Marine Highway System (MHS)
(A Multimodal Short Sea Freight Shipping System)

Version: 1.0
Prepared by:

Surface Congestion Reduction Analysis & Modeling Team (SCRAM)

In partial fulfillment
Of
Requirements for
OR 680 Spring 2010

Date: February 11, 2010

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1 Introduction

1.1 Background

With an ever increasing emphasis on efficiency, one wonders if there is room for improvement in the transportation of goods. Companies and individuals are interested in not only optimizing cost and time but more recently, the carbon footprint of producing the various goods that fuel daily life. Regardless of the origination of goods (international or nationally production and manufacturing), there is a significant requirement for highway travel for interim and final destination delivery. Combining this demand with everyday commuting demands is one of the major contributing factors to our growing roadway congestion. According to the "National Strategy to Reduce Congestion on America's Transportation Network," Department of Transportation (May 2007),"...congestion is costing America an estimated $200 billion a year.[1]" Nearly 98 percent of all domestic freight, including through ports, moves on the United States' nation's highways and railroads[2]. The Federal Highway Administration study entitled, "Estimated Cost of Freight Involved in Highway Bottlenecks – Final Report," indicates that, on average, there are currently 10,500 trucks per day per mile on the Interstate Highway System. But by 2035, that volume is expected to double to 22,700 trucks, with the most heavily used portions of the system seeing upwards of 50,000 trucks per day[3].

Urban communities will feel the greatest impact from the traffic volume increases. According to the Department of Transportation (DOT), trucks account for almost 40 percent of the time Americans spend stuck in traffic in the 50 most congested urban areas. Until recently, additional capacity demands were met by adding more highway lanes. But this is no longer a realistic option. Recent reports indicate that between highways and railroads more than $300 billion is needed to meet this future capacity demand. In addition, in 2007 more than 60 percent of federal highway funding went toward maintenance of existing roadways, leaving little for new development to help increase capacity[4].

With the economic climate, the steady increase in population (and therefore demand), and the growing concern about global warming/cooling, the exploration of alternative methods for goods transport has become a priority. In addition to the growing research in alternative fuels and "just-in-time" delivery planning methodologies, freight movement options for trains and ships could provide viable solutions.

The Department of Transportation published an interim final rule on Oct. 9, 2008, establishing a framework to provide federal support to expand the use of America's Marine Highway. (You can also see the Stay of Effectiveness.) The four primary components of the framework are:

[1] http://isddc.dot.gov/OLPFiles/OST/012988.pdf
[2] http://www.marad.dot.gov/ships_shipping_landing_page/mhi_home/mhi_home.htm
[3] http://www.fhwa.dot.gov/policy/otps/freight.pdf
[4] http://www.marad.dot.gov/ships_shipping_landing_page/mhi_home/mhi_home.htm

1. Marine Highway Corridors: Designating Corridors will integrate the Marine Highway into the surface transportation system and encourage the development of multi-jurisdictional coalitions to focus public and private efforts and investment.
2. Marine Highway Project Designation: Designating Marine Highway Projects is aimed at mitigating landside congestion by starting new or expanding existing services to provide the greatest benefit to the public in terms of congestion relief, improved air quality, reduced energy consumption and other factors. Designated Projects will receive direct support from the Department of Transportation.
3. Incentives, Impediments and Solutions: The Maritime Administration, in partnership with public and private entities, will identify potential incentives and seek solutions to impediments to encourage utilization of the Marine Highway and incorporate it, including ferries, in multi-state, state and regional transportation planning.
4. Research: The Department of Transportation, working with the Environmental Protection Agency, will conduct research to support America's Marine Highway, within the limitations of available resources. Research would include environmental and transportation benefits, technology, vessel design, and solutions to impediments[5].

1.2 Problem Statement and Scope

The primary effort is to analyze the viability of moving freight traffic from Interstate 95 (I-95) to marine highways. This requires the conduct of a comparative analysis on the payoffs to major congestion bottlenecks to include the following components: congestion, fuel savings, and efficiency for moving freight. Additionally, we propose using simulation to provide an analytically rigorous recommendation that would be productive and useful to support emerging initiatives under consideration by US DOT and the Congress on marine highway planning.

The preliminary analysis will be on a small scale by considering a short corridor. If the results of the preliminary analysis prove viable, the next step will be to propose a sufficient design and estimation of the benefits and payoffs. If the results of the preliminary analysis prove non-viable, the results will be investigated to understand what factors make it non-viable.

One important involvement for the team will be to select one inland and one marine highway route that will serve to reduce traffic bottlenecks in and around I-95 and explore options for moving freight traffic to marine highways.

1.3 Customer and Stakeholders

The project is sponsored by Dr. K. Thirumalai (Research Professor, George Mason University, Department of Civil, Environmental & Infrastructure Engineering) and Dr. Chun-Hung Chen (Professor, Department of Systems Engineering & Operations Research).

Other collaborators and stakeholders include:

- I-95 Corridor Coalition
- Virginia Department of Transportation

[5] http://www.marad.dot.gov/ships_shipping_landing_page/mhi_home/mhi_home.htm

- Virginia Port Authority
- Port Authority of New York and New Jersey
- Rutgers (Center for Advanced Infrastructure and Transportation-Freight Traffic Analysis, Intermodal Systems)
- DLR German Transportation Research Center (Short Sea Shipping, CRS & SI Applications)
- GEOEYE – World Leaders in Imageries (CRS & SI Data Systems)
- CSC/AMC Modeling & Simulation (Marine Operations, Multimodal Systems)
- GMU (CRS & SI Tech Applications, Infrastructure Systems, Freight Analysis)

1.4 Surface Congestion Reduction Analysis & Modeling Team (SCRAM)

1.4.1 Karen Davis

Ms. Davis, is a Senior Consultant with Booz Allen Hamilton, providing operations research support for the military medical programs across the Department of Defense (DoD). She has over 8 years of analytical and research experience. She has more than 6 years of experience applying these analytical skills within the DoD and Government. Ms. Davis has continually developed professionally through completing courses and training such as the Program Analysis & Evaluation Analyst Course, Combating Bioterrorism: Implementing Policies for Biosecurity, Operational Test and Evaluation Directorate (DOT&E) Staff Officer Training Course, and the Joint Medical Planners Course. Currently, Ms. Davis has a B.S. and M.S. degree in mechanical engineering and is working on the completion of her second M.S. degree in operations research.

1.4.2 Greg Haubner

Mr. Haubner is a Military Operations Analyst at Systems Planning and Analysis, with 10 years of professional experience. He currently provides on-site support to OPNAV N14, within the Navy's Manpower, Personnel, Training, and Education (MPT&E) domain, analyzing various issues related to Navy recruiting policy, performance, and resources. He also has experience analyzing surface warfare requirements and campaign plans in support of OPNAV N81/6. Before joining SPA, Mr. Haubner served on Active Duty in the United States Navy for five years. He also spent two years in the financial sector prior to joining the military. Mr. Haubner holds a B.S. in Industrial Engineering and is currently working to complete his M.S. in Operations Research.

1.4.3 James Hingst

Mr. Hingst is a Senior Engineer with Modern Technology Solutions, Inc., providing operations research and engineering support to advanced and special technology programs within the Department of Defense. He has 18 years of technical analysis experience across several disciplines, ranging from the modeling and analysis of chemical kinetics, development and analysis of operational air campaign plans, through the application and analysis of advanced technologies to near term missile defense. Mr. Hingst holds a B.S. in Aeronautical Engineering and is pursuing an M.S. in Operations Research.

1.4.4 Bill Judge

Mr. Judge is a senior analyst with Metron, Inc. providing analytic support to the OPNAV N2/N6, that directorate that is responsible for making the budget for Navy Intelligence, Communication and Information Technology. Projects have included assessments of programs performance, translating mission level modeling results into prioritized requirements and assessing impacts of various vulnerabilities, He has supported OPNAV in this capacity for three years and previously worked in a similar capacity for the Federal Aviation Administration.

1.4.5 Christopher Zalewski

Mr. Zalewski is a civilian Operations Research Analyst for the United States Air Force. He has supported studies and analyses for the Air Force and Department of Defense for 18-years as a consultant before moving to a civilian position. In this time he has conducted analyses using discrete event simulation and linear programs. Mr. Zalewski has a B.S. in Aerospace Engineering and an M.S. in Technology Systems Management. He is currently pursing his M.S. in Operations Research.

2 Technical Approach

2.1 Problem Formulation and Analysis

Develop and utilize a scalable, discrete event simulation model to assess the advantages and benefits of transferring shipments from land to marine highways. This should include the following:

- Inland Waterway: Routing from the Port of Virginia terminals (Portsmouth, Newport News and Norfolk) through James River to Parham Landing
- Coastal Waterway: Sea route from the Ports of Virginia (POV)
- Last Mile Analysis : Port access ways in selected ports

2.1.1 Preliminary Problem Statement

While the scope of the problem may still be refined after meeting with our sponsors, our preliminary problem statement is currently as follows:

Analyze benefits and costs associated with implementation of marine highways to alleviate congestion on surface routes. To this effect, the group will analyze two waterways, one inland and one coastal, with potential for reducing freight traffic on surface routes, specifically Interstate 95 (I-95). Broadly speaking, metrics will include reduced landside congestion, efficiency of moving freight, air quality improvements, reduced energy consumption and offsetting savings to landside infrastructure maintenance or construction costs,

Our sponsors have advised us that “starting from a small s[c]ale by considering only a short corridor is fine,” with the goal of using simulation to provide a “rigorous and quantitative recommendation” on the viability of the marine highways.

2.1.2 Assumptions and Limitations

The full scope of the Marine Highway Project extends well beyond our group here at George Mason University. As mentioned above, there are several state, federal, and corporate entities with vested interest in the outcome of the full study. As such, we understand that our analysis will represent only a small piece of the much larger effort. In an effort to provide as much value to our customer in the limited time we have, the following are some assumptions we will make to help us achieve our goal of a useful, scalable simulation of marine highway alternatives:

1. For purposes of building a discrete-event based simulation of potential marine highways, the group will use ARENA software. The software was recommended by our sponsors, and all team members have experience using it through their coursework at GMU, specifically in OR 635.
2. Every effort will be made to seek realistic data for use in our model, from cargo unloading rates on the pier to terminal container capacity. However, where data references are not readily available, the group will consult with our sponsors to discuss reasonable estimates. We do not want to slow the development of our simulation due to one or two inputs that can be updated later, if necessary.
3. Variable and fixed costs associated with operating and maintaining freight vessels and trucks will be researched in as much detail as possible. These will include, but are not limited to: fuel consumption, berthing fees, tolls, maintenance costs, and labor costs. Fixed costs will be analyzed utilizing an annualized average. Variable costs will depend on the amount of freight being shipped, either by weight or by container.

Once the modeling effort gets underway, we will no doubt encounter a few other obstacles along the way. Those will be addressed in conjunction with our sponsors as they arise. In the end, our goal is a scalable simulation, that is, one in which greater detail can be added to the model with relative ease when evaluating various marine highway candidates in the future.

2.2 Requirements Definition

The following requirements were determined after a review of the sponsor's proposal and accompanying information.

1. Develop a discrete-event based simulation for a marine highway system.
2. Estimate the impact of the marine highway on surface route congestion, specifically on I-95.
3. Provide comparison of end-to-end transportation time using surface and marine routes.
4. Provide comparison of total cost using surface and marine routes.

The requirements mentioned above represent our understanding of the project and goals based on a review of several high-level briefs and limited communication with our sponsors. However, we are planning a face to face meeting with our sponsors to make clear exactly what their expectations are for our group. This way we can be sure that we have correctly interpreted our role. It should be noted that recent inclement weather has played a part in our being unable to meet with our sponsors thus far.

2.3 Preliminary Methodology

We propose to design a discrete event simulation which captures the essential elements related to the transportation of freight. Initial thoughts are that the Arena (Rockwell Software) simulation tool will be used, but we are leaving open the possibilities of developing a network optimization using MPL.

2.3.1 Project Design and Development

2.3.1.1 Data Collection and Research

Prior to any detailed simulation development, the team must understand the processes involved with transporting freight. This process will be researched from both the ground transportation and short sea shipping approaches.

Data collection and research will consist of interviewing the primary stakeholders, online research, and (where gaps in data exist) educated guesses. For the ground transportation portion, we intend to research the primary travel routes along the I-95 corridor along which freight is moved by truck. For the short sea shipping portion, we will focus on the operations of a couple key dock facilities in Virginia and the New York/New Jersey areas from which a marine highway system could run.

Regardless of a land or sea route, there are common data types which are needed, such as:

- Road and marine network distances
- Transportation options (ship/truck size, capacity, speed, etc…)
- Costs (fuel, maintenance, labor, fees, taxes, etc…)
- Freight transfer methodologies

It is expected that several weeks will be dedicated to data collection and research. Concurrent with this data gathering, preliminary designs will be created for a network design to be optimized and an Arena simulation of the process. As data is gathered and stakeholders are interviewed, these tools will be refined to better reflect the system being modeled.

2.3.1.2 Preliminary Optimization

Currently, we envision the options between a road or short sea shipping routes as a network that can be optimized. We plan on using MPL to build a linear program to assess the various road or sea transportation methods (size options of transport vehicles). We have chosen this approach because all members of the group have had exposure to basic linear programming methodologies.

This network will be a series of arcs and nodes to represent goods traveling from a warehouse (the source) in New York to some other warehouse (the sink) in Virginia. The model developed will attempt to maximize the amount of freight moved in the minimum amount of time. The network between the two points would represent the road and sea options available to move these goods.

Since travel times, loading queues, fuel costs, etc. can all introduce non-linear aspects to this problem, the linear program developed will be used as a screening tool of the various classes of

transportation options. A class option refers to the cargo capacity of a given means for transport. For example, from the numerous sizes of transport ships and freight trucks, a few of each will be selected to be run in the detailed simulation.

2.3.1.3 Preliminary Simulation

The network developed in the optimization portion of our analysis will be used as a template for a detailed Arena simulation. Each node of the network can be further detailed by the processes that go on at that node. For example, one node in the network may represent a transfer point where goods in a cargo container are moved from a truck or train onto a ship for sea transport. In the optimization, this node may be represented by a single time value where in the simulation a distribution on the times needed and the queues involved can explicitly be captured.

Since a goal of this project is to evaluate the differences between the land and sea shipping methods, one proposal is to develop two similar Arena simulations; one for road and one for sea. Each will focus on the details on their respective transportation processes. This approach will break up the work between team members during the simulation phase of the project. The second proposed approach would be to develop a single discrete event simulation encompassing both the road and sea networks.

3 Expected Deliverables and Results

The outcome of this project will be results that are useful in supporting emerging Marine Highway System initiatives being investigated by the client and associated stakeholders. To that end, a quantitative analysis will be performed using both optimization and simulation techniques and delivered to illuminate the potential benefits and shortfalls of such a system. Primary measures will be a reduction in I-95 traffic and congestion, fuel savings, and freight movement efficiency, leading to an assessment and recommendation of a design to maximize benefits. The optimization and simulation tools developed will be delivered to allow further development or analysis of alternatives that are not within this project's scope.

3.1 Optimization Deliverables and Results

The optimization tool that will be developed will be used to quickly and intelligently collapse the multivariate design space involved in a Marine Highway System development to a subset of those designs with the potential for high benefit that would be suitable to comparatively analyze via more detailed simulation within the limits of what may be accomplished in a semester of work. It is anticipated that several inland and coastal waterway designs will be the end products to compare against each other and the status quo.

3.2 Simulation Deliverables and Results

A detailed, scalable, discrete event simulation will be developed to comparatively analyze the designs developed in the optimization process in order to more fully quantify the benefits and shortcomings of each option. The end result will be a quantitatively substantiated recommendation on the viability and design of a Marine Highway System that shows promise in reducing congestion within the I-95 corridor as well as increases in fuel and freight movement

efficiencies. If such benefits are not to be found, root causes and primary drivers will be determined and presented to inform potential mitigation actions via public policy or other means.

4 Project Plan and Schedule

The feasibility analysis of diverting freight traffic from congested highways to marine highways will have three phases: data collection, analysis and assessment. A notional Gantt chart with phases and subtasks has been composed but, contrary to the timelines defined, there will likely be changes in duration and overlap between phases as the project progresses to allow for smooth transition between phases and accommodate variability in task complexity. The majority of the project resources will be expended during the data gathering phase which will serve as a bounding analysis to the project. The data collection phase will also select several alternative seaborne freight routes for further analysis. After the data collection phase is complete an analytic methodology will be selected that is appropriate for comparing the selected alternatives and analysis will start in earnest. The final assessment phase will bring together all the findings from the project and detail the supporting information, and keys factors that govern the maritime highway feasibility.

4.1 Phase 1: Data Collection

The data collection phase will consist of scoping, selection of potential marine highway alternatives, costing those alternatives, determining the available demand for transport on the alternatives and figuring out the efficiency associated with the alternatives. This portion of the project will be the greatest share of the work and will also serve as a bounding analysis to the project. As the team develops a greater understanding of the factors that affect marine highways the selection of viable candidates for further study will be more apparent. After alternatives are selected, costs associated with those alternatives will be formalized and simultaneously time and fuel efficiency estimates will be developed.

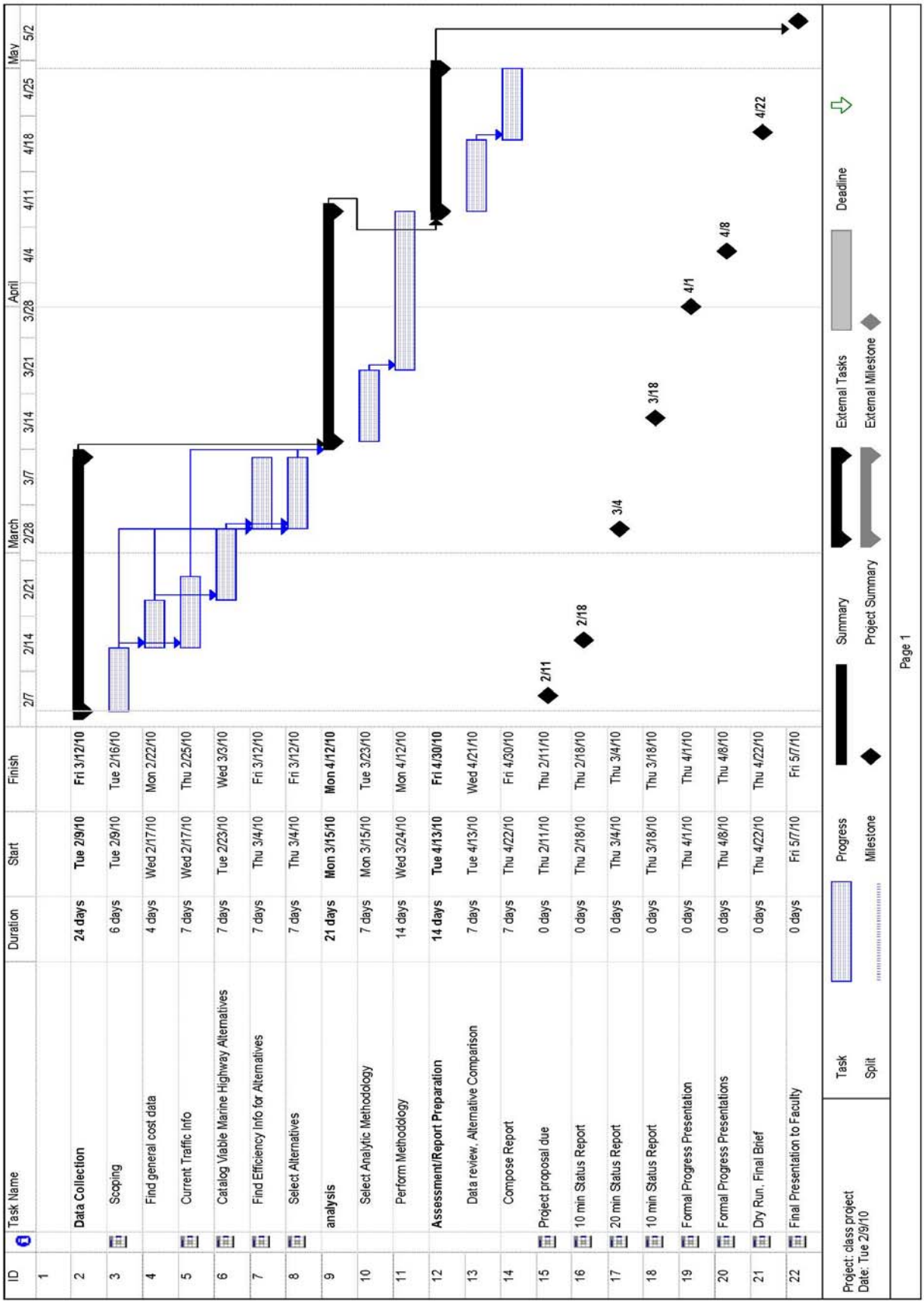
4.2 Phase 2: Analysis

The analysis phase will take the knowledge gained in the data selection phase and refine the bounding analysis into more formal findings. The initial part of the analysis phase will determine appropriate methodologies to further refine and prove the findings of the bounding analysis. Most of the factors involved with freight shipment are random such as demand, transit times, conveyance availability and transshipment times. Due to the many stochastic processes at work in transportation systems simulation may be appropriate for gaining insight into this type of problem. The methodology selected will need to not only fit the nature of the marine highway problem but also the time constraints of the project and set of tools that the team has at their disposal.

4.3 Phase 3: Assessment and report preparation

The Assessment phase will bring together all of the knowledge gained throughout the project and develop the final report. Deliverables will include a discrete event simulation that can be adapted for further study of marine highways. The final report will contain quantitative information about the routes studied. Qualitative key marine highway characteristics will also be

relayed along with potential policy recommendations for facilitating marine highway utilization. Following is a tentative schedule:



ID	Task Name	Duration	Start	Finish
1				
2	**Data Collection**	**24 days**	**Tue 2/9/10**	**Fri 3/12/10**
3	Scoping	6 days	Tue 2/9/10	Tue 2/16/10
4	Find general cost data	4 days	Wed 2/17/10	Mon 2/22/10
5	Current Traffic Info	7 days	Wed 2/17/10	Thu 2/25/10
6	Catalog Viable Marine Highway Alternatives	7 days	Tue 2/23/10	Wed 3/3/10
7	Find Efficiency Info for Alternatives	7 days	Thu 3/4/10	Fri 3/12/10
8	Select Alternatives	7 days	Thu 3/4/10	Fri 3/12/10
9	**analysis**	**21 days**	**Mon 3/15/10**	**Mon 4/12/10**
10	Select Analytic Methodology	7 days	Mon 3/15/10	Tue 3/23/10
11	Perform Methodology	14 days	Wed 3/24/10	Mon 4/12/10
12	**Assessment/Report Preparation**	**14 days**	**Tue 4/13/10**	**Fri 4/30/10**
13	Data review, Alternative Comparison	7 days	Tue 4/13/10	Wed 4/21/10
14	Compose Report	7 days	Thu 4/22/10	Fri 4/30/10
15	Project proposal due	0 days	Thu 2/11/10	Thu 2/11/10
16	10 min Status Report	0 days	Thu 2/18/10	Thu 2/18/10
17	20 min Status Report	0 days	Thu 3/4/10	Thu 3/4/10
18	10 min Status Report	0 days	Thu 3/18/10	Thu 3/18/10
19	Formal Progress Presentation	0 days	Thu 4/1/10	Thu 4/1/10
20	Formal Progress Presentations	0 days	Thu 4/8/10	Thu 4/8/10
21	Dry Run, Final Brief	0 days	Thu 4/22/10	Thu 4/22/10
22	Final Presentation to Faculty	0 days	Fri 5/7/10	Fri 5/7/10

5 References

Thirumalai, Dr. K.T., " Re: OR 680 Capstone Project Question." Email to members of SCRAM Team. PowerPoint brief attached: "USDOT CRS&SI Technology Application, Marine Highway System (MHS), (A Multimodal Short Sea Freight Shipping System), George Mason University Consortium."
29 Jan 3:28 pm

Thirumalai, Dr. K.T., " Re: OR 680 Capstone Project Question." Email to members of SCRAM Team.
2 February 2010, 10:20 am

Chen, Dr. Chun-Hung, " Re: OR 680 Capstone Project Question." Email to members of SCRAM Team.
2 February 2010, 11:05 am

Maritime Administration Marine Highway Programs Website:
http://www.marad.dot.gov/ships_shipping_landing_page/mhi_home/mhi_home.htm

I-95 Corridor Coalition Marine Highway Website:
http://www.i95coalition.org/i95/Projects/ProjectDatabase/tabid/120/agentType/View/PropertyID/61/Default.aspx

Federal Register, Vol. 73, No. 197, pg. 59530, Thursday, October 9, 2008:
http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=2008_register&docid=fr09oc08-20.pdf