Expanding Regional Freight Information Resources for the Upper Midwest Phase IV:

The Great Lakes Maritime Information Delivery System: A Resource for the Regional Analysis of Intermodal Freight Flows in the Great Lakes Region

Interim Report

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Executive Summary

The project reported here represents the fourth phase of a long-term effort to develop and manage the Great Lakes Maritime Information Delivery System (GLMIDS), a web-based resource designed to serve as a comprehensive data repository and information clearinghouse in support of intermodal maritime commerce in the Great Lakes and St. Lawrence Seaway region. The project phase reported here marks a major turning point diverging from previous design and development stages towards the implementation of a sustainable, long-term database management system featuring web delivery of information, an online GIS, and a secure, up-to-date and detailed repository for data in the Great Lakes Region.

This project is one component of a wider set of efforts to acquire, manage and analyze data for intermodal freight transportation in the upper Midwest that extends beyond the water to include highway, rail, air and the transfer of cargoes between these modes. By extending this wider perspective, the project team can furnish data for the study of maritime transportation within the context of the entire freight transportation system, including such diverse topics as the simulation of intermodal shipments through port facilities, the effects of competition between maritime and land-based modes, the opportunities to divert freight from congested landside modes onto the water, and in the implementation of innovative approaches to using freight such as short sea shipping (SSS) opportunities. To this end, the project team has integrated this project into an expanded scope of activity funded through contracts not only with GLMRI, but also with other organizations including The University of Toledo University Transportation Center (UT UTC), the Center for Freight Infrastructure Research and Education (CFIRE), and the US Army Corps of Engineers (USACE). The result is a comprehensive approach to the study of freight that places maritime transportation at its center.

The goal of this long term project is to maintain and continuously improve this integrated system which will thus serve as a resource for public policy decision-making and for linking maritime freight movements, economic viability, and environmental quality throughout the Great Lakes and St. Lawrence Seaway. The data gateway that has resulted from this effort is particularly focused on providing support data for analysis in several key focus areas including:

- Economic impact of Great Lakes shipping
- Safety issues associated with diverting freight traffic to Great Lakes Maritime Transportation System (GL MTS)
- Environmental impacts/benefits compared to other modes
- Shipper savings associated with GL MTS
- Congestion effects of other modes in comparison to GL MTS
- Competition effects of Maritime Transportation and rate effects in other modes
- Shift in intermodal connections and transshipment costs (*e.g.*, “full cost” studies – pavement damage, fuel, savings, crashes, *etc*.)
- The value of shipping to states, cities, regions, *etc*.
- Regional employment

Specific activities to report during this phase of the projected includes continuing work devoted to the acquisition, storage, and management of data involving vessel and commodity flows, port facilities, physical characteristics of the lakes, navigation facilities, and the economy of the Great Lakes Region. This phase of the project focused on more advanced tasks to implement the data delivery system in a higher capacity, given this, the project team identified five overall objectives for Phase IV of the project as summarized below:

- Fill major data gaps identified by the research team
  - Detailed county-level economic data
  - AIS vessel tracking

- Development and customization of analytical tools
  - Network routing
  - Intermodal transfer simulation
  - Optimization of facility locations
  - Accessibility measures to origins and destinations of cargoes
  - Analysis of alternative and proposed modes (*i.e*., short sea shipping)

- Information Delivery
  - Regional Economic Impacts
  - Aggregate Vessel Traffic
  - Aggregate Commodity Flows
  - Port tonnages
  - Regional Commodity Flows

- Linkage of the Great Lakes waterway network to the wider freight transportation system of the upper Midwest: highway, rail, air, intermodal connections, air, *etc*. (additional funds acquired through CFIRE, UTC, USACE)

- Long-term plan for sustainability
  - Begin to divert data collection, management and distribution efforts to a formal Great Lakes maritime exchange (GLMX) in association with MISNA (Maritime Information Services of North America)

  - Principal functions of exchange: 1) to furnish data in support of maritime industry in region, 2) to promote new technologies and investments in the maritime industry, 3) to assist maritime industry in providing safe, efficient, secure and cost competitive freight movements within the region.

In its present form users can take advantage of the GIS location-based query and selection capabilities as well as mapping functions. In addition, advanced analysis capabilities have been incorporated into the system. One notable function is the incorporation of *Quickmaps*. This tool allows novice users with little or no GIS experience to illustrate the linkage between freight movements to population characteristics and economic activity. Additional tools that support advanced analysis capabilities such as routing, travel time and cost computations, location optimization and site selection are undergoing final development. These functions have completed algorithms and scripting and are expected to be implemented in the next phase. As a result, the system will be fine tuned as an effective tool for economic impact analysis and economic development planning using its capabilities in measuring accessibility to markets, locating bottlenecks in the network that restrict freight flows, and identifying feasible locations for warehousing, manufacturing, retail and intermodal connection facilities. The complete GLMIDS system includes:

- A detailed data repository for vessel movements, port functions, commodity flows, economic activities and environmental impacts, *etc*.
- A GIS data viewer for advanced users to view and analyze a variety of data.

- An information delivery site for maps, tables, graphics, text and other features in the form of the ***Atlas of Great Lakes Maritime Commerce***.
- Assembly of data and report information among different geographic areas of impacts and jurisdictions (*e.g*., States and Provinces, Congressional districts, Cities, Counties, Ports, *etc*.).
- A data exchange to support user inquiries and furnish information on demand.
- Establishment of a communication link within the system (*e.g*., email access) for regional stakeholders to request specific information to be posted on the site.
- Establishment of a system for data exchange to analysts in maritime agencies and organizations; also develop a site in the system for analysts within the region to publish the results of their analysis—particularly with regard to public policy issues of interest to the Great Lakes Maritime Industry.
- Development of a library function in the form of a data clearinghouse that reviews and summarizes data from diverse sources--both public and commercial--and provide links for users to branch to from the site.
- A comprehensive centralized resource for providing linkages to additional data resources that do not necessarily represent core functions of the data repository (*e.g*., links to taxes, fees, and other tangential data); this portion of the site would also serve as a gateway to maritime agencies (*e.g*., Coast Guard, USACE, *etc*.)

The vision for the Great Lakes Maritime Information Delivery System has evolved over the course of the project to produce a multidimensional system that can support a wide array of functions that include data storage, delivery of prepared documents, GIS functionality, and a clearinghouse of information for maritime commerce. The main objective originally envisioned for the project remains the same: to maintain a long-term database and data distribution system that is available for port authorities, state transportation agencies, regional planning agencies and economic development organizations, as well as other interested decision makers and stakeholders within the region. The project team solicits feedback and suggestions for continuous improvement of the information delivery system; communication with the industry has been and will continue to be a major objective as this resource evolves and expands over years to come.

1. Introduction

The project reported here represents the fourth phase of a long-term effort to develop and manage the Great Lakes Maritime Information Delivery System (GLMIDS), a web-based resource designed to serve as a comprehensive data repository and information clearinghouse in support of intermodal maritime commerce in the Great Lakes and St. Lawrence Seaway region. The project phase reported here marks a major turning point diverging from previous design and development stages towards the implementation of a sustainable, long-term database management system featuring web delivery of information, an online GIS, and a secure, up-to-date and detailed repository for data in the Great Lakes Region.

This project is one component of a wider set of efforts to acquire, manage and analyze data for intermodal freight transportation in the upper Midwest that extends beyond the water to include highway, rail, air and the transfer of cargoes between these modes. As a result, the project team can furnish data for the study of maritime transportation within the context of the entire freight transportation system, including the simulation of intermodal shipments through port facilities, the effects of competition between maritime and land-based modes, the opportunities to divert freight from congested landside modes onto the water, and in the implementation of innovative approaches to using freight such as short sea shipping (SSS) opportunities. To this end, the project team has integrated this project into an expanded scope of activity funded through contracts not only with GLMRI, but also with other organizations including The University of Toledo University Transportation Center (UT UTC), the Center for Freight Infrastructure Research and Education (CFIRE), and the US Army Corps of Engineers (USACE). The result is a comprehensive approach to the study of freight that places maritime transportation at its center.

The overarching goal of this long term project is to maintain and continuously improve this integrated system which designed to serve as a resource for public policy decision-making and for linking maritime freight movements, economic viability, and environmental quality throughout the Great Lakes and St. Lawrence Seaway. This data gateway that has resulted from this effort is particularly focused on providing support data for analysis in several key focus areas including:

- Economic impact of Great Lakes shipping;
- Safety issues associated with diverting freight traffic to Great Lakes Maritime Transportation System (GL MTS);
- Environmental impacts/benefits compared to other modes;
- Shipper savings associated with GL MTS;
- Congestion effects of other modes in comparison to GL MTS;
- Competition effects of Maritime Transportation and rate effects in other modes;
- Shift in intermodal connections and transshipment costs (*e.g.*, "full cost" studies – pavement damage, fuel, savings, crashes, *etc*.);
- The value of shipping to states, cities, regions, *etc*.; and
- Regional employment.

1.1 Background. The background and origins of this project have been well documented in previous reports for phases I, II, and III, which were based on 1) developing the procedures and protocols for identifying data sources and collecting data; 2) designing the procedures and database structures for organizing, managing and documenting the data; 3) designing and building the system architecture to deliver the information to the wider maritime community; and 4) the selection, design, and programming of analytical tools that will ultimately be appended to the data delivery system in the GLMIDS.

The project began as an expansion of ***Midwest FreightView*** (MWFV), a multimodal online GIS (geographic information system) developed as a ***Citrix Metraframe*** application at the Geographic Information Science and Applied Geographics (GISAG) Center at The University of Toledo. MWFV was originally developed in the Upper Midwest Freight Corridor Study [1] using a specialized ***ArcView GIS*** application for selecting, displaying, and analyzing freight data for highway, rail, air and water modes. The early stages of the project concentrated on expanding MWFV to include the Great Lakes and St. Lawrence Seaway waterway networks, locks, dock facilities, and intermodal connections between maritime and landside modes. As these efforts progressed, the project team received feedback from MWFV users that the system requires a moderate level of GIS expertise; inexperienced users must spend an inordinate amount of time in learning its operation.

As a result, the project team was challenged to revise the system design to develop a more comprehensive web resource that features a more user-friendly interface, and that provides users with quick access to prepared graphs, maps, prepared text, tables, related web links, and other forms of information such as downloadable prepackaged reports of studies completed by analysts who used data from the repository. Two years of system development produced a new improved web site: ***The Great Lakes Maritime Research Information Clearinghouse*** (GLMRIC). At present, the following functions are available on the project web site:

- a directory of resources for Great Lakes Commerce;
- documentation of the contents of the database;
- access to a new update of Midwest FreightView, available through issue of a user ID and password from the project team (See project web page for contact information);
- a new structured page for inclusion of maps, graphics, etc. built into the site;
- a new structured page for viewing dock and terminal in the region; and
- a new version of ***Midwest FreightView*** with updated network and economic data.

Presently the Great Lakes Maritime Research Information Clearinghouse can be accessed at http://maritime.utoledo.edu. This newly restructured delivery system was introduced in a series of user workshops that began in February, 2009 and continued through the spring, additional workshops are being scheduled for 2010. The project team will continue to make new additions to the site as new material is produced. In addition, a number of new functions still remain in the development stage and are undergoing testing behind the scenes; they will be added to the site when they are deemed ready for inclusion and are built into the user interface. The MWFV GIS will still remain as the core delivery system for the maritime transportation database, but the project team has expanded their effort to build a more balanced, comprehensive delivery system as seen on the project web site. Ultimately the complete GLMRIC web resource is envisioned to contain the following:

- A detailed data repository for vessel movements, port functions, commodity flows, economic activities and environmental impacts, *etc*.
- A GIS data viewer for advanced users to view and analyze a variety of data.
- An information delivery site for maps, tables, graphics, text and other features in the form of the ***Atlas of Great Lakes Maritime Commerce***.
- Assembly of data and report information among different Geographic areas of impacts and jurisdictions (*e.g.*, States and Provinces, Congressional districts, Cities, Counties, Ports, *etc*.).
- A data exchange to support user inquiries and furnish information on demand.

- Establishment of a communication link within the system (e.g., email access) for regional stakeholders to request specific information to be posted on the site.
- Establishment of a system for data exchange to analysts in maritime agencies and organizations; also develop a site in the system for analysts within the region to publish the results of their analysis—particularly with regard to public policy issues of interest to the Great Lakes Maritime Community.
- Development of a library function in the form of a data clearinghouse that reviews and summarizes data from diverse sources--both public and commercial--and provide links for users to branch to and from the site.
- A comprehensive centralized resource for providing linkages to additional data resources that do not necessarily represent core functions of the data repository (*e.g.*, links to taxes, fees, and other tangential data); this portion of the site would also serve as a gateway to maritime agencies (*e.g.*, Coast Guard, USACE, *etc*.).

The vision for the Great Lakes Maritime Research Information Clearinghouse has evolved over the past three years from a one-dimensional GIS data repository to today's multidimensional system that can support a wide array of functions including data storage, delivery of prepared documents, GIS functionality, and a clearinghouse of information for maritime commerce. Even as the scope of the information delivery system has expanded, the main objective originally envisioned for the project remains the same: to maintain long-term database and data distribution system that is available for port authorities, state transportation agencies, regional planning agencies and economic development organizations, as well as other interested decision makers and stakeholders within the region. In addition, the project team is committed to developing analytical tools and data extraction capabilities to increase the power of this resource. This includes automated data gathering, software development, and expanded efforts to seek additional sources of data. These goals formed the basis for the work completed in stage IV as discussed below.

1.2 Phase IV Project Initiatives. Specific activities to report during Phase IV include continuing work devoted to the acquisition, storage, and management of data involving vessel and commodity flows, port facilities, physical characteristics of the lakes, navigation facilities, and the economy of the Great Lakes Region. A detailed inventory of data collected and managed to date is provided in Appendix I. In addition, the project team focused on a series of programming and system development tasks that build on the previous phases and raise the data collection and delivery systems to a higher level of performance. These tasks were carried out under the five overall objectives for Phase IV summarized below:

- Continued acquisition and management of highly detailed current economic data over a wide range of sectors at the county level in the U.S.;
- Acquisition and incorporation of the necessary technology for receiving, processing and storing Automatic Identification System (AIS) data for tracking vessel movements in the system;
- Continued development, refinement and implementation of a set of geographic information system or GIS-based analytical tools for users of the system;
- Integrate Great Lakes waterborne commerce data with additional data acquired for a wider range of modes in the upper Midwest from other funded projects; and
- Seek long-term sustainable sources of funding and partnerships with other organizations; proceed with the founding of a ***Great Lakes Maritime Exchange*** (GLMX) for the region to be associated with MISNA (Maritime Information Services of North America).

The remainder of this report will concentrate on meeting the five initiatives outlined here.

2. Phase IV Data Collection and Continued Development of the Project Web Site

The work presented here represents a transition from previous project phases that placed a heavy emphasis on data collection, web design and GIS-based reporting of freight transportation data. Data collection remained an important element of work in Phase IV, but an additional approach to data was included with the identification of critical gaps in the data residing in the repository. In addition, Phase IV showed a shift from earlier designs of the clearinghouse web page to a more comprehensive and robust application that implemented many of the project objectives specified in previous phases. This new web application supports secure data entry portals for dock and terminal operators in the system, it displays (with proper user permissions) vessel movements using AIS technology, and it features a wider range of links to other sites, maps and graphics, and a more comprehensive online GIS. In addition, the project team devoted more attention to the development of more advanced analytical software tools for the clearinghouse site. These analytical tools have continued to undergo testing; implementation into a seamless application launched from the web site has not yet been completed. Finally, the project team has undertaken efforts to seek alternative sources of funding and partnerships with other organizations to assure the long-term viability of this project and the Great Lakes Maritime Research Information Clearinghouse. The remainder of this report will outline these efforts in greater detail.

2.1 Continued Acquisition and Management of Data. The first major task carried out in Phase IV dealt with the continued acquisition and management of data. A complete inventory of data is provided in Appendix I. In contrast to prior phases, Phase IV also included efforts to identify and correct critical gaps in the data. The gaps in the repository can be attributed to a number of factors. In some cases, the data acquired from commercial vendors and governmental agencies have contained some serious shortcomings in terms of completeness, level of detail, sufficient coverage of all necessary economic sectors served by the Great Lakes Maritime Transportation System (GL MTS). In other cases, the methodology used to collect and organize the data (*e.g*., estimated data values *vs*. data values actually measured) is not clearly documented. In still other cases, the desired data are simply not available to the research team due to confidentiality limitations, proprietary agreements, national security, or other restrictions. In still other cases the data are simply not collected or reported.

Where economic data are concerned, data collection efforts in prior phases were hampered due to serious gaps and deficiencies based on disclosure agreements restricting the reporting of data in counties having fewer than three establishments in the same sector. This was particularly problematic with the *County Business Patterns* data residing in the repository; employment figures and related data were simply not available for a significant number of counties. To overcome this problem, the project team has identified two sources of economic data to provide reliable measures at the county-level among a wide range of sectors. These included the ES/202 County Level database from IMPLAN, Inc., a commercial source collected primarily from government sources such as the U.S. Bureau of Economic Analysis, U.S. Bureau of Labor Statistics, U.S. Census Bureau, U.S. Department of Agriculture, and the U.S. Geological Survey. A second source of data came from one of the project team's other sponsors, which consisted of a disaggregated establishment-level database obtained from Dun and Bradstreet. Acquisition of these data eliminate virtually all gaps in the County Business Patterns economic data set and provide sufficient detail and accuracy for delivery of information out of the repository. Two-and three-digit NAICS categories can now be furnished from the repository with our enhanced data.

Other desired data sets included detailed inventories of port functions, featuring commodity tonnages, equipment, intermodal connections, and related data. Much of the data for ports can be obtained, but not from the same source. As a result, the project team assigned a graduate student to identify all sources of

data for Great Lakes ports, standardize those data, and summarize them on the project web page. To date, data summaries have been completed and await posting on the project web site.

Other data missing from the desired comprehensive repository deal with vessel traffic and commodity movements over the lakes and seaway. Any data acquired by the project team are highly aggregated and summarized over the entire system. Detailed data collected and managed by U.S. Customs, the U.S. Coast Guard, the U.S. Army Corps of Engineers and private carriers were requested by the project team and denied for purposes of national security or were deemed of a proprietary nature. To overcome this limitation, the project team sought an alternative solution through the acquisition of data from the Automated Identification System (AIS). These efforts are discussed below.

2.2 AIS Vessel Tracking. The project team has turned its attention to obtaining vessel movement data through the process of automated data acquisition through Automated Identification System (AIS). Data acquired from AIS will be aggregated, assigned to the enhanced USACE waterway network database in within the repository, and related to other data gathered from other agencies and organizations. A major point to be emphasized here is that the project team recognizes the sensitivity of these data and ***will not*** disclose individual vessel movements from the clearinghouse. In fact, ***all*** disaggregated vessel movements will be deleted once the movements are aggregated and assigned to the network. First, the project team wishes to avoid any liability associated with storing disaggregated vessel movements, and second, the GISAG simply does not have the storage capacity. In addition, aggregate movement patterns will be posted with the permission of our partners in the Great Lakes maritime community. The data gathered through these efforts will then be linked to the other data within our repository to provide a more comprehensive picture of vessel traffic, commodity flows, and intermodal connectivity within the Great Lakes maritime transportation system.

Given the recent developments in the application of AIS technology in the region, the project team has begun working on acquisition of AIS data through the Automated Identification System (AIS) in partnership with Great Lakes and Seaway Shipping Online, Inc. (GLSS), a designated a 501 (c)(3) nonprofit incorporated in 2006 (*a.k.a.*, Boat Nerd). This organization has placed several AIS receivers at key points throughout the Great Lakes region and is currently planning to install additional sites. The project team is streaming these data into the repository in fifteen-minute increments. A display of vessel locations picked up by GLSS antennas are shown in a *Google Mashup* snapshot in Figure 1. In keeping with the aforementioned policy of data confidentiality, this page is not available for public access. It is the goal of the project team to acquire AIS vessel movement data and assign those movements to the waterway network for aggregate vessel movement analysis. The detailed dock inventory currently being compiled by the project team can also be incorporated to identify the specific terminals being used at port calls.

Currently, the project team is engaged in new data collection initiatives with the USACE, U.S. Coast Guard and the Internal Revenue Service in organizing data obtained through tracking vessel movements through AIS. Negotiations for the final contract are underway, the project PI will meet with the USACE in Alexandria, Virginia in November, 2009 to finalize the agreement.

Identification of data gaps and efforts to incorporate automated data collection technology will continue to be major components of data acquisition over the long run in the project. In fact, this inventory of desired data currently not residing in the repository will be an important driver in future initiatives, where the project team must expand its efforts to acquire data or find alternative sources.

Figure 1. AIS Vessel Tracking on Secure Web Page. Source: CISS, Inc.

2.3 Continued development, refinement and implementation analytical tools. In addition to data collection efforts, the project team has turned its attention more fully to improved and efficient delivery of information and continued development and testing of analytical tools for implementation in ***Midwest FreightView***. Initial design and programming of these analytical tools began during Phase III of the project, and has continued with programming and testing in Phase IV. The tools and procedures being developed will provide users with advanced capability in network routing, intermodal transfer, location optimization, market and trade area analysis for ports, and accessibility to origins and destinations of cargoes. Data delivery and display tools were developed in an effort to improve the user interface in MWFV. One notable feature that can be highlighted is the implementation of *QuickMaps* into the MWFV. The *QuickMaps* function was developed to enable users to quickly query the database with stand-alone pull down menus, identify variables to map, and display those data on the MWFV user interface. Figures II-1 through II-4 in Appendix II illustrate this function.

In efforts to develop analytical tools, an important prerequisite was the compilation and organization of specialized data sets embedded into the GIS that serve as input data for advanced analysis techniques. The first of these specialized data sets is an integrated freight network consisting of waterways, railroads and highways. The waterway component is an enhanced USACE waterway network that incorporates all of the system's navigation locks as well as individual docks. This network was compiled in a GIS format by the project team with docks and terminals from the USACE Master Dock File serving as transshipment nodes between the water network and highway and rail networks. Figure 2 shows a portion of the region's integrated network. Every dock in the system forms a node between water and landside modes (the project team is well positioned to provide accurate and current dock information, given their relationship with USACE to manage the Master Docks Plus database for the Great Lakes). Node attributes such as commodity type, loading/unloading equipment, berthing dimensions, and related characteristics are encoded for each node. Routing through docks is thus restricted to commodity types, berthing dimensions, carriers having access to the dock, *etc*. Dock facilities were classified in detail and

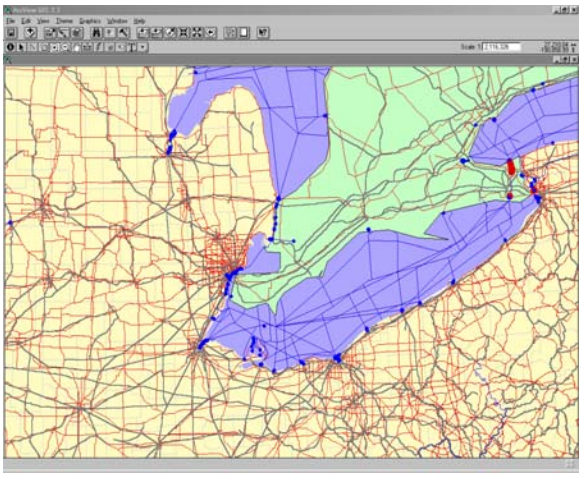

Figure 3. Intermodal Network in Great Lakes
Blue Lines: *USACE Water Links*
Red Lines: *Highways (ORNL/NHPN networks)*
Grey Lines: *ORNL Rail Network*
Blue Dots: *USACE Docks (Master Dock File)*
Red Dots: *Navigation Locks*

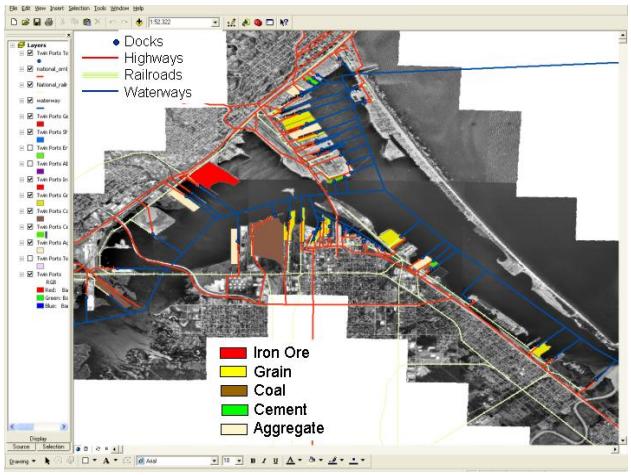

Figure 4. Close-up on Port of Duluth/Superior
"Last mile" connections between waterway network and landside Dock facilities classified by commodities (Source: *Terra Server Imagery*).

georegistered to the GIS database using air photos and satellite imagery (See Figure 3). In addition to docks serving as navigational routing nodes, each navigation lock in the Seaway and the Sault Locks are encoded as nodes in the network. The project team is currently engaged in assigning lock performance statistics to the locks as a means to describe dwell times, throughput times, *etc*., in order to enable simulation of vessel movements through the system. The source of these data on the U.S. side is the USACE LPMS database (the project team is still seeking data for Canadian locks in the Seaway).

The highway network component of this integrated network is the synthesis of the Oak Ridge National Laboratory's Center for Transportation Analysis' highway network (ORNL Highway Network) and the FAF National Highway Planning Network (FAF NHPN). This network thus forms the framework for the execution of specialized routing algorithms that are under development which incorporate not only pathfinding algorithms, but also intermodal transfer through nodes based on cargo type, presence of adequate rail or highway connections, equipment and berthing space at docks, and other characteristics. These routing utilities will permit users to perform a number of functions including network routing, intermodal transfer simulation, and measurement of accessibility to origins and destinations of cargoes. Additional functions will also be added that include identification of optimal facility locations based on location relative to the intermodal network and proximity to markets and origins of shipments. As mentioned previously, analysts will also be able to perform studies of alternative and proposed modes for shipping goods throughout the region (*i.e*., short sea shipping) and diverting traffic onto the Great Lakes maritime transportation system.

Each network contains a unique set of features and attributes not duplicated elsewhere; when these features are combined into a single network, they provide a detailed set of physical characteristics and travel information that can be adopted for a variety of planning and routing functions. In addition, the project team included speed limits to this integrated network that were not originally encoded. The ORNL Rail Network is a second specialized data source for analysis. These data, along with county-to-county centroid mileage and impedance tables by water, rail, and highway modes have been entered into the repository and form the principal input data for models developed by the project team.

These data are currently combined with a wide range of prototype support functions designed for the system. Many of these functions are based on analytical tools for evaluating intermodal transportation opportunities in the Great Lakes Region. Efforts begun in Phase III to develop prototype software modules were in intensified in Phase IV. These modules include the following:

- intermodal routing of cargoes between water and landside modes based on designated origins and destinations;
- location optimization and site selection tools for manufacturing, warehousing, distribution centers, other facilities;
- accessibility computations for trade area analysis, site selection, and regional development;
- performance metrics and statistical reports for the transportation network; and
- economic analyses (input-output, economic impacts, *etc*.)

Software development for these functions has been under development and is nearing completion for implementation into the system in the next phase of the project. One example of the development of prototype software is in calculation of geographic accessibility measures that can be directly mapped in MWFV. Figures II-5 through II-12 in Appendix II illustrate the application of this utility. Geographic accessibility can be defined as a measure of the aggregate proximity of a particular set of facilities relative to a location or set of locations—it is a running measure of density or concentration that can be mapped in the form of a surface. Those regions that contain a large number of nearby facilities with significant production volumes will be more accessible than other regions with fewer facilities or those more distant regions that do not contain any significant number of facilities. Thus, suppliers to the automobile industry will want to locate on those regions having higher concentrations of auto manufacturers in order to reduce transportation costs and to provide adequate just-in-time delivery of parts. In a similar manner, ports can use these measures of the concentration of specific industries or distribution centers to determine whether they are in a position to market their services for delivery to these locations or to identify the potential extent of their surrounding trade areas for shipments of particular types of goods or commodities. The utilities producing the maps in Appendix II-5 through II-12 can provide these insights.

In other developments, members of the project team have worked with GLMRI and CFIRE partners in furnishing data for economic impact studies, input-output analyses, and computation of performance metrics and freight statistics for both the Great Lakes maritime transportation system and the landside networks in the region.

2.4 Continued long-term sustainable sources of funding and partnerships. One of the charges to the project team in this endeavor was to develop the means for long-term sustainability of the repository and information delivery system. The project team responded over the past year by entering into a dialogue with Harbor House Publishers, the new publishers of *Greenwood's Guide to Great Lakes Shipping* to develop a web site for this publication. It is envisioned that such a partnership would yield significant results by minimizing conflicts between a private sector firm and a publicly-funded university, and that both could benefit from subscription fees charged for use of the site. In addition, the project team could furnish data to Harbor House Publishers and vice versa. Greenwood's Guide would thus have a web outlet and a wider array of functions for subscribers through the GLMIDS and access to MWFV. Negotiations are still underway in this endeavor.

Another option for long-term viability is for GLMRI and its partners in the maritime community consider the establishment of a ***Great Lakes Maritime Exchange*** (GLMX) in the form of a non-profit organization that would be financed through subscription fees by its partners in the industry. There are a number of

such exchanges in the coastal regions of the United States and in British Columbia. These exchanges partner with one another through MISNA, an umbrella organization of non-profit ***501(c)(6)*** maritime exchanges in the United States and British Columbia. According to MISNA, the marine exchanges comprising this organization carry out a range of tasks that include:

- Advance Vessel Schedule Information, including ETAs and ETDs
- Advance and real-time vessel movement monitoring (AIS)
- Actual Arrival and Departure Data
- Vessel Traffic Analysis
- Historical Vessel Movement
- Port and Terminal Utilization Studies
- Promote Maritime Interests
- Expert Maritime Analysis and Assistance with Regulatory Compliance [1].

One of the main functions for many of the maritime exchanges is real-time vessel tracking using the AIS System as shown in the Great Lakes/St. Lawrence Seaway system [2]. The advantages noted at their web site is that continuous tracking enhances safety, optimizes transit times through better traffic management, optimizes scheduling of lock passages, improves fleet management for ship owners and assists in navigation through the system, provides faster response times following accidents/incidents, provides data to support national security efforts, and assists in tracking hazardous cargoes [2].

It is further argued here that continuous tracking of vessels can provide a means for effective coordination of intermodal connections in short sea shipping. The system can also provide input functions for long-term vessel tracking such as with the Automated Secure Vessel Tracking System [3]. Long-term vessel tracking can provide useful data to track total vessel traffic over the entire system—including specific channels where dredging is needed or other navigation improvements are required. Continuous vessel tracking can also provide needed data to track vessel emissions and to demonstrate savings in overall emissions by diverting freight traffic from rail and highway to the lakes.

Maritime exchanges maintain strict confidentiality with their client organizations and do not disclose data among organizations without authorization. As discussed previously in this report, the same approach would be adopted in the Great Lakes. Thus a Great Lakes maritime exchange could serve as another partner with GLMRI and the maritime industry as a commercial resource and merits consideration.

Members of the project team have continued in efforts for the formation of a Great Lakes Maritime Exchange (GLMX), in partnership with the Lake Carriers Association and other stakeholders in the maritime community. This discussion has continued with the Lake Carriers Association and with the Maritime Information Services of North America (MISNA). The project team participated in a formal MISNA meeting in Cleveland on October 20th & 21st, 2008 where progress was made toward achieving this goal. The project team having access to AIS data will progress the GLMX organization.

One further development has been the partnership of the project team with the U.S. Army Corps of Engineers Navigation Data Center to develop the prototype data entry system for the MD+ Master Dock File for the Great Lakes. The project team has entered into a second contract with the U.S. Army Corps of Engineers to further test the data collection protocols for this system.

3. Conclusion

The Great Lakes Maritime Research Information Clearinghouse has evolved over the course of the project to produce a multidimensional system that can support an array of functions that include data storage, delivery of prepared documents GIS functionality, and a clearinghouse of information for maritime commerce. Despite the evolving nature of this process, the main objective originally envisioned for the project remains the same: to maintain long-term database and data distribution system that is available for port authorities, state transportation agencies, regional planning agencies and economic development organizations, as well as other interested decision makers and stakeholders within the region. The combined vision of the Great Lakes Maritime Research Institute, the project team and our partners in the industry has led to the version of the Great Lakes Maritime Research Information Clearinghouse presented here. While this research report can document the progress of this project, the real outcomes of the project lie in the project web site, data repository, and the ***Midwest FreightView*** GIS data delivery system.

Progress was made in each of the categories listed below as originally outlined in the project proposal:

- Fill major data gaps identified by the research team
  - Detailed county-level economic data
  - AIS vessel tracking
- Development and customization of prototype analytical tools
  - network routing
  - intermodal transfer simulation
  - optimization of facility locations
  - accessibility measures to origins and destinations of cargoes
  - analysis of alternative and proposed modes (*i.e.*, short sea shipping)
- Information Delivery – integrate waterborne data into a wider perspective
  - Regional Economic Impacts
  - Aggregate Vessel Traffic
  - Aggregate Commodity Flows
  - Port tonnages
  - Regional Commodity Flows
- Linkage of the Great Lakes waterway network to the wider freight transportation system of the upper Midwest: highway, rail, air, intermodal connections, air, *etc*. (additional funds acquired through CFIRE, UTC, USACE)
- Long-term plan for sustainability
  - Begin to divert data collection, management and distribution efforts to a formal Great Lakes maritime exchange (GLMX) in association with MISNA (Maritime Information Services of North America)
  - Principal functions of exchange: 1) to furnish data in support of maritime industry in region, 2) to promote new technologies and investments in the maritime industry, 3) to assist maritime industry in providing safe, efficient, secure and cost competitive freight movements within the region.

The resulting system discussed here is designed to provide the Great Lakes maritime community with a comprehensive centralized resource for data and information. However, it should be emphasized that this project represents a single phase of a continued work in progress; the project team has devoted

considerable effort to the development of a set of analytical tools in the form of stand-alone software that will be incorporated into ***Midwest FreightView*** in the next phase of the project.

Phase IV of this project represented the turning point from initial development phases toward long-term sustainability of the system. Efforts were focused on filling economic and vessel movement data gaps left from previous phases. Further efforts concentrated on the final development and customization of analytical tools for incorporating into MWFV. In addition, the information delivery process was enhanced by incorporating data from a wide array of partners with the waterborne data from GLMRI. Finally, the groundwork is being laid to create the foundation of a GLMX through contracts and associations with additional partners such as USACE, MISNA, GLSS, CFIRE, and UTITI (University of Toledo Intermodal Transportation Institute). These associations and partnerships support the long-term viability of this system. The project team will strive to maintain an open dialog with the members of the industry to assure success in this endeavor. Our dialog has also expanded to a wider audience through the dissemination of results shown in the references section of this report.

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[4] Maritime Information Service of North America (MISNA), (2006) (Internet), *Automated Secure Vessel Tracking System (ASVTS)*, (cited September, 2006), http://www.asvts.org

Dissemination of Results: Phase I-Phase IV

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APPENDIX I

Contents of Data Repository

Much of the data acquired in prior phases of this project came from existing sources—both commercial and government. The data are currently being stored on designated server space at the GISAG Center at The University of Toledo. While the project team maintains a significant volume of data, not all of the repository's contents are available on the project web site. Some data are proprietary and cannot be widely distributed. For example, economic data are available for analysis with partner institutions and joint projects, but cannot be displayed on the project web page. In other cases, the data must be reformatted for compatibility with the remainder of data in the repository and are not yet displayed on the project web page. The list of data currently residing in the repository are listed as follows with a notation of whether they are currently displayed on the project site.

1. Intrastate employment patterns for each commodity type by SIC, NAICS, (displayed by counties and census tracts) (Demographics Plus, Inc. *Business Counts Database*) Available in *Midwest FreightView.*

2. Population and Socioeconomic data representing Market Demand within the region (displayed by counties and tracts) Available in *MidwestFreightView.*

3. ORNL CTA Highway and Rail networks (including RR interlining network) Available in *MidwestFreightView.*

4. Entire contents of North American Transportation Atlas (BTS) Available in *MidwestFreightView.*

5. Port Locations—U.S. (BTS National Transportation Atlas) Available in *MidwestFreightView.*

6. Dock Locations (Army Corps of Engineers) and attributes Available in *MidwestFreightView.*

7. Waterway Network—Great Lakes and Inland Waterways (Army Corps of Engineers) Base network Available in *MidwestFreightView*; prototype network connected to intermodal network not yet available on project web site.

8. FAF Zones and Centroids Available in *MidwestFreightView.*

9. Baseline FAF 2002 and provisional 2007 FAF^2 commodity flows into and out of the Great Lakes Region (based on desire lines) obtained from the FHWA Freight Analysis Framework. Available in *MidwestFreightView*;

10. Employment by NAICS Classification among Counties and MSAs in Study Region (Source: Minnesota IMPLAN Group); Partially available in *MidwestFreightView*. Full database available for joint projects upon request from project team.

11. Lock locations and lock performance statistics—U.S. side. In prototype format and not available on the project web site.

12. Weather Station Data (NOAA, to approx. 60 Miles Inland). Selected temperature data available in *MidwestFreightView*.

13. Updated US Highway Network that combines the HPMS and ORNL Network attributes and includes speeds and estimated travel times on links. Available in *Midwest FreightView* but not fully functional for modeling purposes.

14. Integrated Network—Great Lakes Waterway, Highway, Rail linked to Commercial Docks, Locks (Army Corps of Engineers). In prototype format but not available on project web site.

15. MARAD Annual Vessel Movements (1994-2004). Residing in repository but not displayed on project web site. Available for ftp upon request from the project team.

16. Import/Export Flows (Great Lakes East Coast and Gulf Ports). Residing in repository but not displayed on project web site. Available for ftp upon request from the project team.

17. Satellite Imagery/Aerial Photography of Dock Facilities Available on project web site.

18. Updated Mexican and Canadian Rail and Highway Networks Available in *MidwestFreightView.*

19. Vessel Inventory—Great Lakes Fleet Residing in repository but not yet displayed on project web site

APPENDIX II

Developments in Data Delivery within *Midwest FreightView*

Demo 1: QuickMap Functions

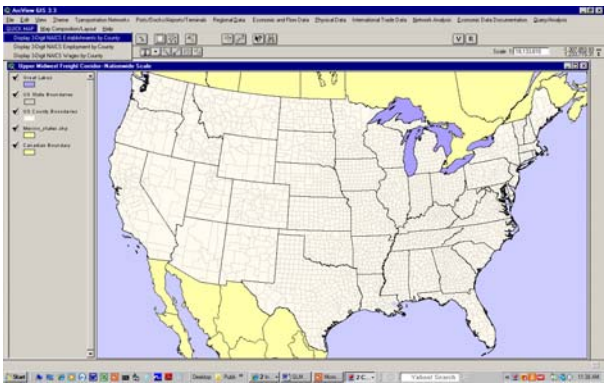

Figure II-1
MWFV display. Accessing the *QuickMap* function to display county level employment in the map.

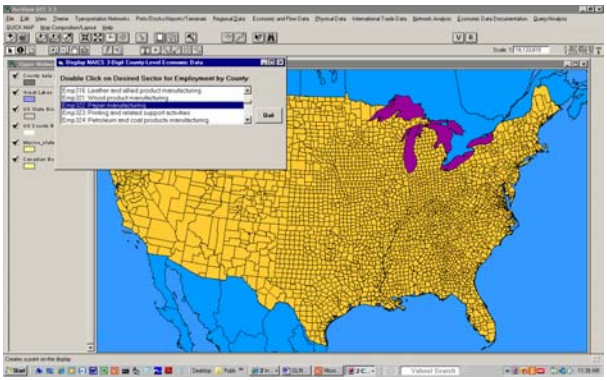

Figure II-2
The *QuickMap* pull down menu selects three digit NAICS code to map. Note that the NAICS code is displayed along with text description. In this case, the variable is Paper Manufacturing.

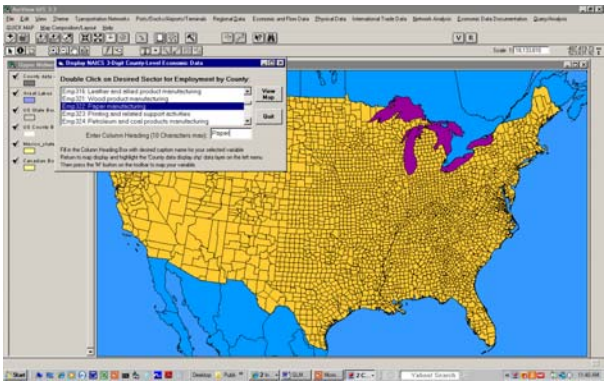

Figure II-3
The *QuickMap* pull down menu features a user-defined variable description for mapping back in MWFV.

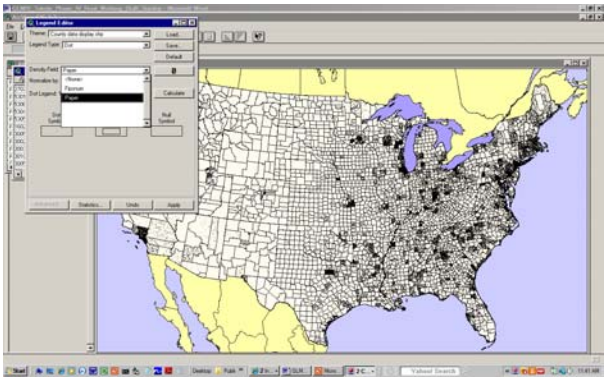

Figure II-4
The MWFV mapping pull down menu displays the user-defined variable and provides user options for mapping. In this case, MWFV produces a dot distribution map of Paper Manufacturing employment (one dot = 10 employees).

Demo 2: Accessibility Computations

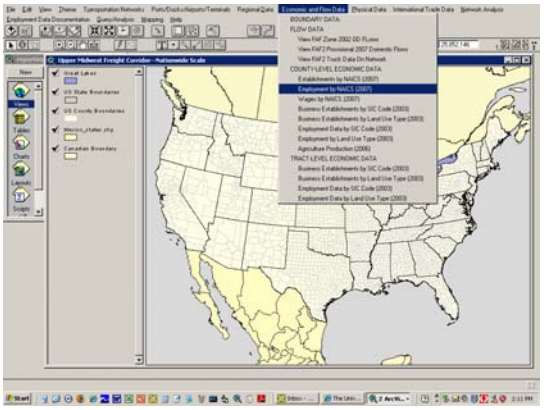

Figure II-5
MWFV display. Open data display menu and access the "Accessibility Computation" Utility.

Figure II-6
The "Accessibility Computation" pull down menu selects three digit NAICS code to compute index for. Note that the NAICS code is displayed along with text description. In this case, the variable is Fabricated Metal Product Manufacturing.

Figure II-7
A new pull down menu appears to select the desired accessibility computation. This menu enables users to select the mode, impedance value, accessibility display technique, and the computation method.

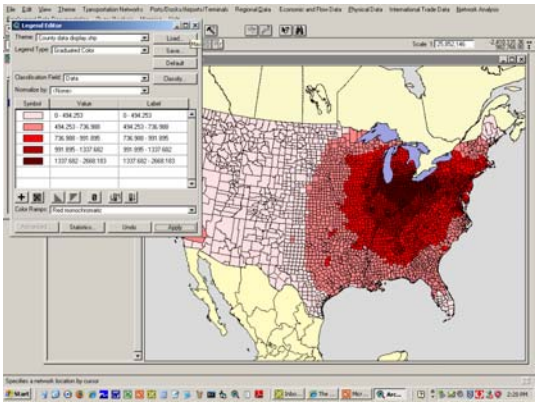

Figure II-8
The MWFV mapping pull down menu displays the map display of continuous accessibility via highway to Fabricated metal Product Manufacturing. The darker regions show those areas closest to the greatest number of firms in this economic sector.

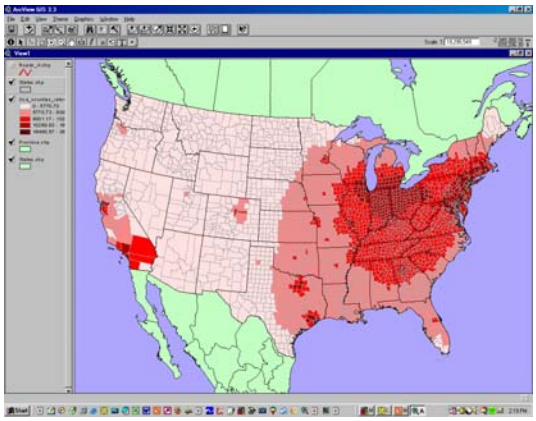

Figure II-9
In this example, MWFV displays continuous accessibility to Wholesale Trade. The darker regions show those areas closest to the greatest number of firms in this economic sector.

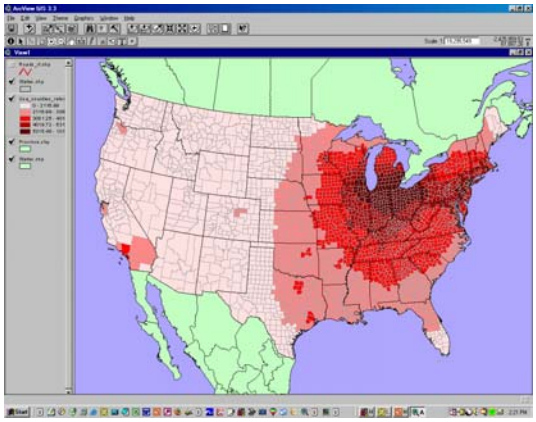

Figure II-10
In this example, MWFV displays continuous accessibility to Heavy Equipment Manufacturing. The darker regions show those areas closest to the greatest number of firms in this economic sector.

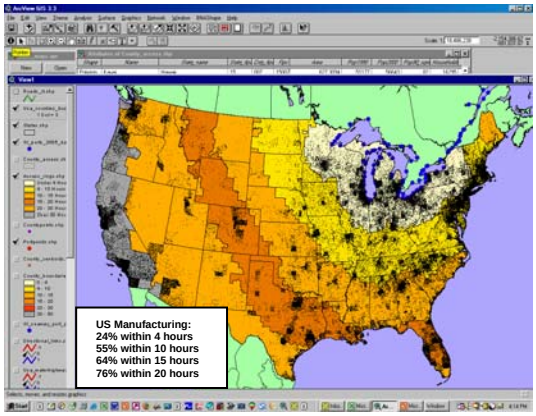

Figure II-10
In this example, MWFV displays combined accessibility from all Great Lakes ports; This map is a measure of impedance (drive time) from each county to their nearest Great Lakes port, thus showing the proximity of the Great Lakes to all manufacturing by county.