MICHIGAN OHIO UNIVERSITY TRANSPORTATION CENTER

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TRAFFIC SIMULATION IN REGIONAL MODELING:
APPLICATION TO THE TOLEDO SEA PORT

INTERIM REPORT

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DISCLAIMERS

Traffic Simulation in Regional Modeling:
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ABSTRACT

A small team of university-based transportation system experts and simulation experts has been assembled to develop, test, and apply an approach to assessing road infrastructure capacity using micro traffic simulation supported by publically available data in partnership with personnel of the Toledo Sea Port and the Toledo Metropolitan Area Council of Governments. Application activities focused on the arterial road infrastructure connecting the Toledo Sea Port to the interstate highway system via Interstate 280. Data was gathered from the Toledo Metropolitan Area Council of Governments and the Ohio Department of Transportation. A micro traffic simulation model was developed using the commercial software product AIMSUN. Multiple simulation experiments were conducted to find and propose relief for traffic bottlenecks. Simulation results showed that publicly available data was sufficient to support modeling and assessment activities. The road infrastructure was seen to have sufficient capacity to support truck movement between Interstate 280 and the seaport. The primary bottleneck was identified as the single entrance lane at the seaport security post. Adding a second lane would relieve the entrance bottleneck but cause a new bottleneck at the exit security post. The latter could be relieved by a second lane as well. In addition, additional truck unloading and loading capacity could be required under small, approximately 30%, increases in volume.

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1. Action Plan for Research

The action plan was designed to help the research team meet its fundamental goals of assessing the adequacy of the capacity of the road infrastructure supporting the Toledo Sea Port as well as determining if publically available data was sufficient to support such an assessment. Meeting these objectives involved the following.

1. Systematically acquire publically available data relevant to the road infrastructure supporting the Toledo Sea Port from TMACOG and the Ohio Department of Transportation (ODOT).
2. In addition, acquire map information describing the road infrastructure from public sources such as Google Earth, Bing Maps and Microsoft Map Point.
3. Transfer the micro traffic simulation technology developed previously under Michigan-Ohio University Transportation Center (MIOH-UTC) sponsorship at Wayne State University to Grand Valley State University.
4. Develop a micro traffic simulation model of the road infrastructure supporting the Toledo Sea Port using the AIMSUN traffic simulation software.
5. Design and conduct simulation experiments to assess the adequacy of the capacity of the road infrastructure.
6. Determine if the publically available data is sufficient to conduct such experiments and determine assess road infrastructure capacity.

2. Introduction

A small team of university-based transportation system experts and simulation experts has been assembled to develop, test, and apply an approach to assessing road infrastructure capacity. This team is supported by funding provided by the MIOH-UTC through the U.S. Department of Transportation (USDOT) with matching funds supplied by Grand Valley State University (GVSU). This report covers the period: September 2010 through December 2011.

The team has been working in the following areas:

1. Gathering and using publicly available data concerning road infrastructure and the traffic that uses such infrastructure.
2. Micro traffic simulation to assess the adequacy of the capacity of the traffic infrastructure, including at what level of demand the infrastructure becomes saturated.

As a proof of concept of the procedures and methods we have developed, the above have been applied to a capacity assessment of the road infrastructure supporting the Toledo Sea Port, focusing on the arterial roads between the port and the interstate highway system.

The effort has been lead by faculty in the GVSU School of Engineering (SOE), Professor Charles Standridge, as well as the WSU Department of Civil and Environmental Engineering (CEE), Professor Emeritus Snehamay Khasnabis. Students from School of Computing and Information Systems (SCIS) at GVSU, particularly M. Qureshi and S. Kesireddy, have ably assisted. Support for our work has been provided by TMACOG, Mr. Warren Henry, as well as ODOT, particularly the staff of the Toledo Sea Port, Mr. Joe Cappel.

3. Objective

The team has established that its primary research objectives are:

- *To assess the adequacy of the capacity of the arterial road infrastructure between the Toledo Sea Port and the interstate highway system.*
- *To determine if publically available data is sufficient for such as assessment.*

The team has addressed the former through the development and application of a micro traffic simulation model developed in AIMSUN. In so doing, the latter objective was also addressed.

4. Scope

For this assessment, it was assumed that all truck traffic used the route between Interstate 280 and the Toledo Sea Port, through the nearest interchange (#9) and via the arterial roads shown in Figure 1: Front to Millard to the Sea Port entry gate.

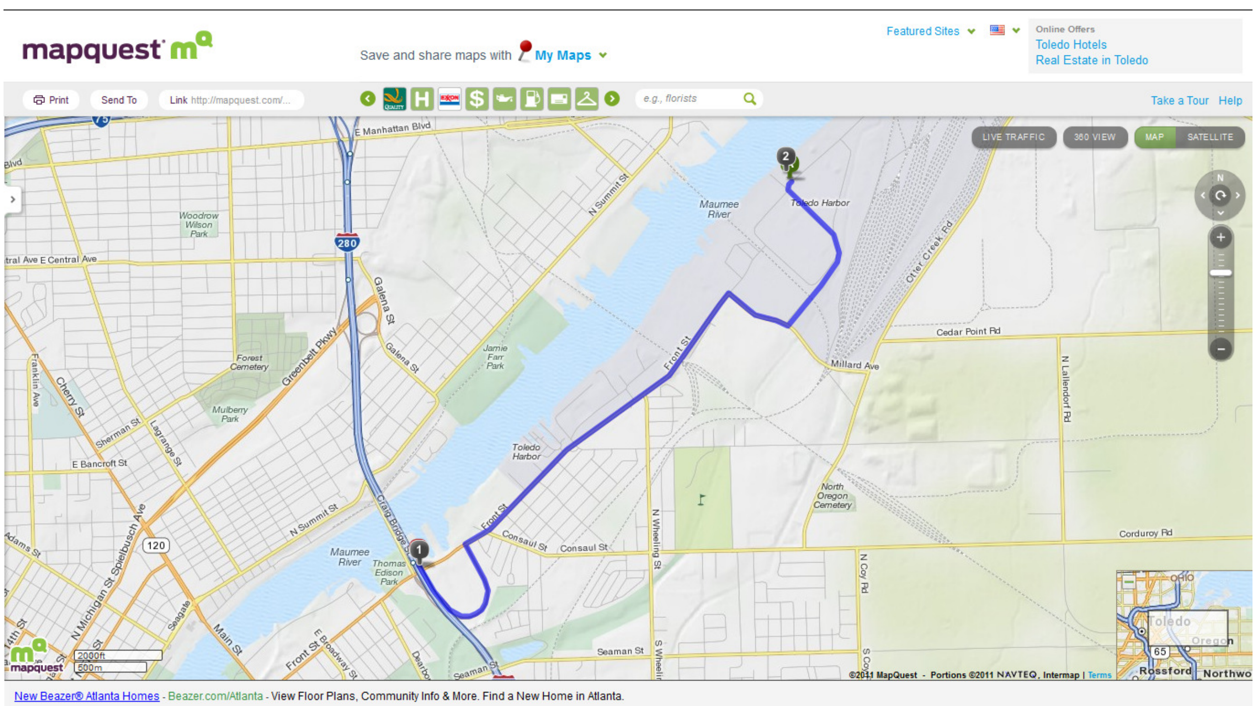

Figure 1. Map of Truck Route between Interstate 280 and the Toledo Sea Port Methodology

A micro-traffic simulation model of the traffic network shown in Figure 1 was developed using AIMSUN. Data sources included TMACOG and ODOT for Lucas County using the following websites.

http://www.ms2soft.com/tcds/tsearch.asp?loc=Tmacog_all&mod=
http://www.tmacog.org/Transportation/Map_Gallery_images/Transportation/MI_Permit_Routes_Lucas_3_09.pdf
http://www.tmacog.org/Transportation/Map_Gallery_images/Transportation/NHS_09.pdf
http://www.tmacog.org/Transportation/Map_Gallery_images/Transportation/Rail_Volume_and_Rail_Yards.pdf http://www.tmacog.org/Transportation/Trans_map_gallery.htm
http://www.tmacog.org/Transportation/Transportation.htm
http://www.dot.state.oh.us/Pages/Home.aspx
http://www.dot.state.oh.us/districts/D02/Pages/default.aspx

A delay time of 2 minutes per vehicle at the entrance/exit security check point is assumed based on the opinion of the Toledo Sea Port staff. This means that every truck stops at the entrance security point for 2 minutes for verification/entry processing/documentation/customs. Similarly on exit, every truck stops at the exit security point for 2 minutes for verification/exit processing/documentation/customs.

Some general traffic was also entering/exiting the port. The same security checkpoint wait time of two minutes was also used for this type of traffic.

In addition, it was assumed that each truck will spend one hour at the designated area for the loading/unloading. Each loading/unloading area has twenty loading/unloading docks.

5. Discussion of Results

The simulation was executed for one-24 hour period. Traffic to the Sea Port was assumed to be uniformly distributed over the 24 hour period. This represents one day of operation at the Sea Port and days appear to be independent.

In addition, the available traffic count was for 24 hours. Information concerning traffic volumes at peak hours in the morning and evening was not available.

However, one simulation experiment used the same traffic load uniformly distributed over a 16 hour period.

Based on the opinion of the Toledo Sea Port staff, it was assumed that 400 trucks would be enter and exit the port facility per 24-hour day. This represented a maximum volume of truck traffic.

Selected quantities input to or resulting from the simulation experiments may be defined as follows.

- Percentage (input): Percentage increase from the initial 400 trucks per day. This was done to help determine the capacity of the road network using increments of 10%.
- Rate (input): Rate is total trucks divided by number of hours simulated. There are two nodes in the traffic network at I-280 exit 9, one for north bound traffic and one for south bound traffic. For example, 400 trucks equally divided between the nodes: (400/2 = 200 trucks) and (200/24 = 8.33 trucks / hour).
- Hours (input): Total simulation hours.
- Inside (output): Total numbers of trucks within the network at the end of the simulation. These trucks could be anywhere within the network such as travelling towards the port or waiting at the entrance security post or waiting at the load/unloading area or waiting at the exit security post or travelling towards the exit node of the network.
- Gone Out (output): Total number of trucks exited from the network. Specifically trucks entered the network, reached the port, entered the port, loaded/unloaded, exited the port and exited the network.
- Total (output): Total numbers of trucks entering the network, equal to the sum of Inside and Gone Out.
- Waiting at Security In (output): Number of trucks waiting at the entrance security post at the end of the simulation.
- Waiting at Security Out (output): Number of trucks waiting at the exit security post at the end of the simulation.
- Waiting at Load / Unload Area (output): Number of trucks waiting at the loading/unloading area at the end of the simulation.
- Other Traffic Blockage: The number of vehicles on all the roads within the network at the end of the simulation.
- Blockage at the Security Post In or Security Post out: Indicted when the number of trucks waiting at the end of the simulation at the Security Post In (Out) is at least 10.
- Blockage at the Load / Unload Area: Indicated when the number of trucks waiting at the end of the simulation at the Load / Unload Area is at least twice the number of unload / load positions

The following tables contain the simulation results for each scenario tested. A number in **boldface** type indicates a traffic blockage condition. Note that no traffic blockage on the arterial roads was identified by any simulation experiment.

Table 1. One Load/Unload Area as well as One Entrance Lane and One Exit Lane at the Security Gate

Percentage Increase over 400 Trucks	Rate (Trk /Hr.)	Hours	Input Total	Inside	Gone Out	Total	Waiting at Security In	Waiting at Security Out	Waiting at Load / Unload Area	Other Traffic Blockage
0	8.33	24	400	36	365	401	4	0	20	No
10	8.33	24	440	29	406	435	4	2	12	No
20	8.33	24	480	57	447	504	5	1	27	No
30	8.33	24	520	64	440	504	6	1	**39**	No
40	8.33	24	560	93	456	549	9	4	**67**	No
50	8.33	24	600	144	463	607	**24**	1	**103**	No
60	8.33	24	640	176	463	639	**80**	3	**89**	No

- Traffic blockage is observed at the loading/unloading area when truck volume is increased by 30 percent.
- Traffic blockage is observed at the entrance security post when truck volume is increased by 50 percent.

Table 2. Two Load/Unload Areas as well as Two Entrance Lanes and One Exit Lane at the Security Gate

Percentage Increase over 400 Trucks	Rate (Trk /Hr.)	Hours	Input Total	Inside	Gone Out	Total	Waiting at Security In	Waiting at Security Out	Waiting at Load / Unload Area	Other Traffic Blockage
0	8.33	24	400	37	364	401	0	1	22	No
10	8.33	24	440	30	405	435	2	1	13	No
20	8.33	24	480	44	460	504	1	3	16	No
30	8.33	24	520	49	455	504	2	2	28	No
40	8.33	24	560	49	500	549	2	5	28	No
50	8.33	24	600	78	529	607	0	**36**	22	No
60	8.33	24	640	110	529	639	1	**70**	19	No

- No traffic blockage is observed at the loading/unloading area.
- No traffic blockage is observed at the entrance security post.
- Traffic blockage is observed at the exit security post when truck volume is increased by 50 percent.

Table 3. Two Load/Unload Areas as well as Two Entrance Lanes and Two Exit Lanes at the Security Gate

Percentage Increase over 400 Trucks	Rate (Trk /Hr.)	Hours	Input Total	Inside	Gone Out	Total	Waiting at Security In	Waiting at Security Out	Waiting at Load / Unload Area	Other Traffic Blockage
0	8.33	24	400	39	362	401	0	0	23	No
10	8.33	24	440	29	406	435	2	1	14	No
20	8.33	24	480	43	461	504	2	0	17	No
30	8.33	24	520	49	455	504	2	0	29	No
40	8.33	24	560	48	501	549	4	1	29	No
50	8.33	24	600	49	558	607	0	3	21	No
60	8.33	24	640	37	602	639	1	0	19	No
70	8.33	24	680	49	641	690	2	1	24	No
80	8.33	24	720	63	654	717	1	1	33	No
90	8.33	24	760	58	724	782	1	2	35	No
100	8.33	24	800	51	694	745	0	0	25	No
110	8.33	24	840	68	814	882	2	2	43	No
120	8.33	24	880	65	759	824	1	0	41	No
130	8.33	24	920	79	827	906	2	5	43	No
140	8.33	24	960	118	858	976	5	0	**74**	No
150	8.33	24	1000	101	902	1003	2	2	**63**	No
160	8.33	24	1040	107	874	981	2	5	**66**	No
170	8.33	24	1080	172	912	1084	4	3	**123**	No
180	8.33	24	1120	193	901	1094	3	2	**152**	No

- Traffic blockage is observed at the loading/unloading area when traffic volume is increased by 140%.
- No traffic blockage is observed at the entrance / exit security post.

Table 4. One Load/Unload Area as well as One Entrance Lane and One Exit Lane at the Security Gate and Sixteen Hour Time Horizon

Percentage Increase over 400 Trucks	Rate (Trk /Hr.)	Hours	Input Total	Inside	Gone Out	Total	Waiting at Security In	Waiting at Security Out	Waiting at Load / Unload Area	Other Traffic Blockage
0	12.5	16	400	139	248	387	**51**	5	**77**	No

- Traffic blockage is observed at the loading/unloading area with no increase in traffic volume.
- Traffic blockage is observed at the entrance security post with no increase in traffic volume.
- No traffic blockage is observed at the exit security post.

6. Conclusions

The results of the micro traffic simulation are consistent with the following conclusions.

1. Publically available data is sufficient to support the assessment of the adequacy of the capacity of the arterial roads connecting the Toledo Sea Port and the interstate highway system via Interstate 280.
2. No traffic blockage on these arterial roads was identified by any simulation experiment. Thus, the capacity of these roads appears to be adequate.
3. There is potential for traffic bottlenecks at the entrance security post. This was seen in tables 1 and 4 when traffic was increased by 50% or equivalently traffic was compressed from a 24 hour period to a 16 hour period. Thus, any compression of traffic, a large number of trucks arriving at the start of the day for example, could lead to such bottlenecks.
4. Relieving the traffic bottleneck at the entrance security post by adding a second entrance lane may lead to a bottleneck at the exit security post requiring a second exit lane as shown in Table 2.
5. There is potential for traffic bottlenecks at the load / unload area. This was seen in tables 1 and 4 when traffic was increase by 30% or traffic was compressed from a 24 hour period to a 16 hour period. A second load / unload area relieves this bottleneck.

7. Recommendations for Future Research

Assessing the potential for bottlenecks at the entrance / exit security post and the loading / unloading area under different truck arrival patterns throughout the day would be of interest. For example, assigning trucks to arrive at specific times during the day such as 9:00 AM and immediately after lunch would be of interest.

8. Recommendations for Implementation

The simulation results support adding an additional entrance lane at the security post resulting in the need for an additional exit lane under the traffic conditions discussed above. Additional unloading / loading space is justified if traffic increases by as little as 30%.

9. List of Acronyms, Abbreviations, and Symbols

CEE	Civil and Environmental Engineering
GVSU	Grand Valley State University
MIOH-UTC	Michigan Ohio University Transportation Center
ODOT	Ohio Department of Transportation
SCIS	School of Computing and Information Systems
SOE	School of Engineering
TMACOG	Toledo Metropolitan Area Council of Governments
USDOT	United States Department of Transportation
WSU	Wayne State University

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