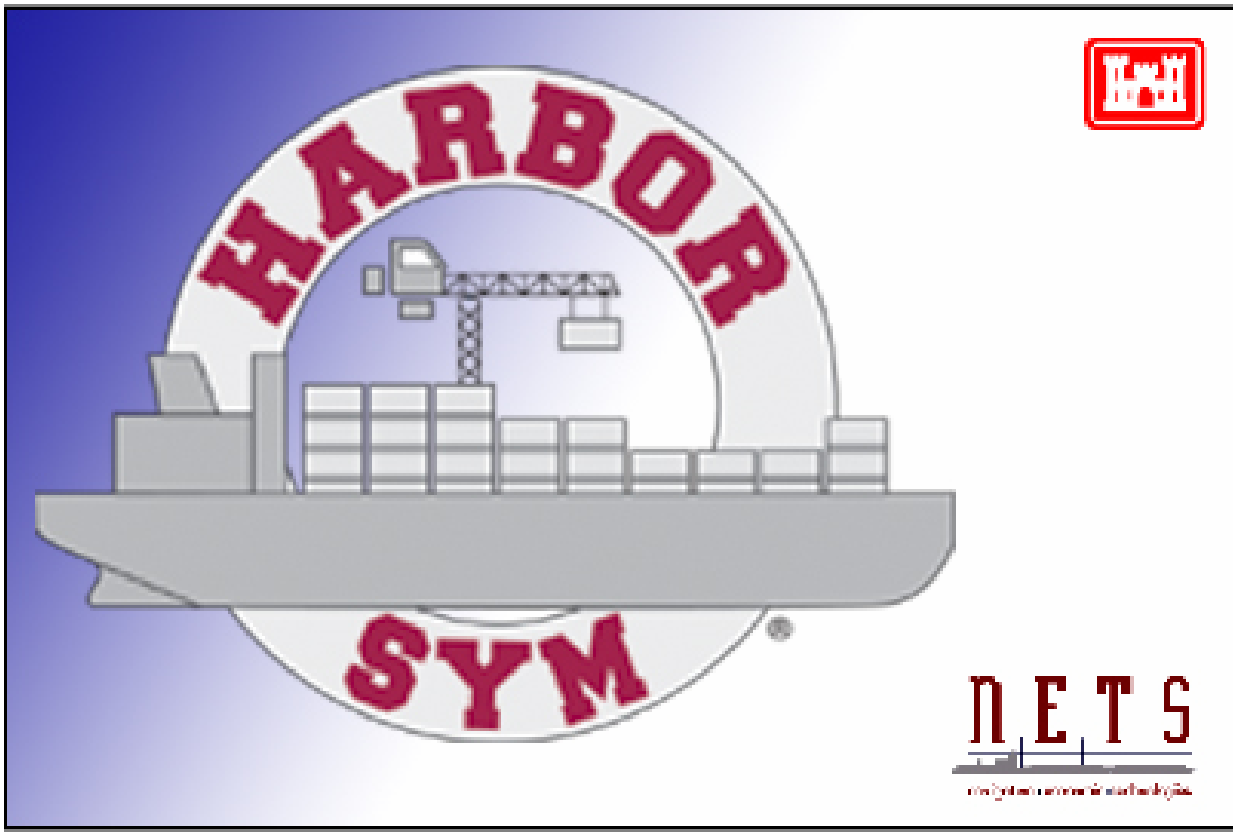
HarborSym Application – User's Manual



U.S. Army Corps of Engineers
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HarborSym Application – User's Manual

Draft

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Section 1
Introduction

The following provides a basic User's Manual for the Harbor System Simulation (HarborSym) software. The application software is designed to simulate the movement of vessels through a harbor. Vessel transits are simulated in order to estimate the economic benefits that would potentially result from making navigation improvements to specified sections of the harbor. The economic effects are primarily measured as overall reductions in transit times and associated changes in vessel operating costs. The simulation results can be used in a comparative analysis of alternative harbor improvements and in a general benefit-cost analysis of proposed navigation improvements.

The node network representation of the harbor is built by the HarborSym user. Then the vessel classifications and commodity categories are defined by the user. The HarborSym model uses these inputs to simulate vessel traffic in a scenario defined by the user. The user is provided many input options that allow flexibility in simulating vessel traffic.

This manual is designed to assist users in evaluating the economic effects of navigation improvements in harbor study areas. Section 2 of the manual discusses software installation procedures and system requirements. Section 3 provides an overview of the standard features and concepts used in the application. Section 4 details the basic menu commands and functions within HarborSym, addressing each menu item. Section 5 describes how to develop a new HarborSym project and Section 6 discusses procedures for simulating future transportation costs and potential cost savings of alternative harbor improvements. Section 7 describes how to use HarborSym output to compare projects. The goal is to provide the user with instructions on the model functions.

Section 2
Installation

The HarborSym software is primarily distributed by Internet download although it can also be distributed by CD-ROM.

2.1 System Requirements

Before installing HarborSym, make sure the computer system meets the required hardware and software requirements:

- Minimum 500mHz processor
- Microsoft Windows 95, Windows 98, Windows Millennium Edition, Microsoft Windows NT 4.0, Windows 2000 or Windows XP
- 256 MB RAM
- 200 MB available hard disk space
- CD-ROM or Internet connection
- Administrator permissions on the computer (if you are using Microsoft Windows NT or Windows 2000)

2.2 Installation Procedures

2.2.1 CD-ROM Installation

- Insert the HarborSym CD-ROM into your CD-ROM drive
- Wait for the setup program to start
- Follow the instructions to complete setup

2.2.2 Internet Download Installation

- Download the installation file to a temporary directory (Example, C:\Temp)
- Click the start button on the Taskbar
- Click Run
- Type the path to the downloaded file (Example, C:\Temp\Setup.exe)
- Click the “OK” button
- Follow instructions to complete setup

2.2.3 Uninstall

- Click the Start button on the Taskbar
- Click Settings
- Click Control Panel
- Double-click Select Add/Remove Programs
- Select “HarborSym”
- Click the Add/Remove button

Section 3
Overview

HarborSym is based on the creation of discrete event Monte Carlo models that simulate movement of vessels through a harbor. The models created in HarborSym have stochastic behavior in terms of generation of trips, transit time on each reach of the harbor, loading and unloading time at docks, and docking and undocking time. The user inputs statistical parameters with minimum , maximum and most likely figures. The application is designed to estimate the economic effect of improvements of the harbor on transit times and vessel operating costs. HarborSym has been designed with many general features to enhance its portability and can be used to evaluate economic effects of improvements on any harbor. The study area is specified by simply developing a model of the harbor network that physically and statistically represents the navigation conditions of the desired study area.

The model consists of the following integrated components:

- A Microsoft Access 2000® database, storing the harbor representation, statistics on vessel transit times, routes through the system and model output (the user does not need to have Microsoft Access installed on their computers;
- A C++ "simulation kernel" that performs the detailed simulation calculations, reading data from the database and storing the output results back in the database and in separate detailed output data files;
- A user interface, written in Visual Basic.NET, allows for data input and editing, graphical display of the system, running of the kernel and output reporting.

The three components work together to satisfy the goal of providing an integrated system for the user. The model includes capabilities to simulate vessel traffic and transit rules in the harbor.

3.1 Basic Concepts

The basic structure of a model developed in HarborSym relies on data to describe the node network, vessel traffic, commodity transfers and traffic rules for vessel movement. A navigation improvement to a harbor changes transit times of vessels in the harbor. All data for each alternative project simulated, along with information on specific data elements used in the simulation and the simulation parameters is stored in tables within an Access® database. The scenario provides the combination of data used by the Monte Carlo process that estimates total transportation time and cost of vessels transiting the harbor.

3.1.1 Harbor, Nodes, Reaches

The harbor is represented as a system of linked nodes. Nodes represent docks, turning areas, anchorages, entry/exit points or other topologic points in the harbor where channel conditions change. At least one node on the network must be defined as an entry/exit point. Nodes are

connected to each other by reaches. A reach signifies a channel between two nodes. Vessel movement statistics are calculated based on vessel movement in reaches.

3.1.2 Vessel Calls

A vessel call includes the movement of a vessel from the harbor entrance to its destination dock, a commodity transfer and the exit of the vessel from the harbor. The amount of time a vessel takes to travel from harbor entrance to destination docks and to the exit point depends upon many factors including the size of the vessel, the commodity loaded and unloaded, the vessel traffic rules implemented along the route and the navigation characteristics of the reaches in the harbor. Some vessel calls may require multiple dock visits within a harbor visit. The operating cost for vessel calls is estimated based upon the length of time in the harbor.

3.1.3 Vessel Call Generation

HarborSym contains a vessel generator capability, by which individual trips are generated during a given period based upon user inputted vessel call list. The user initially has to populate the model with vessel movement parameters such as speed in reach by vessel class and commodity loading and unloading times. These parameters and the commodity flows from the vessel call list are stored in the database and used to generate vessel calls.

3.1.3.1 Vessel Types and Vessel Classes

Vessel types are general categories of vessels such as tankers, general cargo vessels or container vessels as defined by the user. Vessel classes are based upon measurement thresholds and fit within a vessel type. A vessel type contains one or more vessel classes. A vessel class belongs to only one vessel type.

3.1.3.2 Commodity Categories

Commodities are the cargo that is loaded and unloaded by the vessel at the harbor docks. Commodities are categorized by the user based upon the manifest data available. The user defines the units of measure for each commodity category and the tons per unit of measure. The user must also define the loading and unloading time at docks for each commodity category. After commodities are defined, the user establishes which vessel classes are able to carry which commodity categories.

3.1.4 Dock Visits and Commodity Transfers

Vessel calls, dock visits and commodity transfers are each unique, and are uniquely numbered. A dock visit is one visit by a vessel to a dock. A commodity transfer is the loading or unloading of one commodity from one vessel during a dock visit. In a future feature, the vessel generator stores the probability of a call by a particular vessel. The model will choose the particular entrance time, dock destination and commodity transfer based on stored probabilities.

3.1.5 Reach Transit Time

The reach transit time is the time a vessel takes to transit a reach. Transit time of a vessel through a reach is determined based on sampling from a triangular statistical distribution

stored in the database by vessel classification. Improvements to the harbor decrease reach transit times by reducing vessel waiting times at the reach entrance or increasing the average speed of vessels in the reach.

3.1.6 Vessel Transit Rules

Vessel transit rules specify the conditions in which vessels may transit the harbor or meet other vessels. The conditions are based upon reaches and vessel size thresholds, as defined by the user. Vessel transit rules can apply to the entire harbor or to any reach within the harbor. There are 26 available vessel traffic rules that can be tailored and applied to any reach. The vessel transit rules are available from a pull-down menu in the rule definition data entry grid. There are two general types of vessel traffic rules; single vessel rules and multiple vessel rules. Single vessel rules are mostly based upon harbor conditions. Rules for multiple vessels regulate vessel encounters and consider both vessel characteristics and harbor conditions. The user tailors the rules for each reach by specifying parameters in the data entry grid. These parameters include the vessel class the rules apply to, the applicable condition (day, night, fog) and the applicable measurements of the vessel.

Vessel traffic rules impact harbor traffic by delaying a vessels transit through a reach while it waits for harbor conditions to change or for another vessel to leave that reach. A complete description of each rule is contained in Appendix B.

3.1.7 Reach Configuration

The reach configuration data specifies the characteristics of each reach. The vessel transit speeds through each reach are specified by the user for each vessel classification. Information specified for a reach includes a description (name), and the length, width and depth of the channel.

3.1.8 Dock Configuration

The dock configuration data includes the description (name), length, depth and maximum vessel capacity of each dock.

The vessel time at a dock is estimated based upon the minimum and maximum loading and unloading times for the commodities the vessel is transferring and the minimum and maximum vessel docking and undocking time for the vessel.

3.1.9 Rule Violations

Rule violations are defined as incidents where a vessel is delayed to prevent a violation of vessel traffic rules. The HarborSym model does not allow a rule violation to occur, but maintains a file of all rule violations that would have occurred during a simulation.

3.1.10 Scenario

A scenario is the defined run parameters that specify the conditions of a simulation. Scenarios have names and are stored. The same scenario can be used for simulations of vessel traffic on multiple projects.

3.1.10.1 Simulation Duration, Start Date

The model simulates vessel traffic starting at midnight on the start date and continuing for the duration specified by the user. The duration is specified in hours (all time in the model is in hours). Only one simulation period can be specified in a scenario. The user can specify any simulation period within a year or an entire year.

3.1.10.2 Number of Iterations

A Monte Carlo simulation consists of multiple iterations of vessel traffic flow during the same time period. Statistics are developed from the multiple iterations of the simulation. One iteration of a simulation is one duration period starting at the scenario start date. The different parameters affecting vessels transit (speed in reach, docking time, etc.) vary between iterations within the input range set by the user. The user inputs the number of iterations of the simulation to be carried out when defining the scenario, based upon the need for accuracy. As the number of iterations increases, the stability of the simulation output increases. Fifty iterations should provide a stable output for most simulations.

3.1.10.3 Wait Times Before Retry

To prevent a rule violation, the moving vessel must wait. The length of time the vessel must wait before a retry (attempt to move) is defined by the user. The wait time is defined in fractions of an hour. Different wait times can be entered for three types of locations where vessels wait, the Entry, the Docks and Anchorages.

3.1.11 Legs

Legs consist of one or more reaches that a vessel must transit without stopping. A vessel must be able to transit an entire leg without a rule violation. Legs begin and end at the harbor entrance, a dock or an anchorage, which are the nodes at which a vessel can wait.

3.1.12 Port

The port is synonymous with the harbor. A Port Data Entry Grid is accessed from the Navigation Pane. The longitude and latitude of the port is entered to allow HarborSym to determine daylight hours at the port. Daylight savings time applicability is also entered in this data entry grid.

3.2 HarborSym Panes

There are three panes visible to the HarborSym user on the screen; the Graphics Pane, the Navigation Pane and the Data Entry Pane as shown in Figure 3-1. The relative sizes of the three panes can be modified by the user by moving the borders between the panes.

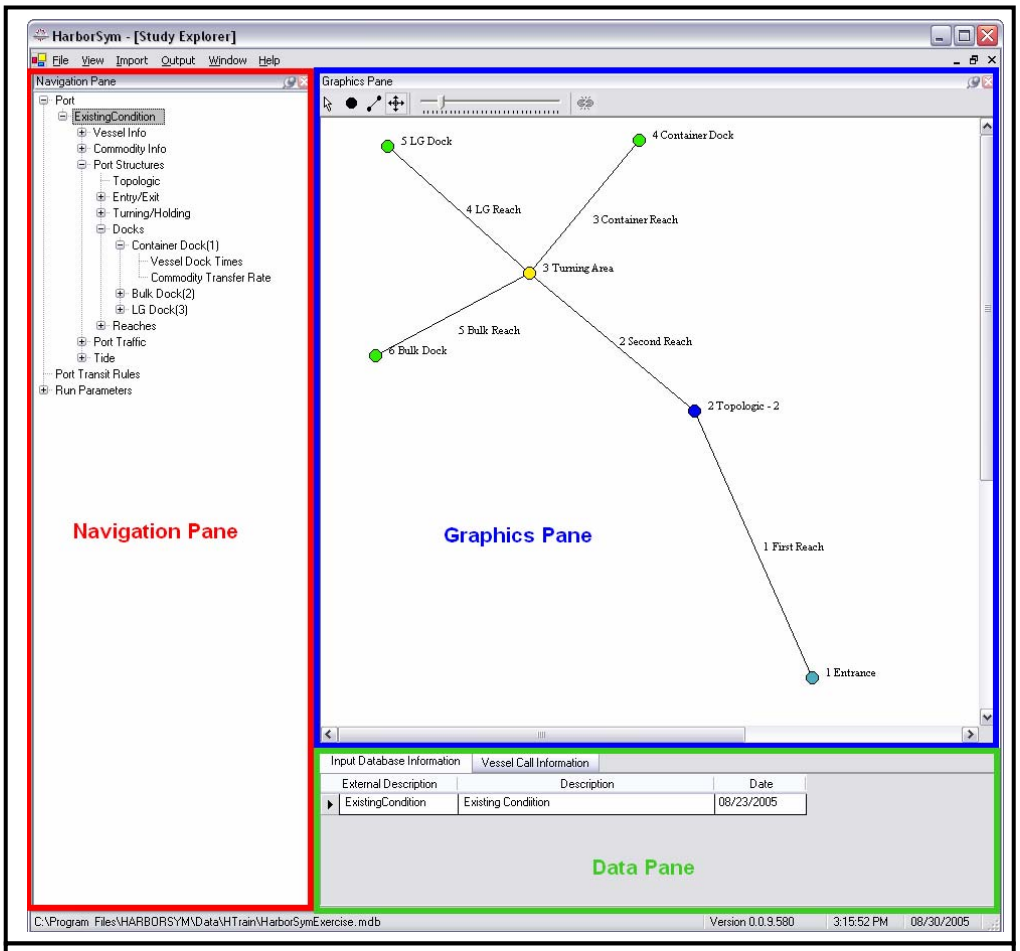


FIGURE 3-1
STUDY EXPLORER

The Graphics Pane is used to represent the harbor. The Navigation Pane contains a hierarchical listing of project components and is primarily used to call up different data entry grids in the Data Entry Pane. The Data Entry Pane contains the data entry grids for the user to input data.

3.2.1 Graphics Pane

The Graphics Pane shows the node network, which is a visual representation of the harbor shown in Figure 3-2. The node network represents a project using nodes and reaches. Nodes are points that represent an entry/exit point, a turning area, an anchorage, a dock or a

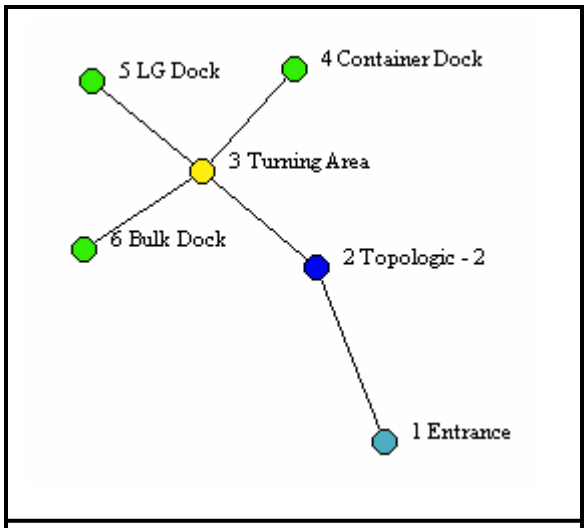


FIGURE 3-2
GRAPHICS PANE

topologic node indicating a change in channel conditions.

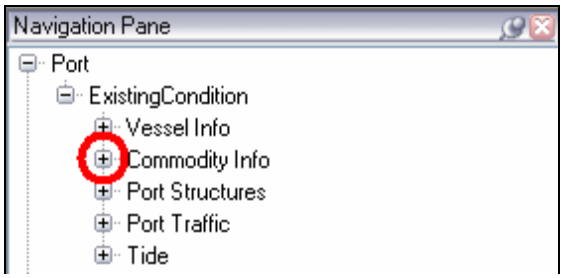


FIGURE 3-3
NAVIGATION PANE

3.2.2 Navigation Pane

The Navigation Pane contains five hierarchical listings for each project; *Vessel Info*, *Commodity Info*, *Port Structures*, *Port Traffic* and *Tide*. These listings are obtained by clicking on the plus icon to the left of the project name as shown in Figure 3-3. To the left of each of these listing is a plus icon, which can call the next level of listings. The plus icon to the left of *Vessel Info* will call the vessel types.

The plus icon to the left of *Commodity Info* will call up each of the commodity categories. Likewise, the plus icon to the left of *Port Structures* and *Port Traffic* will call up *Entry/Exit, Facilities*, *Docks*, *Reaches*, *Unique Vessels*, *Vessel Calls*, *Dock Visits* and *Commodity Transfers* respectively as shown in Figure 3-4.

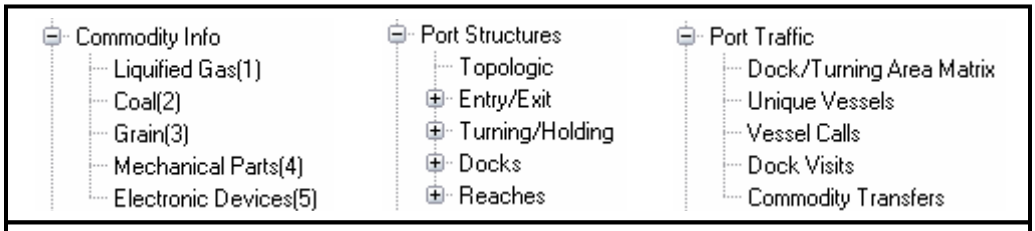


FIGURE 3-4
NAVIGATION PANE EXPANDED

The Data Entry Pane contains the data entry grids that are used to input data into HarborSym. The data entry grids are used primarily to enter the harbor measurements, vessel classification thresholds and the vessel speeds and times. These data entry grids have tabs at the top of the pane to call up different data entry grids as shown in Figure 3-5.

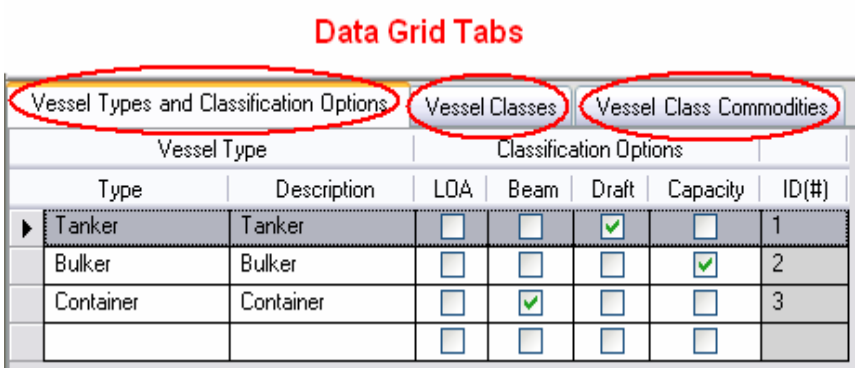


FIGURE 3-5
DATA GRID TABS

3.3 Model Behavior

The model created in HarborSym is event-driven. It generates and maintains a list of vessel calls and when events take place. It also adds and deletes information on the event queue as needed, and processes each event in chronological order. Events handled by the model include: entry of a vessel into the harbor; movement of a vessel into a reach and exit of a vessel from the harbor. As each vessel call is processed, the current time is moved forward to the next vessel call and that event is processed, until the simulation duration has been completed.

At the start of each period of the simulation, the model uses the stored vessel call statistics to generate vessel calls, getting a list of vessel types and dock visits, sorted by arrival date. It then processes each vessel call in the list. As a vessel enters the harbor the model chooses the dock that will be visited and commodities transferred based on probabilities for the particular vessel type. Vessel encounters occur based upon each vessel's independently determined schedule.

The model routes all vessel calls through the harbor, reach-to-reach along their predefined routes, as the appropriate vessel call takes place. Thus, rather than route a single vessel call through the entire system, all vessels are being moved one reach at a time, in turn, based on the appropriate time at which a vessel enters or leaves a reach. This data is stored in an event queue.

As each vessel enters a reach, the time that the vessel will spend in the reach is determined, based on the speed in reach for the vessel class. This sets the time that the vessel will exit from the reach. Thus, as soon as a vessel enters a reach, calculations are made to determine when it will exit, and the exit time is placed on the event queue, which is always maintained in sorted order.

The calculation of vessel exit time involves examination of raw reach transit time, congestion and transit rules. The total transit time of a vessel in a reach is established by first determining if the reach is congested (Is another vessel in the reach?). The travel time in the reach is then calculated by sampling from a user input range of speed in reach for the particular reach and vessel class. A triangular distribution is used for the range of speed in reach.

If transit rules are in effect for the reach (again as set by the user), the exit time of a vessel is determined by whether or not it can pass other vessels, moving in the same or opposite directions. Thus, if certain vessel transit rules are in effect, a vessel cannot enter a given reach until other vessels that entered previously have left. In this manner, the exit time of the vessel from the reach is determined as the "raw" transit time plus the time needed for the previous vessel to leave the reach. A number of different transit rules can be specified, and the actual calculation of exit times involves additional complexity, involving headway between vessels.

As each vessel transits a reach, statistics are accumulated for each vessel, and for each reach. As a vessel leaves the harbor, its total end-to-end transit time, and associated operating cost, is determined. This process is repeated for all vessel calls in a period, all periods of the simulation, and the requisite number of iterations of the simulation.

3.4 Model Outputs

There are two primary forms of model output: (a) information stored back into the database, associated with a scenario, and (b) detailed output files for the scenario. The information stored back into the database is used by the interface to display individual and comparative results for scenarios through output reports as shown in Figure 3-6. The output files are used for verification of input, and detailed exploration and debugging of model behavior.

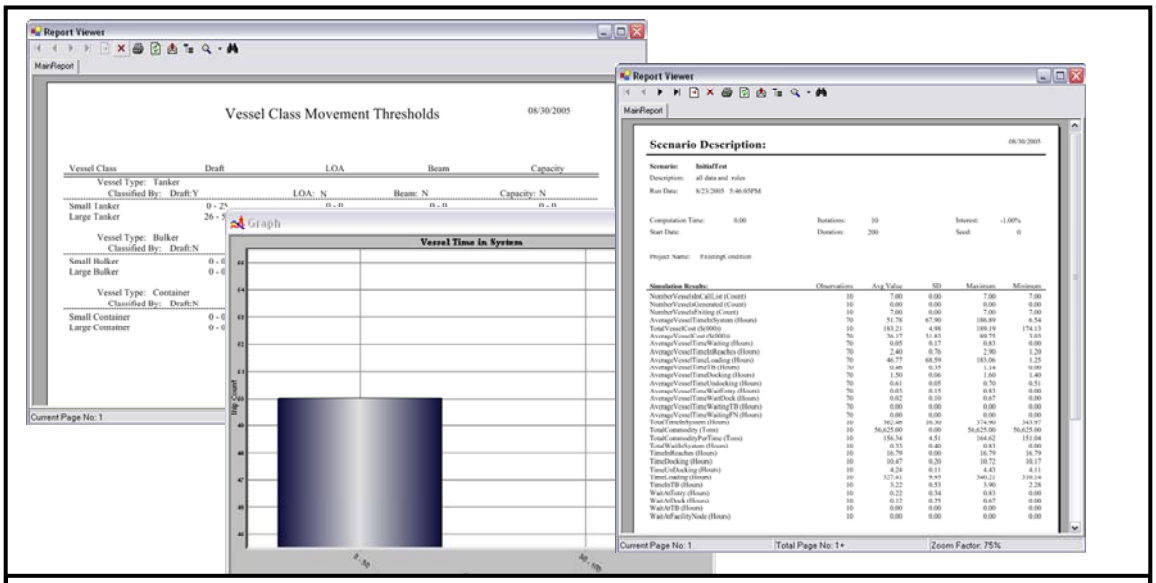


FIGURE 3-6
OUTPUT REPORTS

Section 4
Basic HarborSym Commands and Functions

A harbor is a structure of connected reaches, docks and facilities that must be established to correctly model and simulate traffic. Entering this information can be time consuming and has been a large consideration of the application, leading to the development of many timesaving techniques. HarborSym uses a traditional menu as well as toolbars for immediate access to functions. Whenever the user right-clicks on the map area of the main window, a context-derived menu is displayed for the corresponding object. Message prompts are also applied for context menus.

The following chapter describes the basic menu commands and functions available in HarborSym. The menu commands are presented in the order that they appear on the menu toolbar of the main application window with explanations of what would happen if the particular option was selected.

4.1 File

The following items are found on the File menu pillar as shown in Figure 4-1: "Study Manager," "Configuration Settings" and "Print."

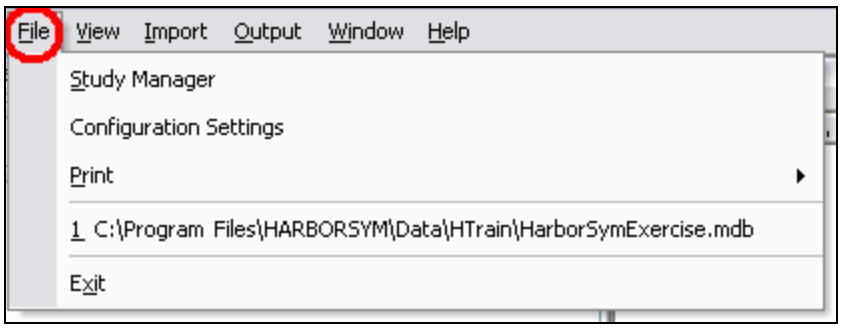


FIGURE 4-1
FILE MENU

4.1.1 Study Manager

When this menu item is selected, a "Study Manager" dialog box is prompted. This dialog box allows the user to specify the file location and the name for a new study and for the projects within a study. The user will benefit by keeping all the files for a study in the same directory.

Study Manager allows the user to "clone" a project and thereby avoid duplicate data entry. The "cloned" project can then be modified to reflect the harbor improvement alternative being evaluated.

4.1.2 Configuration Settings

This function brings up the Configuration Settings Form where validation and simulation settings can be input and edited. The validation settings are ranges of values, as set by the user, that are acceptable for input. Input values outside of the defined range generate an error message during data validation. The configuration settings consist of Tags (Name of Setting), Descriptions (Description of Setting) and Settings (Values).

The configuration settings are tidal time intervals, tidal range parameters and vessel leg wait limit counts. The vessel leg wait limit count will impact the deletion of vessel calls if vessels become "stuck," and can not move because of vessel traffic rules. Complete descriptions of these settings can be prompted by hovering the cursor over the description block.

4.1.3 Print

This function prints HarborSym Data Entry Grids. Page Setup and Print Preview options are available. The Print command prints the Data Entry Grid currently shown in the Data Entry Pane.

4.1.4 Additional Studies

A list of existing studies is shown. The user can change to another study, and avoid using Study Manager, by double clicking on the study name.

4.2 View

Two menu items are listed under this menu pillar: "Study Explorer" and "Display Options" as shown in Figure 4-2. These items control the primary HarborSym screen, which contains the three panes.

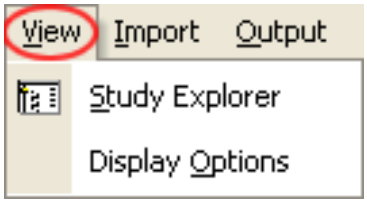


FIGURE 4-2
VIEW MENU

4.2.1 Study Explorer

This function returns the three HarborSym panes (Graphics Pane, Navigation Pane and Data Entry Pane) to view. This command is typically used after using the Study Manager function.

4.2.2 Display Options

This function calls the Display Options Screen, as shown in Figure 4-3 that allows the user to adjust the colors and representations used to represent nodes and reaches in the Graphics Pane. Each node type representation can be modified by clicking on the node type on the left side of the Graphic Pane Options Screen, where all node types are listed. Selection of each node type allows the user to select the icon to represent that node type in the Graphics Pane. This screen is used to determine whether node descriptions and node numbers are shown in the Graphics Pane, and how they are represented. The user should consider the complexity of the harbor to be represented by the node network when selecting and sizing icons. The default sizing and

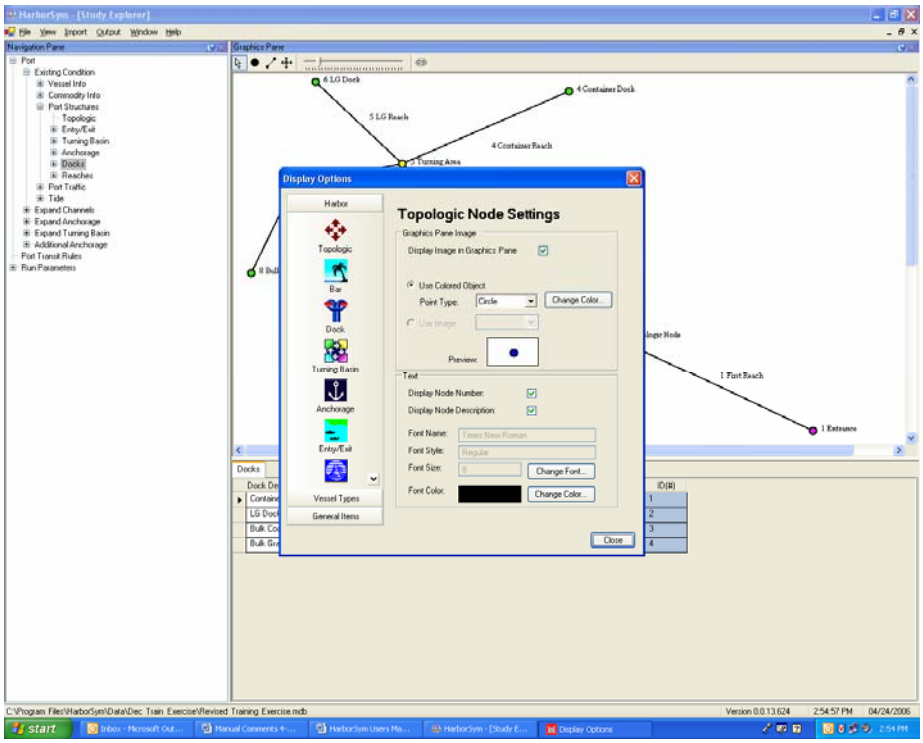


FIGURE 4-3
GRAPHICS PANE OPTIONS

representation should be used to start when building the node network. The Display Options Pane can then be used for modifications of the harbor representation if desired.

4.3 Import

Five menu items are listed under this menu pillar as shown in Figure 4-4: "Commodity Transfer Rate," "Vessel Docking Time," "Vessel Turning Times," "Vessel Speed in Reach" and "Port Traffic." These selections allow the user to use templates and import large amounts of data. The templates are in Microsoft Excel®.

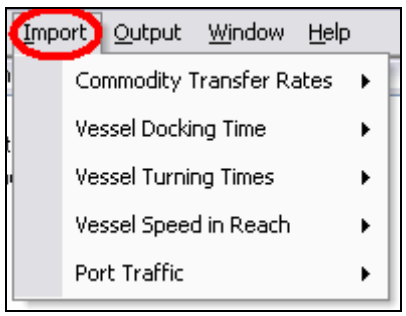


FIGURE 4-4
IMPORT MNEU

Each item has two options; "Create Lookup Spreadsheet," and "Import" as shown in Figure 4-5. The "Create Lookup Spreadsheet" must be used first. The user will then assign a project name to the spreadsheet and assign the file to a directory. Care should be taken in assigning the directory. Additional information about HarborSym templates is available in Appendix A.

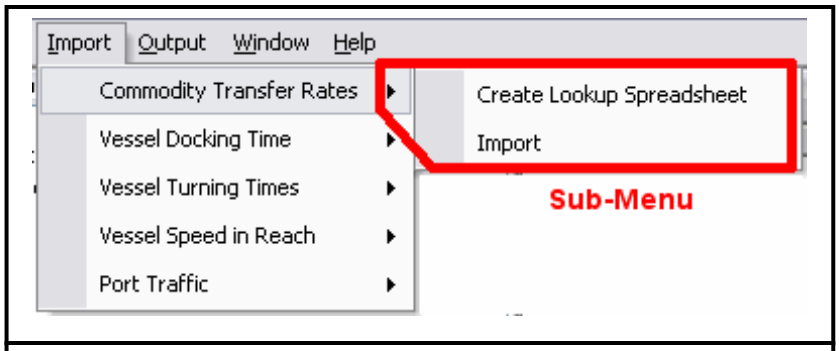


FIGURE 4-5
IMPORT SUB-MENU

4.3.1 Commodity Transfer Rate

The Commodity Transfer Rate is the rate at which a commodity, or cargo, is loaded or unloaded from a vessel. A minimum rate, most likely rate and maximum rate for loading and unloading must be assigned to each commodity category for each vessel classification. The rate is measured in units per hour.

4.3.2 Vessel Docking Time

The Vessel Docking Time is the amount of time a vessel spends docking or undocking. A minimum and maximum Vessel Docking Time, in hours, must be assigned to each vessel classification at each dock.

4.3.3 Vessel Turning Time

The Vessel Turning Time is the speed, in hours, for each vessel type to turn in a turning basin. A minimum, most likely, and maximum turning time must be assigned to each vessel type for each turning basin.

4.3.4 Vessel Speed in Reach

The Vessel Speed in Reach is the speed, in knots per hour, that a vessel can travel in a reach. A minimum and maximum speed must be assigned to each vessel classification for each reach.

4.3.5 Port Traffic

The Port Traffic Template imports the vessel call list. This template includes an extensive amount of data on the vessels visiting the harbor and the commodities they transferred.

4.4 Output

This pillar provides access to HarborSym output through graphs and reports. The three menu options available under the Output menu pillar, as shown in Figure 4-6, are: “Graphs,”

"Reports" and "Export." Output files contain more data about simulations but are not accessed through this file pillar. Output files are accessed through Windows Explorer.

FIGURE 4-6 OUTPUT MENU

4.4.1 Graphs

The Graph Builder Screen allows the user to specify the scenario and projects to include in the graph.

4.4.2 Reports

Several report options are available, "Project Comparison," "Single Scenario," "Transit Rules," "Vessel Class Movement Thresholds" and "Commodity Info" as shown in Figure 4-7. The Project Comparison Report provides a comparison of multiple scenarios under a single scenario. The Single Scenario Report provides detailed data on the simulation of one scenario with a single project. The Transit Rule Report lists the vessel traffic rules by reach. The Vessel Class Movement Thresholds Report lists the range for each vessel class in each project. The Commodity Info Report lists the Units of Measure and tons per unit of measure for each commodity category.

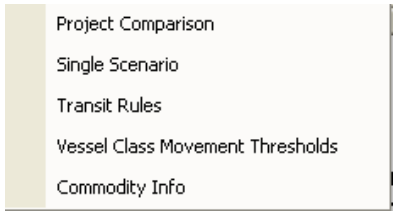


FIGURE 4-7 REPORT SUB-MENU

4.4.3 Export

The export function allows the user to export the vessel call list modified within HarborSym. This function is useful because vessel data may be modified or corrected after the original vessel call list is imported into HarborSym. An Excel spreadsheet is exported to the file selected by the user. The selection of the Export Port Traffic Function is shown in Figure 4-8.

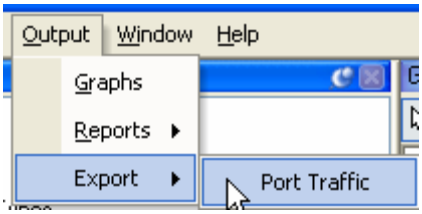


FIGURE 4-8 PORT TRAFFIC SUB-MENU

4.5 Window

Three features are available, Tile Vertically, Tile Horizontally and Cascade.

4.6 Help

The Help menu pillar is shown in Figure 4-9. The "Help" menu pillar offers the "About" command, which displays the version number of the application. This command will obtain the standard "About" dialog box.

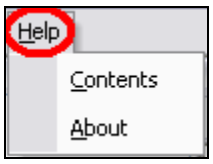


FIGURE 4-9 HELP MENU

Section 5
Developing a HarborSym Study

This section defines the terms and concepts necessary to develop a HarborSym study. The terms and concepts are defined in a sequence to allow the user to logically and efficiently develop a HarborSym study.

The first section describes HarborSym studies and HarborSym projects. The second section describes how the HarborSym node network represents the harbor. The third section defines vessel types and vessel classes and their significance in HarborSym. The forth section defines commodities. The fifth section describers the vessel call list and how to import the vessel call list in an Excel format into HarborSym. The sixth section describes how to input speeds and times into HarborSym, to complete all of the data entry needed to run a simulation. The seventh section describes launching a simulation of vessel traffic. The eighth section describes how to import vessel traffic rules. The ninth section describes cloning an alternative project, which allows a comparison between the "with project" and "without project" conditions. The tenth section describes the advanced features of tide and current, which are optional features. The eleventh section describes the Data Validator Feature, which assists the user in locating data entry problems.

5.1 Studies and Projects

5.1.1 Studies

A HarborSym study is the file designation for the overall benefits analysis conducted within HarborSym. A study is limited to one harbor. A study contains at least one project and must have two projects to conduct a benefits analysis. The first project should represent the current conditions at the harbor. HarborSym should be calibrated by comparing the outputs of the first project with actual data available from the harbor. Additional projects are created to represent possible harbor improvement projects. A comparison of simulation outputs from the original project with the additional projects will assist the user in understanding their potential economic benefits.

5.1.2 Projects

A HarborSym project is a definition of a harbor, including all the physical characteristics of the docks, turning basins, anchorages and reaches within that harbor. The vessel transit rules are part of a project. A study should consist of at least two projects, the existing condition (without project) and an alternative condition (with project). Projects within a study can have the same vessel call list.

5.1.3 Study Manager

The HarborSym Study Manager is a function used to create studies and projects and to navigate between studies. Unless the HarborSym user is working on more than one navigation analysis at a time, the Study Manager function will be used mainly to create new projects within an

existing study with which to analyze alternative harbor improvements. The file directories for storing studies and projects are selected in Study Manager. To create a new study, select Study Manager from the File menu. The Study Manager form, as shown in Figure 5-1, will now open.

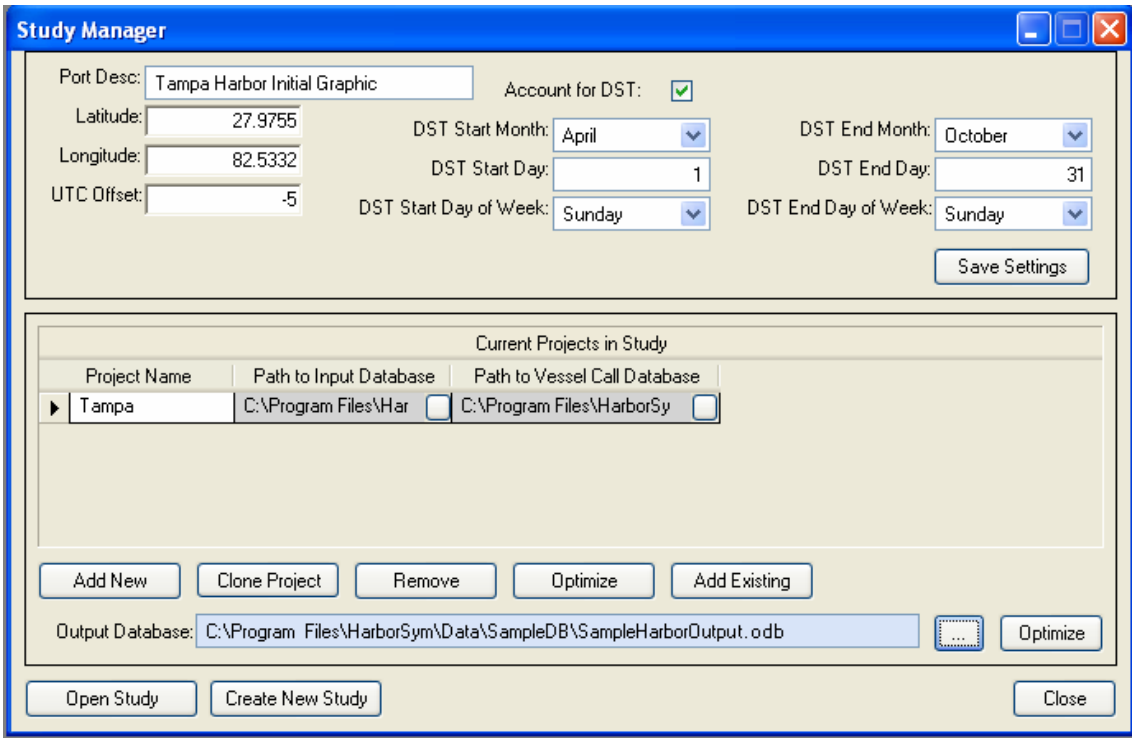


FIGURE 5-1
STUDY MANAGER

Click the Create New Study button. Click the button (...) beside the location field to select the location where files related to this study will be stored. Next, enter the name of the study into the Study Name field and a project name, such as Existing Conditions, into the Project Name field. Click Create to create the study. The Study Manager form can now be closed by clicking on the Close button. After the study is created the user should open the Study Explorer.

The HarborSym model uses Microsoft Access® files extensively and the Study Manager contains an Optimize function that performs the Compact function of Microsoft Access®.

5.1.4 Study Explorer

The Study Explorer is used to access the three HarborSym panes after using Study Manager. Study Explorer is accessed from the View menu pillar.

5.2 The Node Network

The node network represents the harbor and consists of nodes and reaches. Most aspects of the node network will remain unchanged in the without- and with-project conditions. Unless new channels or docks are being considered, the node network itself will not change. All docks, turning areas, harbor entrances and channels need to be mapped in the node network at the onset.

5.2.1 Port Structures

Port Structures are one of the five main headings under each project name in the Navigation Pane. Port Structures consist of nodes and reaches. The five types of nodes are listed in the Navigation Pane under Port Structures. Reaches are also listed under Port Structures in the Navigation Pane.

5.2.2 Nodes

Nodes represent points in the harbor. Nodes are specified by type; docks, turning areas, anchorages, entry/exit points and topologic points.

5.2.2.1 Docks

Docks are nodes where vessels load and unload commodities. Docks are capable of transferring specific commodity categories as selected by the user. The dock description is the name that will appear in the Navigation Pane. In a typical large harbor, the user will need to aggregate docks, to allow representation in the node network. For example, in a harbor with 100 docks might be represented with 10 docks in the node network.

5.2.2.2 Turning Basins / Turning Areas

Turning basins are nodes where vessels turn. The Turning Basin Data Entry Grid contains the turning basin description, the vessel capacity and whether the turning area blocks the channel. The turning basin description is the name that will appear in the Navigation Pane. The user selects whether vessels turn in the turning basin before or after reaching their destination dock, or when the vessel is heaviest or lightest during its vessel call in the Docks Data Entry Grid. The depth of the turning basins will limit the vessels transiting through the turning basin. The terms turning basin and turning area are used interchangeably in HarborSym.

5.2.2.3 Entry/Exit Points

Entry/exit points are nodes where vessels enter or exit the harbor. They are also called bars. A name can be entered for an Entry/Exit point.

5.2.2.4 Topologic Points

Topologic points denote nodes where channel conditions change. These nodes do not require data entry for measurements. All nodes are topologic points and have a topologic point name that will appear in the Graphics Pane.

5.2.2.5 Anchorages

Anchorages are nodes where vessels can wait before entering the next reach. Anchorages are therefore also endpoints between legs. Anchorages have capacity limits and can block channels.

5.2.3 Reaches

Reaches represent channels between nodes in the harbor. Vessels transit the harbor reaches from the harbor entrance to their destination dock. Names, descriptions and measurements are entered for each reach.

5.2.3.1 Legs

A leg is a contiguous set of reaches between which a vessel can not stop to wait. Reaches are defined by the user and grouped into legs by HarborSym. Once a vessel enters a leg, it has priority over any vessel seeking to enter a leg.

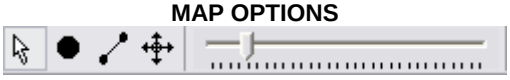
5.2.4 Mapping of Nodes and Reaches

A graphical representation of the harbor network is created in HarborSym by using a computer mouse to insert nodes into a blank Graphics Pane. This technique allows for the easy positioning of nodes so that they are a visual representation of their relative positions to each other. The mapping of nodes and reaches requires proportional distancing of nodes. The distances between nodes are entered as reach lengths, but the reach lengths input into the data entry grid are not reflected in the Graphic Pane.

To map the diagram, use the Node and Reach Mapping Tools as shown in Table 5-1. To add a new node, click on the Add a New Node button with the left mouse button. Click on the blank Graphics Pane where this node is to be located. Place all other nodes on the diagram so that all docks, entry/exit points, turning/holding areas and topological points are represented. Once this is complete the user should connect the nodes using reaches. Select the Add a New Reach tool and then click on a node in the Graphics Pane and then click on another node. This will connect the two nodes with a reach. Continue until all reaches are represented in the Graphics Pane. After the diagram is complete, the user should select a type for each node. This can be done by right clicking on each node and selecting the appropriate type.

TABLE 5-1
NODE AND REACH MAPPING TOOLS

MAP OPTIONS



The following map options are available:

Normal Selection:		Negates the selection of other map options
Add a New Node:		Places node symbols on the screen
Add a New Reach:		Places reach symbols on the screen
Move an Item:		Moves Node and Reach symbols on the screen
Zoom in/Out 100%:		Zoom Function

5.2.5 Defining Node Types and Entering Node Descriptions

To name each node, click the plus icon beside Port Structures in the Navigation Pane and select Topologic as shown in Figure 5-2. Select the Description field for each node and provide a more meaningful name in the Data Entry Grid.

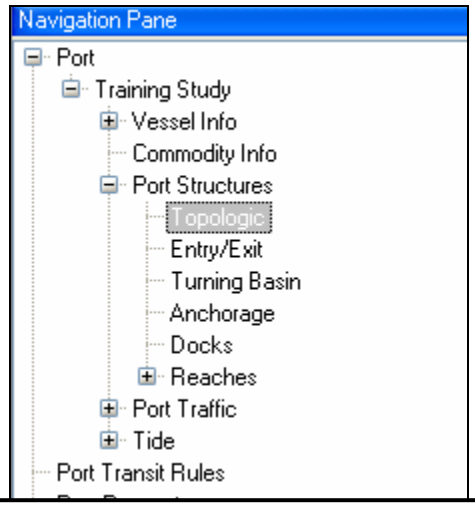


FIGURE 5-2
NODE DESCRIPTIONS

5.2.6 Entering Turning Basin, Dock and Anchorage Measurements

The measurements related to each turning basin and dock should now be defined. Each turning basin node should have measurements entered to define that turning basin. To do this, select the node in the Graphics Pane that represents a turning basin as shown in Figure 5-3. In the

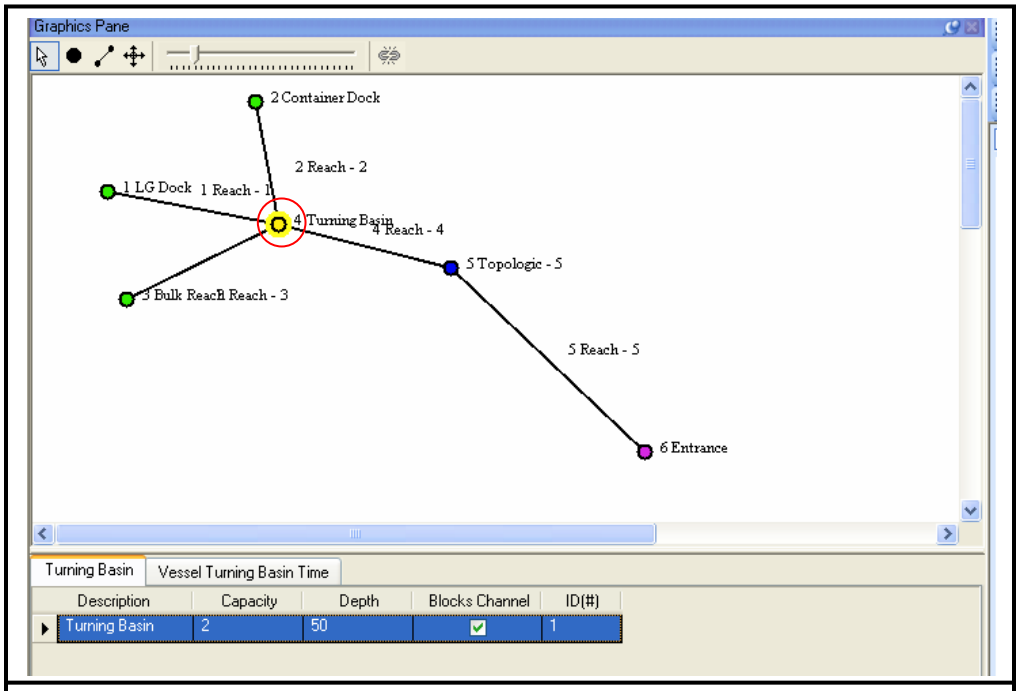


FIGURE 5-3
TURNING BASIN INFORMATION

Data Entry Pane, enter the appropriate information for Description, Capacity and Depth. If a ship blocks the channel while in the turning basin the check box in the Blocks Channel column should be selected.

After all descriptive information concerning the turning basins has been entered; the user should complete the descriptive information for docks. To select a particular dock, click on the node in the Graphics Pane, and the appropriate row in the Data Entry Grid will be highlighted as shown in Figure 5-4. Ensure that a default turning basin is selected for each dock and select when that turning basin will be used (before docking, after docking, light, loaded).

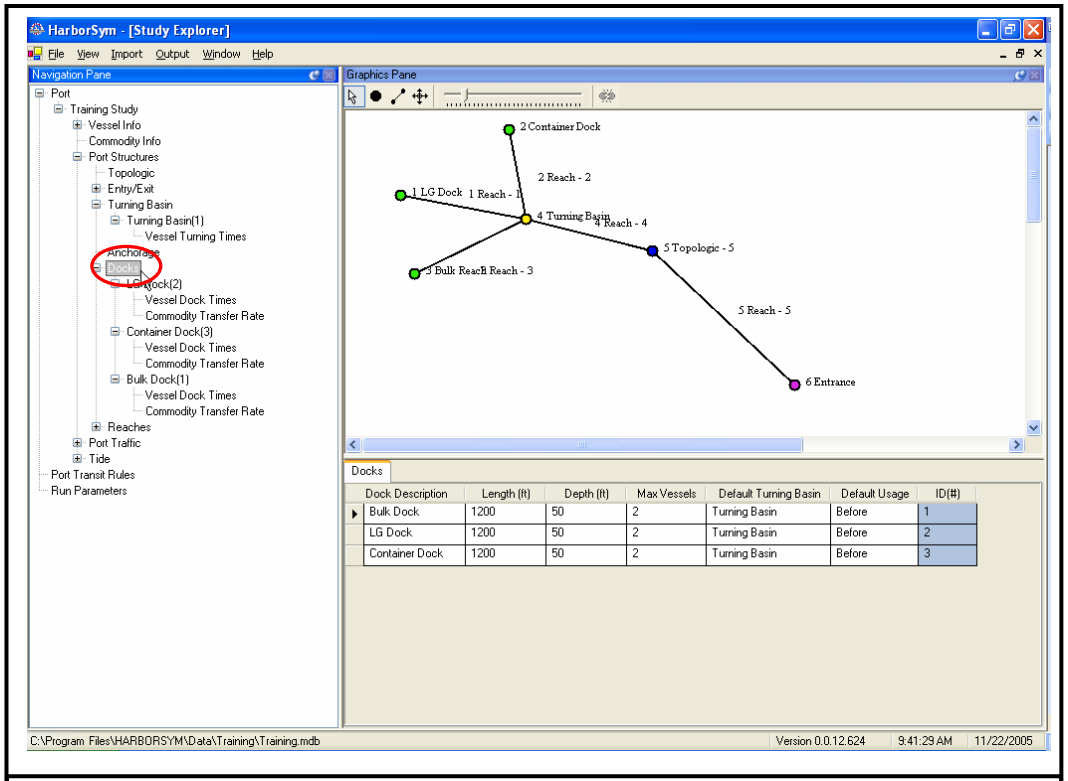


FIGURE 5-4
DOCK MEASUREMENT INFORMATION

The capacity, depth and description of anchorages is entered in the same manner as for turning areas and docks. The user should consider that if vessels are allowed to wait at a turning area, then an anchorage must be entered next to the turning area in the node network to correctly model the harbor.

5.2.7 Defining Reaches

The information defining the physical characteristics of each reach must now be entered. To complete this task, select Reaches in the Navigation Pane as displayed in Figure 5-5.

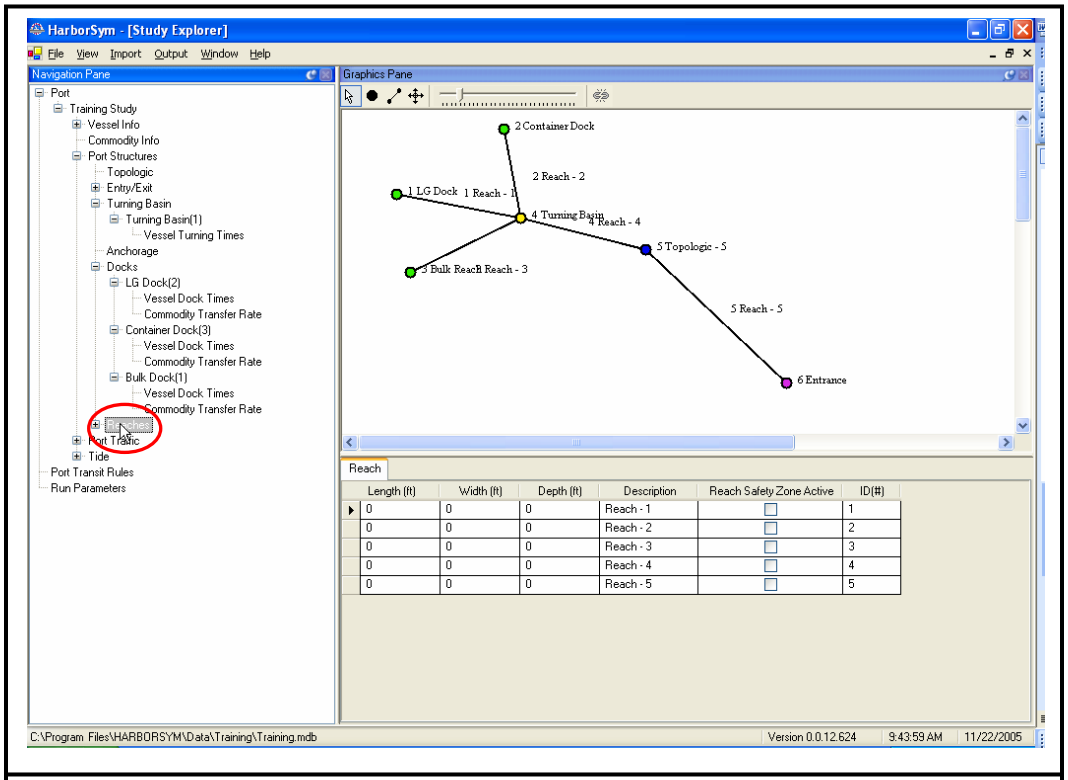


FIGURE 5-5
REACHES SELECTION IN NAVIGATION PANE

The length, width, depth and description can now be entered for each reach in the Data Entry Grid. The user can select a reach in the Graphics Pane and the appropriate row in the Data Entry Grid, where information concerning that reach is displayed, will be highlighted. If there will be any ships carrying critical commodities that require a safety zone through a particular reach, the user should select the check box beside Reach Safety Zone Active for that particular reach. The user can highlight particular reaches and their corresponding rows in the Data Entry Grid by clicking the plus icon beside Reaches in the Navigation Pane and then selecting a particular reach. The reach will then be highlighted in the Graphics Pane and the row of corresponding data will be displaying the Data Entry Grid as shown in Figure 5-6.

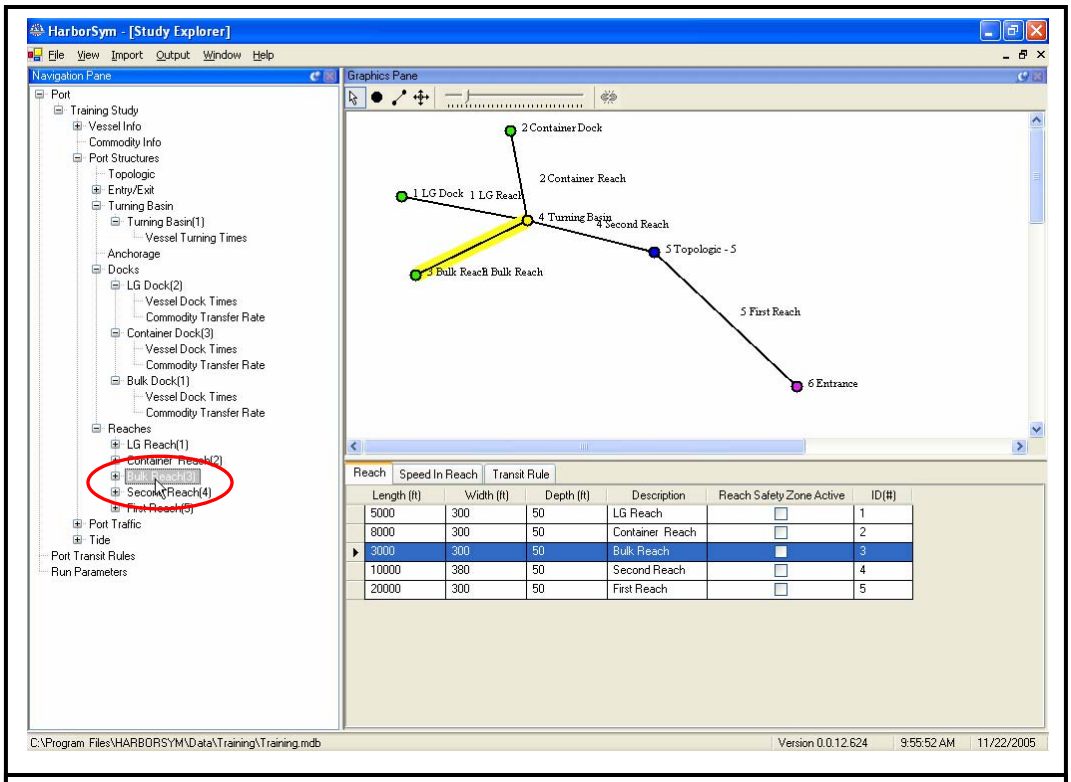


FIGURE 5-6
REACH INFORMATION

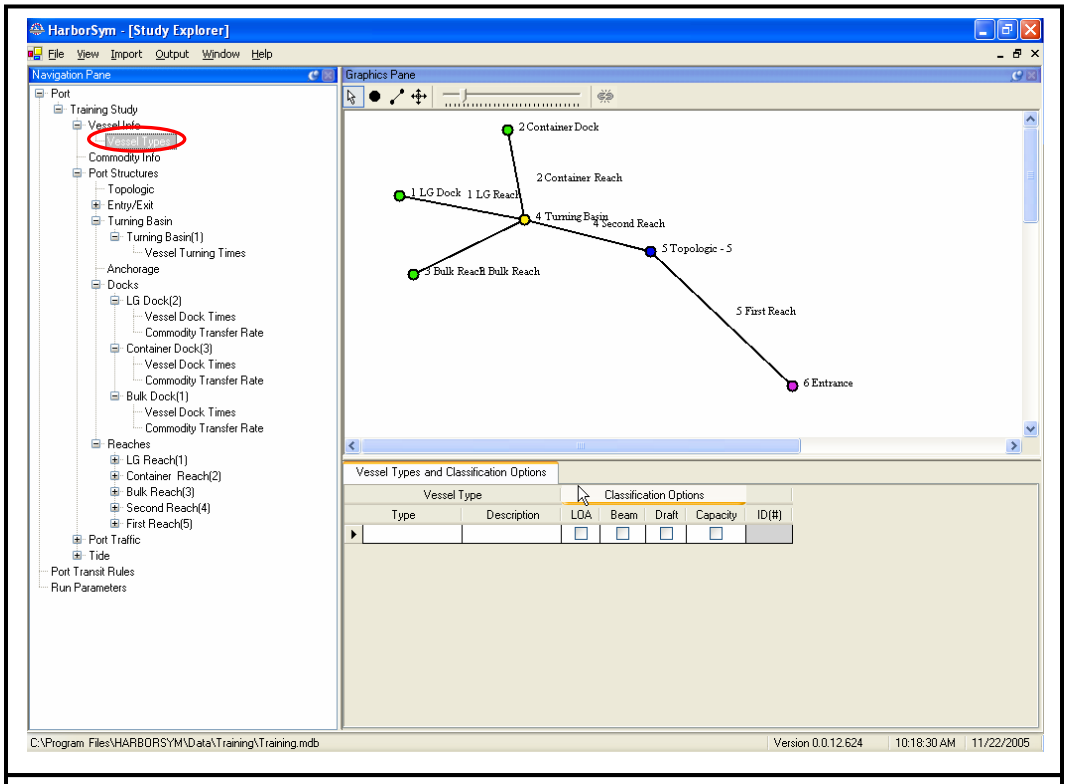
5.3 Vessels

Vessels are the ships that visit the harbor. Vessel types and vessel classes are defined by the user before the vessel call list is entered into HarborSym. HarborSym provides much flexibility in defining vessel types and vessel classes, but the user should consider the availability of data when defining vessel types and vessel classifications.

5.3.1 Vessel Types

Vessel types must be defined by the user for each HarborSym study. The user should normally follow maritime convention. Examples of vessel types include tankers, bulkers, general cargo ships and container ships. To create vessel types and assign parameters to each vessel type, the user should click the plus icon beside Vessel Info in the Navigation Pane. Next, select Vessel Types in the Navigation Pane as shown in Figure 5-7.

The user can now enter the vessel types and select the appropriate classification options in the Data Entry Pane as shown in Figure 5-8.



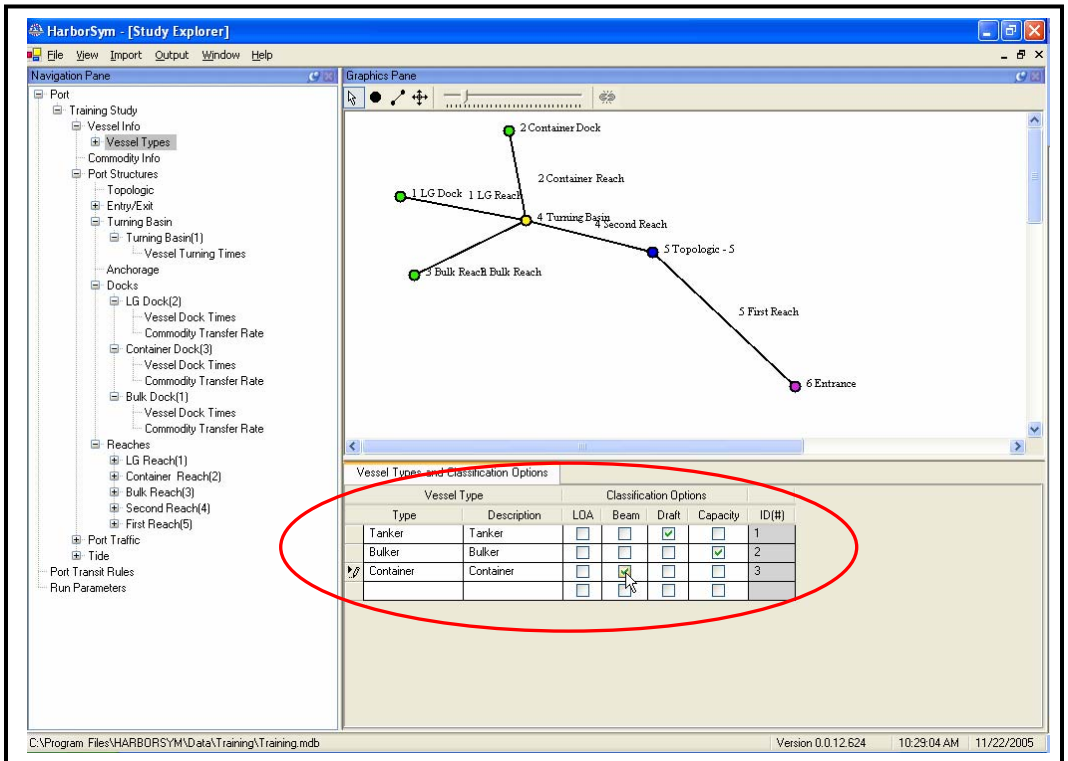


FIGURE 5-8
VESSEL TYPE INFORMATION

5.3.2 Vessel Classifications

Vessel classes are subgroups of vessel types and are the basis for HarborSym data entry. The average speed transiting the harbor, the docking and undocking times, the rate at which commodities are loaded and unloaded are dependent upon vessel classifications. Vessel classes are established by grouping unique vessels frequenting the study area into categories based one or more defining measurements (LOA, Beam and Capacity). The measurements used can differ between vessel types. Also, more than one measurement can be used to define vessel classifications.

LOA – length overall of the vessel

Beam – width of the vessel

Capacity – the amount of commodities (cargo) a vessel can carry, measured in NRT (net registered tons), GRT (gross registered tons) or DWT (deadweight tons).

To define vessel classes within vessel types, click the plus icon beside Vessel Types and select a vessel type as shown in Figure 5-9.

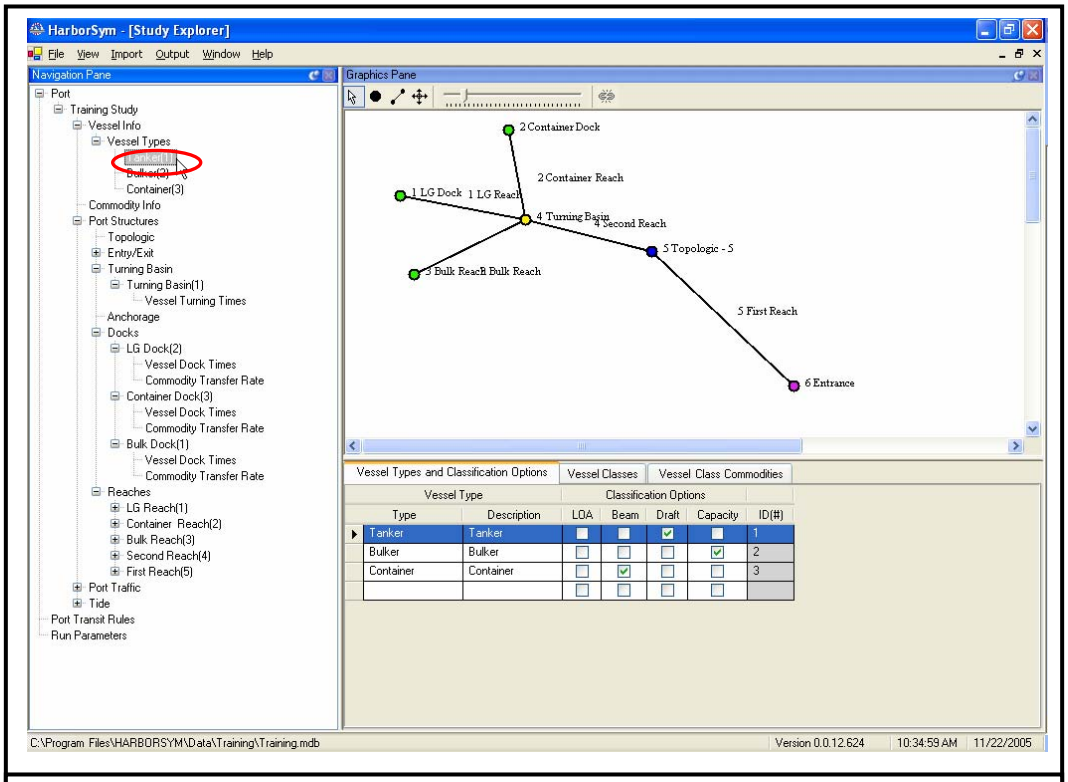


FIGURE 5-9
SELECTION OF VESSEL TYPE

The user needs to pay particular attention to what vessel type is selected before moving to the Vessel Classes tab of the Data Entry Grid because the Vessel Classes Tab in the Data Entry Grid

is directly tied to the Vessel Type that is highlighted in the Navigation Pane. Once the appropriate vessel type is selected, the user should select the Vessel Classes Tab as shown in Figure 5-10.

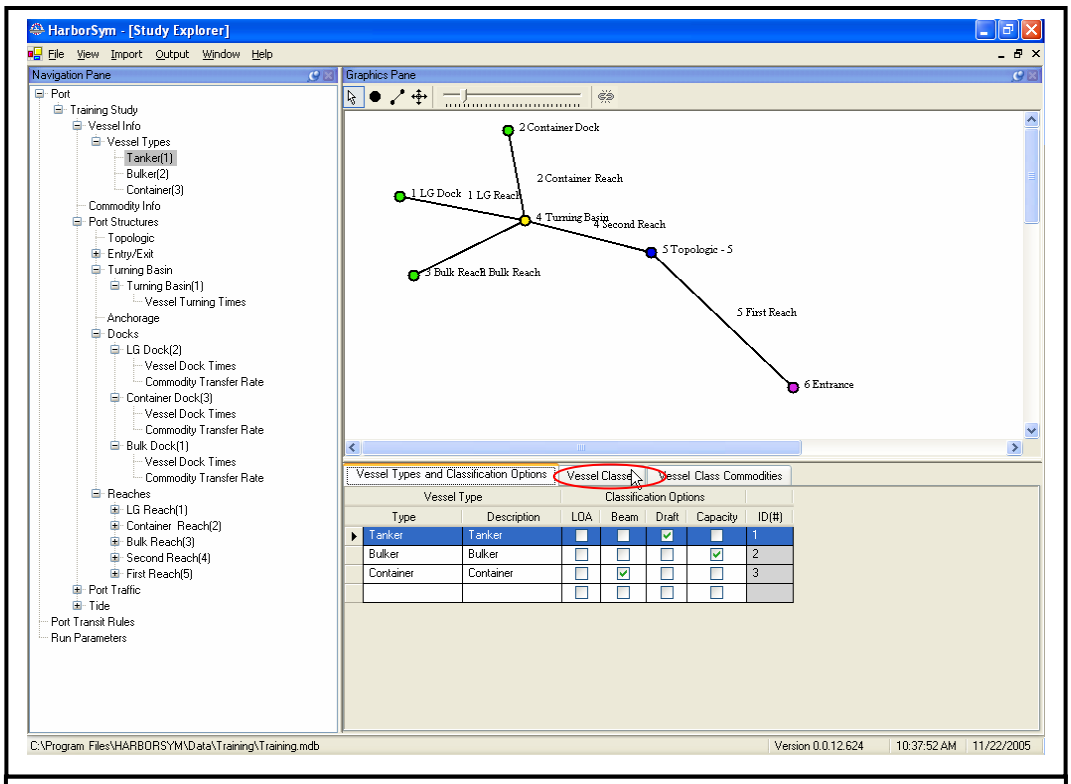


FIGURE 5-10
VESSEL CLASS INFORMATION

The user should then enter the vessel class descriptions and thresholds for the vessel type that were selected. After defining vessel classes for this vessel type, move back to the Vessel Types and Classification Options tab and select the next vessel type and then define the vessel classes for this vessel type until all vessel types have vessel classes defined.

5.3.3 Priority Vessels

A priority vessel is defined in the Vessel Classes Data Entry Grid. Any vessel class can be defined as a priority vessel. A priority vessel has priority over other vessels when transiting through reaches.

5.3.4 Underkeel Clearance

Underkeel clearance is the distance required between the keel, the lowest part of the vessel, and the harbor floor. The default measurement for underkeel clearance is .5 feet. Underkeel Clearance is defined in the Vessel Classes Data Entry Grid.

5.4 Define Commodities

Commodities are the cargos that vessels transfer at docks in the harbor. Commodities are defined into categories based upon the manifest data available. The weight of each commodity category is input in tons per unit of measure. These commodity weights determine the draft of vessels exiting the harbor. Commodity categories are also used to establish transfer rates (vessel loading and unloading rates) for vessels at docks.

5.4.1 Creating Commodity Categories

To define commodities, select Commodity Info in the Navigation Pane as shown in Figure 5-11.

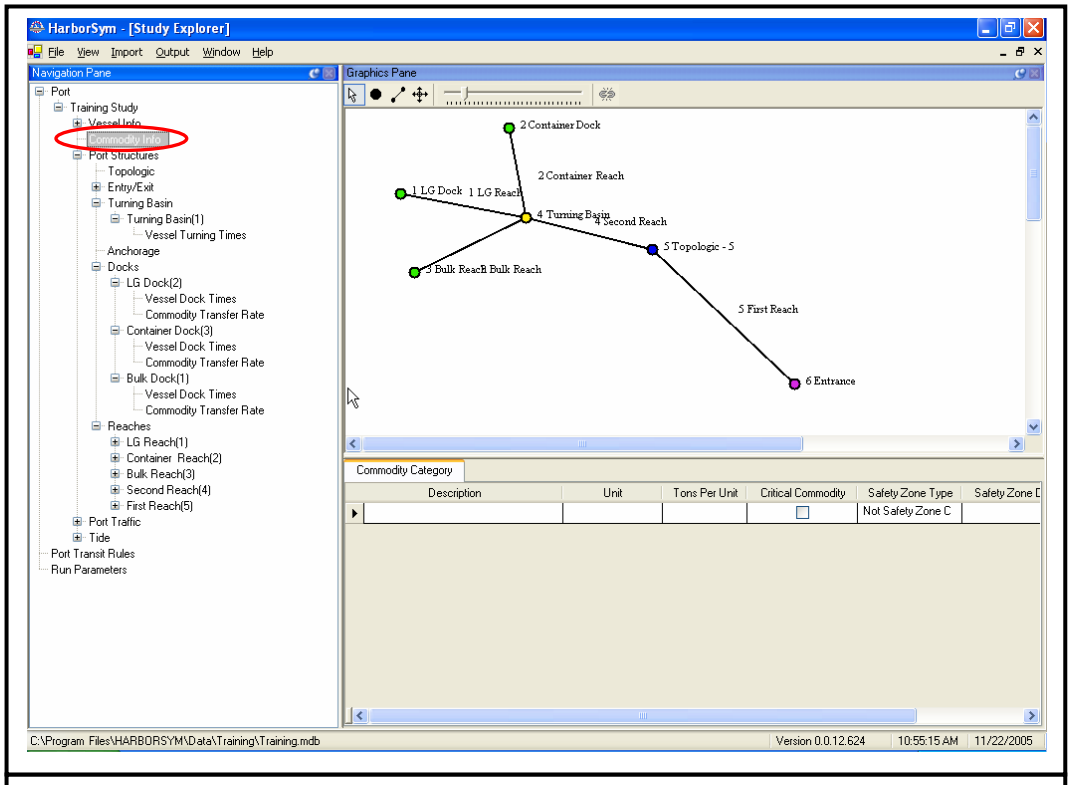


FIGURE 5-11

SELECTION OF COMMODITY INFORMATION

The user can now enter the commodity category description, units of measure and tons per unit for each commodity category as shown in Figure 5-12. If the commodity is a critical commodity then the checkbox in the Critical Commodity column should be selected and the user should select the Safety Zone Type and enter the Safety Zone Distance for this commodity.

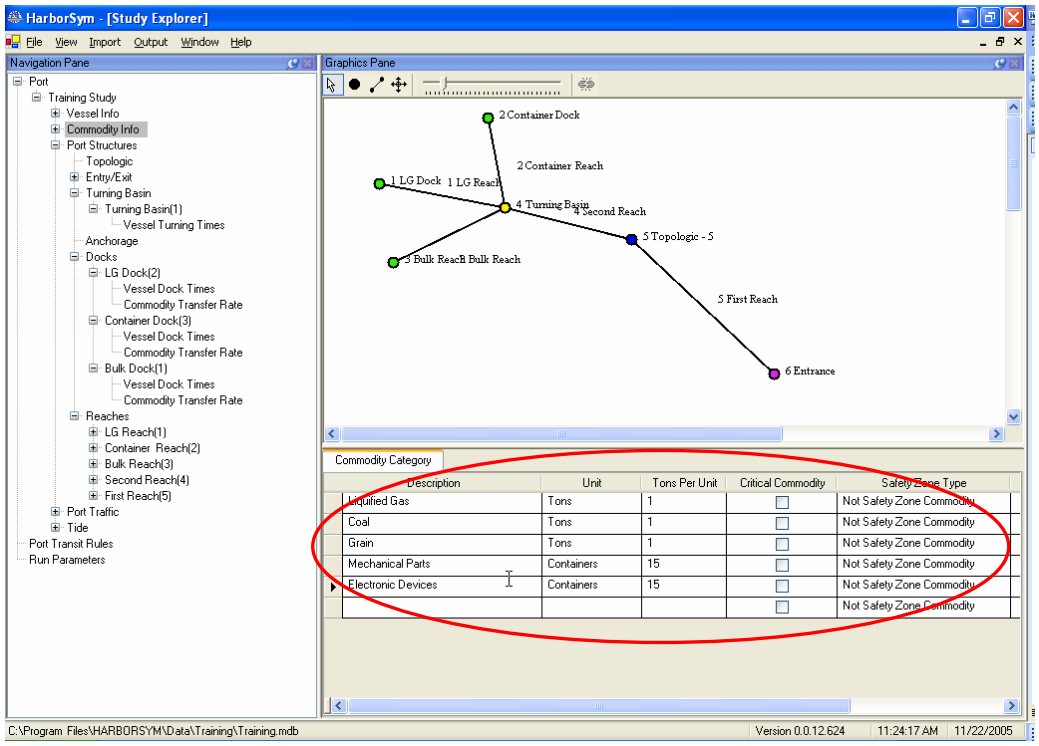


FIGURE 5-12
COMMODITY INFORMATION

5.4.1.1 Critical Commodities

The user can classify commodity categories as critical commodities. Vessels carrying Critical Commodities have safety zones. Safety zones are required distances between vessels. Safety zones must be activated for each reach. This activation is done by clicking on "Reach Safety Zone Active" in the reach definition data entry grid.

5.4.2 Entering Vessel Class Commodities

To define which vessel classes can carry which commodities the user needs to access the Vessel Class Commodities Data Entry Grid. The user should start by clicking the plus icon beside Vessel Info in the Navigation Pane as shown in Figure 5-13.

Next, click the plus icon beside Vessel Types to show all vessel types. The user can now select a vessel type that in the Navigation Pane and then select the Vessel Class Commodities Tab in the Data Entry Pane as shown in Figure 5-14. The Vessel Class Commodities Data Entry Grid will then appear.

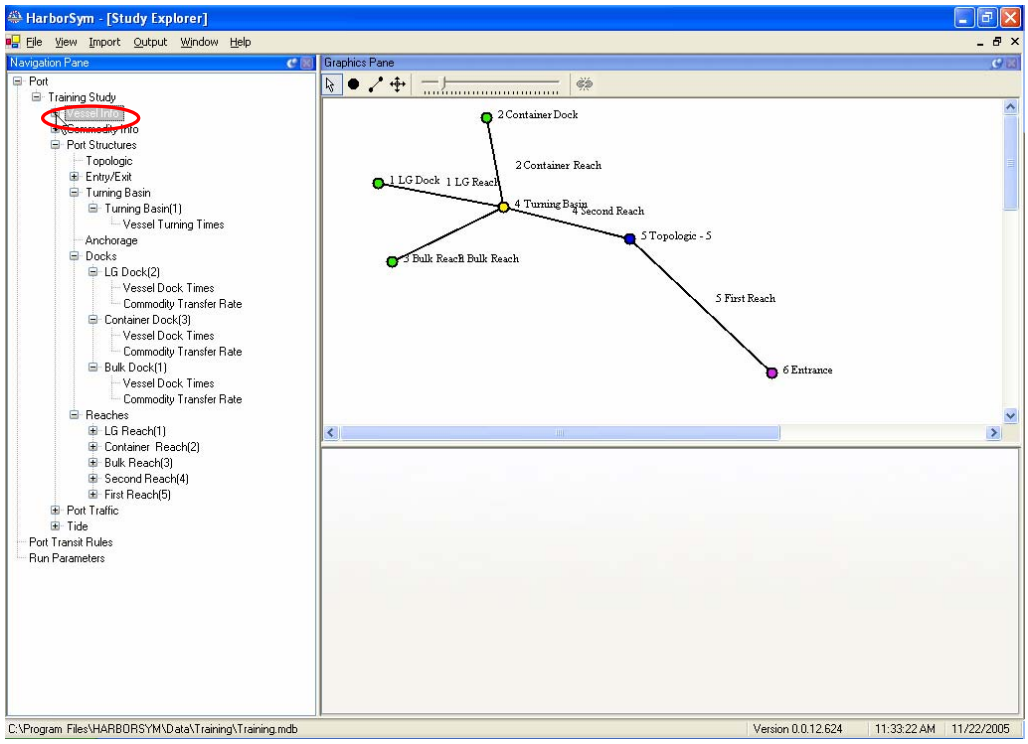


FIGURE 5-13
VESSEL INFORMATION SELECTION

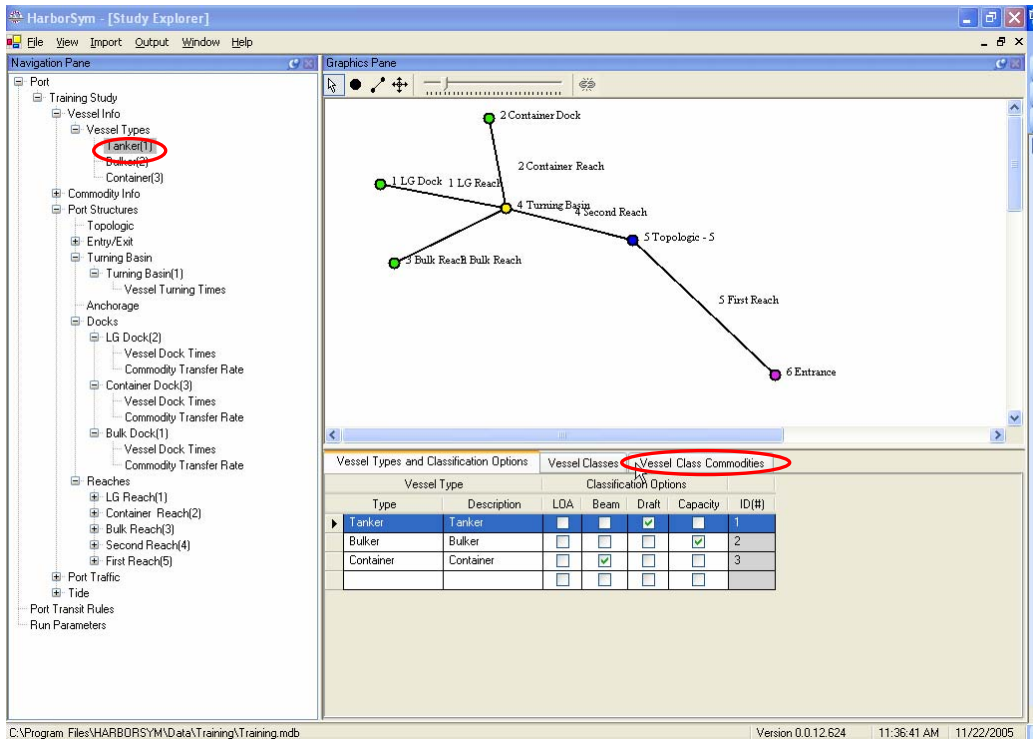


FIGURE 5-14
VESSEL CLASS COMMODITY INFORMATION

After selecting the appropriate vessel class commodities for this vessel type, select the Vessel Types and Classification Options Tab and select the next vessel type. The user can now select the Vessel Class Commodities Tab. Continue with this process until all vessel classes have the commodities they will be carrying selected.

5.5 Vessel Call Lists

The vessel call list is the list of port traffic. The list contains extensive data about the vessels calling and the commodities transferred at the harbor. The required data for the vessel call list includes: movement number, arrival date, arrival time, vessel name, harbor entry point, harbor exit point, vessel arrival draft, dock name, dock number, dock order, commodity, commodity number, tons of each commodity transferred, vessel type number, vessel capacity, LOA (length overall), vessel beam, vessel draft and vessel TPI Factor. Optional data in the vessel call list includes the Vessel Destination (destination port of exiting vessel), NRT (net registered tons), GRT (gross registered tons), DWT (deadweight tons), and Flag (nationality). The user selects NRT, GRT or DWT to represent the vessel capacity for each vessel type. Movements are combined into vessel calls by the HarborSym model and movement numbers can no longer be tracked.

The vessel call list is imported through the Import Port Traffic Template. This template is a Microsoft Excel® workbook with multiple worksheets. Importing the Vessel Call List will fill four data entry grids under Port Traffic in the Navigation Pane.

5.5.1 Create Lookup Spreadsheet

To ensure the vessel, dock and commodity numbers match those assigned within HarborSym, the user can export a spreadsheet that is in the correct format and has the correct number of columns to ensure that the vessel call spreadsheet can be imported back into HarborSym. To create this template, right click on the project name in the Navigation Pane and select Create Lookup Spreadsheet as shown in Figure 5-15.

Select the appropriate location for this file by clicking the button (...) beside the Create Spreadsheet File field. After selecting the location of the file, click OK on the Create Lookup Spreadsheet form as shown in Figure 5-16.

After the message indicating that the spreadsheet is ready for data entry appears as shown in Figure 5-17, the user can click the OK button and then open the spreadsheet using Microsoft Excel®.

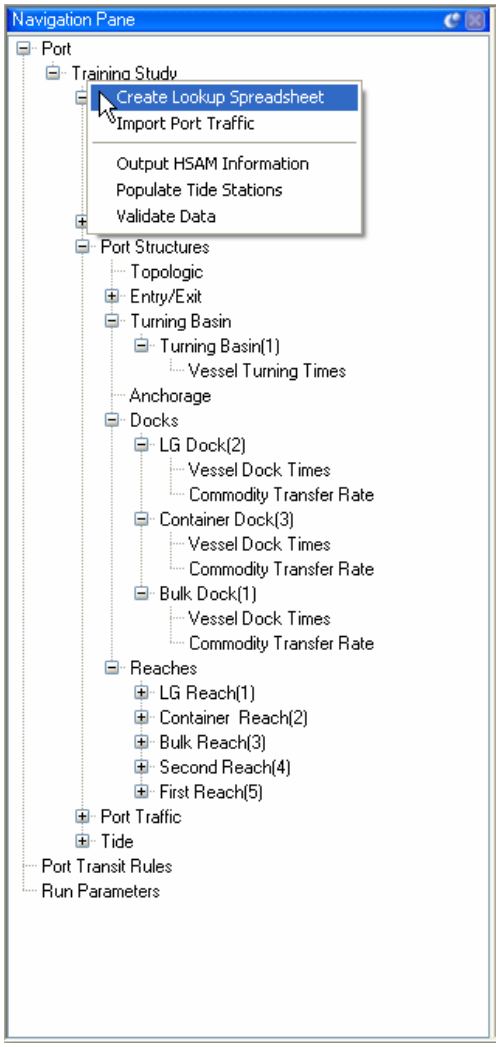


FIGURE 5-15
CREATE LOOKUP SPREADSHEET

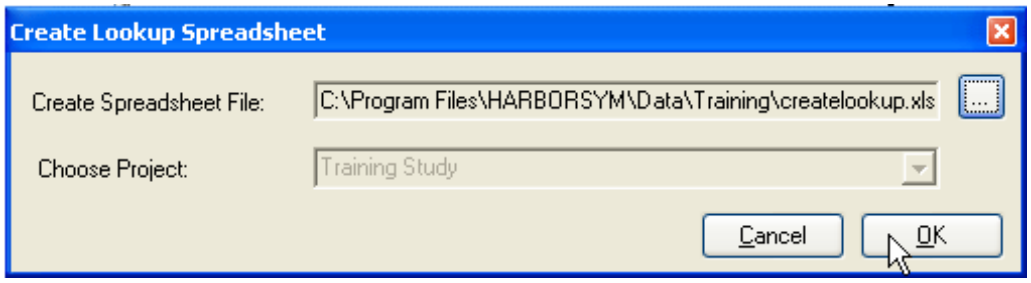


FIGURE 5-16
CREATE LOOKUP SPREADSHEET FORM

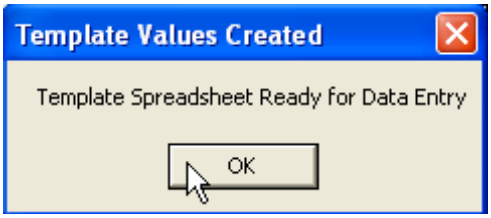


FIGURE 5-17
COMPLETE MESSAGE

5.5.2 Complete Lookup Spreadsheet

The lookup spreadsheet should now be completed with vessel call information. The DockNumber column should be populated based on the dock worksheet. The CommodityNumber column should be populated based on the information on the commodity worksheet and the VesselTypeNumber should be populated based on the information on the vessels worksheet. The Flag field can be populated based on the information on the flags worksheet. If this is a large call list the user can use the Microsoft Excel® VlookUp function to assist with the entry of these values. For a small call list the user can manually enter these values. The remaining information should be completed based on port traffic. After the spreadsheet is completed and has all call information entered the user should save and close the spreadsheet.

5.5.3 Import Vessel Call Spreadsheet

The vessel call list spreadsheet is imported into HarborSym by selecting Import Port Traffic from the Import menu in the Task Bar as shown in Figure 5-18.

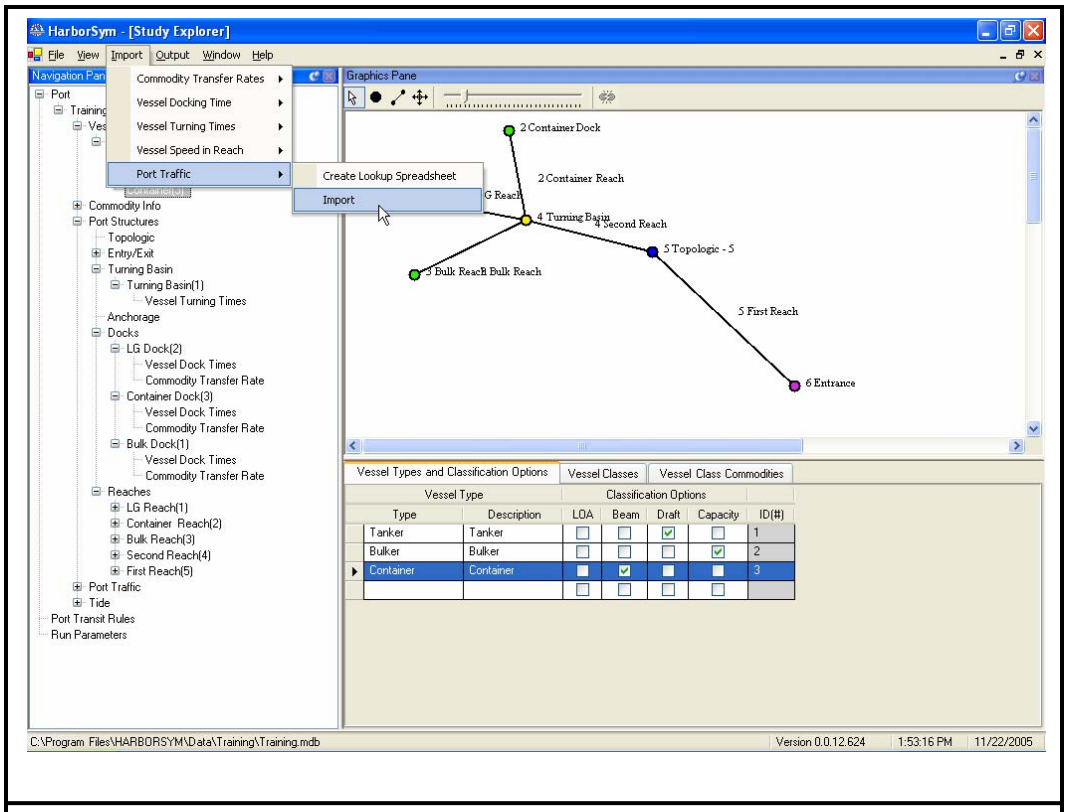


FIGURE 5-18
IMPORT PORT TRAFFIC

Click on the buttong (...) and browse and find the completed vessel call spreadsheet and then ensure that the proper worksheet is selected in the Select Worksheet field. Create Import Log is selected by default and it is recommended that this option be selected. The Create Import Log will create a log of the import and notify the user of any rows that were unable to be imported due to erroneous data. Click the Next button to continue with the import. The user must now select a default vessel class for each vessel type. Ensure that a default class is selected for all vessel types. The default class can be changed by changing the value in the Vessel Type Field as shown in Figure 5-19.

The default for each vessel type is signified by a check in the row for the Default Class value. HarborSym will use the default class to assign a vessel to that class when that vessel cannot be assigned to a specific class based upon its measurements. After the default vessel class has been selected for each vessel type click the Import button. When the import is complete the user will receive the message shown in Figure 5-20 to indicate that the import has completed.

After the user clicks the OK button they will be returned to the Study Explorer.

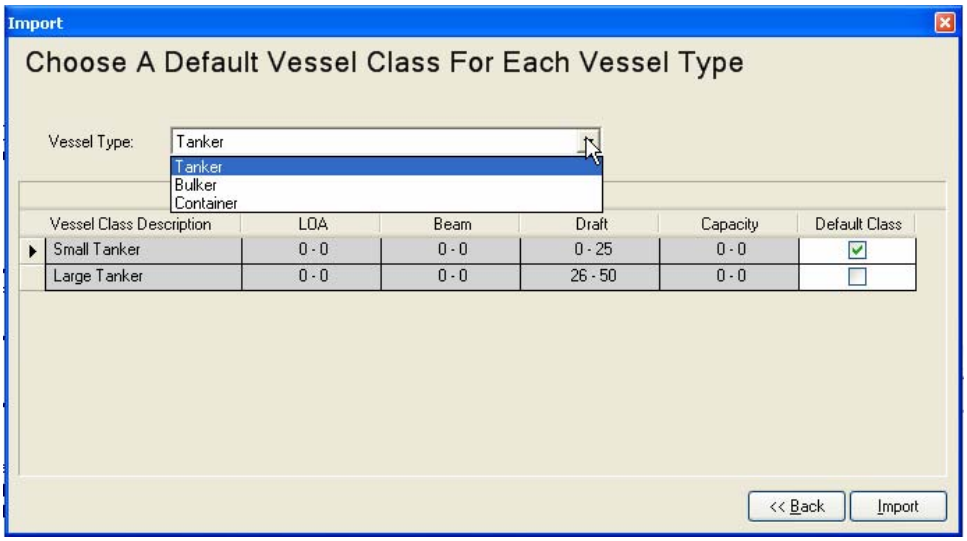


FIGURE 5-19
SELECTION OF DEFAULT VESSEL CLASS

FIGURE 5-20
IMPORT COMPLETE

5.5.3.1 Import Error Log

HarborSym creates an Import Error Log that should be checked to ensure that all data has been imported successfully. This file is in the same location as the vessel call spreadsheet. Locate this file using Windows® Explorer and open it using Notepad. The error log documents default vessel class information, the assignment of vessel classes to each unique vessel and lists the total number of vessel calls, dock visits and commodity transfers. Any records that were unable to be imported due to data errors will be listed in the last section of this document. Any rows that were not imported due to errors can be manually inputted into HarborSym. This can be done by clicking the plus icon beside Port Traffic in the Navigation Pane and then selecting Vessel Calls as shown in Figure 5-21.

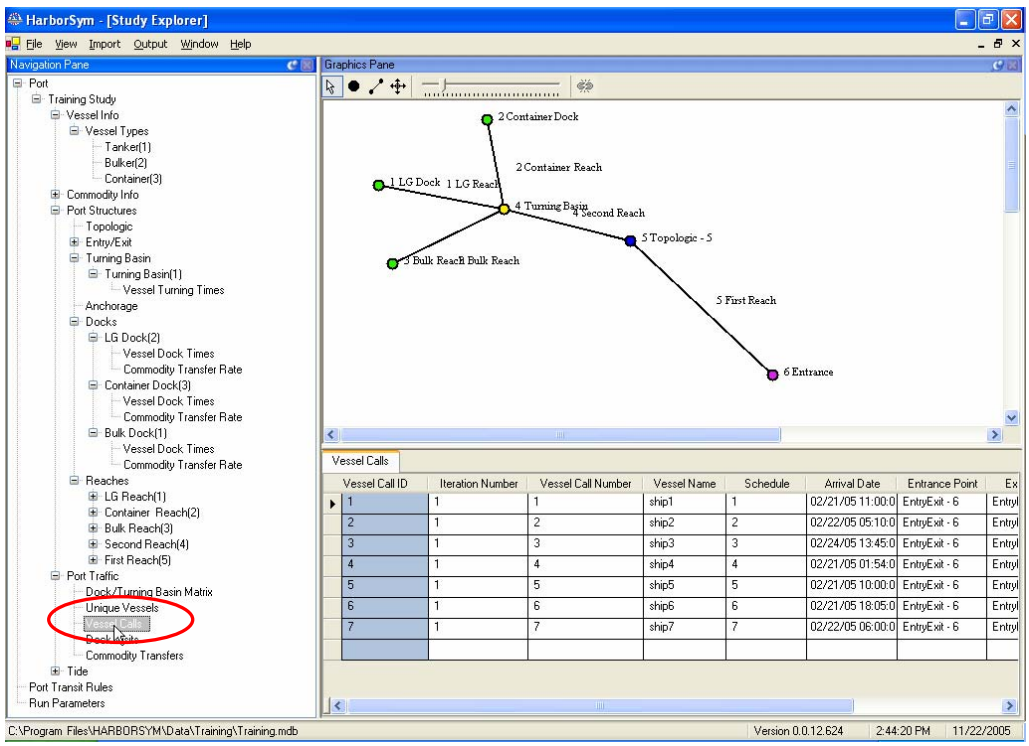


FIGURE 5-21
LIST OF VESSEL CALLS

Additional vessel calls can now be entered in the Data Entry Pane for those vessel calls. In addition, if there are numerous errors then the Microsoft Excel® file can be fixed and re-imported but all current vessel calls will be overwritten at that time.

5.5.4 Port Traffic Data Entry Grids

After the vessel call list is imported, the four data entry grids for port traffic should be reviewed. Each of the columns in these grids contains a sort function that allows the user to review data more easily. For example, the highest and lowest beam of vessels can easily be

reviewed by clicking on the arrow immediately to the right of the beam column heading. Vessel calls can be rendered inactive during a simulation by removing the check in the active column.

5.6 Vessel Speed, Time and Costs

To simulate vessels transiting the harbor and transferring cargo, their speed transiting the harbor and the amount of time spent at the docks must be simulated. A range of speed and times is entered into HarborSym. During the simulation the model varies the speeds and times within that range. Appendix A describes how to use templates for data entry of speeds and times.

5.6.1 Vessel Speed in Reach

Vessel speed in reach is dependent upon the vessel classification, whether the vessel is light (empty) or loaded (full), and the reach the vessel is transiting. To enter the speed in reach for each vessel type for each reach, expand the Reaches portion of the Navigation Pane so that all reach names are displayed in the Navigation Pane as shown in Figure 5-22.

A specific reach in the Navigation Pane should now be selected. Once a reach is selected the user will be able to select the Speed in Reach Tab in the Data Entry Pane as shown in Figure 5-23.

The user is now able to enter the Light and Loaded speeds for each vessel type in this particular reach. It is only necessary to enter vessel speeds for those vessel types that will travel through this particular reach.

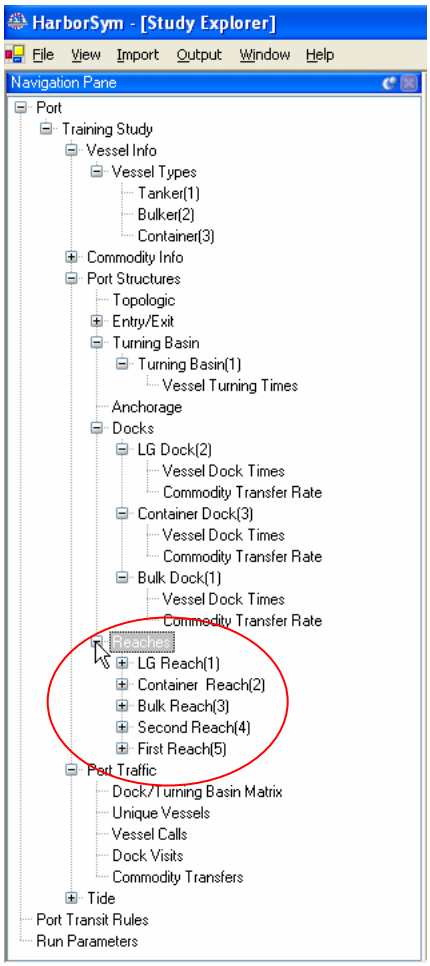
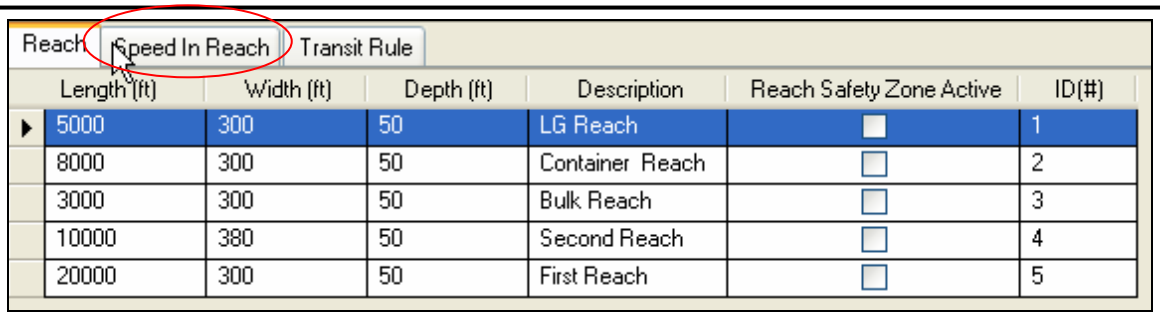


FIGURE 5-22
REACHES



Length (ft)	Width (ft)	Depth (ft)	Description	Reach Safety Zone Active	ID(#)
5000	300	50	LG Reach	☐	1
8000	300	50	Container Reach	☐	2
3000	300	50	Bulk Reach	☐	3
10000	380	50	Second Reach	☐	4
20000	300	50	First Reach	☐	5

FIGURE 5-23
SPEED IN REACH TAB

5.6.2 Vessel Turning Times

The time spent in a turning area is dependent upon the vessel type. A minimum, most likely, and maximum turning time is entered for each vessel type in each turning area. To enter the vessel turning times for each turning basin, expand the Turning Basin portion of the Navigation Pane so that all turning basin names are displayed in the Navigation Pane as shown in Figure 5-24.

After selecting a turning basin in the Navigation Pane, the user will be able to select the Vessel Turning Basin Time Tab in the Data Entry Pane as shown in Figure 5-25.

The user can now enter the minimum, most likely and maximum turning times for each vessel type.

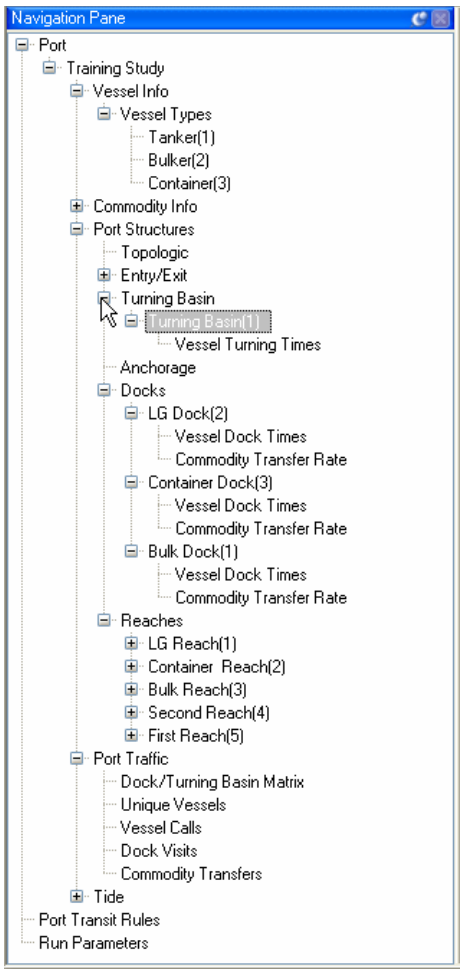


FIGURE 5-24
TURNING BASINS

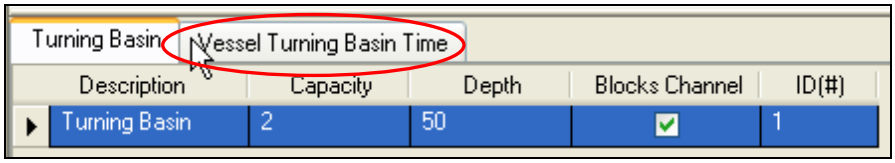


FIGURE 5-25
VESSEL TURNING BASIN TIME TAB

5.6.3 Vessel Docking and Undocking Time

A minimum and maximum docking time and undocking time for each vessel classification at each dock should be entered. To enter the vessel docking and undocking times for each vessel class at each dock, expand the Docks portion of the Navigation Pane so that all dock names are displayed in the Navigation Pane as shown in Figure 5-26.

After the user selects a listed dock they will have the option to select the Vessel Docking Time Tab in the Data Entry Pane as shown in Figure 5-27. The user can then enter the minimum and maximum docking and undocking times for each vessel class at each dock. Vessel docking times need to be entered only for vessel classes visiting the particular dock.

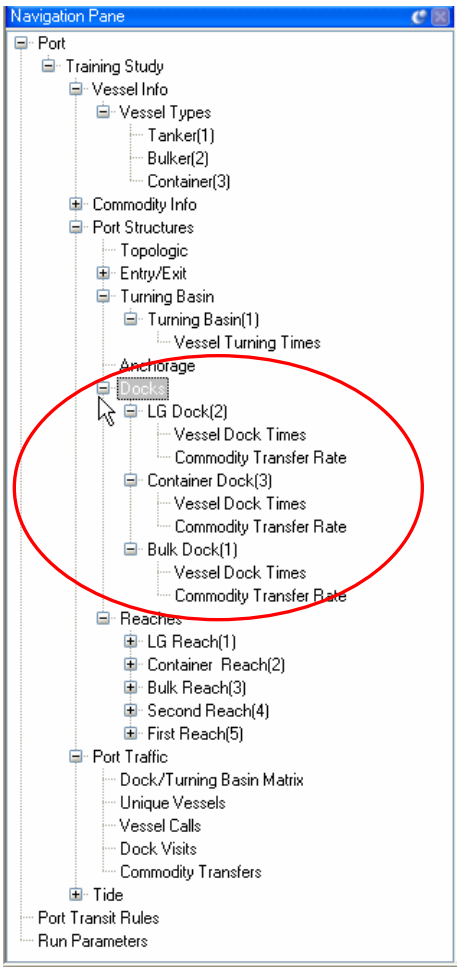
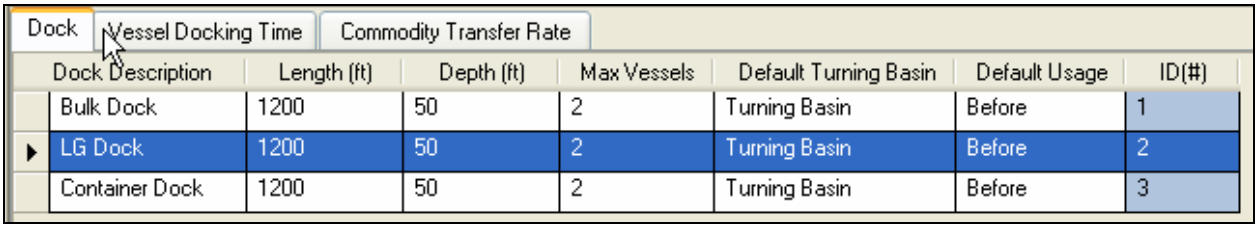


FIGURE 5-26
DOCK LISTINGS



Dock Description	Length (ft)	Depth (ft)	Max Vessels	Default Turning Basin	Default Usage	ID(#)
Bulk Dock	1200	50	2	Turning Basin	Before	1
LG Dock	1200	50	2	Turning Basin	Before	2
Container Dock	1200	50	2	Turning Basin	Before	3

FIGURE 5-27
VESSEL DOCKING TIME TAB

5.6.4 Commodity Transfer Rate

The amount of time spent transferring commodities (cargo) is dependent upon the dock, the vessel type and the commodity category. A minimum, most likely, and maximum loading and unloading time should be entered. To enter the commodity transfer rate for each vessel class and each commodity at each dock, expand the Docks portion of the Navigation Pane so that all dock names are displayed in the Navigation Pane as shown in Figure 5-28.

After the user selects a listed dock they will have the option to select the Commodity Transfer Rate Tab in the Data Entry Pane as shown in Figure 5-29.

The user should then enter the minimum, most likely and maximum loading and unloading rates for the commodities that will be transferred at that dock. Commodity transfer rates need to be entered only for the commodities transferred at that dock. The rows can be filtered to assist with data entry. To filter the rows, click on the column heading in the Data Entry Pane, as shown in Figure 5-30.

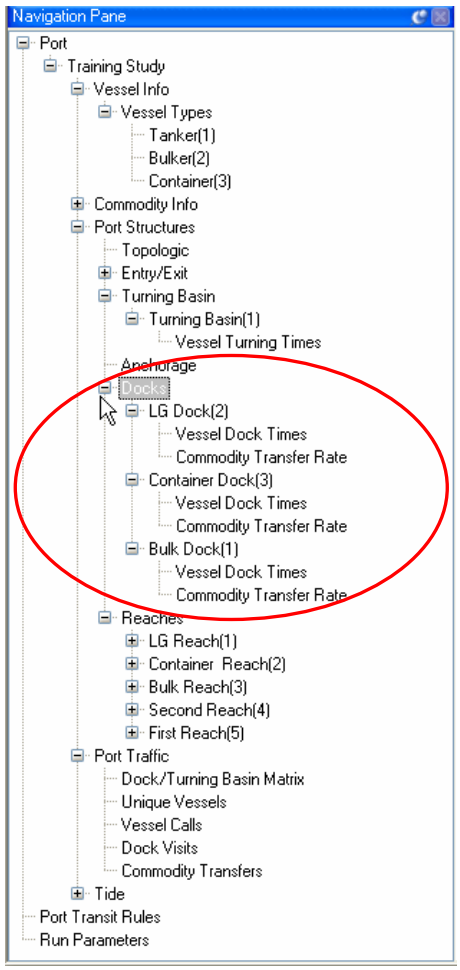
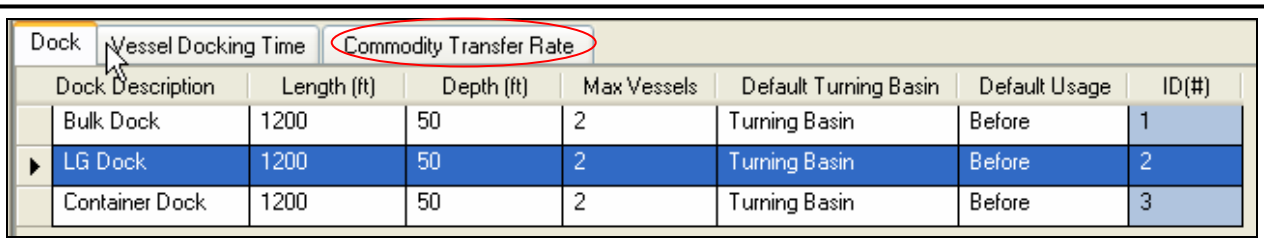


FIGURE 5-28
DOCKS



Dock Description	Length (ft)	Depth (ft)	Max Vessels	Default Turning Basin	Default Usage	ID(#)
Bulk Dock	1200	50	2	Turning Basin	Before	1
LG Dock	1200	50	2	Turning Basin	Before	2
Container Dock	1200	50	2	Turning Basin	Before	3

FIGURE 5-29
COMMODITY TRANSFER RATE TAB

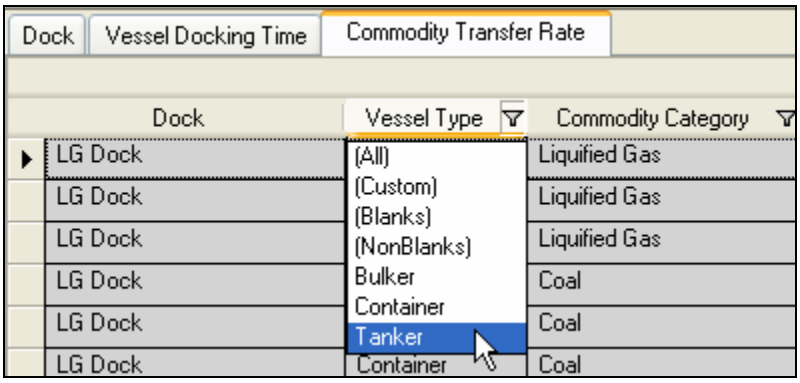


FIGURE 5-30
FILTERING VESSEL TYPES

5.6.5 Vessel Operating Costs

The operating costs of different vessel classes while at sea and in port are necessary to translate the vessel transit times into vessel operating costs for the harbor. To enter vessel operating costs the user should select each vessel type in the Navigation Pane under Vessel Types as shown in Figure 5-31.

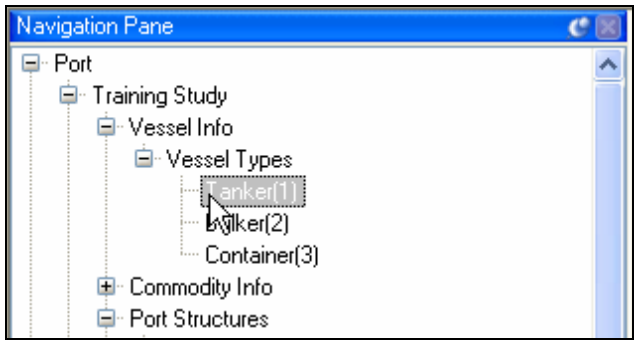


FIGURE 5-31
VESSEL TYPE SELECTION

The user should now select the Vessel Classes Tab in the Data Entry Pane. The Vessel Classes Data Entry Grid will appear with the fields to enter at sea and in port costs for each vessel class. The user will have to use the scroll bar to scroll to the right in the Data Entry Pane to make these fields viewable. Separate costs should be entered for domestic and foreign vessels.

5.7 Simulations

A simulation provides estimates of vessel transit times and operating costs based upon the project and the run parameters. The run parameters are defined by the scenario, which specifies the timing and duration of the simulation. Simulations consist of one or more iterations, as defined by the user.

5.7.1 Scenarios

A scenario is a definition of the run parameters of a simulation. Scenarios define the period of vessel traffic simulated and how the simulation is conducted. Scenarios are stored by name, which appears in the Navigation Pane under Run Parameters. To set up a scenario, click on Run Parameters in the Navigation Pane. The Run Parameters Data Entry Grid will appear, with a field to enter the scenario name. The Scenario Definition Data Entry Grid will display all the options that the user has to specify for a specific scenario. Review and set these parameters as needed. Definitions and further information concerning the different options available can be found in Section 6.1.1, Input Boxes in the Scenario Editor.

5.7.2 Launch a Simulation

After the scenario has been defined the simulation is launched by clicking on the Launch Button at the bottom of the Data Entry Pane. If the study contains multiple projects the user must select the projects to be simulated and click Launch in the new dialog box. If the "Start First Iteration in Step Mode" option was not selected, the simulation will proceed until completion of all iterations.

If the user has chosen to start the simulation in the step mode, the user should click OK on the message received concerning starting the simulation in step mode. Clicking on the Step Button in the Visualization Screen will begin the simulation. Clicking on the Next Button will process the next in the simulation. The user should click on the Continuous Button to have the simulator process events continuously at normal speed. When the simulation is complete the user will see a dialog box with average times and delays displayed. Clicking the OK Button will close the simulation.

5.7.3 Cancel a Simulation

A simulation can be cancelled while in process. Simulations with 50 iterations may take several hours and the user may want to correct data entry based upon the visualization screen. To cancel a simulation, the user should click on Halt. A dialog box will appear with the option to cancel the simulation.

5.8 Transit Rules

Vessel transit rules define the conditions under which vessels can transit reaches or encounter each other. The vessel transit rules for a harbor are usually extensive and have a major impact on vessel transit times. The Harbormaster (the controlling authority of the harbor) typically imposes vessel traffic rules on specified vessel classifications for specified reaches of the harbor. Vessel transit rules are also used to prohibit of vessels with measurements exceeding the capacity of a reach to transit through the reach. Environmental factors such as tide, current, and daylight, are frequently included in vessel traffic rules. There are twenty-six available rules to apply and tailor, in two general types. Single Vessel Rules involve only one vessel and the appropriate vessel parameters are entered only for the "moving vessel." An example is no sailing at night if a vessel is over a size threshold.

Multiple Vessel Rules involve encounters between two vessels. Parameters must be entered for the "moving vessel" and the "other vessel." An example of a multiple vessel rule is a rule that no vessel over a size threshold may encounter a priority vessel. A complete definition of rules and how they are applied is contained in Appendix B. To enter transit rules that apply to the entire port, the user should select Port Transit Rules in the Navigation Pane as shown in Figure 5-32.

To specify transit rules for specific reaches, the user should select the specific reach within Reaches in the Navigation Pane as shown in Figure 5-33. After the reach is selected the user can then select the Transit Rule Tab in the Data Entry Pane.

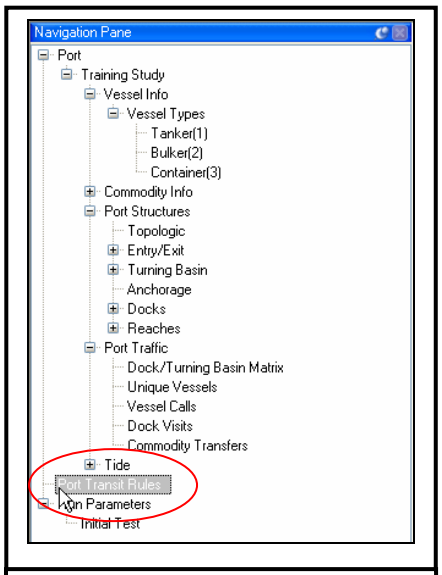


FIGURE 5-32
PORT TRANSIT RULES SELECTION

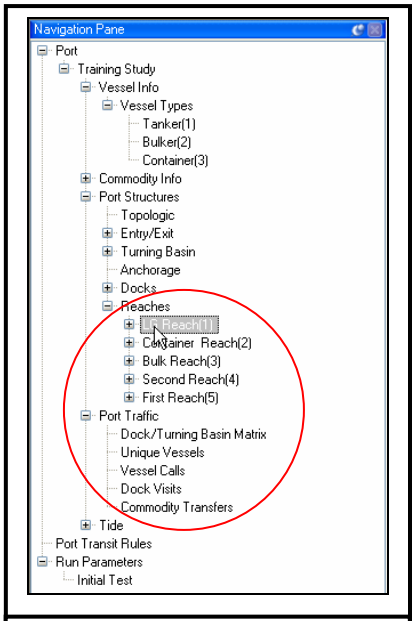


FIGURE 5-33
SELECTING A REACH

5.9 Project Alternatives

The objective of HarborSym is to measure the benefits of harbor improvements. The usual benefits of harbor improvements are a reduction in the time vessels spend in the harbor. The amount of time vessels spend in the harbor under current harbor conditions is estimated by running simulations of vessel traffic in the without project condition. The next step is to estimate the amount of time vessels will spend in the harbor under alternative project conditions, with a harbor improvement alternative implemented. In HarborSym, this "with project" condition is entered as another project within the study.

5.9.1 Cloning

HarborSym Study manager contains a cloning feature that allows the user to create a new project within a study that contains all of the data entered for the original project. The user can then modify the measurements that would change if the harbor improvement was implemented

as the alternative project. To clone a project the user should move to the Study Manager by selecting Study Manager from the File menu. The user should now click the Clone Project button on the Study Manager Dialog Box and enter a name and storage location for this new project. After specifying the name and location of the new project, click the OK button. Click the Close Button to close the Study Manager and select Study Explorer from the View Menu. The new project will appear in the Navigation Pane under Port below the original project.

5.10 Implement Tide and Current

Tide has a significant impact on harbor vessel traffic, because of depth constraints and vessel traffic rules. Tide should be introduced to the model if the draft of any calling vessel approximates the channel depths in the harbor. Current is introduced to the model only if a vessel traffic rule requires consideration of current.

5.10.1 Tidal Stations

Tidal stations are stations from which tides are measured. All tidal stations are available in HarborSym and the appropriate stations should be selected for use in a study. To populate the tidal stations the user should right-click on the project name and select Populate Tide Stations. The latitude and longitude of the harbor and a search radius must be entered to obtain a list of the relevant tidal stations. Once this data has been entered click the Retrieve button. The appropriate tidal stations need to be enabled by checking the enable box. Click the None Button at the bottom of the Dialog Box to disenable to enable all tidal stations. Then enable the appropriate tidal stations. Select Primary or Secondary from the menu for station type. Click the Save button to save these changes.

5.10.2 Current Stations

Current stations are stations from which the flow of current is measured. All current stations are available in the HarborSym model. To enable current stations follow the same process as tidal stations except select “current” as the station type. Current stations are assigned to reaches by clicking on “Current Stations” in the Navigation Pane. The user should click the plus icon beside Tide in the Navigation Pane so that Current Stations will appear. Clicking on Current Stations in the Navigation Pane will prompt the Current Stations Data Entry Grid to appear. Only the reaches with vessel traffic rules considering current will appear in the data entry grid. A current station has to be selected for each reach where a vessel traffic rule uses current.

5.11 Data Validator

The Data Validator function analyzes the data input into HarborSym to determine if there are any errors. The user can right click on the project name and select Validate Data to prompt the Data Validation Form. The screen will appear as shown in Figure 5-33. The user selects the categories with which to validate data and then clicks on Check Data. A report will appear in the same screen. The report will state Error or Warning and list the problem in any categories for which data needs attention. This report can be printed or saved.

The Data Validator will list any data entry fields that are empty, but these empty data entry fields will not necessarily cause a problem. As an example, the Data Validator will list errors for

any vessel class without speeds entered in any reach. However, not all vessel classes transit every reach. Not having a speed entered for passenger vessels on a reach used only to access a container dock should not cause a problem. Having the automated Data Validator function list all missing data fields allows the user to systematically check for problems.

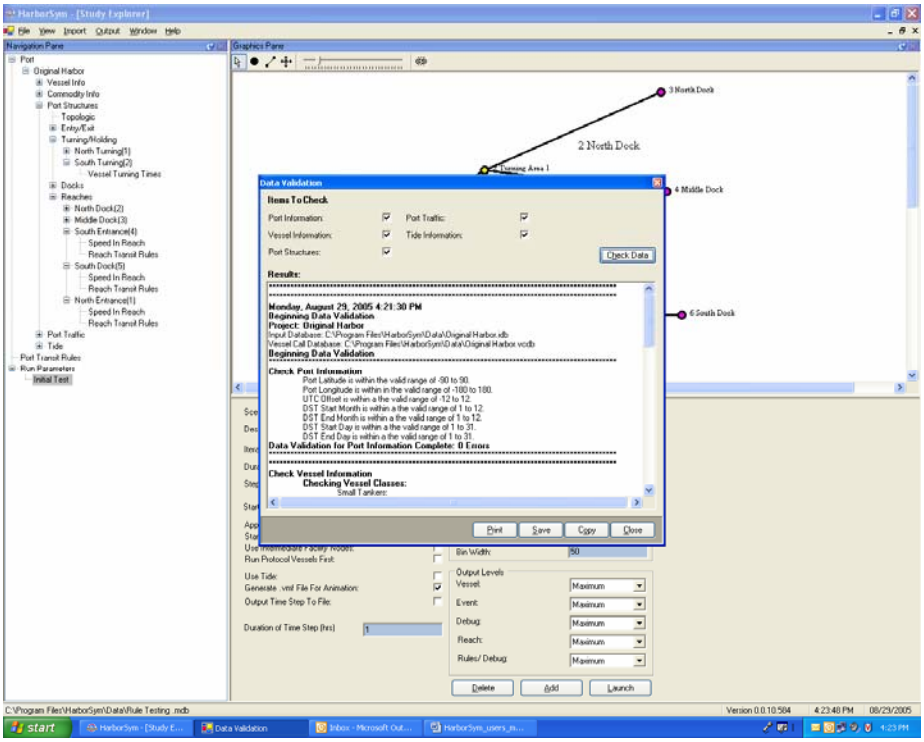


FIGURE 5-33
DATA VALIDATION FORM

Section 6
Run Parameters and Simulation Scenarios

HarborSym estimates transportation costs by simulating vessel movements through the harbor based on user specified parameters. The port conditions are specified by defining projects. The timing and conditions of the simulations are defined by the user through the run parameters. Run parameters are stored within HarborSym in scenarios.

Harbor improvement projects typically are intended to improve transportation efficiency by lowering vessel transit times. Harbor improvements can also result in transportation efficiency gains by allowing vessel to carry more cargo into the harbor. In HarborSym, a new project is created to represent the harbor with improvements. The new project can be cloned from the original project after the node network for the original project is completed. The original project and all alternative projects are stored within the same HarborSym study.

A simulation of vessel traffic within a harbor is launched using a scenario. A scenario is the term used to describe a particular combination of data sets and simulation parameters selected by the HarborSym user. A scenario describes the "Run Parameters" of the simulation. During a simulation, the vessel traffic is routed through the node network based upon historical vessel traffic for the period of time defined in the scenario. HarborSym is agent based, with the assumption that vessels arrive at the harbor based upon limited knowledge of the harbor conditions. A theoretical harbor supervisor has knowledge of all legs in the harbor and approves travel through legs based upon harbor conditions and traffic. Vessel traffic is routed through legs based upon the first arrival having priority, with exceptions for priority vessels.

6.1 Creating Simulation Scenarios

A scenario is a named combination of simulation run parameters. Vessel traffic is simulated in a harbor using navigation conditions described by the project and in the scenario defined by the user. Once the simulation process has been launched, the parameters specified in the scenario are retrieved to simulate traffic behavior in the harbor. Completion of a simulation yields many statistical results that can be compared to other simulations.

A simulation consists of one or more iterations. The iterations in a simulation have the start date and duration period specified by the user. For each iteration, HarborSym tracts the vessel traffic entering and exiting each reach in a harbor and maintains vessel traffic statistics. These vessel traffic statistics are available for each iteration in the output files. Additional iterations of a simulation increase the accuracy of output, but require more processing time. Therefore, the HarborSym user must balance accuracy with processing time when determining the number of iterations in a scenario. The processing time for simulations is also impacted by the duration of the iterations, and the size of the vessel call list for the harbor.

6.1.1 Input Boxes in the Scenario Editor

The following input boxes allow the user to define a simulation scenario. The scenario is the run parameters of the simulation as shown in Figure 6-1. Scenarios are stored and are used to simulate multiple projects.

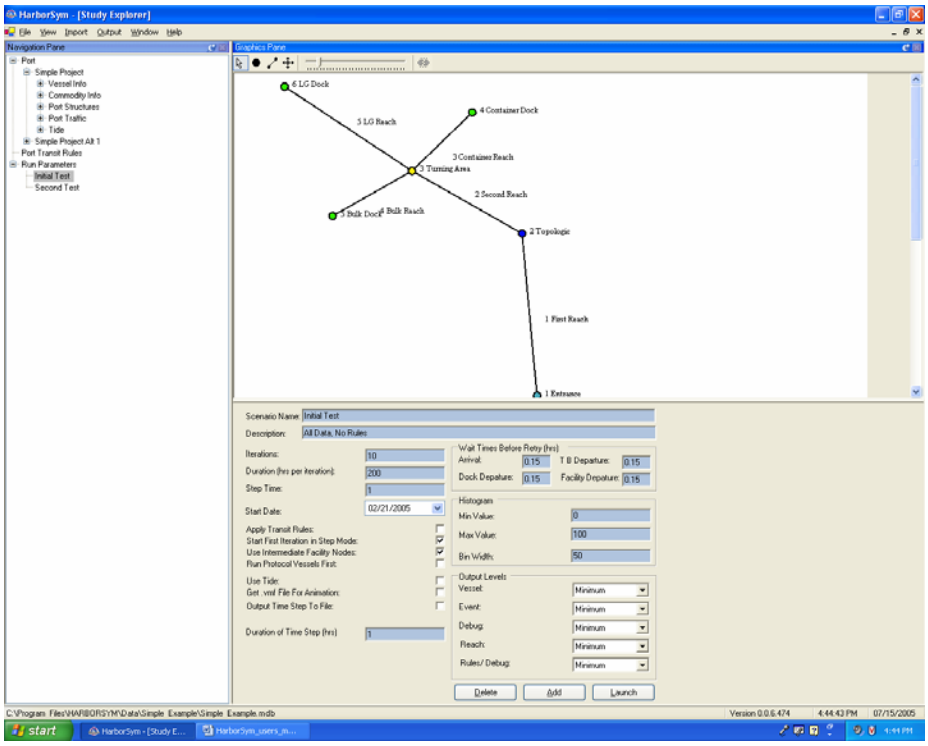


FIGURE 6-1
SCENARIO EDITOR WINDOW IN THE DATA ENTRY PANE

Scenario Name	Each scenario should be named. The scenario will then be available to recall on the Navigation Pane.
Description	This block allows a scenario description that is included in output reports.
Iterations	The user determines number of iterations run during the simulation.
Duration	Duration (hrs per iteration) The length of the simulation period.
Step Time	Maximum time increment used to report vessel status during simulations
Start Date	The date on which the simulation starts.
Apply Transit Rules	Applies the "active" vessel transit rules to the simulation.

Start in Step Mode	Step Mode provides the user with a visualization of vessel traffic in the node network during the simulation.
Use Facility Nodes	Use Intermediate Facility Nodes allows vessels to wait at specified facilities before entering a reach.
Protocol Vessels First	Run Protocol Vessels First provides protocol vessels priority when entering reaches. This priority impacts vessel traffic when reach rules have constraints on vessel encounters.
Use Tide	Allows tide to be used in calculating vessel draft clearances. This option must be used to activate rules that use tide.
Get File for Animation	Obtain simulation output for HSAM visualization.
Output Time Step	Future Feature.
Duration of Time Step	Relates to an output file.
Wait Times Retry	Wait Times Before Retry. The length of time a vessel must wait before trying to enter a reach after a rule violation forces the vessel to wait.
Output Levels	The level of output files produced showing the results of the simulation.
Histogram	Controls an output graph.

6.1.2 Output Control Options in the Scenario Editor Form

There are eight .csv files which are viewable in Excel format; Commodity.csv, DeletedVesselCall.csv, DraftAdjustment.csv, FacilityNodeConstrain.csv, FacilityNodeUsage.csv, TurningAreaConstrain.csv, TurningAreaUsage,csv, and VesselClassStatistics.csv. There are also five ASCII files available as output from a simulation; vessel, event, debug, reach, rules. The user selects the level of output for these files from the menu. Further information about these files is in Appendix C.

6.1.3 Command Buttons in the Scenario Editor

Add	Adds a new scenario with most of the scenario parameters
Delete	Deletes current scenario. Deleting a scenario does not delete the results from that scenario run, however, since these are stored in a different data table.

Launch — Launch will begin the simulation. Brings up the Choose Project Screen, if more than one project is in the study.

6.1.4 Choose Projects Screen

If more than one project exists within a study a Choose Project Screen will appear when a simulation is launched. With this screen, the user selects which projects to simulate by checking the box next to the project name. Buttons exist to select all of the projects listed for simulation, or to select none of the projects for simulation. After the projects are selected, the launch button must be clicked to start the simulation.

6.2 Viewing Simulations

The HarborSym user can opt to run the simulation in step mode. This option requires more processing time for simulations, but it allows the user to visualize vessel encounters during simulations. To view simulations follow steps 1 and 2 below.

1. In the Scenario Editor, click on the "Start First Iteration in Step Mode" box and click on "Launch." In the dialog box that appears, select the projects to simulate. Click on "Launch" again. A dialog box will appear stating "Starting in Step Mode Press Step Button to Continue," with an OK button. Click on "OK." The dialog box will then disappear. The screen with the dialog box is shown in Figure 6-2.

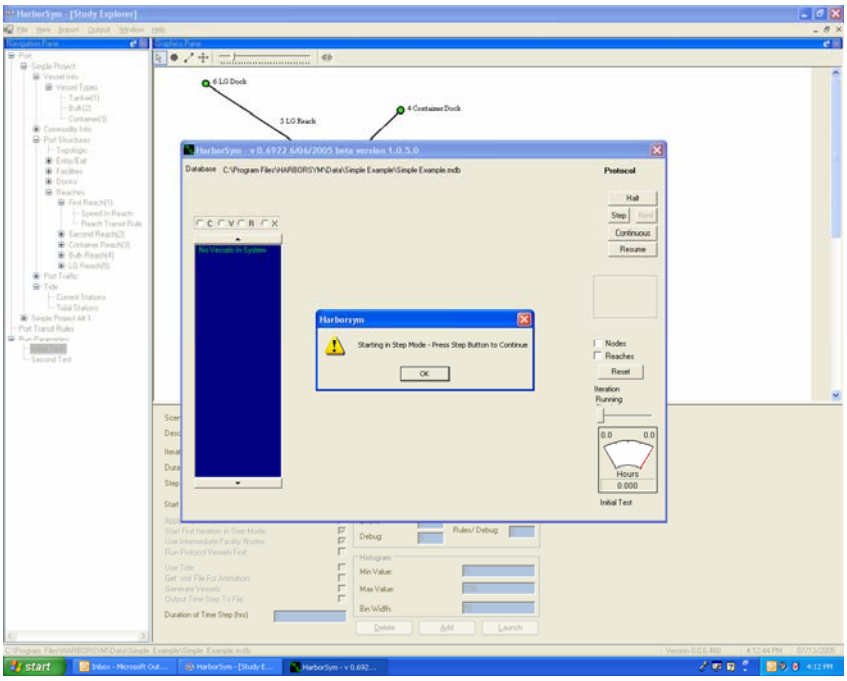


FIGURE 6-2
DIALOG BOX OVERLAYING STEP MODE SCREEN

2. Click on the Step Button in the Step Mode Screen. To visualize vessel encounters click on the Next Button to see static displays in the time increment previously selected. Click on Continuous Button to see the simulations continue until all iterations are complete. Click on the Halt Button to stop the simulations. Figure 6-3 shows the Step Mode Screen that will appear.

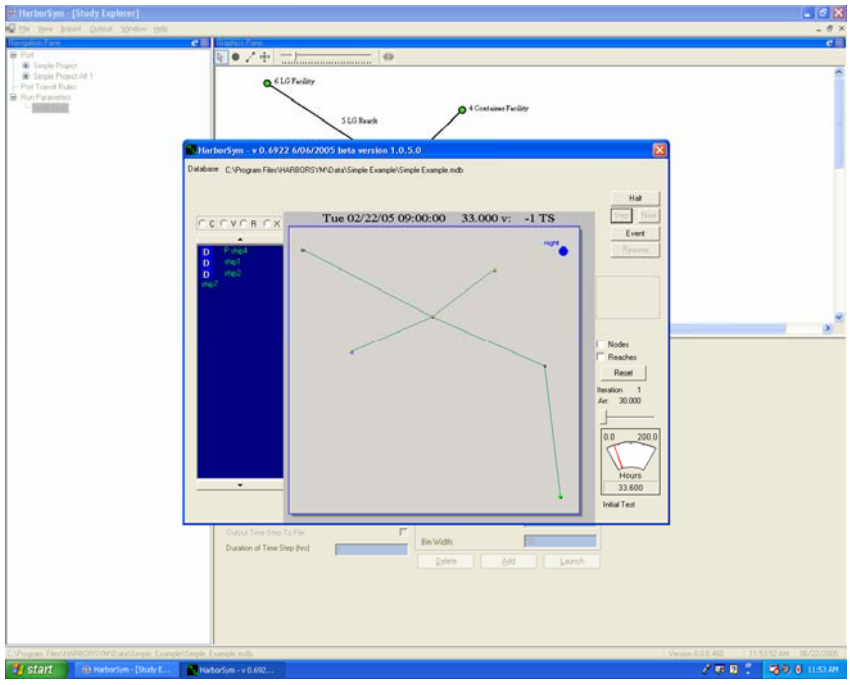


FIGURE 6-3
STEP MODE SCREEN SHOWING SIMULATION

3. The Step Node Screen allows the user to modify the simulation visualization. The Nodes Check Box and the Reaches Check Box on the right side of the screen allow the user to place the names of nodes and reaches on the screen. On the left side of the screen check boxes allow the user to select between monitoring the status of commodities, vessels or reaches during the simulation. The commodities selection will show the cumulative amount of each commodity category transferred as each iteration progresses. The vessel selection will show the current status of each vessel, during the simulation. The vessels are listed as transiting , at a dock, or waiting.

4. During the simulation the user can determine the status of any vessel moving through the harbor, after clicking on the Event Button to halt the simulation. If the user clicks on the vessel representation in the node network, the vessel data sheet with the vessel name and characteristics will appear. If the user clicks on the vessel name in the Status Pane the vessel location in the node network will be displayed. Afterwards, clicking on the Step Button or the Continuous Button will resume the simulation.

6.3 Viewing Simulation Output Results

Project alternatives are analyzed by comparing the output of simulations. Within HarborSym the user can obtain the output of simulations in reports or graphs. Additional, more detailed, external reports are also stored separately in the same folder as the project input file.

Several output reports are available within HarborSym. These output reports are accessed through the Output Pillar on the toolbar. The output reports available are the Project Comparison Report, the Single Scenario Report, the Reach Rule Violations Report, the Transit Rules Report, the Vessel Class Characteristics Report and the Commodity Info Report. The reports are accessed by clicking on Output and then clicking on Reports on the menu that appears. Choosing any of the reports reveals a dialogue box for selection of scenarios or projects, depending upon the report.

6.3.1 Project Comparison Report

The Project Comparison Report compares two or more projects using the same scenario. The Average Vessel Time in System (Harbor) and Average Vessel Cost are compared. The user must choose the Base Project (without-project condition) with which all other selected projects are compared. Once the Base Project is chosen, the user can select as many projects as are available for comparison. To view the Project Comparison Report, proceed as follows:

1. From the menu, click on the “Output” pillar and select “Project Comparison.” A dialogue box titled “Report Scenario Comparison” will appear.

2. Select the scenario and the base project from the first pop-up menu. Select the comparison project by checking the box in the selection below. An example of a Scenario Comparison Report is shown in Figure 6-4. It provides a date stamp for the run and the scenario name. Simulation results are shown in the bottom portion of the report.

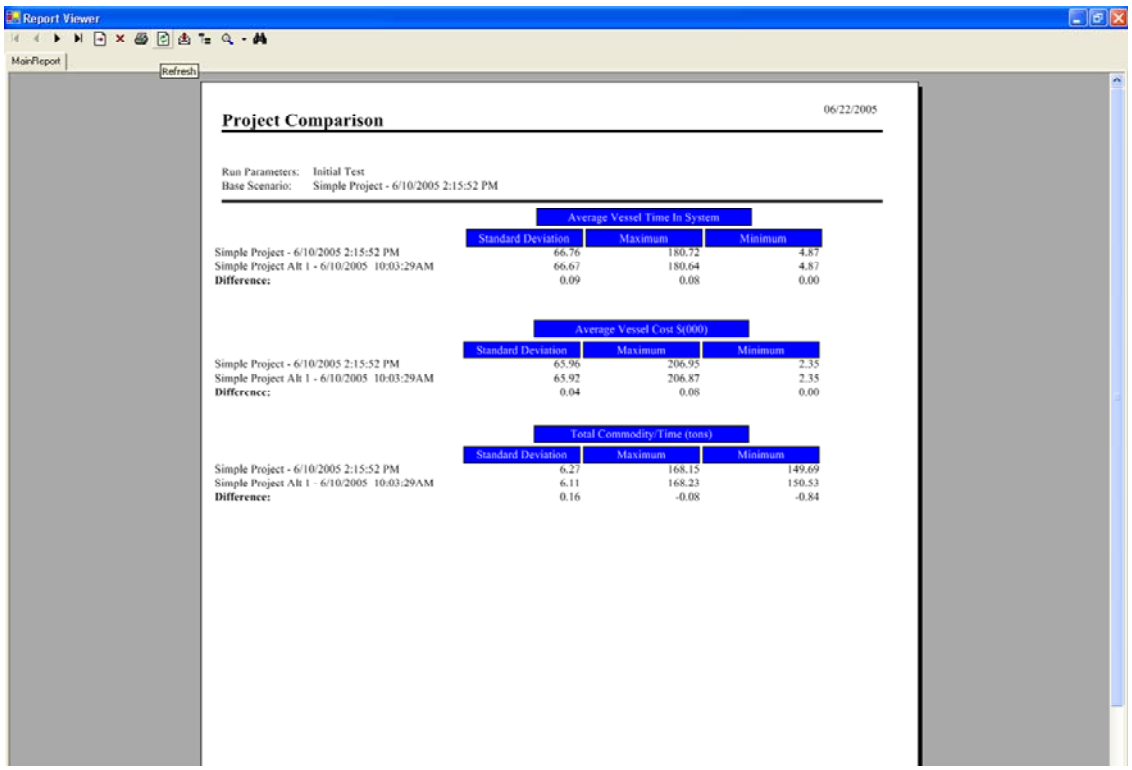


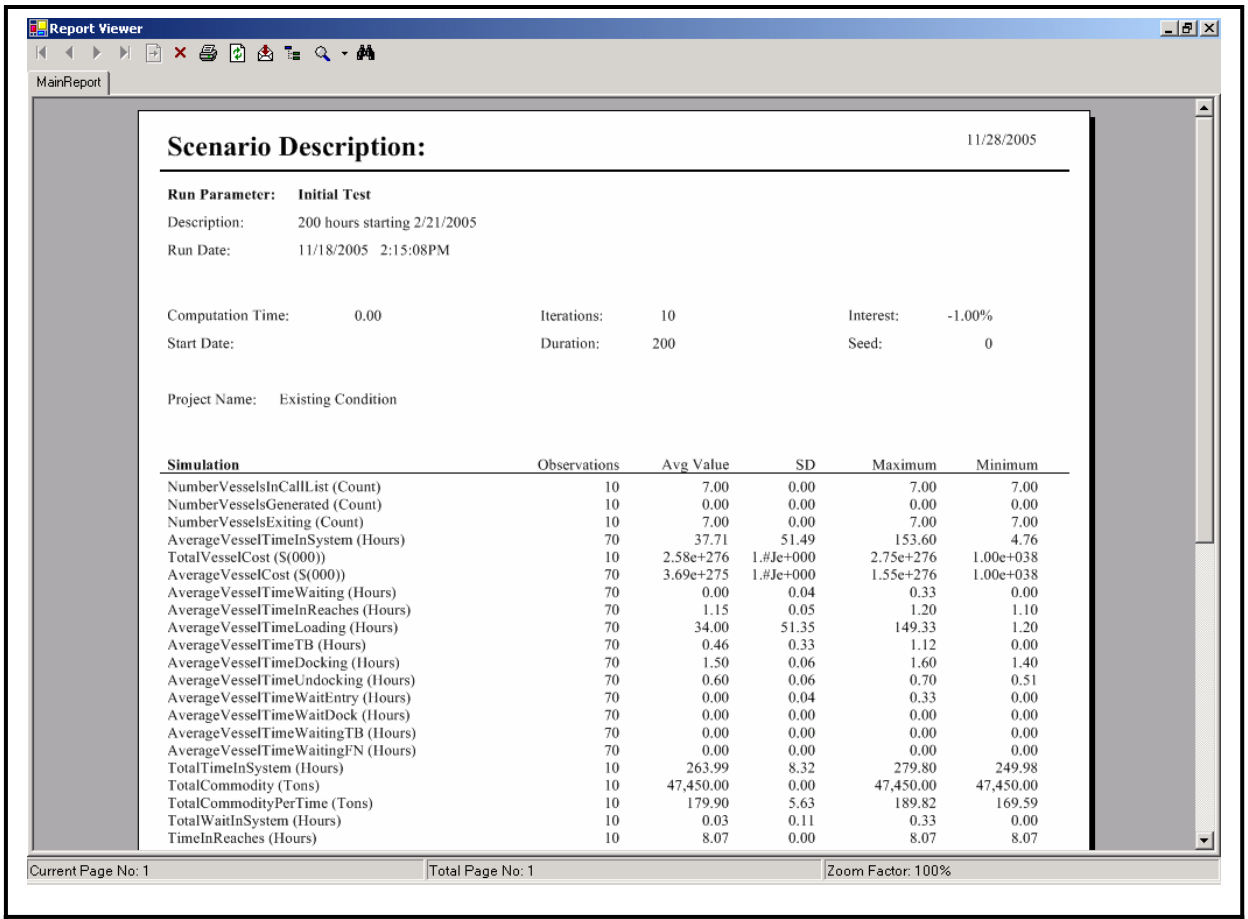
FIGURE 6-4
EXAMPLE SCENARIO COMPARISON REPORT

6.3.2 Single Scenario Report

The Single Scenario Report provides detailed data on a single simulation of a single scenario and single project. The results for all iterations of the simulation are averaged, and the minimum, maximum and standard deviation between the results of iterations are listed.

1. From the menu, click on the "Output" pillar and select "Single Scenario." A dialog box titled "Report Builder" with a menu of scenarios will appear.

2. Select the appropriate scenario. Each scenario / project simulation run is listed in chronological order. An example of a Single Scenario Report is shown in Figure 6-5.



Report Viewer

MainReport

Scenario Description: 11/28/2005

Run Parameter: **Initial Test**
Description: 200 hours starting 2/21/2005
Run Date: 11/18/2005 2:15:08PM

Computation Time: 0.00 Iterations: 10 Interest: -1.00%
Start Date: Duration: 200 Seed: 0

Project Name: Existing Condition

Simulation	Observations	Avg Value	SD	Maximum	Minimum
NumberVesselsInCallList (Count)	10	7.00	0.00	7.00	7.00
NumberVesselsGenerated (Count)	10	0.00	0.00	0.00	0.00
NumberVesselsExiting (Count)	10	7.00	0.00	7.00	7.00
AverageVesselTimeInSystem (Hours)	70	37.71	51.49	153.60	4.76
TotalVesselCost ($(000))	10	2.58e+276	1.#Je+000	2.75e+276	1.00e+038
AverageVesselCost ($(000))	70	3.69e+275	1.#Je+000	1.55e+276	1.00e+038
AverageVesselTimeWaiting (Hours)	70	0.00	0.04	0.33	0.00
AverageVesselTimeInReaches (Hours)	70	1.15	0.05	1.20	1.10
AverageVesselTimeLoading (Hours)	70	34.00	51.35	149.33	1.20
AverageVesselTimeTB (Hours)	70	0.46	0.33	1.12	0.00
AverageVesselTimeDocking (Hours)	70	1.50	0.06	1.60	1.40
AverageVesselTimeUndocking (Hours)	70	0.60	0.06	0.70	0.51
AverageVesselTimeWaitEntry (Hours)	70	0.00	0.04	0.33	0.00
AverageVesselTimeWaitDock (Hours)	70	0.00	0.00	0.00	0.00
AverageVesselTimeWaitingTB (Hours)	70	0.00	0.00	0.00	0.00
AverageVesselTimeWaitingFN (Hours)	70	0.00	0.00	0.00	0.00
TotalTimeInSystem (Hours)	10	263.99	8.32	279.80	249.98
TotalCommodity (Tons)	10	47,450.00	0.00	47,450.00	47,450.00
TotalCommodityPerTime (Tons)	10	179.90	5.63	189.82	169.59
TotalWaitInSystem (Hours)	10	0.03	0.11	0.33	0.00
TimeInReaches (Hours)	10	8.07	0.00	8.07	8.07

Current Page No: 1 Total Page No: 1 Zoom Factor: 100%

FIGURE 6-5
SINGLE SCENARIO REPORT

6.3.3 Reach Rule Violations Report

The Reach Rule Violations Report provides detailed information on the vessel traffic rules that resulted in wait and retrys during a simulation. During HarborSym simulations, the rules are not actually violated. Instead of violating a rule, the moving vessel waits at the entrance to a leg. After the specified time period the moving vessel attempts to move again in a "retry."

1. From the menu, click on the "Output" pillar and select "Reach Rule Violations." A dialog box titled "Report Builder" with a menu of projects will appear.

2. Select the appropriate scenario/ project combination.

6.3.4 Transit Rules Report

The Transit Rules Report provides detailed data on the rules implemented during a simulation. A report is available for each project simulated.

3. From the menu, click on the "Output" pillar and select "Transit Rules." A dialog box titled "Choose Project for Report" with a menu of projects will appear.

4. Select the appropriate project. An example of a Transit Rules Report is shown in Figure 6-6.

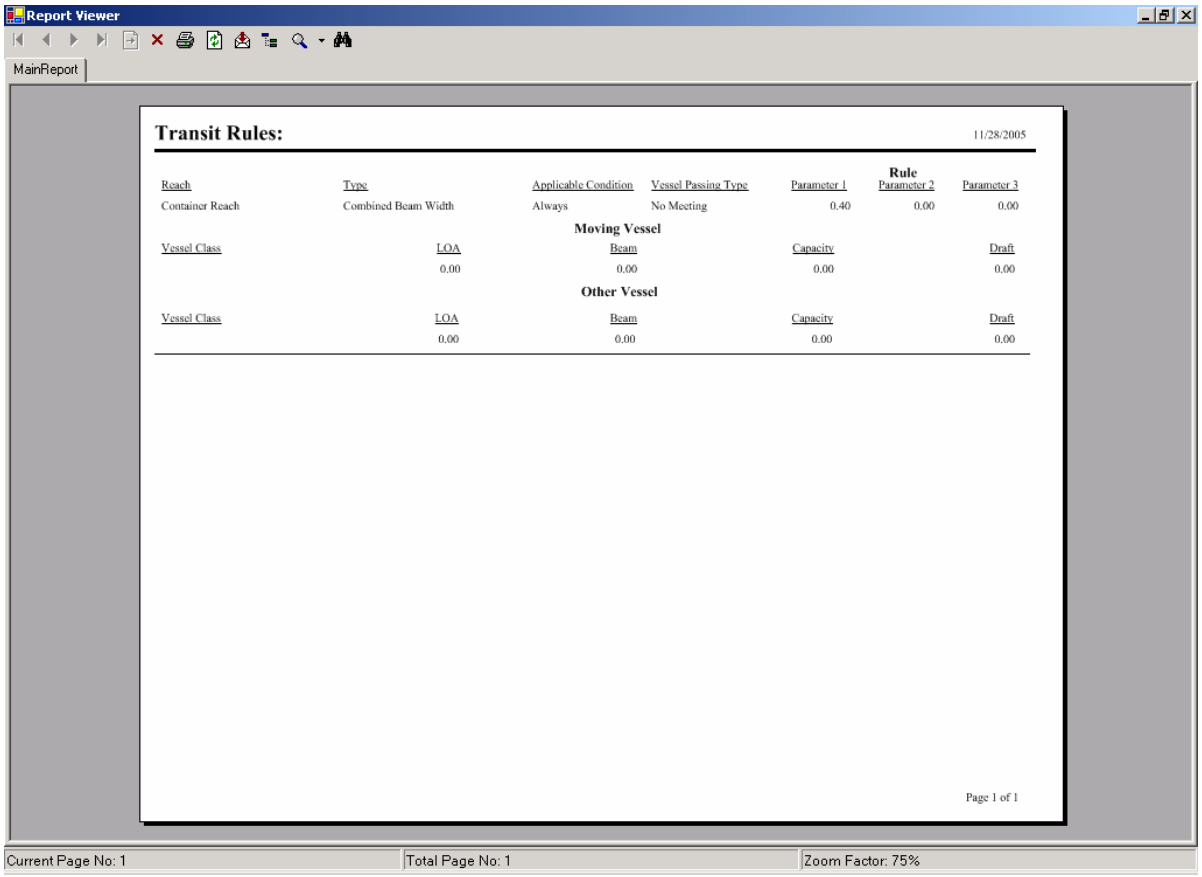


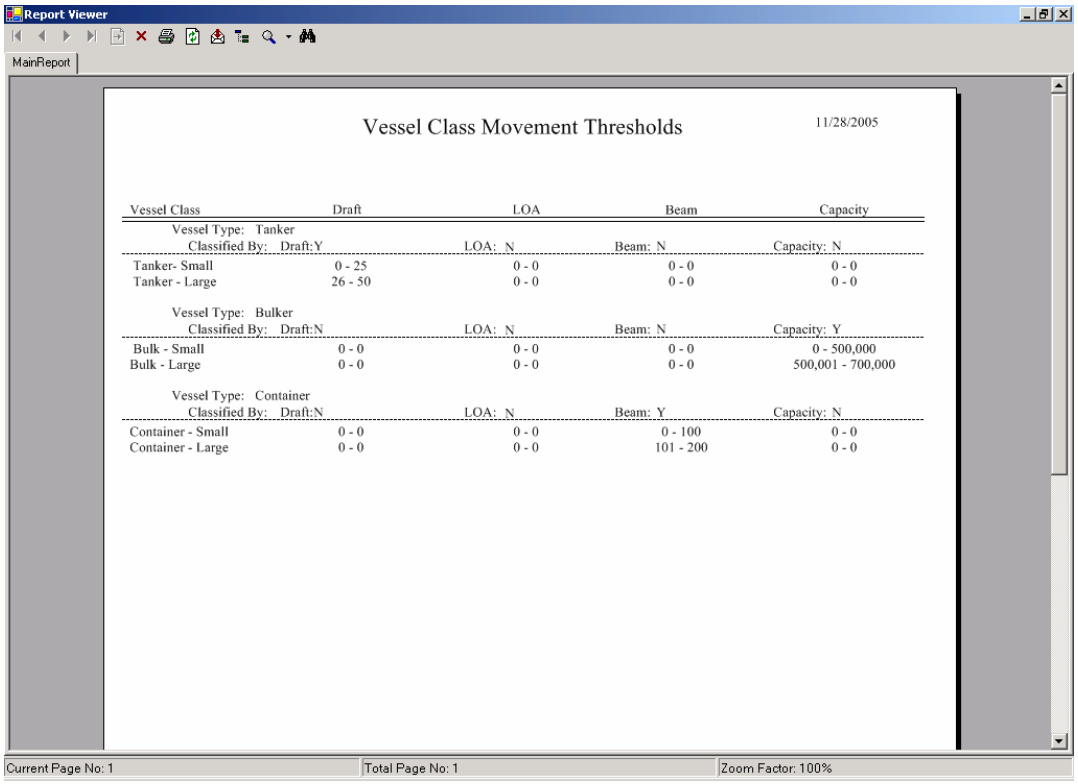
FIGURE 6-6
TRANSIT RULES REPORT

6.3.5 Vessel Class Characteristics Report

The Vessel Class Movement Thresholds Report provides detailed data on the measurement thresholds used to define vessel classes.

1. From the menu, click on the "Output" pillar and select "Vessel Class Movement Thresholds." An input box titled "Choose Projects for Report" with a menu of projects will appear.

2. Select the appropriate project. An example of a Vessel Class Movement Threshold Report is shown in Figure 6-7.



Vessel Class Movement Thresholds 11/28/2005

Vessel Class	Draft	LOA	Beam	Capacity
Vessel Type: Tanker				
Classified By:	Draft:Y	LOA: N	Beam: N	Capacity: N
Tanker- Small	0 - 25	0 - 0	0 - 0	0 - 0
Tanker - Large	26 - 50	0 - 0	0 - 0	0 - 0
Vessel Type: Bulker				
Classified By:	Draft:N	LOA: N	Beam: N	Capacity: Y
Bulk - Small	0 - 0	0 - 0	0 - 0	0 - 500,000
Bulk - Large	0 - 0	0 - 0	0 - 0	500,001 - 700,000
Vessel Type: Container				
Classified By:	Draft:N	LOA: N	Beam: Y	Capacity: N
Container - Small	0 - 0	0 - 0	0 - 100	0 - 0
Container - Large	0 - 0	0 - 0	101 - 200	0 - 0

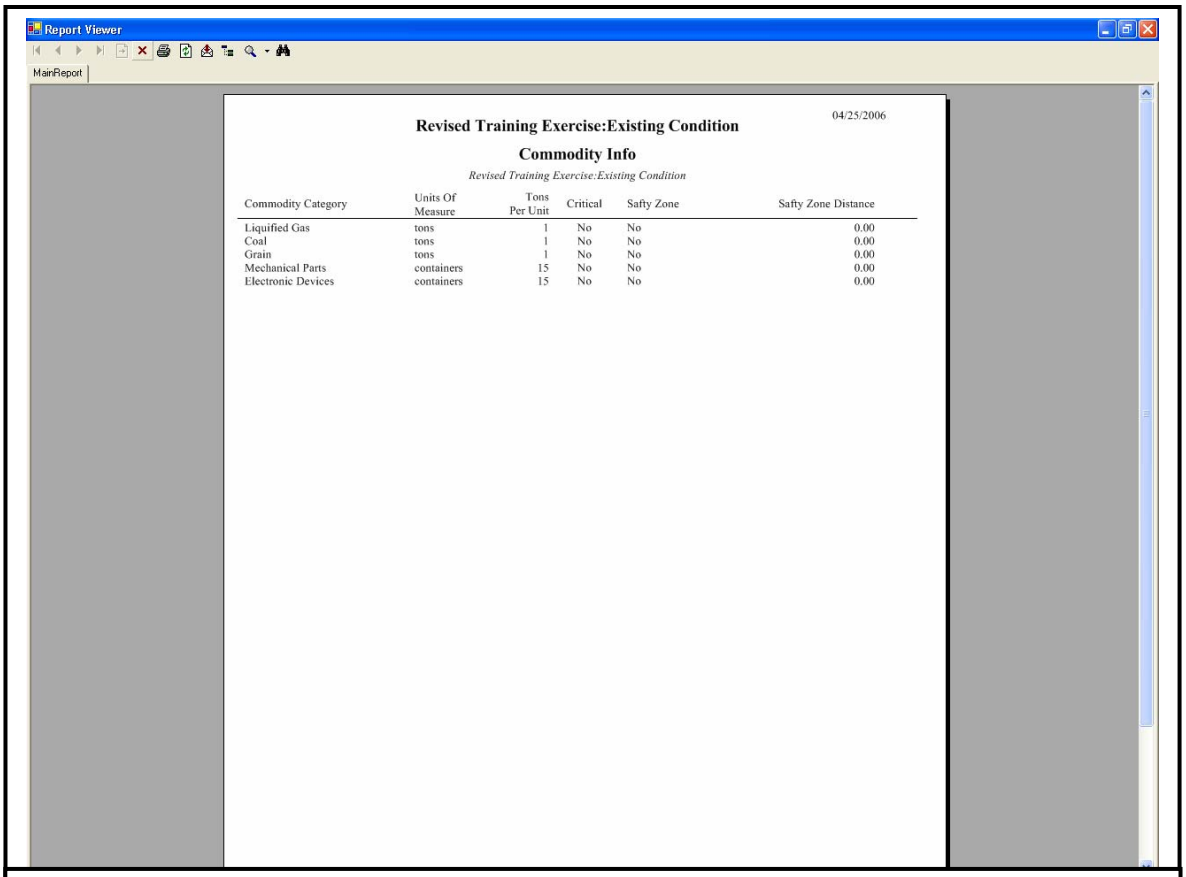
FIGURE 6-7
VESSEL CLASS MOVEMENT THRESHOLD REPORT

6.3.6 Commodity Info Report

The Commodity Info Report provides detailed data on the units of measure and tons per unit of commodity categories.

1. From the menu, click on the “Output” pillar and select “Commodity Info.” An input box titled “Choose Project for Report” with a menu of projects will appear.

2. Select the appropriate project. An example of a Commodity Info Report is shown in Figure 6-8.



Commodity Category	Units Of Measure	Tons Per Unit	Critical	Safty Zone	Safty Zone Distance
Liquified Gas	tons	1	No	No	0.00
Coal	tons	1	No	No	0.00
Grain	tons	1	No	No	0.00
Mechanical Parts	containers	15	No	No	0.00
Electronic Devices	containers	15	No	No	0.00

FIGURE 6-8
COMMODITY INFORMATION REPORT

6.3.7 Output Files

Extensive data about simulations is available in output files. These files are obtained in Windows® Explorer. Appendix C contains detailed descriptions of the output files.

Section 7
Understanding HarborSym Output

HarborSym estimates vessel transit times based upon the harbor conditions defined by the project and simulation conditions defined by the scenario. Simulation output includes the average time per vessel call and total time for all vessel calls at each phase of a harbor visit. The time spent by vessels in a harbor consists of the time transiting reaches and turning basins, the time waiting to prevent a rule violation, and the time loading and unloading commodities at docks. Vessel can wait outside the harbor at an entrance, in anchorages and at docks. The average and total time spent waiting at each of these locations by each vessel class should be reviewed to determine how traffic is flowing through the harbor in the model.

HarborSym simulates vessel traffic one leg at a time and determines which vessels can proceed through a leg based upon the user defined vessel traffic rules. Detailed output files are produced to tabulate reach rule violations. These internal and external reports can be used to determine the reaches in which vessel traffic is constrained and the vessel traffic rules that result in delays.

7.1 Vessel Time in System and Total Vessel Cost

Vessel time in system is estimated based upon simulations of vessel traffic through the harbor. Total vessel cost is the cost of operating vessels in the harbor, which is estimated by multiplying the vessel operating cost for each vessel by the time in system for each vessel. The sum of vessel time spent transiting, turning, docking, loading, and waiting equals the time in system. Vessel traffic rules impact transit times because potential rule violations result in waiting time.

7.1.1 Reach Rule Violations

Vessel traffic rule violations do not occur during HarborSym simulations because vessels wait until they can proceed. In HarborSym output reports these waits are listed as rule violations. The count of violations of each rule at each reach is listed in output reports. However, these are actually the count of vessel waits incurred to prevent rule violations. The HarborSym model prevents rule violations by forcing vessels to wait, but counts these forced waits as rule violations. Each unsuccessful retry is counted as an additional rule violation. By reviewing reach rule violations the user can determine where transit rules are resulting in vessels waiting.

7.1.2 Vessels Exiting / Deleted Vessels

Vessels that enter the harbor during a simulation will either exit the harbor, remain in the harbor when the simulation ends, or be deleted during the simulation. The number of vessels exiting the harbor will be less than the number of vessels in the vessel call list because some vessels will be at docks or transiting reaches when the simulation ends and HarborSym simulations start without vessels in the harbor.

The user should consider that the number of vessels exiting the harbor may be reduced because some vessel calls are deleted when vessels become “stuck” at a node in the harbor. The time in system for these deleted vessel calls are not included in output reports. When comparing

projects, the number of deleted vessel calls should be considered. The user should try to minimize deleted vessel calls by increasing the number of retrys allowed during simulation. If deleted vessel calls can not be avoided, the user should compare the number of deleted vessel calls between projects. Deleted vessel calls will impact the total amount of commodity loaded and unloaded during a simulation, but HarborSym will still underestimate the benefits of the "with project" condition if there are fewer deleted vessel calls in the "with project" condition.

7.1.3 Vessel Time Waiting

Vessel time waiting is the time vessels spend waiting to prevent a rule violation. Vessels can wait either at the entrance, at a dock, or at an anchorage. Vessel time waiting is the primary variable changed by harbor improvements.

7.1.4 Vessel Cost

Vessel cost is the product of vessel time in system and vessel operating cost. HarborSym calculates vessel operating cost. The time spent in the system consists of time spent in at the docks and the time spent transiting to and from the docks. "In port" costs are used for the time vessels are at a dock and "at sea" costs are used for the time a vessel spends transiting through the harbor.

7.2 Commodity Tons and Project Comparisons

To estimate the benefit of a harbor improvement the cost of operating vessels in the "with project" condition is compared to the cost of operating vessels in the "without project" condition. A consistent unit of measure is needed for this comparison. The Total Vessel Cost figure provided by HarborSym output is not a consistent unit of measure because the amount of commodity moved may vary between projects. Therefore the user must manually calculate the cost per ton by dividing total commodity tons by total vessel cost.

7.2.1 Commodity Tons

Commodity tons are the amount of commodity transferred during the simulation. The total commodity tons can be expected to vary between projects is the number of vessel exiting the harbor varies.

7.2.2 Project Comparisons

Cost per ton provides a consistent unit of measure to compare projects. A future version of HarborSym will include the distance commodities have traveled so that project comparisons can be based upon ton miles.

7.3 Future Fleet Characteristics

The vessel fleet visiting a harbor can be expected to change significantly during the planning horizon of a navigation study, for several reasons. The change in the vessel fleet results from changes in world fleet characteristics, and changes in the commodities transferred at the harbor as documented by the harbor commodity forecast. Projecting the impact of these factors on the

harbor's future vessel call list is difficult. Yet the vessel call list is essential to estimating the benefits of harbor improvements. A vessel generation feature will be provided in a future HarborSym version to assist with developing a vessel call list based upon a commodity forecast.

Appendix A
Importing Data Into HarborSym

Templates can be used to import data into HarborSym and reduce the amount of manual data entry effort required of the user. The templates use Microsoft Excel spreadsheets to format data consistently so large amounts of data can formatted using Excel's features. There are three steps to using templates in HarborSym, creating the spreadsheet template within the study, completing the spreadsheet template, and importing the spreadsheet.

A.1 Importing the Vessel Call List

Port traffic is imported through the Lookup Spreadsheet. The spreadsheet is one of six spreadsheets in the Port Traffic Import Template, which is an Excel workbook. The workbook contains separate spreadsheets titled, Commodity, Dock, Vessels, Calls and Flags. The Lookup Spreadsheet, which is the spreadsheet that is imported into HarborSym is titled Calls. The Commodity Spreadsheet converts commodity category descriptions to commodity category numbers. The Dock Spreadsheet converts dock descriptions to dock numbers. The Vessel Type description converts vessel type descriptions to vessel type numbers. The Calls Spreadsheet contains links to the previous three spreadsheets through the VLOOKUP function. This function obtains vessel class numbers, dock numbers and commodity category numbers. The Flags Spreadsheet lists the nation code for each nation.

A.2 Importing Vessel Speed in Reach

Vessel speed in reach must be entered for each vessel classification and each reach. The average light and average loaded speed are entered in the single spreadsheet of this template.

A.3 Vessel Docking Time

The minimum and maximum docking and undocking time for each vessel classification at each dock is input in this template.

A.4 Vessel Turning Time

The minimum, most likely, and maximum vessel turning time for each vessel type at each turning area is input in this template.

A.5 Commodity Transfer Rates

The minimum, most likely, and maximum loading and unloading rate is input for each commodity category at each dock.

Appendix B
HarborSym Vessel Traffic Rules

B.1 Introduction

A large selection of vessel traffic rules are available to the HarborSym user to apply to the entire harbor or to particular reaches within the harbor. Multiple rules may be selected for any reach. The vessel traffic rules are for single vessels or for vessel encounters, and are based on harbor conditions and vessel parameters. The different rules require different data entry parameters, which are defined in Table B-1. The traffic rules that can be implemented are described in Table B-2.

Vessel traffic rules regulating vessel encounters are defined by the user. For each reach during each time step the HarborSym model analyzes vessel encounters. Every vessel encounter is based upon the moving vessel and the other vessel. The other vessel is defined as the vessel that has already been approved to proceed through a reach. The approach of the moving vessel to the reach is evaluated by the HarborSym model to determine if an encounter between the moving vessel and the other vessel would result in a rule violation. If a vessel traffic rule would be violated by the moving vessel proceeding through the reach and encountering the other vessel, the model calculates the wait time for the moving vessel while the other vessel proceeds through the reach. After waiting, the moving vessel then proceeds through the reach.

The columns in the Transit Rule Data Entry Grid are described below, starting from the left side of the grid. Some of the blocks have menus selections. The blocks for which data entry is mandatory are highlighted.

Desc: Checking this box prompts a description of the rule.

Reach: The name of the reach is listed

Active: Checking this box activates the rule during the next simulation, if "Apply Transit Rules" is selected in the scenario definition.

Type: This column is used to select a rule from the menu of thirty rules. The titles of the vessel transit does not adequately describe the rules, but holding the cursor over the Type box in the Data Entry Grid will prompt a definition of the rule to appear on the screen.

Application Condition: This column allows a selection of always/day/night/fog in which the rules will apply.

Vessel Passing Type: Used to select passing/overtaking/ or either encounter with which to apply multiple vessel rules.

Rule Parameter 1 / Parameter 2 / Parameter 3: These columns are for the specific data input required for some rules. The type of data entry varies between rules and is defined by the rule definition table as specified in Table B-3. If data entry in one of these block in required, the block is highlighted.

Moving Vessel Class / LOA / Beam / Capacity/ Draft: These columns allow the user to specify the moving vessels to which the vessel traffic rule applies. The moving vessel fitting the measurements defined in these blocks will wait before entering a reach depending upon the other vessel as specified in Table B-4.

Other Vessel Class / LOA / Beam / Capacity/ Draft: These columns allow the user to specify the other vessels to which the vessel traffic rule applies. The other vessel fitting the measurements defined in these blocks will cause the moving vessel to wait before entering a reach, depending upon the definition of the rule and the moving vessel as specified in Table B-5.

TABLE B-1
VESSEL TRAFFIC RULES – NUMBER AND TITLE

Transit Rule Type Number	Transit Rule Type Short Description
0	No Rule
1	Vessel LOA or Beam or Capacity
2	Combined Beam Width
3	Combined Draft
4	Capacity1: Capacity Limit V1 AND (Draft Limit OR Capacity Limit V2)
5	Capacity2: Capacity Limit V1 AND (Draft Limit AND Capacity Limit V2)
6	NOT IMPLEMENTED: NoMeetingDWTDraft3
7	Capacity3: (Capacity AND Draft Limit V1) OR (Capacity AND Draft Limit V2)
8	Critical Commodity Vessel
10	NOT IMPLEMENTED: MaintainSafetyZone
11	Draft AND Combined Beam Width Limit
13	Draft Limit V1 Protocol Vessel V2
14	Any Vessel
16	Vessel Class V1 Protocol Vessel V2
17	Draft Plus Tide
18	Draft Limit
19	Draft Range LOA Limit Current Limit
20	Draft Limit Current Limit
21	LOA Limit Current Limit
22	Directional Draft Limit Current Limit
24	NOT IMPLEMENTED: Directional Draft Limit LOA Limit
25	Draft Plus Tide To Max Draft
26	Beam Reach Width Limit
27	Draft Exceeds Depth Using Tide / Underkeel
28	Vessel Class Beam Limit
29	Vessel Class LOA Limit
30	Draft Limit V1 OR Draft Limit V2

TABLE B-2
TRANSIT RULE DEFINITIONS

Transit Rule Type Number	Transit Rule Type Description
1	Single Vessel Rule. This is an OR rule applying to moving vessel only. A vessel cannot move if its LOA, Beam, or Capacity is greater than the value specified in the corresponding rule (MovingVesselLOA, MovingVesselBeam, MovingVesselCapacity).
2	Two valid vessels are required. The rule is triggered if the combined beam width of the vessels is greater than the reach width multiplied by the fractional value specified in Parameter 1,
3	Two valid vessels are required. The rule is triggered if the combined draft of the vessels is greater than the value specified in Rule Parameter 1
4	Two valid vessels are required. The rule is triggered if a vessel above a certain capacity (MVCapacity) encounters another vessel that is above EITHER a draft (OVDraft) OR capacity (OVCapacity) limit. SYMMETRICAL
5	Two valid vessels are required. The rule is triggered if a vessel above a certain capacity (MVCapacity) encounters another vessel that is above BOTH a draft (OVDraft) AND capacity (OVCapacity) limit. SYMMETRICAL
6	No meeting – dwt/draft Max DWT MV Max Draft MV And Max DWT OV Max draft OV
7	Two valid vessels are required. The rule is triggered if EITHER vessel is above respective limits for BOTH capacity AND draft. Four values are supplied: MV Capacity, MV Draft, OVCapacity, and OV Draft.
8	Two valid vessels are required. Rule violation for the moving vessel if the vessel in reach (OV) is a critical commodity vessel (typically LNG, LPG, NH3, Passenger) based on commodity category carried at any point in vessel call.
10	1,000 ft safety zone vessels carrying NH3 500 ft safety zone vessels carrying LNG, LPG NOT IMPLEMENTED
11	Two valid vessels are required. The moving vessel draft must exceed MV Draft and combined beam width must be greater than Rule Parameter 1
13	Two valid vessels are required. The moving vessel cannot encounter a protocol vessel in the reach if the MV draft exceeds the rule MV draft.
14	Two valid vessels are required. The moving vessel cannot have the designated encounter (pass, overtake, meet) if there is any vessel in the reach.
16	Two valid vessels are required. A moving vessel of specified class (MV CLASS) cannot have the designated encounter with a protocol vessel in the reach
17	Single Vessel Rule. No movement allowed if vessel draft is greater than (Rule Parameter 2 + minimum tide during interval). Rule parameter 2 defines maximum allowable sailing draft on 0 tide. 0.001' tolerance is used.
18	Single Vessel Rule. No movement if draft > MV Draft
19	Single Vessel Rule. No sailing if MV draft in range between Rule MV Draft AND Rule P2 AND LOA > Rule MV LOA AND Current > P3
20	Single Vessel Rule. No sailing draft> MV Draft AND current>P3
21	Single Vessel Rule. No sailing if MV LOA > Rule MV LOA AND Current > P3
22	Single Vessel Rule. No movement allowed in P1 direction if MV Draft > Rule MV Draft, Current >P3. P1 <0 inbound, P1 > =0 outbound
24	Single Vessel Rule. No movement allowed in P1 direction if MV LOA > Rule MV LOA, Current >P3. P1 <0 inbound, P1 > =0 outbound
25	Single Vessel Rule. No movement allowed if vessel draft is greater than (Rule Parameter 2 + minimum tide during interval). Rule parameter 2 defines maximum allowable sailing draft on 0 tide. 0.001' tolerance is used. MV Draft is max draft overall
26	Single Vessel Rule. No movement if MV Beam plus Rule Parameter 1 > Reach Width
27	Single Vessel Rule. No movement if MV Draft plus underkeel > (depth plus minimum tide in period). Underkeel based on vessel class.
28	Single Vessel Rule, no movement if class = rule vessel class and moving vessel beam > rule beam - single vessel rule, enter values for beam, class in MV fields

TABLE B-2 TRANSIT RULE DEFINITIONS	
Transit Rule Type Number	**Transit Rule Type Description**
29	Single Vessel Rule, no movement if class = rule vessel class and moving vessel LOA > rule LOA - single vessel rule, enter values for beam, class in MV fields
30	Two valid vessels are required. No movement if either MV draft > Rule MV Draft OR OV draft > Rule OV Draft. The rule is triggered if EITHER vessel is above respective limits for draft. Two valid values required, MV Draft, OV Draft

TABLE B-3
VESSEL TRAFFIC RULES – NUMBER AND PARAMETER USAGE

Transit Rule Type Number	P1 Usage Description	P2 Usage Description	P3 Usage Description
0	N/A	N/A	N/A
1	N/A	N/A	N/A
2	decimal fraction of channel width (0 to 1.0)	N/A	N/A
3	Maximum Combined Draft	N/A	N/A
4	N/A	N/A	N/A
5	N/A	N/A	N/A
6	N/A	N/A	N/A
7	N/A	N/A	N/A
8	N/A	N/A	N/A
10	N/A	N/A	N/A
11	Combined Beam Width	N/A	N/A
13	N/A	N/A	N/A
14	N/A	N/A	N/A
16	N/A	N/A	N/A
17	N/A	Maximum Sailing Draft Without Tide	N/A
18	N/A	N/A	N/A
19	N/A	Max Draft	Max Current
20	N/A	N/A	Max Current
21	N/A	N/A	Max Current
22	<0 inbound >=0 outbound	N/A	Max Current
24	<0 inbound >=0 outbound	N/A	Max Current
25	N/A	Max Draft With Tide	N/A
26	Required Excess Width	N/A	N/A
27	N/A	N/A	N/A
28	N/A	N/A	N/A
29	N/A	N/A	N/A
30	N/A	N/A	N/A

TABLE B-4
VESSEL TRAFFIC RULES – NUMBER AND MOVING VESSEL CHARACTERISTICS

Transit Rule Type Number	Single Vessel Rule	Tide Type	Moving Vessel LOA_ Required	Moving Vessel Beam_ Required	Moving Vessel Capacity_ Required	Moving Vessel Draft_ Required	Moving Vessel Class ID_ Required
0	FALSE	0	FALSE	FALSE	FALSE	FALSE	FALSE
1	TRUE	0	TRUE	TRUE	TRUE	FALSE	FALSE
2	FALSE	0	FALSE	FALSE	FALSE	FALSE	FALSE
3	FALSE	0	FALSE	FALSE	FALSE	FALSE	FALSE
4	FALSE	0	FALSE	FALSE	TRUE	FALSE	FALSE
5	FALSE	0	FALSE	FALSE	TRUE	FALSE	FALSE
6	FALSE	0	FALSE	FALSE	FALSE	FALSE	FALSE
7	FALSE	0	FALSE	FALSE	TRUE	TRUE	FALSE
8	FALSE	0	FALSE	FALSE	FALSE	FALSE	FALSE
10	FALSE	0	FALSE	FALSE	FALSE	FALSE	FALSE
11	FALSE	0	FALSE	FALSE	FALSE	FALSE	FALSE
13	FALSE	0	FALSE	FALSE	FALSE	FALSE	FALSE
14	FALSE	0	FALSE	FALSE	FALSE	FALSE	FALSE
16	FALSE	0	FALSE	FALSE	FALSE	FALSE	TRUE
17	TRUE	1	FALSE	FALSE	FALSE	FALSE	FALSE
18	TRUE	0	FALSE	FALSE	FALSE	TRUE	FALSE
19	TRUE	2	TRUE	FALSE	FALSE	TRUE	FALSE
20	TRUE	2	FALSE	FALSE	FALSE	TRUE	FALSE
21	TRUE	2	TRUE	FALSE	FALSE	FALSE	FALSE
22	TRUE	2	FALSE	FALSE	FALSE	TRUE	FALSE
24	TRUE	2	TRUE	FALSE	FALSE	FALSE	FALSE
25	TRUE	1	FALSE	FALSE	FALSE	TRUE	FALSE
26	TRUE	0	FALSE	FALSE	FALSE	FALSE	FALSE
27	TRUE	0	FALSE	FALSE	FALSE	FALSE	FALSE
28	TRUE	0	FALSE	TRUE	FALSE	FALSE	TRUE
29	TRUE	0	TRUE	FALSE	FALSE	FALSE	TRUE
30	FALSE	0	FALSE	FALSE	FALSE	TRUE	FALSE

TABLE B-5
VESSEL TRAFFIC RULES – NUMBER AND OTHER VESSEL CHARACTERISTICS

Transit Rule Type Number	Other Vessel LOA_ Required	Other Vessel Beam_ Required	Other Vessel Capacity_ Required	Other Vessel Draft_ Required	Other Vessel ClassID_ Required
0	FALSE	FALSE	FALSE	FALSE	FALSE
1	FALSE	FALSE	FALSE	FALSE	FALSE
2	FALSE	FALSE	FALSE	FALSE	FALSE
3	FALSE	FALSE	FALSE	FALSE	FALSE
4	FALSE	FALSE	TRUE	TRUE	FALSE
5	FALSE	FALSE	TRUE	TRUE	FALSE
6	FALSE	FALSE	FALSE	FALSE	FALSE
7	FALSE	FALSE	TRUE	TRUE	FALSE
8	FALSE	FALSE	FALSE	FALSE	FALSE
10	FALSE	FALSE	FALSE	FALSE	FALSE
11	FALSE	FALSE	FALSE	FALSE	FALSE
13	FALSE	FALSE	FALSE	FALSE	FALSE
14	FALSE	FALSE	FALSE	FALSE	FALSE
16	FALSE	FALSE	FALSE	FALSE	FALSE
17	FALSE	FALSE	FALSE	FALSE	FALSE
18	FALSE	FALSE	FALSE	FALSE	FALSE
19	FALSE	FALSE	FALSE	FALSE	FALSE
20	FALSE	FALSE	FALSE	FALSE	FALSE
21	FALSE	FALSE	FALSE	FALSE	FALSE
22	FALSE	FALSE	FALSE	FALSE	FALSE
24	FALSE	FALSE	FALSE	FALSE	FALSE
25	FALSE	FALSE	FALSE	FALSE	FALSE
26	FALSE	FALSE	FALSE	FALSE	FALSE
27	FALSE	FALSE	FALSE	FALSE	FALSE
28	FALSE	FALSE	FALSE	FALSE	FALSE
29	FALSE	FALSE	FALSE	FALSE	FALSE
30	FALSE	FALSE	FALSE	TRUE	FALSE

Appendix C
HarborSym Output Files

C.1 Output Files with Output Level Selected by the User

There are five output files designed to assist the user and track the output of simulations. The user selects the level of detail in these files when defining a scenario. The files are the vessel output file, the event output file, the debug output file, the reach output file and the rules/debug output file. The output files contain the port name and the study name in their heading.

C.1.1 Vessel Output File .ves

This file contains a listing of the transits of each vessel. The Leg of each transit by the vessel is listed. A leg is a vessel transit from entrance to destination, a transit between destinations within the harbor, or a transit from destination to the harbor exit.

C.1.2 Event Output File .evn

This file lists each event sequentially. The first column is the iteration number and the second column is the time of the event, listed by the number of hours since the start of the simulation.

C.1.3 Reach Output File .rea

This file lists the entrance time and exit time of each reach transit by each vessel.

C.1.4 Debug Output File .dbg

This file lists each calculation during the course of a simulation. The increments of commodity transfer and the transit time calculations for each vessel are shown.

C.1.5 Rule Violation .rul

This file lists rule violations by leg transited by each vessel.

Check Leg	A Ship Protocol Run:	N Leg	Entry Time:	26.000	VCall:	V Number:	Leg:	
End Check Leg	Rule Violations:	0	Segment Start:	0	End:	Farthest	LegBlock:	Blocking Segment:

C.2 .csv Files in Excel Format

The simulation runs result in several Excel files which the user can review. The user does not select the level of output for .csv files. The .csv files list the results from each iteration in a simulation. The iteration number is the first column in each spreadsheet.

C.2.1 Scenario Name Port Name .csv

This file contains the same information as in the single scenario report, broken out by iteration.

HEADING	DESCRIPTION
Iteration	Number of iteration, starting at one for the first iteration
Calls	Number of vessels calling on harbor during iteration
Generated	Number of generated vessels calling on harbor
Exiting	Number of vessels exiting harbor during iteration
TotalTimeInSystem	Total time all vessels spent in the harbor
TotalTimeInReaches	Total time all vessels spent in harbor reaches
TotalTimeDocking	Total time all vessels spent docking
TotalTimeUndocking	Total time all vessels spent undocking
TotalTimeLoadingUnloading	Total time all vessels transferring commodities
TotalTimeTurningBasin	Total time all vessels spent in turning basins
TotalTimeWaitingAtEntrance	Total time all vessels spent waiting to enter harbor
TotalTimeWaitingAtDock	Total time all vessels spent waiting to leave docks
TotalTimeWaitingAtTurningBasin	Total time all vessels spent waiting in turning basins
TotalTimeWaitingAtFacilityNodes	Total time all vessels spent waiting in facility nodes
TotalVesselTimeWaitingAllSources	Total time all vessels spent waiting anywhere
TotalTime	Total time all vessels spent anywhere
TotalCost	Total cost of all vessels using harbor
AverageVesselTime	Average time a vessel spent in the harbor
MaxVesselTime	Maximum time any vessel spent in the harbor
MinVesselTime	Minimum time any vessel spent in the harbor
SDVesselTime	Standard deviation of time spent by vessels in harbor

C.2.2 RuleViolation.csv

Lists all details of vessel traffic rule violations that occurred during the previous simulation. The scenario name and project simulated are included in the output file name. The rule violation data provided is listed below by column heading.

HEADING	DESCRIPTION
Iteration	Number of the iteration, starting at one for the first iteration
Time	Time measurement in hours of time into iteration
MVVesselCallID	Vessel call ID number of the moving vessel
MVVesselNumber	External identifier number of the moving vessel
MVName	Name of the moving vessel
Reach	Reach number for the reach the rule violation occurred
RuleNumber	Number of the vessel transit rule violated
PortRule	Rule number of rule implemented for the entire port
TransitRuleNumber	Rule number of rule implemented for the reach
Description	Description of the rule violated
ApplicableCondition	The condition for rule application previously selected by the user
MVLOA	LOA of the moving vessel
MVBeam	Beam of the moving vessel
MVCapacity	Capacity of the moving vessel
MVDraft	Draft of the moving vessel
MVType	Vessel type name of the moving vessel
MVClassID	Vessel class ID number of the moving vessel
MVClass	Vessel class of the moving vessel
MVUnderkeel	Underkeel clearance allowed for the moving vessel
OVVesselCallID	Vessel call ID number of the other vessel (-1 default)
OVesselNumber	Identifier Number of the Other Vessel
OVName	Name of the Other Vessel
OVLOA	LOA of the Other Vessel
OVBeam	Beam of the Other Vessel
OVCapacity	Capacity of the Other Vessel
OVDraft	Draft of the Other Vessel
OVType	Type of the Other Vessel
OVClassID	ID number of the Vessel Class
OVClass	Class of the Other Vessel
Status	1,2, 3
OVPriority	0 for non-priority, 1 for priority vessel

HEADING	DESCRIPTION
MVReachEntryTime	Simulation Time That Moving Vessel Enters Reach
MVReachExitTime	Simulation Time That Moving Vessel Exits Reach
ReachWidth	Width of Reach Where Rule Violation Occurred
ReachDepth	Depth of Reach Where Rule Violation Occurred
MinimumTide	Depth Adjustment
MaximumTide	Depth Adjustment

C.2.3 Draft Adjustment.csv

This Excel spreadsheet lists the details of draft changes in vessels that exceed the minimum or maximum draft for their vessel class. The column headings are listed below.

HEADING	DESCRIPTION
Iteration	Iteration number, starting at one
Time	Hours into simulation starting at one
VesselsCallID	ID number of vessel call, assigned by HarborSym
VesselNumber	ID number of the vessel in the vessel call
VesselClass	Vessel classification of the vessel in the vessel call
VesselName	Name of vessel in vessel call
AdjustmentType	Above Maximum / Below Minimum / Next Leg
InitialDraft	Draft entering harbor
CurrentDraft	Test Draft or Maximum / Minimum Draft for Vessel Class
TestDraft	Draft (feet) after commodity transfer based on TPI and exiting load
DraftChange	Change in draft (feet) resulting from commodity transfer
DockVisit	Not Used
TonsCommodityTransfer	Tons of commodity imported/exported
ClassMinimumDraft	Minimum Draft for Vessel Classification
ClassMaximumDraft	Maximum Draft for Vessel Classification
UnderkeelClearance	Underkeel Clearance for Vessel Classification
MinimumTide	Depth Adjustment
MaximumTide	Depth Adjustment

C.2.4 DeletedVesselCall.csv

This file provides a list of the vessel calls deleted because the vessel was unable to move after the specified number of retrys.

HEADING	DESCRIPTION
Iteration	Iteration number, starting at one
Time	Hours into simulation, in fractions
Vessel Call ID	The vessel call ID Number
Vessel Name	Name of vessel deleted in the vessel call
Situation	Location of vessel when vessel call deleted

C.2.5 Commodity.csv

This file lists the total imports and exports of each commodity category, during each iteration.

HEADING	DESCRIPTION
Iteration	Iteration number, starting at one
Commodity	Name of commodity category
ActualImportInIteration	Total tons of commodity category imported during iteration
TotalImportInVCDB	Total Tons of Commodity Imported in Vessel Call List
ActualExportInIteration	Total tons of commodity category exported during iteration
TotalExportInVCDB	Total Tons of Commodity Exported in Vessel Call List

C.2.6 VesselClassStatistics.csv

This file lists the average, minimum and maximum for each statistic for each vessel class.

HEADING	DESCRIPTION
Statistic	Description of Statistic
Class	Name of Vessel Class
N	Number of Exiting Vessels of Each Vessel Class
Average	Average of the Statistic
Maximum	Maximum of the Statistic
Minimum	Minimum of the Statistic

C.2.7 VesselCall.csv

This file lists detailed information for every vessel call.

HEADING	DESCRIPTION
Iteration	Number of Iteration
Protocol	0 if not protocol vessel, 1 if protocol vessel
Priority	Not Used

HEADING	DESCRIPTION
Name	Name of Vessel
Class	Class of Vessel
Count	Count of Vessels Within Iteration
Call ID	Vessel Call ID Number
Vessel ID	Vessel ID Number
Number of Dock Visits	Number of different docks visited within a vessel call
Arrival Time	Simulation Time that Vessel Arrives at Harbor
Entry Time	Simulation Time that Vessel Begins Transit Through the First Reach
Exit Time	Simulation Time that Vessel Exits Harbor
Net Time	Difference Betweeen Entry Time and Exit Time
Total Time	Not Used
Waiting Dock	Amount of Time Spent Waiting to Leave the Dock
At Dock	Amount of Time Spent Loading And Unloading
Docking	Amount of Time Spent Docking
Undocking	Amount of Time Spent Undocking
Wait at Entry	Amount of Time Between Arrival and Entry
At Turning Basin	Amount of Time Spent Turning
WaitingFacilityNode	Amount of Time Spent Waiting at Anchorages
Total In Reaches	Amount of Time Spent Transiting Through Reaches