_RIDE_PERCENTAGE_*	Int.	50 percent	1..100 percent
MAX_KISS_RIDE_PERCENTAGE_*	Int.	35 percent	1..100 percent
KISS_RIDE_TIME_FACTOR_*	Dec.	2.5	1.0..4.4
KISS_RIDE_STOP_TYPES	Text	EXTERNAL	
MAX_KISS_RIDE_DROPOFF_WALK	Dec.	100 meters	10..500 meters
MAX_LEGS_PER_PATH	Int.	1000	10..10000
FARE_CLASS_DISTRIBUTION	List	0	
DEFAULT_PARKING_DURATION	List	0.0 hours	0.0..24.0 hours
LOCAL_ACCESS_DISTANCE	Dec.	2000 meters	100..7500 meters
LOCAL_FACILITY_TYPE	Text	EXTERNAL	MAJOR..LOCAL, EXTERNAL
LOCAL_IMPEDANCE_FACTOR	Dec.	0.0	0.0..25.0
MAX_CIRCUITY_RATIO	Dec.	0.0	0.0..10.0
MIN_CIRCUITY_DISTANCE	Dec.	2000 meters	0..10000 meters
MAX_CIRCUITY_DISTANCE	Dec.	20000 meters	0..100000 meters
MIN_DURATION_FACTORS	List	0.1, 0.5, 0.8, 1.0	0.0..1.0

Control Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
UPDATE_PLAN_RECORDS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
REROUTE_FROM_TIME_POINT	Time	0:00	
PRINT_UPDATE_WARNINGS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
MAXIMUM_NUMBER_OF_ITERATIONS	Int.	0	0..100
LINK_CONVERGENCE_CRITERIA	Dec.	0.0	0..10.0
TRIP_CONVERGENCE_CRITERIA	Dec.	0.0	0..10.0
INITIAL_WEIGHTING_FACTOR	Dec.	1.0	0.0, >= 0.5
ITERATION_WEIGHTING_INCREMENT	Dec.	1.0	0.0..5.0
MAXIMUM_WEIGHTING_FACTOR	Dec.	20.0	0.0, >= 2.0
NEW_LINK_CONVERGENCE_FILE	File		[project_directory]filename
NEW_TRIP_CONVERGENCE_FILE	File		[project_directory]filename

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.23. SimSubareas - Quick Reference

Version 5.0.2

Usage

SimSubareas [-flag] [control_file]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	MAX_PROBLEM_COUNT	Int.	0	>= 0
	NUMBER_OF_THREADS	Int.	1	1..24

System File Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	NODE_FILE	File		[project_directory]filename
YES	NEW_NODE_FILE	File		[project_directory]filename

File Service Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	NOTES_AND_NAME_FIELDS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Control Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	NUMBER_OF_SUBAREAS	Int.	8	1..1000
	PARTITIONS_PER_SUBAREA	Int.	1	1..1000
	CENTER_NODE_NUMBER	Int.	0	>=0
	SUBAREA_BOUNDARY_FILE	File		[project_directory]filename

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.24. Simulator - Quick Reference

Version 5.0.41

Usage

Simulator [-flag] [control_file]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Simulate the second-by-second movements of vehicles and persons through the network.
2. Generate performance statistics, track individual travelers, and summarize events.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	MAX_PROBLEM_COUNT	Int.	0	>= 0
	NUMBER_OF_THREADS	Int.	1	1..24

SIMULATOR_REPORT_*	Text		program report name

System File Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
YES NODE_FILE	File		[project_directory]filename
YES LINK_FILE	File		[project_directory]filename
YES POCKET_FILE	File		[project_directory]filename
YES CONNECTION_FILE	File		[project_directory]filename
YES PARKING_FILE	File		[project_directory]filename
YES LOCATION_FILE	File		[project_directory]filename
YES VEHICLE_TYPE_FILE	File		[project_directory]filename
YES VEHICLE_FILE	File		[project_directory]filename.*
YES PLAN_FILE	File		[project_directory]filename.*
LANE_USE_FILE	File		[project_directory]filename
TURN_PENALTY_FILE	File		[project_directory]filename
ACCESS_FILE	File		[project_directory]filename
SIGN_FILE	File		[project_directory]filename
SIGNAL_FILE	File		[project_directory]filename
PHASING_PLAN_FILE	File		[project_directory]filename
TIMING_PLAN_FILE	File		[project_directory]filename
DETECTOR_FILE	File		[project_directory]filename
TRANSIT_STOP_FILE	File		[project_directory]filename
TRANSIT_FARE_FILE	File		[project_directory]filename
TRANSIT_ROUTE_FILE	File		[project_directory]filename
TRANSIT_SCHEDULE_FILE	File		[project_directory]filename
TRANSIT_DRIVER_FILE	File		[project_directory]filename
HOUSEHOLD_FILE	File		[project_directory]filename.*
NEW_PROBLEM_FILE	File		[project_directory]filename.*

Data Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
DAILY_WRAP_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

SUMMARY_TIME_RANGES	Text	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SUMMARY_TIME_INCREMENT	Time	15 minutes	0, 2..240 minutes

Select Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
SELECT_HOUSEHOLDS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_MODES	List	ALL	e.g., ALL or 1, 12..14 or WALK, HOV2..HOV4
SELECT_PURPOSES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_START_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SELECT_END_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SELECT_TRAVELER_TYPES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_VEHICLE_TYPES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_PROBLEM_TYPES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300

Flow, Time Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
UPDATE_FLOW_RATES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
UPDATE_TURNING_MOVEMENTS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
CLEAR_INPUT_FLOW_RATES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
UPDATE_TRAVEL_TIMES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
LINK_DELAY_UPDATE_RATE	Int.	0	-1..5000
LINK_DELAY_FLOW_FACTOR	Dec.	1.0	1..100000
EQUATION_PARAMETERS_*	List	BPR, 0.15, 4.0, 0.75	BPR, 0.15, 4.0, 0.75

Router Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
IMPEDANCE_SORT_METHOD	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
SAVE_ONLY_SKIMS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
WALK_PATH_DETAILS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
IGNORE_VEHICLE_ID	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
LIMIT_PARKING_ACCESS	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
IGNORE_TIME_CONSTRAINTS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

END_TIME_CONSTRAINT	Time	0 minutes	0..360 minutes
IGNORE_ROUTING_PROBLEMS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
PERCENT_RANDOM_IMPEDANCE	Dec.	0.0 percent	0.0..100.0 percent
HOUSEHOLD_TYPE_SCRIPT	File		[project_directory]filename
WALK_SPEED	Dec.	1.0 mps	0.5..4.0 mps
BICYCLE_SPEED	Dec.	4.0 mps	1.0..10.0 mps
WALK_TIME_VALUES_*	List	20.0 impedance/second	0..1000.0
BICYCLE_TIME_VALUES_*	List	15.0 impedance/second	0..1000.0
FIRST_WAIT_VALUES_*	List	20.0 impedance/second	0..1000.0
TRANSFER_WAIT_VALUES_*	List	20.0 impedance/second	0..1000.0
PARKING_TIME_VALUES_*	List	0.0 impedance/second	0.0..1000.0
VEHICLE_TIME_VALUES_*	List	10.0 impedance/second	0..1000.0
DISTANCE_VALUES_*	List	0.0 impedance/meter	0.0..1000.0
COST_VALUES_*	List	0.0 impedance/cent	0.0..1000.0
FACILITY_BIAS_FACTORS_*	List	1.0	0.5..2.0
LEFT_TURN_PENALTIES_*	List	0 impedance	0..10000
RIGHT_TURN_PENALTIES_*	List	0 impedance	0..10000
U_TURN_PENALTIES_*	List	0 impedance	0..10000
PARKING_PENALTY_FILE	File		[project_directory]filename
TRANSIT_PENALTY_FILE	File		[project_directory]filename
TRANSFER_PENALTIES_*	List	0 impedance	0..100000
STOP_WAITING_PENALTIES_*	List	0 impedance	0..100000
STATION_WAITING_PENALTIES_*	List	0 impedance	0..100000
BUS_BIAS_FACTORS_*	List	1.0	1.0..3.0
BUS_BIAS_CONSTANTS_*	List	0 impedance	0..10000
RAIL_BIAS_FACTORS_*	List	1.0	0.1..1.0
RAIL_BIAS_CONSTANTS_*	List	0 impedance	-1000..0
MAX_WALK_DISTANCES_*	List	2000 meters	100..20000 meters
WALK_PENALTY_DISTANCES_*	List	2000 meters	100..10000 meters
WALK_PENALTY_FACTOR	Dec.	0.0	0.0..25.0
MAX_BICYCLE_DISTANCES_*	List	10000 meters	1000..40000 meters
BIKE_PENALTY_DISTANCES_*	List	10000 meters	1000..20000 meters
BIKE_PENALTY_FACTOR	Dec.	0.0	0.0..25.0

MAX_WAIT_TIMES_*	List	60 minutes	5..400 minutes
WAIT_PENALTY_TIMES_*	List	60 minutes	5..200 minutes
WAIT_PENALTY_FACTOR	Dec.	0.0	0.0..25.0
MIN_WAIT_TIMES_*	List	0 seconds	0..3600 seconds
MAX_NUMBER_OF_TRANSFERS_*	Int.	3	0..10
MAX_NUMBER_OF_PATHS_*	Int.	4	1..10
MAX_PARK_RIDE_PERCENTAGE_*	Int.	50 percent	1..100 percent
MAX_KISS_RIDE_PERCENTAGE_*	Int.	35 percent	1..100 percent
KISS_RIDE_TIME_FACTOR_*	Dec.	2.5	1.0..4.4
KISS_RIDE_STOP_TYPES	Text	EXTERNAL	
MAX_KISS_RIDE_DROPOFF_WALK	Dec.	100 meters	10..500 meters
MAX_LEGS_PER_PATH	Int.	1000	10..10000
FARE_CLASS_DISTRIBUTION	List	0	
DEFAULT_PARKING_DURATION	List	0.0 hours	0.0..24.0 hours
LOCAL_ACCESS_DISTANCE	Dec.	2000 meters	100..7500 meters
LOCAL_FACILITY_TYPE	Text	EXTERNAL	MAJOR..LOCAL, EXTERNAL
LOCAL_IMPEDANCE_FACTOR	Dec.	0.0	0.0..25.0
MAX_CIRCUITY_RATIO	Dec.	0.0	0.0..10.0
MIN_CIRCUITY_DISTANCE	Dec.	2000 meters	0..10000 meters
MAX_CIRCUITY_DISTANCE	Dec.	20000 meters	0..100000 meters
MIN_DURATION_FACTORS	List	0.1, 0.5, 0.8, 1.0	0.0..1.0

Simulation Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
SIMULATION_START_TIME	Time	0:00	
SIMULATION_END_TIME	Time	24:00	
TIME_STEPS_PER_SECOND	Int.	1	1..10
CELL_SIZE	Dec.	0.0 meters	0, 3..10 meters
PLAN_FOLLOWING_DISTANCE	Int.	526 meters	0..2000 meters
LOOK_AHEAD_DISTANCE	Int.	260 meters	0..2000 meters
LOOK_AHEAD_LANE_FACTOR	Dec.	4.0	1.0..25.0
LOOK_AHEAD_TIME_FACTOR	Dec.	1.0	0.0..5.0
MAXIMUM_SWAPPING_SPEED	Dec.	40 mps	-1..40 mps

MAXIMUM_SPEED_DIFFERENCE	Dec.	10 mps	0..10 mps
ENFORCE_PARKING_LANES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
FIX_VEHICLE_LOCATIONS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
DRIVER_REACTION_TIME_*	List	1.0 seconds	0.0..5.0 seconds
PERMISSION_PROBABILITY_*	List	50 percent	0..100 percent
SLOW_DOWN_PROBABILITY_*	List	0 percent	0..100 percent
SLOW_DOWN_PERCENTAGE_*	List	0 percent	0..50 percent
MAX_COMFORTABLE_SPEED_*	List	37.5 mps	0, 15..40 mps
TRAVELER_TYPE_FACTORS_*	List	1.0	0.5..2.0
PRIORITY_LOADING_TIME	Time	60 seconds	0..6500 seconds
MAXIMUM_LOADING_TIME	Time	120 seconds	0..6500 seconds
PRIORITY_WAITING_TIME	Time	60 seconds	0..6500 seconds
MAXIMUM_WAITING_TIME	Time	120 seconds	0..6500 seconds
MAX_DEPARTURE_TIME_VARIANCE	Time	60 minutes	0..180 minutes
MAX_ARRIVAL_TIME_VARIANCE	Time	60 minutes	0..180 minutes
RELOAD_CAPACITY_PROBLEMS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
COUNT_PROBLEM_WARNINGS	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
PRINT_PROBLEM_MESSAGES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
UNSIMULATED_SUBAREAS	List	NONE	e.g., 1, 2, 4..10, 100..200, 300
MACROSCOPIC_SUBAREAS	List	NONE	e.g., 1, 2, 4..10, 100..200, 300
MESOSCOPIC_SUBAREAS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
MICROSCOPIC_SUBAREAS	List	NONE	e.g., 1, 2, 4..10, 100..200, 300
TURN_POCKET_FACTOR	Dec.	0.8	0..1.0
MERGE_POCKET_FACTOR	Dec.	0.6	0..1.0
OTHER_POCKET_FACTOR	Dec.	0.5	0..1.0

Snapshot, Delay, Volume, Ridership Output Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
NEW_SNAPSHOT_FILE_*	File		[project_directory]filename
NEW_SNAPSHOT_INCREMENT_*	Time	900 seconds	0.1..1800 seconds
NEW_SNAPSHOT_TIME_RANGE_*	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
NEW_SNAPSHOT_LINK_RANGE_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
NEW_SNAPSHOT_SUBAREA_RANGE_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300

NEW_SNAPSHOT_COORDINATES_*	List	ALL	Min X, Min Y, Max X, Max Y
NEW_SNAPSHOT_MAX_SIZE_*	Int.	0	0..4096
NEW_SNAPSHOT_LOCATION_FLAG_*	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
NEW_SNAPSHOT_CELL_FLAG_*	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
NEW_SNAPSHOT_STATUS_FLAG_*	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
NEW_SNAPSHOT_COMPRESSION_*	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
NEW_LINK_DELAY_FILE_*	File		[project_directory]filename
NEW_LINK_DELAY_INCREMENT_*	Time	15 minutes	0, 2..240 minutes
NEW_LINK_DELAY_TIME_RANGE_*	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
NEW_LINK_DELAY_LINK_RANGE_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
NEW_LINK_DELAY_SUBAREA_RANGE_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
NEW_LINK_DELAY_COORDINATES_*	List	ALL	Min X, Min Y, Max X, Max Y
NEW_LINK_DELAY_VEH_TYPES_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
NEW_LINK_DELAY_TURN_FLAG_*	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
NEW_LINK_DELAY_FLOW_TYPE_*	Text	VEHICLES	VEHICLES, CAR_EQUIV/PCE, PERSONS
NEW_PERFORMANCE_FILE_*	File		[project_directory]filename
NEW_PERFORMANCE_INCREMENT_*	Time	15 minutes	0, 2..240 minutes
NEW_PERFORMANCE_TIME_RANGE_*	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
NEW_PERFORMANCE_LINK_RANGE_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
NEW_PERFORMANCE_SUBAREA_RANGE_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
NEW_PERFORMANCE_COORDINATES_*	List	ALL	Min X, Min Y, Max X, Max Y
NEW_PERFORMANCE_VEH_TYPES_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
NEW_PERFORMANCE_TURN_FLAG_*	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
NEW_PERFORMANCE_FLOW_TYPE_*	Text	VEHICLES	VEHICLES, CAR_EQUIV/PCE, PERSONS
NEW_TURN_VOLUME_FILE_*	File		[project_directory]filename
NEW_TURN_VOLUME_FILTER_*	Int.	0	>= 0
NEW_TURN_VOLUME_INCREMENT_*	Time	15 minutes	0, 2..240 minutes
NEW_TURN_VOLUME_TIME_RANGE_*	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
NEW_TURN_VOLUME_NODE_RANGE_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
NEW_TURN_VOLUME_SUBAREA_RANGE_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
NEW_RIDERSHIP_FILE_*	File		[project_directory]filename
NEW_RIDERSHIP_TIME_RANGE_*	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
NEW_RIDERSHIP_ROUTE_RANGE_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300

NEW_RIDERSHIP_ALL_STOPS_*	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Occupancy, Event, Traveler, Speed Bin Output Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
NEW_OCCUPANCY_FILE_*	File		[project_directory]filename
NEW_OCCUPANCY_INCREMENT_*	Time	900 seconds	1..3600 seconds
NEW_OCCUPANCY_TIME_RANGE_*	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
NEW_OCCUPANCY_LINK_RANGE_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
NEW_OCCUPANCY_SUBAREA_RANGE_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
NEW_OCCUPANCY_COORDINATES_*	List	ALL	Min X, Min Y, Max X, Max Y
NEW_OCCUPANCY_MAX_FLAG_*	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
NEW_EVENT_FILE_*	File		[project_directory]filename
NEW_EVENT_FILTER_*	Time	0 seconds	>= 0 seconds
NEW_EVENT_TIME_RANGE_*	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
NEW_EVENT_TYPE_RANGE_*	List	ALL	TRIP_START_TIME, TRIP_END_TIME, TRIP_DURATION, VEH_START_TIME, VEH_END_TIME, VEH_LOST_TIME, TRANSIT_WAIT, TRANSIT_BO
NEW_EVENT_MODE_RANGE_*	List	ALL	WALK, BIKE, DRIVE, RIDE, TRANSIT, PNR_OUT, PNR_IN, KNR_OUT, KNR_IN, TAXI, OTHER, HOV2, HOV3, HOV4
NEW_EVENT_LINK_RANGE_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
NEW_EVENT_SUBAREA_RANGE_*	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
NEW_EVENT_COORDINATES_*	List	ALL	Min X, Min Y, Max X, Max Y

Control Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
DEBUG_TIME_RANGE	Time	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
DEBUG_VEHICLE_LIST	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
DEBUG_LINK_LIST	List	ALL	e.g., 1, 2, 4..10, 100..200, 300

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.25. TransimsNet - Quick Reference

Version 5.0.8

Usage

TransimsNet [-flag] [control_file]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Synthesize TRANSIMS network files from generic node and link information. Node, Link, Activity Location, Parking, Process Link, Lane Connectivity, and Pocket Lane files are generated by the program.
2. The program also generates Sign and Signal Warrant files that can be used as input to the IntControl program to synthesize the TRANSIMS Unsignalized Node, Signalized Node, Timing Plan, Phasing Plan, Detector and Signal Coordinator files.
3. Copy an existing network and update or delete network components associated with selected links or nodes.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0

MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
MAX_PROBLEM_COUNT	Int.	0	>= 0
NUMBER_OF_THREADS	Int.	1	1..24
TRANSIMSNET_REPORT_*	Text		program report name

System File Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
YES	NODE_FILE	File		[project_directory]filename
YES	ZONE_FILE	File		[project_directory]filename
YES	LINK_FILE	File		[project_directory]filename
YES	NEW_LINK_FILE	File		[project_directory]filename
YES	NEW_POCKET_FILE	File		[project_directory]filename
YES	NEW_CONNECTION_FILE	File		[project_directory]filename
YES	NEW_PARKING_FILE	File		[project_directory]filename
YES	NEW_LOCATION_FILE	File		[project_directory]filename
YES	NEW_SIGN_FILE	File		[project_directory]filename
YES	NEW_SIGNAL_FILE	File		[project_directory]filename
	SHAPE_FILE	File		[project_directory]filename
	POCKET_FILE	File		[project_directory]filename
	LANE_USE_FILE	File		[project_directory]filename
	CONNECTION_FILE	File		[project_directory]filename
	TURN_PENALTY_FILE	File		[project_directory]filename
	PARKING_FILE	File		[project_directory]filename
	LOCATION_FILE	File		[project_directory]filename
	ACCESS_FILE	File		[project_directory]filename
	SIGN_FILE	File		[project_directory]filename
	SIGNAL_FILE	File		[project_directory]filename
	NEW_NODE_FILE	File		[project_directory]filename
	NEW_ZONE_FILE	File		[project_directory]filename
	NEW_SHAPE_FILE	File		[project_directory]filename
	NEW_LANE_USE_FILE	File		[project_directory]filename
	NEW_TURN_PENALTY_FILE	File		[project_directory]filename

NEW_ACCESS_FILE	File		[project_directory]filename

File Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
NOTES_AND_NAME_FIELDS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Projection, Smooth Data, Difference Data Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
INPUT_COORDINATE_SYSTEM	List		LATLONG, DEGREES/MILLION_DEGREES or STATEPLANE/UTM, code, FEET/METERS/MILES/KILOMETERS
INPUT_COORDINATE_ADJUSTMENT	List		X Offset, Y Offset, X Factor, Y Factor
OUTPUT_COORDINATE_SYSTEM	List		LATLONG, DEGREES/MILLION_DEGREES or STATEPLANE/UTM, code, FEET/METERS/MILES/KILOMETERS
OUTPUT_COORDINATE_ADJUSTMENT	List		X Offset, Y Offset, X Factor, Y Factor
OUTPUT_XYZ_SHAPES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
OUTPUT_XYM_SHAPES	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Control Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
DEFAULT_LINK_SETBACK	Dec.	7.5 meters	0..30 meters
DEFAULT_LOCATION_SETBACK	Dec.	30 meters	0..100 meters
MAXIMUM_CONNECTION_ANGLE	Int.	120 degrees	90..180 degrees
ADD_UTURN_TO_DEAD_END_LINKS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
SIGNAL_ID_AS_NODE_ID	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
EXTERNAL_ZONE_RANGE	List	0	0..10000
EXTERNAL_STATION_OFFSET	Int.	30 meters	0..100 meters
ZONE_BOUNDARY_FILE	File		[project_directory]filename
ZONE_FIELD_NAME	Text		ZONE, TAZ, Z, ID
POCKET_LANE_WARRANT_*	Text		FROM, TO, AT, TYPE, LENGTH meters, LANES
TRAFFIC_CONTROL_WARRANT_*	Text		MAIN, OTHER, AT, TYPE, SETBACK meters, GROUP
FACILITY_ACCESS_WARRANT_*	Text		TYPE, AT, SETBACK meters, MIN_LEN meters, MAX_PTS
PARKING_DETAILS_WARRANT_*	Text		AT, TIME, USE, IN seconds, OUT seconds, HOURLY cents, DAILY cents
STREET_PARKING_WARRANT_*	Text		TYPE, AT, TIME

UPDATE_NODE_RANGE	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
UPDATE_LINK_RANGE	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
UPDATE_NODE_FILE	File		[project_directory]filename
UPDATE_LINK_FILE	File		[project_directory]filename
DELETE_NODE_RANGE	List	NONE	e.g., 1, 2, 4..10, 100..200, 300
DELETE_LINK_RANGE	List	NONE	e.g., 1, 2, 4..10, 100..200, 300
DELETE_NODE_FILE	File		[project_directory]filename
DELETE_LINK_FILE	File		[project_directory]filename
LINK_DETAIL_FILE	File		[project_directory]filename

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.26. TransitDiff - Quick Reference

Version 5.0.0

Usage

TransitDiff [-flag] [control_file]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

Configuration Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
TITLE	Text		
REPORT_FILE	File		filename[_partition][.prn]
REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
PROJECT_DIRECTORY	Path		
MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
MODEL_END_TIME	Time	24:00	> [model_start_time]
UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
MAX_WARNING_MESSAGES	Int.	100000	>= 0
MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
MAX_PROBLEM_COUNT	Int.	0	>= 0
NUMBER_OF_THREADS	Int.	1	1..24

TRANSITDIFF_REPORT_*	Text		program report name

System File Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
YES NODE_FILE	File		[project_directory]filename
YES LINK_FILE	File		[project_directory]filename
YES TRANSIT_STOP_FILE	File		[project_directory]filename
YES TRANSIT_ROUTE_FILE	File		[project_directory]filename
YES TRANSIT_SCHEDULE_FILE	File		[project_directory]filename
YES VEHICLE_TYPE_FILE	File		[project_directory]filename
TRANSIT_DRIVER_FILE	File		[project_directory]filename

File Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
NOTES_AND_NAME_FIELDS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N

Control Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
YES COMPARE_NODE_FILE	File		
YES COMPARE_LINK_FILE	File		
YES COMPARE_TRANSIT_STOP_FILE	File		
YES COMPARE_TRANSIT_ROUTE_FILE	File		
YES COMPARE_TRANSIT_SCHEDULE_FILE	File		
COMPARE_TRANSIT_DRIVER_FILE	File		
NEW_TRANSIT_DIFFERENCE_FILE	File		

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.27. TransitNet - Quick Reference

Version 5.0.6

Usage

TransitNet [-flag] [control_file]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Create or update transit network file from route header and nodes files.
2. Add transit-related activity locations, process links, and parking lots to the network files.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0
	MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	MAX_PROBLEM_COUNT	Int.	0	>= 0
	NUMBER_OF_THREADS	Int.	1	1..24

TRANSITNET_REPORT_*	Text		program report name

System File Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
YES NODE_FILE	File		[project_directory]filename
YES LINK_FILE	File		[project_directory]filename
YES CONNECTION_FILE	File		[project_directory]filename
YES ROUTE_NODES_FILE	File		[project_directory]filename
YES VEHICLE_TYPE_FILE	File		[project_directory]filename
YES NEW_TRANSIT_STOP_FILE	File		[project_directory]filename
YES NEW_TRANSIT_ROUTE_FILE	File		[project_directory]filename
YES NEW_TRANSIT_SCHEDULE_FILE	File		[project_directory]filename
YES NEW_TRANSIT_DRIVER_FILE	File		[project_directory]filename
ZONE_FILE	File		[project_directory]filename
SHAPE_FILE	File		[project_directory]filename
PARKING_FILE	File		[project_directory]filename
LOCATION_FILE	File		[project_directory]filename
ACCESS_FILE	File		[project_directory]filename
TRANSIT_STOP_FILE	File		[project_directory]filename
TRANSIT_ROUTE_FILE	File		[project_directory]filename
TRANSIT_SCHEDULE_FILE	File		[project_directory]filename
TRANSIT_DRIVER_FILE	File		[project_directory]filename
NEW_PARKING_FILE	File		[project_directory]filename
NEW_ACCESS_FILE	File		[project_directory]filename

File Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
NOTES_AND_NAME_FIELDS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
ZONE_EQUIVALENCE_FILE	File		[project_directory]filename

Control Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	PARK_AND_RIDE_FILE	File		[project_directory]filename
	STOP_SPACING_BY_AREA_TYPE_*	List	200 meters	37.5..3200 meters
	STOP_FACILITY_TYPE_RANGE	Text	PRINCIPAL..FRONTAGE	FREEWAY..EXTERNAL
	TRANSIT_TIME_PERIODS	Text	NONE	e.g., NONE, 6:00, 10:00, 16:00
	TRANSIT_TRAVEL_TIME_FACTORS_*	List	1.0	0.5..3.0
	MINIMUM_DWELL_TIME	Time	5 seconds	0..300 seconds
	INTERSECTION_STOP_TYPE	Text	NEARSIDE	NEARSIDE, FARSIDE, MIDBLOCK
	INTERSECTION_STOP_OFFSET	Dec.	10.0 meters	0..100 meters

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.28. TripPrep - Quick Reference

Version 5.0.2

Usage

TripPrep [-flag] [control_file] [partition]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

Configuration Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
TITLE	Text		
REPORT_FILE	File		filename[_partition][.prn]
REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
PROJECT_DIRECTORY	Path		
MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
MODEL_END_TIME	Time	24:00	> [model_start_time]
UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
MAX_WARNING_MESSAGES	Int.	100000	>= 0
MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
MAX_PROBLEM_COUNT	Int.	0	>= 0
NUMBER_OF_THREADS	Int.	1	1..24

TRIPPREP_REPORT_*	Text		program report name

System File Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
YES TRIP_FILE	File		[project_directory]filename.*
SELECTION_FILE	File		[project_directory]filename.*
VEHICLE_FILE	File		[project_directory]filename.*
NEW_VEHICLE_FILE	File		[project_directory]filename.*
NEW_TRIP_FILE	File		[project_directory]filename.*

Data Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
TRIP_SORT_TYPE	Text	DO_NOT_SORT	DO_NOT_SORT, TRAVELER_SORT, TIME_SORT

Select Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
SELECT_HOUSEHOLDS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_MODES	List	ALL	e.g., ALL or 1, 12..14 or WALK, HOV2..HOV4
SELECT_PURPOSES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_START_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SELECT_END_TIMES	List	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SELECT_ORIGINS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_DESTINATIONS	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECT_TRAVELER_TYPES	List	ALL	e.g., 1, 2, 4..10, 100..200, 300
SELECTION_PERCENTAGE	Dec.	100.0 percent	0.01..100.0 percent
DELETION_FILE	File		[project_directory]filename
DELETE_HOUSEHOLDS	List	NONE	e.g., 1, 2, 4..10, 100..200, 300
DELETE_MODES	List	NONE	e.g., ALL or 1, 12..14 or WALK, HOV2..HOV4
DELETE_TRAVELER_TYPES	List	NONE	e.g., 1, 2, 4..10, 100..200, 300

Control Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES

MERGE_TRIP_FILE	File		[project_directory]filename.*
MERGE_VEHICLE_FILE	File		[project_directory]filename.*
MAXIMUM_SORT_SIZE	Int.	0	0, >=100000 trips
UPDATE_TRIP_PARTITIONS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
UPDATE_TRAVELER_TYPE	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
TRIP_PROCESSING_SCRIPT	File		[project_directory]filename

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

17.29. Validate - Quick Reference

Version 5.0.5

Usage

Validate [-flag] [control_file]

```
Optional Flags:
 -Q[uiet] = execute without screen messages
 -H[elp] = show program syntax and control keys
 -C[ontrol] = create/update a default control file
 -K[eyCheck] = list unrecognized control file keys
 -P[ause] = pause before exiting
 -N[oPause] = never pause before exiting
 -D[etail] = execute with detailed status messages
 -X[ML] = write an XML file with control keys
```

Purpose

1. Compare link delay file to link and/or turning movement counts.
2. Compare link volume and/or movement files to link and turning movement counts.
3. Generate statistical reports for volume level, facility type, area types, link group (screenline), zone group (district), and turning movements.
4. Output link volume data by time increment and time period ranges.
5. Compare transit ridership by line group and/or stop groups to ridership counts.

Configuration Keys

REQ?	KEY	TYPE	DEFAULT	VALUE RANGES
	TITLE	Text		
	REPORT_FILE	File		filename[_partition][.prn]
	REPORT_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
	PROJECT_DIRECTORY	Path		
	MODEL_START_TIME	Time	0:00	>= 0 [seconds], 0.0 [hours], 0:00
	MODEL_END_TIME	Time	24:00	> [model_start_time]
	UNITS_OF_MEASURE	Text	METRIC	METRIC, ENGLISH
	RANDOM_NUMBER_SEED	Int.	0	0 = computer clock, > 0 = fixed
	MAX_WARNING_MESSAGES	Int.	100000	>= 0

MAX_WARNING_EXIT_FLAG	Bool	TRUE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
MAX_PROBLEM_COUNT	Int.	0	>= 0
NUMBER_OF_THREADS	Int.	1	1..24
VALIDATE_REPORT_*	Text		program report name

System File Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
YES NODE_FILE	File		[project_directory]filename
YES LINK_FILE	File		[project_directory]filename
ZONE_FILE	File		[project_directory]filename
POCKET_FILE	File		[project_directory]filename
CONNECTION_FILE	File		[project_directory]filename
SIGNAL_FILE	File		[project_directory]filename
PHASING_PLAN_FILE	File		[project_directory]filename
TIMING_PLAN_FILE	File		[project_directory]filename
TRANSIT_STOP_FILE	File		[project_directory]filename
TRANSIT_ROUTE_FILE	File		[project_directory]filename
TRANSIT_SCHEDULE_FILE	File		[project_directory]filename
TRANSIT_DRIVER_FILE	File		[project_directory]filename
LINK_DELAY_FILE	File		[project_directory]filename
RIDERSHIP_FILE	File		[project_directory]filename

File Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
NOTES_AND_NAME_FIELDS	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
ZONE_EQUIVALENCE_FILE	File		[project_directory]filename
LINK_EQUIVALENCE_FILE	File		[project_directory]filename
STOP_EQUIVALENCE_FILE	File		[project_directory]filename
LINE_EQUIVALENCE_FILE	File		[project_directory]filename

Data Service Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES

DAILY_WRAP_FLAG	Bool	FALSE	TRUE/FALSE, YES/NO, 1/0, T/F, Y/N
SUMMARY_TIME_RANGES	Text	ALL	e.g., ALL, 0..97200 seconds, 0.0..27.0 hours, 0:00..27:00
SUMMARY_TIME_INCREMENT	Time	15 minutes	0, 2..240 minutes

Control Keys

REQ? KEY	TYPE	DEFAULT	VALUE RANGES
INPUT_VOLUME_FILE	File		[project_directory]filename
TRAFFIC_COUNT_FILE	File		[project_directory]filename
TURN_VOLUME_FILE	File		[project_directory]filename
TURN_COUNT_FILE	File		[project_directory]filename
LINK_GROUP_COUNT_FILE	File		[project_directory]filename
STOP_GROUP_COUNT_FILE	File		[project_directory]filename
NEW_VOLUME_FILE	File		[project_directory]filename
NEW_VOLUME_COUNT_FILE	File		[project_directory]filename
ANALYSIS_METHOD	Text	VOLUME	VOLUME, VMT
ADJUSTMENT_FACTOR	Dec.	1.0	0.05..10.0
FACILITY_TYPE_LABELS	File		[project_directory]filename
AREA_TYPE_LABELS	File		[project_directory]filename

Notes

Each '_FILE' key has a corresponding '_FORMAT' key. The following file formats can be used for input and ouput files.
TEXT, BINARY, FIXED_COLUMN, COMMA_DELIMITED, SPACE_DELIMITED, TAB_DELIMITED, CSV_DELIMITED, DBASE, SQLITE3, VERSION3

18. Appendix D: Key Personnel

Transportation Research and Analysis Computing Center (TRACC)

- Hubert Ley
- Vadim Sokolov
- Michael Hope
- Joshua Auld
- Young Soo Park
- Kuilin Zhang
- Xueying Kang
- Larry Amiot
- Joe Reitzer
- Gail Tate

Sub-Contractors:

- **AECOM**
  - David Roden – Team Leader
- **Chicago Metropolitan Agency for Planning (CMAP)**
  - Kermit Wies – Team Leader
- **Illinois Institute of Technology (IIT)**
  - Zongzhi Li – Team Leader
- **Northern Illinois University (NIU)**
  - Reinaldo Moraga – Team Leader

Biographies

Dr. Hubert Ley is Director of the Transportation Research and Analysis Computing Center at Argonne National Laboratory. He is leading the effort in promoting the use of high fidelity simulation approaches throughout research efforts in the general area of transportation research. Key priorities identified by USDOT and the Federal Highway Administration include the application of computational structural mechanics to build high fidelity large scale bridge models for a multitude of purposes, computational fluid dynamics to address complex mechanisms such as the pickup of sediment causing the formation of scour holes around bridge piers under flood conditions, and extensive transportation system modeling using TRANSIMS to address pressing issues such as congestion and the development of emergency evacuation plans. Before becoming the director of TRACC in May 2010, Dr. Ley led the transportation simulation efforts at TRACC. This included the development of visualization applications, the development of an integrated development environment for TRANSIMS (TRANSIMS Studio), parallelization and optimization of TRANSIMS for a cluster computing environment, the development of network editors, and other tools simplifying and standardizing the application of TRANSIMS. Dr. Ley also leads the TRANSIMS training efforts at TRACC, including the development of the three day training course that has been held multiple times per year for all TRANSIMS users across the US.

Dr. Vadim Sokolov is an expert in transportation network modeling, operations research, large-scale optimization and scientific computing. He was formally trained as a mathematician and after receiving his Ph.D. in Computational Mathematics became a computational transportation engineer at the Transportation Research and Analysis Computing Center (TRACC) at Argonne National Laboratory. At TRACC, Dr. Sokolov was responsible for developing and validating a “normal” day TRANSIMS model for the Chicago Metropolitan Area. Dr. Sokolov developed an interface to the existing METIS libraries. METIS is a family of programs for partitioning of unstructured graphs. The interface allows partitioning of the TRANSIMS network which can be then used to run the Microsimulator in a multi-processor and multi-computer environment. Dr. Sokolov developed Graphical User Interface applications for running TRANSIMS case scenarios on the TRACC cluster, as well as GUI for the production of TRANSIMS animations. He has also developed a Python utility performing temporal and spatial ‘smoothing’ of the snapshot data, allowing the efficient production of high quality animations. Dr. Sokolov has played a major role in developing the evacuation model for the Chicago business district, with work sponsored by the Illinois Department of Transportation. He was responsible for developing a TRANSIMS transit model based on Google Transit Feed data provided by Chicago’s regional transportation authorities. Currently, Dr. Sokolov is the lead developer of The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model (GREET). The GREET model allows users to fully evaluate energy and emission impacts of advanced vehicle technologies and new transportation fuels, the full fuel cycle from wells to wheels. This work is sponsored by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

Mr. Michael Hope is an expert in transportation modeling and software development. He has undertaken three major transportation modeling efforts. He was the sole modeler in a TRANSIMS analysis of Sycamore, IL which projected the effect of adding turn lanes to the downtown area. He was the lead tool programmer and model developer for the TRANSIMS evacuation case studies undertaken as part of TRACC’s downtown evacuation study funded by IDOT. Finally, he was the lead developer of a TRANSIMS model to project the effects of an extension of a Chicago expressway. Mr. Hope pioneered a massively parallel implementation of the TRANSIMS Microsimulator. The effort made use of MPI techniques, domain decomposition, extensive source code modification, and advanced profiling techniques to produce a product which was tested to be scalable at 128 processors with an efficiency of nearly 40%. He presented his findings at the 2009 Joint Summer Meeting TRB conference in Seattle. Mr. Hope is the sole developer of the TransimsVIS visualization software for TRANSIMS which includes such features as sub-second vehicle trajectory depiction, movie creation, pseudo-3D navigation, novel traffic visualization paradigms, and full GIS functionality. Mr. Hope is also the lead developer of the TransimsEDT network editing software which includes such features as full network editing capabilities, transit editing capabilities, high performance network drawing, and web-based satellite acquisition, caching, and display. He has co-instructed half a dozen TRANSIMS training courses and was a presenter at the first annual TRANSIMS workshop.

Dr. Joshua Auld has been a Ph.D. candidate in the department of Civil and Materials Engineering at the University of Illinois at Chicago (UIC). His primary research interest is in the field of travel demand modeling, specifically focusing on activity-based modeling approaches. He received his B.S. from the University of Illinois at Urbana-Champaign (UIUC) in 2002 and his M.S. from UIC in 2007. His current research focuses on activity-based modeling using a behavioral process-based approach. This involves collecting and analyzing activity-scheduling and travel information to understand the underlying decision processes and integrating these processes into the full travel demand model. He is the lead developer of a new, dynamic activity based model, the ADAPTS model, which attempts to simulate an individual's activity planning behavior in addition to their realized travel patterns. He was also the lead developer of a new population synthesis program for the Chicago Metropolitan Agency for Planning. In addition to his work in travel demand modeling, he also has extensive experience in travel survey design, serving as the designer and lead developer of the UTRACS internet-based GPS travel survey used in a recent data collection effort sponsored by the Illinois Center for Transportation.

Dr. Young Soo Park has over 20 years of R&D experience in broad areas of systems, computation, robotics, and artificial intelligence. He was formally educated in the field of robotics, and subsequently conducted R&D for nuclear applications in remote operation, computation, process diagnostics/inspection, and later transportation modeling. He joined TRACC in 2007 to conduct development of emergency evacuation models for the Chicago Metropolitan Area. In this scope of work, he provided methods for using TRANSIMS to implement evacuation event simulation. The development included a comprehensive set of methods for evacuation demand generation, and imposing traffic control actions. Much work devoted to the analysis of integrated router-microsimulation stabilization will later contribute to validation of evacuation models. Besides the normal use of TRANSIMS, he also developed new modeling methods to meet the unique needs of evacuation simulation. An intelligent method was developed for evacuation demand modeling which can take into account incomplete geographic and demographic data. He also coordinated a collaborative work scope for development of microscopic models of human behaviors, including agent based modeling of building evacuation, and spread of information. His other affiliations beside TRACC include supervision of the robotics laboratory at ANL, affiliation with the University of Chicago as a fellow of the Computation Institute as well as the Biomedical Institute of Advanced Surgery and Endoscopy.

Dr. Kuilin Zhang is an expert on multimodal transportation network modeling and traffic simulation, transportation planning, travel demand analysis, rail-based intermodal freight systems, and Intelligent Transportation Systems. At TRACC, Dr. Zhang's main research interests focus on developing optimization, simulation, economic models and decision making tools for multimodal transportation and logistics systems targeting efficiency, energy, environment, and resilience benefits. In particular, he works on developing simulation tools and optimization models for emergency evacuation planning, mitigation, preparedness, response, and recovery under man-made or natural disasters on the TRANSIMS platform. He has worked on various national and international projects, such as the Strategic Highway Research Program (SHRP 2 C04), and the National Cooperative Highway Research Program (NCHRP 08-57) funded by the Transportation Research Board, and the REORIENT project for seamless inter-modal freight transport funded by the European Commission. He has been a key developer of a Federal Highway Administration (FHWA) funded intelligent transportation network planning and evaluation tool DYNASMART-P for six years. He also developed a rail-based intermodal freight network simulator, an integrated passenger transportation corridor management planning and evaluation tool

DYNASMART-ICM, and an integrated regional demand and network simulation tool in light of his research projects. Dr. Zhang has published over 20 peer-reviewed papers in international journals and conference proceedings and 3 technical reports on traveler behavior, dynamic traffic assignment, congestion pricing, Bus Rapid Transit, rail-based intermodal freight systems, and integrated passenger transportation corridor management. He is a regular reviewer for international journals such as Transportation Research Part A, Transportation Research Record, Journal of Advanced Transportation, and IEEE ITS.

Ms. Xueying Kang is an expert on transportation network modeling and simulation. She graduated from Clemson University with a master's degree in Transportation Engineering in 2009. Her primary research domain is Microscopic Transportation Simulation and Intelligent Transportation Systems (ITS). She was a key graduate assistant researcher in developing the intelliDriveSM enabled Plug-in Hybrid Electric Vehicle (PHEV) funded by the National Science Foundation (NSF), which involved modeling rural and urban transportation networks and analyzing alternative transportation consumptions of advanced vehicles with ITS capabilities. She has specialized in developing application programming interface (API) of PARAMICS microsimulator for incident management strategy and evaluating wireless networks of traffic surveillance systems. Ms. Kang joined TRACC in the beginning of 2011 and will be responsible of simulating TRANSIMS evacuation cases for the RTSTEP project.

David B. Roden, PE is Senior Consulting Manager at AECOM with 30 years of experience in travel demand forecasting, traffic simulation, transportation planning, and commercial software development and support. He has been the primary TRANSIMS software developer since 2002 and is currently implementing TRANSIMS Version 5.0 to support interfaces to advanced activity-based demand models in Jacksonville, Florida and Sacramento, California. Over the last ten years, he successfully managed TRANSIMS applications for the Federal Highway Administration (FHWA) as part of the White House Area Transportation Study and demonstration projects in Columbus, Ohio, Atlanta, Georgia and Portland, Oregon. He also evaluated and tested EPA's MOVES software for FHWA. In addition, Mr. Roden was the project manager for a national survey of the major issues faced by state agencies and MPOs in developing, applying, and maintaining micro simulation models for transportation planning studies. The NCHRP report "Best Practices in the Use of Micro Simulation Models" outlines where, when and how micro simulation modeling can be best supported, justified, and cost effective. Mr. Roden has a B.S. from the University of Arizona and a M.E. from the University of California at Berkeley.

Dr. Kermit Wies is with the Chicago Metropolitan Agency for Planning where he serves as Deputy Executive Director for Research and Analysis. Kermit has over 25 years' experience in urban systems modeling and planning and was the principal author of the 2030 Regional Transportation Plan for the Chicago metro area. Presently, Kermit is the project manager for CMAP's Strategic Plan for Advanced Model Development; a multiyear program to establish agent-based forecasting and analysis techniques for regional planning in Chicago.

Dr. Zongzhi Li is an associate professor at the Illinois Institute of Technology (IIT), Chicago, Illinois. He received BE from Chang'an University, Xi'an, China; and MSCE, MSIE, and PhD (December 2003) all from Purdue University, West Lafayette, Indiana. Dr. Li's areas of expertise are in multimodal transportation systems infrastructure, mobility, safety and security performance modeling; sustainable transportation asset management under risk and uncertainty; and transportation network economics. Since 2004, Dr. Li has conducted a vast amount of research at IIT totaling over three million dollars in the related areas. He has published extensively with three books, three book chapters, and over twenty referred technical papers. Currently, he serves as an editorial board member of ASCE Journal of Infrastructure Systems, the secretary of Transportation Research Board (TRB)'s Transportation Asset Management Committee, and associate director of IIT Center for Work Zone Safety and Mobility. He was awarded the 1998 International Road Federation fellowship, won the 2000 Charley V. Wootan Award by the U.S. Council of University Transportation Centers, and was appointed as a senior research fellow of the Reason Foundation in 2008.

Dr. Reinaldo Moraga is an Assistant Professor in the Department of Industrial and Systems Engineering at the Northern Illinois University. He received two BSc degrees in Wood Engineering (1988) and in Industrial Engineering (1993) from Universidad del Bio-Bio, Chile, and has degrees of MSc and PhD in Industrial Engineering from University of Central Florida. Dr. Moraga's dissertation was recognized by the Institute of Industrial Engineers with the 2003 Pristker Doctoral Dissertation Award. He has written more than 30 technical articles in proceedings and journals. He also serves as an editorial board member of the International Journal of Applied Management Science (IJAMS). His research interests are Simulation Modeling, Operations Research, Metaheuristics, and Disaster Operations Management. Currently, Dr. Moraga is working on agent-based simulation modeling for building evacuation and the dispersion of emergency information throughout a particular region.

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19. Appendix E: Training Announcements

Argonne NATIONAL LABORATORY

TRANSIMS

Training Course

January 19-21, 2011

Argonne, IL

The Transportation Research and Analysis Computing Center at Argonne National Laboratory will hold a training course on the regional transportation analysis code TRANSIMS. The course is targeting primarily analysts new to the TRANSIMS methodology, and covers both the theoretical underpinnings as well as the practical application of the code. Participants will develop a full understanding of the general TRANSIMS principles, implementation details, data requirements, capabilities, and limitations of the software.

TRANSIMS (short for Transportation Analysis and Simulation System) is an integrated set of tools developed to conduct regional multimodal transportation system analyses. With the goal of establishing TRANSIMS as an ongoing public resource available to the transportation community, TRANSIMS is made available by the Federal Highway Administration under a NASA Open Source Agreement and is therefore readily available to the community.

The software is compatible with regular Windows and Linux desktop or server systems, but can also make use of high performance computing systems such as the TRACC cluster, a 1024 core Linux system with 240TB of disk space and extremely fast network connections across the United States. This cluster is generally available to researchers in the US transportation community and is currently being used for TRANSIMS traffic simulation, emergency evacuation modeling, computational fluid dynamics for bridge analysis, and structural mechanics codes to determine crashworthiness and structural integrity of highway components and vehicles.

TRACC has relocated to the Argonne National Laboratory Site

Location

The training course will be held at the **Transportation Research and Analysis Computing Center (TRACC) at Argonne National Laboratory, Building 222** (see maps on reverse side). The training sessions will also be broadcast over the Internet (using Adobe Connect) at

http://anl.acrobat.com/transims_training/

Registration

Participation in the training course is free. Please contact us at TRACC by phone or e-Mail if you would like to attend the training sessions either by Internet or in person.

This is the thirteenth TRANSIMS training course held by TRACC. It has evolved from the need to quickly and efficiently train students and collaborators in the practical application of the code. While addressing the fundamental principles to a degree that allows for a better understanding of the capabilities and limitations of the TRANSIMS approach, the main focus is on the use of the individual components. It also focuses on the issues of network conversion, trip conversion, routing, microsimulation, feedback, and visualization. **For this course, participants will also gain experience in the new TRANSIMS Version 5 as well as TRANSIMS Studio applications. Therefore the use of a laptop while attending the lectures is highly encouraged.**

Course Instructors:

Dr. Hubert Ley, Dr. Kuilin Zhang, Michael Hope, Dr. Vadim Sokolov
Argonne TRACC, 9700 South Cass Avenue, Argonne, IL, 60439
630.252.5200, TRANSIMS@anl.gov

David Roden, Senior Consulting Manager
AECOM, 2101 Wilson Boulevard, Suite 800, Arlington, VA 22201
703.340.3069, david.roden@aecom.com

Dr. Zongzhi Li, Associate Professor, CAE
Illinois Institute of Technology, 3201 South Dearborn Street, AM 102
Chicago, Illinois 60616
312.567.3556, lizz@iit.edu

TRACC

Transportation Research and Analysis Computing Center at Argonne National Laboratory

Argonne National Laboratory is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC

TRANSIMS

Training Session Agenda

Wednesday, January 19 (all times CST)

8:30 Registration

9:00 Introductions, Project Overview (Hubert Ley)

9:15 TRANSIMS Highway and Transit Network Models (Vadim Sokolov)

10:15 Coffee Break

10:30 TRANSIMS 4 Demand Model. OD Table Conversion (Vadim Sokolov)

11:30 TRANSIMS 4 Macroscopic Model, Route Choice (Vadim Sokolov)

12:30 Lunch Break

1:45 TRANSIMS 4 Microsimulator (Vadim Sokolov)

2:45 Traffic Assignment: System Optimal and User Equilibrium (Kuilin Zhang)

3:45 Coffee Break

4:00 Demand, Supply Integration in TRANSIMS, Stabilization Process (Vadim Sokolov)

5:00 Adjourn

Thursday, January 20

9:00 Current Status of the Chicago Model (Zongzhi Li)

10:00 New Features of TRANSIMS Version 5 (David Roden)

12:30 Lunch Break

1:45 New Features of TRANSIMS Version 5 (David Roden)

5:00 Adjourn

Friday, January 21

9:00 TRACC Cluster Tour, Hands-on Training (Hubert Ley)

10:30 Coffee Break

11:45 TRANSIMS Studio (Hubert Ley)

12:30 Lunch Break

1:45 TransimsEDT Network Editor (Michael Hope)

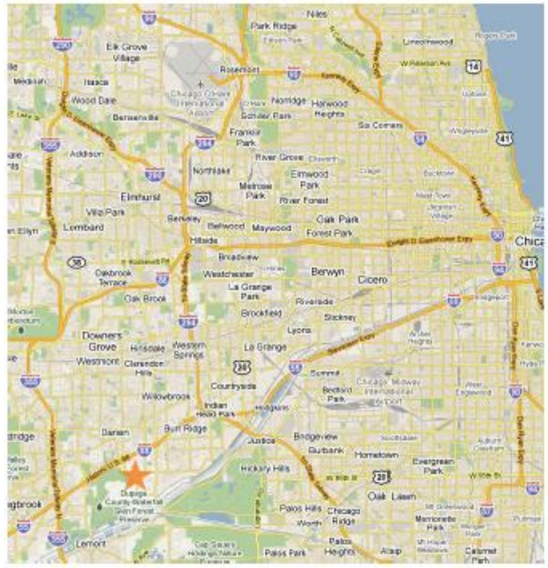
3:15 Coffee Break

3:30 TransimsVIS Visualizer (Michael Hope)

5:00 Adjourn

Training Site:
Transportation Research and Analysis Computing Center
Argonne National Laboratory
9700 South Cass Avenue, Building 222
Argonne, IL 60439
630.252.5200
http://www.tracc.anl.gov

Training Location



Directions to Argonne

Argonne National Laboratory occupies 1,500 wooded acres about 25 miles southwest of Chicago. The laboratory hosts thousands of visitors each year. Argonne is easily accessible by car or public transportation from downtown Chicago, as well as from Chicago's two airports. (Google Maps)

To reach Argonne from O'Hare International Airport, take I-294 south to I-55. Exit west on I-55 (toward St. Louis) and continue for about four miles to Cass Avenue. Exit south on Cass and turn right at the Argonne sign on Northgate Road, immediately south of I-55. Follow Northgate Road to the Argonne Information Center.

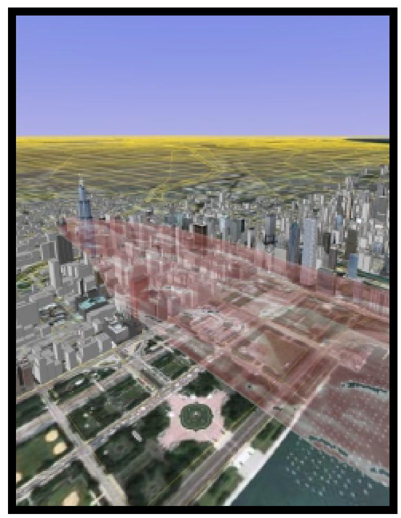
To reach Argonne from Midway Airport, take Cicero Avenue north to I-55. Enter I-55 south and continue for about 14 miles to Cass Avenue. Exit south on Cass and turn right at the Argonne sign on Northgate Road, immediately south of I-55. Follow Northgate Road to the Argonne Information Center.

The Regional Transportation Simulation Tool for Evacuation Planning

Project Overview

The Regional Transportation Simulation Tool for Evacuation Planning (RTSTEP) is a research project that includes the development of a software package that can be used by first responders and evacuation planning teams as a decision support tool. The tool allows simulating a response of a transportation system to one or more emergency events. The tool allows predicting response of public to a government notice regarding an evacuation and estimating of congestion on roads and transit networks. This project is sponsored under the Regional Catastrophic Preparedness Grant and is managed by Chicago OEMC (Office of Emergency Management and Communications). The project team includes five private and public organizations – Argonne National Laboratory, AECOM, Chicago Metropolitan Agency for Planning, Illinois Institute of Technology and Northern Illinois University. The project started on December 13, 2010. It will run for 11 months until November 2011.

Background



Prior to the RTSTEP project, Argonne National Laboratory conducted work in this general area on a project for the Illinois Department of Transportation and the Illinois Emergency Management Agency for a project established by the Illinois Terrorism Task Force. The latter project dealt with the development of methodologies to model the responses of the transportation system in response to a radiological dispersion device exploding near the Willis Tower (the former Sears Tower) in the Chicago Business District. Contacts between Argonne and Chicago OEMC lead to discussions regarding the potential use of transportation planning tools and technologies to develop a comprehensive tool which could be used by evacuation planners to predict the responses of a transportation evacuation for a given event in a given region. This idea is not novel. There were previous attempts to develop evacuation planning tools in the past. However, all of the previous attempts relied upon transportation models and software packages which were designed to be used for a "normal day" planning. The "normal day" models are somewhat restrictive and contain many assumptions which do not lead to realistic results in cases when they were applied to modeling evacuations from major cities during both advance notice and no-notice events. The RTSTEP project is intended as a proof of concept to develop a comprehensive tool that implements a model which is specifically designed for emergency evacuation scenarios. This project pushes the envelope about how the transportation network response could be predicted for emergency evacuation, taking into account public behavioral aspects, potential traffic management strategies, types of an emergency event, infrastructure damage, etc.

Purpose and Function of RTSTEP

The focus of the RTSTEP decision support tool is on the effects of evacuations on the regional transportation network, as well as the response of the transportation network to the sudden and unusual demand. The effects are dynamic in nature, with scenarios changing potentially from minute to minute. The scope of the tool includes all of the aspects of transportation planning.

A very detailed **network** of the area is used as a part of the model. Such details as turn lanes, lane connectivity, traffic signals data, and transit station locations are included in the model of the network. This allows modeling both events related and managed changes in the transportation network. Next, are some examples of such changes.

Argonne NATIONAL LABORATORY
Transportation Research and Analysis Computing Center

Event-related network changes

- Network discontinuities – closed, damaged or blocked facilities
- Power outages or traffic control malfunctions
- Disrupted communication channels
- Travelers driving on shoulders and off-network facilities
- Transit vehicles passenger capacity and loading rates

Managed changes

- Dedicated evacuation roadways and emergency responder routes
- Reprogrammed traffic signals – new timing and phasing plans
- Turn and access restrictions – bus only lanes
- Discontinuing toll collection and opening toll plazas
- Reversible roadways, lanes, and ramps
- Changes to transit routes, stops, and schedules
- School and private bus fleets
- Evacuating schools, hospitals, elderly care facilities, and transit dependent populations

To predict the **travel patterns** on the network (transportation demand) the behavioral response model was developed and implemented as a part of the tool. This model determines how the individuals (or household aggregates) will react to the evacuation order. This model is combined with a hazard-based model to determine how long it will take the individuals to react to the evacuation order and an egress model based on land-use and building characteristics to determine how long it takes the individuals to leave their location once they have decided to act. The model is highly customizable and could model, based on the data availability, public reaction depending on the following factors:

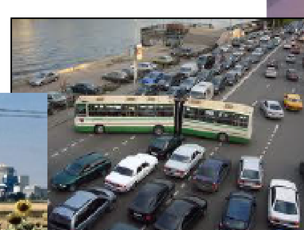
- Demographics Characteristic (house hold size and structure, age, sex)
- Vehicle availability
- Proximity to transit stations and shelters
- Type of an event notice and a type of notice
- Access to information sources (Radio, TV, Internet, in-vehicle navigation system)
- Distance from the affected area

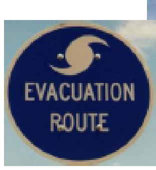
Most of the features of the model are available through a friendly **graphical user interface.** Another purpose of the GUI is to visualize the results of a simulation run (http://youtu.be/mN7kq0ITAys).

Potential Applications

Throughout the RTSTEP project, the main application was to model an evacuation resulted by a no-notice event, such as chemical or radiological attacks and/or hazardous material spills. The tool can also be used to develop plans for other type of events. Here are some of the potential applications:

- Advanced notice evacuation (hurricane, flood, etc.)
- Special events (sport games, concerts, festivals, etc.)
- Accidents
- Severe weather conditions
- Nuclear Power Plants Evacuation





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