Evolution of a Chicago Region TRANSIMS Application

*Hubert Ley*
Transportation Research and Analysis Computing Center
Energy Systems Division
Argonne National Laboratory
August 24, 2012
About Argonne: One of DOE’s Largest Research Facilities

http://www.anl.gov/

- Located 25 miles from the Chicago Loop, it was the first national laboratory, chartered in 1946
- Operated by the University of Chicago for the U.S. Department of Energy
- Major research missions include basic science, environmental management, and advanced energy technologies
- About 3,000 employees, including about 1,000 scientists and engineers, of whom 750 hold doctorate degrees
- Annual operating budget of about $475 million (80% from DOE)
- Since 1990, Argonne has worked with more than 600 companies and numerous federal agencies.
User facilities at Argonne

Advanced Photon Source

Transportation Research and Analysis Computing Center

Leadership Computing Facility

Electron Microscopy Center

Argonne Tandem Linac Accelerator System

Center for Nanoscale Materials
TRACC - A National User Facility to Meet USDOT Advanced Computation Needs

- USDOT and USDOE transportation research programs, private industry, and state and regional transportation agencies are moving to simulation-based design and analysis for improvements in efficiency, economics, and safety.

- Higher fidelity analysis in areas such as crashworthiness, aerodynamics, combustion, thermal management, weather modeling, and traffic simulation require access to state-of-the-art computational and visualization facilities.

- Argonne expertise in high-performance computing and transportation system analysis provides the basis for a national HPC user facility and a focal point for computational research for transportation applications.
TRACC User Profile

TRACC Cluster User Groups
January - March, 2011

- university, 40%
- government, 28%
- professional transportation organizations, 7%
- local transportation agencies, 2%
- state transportation agencies, 9%
- industry, 7%
- research cntr, 7%
Computational Fluid Dynamics and Computational Structural Mechanics

- Commercial applications such as LS-Dyna, adapco Star-CD, and adapco Star-CCM+ scale well on a cluster of this particular design

- Based on proven and reliable commercial models, cutting edge research involves the addition of crucial modeling capabilities such as
  - Sediment relocation at bridge pier foundations
  - Parametric vibrations in bridge stay cables
  - Many more ...

High priority transportation-related issues are “messy” and need robust and well-calibrated methodologies in the hand of many agencies and consulting companies

- TRACC provides a platform that is substantially larger than an existing platform available to transportation researchers
- TRACC focuses on calibration and validation of cutting edge modeling approaches
TRANSIMS User Support and Training

TRACC is providing training courses on TRANSIMS and other subject areas to the transportation research community in the US.

- Training courses are offered approximately 10 times per year in varying locations.

- Participation is free, and training courses are broadcast over the Internet to reach additional users.

- TRACC is holding additional training sessions on emerging capabilities through the Internet.

The goal is to build a strong community of expertise.
Supported TRANSIMS Models (selected)

Washington, DC

Atlanta

Chicago

Los Angeles

Sacramento
TRANSIMS at a Glance

- **Activity-based** large regional models, e.g. Chicago, Washington DC, Atlanta
- **Microscopic** simulation of passenger and transit vehicles
- **Open source** allows for the integration with dispersion models, infrastructure databases, communication, etc
- Originally developed by **Los Alamos** and now developed as an open source tool set

**High Fidelity**

**Multi Modal**
Typical Applications

- Congestion Mitigation (FHWA, AECOM)
- Hurricane Evacuation (Louisiana State University)
- Land-Use Change (FHWA, City of Moreno Valley)
- Nuclear Power Plants Evacuation Plans (NRC, AECOM)
TRANSIMS at TRACC

- Development of tools and methodologies to support a faster and more reliable modeling process
  - **Parallelization** and coordination of simultaneous execution of partitioned data sets
  - Adaptation of TRANSIMS to run effectively on high performance computing platforms
  - Development of high level tools such as network editors and TRANSIMS Studio
  - High performance **visualization** to aid in developing and debugging large complex transportation system models
  - **Training classes** to support new and advanced TRANSIMS users

- Development of a Chicago TRANSIMS model
  - Used as the basis for TRANSIMS software and methodology improvements
  - Model is largely based on data and previous models from CMAP
  - The model is being shared with other research teams, e.g. IIT/CDOT

- Focus on transportation system aspects of emergency evacuations
  - Funding by IDOT provided initial resources to build the regional Chicago model
  - Funding by OEMC (City of Chicago) supported the development of RTSTEP
TRANSIMS Visualization

- 3-d plus time navigation
- Regional area to street level detail zooming capability
- Targets model developers and the model debugging process
TRANSIMS Visualization

- Effective visualization allows the human brain to detect simulation flaws or actual congestion problems.
- Heat plots for larger areas and street level bar graphs for higher resolution areas allow for understanding dynamic effects causing bottlenecks.
Modeling and Simulation of an Emergency Evacuation Scenario for the Chicago Metropolitan Area

2007-2009
Modeling and Simulation of an Emergency Evacuation Scenario for the Chicago Metropolitan Area

- Model the effects of a no-notice event on the multi-modal regional transportation system in the Chicago metropolitan area
- The chosen scenario postulates a radioactive release following an explosion at the base of the Sears Tower
- This project deals with the dynamic effect on the transportation system

- ~10,000 square miles
- 40,000 links
- 14,000 intersections
- 9 million residents
- ~26.5 million vehicle trips
- ~1.5 million transit trips
- 500,000 concurrent drivers

Chicago Downtown Evacuation (IDOT, IEMA, US DOT, ITTF)

Chicago Normal Day Model (US DOT)
Network Editing
Google Maps and Street View
GCM Sensor Data
TRANSIMS Validation and Forecasting

- GCM sensor data has been captured for several years
- ~750 active sensors
- 5 minute volumes and speeds
- Valuable for future work in the Chicago area, e.g. dynamic traffic assignment other than TRANSIMS
- Data mining for special events and other potential validation of emergency conditions
Traffic Rerouting

- Traffic rerouted to resolve congestion, redirect traffic, or allow access by emergency vehicles
- Method based on Modification of
  - Turn_prohibition table
  - Lane_use table
Traffic Rerouting: Dense Urban Areas

- Modify Turn_Prohibition Table
RTSTEP - A Regional Transportation Simulation Tool for Evacuation Planning

2010-2011
Regional Transportation Simulation Tool for Evacuation Planning (RTSTEP)

- **Decision support tool** for evacuation planning that can be used while establishing emergency response plans constrained by the transportation system
- Analyze the effectiveness of emergency response strategies that modify the transportation system and disseminate traveler information
  - Emergency evacuation traffic
  - Escape routes
  - Routes for incoming emergency responders
  - Simulate the impact of destination, mode, and route choice decisions on transportation system performance
Regional Transportation Simulation Tool for Evacuation Planning (RTSTEP)

- This project was sponsored by DHS/FEMA under the RCPG (Regional Catastrophic Preparedness Grant)
- Supervised by OEMC (Yilmaz Halac, Office of Emergency management and Communications in Chicago)
- Project aimed at developing a tool that can be utilized to configure, simulate, and visualize regional evacuations for the Chicago Metropolitan Area
- TRACC partnered with AECOM, Northern Illinois University, the Illinois Institute of Technology and the Chicago Metropolitan Area for Planning
The RTSTEP Team

- AECOM
- NORC at the UNIVERSITY of CHICAGO
- OEMC
- Argonne National Laboratory
- ILLINOIS INSTITUTE OF TECHNOLOGY
- Chicago Metropolitan Agency for Planning

- Normal Day Model
- Soft Development
- Student Assistants
- Social Science Research
- Network Data Trip Tables
- GIS Data Feedback
- Egress Models
RTSTEP Data Sources (selected)
Average day model refinement

- Intersection controls (more than 600 were coded manually)
- Intersection node adjustment (location, connectivity)
- Freeway and Ramp Errors Revision
- Lane Use Update
- Pace Transit Route Editing
- Average Day Plan Update
- Validation
- Assignment parameters calibration
Demand

Respond to evac order:
Model: Hazard-based -> f(HH, Zone, Threat)

T_{evac} = S^{-1}(rand)

Response Type:
Model: Nested Logit -> f(HH, Zone, Threat)

EvacNet

Shelter in Place  Evacuate  Ignore

No Stop  One Stop  Two Stops

Shelters  Zones  External

Write Trips new trip file

Egress Model

T_{evac} = S^{-1}(rand)
Intended response survey

- Online intended response survey
- Understand individuals’ responses to no-notice evacuation
- 533 responses
- Internet-based Stated Response Survey for No-Notice Evacuations
- Collaboration with UChicago NORC
- 39K Emails
- Cook and 7 Collar Counties

Table 9.12: Survey Sample Characteristics

<table>
<thead>
<tr>
<th>Household-level</th>
<th>Person-level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HH Size</td>
</tr>
<tr>
<td></td>
<td>Survey</td>
</tr>
<tr>
<td>1</td>
<td>20%</td>
</tr>
<tr>
<td>2</td>
<td>33%</td>
</tr>
<tr>
<td>3</td>
<td>20%</td>
</tr>
<tr>
<td>4+</td>
<td>27%</td>
</tr>
<tr>
<td>Income</td>
<td>Survey</td>
</tr>
<tr>
<td></td>
<td>56-65</td>
</tr>
<tr>
<td>&lt;25</td>
<td>9%</td>
</tr>
<tr>
<td>25-50</td>
<td>17%</td>
</tr>
<tr>
<td>50-75</td>
<td>15%</td>
</tr>
<tr>
<td>75-100</td>
<td>20%</td>
</tr>
<tr>
<td>&gt;100</td>
<td>27%</td>
</tr>
<tr>
<td>blank</td>
<td>17%</td>
</tr>
</tbody>
</table>

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

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

|                  | Education | Survey | Census |                  |
|                  | Yes       | 32%    | 36%    |                  |
|                  | No        | 68%    | 64%    |                  |

|                  | Associate / Bachelor | Survey | Census |                  |
|                  | Yes                  | 29%    | 28%    |                  |
|                  | No                   | 32%    | 13%    |                  |

|                  | Total Sample Size    |                  |
|                  | HH                   | 205               |

|                  | Total Sample Size    |                  |
|                  | Adult                | 427               |
|                  | Child                | 106               |

Survey Interface

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:

- 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

Very Unlikely

Neutral

Very Likely
Survey Results

Average Distance (miles)

- Low: 85
- Moderate: 124
- High: 153

Evacuation Distance (miles)

Evacuation Destination Type

- Evac Shelter: 51% Low, 61% Moderate, 49% High
- Friends/family: 31% Low, 27% Moderate, 32% High
- Return home: 17% Low, 10% Moderate, 9% High
- Hotel: 1% Low, 2% Moderate, 9% High
Evacuation Routes

- A set of routes were obtained from CDOT
- The set was refined and extended to cover the entire region
- TRACC developed a tool that allows the implementation of control strategies for intersections
User Interface

Visualization at TransimsVIS

Evacuation scenarios are defined using the Transims Visualization tool. First, select the settings used to define the evacuation for EvacDemand and EvacNet, then press "Plot" to choose the evacuated areas, shelter locations and evacuation routes.

Normal Day Run setup at TRANSIMS Studio

Evacuation Setup at RTSTEP
Case Studies

- Urban Area
- Rural Area
- Egress Model

### WRIGLEY FIELD CASE STUDY

<table>
<thead>
<tr>
<th></th>
<th>No evacuation planning</th>
<th>With evacuation planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evacuation Responses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Return home</td>
<td>467 (0.4%)</td>
<td>467 (0.4%)</td>
</tr>
<tr>
<td>Ignore evacuation</td>
<td>4,078 (3.7%)</td>
<td>4,204 (3.9%)</td>
</tr>
<tr>
<td>Shelter in place</td>
<td>29,588 (27.1%)</td>
<td>29,342 (26.9%)</td>
</tr>
<tr>
<td>Evacuate to shelter</td>
<td>– (–)</td>
<td>45,864 (42.0%)</td>
</tr>
<tr>
<td>Evacuate - leave region</td>
<td>12,185 (11.2%)</td>
<td>12,192 (11.2%)</td>
</tr>
<tr>
<td>Evacuate - Go to friends/family/hotel</td>
<td>62,821 (57.6%)</td>
<td>17,070 (15.6%)</td>
</tr>
<tr>
<td>Total population @ start</td>
<td>109,139 (100.0%)</td>
<td>109,139 (100.0%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other impacted individuals</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Diverted trips, due to evacuation</td>
<td>160,022</td>
</tr>
<tr>
<td>Cancelled trips</td>
<td>274,770</td>
</tr>
</tbody>
</table>
Questions?

For more information, please contact Hubert Ley
630-252-8224
hley@anl.gov