NATIONAL ECONOMIC DEVELOPMENT

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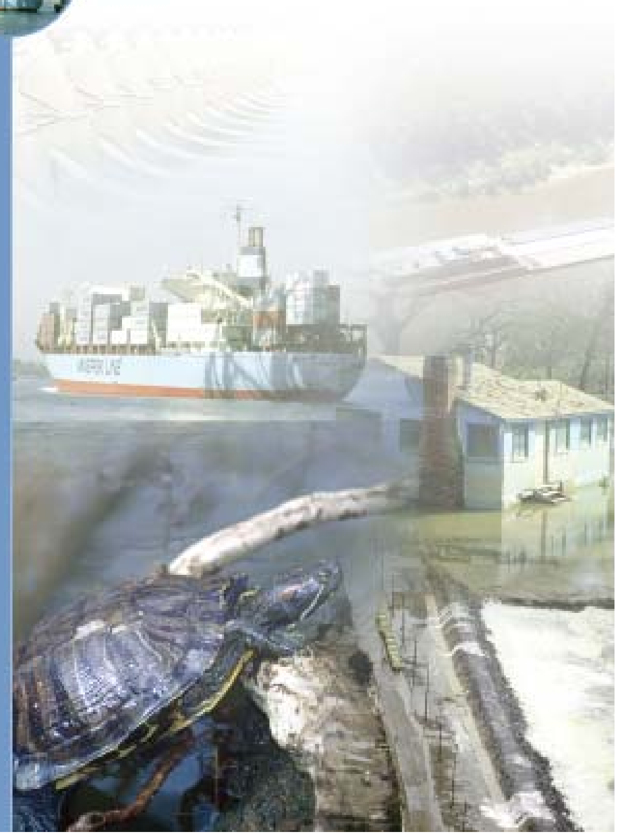

DEEP DRAFT NAVIGATION

IWR Report 10-R-4

April 2010

NATIONAL ECONOMIC DEVELOPMENT

MANUAL FOR DEEP DRAFT NAVIGATION

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US Army Corps of Engineers®

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U.S. ARMY INSTITUTE FOR WATER RESOURCES

The Institute for Water Resources (IWR) is a Corps of Engineers Field Operating Activity located within the Washington DC National Capital Region (NCR), in Alexandria, Virginia and with satellite centers in New Orleans, LA and Davis, CA. IWR was created in 1969 to analyze and anticipate changing water resources management conditions, and to develop planning methods and analytical tools to address economic, social, institutional, and environmental needs in water resources planning and policy. Since its inception, IWR has been a leader in the development of strategies and tools for planning and executing the Corps water resources planning and water management programs.

IWR strives to improve the performance of the Corps water resources program by examining water resources problems and offering practical solutions through a wide variety of technology transfer mechanisms. In addition to hosting and leading Corps participation in national forums, these include the production of white papers, reports, workshops, training courses, guidance and manuals of practice; the development of new planning, socio-economic, and risk-based decision-support methodologies, improved hydrologic engineering methods and software tools; and the management of national waterborne commerce statistics and other Civil Works information systems. IWR serves as the Corps expertise center for integrated water resources planning and management; hydrologic engineering; collaborative planning and environmental conflict resolution; and waterborne commerce data and marine transportation systems.

The Institute's Hydrologic Engineering Center (HEC), located in Davis, CA specializes in the development, documentation, training, and application of hydrologic engineering and hydrologic models. IWR's Navigation Data Center (NDC) and its Waterborne Commerce Statistical Center (WCSC) in New Orleans, LA, is the Corps data collection organization for waterborne commerce, vessel characteristics, port facilities, dredging information, and information on navigation locks.

Other enterprise centers at the Institute's NCR office include the International Center for Integrated Water Resources Management (ICIWaRM), which is a distributed, intergovernmental center, established in partnership with various Universities and non-Government organizations and UNESCO; and a Conflict Resolution and Participation Center which includes a focus on both the processes associated with conflict resolution, and the integration of public participation techniques with decision support and technical modeling – Computer Assisted Dispute Resolution (CADRe). The Institute plays a prominent role within a number of the Corps technical Communities of Practice (CoP), including the Economics CoP. The Corps Chief Economist is resident at the Institute, along with a critical mass of economists, sociologists and geographers specializing in water and natural resources investment decision support analysis and multi-criteria tradeoff techniques.

For further information on the Institute's activities associated with the Corps Economics Community of Practice (CoP) please contact Chief Economist, Dr. David Moser, at 703-428-6289, or via-mail at: david.a.moser@usace.army.mil. The IWR contact for the Corps Planning CoP activities is Ms. Lillian Almodovar at 703-428-6021, or at: lillian.almodovar@usace.army.mil.

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FOREWORD

The Corps of Engineers Planning Excellence Program is designed to build planning capability now and for the future. Economics is a vital component of the planning process and updating the National Economic Development manual series is a key element of the Planning Excellence Program.

I appreciate the efforts of the interdisciplinary team across the Corps, local sponsors and others who contributed to this manual. I am pleased to endorse its use as a tool for the Planning Community of Practice to reach out to all who are interested in our work.

Harry E. Kitch,
Planning Community of Practice Deputy,
Planning Civil Works

Transparent and defensible economic analysis provides a critical piece of information for decision making. It is incumbent on the economist to inform others about sources and validity of all the data, models, and assumptions that are part of the analysis. The economist must also acknowledge the key uncertainties, their impacts on the economic analysis, and the overall confidence in the economic values presented to decision makers.

Dr. David Moser
Chief Economist
U. S. Army Corps of Engineers

OTHER NATIONAL ECONOMIC DEVELOPMENT MANUALS

09-R-3	National Economic Development Procedures Manual: Primer, June 2009
09-R-2	National Economic Development Procedures Manual: Overview, June 2009. *This manual is the update of 91-R-11*.
93-R-12	National Economic Development Procedures Manual National Economic Development Costs, June 1993
93-R-2	National Economic Development Procedures Manual Public Surveys Volume 1 – Use and Adaptation of Office of Management & Budget Approved Survey Questionnaires, January 1993
91-R-13	National Economic Development Procedures Manual Deep Draft Navigation, November 1991. *This is the outdated version of this manual.*
91-R-10	National Economic Development Procedures Manual – Volume II -Urban Flood Damage, October 1991. This manual has been updated and is available at: http://www.CorpsNEDmanuals.us
91-R-6	National Economic Development Procedures Manual Coastal Storm Damage and Erosion, September 1991.
91-R-7	National Economic Development Procedures Manual – Volume IV – Recreation July, 1991
90-R-11	National Economic Development Procedures Manual – Recreation Volume III, A Case Study Application of Contingent Value Method for Estimating Urban Recreation Use and Benefits, November 1980
88-R-2	National Economic Development Procedures Manual – Urban Flood Damage, March 1988. This manual has been updated and is available at: http://www.CorpsNEDmanuals.us
87-R-10	National Economic Development Manual Agricultural Flood Damage, October 1987.
86-R-4	National Economic Development Procedures Manual – Recreation, Volume 1- Recreations Use and Benefit Estimation techniques, March 1986
86-R-5	National Economic Development Procedures Manual – Recreation, Volume II – A guide for Using the Contingent Value Methodology in Recreation Studies, March 1986.

PREFACE

This deep draft navigation NED manual is one of a series of guides to assist Corps field economists in computing National Economic Development benefits. This manual will be published on-line as an interactive version. This web-based version has the flexibility to be easily updated as new information becomes available and new methodologies are developed. The Manual describes accepted economic analysis procedures for deep draft navigation projects. It also describes the fundamentals of containership analysis. Containership traffic analysis is currently undergoing research and analytical advancements. Approved new methods for containership analysis will be provided in future updates of the Manual. Field economists engaged in containership analysis should contact the Deep Draft Navigation Planning Center of Expertise for up-to-date methodologies and to get specialized planning expertise.

The previous manual was published in 1991 by the Institute for Water Resources (IWR). Dr. Kevin Horn, under contract with IWR, wrote the majority of the content of the current version. Kevin Knight, an IWR economist, wrote various sections and Appendix B. Susan Durden of IWR managed the development of the preliminary draft manual. Erin Wilson managed, wrote various sections, coordinated reviews, and produced the final version of the document. Diana Hallman of Web and Writing Solutions Company was the lead editor. Lillian Almodovar was the lead program manager.

Review of the preliminary draft of this manual was provided by members of the Deep Draft Navigation Planning Center of Expertise, a virtual team made up of subject matter experts in the field of navigation economics throughout the Corps. Reviewers included: Ken Claseman, Bernard Moseby, Edmund O'Leary, Erin Wilson, and Kevin Knight. The final draft was reviewed by Dan Abecassis, Ken Claseman, Aaron Game, Naomi Fraenkel, Kevin Knight, Frank Reynolds, and Brian Shenk. Other reviewers and contributors include (in alphabetical order): Gloria Appell, Larry J. Cocchieri, Mark Haab, Keith Hofseth, Harry Kitch, Ian Mathis, Dr. David Moser, Rebecca Moyer, Norm Starler, and others at the Institute for Water Resources.

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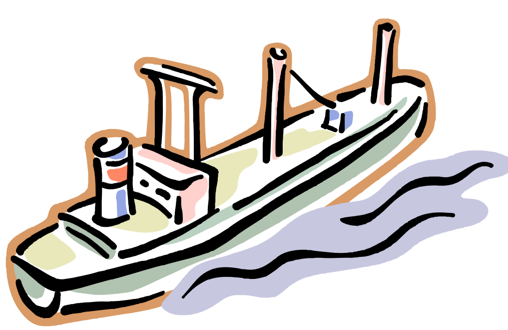

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CHAPTER 1 – INTRODUCTION

1.0 Overview

The purpose of this manual is to provide a practical guide for evaluating National Economic Development (NED) benefits of Federal projects to facilitate deep draft commercial navigation. Specifically, this manual is intended to be used by the U.S. Army Corps of Engineers (Corps) for economic analyses.

1.1 Application of the Manual

This manual is written for Corps economists and non-Federal sponsors who are familiar with the Principles & Guidelines (P&G) requirements and have experience in economic analyses, but whose areas of expertise may not include deep draft navigation project analysis. This manual is not intended nor recommended for economists with limited experience or expertise on Corps economic analyses procedures.

Corps economists, planners, and particularly project managers must be able to explain the concept of NED benefits and the need for rigorous study to stakeholders. In turn, the project sponsor can provide their insight as to vessel operating practices, trade practices, port problems and opportunities. Exchange of information is needed prior to and during the reconnaissance phase as well as during the feasibility study. This helps to ensure that the planning effort will consider sensible alternatives and produce a recommended plan that is effective, efficient, complete, acceptable, and reasonably maximizes net NED benefits consistent with the sponsor's ability to pay.

1.2 The Deep Draft Navigation System

The role of the U.S. Army Corps of Engineers with respect to navigation is to reduce navigation hazards and to enable reliable and efficient waterborne transportation systems (channels, harbors and waterways) for the movement of commerce, national security needs, and recreation. The Corps accomplishes this mission through a combination of capital improvements..Capital improvement activities include the planning, design, construction, and maintenance of new navigation channel works.[1]

Much of the U.S. economy and history has been shaped by its ports on the seacoasts, rivers and the Great Lakes. The sophisticated network helps move billions of tons of cargo efficiently from all parts of the globe, contributing to a relatively low cost of goods and subsequent high standard of living.

Imports provide American consumers access to the global marketplace. Electronics, clothing and other consumer goods from China, bananas from Central America, wine from Chile and Australia, and shoes from Italy all make their way to U.S. consumers on cargo ships that arrive at ports. Many finished goods are shipped in large metal boxes known as containers, which are then loaded onto trains or trucks for delivery to their final destinations. Today, the U.S. is served by publicly- and privately-owned marine facilities located in approximately 360 commercial sea and river ports. Figure 1-1 shows some of the nation's largest ports in terms of tonnage.

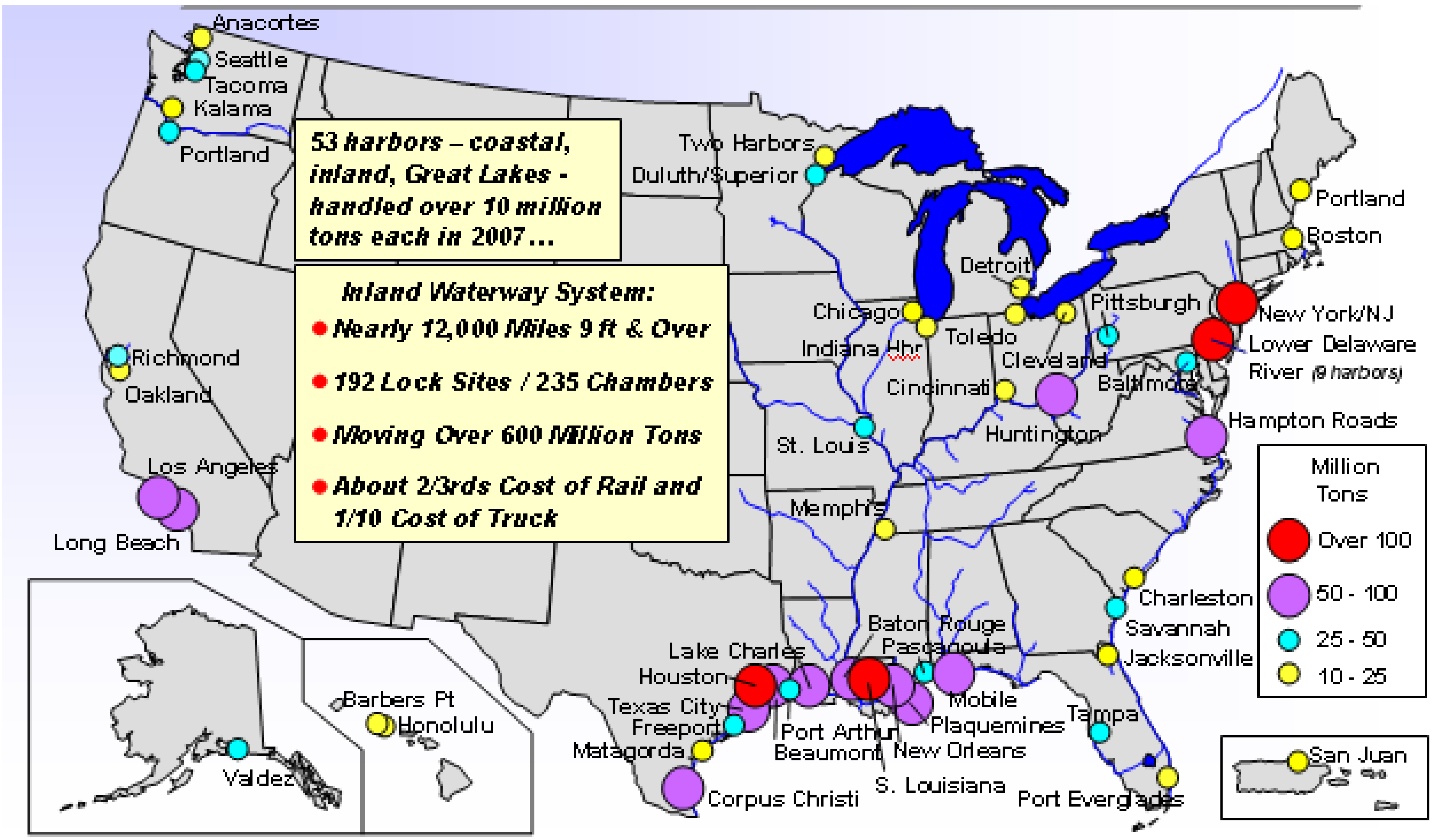
[1] *Planning Guidance Notebook, April 2000*

In 2008, 3 U.S. ports—Los Angeles, Long Beach, and New York/New Jersey—ranked among the world's top 20 container ports when measured by TEUs, placing 16th, 17th, and 20th, respectively.

"America's Container Ports: Freight Hubs that Connect Our Nation to Global Markets," U.S. Dept. of Transportation, June 2009

Port of New York

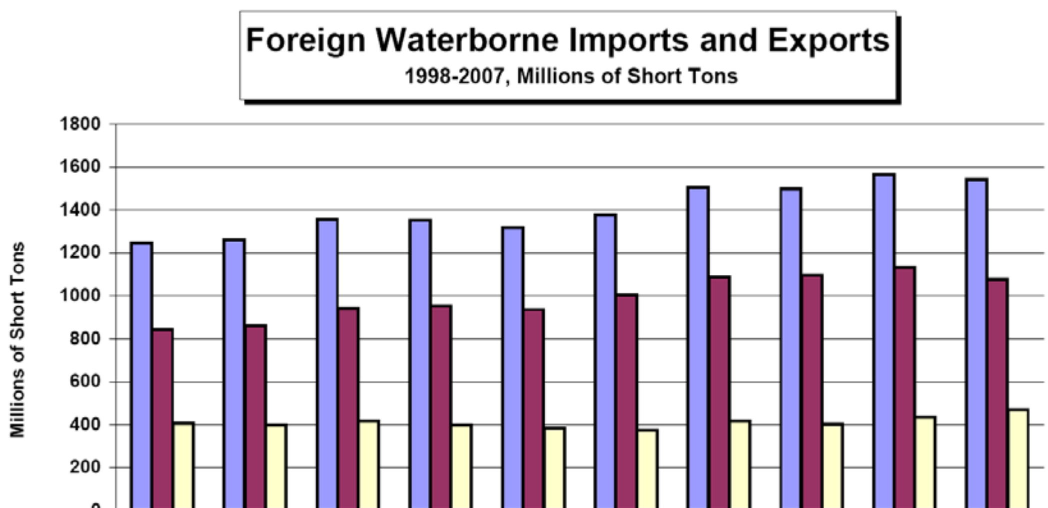
Figure 1-1: Principle Ports of the United States
(based on Cargo Tonnage in 2007)



Much of total domestic production of basic commodities and finished products is shipped via waterborne transportation, including produce, lumber, iron ore, steel, scrap steel, phosphate, plastics, film, machinery and modular homes. About two-thirds of all U.S. wheat and wheat flour, one-third of soybean and rice production, and almost two-fifths of U.S. cotton production is exported via U.S. ports. U.S.-produced coal, grain and forest products also compete well in international markets because of our efficient transportation system. Approximately 4.1 million passenger cars, vans, SUVs and light trucks passed through U.S. seaports in 2005. And, for the cruise industry, more than 9.9 million passengers traveled on 4,211 cruises during 2008[2].

Table 1-1 below shows the general national trend over the time period 1998 and 2007. Total foreign imports have typically been more than twice the amount of foreign exports. This is what is commonly referred to as a "trade deficit". Nations that have exports in excess of imports realize a "trade surplus". The total amount of cargo is shown in millions of short tons.

Table 1-1: Foreign Waterborne Imports and Exports, 1998-2007



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total	1245.4	1260.8	1354.8	1350.8	1319.3	1378.1	1504.9	1498.7	1564.9	1542.5
Inbound	840.7	860.8	939.7	951.8	934.9	1004.8	1089.1	1096.9	1130.9	1075.7
Outbound	404.7	400.0	415.0	399.0	384.3	373.3	415.8	401.8	434.0	466.8

Source: Waterborne Commerce Statistics, 2007

1.3 Inland And Deep Draft Navigation

Figure 1-1 shows both inland and deep draft navigation ports; however inland navigation is different than deep draft navigation. Deep draft navigation is geographically connected to the coasts and Great Lakes; whereas, inland navigation is located in the interior of the nation, usually along rivers and narrower water corridors with harbors, locks, and channels that function as an interacting system. While it is true that most "inland" projects are riverine, inland analysis also applies to coastal systems such as the Gulf Intracoastal and Atlantic Intracoastal waterways. Vessel sizes tend to be homogenous and most movements traverse multiple stops in a system. Analysis focuses on the overall

[2] *Source: http://www.marad.dot.gov/documents/North_American_Cruise_Statistics_Quarterly_Snapshot.pdf*

efficiency of the system and comparison of the cost of transportation by alternate modes.

This manual considers deep draft to generally apply to all other waterways and harbors that are not physically or functionally a part of an "inland" system, regardless of depth or location. It should be noted that ER 1105-2-100 defines deep draft as any channel greater than 14 feet. It is possible to have an inland channel with a depth of 14 feet or greater, but economic analysis for that type of project will likely follow inland/shallow draft (defined by regulation as equal to or less than 14 feet) analysis procedures. Most deep draft navigation is coastally-located, but may include inland areas such as the Ports of Stockton, California and Portland, Oregon. Deep draft ports often compete with each other to attract commerce vs. inland ports that often work as a system. The vessels that use the ports and the way they operate are diverse and analysis focuses on vessel and port operational efficiency and comparative transportation costs via alternate ports.

1.4 Organization of this Manual

This manual is organized into three parts plus an appendix:

Part I – Introduction

1.0 – Introduction
2.0 – Corps Planning Process
3.0 – NED Objective
4.0 – Port and Vessel Basics
5.0 – Port and Vessel Operations

Part II – Data Collection and Forecasts

6.0 – Overview of the Economic Analysis
7.0 – Data Collection
8.0 – Economic Study Area
9.0 – Commodity Flows and Forecast
10.0 – Vessel Fleet Composition and Forecasts
11.0 – Determine Transportation Costs
12.0 – Describe Existing and Without-Project Conditions
13.0 – With-Project Alternatives
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A – Terminology
B – Calculating Benefits: 4 Cases
C – Tide Analysis
D – Cruise Ships
E – Container Ships
F – Types of Dredges
G – Additional Examples and Tables

1.5 Summary

Chapter 1 provides an introduction to the practical guide for evaluating National Economic Development (NED) benefits of Federal projects to facilitate deep draft commercial navigation. The applicability of this manual is for Corps economists who are familiar with the Principle & Guidelines (P&G) requirements, but whose areas of expertise may not include deep draft navigation project analysis; however others may benefit from its use as well. Chapter 1 also introduced the role of the U.S. Army Corps of Engineers with respect to deep draft navigation and introduces key differences between inland and deep draft navigation.

Miami Harbor

CHAPTER 2 – CORPS PLANNING PROCESS

2.0 Overview

This chapter will review the Corps planning process outlined in the Planning Guidance Notebook (PGN) that is the foundation upon which to build a deep draft NED study. This chapter will also define the project federal role, federal interest, and briefly review selected topics in the Planning Guidance Notebook (PGN) evaluation process for deep draft navigation transportation benefit cost analysis. Consistency with the P&G, PGN, Engineering Regulations (ERs) and Circulars (ECs), Economic Memoranda (EMs) are a basic requirement in all studies and all supplemental guidance, including this manual.

2.1 Corps Guidance

Principles and Guidelines, Planning Guidance Notebook

*The **Principles & Guidelines** **(P&G)** (*Executive Order 11747) prescribe as the basic requirements and the planning process that applies to all water resource projects. Procedures directly related to the purpose of this manual are deep draft Navigation (Section VII). Other procedures that may apply include Inland Navigation (Section VII), Recreation (Section VIII) and Commercial Fishing (Section IX). Chapter II was incorporated in their entirety into the ***Planning Guidance Notebook*** (ER 1105-2-100, Appendix E). It is the principal reference for performing Corps water resource studies. It is an Engineering Regulation (ER) that consolidates P&G study requirements and others imposed by law (e.g., cost-sharing pursuant to P.L. 99-662) and policy determinations. The Notebook covers study content, format, economic and environmental considerations and procedures for evaluation.

Other Sources

Economic Guidance Memoranda (EGM) updates economic data and requirements used in study planning. This include vessel operating cost data and current discount rates to be used for project costs and benefits.

Engineering guidance is contained in ***Engineering after Feasibility Studies*** (ER 1110-2-1150) and ***Engineering and Design for Civil Works Projects*** (draft ER accompanying EC 1110-2-268). Other non-Corps sources for general navigation and economics information include:

- *Approach Channels – A Guide for Design*, PIANC Publication PTC-II-30, June 1997
- *Economic Methods of Channel Maintenance,* PIANC Bulletin 67, 1989
- *Capability of Ship Maneuvering Simulation Models for Approach Channels and Fairways in Harbors*, PIANC Bulletin 77; 1992
- *PIANC: The International Navigation Organization*: www.pianc.org
- *AAPA*: *American Association of Port Authorities*: www.aapa-ports.org

2.2 Study Authorities

Study authority is what gives the Corps the right to study various navigation problems. The authority comes through legislation or appropriate Congressional committee resolutions. Specific study authority is required if the project is to be congressionally authorized. The Corps has distinct authorities to conduct deep draft navigation studies and projects in addition to navigation specific programs: Congressionally Authorized Projects and the Continuing Authorities Program (commonly called CAP). Congressionally Authorized Projects are generally larger than CAP Projects and subject to detailed evaluation to Support a Chief's Report and subsequently reviewed by the OSA Office of Management and Budget.

Continuing Authorities Program (CAP)

CAP programs do not require specific Congressional authorization and are for specific purposes within Federal expenditures limits. Programs include but are not limited to:

- **Small Navigation Projects** (Section 107, Rivers & Harbor(R&H) Act of 1960). These differ from congressionally authorized projects only in size. The projects often include small fixes, breakwater modifications, jetties, etc. Evaluation procedures are the same as for Congressionally Authorized projects, except for the level of detail.
- **Mitigation for Shore Damage Due to Federal Navigation Projects** (Section 101, WRDA 1986 and Section 111, R&H Act of 1968). This allows the development and construction of projects that prevent or mitigate the damages caused by Federal navigation work.
- **Snagging and Clearing for Navigation** (Section 208, Flood Control Act of 1954). Incidental navigation benefits may apply.
- **Modification of Bridges that Obstruct Navigation** (P.L. 76-647, Bridge Alteration Act). Currently this program is administered by the Coast Guard. Economic evaluation is performed using U.S. Department of Transportation benefit-cost criteria.
- **Beneficial Use of Dredged Materials**. When determining an acceptable method of disposal of dredged material, districts are encouraged to consider options that provide opportunities for aquatic ecosystem restoration. Economist may evaluate the least cost, and environmentally acceptable method of disposal.

Special Navigation Programs

There are several "Special Navigation Programs" that may involve commercial navigation and to which this manual may apply (legislative authority is in parenthesis):

- **Snagging and Clearing for Navigation (Section 3, R&H Act of 1945).** Evaluation is required. Any commercial or recreation navigation benefits may apply.
- **Drift and Debris Removal (Section 202, WRDA of 1976).** Evaluation is required. Benefits are generally commercial and/or recreation vessel damage reduction, but may include restoration or increase in property values and other NED benefits.

- **Removal of Wrecks and Obstructions (Section 19, R & H Act of 1899).** No evaluation is required.
- **Aids to Navigation**. These are buoys, lights, ranges, markers, and other devices and systems required for safe navigation or to achieve the project benefits. Aids to navigation are usually provided by the Coast Guard.

2.3 Federal Role, Objective, and Interest

Developing the plan for a deep draft navigation project begins with defining the Federal Role and Federal Objective for the project. This is the basis that drives the study analysis to find the National Economic Development (NED) plan.

> "The **Principles and Guidelines** (P&G) provide that planning, which is to contribute to National Economic Development, is to be consistent with *protecting the Nation's environment, pursuant to national environmental statutes,* applicable executive orders, and other Federal planning requirements. With respect to "protecting the Nation's environment", the Corps has adopted the standard that it "*is achieved when damage to the environment is eliminated or avoided and important cultural and natural aspects of our nation's heritage are preserved*".

The PGN states that the single overarching *objective* of the Federal Government is to contribute to National Economic Development (NED) consistent with protecting the Nation's environment. The Federal Objective is used repeatedly throughout the Civil Works planning process and defines the limits to Federal cost sharing.

> *"The **role** of the U. S. Army Corps of Engineers with respect to navigation is to provide safe, reliable, and efficient waterborne transportation systems (channels, harbors, and waterways) for movement of commerce, national security needs, and recreation. The Corps accomplishes this mission through a combination of capital improvements and the operation and maintenance of existing projects."*
>
> *-ER 1105-2-100*

Federal Interest is the basis for Federal participation in water resource projects including cost sharing and other project responsibilities. It determines how and where the government can spend taxpayer money. The Federal role also determines whether the local or Federal partner pays for various items. The economist's NED evaluation is independent of cost-sharing requirements.

Verification of the Federal Interest in a project is a prerequisite to project implementation. Study reports must have a conclusive statement of why such interest does or does not exist. Federal Interest in a project depends upon whether it provides benefits to the nation by facilitating commerce. This requires identification of opportunities, constraints, public purpose and access, and the commerce served.

In addition the Federal Interest pre-requisite, there are several other important considerations to keep in mind:

- **Project Components:** Federal participation in project components is limited to general navigation features such as channels, basins, protective works, and aids to navigation such as buoys and lights. The Corps is responsible for general navigation features whereas the U.S. Coast Guard is responsible for aids to navigation. This distinction is particularly important when defining cost sharing.

- **Public Purpose:** The fundamental public purpose of a navigation project is to facilitate the movement of vessels and the transportation of passengers and cargo. Public purpose requires that there be multiple users and project beneficiaries, or an expectation of multiple usages in the future.

- **Public Access:** In addition, Federal projects must be open to public use for the projects' purposes. For navigation projects, the access required is at least one location with the vessel or cargo service facilities needed to achieve project benefits open to all users on equal terms.

2.4 Corps Planning and Risk Analysis Process

The Corps uses a six step planning process, augmented with a risk analysis framework, to make responsible risk informed decisions and select the plan with the highest NED benefits consistent with environmental considerations.

Risk Analysis: Management, Assessment, and Communication

Risk is the probability and outcome of an event occurring. Outcomes include both a loss due to some hazard and/or an opportunity from an event. As an example of risk, there could be a 1 in 100 chance that a ship entering a port could collide with another ship (the probability of the event) and cause damages (the outcome). Likewise, there is a 99 in 100 chance of a safe passage and no damages.

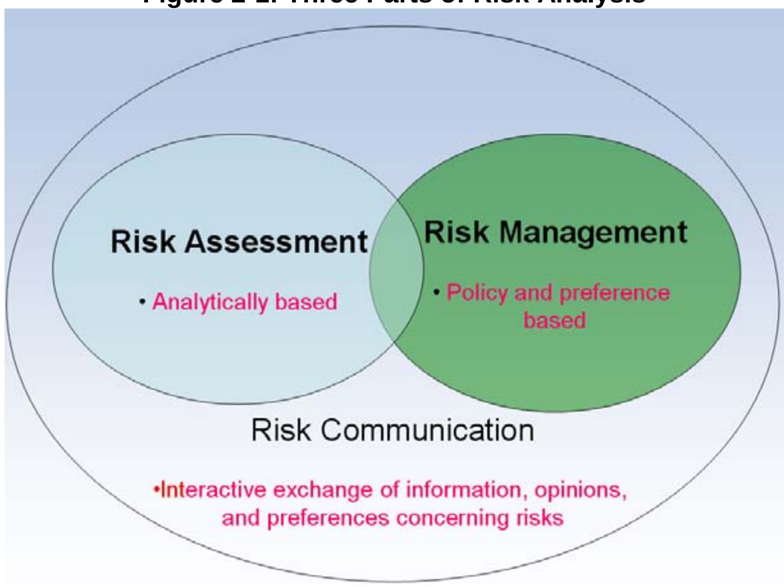
Uncertainty is the result of imperfect knowledge concerning the present or future state of a system, event, situation, or (sub) population under consideration. Uncertainty leads to lack of confidence in predictions, inferences, or conclusions. There are two basic kinds of uncertainty: knowledge uncertainty and inherent variability.

There are three main parts to risk analysis: assessment, communication, and management. Risk assessment is a systematic, evidence based approach for describing the likelihood and consequences of any action, including not action. Risk communication is the open, two-way exchange of information and opinion about risks and uncertainties leading to a better understanding that will facilitate risk management decisions. Risk management is the process of problem finding and initiating action to identify, assess, select, implement, monitor and modify over time, actions to alter and manage levels of risk, as compared to taking no action.

Figure 2-1 shows the interrelatedness of the three parts of risk analysis and the notion that risk communication is a vital and joining activity that must take place for the analysis to be an effective decision framework. Note that the technical scientific work takes place in the risk assessment while risk management is more concerned with applying social values and policy to sort through options and tradeoffs revealed in the risk assessment.

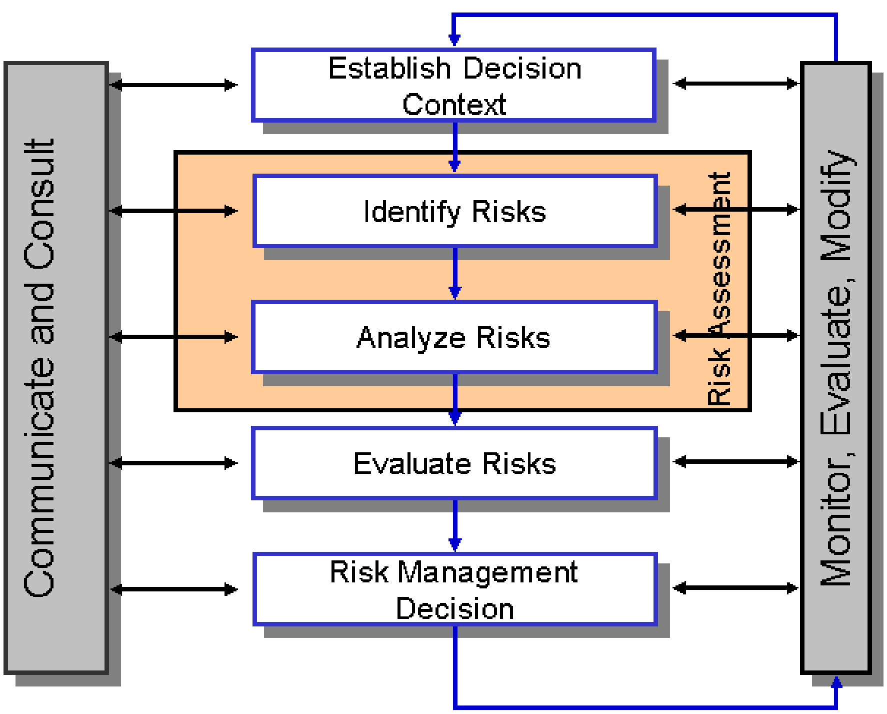
More information on risk can be found at:
http://www.iwr.usace.army.mil/riskanalysis/

Figure 2-1: Three Parts of Risk Analysis



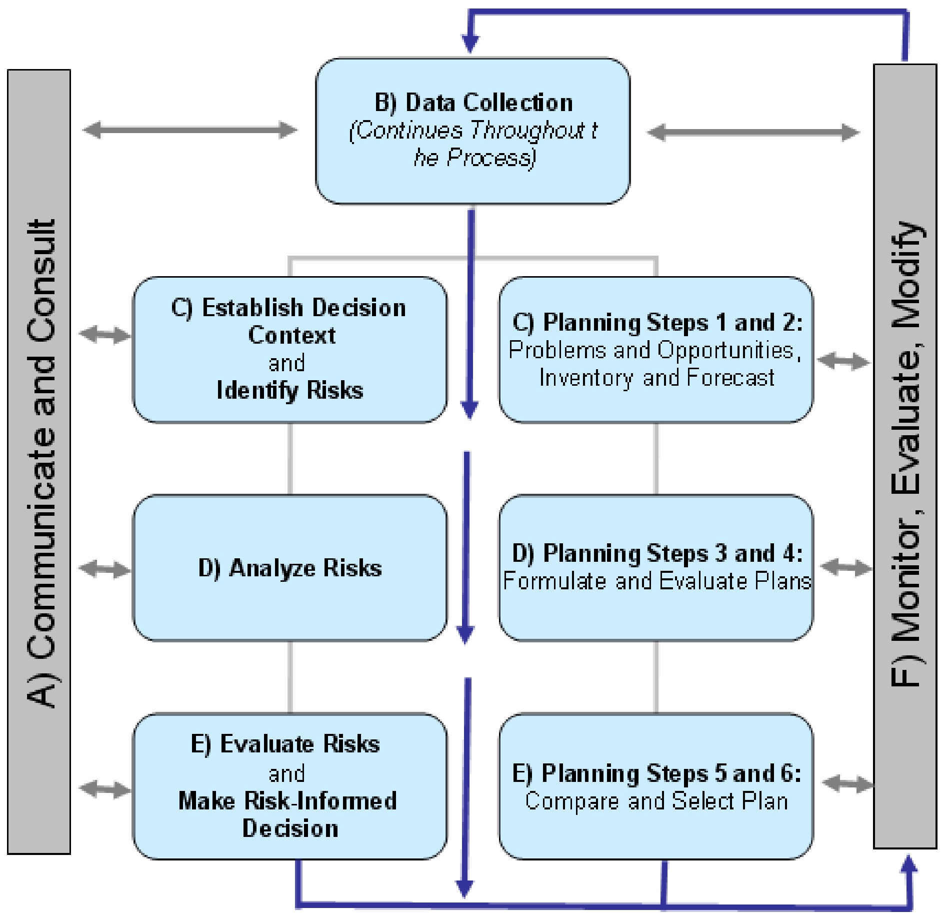
The steps suggested for risk-informed decision making are shown in Figure 2-2 below.

Figure 2-2: Risk-Informed Decision Making



These risk-informed decision making steps can be worked in conjunction with the Corps' 6-Step Planning Process. The description and figure below is a suggested "mind map" for this process. However, one should recognize that this process is highly iterative.

Figure 2-3: Risk-Informed Decision Making and 6-Step Planning Process



A) Communicate and Consult *(Continues throughout Process)***:** Active communication is an essential part of risk analysis. Communicate and consult with internal and external stakeholders as appropriate at each stage of the process. If there are shared risk management decisions, they should be identified, the decision participants recorded and a formal agreement documenting the shared responsibility for the decision prepared and signed by all responsible participants.

Economists and planners face several challenges in communicating and consulting with team members and project stakeholders. First, open communication and consulting means fully describing the uncertainties, challenges, and risks that the stakeholders face based on the best available information. Risks should not be minimized or made glossy, but rather presented as they are. This leads to another challenge, communicating risks and risk analysis procedures in an understandable fashion. In communicating, using jargon, acronyms, and technical language is not a good idea. For example, economists often say words like “NED, NER, average annual equivalent benefits, exceedance probability” and so on. The average person has no idea what these common economic and Corps terms are. Be sure to fully explain all concepts or choose other words in communicating and consulting that match the intended audience knowledge level.

Below are some other helpful hints in becoming a better communicator and consult:

- Trust is the necessary condition for effective communication.
- Communication implies listening as well as transmitting.
- It is important that there be visible advocates for the use of risk analysis and management techniques at the highest organizational levels.
- Spell out all acronyms and fully describe
- Clearly label all figures and make sure they are readable
- Use visuals to display the story
- Relate information to other more familiar information
- Test the report writing and figures on those not familiar with the Corps or the study

B) Data Collection *(Continues throughout the process)***:** Collecting data is officially recognized in Planning Step 2, but the planning process is highly iterative and therefore is necessary throughout the process.

C) Establish Decision Context and Identify Risks *(Planning Steps 1 and 2)*: In a risk-informed decision making framework, this step establishes the decision context in which a risk management decision will be made. It includes identifying and defining the management problems and opportunities, the risks relevant to the decision context, inventorying and forecasting appropriate data, and establishing measurable objectives to which the risk management process is being applied. Decision-making criteria, evident uncertainties, and the questions to be answered in subsequent analytical steps are identified in this step. It includes asking and answering “what can go wrong (or right)” and “how can it happen” about the problem setting.

D) Analyze Risk *(Planning Steps 3 and 4):* Alternative plans and appropriate mitigation of adverse effects are to be formulated in a systematic manner to ensure that all reasonable alternatives are evaluated. Each alternative formulated should consider four criteria: completeness, effectiveness, efficiency, and acceptability. Estimate the consequences and likelihoods of the risks identified in the previous step. At the same time recognize and report decision critical knowledge uncertainties and incorporate them as a source of risk. The consequence and likelihood for each risk may be combined to produce an estimated level of risk. Alternative management strategies are analyzed in this step. The risks to the four accounts should also be considered; the four accounts are: National Economic Development Benefits (NED), Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE).

Steps c and d together comprise the risk assessment task. This is often the principle analytical step in the risk management process. In some decision contexts a complete risk assessment may not be needed or may not be possible to complete in support of decision making. In these instances the analytical steps are modified as necessary.

E) Evaluate Risks and Make Risk-Informed Decision *(Planning Steps 5 and 6):* Risk management alternatives are evaluated and compared to identify the best NED solution. The best compatible elements of different plans may be combined, provided they are incrementally feasible and justified. The final screening process brings together economic efficiency considerations, risk, and evaluation of effects among final plans. Consider the cost to reduce increments of risk. Who bears the risk, what risks are reduced, borne, transferred, etc?

The NED Plan represents the decision to accept or take action to manage the identified risks. If action is taken, a risk management strategy is developed and implemented. Desired and measurable outcomes of the management strategy are identified at this step so the success of the plan can be monitored and evaluated. To the extent there is significant known analytical uncertainty, the risk management strategy will include an adaptive management plan to reduce such uncertainties over time and as needed modify the execution of the actions taken.

F) Monitor, Evaluate, Modify*:* The purposes of post implementation monitoring are: to assure that there is progress toward achieving the outcomes of the implemented risk management strategy; if there is an adaptive management process there will be a data collection targeted to testing hypotheses required to reduce analytical uncertainties identified in the initial planning process; and, to scan the overall setting for the activity to identify hazards or changes in socioeconomic preference or conditions that may not have been recognized during the initial risk analysis process, or that may have changed in their significance. In all cases the risk mitigation strategy may be modified in accordance with what is learned.

2.5 Project Delivery Team (PDT)

No work is done in isolation. The economist must work with his or her PDT to be successful in accurately describing the economic analysis. A PDT is composed of several team members from all aspects of planning and more. Each deep draft navigation team is likely to have or should consider having a coastal engineer, cost-engineer, biologist, economist, plan formulator, project manager, regulatory representative, real estate specialist, and an operations representative. However, each project and team is different and may have additional needs or special skills.

The team is important for plan formulation and providing data input for the NED costs and benefits. The team also helps frame the economist's analysis and describe the four accounts. Likewise, the economist assists the team and provides them information to help steer the study course and their work.

2.6 Plan Formulation

A plan formulators' role often coincides with the economists' role. Below is a brief list of a few plan formulator tasks:

- Lead Planning Process
- Project Authorization Document
- Set Planning objectives
- Problem identification
- Set Planning objectives
- Define existing condition
- Define future with and without project conditions
- Development of alternatives
- Trade off analysis
- Cost Sharing
- Technical Integration
- Facilitate review process and issue resolution.

While not all tasks directly relate to economics, many of them do. Economists are key in setting planning objectives because they will often measure the objective's success. The existing, future without- and with-projects conditions are often defined through the economic analysis. When plan formulators develop alternatives, certain criteria are required to be met in formulating plans: efficiency, completeness, acceptability, and effectiveness. Inherently, an economist measures effectiveness and efficiency which makes their role in plan formulation essential.

Economists are required to perform an incremental alternatives analysis, which measures efficiency and effectiveness of alternatives. The economist can help the team determine the independent alternatives and combination of alternatives in the evaluation. The economist should be able to help build plans based on the need for the incremental analysis. Therefore, the economist's role is essential in the plan formulation.

Economists often play a role in many plan formulation activities outside of NED analysis. For example, an economist may assist in cost analyses for Dredge Materials Management, Operating, Regional Sediment Plans, and mitigation.

2.7 Environmental Considerations

Deep draft navigation projects will usually involve analysis of one or more major environmental issue including fish and wildlife impacts particularly on endangered species, contaminated sediments, and air quality. This makes the role of the environmental team member (whether biologist, ecologist, environmental scientist, or related discipline) crucial to the success of the project. Economists must understand the underlying environmental concerns on any project for several reasons:

- Environmental mitigation costs are NED project costs and will influence the level of net NED benefits

- Economists may be asked to perform a trade off analysis (e.g. NED vs. Environmental Quality-EQ benefits and costs, NED vs. NER)

- Cost effectiveness/Incremental cost analyses are required for environmental mitigation or other components and should be performed by economists.

- Environmental impact documentation often requires help from an economist on broader socioeconomic and population impacts.
- The economic outputs can often fuel debate over environmental consequences and quantifying environmental outputs
- Collaborative planning often means that economists will have to work with stakeholders including those that have environmental and social concerns. Such collaboration includes explaining economic concepts and results.
- Ballast water can be subject to environmental restrictions which impacts the cargo loading capabilities.
- The Clean Water Act can impact vessel operations and alternatives.
- Regional Sediment Management can impact environmental and NED costs and benefits from adding and/or removing sediment in various areas (such as beaches).

Dredging at Brunswick Harbor

For these reasons, it is a good idea to work with the team biologist or environmental specialist to understand the environmental concerns and opportunities. The biologist also will have an understanding of the Corps Environmental Operating Principles, which is key to plan formulation and consequently the economic analysis.

Environmental concerns with deep draft projects can be significant and can cause long delays, project modifications, or possibly jeopardize the feasibility and acceptability of the project. The Corps' Environmental Operating Principles should guide all project analyses; the PDT has the delicate role of trying to balance the environmental elements and economic development. While the project economist is working to ensure alternatives are economically justified, the economist must understand that alternatives must be environmentally acceptable.

The NEPA requires that each study will at a minimum require the Corps to complete an Environmental Assessment (EA). In the case of larger, more controversial studies, an Environmental Impact Statement (EIS) will be required by the National Environmental Policy Act (NEPA). These NEPA analyses go beyond the project economics and the natural environment to include the entire human environment which means considering other factors including such as "Social Justice." The law says that any Federal agency will appropriately identify and address any disproportionally high or adverse effects on minority and low-income populations. The economist may assist in describing such impacts.

Environmental considerations can and will change the NED analysis. Navigation projects often mean disturbing aquatic ecosystems in the channel footprints and surrounding areas. Endangered species can impact the NED costs and timeframes used to bring all values to present value. For example, sea turtle nesting will lengthen the construction period because construction often cannot occur during this period. Sea turtle and/or other endangered species monitoring will also increase project costs which impacts the NED analysis.

However, not all environmental impacts are negative. For example, it is possible that modifying a channel could remove hundreds of trucks from the road thus reducing transit via highways. This could result in net improvements in air quality through the removal of air pollutants from diesel trucks transporting goods to and from the port which could offset the increased air pollution from the use of larger vessels.

The bottom line is that an economist must understand more than just economics to successfully do an analysis of a Corps deep draft navigation project.

2.8 Key Concepts

This chapter covered the basic formulation process required by the P&G, the PGN and the Risk Informed Decision Making process for completing a NED evaluation for deep draft navigation:

- Corps Planning Guidance is comprised of:
  - Principles & Guidelines (P&G) (Executive Order 11747)
  - Planning Guidance Notebook (PGN) (ER 1005-2-100)
  - Engineering Regulations (ER)
  - Engineering Circulars (EC)
  - Engineering Memorandums (EM)
- Consistency with the P&G and the PGN is a basic requirement in all studies and all supplemental guidance, including this manual.
- Three main project authorities exist: congressionally authorized, Continuing Authorities Program (CAP) and Special Navigation Programs.
- The 6-step planning process is: 1) Problems and Opportunities; 2) Inventory and Forecast; 3) Plan Formulation; 4) Evaluation; 5) Comparison; and 6) Plan Selection. This process should be combined with risk-informed decision making.
- Risk Analysis has three main parts: communication, assessment and management. The economist typically most contributes to the assessment piece.
- The alternative plan with the greatest net National Economic Development benefit consistent with protecting the environment, which is also known as the NED plan, is to be recommended unless there is an overriding reason for selecting another plan.
- The planning delivery team is comprised of various experts. The economist should understand their own role and how it interacts with the other team members. Economists also play an important role in plan formulation.
- Environmental considerations can modify the plan formulation and economic analysis. Additionally, the economist may an important role in environmental tasks.

Port of San Francisco

CHAPTER 3 – NED OBJECTIVE

3.0 NED Objective: Highest Net Benefits

NED benefits are contributions to National Economic Development that increase the value of the national output of goods and services. The NED Objective is to maximize the total net Federal NED benefits for a project consistent with protecting the environment (Principles and Guidelines, March 1986). Despite the requirement to consider the four accounts, the NED is still the main factor for selecting an alternative plan. It is the primary basis for Federal investment in water resource projects and is measured in average annual equivalent terms.

Net NED Benefits

Net NED benefits are NED benefits reduced by NED costs. NED costs are essentially the costs to the nation for a specific project implementation. Economists must determine which NED benefits and costs can and should be counted towards the final net NED benefit total in average annual equivalent values.

The comparison of NED benefits and costs is generally expressed as a ratio of benefits to costs. Economic justification requires that benefits exceed costs and therefore the benefit/cost ratio must exceed 1.0. While the benefit/cost ratio is a convenient device to verify justification and is often used in the Budget Engineering Circulars, net NED benefits are the best measure of the project's contribution to National Economic Development.

The plan with the highest benefit/cost ratio and the plan with maximum net NED benefits may not coincide. Conceptually, the most efficient use of resources is when benefits exceed costs by the maximum amount. Therefore, maximum net NED benefits are used as the primary determinant of the most efficient plan or plan scale.

All reports should include information and data sufficient to define the upper (maximum net benefit) and lower portions of the net benefits curve for a number of alternative plans and plan scales. The total benefit, total cost curves, incremental benefit, and incremental cost curves should be shown for each alternative plan or scale of plan so that the relationship between costs and benefits is evident. The most efficient plan can be determined by analysis of the relationship between costs and benefits, discounted to account for the time value of money and expressed in average annual equivalent terms.

3.1 NED Benefits

NED benefits must be expressed in monetary units for benefit-cost analysis. This is true even if the goods and services are not marketed. The conceptual basis for determining the value of such NED benefits is willingness-to-pay (WTP) by the users of project outputs.

Benefits of deep draft navigation projects are derived mainly from transportation cost savings, or higher net income to commodity users or producers during the economic period of analysis. Some of these benefits could also occur during the construction period (benefits during construction) and these should also be accounted as NED benefits.

Below is a list of general NED benefits, for more detailed information, please see Chapter 14.

Transportation Cost Savings

- Increased Loads for Existing Vessels
- Switch to Larger Vessels
- Enhanced Maneuverability and Delay Reduction
- Shift of Origin: cost reduction in transporting and producing the commodity
- Shift in Mode or Harbor: commodities travel another route that is more cost-effective to the same destinations
- Other: reduced cargo handling costs, reduction of tug assistance, reduction in accident rate and cost of damage, lower cost switch from land transportation, advanced maintenance, reduced insurance, interest and storage costs.

Higher Net Revenues

- Shift of Destination: increase in net revenue to the commodity producers
- Induced Movement: if a commodity or additional quantities of a commodity are produced and consumed as a result of lower transportation costs, the benefit is the commodity value less all production and transportation costs

Other NED/NER Benefits

Other NED benefits include, but are not limited to:

- Recreation
- Flood damage reduction
- Coastal storm damage reduction
- Location or land enhancement by filling with dredged material (however, there is no Federal investment in a Corps project that is intentionally or effectively a land development project and projects generally should not use land enhancement as a large incidental benefit)
- Utilization of unemployed or underemployed labor in various markets
- National ecosystem restoration (NER) benefits, which are generally not monetized but appear in the form of additional acres, habitat units, fish counts, or biodiversity indices
- Reduced landside transportation costs (if it can be demonstrated that cost reductions will occur because of the project and would not occur without it).
- Beneficial Use of Dredge Materials: these may be either in an increase in NED benefits or a decrease in NED costs from multiuse of materials. Examples are landfill used for development, construction materials, topsoil, marsh creation, and beach restoration.

- Other environmental and economic benefits from regional approaches to sediment management (such as reduction lifecycle maintenance costs, increased habitat benefits, increased beneficial use of sediment resources, increased efficiencies through regional strategies and partnerships)

3.2 NED Costs

NED costs are critical to the planning process and serve a key purpose in evaluating, comparing and selecting project alternatives. Both the *financial* costs (often assumed to be the construction and mitigation costs) and *economic* costs (including the opportunity cost of not investing in the next-best alternative project) throughout the project lifecycle must be considered. This requires not only an economic evaluation, but also detailed engineering cost estimates for specific construction pieces as part of the NED plan and risk consideration on the cost.

It is important to consider all costs related to the navigation project, even if it appears that some are not directly linked to the project. Below is a list of general NED costs, please see Chapter 14 for more details:

- Project Costs (construction, mitigation[3], etc.)
- Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R)
- Interest During Construction (IDC): These costs are hidden, unpaid costs that must be accounted for when determining the NED costs of a project. The cost of this waiting period is known as the “opportunity cost” and it reflects the foregone opportunity of investing the money for other purposes.
- Associated Costs: all costs other than those above that are required to fully implement a project for the life of the project

> caution
>
> *Cost-sharing responsibilities are independent of the NED costs. All project related costs must be considered in an alternative, no matter who pays, as these are costs to the nation as a whole.*

When determining NED costs, it is important to differentiate the projected financial and economic costs from the “sunk costs”. “Sunk costs” are costs that have been incurred, but which cannot be recovered. Any improvements the sponsor may have made or will make without a project are excluded in the analysis. Feasibility and other study costs are considered sunk costs.

[3] *Mitigation may actually start prior to construction (or credited) and could also go beyond the construction period depending on the mitigation measure.*

3.3 Economic Evaluation Procedures

The P&G and the PGN describe NED benefit evaluation procedures for each type of water resource project. This manual generally follows these steps, but in a slightly different order. These procedures are:

a. Determine the Economic Study Area

This step assesses the inland and waterways transportation network in relationship to commodities. The economic study area differs from the footprint of the project study area which typically begins at the entrance channel and extends to the furthest terminal that is anticipated to benefit from the deepening and widening measures. When delineating the economic study area, consider all foreign and domestic origins and destinations of the types and quantities of cargo being shipped, the flow of the commodities on land from ports, political and economic boundaries. The planning study area may only focus on the immediate project area, but the economic study area extends further out to consider the flow of goods.

The inland trade region served by a port is called its hinterland. That hinterland usually consists of a number of cargo hinterlands defined by the inland origins or destinations of specific commodities. Collectively, the cargo hinterlands of actual and potential commerce of the project port define the economic study area.

b. Identify Types and Volumes of Commodity Flow

This step describes the commerce flow of the port in terms of types and volumes. The composition of a port's commerce is readily available from the Corps of Engineers' Waterborne Commerce Statistics Center (WCSC) in New Orleans. These statistics cover about 2,500 harbor and waterway points. However, the most recent data available is often two years behind. Always check to ensure units are consistent among all sources. Other sources of information will be needed in order to identify the domestic and overseas origins and destinations of specific commodities. [*See Chapter 7, Data Collection.*] A large number of origins and destinations can be involved, even for a single commodity.

Adequate origin-destination identification is needed to support traffic projections. All cargoes should be identified, but the project evaluation will focus on those that comprise the bulk of the cargo traffic or would benefit the most from a project.

c. Project Waterborne Commerce

Estimates of a port's future commerce for the period of analysis are linked to the port's hinterland and the extent to which it shares commodity flows with other ports. The projections or estimates of port commerce should be a sensible share of trade route, national trade and world trade, and supported by analysis of the economic potential of the port's hinterlands. Port traffic forecasts should generally not claim commerce (and benefits) that belong to other ports unless it can be demonstrated that such a shift in origin or destination will actually occur, is attributed to a transportation cost savings, and the facilities of the new port can accommodate these vessels.

> *"The vessel fleet composition is determined by analyzing past trends in vessel size and fleet composition and trends in the domestic and world fleet. The vessel fleet composition is determined for both with- and without-project conditions. Changes in fleet composition may vary by trade route, type of commodity and volume of traffic. Canal restrictions, foreign port depths and lengths of haul also affect the vessel fleet composition."*
>
> *-Planning Guidance Notebook*

d. Determine Vessel Fleet Composition and Cost

It is usually advantageous to begin by identifying the vessels, and therefore the cargoes, that may benefit from harbor improvements—or previously identified problems and potential benefits are verified. This provides the basis for limiting or focusing study efforts on the commodities that are likely to be benefited. Identification of the historical, present and future port fleets are separate but related efforts. This necessary prerequisite to the forecast of future without- and with-project fleets identifies actual vessel operations (e.g., light loading and use of alternatives) over the period of analysis.

e. Determine Current Cost of Commodity Movements

Current guidance requires estimation of full origin-to-destination costs including port cargo handling. The basic premise in NED evaluation is that cost considerations and demand for the commodities will determine the choice of cargo routings and the types of vessels used. In practice, other considerations may apply as well. Transportation costs, however, are a good premise for scientifically predicting choice. Inland transportation costs can only be ignored if the economist can demonstrate that neither the hinterlands nor the mode of transportation will change in the alternatives.

f. Determine Current Cost of Alternative Movement: Non-Structural Alternatives

A variety of alternatives may be employed that can affect the need for and justification of the project. The alternatives include vessel operating practices, unconventional port facilities and vessels, and cargo routing through alternative ports. These non-structural alternatives are implemented by non-Federal interests. Logic suggests that cost-effective alternatives are already being employed.

Current guidance requires evaluation of non-structural alternatives because their NED cost is independent of who pays for them. It is difficult to address all alternatives at one time. This manual suggests evaluation of specific types of alternatives in a more iterative process throughout the study in order to address each of them in a systematic way. Table 3-1 shows four examples of non-structural alternatives, which information will be the basis for the evaluation, and what would need to be further evaluated and described for each alternative.

Table 3-1: Non-Structural Alternatives Evaluation

Alternative	*Evaluation*	*Description Area*
Vessel Operating Practices	*Baseline Information*	*Project Conditions*
Unconventional Facilities	*Baseline Information*	*Planning Setting*
Unconventional Vessels	*Fleet Analysis*	*Fleet Forecast*
Alternative Ports	*Multiport Analysis*	*Traffic Projections*

g. Determine Future Cost of Commodity Movements

Future costs of commodity movements, given the projected vessel fleet composition for each commodity and the vessel operating costs, are estimated using price levels at a common point in time for both. Effectively, any difference in existing and future commodity movement costs depends on improved efficiency in transportation. The project may permit or induce improvements in port facilities and rail or road infrastructure. However, the efficiency will predominantly improve because vessels can carry more goods or larger vessels can be employed. Vessel operating costs are key to this analysis.

Since the history of deep draft vessels have shown a trend to be larger and more efficient over time (independent of the project), there is a potential to incorrectly attribute such efficiencies to the project. However, if the more efficient vessels require modifications that wouldn't normally be undertaken, then these modifications are counted as NED costs and the benefit of these modifications can be counted as NED benefits.

h. Determine Use of Harbor and Channel Without- and With-Project

This determination of use integrates the results from the preceding steps. This step results in defining the existing, without- and with-project conditions. The existing condition is the baseline for NED analysis. It describes the current planning setting. The "without-project" condition is a forecast over the period of analysis, which is typically 50 years (it will be the same time span considered for the with-project condition). It reflects how the existing condition will change over time without the project's construction. It is also known as the "No Action Plan." The "without-project" condition alternative includes an array of practices, facilities and uses of alternate ports.

> caution
>
> *The most common problem experienced at this point is inadequate description of the without-project condition. It must be adequately described.*

The "with-project" condition is the condition of a given alternative over the period of analysis. While policy dictates 50 years cannot be exceeded, a shorter study period can be used if the project life is less than 50 years (see planning guidance for more details). Incremental analysis, analysis of alternatives, and risk analyses all inform the final with-project plan. The with-project condition can be structural or non-structural; both should be analyzed. Non-structural measures may be implemented by non-Federal entities and project users that could reduce or eliminate the need for Federal project investment.

Current guidance requires that all studies formulate and evaluate alternative improvement plans, including the "No Action Plan" which is the "Without-Project Condition". This provides a basis for screening the completeness, effectiveness, efficiency and acceptability of the recommended plan. The comparison of NED benefits and costs serves as the basis for determining the efficiencies of the various plans (including the locally preferred plan if it differs from the Federally-supportable plan (NED) or a granted exception to the NED plan).

i. Compute NED Benefits

The final step in the evaluation process is to determine the NED plan by comparison of the alternate improvement plans. In order to demonstrate that the NED plan reasonably maximizes net benefits, plan comparisons are needed.

The alternate plans that can be used for comparison are:

- alternate or different types of improvements
- incremental scale of improvements

The number of alternative with-project plans will depend on site-specific conditions. Many studies screen out alternative improvements in preceding steps, only needing to optimize size at this point. The accuracy in determining the NED plan will depend on how closely costs and benefits are matched. When channel deepening is involved, for instance, the optimal depth must be identified to the nearest foot. Therefore, it is recommended that any deepening alternatives be analyzed in one-foot incremental depths in the final array of alternatives.

In order to provide an acceptable level of precision, it is essential to anticipate the need for incremental justification early in the study so that the economic and engineering analyses will have comparable levels of detail.

3.4 Analytical Requirements

Current guidance contains some specific and general assumptions and requirements that are to be observed in NED evaluation. The manual introduces these concepts in this section, but more specific procedures to meet analytical requirements are addressed Part II of the manual. This section serves only as a brief introduction.

Analytical Assumptions

Current guidance provides certain assumptions that are to be used in describing the without- and with-project conditions. These assumptions apply to conditions that otherwise cannot be determined conclusively, or would require disproportionate study effort. They are:

- Alternate harbor and channel improvements available to the transportation industry over the planning period include those in place and under construction at the time of the study and the authorized improvement projects that can reasonably be expected to be in place over the planning period.

- Authorized operation and maintenance is assumed to be performed in the harbors and channels over the period of analysis unless clear evidence is available that maintenance of the project is unlikely to be performed.

- In projecting commodity movements involving intermodal movements, sufficient capacity of the hinterland transportation and related facilities, including port facilities, is assumed unless there is substantive data to the contrary.

Systems and Multiport Analysis

Current guidance contains a general requirement for systems analysis. This means evaluating the physical, economic, environmental, and interconnected project systems. Evaluation procedures specifically require system analysis for inland waterways. The requirement is implicit in the deep draft requirement for multiport analysis and by extension applies to all commercial and recreational harbors. The inland requirement focuses on the waterway system and the effect of the project on system delays. The analysis for harbors requires consideration of project impact on the port system or alternate ports and the transportation system or vessel fleet composition.

A multiport analysis can help meet this systems analysis requirement. A multiport analysis is as its name suggests: an analysis (usually a simulation analysis) of the ports that are connected and related to the study port. This analysis is usually a subset of the project port analysis in which the benefiting fleets and cargoes are the baseline for a similar analysis of transportation costs for other ports. The reason that a multiport analysis is often necessary is because with- or without-project conditions can be influenced by port competition. Any with-project alternatives could induce regional transfer of cargo among competing ports and result in RED benefits to the project port. Therefore, the economist needs to determine to what extent competition exists, and how does this impact the with- and without-project conditions.

Additionally, a project must be evaluated as an environmental system. For example, dredging the channel could lead to changes in the regional sediment system, such as shifting sediment movement patterns. These could have associated environmental, and NED costs and benefits to consider immediately and over a project life.

Incremental Analysis

Incremental analysis involves examining increments of plans or project features and determines the incremental costs and incremental benefits. Increments of plans should continue to be added and evaluated as long as the incremental benefits exceed the incremental costs. When the incremental costs exceed the incremental benefits, no further increments are needed.

Increments for deep draft navigation projects may relate to project depth (-38 ft, -39 ft, -40 ft), project width (150 ft, 200 ft, 250 ft), project reach (Outer Harbor, Inner Harbor) or as a combination.

A separable element is a functional general navigation feature that can be evaluated separately from the rest of the project. Its justification is based upon its own merits. Look at the separable cost and the separable benefit of a separable element to determine whether it is economically justified. It is important to try to narrow down alternatives prior to doing an incremental analysis to avoid costly, extensive, and unnecessary analyses.

The optimal plan will be identified as the plan which maximizes the net NED benefits.

Risk-Informed Decision Making

The Risk-Informed Decision Making process described in previous sections provides a general framework that can be incorporated in various economic functions. The general requirement is to identify all assumptions, predicted variables, estimated values and parameter values that are critical to the report recommendation and the value of each critical factor where the recommendations would change or feasibility would be questioned. The specific analyses which are, or may be, required address assumptions as to traffic projections, rates, vessel operating costs, vessel fleet composition or vessel fleet characteristics.

A risk analysis of the parameters influencing each alternative must be conducted to:

- Identify all critical parameters underlying the justification of each alternative
- Determine the range of conditions under which each alternative is justified.
- Identify potential risks, how it could occur, the likelihood of the risk and consequences

The analyst should distinguish between external and internal parameters. External parameters are those factors which occur independently of project implementation, for example, custom fees. Internal parameters are those factors directly related to project implementation, for example, commodity flows.

> *"Sensitivity Analysis. Districts are expected to use risk and uncertainty techniques in all deep draft navigation studies at least in the form of sensitivity analysis. The uncertainty in the estimates of critical variables should be analyzed. These variables specifically related to deep draft navigation may be traffic projections, especially foreign shipments, fleet composition, and cost of commodity movements"*
>
> *-ER 1105-2-100*

Specific areas that might be addressed in a risk analysis are:

- Uncertainty in commodity forecast
- Variation in fleet composition
- Sensitivity of transportation costs to fuel price fluctuations, or other factors
- Climate change impacts on sea levels (See EC 1165-2-211) such as dockside infrastructure, draft and sediment changes, and possibly demand changes
- Southeast Asia's growing and shifting economy
- Movements towards less foreign oil dependence

> *By building an easy-to-update spreadsheet, with as few nested formulas as possible, sensitivity analyses become easier to perform and more transparent to reviewers. Ensure to document the spreadsheets and methodologies used to make model review and certification easier.*

3.5 Key Concepts

This chapter covered the basics for NED planning of deep draft navigation concepts:

- Verification of the Federal Interest in a project is a prerequisite to the National Economic Development Plan (NED) plan implementation. The determination of Federal Interest in navigation projects requires identification of opportunities, constraints, public purpose and access, and the commerce served.
- The single overarching objective of the Federal Government is to contribute to National Economic Development (NED) consistent with protecting the Nation's environment.
- Projects are increasing becoming multi-objective and may have NED and NER components that must consider the four accounts as well: NED, environmental quality (EQ), Other Social Effects (OSE), and regional economic development (RED).
- Net NED benefits are contributions to National Economic Development that increase the value of the national output of goods and services.
- The NED plan for a project is the plan that reasonably maximizes net NED benefits. The relationship between costs and benefits, discounted to account for the time value of money at a constant price level and expressed in average annual values or equivalent annual, determines the most efficient plan.
- Benefits of deep draft navigation projects are derived mainly from transportation cost savings, improved safety or higher net revenues.
- Several analyses are important: risk, systems, multiport and incremental.
- Communicate and consult with all stakeholders to ensure the best quality report, risk communication and more.
- Recognize existing vessel behavior and behavioral changes under various alternatives.

Big Stone Anchorage in Delaware Bay, Lightering

CHAPTER 4 – PORT AND VESSEL BASICS

4.0 Overview

This chapter is intended to provide an overview of deep draft vessels and their characteristics. The following topics will be briefly discussed in this chapter:

- harbor and port systems and their hinterlands
- general navigation features
- types of deep draft vessels
- special carriers and passenger vehicles
- basic vessel characteristics

4.1 Harbor and Port Systems

A harbor is a sheltered part of a body of water deep enough to provide anchorage for ships or a place of refuge. A port is a place by a waterway where ships and boats can dock, load and unload. Together they form the planning setting for the prospective project and are most commonly referred to as ports.

No two ports are the same. Specialty ports and harbors are easier to understand and document because the focus is specific in terms of cargoes and fleets. General purpose harbors can be much more complex because they host a variety of cargoes and fleets that may or may not be affected by improvements.

Hinterlands

The inland trade region served by a port is called its hinterland. That hinterland usually consists of a number of cargo hinterlands defined by the inland origins or destinations of specific commodities. The port hinterland is also known as the “economic study area.”

For the purposes of the NED analysis, the economist is interested in the port cargo hinterlands defined by the vessels and their cargoes to be benefited by the project. Port hinterlands can be broadly classified as captive or competitive:

- **Captive** cargo hinterlands will use the study port exclusively for either origin or destination
- **Competitive** cargo hinterlands are those where there is a choice between ports for the origin or destination of the cargo, making a multiport analysis necessary.

An in-depth look at port hinterlands and their importance to the study analysis is presented in Chapter 8.

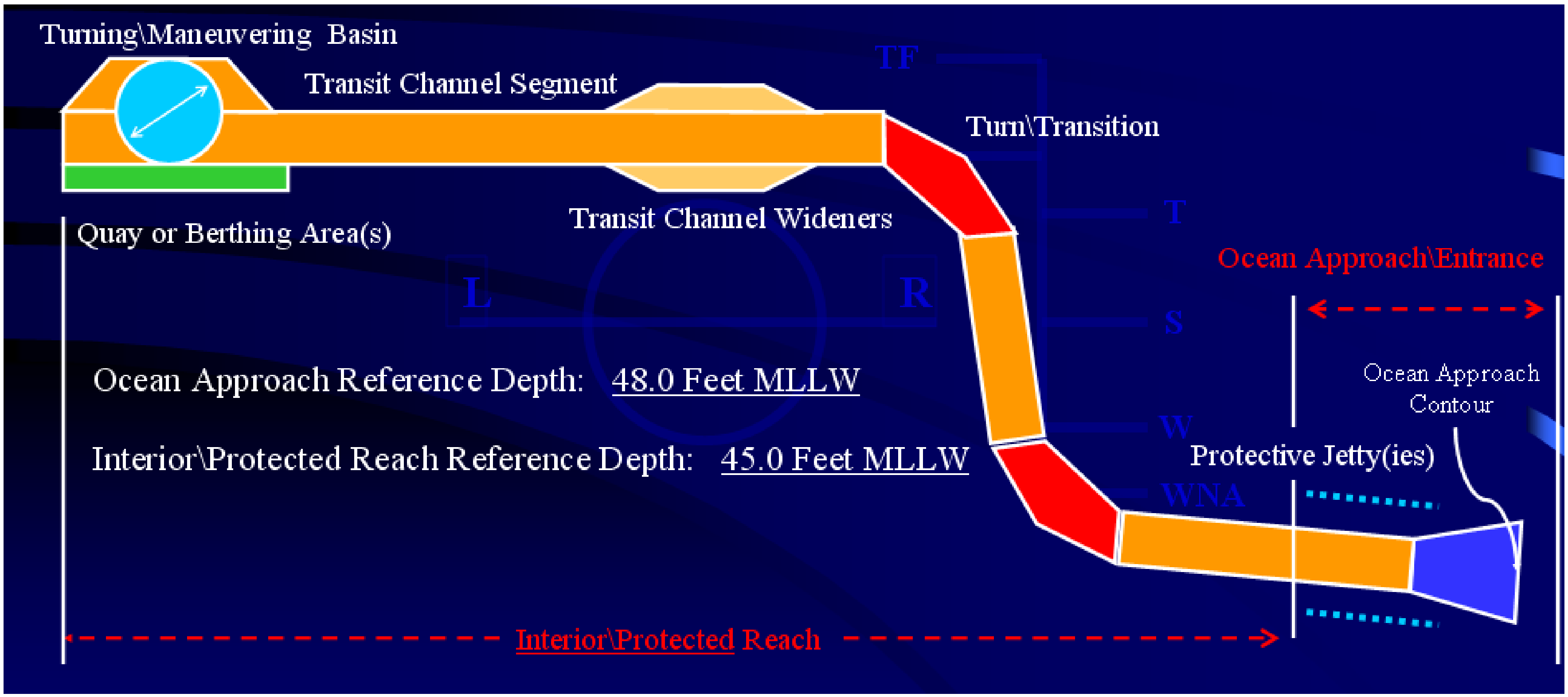
Ports often find themselves competing with other ports nearby for the same cargo movements. Ports may try to reduce prices, improve facilities, or physical conditions to gain business from the other port. It is also possible that ports may have a co-dependent relationship. The interactions among ports are important in understanding the port hinterland.

General Navigation Features

Each port typically has special structures to improve safety in channels, facilitate transportation, or to maintain channel depths. Some common navigation structures are: Channels, Anchorages, Turning Basins, Breakwaters, Lock and Dams, Jetties, Pile Dikes, Wingwalls, etc.

Definitions and descriptions of these features can be found in Appendix A. These features can also be structural alternatives. Below is an example of a port layout. The figure below shows the interior depth, which is the project depth of a port.

Figure 4-1: Example Port Diagram



Port Support Services

Port activities depend on a variety of public and private entities for basic and specific services such as:

- Safety
- Security
- Utilities
- Vessel repair
- Certification of cargo weights and grades
- Tug Assistance
- constructing and maintaining piers, berths and other general navigation features
- storage facilities

The absence of cargo surveyors, a Board of Trade, or Maritime Exchange may affect the ability of a port to attract and service new commodities. Amenities such as housing and recreation are significant for vessel home ports. As the economic analysis continues, these obscure factors may be necessary to describe in the project conditions because it may impede benefit realization.

4.2 Vessel Characteristics

Understanding the port and its vessels are the first steps in understanding deep draft navigation. This includes general characteristics and vessel movements.

General Characteristics

Various types of ships have various characteristics and come in all shapes and sizes. Typical physical inventory characteristics of marine vessels useful to the economist include:

- Type of Vessel: container, general cargo, tankers, etc.
- Build Year and Month
- Length Overall (LOA)
- Beam Width
- Draught or Draft
- Height
- Deadweight: weight of vessel
- Design Deadweight: maximum tonnage a vessel can hold (or transport)
- TPI (Tons per inch) immersion: the amount of tons of cargo related to how much deeper a vessel will draft
- Design Draft of Vessel
- Gross Tonnage: internal vessel capacity
- Speed (at sea and at port)
- Fuel Type and Consumption
- Vessel name (and former name, if applicable)
- Hull number (IMO)

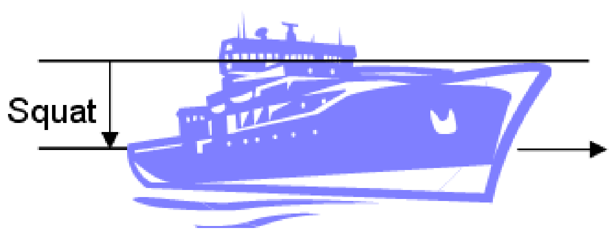
Every vessel has a unique hull number, also known as an IMO number. This enables the classification and registration societies to track a vessel regardless of possible frequent ownership and/or name changes. Likewise, the hull number can be used to track the name changes and avoid vessel identity problems associated with mis-specified names such as “George,” “George IV,” “George 4,” and “Goerge 4.”

Vessel Movements

There are certain patterns and behaviors that the economist should be familiar with and how it impacts the analysis. For example, minimum vessel speeds to maintain steerage are typically 4 knots more than the current. The most commonly observed speeds are 5 to 10 knots (EM 1110-2-1613). The speed is important when evaluating the total cost of transit time later on. Speed is dependent on the vessel's physical capabilities, the environment, and the human response to both.

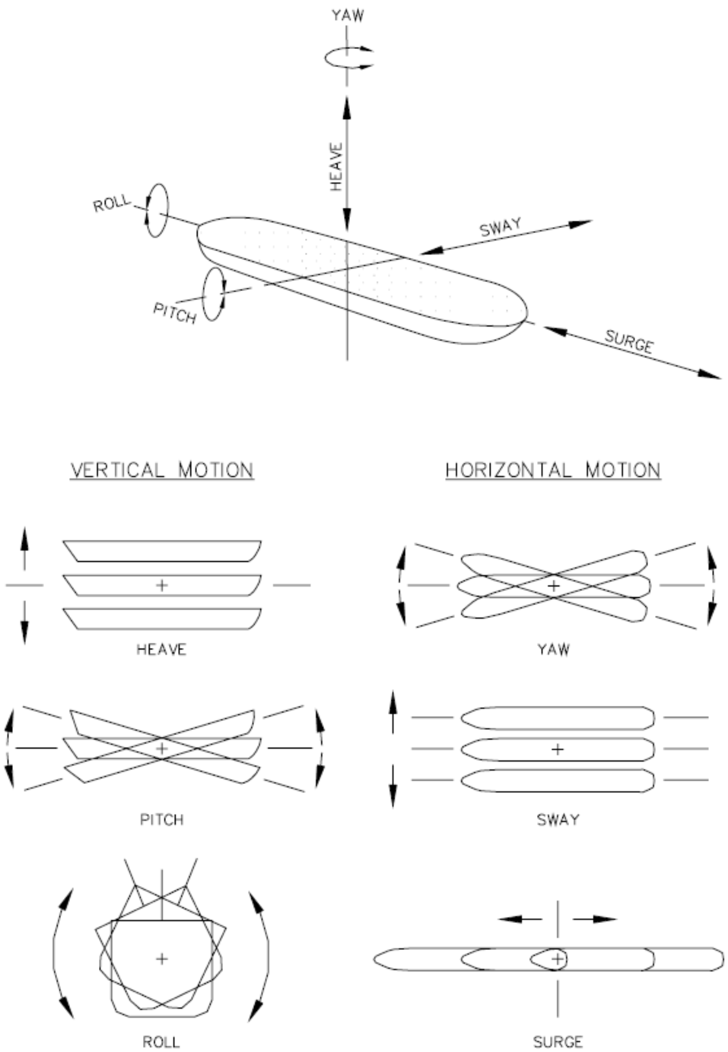
Economists must understand a little about the nature of a ship's movement. This includes knowing about how ships move in water and how they compensate for some of these movements. Figures 4-2 and 4-3 show this general nature. The first figure show how a ship's stern (back of the ship) lowers into the water as the bow (front of the ship) remains higher when a ship is moving. This vertical shift can change depending on the channel dimensions and other considerations.

Figure 4-2: Squat Motion



The next figure shows six different ship movements: yaw, heave, roll, pitch, sway, and surge. Yaw is when the ship spins. Heave is the vertical up and down movement of the entire ship. Roll is the movement in which the ship could flip over upside down and is a rocking from side to side. Pitch is when the ship tilts, such as in a squat. Sway is horizontal movement of the entire boat to starboard and portside without a rocking (right and left). Surge is frontwards and backwards movements without any rocking. Although these movements are discussed independently, it is highly likely that more than one movement can occur at once.

Figure 4-3: Ship Motions



Propellers, bow thrusters, and rudders can help a ship balance, avoid any accidents, and maneuver properly. While most are familiar with propellers and rudders, bow thrusters are propulsion systems on the stern that better steer ships.

Another tool is the use of ballast to trim or balance the vessel. In normal operations, most ships have capabilities to change the load and ballast conditions to provide desirable trim position. A ship in ballast (without any cargo) is loaded by pumping seawater into ballast tanks to provide sufficient draft to submerge the ship propeller and rudder. A small trim by the stern is usually beneficial for improved maneuverability and usually required by local pilots. Ships in motion will tend to change static trim conditions; tankers tend to trim down by the bow and containerships (and other fine-formed ships) trim down by the stern (EM 1110-2-1613).

Vessel Speeds

The published Corps vessel operating costs show "representative" speeds for major ship types. They can be used to simplify cost calculations, even though individual actual speeds may be a few knots faster or slower.

Speeds vary depending on conditions, as a result, sea time and transportation costs will be understated if actual or representative speeds are applied to the most direct port-to-port distances. The simplest solution is to inflate the travel distance by assuming some voyage circuitry.

caution

Average effective speeds of vessels may be as much as 30 percent slower than "representative" because of bad weather and course deviations.

4.3 Types of Deep Draft Vessels

The general trends in ship building have been towards larger vessels due to gains in economic efficiency. Many tankers, other bulk carriers, and containerships are trending towards larger design drafts of over 40 feet (12.2 meters). This means that as of 2006, many of the U.S. ports were unable to accommodate these vessels. On the other hand, most general cargo ships are usually designed for maximum draft of 40 feet, and do not normally play an important role in the design depths of many navigation projects unless the without project condition is less than 40 ft. and the vessels are channel constrained.

Breakbulk Vessel (General Cargo)

Breakbulk vessels are among the world's oldest types of vessels. They carry bulk and odd-sized cargo that is often stored in bags and placed onto pallets. The vessels are compartmentalized with several "holds" for stowing cargo. Cranes on the ship lift the cargo from alongside the ship into and out of the holds. Breakbulk vessels represent a declining share of the world fleet and are used mainly at ports that do not have significant facilities for containers.

Breakbulk Vessel

Bulk Carrier

Bulk carriers, also known as bulkers or bulk freighters, carry bulk commodities such as petroleum, grain, coal, cement, or ore, which are not packaged and transported in cargo holds which are storage containers. Generally bulk carriers require crews to move much of the cargo (vs. cranes or other equipment) which makes these vessels sometimes a bit risky for crewman and time consuming.

There are various types of bulk carriers that range in size from single cargo holds to much larger holding hundreds of thousands of deadweight tons(DWT) of cargo. The names of the vessel sizes from smallest to larges are small, handysize, handymax, panamax, capsize and very large.

There are some variations of bulk carriers that serve different purposes. There are three general types of bulk carriers: 1) Dry Bulk: carries dry goods such as lumber or grain; 2) Liquid Bulk: carries liquid goods like petroleum; 3) Combined: carries both dry and liquid bulk. Some vessels can load and unload themselves with cranes ("geared bulk" vs. "gearless"); some use escalators and conveyor belts ("self dischargers"); some can package good on board while loading ("Bulk In/Bags Out (BIBO)"). The cargo itself can also be risky ranging from abrasive to corrosive to combustible. "Lakers" are predominant bulk carriers on the great lakes are more resistant to corrosion.

Bulk Carrier

Container Vessel (Containership)

Containerships, also known as “box ships" or "box boats” are specifically outfitted to carry containerized cargo, such as cargo stored in aluminum boxes. The containers carry various types of cargo and can be used on semi-trucks chassis, rail cars, or stacked on ships. Containers are typically measured by twenty-foot equivalent units or TEUs, although many boxes are increasingly measured by forty-foot equivalent units (FEUs). Containerships carry the majority of the world's finished goods and have been in existence since the 1950’s. Common goods that Americans are familiar with are tennis shoes, lamps, clothes and other household items that are typically imported, shipped to retail distribution centers, and then to a retail store. Boxes or containers are demanded due to their flexibility in movements and it is stated that a full containership could be loaded/unloaded several times faster than conventional ships of the same size.

Containerships, like most all ships, have had an increasing trend capacity. As of 2009, the Emma Maersk was the largest container ship in the world. According to A.P. Mooler – Maersk Group, this containership can carry up to 11,000 TEUs per voyage, more if it carries some empty containers; it fully loads to nearly 51 feet and the ship is 12 stories high.[4] The ship is about 1,300 feet (397 meters) long and 180 feet wide (56 meters). However, there are also smaller feeder ships that can have less than 400 TEUs. As of 2009, the average containership carries about 5,000 to 6,000 TEUs. Below is a chart of the various containership sizes[5]:

Containership	TEU Capacity
Feeder: able to enter most ports, go between container ports that are not served by larger ships	<500
Feedermax: A fully cellular ship	500 to 1,000
Handy: A fully cellular ship	1,000-2,000
Sub-Panamax: able to enter most ports, go between container ports that are not served by larger ships	2,000 to 3,000
Panamax: ship that has up to the maximum dimensions to fit through the Panama Canal prior to the expansion	3,000 to 5,000
Post-Panamax: ships that are too large to fit through Canal prior to construction expansion; in general, Generation 1 vessels range from 4,500 to 6,600 TEUs and Generation 2 vessels ranges from 6,300 TEUs and upwards; however, the deadweight tons and breadth should be examined as well	4,500 to 12,500
Suez-Max Ultra Large Container Ships (ULCS): largest ships able to transit the Suez Canal	10,000 to 14,000
Post-Suez-Max: cannot fit through Suez Canal as of 2009	<18,000
Post-Malacca-Max: intended to pass through expanded Suez Canal, could only enter Rotterdam and Singapore at 2009 depths	18,000

Table 4-1: Containership Sizes

Containership

Similar to tankers there are lots of specialty containerships such as reefer, refrigerated, open bulk, ore bulk, and more.

[4] *Thompson, Jonathan. "MS Emma Maersk: Santa's Giant Helper Arrives" The Independent (UK) Posted 5 November 2006 <http://www.independent.co.uk/news/uk/this-britain/ms-emma-maersk-santas-giant-helper-arrives-423031.html>*

[5] *Global Security, http://www.globalsecurity.org/military/systems/ship/container-types.htm, , and Maritime Connector, http://www.maritime-connector.com/ContentDetails/69/gcgid/80/lang/English/Container-ship.wshtml, Accessed June 2009*

To learn more, the Container Handbook Website offers other helpful information: http://www.containerhandbuch.de/chb_e/stra/index.html?/chb_e/stra/stra_01_03_01_02.html

Lighter Aboard Ship (LASH)

The lighter aboard ship (LASH) refers to a large carrier vessel that often carries barges (or lighters). The barges first load at an inland or shallow port and then are towed to the LASH ship, which has cranes to lift up the barges efficiently.

Lighter Aboard Ship

Roll-On/Roll-Off (RO/RO) Vessel

Roll-On/Roll-Off [RO/RO] vessels are specifically designed to carry wheeled and tracked vehicles, mostly cars. The vehicles are driven or towed on and off the ship along ramps that are built into each vessel. According to the Journal of Commerce, in 2008 the Port of New York/New Jersey was the busiest vehicle-handling port in the US, followed by the Port of Jacksonville[6].

Roll On/Roll Off Vessel

[6] "Ro/Ro Up at Port of Jacksonville" Posted 9 April 2009 <http://www.breakbulk.com/content/?p=587>

Tankers

Tankers are some of the world's largest propelled ships. A tanker is a ship that is specially designed to carry liquids such as oil, ammonia, or liquefied natural gas. Consequently, these vessels are increasingly being built with safety features such as containing double-hulls (2 skins). As of 2005, the United States Maritime Administration reported 4,024 tankers of 10,000 DWT or greater worldwide; 2,582 of these are double-hulled. [7].

There are two general categories of tankers: crude and product. Crude carriers tend to be larger and carry unrefined products. So-called supertankers, which exceed 200,000 DWT, are employed to transport crude petroleum from the oil fields to refineries. These ships often have some of the deepest drafts when they are carrying products. The largest tanker vessel, Ultra Large Crude Carriers' (ULCCs) drafts can approach 100 feet (30.5 meters) which means that it cannot enter any major world port. Smaller shuttle tankers are also used to transport oil from off-shore to inland; the trend through the 2000s for these vessels is to become large.

Product carriers tend to be smaller, trekking smaller distances, and carrying more petrochemical, such as gasoline, kerosene and lubricating oils. While historically these product vessels were generally less than 30,000 DWT, there is a trend towards making product tankers larger and having more than 25 percent of the fleet being larger than 30,000 DWT. Barges also may be used to carry petrochemicals.

Chemical Tanker

[7] "[World Merchant Fleet 2001–2005](#)". *United States Maritime Administration, Office of Data and Economic Analysis (July 2006) pp: 3, 5, 6.*

Oil Tankers

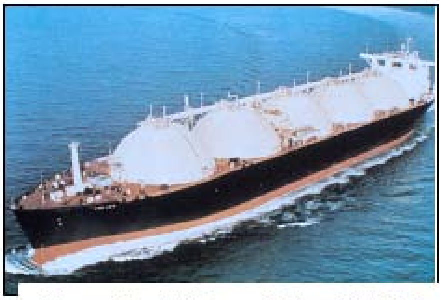
Military and Coast Guard Ships

These ships range from very large aircraft carriers to small craft. Other security forces may also have more recreational type vessels. While the smaller vessels are less important for analysis, the larger ones can definitely impact traffic patterns and constraints.

4.4 Special Carriers/Passenger Vehicles

Liquefied Natural Gas (LNG) Tankers

Liquefied natural gas (LNG) is natural gas that has been cooled to the point that it condenses to a liquid. Liquefaction reduces the volume by approximately 600 times, making it economical to ship. LNG is shipped throughout the world in specially constructed seagoing vessels. Because of safety reasons, LNG terminals are often located furthest from population centers and require a safety zone while transiting. A safety zone is a designated buffer area in which no moving vessel can come within a certain distance.



Liquefied Natural Gas (LNG)

Liquid Petroleum Gas (LPG)

Cruise Ships

In response to the growing cruise industry, cruise vessels have been increasing in size and providing more on-board amenities such as rock climbing, gyms, casinos and huge theaters. Some of the 2007 vessels, such as the Royal Caribbean International Genesis Class, weigh 220,000 tons, have a beam in excess of 154 feet, a length of nearly 1,200 feet, and can accommodate 5,400 or more passengers.

Cruise Ships

Cruise Ships

Dredges

While the onboard instrumentation of modern dredges is computer-assisted, the basic excavation methods of dredges have remained the same since the late 1800s. The three main types of dredges are mechanical dredges, hydraulic dredges and airlift dredges. The type and size of the dredging vessel varies based on the amount of sediment to be dredged, the types of excavated material, and distance to disposal site.

Dredging is an excavation operation usually carried out in shallow seas or fresh water areas with the purpose of gathering up bottom sediments and disposing of it at a different location, mostly to keep waterways navigable. After the initial excavation needed to establish a channel, dredging must be done periodically to keep it clear and safe for navigation. This is called maintenance dredging. Once sediments are dredged from the waterway, it is called dredged material.[8]

More information on dredging is found in Appendix F.

Tug Boats

Tug boats operate in various ports to assist ships while maneuvering in port. Very large container ships will often use tug boats to assist in turns and berthing. Cruise ships typically have bow thrusters which allows for better maneuvering and less need for tug assistance. Tugs have an hourly operating cost which should be a consideration in alternatives that may reduce the amount of tugs needed.

Special Purpose Fleets

Special purpose fleets exist when there are particular port or cargo circumstances that result in vessels that are uniquely designed for that trade and generally have little or no other efficient deployment (e.g. wood chip vessels).

Special purpose vessels usually have draft, beam, or other physical characteristics that are distinctively different from conventional marine vessels that make them particularly suitable for the local port and trade, but usually unsuitable for other deployments.

Special purpose fleets typically have higher capital (new building) costs and higher operating costs, particularly if the ships have unique equipment for cargo handling and stowage. These vessels will often have longer service lives as a result of being more capital intensive from an investment perspective (e.g. self-unloading bulk vessels such as cement carriers).

Special purpose fleets may be deployed as a substitute for other structural conditions at the local harbor or the trade route due to certain circumstances such as draft constraints. Special purpose vessels, once built, typically have little or no other efficient use. Consequently, where these vessels exist it must have been determined that they were the most efficient alternative to deployment of conventional vessels.

[8] *USACE Education: Navigation: http://education.usace.army.mil/navigation/lessons/6/dredgels6lv2.html, Accessed July 2009*

Lloyd's Register Vessel Categories (2004)[9]**:**

Ultra Large Crude Carriers (ULCCs): 300,000 – 550,000 DWT. Used for carrying crude oil on long haul routes from the Arabian Gulf to Europe, America and the Far East, via the Cape of Good Hope normally discharging at custom built terminals.

Very Large Crude Carriers (VLCCs): 200,000 – 299,999 DWT. On similar routes to ULCCs but with greater flexibility in discharging port options owing to their smaller size, and for this reason also employed ex-Mediterranean, West African and even North Sea Terminals. They can be ballasted through the Suez Canal.

Suezmax: Before its closure in 1967 the Suez Canal could only cope with 80,000 tonne deadweight tankers, though larger vessels could go through in ballast, and the maximum draft available was 37 feet. An enlargement to enable the canal to take 200,000 ton tankers was proposed.

Capesize: 100 – 180,000 tonnes deadweight, draft approximately 17 meters. To govern the design of large ships built to serve deepwater terminals handling raw materials, such as iron ore, from Brazil. Too big for the Panama or Suez canals, Capesize vessels voyage via Cape Horn or the Cape of Good Hope.

Malaccamax The maximum hull form using the maximum draft permissible to pass through the Strait of Malacca, Malaysia

Panamax: 65,000 to 80,000 DWT The largest acceptable size in order to transit the Panama Canal. Ships' lengths are restricted to 275 meters, and maximum permitted width is slightly more than 32 meters. Cargo intake is usually restricted to approximately 52,500 tonnes on the Panama Canal Draft.

Aframax: A tanker of maximum 79,999 tonnes deadweight, or the largest tanker size in the Average Freight Assessment Scale

Handysize Bulkers: 35,000-50,000 DWT. This allows for each category to increase in size and some now consider the larger size in this range as the Handymax

Minibulkers: Less than 10,000 DWT. Mainly employed in the coastal and short sea trade.

[9] *<www.lr.org/Publications/Info+30+Ship+sizes.htm>*

4.5 Key Concepts

This chapter covered the basics of deep draft vessels and how they operate:

- Hinterlands are inland trade regions served by a port. Cargo hinterlands are broken down by specific commodity traffic. Port hinterlands can broadly be described as captive or competitive.
- Most ports have the same general features and support services such as channels, anchorages, basins, vessel repair, tugs, etc.
- Each vessel has its own unique characteristics and vary in year built, length overall, beam width, draft, weight, capacity, and more. The standard vessel movements are squat, yaw, heave, pitch, roll, surge, and sway.
- Standard types of deep draft vessels are breakbulk, bulk carrier, containerships, lighter abroad, RO/RO, tankers, military, and special carriers and passenger vessels.
- The Lloyd’s Register has several vessel categories that are dependent on deadweight tons and they range from Minibulkers to Ultra Large Crude Carriers (ULCCs).

Savannah Harbor

CHAPTER 5 – PORT AND VESSEL OPERATIONS

5.0 Overview

The economist needs to develop an independent understanding of the port system, how vessels interact, and trends relating to navigation issues.

This chapter will discuss how vessels move in port, non-structural measures that ports currently or potentially could take to manage cargo, and the trade routes for various services. This is important to the economist because many of these operations will be described and modeled in the economic analysis. The subtle differences in operations can change the large analysis of transportation costs and determining the NED plan later on.

This chapter also describes in more detail some of the common cross continent trade routes such as the Panama and Suez Canals. It also discusses some of the constraints in these canals and navigation in general. Risk-taking behavior as related to underkeel clearance restrictions is also discussed.

5.1 Movement in Ports

This section describes some of the basic vessel operations in ports. These operations could also be considered non-structural alternatives. These non-structural alternatives may describe the existing condition at various ports, but they may also help describe the existing constraints and problems while presenting opportunities.

Typical Ship Entrance and Exit Protocol

When a ship wants to enter a port, the ship at sea will give notice to the local port authority and pilot group several days before approaching the port entrance. Upon arrival at the entrance, the ship will be met while underway or at anchor by one or more locally licensed pilots who provide the navigation service of guiding the ship safely to the proper berth or terminal. The boat meeting and pilot transfer to the ship take place at a designated anchorage area located near the ocean at the end of the entrance channel marked by a sea buoy. Local tug services are also usually contacted and plans finalized for the ship transit. Many tug companies also provide a tug pilot who will also board the ship to help guide the ship during the final phase of the transit and the actual docking and mooring at the ship berth. At some ports, the local pilot also acts as the tug docking pilot.

While every port is different, this is the most common method of a ship entering port. A local shipping agent or firm is usually also involved as the commercial chartering. They are an entity acting in the business transaction between the cargo shipping entity, the ship owners offering transportation services, and the destination company ordering or requesting the commodity.

The outbound ship transit from the berth back to the open sea where control is transferred from the local pilot to the master is much the same as the inbound transit, except in reverse sequence.

Underkeel Clearance Practices

Underkeel clearance is measured by the vertical difference between the lowest protruding section of the hull, sometimes referred to as "scantling draft," [10] and the minimum actual channel depth (including advance maintenance dredging). It cannot include vessel hull measurements above the waterline, but must be estimated from the vessel characteristics, sailing draft and trim, and channel dredging conditions relative to authorized depth and actual depth. Note: authorized depth and actual depth may vary over the dredging maintenance cycle.

It should be assumed that whatever underkeel clearance is in use presently will be in use with a deepened channel. Without- and with-project margin for clearance should be the same unless differential conditions under with-project conditions logically allow otherwise. Reduced underkeel clearance is often classified as a vessel operation alternative, but it really is not.

Underkeel clearances can be imposed by harbor and port authorities, Bar Pilots, or the Coast Guard as a safety measure, but they are not "hard rules." However, some vessels may still sail at less than the imposed amount, especially if the underkeel clearance is greater than two feet. Increasingly, as vessels are being designed with electronic navigation aids, the degree of clearance required could be potentially reduced. The Columbia River's LoadMax system is a good example of implementing an underkeel clearance monitoring systems to potentially reduce clearances. LoadMax makes real-time and predicted water depth information available to vessel operators, allowing them to make optimal use of the water level at any given time and plan movements with greater precision.

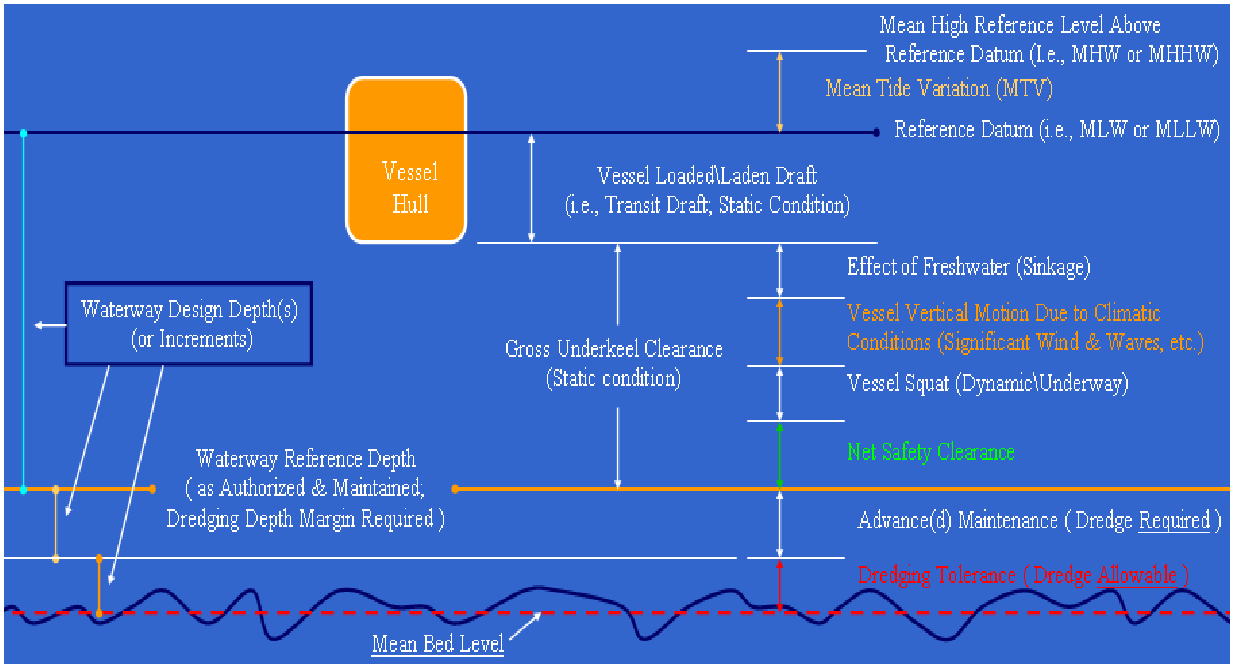
For non-hazardous cargoes, underkeel clearance historically has been regarded as a proprietary matter of the vessel owner's willingness to accept risk of damages from a "bottom incident." More recently, sensitivity to environmental concerns has led to imposition of underkeel clearance guidelines by harbor and port authorities.

The decision to use insufficient underkeel clearance is often a matter of risk tolerance; risk tolerance is the extent to which pilots accept risks from how they choose to operative their vessel. Risk-averse pilots will likely have more underkeel clearance than those less risk averse and willing to accept more risk. Some vessel lines will have statements of minimum underkeel clearances (usually around one meter, ranging from two to four feet). These are usually related to marine insurance coverage. Typically more underkeel clearance is preferred to less, from a risk aversion perspective. Risk tolerance is also dependent on whether the bottom conditions are silt or rock. However, increasingly, vessels are designed with electronic navigation aids, which potentially reduce the degree of clearance required.

It is essential to identify actual vessel operating practices and the alternatives employed to minimize intrusion into the safety zone (tides, speed, trim). To the extent those alternatives permit use of larger or deeper vessels than implied by Corps design criteria, the alternatives are to be reflected in without- and with-project conditions. **Policy recognized the common practice of vessels utilizing tide in their operations**

[10] *Scantling draft is the maximum draft at which a vessel complies with the governing strength requirements. Usually used when the scantling draft is less than the geometrical draft corresponding to the freeboard calculated according to the Load Line Convention*

Figure 5-1: Vessel Underkeel Clearance(s) and General Waterways Description



Berth and Port Depth Movement Indicators

The water depths at berths used by vessels that may benefit from the project are as important as channel geometry. Analysis of berth water depths include:

- Berths deeper than the channel depth are a good indication of use of tides (and channel potentially showing deepening benefits)
- Berth depths a foot or two shallower than the adjacent channel are common because the extra underkeel clearance is unnecessary because the ships are not in motion. When the ship is in motion, squat lowers the stern vertically into the water further and there is also roll that requires more underkeel clearance for safety.
- Berths shallower than a foot or two need to be explained, particularly if there have been previous deepenings. This could indicate that structural berth changes could be expensive structural changes to the berths.

5.2 Port Facilities

It is important to define not only statistical data, but current facility conditions, practices, and how they relate to the statistical data found in the previous chapter. Port facilities and physical conditions should be described. Port facilities may not be in the most advantageous location with respect to the harbor's channels. The physical location of the facilities can be a clue that institutional or other constraints limit the utilization of channels.

The existing conditions are also the baseline for projecting future with- and without-project and for comparison in the NED analysis. The objective of without-project investigations is to determine whether port facilities can accommodate without-project projected port traffic (and later on with-project projected port traffic). A natural extension of this effort is to identify new facilities that may optimize the harbor improvements or otherwise affect the need for or scale of the project. This will help identify the problems and opportunities. It may also predict the actions that the port would take if no Federal action was taken.

Port Capacity

The actual capacity of a facility or channel will be more or less than its design capacity depending on the demands of port commerce and the operating conditions acceptable to the individuals involved. Although the same or similar safety and environmental regulations apply at all U.S. ports, there are port to port variations in practices that tend to persist over time because of local labor agreements or, in the case of ship pilots, state licensing and supervision.

Port facility information should be summarized in the study report. Because the rate of cargo transfer between ship and shore seldom constrains capacity, storage capacity is used as the basic determinant of berth capacity. Both berth size and storage area (or quantities) should be readily available for both existing and proposed facilities. Table 5-1 shows a rough estimate of annual capacity and turnover for a given port. This also serves as an example of the type of information needed in the economic analysis.

Table 5-1: Approximate Annual Capacity of Cargo Berths[11]

Type Cargo	Approximate Berth Size	Storage Capacity (Area or Quantity)	Annual Capacity
Break Bulk	500’	2 acres bldg + 2 open	90,000 tons
Container	850’	5-20 acres open	90,000 FEU
Tanker	850’	500,000 bbl. = 10+ acres	Tank cap x 12(1)
Coal	850’	Direct, ex-rail	1-2 ships/wk (1)
Coal	850’	Stacker/reclaimer=20+ acres	Storage cap x 12(1)
Grain	750’	2-5,000,000 br = 15 acres	Silo cap x 24(1)
Ores & Minerals	750’	Direct to/from rail cars	1 ship/wk (1)
Ores & Minerals	750’	via shipside stockpile	6 ship/yr (1)
Ores & Minerals	750’	via stacker/reclaimer	Stockpile x 6(1)

(1) Turnover rate varies with trade. Local inquiry will be needed.

Terminal capacity is, at best, an estimate. Individual estimates may be biased for competitive reasons. Therefore, it is advisable to supplement terminal operator interviews with comparative estimates based on the criteria of an independent authority. The approximate annual throughput of cargo at any or all facilities may be obtained by inquiry. For relevant commodities, it will be necessary to account for actual quantities through specific terminals in order to have an accurate basis for computing benefits.

[11] *Adapted from the Maritime Administration Handbook*

For new facilities that may be required to handle “new” commodity movements, specific information available in port development or facility feasibility studies should include facility location, size and cost.

Port-Specific Variation in Facility Utilization

Each port operates differently and these local differences can have a significant effect on cargo handling costs as well as port capacity. Factors to describe and consider are listed below; however, these could also pose navigation constraints.

- Noise regulations
- Emission regulations
- Land transportation services working hours
- Operating personnel working hours
- Ability to work around clock
- Ability to work during rain or inclement weather
- Size of work crews (usually are negotiated at local level, even for national or regional labor contracts)

Port-Specific Variation in Channel Utilization

Port-specific variation in channel utilization is more prevalent for many reasons, including geography and climate. Vessel operation practices have a great impact on project economics. They play a big part in vessel operation (and hence transportation) costs.

Practices vary widely because navigation safety depends on individual judgments. The marine environment requires some acceptance of risk in vessel operations. The amount of risk acceptance at any one port is effectively determined by ship pilots, since there is no law or regulation that defines vessel safety as such or minimum safe clearances. The actual amount of risk-taking in a port is likely to be less than that implied by Corps channel design criteria because various expedients or alternatives are employed to avoid or reduce risk.

Certain vessel operation practices, such as underkeel clearance and traffic control policies, are likely to be practiced in the future in both without- and with-project conditions. For example, one-way traffic can impose significant delay costs on vessels, which for some (small) vessels.

Unlike facility alternatives, which may or may not be disposed of as part of the without- or with-project conditions, vessel operating alternatives are part of the without- and with-project conditions. They will be treated more fully Part II:

- Underkeel Clearance
- Use of Tides
- Reduced Speeds
- Reduced Trim
- Ballast and Bunkering
- Alternate Vessel Itinerary

5.3 Non-Structural Measures

Several non-structural measures may be taken at various ports to solve problems without high costs structures. Some of these measures may be under the without-project conditions, others may also be considered for non-structural with-project conditions. Some common measures and behaviors include tide riding, light loading, and lightering, but are not limited to only what this manual mentions. Part II of the manual also has a further elaboration on non-structural measures.

Tide Riding Behavior

Tide riding is using tides to move vessels through water which would normally be either not deep enough or too deep. It can also include using tides for control, such as on deep draft rivers when pilots go against the tide. Pilots are a good source of information on tide riding. However, the majority of tide riding occurs in coastal ports where vessel operators can take advantage of the following two situations:

- **High Tide Riding Behavior** is the use of tides to move vessels through water which is normally not deep enough to allow passage.
- **Low Tide Riding Behavior** may apply to the use of tides to move vessels under bridges when the air draft is very high.

Riding the tide is only applicable to ports near enough to the sea that vessels can actually ride the tide in or out.

The need to use of tides can cause vessel delay costs, can involve shoreside terminal delay costs and may involve costs related to vessel and terminal scheduling. The tide riding practice is likely to exist in the without- and with-project condition; however, it is still important to consider the potential marginal impacts under various scenarios. Any fleet changes and the fleet's likely behavior should be considered. Models, such as HarborSym (www.nets.iwr.usace.army.mil/HarborSym), can account for any differences. Pilots often can be the best source of information for describing this practice.

Later on in the analysis relevant information that may be needed to determine vessel tide delay costs include the normal starting and working times, premium pay and non-working times.

Tide riding can increase a vessels' risk in safely transiting. The vessel operator has a smaller margin for error when the vessel requires the tide to be higher or lower. An error related to depth could mean scraping the vessel bottom and potentially causing environmental damage among other things. An error in regards to air draft could mean ramming into the bottom of a bridge. Both outcomes can have serious consequences.

High Tide Riding Behavior

Whenever there is a predictable water depth greater than the official controlling project depth, it is likely to be used by the deepest draft vessels. Draft constrained vessels can exercise the option to wait for favorable tides and sail with the prevailing underkeel clearance using tidal variations.

The use of tides to address sailing draft constraints is a common practice by pilots and captains. This is true particularly for bulk shipping and tankers, and sometimes for container vessels not otherwise schedule-constrained to sail without the tide. High tide riding behavior is revealed as vessel sailing drafts that are greater than the authorized channel depth less prevailing underkeel clearances.

> *Solving the tide mystery. . .*
> *Sea Harbor has an authorized channel depth of 42 feet with a four-foot underkeel clearance as required by the pilots. However, vessels are entering Sea Harbor with sailing draft greater than 38 feet. There are several possible conclusions to this mystery:*
> *a) Pilots are not respecting the four-foot underkeel clearance*
> *b) The data is incorrect*
> *c) Vessels are using high tide to enter*
>
> *While a and b are possible, c is likely the reason for having drafts of greater than the authorized draft.*

A common assumption is that channel deepening will eliminate high tide riding. And, in fact, usually deepening will eliminate high tide riding for vessels that are no longer sailing draft constrained. However, some vessels will continue to be sailing draft constrained in with-project conditions and will continue to ride high tides, although perhaps with more cargo.

Low Tide Riding Behavior

Low tide riding behavior is associated with air draft constraints. There is often little explicit consideration of air draft constraints from such things as bridges and nearby FAA airspace because typically they lie outside the Corps plan formulation. However, the economist needs to recognize the possibility that air draft constraints and low tide riding may affect a class of vessels that can benefit from a deeper channel.

The benefits of deepening when air draft constraints exist are that the vessel can carry more cargo and maintain the same air draft safety margin and/or avoid tidal delays.

Light Loading

Light loading from a NED perspective exists when the vessel is carrying less cargo tons than maximum capacity because of sailing draft constraints or because there is not enough cargo or heavy cargo to weigh it down. The economist must determine that the observed light loading is actually the result of without-project conditions at the port rather than constraints at other ports, shipment size, cargo volume or density fluctuations.

For the light loaded fleet, the economist must determine how much more cargo (in DWT) would be handled under with-project conditions. Generally, the additional cargo that can be carried will be less than the total deadweight capacity of the vessel and governed by the immersion factor. The immersion factor is the change in draft for each weight carried; it is usually measure in tons per inch.

Fully loaded bulk vessels that are not draft constrained will commonly sail with a percentage of DWT capacity related to cargo (the rest is fuel, water, supplies, etc.). This percentage depends on vessel size and is typically as shown in the table below. The table provides a generic load capacity.

Table 5-2: Percentage of Capacity Loaded

Size of Vessel	Percentage Capacity Loaded
< 20,000 DWT	90%
20,000 - 70,000 DWT	92%
70,000 – 120,000 DWT	95%
>120,000 DWT	97%

Container and general cargo vessels will normally be less than fully loaded in terms of DWT because of cargo density characteristics. Containerships also have a maximum box capacity. Loading will depend on cargo weight, transport of any empty boxes, ship balance, schedules, demand, and many other factors. The DWT of some vessels may be less utilized (as in the case of PPC and wood chip vessels). Particular trades may have lower DWT percentages of fully loaded vessel space when the cargo densities are low and deck stowage is limited. For some general cargo trades ballast may be substantial, affecting the observed sailing drafts, which will not correlate well with the cargo tonnes for otherwise "fully loaded" vessels.

Bulk vessels can normally be assumed to be light loaded for the port deployment before or after the port if the sailing draft is observed to be less than the design draft under unconstrained depth conditions.

Lightering

Some bulk vessels will lighter cargo (or "top off") before or after calling the subject port in without-project conditions. Lightering allows ships that are loaded too deeply to come to berth partially unloaded onto smaller vessels.

Lightering typically takes places in a dedicated, deepwater anchorage in a sheltered location. The vessel being offloaded can be anchored or drifting while another vessel pulls alongside and moors to the other vessel. This other vessel accepts the offloaded cargo. Once the cargo is offloaded, the original vessel is now drafting shallower to enter the port safely which could take up to 24 hours to complete multiple lifts. Some examples of inshore lightering areas are Delaware Bay, San Francisco Bay, and Long Island Sound. The majority of offshore lightering occurs in the Gulf of Mexico, but it also occurs near Long Island nearby New Jersey, San Diego in California, the capes of Virginia and the Bahamas. This practice also sometimes occurs in Caribbean ports where a mother ship exists and sends smaller vessels into various nearby ports.[12]

This tends to raise the unit transportation cost, but sometimes may also be considered as a non-structural alternative if it isn't in the without-project conditions. The economist should conclusively determine that topping off or lightering is not a regular practice for a portion of the fleet.

[12] *National Research Council (NRC), Oil Spills From Tank Vessel Lightering, 1998*

5.4 Vessel Routes and Call Patterns

Ships calling regularly at a port usually follow specific trade routes and patterns. The trade routes will be a function of the commodity(ies) carried by the ship and the inland commodity hinterlands (the geographic areas where port commerce originates and terminates). The Panama and Suez Canals are two important considerations in most U.S. foreign trade. Below is a sample itinerary for a ship named “World Rising.”

Table 5-3: Sample Vessel Itinerary

INBOUND PORT	“WORLD RISING”	OUTBOUND PORT	“WORLD RISING”
Xiamen	18-Nov	Oakland	8-Dec
Yantian	19-Nov	Long Beach	10-Dec
Hong Kong	20-Nov	Kaohsiung	23-Dec
Kaohsiung	22-Nov	Hong Kong	25-Dec
Long Beach	5-Dec	Xiamen	27-Dec
Oakland	7-Dec		

Typically, the least cost routes to various destinations are the prevailing routes for commodities. For example, Table 5-4 shows the cost per ton of transporting widgets to various inland hinterlands using different routes and widget shippers. This shows that the Shipper C using the Suez Route is the lowest cost for nearly all cities. Shipper A is not the least cost shipper for any destination city. Shipper B would likely ship to Arch’s Landing and Johnson City because it has the lowest transportation costs.

Table 5-4: Widget Transportation Cost Per Ton From Overseas to Hinterlands

	Shipper A: Panama Route	Shipper B: European Route	Shipper C: Suez Route
Jazz City	$86.74	$88.04	$81.72
Crawfish County	$66.55	$67.86	$61.54
Country Town	$43.52	$46.04	$42.37
Arch's Landing	$39.74	$22.61	$31.84
Southern City	$40.29	$45.15	$32.39
Metropolis	$39.74	$44.61	$31.84
Springfield	$84.71	$90.24	$84.31
Johnson City	$40.29	$28.15	$32.39

Be sure to separate landside and water costs in the analysis

Table 5-5 below shows trade route distances that include an allowance for circuitry.

Table 5-5: Trade Route Round Trip Distances[13]

Trade Route (U.S. Coast-Foreign Range)	Bulk and Tanker Distances	Liner and Neobulk Distances
Atlantic - Australia & New Zealand	19,500	26,500
Atlantic - Caribbean	3,500	5,000
Atlantic - East Coast South America	9,000	13,500
Atlantic - Far East	19,000	27,000
Atlantic - India to Red Sea	23,500	29,500
Atlantic - South & East Africa	15,000	20,000
Atlantic - Southeast Asia	20,500	28,000
Atlantic - West Africa	10,000	14,000
Atlantic - West Coast Central America	4,500	6,000
Atlantic - West Coast South America	6,500	9,000
Gulf - Australia New Zealand	18,500	25,500
Gulf - Caribbean	3,500	4,500
Gulf - East Coast South America	10,500	14,500
Gulf - Far East	21,000	26,500
Gulf - India to Red Sea	24,694	33,500
Gulf - Mediterranean	11,500	15,500
Gulf - North Europe	10,000	12,000
Gulf - South & East Africa	16,000	28,500
Gulf - South East Asia	23,000	31,000
Gulf - West Coast Central America	2,500	3,500
Gulf - West Coast South America	5,500	10,500
Intercoastal Pacific - Atlantic	11,500	15,500
Intercoastal Pacific - Gulf	11,000	15,000
Lake - Mediterranean	11,500	15,500
Lakes - Far East	26,000	35,000
Lakes - North Europe	7,500	10,500
North Atlantic - Mediterranean	9,000	12,000
North Atlantic - North Europe	7,000	8,000
Pacific - Australia & New Zealand	14,500	19,500
Pacific - Caribbean	8,000	10,500
Pacific - East Coast South America	1,550	17,000
Pacific - Far East	11,500	16,500
Pacific - India to Red Sea	21,500	29,000
Pacific - Mediterranean	21,500	29,000
Pacific - North Europe	17,500	24,000
Pacific - South & East Africa	21,000	28,500
Pacific - Southeast Asia	14,000	19,000
Pacific - West Africa	16,500	22,000
Pacific - West Coast Central America	9,500	13,000
South Atlantic - Mediterranean	9,000	12,000

[13] *Merchant Fleet Forecast of Vessel in U.S. – Foreign Trade, by Temple, Barker and Sloane, Inc. U.S. Department o Commerce, Maritime Administration, Washington, EC, May 1978*

Panama and Suez Canals

The Panama Canal and Suez Canal are key transit points to reach various U.S. markets for selected international trade routes, and conversely to reach overseas markets from designated U.S. ports. The Panama Canal is actually a network of artificial channels and locks that connects various lakes. The three existing locks are Gatun, Miraflores, and Pedro Miguel. The multimedia link on the Panama Canal Authority website has live cameras at these points to actual view the canal. However, the new canal expansion will bypass these existing locks and replace them with two new locks. The expansion is scheduled to open in 2014. More information can be found in the Panama Canal Authority website, but it is also discussed further below under “Navigation Constraints” (Section 5.5)

The Suez Canal, owned by the Suez Canal Authority, is located in Egypt and serves as a major worldwide transit point that connects Europe and Asia without going around Africa.

These canals are the main travel path for certain vessels and commodities. For example, many container ships carry consumer goods between China and the Eastern U.S. Coast via the Panama Canal. This is known as the main type of trans-Pacific Panama Canal service. The Suez Canal on the other hand transports a large number of tankers carrying oil.

Liner and Charter Service

The shipping industry is a private and highly competitive industry. Trillions of dollars worth of goods are traded throughout the world each year .According to the World Trade Organization, the dollar value of world merchandise exports had been $11.76 trillion in 2006[14].

The activity of the industry is divided into several categories, namely, liner service and tramp/charter shipping.

Generally, there are two patterns of commercial vessel services other than home port domiciled services for such things as cruise lines and fishing vessels.[15]

- **Liner Patterns**

  Liner service involves regularly scheduled shipping operations on fixed routes. Cargoes are accepted under a contract between the ship operator and the shipper. Competition in liner service is regulated generally by agreements among the ship owners.

- **Tramp/Charter Patterns**

  Charter vessels typically call on demand (sometimes referred to as “random”) as opposed to scheduled without fixed routes. Although charter vessels are “scheduled” from a contractual perspective, the vessels (and sometimes the schedule) usually do not repeat at regular fixed time intervals. Consequently, the same vessel (identified by name) will usually not be seen regularly calling at fixed intervals.

[14] *“Risks lie ahead following stronger trade in 2006” WTO Press Release 2007 <http://www.wto.org/english/news_e/pres07_e/pr472_e.htm>*

[15] *Home port domiciled fleets are vessels that call primarily at the study port such as fishing fleet vessels or short cruise deployments.*

For vessels under long-time charter or given a particular trade and sufficient time period, the same vessel name may appear under multiple charters over time.[16] These ships are typically smaller and can be subject to freight rate swings from crop demands, or foreign political upheavals.

Liner Service

Competition in liner service is regulated generally by agreements (known as conferences) among vessel owners. These conferences stabilize conditions of competition and set passenger fares or freight rates for all members of the conferences. In the U.S., steamship conferences are supervised by the Federal Maritime Commission in accordance with the Shipping Act of 1916. Rate changes, modifications of agreements and other joint activities must be approved by the commission before they are effective. Measures designed to eliminate or prevent competition are prohibited by law.

Some vessel fleets under long-term charter will display quasi-liner services with respect to calling at the same port or ports, sometimes with the same or similar frequencies. Trades such as vehicle carriers (Pure Car Carriers), chemicals and refined petroleum products will display these patterns for chartered foreign flag (registry) vessels. The U.S. domestic cabotage (Jones Act) trade will also reflect a small fleet of U.S. flag vessels making relatively regular port calls such as domestic movements of petroleum products. Schedules for each vessel for each port can sometimes be distinguished through analyzing the vessel call list.

Tramp/Charter Shipping Service

Tramps, known also as general-service ships, maintain neither regular routes nor regular service. Usually tramps carry shipload lots of the same commodity for a single shipper. Such cargoes generally consist of bulk raw or low-value material (such as grain, ore, or coal) for which inexpensive transportation is required. About 30 percent of U.S. foreign commerce is carried in tramps.

Freight rates fluctuate according to supply and demand. When aggregate cargo quantity is less than ship capacity, rates are low. Charter rates are also affected by other circumstances, such as crop failures and political crises. Charter parties are of three kinds:

- **Voyage Charter** (most common) – provides transport for a single voyage and designated cargo between two ports in consideration of an agreed fee. The charterer typically provides all loading and discharging berths and port agents to handle the ship and the ship owner is responsible for providing the crew, operating the ship and assuming all costs in connection with the voyage.

- **Time Charter** – provides for lease of the ship and crew for an agreed period of time. The time charter does not specify the cargo to be carried but places the ship at the disposal of the charterer, who must assume the cost of fuel and port fees.

- **Bareboat Charter** – provides for the lease of the ship to a charterer who has the operating organization for complete management of the ship.

---

[16] *Bulk sector vessels may be sold (traded) frequently during the life of the vessel, often with a name change.. Consequently, the same vessels may be calling in particular bulk sector trades (although with different names). Most of the vessel databases trace former names using the same unique hull number, so the identity of vessels can be tracked even while the names that appear on pilots' logs, etc., are different.*

> The bareboat charter transfers the ship, in all but legal title, to the charterer, who provides the crew and becomes responsible for all aspects of its operation.

The leading tramp-owning and tramp-operating nations of the world are Norway, Great Britain, the Netherlands and Greece. The carrying capacity of a typical, modern, well-designed tramp ship is about 12,000 DWT and its speed is about 15 knots. The recent trend is toward tramps of 30,000 DWT, without much increase in speed.

Industrial Carriers

Industrial carriers are vessels operated by large corporations to provide transportation essential to the processes of manufacturing and distribution. These vessels are run to ports and on schedules determined by the specific needs of the owners. The ships may be corporate owned or may be chartered.

For example, the B&B Steel Corp. maintains a fleet of Great Lakes ore carriers, a number of specialized ships that haul ore from South America to a northeastern port, and a fleet of dry-cargo ships that transports steel products from the same northeaster port to the Pacific coast. Also, many oil companies maintain large fleets of deep-sea tankers, towboats, and river barges to carry petroleum to and from refineries.

Tanker Operation

All tankers are private or contract carriers. In general, many tankers do not have bow thrusters making them dependent on tug boats when maneuvering in port. However, shuttle tankers do have bow thrusters; these vessels transport oil from off-shore oil fields and thus require enhanced maneuverability.

The largest tanker vessel, Ultra Large Crude Carriers (ULCCs), will most often be used for dedicated service routes such as from the Persian Gulf, around the Cape of Good Hope, and to offshore ports in Europe. Therefore, some type of lightering or offshore activity accompanies these vessels. Given the location of the oil reserves in the Middle East, the Suez Canal is an important pathway.

Cruise Ships

More than 9.7 million passengers traveled on 4,463 cruises during 2005 (AAPA). In response to the growing cruise industry, cruise vessels have been increasing in size and providing more on-board amenities. Large cruise ships also often require high air clearance, which can be challenges at times to go under bridges and may be restricted in certain ports that have an airport nearby with designated flight space. These ships also typically have bow thrusters and therefore can maneuver more easily without dependence on tug boats. Often these ships have port priority and may cause other ships to be delayed.

This document has some important considerations for analyzing cruise ships. However, **this section will be expanded in the future to further refine methods for cruise ship analysis** and incorporating vessel operating costs in Appendix D.

> caution
>
> *Waterborne commerce refers to commercial navigation activities. In 1932 Congress expanded the definition of "waterborne commerce" to include recreation activities. Cruise ships are not considered recreation; instead, they are considered to be commercial per Section 230 of WRDA 1996. Most deep draft navigation projects will not have non-commercial recreation. However, if recreation is impacted, please consult with senior economists for further assistance. These could be considered incidental benefits; therefore special benefit calculation policies apply which are different from standard practices. Additionally, for the evaluation of recreation benefits, see specific guidance in companion manuals in this IWR series IWR 86-R-4 and IWR 86-R-5.*

Military and Coast Guard Ships

Certain ports have military and Coast Guard traffic and berths. These vessels serve national security and public safety purposes and therefore may have additional requirements and needs. Military vessels can also be very large and have additional channel requirements for maneuvering, such as aircraft carrier accessibility. It is important to understand if the military, Coast Guard or another security agency uses the port and how they interact with the ongoing port traffic and physical constraints. Their movements can range from daily to once-a-year use of the harbor and should be examined further.

> *"Consultations should be conducted with the local Coast Guard. . .Their views on navigation channel and bridge safety, ship maneuverability, navigation traffic management, navigation operational restrictions, and optimum placement of aids to navigation should be incorporated into the design and presented in appropriate reports and design memoranda."* (EM 110-2-1613)

5.5 Navigation Constraints

There are several types of constraints that impact port and vessel operations. These constraints need to be considered in describing and modeling any without- or with-project conditions. Some constraints may also be opportunities for improvement under the with-project alternatives and some are external factors out of the team's hands to manage.

Beam Constraints

Beam is the width of the ship at its maximum width. Beam constraints related to channel width exist when two vessels cannot safely pass in the channel as an ordinary operation (excluding weather-related events, such as fog and high winds).

Most pilots will require channel width to be four times the vessel width, allowing for two times the vessel width for beam clearance between passing vessels to allow for ample clearance between each vessel and the channel lane. ER 1110-2-1613 details the Corps engineering guidance on this and other aspects. However, every port is different and this constraint should be discussed and researched in the pilot's handbooks and through port and pilot discussions.

Beam constraints are particularly important when larger beam vessels are projected as part of the with-project vessel fleet forecast. To the extent that beam operational conflicts exist that are not addressed with the plan formulation, the affected vessels will experience delays as a result of one-way channel movements.

Beam conflicts and resulting delays can be simulated by a queuing model that looks at the probability that vessels will arrive at or near the same time and thus be delayed. The HarborSym Model (www.nets.iwr.usace.army.mil/HarborSym/) from IWR can help model this feature. Some port and vessel scheduling can avoid these passes, so it is important to discuss these scenarios with the port and pilots.

It is important that the economist verify that the beam conflicts are operational across a size category of vessels and not subject to pilot discretion, weather, tide circumstances, etc. A distinction should be made between beam clearance preferences and actual practices.

Vessel Length Restrictions

Vessel length restrictions may be absolute prohibitions or may be relative to remedial measures, which typically include additional tug assistance and/or requirement of working bow thrusters. Each additional tug adds an increase in the transportation cost of the vessel movement.

Bow thruster restrictions are a common practice. They require that vessels of a certain size (LOA) have working bow thruster(s) for enhanced maneuverability in the channel or additional tug assistance (or other restrictions):

- Most conventional large bulk vessels do not have bow thrusters including tankers.
- Smaller bulk vessels may be equipped, particularly if they are deployed in trades with frequent port calls (e.g. chemical carriers and shuttle tankers)
- Most container vessels have bow thrusters for enhanced maneuverability while docking and undocking.

In some instances improved tug performance may eliminate the requirements for bow thrusters for channel maneuverability with curvature.

The economist should understand the relationships between tug assistance (number, type and horsepower) and bow thrusters when there are channel maneuverability issues for particular sizes of vessels applicable to the benefiting fleet. Adding tugs can also be considered a non-structural alternative, but this also adds additional costs.

Panama Canal

One natural constraint for ships transiting west to east is the Panama Canal. The Panama Canal is actually a network of artificial channels and locks that connect various lakes. The width of the existing lock chambers (Gatun, Miraflores, and Pedro Miguel) are 110 feet wide by 1,050 feet long. However, the largest vessel that can transit the canal is a Panamax vessel. EM 1110-2-1613 dictates that the maximum sailing dimensions are 105.75 feet (32.2 meters) beam width, 950 feet (289.6 meters) long, and 39.5 feet (12.5 meters) depth in fresh water (less in the dry season) and about 38.5 feet in saltwater. Consequently, vessels sailing from the East Coast U.S. (ECUS) and Gulf Coast U.S. (GCUS) will typically not sail deeper than 38.5 feet unless they lighter or otherwise discharge cargo prior to transiting the Canal.[17] There are also additional restriction in various places in the canal and air draft restriction from the Bridge of the Americas.

More recently, construction has begun to increase the depth and channel width a bypass the existing locks. The expansion also includes two new locks that have three chambers each. One will be on the Atlantic side and one on the Pacific side. The locks are schedule to be completed in 2014. The new lock dimensions will be 180 feet wide, 1,400 feet long, and 60-feet deep. This means that a post-Panamax vessel capable of sailing through the canal will be up to 160 feet beam, 1,200 feet long, and 50-feet deep. This would reduce restrictions and increase the amount of goods carried. The expanded canal would have the capability to allow a 12,000 TEUs containership to pass, which more twice that of the existing canal that allows 5,000 TEUs.

Panama Canal Tolls:
The following website describes how tolls were historically set and how they are set today: http://www.pancanal.com/eng/maritime/tolls.html.

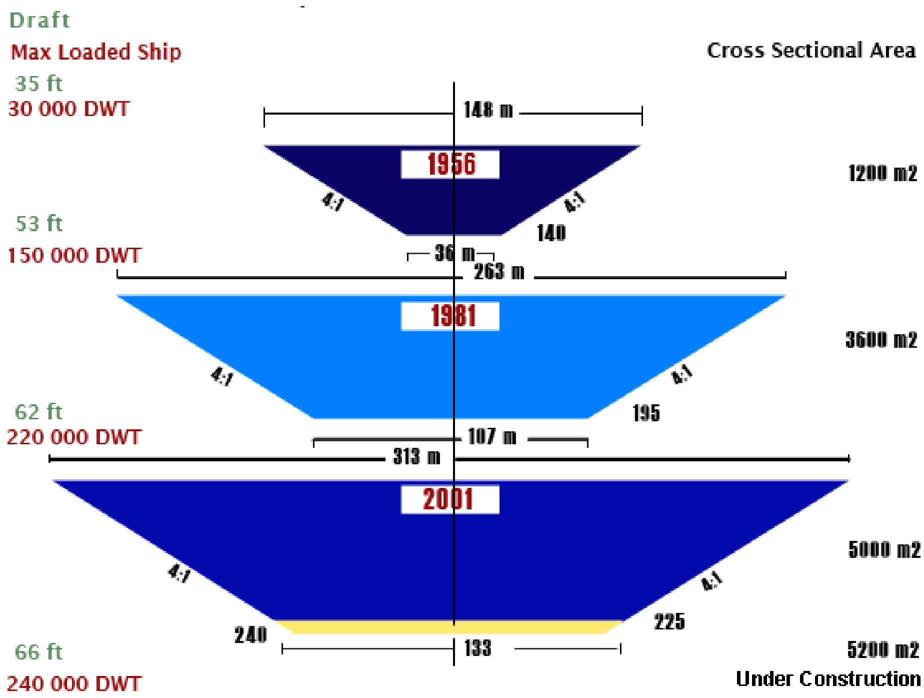
The multimedia link on the Panama Canal Authority is recommended to get a better view of the canal and its expansion through live cameras and more. A paper titled "Implications of Panama Canal Expansion to U.S. Ports and Coastal Navigation Economic Analysis" (http://www.iwr.usace.army.mil/inside/products/pub/pubsearchT.cfm) by IWR further examines some of the issues related to the Panama Canal and future manual updates will provide more information.

Suez Canal

The Suez Canal, owned by the Suez Canal Authority, is located in Egypt and serves as a major worldwide transit point that connects Europe and Asia without having to circumnavigate Africa. The canal is about 118-miles long and has a single lane with several passing zones and no locks. The maximum sailing draft as of 2009 was 62-feet according to the Suez Canal Authority. Some vessels may be constrained by the Suez Canal Bridge which is 223-feet high. The channel accommodates what is known as the Suezmax, which is almost exclusively tankers and has a width of up to 151-feet and 150,000 tons. The existing width can accommodate a vessel of up to 230-feet, but there are few tankers that meet this criterion and can fit within the depth. However, planned improvements that are scheduled to be completed in 2010 will increase the depth to 66-feet. The improvements would allow supertankers to pass though. More information on the canal is available at: http://www.suezcanal.gov.eg/. A cross-sectional area shows the various vessels sizes that can transit the canal.

[17] *Container vessels will discharge cargo at terminals adjacent to the Canal entrances. Bulk vessels will load for the maximum canal transit draft, about 38.65 feet, regardless of the U.S. port depth.*

Figure 5-2: Cross Section of Suez Canal[18]



Other Constraints

Any other impediments to unconstrained movements of vessels should be identified because they might constrain growth of the fleet from the perspective of numbers and sizes of vessels expected to call. They can include:

> Section 2-7 of EM 1110-2-1613 lists several considerations for constraints and risks

Airspace Restrictions: many ports are located near airports. Some vessels or cranes may be so tall that they are in regulated airspace.

Traffic Management: Traffic management is used in a few major European ports and international canals, like Suez and Panama. It is similar to air traffic control operations and just as sophisticated.

Encounter Restrictions: Some ports issue encounter restrictions on movements of hazardous cargoes such as liquefied natural gas (LNG) vessels or military vessels. These restrictions require other vessels of particular sizes not to pass (encounter) these vessels. Sometimes, the restriction is to stop all movements in a port. Although LNG vessel calls may be low at the time of the study, the economist should anticipate how these restrictions will affect the benefiting fleet, particularly if there is a growth in LNG and the benefiting fleet leading to more encounters and

[18] *Suez Canal Authority, 2009, http://www.suezcanal.gov.eg/sc.aspx?show=12*, Accessed July 2009

delays. The military's role in the port should be analyzed and described if it impacts the port operations.

Bridge Restrictions: The economist should make allowance for any bridge delays or restrictions for opening/closing and accommodation of passing vessels that may be present.

Weather-Related Constraints: Weather-related constraints can be acknowledged unless there is evidence that sustained disruptions to normal operations occur (such as seasonal fog).

Port and Landside Capacity Constraints: The economist should understand the capacity of cargo handling and storage systems and any landside constraints that may affect the ability of the marine terminal to receive or discharge cargo in sufficient volume to meet ship berth times. Berth capacity constraints will be an absolute impediment to vessels in the absence of such things as new cargo handling and storage capacity. Such constraints can result in capping vessel and cargo forecasts as a function of maximum port throughput.

Cruise Ship Priority: Some ports give priority to cruise ships in order to keep their passengers happy. The economist should be aware of this arrangement and consider this in their analysis.

Safety Zones: Certain vessels such as oil tankers, LNG and cruise ships may have more restrictive rules surrounding their movements. For example, other traffic in the port may have to come to a complete stop while an LNG vessel is moving. Other vessels may have an increased buffer zone for nearby vessels. This movement and restriction can be modeled using HarborSym.

Capacity: Once a good is transported to the port, sometime it is directly shipped onto its final destination and other times it is stored on-site or nearby. Containers in particular are often stored before they are shipped; this is evident by the stacks of boxes in the port. It is possible that some ports now or in the future may have troubles moving these boxes out quick enough and not have enough storage capacity. Cranes can be so fast that they can unload boxes almost too quickly. The same potential capacity issue could be said for other cargo and petroleum. The economist should investigate this as a possibility.

External Factors: Other factors may be outside the team or port's controls. These factors can be easily be used in the existing conditions if they are ongoing; however, predicting the future on some of these factors is impossible. Some examples include: NAFTA or GAFTA regulations, union strikes, whale strikes resulting in changes in vessel operational rules, hurricanes, war, acts of God and so on.

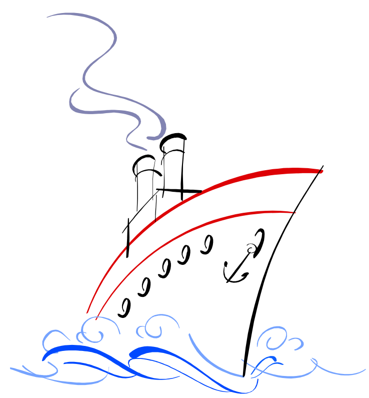
5.6 Key Concepts

In this chapter, key concepts about the Harbor and Port systems are:

- Ports have a standard procedure for vessels entering and exiting that usually involves local pilots moving ships about a given port.
- Underkeel clearance is the distance below the ship to the channel floor and a certain amount is required depending on conditions to allow safer vessel passage.
- Port facilities have the ability to store and process various types of cargoes. They also may have various regulations, and abilities to work depending on conditions. Each port is unique in its capabilities.
- Vessels can use non-structural measures such as tide-riding behavior, light loading, and lightering to overcome certain restrictions.
- Port and vessel deployment patterns that account for the calling vessel distribution at the port are an essential element of the economic analysis. Certain vessel or cargo types have a more predictable pattern
- Navigation-related constraints such as beam, vessel length, airspace, traffic, landside and others affect which vessels will call at a port and how they will behave.
- The Panama and Suez Canal are important transit points and impact the vessel dimensions that traverse the canals and how the shippers plan trade routes.

Retired Corps Survey Boat "Marnala", Seattle District

PART II – THE ANALYSIS



CHAPTER 6 – OVERVIEW OF THE ECONOMIC ANALYSIS

6.0 Overview

Part I covered the basics of planning and navigation. Part II will focus on the analysis steps in order to identify the NED plan. This chapter lays the foundation for the economic analysis. Additionally, HarborSym which is an economic navigation tool, risk analysis, and multiport analysis are generally described.

6.1 Analysis Framework

Although this manual lays out a general step by step process to perform an economic analysis, it is important to remember that the process is iterative and is never a clean step by step process. Below is a general description of the process as defined by chapters, and how it relates to the PGN steps. In parentheses are the PGN steps that correspond to each chapter. Figure 6-1 shows the general organization of the remaining manual.

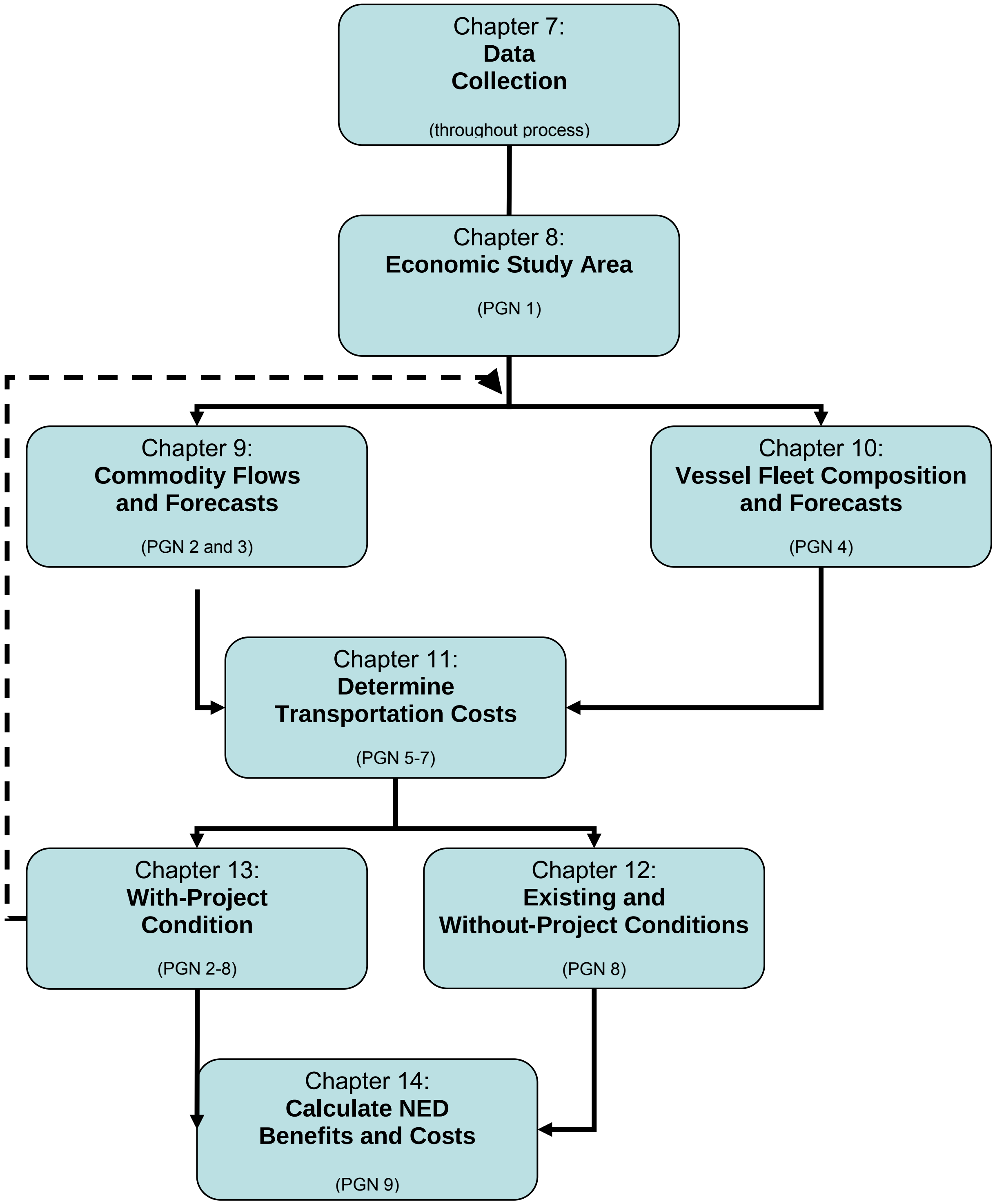
Chapter 7- Data Collection (*throughout process*): The collecting of data occurs throughout the entire process. It is likely easier to collect more data at the beginning of the study than later on. However, this is an important step in order to be able to describe the study area, understand commodity and vessel movements, analyze costs, and eventually describe the without- and with-project conditions.

Chapter 8 - Economic Study Area *(PGN 1:* Determine Economic Study Area): This manual describes how to determine the economic study area and the differences between the planning area and the economic study area. This step sets the basis for the identification of the future without- and with-project conditions. The economist will describe the port facilities, physical conditions of the navigation system, port practices, operating conditions, and more.

Chapter 9 - Commodity Flows and Forecasts (*PGN 2-3:* Indentify Types and Volumes of Commodity Flow; and, Project Waterborne Commerce): Once the overall setting is understood, the next step is to determine the existing and future commodity flows. The projected demand for a commodity will dictate how much of a good is transported and to where it is transported. These two elements are critical and highly intertwined in the next step, which is to determine which vessels transport what goods and to where.

Chapter 10 - Vessel Fleet Composition and Forecasts (*PGN 4:* Determine Vessel Fleet Composition and Cost): The previous step determined which goods are demanded and where they are transported. In this step, the economist determines the current vessel fleet composition and projects the future one based on several factors such as projected flows, current vessel fleet, share of world fleet available for future use, trade routes, etc

Figure 6-1: Manual Analysis Framework



Chapter 11 - Determine Transportation Costs (*PGN 5-7*: Determine Current Cost of Commodity Movement; Determine Current Cost of Alternative Movement; and, Determine Future Cost of Movement): This step brings together the previous steps to determine the total origin-to-destination costs including handling, transfer, fuel, storage, and accessory charges for the existing and without-project condition. PGN step 6 refers to the need to evaluate non-structural measures in alternatives.

Chapters 9-11, With-Project Iterations: *the first time through these steps will likely be analyzing the without-project condition. However, these same steps will need to be repeated for the with-project alternatives in order to define the various alternatives and the with-project condition. It is typically difficult to simultaneously do both the with- and without-project evaluations because the without-project problems and opportunities may not be determined until transportation costs are found and described in the without-project condition first. Each step is so inter-related that the process, although displayed more linearly, is often iterative. It may be easier to repeat the steps for each alternative rather than trying to simultaneously evaluate all. This process is up to the team and economist to decide the best approach.*

Chapter 12 - Existing and Without Project Conditions (*PGN :* Determine Use of Harbor With- and Without-Project): This chapter breaks down PGN Step 8 into Chapters 13 and 14. This step essentially draws on all of the knowledge found in the previous steps to describe the existing condition which is the basis of describing the future without-project condition. The description should include a description of the economic study area, existing and future commodity flows and how the vessel fleet is impacted over the period of analysis. The without-project condition should define and quantify delays due to tide use, problems with passing lanes, safety issues, etc. Then, this information should be related to total origin-to-destination costs. This description will be the baseline in which to measure the impacts of the with-project alternatives. The main product of this step is to find the average annual equivalent (AAE) value of transportation costs under the without-project condition. This AAE value is a compilation of all without-project costs and will be compared to marginal impact of all with-project alternatives. (Also)

Chapter 13 - With-Project Conditions (*PGN 2-8*): Like Chapter 12 above, the with-project condition will need to be described similarly for each alternative. Chapters 9 to 13, which correlate to PGN Steps 2 through 8, will be completed for each alternative to a lesser or greater extent of detail depending on the alternative. Additionally, this step requires determining the NED costs for each alternative, which are the total project costs to implement the project. This step also finds a comparable AAE value for the total costs of transportation for each alternative. This value will be compared to the without-project value in the next step. This chapter discusses several types of alternatives that may be considered. Also, quantify impacts of plans on delays, safety, passing, etc.

Chapter 14 - Calculate NED Benefits and Costs *(PGN 9:* Compute NED Benefit): In this step, the difference in total AAE values between the with- and without-project is estimated. Any drop in the total transportation cost for each alternative is recorded as the AAE benefit (from transportation cost savings) for that project. These benefits are then compared to the NED cost for implementing each alternative. The difference between the AAE benefit and AAE NED cost is known as the net NED Benefits. The alternative with the highest AAE net NED Benefits is the recommended NED Plan.

Now that the steps are generally set forth, the economist can begin learning more about each step in detail. The key process to remember is that the analysis is iterative. In the end, there should be a description of the without- and with-project conditions and an associated NED benefit and NED cost with a benefit cost analysis that demonstrates the efficiency for each alternative.

6.2 Multiport Analysis

Multiport analyses may or may not be needed depending on circumstances. There are also several scales of doing a multiport analysis from qualitatively describing the conditions to using an advanced model that reflect all port movements across a coast or nation. The essential steps to remember are those listed above. These same steps apply to a multiport analysis, but the steps are expanded further to analyze the additional ports and channels as a network.

Multiport analyses are typically unnecessary for captive commodity ports or ports that are so far away from any nearby competition with no good relationship between the two ports, such as 400 plus miles away. The multiport analysis can be focused and brief when the benefits of cargo substitutions from other ports are expected to be small or there is not a strong argument that authorized projects at competing ports will have a substantial effect on the project port. Conversely, the multiport analysis will need to be developed in greater detail if the benefits of cargo substitutions from other ports are expected to be large or there is a strong argument that authorized projects at competing ports will have a substantial effect on the project port. In general, a simple and more descriptive approach is suggested for all studies; an expanded and more quantitative approach is highly recommended for large, controversial, or highly port inter-related projects.

The economist role in multiport analysis is to identify relevant competing port trade flows based on analysis of trade routes, commodities, and port facilities. Commodity movements to or from competitive inland hinterlands to or from the same world trade areas are candidates for detailed analysis. Where the commodities are not identical (such as wheat and corn), or the trade routes are distinct (such as exports to different world areas), the opportunities for commodity transfers are likely to be low.

Hinterlands do not have to overlap at both the origin and destination. Competitive movements would include market and product competition, including substitute products. The economist needs to specify the complete origin-to-destination production and distribution costs applicable to each port to predict the commodity and fleet flows. This total cost will help predict the impacts of various product alternatives because the total delivery least cost route is likely to prevail among most goods.

This manual breaks the multiport analysis into the same economic analysis steps as described above. Each chapter in Part II discusses how multiport analysis could apply. Although this manual lists several multiport methods, it is at the discretion of the economist, team, and chain of command as to whether less or more work is needed in these areas. This manual serves as a starting point for multiport considerations.

6.3 Models: HarborSym

While there are many planning and navigation models, most are spreadsheets developed for a specific application and don't often fulfill the Corps's requirements for considering risk. One "corporate" model available is HarborSym which does widening analysis and incorporates risk in several areas. Future model improvements should include deepening, and containership analysis. Even though HarborSym is the corporate model, it does not limit the economist to only using this model. Corps guidance endorses any Corps certified model; this may mean going through the effort to certify other "non-corporate" models. For updated guidance and more information on model certification, please go to: http://www.usace.army.mil/CECW/PlanningCOP/Pages/models.aspx

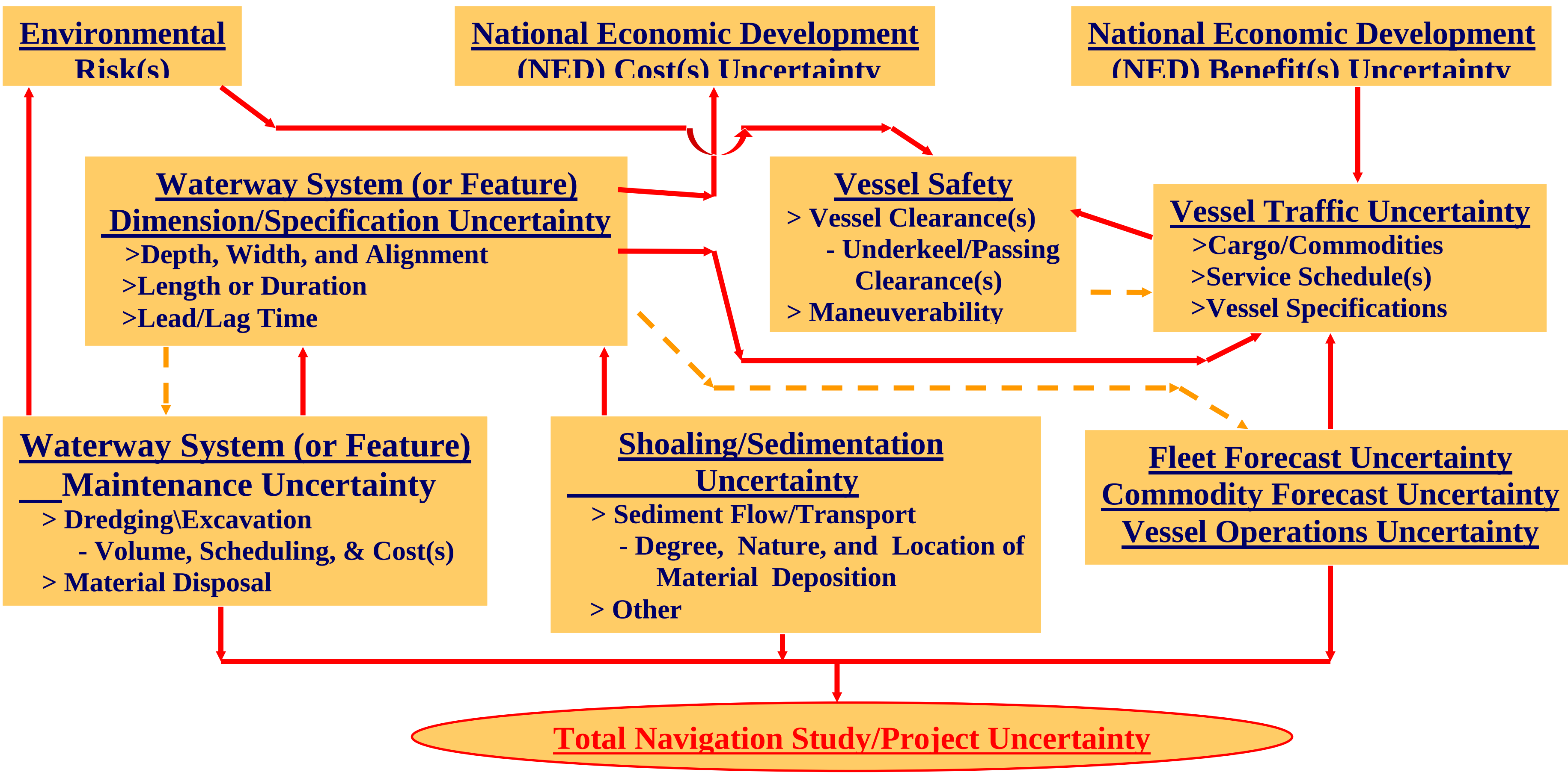
HarborSym is a planning-level simulation model designed to assist in economic analyses of coastal harbors. With user provided input data, such as the port layout, vessel calls, and transit rules, the model calculates vessel interactions within the harbor. Unproductive wait times result when vessels are forced to delay sailing due to transit restrictions within the channel; HarborSym captures these delays. Using the model, analysts can calculate the cost of these delays and any changes in overall transportation costs resulting from proposed modifications to the channel's physical dimensions or sailing restrictions. This in turn will drive the calculation of the NED benefits. Developed as a data driven model, HarborSym allows users to analyze changes without modifying complex computer code. This approach also enables analysts to apply the model to many different ports by altering the network representation of the harbor (http://www.pmcl.com/harborsym/default.htm).

Communicating and consulting is an ongoing endeavor throughout the planning process. The risk-informed decision making framework puts emphasis on this task. Depending on the team structure, the economist may not engage the non-Federal sponsor directly as the project manager; however, it does not make the economist's role in this task any less important. The economist must communicate and consult with team members, non-Federal sponsors, and other stakeholders through each step.

6.4 Risk and Uncertainty

Risk analysis has three main parts: communication, assessment and management. Figure 6-2 is flow diagram of risks and how they can impact the study. These risks can be described qualitatively, at a minimum, and depending on the likelihood of the risk and the consequence of the risk, they can be described quantitatively. This diagram is a starting point to understanding the logical flow of navigational risks and relationships. More information on risk can be found at: http://www.iwr.usace.army.mil/riskanalysis/

Figure 6-2: Risk and Uncertainty Flow Diagram for Deep Draft Navigation Projects



6.5 Key Concepts

This chapter sets up the framework for deep draft navigation economic analysis and the remaining chapters in the manual. The key concepts are:

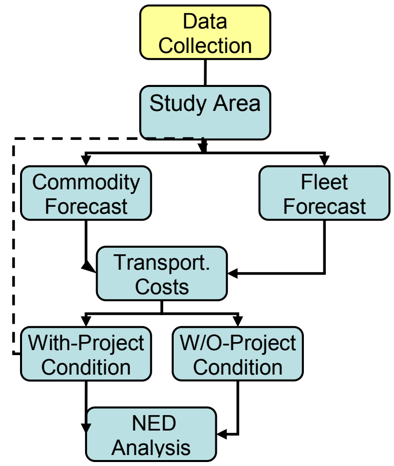
- The planning process is iterative and broken down into the following steps: data collection, economic setting and study area, commodity flows and forecasts, vessel fleet composition and forecasts, determine transportation costs, with-project condition, existing and without-project conditions, and calculate NED benefits and costs.
- Multiport Analysis is recommended at some scale for all studies.
- HarborSym is a Corps model that can assist in doing deep draft economics analysis.
- Risk analysis should recognize the interactions among the various navigation elements.

For more information on risk analysis, visit:

Corps Risk Analysis Gateway

http://www.iwr.usace.army.mil/riskanalysis/

CHAPTER 7 – DATA COLLECTION



7.0 Overview

Prior to starting any analysis or describing any conditions, data collection is a vital first step to understanding the port and issues at hand. This section provides select sources for the data that will be gathered and talks about information needs for various operating practices at the port. Data collection will continue throughout all phases of the study process to ensure the best and most up-to-date information.

The data collection phase of the project records the vessels calling the port, their cargoes, their practices and the possible impacts on competing ports. A detailed list of other data needs and considerations can be found in section 2-7 of EM 1110-2-1613. Gathering objective information is important. The economist should explain all data and sources, and seek sources that are objective. Securing a 10-year time series of vessels calling the subject port and their associated cargo commodity flows is a good place to begin the data collection phase of the project.

7.1 Use of Empirical Data

The use of good empirical data is critical to establishing a solid foundation of baseline information. Good empirical data is complete, accurate, is consistent, time stamped, and meets best professional standards (such as those independently reviewed). Baseline information will describe the existing condition at the port, its calls, and its cargo hinterlands. Interviewing is encouraged to gather background information about or otherwise explain the empirical data. Data collected through interviews should only be used as a substitute for data when that data is otherwise unobtainable.

Sometimes there is uncertainty about the level of detail needed or the accuracy of the details collected, particularly for geographic, transportation and timeframe data. This is one source of risk that should be described in the economics report.

It is better use data at the level that the data is provide rather than to engage in subjective disaggregation or aggregation based on partial information. Data should also be aggregated to protect proprietary information. This is particularly true for commodity flows. Agreements can be made to legally obtain proprietary industry data without disclosing it to the public in specific detail.

The economist needs to use care when aggregating data (or choosing not to aggregate data). For instance:

- Avoid aggregating together both benefiting and non-benefiting cargoes.
- Avoid detailing markets with different cargoes and rates of growth that cannot be distinguished and related to the benefiting vessel fleet.
- Do roll up excessive detail into representative aggregates.

7.2 General Sources of Information

The following sections serve as a toolbox of sources to find project data that will be useful in the analysis.

Identify Shared Data among Districts

The local USACE District, the Division office and the Deep Draft Navigation Center of Expertise (DDNPCX) can point to good sources of information regarding the study port. They can help locate other projects, concurrent or historical, that might have economic studies for the subject port, a competing port, another port in the region, or a port with similar characteristics. Additionally, it is also important to check with other port studies to ensure consistent data, projections, and so on.

The Deep Draft Navigation Planning Center of Expertise for the Corps can also provide other good information for contacts and assistance. The Center will also assist in coordinating independent technical reviews. The center is located in the South Atlantic Division.

National Deep Draft Navigation Planning Center of Expertise

The U.S. Army Corps of Engineers Director of Civil Works established the National Deep Draft Navigation Planning Center of Expertise (DDNPCX) at the Corps South Atlantic Division in Atlanta, Georgia on August 25, 2003.

It is one of several national centers of expertise supporting the accomplishment of planning studies for Deep Draft Navigation, Inland Navigation, Ecosystem Restoration, Hurricane and Storm Damage Prevention, Water Supply and Reallocation, Hydropower and Flood Damage Reduction. The national planning centers are part of an initiative to improve the quality and effectiveness of the Corps planning process for water resources projects called the Planning Excellence Program (PEP). The PEP includes training and work force capability improvement, enhanced quality assurance and control efforts, process improvement and regional and national planning centers.

http://www.sam.usace.army.mil/ddncx/default.html

Welcome to the US Army Corps of Engineers

Navigation Data Center

Waterborne Commerce Statistics Center

Mission

The primary function of the Waterborne Commerce Statistics Center, under the authority of the Rivers & Harbors Act of 1922, is to collect, process, distribute, and archive vessel trip and cargo data. These statistics are used to analyze the feasibility of new projects and to set priorities for new investment, and for the operation, rehabilitation and maintenance of existing projects.

Domestic and foreign vessel trips and tonnages by commodity for ports and waterways are covered in the Waterborne Commerce of the U.S., Parts 1-5. Foreign waterborne commerce between the U.S. and foreign countries are summarized by U.S. port, foreign port, foreign country, commodity group, and tonnage. Data summaries include origin to destination information of foreign and domestic waterborne cargo movements by region and state, and also waterborne tonnage for principal ports and state and territories. Internal waterway tonnage indicators are updated monthly on the NDC website.

Under Federal law, vessel operating companies must report domestic waterborne commercial movements to the Corps. The types of vessels include: dry cargo ships and tankers, barges (loaded and empty), fishing vessels, towboats (with or without barges in tow), tugboats, crew boats and supply boats to offshore locations, and newly constructed vessels from the shipyards to the point of delivery. Vessels remaining idle during the monthly reporting period are also reported.

Movement data acquired by the Center is primarily for the use of the Corps and other government agencies; however, summary statistics, which do not disclose movements of individual companies, are also released to private companies and to the general public.

The Waterborne Commerce Statistics Center's standard publications, *Waterborne Commerce of the United States*, is issued in five parts (one to cover each coast and a national summary). Also available is *The Public Domain Database* which contains aggregated information of foreign and domestic waterborne cargo movements. *Transportation Lines of the United States* contains listings of domestic vessel operators, details their equipment and references their service areas. Most data are available in both hard copy and electronic form. Specialized data processing requests are considered on a case-by-case basis and are charged accordingly.

Comments or Questions Contact: WCSC
Waterborne Commerce Statistics Center (WCSC)
PO BOX 61280
New Orleans, LA 70161-1280
(504) 862-1424 or (504) 862-1404

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http://www.iwr.usace.army.mil/ndc/wcsc/wcscmiss.htm

Interviewing

There is no substitute for empirical data. However, insights from those familiar with the port, its practices, cargoes, and fleets are helpful. Interviews should be considered with:

- Pilots, Captains
- Harbormasters
- Ships Agents
- Port Master Planners
- Industry specialists
- Others that work for or conduct business with the port

> *Information obtained in interviews should be considered proprietary and should be compiled as part of aggregate information when describing vessels or commodity flows in the report. Also, individual estimates may be biased for competitive reasons. Therefore, it is advisable to supplement interviews with comparative estimates based on the criteria of an independent authority.*

7.3 Economic and Demographic Data

Local entities, such as states and counties, often publish economic and demographic information relating to their locale. Use these sources to supplement economic data about the port's cargoes. Economic and demographic data describing the hinterlands should include, but not be limited to:

- commodity markets
- commodity transportation methods
- population
- labor market descriptions

Other Sources:

- U.S. Census Bureau (www.census.gov): collects economic, population, business and industry, geographical, and other information by county, state, and as a nation.
- Bureau of Labor Statistics (www.bls.gov): collects business and economic statistics.
- FedStats (www.fedstats.gov): links to other database sites such as other agencies, states, and more on all types of data.
- USDA Economic Research Service (www.ers.usda.gov): collect data on food, farming, natural resources, and trade.
- Vanderbilt University Frequently Used Sites Related to U.S. Federal Government Information: http://www.library.vanderbilt.edu/romans/fdtf/statistics.html
- U.S. Bureau of Economic Analysis (http://www.bea.gov/): GDP, trade, industry, personal income, and regional data

7.4 Harbor Data

It is important to develop an independent understanding of the harbor and its practices, trends, and related navigation issues. Specialty harbors are usually much easier to understand and document because the focus is specific in terms of cargoes and fleets. General purpose harbors can be much more complex because of a variety of cargoes and fleets that may or may not all be affected by improvements.

Information about the harbor can be found in:

- Master Facility Plan
- Strategic plans
- Pilot rules on channel constraints
- Encounter policies (rules for meeting and passing vessels)
- Tide data
- Port facilities
- Operational practices
- Pilots; logs
- Captains' logs
- Ship manifests
- Harbormaster
- Pilot's logs
- Ship's agents
- Shippers
- Manifests
- Websites on the port, its business associates, or the pilots
- Corps of Engineers Port Series and other publications at the NDC web site (www.ndc.iwr.usace.army.mil).
- NOAA National Ocean Service, National Ocean Service (http://oceanservice.noaa.gov): information on oceans, coasts, charting, navigation and more.

Some of this data, such as captain's or shipper's logs, may be hand-written, so interviews and follow-ups will likely be necessary.

Port master plans and capital improvement plans are also helpful, but they also may be too optimistic and confuse RED from NED benefits.

A series of maps or map overlays is helpful to show all desirable information, including:

- Channels
- Facilities
- Political boundaries
- Overland transportation routes
- Satellite, topographical, and/or navigation maps and charts
- Water depths
- Land use or zoning

GIS may be a helpful tool for collecting and organizing data. Many districts have their own GIS database with many of this information already. There are also sources like **CorpsMap** at https://corpsmap.usace.army.mil/.

Port development usually has to compete for use of the waterfront and zoning laws may also affect development. The most efficient cargo handling is at ground level and often less appealing to cities than high-rise structures that can outbid port facilities for a waterfront site. While Coastal Zone Management was intended to address some of these issues, but nevertheless, baseline information should identify which entities are involved in zoning and the specific regulations or restrictions that are relevant.

Most public ports have a Master Facility Plan for the next 5 to 20 years that is typically developed by an outside port consultant. Private ports, including terminal operators, usually have facility plans for capital expenditures and investments, particularly in growing markets. Both of these types of plans can provide an initial view of what the ports are thinking or hoping for with respect to cargo and facilities. Most strategic plans are useful for identifying prospective changes in cargo and related port facilities.

7.5 Commodity Flows

The economist should acquire a sense of the commercial perspectives of port users and service providers with respect to cargo flows. Marine markets are highly fragmented, both geographically and from the perspective of the services provided (e.g. maritime or landside). Commercial users and providers often have some form of strategic plan for port use. The economist should discretely inquire about these proprietary port use perspectives.

Complete origin-to-destination commodity flows, existing and historical, will need to be identified. A ten year time series is recommended for the purposes of commodity projections, and a three year series is recommended to demonstrate ports of origin and destination, underkeel practices, and channel constraints. Hinterland boundaries are normally defined between the port and the cargo origin and/or destination.

Transportation costs typically will determine the choice of vessel type and cargo routing. The preliminary “trends/opportunities” stage of the cargo analysis should include all reasonable cargoes and markets. The economist should initially attempt to understand the major commodity flows and trends in an aggregated fashion without detailed specification of hinterlands.

Look out for differences in units of measurement. Navigation units often vary. For example, “ton” equals 2,000 pounds and is also called a “short ton”; a “long ton” equals 2,240 pounds, and a “tonne” or “metric tonne” weighs 2,204 pounds

Commodity Data Sources

The Waterborne Commerce Statistics Center (WCSC) provides easily accessible time-series data on an annual basis. The detailed WCSC commodity codes provide information that is boht detailed and aggregated. The economist shoud use the appropriate level for the analysis. These codes are generally consistent across Federal agencies.

Other information is available at the sites below. However, WCSC has more detailed information for the U.S. Census and PIERS through Memorandum of Understanding (MOUs) and a contract than what can be found on-line for these sources. Therefore, it recommended to start data collection with WCSC prior to purchasing any data.

- U.S. Census Bureau: www.census.gov
- USDA Economic Research Service: www.ers.usda.gov
- State Economics Data
- County or other Regional Economics Data
- Journal of Commerce (JOC) – Port Importing/Exporting Reporting Service (PIERS)
- Global Insight: www.globalinsight.com

7.6 Fleet data

Each study is required to describe and forecast the future vessel fleet. Here are some sources that can assist in this task:

- U.S. Army Corps of Engineers
    - Navigation Data Center (http://www.ndc.iwr.usace.army.mil): commodity movements, tonnage, dredging, announcements, and more.
    - Waterborne Commerce Statistics Center: this is part of the Navigation Data Center. http://www.ndc.iwr.usace.army.mil/wcsc/wcsc.htm
    - Navigation Economic Technologies (NETS) models and processes (http://www.nets.iwr.usace.army.mil)
- U.S. Customs Bureau (http://www.cbp.gov/xp/cgov/trade/): information on trade activities
- U.S. Census Bureau: http://www.census.gov/
- Lloyd’s Register: some information requires a paid subscription (WCSC may be able to provide at not cost to the Corps, check with them first)
    - Lloyd’s Register of Ships Online (http://www.sea-web.com)
    - Lloyd’s Register Fairplay (http://www.lrfairplay.com)
    - Lloyd’s Register Fairplay: Internet Ships Register (http://www.ships-register.com)
- Clarkson Research Services (http://www.crsl.com)
- Jane's Maritime References
- Pilots logs
- Captains logs
- Ships agents
- Ship manifests
- Shippers
- Harbormaster

Local and Regional Fleet

The local port fleet inventory can be based on pilots’ logs and/or waterborne commerce statistics (existing and historical), and augmented by the appropriate physical characteristics from one or more of the vessel directories. The port fleet can be viewed as a subset of the larger world fleet (see next section). For example, for a port fleet for the ‘Small Port USA’, a list can be developed from pilots' logs of vessel names calling at the 'Small Port USA'. The Lloyd's Number can then be determined and associated vessel physical characteristics compiled from the world fleet. The data can be distilled into a range of applicable vessel sizes using categories as appropriate.

The regional fleet is a subset of the world fleet and contains the local fleet. It should be described and will become the foundation of the multiport analysis.

World Fleet Descriptions

There is a large amount of information available regarding the world fleet, including physical attributes of individual vessels, which can be identified by hull number. Section 4.2 Vessel Characteristics has a list of various characteristics to inventory.

Vessel Specification Directories

For a complete directory of vessel physical specifications, consult commercial listings such as:

- Lloyds: http://www.sea-web.com/handler.aspx?control=seaweb_welcome
- Lloyd's Fairplay: http://www.lrfairplay.com/, http://www.ships-register.com/
- Clarkson: http://www.crsl.com/

Each directory has its own sorting capabilities, which allows the economist to compile particular vessels by type and size. These often require purchasing various data sets or access levels. Downloading fleet information allows sorting by the fleet by size and age. Age usually correlates well with vessel replacement and can reveal trends in vessel sizes, etc. Vessel fleet average service life (age) is now regarded to be 25 years due to higher vessel costs and improved steel life (as opposed to 20 years historically). However, vessel replacement can be more or less depending on the vessel owner's perception of profits of the vessel into the future.

7.7 Operational Data

Vessel Operations

Vessel trip data, manifests and captain's logs contain information on:

- vessel operations
- vessel operation by draft
- sailing drafts (fore, aft, trim)
- cargo weight
- bunker weight
- water/ballast weight

The data are often not collected in a time series that would be useful. Detailed information about cargoes and vessel operation is often considered proprietary. Often vessel charterers and operators won't disclose the information. Certain confidentiality agreement can be signed despite the Freedom of Information Act and this should be explored with the team contracting experts and lawyers. If all else fails, use the best and most acceptable information available and note the level of accuracy and risk involved in relying on that information.

For example, pilots' logs will often identify vessel operations by draft, but in many instances the data will be rounded and not supplied for fore and aft such that trim can be computed. These data would normally be precisely available from the captain's logs and the manifest, but they are usually unavailable whereas pilots' data can often be obtained for a considerable historical time period.

Deployment Patterns

The economist needs to describe the port and vessel deployment patterns that account for the particular distribution of vessel sizes calling the study port. Usually this can be done by assigning particular vessels to routes or geographic deployments reflective of liner and charter operations.

The economist should:

- identify the relevant benefiting fleet from a trade perspective, which can then be integrated with appropriate commodity forecasts
- identify the deployment patterns of the benefiting fleet and focus on these deployments for changes in without- and with-project conditions
- separate vessels and deployments that do not impact the NED analysis and simplify the focus of the vessel and commodity forecasts.

Inland Transportation Rate Information

It may be desirable to use some generalized costs for truck and rail transportation for preliminary identification of hinterlands. These costs can also impact the deployment routes and operation of various ports and is critical in multiport analysis. Sources for such costs are statistics from:

- Interstate Commerce Commission (rail and truck)
- Federal Power Commission (pipelines)
- Trade associations such as the Association of American Railroads and the American Trucking Associations, Inc.

Carrier tariffs are complex and it is difficult to identify the commodity classification and routing that produces the most favorable rate. In some cases, actual effective rates can be picked up in baseline interviews and may be available in prior studies, analyses, or in articles in professional journals or trade publications.

Most carriers will provide a reasonable number of quotes. A traffic expert at the local port authority may be another source of expertise. More than one or two dozen requests for quotes are likely to be considered unreasonable by those sources.

For more rates or those not readily available, it will be necessary to hire an expert. Traffic services charge per quote, so it is a good idea to limit rate acquisition to the rates really needed.

Trucking statistics are limited. Inquire at the port regarding local moves, cartage, or container drayage to ramp locations. Having a blend of rates for unit trains, multiple and single cars is common. As a source for specific cost levels has limitations, but its blended rates are probably more representative of effective costs for specific movements.

Climatology Data

Climatology impacts the operation of vessels moving about a port. Data on the height and duration of the tide cycle is needed to calculate the cost of vessels using tides. Data on the frequency of weather conditions may be needed if increased channel depths will reduce delays or damage due to winds, waves, currents, or low visibility (provided a threshold level for "bad weather" can be established).

Sources of information:

- NOAA Tide Tables show time and height of tide for places worldwide
  - U.S. Coast Pilot published by NOAA's National Ocean Service (http://www.nauticalcharts.noaa.gov/nsd/cpdownload.htm)
  - Tides and Currents (Tide Tables) (http://co-ops.nos.noaa.gov/)
  - NOAA NOS Tides Online : (www.tidesonline.nos.noaa.gov)
  - NOAA's National Climatic Data Center (http://lwf.ncdc.noaa.gov/oa/ncdc.html)
- Wind and wave statistics: Summary of Synoptic Meteorological Observations (SSMO) by National Climatic Data Center

A port which is subject to strong tidal influence will typically gain and lose several feet of water throughout the day due to astronomical tides.

There are two low tides in each tidal cycle (so usually two low tides in each day). The averages are taken over a period called the National Tidal Datum Epoch (a 19-year epoch). Since there is no standardized tidal datum at present in the United States, care must be taken when utilizing both bathymetric (or hydrographic) charts and topographic maps to ensure that all vertical values either refer to the same datum or have been adjusted to the same datum.

For more information, as well as graphics, depicting tide analysis, please consult the Appendix C.

7.8 Data for Multiport Analysis

Multiport analysis data will be similar to that developed for the port. It must be prepared for all competing (or potentially competing) and highly inter-related ports. These ports are the ones that compete or are dependent on one another for various commodities, substitute commodities, and/or related vessel movements. Competing ports can be identified at the local and sometimes the national, level and do not need to be contiguous to the study port. The later economic steps can also assist in identifying shared commodities hinterlands, and shared fleets.

If these ports can be identified up front, it may be advantageous to collect data on the regional fleet, inland transportation costs, physical conditions, and commodities. The vessel fleet characteristics and resulting inventories should be described completely for each competing port. Those shared with the benefiting local fleet, as determined later in the process, will be described in more detail in the study report and compared to both the local and world fleets. The regional and possibly national fleet inventory is more important to fully capture in multiport analyses versus a single study port analysis. Therefore, the fleet inventory and information will be more extensive.

Inland transportation costs are also important to capture for the study port and the competing ports. Typically, the cheapest overall transportation route is utilized. Differences in port physical conditions, such as having more efficient cranes or loading area, can also impact the analysis. Therefore, information similar to the study port such as channel depths, widths, berth information and more should be collected. Commodity data will also be essential.

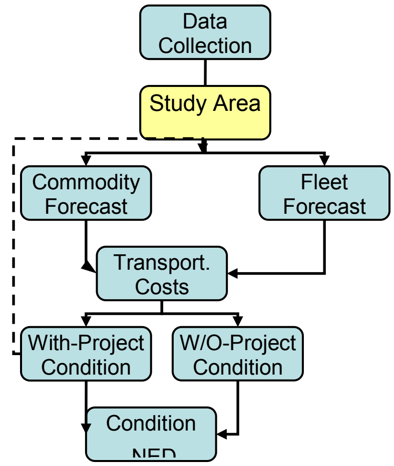
As the economic analysis goes on, other factors may become more important in a multiport analysis. Often times, the economist has to return back to data collection after discovering new information later on in the analysis. This is just part of the iterative nature of the analysis.

7.9 Key Concepts

In this chapter, the reader learned how to:

- Find good sources of information about the economic area, port, fleet, the commodities being moved by the fleet and the economics of the study area. This information should be summarized and become the basis of analysis and establishing the existing condition.
- Empirical and objective data is best; however, interviews and shared information can also be useful but must be objectively evaluated for any bias
- Fleet information should be found on the local, regional and world scale for comparison later on.
- Vessel deployments and routes are important along with collecting information about alternative inland routes.
- Information on tides and weather will also play an important role later on.
- Consider information to describe competing ports for the multiport treatment

CHAPTER 8 – ECONOMIC STUDY AREA



8.0 Overview

Although the Planning Guidance Notebook (PGN) shows determining the economic study area as the first step in the planning process, this step is usually performed in an iterative manner. First, the data that was discussed in the previous chapter can be used to describe the economic study. Later on, as the study progresses, additional data is collected and the vessels potentially benefited by the project and their cargoes are identified, the economic study area can be described in more detail.

8.1 Economic Study Area

The data collected for the economic study area is used to describe the without- and with- project conditions. It includes identification of physical and institutional constraints and port and vessel operating practices, including underkeel clearance, use of tides, passing rules, etc.

When the planning setting and the economic study area are similar, which is often the case, economists and other team member should work together to avoid duplicating efforts and data collection. It may be desirable to acquire historical and socio-economic data as part of the planning setting information. The information needed for economic analyses includes the port facilities, conditions, and operational practices that affect the amount of project benefits that may be realized.

The economic study area is the geographical area used to project commodity flows and to target competing ports in order to undertake a multiport analysis (when appropriate). The economic study area encompasses a set of assumptions about the physical, socio-economic, economic and policy conditions that will apply at the project site in the future. It is identified using vessel traffic and commodity flow statistics and also helps establish the conditions used in modeling the existing conditions. A main concept in determining the economic study area is hinterlands, which are inland trade regions. These conditions are relevant to NED evaluation and are the basis of the without-project condition.

8.2 Determining and Classifying Hinterlands

Chapter 4 discussed the basic concept of hinterlands. The economic study area is seldom limited to the immediate port area. Identification of commodity flows is necessary before describing the economic study area, including the hinterland. The economic study area is a collection of cargo hinterlands and is also known as the port hinterland. Cargo hinterlands are defined by the actual and potential inland origins and destinations for a given commodity and project port . Port traffic and project benefits will depend on the commerce of the region and the degree to which other ports share in this commerce. For NED analysis, the economist is interested in the port cargo hinterlands defined by the vessels and their cargoes to be benefited by the project.

Port hinterlands can be broadly classified as captive or competitive. Captive hinterlands rely exclusively on the study port. They may exist in the case of bulk commodities which originate from an exclusively localized source, such as phosphate in south Florida shipped in bulk through Tampa. Captive hinterlands also reflect commodities that are terminated in the local hinterland, such as imported cement for local construction or petroleum refined into asphalt for local consumption. Competitive cargo hinterlands are those where there is a choice between ports for the origin or destination of the cargo. This choice often leads to a more extensive multiport analysis. This chapter will discuss this analysis later on in more detail.

Determining Cargo Hinterlands

The U.S. origins and destinations of port commerce, or “hinterlands”, are commodity-specific for most liquid and dry cargoes. Those commodity flows usually can be determined by production and distribution costs in the absence of institutional constraints, such as any trade embargos or similar restrictions.

There are two basic approaches to identifying cargo hinterlands and whether or not there is port competition:

1. Trace overland movements to or from the port (and competing ports if appropriate).
2. Estimate overland transportation costs by the modes used and use the simplifying assumption that lowest cost determines port routing.

To start, or for very rudimentary analysis, the geographic midpoint between ports can be used to identify whether there are important origins or destinations at the margin.

The economist must decide the appropriate level of effort to expend compiling all relevant origin-to-destination costs. Time should be allocated to the most important cost components and variables affecting differences in origin-to-destination costs.

At this point the economist should have an available base of data that includes the production, consumption and distribution characteristics of benefited commodities under the project plan. Charts of representative origin/destination nodes of the principal benefited commodities can be used to:

- Directly describe commodities captive to the project port
- Map commodity hinterlands of the principal benefited commodities that are not captive to the project port

The port hinterland may be described in multiple ways. The primary hinterland is the area which primarily receives cargo from a given port. An overlapping (or competitive) hinterland is an area from which two or more ports derive their cargoes and a given commodity could flow to any port depending on rate, service and other characteristics. Hinterlands are not always fixed and can be fluid depending upon changing conditions.

!	*The rate structures of trucks, pipelines, and railroads and the existence of captive customers can distort hinterlands considerably. Interviewing terminal operators will help in identifying such factors, especially if preceded with a preliminary identification.*

Working with Hinterland Data

The hinterland map of representative inland origins/destinations varies among commodities. Grains will usually have a wide hinterland that differs by grain variety, such as corn, wheat and oats. Coal will normally have a smaller hinterland properly differentiated for major categories such as steam and metallurgical coals. By comparison, cement imports usually have a comparatively small and predominantly local hinterland unless there are barge movements associated with imports.

Port hinterlands will vary by such things as commodity, trade routes, geography and domestic transportation routes. Hinterlands may change through seasonal or cyclical fluctuations in world trade. The commodity should be well-defined and should constitute a substantial portion of the NED benefits of the project. For most ports, a few well-defined commodities will encompass most of the hinterland (and also therefore the scope of any needed multiport analysis).

It is best to describe hinterlands in ways that data is most readily available for both historical data and future forecasts. Foreign hinterlands are often country specific. Where there is a dispersion of cargo among contiguous countries, region-specific forecasts may be used. Local and national hinterland data is typically described by Metropolitan Statistic Area (MSA), county or state, depending on the commodity. Projections may vary widely among sources and regions, and caution should be used in selecting the most useful, relevant geographic base. It may be desirable to use multiple geographic regions if projections vary widely.

caution

Caution should be used in selecting the most useful, relevant geographic base. It may be desirable to use multiple geographic regions if projections vary widely. However, this could add complexity as the distances from a geographic area will be a weighted average of each country's distances.

8.3 Summarizing Economic Study Area

The economic study area is the inland trade region served by the project port. The geographical extent of the region is determined by cargo origins and destinations. The extent to which it coincides with the planning setting is port-specific. Hinterland maps will vary by commodity. The description of the economic study area covers the physical, economic and policy conditions that will apply at the project site under existing and more than likely without- and with-project conditions. Documentation of the economic study area includes:

- port facilities and physical conditions
- facility capacity (approximate annual capacity of cargo berths)
- facility berths and access channels (water depths)
- climatology data
- height and duration of tide cycles
- frequency of adverse weather conditions
- facility alternatives, such as:
- transshipment ports
- lightering
- pipelines and conveyors
- very long piers
- platforms and islands
- port practices and operating conditions

- vessel operation alternatives
- underkeel clearance
- use of tides
- reduced speeds
- reduced trim
- ballast and bunkering
- alternate vessel itinerary
- port institutions
- land use
- support services
- Hinterland maps of representative origins and destinations by commodity
- Commodity tables providing information about the type of commodity, quantity, weight and value
- Inland transportation modes
- Descriptions of actual commerce
- Descriptions of potential (new) commerce, if any
- Other useful information that is relevant to the study

8.4 Multiport Analysis in Competitive Hinterlands

Determining the hinterlands is a crucial step in identifying competing ports. The economist determines competing port hinterlands through data collection, interviews, and working through the hinterland process as described above for several ports. Additionally, the next economic analysis steps can help identify competing ports based on commodity and vessel flows. This in turn impacts the port hinterlands and is iterative. A multiport analysis is necessary when competitive port hinterlands are identified. It is not needed for captive hinterlands and is relatively unimportant for marginal hinterlands (which are often treated as captive), unless the nature of the project significantly alters the scope of traditional captive or marginal hinterlands.

Multiport analysis should focus on competitive hinterlands where overlapping port and cargo hinterlands are affected by with-project conditions or could change without-project condition assumptions. The existing and future geographic hinterland, with- and without-project, should be defined as carefully as possible to reflect competitive markets, ports and opportunities for diverted cargo, as well as other considerations. This includes describing physical characteristics of competing ports, commodity flow, and vessel composition.

The economist should identify hinterland clusters with respect to geography and transportation that account for a majority of the benefiting cargoes. The hinterland should be described sufficiently so that secondary forecast data (e.g., population, income, employment) can be used or referenced. Generally the routes that are the least expensive will determine the commodity; however this is not true for container traffic.

Differences in the characteristics of services may explain why containers are handled at ports other than the least total cost port. Examples of service differences that may account for market shares include:

- regional warehouses and distribution centers
- differences in rail intermodal among ports, including first port of call (imports) and last port of call (exports)
- interactions with load centering system capabilities, including markets served and such things as railway clearances for high cube boxes
- promised delivery dates for various goods

Container hinterlands should be broadly defined in terms of geographic scope and port substitution possibilities to accommodate different patterns of vessel deployments, load centering, and rail/water alternatives.

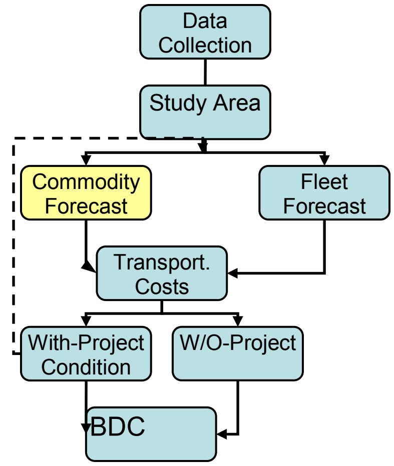
Least total cost criteria to define port competition will typically result in changing hinterlands in response to cost changes. Typically, the with-project condition at the port or authorized improvements at other ports will affect cost and hinterland boundaries.

8.5 Key Concepts

In this chapter, the reader learned key concepts about determining the economic study area, including the hinterland:

- Determining hinterlands are critical in a multiport analysis to determine if they are competitive or captive.
- The economist must decide the appropriate level of effort to expend compiling all relevant origin-to-destination costs. Time should be allocated to the most important cost components and variables affecting differences in origin-to-destination costs.
- Cargo hinterlands can be broadly classified as captive or competitive (and sometimes as marginal). Port hinterlands will vary by such things as commodity, trade routes, geography and domestic transportation routes. Hinterlands may change through seasonal or cyclical fluctuations in world trade.
- Multiport analysis should only focus on competitive hinterlands where overlapping port hinterlands are affected by with-project conditions.
- Two basic approaches to identifying cargo hinterlands are to:
    - Trace overland movements to or from the port (and competing ports if appropriate).
    - Estimate overland transportation costs by the modes used and use the simplifying assumption that lowest cost determines port routing.

CHAPTER 9 – COMMODITY FLOWS AND FORECAST



9.0 Overview

Cargo information is used for an initial determination of the economic study area and to provide the basis for commodity flow projections or forecasts. This chapter will discuss commodity identification and how to describe the baseline information. Typically, a 10-year historical time series of commodity flows is prepared to form the baseline for the 50-year projection needed for the NED analysis.

Existing and projected commodity flows and vessel flows, as discussed in the next chapter, must be integrated to develop a cohesive, consistent approach to NED benefits for the project. These benefits combine resource savings to vessels and cargoes. Commodity projections ultimately drive vessel fleet projections in terms of the numbers and sizes of vessels for without- and with-project conditions.

9.1 Determine Relevant Commodities

The economist should identify and understand the major commodity flows and trends in an aggregated fashion using such sources as those described in the Data Collection chapter. The data provides an immediate view of cargo trends (i.e., up, down, no change) by type (foreign and domestic) and direction and of those that are particularly important to the port in terms of volume. This data is important to determine the economic study area.

Most harbor projects address inefficiencies in the operations of the existing vessel fleet. This is usually the result of increased cargo, because larger, more-efficient vessels will seldom be deployed in a service with relatively stagnant cargo volumes.[19] Increased cargo arguably leads to the increased use of larger sized vessels, and/or more light-loaded vessels, and hence to opportunities for efficiencies.

A preliminary list of relevant commodities is also derived from the stated concerns of local interests, the request or authorization for the study, or the specification of problems and opportunities. Such commodities are relevant, regardless of whether the project will help. The effort in investigations should be to narrow that list and make it more specific, not identify additional concerns. The initial short list will include actual commerce and possible new or increased potential commerce.

Actual Commerce

The objective of Corps deep draft navigation projects is to lower transportation costs for carriers and consumers to share. This is usually done through better utilization of present vessels, or by use of larger, more efficient vessels. The data on vessel sizes and their actual drafts, discussed in the next chapter, will generally help identify the commodities (or portions thereof) that may benefit.

Table 9-1 is an example of the commerce that the economist should consider and display. This table was developed for 'Small Port USA' and uses the major Waterborne Commerce Statistics Center (WCSC) commodity headings to illustrate the commodity tons and distributions. The data provide an immediate view of what cargoes by type

[19] *A possible exception is liner services or quasi liner services such as dedicated vessels calling multiple ports in a string.*

(foreign and domestic) and direction are growing and particularly important to the port in terms of volume. The Year 1997 in Table 9-1 was a relatively high year for 'Small Port USA' for cargo volumes (exports) to which future years could be compared. Table 9-1 clearly identifies the major cargo tonnages to be exports of manufactured equipment and farm products. More detailed commodity descriptions in each of these categories might be useful for further disaggregation, particularly if the details are relevant to different export markets and/or benefiting vessel fleets.

Table 9-1: 'Small Port USA' Example Commerce
(000 tons- top chart, and percent of total- bottom chart)

	1997 Imports	1997 Exports	1998 Imports	1998 Exports	1999 Imports	1999 Exports	2000 Imports	2000 Exports	2001 Imports	2001 Exports
Total	93	487	72	434	25	318	234	473	80	457
Coal		1	0	0	0	0	0	0	0	0
Petroleum	0	10	0	13	0	35	123	5	0	5
Chemicals	1	42	1	30	0	16	2	25	1	21
Crude Materials	10	44	3	30	0	12	2	12	6	10
Primary Manufactures	9	65	4	60	1	39	9	70	1	55
Farm Products	20	158	14	160	5	127	21	152	10	151
Manufactured Equipment	52	156	49	126	19	78	73	180	58	175
Unknown	1	11	1	15	0	11	4	29	4	40
	1997 Imports	**1997 Exports**	**1998 Imports**	**1998 Exports**	**1999 Imports**	**1999 Exports**	**2000 Imports**	**2000 Exports**	**2001 Imports**	**2001 Exports**
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Coal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Petroleum	0%	2%	0%	3%	0%	11%	53%	1%	0%	1%
Chemicals	1%	9%	1%	7%	0%	5%	1%	5%	1%	5%
Crude Materials	11%	9%	4%	7%	0%	4%	1%	3%	8%	2%
Primary Manufactures	10%	13%	6%	14%	4%	12%	4%	15%	1%	12%
Farm Products	22%	32%	19%	37%	20%	40%	9%	32%	13%	33%
Manufactured Equipment	56%	32%	68%	29%	76%	25%	31%	38%	73%	38%
Unknown	1%	2%	1%	3%	0%	3%	2%	6%	5%	9%

Potential Commerce

At the early stage in developing the existing and future cargo flows, the economist should identify a wide range of new cargo opportunities, if applicable. The opportunities should include planned commitments, highly likely prospective, good potential and just possibilities from the perspective of shippers, port and terminal operators, and vessel owners/operators and agents.

At the initial stage of analysis all reasonable cargoes and markets should be included. A fragmented commodity analysis might otherwise be developed. The economist should also identify any regional cargo transfers. These can become variables in sensitivity analysis as well.

For market opportunities (cargoes not currently existing at the project port), the economist should develop a sense of likelihood. Market studies and financial and facility commitments are usually helpful in distinguishing between a business plan/strategy and an idea. Prospective cargoes are often merely routine expressions of interest, particularly in bulk trades where cargo and port shopping is a common practice for new entrants seeking the best deal. The economist should identify trends such as multiple expressions of interest by a particular commodity group compared to varied and dissimilar expressions of interest by widely different cargo groups such as bulk liquids versus general cargo. Prospective cargoes are ideally documented with letters of intent and related signs of commitment. However, sometimes due to the port's competitive nature, they are unwilling to publicly disclose these details and diligence must be exercised when documenting the prospective cargoes.

Port Commerce Data

The economist should prioritize the benefiting cargoes in terms of volume and vessel size characteristics. The largest existing or planned/prospective cargoes based on tonnage, voyage distances and vessel sizes deployed will usually be the nucleus of the NED benefits for the project.

Tabular summaries are the best way to organize commodity data for their indicated uses. Summaries should also be shown in the main study report or its "Economics Appendix" to provide support for forecasts and benefit calculations.

Information to be collected includes:

- size and composition of cargoes (annual tonnage by commodity or commodity category)
- origins and destinations of the cargoes (inland or hinterland and external)
- origins and destinations of transportation modes
- distance from origins to destinations

The economics report should include a multi-year summary of all port commerce. An additional summary identifying the specific commodities associated with problems and opportunities to be addressed by the project is also needed. Five or more years of comparative data is desirable and an indication of growth trends, and how they were determined, should be shown.

Waterborne Commerce datum is often used in this task, but should be aware that the datum is usually behind a few years. Additionally, be sure to check the units of measurements.

9.2 Commodity Flows in a Multiport Analysis

Most deep draft navigation studies focus on one port; however, whenever trade routes are shared or competed for among different ports, the economist may need to expand the study to other ports in a multiport analysis. If it is determined that commodities will move from one port to another under the with- and without-project conditions, the impact of this movement on NED benefits must be determined and accounted for in the analysis (ie, it must be demonstrated that this transfer is attributed to total least cost delivery of commodity). The variability in hinterland costs from the perspective of a multiport with-project condition is usually limited to changes in vessel costs. Therefore, multiport analysis typically uses the lowest least cost criterion as the basis for diversion, which is most appropriate for bulk commodities in the absence of special commodity handling or storage requirements. Least total cost has the advantage of objectivity if all relevant costs are properly defined and measured.[20]

[20] *Although bulk commodities may be most susceptible to a least total cost analysis, caution should be exercised because the costs of commodity handling and storage systems can vary by capacity and throughput, making this aspect of "port costs" challenging to the planner.*

As an example, Table 9-2 shows competing ports (Sea Harbor, Hurricane Harbor, Sea Breeze, Muddy Harbor and Wind Port) and the trucking cost (cost per ton) from each port to the various hinterlands for widgets. One would infer from the data that the ports that have lowest costs to a hinterland will likely serve that hinterland. In this case, Jazz City and Crawfish County would get their widgets from Sea Harbor which can transport them at little to no cost. However, Johnson City would get their widgets from Muddy Harbor. Now, let's say that the Corps improves Sea Harbor. If the improvement decreases transportation costs to Johnson City from $103.52 to $50, then no commodity is likely to be diverted because Muddy Harbor is still cheaper. However, if the cost is now all of sudden less than $2.28 from Sea Harbor, it could divert widget from Muddy Harbor to Sea Harbor.

Table 9-2: Widget Trucking Costs, Competing Ports to Hinterland Areas Served

	Ports				
Hinterland	**Sea Harbor**	**Hurricane Harbor**	**Sea Breeze**	**Muddy Harbor**	**Wind Port**
Jazz City	$ 36.35	$ 78.43	$ 126.63	$ 174.67	$ 264.93
Crawfish County	$ 40.35	$ 58.29	$ 127.72	$ 175.76	$ 266.02
Country Town	$ 48.61	NA	$ 73.24	$ 107.24	$ 147.18
Arch's Landing	$ 49.16	NA	$ 20.33	$ 76.55	$ 55.00
Southern City	$ 49.71	NA	$ 32.33	$ 80.37	$ 168.45
Metropolis	$ 50.25	NA	$ 32.88	$ 80.92	$ 169.00
Springfield	$ 48.61	NA	$ 32.33	$ 80.37	$ 167.91
Johnson City	$ 103.52	$ 35.26	$ 3.23	$ 2.28	$ 71.17

Additionally, it is important to distinguish between different commodities in terms of production, consumption and distribution characteristics that affect port competition. For example, port substitution possibilities are generally more abundant for corn than for wheat. Although both are similar, each has distinct production, consumption and distribution characteristics. Another example is coal, which can be used for steam (utility generation and industrial heating) or for metal smelting. Steam coal cannot be used as a substitute for metallurgical coal because of its lower heat properties, but metallurgical coal may be used as a substitute for steam coal.

9.3 Commodity Forecasts

Identifying the existing cargo hinterlands, as discussed in Chapter 8, is a critical element in developing commodity forecasts. Once the existing hinterland is known, the future hinterland, if expected to change, can be forecasted with more accuracy. The specificity of port hinterlands for commodity projections will vary by cargo and the data available for forecasting. The selection of the appropriate geographic hinterland should facilitate the use of existing forecasts and time series of economic activity relevant to the benefiting cargoes. It may be desirable to use multiple geographic regions projections if port hinterland projections vary widely such as regional compared to national hinterlands for exports.

There will usually be short-term projections (three to five years) for recognized geographic hinterlands such as foreign countries and states.[21] These projections are often not particularly useful to the very long-term perspective (upwards to 50 years). The existing hinterland will have a history of economic activity and some short-term projections for without- and with-project conditions.

Commodity Markets

Most firms categorize their markets with respect to predicted growth, competitive risk (probability of loss from a decline in business) and expected profitability. Similarly, for cargo forecasting purposes the economist should be aware that markets will display different rates of growth, and these can be reflected in the selection of commodity hinterlands. It may be necessary to disaggregate the commodity by use or user when there are different segments for a similar geography that display different rates of growth. Some examples are steam coal for utility consumption, metallurgical coal for steel making, and building materials growth may be tied to the housing industry and so products like lumber, gypsum, and cement could be connected. The different uses/users should reflect substitution possibilities from other products as well as competitors.

Generally, large markets will have slower growth than emerging smaller markets. However, a small percentage of a large volume will result in more cargo than a large percentage (growth) of a small volume. The growth in cargo from the perspective of tons is important because this translates into vessel calls for the benefiting fleet. Consequently, other things being equal, forecasts of cargo with the most growth in volume (DWT) should be carefully developed.

Assumptions and Timeframes

Most long-range commercial or proprietary forecasts of economic activity are related to business cycles and span a period of three to five years. Long-term in the commercial sector is usually 10 years. Although longer-term investments are made for capital assets with physical and economic lives greater than 10 years (e.g., marine vessels with a 25-year projected life), detailed annual forecasts usually do not extend beyond five years. The investment normally assumes a long-term rate of growth or plateau growth after some extension of the near-term five to 10 year forecast.[22]

Economists are essentially on their own when making a very long-term commodity forecast (outward to 50 years). Although there are some long-term (outward to 25 years) projections for population, there are no known commercial or proprietary long-term forecasts for cargo. These kinds of projections normally do not exist because there is no perceived need for them and the time duration is regarded as too long for a reliable forecast to be developed.

After ten or twenty years, very long-term projections usually become trend line or regression analysis (extrapolation) exercises in the absence of other very long-term projections for major inputs such as population and income. This is the case for commercial sector products whose long-term trend line is often related to past average growth. The timeframe is less important than the reasonableness of the growth that is projected. For example, a compound annual growth rate of seven percent results in a doubling of the baseline every ten years.

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[21] *Some longer term domestic population forecasts will normally exist.*

[22] *Another overlooked issue is that proprietary forecasts and related business strategic and capital investment plans usually have substantially higher discount rates that reflect the after tax cost of debt and equity capital and associated business risks. . . The substantially higher cost of capital results in very long-term projections having less importance because of the prevailing discount rates for a present value analysis.*

A consistently sustained and relatively high rate of growth for a long period of time relative to historical growth will raise questions about a given forecast in the absence of special circumstances such as an industrializing nation or new technology. Additionally, a high R-squared value, which generally measures the correlations between variables, could be falsely high because the high amount of explanatory variables. A theoretical relationship needs to be connected between the dependent and explanatory variables.

It is not unusual to work with multiple timeframes in which the level of detail in the forecast varies. This is particularly important because the growth projections during the first five to ten years of the project will have the largest impact on benefits from the perspective of a discounted present value. The initial projections will have the largest effect and will represent an adjusted baseline throughout the duration of the project absent any subsequent declines in cargo from resource depletion, new competition or some other factor. Most economists understand that increases in cargo more than twenty years in the future have little effect on benefits because of the discounting of future values to present values.

Assumption: Analytical forecasting presumes that the past relationships between the independent variable(s) and dependent variable will remain unchanged in the future.

9.4 Methods

Forecast methods are sometimes described as analytical or subjective with respect to the primary source of data.

Analytical Forecast Methods

Analytical forecasting methods use mathematical or statistical tools to make projections, usually in conjunction with secondary data. Analytical projections are usually considered objective because of the use of data and formulas that can be confirmed and replicated.

The basis for all analytical forecasts is the historical data relevant to observed trends in quantity demanded for the particular cargo hinterland. Analytical methods usually reflect trend analyses to fit the observed pattern of changes in quantity demanded to changes in explanatory variables such as cargo volume and population.

Time is a common means of relating determinants of demand (cargo volumes), usually measured in years. However, changes in time do not usually produce shifts in demand. Time typically represents some other variable(s) that is changing and related to demand, such as population and income.

Analytical forecasts fit one or more independent explanatory variable to the dependent variable, cargo tonnage. The exact representation of the relationship between independent variables and the dependent variable is a matter of trial and error for “goodness of fit” statistical measures using regression. Disaggregation of data may be important to find the "best" fit in these forecasts. The relationship may be quite straightforward (e.g., linear regression), or more complex (e.g., non-linear multiple regression). The ideal situation would be when one or a limited number of independent variables can be fit to the dependent variable to explain historic changes in quantity demanded. Then, if there are existing forecasts for the independent variables, these can be used to forecast the dependent variable.

Analytical forecasting presumes that the past relationships between the independent variable(s) and dependent variable will remain unchanged in the future. For example, if population growth is a major cause of historic cargo demand, future population growth will remain a cause of cargo demand if there are no intervening changes. (Note: these assumptions ignore possible changes in such things as technology, substitute products and market saturation that may make past (statistically) inferred relationships between independent and dependent variables irrelevant). This is a source of uncertainty that should be described and incorporated into the risk analysis.

Most analytical forecasts are for short periods of time ranging from less than one year to several years. Some of the tools appropriate to these perspectives emphasize changes in demand over seasons or business cycles. These perspectives are usually not relevant for very long-term cargo forecasts. Shorter term fluctuations in demand will be smoothed out over the long term (from the perspective of annual demand). Although there may be business cyclical effects, these are almost always impossible to predict on a near-term basis.

Models for predicting values are formed using theoretical relationships between independent and dependent variables. If this model is incorrect or the independent variables are actually correlated, then there will be a resulting model error. Added, the data used in the model could be uncertain along with its application into the future resulting in greater model uncertainty. These factors should be controlled as best as possible and once that it is done, the strength of the model can be testing.

The strength of the inferred statistical relationship is the degree to which the changes in the independent variable(s) are reflected in changes in the dependent variable. The goodness of fit or "coefficient of determination" (otherwise known as R-squared) measures the degree to which changes in the dependent variable are reflected by changes in the independent variable(s). An R-square of 1.0 is perfect and indicates that all of the observed changes in the dependent variable are reflected by changes in the independent variable(s). An R-square of 0.10 indicates that 10 percent of the changes in the dependent variable happen to coincide by changes in the independent variable(s). A perfect (1.0) or near perfect (0.90) R-square, with other things being equal, is ideal for fitting past data between the independent variable(s) and the dependent variable.

There are two issues related to regression based forecasts:

- Even a perfect or near perfect R-square does not prove that there is a causal relationship between the independent and dependent variables. It merely indicates that the variables change in a manner similar to each other.
- Good R-squared values are commonly regarded to be in the range of 0.70 upward. This means that the better regressions normally leave a certain measure of “unexplained” changes in the dependent variable that are not accounted for by the independent variables used. A search for additional independent variables that do not confound the forecast through interrelationships between the variables often does not improve the R-squared coefficient. Measuring and describing this uncertainty is important.

In instances when the R-squared statistic is low (less than 0.70), the regression “explains” the observed changes in the dependent variable, but not very well. Other approaches are usually necessary to supplement or supplant the analytical statistical based regression approach.

Subjective Forecast Methods

Subjective forecast methods reflect personal opinions and are distinguished by the lack of reliance on mathematical or statistical data manipulation. Subjective forecasts are less objective than analytical forecasts because there are no data sets or formulas that can be reviewed and replicated. Subjective forecasts work best when there is an absence of data on demand and supply or when the data are no longer appropriate to the future, as evidenced by low R-square values or general lack of reliability of analytical methods.

New markets and/or major changes in commodity volumes usually cannot be accurately depicted by trends and historical trend based analytical forecasts. Instead, cargo experts will usually be cited, along with trade publications and industrial commercial forecasts. Expert opinion may also be obtained through surveys or interviews with shippers or closely related transportation sector providers.

There are several issues related to the use of subjective (opinion based) forecasts:

- The qualifications of experts with respect to forecast capabilities are often relative and not easily verified. Consequently, when expert opinions and related approaches such as shipper surveys produce dissimilar results, the economist may have difficulty resolving the differences.
- The economist is typically interested in a very long-term forecast, whereas the expertise may be focused on the near term. Experts are often unable or unwilling to think very long term because of the inherent risks involved in what they may consider to be mere speculation.
- It is often very difficult in subjective forecasts to identify the assumptions made by the providers and link these to the forecast. Analytical forecasts can be examined from the perspective of the data, formulas and relationships; but subjective opinions are often not similarly deducible other than through more complex revealed preference and stated preference approaches that are beyond the capabilities of most economists. Moreover, special skills are needed to perform preference surveys that are not easily demonstrated, replicated, or documented. Consequently, cargo projections seldom rely on more complex preference surveys of shippers other than in the realm of mode choice, typically rail versus truck, where the two are viewed as substitutes for each other.

The Office of Management and Budget (OMB) has certain rules on surveying the public, using pre-approved surveys, and obtaining permission if more than a handful of people are surveyed. Additionally, the economist should review guidance, such as IWR Report 93-R-2, on how to objectively collect data.

9.5 Accuracy

Accuracy is probably the most sought after criterion for evaluating forecasts. There are several measures of forecast accuracy, including residuals analysis and confidence intervals.

Residuals Analysis

Residuals analysis compares the differences between the actual values and the predicted values. The objective is to determine patterns of forecast error, such as regularly or irregularly recurring observed differences between actual and expected values. If residuals analysis indicates that the forecast errors are random and show no observed patterns, the errors may be smoothed out and the forecast adjusted to remove outlier values using methods such as influential observation analysis. This is a method that helps determine the impact of removing outliers one by one on the final results. (Hint: many statistical software packages have this.).

A popular way to express residuals analysis is the sum of the forecast errors and the average of the sum of the absolute value of the forecast errors. When the sum of the forecast errors is near zero, there is little bias in the forecast in terms of a tendency to consistently over or under forecast (the positive errors tend to cancel out the negative errors of over and under forecasting, respectively). A relatively large positive or negative cumulative forecast error is evidence of a possible bias in terms of a tendency to over or under forecast. The average bias or an adjustment can be used to calibrate future forecasts by including a bias (error) factor to subtract (over forecast) or add (under forecast).

The average of the sum of the absolute values of the forecast errors can be used to express the average error as a percentage of the forecast itself. In some instances, there are norms (or at least rules of thumb) for what is an acceptable mean absolute value expressed as a percentage of error of the forecast. For relatively stable environments, percentage errors may range less than five percent. For more dynamic environments, the percentage of error (average absolute value) may range upward to 20 percent. These statistics should be described as part of the risk analysis.

Confidence Intervals

One of the advantages of analytical forecasts based on regression is that a confidence interval for error can be statistically estimated. If the forecast errors are assumed to be normally distributed with respect to over and under forecasting (zero bias), a standard normal distribution can be used to develop confidence intervals (probability levels that the forecast will be within specified upper and lower ranges).

Most statistical regression packages, and the commonly used Excel (with the statistical toolpack add-in), will compute the "standard error" of the forecast as a measure of dispersion between forecast and actual values. When the standard error is small relative to the mean (forecast value), there is relatively little dispersion between the forecast and actual values such as a standard error value of 1 and a forecast value of 100. When the standard error is large relative to the mean (forecast value), there is substantial dispersion between the forecast and actual values such as a standard error value of 20 and a forecast value of 100.

Assuming a standard normal distribution of forecast errors reflecting an absence of bias to over or under forecast relative to actual values, the forecast confidence levels can be set as plus and minus a multiplier of the standard error value from the forecast value. For example, a 95 percent confidence interval is plus and minus 1.96 standard errors from the mean forecast.[23] For a forecast of 100 and a standard error of 1, the 95 percent confidence interval would be 100 plus 1.96*1 and 100 minus 1.96*1, or 101.96 to 98.04. There is 95 percent confidence when the forecast is 100 and the standard error is 1 that the actual forecast will be between 98.04 and 101.96 (or, expressed in whole units, 98 to 102). For the larger standard error of 20, the 95 percent confidence interval would be between 60.8 and 139.2. The forecast is 95 percent confident to be between 61 and 139 (rounded) under these circumstances.

The effects of the relatively large standard error in relation to the forecast (mean) value through the confidence interval are quite pronounced. When there are relatively large standard errors, it is evident that the forecast does not track quantity demanded well and results in substantially broad confidence intervals commonly set at 95 percent (1.96 standard deviations) relative to the forecast.

[23] *Refer to any introductory statistical text for further information on the standard normal distribution and confidence intervals.*

Whenever there are large residuals in relative (bias) or absolute values and/or large standard errors, the forecast will have relatively high statistical measures of error. In some instances, the nature of the phenomenon being forecasted has so much variability that it is difficult to arrive at smaller error and a smoother trend line. It can become complicated when the independent variable has variation. One way to “clean” a forecast of historical errors is to smooth out extreme values (high and low) relative to actual. The amount of smoothing is subjective in terms of the number of “error” values to be replaced until the economist arrives at good measures of fit (accuracy) relative to the actual values. A progressive removal of “outlier” values will bend the forecast to reflect the economist’s view of reality. The outliers should be explained and analyzed using methods such as influential variable analysis. The forecast should not be sterilized by removing sufficient outlier values relative to actual values to have a good fit. Unless the discrepancies between the forecast and actual values are truly random, the removal of outlier values will interject a subjective notion of stability into the forecast that may not be reasonable in relation to future trends.

The purpose of smoothing is to remove extreme values that distort the overall accuracy of the forecast. A few extreme errors can result in a substantial change in residuals and standard error statistics. The economist should remove extreme values or smooth them to fit actual data, particularly if there is evidence that the observed fluctuations are random and not part of a pattern (which residuals analysis should reveal by plotting forecast errors).

9.6 Using Forecasts – Top-Down and Bottom-Up

Forecasts can be developed or purchased from companies. Whichever form that is chosen, ensure that the forecasts are defendable and forecast the necessary information at an appropriate level of aggregation. The P&G requires evaluating a scenario in which commodity growth is capped at 20 years.

Top-Down Forecasts

Top-down forecasts typically used in port studies represent an aggregated approach to commodities and/or regions. The forecast is nominally applicable to the project port from a commodity and/or geographic perspective. The problem is to identify the range of applicability. Because top-down forecasts typically represent a broad coverage of commodity and/or geography, disaggregating to the local port can be difficult. Users of top- down forecasts have to develop rules of thumb or assumptions about disaggregating shares of forecasted values to the region and local port. Previous efforts using similar forecasts for other ports may provide some guidance, but the disaggregation often is subjective and an explicit set of criteria for disaggregation may be absent. For this reason, top-down forecasts that produce large changes in cargo volumes at local ports are usually suspect.

A common form of top-down forecast is a world trade macroeconomic projection that has to be disaggregated to U.S. trade and then to U.S. coast and ultimately to local ports. In some instances, the macro forecast may already be partially disaggregated, as in the case of world trade to U.S. trade. The economist is left with the task of moving from the U.S. to coastal regions and then local ports. This is often accomplished through the use of market shares, but the results should be vetted against recent historical practices and evolving trends. Dynamic short-run shifts in trade among coastal regions and ports are circumspect, particularly when they lead to substantially increased cargo for the local project port.

The macro forecasts are particularly useful for very long-term growth trends for broad categories of marine cargo such as bulk, liquid and containerized. However, most top-down commercially developed world and related U.S. trade forecasts seldom extend beyond 10 years. The economists should be aware that there are model errors associated with the macro forecasts that should be described.

Bottom-Up Forecasts

Bottom-up forecasts reflect the opinions and perspectives of shippers. Most shippers use a short-term forecast timeframe unless there are capital investments and detailed strategic plans such as those that commonly occur in the bulk commodity sectors. Although shippers may be reluctant to share strategic plans other than in an aggregate sense, these are the best expressions of shipper expectations relative to growth. The problem is reconciling divergent growth perspectives from different shippers that appear to have similar competitive circumstances. Where hinterland shippers are relatively few in number, a complete survey of all important users is most desirable. Where there are a large number of hinterland shippers, the survey should be stratified to proportionately reflect the different distributions of commodity flow characteristics of the hinterland population.

Unless the survey is representative of different users (beneficiaries), the results cannot be accurately generalized to the hinterland population of project beneficiaries. Non-representative project hinterland user surveys cannot be used other than on a case-by-case basis. The economist will have considerable difficulty trying to generalize from specific surveys to a hinterland population of shippers. In these situations, it is not uncommon to see ranges of multiple forecasts or scenarios developed to deal with the high level of uncertainty. Better survey coverage eliminating the uncertainty is preferable to multiple forecasts or scenarios.

Best Forecast

It is difficult to have a “best” forecast because of inherent bias, low standard errors and large confidence intervals. Rather, there is usually a combination of approaches and forecasts. The choice of the most appropriate forecast will be determined by the character of the hinterland commodity flow information available. The projections of primarily heterogeneous (such as containerized cargoes) will likely reflect historical time series adjusted by macroeconomic projections for future growth of independent variables. Homogeneous commodity flows of bulk materials will be more susceptible to user surveys to identify expansion plans and the potential for diverted or induced cargoes resulting from with-project conditions.

Caution should be used when aggregating or combining different forecasting techniques so that the economist does not bias results by using different methodologies to obtain the most optimal forecast.

Because all forecasts have a range of inherent error, the economist should be able to express forecasts in a range of values for "high" and "low" relative to critical assumptions with respect to the forecast. The best forecast may be one that appears to be less accurate but is more readily expressed in different levels such as high and low for changes in critical assumptions. A forecast is similar to a point estimate in that an upper and lower bound is needed to express its reasonableness and sensitivity to changes in assumptions.

Projections of changes to the current hinterland traffic should be analyzed across different forecasts, existing or prospective. This insures that the variables used are reasonable representations of the different techniques and applications instead of merely aggregations of optimistic scenarios most attractive to the economist or project. With multiple forecasts, the economist can better indicate the robustness of the projections relative to other assumptions and related projections for high and low values.

Forecasts of the volume of hinterland commodity flows should reflect current traffic, diverted traffic and induced traffic for different commodities. They should also identify the benefit category, vessel type and trade route associated with each projection. Each commodity flow projection should identify the potential for diversion to other ports as a result of other projects. This database and projection will be the primary input to multiport analysis.

9.7 Forecast Period

There is no specific forecast time period for traffic projections over the project life. A 50-year period of analysis is normally used for deep draft navigation projects. However, for various reasons a shorter time period may be preferable for commodity projections. The constraints on the forecast interval may be demand and/or supply related. Regardless, the analysis should show a “50-year” consideration that may be explicit by showing the full 50-year period of analysis or implicit by showing that the forecast interval is constant for the remainder of the 50-year period beyond some future demand or supply constraint.

Demand Driven

Demand driven constraints for both imports and exports on the forecast interval are usually related to a declining industry. Or, demand could be too unpredictable to determine whether there is a long-term growth trend, or an emerging industry that has initial high growth (that is not sustainable in the long run. In these instances, it is not uncommon to cap the demand curve by freezing the forecast interval for growth purposes. The more uncertain the quantity demanded, the shorter will be the forecast interval during which growth will be projected. Imports and exports are likely to have various differences and should be treated separately.

Imports and/or exports of cargoes susceptible to government quotas and restrictions may have to be capped in the near term to reflect these institutional constraints.

Among the shortest forecast intervals is the assumption of no growth in quantity demanded from the without-project condition. Although a no-growth assumption may seem extreme, it is more reasonable than assuming growth when it cannot be supported by analytical or subjective methods.

Demand driven forecasts may also reflect declining industries from a technological perspective. For example, the quantity demanded for breakbulk shipping may experience declines as there is an increased demand for containers.

Supply Driven

Supply driven import and/or export constraints on the forecast interval are usually related to reductions in raw materials and natural resources. For example, in agriculture the supply and productivity of cultivated and developable land or factors such as water for irrigation may be important for the volume of crops. For minerals, the economically recoverable reserves at various prices are a relevant determinant of the supply. Some resource-based minerals and commodity groups may have estimates of recoverable reserves. In many instances, unconstrained 50-year projections with a relatively inelastic supply curve for resources are not appropriate other than for capping supply because of uncertainty or other supply limitations.

9.8 Forecast Integration

Commodity projections and other related data (such as vessel load factors, ship building schedules, etc) are useful as inputs to the vessel fleet projections to determine the number of benefiting ship trips and the sizes of benefitted vessels. Consequently, the commodity projections should be developed for timeframes and durations that are compatible with the vessel fleet projections. The capacity of the port to handle the commodity forecasts needs to be assessed. The acquisition of new cranes, equipment or facilities to accommodate commodity and fleet projections should be verified with the study port.

Port Capacity

Port capacity constraints may exist with respect to the volume of cargo throughput that can be handled at the existing facilities. Furthermore, it should be verified if upgrading or adding cranes and equipment will be required to handle more commodities and/or larger vessels. If so, the marginal cost above and beyond what the port would have done under the without-project condition should be considered later on as an associated cost. Although cargo expansion may be possible, if there is no clear evidence of increased capabilities (notably land), it may be necessary to constrain the commodity projections. A similar analysis should extend to hinterland transportation port access if capacity constraints appear to exist.

Vessel Fleet Forecast

Ultimately, the commodity projections without-project and with-project, including diverted and induced traffic, will become integrated with the vessel fleet projections. Where the commodity projections are the same for without- and with-project conditions, the vessel fleet will be relatively unaffected, other than through fleet trends with respect to size distribution and efficiencies resulting from the with-project conditions.

The commodity projections are dynamic when there is increased cargo (diverted and/or induced movements) under with-project conditions. Increased cargo may result in a different category of benefiting vessels. Alternatively, increased cargo will result in more benefiting vessel calls in the with-project conditions. Increased cargo may affect the sizes or size distributions of the benefiting fleet rather than just the number of vessel calls. Under these circumstances, an incremental approach to the vessel fleet forecast reflecting benefiting cargoes is appropriate.

Initially, the vessel fleet projections should reflect without- and with-project conditions for the existing cargo, assuming no change in cargo for the with-project conditions. Next, increased cargo resulting from the with-project conditions can be used to augment the vessel fleet forecast of numbers and sizes of ships calling for the existing and projected without-project condition. The changes in the vessel fleet distribution in response to increased cargo with-project conditions should be tracked separately from the perspective of benefiting vessels. The NED benefits associated with increased vessel efficiencies for the without-project condition cargo and attendant growth will probably be different from the NED benefits associated with diverted and induced movements.

From a fleet perspective, the only distinction between without- and with-project forecasts may be increased numbers and sizes of vessels. However, from a NED perspective the components of the vessel fleet relating to commodity benefits (existing, diverted and induced) need to be tracked separately. Accordingly, the parts of the commodity projections under with-project conditions should be interjected into the corresponding vessel fleet from the perspective of benefiting cargoes and ships.

Additional Forecasting Information, here are some additional resources that may assist in forecasting:

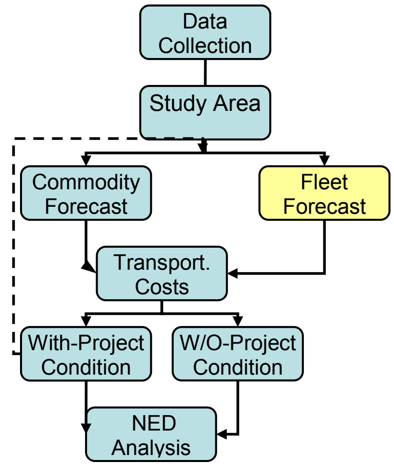
- *Long-term Forecasting of World Grain Trade and U.S. Gulf Exports*, NETS Publication, November 2004
- *A Review of 16 Planning and Forecasting Methodologies Used in U.S. Corps of Engineers Inland Navigation System*, June 1992

9.9 Key Concepts

This chapter is all about commodity movements and:

- The relevant commodities for the study port should be determined and described in terms of actual and potential commerce. The origin and destination information along with transportation modes should be determined.
- Commodity flows tend to follow the least costs transportation route. However, containers may need special examination that demonstrates the delivery costs based on inland routing to distribution centers.
- Forecasts for project conditions should be for 50 years. Many commercial forecasts are limited to less than 10 years.
- Subjective forecasts reflect personal opinions and should be used with caution and in combination with analytical data.
- Long term projections usually use analytical approaches such as trend line or regression analysis. Analytical methods using residual analysis and confidence intervals can add credibility to the forecast.
- Forecasts can be bottom up, top down, demand driven and/or supply driven. There is no “best” forecast, but all forecasts should be integrated with port capacity and vessel fleet forecasts.

CHAPTER 10 – VESSEL FLEET COMPOSITION AND FORECASTS



10.0 Overview

This chapter discusses detailed procedures for developing the existing and without-project vessel fleet compositions and their transportation costs, which correlate with the commodity analysis discussed in the previous chapter. This chapter also expands on the discussions about data in Chapter 7 by using several examples to illustrate the types of data and reports that will need to be generated. The following chapter will bring the commodities, port, and vessel information together to determine transportation costs.

10.1 Vessel Fleet Description

To fully understand the vessel fleet composition for a given port, the economist needs to become very familiar with the existing vessel fleet from the following perspectives:

- Fleet operations, services and deployments – similarities, patterns and disparities
- Fleet trends – number, size, sailing drafts, etc.
- Fleet constraints – draft, channel width, curvature, air draft, tide, cargo, etc.
- Fleet capacity issues – number, size and retirements versus new buildings
- Relevant fleet size – world, regional, or local

It is usually helpful to prepare a 10-year time series of annual vessel trips, calls and sailing drafts. The economist should be particularly interested in whether there are obvious trends relating to the number of deeper sailing drafts and the number of deep draft vessels relative to the authorized project depth.[24]

Once the economist is sufficiently familiar with the detailed characteristics of the vessel fleet, the long-term forecast will be less daunting and often more objective. By knowing as much as possible about the characteristics of the existing fleet (and historical fleet relevant to the project), the economist can better forecast the future fleet. This existing fleet will be the logical point of departure for without-project vessel fleet forecasts.

Vessel Fleet Characteristics

It is time now to turn to an analysis of the port fleet vis-à-vis the world fleet for a given condition. Vessel fleet data can be organized, analyzed, and input into the appropriate condition description. This section expands upon the discussions in Chapters 4 (Port and Vessel Basics) and 7 (Data Collection).

Vessel data collection should be a compilation of actual vessel calls (by service and vessel type) at the project port during a given year. Table 10-1 is an example of part of a port fleet compiled for ‘Small Port USA’. The list was developed from pilots’ logs of vessel names calling ‘Small Port USA’, from which the Lloyd’s Number was determined and associated vessel physical characteristics were compiled. The data can be distilled into a

[24] *This discussion assumes that deepening is a likely project alternative. The discussion of increased numbers of deeper sailing drafts implies decreased or stagnant numbers of shallower sailing drafts, resulting from an overall shift in the sailing draft distribution of trips.*

range of applicable vessel sizes using IWR categories (from the Vessel Operating Costs) or other ranges appropriate to the local port. A world fleet of similar vessel sizes will then need to be compiled.

Table 10-1: 'Small Port USA' Vessel Fleet Calling in Year 2000

Vessel	Lloyd's Number	Flag	Breadth (feet)	Depth (feet)	Building Year	Draft/ Draught (feet)	Deadweight Tons (DWT)	Gross Registered Tons (GRT)	Length Overall (LOA, m)	Sailing Speed	Twenty Equivalent Units (TEUs)
George II	1527697	Norway	31.99	12.30	1992	10.60	1850	347	39	10	50
Alabama Glory	4677954	U.S.	49.21	23.03	1960	17.09	2610	2602	70	13	161
Transfer Star	5468156	St. Vincent	42.06	21.16	1976	17.42	2029	2700	81	12	175
Super Star	9987212	St. Vincent	40.52	21.49	1977	17.85	2500	2832	81.5	13	182
Pioneer Trader	6324875	Bahamas	42.81	22.54	1974	13.91	1760	1919	69.75	12.5	129
Ulysses	3122581	Antigua	46.59	26.08	1975	16.24	2700	1160	87.89	14	184

Table 10-2 is an example of a local port fleet distilled into a set of sizes and appropriate physical characteristics pertinent to the fleet, particularly DWT, TEU capacity and maximum sailing draft. Rarely will the world fleet and the local port fleet perfectly overlap. By definition, the world fleet reflects a wide variety of situations that influence vessel size related to ports, cargoes and trade routes. The local port fleet will reflect a particular composition of the world fleet in terms of vessel size.

Table 10-2: 'Small Port USA' Vessel Fleet Characteristics[25]

DWT	LOA (Feet)	LBP (Feet)	Beam (Feet)	Design Draft (Feet)	Service Speed (Knots)	TPI (Tons/inch)	GRT	Cargo Draft (Feet)	Sail Draft (Feet)	Cargo (Tons)	DWT Used	TEU Capacity
4,000	295	279	43	19	12	28.1	2810	12.86	13.86	1200	0.65	215
3,500	277	256	49	17	13	27.5	2602	11.74	12.74	1200	0.65	160
3,000	274	246	46	17	12.5	24.7	1948	11.93	12.93	1200	0.65	155
2,500	267	243	44	16	13.5	21.9	2075	12.12	13.12	1200	0.65	144
2,000	245	220	43	14	12.5	19.2	1919	11.72	12.72	1100	0.65	120
1,500	213	196	42	14	12	17.1	1650	10.96	11.96	1000	0.7	80
1,000	202	185	42	13	12	15.3	1457	8.71	9.71	800	0.7	40

The 'Small Port USA' vessel fleet is particularly unique to its trade (Caribbean Islands), with no other U.S. or major foreign ports served. Comparisons with a world fleet of small general cargo vessels were not deemed to be relevant given the uniqueness of this trade. Similar analyses would apply to home port local fleets such as commercial fishing, etc.

[25] *Note: Sail Draft = Cargo Draft plus one foot of underkeel clearance. Cargo (short tons) reflects typical volumes (rounded to nearest 100 tons) for sailings that are regarded as "full" with respect to existing channel conditions. Most of the vessels are draft constrained for typical cargo tonnes (cargo) and have excess capacity based on design draft which would result in carrying more cargo (tonnes) as a result of deeper draft under with-project conditions. LOA= Length Overall, LBP= Length Between Perpendiculars, DWT= Deadweight Tons, TEU= Twenty Equivalent Units*

World Fleet Characteristics

Once the port's vessel calls have been compiled, economists need to compile a world fleet inventory for relevant vessel sizes. Table 10-3 summarizes the "world fleet" from the perspective of the type and size categories of vessels. This is an example of what should be shown in the economic analysis for a given year.

Table 10-3: Sample World Fleet Summary

Category/Subcategory	Total Quantity
Containerships	
Post-Panamax	283
Panamax	472
Sub-Panamax	498
Handysize	915
Feedermax	587
Feeder	447
Total Containerships	*3,202*
Tankers	
Very Large Crude Carrier (VLCC)	439
Suezmax	315
Aframax	636
Panamax	258
Handysize	1,082
Small	687
Total Tankers	*3,417*
Bulk Carriers	
Capesize	623
Panamax	1,079
Handymax	1,228
Handysize	2,800
Total Bulk Carriers	*5,730*
Gas Carriers	1,147
Chemical Carriers	2,168
Multi-Purpose	3,380
Roll On/Roll Off (RO/RO)	1,538
Reefer	1,284
Offshore Service	3,813
Total Ships	**25,679**
Total Clarkson's Universe	**25,683**

The purpose of compiling an inventory of vessel physical characteristics is to identify if there are size trends within the categories that occupy the fleet.

Example: World Containership Vessel Trends

World fleet trends are particularly useful when there are changes in a maturing fleet such as Post-Panamax container vessels or a high degree of stability in a mature fleet such as Panamax container vessels.

Table E-1 in Appendix E shows the 2004 world statistics for Panamax containerships. The Panamax size category is defined as: length 280 ft., beam <32.27 ft., design draft 12.2 ft., DWT <62,000 tonnes, and TEU capacity 3,000 to 4,400 tonnes. The world container fleet as of January 2004 had 467 Panamax size vessels, ranging in age from one to 27 years.

An examination of the vessel characteristics compiled in Table E-1 (Average LOA, Average Beam, Average Draught, Average DWT and Average TEU capacity) indicates nearly constant size characteristics (LOA, beam, draught and DWT) with slightly higher TEU capacity for more recent new buildings.[26] The vessel inventory by age and capacity (DWT and TEU) are used to identify prospective retirements using an average age criterion (25 years) although it is recognized that other methods to find replacements may be more refined such as cash flow analysis with benefit/cost analysis. Vessel retirements are used to determine future fleet composition.

The data in Table E-1 suggest that the Panamax container vessel fleet is relatively stable in size other than a slight increase in average TEU capacity. Table E-2 in Appendix E contains an inventory of the world fleet of Post-Panamax container vessels. Compared to the Panamax, the Post-Panamax container vessel category is a relatively recent phenomenon, with over 65 percent of the TEU capacity of this fleet of 282 vessels as of January 2004 having been built after 1999. The fleet size characteristics are evolving as well, with a trend to larger LOA, a beam stabilizing at about 133.2 feet, and a draft stabilizing at about 45.6 feet.

Similar analysis of other fleets would show shifts in the fleet sizes within particular size categories. For example, there have been more Handymax new buildings (40,000 to 50,000 DWT) with a tendency to be constructed closer to the upper range (50,000 DWT). This kind of trend provides insight into the future sizing of the world fleet, as well as likely replacements resulting from age and factors other than growth of capacity from growth in trade.

Expanding this example further, Table 10-4 is a three-year time series of the types of container vessels calling at “Sea Harbor” in 2001 – 2003 compiled from pilots’ logs and augmented by commercial directory data. The majority of the container fleet calling Sea Harbor is Panamax. The Panamax went from nearly half of the identified ships and 55 percent of the total calls in 2001 to 11 percent of the total calls and 12 percent increase of total container ship calls in 2003. There has been a corresponding decrease in smaller container vessels calling at Sea Harbor during the period, notably for Handysize. The Handysize dropped from 158 in 2001 to 105 calls by 2003. By 2003, Sea Harbor had mostly Panamax container vessels, augmented by Sub-Panamax and Handysize. For all practical purposes, there were no regular Post-Panamax, Feedermax, or Feeder

[26] *Increasingly, Panamax new buildings are seeking to maximize TEU capacity because of existing Panama Canal constraints (i.e., without the third lock of the Panama expansion) on vessel size.*

container vessel calls at Sea Harbor.[27] This example shows one format to display trends and what trends to look for.

Table 10-4: Sea Harbor Container Vessel Calls, 2001-2003

Vessel Type	2001 Ships	2001 Ship Distribution	2001 Calls	2001 Call Distribution	2002 Ships	2002 Ship Distribution	2002 Calls	2002 Call Distribution	2003 Ships	2003 Ship Distribution	2003 Calls	2003 Call Distribution
Post-Panamax	1	0.48%	1	0.11%	0	0.00%	0	0.00%	3	0.96%	7	0.54%
Panamax	104	49.76%	510	54.84%	161	56.69%	680	61.87%	190	60.70%	872	67.34%
Sub-Panamax	46	22.01%	170	18.28%	63	22.18%	204	18.56%	64	20.45%	255	19.69%
Handysize	33	15.79%	158	16.99%	32	11.27%	130	11.83%	30	9.58%	105	8.11%
Feedermax	2	0.96%	3	0.32%	1	0.35%	3	0.27%	1	0.32%	5	0.39%
Feeder	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	0.32%	1	0.08%
Subtotal	**186**	**89.00%**	**842**	**90.54%**	**257**	**90.49%**	**1,017**	**92.54%**	**289**	**92.33%**	**1,245**	**96.14%**
Missing TEU	23	11.00%	88	9.46%	27	9.51%	82	7.46%	24	7.67%	50	3.86%
Grand Total	**209**	**100.00%**	**930**	**100.00%**	**284**	**100.00%**	**1,099**	**100.00%**	**313**	**100.00%**	**1,295**	**100.00%**

Vessel Itineraries

This section is the application of Section 5.4 on Vessel Routes and Call Patterns to the various conditions. The economist should determine the port and vessel deployment patterns that account for the distribution of sizes of vessels calling under the existing conditions. Deployment assignment of a vessel to functional service, such as a route. Usually vessels are assigned to routes or geographic deployments reflective of liner and charter operations. Once this is done, it can be expanded to forecast the without-project condition.

One analysis method is to list which routes correspond to various vessel classes. Each commodity would be handled in the same manner, assigning vessels by name and/or size to particular geographic markets to explain the vessel distribution. The geography of the fleet deployment can illustrate what factors affect local vessel size. For example, in 2007, many fertilizer exports from Florida were transported via Panamax vessels to the development ports of Southeast Asia and India. The Handysize vessels transported fertilizer to the less developed ports is Asia.

A least costs analysis can be completed once the transportation costs are estimated. The least cost often determines the various itineraries (with some potential exceptions, such as containerships) and how each would be impacted for various conditions. Specifically, this analysis identifies any changing itineraries between the without- and with-project conditions.

Vessel Capacity Analysis

The world fleet represents the aggregation of the associated deployments and conditions under which these vessels serve. Its distribution can be used as a relatively unconstrained benefiting fleet for purposes of comparison to the local fleet.

As an example analysis, the world container fleet cited in Table 10-5 indicates that slightly more than one-half of the nominal TEU capacity (defined as the maximum TEUs that a ship can carry by volume) is associated with Panamax and Post-Panamax vessels. Although Handysize, Feedermax and Feeder

[27] *Because these are liner services, one would expect to see regularly reoccurring rotation of port calls by Post-Panamax, Feedermax, and/or Feeder instead of sporadic calls, most likely reflecting a charter or shift in rotation for other deployments not regularly calling Sea Harbor.*

vessels comprise about 60 percent of the world fleet number of total container vessels, they reflect only about 25 percent of the nominal TEU capacity of the world fleet. Based on this table and Table 10-4 above, about 41 percent of the world fleet classes and nearly one-third of nominal TEU world vessel fleet capacity are represented by container vessel types (Post-Panamax, Feedermax and Feeder) that do not regularly call at Sea Harbor.

In comparison to the world container fleet relevant to existing conditions at Sea Harbor, the Panamax class represents only 27.5 percent of world TEU capacity; whereas it dominates Sea Harbor calls and reflects about 80 percent of the total TEU capacity calling Sea Harbor.[28] This type of comparison analysis can help predict future trends and describe the without- and with-project conditions.

Table 10-5: 2004 World Fleet Container Vessels and TEU Capacity[29]

VESSEL TYPE	NUMBER OF VESSELS	TEU CAPACITY	TEU CAPACTIY RANGE	PERCENT OF VESSELS	PERCENT OF TEU CAPACITY
Post-Panamax	282	1,638,754	4,500-12,500	8.9%	25.3%
Panamax	467	1,779,287	3,000- 5,000	14.7%	27.5%
Sub-Panamax	494	1,224,795	2,000-3,000	15.5%	18.9%
Handysize	907	1,282,917	1,000-2,000	28.5%	19.8%
Feedermax	584	414,188	500-1,000	18.4%	6.4%
Feeder	444	137,359	<500	14.0%	2.1%
Total	3,178	6,477,300		100.0%	100.0%

The world fleet vessel number and capacity distribution shown in Table 10-5 is fairly typical across different vessel types: a disproportionately large number of small vessels account for a very small proportion of nominal fleet capacity measured in TEU and/or DWT compared to a small number of very large vessels that account for a very large proportion of nominal fleet capacity.

Productivity and efficiency will vary according to the type of vessel and conditions on its trade routes. Vessel voyage records show actual experience, but collections of such statistics are not readily available. Generalized values for use in making adjustments to vessel capacity needed to calculate transportation costs are shown in Table 10-6. The “representative” values do not reflect extreme variations in real life, but may be useful to get a ballpark idea on some vessels. The economist needs to verify the applicability of these assumptions for specific studies and find more recent values as these values do not reflect such changes as the very large vessels being built like the Susan or Emma Maersk with approximately 11,000 TEU capacity.

[28] *An approximation of the annual capacity of container vessel total TEU calling at Sea Harbor based on 2003 calls is 3.847 million TEUs, of which Panamax calls likely contribute about 3.1 million TEU capacity annually, based on an average of 3,500 TEUs for Panamax, 2,500 TEUs for Sub-Panamax, and 1,500 TEUs for Handysize.*

[29] *G.E.C., Inc., based on the Clarkson Register, January 2004*

Table 10-6: Adjustments for Estimating Actual Vessel Capacity (1991)

Cargo Carried	General Cargo	Container Neo Bulk	Neo Bulk	Dry Bulk	Tanker
Cargo Capacity Factors	(adjust ship DWT for fuel, stores, water)				
<20,000 DWT	0.9	0.85	0.9	0.9	0.9
20-70,000 DWT	0.9	0.9	0.92	0.92	0.92
70-120,000 DWT	NA	NA	0.95	0.95	0.95
>120,000 DWT	NA	NA	0.97	0.97	0.97
Cargo Density Factors	(adjust weight capacity for cubic limits)				
all sizes	0.66	0.77	1	1	1
Cargo Load Factors	(adjust for average vs. full payload)				
heavy leg	0.85	0.85	1	1	1
other legs	0.85	0.85	varies	varies	varies

10.2 Vessel Traffic, Inventory, and Replacement Trends

Historical trends are important and need to be established to serve as a baseline for with- and without-project forecasts. Typical trends to evaluate include:

- Vessel traffic
- Vessel inventory
- Fleet age and turnover
- World fleet in comparison to local fleet
- Vessel capacity versus size
- Special vessels types

Vessel Traffic Statistics

It is desirable to collect additional vessel traffic statistics, based on the needs of the NED analysis. Additional information to be considered includes:

- Vessel Calls by Sailing Drafts in one-foot increments (See example on Table 10-7 of partial data for a given port)
- Outbound Container Vessel Calls by Draught and Sailing Draft Greater Than 30 Feet. Table E-4 in Appendix E represents part of the information required to compare Sea Harbor 2003 container vessel sizes (draught) and sailing drafts with 2001 patterns.[30]
- Excess Draught by Year and Direction. Table E-5 in Appendix E relates "excess draught" (maximum draught minus sailing draft) for the container fleet over the time period 2001 through 2003 by direction. Although the data show a similar pattern of excess draught by year and direction, Table E-4 in conjunction with other data show the trend for Sea Harbor as larger vessels loading deeper (rather than existing vessels loading deeper).
- Fleet by Channels Used and Vessel Size

[30] *The 2001-2003 timeframe should not be assumed as generally acceptable for port fleet time series without other information.*

Table 10-7: Example - Vessel Sailing Drafts by One-Foot Increments

		Vessel Drafts by Foot						
Vessel Type	**Service Name**	**<30 feet**	**30.0-30.9**	**31.0-31.9**	**32.0-32.9**	**33.0-33.9**	**34.0-34.9**	**>35**
Feedermax	East Coast U.S. Africa	9	0	0	0	0	0	0
Handysize	East Coast U.S. Mediterranean	28	0	0	0	0	0	0
Handysize	East Coast U.S. Africa	31	4	2	0	0	0	0
Panamax	East Coast U.S., European Union, Mediterranean	3	5	5	3	0	0	10
Panamax	Far East Panama Canal East Coast U.S.	0	1	1	1	1	0	0
Panamax	Far East Suez Canal East Coast U.S.	13	9	6	18	9	6	25
Sub-Panamax	East Coast U.S. Mediterranean	0	3	2	1	1	1	5

Vessel Inventory Trends

Whether forecasts are top-down or bottom-up, the economist needs to consider the existence of trends in the fleet (including age) that are relevant to the future numbers and sizes of the benefiting fleet.

Aggregate fleets are useful compilations that can show trends in vessel size by age (refer to Table E-1 in Appendix E). Often port fleets have to be compiled for several years to identify shifts in the numbers and sizes of vessels. Tables E-3 through E-5 in Appendix E are additional examples from Sea Harbor to reflect the type of data, and representation that should be used in an NED analysis. This information will help describe the existing condition to understand the current port usage and to help predict future usage and needs. Although these examples are only for containerships, similar analysis would apply to other vessels.

From the fleet trend perspective, larger vessels loading deeper is considerably different from existing vessels loading deeper. For more vessels sailing deeper, the issue is whether there have been changes in fleet size distribution that reflect the changes in draft distribution. The underkeel clearance trends can also be helpful.

Table E-3 in Appendix E depicts the distribution of sailing drafts for container vessels calling Sea Harbor during the period 2001 through 2003. In the space of three years, the number of calls increased from 913 to 1,275. In 2001, the percentage of outbound container vessels delayed by tide (sailing draft >38.00 feet) was 5.26 percent of the total (913 calls) compared to 12.05 percent of the total of 1,275 outbound calls in 2003. Although the time span is short, the data clearly indicate more calls by deeper loaded vessels.[31] Table E-4 is part of the information that needs to compare 2003 container vessel sizes (draught) and sailing drafts to 2001 patterns.[32] Both tables are important to any vessel analysis.

[31] *The comparatively short timeframe for compiling the Sea Harbor container fleet (2001 to 2003) does not reflect prior data that shows a longer trend to larger container vessels.*
[32] *The 2001-2003 timeframe should not be assumed as generally acceptable for port fleet time series without other information.*

Table E-5 in Appendix E relates “excess draught” (maximum draught minus sailing draft) for the container fleet over the time period 2001 through 2003 by direction. Although the data show a similar pattern of excess draught by year and direction, Table E-4 in conjunction with other data would show larger vessels loading deeper as the trend for Sea Harbor (rather than existing vessels loading deeper). This information can help the economist determine if more depth would be beneficial and utilized for various vessel types.

For short-term trends such as those displayed in Table E-3, the economist should identify whether there have been structural changes in the fleet during this period that would account for the observed trends. For example, are larger vessels calling with deeper sailing drafts or are the existing vessels loading deeper as a result of increased cargo?[33] From the standpoint of the sailing draft distribution the answer is meaningless, but from the fleet trend perspective larger vessels loading deeper is considerably different from existing vessels loading deeper.

Fleet Age Distributions and Vessel Replacement

Vessel age distributions are important because it’s one factor in replacement. Once the vessels reach a certain age, it is likely that this will indicate the time for a new investment to maintain or expand existing fleet capacity. Replacement age may vary by fleet and type of service. Normally, 25 years has been used; but for some specialized fleets such as refrigerated vessels, products tankers and pressurized vessels (LNG, LPG, ammonia, etc.), the age may be higher.

Age distributions can be compiled from the perspective of the world fleet and/or detailed data on the local fleet. The simplest assumption to project replacement rates for the world and local fleets is to assume that all vessels will be replaced in kind with no growth in the vessel sizes. In actuality, predicting this trend is difficult. Old ships being replaced are replaced with the same or similar capacity, with larger vessels, or new (growth) trade could require additional capacity and ships that vary by size

When the world fleet and the local fleet are not dissimilar but the age distributions are dissimilar, there are implications for capacity changes. For example, the local port may have much older vessels than the rest of the world. What is deemed as older in the world market may be deemed acceptable for the local market; thus, much older local vessels are replaced with younger, but still "older" world vessels.

Turnover, Replacement and Redeployment Trends

There are several signals for turnover, replacement and redeployment trends. This includes aging, the commodity demand, capacity trends and efficiency, build rates, and more.

The gradual replacement of the aging components of the local, regional, or world fleet as a result of retirement (age) signals a chance to change the fleet mix of size and capacity. However, another indicator of replacement in addition to age is the anticipated future cash flow of a vessel and route. A vessel could be replaced in a year if it was determined to be functionally obsolescent. Likewise, a vessel might be used for much longer than initially anticipated if such use had greater benefit than cost of replacement.

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[33] *Because the container vessels are liner services calling multiple domestic and foreign ports, the increased cargo may not be necessarily related to Sea Harbor only.*

In some instances there are clear trends that new orders or recent new buildings have been of a larger size within a fleet category, such as the tendency to larger TEU capacity on Panamax vessels nearing the maximum quantity that deck stowage will allow. Where new investment or redeployment of existing vessels such as larger (draught) container vessels calling Sea Harbor is clear, it is reasonable to assume that the existing vessel fleet capacity mix will not be replaced in kind.

Vessel fleets have been growing larger, with spurts of dramatic development in size for particular sectors followed by more gradual shifts to larger vessels. Bulk fleets shifted to larger vessels dramatically in the 1980s and to a lesser degree in the 1990s. Container vessels have been undergoing the Post-Panamax vessel size explosion since the late 1990s.

Other than dramatic introductions of new large-capacity vessels (usually in response to rapidly growing markets that will economically sustain larger vessels), most mature fleets exhibit very gradual shifts in the size distribution of vessel capacity. For the most part, this gradual movement will be checked by absolute constraints (such as at the Panama Canal).

Usually, without-project conditions are not the impediment that prevents the replacement of the existing vessel fleet with much larger vessels. The economist will have to make the case that with-project conditions will result in a substantial (as opposed to a gradual) shift in the vessel fleet. The argument of a shift of vessel size at the local level in the absence of new markets or substantial increase in commodity flow is particularly difficult to sustain in the absence of a clear trend to larger vessels for without-project conditions.

Vessels may follow deployment life cycles among trades, cargoes and for size. The introduction of very large bulk ships and container ships in certain trades usually does not result in an increase in retirement of smaller older vessels. Instead, they are displaced to other trades pending economic replacement at the end of the life cycle. The Post-Panamax container vessels displaced Panamax vessels to smaller trades that most likely displaced Sub-Panamax vessels, etc.

There are obvious geographic and deployment limits to vessel displacement. Nevertheless, there is a clear pattern of deployments of new buildings that may have little relation to the local or regional port fleet except by substitution over time and geography.

Rather than assume a fair share (or otherwise) portion of larger new buildings, the economist must be able to demonstrate the likelihood of deployment of new capacity that has direct or indirect implications for the local port fleet.

Redeployment of larger displaced vessels is usually linked to growth in the trades. For example, some of the north-south East Coast U.S. trade routes in the container sector have been progressively experiencing larger container vessels as the volume of trade increases.

The fleet size changes in any trade are particularly useful in identifying the trends and then projecting future changes based in part on the availability of displaced tonnage from other sectors of the world fleet in conjunction with growth in trade for the particular service or cargo.

Capacity Versus Size Trends

For bulk vessels, shipper interviews will indicate the criteria for shipment size and frequency and the tradeoffs regarding larger vessels.

For liner vessels, size deployment and growth issues are often mingled, dependent on the services and changes in port calls and deployments. Lines will usually make every effort to minimize cost by efficiently deploying the largest size vessel with due allowance for seasonal cargo volume fluctuations and normally some allowance for short-term growth in trade. The largest vessel will be conditioned on the service frequency that is regarded to be most competitive with the demands of the shippers. Weekly service frequency is usually expected for most major liner trades. Consequently, vessels will often be sized for these factors and changes in vessel size will require a substantial change in cargo volume from growth and/or change in deployment (additional ports or feeding services, etc.)

Vessel capacity (tonnage or TEU) will usually be linked to projected cargo volumes. Even modest cargo volume growth can have a substantial impact on the amount of vessel tonnage during a long-term forecast. Unless there is a change in the fleet size distribution, the fleet will grow in number proportional to the projected commodity growth. Changes in the fleet distribution with a shift toward larger vessels will reduce the number of vessels because fewer larger ships will replace the capacity of smaller vessels.

Cargo projections will usually be used to grow the fleet capacity. Then, a projection of vessel size distributions will be used to allocate the fleet capacity to different size strata. The size strata distributions should be compatible with past trends, other ports, similar fleets, and/or forecasts.

Substantial commodity growth accompanied by pronounced shifts in vessel size distribution can dramatically change the composition of the numbers and sizes of vessels in the local fleet. Although one may assume the reasonableness of both the cargo and the fleet distribution projections, the interaction between the two forecasts can have major implications for a fleet that may have been relatively constant in size and/or number of vessels. The economist is faced with a tradeoff between the number of vessel calls of the same size driven by the commodity projections or the sizes of vessels calling driven by the commodity projections and the size distributions of tonnages across fleet capacity.

The economist should consider developing a sequential vessel fleet forecast that reflects commodity growth but no change in vessel size distribution and then subsequently introduce shifts in size distributions of capacity for without- and with-project conditions. Different shifts in fleet size capacity distributions might be used to demonstrate the effects on total numbers and sizes of calls during a very long-term forecast. This will allow analysts to obtain a better understanding of the interaction between commodity projections and fleet size projections on the numbers and sizes of calls, rather than a point estimate based on one size distribution.

Special Purpose Fleets

Special purpose fleets may be prospective for continuation under the without-project conditions or for substitution by conventional vessels under with-project conditions. The economist should look at the fleet profile to determine if the average age of the non-specialized fleet applies to the specialized fleet (as discussed in Section 4.4). To forecast a comparatively young special fleet with no immediate retirement prospects, it is advisable to use similar fleets for which there is published information or a marine consultant may be useful in developing a life-cycle profile for the fleet.

Early in the plan formulation, it should be determined whether and to what extent special purpose fleets such as shallower or narrower vessels might serve as substitutes for conventional vessels constrained by local port conditions. Specialized vessels usually have to be in place under without-project conditions to be efficient compared to conventional vessels.

It’s important to understand the degree to which special purpose vessels can serve as an economically efficient alternative to conventional vessels under without-project conditions or under different with-project conditions. The economist should be able to demonstrate that unique vessel designs with respect to size are not feasible compared to conventional vessels. Otherwise, special purpose vessels may be feasible in plan formulation for without-project conditions as well as some ranges of with-project conditions.

10.3 Reconciling Port and World Fleets

The local fleet should be expressed as a subset of the relevant world fleet (such as container vessels calling Sea Harbor). This might not be true if the port fleet is truly local and not otherwise reflected elsewhere in the world fleet (e.g. ‘Small Port USA’). It is useful to try to describe the local port share of the world fleet from the perspective of the existing fleet and the historical fleet. The share of the local port of the world fleet or regional fleet can be described in the context of the actual deployment of the vessels (historical and existing fleets) and, later, the projected fleet for without- and with-project conditions.

One important reason for compiling the vessel fleet distribution beyond the local port is to have a context for how the local port fleet might change over time (without-project conditions) and under with-project conditions. This is particularly important when the world fleet is changing in sizes and numbers of vessels and the issue is to what extent the local fleet will change in numbers and sizes proportional or disproportional to the world fleet.

Comparing the port and world fleet distributions allows discovery of:

- How the port and world fleet are related
- To what extent is the local fleet unique
- Can the local fleet be disaggregated into world fleets based on geography, routes served and cargoes that will be consistent with the world fleet?

If the economist can demonstrate that the local port's share of a vessel fleet size strata has been changing and indicate why that has occurred (trade route or cargo circumstances), it will be much easier to project growth in the share of larger vessels vis-à-vis other ports.

For example, if competing ports or terminals in the same port partially serve different markets with different size vessels, it should be easy to demonstrate that the vessel size and the local port are related to the particular markets served. One terminal may primarily load Handymax vessels for smaller ports, whereas another may load Panamax for larger ports. The respective shares of the sizes of the bulk fleet can be explained on the basis of markets served and with-project conditions relative to the vessel fleet.

Vessels have economies of scale such that larger ships typically cost proportionally more than smaller vessels to purchase and operate but can carry much more cargo.[34] Consequently, larger vessels will have lower average total costs per tonne of cargo when they are efficiently utilized compared to smaller efficiently utilized vessels. Therefore, as cargo volume grows over time and in the absence of shipment size constraints, it would appear reasonable that those larger vessels might displace smaller tonnages. The most desirable situation is when it can be demonstrated, using a time series analysis, that the substitution of larger vessels for smaller tonnage has occurred for the local port. Further substitution for the same trade might be continent on with-project conditions; and further substitution for other trades for the local fleet might be contingent on growth in trade volume.

10.4 Fleet Forecasts

By analyzing and comparing the port and world vessel fleets, the economist has observed trends and developed some assumptions in regard to the future fleet Sometimes the forecast assumptions are not explicit and have to be inferred from the forecast itself.

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Commercial forecasts can be problematic in disaggregating them to the specific port that is being studied. Often the same trends observed in commercial fleet forecasts can be discerned by looking at the vessels on order that are usually contained in the commercial directories of existing and new buildings (orders).

The economist should first verify if existing fleet forecasts have been recently performed by the port or industry. Commercial sector vessel fleet forecasts exist, usually devoted to a particular segment of the world fleet such as dry bulk, refrigerated vessels, etc. Seldom will there be a world fleet forecast for all vessels in one compendium. The commercial sector is normally producing special fleet sector studies serving particular cargo niches around vessel types and trades.

For specialized fleets, commercial sector vessel fleet forecasts are very useful. Some of the niche vessel/cargo markets are particularly volatile and subject to change. Examples of specialized vessel niches that can be linked to particular trades and developments include Pure Car Carriers (PCC) as a segment of Roll-On-Roll-Off (RORO), dry bulk Handy size vessels, ammonia and other pressurized vessels, and refrigerated carriers.

[34] *Vessel new building costs and most categories of operating expenses (other than crew) correlate well with size expressed as DWT.*

For example, Table 10-8 compares a 1998 container vessel fleet forecast for Sea Harbor in 2003 with actual developments with respect to the design draft of vessels calling. The actual vessel calls by design draft clearly demonstrate that the 1998 forecast significantly understated the shift to larger container vessels (design draft) that would call Sea Harbor within a few years of the forecast. By 2003 the actual container fleet for design vessels 44 feet and greater was larger with respect to design draft than the projected fleet for 2010!

Table 10-8: World Containership Fleet Forecast 2000-2050 and Actual Fleet in 2004: Number of Fully Cellular Vessels by Draft Category

Design Draft (ft.)	Projected 2000	Actual (1) 2003	Actual (2) 2003	Projected 2003	Actual (2)-Projected	Error	Projected 2010	2020	2030	2040	2050
<38	1,925	2,318	2,078	2,154	-76	-3.64%	2,798	3,246	3,384	3,348	3,175
38	209	122	240	250	-10	-4.35%	382	473	514	621	718
39	124	125	122	129	-7	-5.41%	140	141	156	175	195
40	113	24	125	122	3	2.58%	145	163	165	192	216
41	22	174	24	24	0	1.46%	28	31	31	31	34
42	159	113	174	195	-21	-11.86%	312	392	486	590	683
43	111	10	113	127	-14	-12.22%	173	205	242	290	332
44	8	97	10	8	2	23.14%	7	6	5	5	4
45	55	143	97	60	37	38.53%	72	81	97	116	130
46	47	12	143	62	81	56.35%	121	195	260	321	373
>46	11	47	59	13	46	78.39%	18	22	25	31	35
Total	**2,784**	**3,185**	**3,185**	**3,142**	**43**	**1.35%**	**4,196**	**4,955**	**5,365**	**5,720**	**5,895**

Notes: Actual (1) 2003 contains fractional design drafts (feet) not rounded. Actual (2) 2003 rounds fractional design drafts (feet) upward to nearest foot of measurement.

Understanding recent historical vessel forecasts and their relationship to the present fleet at the subject port can provide insight into the issues in making long-term projections for the benefiting fleet.

In Table E-5 in Appendix E, for example, for Sea Harbor, the local fleet had been growing in size substantially greater than what had been forecasted. Similar comparisons could be made for other major East Coast U.S. ports with similar services and vessels such as Norfolk and Charleston.

10.5 Fleet Forecasting Approaches

There are a number of different approaches to vessel fleet forecasting, ranging from disaggregation of the world fleet to a regional fleet or conversely from a local fleet aggregation to a regional fleet. Technical approaches will differ with respect to:

- demand-supply models
- efforts to optimize the port fleet from a vessel efficiency size perspective

This section will address the perspectives of top-down (disaggregate) or bottom-up (aggregate) forecasting. The approach taken to the fleet forecast (top-down or bottom-up) is dependent on the circumstances. Sometimes both approaches should be used to insure a measure of reality and reasonableness of results, particularly for small specialized fleets such as pressurized vessels (LNG, LPG, ammonia, etc.).

The best forecast is one that has clear and reasonable assumptions about the future linked to the changes in the number and size of vessels in the fleet over time.

Top Down (Disaggregate)

The top-down approach will develop a macro level forecast and disaggregate to a more specific focus relevant to the local port. Typically a world or regional fleet forecast is developed that is then used to develop a local port benefiting fleet forecast.

Disaggregating the world fleet to the local fleet involves assumptions about the share of the changes of vessel capacity relative to the routes/deployments serving the region and the port, including changes thereto.

For example, the forecasted number of container vessels by size categories for a long-term world fleet container vessel forecast could be summarized for ten-year. The data might show the total number of vessels and nominal fleet capacity for five-year periods between 2004 and 2050. A similar forecast for bulk vessels would use DWT tonnes as a nominal measure of fleet capacity rather than TEU.

The world fleet container vessel forecast in Table E-6 in Appendix E shows:

- The total fleet capacity will be increasingly dominated by Post-Panamax vessels, increasing from 26 percent of total nominal fleet capacity in 2004 to nearly 46 percent by 2050.
- The share of Panamax fleet of total world container fleet nominal capacity is projected to slightly decrease from 27 percent in 2004 to 24 percent in 2050.
- Although the total number of Panamax and Sub-Panamax container vessels will rise as a percentage of the fleet, their aggregate nominal capacity share of the total will decline.
- The total number of Handysize and Feedermax vessels will decline as a share of the total world fleet.

The implications of the world fleet forecast for the regional or local fleet are most obvious when there is a close similarity between them. Accordingly, given sufficient depth, it would appear inevitable that the Post-Panamax vessels will eventually begin to call the East Coast for appropriate deployments other than the Panama Canal. The local fleet forecast would have to make assumptions about the extent to which Post-Panamax vessels would penetrate the ECUS by way of new deployments or substitution of existing Panamax vessel services.

Bottom Up (Aggregate)

Fleet forecasts of the benefiting vessels can be aggregated to a local or regional level by a compendium of the services or deployments. The local fleet trends (usually short term) are helpful in identifying changes that might be reflected on a more regional scope. A time series of calls and drafts for five to ten years is the basis for the projections. Sometimes shorter-term trends are documented through pilots' records. The shorter-term trends will typically tend to be clearer for liner services because of the greater stability of the vessel fleet. The charter market will display shifts among similar size vessels and sailing drafts as a function of ship supply and demand or shifts in shipment size and deployment.

The local fleet is compared to that of similar ports with similar services. For example, container vessels calling at the East Coast U.S. could be compared for the same services, particularly in the Far East and Europe, for such things as sailing draft. Bulk vessels with similar deployments could likewise be compared, such as white bulk product (related to cement) exports from the Columbia River and San Diego Harbor, coal bulkers at Baltimore and Norfolk, and grain bulkers at GCUS (particularly Lower Mississippi and Houston).

The fleets are compared for similarities and differences for particular shared trades and routes. If the vessel fleet or cargo and deployments are sufficiently similar, a regional fleet can be compiled to which the local fleet can be related as a market share. Changes in with-project conditions at the local fleet can be used to adjust the market shares of the regional fleet and/or the world fleet.

Assumption: Usually changes in the fleet size distribution are presumed to be gradual unless there are significant constraints that are removed by the with-project conditions accompanied by major commodity growth.

Tables 10-9 and 10-10 are good examples of what may be seen in an economic analysis. For example, Table 10-9 depicts similar information for bulk vessels for a vessel queuing study where transit drafts were not of interest. Table 10-10 depicts the size distributions (LOA) of vessels calling the "Upper River of Wind Harbor", used to disaggregate the total number of projected calls by vessel type. The comparatively small number of vessels, low projected growth of the number and size of vessel calls, and lack of any harbor improvements that might affect the fleet did not necessitate use of a world fleet projection.

Jax Port, Jacksonville District

Table 10-9: Upper River Tanker Vessel Arrivals (Inbound Only), 2002-2004

	2004		2003		2002		2004-2003		2004-2002	
LOA (ft.)	**Count**	**Percentage**	**Count**	**Percentage**	**Count**	**Percentage**	**Average**	**Percentage**	**Average**	**Percentage**
498	1	0.9%	0	0.0%	0	0.0%	1	0.4%	0	0.3%
531	3	2.6%	3	2.6%	2	1.9%	3	2.6%	3	2.4%
585	74	64.3%	67	58.8%	68	64.2%	71	61.6%	70	62.4%
650	10	8.7%	11	9.6%	19	17.9%	11	9.2%	13	11.9%
685	10	8.7%	20	17.5%	6	5.7%	15	13.1%	12	10.7%
716	0	0.0%	0	0.0%	2	1.9%	0	0.0%	1	0.6%
745	16	13.9%	13	11.4%	9	8.5%	15	12.7%	13	11.3%
771	1	0.9%	0	0.0%	0	0.0%	1	0.4%	0	0.3%
838	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Total	115	100.0%	114	100.0%	106	100.0%	115	100.0%	112	100.0%

Table 10-10: Upper River Vessel Calls by Vessel Type by Calendar Year

Vessel Type	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Breakbulk	70	71	71	72	73	74	74	75	76	77	77	78	79	80	80	81	82	83	84	85	85	86
Bulk	150	152	153	155	156	158	159	161	162	164	166	167	169	171	172	174	176	178	179	181	183	185
NCT container	726	784	843	907	973	1,043	1,087	1,132	1,132	1,132	1,132	1,132	1,132	1,132	1,132	1,132	1,132	1,132	1,132	1,132	1,132	1,132
New container	0	0	0	0	0	0	0	0	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,300	1,300	1,300
Ro-Ro	70	71	71	72	73	74	74	75	76	77	77	78	79	80	80	81	82	83	84	85	85	86
Tank	230	232	235	237	239	242	244	247	249	252	254	257	259	262	264	267	270	272	275	278	281	283
Tug/Barge	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	114	115	116
Other	25	25	26	26	26	26	27	27	27	27	28	28	28	28	29	29	29	30	30	30	31	31
Total	1,365	1,429	1,495	1,565	1,638	1,715	1,765	1,817	2,124	2,231	2,338	2,445	2,552	2,660	2,767	2,874	2,982	3,089	3,197	3,204	3,212	3,220

Notes: Vessel trips are counted as one-way passages.
New container terminal assumed to open in year 2012.

10.6 Summary of Assumptions

Regardless of the approach, the forecast will rest on the adequacy of its assumptions. As long as the assumptions are reasonable, the forecast should be reasonable. This section will summarize the important assumptions to consider inherently as part of a long-term vessel fleet forecast.

Turnover and Replacement

Assumption: Over the life of a 50-year forecast, part of the fleet will be replaced two times under a 25-year age life. However, this assumption should be examined carefully considering the benefits and costs for shippers for replacing various vessels.

Assumption: The simplest way to project the world and local fleets is to assume that all vessels will be replaced in kind with no growth in the size of vessels.

Assumption: Where new investment or redeployment of existing vessels is clear (such as larger (draught) container vessels calling Sea Harbor), it is reasonable to assume that the existing vessel fleet capacity mix will not be replaced in kind.

Other than dramatic introductions of new large-capacity vessels, most mature fleets exhibit very gradual shifts in the size distribution of vessel capacity. For the most part, the gradual movement of the mature vessel fleets to larger sizes will be checked by absolute constraints that prevail in the trade (such as the Panama Canal).

When there is an assumption of significant redeployment of larger vessels to the local fleet, the economist has the responsibility for demonstrating the reasonableness of this phenomenon relative to growth trends (vessel and commodity) and share of the relevant world fleet.

Share of World Fleet

Assumption: It is unlikely to realize the optimal fleet when there are a limited number of the most efficiently sized vessels and they are usually shared among the ports.

Economists normally assume that under with-project conditions the port fleet might reflect the most efficient distribution of the vessel fleet. The so-called "optimized" fleet would reflect the most efficient sized vessels assigned from the world or regional fleet to the local port. However, the same argument could be made for other ports and projects as well, with a resulting shortage of optimum sized vessels.

Capacity versus Size

Vessels have economies of scale such that larger ships typically cost proportionally more than smaller vessels to purchase and operate but can carry nearly four times as much cargo.[35] Consequently, larger vessels will have lower average total costs per tonne of cargo when they are efficiently utilized compared to smaller efficiently utilized vessels.

[35] *Vessel new building costs and most categories of operating expenses (other than crew) correlate well with size expressed as DWT.*

Assumption: As cargo volume grows over time and in the absence of shipment size constraints, it is reasonable that those larger vessels might displace smaller-sized vessels.

Assumption: Unless there is a change in the fleet size distribution, the fleet will grow in number proportional to the projected commodity growth.

Special Purpose Fleets

A rule of thumb is that specialized vessels (in terms of design) usually must be in place under without-project conditions to be efficient compared to conventional vessels. Special purpose vessels once built typically have little or no other efficient use.

Assumption: Where specialized vessels exist, it must have been determined that they were the most efficient alternative to deployment of conventional vessels.

10.7 Summarizing Analysis Data

It is helpful to prepare a 10-year time series of annual vessel calls and sailing drafts. The economist should determine obvious trends relating to the number of deeper sailing drafts and the number of deep draft vessels relative to the authorized project depth. The ideal is to be able to show from the data that there is a "fleet draft shift" over time, with higher percentages of deeper drafts relative to the authorized depth. The fleet draft shift trend is a clear indication of use of larger vessels.

Once the economist has an understanding of the trends in vessel trips, calls, and drafts, the next step is to obtain a similar time series (10 years suggested) for commodities from the Waterborne Commerce Statistics Center (WCSC). The WCSC reports total tons by commodity group and type of movement.[36] The commodity trends should be related to the vessel trends with respect to the number of calls if there is no substitution of larger vessels. The economist should look for a clear trend of growth of commodity volumes (particularly significant cargoes) from the perspective of share of total tons and use of deeper draft vessels. Where there are no clear commodities trends, the economist must look for evidence of possible new cargoes or take into consideration that with deepening more cargo may move on fewer vessels (or more cargo may be induced).

Calls and drafts will provide the first evidence that vessels are calling with drafts nearly equal to or exceeding the authorized project depth (tide riding). However, the data will not indicate the actual size of the vessels in terms of draught (maximum sailing draft) and other vessel characteristics.[37]

[36] *The WCSC data do not explicitly report containerized cargo tons or units (TEUs). Time series for these data are available from WCSC and the public domain. Planners should be aware that containerized units (TEUs) may be reported for loaded boxes or all boxes, loaded and empty. In addition, there is a degree of uncertainty in TEU numbers because they are based on larger boxes (40-foot or larger) that are dominant in U.S. marine terminals. Thus, the planner should expect to find slight differences in the estimates of "TEUs" for particular ports and years.*

[37] *Trips and drafts data do not reveal vessel identities, which may be important for small specialty harbors and cargoes served by a small number of vessels making repetitive calls.*

10.8 Fleet Composition in Multiport Analysis

At this point, the economist should have a good idea about which ports and cargoes are competitive with the study port. In a more extensive multiport analysis, the economist should develop vessel calls and draft profiles for each port based on similar cargoes and overlapping or similar markets. This is particularly important if the authorized project depths at these ports are equal to or greater than the project port.

When the same or a similar vessel fleet is calling competing ports, the fleet characteristics relative to sailing drafts at deeper ports is an indication of what may occur at the project port. The vessel calls, drafts trends and the commodity volume trends at the project port can be viewed in the context of the activities of competing ports. For example, clear growth trends in vessel calls and drafts at competing ports with deeper authorized drafts could be an indicator of project port opportunities under with-project conditions. Conversely, the absence of clear trends for competing ports with the same or less authorized depths suggests that the project port may not be unique. The absence of trends in the vessel and cargo sectors may be caused by conditions such as volatile bulk commodity markets that are unrelated to channel depth.

The following tasks should be completed as part of this step:

- Determine the given fleet composition and trends at competing ports (using similar sources used for the subject port). The existing fleet forecast analysis for the study port can be applied to movements through competitive ports if coastal or trade route fleets are similar.
- A separate fleet forecast should be prepared for competing ports only if the fleets are structurally different and causes can be assigned to the observed distinctions. For example, vessels may shift to various ports depending on the various port drafts and berth sizes available.
- Determine if the study port is a market leader or a market laggard with respect to commodity tons and vessel calls and drafts at similar and/or competing ports
- When there are differences in fleets among competing ports, the economist needs to convert vessel characteristics into costs for relevant commodity trade routes. If the differences between fleet size characteristics are constant, the resulting differences in fleet costs are clear. However, when there are different fleet size distributions at competing ports, the economist has to calculate a weighted average fleet cost for each port commodity trade route to reflect the different composition of vessel characteristics

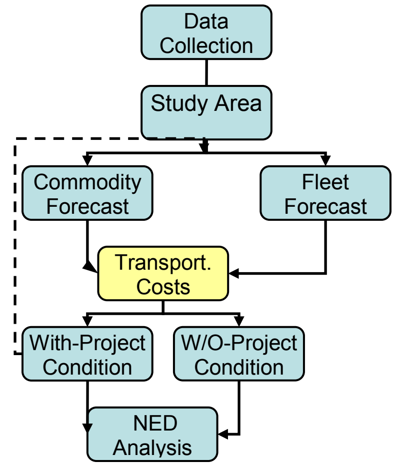
10.9 Key Concepts

The key chapter concepts about vessel fleet composition and forecasts are:

- Vessel fleet descriptions should be at the local, regional, and international levels. Vessel characteristics should be described, compared and contrasted to lead into reasonable fleet forecasts.
- Historical trends help establish the baseline for forecasts and compiling a vessel inventory is crucial to the process
- Vessel itinerary and a vessel capacity analysis ensures reasonable forecasts in combination with reconciling port and world fleet size distributions
- Trends on vessel traffic, inventory, age, turnover, replacement and redeployment help the economist understand how often vessels that call at the port are replaced, and that has implications on sizes of vessels to call in the future.
- Similar to commodity forecasting top down, bottom up, demand driven, and/or supply driven are techniques for forecasting. Additionally, size optimization model may also be useful.
- All assumptions should be listed and there are some commonly held assumptions such that larger vessels have economies of scale.
- Separate forecasts and analysis are necessary for competing ports in a multiport analysis.

Port of Oakland

CHAPTER 11 – DETERMINE TRANSPORTATION COSTS



11.0 Overview

The PGN calls for use of current transportation costs in NED evaluation. Costs are to include the full origin-to-destination costs, including necessary handling, transfer, storage, and other accessorial charges.

In the case of ocean transportation, rates are volatile and there is evidence that they are unrelated to long run costs. The practical solution for ocean carrier costs has been to estimate operating costs based on sampling and vessel replacement.

Section 7a of the Department of Transportation Act of 1966 (P.L. 89-670) requires use of prevailing overland carrier rates for inland waterway studies. Inland carrier rates may correspond more closely to marginal costs, but under deregulation the effective rates may be unobtainable. For the navigation studies covered by this manual, any combination of actual rates or cost estimates based thereon may be used. However, efforts to identify and apply marginal costs more precisely can be challenging.

Historically, deep draft navigation studies have focused only on the incremental change in ocean transportation costs attributable to channel improvements. That simplifies the analysis greatly and is acceptable if there are conclusive reasons why the channel improvement will not affect the vessel fleet composition or the commerce of other ports.

11.1 Ocean Transportation Costs

Channel improvement benefits are directly related to vessel operating costs. If the costs go down due to fuel price fluctuations, competitive pressures, or technological improvements, benefits will be decreased in the same proportion. This can cause great stress. The Institute for Water Resources develops vessel operating costs which are approved by Headquarters and published as an Economic Guidance Memorandum (EGM) every two years. The EGM includes vessel operating costs for certain common vessel types, but the PGN allows license to develop port-specific vessel costs. That license can be used for unique vessels or vessel fleets. An example of ocean transportation costs can be found in Appendix G.

Vessel Operating Costs

The Corps has issued information on deep draft and shallow draft vessel operating costs since the 1960s. Costs are presented for basic vessel types in the array of sizes desired by Corps economists (deep sea tankers, dry bulkers, containerships, and general cargo vessels; inland towboats and coastal tugs by horsepower, barges by type and size). The information is published in ***Economic Guidance Memorandums***. This can be found at: http://www.usace.army.mil/CECW/PlanningCOP/Pages/egms.aspx

The three major components of vessel operating costs are:

- vessel replacement or financial costs
- fuel
- fixed operating costs, including crew and all other costs.

Table 11-1: Sample of Vessel Operating Costs for Foreign Containerships

ESTIMATED FOREIGN FLAG CONTAINERSHIP COSTS (FY99 PRICE LEVELS)
ITF APPROVED - OPEN REGISTRY - 7 YEARS OLD - DIESEL SHIP

TEU	600	1,000	1,200	1,400	1,600	2,000	2,200	2,500
DWT	9,000	14,000	17,000	20,000	23,000	28,000	31,000	35,000
Replacement Cost	19,627,747	24,216,000	28,804,252	33,392,504	37,980,757	42,569,009	49,451,387	54,039,640
CRF: 6.875 %, 20 Yrs	0.0935	0.0935	0.0935	0.0935	0.0935	0.0935	0.0935	0.0935
Annual Capital Cost	1,834,759	2,263,659	2,692,559	3,121,459	3,550,359	3,979,259	4,622,609	5,051,509
Crew Cost	701,135	742,703	784,271	825,838	867,406	908,974	971,325	1,012,893
Lubes & Stores	229,401	237,396	245,391	253,387	261,382	269,378	281,371	289,367
Maintenance & Repair	483,084	494,046	505,009	515,972	526,935	537,897	554,341	565,304
Insurance	314,233	328,460	342,687	356,914	371,141	385,368	406,708	420,935
Administration	101,053	101,384	101,715	102,046	102,377	102,708	103,205	103,536
Fixed Annual Op Cost	1,828,906	1,903,990	1,979,073	2,054,157	2,129,241	2,204,325	2,316,951	2,392,035
Total Annual Fixed Cost	3,663,665	4,167,649	4,671,633	5,175,616	5,679,600	6,183,584	6,939,560	7,443,544
Total Daily Fixed Cost	10,468	11,908	13,348	14,787	16,227	17,667	19,827	21,267
Daily Fuel Cost at Sea	2,255	3,514	4,346	5,073	5,791	7,070	7,772	8,706
Daily Fuel Cost in Port	384	384	480	480	480	576	576	582
Daily Total Cost at Sea	12,722	15,421	17,694	19,860	22,019	24,737	27,599	29,973
Daily Total Cost in Port	10,852	12,292	13,828	15,268	16,708	18,244	20,404	21,850
Hourly Total Cost at Sea	530	643	737	828	917	1,031	1,150	1,249
Hourly Total Cost in Port	452	512	576	636	696	760	850	910

Vessel Costs

Vessel operating costs per day or per hour must be converted to voyage or ton-mile costs for most study purposes.

The actual ton-mile, or transportation, costs will depend in part on how fully laden the project port vessels are on their voyages. Cargo deadweight or payload seldom exceeds 95 percent of the nominal deadweight used to display operating costs by vessel size. The tons per inch (TPI) immersion factors are applicable only to incremental changes in draft in the usual range of loaded vessel drafts.

Additional assumptions needed to produce transportation costs include:

- vessel lading on all loaded and light legs of its voyage
- idle and productive port time
- sea time that reflects voyage circuitry and weather delays

Assumption validity will affect transportation costs as much or more than the accuracy of daily vessel costs. When vessel costs (or benefits) appear to be too low, the problem usually is that the transportation costs are unrealistic, not the operating costs.

Transportation costs can be calculated using project port information on vessel itinerary, load factors and voyage cycle time previously described. Alternately, effective annual capacity can be estimated using assumptions of voyage circuitry, load factors, and port and sea time from vessel fleet forecasts.

Port-specific information is most readily available for bulk carriers and tankers, especially those with regular port–to-port routes.

For liner vessels and other vessels with complicated itineraries, port-specific information is desirable, but use of "effective capacity" assumptions may be a necessary expedient. It is generally accepted that liner vessels spend about 60 percent of their time in port and about 15 percent loading and unloading cargo.

Vessel productivity will vary according to the type of vessel and conditions on its trade routes. Generalized values are shown in Table 11-2 for the adjustments to voyage duration to calculate transportation costs. Its "representative" values may not reflect extreme variations in real life, but may be useful in the absence of more specific information for the vessels at the project port. It is recommended that the economist verify these assumptions for specific studies.

Table 11-2: Vessel Duration Adjustments per Voyage

Cargo Carried	**General Cargo**	**Container Neo Bulk**	**Neo Bulk**	**Dry Bulk**	**Tanker**
Voyage Duration	(in days, depends on itinerary and cargo)				
Unproductive Port Time	(Total for entering/ clearing/ holidays/ etc.)				
U.S. - North Europe	7	4	3	1	1
Central & West Coast South America	10	8	4	2	1
Mediterranean & East Coast South America	23	10	5	3	1
Australia, Pacific Islands	27	14	5	3	1
East & West Africa, Red Sea	35	16	15	12	1
Loading & Unloading	(for each loaded leg of the voyage)				
<20,000 DWT	7	2	4.5	3	2
20-70,000 DWT	8	3	7	4	2
70-120,000 DWT	NA	NA	9	6	2
>120,000 DWT	NA	NA	NA	7.5	3
Sea Time	(depends on actual distance, plus one day for each canal)				

Delay Costs

The cost of delays is a significant factor in ocean transportation costs. The adjustment in Table 11-2 for unproductive port time covers delays waiting for:

- tides (See Appendix C)
- better weather
- inspections
- clearance
- vessel crew’s inability to work cargo due to strikes or holidays

The adjustment *is* appropriate for delays elsewhere than the project port. The cost of delays should be determined with reasonable precision because any cost reduction attributable to the project flows directly to project benefits. Delays due to weather or awaiting tides are accounted for as additional port or sea time of cargo vessels. This understates the value of the *time* somewhat because it does not reflect lost employment opportunity, but the difference is so slight it is not worth pursuing.

For fishing vessels and pleasure boats, lost opportunity is the customary measure of delay cost.

The cost (and to some extent the frequency) of weather and tide delays of cargo vessels will increase with larger vessel size. Project port delay costs can be quantified in the calculation of per ton transportation costs or as a separate calculation:

- A separate calculation is preferable for weather delays because it can handle seasonal variation.
- A calculation for tide delay costs as part of transportation costs is preferable, because delays are related to vessel sizes.

Assumption: In calculating tide delay costs, models like HarborSym can assist in predicting delay and estimating the associated costs. If a with-project alternative cannot change the weather or tide delays, then these become less important to capture. See Appendix C for more information on tides.

Mean High and Mean Low Tides

The simplest calculation method uses mean high and mean low tide heights at the project port and the daily duration of intermediate heights based on relationships shown in the Tide Tables. The tide required will depend on vessel draft. The useable tide window and maximum tide will be determined by the vessel's channel transit time.

Cost of delay time for each channel transit by a tide-dependent vessel is its daily operating cost (sea cost for entering vessels, port cost for departing vessels) minus the daily duration of usable tides. Tide heights will vary with port location and moon phase.

Some studies have used an average amount of delay for vessels of a given size, based on vessel operator records or observation. That degree of simplification is discouraged.

Using one-foot increments of tide and ignoring fractions is appropriate. Applying assumptions as to "average" delay may overstate or understate delay costs. Use of the mean high and low tides may also understate delay when tides are not symmetrical.

More information about tide analysis can be found in Appendix C.

Vessel Damage and Risk Costs

Project benefits for vessel damage or risk reduction may apply due to deeper channels, wider channels, or better weather protection. Damage reduction benefits are usually associated with pleasure or fishing craft because of the large number of small craft and their potential for frequent but relatively minor damage due to groundings, collisions, or allisions. Accident statistics are available for small craft, but quantifying the safety benefits is usually impractical due to diversity of operators and their practices.

Marine accident records are available from the U.S. Coast Guard annual compilation of casualty statistics in an automated system called Coast Guard Automated Main Casualty Data Base (CASMAIN). In some accidents, the Coast Guard will conduct an inquiry, which may also be valuable in determining navigation problems. The National Transportation Safety Board also reviews specific accidents and develops reports and recommendations on site-specific safety issues. Information from the local pilots and, at some ports, data from vessel traffic services (VTS), if available, can provide valuable information in designing proposed channel improvements. The local Coast Guard District Office and Captain of the Port should be consulted for any available data and investigation summaries. The U.S. Committee on the Marine Transportation System may also have additional information.

Damage statistics for large vessels may not be useful, but their deviations from safe clearances are more apparent. It is generally more rewarding to claim safety benefits for large vessels based on risk reduction. Their collisions are infrequent and tend to be catastrophic and unrelated to channel constraints. Their groundings seldom require shipyard repairs, but may result in difficult-to-determine costs such as suspension of hull insurance.

A cost for risk-taking is needed in order to determine safety benefits. It may be needed to justify the safety margins designed into Corps projects. However, this would not be the case if similar risks are taken with and without a project. It could also be the case that risks could be higher in the with-project condition. In lieu of actual damages, the economist should rely on logic and economic theory:

- Logic: vessel operators will use substandard clearances when possible as long as their perceived benefits from doing so (revenues/ job security) exceed their perceived costs from potential damages.
- Economic theory: perceived benefits may be unrelated to costs; the appropriate comparison is between the marginal savings in the cost of transportation and the marginal costs attributable to risk taking.

Provided there is a pattern to the risk-taking at the project port (vessels above a certain size use a safety clearance less than the Corps design standard), the point at which decreasing cost savings intersects increasing risk costs can be identified and related values can be determined.

Charleston Harbor

Table 11-3: Identification of Risk Cost of Substandard Underkeel Clearance

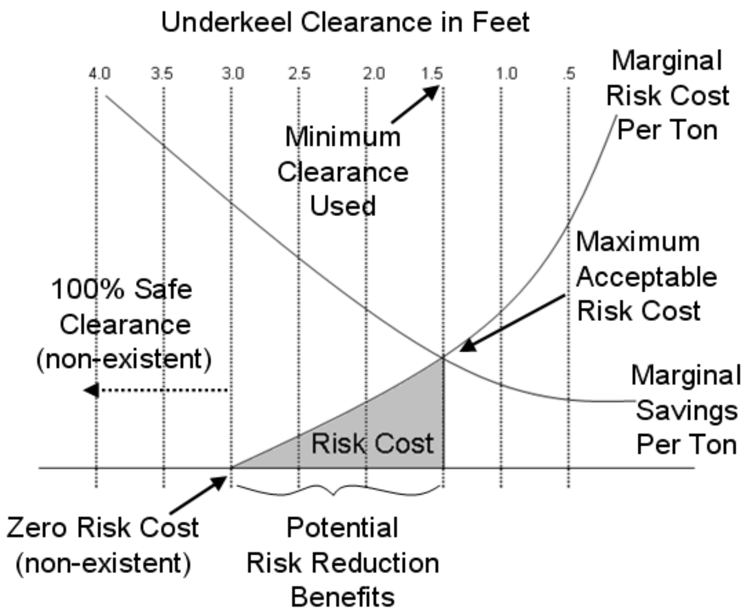


Table 11-3 illustrates the risk theory for underkeel clearance that could occur under both the without- and with-project condition. The vertical axis is in dollars and the x-axis is underkeel clearance. The "marginal savings per ton" is the incremental benefit per ton of loading more and subsequently reducing underkeel clearance. The "marginal risk cost per ton" is the incremental damage per ton for each foot of reduced underkeel clearance. This line is a probabilistic function of estimated damages. Vessels will accept an underkeel clearance in which the marginal cost of the risk equals the marginal benefit per ton. Accounting for the nonlinear curves of savings and risk costs would produce a more accurate number. Average transportation costs will change with vessel size and route, and total project risk costs will require similar calculations for all cargoes carried on relevant ship sizes. Risk costs must be calculated for the without- and with-project conditions to determine the amount of cost reduction and project benefits.

Usually there are operating rules or engineering regulations that determine the amount of underkeel clearance. Corps manual EM 1110-2-1613, Hydraulic Design of Deep Draft Navigation Projects, is a good guide to risk-free depth and horizontal clearances, but it is advisable to check with project port pilots and vessel operators to determine their standards.

Identification of substandard clearance actually used will require statistics that demonstrate a pattern to risk-taking. The economist will see a plateau of vessel drafts deeper than the generally recognized safe depth or a plateau of sizes bigger than the largest size considered safe for the channel width.

The Corps design criteria usually call for two or three feet of safety clearance under the deepest point of the ship. In practice a two-foot clearance is common and in a few ports it may be 1.5 feet. Depending on the specific port, that could leave a difference of 0.5 to 1.5 feet to be accounted for by risk.

This concept can be applied to "oversize" as well as "overloaded" vessels, provided a lower level of precision is acceptable (as shown in Table 11-4).

Example: Muddy Harbor Risk Costs

For example, Table 11-4 displays the vessel sizes for “Muddy Harbor.” The port is naturally deep but has swift currents and constrained maneuvering room. Based on Corps channel design criteria, the channel could be considered nearly risk-free only for vessels up to 15,000 DWT. However, larger vessels routinely used the channel, with a distinct plateau of sizes at 40,000 DWT. This same type of analysis would be done for both the without- and with-project condition.

Table 11-4: Identification of Risk Cost for Oversize Vessels

Vessel DWT (payload)	Vessel Revenue	Revenue Per Ton	Marginal Revenue Per Ton	Risk Cost Per Ton
15,000	$ 480,000	$ 32.00	$ -	$ -
20,000	$ 510,000	$ 25.50	$ 6.50	$ 1.50
30,000	$ 560,000	$ 18.67	$ 6.83	$ 2.50
40,000	$ 600,000	$ 15.00	$ 3.67	$ 3.67

The calculation of risk costs and risk reduction benefits is performed apart from transportation costs and the results displayed separately.

In the case of "oversize" vessels, the "per ton" costs are applied to the tonnage of cargo expected to move in the specific sizes and could be integrated into transportation costs easily.

In the case of "overloaded" vessels, it is possible to calculate the risk cost for the actual increments of reduced clearance by specific vessels or vessel types, but that is time-consuming.

Provided the vessel fleet is reasonably homogenous and there is essentially just one difference between zero risk and acceptably safe clearances (typically 2' vs. 3'), risk costs or benefits can be taken as one-half the deepening benefits for the initial deepening increment equal to that difference (e.g. one-half the benefits of deepening a 35-foot channel to 36 feet when the difference is 2' vs. 3').

caution

Some projects may cause vessels to continue to act in risky behaviors similar to their current behaviors to capitalize on the improvements even more. Certain projects could actually induce more risky behaviors. Therefore, it is important to consider these possibilities as well and describe this.

If project benefits have been calculated based on substandard but actual underkeel clearances, the accounting for risk will add benefits. Alternately, if benefit calculations used the standard risk-free clearance but vessels use less (e.g. they operate in a 35-foot channel as though it were 36 feet deep), accounting for risk-taking reduces those benefits. In either case, the improvement project should reduce the need for risk reduction measures by vessel operators (slower speeds, etc.). To the extent those cost reductions can be quantified they are benefits. Absent an identifiable cost, trim reduction can only be used to explain actual drafts.

Risk costs and tide delays are both likely to apply to both the without- and with-project conditions. A net reduction is likely because, typically, there will be a smaller number of larger vessels that can be delayed and the opportunities and incentive to accept risk will be reduced.

11.2 Inland Transportation Costs

Inland transportation rates or costs are another important cost component. Because inland origins and destinations usually outnumber the vessel trade routes, a disproportionate amount of effort may be required.

One alternative is to limit the number of inland movements to those of significant size. To do that, one will need a preliminary identification of the port hinterland and the principal commodity movements.

The most useful alternative is to use costs in lieu of rates. Hinterland definition and multiport analysis require sufficient rate and cost information.

Carrier tariffs are complex and it is difficult to identify the commodity classification and routing that produces the most favorable rate. Costs are almost always adequate for initial identification of port hinterlands. They may be adequate for benefit calculations and analyses.

For simple applications such as identifying the hinterlands of two ports with somewhat identical depths and vessel costs, inland costs can be assumed to be linear and hinterland boundaries will be determined by inland route length.

When vessel costs are not equal or more than two ports are involved, it will be necessary to mimic the non-linearity typical of actual rates. The simplest way is an allowance for terminal costs plus the linear ton-mile cost. This is the basis for most cost algorithms and transportation cost models. Several models are available, ranging from simple modal cost estimates to multimodal system models that can be used to determine port routing. One model may not have the combination of modes needed for the project port's analysis. It may be necessary to use a combination of models or manual calculations.

Port, Terminal and Cargo Transfer Costs

Identification of port expenses is part of the requirement to account for all transportation costs. They are not included in the deep draft vessel operating costs produced by the Corps. They may or may not be included in ocean vessel rates. Port expenses include a number of charges.

Some charges are a large part of overall transportation cost and can affect port selection, but are unlikely to be affected by channel improvements. Other expenses such as tug assistance and pilotage are relatively insignificant in overall costs, but can be reduced by channel improvements.

Although it may be desirable to analyze only the costs affected by channel improvements, the appropriate way to package them is with port expenses per the requirement.

Components of port expenses are similar port to port, but cost levels and billing methods vary regionally and by port. Table 11-5 shows the usual components of port expenses. While the table shows typical sources for the individual cost items, a most helpful source will be someone at the project port who is familiar with the various charges and tariffs and willing to explain them. That person is likely to be concerned with costs at competing ports. All the port expense information needed should be able to come from one source.

Table 11-5: Port Charges and Sources

Item	Potential Source
Wharfage	Terminal owner or terminal operator tariff
Dockage	Terminal owner or terminal operator tariff
Receiving and Delivery	May be negotiate rate or in terminal tariff
Stevedoring (cargo handling)	Negotiated rate, generally considered proprietary
Pilotage	Tariff rate based on vessel size and/or draft
Tug Assistance	Tariff rate based on time and/or service
Line handling	May be published, based on time or service
Customs & Government Services	Combination of published fees and negotiated rates, local inquiry needed
Agency and Inspection Fees	
Assessments, etc.	

Although port expenses in foreign ports approximate those in U.S. ports, the prevailing practice in NED analysis is to disregard them because a disproportionate amount of effort could be involved with multiple overseas origins and destinations.

For analysis of domestic coastwise or domestic offshore movements, it may be necessary to identify both origin and destination port costs. This will determine whether channel improvements produce a shift in port routing or transportation mode. If any U.S. harbor user fees (Federal or local) are included in transportation costs, offsetting benefits should be shown. Alternately, as transfer payments, the fees can be omitted from both costs and benefits.

Although stevedoring and cargo receiving and delivery charges are the biggest port expenses, those costs may not be readily available because they are generally negotiated and are considered proprietary. Therefore, the economist should check with their colleague first to try to obtain an estimate of these costs.

Summarizing Transportation Costs

The PGN calls for use of current transportation costs in NED evaluation, and states that those costs are to include the full origin-to-destination costs, including necessary handling, transfer, storage and other accessorial charges. They include:

- Modal and Inland Costs
- Ocean transportation costs
    - Vessel fleet
    - Vessel light loading
    - Vessel payloads
    - Voyage Distance and Duration
    - Tides

- Vessel Operating Costs, including:
    - Fuel
    - Replacement
    - Crew
    - Supplies
    - Maintenance
    - Insurance
    - Fixed operating costs
    - Costs associated with underkeel clearance practices
- Port, Terminal and Cargo transfer costs
    - Use of facilities (wharfage and dockage)
    - vessel loading and unloading (stevedoring)
    - cargo transfer to/from inland carriers (receiving and delivery)
    - tug assistance
    - pilotage
    - inspections

11.3 Transportation Costs in Multiport Analysis

For the multiport analysis, ocean transportation costs, inland transportation costs, and port and cargo costs need to be calculated for vessels and cargos at each competing port. These costs will serve as the baseline for later projections and least cost analysis. Least total cost delivery analysis enables classifying commodity flows as “captive” or “competitive,” unless there are non-price aspects of port competition. This means that the least cost route is likely to prevail unless there are other factors outside of the transportation chain that influence the route.

For example, container traffic may by ports other than the least distant port from the hinterland, within a range of transportation cost differentials to ton or TEU/FEU[38], for reasons such as location of distribution centers. Competitive cost differentials represent a zone of indifference between exclusively “captive” and exclusively “competitive” traffic classifications in circumstances of non-price competition. When traffic is shared because of non-price competition, the economist has to allocate the flows among competing ports on a historical market share basis or on non-price service characteristics such as frequency and reliability.

Transportation costs are found similarly as the study port and therefore can be an extensive analysis if done to this level of detail. The economist must decide on an appropriate level of effort to compile all relevant origin-to-destination costs. Economists should identify the most important components of delivered transportation cost (vessel, port, and hinterland) from the standpoint of size and variability. Domestic transportation costs, such as rail and truck, are often the most important factor because they shape the port hinterlands.

Competitive hinterlands, trade routes and ports usually are determined on the basis of delivered cost unless important institutional factors exist, such as inventory in transit or domestic transportation routes. Shipper interviews and market analysis can provide the appropriate criteria, including institutional factors, to delineate competitive hinterlands and trade routes as part of a least total cost framework.

[38] *Container traffic for overlapping port hinterlands may be handled by particular lines on a least total cost basis that is particular to vessel deployments and utilizations and not necessarily reflected in the planner’s compilation of total costs of vessel, port, and hinterland.*

The objective is to develop production and distribution cost differentials between competing hinterland flows and ports. Economists should identify the transportation cost components where there are the greatest differentials. There may be tradeoffs in hinterland trade route flows between economies of scale of larger vessels and increased distances between the origin/destination and port.

For example, shifts in flows may occur based on delivered cost differences associated with different vessel routings, ports, and hinterland flows. This is particularly relevant for general cargo and containers, which have a wider geographic range of ports compared to bulk cargoes.

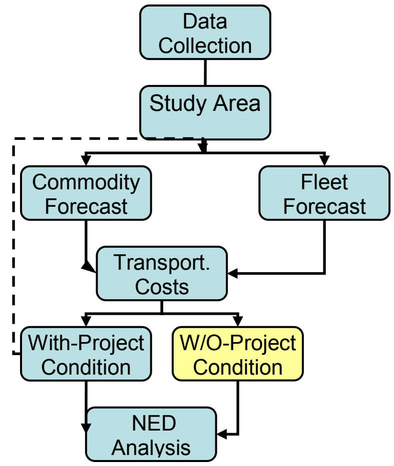
Models that can determine port routing will facilitate multiport analysis, but one model may not have the combination of modes needed for the project port's analysis. It may be necessary to use a combination of models or manual calculations.

11.4 Key Concepts

This chapter covered how to calculate ocean transportation costs and inland transportation costs. Key concepts are:

- Generic vessel operating costs are published as EGMs about every 2-3 years. The major components of these costs are financial costs, fuel, and fixed operating costs
- The PGN calls for use of current transportation costs in NED evaluation and states that those costs are to include the full origin-to-destination costs, including necessary handling, transfer, storage and other accessorial charges.
- Additional vessel costs derive from loading/unloading, idling, productive, and sea time. Weather delays, tides, traffic and other factors can increase transportation time and therefore increase costs.
- Vessels will operate around risks and also accept certain risks depending on the likelihood and consequence of the risk. Hypothetically, the vessel operators will assume the same amount of risk that allows an equal benefit for that risk.
- Alternative movement and inland transportation costs are important to determine the commodity movement if no action is taken in the future.
- Multiport analysis requires that alternative transportation costs, including other ports, to be examined more carefully to determine whether or not with-project alternatives will merely transfer commerce or actually decrease transportation costs as a whole.

CHAPTER 12 – DESCRIBE EXISTING AND WITHOUT-PROJECT CONDITIONS



12.0 Overview

This chapter is an overview of existing conditions and how it relates to determining the without-project condition. The without-project condition is the basis of NED analysis and the alternative to which all other alternatives are compared. By this point, the existing condition description should be nearly complete and the future without-project well underway.

The existing condition is the basis for the without-project condition. It should describe what is happening at a harbor and why. In previous chapters, the following concepts were reviewed:

- navigation and planning basics
- data collection and appropriate information sources
- describing the planning setting and economic study area
- commodity flows and forecasting
- vessel fleet composition
- transportation costs

These concepts compiled together not only are a framework to describe the existing conditions, but they are the basis for the without-project conditions and defining the with-project alternatives.

12.1 Existing Condition

The existing condition simply describes the project area based on the most currently available information. The condition represents a scenario from which other impacts can be measured and calibrated to. The existing condition generally focuses on the portion of the port, its fleet and commodity flows that will be affected by the project. Information developed and data collected as part of the process of defining the existing condition will provide the foundation for describing the planning setting for the study, defining the economic study area, determining transportation costs, and identifying problems and opportunities.

12.2 Determine Future Without-Project Condition

The without-project condition simply consists of those future conditions most likely to prevail in the absence of the proposed project. It starts at a base year, the year at some point in the future when the proposed alternatives would be fully functional and start generating benefits, typically continues out 50 years from that point. The base year is not the same as the study year. When the future is uncertain, which it often is, multiple without-project condition scenarios can be used to describe this uncertainty.

Generally, it may be desirable to distinguish between the point of reference for measuring impacts (the existing conditions) and the point of reference for measuring project benefits and costs (the without-project condition.)[39]

[39] *The decision to differentiate between the baseline and without-project conditions will be determined largely by changes that are expected to take place between the time the analysis is conducted and the time the project is*

As a general rule, specifying the without-project condition should revolve around the concepts discussed in this chapter, which are:

- tractability
- resolved issues
- critical issues
- commodity flows
- fleet composition

Tractability

The purpose of the economic analysis is to recommend a course of action. In reaching this recommendation, it is imperative that the logic upon which the recommendation is based be presented in a straightforward manner. Each decision, assumption, or parameter estimate associated with any condition/ combination is predicated on previous decisions, assumptions, or parameter estimates. The economist must decide which of these best contribute to understanding the logical flow that leads to the recommended course of action.

Subject to resolved and critical issues, the without-project condition should follow the path that allows for the clearest explanation of the analysis.[40]

Resolved Issues

At this point, the analysis will have resolved some issues with respect to the project. The purpose of the multiport and alternatives analysis is to determine how the competitive position of the project is altered by actions at the port and/or at competing ports. It is possible that some of these actions will not affect the estimated project commodity flow levels or relative transportation costs. If this is the case, these factors should be considered resolved issues and simply be incorporated into the without-project condition.

Critical Issues

The most difficult aspect of specifying the without-project condition revolves around critical issues. These are the factors that cause relatively large changes in commodity flows or transportation costs. At this stage of the analysis, the economist must make a judgment as to which future conditions are most likely to prevail and include them as part of the definition of the without-project condition or to specify multiple scenarios. Sensitivity analysis could also be key to this issue. The economist must rely on information generated during the data collection and data analysis phases of the study to assess critical issues.

implemented. If significant changes are expected, it may be desirable to distinguish between the effects of these changes and changes which can be directly related to the proposed project.

[40] *Perhaps a more functional method for understanding this concept is the distinction between generating results (the analysis) and presenting the results. Do not clutter the presentation of the analytical results with a broad discussion of all the analytical details and iterative procedures supporting the logical flow that led to the results.*

12.3 Understanding the Issues

Vessel Calls and Drafts

In terms of vessel calls and drafts, the economist should determine obvious trends relating to the number of deeper sailing drafts and the number of deep draft vessels relative to the authorized project depth.[41] A rising number of deeper draft vessel calls will usually result in greater percentages of these calls compared to total calls over time.

The ideal is to be able to show from data trends that there is “fleet draft shift” over time, with higher percentages of deeper drafts relative to the authorized depth. The fleet draft shift trend is a clear indication of changes in the use of the harbor by larger vessels and/or deeper loaded existing vessels.[42]

There may not be a clear trend to deeper vessel drafts due to fluctuations in the number of related vessel calls (such as volatile bulk commodity markets), or container vessels calling with a disparity of drafts based on changing deployments, cargo volumes and densities. Under these circumstances, the economist will need to understand the aggregate trends in vessel calls and sailing drafts displayed by the vessel calls and drafts data.

An absence of a clear trend in the numbers of deeper vessel drafts/calls is not an indication that a project is not needed. It indicates that there are other factors that prohibit the emergence of a discernable trend for a “fleet draft shift” to be displayed by the calls/drafts data.

For example, a fleet draft shift will not be observed if the existing fleet is already calling near maximum loaded drafts (such as very high proportions of total calls within two to four feet of the authorized channel depth with allowances for underkeel clearances and tides included). The call data will also indicate the extent of tide riding behavior by vessels calling (inbound or outbound) at or exceeding the project authorized depth. This is often a good second point of departure when the overall trip data are stagnant or not clearly shifting in terms of deeper sailing draft calls.

It is counterproductive to engage in cargo characterization and projection before understanding the existing characteristics and operations of the vessel fleets at the harbor.

[41] *This discussion assumes that deepening is a likely project alternative. The discussion of increased numbers of deeper sailing drafts implies decreased or stagnant numbers of shallower sailing drafts, resulting from an overall shift in the sailing draft distribution of trips.*

[42] *At this point in the analysis, it is not particularly important to determine whether existing vessels are loading deeper or larger vessels are calling. The issue is the extent to which more deeper-sailing drafts are evident from the vessel trips and drafts data.*

Commodity Trends

Once the economist has an understanding of the trends in vessel calls and drafts, the next step is to obtain a similar time series (10 years suggested) for commodities from the Waterborne Commerce Statistics Center (WCSC). The WCSC reports total tons by commodity group and type of movement.[43]

Deep Draft harbors are usually characterized by a preponderance of foreign commerce. There will be domestic commerce in some trades (particularly coastal movements of refined products). However, the draft-constrained and growing fleets with respect to deeper draft calls reflect foreign trade. Alaska, Hawaii and the U.S. Gulf can be exceptions to the foreign trade trends.

The commodity trends should be related to the vessel call trends if there is no substitution of larger vessels. The economist should look for a clear trend of growth of commodity volumes (particularly significant cargoes) from the perspective of share of total tons and use of deeper draft vessels. When the commodity trends are not well defined or are fluctuating in volume, the vessel calls will usually display similar behavior.

Where there are no clear positive commodities trends, the economist must look for evidence of possible new cargoes or take into consideration that with deepening more cargo may move on fewer vessels (or more cargo may be induced).

Flat commodity trends do not necessarily indicate an absence of future growth, but they do require that a stronger case be built for growth expectation that is not premised on the adage “if we build it they will come.” Cargo volume information (beginning with WCSC) that does not support a growth trend will need to be augmented by research into such things as markets that may arise under the with-project conditions or that are linked to future without-project conditions.

Identify Navigation-Related Constraints

Calls and drafts will provide the first evidence that vessels are calling with drafts nearly equal to or exceeding the authorized project depth (tide riding). However, the data will not indicate the actual size of the vessels in terms of draught (maximum sailing draft) and other vessel characteristics.[44]

Comparing the draft to the sailing draft for each “constrained” vessel is the clearest indication that vessels are calling light loaded. "Constrained" means that a vessel would choose to travel at a deeper draft if it were possible. (There are instances when some light loading may be a function of fluctuations in matching vessel capacity (DWT) and cargo. This is particularly common in bulk sectors where larger vessels may be chartered at lower costs per ton carried while still light loaded.)

However, there are also draughts substantially higher than sailing drafts for container vessels on multiple port rotations where cargo volume and density

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[43] *Contact WCSC for domestic containerized cargo data or to obtain .international container data provided by PIERS. Planners should be aware that containerized units (TEUs) may be reported for loaded boxes or all boxes, loaded and empty. In addition, there is a degree of uncertainty in TEU numbers because they are based on larger boxes (40-foot or larger) that are dominant in U.S. marine terminals. Thus, the planner should expect to find slight differences in the estimates of “TEUs” for particular ports and years.*

[44] *Published trips and drafts data do not reveal vessel identities, which may be important for small specialty harbors and cargoes served by a small number of vessels making repetitive calls. Contact WCSC to obtain this information.*

fluctuate across the ports called, particularly if the project port is not a first or last port of call on a wider Trans Atlantic or Trans Pacific deployment.

The arriving and departing times recorded by pilots for loaded vessels can be matched with tide cycles to determine the extent to which vessels sailed concurrent with tides (tide riding). This is particularly important whenever reported sailing drafts equal or exceed the authorized project depth (less allowance for underkeel clearances, etc.).

Port capacity or other impediments, as discussed in Chapter 5, not directly related to the without-project conditions may affect the numbers and sizes of vessels that can be handled. For example, air draft constraints by bridges may limit vessel sizes or operations (low tide riding behavior).

The economist should understand the capacity of cargo handling and storage systems and any landside constraints that may affect the ability of the marine terminal to receive or discharge cargo in sufficient volume to meet ship berth times. Berth capacity constraints will be an absolute impediment to vessels in the absence of such things as new cargo handling and storage capacity.

Once the secondary data have been studied, the economist can conduct field visits to acquire a more complete understanding of navigation operations and constraints. Care must be taken to reduce any bias in this process..

- Field visits should include discussions with pilots and vessel operators. Local pilots are the best source for current (and usually more detailed) vessel data. Pilot data on vessel transits usually identify the specific features of each call.
- Port ship agents are usually familiar with harbor conditions and how vessels may be affected by navigation constraints.
- Vessel operators can provide insight into whether there are particular navigation issues at the local port that affect deployment and efficient vessel use readily observable. For example, vessels may be rerouted to deeper ports prior to calling at the project port because of draft issues. The rerouting of vessels can be costly because of the extra time involved in circuitous navigation. Effectively, the vessels are lightering their cargo at other ports before calling the project port.

12.4 Commodity Flows

It is important as part of the economic analysis to discuss and evaluate commodity flows disaggregated by commodity group, trade route and benefit category. This disaggregation also contributes to defining the without-project condition. By examining the disaggregate commodity flows, it is possible to determine if a factor has a robust (widespread) impact on traffic or is limited to a small number of origin-destination pairs or scenarios. This is addressed as part of the risk analysis.

Generating the commodity flows includes analyzing the existing traffic and transportation costs along with other factors to forecast future commodity flows. This will help determine if a multiport analysis is necessary. The without-project condition could be multiple scenarios; one scenario could be chose or to make the analysis more robust to reflect uncertainty, several scenarios could be evaluated. The result is, an estimated project commerce or range or project commerce adjusted for each study year (or time interval) and scenario.

12.5 Fleet Composition

Delineating the fleet composition for the without-project condition follows the same logic as the adjustments to the commodity flows described above.[45] The current fleet reflects a mix of current cargo type, primarily this is dry bulk, liquid, breakbulk and containers. As the commodity mix changes, the fleet will be adjusted to reflect these changes throughout the period of analysis. The fleet composition will also reflect any operational considerations, practices, or constraints existing at the project, as well as effects of user-implemented projects.

How the fleet changes in response to various factors will provide information that will assist in defining the without-project condition and commodity flow assessment. Factor could include ship building rates, world economic conditions, and more. Factors that do not have a broad impact on the fleet composition (that is, they are not robust) are best addressed in the risk analysis. Factors that do have a broad impact on the fleet composition should be assessed in terms of their likelihood of occurrence and included in the without-project condition as appropriate.

12.6 Multiport Analysis: Wrapping It All Up

At this point, it is likely that the existing condition in multiport circumstances has nearly been described already. This is the basis of forecasts in the without- and with-project multiport conditions. If the without- and with-project conditions have not yet been described in relationship to competing ports, then the economist may need to repeat the analysis steps. The process is iterative and it is usual to have multiple iterations to calibrate, clarify, and better define the conditions.

The end product is usually a subset of the project port analysis in which the benefiting fleets and cargoes are the baseline for a similar analysis of transportation costs for other ports. The effort devoted to the multiport analysis should be proportional to the expected impacts on NED benefits for the project port.

The analysis will encompass:

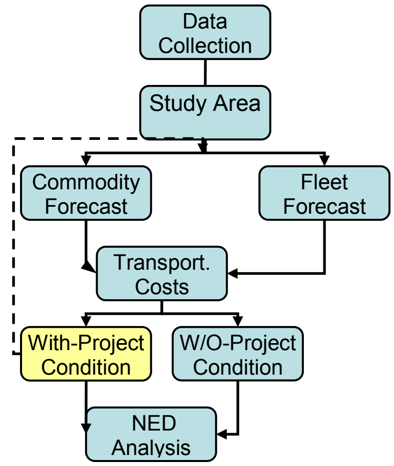
- introductory overview of the multiport system
- multiport hinterland description
- competing commodities
- regional fleet description
- transportation costs for cargoes moving through each competing port

[45] *In this discussion, it is assumed that the project in question is not so important to international trade that it significantly alters the world fleet. If the project is important to international trade, both the fleet and commodity forecasts must be completed simultaneously with specification of alternative conditions.*

12.7 Key Concepts

- Existing conditions are the foundation for NED analyses and benefit calculations. It describes what is happening at a harbor and why. It is the basis for forecasting the without-project condition.
- The without-project condition is the baseline for all with-project comparisons. It is a set of assumptions that covers the physical, economic and policy conditions that will apply at the project site in the future.
- The economist should “tell the story” by taking the reader to the harbor through maps, tables and graphs that familiarize the reader with the situation.
- The economic analysis should be clearly written, traceable, describe resolved and critical issues, risks, uncertainties, and constraints. All facts should be laid out clearly for decision makers to be able to make the most informed decision based on the most up-to-date information.
- Vessel fleets and commodity composition and trends require description and analysis.
- Multiport analysis is usually a subset of the project port analysis in which the benefiting fleets and cargoes are the baseline for a similar analysis of transportation costs for other inter-related ports.

Navy Vessel



CHAPTER 13 – WITH-PROJECT ALTERNATIVES

13.0 Overview

The Corps is responsible for fully analyzing an array of alternatives to determine the NED plan. The Corps must consider a no action plan (without-project condition), structural and non-structural alternatives in this analysis. Essentially, describing the with-project alternatives will require repeating the steps discussed in Part II. The process is iterative, but necessary. Therefore, this section will have some repetition to summarize and elaborate on some of the concepts discussed in the previous chapters, such as non-structural measures in Chapter 5. However, in general this section will focus on some of the common alternatives and how to describe the alternatives. Risk should also be an important consideration in forming and analyzing alternatives.

13.1 Structural Alternatives

Certain physical measures could be implemented and invested in by the Federal Government and non-Federal agency and/or project users. These may be used in combination with non-structural alternatives or independently. Some examples of general navigation features are:

- deepening and/or widening channels
- creating a vessel passing lane
- expanding or creating an anchorage area
- building a jetty or breakwater
- expanding or creating a turning basin

These structural measures are designed by engineers using a design vessel. The design vessel is the prototype vessel that is expected to use the harbor in insignificant numbers. The economic analysis should be able to show that the fleet and commodity forecast support the design vessel. If not, then a smaller design vessel should be used.

It is important to analyze structural measures incrementally by scale and segment. For example, the depth of a channel section should first be analyzed using 2 to 3-foot increments and then narrowing it down to 1-foot increments. If there is another segment that is being widened and deepened, it would have a similar depth incremental analysis on top of an incremental widening analysis. The widening increments will be relative to the channel size, and having a full-scale of alternatives, and could be from 25- to 100-foot increments. Additionally, the two segments must be incrementally analyzed together along with any other segments.

There are several types of risks to consider when formulating alternatives. First, it is possible that the market could turn and a given alternative may not be supportable if it was chosen as the NED plan. All alternatives pose risks to the environment such as causing temporary and permanent environmental damages. Next, the alternatives could increase or decrease vessel risks of collisions, allisions, or groundings. Furthermore, there are endless possibilities of where something could go wrong, but the most likely ones should be described under each alternative.

13.2 Non-Structural Alternatives

Contrary to the sound of its name, non-structural alternatives are measures that can be implemented by non-Federal agencies and project users that reduce or eliminate the need for Federal project investment. These alternatives could be part of the without- or with-project alternative. There are two main categories of "non-structural" alternatives:

- structural alternatives implemented by project users
- operational practices such as traffic management, lightering, and light loading (the basics of lightering and light loading are found in Chapter 5)

Solutions for handling cargo that don't require extensive structural changes to channels are generally treated as non-structural alternatives to the project in NED evaluation. Table 13-1 below lists some of the potential alternatives and annual tonnage associated with these facilities.

Analyzing these alternatives should occur early in the evaluation process in order to avoid:

- an unwieldy number of candidates for alternatives
- disposition on physical and financial feasibility

Table 13-1: U.S. Waterborne Commerce via Unconventional Facilities

Type Facility	Approximate Annual Tonnage (000)	
	Tanker	Dry Bulk
Transshipment Ports	90,000	< 10,000
Lightering, Midstreaming	50,000	< 1,000 (1)
Marine Pipelines	40,000 (2)	- 0 -
Very Long Piers	15,000	< 1,000
Offshore Platforms	5,000	- 0 -
Artificial Islands	- 0 -	- 0 -

(1) Peak coal movement at New Orleans was 10 million tons
(2) Includes unutilized Louisiana Offshore Oil Port capacity

Typically, the need for a channel project arises because it is desirable to bring the ship to port facilities where cargo can be stored and transferred between transportation modes. The alternatives are to extend the facilities to where the vessel is (marine pipelines, conveyors, or very long piers) or to transship the cargo using another vessel offshore or in another port (lightering and transshipment ports).

Non-structural alternatives to explore are those that have been proven in service elsewhere that have application to the project port. Provided there is a suitable site in the right location, the approximate costs of actual applications will indicate whether the facility may be a feasible alternative at the project port and whether additional information is needed to determine if it can be implemented.

All facilities including non-structural alternatives are a non-Federal responsibility. There are numerous reasons why some seemingly attractive alternatives are not implemented. An assurance of a large, immediate volume of business is usually a prerequisite to financing because most unconventional facilities are suitable only for certain cargoes and all costs have to be recovered promptly. The alternative has to provide vessel turnaround competitive with conventional facilities.

Design transfer rates are achieved about 30 percent of the time at conventional facilities. The days allowed for loading or unloading in vessel charters are more useful indications of actual turnaround time.

Further analysis of unconventional alternatives is needed only for those that will be considered as part of the NED evaluation. Discussions of typical unconventional alternatives follow below.

Transshipment Ports

Transshipment ports can expedite vessel turnaround by transferring cargo via storage. A transshipment port is a central port that berths deeper and larger vessels that carry large amounts of cargo. Then, smaller vessels are sent out to ports that have less depth. The cargo may be stored at the facility to facilitate movements more quickly later on. Below are some regional transshipment ports:

- **Bahamas and Caribbean Islands**
  These tanker terminals are the biggest transshipment ports used by the U.S. because they unload very or ultra large crude carriers (VLCC and ULCC) in two to three days (versus as much 16 days for VLCC or ULCC discharge via lightering). There are 10 transshipment facilities in this region that have deep natural depths. Nine of these facilities transship cargo via storage. Half of the facilities are associated with refineries and little deviation is needed for U.S. crude imports. Here is some more information about these facilities:
    - 6 terminals can accommodate vessels of 500,000 DWT and drafts of 90 to 119 feet
    - Charges are computed in cents per barrel (including 15 to 30 days storage)
    - A Cayman Islands facility offers direct vessel-to-vessel transfers for cents per barrel
- **Lower St. Lawrence**
  Grain transshipped via Lower St. Lawrence elevators is the second largest use of transshipment ports for U.S. commerce. Excluding barge-to-ship transfers that are intermodal transfers, it is the only U.S. dry bulk commodity transshipped in large volumes.
    - Canadian elevators charge by the cents per bushel for a round turn
    - Combined cost of a lake carrier and transfer approximates the differential for Great Lakes direct versus Lower St. Lawrence loadings.
    - Ocean rates are lower than U.S. East Coast ports

  - Transshipment of dry bulks other than grain is limited because the commodity volume and strategic location needed to justify transshipment facilities seldom coincide.
  - NOTE: there have been proposals for coal and grain transshipment terminals in the Bahamas and Caribbean but none have been built. There is a bauxite and manganese ore transshipment terminal in Trinidad, but it has only 35 feet of water.

- **Mobile Harbor and the Lower Mississippi**
  With the deepening of Mobile Harbor and the Lower Mississippi, the multipurpose bulk plants at those ports may be able to provide transshipment alternatives.
  - Current vessel to vessel transfer charges are a few dollars per ton direct and are about twice as much per ton via storage.
  - Charges for specific commodities can be determined by inquiry.

- **General and Containerized Cargo Transshipment**
  Transshipment of general and containerized cargoes is somewhat routine because trade volumes do not support direct service between all ports. This type of transshipment occurs in load center ports, generally outside the U.S.
  - A few container feeder services have operated between the Great Lakes and Montreal, Boston and New York, Baltimore and Norfolk, but these have been marginally competitive with overland carriers.
  - In addition to the feedership (barge) operating costs, there are two additional handlings of the containers that are purchased in dollars for each handling.

Lightering

The record of safety for lightering is generally considered good and is improving; however, tankers that participate in lightering always risk the chance of oil spills. More common risks come from hose ruptures, valve failures, tank overflows, and more serious accidents have been caused by procedural error and communication problems. Risks can be reduced through improved lightering standards and practices, design changes, training and certification of personnel, inspections, better information availability to the industry, deeper channels to reduce lightering, and enforcement of standards.[46]

Lightering tends to raise the unit transportation cost. The increased costs of topping off or lightering will be the NED basis of benefits and include all port and vessel costs. Normally, these increased costs will be substantially less than the efficiencies from a vessel that is fully light loaded for its entire deployment. The economist should conclusively determine that topping off or lightering is not a regular practice for a portion of the fleet.

In the U.S., most lightering is to partially discharge large vessels. The need for accurate weights and grades in international trade inhibits its use for exports, particularly grain.

[46] *National Research Council, "Oil Spills From Tank Vessel Lightering," 1998*

Note: *When lightering already exists in an area, there is a NED benefit for reducing the costs; however, this is based on the release of lightering resources for other uses. This may not be economically possible in some circumstances when resources are released for part of a date.*

- Gulf of Mexico
  - used for full discharge of very large tankers
  - used routinely to lighten tankers offshore
  - performed by "small" tankers, usually 25,000 to 50,000 DWT, foreign flag
  - cost of lighterage service is measured in cents per barrel (U.S. flag vessels can be three times more expensive, but is still measured in cents)
  - Cost of delay time for lightered vessel
  - Self-unloading vessels in the 19,000 to 38,000 DWT range have been offered for coal topoff at a few dollars per ton. Quotes include the coal terminal charges at the initial loadout port.
- New York Harbor, Delaware Bay, San Francisco Bay
  - Used routinely to lighten tankers offshore
  - Performed with barges
  - Reported costs (including tugboat hire) range around 20 cents per barrel
  - Self-unloading vessels in the 19,000 to 38,000 DWT range have been offered for coal topoff at a few dollars per ton in Delaware or Chesapeake Bay. Quotes exclude coal terminal charges at the initial loadout port.
- Lower Mississippi
  - A variant called "midstreaming" (meaning ship to ship movements) used to load coal vessels directly from river barges
  - Coal terminal transfer charges range from a few cents per ton in Norfolk to over several dollars per ton in New Orleans, with lower rates on the Great Lakes and higher rates on the West Coast.

Pipelines and Conveyors

Pipelines and conveyors are commonly used devices to link vessels with shoreside storage. There are numerous actual and proposed applications within ports as well as outside them. One application is an offshore pump station. An example of a pump station is the Louisiana Offshore Oil Port (LOOP). Tankers pull up to an offshore mooring to unload part of their oil in order to transit into port and further inland to unload the rest. This operation also faces similar risks as lightering and light loading such as hose ruptures, valve failures, tank overflows, and more serious accidents have been caused by procedural error and communication problems. These could spill contaminants into the ocean water, injure workers or cause structural damage. Additionally, environmental risks are associated with an underwater pipeline.[47]

Offshore applications are more widely recognized because they are more numerous, especially marine pipelines, and because some are notable engineering feats. They include:

- Ore loadout facilities in Brazil, Chile, Peru, New Zealand, Australia (two of which use slurry pipelines)
- Louisiana Offshore Oil Port (LOOP)
    - A hybrid that includes a pumping platform as well as vessel buoys and underwater lines
    - Vessel pull up to permanent mooring station to offload enough oil to be able to transit shallower channels
    - Two-thirds of its $700 million cost was for shoreside storage and transmission lines
- U.S. Offshore tanker berths
    - Most of the U.S. offshore tanker berths are simply mooring buoys and a submersible line
    - Many located on the California coast due to benign weather conditions (and handle more oil than LOOP)

Within-port applications typically supplement dredging schemes or address dredging constraints. They are more attractive as alternatives. Examples include:

- four-inch floating products line used at Nantucket because berth dredging was delayed by environmental concerns
- proposed consolidated tanker terminal in the Los Angeles outer harbor that would connect with tank terminals located on interior channels where further deepening is impractical
- Gulf Coast ports have multi-user tanker piers (usually a pair) to conserve use of waterfront, with pipelines serving several inland tank farms.
- At Jacksonville, the utility company has installed a lengthy conveyor to receive coal from the main harbor channel instead of the shallower nearby channel

Similar use of conveyors to pipelines is rare. Slurry pipelines have been built to transport coal between interior points but are rare at ports. Dry bulk unloaders cannot cope with ship motions, so the only U.S. use of offshore facilities has been for oil.

The cost of pipeline or conveyor alternatives is highly site-specific and sensitive to volume (unlike transshipments):

- Incremental extension of either might cost a couple hundred dollars per foot for acceptable capacities for shipload quantities with an effective limit on about 2500 feet before costs go up exponentially for repumping or flights of conveyors

47 *National Research Council, Oil Spills From Tank Vessel Lightering, 1998*

- A simple ship mooring with multiple buoys might cost up to a half-,million dollars
- A pier within the harbor or a single point mooring for tankers offshore will cost upwards of a couple million dollars

A rough approximation of charges per ton is:

- additional cost of having storage 2000 feet or more from the tanker berth or waterfront transfer facility is measured in cents per ton
- the use of LOOP costs several dollars per ton

Very Long Piers

One alternative to avoid dredging a channel deeper or wider, one alternative is to extend piers out into the channel. Typically, long piers have been used in bays or estuaries where there is some weather protection and insufficient natural depths for using anchorages or moorings. Due to their cost, site-specific conditions generally dictate their use.

This does pose some inherent risks. The seas may be rougher that far out and could cause difficulties for docking vessels or structural damage. The commodities being transported could have to travel a longer distance from the pier to shore which could expose the commodities to high risk.

Very long piers include:

- Richmond Long Wharf in San Francisco Bay, extending 4200 feet to natural depths of 35 feet
- Leonardo (NJ) Navy Pier in Sandy Hook Bay serves the Earle Ammunition Depot and is the longest U.S. pier at 11,000 feet
- Other U.S. piers range from 1,400-1,700 feet and handle dry bulks or oil
- Piers cost about 110 times as much as pipelines or conveyors, foot for foot

Platforms and Islands

The ultimate facility alternative is to provide cargo storage where the vessel is by means of platforms and islands. The cost of doing so in very deep water is prohibitive but there are practical applications of offshore structures.

Conventional shipside working surfaces are generally considered to be too valuable to use as storage areas. Due to even higher costs, platforms are used only for terminal equipment and operations.

Similar to the LOOP platform, the Drift River Terminal in Cook Inlet is an offshore platform connected by submarine pipeline to onshore storage. However, it is a loadout terminal (the second largest shipping point for Alaska crude) and tankers berth alongside in 60 feet of water.

Two examples of artificial islands to provide storage are the "Sea Island" crude transshipment terminal off South Riding Point, Bahamas and a salt transshipment terminal off the northeast coast of Brazil. The Bahamas terminal is only 4000 feet offshore, but has berth depths of 85 and 100 feet. The Brazil terminal is almost nine miles offshore, with less than 20 feet alongside for small shuttle vessels. It is a steel-bulkheaded rectangle of about four acres, able to store 100,000 tons, and uses an overwater conveyor to a separate platform-mounted shiploader to load vessels up to 35,000 DWT size. An acre will support high-density storage for about 35,000 tons of coal, 80,000 barrels of oil.

Marine terminal selection criteria shown in Table 13-2 provide a tool to screen facility alternatives. Look for information on construction costs for pipelines, as well as information relating tanker size to pipeline size. For more information on conveyors, piers and other structures, contact vendors and look for notices of construction contract awards.

Table 13-2: Marine Terminal Selection Criteria and Risk Consideration

Limitations on Use	Fixed Piers & Platforms	Multi-Buoy Mooring	Single Point Mooring
While berthing			
Waves	3-4’	6-8’	6-8’
Wind	25 kts	25 kts	25 kts
While moored			
Waves ahead	10’	10’	Over 15’
Waves abeam	3-4’ (1)	3-4’ (est)	NA
Wind	50 kts	20-40 kts (1)	60 kts
Transferring Cargo			
Waves	3-10’ (2)	3-10’ (2)	10-12’
Wind	30 kts	25-35 kts (1)	40 kts
Distance offshore	Close	Medium	Furthest
Maneuver area & seabed required	Small	Moderate	Large
Unberthing ease	Fair to good	Poor	Excellent
Tugs used	Required	Usually no	Usually no
Launches used	Sometimes	Required	Required
Investment	High	Low	Moderate (buoys) High (structure)
Susceptibility to damage	Moderate to high	Low	Low/Mod (buoys) Mod/High (fixed structure)

(1) Depends on wind velocity and direction
(2) Depends on wave height and direction
Source: Beazley, Raymond A. and Ralph P. Schlenker, “A Rational Approach to Marine Terminal Selection” (Paper delivered at Ocean 73, 4th Annual International Conference on Engineering in the Ocean Environment, Seattle, October 25, 1973)

13.3 Structural Alternatives Implemented by Project Users

> *Alternative plans shall not be limited to those the Corps of Engineers could implement directly under current authorities. Plans that could be implemented under the authorities of other Federal agencies, State and local entities and non-government interest should also be considered.*
>
> ER 1105-2-100 Section 2-3.c(1)

Structural alternatives that could be implemented by project users include such things as:

- special vessels
- piers, wharves, berth changes
- adding cranes, or on-side facilities to improve efficiency

The importance of addressing user-implemented structural alternatives is their potential direct effect on project costs or their direct or indirect effect on estimated transportation costs.

In some cases, user implemented alternatives would simply be reflected in project costs as associated costs. In these instances, the analyst must consider the alternatives to the user; that is, facilities at competing projects. For example, the user may have alternative facilities with excess capacity or which better facilitate capacity expansion in response to increased traffic levels. Of course, the reverse may also be true, with facilities at the proposed project having excess capacity or which better facilitate facility expansion.
In other cases, user-implemented alternatives will affect the transportation (distribution) costs at which traffic moves through the project.

> *For example, utilizing a deeper channel typically requires deeper berths at the project, as well as deeper berths at overseas destinations. For some shippers, the lack of adequate overseas facilities may limit their need for greater depths at their berths, which would limit full utilization of the new channel depth. The ability of this shipper to benefit from the project is predicated on the willingness to deepen berths at project facilities.*

Those aspects of the project that would be implemented by users must be specified for each project alternative combination. A determination must then be made as to which alternative implementation the user is most likely to take for each project alternative combination. The economist should identify any impacts on project scope and costs (including associated costs), modify the commodity flows and project fleet composition and compute new transportation costs.

Operational Practices

Operational practices such as tide-riding, traffic management, or lightering should be identified and a determination made as to their applicability. They will also be considered in the multiport analysis and as part of the alternative scenarios being evaluated for the project.

Two important issues must be specifically addressed in relation to operational practices:

- The first issue is whether these practices are currently in use. If so, care must be taken to determine the degree to which these practices are currently reflected in transport costs. For example, lightering is a common practice for petroleum shippers and will frequently be reflected in the baseline transportation costs.
- For operational practices not currently in use, a determination must be made as to their economic feasibility now and in the future. It must be stressed that non-standard operating practices are observed at numerous places throughout the world. If such practices are not used at the project in question, it should be concluded that these practices have been evaluated by shippers and carriers and were found to be not economical under existing conditions. The economist must then determine which of the following best describes the absence of these practices for the project (particular reasons for the absence of an operational practice must usually be obtained from shippers and carriers currently utilizing the project):
    - information deficiencies, such as lack of real time channel depth information
    - the practice is uneconomical given the particular physical and institutional setting of the project
    - insufficient traffic levels

Of concern at this stage of the evaluation is the possibility that certain practices are not currently used due to insufficient traffic levels or data. If this is the case, the level of traffic where these practices might be implemented should be determined. When the projected commodity flow exceeds this level of traffic, the economist should assume that the practice will be implemented and transportation costs via the project altered to reflect the practice.

13.4 Determine With-Project Conditions

The with-project condition(s) consists of those future conditions the economist believes most likely to prevail for each alternative plan. To compare each of the alternatives to the without-project condition, it is necessary to specify the commodities flows and associated transport costs for each year during the period of analysis, or for acceptable increments of time, along with any physical or operational changes that will be made. **Defining the with-project condition will follow the same logical flow as defining the without-project condition.**

Differences in the with- and without-project conditions must arise from factors that can be tied to the implementation of a specific alternative. Typically, differences between the conditions should arise from direct or indirect changes in the less costly transport routing alternative.

Commodity Flows

It is useful to distinguish between three types of commodity flows in the with-project condition:

- continuation of without-project commerce (traffic that does not divert to alternative ports in any of the multiport scenarios)

- diversions from competing ports to the study port (includes both traffic diverted from the study port in the without-project condition, as well as traffic diverted from competing projects for a given project alternative)
- induced traffic and traffic with a shift of origin or destination

Disaggregation of commodity flows helps determine which factors have the largest impact on estimated flows as well as the likely major beneficiaries of the project.

Beneficiaries are defined in a broad sense and might include specific shippers and/or carriers, particular commodity types or specific origin-destination commodity flows. Factors that lead to major changes in the beneficiaries are likely to be critical factors such the closure of a plant that would normally export good through the port. The economist must clearly define the with-project conditions including a detailed description of the major factors that can influence the benefit estimates for each alternative.

Fleet Composition

Differences between the fleet compositions in the without- and with-project conditions arise from two sources:

- uneven growth in commodity types
- changes in project characteristics (e.g. a deeper channel)

The current fleet mix should be modified over time to reflect the reduction or elimination of constraints on vessel size due to channel dimensions at the project port and other ports of call.

It must be noted that the fleet composition does not necessarily change in response to project implementation.

> *For example, few projects are likely to alter the composition of the general cargo or auto carrier fleets; only the number of vessel calls will change. Since fleet composition is derived from the commodity flows, any factor not altering the fleet composition is unlikely to be critical in relation to project justification.*

In most instances, any factor not influencing commodity flows or transportation costs will not influence project justification.[48] Assumptions, conditions at competing projects and other factors that describe the project setting are important and should be assessed for their possible impact on commodity flows and fleet composition.

Temporal or Geographic Segmentation

Aspects of each project alternative such as a phased construction or phased projects must be contemplated as integral components of a specific project implementation. At this stage of the evaluation, the importance of segmentation (either temporally or geographically) is the possible impact on alternative transport routings and costs over time.

[48] *There are a limited number of exceptions to this generalization (for example, military preparedness, safety, and risk).*

The economist should identify the timing of implementation and associated changes in the fleet composition and commodity forecast when applicable. It is important to take into consideration the possible interrelationships between user-implemented actions and project segmentation or phased construction.

Describe With-Project Condition

At this stage of the evaluation, it should be possible to present a complete description of port use in the with- and without-project conditions. Differences between the various conditions (and the reasons for them) should be highlighted.

As a check on completeness, it should be possible to specify the following information for each movement. The commodity between Points A and B is a function of the with- and without-project tonnage and lowest transportation cost of each condition. In other words, the movement can be described as a vector of tonnages and associated least cost transportation routings for each condition.

The without-project condition is a function of the assumptions of the analysis as they relate to current and projected future conditions, multiport impacts, and project specific assumptions if no action is taken. The with-project condition is a function of the assumptions of the analysis as they relate to forecasted future conditions, multiport impacts, and project specific assumptions under the alternative scenario.

As a result, any specific commodity flow would be described quantitatively by tonnage and transportation costs and qualitatively by the assumptions and conditions underlying the quantitative estimates. A similar set of specifications can be developed for scenarios not included in the without- or with-project conditions and would be used in risk analysis.

13.5 Summarizing the Datum and Risks

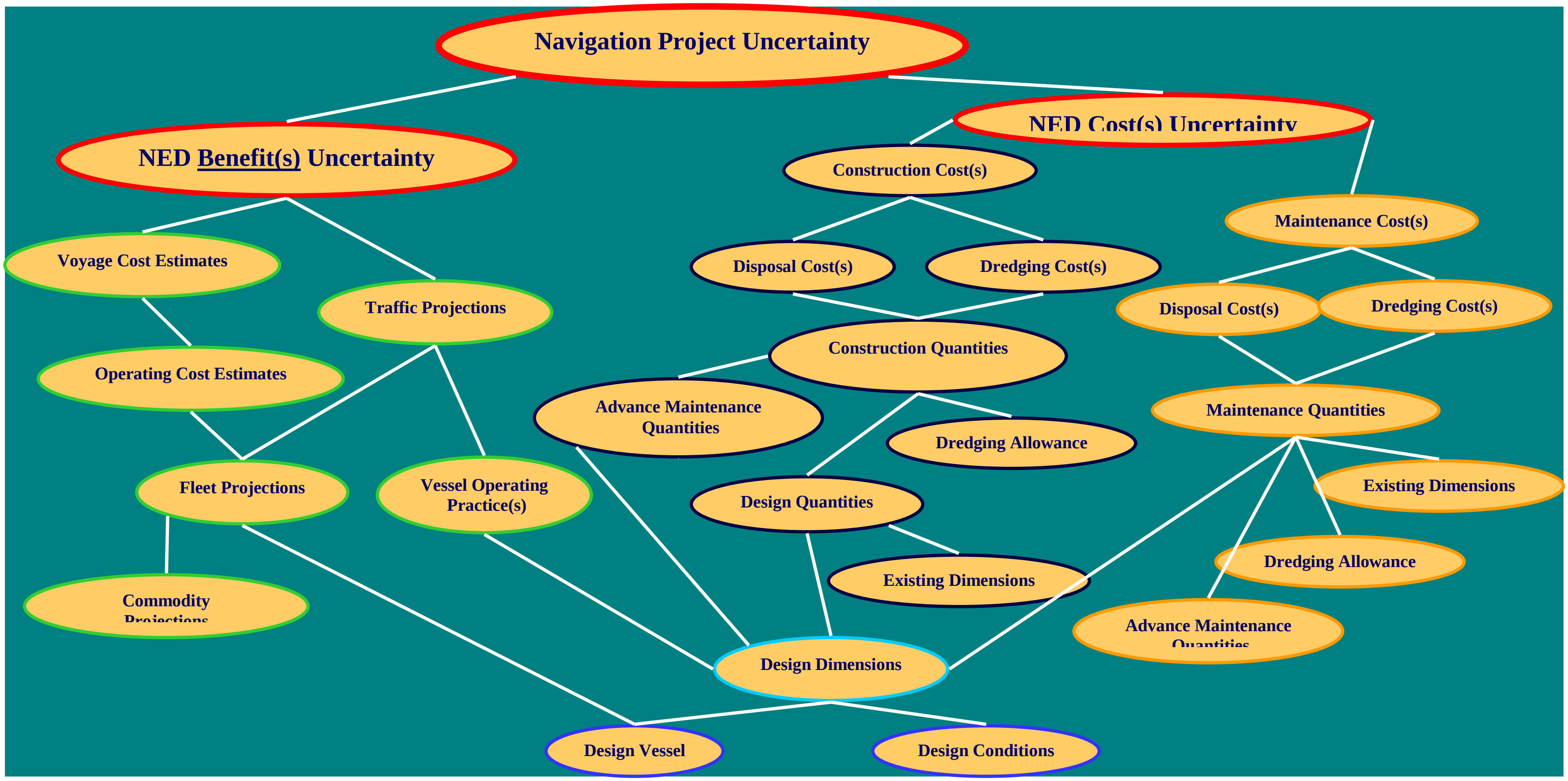
It should now be possible to structure a matrix that relates commodity flow levels and transportation costs for each project alternative. A traffic level and associated transportation cost can be estimated for each possible project alternative.

Many alternatives likely have more non-measurable or unknown residual risks that should be described. For example, an alternative may have the add-on feature of a better vessel tracking system that could reduce transportation risks further and increase benefits. At the same time, an alternative could have a deeper channel to allow for a more safety clearance, but also induce risk-taking behavior known as a moral hazard. Any reduced risk should be described for each plan, but also the potential moral hazard should be noted as well. (see Table 11-3).

Throughout the process, many assumptions were used that are uncertain. It is important to describe these risks and possibly quantify them. Figure 13-1 on the next page portrays some of the sources of uncertainty in the NED costs and benefits which ultimately impacts the final results and analysis. This diagram is intended to offer considerations rather than be prescriptive.

Cape Canaveral

Figure 13-1: Sources of Uncertainty



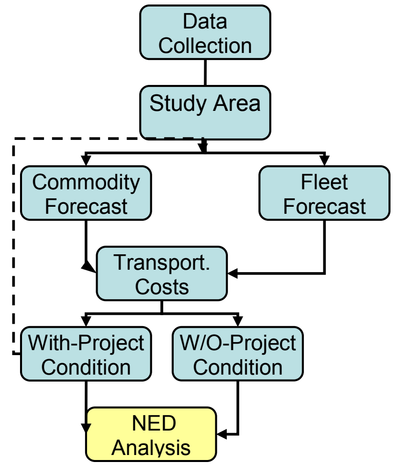
13.6 Key Concepts

This chapter covered the following concepts:

- Structural alternatives are measures that typically involve the physical alteration of the Federal waterway such as deepening and widening the channel, building jetties and other structures in Federal waters. These measures could be implemented by non-Federal sponsors or many general navigation features can be cost-shared with the Federal government.
- Non-structural alternatives are measures that don't require physical alteration of what is considered a Federal waterway. This can include structural measures implemented by the port, various operational changes such as transshipment ports, lightering, and pipelines.
- Structural alternatives implementable by project users would include such things as construction of special vessels, piers, and wharves
- Structural and non-structural measures can be combined to reduce residual risks and increase benefits. Risk can derive from all components of the analysis and should be described qualitatively at a minimum.
- There are three types of with-project commodity flows:
    - continuation of without-project commerce
    - diversions from alternate ports to the proposed project
    - induced traffic or traffic with a shift of origin or destination
- The current fleet mix should be modified over time to reflect the reduction or elimination of constraints on vessel size due to channel dimensions at the project port and other ports of call.
- At this point, a complete description of project use in the without- and with-project conditions and datum can be complete

Deepening at Savannah Harbor

CHAPTER 14 – CALCULATE NED BENEFITS AND COSTS



14.0 Overview

Chapter 3 of this manual provides an introduction of NED costs and benefits and their use in identifying the NED plan. This chapter takes a look at discrete elements of the NED Benefit and Cost calculations. It places these elements into a benefit/cost analysis framework so that relationships between project conditions, alternatives and forecasts can be summarized and presented in a manner that leads to selection of the best plan.

The ultimate output is the expression of benefits and costs through various displays such as:

- present value
- net present value
- benefit/cost (B/C) ratio
- average annual equivalent value

14.1 Benefit/Cost Analysis

The last analytical step in the feasibility study is an evaluation of project alternatives to establish tradeoffs between the various project objectives and alternatives. One conceptual framework for assessing these tradeoffs is benefit/cost analysis.

The fundamental idea is to develop a without-project condition (or set of conditions) against which alternative project incremental benefits and costs can be measured. Benefit/cost analysis requires a bookkeeping/accounting approach that uses the proper definitions and measurements and includes all relevant, applicable uses of resources for the various project conditions and alternatives. The actual NED plan is not chosen based on the highest B/C ratio, but on the highest net benefits (total annual benefits minus total annual costs); however, the B/C ratio usually plays an important role when it comes to the budgetary prioritization.

14.2 NED Costs

Chapter 3 discusses the theory and basics of NED costs. The following are costs that need to be assessed and totaled in the generation of a cost stream associated with each alternative over the period of analysis:

- Project costs (construction, mitigation, etc.)
- Associated Costs
- Operation, Maintenance, Repair, Replacement, and Rehabilitation Costs (OMRR&R)
- Interest During Construction (IDC)

The role of the economist in assessing these costs is: to insure that the estimated costs include the cost of all measures (features) required in achieving the estimated benefits or traffic (commodity and vessel) volumes; and, that sufficiently detailed information is available for defining and evaluating prospective project segmentation and phasing. These costs are more extensive and greater than costs used for estimating cost-sharing responsibilities. This is because they include all of the measures including those implemented by non-Federal entities.

Although costs are often presented as lump-sum items, it is useful to display dis-aggregations of costs applicable to particular categories when there are differences between project alternatives, segments, and/or phases. For example, dredging costs should be broken out by foot which will lead to finding the optimal incremental depth for a navigation segment.

> *Remember sunk costs cannot be counted as NED costs.*

Project Costs

Project costs are the direct costs to implement a project. These costs are mainly construction costs and include the cost of mitigation. The major construction costs for deep draft projects are typically Federal and non-Federal. These costs are the value of the resources that must be committed in implementing each project alternative prior to the generation of project benefits. From a NED perspective, the distinction between Federal and non-Federal costs is unimportant. Federal and non-Federal costs both represent resources committed to project implementation and therefore should be reflected as NED costs. Examples of these costs include: building jetties, walls, dredging channels and berths.

Associated Costs

Associated costs are any public or private Federal or non-Federal expenditure on navigation infrastructure and facilities necessary to achieve the estimated benefits or traffic levels for each project alternative. Associated costs are typically incurred by project users as part of an ongoing transportation or logistics process. Therefore, costs may have to be obtained from these parties or estimated by the study's cost engineer.

They may represent: fixed costs of doing business, fixed costs of project implementation (e.g. berth side deepening), variable costs of the transportation process.

Examples of associated costs include:

- Lands, easement, relocations, rights-of-way, and disposal sites (LERRDS)
- Landside and Ancillary Costs: Landside and ancillary costs such as cranes, improved infrastructure and upgraded rail and truck lines must be considered part of the total project costs if these features are needed for a given alternative to be functional.
- Any bridge replacements, or other structural modifications in the surrounding area

- Pipelines that may require rerouting (note: this can often increase costs dramatically, lead to lawsuits, and lengthen construction time)
- Deepening of adjacent berthing areas

Some associated costs such as pipeline relocation are typically included as project implementation costs. In most cases, these costs are unrelated to project throughput, but are required to implement a project alternative at the estimated benefit or traffic levels.

Self-Liquidating or Associated Costs?

Certain associated costs have been handled through the self-liquidating cost concept. A self liquidating cost is the cost of a particular asset that can be operated in such a way that it repays the money spent to acquire it.

It is necessary to address two aspects of associated costs:

- Complete identification and accountability in the analysis, separate out the self-liquidating costs
- Inclusion of associated costs in project implementation costs or in the comparative transportation costs.

When an associated cost can be identified with project throughput, it is usually desirable to address it in the comparative transportation cost analysis. Otherwise, it would be reflected as a lump-sum cost of project implementation similar to a capital investment.

> *For example, increased storage area for additional cargo could be provided at the same unit cost as existing storage area, other things being equal. If this were the case, the associated cost of increased storage area would be reflected in the transportation costing analysis. The cargo storage cost would be self-liquidating and would not need to be specifically reflected in the project implementation costs.*

A related concept to associated costs is offsetting benefits and costs. It is sometimes difficult to determine whether a private sector action will be taken in response to a proposed project. For example, will larger vessels require the purchase of larger equipment for cargo handling such as container cranes? This is largely an issue of technological and economic obsolescence. The problem arises because most deep draft projects have an existing infrastructure. When the alteration is required, such as deeper side channels to facilities, the cost should be addressed as an associated cost.

Unfortunately, it is not always clear that an infrastructure alteration is required. When it cannot be determined that a cost is required, it is typically assumed that the cost has an offsetting benefit of equal magnitude. In effect, offsetting benefits and costs are assumed to be self-liquidating.[49]

[49] *The distinction between offsetting benefits and costs and associated costs may not always be readily apparent. Associated costs can always be directly related to achieving some level of benefits. Offsetting benefits and costs are difficult to directly relate to benefits or specific alternatives.*

Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R)

Operation, maintenance, repair, replacement and rehabilitation (OMRR&R) costs are the costs of all the activities required to make the project work as designed in order to realize and sustain the benefits identified during the planning phase. OMRR&R costs can be significant for navigation projects, particularly as disposal sites reach their capacity. These costs are analyzed over the project life and analyzing various OMRR&R schedules can help minimize NED costs.

The difference between these costs and construction costs is that the latter represent a capital investment (deepening, widening, etc.) usually incurred one time when the project is implemented, whereas OMRR&R costs are incurred periodically over the project life. These costs may be incurred annually or fluctuate at some intervals, including advanced maintenance. OMRR&R costs are often estimated using standard engineering cost estimating techniques. The OMRR&R costs should reflect the conditions particular to the project, which may or may not change with respect to deepening or increase under other circumstances such as widening.

Interest During Construction Costs (IDC)

Interest During Construction (IDC) costs are economic costs that must be accounted for when determining the NED costs of a project. In economic terms, this is the cost of the foregone opportunity to invest the money for some other use. Therefore, the hypothetical return for another investment, measured as interest during construction, is an NED cost. The Corps must use the prescribed discount rate to estimate this cost. IDC is not a financial cost, thus it is not used to determine cost sharing responsibilities.[50] Deep Draft navigation projects typically take several years to construct, beginning with the detailed “plans and specs” phase (which is considered to be part of the project’s construction), stretching all the way to the project’s closeout. In effect, the Nation needs to wait while the project is being built before the benefits can be realized.

Procedurally, IDC can be calculated in a number of ways. IDC becomes particularly important when comparing alternatives having significantly different construction schedules, but very close NED benefits. In addition, projects having very long construction schedules have later been found to be cost prohibitive due to the high IDC, even if the actual financial costs were relatively low. Samples of IDC calculations can be found in the National Economic Development Procedures Manual—Urban Flood Damage.[51]

Interest during construction (IDC) reflects that project construction costs are not incurred in one lump sum but as a flow over the construction period. Interest during construction is often computed based on the assumption that construction expenditures are incurred at a constant rate over the construction period.

For many deep draft harbor projects, this assumption provides a good approximation of interest during construction. When more detailed information on the construction schedule is available, it should be used. It is also important whenever there are major lump-sum capital (construction) costs incurred at

[50] *IDC costs on a $100 million project can, depending on the construction schedule and discount rate, add tens of millions of dollars to the NED project costs. Non-Federal partners, among others, have expressed concern and confusion about the need to include such a cost in the project evaluation; especially when they learn that no one actually pays these costs.*

[51] *http://www.iwr.usace.army.mil/inside/products/pub/iwrreports/91-R-10.pdf*

particular points in the schedule such as blasting or the creation of dredge disposal areas.

> *Long construction periods may also lead to benefits during construction which may offset IDC costs. For example, if one channel segment is built first, it may produce benefits prior to the rest of the phases being built.*

Interest during construction is computed as follows. If B is the project base year (the year in which construction costs end and the project begins to derive benefits), then the total cost incurred during construction, including actual expenditures and implicit interest payment, is the equivalent lump-sum expenditure in the base year, C_B, which is computed as:

$C_B = \sum^{t}_{i=1} C_i (1+r)^{t-1}$; where

C_i construction expenditures in period i

r per unit interest rate; and

t number of construction periods up to the year that the project is implemented, which is the start of the period of analysis

Likewise, $IDC = C_B - C_i$

If all costs have been correctly accounted for, a NED cost stream of the form (C_B, O_1, O_2,…,O_n) will be generated for each project alternative, where C_B represents the total construction costs up to the beginning of year 1 (baseline year) and the O_i are the O&M costs in project year 1 from year 1 (baseline year) to the end of the project life. This cost stream represents the resource costs associated with each project alternative over its life necessary to achieve the estimated benefits or traffic levels for that project alternative.

> *In practice, economists are usually required to modify this formula slightly to measure IDC at the mid-month points rather than years since construction is typically measured in months.*

14.3 NED Benefits

To illustrate how benefits are computed, it will be conceptually useful to initially restrict the following discussion to the base year and to view each alternative not as a physical configuration of the project but as a database describing the relevant transportation characteristics of elements (e.g., commodity movements or vessels) that benefit from each alternative.

For each movement under each project alternative, a total transportation cost was computed (see Chapter 11). Transportation savings are the difference in transportation costs between the without-project condition and the conditions most likely to prevail for each alternative, known as the with-project conditions. The savings in the base year of a project for a specific movement and project alternative is the difference between $TC_{W/O}$ and TC_W, the transportation costs for the without-project and alternative project conditions.

For discussion purposes, it is useful to classify transportation costs savings into two general categories:

- movements that use the project under all alternatives (cost reduction benefits)
- movements that use the project under some but not all of the alternatives (increased traffic benefits)

Based on this distinction and the difference in transportation costs between alternatives, transportation benefits can be estimated as described below. Cruise ship benefits can have benefits in both categories and are discussed below in more detail.

The main categories of NED benefits stem from the following:

A. Transportation Cost Savings

B. Higher Net Revenue

C. Other NED/NER Benefits

As the scale of the project increases, it is likely that all three forms of cost savings will be present.

A. Transportation Costs Savings

Cost reduction benefits result from a decrease in the cost of shipping commodities that reflect the same origin-destination pattern and harbor in all project conditions. Cost reduction benefits generally take one of three forms:

- **Increased loads for existing vessels reduce unit costs**
- **Switch to larger vessels**
- **Enhanced vessel maneuverability and delay reduction**
- **Shift of Origin or Destination**: Benefits derive from the cost reduction in transporting and producing a given commodity. These benefits can also be measured as an increase in net revenues; however, both cannot be counted at once. Logically, transportation costs savings benefits cannot exceed the increase in net revenues from this shift if both benefits were estimated. A multiport analysis may be necessary to claim these benefits.
- **Shift in Mode or Harbor**: For commodities with the same origin and destination, these benefits derive from providing a more efficient route or transit point. Benefits are the difference in costs of mode transportation between the without-project condition (such as when rails, trucks, different waterways or ports are used) and the with-project condition (improved waterways or channels). A multiport analysis may be necessary to claim these benefits
- **Other**: reduced cargo handling costs, reduction of tug assistance, reduction in accident rate and cost of damage, lower cost switch from land transportation, advanced maintenance, reduced insurance, interest and storage costs.

Increased Loads for Existing Vessels

Decreasing the unit cost per ton of a commodity is a NED benefit. Decreasing unit costs could potentially be done through increasing existing vessel loads.

For example, Sea Harbor currently has a draft of 42 feet and there are no existing port plans to deepen the harbor under the without-project condition. The existing widget carriers can sail at depths as much as 50 feet, but given these without-project conditions, they operate in a light-loaded status for the 42 foot depths. In this study, the widget carriers are the design vessel. One alternative is proposing to deepen Sea Harbor to 50 feet to accommodate the design vessel. This means that the widget carriers can now load more widgets.

It is assumed that the widget route from Wind Port to Sea Harbor will not change between the without- and with-project conditions. Loading deeper could increase the costs from Wind Port to Sea Harbor, but for this example, it is assumed that there will be no transit cost changes. The "per unit" cost for widgets will decrease under this proposed with-project condition because the transportation costs are staying the same, but more widgets can be shipped. The number of widget carriers needed could also decrease if the number of widgets demanded did not change, but let's assume that the quantity demanded is high enough to fill the same amount of vessels and thus transportation costs are constant.

The decrease in per widget cost can now be calculated based on this information. The existing transportation cost would be divided by the new amount of widgets shipped. The alternative unit widget cost can be subtracted from the without-project unit widget cost to find the unit savings. This reduction in unit widget cost multiplied by the total amount of widgets is the NED benefit if widgets were the only good impacted at the Sea Harbor. The NED cost would be the cost to deepen from 42 feet to 50 feet. The difference between the NED costs and NED benefits is the net NED benefits.

Essentially, this is the cost savings from a reduction in the number of vessel trips to move the commodity forecasted tonnage.

Appendix B shows a more expanded example of this.

To get more technical, benefits arising from increased loads per vessel can be computed as follows. Let D be the project depth for the without-project condition and D_{MAX}, be the maximum operating draft of vessels moving commodity i to or from point j via the project.

Then:

(1) if ($D_{project\ depth,\ w/o} \geq D_{MAX}$, i, j), $TC_{W/O} = TC_W$; and

(2) if ($D_{project\ depth,\ w/o} < D_{MAX}$, i, j) then $TC_{W/O} \geq TC_W$

where $TC_{W/O}$ and TC_W represent the per unit transportation costs of the movement associated with particular without- and with-project conditions. It should be noted that D and D_{MAX}, i, j, as well as estimated transportation costs would reflect adjustments for squat, trim and other operational characteristics.[52] Equation 1 says that if the maximum operating draft of the without-project vessels is less than the without-project depth, than there is no benefit in deepening the channel. The transportation costs would then be the same between the without- and with-deepening projects. However, Equation 2 says that if the operating depths of the without-project vessels are deeper than the

[52] *The vessel operating characteristics should be fully described in the baseline conditions and would not concern the planner at this time other than through certainty of their correct inclusion for without- and with-project conditions because the drafts and cargoes carried by vessels are affected.*

current channel, then the total transportation costs would be less if the channel were deepened. Therefore, the total transportation cost savings per unit of moving commodity i to/from point j via the deeper channel is a NED benefit.

Switch to Larger Vessels

Depending on the characteristics of the proposed project, carriers may have an incentive to use larger vessels, possibly draft constrained, with a resulting increase in average load per vessel (and a corresponding cost reduction per ton of cargo carried). This will be reflected as a shift in the fleet forecast between the without-project and with-project alternative fleets.

Larger vessels at the same draft as smaller vessels can carry larger loads. It is often more cost-effective to transport goods on larger vessels, even if not fully loaded to maximum DWT capacity.[53]

For example, widening without deepening allows for larger, more cost-effective vessels to enter Muddy Harbor light-loaded with widgets. The without-project condition describes: the physical conditions at Muddy Harbor, how Muddy Harbor's channels do not allow larger vessels because vessel turns are too wide, how the smaller fleet transports widgets, that the widgets are coming from Wind Port, and how many widgets are and will be demanded and delivered to the hinterlands of Muddy Harbor over the period of analysis. Then the with-project condition would describe over the period of analysis: how the channel would be widened, how larger and more cost-effective vessels could turn and enter port that the widgets would still come from Wind Port, and how the widgets could then be transported on more cost-effective, larger vessels.

Now that the conditions are defined, the unit cost for each scenario in Muddy Harbor is calculated. First, the present value transportation cost of using smaller vessels is calculated. This process uses variables such as total transportation time, vessel operating costs and so on for moving widgets from Wind Port to Muddy Harbor over the period of analysis (HarborSym can help on this). Next, the total amount of widgets being shipped is divided by the total present value of transportation costs. This result is the unit cost of widgets under the without-project condition.

Next, this same process is repeated for the with-project alternative and the cost is found to be less due to the use of fewer larger vessels. These two unit costs (without- and with-project) are subtracted from one another. Finally, the difference in unit cost per widget is multiplied by the widgets demanded through the period of analysis. This is the total value reduction in widget costs which is a NED benefit. Furthermore, the cost of the widening is the NED cost. Subtract the NED cost from the NED benefit and the net NED benefits are found and can be annualized into annual average equivalent values. This same process would be repeated for other types of vessels and goods and may also be combined with benefits from increased loads as discussed in the Sea Harbor example above.

Appendix B shows a more expanded example of this.

To put this more technically, cost reduction benefits resulting from the use of larger vessels can be computed as follows:

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[53] *The economies of scale displayed by larger hulls of the same category of vessel can enable larger vessels to be light loaded relative to maximum draft/DWT and still have a lower unit cost per ton of cargo carried than more fully loaded smaller vessels. The planner should be sensitive to the loss of scale economies because at some point light-loaded larger vessels will be less cost effective than more fully loaded smaller vessels. Added, the initial vessel switch could have higher costs in the beginning.*

If D is the project depth for the without-project alternative and D_{ALT}, is the maximum operating draft of the larger vessels (or a class of vessels) moving commodity i to or from point j via the project for some alternative. Then:

(1) if ($D_{project\ depth,\ w/o} \geq D_{ALT}$, i, j), $TC_{W/O} = TC_W$; and

(2) if ($D_{project\ depth,\ w/o} < D_{ALT}$, i, j) then $TC_{W/O} \geq TC_W$

where $TC_{W/O}$ and TC_W represent the transportation costs of the movement associated with particular without- and with-project conditions. In Equation 1, if the large alternative v can fit within the existing channel, then they are likely already doing this and there is no benefit because total transportation costs will not change. Stated alternatively, vessel classes whose maximum operating draft already fit in the channel would not benefit from a deeper channel. Equation 2 shows that if a deeper, presumably more cost-effective vessel class requires a deeper channel than the total transportation cost would be less than the without-project costs for that class.

Enhanced Maneuverability and Delay Reduction

For deep draft projects, it can be expected that changes in the physical characteristics of the existing project (such as widening, anchorages and passing lanes) may alter vessel maneuverability and result in decreased transit time. Some or all of the large vessels using tides to transit a channel may no longer be tide dependent. Benefits attributed to enhanced vessel maneuverability or delay reduction are usually computed as time savings multiplied by some per-unit cost applicable to vessel underway operations or idling at port. In other instances, accessorial related vessel costs (such as tug requirements or time for harbor maneuvers) may change.

To compute these benefits the economist should:

- Determine the number of vessel calls that would benefit from enhanced maneuverability
- Determine the time savings for each vessel (or class of vessels) associated with particular circumstances.[54]
- Multiply the time savings by unit transportation costs of the vessel to determine cost savings per vessel.
- Sum the cost savings per vessel over all vessels to estimate total cost savings arising from enhanced maneuverability and/or tide delay and weather delay reductions for a given project year.

Models such as HarborSym can assist in this step.

Expanding the Sea Harbor example, assume the port was deepened from 42 feet to 50 feet and the original assumption was that the higher quantity demanded for widgets would keep the amount of widget carriers constant despite having larger

[54] *Time savings for enhanced maneuverability may vary by type vessel, direction with respect to tidal flows, size of vessel, laden conditions, and other features such as the existence of bow thrusters versus tug assistance, etc. In practice, time savings may be the same for inbound and outbound movements of the same call, but the planner needs to ascertain this.*

vessels. Now let's change the assumption to say that the widgets demanded are constant instead of increasing, so the amount of widget carriers necessary is relatively reduced. Fewer widget carriers mean fewer delays to doodad, trinket, and other widget carriers in the port. Fewer carriers mean faster and safer maneuverability around the port. Assuming that the doodad and trinket carriers remain constant, the economist can determine the without- and with-project transportation costs and time for all vessel movements. The total reduction in transportation costs due to a reduction in time between the without- and with-project conditions would be an NED benefit. Traffic models, such as HarborSym, can assist on this process.

B. Higher Net Revenues

There are two sources of benefits that are indirectly related to transportation cost savings:

- **Shift of Origin or Destination**: Benefits are from higher net revenues in shifting the transportation and production of a given commodity from a one origin and/or destination to another. This can also be estimated as transportation cost savings, but not both. This is to avoid double counting benefits. Therefore, if higher net revenues are used, they must not be more than the transportation cost savings. A multiport analysis may be necessary to claim these benefits.
- **Induced Movement**: if a commodity or additional quantities of a commodity are produced and consumed as a result of lower transportation costs, the benefit is the commodity value less all production and transportation costs

ER 1105-2-100 defines induced as the following:

> *"New movement benefits are claimed when there are additional movements in a commodity or there are new commodities transported due to decreased transportation costs. The new movement benefit is defined as the increase in producer and consumer surplus, thus the estimate is limited to increases in production and consumption due to lower transportation costs. Increases in shipments resulting from a shift in origin or destination are not included in the new movement benefits. This benefit cannot exceed the reduction in transportation costs achieved by the project." (ER1105-2-100)*

In the case of induced movements, benefits should be based on changes in net income to the commodity producer or user. Though this category of benefits is recognized in policy, it is extremely difficult to support and estimate with some degree of accuracy and its use in economic analysis of deep draft projects is not encouraged. These benefits are typically estimated as one-half of the difference in the maximum and minimum transportation costs for each alternative, which is a surrogate for the change in producer surplus (income) that results from an increased output. When better or more detailed information is available, it should be used.

C. Other NED/NER Benefits

Other NED benefits include, but are not limited to:

- Recreation (subject to budgetary limits of 50% of total benefits)
- Flood damage reduction
- Coastal storm damage reduction

- Location or land enhancement by filling with dredged material (however, there is no Federal investment in a Corps project that is intentionally or effectively a land development project and projects generally should not use land enhancement as a large incidental benefit)
- Reduced associated costs
- Utilization of unemployed or underemployed labor in various markets
- National ecosystem restoration (NER) benefits, which are generally not monetized but appear in the form of additional acres, habitat units, fish counts, or biodiversity indices
- Reduced landside transportation costs (if it can be demonstrated that cost reductions will occur because of the project and would not occur without it) [55]
- Benefits During Construction: these can be a combination of any of the above benefits that accrue prior to the base year
- Other environmental and economic benefits from regional approaches to sediment management (such as reduction lifecycle maintenance costs, increased habitat benefits, increased beneficial use of sediment resources, increased efficiencies through regional strategies and partnerships)

Cruise Ship Benefits

Section 230 of WRDA 1996 directs the Corps of Engineers to categorize all benefits generated by cruise ships as commercial navigation benefits. Benefits of navigation improvements affecting cruise ships arise from more efficient ship operations and increased tourism or enhanced tourism experience.

IWR Report 99-R-8 "The US Cruise Industry Evaluation of National Economic Development Benefits"[56] provides descriptions of benefits to cruise vessels which include:

- decreases in vessel operating costs
- increases in producer surplus (net revenues, profits)
- benefits to passengers (increase in the value of passenger experience or reductions in passenger opportunity costs of time and out-of-pocket expenses).

This document has some important considerations for analyzing cruise ships benefits but does not provide a detailed methodology for cruise ships benefit analysis. This section of this Manual will be expanded in the future to further refine methods for cruise ship analysis.

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[55] *The basis for claiming such benefits is the P&G requirement to consider all transportation costs from origin to destination. Since the P&G does not specifically recognize landside transportation benefits, an obligation to claim such benefits and show associated costs does not apply. The acceptability and amount of such benefits will depend on how good a case can be made that the project is the proximate cause of the cost reductions, how well the cost reductions can be documented as part of the origin-destination transportation costs, and whether all associated costs have been identified. Generally, this will limit benefits to the reduced cost of cargo handling or reduced inland transportation costs attributable to specific improvements in the immediate port area.*

[56] *http://www.iwr.usace.army.mil/inside/products/pub/iwrreports/99r08.pdf*

Reduction in User Fees

Pursuant to the Water Resources Development Act of 1986 (P.L. 99-662), Federal user charges will be assessed for use of certain waterways (fuel tax) and harbors (harbor maintenance fees) and project sponsors may assess local user fees to recover their project cost share. Conceptually, they are treated as transfer payments from one entity to another.

If a project does not impact the user fee, then these fees do not reduce the NED cost of the project. If the project reduces a cost that is being covered by a user fee, which is itself reduced, then the reduction can be included as an additional project benefit.

14.4 Identifying the NED Plan

NED Benefits

NED benefits are contributions to National Economic Development that increase the value of the national output of goods and services. They are the primary basis for Federal investment in water resource projects. Net NED benefits are NED benefits reduced by NED costs. The NED plan for a project is the plan that most reasonably maximizes net NED benefits in average annual equivalent terms.

There are several steps involved to actually determining the NED plan. The step are summarized and also further elaborated on:

- Determine costs and benefits over the period of analysis
- Discount the costs and benefits for all alternatives to a single “base year” present value; in the case of interest during construction or benefits during construction one would appreciate values forward to the base year
- Amortize the present values to find the average annual equivalent (AAE) costs and benefits
- Subtract the AAE costs from AAE benefits for each alternative to find the net AAE benefits
- Choose the plan that has the highest net AAE benefits

Compute Benefit and Cost Stream over Project Life

First, the total cost including OMRR&R for each alternative, segment, and increment must be estimated. For each movement, the economist should compute the difference in transportation costs between the with- and without-project conditions for each project alternative and each time period of the project life. The economist will sum the savings for each time period of the project life to obtain total benefits for each project. This will yield a benefit stream over time for each alternative of the form (B_{1i}, B_{2i}, …, B_{ni}), where n is the project life and i represents an index of project alternatives.

A recap of benefit estimates and an example can be found in Appendix G.

Discounting Benefits and Costs

To properly compare the benefit and cost streams associated with each project alternative, benefits and costs must reflect a common time standard. This is accomplished through discounting, a procedure that adjusts the value of a stream of benefits or costs to reflect the time value of money. Discounting converts a future stream of payments into an equivalent lump-sum payment at some point in time, typically the base year for project studies. This lump-sum payment is called the present value of the payment stream discounted at an interest rate, reflecting the time value of money.

The present value, PV_B, of a stream of payments (P_1, P_2, …P_n) can be calculated as:

$$P_1/(1+r) + P_2/(1+r)^2 + . . . + P_n/(1+r)^n$$
$$= \sum_{t=1}^{n} [P_t/(1+r)^t],$$

where *r* is the discount rate, *t* is the project year, and *n* is the project life.

In other words, the total present value of the stream of benefits equals the sum of the following: the benefit value of each out year one divided by one plus the interest rate for year one plus the benefit value of year two divided by one plus the interest rate squared $(1+r)^2$ plus . . .(the pattern continues for each out year changing the benefit for that year and the power to which (1+r) is raised to).

The net present value (NPV) of an alternative is defined as the excess of benefits over costs discounted to reflect the time value of money. The cost stream would be estimated just as the benefits were and they would be subtracted from one another. Using the cost stream (C_B, O_1, O_2, …, O_n) and the benefit stream (B_1, B_2, …, B_n), the net present value can be computed as:

$$NPV = \sum_{t=1}^{n} [(B_t - O_{t)} /(1+r)t] - C_B,$$

where *n*, *t*, and *r* are defined above. The NPV is the basis for comparing the value of alternatives. The appropriate discount rate for water resources studies is determined annually based on the average yield of marketable U.S. securities having a date to maturity exceeding 15 years. It is distributed annually by the Office, Chief of Engineers and available on the web (http://www.usace.army.mil/CECW/PlanningCOP/Pages/egms.aspx or http://www.treasurydirect.gov/govt/rates/tcir/tcir_fy2010_opdirannual.htm). Costs are done in the same manner.

Average Annual Equivalent Benefits and Costs

The Corps guidance requires the final NED benefits and costs to be in terms of the average annual equivalent value rather than a discounted lump sum represented by present value and net present value.[57] Therefore, the values must be amortized. This is a discounting technique that converts a stream of unequal payments into an equivalent stream of equal payments in each time period. The average annual equivalent of a stream of payments (P_1, P_2, …, P_n) is a stream of constant payments, P, where the discounted value of both streams is

[57] *When comparing projects, it is important to make sure that the timeframes for which the average annual equivalents are computed are the same.*

equal. Average annual equivalents are primarily used as a scaling factor in discussing or presenting benefits and costs.

How to Calculate the AAE

AAE Value is found by discounting the stream of future benefits and costs to a common present value and multiplying each value by an amortization rate. The amortization rate draws from the interest rate and period of analysis. The Federal discount rate for Civil Works is published each year and must be used. The period of analysis is typically 50 years. Together, the amortization rate, period of analysis, and present values are used to estimate the average annual equivalent benefits and costs, which can then be subtracted to find the net benefits.

14.5 Determine the NED Plan

Now that the NED Benefits and Costs have been determined, brought to present value and amortized, the net present value of NED Benefits can be found. The project with the highest net present value is the NED Plan. This is calculated by simple subtraction:

Net AAE NED Benefits =

NED Average Annual Equivalent (AAE) Benefits – NED AAE Costs

Total NPV NED Benefits = NPV NED Benefits – NPV NED Costs

**The plan with the highest Net AAE NED benefits is the same plan as the one with the highest Total NPV NED Benefits.*

In a comparison of alternatives, the feasibility of each alternative is identified and determines the need for any additional analysis of the alternative. It will facilitate specification of parameter variations for the sensitivity analysis. Table 14-1 below show Alternative 2 to be the NED plan and also have the highest B/C ratio; however, it is possible that the NED plan doesn't have the highest B/C ratio.

Table 14-1: Comparison of Alternatives as Present Values

ALTERNATIVE	PRESENT VALUE OF COST	PRESENT VALUE OF BENEFITS	NET PRESENT VALUE OF ALTERNATIVE
Without-Project	$ 1,000	$ 1,500	$ 500
Alternative 1	$ 2,000	$ 2,600	$ 600
Alternative 2	$ 3,000	$ 3,750	$ 750

NED Incremental Justification

When a proposed project can be divided into separate benefit segments, the economic criteria for project justification requires that each project segment be either independently or conditionally justified.

In most instances, project segments will be defined based on physical and cost differences that can be observed and appear to be significant. For harbors, this might involve different reaches, depths, channels or zones within a particular reach or channel that have different traffic and/or vessel flows. A segment might be defined based on facility density or the distribution of project costs.

Any parameter developed in the previous chapters for computing benefits and costs could provide a basis for defining project segments.[58] The available data should be sufficiently refined to support project segmentation. Total project benefits and costs are then the sum of the benefits and costs of the individual segments.

Each segment must be incrementally justified using the same procedures to find the AAE benefits and costs.

14.6 Final Analysis Summary

The project analysis objective is to prepare recommendations and information for decision-making. This section focuses on the presentation of information which leads to and supports the recommended course of action, including statement of objective, recommended course of action, assumptions, alternative courses of action, and a concise summary of the results of the economic analysis. Appropriate citations/documentation of all results must be presented. Based upon all the available data and the results of the feasibility analysis, the best alternative will be selected.

The selection of the recommended alternative is based on a comparison of the effects of each alternative and their relative degree of success in fulfilling project objectives. Formally, the NED alternative maximizes net project benefits, where net benefits are defined to include all project impacts and acceptable levels of risk. Net benefits are computed as the difference between the present value of benefits and present value of costs for each alternative. The recommendations should be supported by a detailed assessment of the advantages and disadvantages of each alternative with a clear justification and explanation of the rationale for selection of the recommended alternative. Economic impacts of each alternative, with associated effects of the risk analysis, will provide a basis for the critique of each alternative and selection of the best alternative.

In discussing the selection of the recommended alternative, three general features of the analysis should be set forth:

- there should be a clear statement identifying the most likely scenario, that is, the assumptions and future conditions underlying the analysis that led to the selection;
- if applicable, phased implementation of the recommended alternative should be presented; and,

[58] *Although it is desirable to justify each project segment or component on its own merits, this is not always possible because justification of some segments may be conditional on justification of other segments or project components.*

- the critical parameters underlying the recommended alternative must be transparent. It need not fully recount the steps of the economic analysis, but it must provide an understanding of the important decisions and results of the economic analysis.

For a Review Guide and Checklist on Consideration for Deep Draft Navigation and Economics, please visit:
http://www.sam.usace.army.mil/ddncx/reviewguide.asp

14.7 Key Concepts

This chapter's key concepts are:

- Benefit/Cost Analysis is one conceptual framework for assessing tradeoffs between various project objectives and alternatives and measuring the effectiveness of various alternatives.
- Types of NED costs that need to be assessed are:
  - project implementation (construction) costs
  - operation, maintenance, repair, replacement and rehabilitation (OMRR&R) costs
  - interest during construction
  - associated landside and port costs
  - any mitigation, monitoring or other environmental costs
  - lands, easements, relocations, rights-or-way, disposal sites (LERRDS)
- Associated costs are any public or private Federal or non-Federal expenditures on navigation infrastructure and facilities necessary to achieve the estimated benefits or traffic levels for each project alternative.
- A self liquidating cost is the cost of a particular asset that can be operated in such a way that it repays the money spent to acquire it.
- NED benefits derive from improved transportation efficiencies, higher net revenues, induced movements, or other benefits such as flood or coastal storm risk reduction, utilization of under-employed labor, and more.
- NED benefits less NED costs equals net NED benefits. The highest net NED benefits determines the NED plan. These values must be discounted to a present value and amortized over the project life or 50 years, whichever is most appropriate, to find the average annual equivalent benefits and costs as required by policy.

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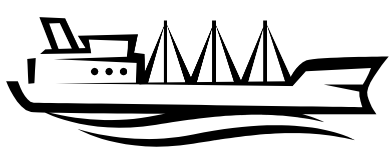


APPENDIX A: TERMINOLOGY[59]

A.1 Navigation Terms

For additional Terms See EM 1110-2-1613: http://140.194.76.129/publications//eng-manuals/em1110-2-1613/glossary.pdf

Anchorage—An area inside a water body providing the ships some protection from the weather while lying at anchor to stand by, load or unload cargo, await repairs, etc. (EM 1110-2-2904). They are protected areas where shippers lay down their anchors and wait to exit the harbor. Improvements to anchorages or "berthing areas" are generally paid by the non-Federal sponsor

Allisions— when a moving vessel strikes a fixed object

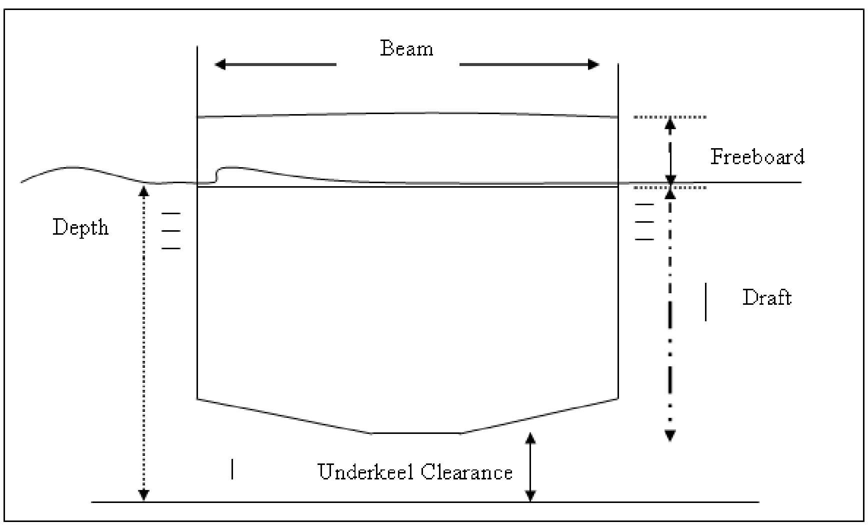
Backhaul—'backhaul' cargo refers to cargo that is on a vessel's return trip

Ballast—water that is held in the bottom of a ship to prevent the ship from capsizing

Bale Capacity—capacity of a vessel based on standardized cubic measure for cargo and stowage

Beam— the beam of a ship is its width at its widest point. Vessel beams are an important factor determining the width of channels.

Figure A-1: Vessel Diagram



Berth—a space where vessels come to dock or set anchor

Bow Thruster—a device built into, or mounted to, the bow of a ship to make it more maneuverable.

Bow— The bow of the ship refers to the forward part of a vessel

[59] *Many of these terms are from the 1991 Deep Draft Navigation NED Manual, IWR Report 91-R-13*

Breakwater—Structures designed to provide shelter from waves and improve navigation conditions. Such structures may be combined with jetties where required (EM 1110-2-2904).

Build Year—the year that a ship was built and completed

Bulk Carriers—Ships designed to carry dry or liquid bulk cargo. Category includes: ore/bulk/oil carriers (OBO) and other combination bulk/oil carriers.

Bulkhead—similar to a seawall, it is a constructed barrier in the water

Bunker—low grade coal or heavy oil used to power a ship

Cabotage—Domestic water transports. Can be coastwise, intercoastal, inter-island, or through inland waterways.

Call—this denotes when a ship is coming to visit a port and berth

Channel—a natural or man-made deeper course through a reef, bar, bay, or any shallow body of water, often used by ships.

Figure A-2: Channel Cross Sections

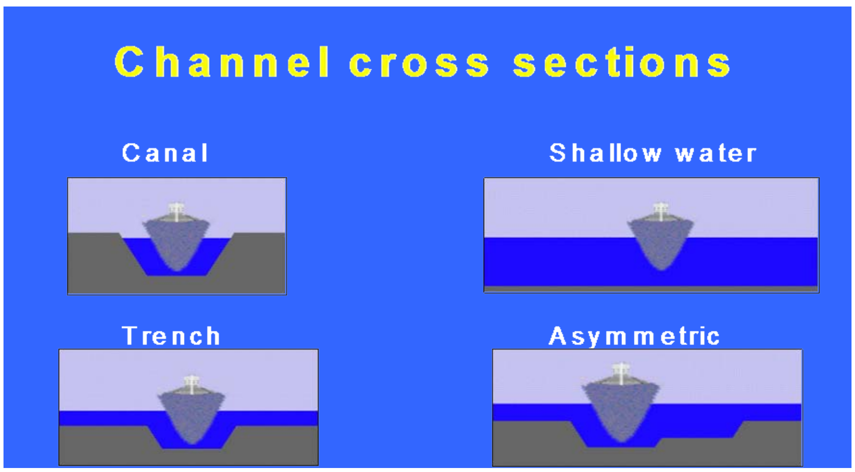
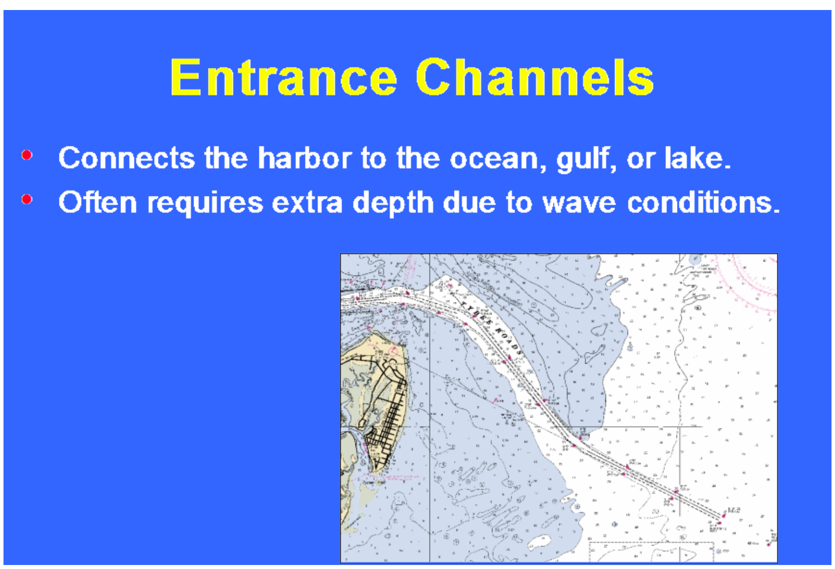


Figure A-3: Entrance Channels



Collision—when two moving vessels strike each other

Container Vessels—Ships equipped with permanent container cells that hold containers

Deployment—assignment of a vessel to functional service, such as a route

Design Vessel—a prototypical vessel configuration that is used for evaluation of design specification of a navigation feature

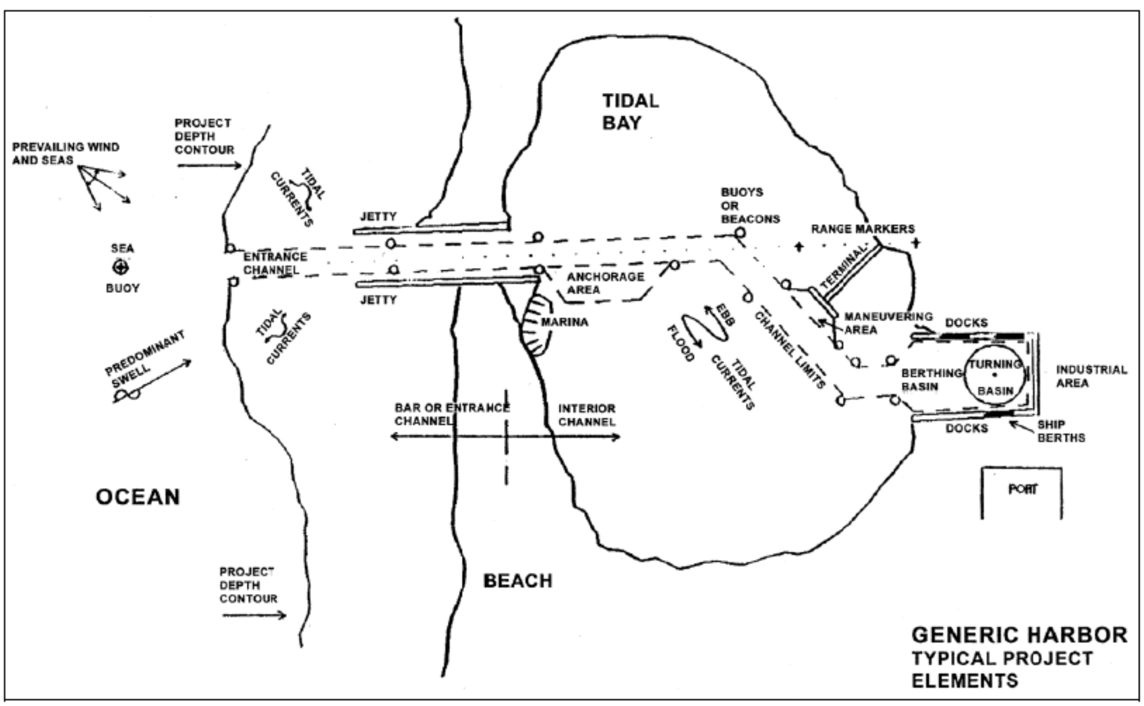
Draft or Draught— The **draft** (or **draught**) of a vessel is one of the most common pieces of information used in Corps navigation studies and can be defined as the distance between the waterline and the bottom of the ship's hull (keel) (see Figure A-1). In other words, it is the amount of water needed to for a ship to navigate safely. Channel deepening projects generally require a thorough analysis of vessel drafts. There is an important distinction between a vessel's design draft and its operating draft. The design draft of a vessel is the maximum draft a vessel could potentially reach fully loaded whereas the operating draft (as required for most Corps studies) examines the typical draft that is employed since it is rare that vessels will sail at their maximum design draft.

Dredges— *please see Appendix F*

DWT—Deadweight Tonnage—the carrying capacity of a vessel in tons (most references now show metric tons). It is the difference between the light and loaded displacement (weight of the ship itself vs. ship plus cargo, fuel, stores and water).

Entrance Channel—A navigable channel connecting the ocean or lake to an enclosed water body such as a bay, estuary, river, or mouth of a navigable stream (EM 1110-2-1613).

Figure A-4: Typical Project Elements



Feedermax Vessel—a cellular containership that holds about 500 to 1,000 TEUs

FEU—Forty-foot equivalent unit—This is an 40 X 8 X 8.5 feet dry cargo intermodal container used as a measurement of container volume. See also TEU, twenty-foot equivalent-unit. One FEU equals two TEU.

Freeboard—the freeboard of a ship is the distance above the waterline and represents a margin of safety for vessel loading.

Fronthaul— cargo that is carried on the trip out vs. return trip, opposite of backhaul

Grounding—when a vessel strikes the bottom of the sea or channel

GRT—Gross Registered Tons. Internal cubic capacity of the ship expressed in tons on the basis of 100 cubic feet per ton. This differs from DWT because it measures the area versus the weight, same as gross tonnage.

Harbor—A harbor is a sheltered part of a body of water deep enough to provide anchorage for ships or a place of refuge. Key features of all harbors include shelter from both long-and short period open ocean waves, easy safe access to the ocean in all types of weather, adequate depth and maneuvering room within the harbor, shelter from storm winds and cost-effective navigation channel dredging.

Homogenous TEU Capacity—standardized measure of slot capacity relative to the deadweight rating of a ship hull; traditionally, this measure has been 14 metric tons per TEU

Hull—A **hull** is the body of a ship or boat. It is a central concept in floating vessels as it provides the buoyancy that keeps the vessel from sinking, also known as an IMO number.

Interior Channel—The access channel system inside a water body that connects the entrance channel (inlet or bar) to a port or harbor with appropriate ship facilities. Interior channels are usually located to provide some protection from waves and weather and are located in bays, estuaries, or rivers (EM 1110-2-1613).

Jetties—Structural features that provide obstructions to littoral drift, control entrance currents, prevent or reduce shoaling in the entrance channel, maintain channel alignment, and provide protection from waves for navigation (EM 1110-2-1613).

Figure A-5: Jetties and Pile Dikes

These structures, shown to the left, are designed to force the water passing by them into the channel. The energy of the flowing water helps to keep sediments from settling and building shoals in the channel. By redirecting the flow of the river, pile dikes protect the bank from erosion, too.

<u>LASH</u>—Lighter Aboard Ship. The ship carries barges in special compartments analogous to cellular (container) vessels.

<u>LBP</u>—Length between Perpendiculars

<u>LOA</u>—Length Overall

<u>LO/LO</u>—"lift on/lift off" —containerized cargo which is loaded and offloaded by a ports cranes

<u>Load Center</u>—A high volume container port effectively reducing vessel port calls by concentrating intermodal sea-land transfers at a few large ports rather than spreading them out among a larger number of small ports.

<u>Lock and Dam</u>—a device for raising and lowering boats from one water level to another. It is often associated with a dam.

<u>Longshoremen</u>— those employed to unload and load ships

<u>Macro-Bridge</u>—Also known as "land bridge". It is the same as mini-bridge, except that it involves substitution of land transportation across the United States in place of water service, for traffic that originates and terminates outside of the United States.

<u>Manifest</u>—a detailed summary sheet of all cargo being carried for each vessel trip; information also includes origin, destination, value, number, etc.

<u>Micro-Bridge</u>—Interior point intermodal service similar to mini-bridge, except that cargo originates or terminates at an inland city rather than another port city. The cargo moves on a single (ocean) bill of lading to and from the interior point and the port.

<u>Mini-Bridge</u>—Substitution of rail or truck service for water transportation between two U.S. port cities for cargo originating or terminating in a port city.

<u>Neobulk</u>—type of general cargo such as cars, timber, steel, etc.

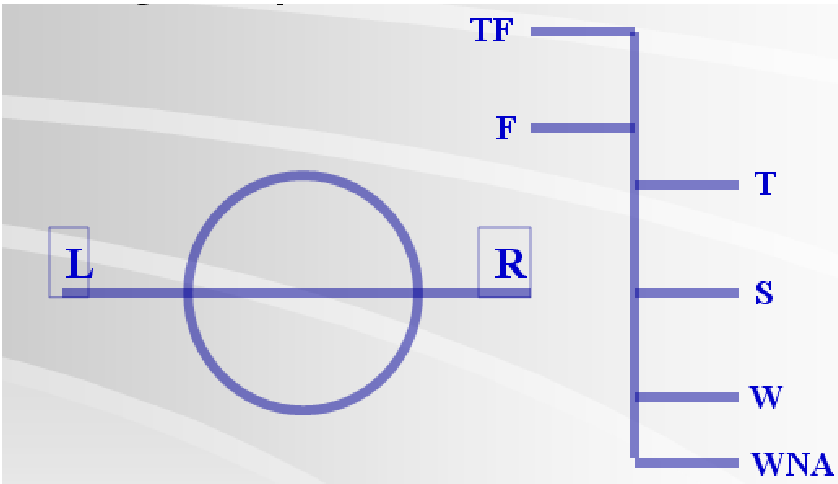
<u>Nominal TEU Capacity</u>—maximum number of TEUs that a vessel can carry by volume; the sheer number of capacity as measure by the number of slots

<u>Panamax Vessel</u>—Ships built to maximize capacity within the Panama Canal lock size limits of 950 feet long, 106 feet wide. Design draft is usually no greater than 40 feet and sails no greater than the 39.5 feet canal limit, with deadweights up to 80,000 tons.

<u>Pile Dike</u>— A dike constructed of a group of piles braced and lashed together along a riverbank. *See Jetties for a picture*

<u>Plimsoll Line:</u> this figure is required to be on all ships to designate the various loading depths in various conditions. L and R stand for Lloyd's Register. TF = tropical fresh water; F = fresh water, T = tropical seawater ; S = summer temperate seawater ; W = winter temperate seawater; WNA = winter North Atlantic.

Figure A-6: Plimsoll Line



Port—A port is a place by a waterway where ships and boats can dock, load and unload.

Post-Panamax Vessel—a fully cellular containership that can carry more than 4,000 TEUs; a vessel that is larger than the original Panama Canal dimensions, but will fit under the Panama Canal expansion

RO/RO—Roll-On/Roll-Off Vessels. Ships which are especially designed to carry wheeled containers, vehicles, or trailers and only use the roll-on/roll off method of loading and unloading. Containers and trailers are usually stowed onboard on their chassis. Vehicles can be driven on and off.

Sailing Draft—the vertical depth below the water surface in which the vessel moves in

Scantling Draft—the maximum draft at which a vessel complies with the governing strength requirements of classification societies.

Sub-Panamax Vessel—a fully cellular containership that is less than the maximum dimensions to transit the Panama Canal and can carry between 2,000 and 3,000 TEUs

Surge—The longitudinal oscillatory linear motion about the center of gravity (origin of body axis) in the ship travel direction, usually due to wave effects; motion backward and forward (fore and aft direction) (EM 1110-2-1613).

Squat—the tendency of a ship to draw more water astern than when stationary, this amounts to less available underkeel clearance

Stern—the stern refers to the back end of the vessel

Tank Vessel (Tanker)—Ships which carry liquid products, such as crude petroleum, petroleum product, chemicals, liquid natural gas and molasses.

TEU—Twenty-foot equivalent unit. A dry cargo container unit measuring 40 X 8 X 8.5 feet used as a measure of container capacity.

Ton— a unit of measurement used in shipping assuming 100 cubic feet of cargo equals one ton, equals 2000 pounds and is also called a “short ton”, a “long ton” equals 2240 pounds, and a “tonne” is 2204 pounds

Tonne—a metric tonne is 2204 pounds.

TPC Immersion—the amount of tons that it takes to lower a ship's draft one centimeter

TPI—Tons per Inch. Measure of vessel capacity equal to the weight of displaced water if vessel draft were to change by one inch.

Traffic Diversion—Any commodity flow which ceases to use the project under some project alternative or scenario.

Trim— to adjust a vessels balance through ballast or cargo movements; sailboats use sails to do this

Turning Basin—An area that provides for the turning of a ship (bow to stern). Turning basins are usually located at or near the upper end of the interior channel and possibly at one or more intermediate points along long channels (EM 1110-2-1613).

Underkeel Clearance—the distance between the bottom of the ship and the sea or channel floor directly under the vessel

Figure A-7: Turning Basin Diagram

ULCC (Ultra Large Crude Carrier)—Crude petroleum vessel exceeding 300,000 DWT.

VLCC (Very Large Crude Carrier)—Crude petroleum vessel exceeding 150,000 DWT but less than 300,000 DWT.

Wharf—A waterside structure, usually parallel to the waterway bank, at which a vessel may be berthed alongside from which cargo or passengers can be loaded or discharged. A pier or dock built on the
shore of a harbor, river, or canal.

Wingwall—usually acts as a retaining wall or as a support for an abutment.

Yaw—A temporary swing off course by a vessel, usually because of waves, but may be caused by poor steering, currents, or wind. The horizontal angular deviation of a vessel’s longitudinal axis from the desired line of track. The angular, oscillatory motion (rotation) about the ship vertical axis; to alternately swing to and fro off course, usually by wave action (EM 1110-2-1613).

A.2 Oceanographic Terms[60]

Bench Mark—A fixed physical object used as reference for a vertical datum. A tidal bench mark is one near a tide station to which the tide staff and tidal datum are referred.

Diurnal—Having a period or cycle approximately 1 tidal day. Thus, the tide is considered diurnal when only one high water and one low water occur during a tidal day, and the tidal current is considered diurnal when there is a single flood and single ebb period in the tidal day.

Extreme High Water—The highest elevation reached by the sea as recorded by a tide gauge during a given period. NOS routinely documents monthly and yearly extreme high water for its control stations.

Extreme Low Water—The lowest elevation reached by the sea as recorded by a tide gauge during a given period. NOS routinely documents monthly and yearly extreme low water for its control stations.

High Water (HW)—The maximum height reached by a rising tide. The height may be due solely to the periodic tidal forces or it may have superimposed upon it the effects of prevailing meteorological conditions.

Higher High Water (HHW)—The higher of the two high waters of any tidal day.

Higher Low Water (HLW)—The higher of the two low waters of any tidal day.

Low Water (LW)—The minimum height reached by a falling tide. The height may be due solely to the periodic tidal forces or it may have superimposed upon it the effects of meteorological conditions.

Lower High Water (LHW)—The lower of the two high waters of any tidal day.

Lower Low Water (LLW)—The lower of the two low waters of any tidal day.

Mean High Water (MHW)—A tidal datum. The arithmetic mean of the high water heights observed over a specific 19-year metonic cycle.

Mean Higher High Water—A tidal datum. The arithmetic mean of the higher high water heights of a mixed tide observed over a specific 19-year metonic cycle.

Mean Low Water (MLW)—A tidal datum. The arithmetic mean of the low water heights observed over a specific 19-year metonic cycle.

Mean Lower Low Water (MLLW)—A tidal datum. The arithmetic mean of the lower low water heights of a mixed tide observed over a specific 19-year metonic cycle.

Semi-diurnal—Having a period of cycle of approximately one-half of a tidal day. The predominating type of tide throughout the world is semidiurnal, with two high waters and two low waters each tidal day.

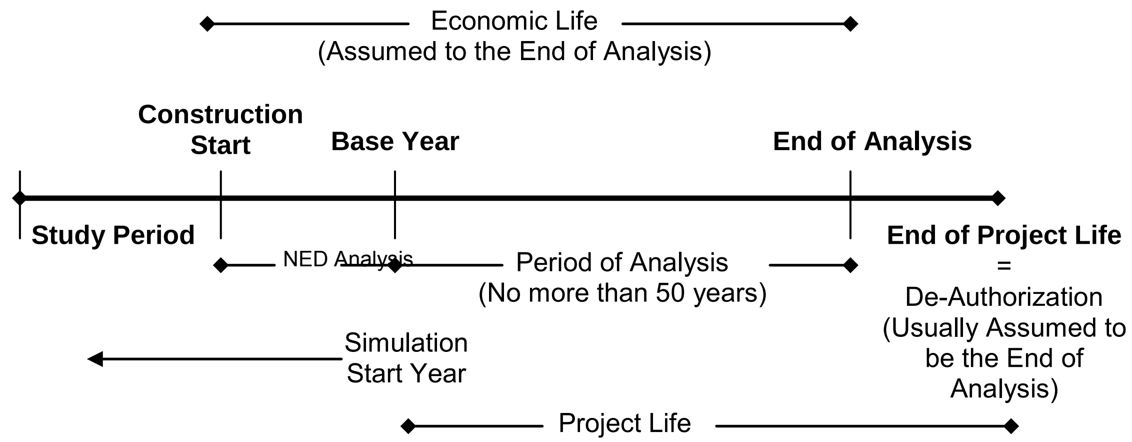
Tide curve—A graphic representation of the rise and fall of the tide.

WCSC—The Waterborne Commerce Statistical Center.

[60] *These appeared in the Corps' SR-7 Report "Tides and Tidal Datums in the United States" by the Coastal Engineering Center, February 1981, pages 93-113.*

A.3 Planning Terms

Figure A-8: Planning Life Cycle



BDC = Benefits During Construction

PED = Preconstruction, Engineering and Design; this begins prior to construction but its costs are counted in total costs

Associated Costs—Any public or private Federal or non-Federal expenditures on general navigation features ancillary to the project necessary to achieve estimated benefits or traffic levels for each project alternative.

Average Annual Equivalent—A discounting technique that converts a stream of unequal payments into an equivalent stream of equal payments, where both streams have the same present value. This is different from average annual because average annual does not amortize the total present value, but rather it averages the value.

Baseline Condition—A scenario from which project impacts can be measured, i.e., a point of reference.

Benefit-Cost Analysis—An analytical method for comparing the positive (benefits) and negative (costs) impacts of an action.

Benefit-Cost Ratio (BCR)—The ratio of discounted project benefits to discounted project costs. BCR's are less than one when a project's costs exceed its benefits.

Cost Reduction Benefits—Project benefits which result from a decrease in the cost of shipping commodities that reflect the same origin-destination pattern and harbor in all project conditions.

Critical Parameters—Those analytical factors that are the major determinants of the level of project benefits and costs.

Discount Rate—The interest rate used to convert a flow (benefits or costs) into an equivalent stock (Present Value).

Discounting—A procedure which adjusts the value of a stream of benefits or costs to reflect the time value of money. Discounting converts a flow into an equivalent stock at some point in time. This stock is called the present value of the flow discounted at interest rate r.

Existing Condition—A description of the project setting based on present conditions; it simply describes "what is" at the time the analysis is undertaken.

Hinterland—The geographic areas where port commerce originates and terminates.

IDC—"interest during construction" is the opportunity cost of capital incurred during construction

Increased Traffic Benefits—Project benefits which can be attributed to increased traffic levels as a result of decreasing transportation costs. The increase in traffic may result from any of the following reasons: shift of origin, shift of destination, or induced movements.

Incremental Analysis—a process to determine the next added segment of a project, or project scales. This analysis answers the question, "are there more benefits than costs if we add this next piece or scale to a project?" The analysis continues until costs are greater than benefits.

Incremental Benefits (Costs) —The difference in benefits (costs) between two Project Alternatives

Induced Movement (Traffic Benefits)—Project benefits that result from an increase in commodity flows relative to the without-project condition and which do not reflect a change in origins or destinations.

Internal Rate of Return (IRR)—The interest rate which discounts the benefit and cost streams so that they yield a Net Present Value of zero.

Most Likely Scenario—Those future conditions the analyst believes most likely to prevail.

NED Benefits—The complete benefit stream associated with implementation of a project alternative over the project life that is obtained when the project alternative is implemented.

NED Costs—The complete cost stream associated with implementation of a project alternative over the project life that is necessary to achieve the estimated benefit or traffic levels.

Net Present Value—The excess of inflows (benefits) over outflows (costs) discounted to reflect the time value of money.

Non-Structural Alternatives—A project alternative which does not alter the physical characteristics associated with the existing condition. Non-structural alternatives would include operational and management practices, and minor structural improvements that enhance utilization of the existing project.

OBERS—Acronym for the Office of Business Economics of the U.S. Department of Commerce, the Economic Research Service of the U.S. Department of Agriculture. OBERS is the short title for projections of economic activity and population now produced by the Bureau of Economic Analysis (BEA) in Commerce. Originally they were a cooperative effort under the Water Resources Council and part of the water resources planning program.

Opportunity Cost—the cost of passing up the next best choice in a decision

Payback Period—The shortest project life yielding a Net Present Value of zero at the current discount rate.

Phased Construction—An implementation strategy whereby the project is constructed in discrete segments with benefits and costs assigned to each individual segment.

Project Segmentation—The practice of dividing a project alternative into discrete components which can be individually evaluated and implemented.

Self-Liquidating Costs— A **self liquidating cost** is the cost of a particular asset that can be operated in such a way that it repays the money spent to acquire it.

Sensitivity Analysis—An analytical technique designed to identify those factors that are the major determinants of the level of project benefits and costs. The sensitivity analysis will assist in identifying critical study parameters and how they impact the results.

Separable Element—a functional general navigation feature that can be evaluated separately from the rest of the project.

Shift of Origin (Destination) Benefits—Project benefit that result from changes in the origins or destinations of traffic movements due to project implementation that increases efficiency.

Structural Alternatives—A project alternative which significantly alters the physical characteristics of the project area associated with the Existing Condition.

Study Year—the year in which a project is being studied, often it is the same as the existing condition; it is usually not the same as the base year usually

"With-project" Condition—The set of future conditions the analyst believes most likely to prevail for each project implementation over the period of analysis. These conditions may vary for each project alternative.

"Without-project" Condition—The set of future conditions most likely to prevail in the absence of the proposed project. It does not describe conditions as they exist at the time of the study, but describes the conditions that are expected to prevail over the planning horizon in the absence of a project.

APPENDIX B: CALCULATING BENEFITS: 4 CASES

In this appendix we will step back and look at four different cases concerning the calculation of NED benefits:

- increased loading of vessels
- switch to larger vessels
- reduction in tide delays
- increased traffic benefits

B.1 Application 1: Increased Loading of Vessels

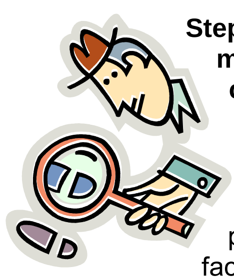
Step 1: Determine if the shipping companies would load more fully for that particular vessel once the depth constraint is removed.

Step 2: Determine unit cost of "without project" condition

Step 3: Determine unit cost of "with project" condition

Step 4: Compute Project Savings over the Project Life

Let's assume a 50,000 DWT vessel is systematically entering the channel partially loaded. In other words, cargo space is available, but the shippers intentionally leave the space empty, only carrying a total of 25,000 DWT. At the same time, the vessel companies have been complaining about the shallow depth and are threatening to leave the port altogether. They claim that if the channel were deepened by several feet, they would be able to load their vessels more fully which would require a deeper draft. This would substantially reduce their transportation costs per ton.



Step 1: Determine if the shipping companies would load more fully for that particular vessel once the depth constraint is removed.

Shipping companies hold strong feelings about the availability of water. In their view, "deeper is always better" and optimizing a vessel would provide them with the lowest possible unit costs. One way to separate hearsay from the facts is by comparing the design draft with a vessel's operating draft. If it is discovered that vessels routinely leave several feet of available cargo space open, they may be engaging in light loading practices. This is especially true when the drafts "bump up" against the maximum allowable depth. Be sure to examine the vessel's complete voyage, however. The study port may happen to be the last particular leg in the journey or the next port may only accommodate a shallow draft. The loading may always be lightest load for that leg of the journey.

Step 2: Determine unit cost of "without project" condition

Sea and port voyage costs are defined as all the costs necessary for a vessel to operate. Costs include fixed costs such as crew, insurance and depreciation of the vessel. Variable costs such as the fuel costs are a function of the trip's length. Fortunately, the Corps determines many of these standardized costs by vessel size and category, but not for all vessels such as tugs. The vessel operating costs are updated every few years. The following is a snapshot of the vessel operating costs for one such vessel.

It should be mentioned that details of the costs are protected under Section 4 of the Freedom of Information Act. Planners must remember to present the costs in an aggregate form to prevent shipping companies from gaining unfair competitive advantages.

Tampa Harbor

Table B-1: Vessel Operating Costs
Foreign Flag General Cargo Vessel (US $ 2004 Price Levels)

Deadweight Tonnage (DWT)	35,000	50,000	80,000
Replacement Cost (s)	$17,272,000	$19,662,000	$25,046,000
CRF (5.625%)	0.0754613	0.0754613	0.0754613
Average Annual Equiv Cost	$1,303,370	$1,483,720	$1,890,000
Fixed Operating Cost(s)			
Crew Cost	$734,810	$752,120	$769,430
Lubes & Stores	$196,570	$215,560	$246,020
Maintenance & Repair	$242,390	$305,910	$384,340
Insurance	$146,110	$158,280	$181,370
Administration	$208,350	$218,300	$236,130
Total Annual Fixed Operating Cost(s)			
Applied Operating Time	345	345	345
Applied # of Operational Days/Yr	24.0	24.0	24.0
Applied # of Operational Hours/Day	$8,130	$8,980	$10,580
Total Daily Capital & Fixed Operating Costs			
Daily Fuel Costs			
Daily Fuel Cost at Sea	$4,800	$5,390	$6,340
Daily Fuel Cost at Port	$480	$600	$600
Daily Total Costs			
Total Daily Cost at Sea	$12,930	$14,370	$16,920
Total Daily Cost at Port	$8,610	$9,580	$11,180
Hourly Total Costs			
Hourly Total Costs, at Sea	$539.00	$599.00	$705.00
Hourly Total Costs, at Port	$359.00	$399.00	$466.00
Vessel Characteristics/Physical Specifications			
Length Overall (LOA; feet)	607.6	676.5	779.2
Beam or Breadth (BX; Extreme; feet)	89.7	99.5	114.2
Draught; Summer (feet)	35.5	39.7	46
Immersion Rate (metric tons/in; TPI)	109.7	137	183.7
Horsepower (Total)	10460	11670	14110
Service Speed (Knots)	14	14	14

So for this 50,000 DWT vessel, it would cost approximately $599 per hour at sea and $399 per hour at port. Assuming that the voyage from Asia is 6,000 miles and with a sailing speed of 14 knots per hour (from the vessel operating cost table), the vessel would spend 428 hours at sea at a cost of $256,000. If vessel remains in port for 48 hours as it unloads and reloads cargo, its port costs would then be $19,000.

The costs at sea are ($599 per hour at sea) x (428 hours at sea) = $256,372
The costs at port are ($399 per hour at port) x (48 hours at port) = $19,152
Total costs = $256,372 + $19,152 = $275,524
Unit costs without project = ($275,524/25,000) = $11.02/ton

Ships will rarely load to total design weight. Be sure to adjust for fuel, ice and stores. The maximum cargo should never occupy greater than 90% of a vessel's total deadweight.

Step 3: Determine unit cost of "with project" condition

This is a key step. The economist should determine how much more cargo that vessel could accommodate for each additional foot of deepening. The immersion factor, defined as the relationship between a change in a vessel's load and a change in its draft, can vary depending on the type of vessel.

By examining the vessel's immersion factor (provided in the vessel operating cost table), one foot of additional depth would enable this particular vessel to load 1,644 more tons of cargo. Two feet of additional depth would be 3,288 more tons, etc. Since the vessel can now load more fully, the unit transportation costs drop.

(Immersion Factor) x (# of Inches of Cargo Space)
(137 tons/inch) x (12 inches) = 1,644 tons/foot

Unit costs with 1' deepening = $275,524/26,644 = $10.34/ton

Step 4: Compute Project Savings over the Project Life

These are defined as the difference in transportation costs with and without a project. The unit cost savings are then multiplied by the forecasted tonnages. Be sure to discount and annualize correctly when developing the stream of benefits over the planning horizon.

Project Savings = ($11.02/ton) – ($10.34/ton) = ($0.68/ton)

For each movement, the analyst should compute the difference in transportation costs between the "with" and "without project" condition for each project alternative and each time period of the project life. Differences in transportation costs for each year are computed in the same manner as described above for the base year. The analyst will then sum the savings for each time period of the project life to obtain total benefits for each project. This will yield a benefit stream over time for each alternative of the form (B_{1i},, B_{2i}, …, B_{ni}), where *n* is the project life and *i* represents an index of project alternatives.

Dredging at Brunswick Harbor

B.2 Application 2: Switch to Larger Vessels

Step 1: Determine if the shipping companies would switch to the larger class of vessel once the draft constraint is removed.

Repeat Steps 2 through 4 from Application 1

Step 5: Determine if Congestion is reduced leading to efficiency benefits

Let's assume the port you are analyzing is the first U.S. port of entry from Asia. When looking at the vessel logs, you notice a homogenous fleet of vessels are routinely loaded to their maximum draft each time upon entry. You also read that same shipping company is planning to replace some of their existing fleet with newer, larger vessels (as evidenced by their order book). The larger vessels are already used overseas while the shipping companies, once again, tell the Corps that they would switch over to these vessels at your port, if only it were deepened by several feet.

Step 1: Determine if the shipping companies would switch to the larger class of vessel once the draft constraint is removed.

This is perhaps one of the greatest challenges—predicting if and when vessel companies will switch over to larger vessels. If that case can be made, you would still need to prove that your particular port would secure the larger vessels. Many shipping companies make their investment decisions years in advance and it will often take several years after the project's completion before the newer vessels are fully utilized. They most likely will hold onto their smaller, older fleet and phase in the larger ones as older vessels reach their replacement age (generally 25 years, but depending on future vessel benefits and costs).

Repeat Steps 2 through 4

The transportation cost savings are defined in the same manner as the reduced light loading example. It will be obvious that the total voyage costs will be greater given to the larger size of the new vessel, but the per-unit costs should be lower and fewer ships would be needed. (Why else would shippers switch to a larger fleet other than to capitalize on the "economies of scale" granted by a larger vessel?)

Step 5: Determine if Congestion is reduced leading to efficiency benefits

This step can be tricky. When fewer ships now carry the same load, congestion can be reduced. Models such as HarborSym can help determine if congestion is actually reduced in a specific location. The amount of time that is saved by each vessel is the difference in transit time under without project conditions less the with-project conditions transit time. The times savings would be multiplied by the appropriate vessel operating costs ("at port" and/or "at sea") associated with that vessel for all vessels.

B.3 Application 3: Reduction in Tidal Delays

Step 1: Determine whether shippers would be able to adjust their schedule

Step 2: Determine the probability that a tide will be below 5 feet, assuming a 6 foot mean height of water for tides

Step 3: Calculate the hourly cost of delays

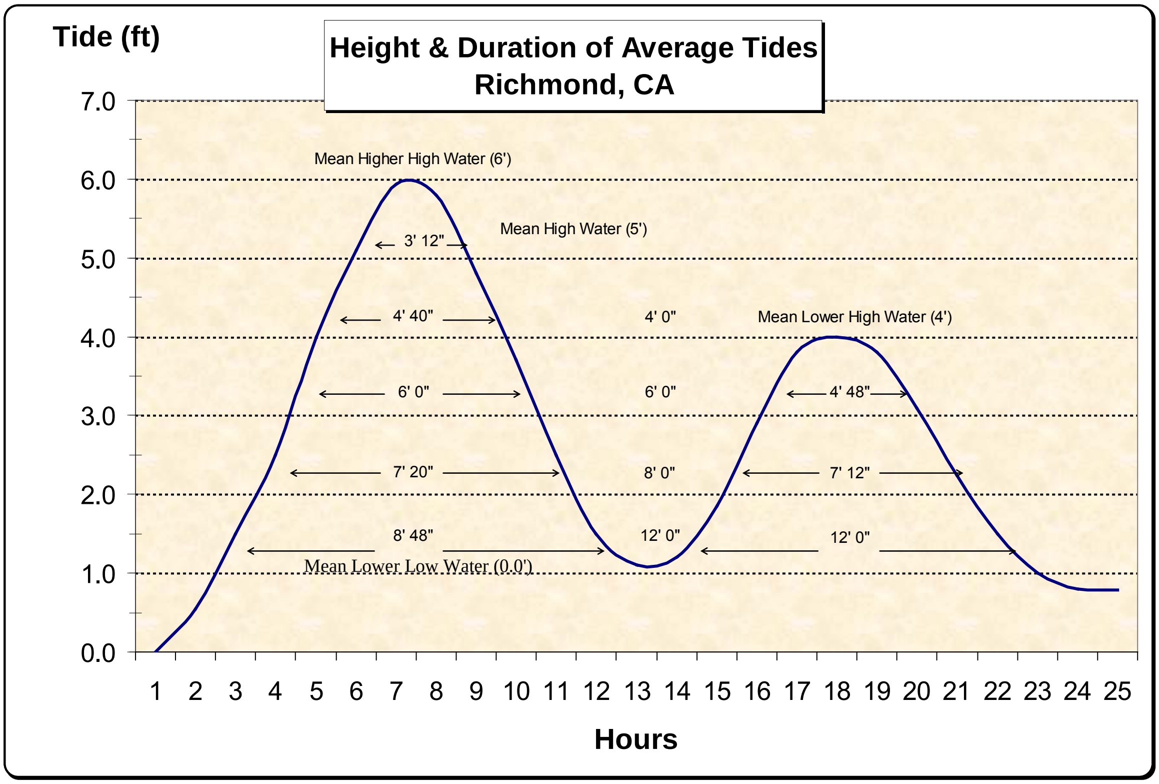
Step 4: Number of Calls per year for that particular vessel

When undertaking a port improvement study, it is important to account for the natural tidal and seasonal fluctuations within the particular port. A port will typically gain and lose several feet of water throughout the day due to astronomical tides.

Table B-2. Estimated Daily Tide Availability at Richmond, CA
(tide duration in hours' and minutes")

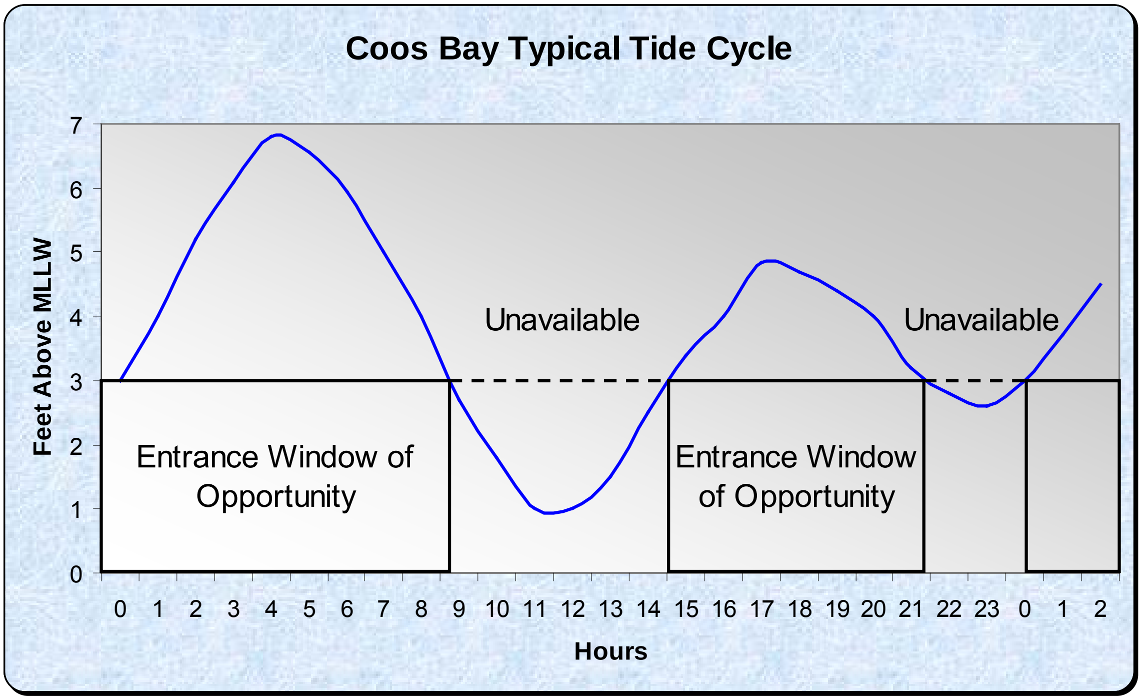
Tide Available	*Spring Tides*	*Neap Tides*	*Average of Extremes*	***Mean Tide***
+5	*6'24"*	*N/A*	*3'12"*	***N/A***
+4	*9'20"*	*N/A*	*4'40"*	***8'0"***
+3	*12'0"*	*9'36"*	*10'48"*	***12'0"***
+2	*14'40"*	*14'24"*	*14'32"*	***16'0"***
+1	***17'36"***	***24'0"***	***20'48"***	***24'0"***

Figure B-1: Height and Duration of Average Tides in Richmond, CA



The figures above display a typical tide cycle. In a typical tide cycle, there are two windows of tide unavailability. One window is approximately six hours in duration and the other window is approximately three hours in duration.

Figure B-2: Coos Bay Typical Tide Cycle



The Coos Bay example, shown above, displays the calculation for the expected value of delay for incoming vessels moving at the channel depth (requiring 3' of underkeel clearance). The probability of arriving with unavailability is calculated by dividing the hours of unavailability by the total hours in a tide cycle (24.8 hours). The average delay assumes that vessels arrive randomly, resulting in an average delay equal to half the maximum possible delay. The expected value of delay per vessel is calculated by multiplying the probability of experiencing a delay by the average delay. The total expected delay is the sum of the expected value of delay for each window of tide unavailability.

Table B-3: Calculation of Expected Arrival Delays

	Window A	Window B
Hours of Unavailability	**6**	**3**
Probability of Arriving with Unavailability	**24%**	**12%**
Average Delay (hours)	**3**	**1.5**
Expected Value of Delay (hours)	**0.73**	**0.18**
Total Expected Delay (hours)		**0.91**

Let's suppose your port in question has a present constraining depth of -30 feet MLLW. At the same time, Bar Pilots have mandated an underkeel clearance requirement of 3 feet for all inbound and outbound vessels. Therefore, any vessels loaded deeper than 27 feet (30 feet minus 3 feet) would either need to reduce its load or wait for enough water from the tide to safely transit the harbor.

The economist, in reviewing the pilot's logs, notices that a vessel has been arriving loaded to 32 feet. We can infer that this vessel would have not been able to transit the channel without the use of tides. Let's assume that for this particular route, the shippers wait for 5 feet of tide outbound, which according to NOAA's tide charts, are only available for a few hours per day.

In this case, the economist should:

Step 1: Determine whether shippers would be able to adjust their schedule

This is highly unlikely in the case of containerships. Most shippers would rather incur the losses associated with tidal delays than to reschedule/optimize their entire voyage. The basic assumption in calculating tide delay costs is that vessel arrival and departure times are random.

Step 2: Determine the probability that a tide will be below 5 feet.

This can be determined by first identifying the closest tide station and making slight adjustments for the bay or harbor based on consultations with coastal engineers

Step 3: Calculate the hourly cost of delays

This can be considered as the hourly sea cost for inbound vessels or the hourly port cost for outbound vessels. At times, it may be appropriate to assume the average of sea and port costs.

Step 4: Number of Calls per year for that particular vessel

Without a project, the total transportation costs would be:

($ Sea Cost) + ($ Port Cost) =

With a project deepening, repeat the calculations. The removal of the tidal delays and subsequent reduced transportation costs represent the NED benefits.

Economists should expect to make adjustments based on actual shipping practices and clearance requirements when determining the "without project" sailing drafts.

The basic assumption in calculating tide delay costs is that vessel arrival and departure times are random. The simplest calculations use the mean high and mean low tide heights at the project port and the daily duration of intermediate heights based on relationships shown in the Tide Tables. The tide required will depend on vessel draft and the useable tide window and maximum amount of tide that can be used will be determined by the vessel's channel transit time. Cost of delay time for each channel transit by a tide-dependent vessel is its daily operating cost (sea cost for entering vessels, port cost for departing vessels), minus the daily duration of usable tides.

B.4 Application 4: Increased Traffic Benefits

Step 1: Determine which industries would leave the alternative port to your port as a result of the improvements

Step 2: Calculate without project costs

Step 3: Calculate with project costs with alternate location

Step 4: Calculate the savings in costs (defined as the difference between the "without project" costs and the "with project" costs

In addition to the decreased transportation costs for existing movements, the proposed project also may increase the level of traffic as a result of decreasing transportation costs. The increase in traffic may result from any of the following reasons: (1) shift in origin; (2) shift in destination; or (3) induced movements.

Shift in origin and destination benefits reflect the results of the multiport analysis. Induced movement benefits represent an increase in trade resulting from a sufficient decline in relative transportation costs to and from the region for a particular commodity. In the former case, benefits are based on comparative transportation costs via the project and alternate ports using the results of the multiport analysis as described in the previous chapter. The only difference in computing the benefits is that "without project" costs reflect transportation costs via an alternative port which is not the existing project. The estimated benefit is still the difference between transportation costs in the "with" and "without project" conditions.

In the case of induced (new) movements, benefits should conceptually be based on changes in net income to the commodity producer or user. Unfortunately, this change in net income is not easily estimated. Typically, these benefits are estimated as one-half of the difference in the maximum and minimum transportation costs for each alternative. A problem with using this rule-of-thumb is that prior to accepting induced traffic, the analyst may have generated detailed information on the traffic that provides a better basis for estimating benefits. When better or more detailed information is available, it should be used for estimating benefits; otherwise the rule-of-thumb is acceptable.

Step 1: Determine which industries would leave the alternative port to your port as a result of the improvements

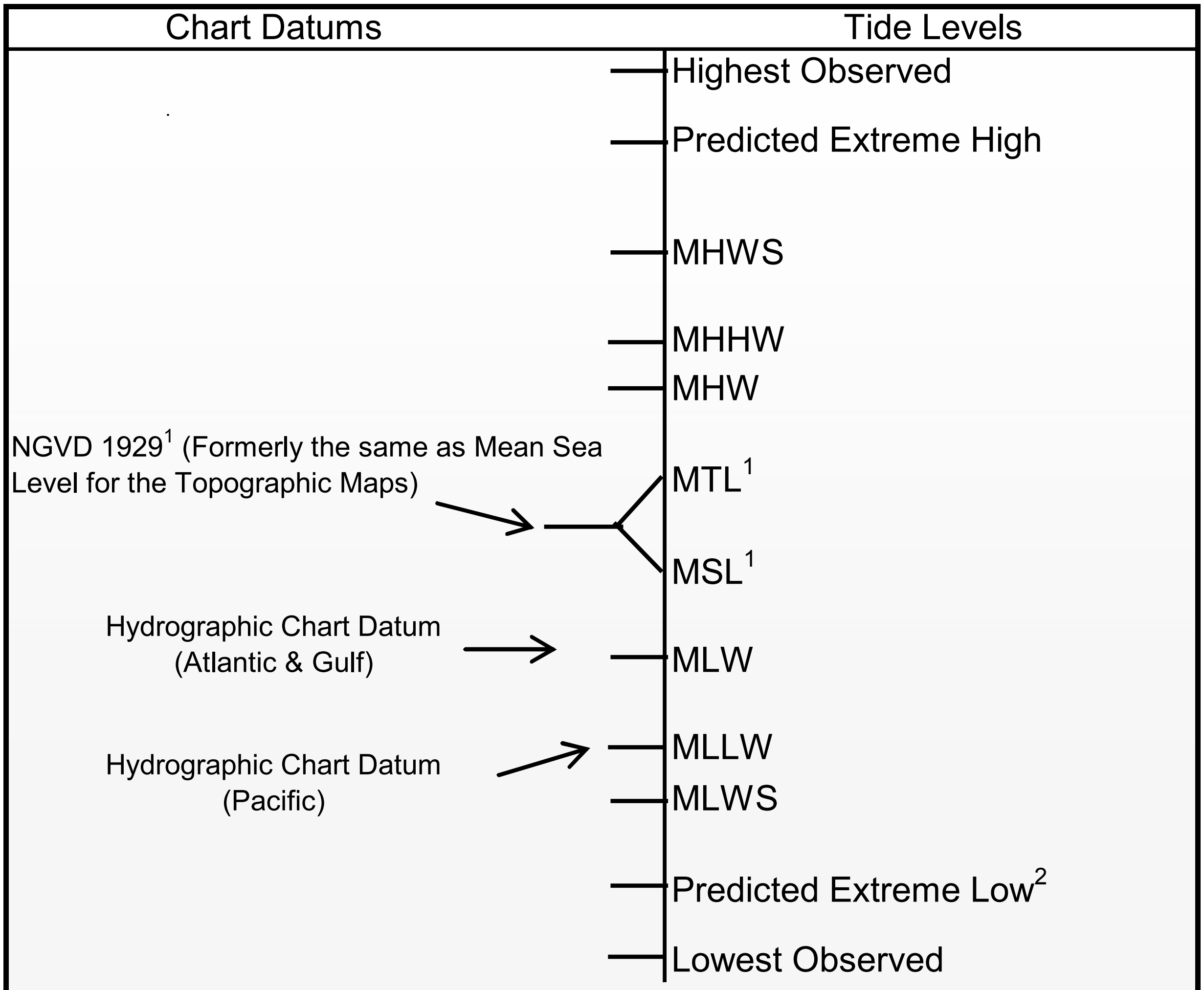
Step 2: Calculate without project costs

Step 3: Calculate with project costs with alternate location

Step 4: Calculate the savings in costs (defined as the difference between the "without project" costs and the "with-project" costs

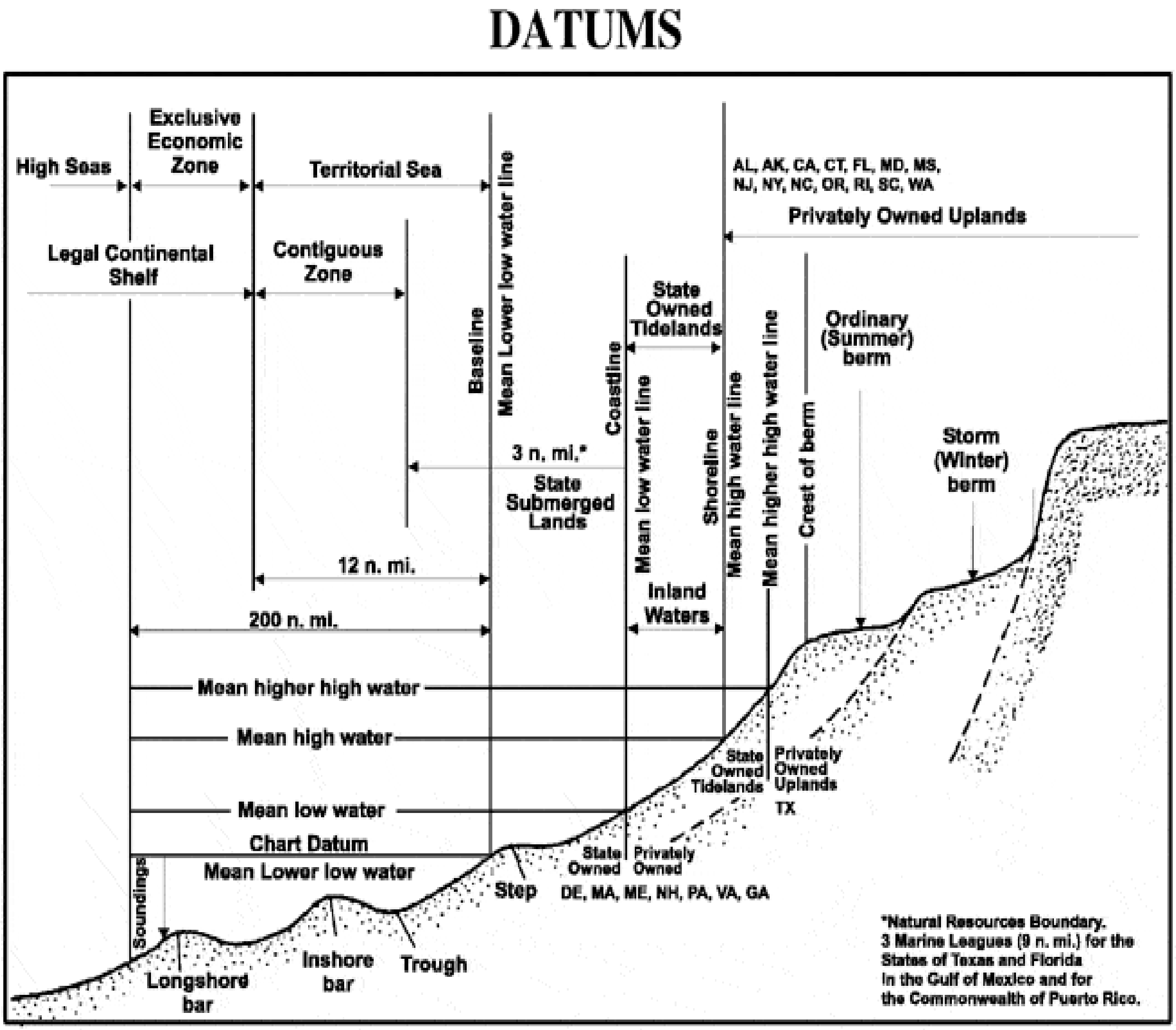
APPENDIX C: TIDE ANALYSIS

Figure C-1: Tide Chart



[1] The position of MSL, MTL, and NGVD, 1929 relative to each other varies with location.

Figure C-2: Tide Levels



Tide Tables

NOAA's National Ocean Service (NOS) maintains 50 primary tide stations and over 175 secondary tide stations at selected sites along the Atlantic Coast, Gulf Coast and Pacific Coast, including Alaska, Hawaii and Puerto Rico. These tables provide predicted high and low tide levels for the primary stations and also provide a means of estimating these tidal values for a large number of secondary stations. The values which can be obtained for the secondary stations are approximate and the cautions given in the NOS Tide Tables should be observed.

Tide heights will vary with port location and moon phase. The figures below illustrate the variation in average tide for a sample of tide stations. Generally (but not in all cases), the fluctuation in tide rises as the distance from the earth's equator increases.

Figure C-3: NOAA/NOS/CO-OPS Tide Height Data

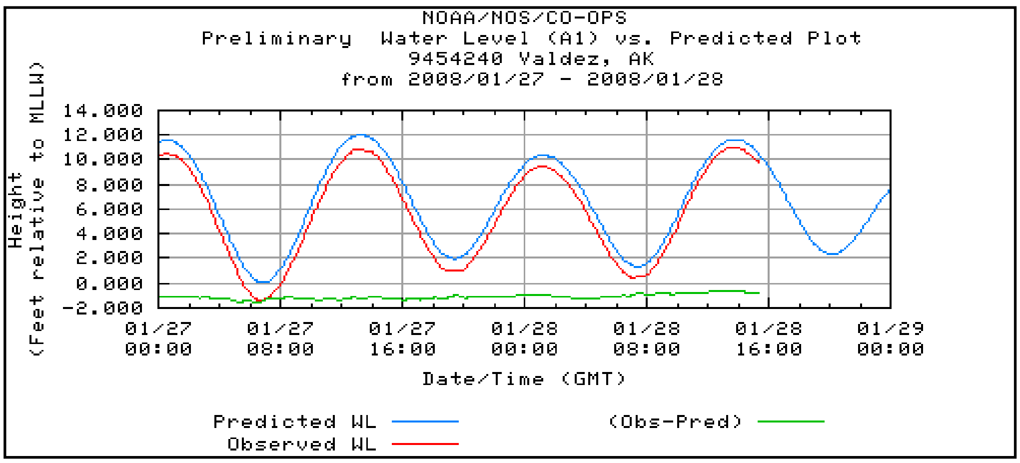


Figure C-4: Ocean City Inlet, MD Water Levels

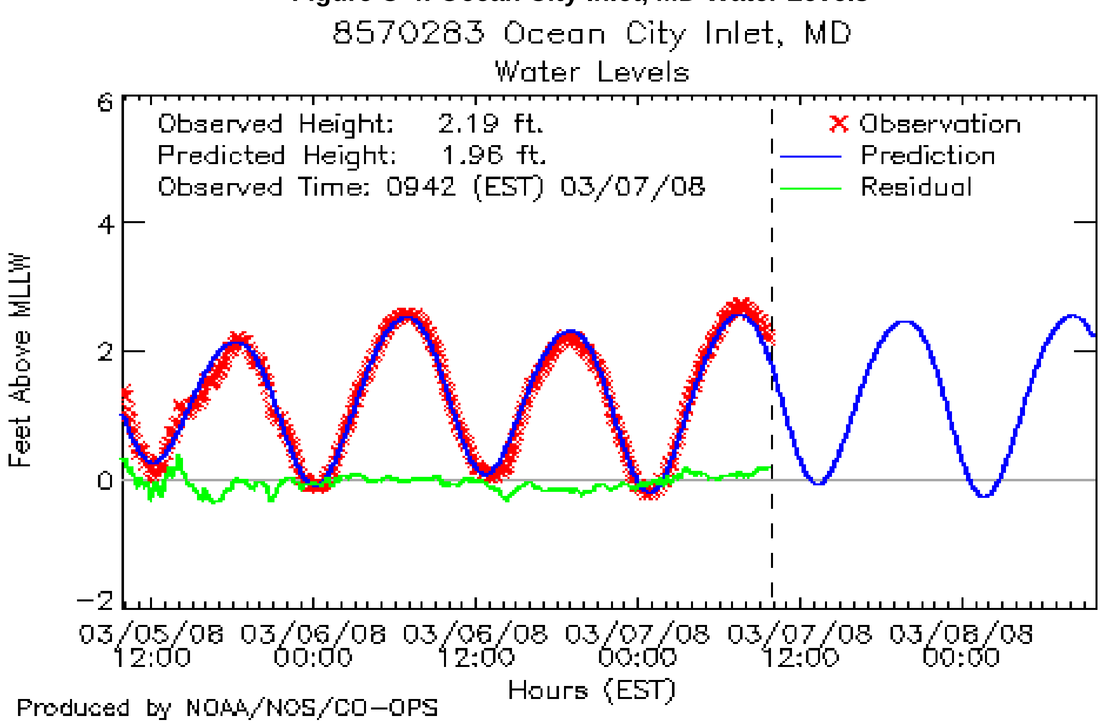
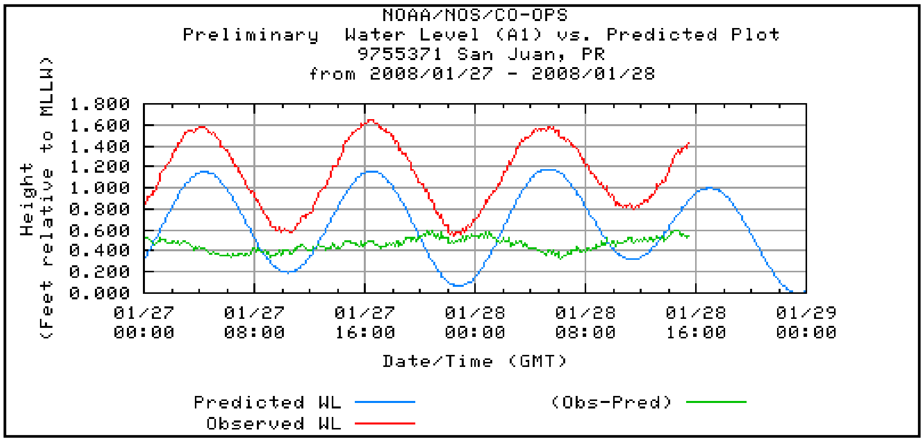


Figure C-5: San Juan, Puerto Rico Tide Height



The Coos Bay example in Appendix B displays the calculation for the expected value of delay for incoming vessels moving at the channel depth (requiring 3' of underkeel clearance). The probability of arriving with unavailability is calculated by dividing the hours of unavailability by the total hours in a tide cycle (24.8 hours). The average delay assumes that vessels arrive randomly, resulting in an average delay equal to half the maximum possible delay. The expected value of delay per vessel is calculated by multiplying the probability of experiencing a delay by the average delay. The total expected delay is the sum of the expected value of delay for each window of tide unavailability.

Table C-1: Calculation of Expected Arrival Delays

	Window A	Window B
Hours of Unavailability	**6**	**3**
Probability of Arriving with Unavailability	**24%**	**12%**
Average Delay (hours)	**3**	**1.5**
Expected Value of Delay (hours)	**0.73**	**0.18**
Total Expected Delay (hours)		**0.91**

APPENDIX D: CRUISE SHIPS

To be included in future versions

"Disney Magic" at Cape Canaveral

APPENDIX E: CONTAINERSHIPS

Research in containership economic evaluation methods is ongoing. For the latest updates in guidance and methods, please consult the Deep Draft Navigation Planning Center of Expertise before beginning an analysis and to get specialized planning expertise.

The following tables support Chapter 10 "Vessel Fleet Composition and Forecasts."

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Table E-1: Container Panamax Vessel Size Fleet Characteristics[61], 2004

(Lengths in meters, LOA= Length Overall, DWT= Dead Weight Tons, TEU= twenty-foot equivalent units)

Build Year	Age	Number of Vessels	Average LOA	Average Beam	Average Draught	Average DWT	Total DWT	Average TEU Capacity	Total TEU Capacity	Percent by Age	Percent by DWT	Percent by TEU
1977	27	3	258.6	32.3	13.1	48,446	145,337	3,077	9,232	0.6%	0.6%	0.5%
1978	26	4	258.5	32.3	13.1	49,935	199,740	3,126	12,505	0.9%	0.8%	0.7%
1979	25	1	258.5	32.3	13.2	50,027	50,027	3,101	3,101	0.2%	0.2%	0.2%
1980	24									0.0%	0.0%	0.0%
1981	23	2	278.7	32.3	13.0	52,540	105,080	3,635	7,270	0.4%	0.4%	0.4%
1982	22	3	257.7	32.3	12.1	42,886	128,657	3,357	10,072	0.6%	0.5%	0.6%
1983	21	3	264.8	32.3	11.8	38,320	114,960	3,023	9,070	0.6%	0.5%	0.5%
1984	20	8	273.3	32.3	12.6	52,935	423,480	3,912	31,294	1.7%	1.7%	1.8%
1985	19	10	275.0	32.3	12.3	53,895	538,952	4,094	40,940	2.1%	2.2%	2.3%
1986	18	20	251.3	32.2	11.9	44,635	892,700	3,138	62,769	4.3%	3.7%	3.5%
1987	17	15	259.8	32.2	11.9	45,224	678,362	3,210	48,144	3.2%	2.8%	2.7%
1988	16	19	270.6	32.3	12.2	49,416	938,907	3,414	64,871	4.1%	3.9%	3.6%
1989	15	12	281.6	32.3	12.7	53,802	645,627	3,792	45,498	2.6%	2.7%	2.6%
1990	14	12	283.2	32.3	13.0	57,657	691,889	3,774	45,284	2.6%	2.9%	2.5%
1991	13	18	266.2	32.2	12.6	53,476	962,562	3,628	65,307	3.9%	4.0%	3.7%
1992	12	20	264.8	32.2	12.4	50,630	1,012,604	3,504	70,071	4.3%	4.2%	3.9%
1993	11	28	271.3	32.2	12.5	53,137	1,487,844	3,736	104,595	6.0%	6.1%	5.9%
1994	10	33	265.1	32.2	12.2	50,501	1,666,543	3,717	122,664	7.1%	6.9%	6.9%
1995	9	27	271.8	32.2	12.4	52,983	1,430,542	3,936	106,280	5.8%	5.9%	6.0%
1996	8	25	266.9	32.2	12.3	52,654	1,316,340	3,785	94,625	5.4%	5.4%	5.3%
1997	7	36	270.4	32.2	12.4	52,760	1,899,377	3,926	141,332	7.7%	7.8%	7.9%
1998	6	39	276.0	32.2	12.5	53,716	2,094,927	3,971	154,882	8.4%	8.6%	8.7%
1999	5	9	275.0	32.2	12.9	59,240	533,160	4,196	37,761	1.9%	2.2%	2.1%
2000	4	24	274.9	32.1	12.9	57,528	1,380,664	4,278	102,665	5.1%	5.7%	5.8%
2001	3	19	253.1	32.2	11.8	48,456	920,655	3,808	72,347	4.1%	3.8%	4.1%
2002	2	43	274.0	32.2	12.7	52,919	2,275,507	4,188	180,100	9.2%	9.4%	10.1%
2003	1	34	264.1	32.2	12.2	50,355	1,712,065	4,018	136,608	7.3%	7.1%	7.7%
Total		467					24,246,508		1,779,287	100.0%	100.0%	100.0%
Average							51,920		3,810			

61 *G.E.C., Inc., based on the Clarkson Register, January 2004*

Table E-2. Container Post-Panamax Vessel Size Fleet Characteristics[62]: 2004

Length is in meters, LOA= Length Overall, DWT= Dead Weight Tons, TEU= twenty-foot equivalent units)

Build Year	Age	Number of Vessels	Average LOA	Average Beam	Average Draught	Average DWT	Total DWT	Average TEU Capacity	Total TEU Capacity	Percent by Age	Percent by DWT	Percent by TEU
1988	16	5	275.2	39.4	12.6	54,032	270,159	4,340	21,700	1.8%	1.3%	1.3%
1989	15									0.0%	0.0%	0.0%
1990	14									0.0%	0.0%	0.0%
1991	13	1	275.7	37.1	14.0	62,277	62,277	4,427	4,427	0.4%	0.3%	0.3%
1992	12	6	275.2	37.2	13.6	61,256	367,536	4,530	27,178	2.1%	1.8%	1.7%
1993	11									0.0%	0.0%	0.0%
1994	10	3	284.7	37.3	13.2	59,851	179,553	4,445	13,335	1.1%	0.9%	0.8%
1995	9	17	286.1	38.5	13.5	64,170	1,090,885	4,757	80,873	6.0%	5.2%	4.9%
1996	8	21	285.7	40.6	13.7	70,548	1,481,516	5,535	116,239	7.4%	7.1%	7.1%
1997	7	20	290.3	40.5	13.8	73,367	1,467,341	5,565	111,304	7.1%	7.0%	6.8%
1998	6	17	303.5	41.3	13.9	83,823	1,424,998	6,232	105,948	6.0%	6.8%	6.5%
1999	5	14	300.7	40.6	13.6	76,647	1,073,060	6,113	85,576	5.0%	5.1%	5.2%
2000	4	34	289.7	40.8	13.8	73,615	2,502,903	5,855	199,056	12.1%	11.9%	12.1%
2001	3	63	287.0	40.1	13.8	73,437	4,626,552	5,798	365,254	22.3%	22.1%	22.3%
2002	2	45	293.8	40.3	14.1	77,599	3,491,940	6,103	274,649	16.0%	16.7%	16.8%
2003	1	36	300.5	40.6	13.9	81,051	2,917,821	6,478	233,215	12.8%	13.9%	14.2%
Total		282					20,956,541		1,638,754	100.0%	100.0%	100.0%
Average							74,314		5,811			

[62] *G.E.C., Inc., based on the Clarkson Register, January 2004*

Table E-3: Container Vessel Sailing Drafts and Draft Distributions for Sea Harbor

Outbound	Trips			Distribution		
	2001	2002	2003	2001	2002	2003
< than 30.00 Feet	304	258	236	33.30%	23.91%	18.51%
30.00 to 30.99 Feet	51	80	73	5.59%	7.41%	5.73%
31.00 to 31.99 Feet	66	102	72	7.23%	9.45%	5.65%
32.00 to 32.99 Feet	138	158	178	15.12%	14.64%	13.96%
33.00 to 33.99 Feet	36	78	92	3.94%	7.23%	7.22%
34.00 to 34.99 Feet	67	68	114	7.34%	6.30%	8.94%
35.00 to 35.99 Feet	59	75	93	6.46%	6.95%	7.29%
36.00 to 36.99 Feet	116	131	175	12.71%	12.14%	13.73%
37.00 to 37.99 Feet	28	62	85	3.07%	5.75%	6.67%
38.00 to 38.99 Feet	19	28	40	2.08%	2.59%	3.14%
39.00 to 39.99 Feet	23	30	69	2.52%	2.78%	5.41%
40.00 to 40.99 Feet	6	7	32	0.66%	0.65%	2.51%
41.00 to 41.99 Feet		2	9	0.00%	0.19%	0.71%
42.00 to 42.99 Feet			7	0.00%	0.00%	0.55%
Total	**913**	**1,079**	**1,275**	**100.00%**	**100.00%**	**100.00%**

Inbound	Trips			Distribution		
	2001	2002	2003	2001	2002	2003
< than 30.00 Feet	327	297	301	35.97%	27.58%	23.63%
30.00 to 30.99 Feet	83	104	91	9.13%	9.66%	7.14%
31.00 to 31.99 Feet	44	88	92	4.84%	8.17%	7.22%
32.00 to 32.99 Feet	152	142	177	16.72%	13.18%	13.89%
33.00 to 33.99 Feet	50	77	100	5.50%	7.15%	7.85%
34.00 to 34.99 Feet	52	74	105	5.72%	6.87%	8.24%
35.00 to 35.99 Feet	57	82	87	6.27%	7.61%	6.83%
36.00 to 36.99 Feet	107	124	155	11.77%	11.51%	12.17%
37.00 to 37.99 Feet	25	53	76	2.75%	4.92%	5.97%
38.00 to 38.99 Feet	7	20	39	0.77%	1.86%	3.06%
39.00 to 39.99 Feet	5	13	37	0.55%	1.21%	2.90%
40.00 to 40.99 Feet		3	9	0.00%	0.28%	0.71%
41.00 to 41.99 Feet			5	0.00%	0.00%	0.39%
42.00 to 42.99 Feet				0.00%	0.00%	0.00%
Total	**909**	**1,077**	**1,274**	**100.00%**	**100.00%**	**100.00%**

Table E-4: Sea Harbor 2003 Outbound Container Vessel Calls by Draught and Sailing Draft Greater Than 30 Feet

Draught (Feet)	Sailing Draft (Feet)													Total
	31	32	33	34	35	36	37	38	39	40	41	42	43	
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	1	0	0	0	0	0	0	0	0	0	0	0	1
33	7	5	2	1	1	0	0	0	0	0	0	0	0	16
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	4	3	3	3	2	2	1	0	0	0	0	0	0	18
36	0	1	5	0	0	1	3	1	1	1	0	0	0	13
37	4	0	10	8	9	11	12	1	0	0	0	0	0	55
38	14	8	25	17	6	9	10	1	0	0	0	0	0	90
39	7	12	26	10	10	5	12	10	10	9	0	0	0	111
40	4	2	10	2	11	10	20	8	2	0	0	0	0	69
41	0	1	2	0	1	1	2	1	0	1	0	0	0	9
42	16	17	34	22	33	25	43	15	11	13	7	0	1	237
43	13	17	48	25	28	20	43	17	2	3	1	3	0	220
44	0	1	0	0	1	1	2	3	0	2	0	0	0	10
45	3	4	12	7	12	10	27	27	14	41	24	6	6	193
46	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	0	0	1	0	0	0	1	1	0	0	0	0	0	3
Total	**72**	**72**	**178**	**95**	**114**	**95**	**176**	**85**	**40**	**70**	**32**	**9**	**7**	**1,045**

Notes: Reported sailing draft exceeds maximum draught for 22 calls. Vessels with less than 30 feet sailing draft or draught omitted.

Table E-5: Excess Draught of Container Vessels Calling at Sea Harbor

Excess Draught (Feet)	Number of Vessel Calls						Distribution of Vessel Calls					
	Inbound 2001	Outbound 2001	Inbound 2002	Outbound 2002	Inbound 2003	Outbound 2003	Inbound 2001	Outbound 2001	Inbound 2002	Outbound 2002	Inbound 2003	Outbound 2003
0	23	44	27	49	28	51	3.90%	7.04%	3.44%	5.89%	2.87%	4.88%
1	21	26	23	28	39	52	3.57%	4.16%	2.93%	3.37%	4.00%	4.98%
2	32	47	54	46	64	68	5.43%	7.52%	6.88%	5.53%	6.56%	6.51%
3	43	53	57	69	59	68	7.30%	8.48%	7.26%	8.29%	6.05%	6.51%
4	52	57	49	58	72	97	8.83%	9.12%	6.24%	6.97%	7.38%	9.28%
5	44	66	71	98	108	148	7.47%	10.56%	9.04%	11.78%	11.07%	14.16%
6	80	56	109	116	111	126	13.58%	8.96%	13.89%	13.94%	11.37%	12.06%
7	61	64	89	86	111	118	10.36%	10.24%	11.34%	10.34%	11.37%	11.29%
8	83	65	105	80	119	89	14.09%	10.40%	13.38%	9.62%	12.19%	8.52%
9	48	51	63	66	88	75	8.15%	8.16%	8.03%	7.93%	9.02%	7.18%
10	41	47	49	55	70	78	6.96%	7.52%	6.24%	6.61%	7.17%	7.46%
11	27	24	53	48	54	41	4.58%	3.84%	6.75%	5.77%	5.53%	3.92%
12	29	19	29	27	43	26	4.92%	3.04%	3.69%	3.25%	4.41%	2.49%
13	3	1	3	4	6	4	0.51%	0.16%	0.38%	0.48%	0.61%	0.38%
14	2	5	4	2	3	3	0.34%	0.80%	0.51%	0.24%	0.31%	0.29%
15	0	0	0	0	1	1	0.00%	0.00%	0.00%	0.00%	0.10%	0.10%
16	0	0	0	0	0	0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
17	0	0	0	0	0	0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total	**589**	**625**	**785**	**832**	**976**	**1,045**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Notes: Vessels with less than 30 feet sailing draft or draught omitted.

Table E-6: World Container Vessel Fleet Forecast Summary and Distribution

Year	Post-Panamax Vessels	Post-Panamax TEUs	Panamax Vessels	Panamax TEUs	Sub-Panamax Vessels	Sub-Panamax TEUs	Handysize Vessels	Handysize TEUs	FeederMax Vessels	FeederMax TEUs	Feeder Vessels	Feeder TEUs	Total Vessels	Total TEUs
2004	302	1,768,754	484	1,854,449	515	1,280,038	911	1,297,892	603	426,004	363	128,013	3,178	6,755,150
2005	336	1,989,754	520	1,998,449	541	1,343,938	941	1,342,016	627	445,476	371	131,316	3,336	7,250,949
2006	367	2,191,254	548	2,111,179	568	1,411,216	968	1,382,799	649	463,487	379	134,442	3,479	7,694,377
2007	400	2,405,754	577	2,229,107	598	1,487,501	993	1,422,823	671	481,630	386	137,167	3,625	8,163,982
2008	435	2,633,254	611	2,368,037	626	1,560,818	1,022	1,467,410	692	499,240	395	140,826	3,781	8,669,585
2009	474	2,886,754	646	2,508,743	655	1,633,169	1,055	1,518,404	716	518,061	406	145,169	3,952	9,210,300
2010	496	3,029,754	664	2,579,803	672	1,677,011	1,066	1,537,941	729	528,504	409	146,192	4,036	9,499,205
2015	611	3,788,054	737	2,917,237	764	1,901,579	1,144	1,660,134	804	584,340	440	158,699	4,500	11,010,043
2020	733	4,630,741	800	3,204,320	877	2,183,857	1,190	1,751,217	857	632,058	453	166,954	4,910	12,569,147
2025	872	5,605,118	903	3,617,055	990	2,476,852	1,236	1,841,835	893	669,045	469	176,155	5,363	14,386,060
2030	1,041	6,766,500	1,034	4,136,000	1,092	2,730,000	1,336	2,004,000	968	726,000	495	185,625	5,966	16,548,125
2035	1,238	8,047,000	1,170	4,680,000	1,219	3,047,500	1,454	2,181,000	1,056	792,000	526	197,250	6,663	18,944,750
2040	1,460	9,490,000	1,327	5,308,000	1,374	3,435,000	1,609	2,413,500	1,181	885,750	583	218,625	7,534	21,750,875
2045	1,702	11,063,000	1,488	5,952,000	1,552	3,880,000	1,754	2,631,000	1,308	981,000	637	238,875	8,441	24,745,875
2050	1,985	12,902,500	1,684	6,736,000	1,745	4,362,500	1,914	2,871,000	1,434	1,075,500	697	261,375	9,459	28,208,875
2004	9.50%	26.18%	15.23%	27.45%	16.21%	18.95%	28.67%	19.21%	18.97%	6.31%	11.42%	1.90%	100.00%	100.00%
2005	10.07%	27.44%	15.59%	27.56%	16.22%	18.53%	28.21%	18.51%	18.79%	6.14%	11.12%	1.81%	100.00%	100.00%
2006	10.55%	28.48%	15.75%	27.44%	16.33%	18.34%	27.82%	17.97%	18.65%	6.02%	10.89%	1.75%	100.00%	100.00%
2007	11.03%	29.47%	15.92%	27.30%	16.50%	18.22%	27.39%	17.43%	18.51%	5.90%	10.65%	1.68%	100.00%	100.00%
2008	11.50%	30.37%	16.16%	27.31%	16.56%	18.00%	27.03%	16.93%	18.30%	5.76%	10.45%	1.62%	100.00%	100.00%
2009	11.99%	31.34%	16.35%	27.24%	16.57%	17.73%	26.70%	16.49%	18.12%	5.62%	10.27%	1.58%	100.00%	100.00%
2010	12.29%	31.89%	16.45%	27.16%	16.65%	17.65%	26.41%	16.19%	18.06%	5.56%	10.13%	1.54%	100.00%	100.00%
2015	13.58%	34.41%	16.38%	26.50%	16.98%	17.27%	25.42%	15.08%	17.87%	5.31%	9.78%	1.44%	100.00%	100.00%
2020	14.93%	36.84%	16.29%	25.49%	17.86%	17.37%	24.24%	13.93%	17.45%	5.03%	9.23%	1.33%	100.00%	100.00%
2025	16.26%	38.96%	16.84%	25.14%	18.46%	17.22%	23.05%	12.80%	16.65%	4.65%	8.75%	1.22%	100.00%	100.00%
2030	17.45%	40.89%	17.33%	24.99%	18.30%	16.50%	22.39%	12.11%	16.23%	4.39%	8.30%	1.12%	100.00%	100.00%
2035	18.58%	42.48%	17.56%	24.70%	18.30%	16.09%	21.82%	11.51%	15.85%	4.18%	7.89%	1.04%	100.00%	100.00%
2040	19.38%	43.63%	17.61%	24.40%	18.24%	15.79%	21.36%	11.10%	15.68%	4.07%	7.74%	1.01%	100.00%	100.00%
2045	20.16%	44.71%	17.63%	24.05%	18.39%	15.68%	20.78%	10.63%	15.50%	3.96%	7.55%	0.97%	100.00%	100.00%
2050	20.99%	45.74%	17.80%	23.88%	18.45%	15.46%	20.23%	10.18%	15.16%	3.81%	7.37%	0.93%	100.00%	100.00%

*Notes: Based on a percentage distribution of 45/25/15/10/4/11 between Post-Panamax, Panamax, Sub-Panamax, Handysize, Feedermax and Feeder for new capacity (TEUs) related to world trade growth and and 30 percent capacity replacement with next largest vessel size.

Source: G.E.C., Inc.

Miami Harbor Container Terminal

E.1 Containership Benefit Analysis

The benefits analysis for channel deepening should consider a given port within the context of the world navigation system. Container trade is unlike most other deep draft commerce evaluations in that benefits not only accrue to the port being studied but for the system of ports linked by container trade. Similarly, constraints at one port can also have system wide impacts. Vessels call on a succession of ports to load and/or unload containers. These trade routes should be fully described in the analysis and analyzed separately. Examples of trade routes are: ECUS (East Coast United States), the Far East (China) through the Panama Canal and to the East Coast, or the Gulf Coast the Easter United States.

The commodity forecasts should consider world trade, the fleet forecast beginning with the world fleet, and container traffic at a given port for each specific trade route. An analysis of container vessel sailing drafts at multiple ports around the world can be used to forecast future loading patterns for each vessel class at alternative project depths at a given port. However, the best available information should always be used first.

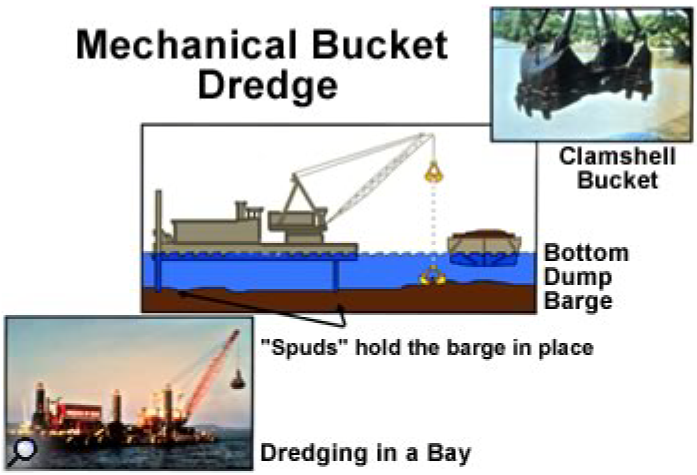
If a physical constraint exists within the system (e.g., shallower draft at one port within the vessel's rotation), this constraint impacts the entire system. It does so by limiting the number of containers that can be loaded on the vessel at ports prior to the constraining port or that can be carried from the port causing the restriction, thus resulting in increased voyage costs per metric ton of cargo on those voyage legs. Additionally, the landside transportation costs could also impact the port routes. While understanding the nature of the system there is not one way to forecast how these routes will be constituted in the future. One common assumption is that industry will make the changes necessary to take advantage of increased channel depths at a given port.

APPENDIX F: TYPES OF DREDGES[63]

To learn even more about dredging go to:
http://education.wes.army.mil/navigation/dredging.html

While the onboard instrumentation of modern dredges is computer-assisted, the basic excavation methods of dredges have remained the same since the late 1800s. Dredges are the main tools to deepen or widen a channel and so it is important to understand a bit about how they work. The types of dredges will also often impact any NEPA documentation which could impact the project costs and four accounts in plan formulation. It is important for the economist to understand that this may also lead to dredging windows. During certain time periods, such as sea turtle nesting, dredging may have to cease. This impacts the construction schedule, operation and maintenance, and the economics. The economist should consider the dredging window in costs and benefits evaluation.

The three main types of dredges are mechanical dredges, hydraulic dredges, and airlift dredges.



Mechanical dredges remove material by scooping it from the bottom and then placing it onto a waiting barge or into a disposal area. *Dipper dredges* and *clamshell dredges*, named for the scooping buckets they employ, are the two most common types.

Mechanical dredges are rugged and can work in tightly confined areas. They are mounted on a large barge and are towed to the dredging site and secured in place by anchors or anchor piling, called *spuds*. They are often used in harbors, around docks and piers, and in relatively protected channels, but are not suited for areas of high traffic or rough seas.

Usually two or more disposal barges, called dump scows, are used in conjunction with the mechanical dredge. While one barge is being filled, another is being towed to the dump site. Using numerous barges, work can proceed continuously, only interrupted by changing dump scows or moving the dredge. This makes

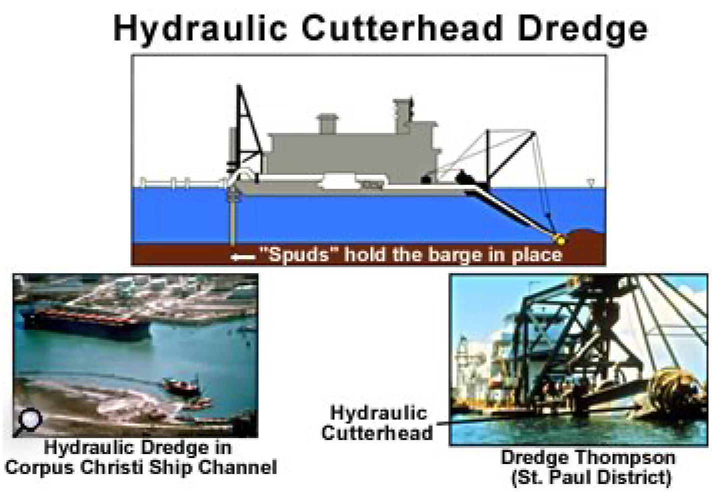
[63] *USACE Education, http://education.usace.army.mil/navigation/lessons/6/dredgels6lv2.html, Accessed July 2009*

mechanical dredges particularly well-suited for dredging projects where the disposal site is many miles away.

Mechanical dredges work best in consolidated, or hard-packed, materials and can be used to clear rocks and debris. Dredging buckets have difficulty retaining loose, fine materials, which can be washed from the bucket as it is raised. Special buckets have been designed for controlling the flow of water and material from buckets and are used when dredging contaminated sediments.

Hydraulic Dredges

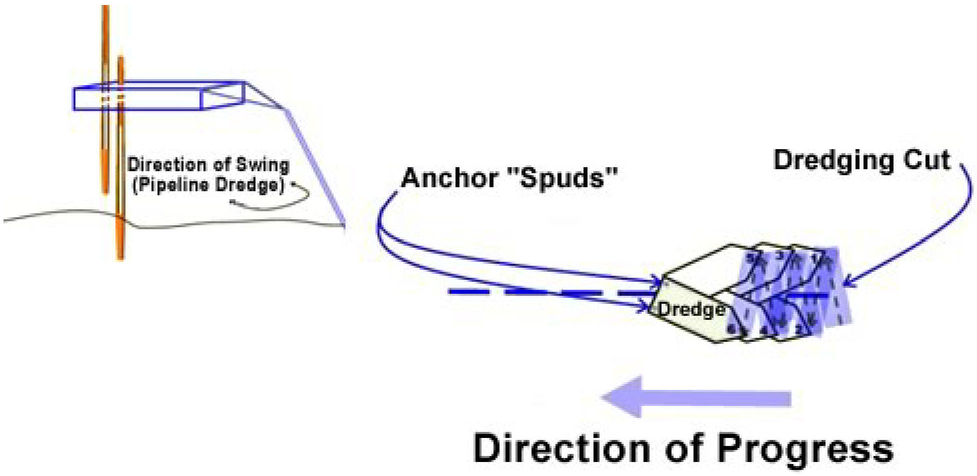
Hydraulic dredges work by sucking a mixture of dredged material and water from the channel bottom. The amount of water sucked up with the material is controlled to make the best mixture. Too little water and the dredge will bog down; too much and the dredge won't be efficient in its work. There are two main types of hydraulic dredges -- pipeline and hopper dredges.



Cutterhead Pipeline Dredge

A pipeline dredge sucks dredged material through one end, the intake pipe, and then pushes it out the discharge pipeline directly into the disposal site. Because pipeline dredges pump directly to the disposal site, they operate continuously and can be very cost-efficient. Most pipeline dredges have a *cutterhead* on the suction end. A cutterhead is a mechanical device that has rotating blades or teeth to break up or loosen the bottom material so that it can be sucked through the dredge. Some cutterheads are rugged enough to break up rock for removal. Pipeline dredges are mounted (fastened) to barges and are not usually self-powered, but are towed to the dredging site and secured in place by special anchor piling, called *spuds* (see sidebar).

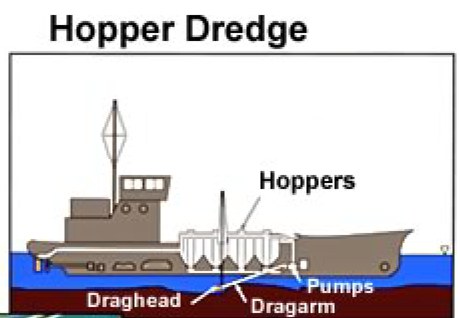
Cutterhead pipeline dredges work best in large areas with deep shoals, where the cutterhead is buried in the bottom. Water pumped with the dredged material must be contained in the disposal site until the solids settle out. It is then discharged, usually back into the waterway. This method of dredging is not suitable in areas where sediments are contaminated with chemicals that would dissolve in the dredging water and be spread in the environment during discharge.

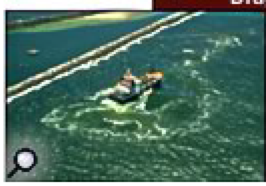


Hopper Dredges

Hopper dredges are ships with large hoppers, or containment areas, inside. Fitted with powerful pumps, the dredges suck dredged material from the channel bottom through long intake pipes, called *drag arms*, and store it in the hoppers. The water portion of the slurry is drained from the material and is discharged from the vessel during operations. When the hoppers are full, dredging stops and the ship travels to an in-water disposal site, where the dredged material is discharged through the bottom of the ship.

Split hull hopper at ocean dredged material disposal site





Hopper Dredge Working at a Coastal Entrance

Hopper dredges are well-suited to dredging heavy sands. They can maintain operations in relatively rough seas and because they are mobile, they can be used in high-traffic areas. They are often used at ocean entrances, but cannot be used in confined or shallow areas. Hopper dredges can move quickly to disposal sites under their own power, but since the dredging stops during the transit to and from the disposal area, the operation loses efficiency if the haul distance is too far.

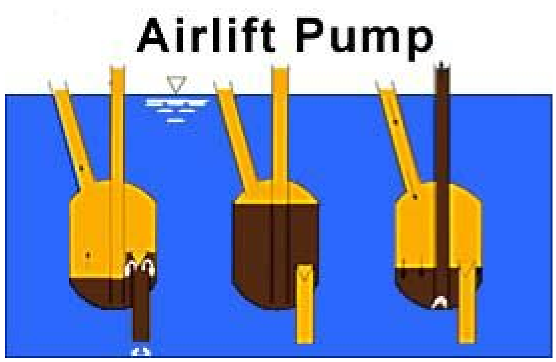
Sidecaster Merritt, Wilmington District

Specialty Dredges

There are special hydraulic dredges called sidecasters and dustpan dredges. Both of these dredges are used to remove loosely compacted, coarse-grained material and place it in areas close to the navigation channel. They are not widely used. The dustpan dredges were specifically developed for jobs on the Mississippi River. Side-casting of dredged material, done mainly on some smaller projects, is also limited to fairly unique situations and environments.

Dustpan dredge JADWIN, Vicksburg District

Airlift Dredge



Airlift dredges are special-use dredges that raise material from the bottom of the waterway by hydrostatic pressure. They have cylinders that operate like pistons. Material is drawn through the bottom of the cylinder. When it is full, the intake valve closes, trapping the material. Then, compressed air forces the material out through a discharge line to a waiting dumpscow or directly to a disposal site. Airlift dredges bring dredged material to the surface with a relatively small amount of water, which is good when environmental contamination is an issue.

Airlift pumps have not been widely used in the United States. They do not typically achieve high production rates, but are well-suited for projects where either site conditions or sediment quality concerns make other dredges inappropriate. They can be used in tight quarters around docks and piers, in rough seas, and in deep water.

The additional photos further illustrate the types of dredging vessels:

Cutter Suction – Pipeline Dredge

Dustpan Dredge

Dipper Dredge

Hopper Dredge

Auger Dredge

Bucket Dredge

APPENDIX G: ADDITIONAL EXAMPLES AND TABLES

G.1 Summary of Ocean Transportation Costs

The following calculations are based on an example from the previous deep draft manual. These still provide an example of ocean transportation costs show how baseline information is used; however, some o the values may be outdated. The costs are for a hypothetical movement of bulk grain to the Mediterranean from a U.S. Atlantic Coast port with a 40-foot channel, with 50 percent of the vessels returning light and 50 percent backhauling steel. Specific assumptions and data sources are as follows:

- Vessel Fleet. The January I, 1988 world fleet of bulk carriers with loadline drafts of 28 to 45 feet was used. The distribution of vessel sizes by draft was provided by the Maritime Administration. A segment of the world fleet was used to simplify calculations. A more scientific way to determine the upper size limit would use transport cost light loaded.
- Vessel Light loading. A "typical" distribution of actual drafts was derived from statistics in a Newark Bay study report (see Table IV-I) It was assumed that this light loading reflected trade route draft constraints and no specific adjustment was needed for itinerary. The same distribution of light loading was used for all loaded vessels, with inbound vessel drafts reduced an additional foot to account for fuel consumption.
- Vessel Payloads. Factors shown in Table G-2 were used to adjust deadweight to payload, which was further reduced for light loading. Vessel immersion rates in tons per inch (TPI factors) shown in IWR's 1987 vessel costs were used, with interpolation for intermediate sizes, to determine net payload.
- Voyage Distance and Duration. Tables G-2 and G-3 were used. For vessels loaded both ways, the average of bulk and neo-bulk distances was used (10,500 miles or 31 sea days at 14 knots). Total port time was based on loading and unloading, both directions (11 working and 8 non productive days). Distance and duration for vessels with one way grain loads were 9000 miles, 27 sea days and 7 port days.
- Tides. Duration and height are based on the average of spring and neap tides at Richmond, shown in Appendix C.
- Vessel Operating Costs. IWR's 1988 vessel costs (issued in late FY89) were interpolated to world average deadweights for loadline draft.
- Underkeel Clearance. A total of 3 feet was allowed for safety clearance and trim, squat and roll. This is the clearance that the largest vessels are likely to use. Smaller vessels may use fewer draft reduction measures. For simplicity, the example understates tide dependency and does not calculate risk costs.

Table G-1: Distribution of Vessels with Actual Drafts Less than Maximum Drafts

TABLE IV-1
DISTRIBUTION OF VESSELS WITH ACTUAL DRAFTS LESS THAN MAXIMUM DRAFTS
(number of vessels "lightloaded" and overall percentage)

Draft Actual vs Maximum (ft), Newark Containerships Inbound - 35' Channel

Maximum	<0	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13	>13
<30	13	10	23	27	41	23	9	3	3	2		1				
30			1	3	6	7	6	5	4	4	7	4				1
31	2	2	1	3	4	6	6	12	9	7	5	3	2			
32	3				4	2	6	6	3	1	1	1				
33			3	4	7	11	8	12	1	3	3	3	1			
34		2	2	5	9	11	13	13	13	11	3		1	1		
35					1		4	1			1					1
36		1		1	5	2	5	6	3	5	4	8	16	17	38	29
37						1	1		1		2					
38			1	1	3	7	4	11	18	15	16	7	8	9	4	4
39			1	1		2	4	4	2	2	6	2		2	1	
41									1	2	3	10	2	3		
43											1	4	2	2		2
% <35	4.2	3.2	6.9	9.7	16.4	13.9	11.1	11.8	7.6	6.5	4.4	2.8	0.9	0.2	0.0	0.2
% >34	0.0	0.3	0.6	0.9	2.8	3.8	5.6	6.9	7.8	7.5	10.3	9.7	8.8	10.3	13.4	11.3

Draft Actual vs Maximum (ft), Houston Tankers Inbound - 40' Channel

Maximum	<0	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13	>13
36			1													
37	2	2	1													
38		5	3	1												
39		4		1												
40			7	1	1	1										
41			2	3												
42					3	3	2	1								
43						2	7	1								
44							3	5	6							
46										1		1				
47										1			1			
49													1	1		
>49																2
%	2.6	14.5	18.4	7.9	5.3	7.9	15.8	9.2	7.9	2.6	0.0	1.3	2.6	1.3	0.0	2.6

Draft Actual vs Maximum (ft), Newark General Cargo Vessels Inbound - 35' Channel

Maximum	<0	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13	>13
<30	8	4	12	15	8	11	11	12	12	4	9	9	4	3	4	5
30			1		7	11	18	18	14	8	4	4	3	2		6
31				1	6	16	14	8	8	9	6	12	11	3	2	4
32				2	2	2	2	4	8	14	7	7	5	3	2	3
33							1	2	4	5	6	5	3	3	3	
34										1				2		
35							1	1		1	6	5	2	4	3	2
%<35	1.9	0.9	3.1	4.3	5.4	9.5	10.9	10.4	10.9	9.7	7.6	8.7	6.1	3.8	2.6	4.3
%>34	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.0	0.0	4.0	24.0	20.0	8.0	16.0	12.0	8.0

G.2 Sample Calculations

The following sample calculations based on the previous deep draft manual may prove useful in further understanding of how transportation costs are found with tide delays. They are based on a single vessel design deadweight of 50,578 tonnes (metric) at a loadline draft of 40 feet. The immersion rate is 140 tonnes per inch, and it is assumed to be light loaded 1 foot both ways. Its costs are $13,927 per sea day, $9,681 per port day. Costs are calculated per tonne. Alternately, vessel capacity could be converted to short tons.

Note: The deepening calculation example is consistent for bulk cargo calculations but not appropriate for containerships.

Vessel Payloads:

50,478 tonnes = ship deadweight

X .92 = allowance for fuel, stores, water

46,532 tonnes = cargo deadweight

-1,680 tonnes = allowance for 1 ft. light loaded

44,852 tonnes = payload using 2 ft. of tide at U.S. port

-3,360 tonnes = 2 ft. light load in lieu of tide delay

41,292 tonnes = payload without use of tide

Voyage Costs

	One-Way Load	**With Return Load**
Distance	9,000 miles	10,500 miles
Sea Time @ 14 knots	27 days (26.8)	31 days (31.3)
Port Time	7 days	19 days
Sea Cost	$ 376,029	$ 431,737
Voyage Cost	$ 67,767	$ 183,939
Cost per Tonne, 1 ft. light load	$ 443,796	$ 615,676
Cost per Tonne, 3 ft. light load	$ 9.89	$ 6.86
	$ 10.70	$ 7.42

Tide Delay at U.S. Port

	Outbound	**Inbound**
Time Needed	2 feet	1 foot
Time Needed	.3945 port day	.1333 sea day
Delay Cost	$ 3,819	$ 1,856
Potential Revenue	$33,230 @ 9.89	$11,525 @ 6.86
Acceptable Delay Cost	$ 3,819	$ 1,856

Ocean Transportation Costs

	One-Way Load	**With Return Load**
Voyage Costs	$ 443,796	$ 615,676
Tide Delay Costs	$ 3,819	$ 5,675
Total Costs	$ 447,615	$ 621,351
Cost per Tonne	$ 9.98	$ 6.93

Average Cost per Tonne/Short Ton Grain	$8.46/$7.67
Incremental Cost per Tonne/Short Ton Steel	$3.87/$3.52
Average Cost per Tonne/Short Ton All Cargo	$7.95/$7.21

G.3 Calculations

The following tables show a calculation of costs for the entire port fleet. Additional tables would have been required to show separate fronthaul and backhaul costs.

Mobile Harbor

Table G-2: Sample Vessel Payloads in Tonnes in Normal Range of Actual Drafts

VESSEL PAYLOADS IN TONNES IN NORMAL RANGE OF ACTUAL DRAFTS

MAX	VESSEL	FLEET	AVG	CARGO	CARGO......	CARGO PAYLOAD IF LIGHTLOADED.......						
DRAFT	#	TTL DWT	DWT	DWT	TPI	1 FT	2FT	3FT	4FT	5FT	6FT	7FT
45	73	5163900	70738	67201	174	65113	63025	60937	58849	56761	54673	52585
44	82	5399300	65845	60578	167	58574	56570	54566	52562	50558	48554	46550
43	148	9290400	62773	57751	160	55831	53911	51991	50071	48151	46231	44311
42	113	6990600	61864	56915	153	55079	53243	51407	49571	47735	45899	44063
41	218	12545800	57550	52946	147	51182	49418	47654	45890	44126	42362	40598
40	165	8345500	50579	46532	140	44852	43172	41492	39812	38132	36452	34772
39	85	3651900	42964	39526	133	37930	36334	34738	33142	31546	29950	28354
38	172	7154400	41595	38268	126	36756	35244	33732	32220	30708	29196	27684
37	356	13480800	37867	34838	119	33410	31982	30554	29126	27698	26270	24842
36	410	14314300	34913	32120	102	30896	29672	28448	27224	26000	24776	23552
35	512	16173500	31589	29062	95	27922	26782	25642	24502	23362	22222	21082
34	359	9636700	26843	24696	90	23616	22536	21456	20376	19296	18216	17136
33	373	9092800	24377	22427	85	21407	20387	19367	18347	17327	16307	15287
32	373	8842400	23706	21810	80	20850	19890	18930	17970	17010	16050	15090
31	284	5790400	20389	18350	75	17450	16550	15650	14750	13850	12950	12050
30	225	4164800	18510	16659	70	15819	14979	14139	13299	12459	11619	10779
29	109	1678800	15402	13862	65	13082	12302	11522	10742	9962	9182	8402
28	50	701300	14026	12623	60	11903	11183	10463	9743	9023	8303	7583

Table G-3: Sample Vessel Transportation Cost per Tonne in Normal Range of Actual Drafts

VESSEL TRANSPORTATION COST PER TONNE IN NORMAL RANGE OF ACTUAL DRAFTS (1)

MAX	%FLEET	AVG	COST PER DAY....		TRANSPORTATION COST FULL AND LIGHTLOADED...							
DRAFT	DWT	DWT	SEA	PORT	FULL	1 FT	2 FT	3 FT	4 FT	5 FT	6 FT	7 FT
45	0.036	70738	15914	10963	5.99	6.18	6.39	6.61	6.84	7.09	7.37	7.66
44	0.038	65845	15406	10619	6.44	6.66	6.89	7.15	7.42	7.71	8.03	8.38
43	0.065	62773	15086	10404	6.61	6.84	7.08	7.34	7.63	7.93	8.26	8.62
42	0.049	61864	14992	10340	6.67	6.89	7.13	7.38	7.65	7.95	8.27	8.61
41	0.088	57550	14571	10072	6.97	7.21	7.47	7.74	8.04	8.36	8.71	9.09
40	0.059	50579	13927	9681	7.59	7.87	8.18	8.51	8.87	9.26	9.69	10.16
39	0.026	42964	13196	9247	8.48	8.84	9.23	9.65	10.12	10.63	11.19	11.82
38	0.050	41595	13064	9168	8.68	9.03	9.42	9.84	10.31	10.81	11.37	11.99
37	0.095	37867	12659	8913	9.24	9.64	10.07	10.54	11.05	11.62	12.26	12.96
36	0.101	34913	12311	8688	9.75	10.14	10.56	11.01	11.51	12.05	12.65	13.30
35	0.114	31589	11970	8495	10.50	10.92	11.39	11.90	12.45	13.06	13.73	14.47
34	0.068	26843	11482	8220	11.87	12.42	13.01	13.67	14.39	15.20	16.10	17.11
33	0.064	24377	11219	8071	12.79	13.40	14.07	14.81	15.63	16.55	17.59	18.76
32	0.062	23706	11140	8026	13.06	13.67	14.33	15.05	15.86	16.75	17.75	18.88
31	0.041	20389	10748	7805	15.01	15.78	16.64	17.60	18.67	19.89	21.27	22.86
30	0.029	18510	10525	7679	16.21	17.07	18.03	19.10	20.30	21.67	23.24	25.05
29	0.012	15402	10158	7471	18.84	19.96	21.23	22.66	24.31	26.21	28.44	31.08
28	0.005	14026	9995	7379	20.37	21.61	23.00	24.58	26.40	28.50	30.97	33.91

Table G-4: Sample Vessel Tide Delays in Fractional Days

VESSEL TIDE DELAYS IN FRACTIONAL DAYS (2)

MAX DRAFT	COST PER DAY SEA	PORT	OUT-FULL	IN-FULL -1 FT	-1 FT -2 FT	-2 FT -3 FT	-3 FT -4 FT	-4 FT -5 FT	-5 FT -6 FT	-6 FT -7 FT
45	15914	10963	NA	NA	NA	0.8667	0.8055	0.55	0.3945	0.1333
44	15406	10619	NA	NA	0.8667	0.8055	0.55	0.3945	0.1333	0
43	15086	10404	NA	0.8667	0.8055	0.55	0.3945	0.1333	0	0
42	14992	10340	0.8667	0.8055	0.55	0.3945	0.1333	0	0	0
41	14571	10072	0.8055	0.55	0.3945	0.1333	0	0	0	0
40	13927	9681	0.55	0.3945	0.1333	0	0	0	0	0
39	13196	9247	0.3945	0.1333	0	0	0	0	0	0
38	13064	9168	0.1333	0	0	0	0	0	0	0
<38	NA	NA	0	0	0	0	0	0	0	0

Table G-5: Sample Adjusted Distribution of Vessel Sizes with "Acceptable" Light loading

ADJUSTED DISTRIBUTION OF VESSEL SIZES WITH "ACCEPTABLE" LIGHTLOADING (3)

MAX DRAFT	SHIP REV PER FT/PORTCOST FULL	-1 FT	-2 FT	-3 FT	...ADJUSTED OUTBOUND DWT DISTRIBUTION... FULL	-1ft	-2ft	-3ft	-4ft	-5ft	-6ft
45	1.141	1.177	1.216	1.258	NA	NA	NA	82.82	14.38	1.75	1.05
44	1.214	1.256	1.300	1.348	NA	NA	55.44	27.38	14.38	1.75	1.05
43	1.220	1.262	1.307	1.355	NA	24.91	30.53	27.38	14.38	1.75	1.05
<43	"NORMAL" DISTRIBUTION				7.71	17.2	30.53	27.38	14.38	1.75	1.05

MAX DRAFT	SHIP REV PER FT/SEACOST FULL	-1 FT	-2 FT	-3 FT	....ADJUSTED INBOUND DWT DISTRIBUTION... FULL	-1ft	-2ft	-3ft	-4ft	-5ft	-6ft
45	0.786	0.811	0.838	0.867	NA	NA	0	82.82	14.38	1.75	1.05
44	0.837	0.865	0.896	0.929	NA	0	55.44	27.38	14.38	1.75	1.05
43	0.841	0.870	0.901	0.934	0	24.91	30.53	27.38	14.38	1.75	1.05
42	0.816	0.843	0.872	0.903	0	24.91	30.53	27.38	14.38	1.75	1.05
41	0.843	0.872	0.903	0.937	0	24.91	30.53	27.38	14.38	1.75	1.05
40	0.915	0.949	0.986	1.026	7.71	17.2	30.53	27.38	14.38	1.75	1.05
<41	"NORMAL" DISTRIBUTION				7.71	17.2	30.53	27.38	14.38	1.75	1.05

Table G-6: Sample Average Tide Delay Costs per Vessel Voyage

AVERAGE TIDE DELAY COSTS PER VESSEL VOYAGE (4)

MAX DRAFT	%FLEET DWT	AVG DWT	COST PER DAY SEA	PORT	...........COST OF TIDE DELAY........... FULL	-1FT	-2FT	-3FT	-4FT	-5FT	-6FT
45	0.036	70738	15914	10963	NA	NA	NA	15911	13207	9169	5386
44	0.038	65845	15406	10619	NA	NA	15408	12790	8879	5216	1416
43	0.065	62773	15086	10404	NA	15093	12529	8698	5110	1387	0
42	0.049	61864	14992	10340	13084	12452	8644	5078	1378	0	0
41	0.088	57550	14571	10072	10987	8414	4945	1343	0	0	0
40	0.059	50579	13927	9681	8072	4747	1290	0	0	0	0
39	0.026	42964	13196	9247	4527	1233	0	0	0	0	0
38	0.050	41595	13064	9168	1222	0	0	0	0	0	0
<38	0.589	NA	NA	NA	0	0	0	0	0	0	0

Table G-7: Sample Transportation Cost per Tonne with Adjusted Fleet and Tide Delays

TRANSPORTATION COST PER TONNE WITH ADJUSTED FLEET AND TIDE DELAYS (5)

MAX	%FLEET	AVG	........AVERAGE COST FULL AND LIGHTLOADED.......							AV COST
DRAFT	DWT	DWT	FULL	-1FT	-2FT	-3FT	-4FT	-5FT	-6FT	BY DRAFT
45	0.036	70738	NA	NA	NA	6.87	7.07	7.26	7.46	6.91
44	0.038	65845	NA	NA	7.16	7.38	7.59	7.81	8.06	7.30
43	0.065	62773	NA	7.11	7.31	7.51	7.73	7.96	8.26	7.40
42	0.049	61864	6.82	7.12	7.29	7.48	7.68	7.95	8.27	7.35
41	0.088	57550	7.12	7.37	7.57	7.77	8.04	8.36	8.71	7.65
40	0.059	50579	7.76	7.98	8.21	8.51	8.87	9.26	9.69	8.35
39	0.026	42964	8.60	8.87	9.23	9.65	10.12	10.63	11.19	9.41
38	0.050	41595	8.71	9.03	9.42	9.84	10.31	10.81	11.37	9.59
37	0.095	37867	9.24	9.64	10.07	10.54	11.05	11.62	12.26	10.25
36	0.101	34913	9.75	10.14	10.56	11.01	11.51	12.05	12.65	10.73
35	0.114	31589	10.50	10.92	11.39	11.90	12.45	13.06	13.73	11.59
34	0.068	26843	11.87	12.42	13.01	13.67	14.39	15.20	16.10	13.27
33	0.064	24377	12.79	13.40	14.07	14.81	15.63	16.55	17.59	14.36
32	0.062	23706	13.06	13.67	14.33	15.05	15.86	16.75	17.75	14.61
31	0.041	20389	15.01	15.78	16.64	17.60	18.67	19.89	21.27	17.03
30	0.029	18510	16.21	17.07	18.03	19.10	20.30	21.67	23.24	18.46
29	0.012	15402	18.84	19.96	21.23	22.66	24.31	26.21	28.44	21.83
28	0.005	14026	20.37	21.61	23.00	24.58	26.40	28.50	30.97	23.66
OVERALL AVERAGE COST PER TON WEIGHTED BY DEADWEIGHT DISTRIBUTION										10.95

Notes to tables G-3 throughG-37:

(1) Average cost for grain and backhaul steel. Actual vessel rates may differ for front and backhaul cargos. Computed as 50 days seacoast + 26 days port cost + payload x 3, to reduce the number of tables shown. Separate calculations for front and backhaul cargos are the usual way this is done.

(2) NA indicates vessels that cannot transit the channel using tides, without draft reduction by light loading. The upper limit of acceptable light loading was assumed to be in the normal range of actual drafts, based on comparison with transport cost by fully loaded smaller vessels.

(3) In order to establish the maximum amount of acceptable tide delay, many studies use an arbitrary assumption of one-half day. A more scientific approach used here is to compare revenue foregone if light loaded another foot, with the cost of the required tide delay. Payload per foot of immersion x average transport cost was used to approximate revenue. The higher cost of seatime offsets the draft reduction of inbound vessels due to fuel consumption, but adjustments to both inbound and outbound fleets are almost identical.

(4) Computed as the cost of a fractional port day for vessels delayed outbound plus, 50% of the cost of a fractional seaday for inbound vessels. This assumes backhauls were distributed proportionate to fleet capacity. (5) Computed by adding transport cost per ton for applicable vessel sizes (Table G-3) and voyage tide delay costs (Table G-7).

Gulfport Harbor

G.4 Recap of Benefit Estimates

Consider a single movement such as corn shipped from Indiana to Rotterdam, which will be denoted as M_B in the without-project condition and M_A for some alternative. Based on the previous analysis in this manual, we can fully describe the movement for each alternative with respect to estimating benefits by:

$M_i \approx (T_i, V_i, R_i, C_i)$, where

- $\approx$ a descriptive operator relating the movement to its characteristics;
- T_i tonnage of the movement under alternative i;
- C_i the cost for shipping T_i on vessel type V_i via routing R_i;
- V_i vessel identifier (such as vessel type or capacity) for the movement under alternative i; and
- R_i routing identifier (such as export harbor) for the movement under alternative i.

We have described the movement of corn from Indiana to Rotterdam under the baseline, B, and alternative A by:

$M_B \approx (T_B, V_B, R_B, C_B)$ and
$M_A \approx (T_A, V_A, R_A, C_A)$.

The transportation benefit for this movement is computed as:

$$(C_B - C_A)T_B - ½ (C_B - C_A) (T_A - T_B),$$

where the right-hand term is the savings imputed to new traffic and the left-hand term is the savings for existing traffic regardless of whether or not it used the project in the without-project condition.

Note that neither the vessel nor routing characteristics directly enter the benefit estimation equation. They do, however, influence the manner in which we classified benefits earlier in this section.

> For example, when $T_A=T_B$, the right-hand term is zero and this describes the condition applicable to the cost reduction benefit; that is, the same traffic through the same harbor under both project conditions. When $V_A=V_B$, this is a case in which traffic moves on the same vessel type in both conditions (i.e., a deeper loading benefit), whereas when V_A is unequal to V_B, this represents the use of a larger vessel.

The P&G does not define benefits; it specifies how to classify benefits based on vessel and routing characteristics and how the benefit associated with each class can be computed. When the analysis discussed previously in this manual is complete, the disaggregation of benefits as described above and in the P&G is a matter of presentation, not computation.