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Standard Port-visit Cost Forecasting Model for US Navy Husbanding Contracts

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18 December 2009

by

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Abstract

Husbanding services are crucial elements of a port visit. In support of mission objectives, combatant commanding officers and sealift masters rely on contractors to act on the US Navy's behalf in coordinating the delivery of supplies or performance of services. Through the years, the cost of port services around the world has increased in various magnitudes. However, the US Navy's ability to track and analyze port-visit costs changes remains rudimentary. Current systems lack the functionality needed by the stakeholders to effectively and efficiently forecast port-visit costs.

The researchers developed a Web-based modularized application that stores and displays invoices, generates reports and, more importantly, forecasts future port-visit costs using the standard port-visit cost forecasting model for husbanding contracts. The forecasting function of the application provides two predictive methods, namely confidence interval estimator and exponential smoothing. The analysis clearly shows that low requirement variability improves the reliability of the interval, while high frequency of port-visits increases the accuracy of the exponential smoothing results. The capabilities of the application provide stakeholders with a valuable tool to analyze port-visit requirements and costs trends.

Keywords: Husbanding Services, Standard Port-visit Cost Forecasting Model, Husbanding Service Provider, Port-Visit Cost Reports, LOGREQ, CRAFT, WWCRAFT, LogSSR, LOGCOP, COMFISCS, FISCs, CLASSRON, TYCOMS, NAVSUP

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Lieutenant Commander Michael Alvin A. Marquez received a Master of Business Administration degree from the Naval Postgraduate School in December of 2009. He enlisted in the United States Navy in 1991 as a personnelman. He accepted a commission as an Ensign under the Seaman-To-Admiral (Legacy) Program in 1998 and earned his Bachelor's degree in Computer Science from the University of San Diego. He served his division officer tours aboard USS DULUTH (LPD 6) as the Electrical Officer and USS BELLEAU WOOD (LHA 3) as the Materials Officer. Upon completion of his Supply Officer tour aboard USS VELLA GULF (CG-72), he reported to the Commander of Task Force Five Three as the Officer-In-Charge of Sealift Logistics Command Central Detachment in Dubai responsible for all USN and MSC logistics and port operations in the United Arab Emirates. He is currently assigned to the Naval Sea Systems Command in Washington, DC.

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List of Acronyms and Abbreviations

ACO	Administrative Contracting Officer
AOR	Area of Responsibility
C3F	Commander, Third Fleet
C3M	Consolidate Husbanding Contract located in Canada, Caribbean, Central America, Mexico, and South America
CDR	Commander
CENTCOM AOR	Central Command Area of Responsibility
CG	Guided Missile Cruisers
CHT	Collection, Holding and Transfer
CLASSRON	Class Squadron
CLIN	Contract Line-item Number
CMP	Continuous Monitoring Program
CNO	Chief of Naval Operation
COMFISCS	Commander, Fleet and Industrial Supply Centers
CONUS	Continental United States
CPF	Commander Pacific Fleet
CRAFT	Legacy Cost Reporting, Analysis & Forecasting Tool
DDG	Guided Missile Destroyer
DoD	Department of Defense
ELRT	Expeditionary Logistics Response Teams
EUCOM	United States European Command
FAR	*Federal Acquisition Regulation*
FFG	Guided Missile Frigate
FFP-IDTC	Firm-fixed-price—Indefinite-delivery Type Contract
FFV	Fresh Fruits and Vegetables
FISCs	Fleet and Industrial Supply Centers
FISCSD	Fleet and Industrial Supply Center San Diego
FISCSI	Fleet and Industrial Supply Center Sigonella
FISCY	Fleet Industrial Supply Center Yokosuka
HSP	Husbanding Service Provider
HTTP	Hypertext Transfer Protocol
IP	Internet Protocol
ISS	Inchcape Shipping Services
IT	Information Technology

KO	Contracting Officer
LHD	Multi-purpose Landing Helicopter Dock
LOGCOP	Logistic Common Operating Picture
LOGREQ	Logistical Requirements
LogSRR	Logistics Support Services Repository
LPD	Landing Platform Dock
MAPE	Mean Absolute Percentage of Error
MLS	Multinational Logistics Services
MySQL	My Structured Query Language
NAVSUP	Navy Supply Systems Command
NC	Non-contract Items
NPS	Naval Postgraduate School
NRCD	Navy Regional Contracting Detachment
OCONUS	Outside Continental United States
OOTW	Operations Other Than War
PAT	Process Action Team
PCO	Procurement Contracting Officer
PHP	Hypertext Preprocessor
PKI	Public Key Infrastructure
PVCR	Port-visit Cost Reports
RADM	Rear Admiral
SOW	Statement of Work
SPCFM	Standard Port-visit Cost Forecasting Model
SSN	Fast Attack Submarine (Nuclear)
SUPPO	Supply Officer
TAO	Fleet Replenishment Oilers
TYCOMS	Type Commanders
UAE	United Arab Emirates
UK	United Kingdom
US	United States
WWCRAFT	Worldwide Cost Reporting, Analysis, and Forecasting Tool

I. Introduction

Husbanding services are crucial elements of a port visit. In support of mission objectives, combatant commanding officers and sealift masters rely on contractors to act on the US Navy's behalf in coordinating the delivery of supplies or the performance of services. Through the years, the cost of port services around the world has increased in various magnitudes. However, the Navy's ability to track and analyze port-visit cost changes remains rudimentary, since current systems lack the functionality needed by the stakeholders to effectively and efficiently forecast port-visit costs. This project focuses on developing and testing the Standard Port-visit Cost Forecasting Model (SPCFM), a Web-based forecasting application designed to enhance current system capabilities and predict port-visit costs.

The high-level echelons, such as Navy Supply Systems Command (NAVSUP),[1] Type Commanders (TYCOMs),[2] Fleet Commanders,[3] and Class Squadrons (CLASSRONs),[4] have long desired improvements on predicting port-visit cost through better forecasting. For the numbered Fleet Commanders, the biggest challenge relates to projecting the budget of port-visit costs. As of this year, TYCOMs delegated the management of port visits to the numbered Fleet Commanders. Prior to delegating the management function, TYCOMs managed the cost of port visits, while the Fleet Commanders wrote the messages tasking ships to

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[1] NAVSUP manages supply chains that provide material for Navy aircraft, surface ships, submarines and their associated weapon systems.

[2] Type Commanders control ships within a type category. Aircraft carriers, aircraft squadrons, and air stations are under the administrative control of the appropriate Commander Naval Air Force. Submarines come under the Commander Submarine Force. All other ships fall under Commander Naval Surface Force.

[3] The US Navy is currently organized into five fleets: Second Fleet in the Atlantic, Third Fleet in the Eastern Pacific, Fifth Fleet in the Arabian Gulf and Indian Ocean, Sixth Fleet in the Mediterranean, and Seventh Fleet in the Western Pacific.

[4] CLASSRONs analyze metrics across ships of a class, access current readiness and cost control processes.

visit specific ports. Now, TYCOMs gives each of the Fleet Commanders a budgeted amount to allocate among several port visits.

During a site visit to Third Fleet, the researchers learned that the Third Fleet N4 had to rely on locally developed spreadsheets and available information from LOGCOP (Logistic Common Operating Picture)[5] to validate the feasibility of a port visit based on current budget constraints. Therefore, Fleet Commanders are very interested in a port-visit cost forecasting tool for their strategic operational planning (C3F N4A, 2009).

On a ship level, one of the many challenging responsibilities of a ship's Supply Officer (SUPPO) during a deployment is coordinating the ship's port-visit support with the Husbanding Service Provider (HSP).[6] The support and cost vary depending on the geographical location, the ship's mission, and resources available in the region (Hall & Adams, 2007). The SUPPO needs such a forecasting tool to help assess a ship's upcoming port-visit cost. Currently, existing systems do not have the capability to forecast and assist in mitigating costs. This project provides a cost-estimating module that supply officers could use in projecting the cost of an upcoming port visit.

The process of developing the application includes collecting a four-year data set of invoices, from 2006 to 2009. Prior to populating the database, the project team members developed, debugged, and tested the Web-based application. Due to Contract Line-item Number (CLIN) discrepancies, which will be discussed in later chapters, team members manually typed into the database invoices from 2006 to 2007. After validating each invoice entered in the system, the application generated

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[5] LOGCOP (Logistic Common Operating Picture) is a Pacific Fleet Command initiative for a Web-based decision-support tool.

[6] Husbanding Service Providers are non-government personnel and do not have access to classified messages; therefore, ship supply officers send the ship's orders for supplies and services (less ship's classified information) directly to the HSP via e-mail.

port-visit costs forecasts for visiting ships in 2008 and 2009. Lastly, the team members gathered all actual invoices and forecast reports to analyze the results.

The paper is composed of eight subsequent chapters. Chapter II provides background information on the need for a port-visit costs forecasting tool by the higher echelons and the Supply Officer, and describes how the available resources (e.g., CRAFT, the WWCRAFT, the LogSRR, and LOGCOP) do not currently have the capability to effectively and efficiently forecast port-visit costs.

Chapter III reviews the strategic approach of the Navy Supply Systems Command (NAVSUP)'s to Global Husbanding Services. It also discusses how the Commander, Fleet and Industrial Supply Centers (COMFISCS), is implementing this vision by standardizing the husbanding-service process throughout the Fleet and Industrial Supply Centers (FISCs) that handle husbanding contracts. Finally, the chapter reviews the basic husbanding services included in a Statement of Work.

Chapter IV describes the development of the project website and its functionalities. The chapter describes, in detail, the processes involved in the development of the website such as data gathering, the CLIN structures used, and the operating system environment employed. Additionally, it describes the website functionalities such as administrative function, data security, invoice display, report generation, and forecasting function.

Chapter V describes the two estimation methods—t-statistic and exponential smoothing—used in the SPCFM forecasting functionality, and the algorithms applied to compute the estimated port-visit costs. In addition to describing the methods and algorithms, this chapter also shows the pseudo-code as applied in the forecasting functionality.

Chapter VI discusses the four-case analysis conducted to validate the efficiency and effectiveness of the forecasting model.

Chapter VII discusses the results and conclusions derived from the analysis. Additionally, the chapter also discusses the SPCFM performance, data quality and its impact to the stakeholders.

Chapter VIII discusses recommendations the researchers deemed necessary and critical in the implementation of an effective and efficient forecasting tool.

II. Background

Due to a ship's dynamic schedules and varying missions, coordinating port visits is a very demanding and tedious task. To plan and prepare for a port visit, the SUPPO relies on previous port-visit cost invoices on file for that particular country or port. Additionally, the SUPPO can obtain Port-visit Cost Reports (PVCR) from incumbent Fleet and Industrial Supply Centers (FISC) to help during the planning stage. Once the ship receives notification of a scheduled port visit (Figure 1), the ship sends its logistical requirements (LOGREQ), or orders, to the regional FISC via classified message. At the same time, the SUPPO provides, via e-mail, a copy of the unclassified LOGREQ message directly to the HSP.

Upon receipt of a sanitized LOGREQ, the HSP acknowledges the order, makes preparations, and provides the SUPPO with an estimate. The SUPPO uses the HSP estimate and previous PVCR to predict the upcoming port-visit cost during his brief with the Commanding Officer. Hence, no forecasting tool is readily available for the supply officer independent of the HSP's estimate. The regional FISC replies to LOGREQ confirming the ship's requirements. When the ship arrives at the designated port, the HSP executes and delivers the required supply and services.

During the execution and delivery process, the ship and the FISC's representatives inspect and receive the goods and services provided. On the last day, the SUPPO and HSP resolve any disputes on services rendered and finalize payment. Most of the time, the SUPPO lacks the background information of excessive service costs from prior invoices. Without the necessary forecasting tool, the SUPPO cannot compare the anticipated services with the previous port-visit cost data.

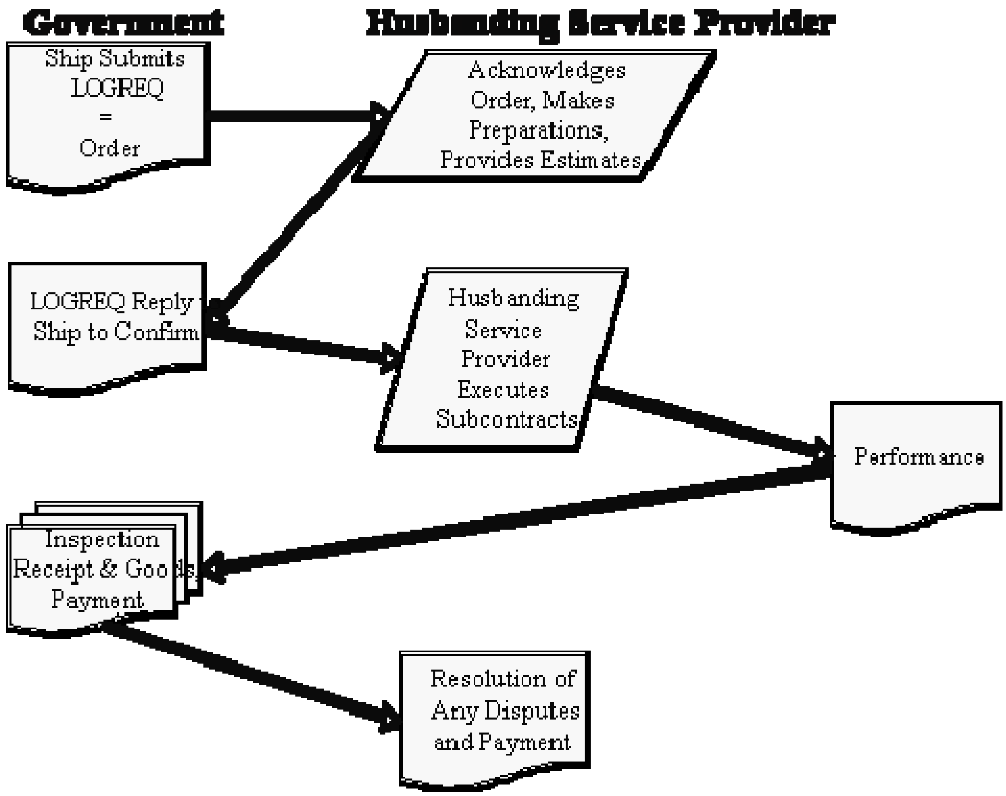

Figure 1. Flow chart of HSP ordering process.
(From King, 2009, January 30)

A. Current Resource Tools Available, and their Limitations

There are tools currently in use, as well as systems being developed and enhanced, to help track a ship's port-visit costs. However, the available tools do not have the forecasting capability to estimate port-visit costs. This section provides an overview and discusses the limitations of each system.

1. Legacy Cost Reporting, Analysis and Forecasting Tool (CRAFT)

The Legacy Cost Reporting, Analysis and Forecasting Tool (CRAFT), fielded in 1997 (King, 2009a, June 9), is a database used to track ships' port-visit costs in the 7th Fleet Area of Responsibility (AOR). Aside from being a data repository, the CRAFT provides basic query reports to help US Navy leadership assess ships' port-visit costs. The basic query reports include ships' port-visit costs per Contract Line-item Number (CLIN) at specific ports. However, the CRAFT lacks the capability to predict future port-visit costs.

The port-visit costs data stored in the system comes from the two reports provided by the contractor who is awarded the husbanding services contract. The FISC also provides a copy of the CRAFT software program to the successful contractor. The contractor's responsibility includes the use of the program in providing the LOGREQ initial cost estimate and the actual cost report (NAVSUP, 2009f).

a. LOGREQ Initial Cost Estimate

The contractor's LOGREQ initial cost estimate shows the price quote for all of the items ordered by ships, activities, and individuals identified in the contract. The contractor provides this CRAFT estimate to the ship and respective FISC within two working days[7] after receipt of the ship's order. The contractor sends the estimate as a message embodied in an e-mail to the ordering ship. The contractor also transmits the estimate to the respective FISCs for incorporation to the CRAFT database. The CRAFT estimate includes any additional costs and potential savings during the port visit (NAVSUP, 2009f).

b. Actual Cost Report

The Navy requires the contractor to submit a CRAFT Actual Report to the respective FISC within seven calendar days after completion of the ship's visit. The respective FISC receives the report, covering all of the ship's husbanding services

[7] In the case in which the Contractor receives the order with less than two (2) working days prior to the arrival of the ship, the Contractor shall make every effort possible to provide the CRAFT estimate prior to the ship's arrival or per the guidelines set forth in the contract.

port-visit costs,[8] regardless of payment status, for incorporation into the database (NAVSUP, 2009f).

According to LCDR Jerry King, NAVSUP 02A, the Fleet will continue to use the CRAFT until LogSSR or other systems can replace the legacy system (King, 2009, June 11).

2. Worldwide Cost-reporting, Analysis and Forecasting Tool (WWCRAFT)

The WWCRAFT was an “enhanced” version of the CRAFT developed and utilized by FISCSI and NRCD Naples, Italy, to track ships port-visit costs within the 5th and 6th Fleet AORs. The FISCSI’s current husbanding contract stipulated the use of WWCRAFT in place of CRAFT (NAVSUP, 2009f). However, NAVSUP’s newly developed designated-data repository, LogSSR, renders the WWCRAFT obsolete (King, 2009b, June 9). Although the WWCRAFT no longer exists, it is still worthwhile to discuss the system and its enhanced functionalities and compare it with the CRAFT.

Similar to the CRAFT, the WWCRAFT was an overall-port-visit management system designed to capture LOGREQ inputs and quotes. However, unlike the CRAFT, the WWCRAFT captured validation and acceptance of service requirements via e-mail communication and alert systems (King, 2009a, June 9). The contractor, upon award of the husbanding contract, received access to WWCRAFT as a “Husbanding Contractor” user. Similar to the CRAFT, the Navy required the contractor to submit two reports, the LOGREQ initial cost estimate and the actual-cost report.

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[8] The term "port-visit costs" includes all supplies or services identified in the SUPPLIES/SERVICES AND PRICES section of the contract, supplies or services furnished under another FISCSI NRCD contract, and any other charge paid by the ship during the port visit.

a. LOGREQ Initial Cost Estimate

Similar to the CRAFT requirement, the initial cost estimate was a price quote of all the items ordered by ships, activities and individuals identified in the contract. Unlike the CRAFT, the WWCRAFT was capable of generating a text e-mail with the initial cost estimate and sending it to the SUPPO of the ship. When the ship's SUPPO replied to the e-mail sent by the system, the WWCRAFT classified and stored the e-mail response to the correct port visit file. If the ship's SUPPO requested additional services, the contractor could easily access and add the new requirement to the WWCRAFT system (NAVSUP, 2009f).

b. Actual Cost Report

The Navy also required the Contractor to submit the actual-cost report to the WWCRAFT system within seven calendar days from the completion of the ship's port visit. Unlike the CRAFT, the WWCRAFT provided the contractor with the option to select the line-items as actual or estimated cost, identifying the unpaid CLINs prior to the ship's departure (e.g., telephone, cell phone bills). Upon receipt of final invoice, the contractor could easily access and update the report on the database. Once the final report was submitted, the WWCRAFT generated a Port-visit Cost Report (PVCR) and sent it to the ship for review (NAVSUP, 2009f).

The WWCRAFT did not have a forecasting capability to predict upcoming port-visit costs. It had an analysis function limited to averaging the total port-visit costs incurred by a certain category of ships (e.g., DDG, FFGs, etc.) over a time period. Since the approach included all the historical data that skews cost results, particularly outliers, the total-cost average approach presented a problem in depicting accurate future cost.

It is worthwhile to note that the two systems, CRAFT and WWCRAFT, in spite of the commonality of their purpose, are different and are not standardized; therefore, they do not conform to Naval Supply Systems Command's (NAVSUP) strategic approach to Global Husbanding Services (King, 2009, June 30).

The Contract Line-item Number (CLIN)[9] structure used in these two tools reflects major differences in HSP contracts across the fleet. Although the services rendered to the ships are the same at each AOR, the Husbanding Contracts lack a standard CLIN structure between 7th Fleet and 5th/6th Fleets. Each version of the CRAFT displays line-items under a different CLIN. The accessibility of the system to authorized users also presented a gap between the two systems. Unlike the CRAFT, the WWCRAFT required a user ID and password to access the system. Regardless, not all supply officers knew that either system existed to assist in viewing port-visit cost invoices.

3. Logistics Support Services Repository (LogSSR)

The Logistic Support Services Repository (LogSSR)[10] is a NAVSUP initiative designed to collect data for a standardized "future CLIN structure." According to King, this structure has not yet been implemented for the husbanding contracts. NAVSUP's ultimate goal is to standardize future contracts and capture the standardized husbanding-cost data set for government stakeholders such as Contracting Offices, Ships, TYCOMs, and Fleet Staff (King, 2009b, June 9).

The ePortal and the InforM-21 are the two major Information Technology systems explicitly used in the development of the LogSSR tool (King, 2009a, June 9). The ePortal provides foreign national HSPs a way to furnish port-visit cost data after completion of a port visit. This IT system also provides Public Key Infrastructure (PKI)-enabled access to government personnel designated to review the data, which is similar to the CRAFT system. On the other hand, the InforM-21 system provides a consolidated, standardized database of port-visit cost information and feeds data to other systems like the Continuous Monitoring Program (CMP) and the Logistics Common Operating Picture (LOGCOP).

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[9] Contract Line-item Number (CLIN) is a list of services or products to be provided by the contractor.

[10] Pronounced as Log-Ser.

In January 2009, the LogSSR database development began (Figure 2), which includes identifying all system requirements. Live data collection began in June 2009, followed by historical data capturing, filtering, and LOGCOP extraction in August 2009 (King, 2009a, June 9).

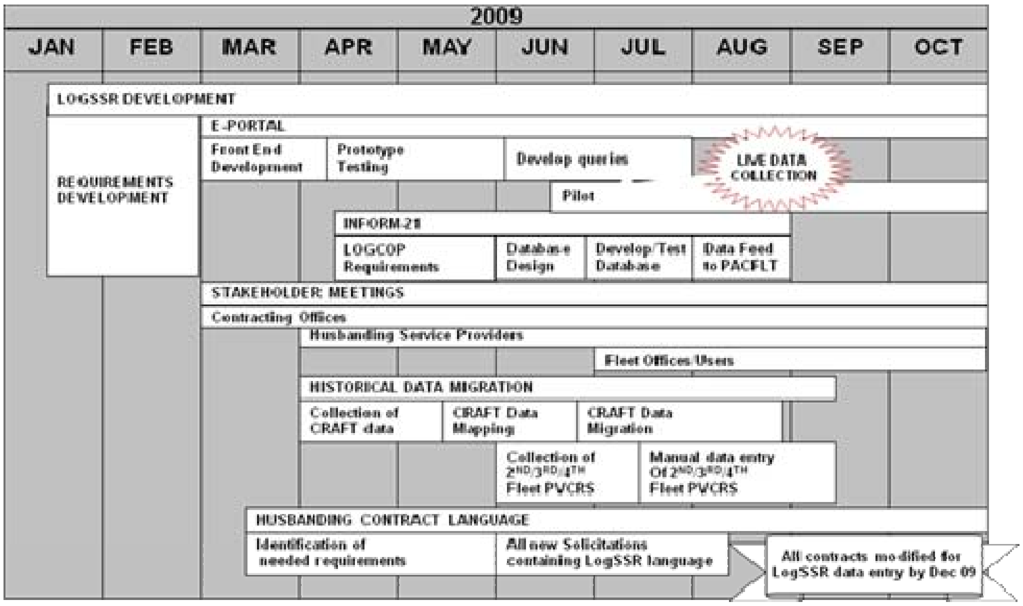

Figure 2. Gantt Chart Showing LogSSR Development
(From King, 2009a, June 9).

Figure 3 shows a comparison of CRAFT, WWCRAFT, and LogSSR. All three systems serve as data-storage repositories and provide basic query reports. The LogSSR, which replaces the WWCRAFT, shows it does not have a forecasting capability to estimate port-visit cost.

SYSTEM / TOOL	LEGACY CRAFT	WW CRAFT	LOGSSR
Data Storage	X	X	X
Data Standardization			X
Global Data Collection		X	X
Data Extraction			X
Information Assurance Requirements			X
Basic Query	X	X	X
Analysis Capability		X	*
Capture acceptance, validation, or certification of port services		X	
Port Visit Workflow		X	
E-mail Communication		X	
Management by Exception Alerts		X	

Figure 3. System comparison of CRAFT, WWCRAFT, LogSSR
(From King, 2009a, June 9).

4. Logistic Common Operating Picture (LOGCOP)

LOGCOP (Logistic Common Operating Picture) is a Web-based information technology decision-support tool established by Commander Pacific Fleet (CPF) N4[11] to provide logistical planners with the information needed in operational planning. LOGCOP extracts information from several different logistic resources and assesses the data against predetermined parameters. It provides a stoplight chart display advising the leadership of the Navy's overall capacity to support an operation and enables the commander and his staff to make timely and sound operational decisions based on real or nearly real-time logistics data (Burke, 2009).

[11] N4 is the Logistics Department included in one of several Functional Departments in the command.

Currently, LogSSR and the Continuous Monitoring Program[12] provide LOGCOP supply metrics port-visit costs data. It has a Port-cost Estimation Tool, which provides average daily port cost. The average, daily port-visit cost calculations are calculated as the total port-visit cost average against the number of days in port. Number of visits is a major factor, since it is the basis for trend analysis. However, it does not break down the ship's requirements and has no forecasting capability.

B. Standard Port-visit Cost Forecasting Model (SPCFM) Capabilities and Limitations

The project team members recognize the need for a better forecasting tool that would be relevant to the strategic approach towards global husbanding service envisioned by the Naval Supply Systems Command (NAVSUP). A Web-based tool should assist the SUPPO in analyzing and forecasting upcoming port-visit costs. In contrast with the CRAFT and WWCRAFT, the project module would provide a forecasting function using statistical and decision-modeling approaches. With predictive functionalities, the SUPPO could confidently brief his Commanding Officer concerning the cost of the port visit and would be in a better position to eliminate unnecessary line-items in the HSP's port-visit cost estimate. The objective is not to replace the systems that are being developed or enhanced, such as the LogSRR or the LOGCOP, but rather to augment these systems (Figure 4) by providing a capability to forecast cost.

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[12] The Continuous Monitoring Program (CMP) consists of shipboard extractors for ship's Supply Department, which provide supply officers and supply personnel with a great tool to improve their operations. The on-board CMP extractors provide summary reports and detailed data, and can be run as often as desired to monitor key or pulse areas. For Pacific Fleet ships, monthly CMP files are forwarded to Afloat Training Group Pacific. The CMP files received from ships are loaded to a Web server, where both summary and detailed "drill down" data can be accessed by authorized users.

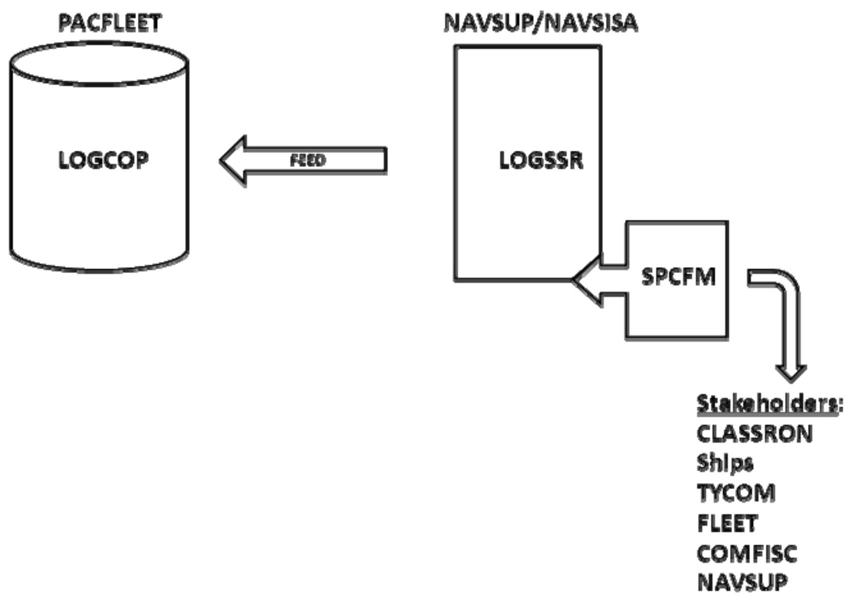

Figure 4. Standard Port-visit Cost Forecasting Model Objective to Augment Capabilities of LogSSR and LOGCOP

C. Background Summary

This chapter provided background information on the need for a port-visit costs forecasting tool by the higher echelons and the supply officer. The chapter also discussed the available resources in the fleet to help track ships' port-visit costs (namely CRAFT, the WWCRAFT, the LogSRR, and LOGCOP) and how these systems currently do not have the capability needed by the stakeholders to effectively and efficiently forecast port-visit costs. Lastly, the chapter introduced a standard predictive model and discussed the forecasting capability of the module as an enhancement to established systems such as LogSSR and LOGCOP.

III. Literature Review

This chapter reviews NAVSUP's strategic approach to global husbanding services and how the Commander, Fleet and Industrial Supply Centers (COMFISCS) is implementing this vision by standardizing the husbanding service process throughout the FISCs that handle husbanding contracts. The chapter begins with NAVSUP's definition of the husbanding service-provider concept and the husbanding contract. It then discusses COMFISCS' worldwide coverage of husbanding contracts, the global husbanding initiatives at various FISCs, the future of husbanding service providers' contracts, and the basic husbanding services included in the Statement of Work.[13]

A. Husbanding Service Provider (HSP) Concept

On January 6, 2009, NAVSUP presented a brief to the Chief of the Supply Corps on its global standardization initiative with the husbanding contracts (King, 2009, January 30). The brief started with an explanation of why the US Navy does not have husbanding "agent" contracts. In a standard commercial husbanding contract, a ship designates an "agent" to act on its behalf, wherein the "agent" binds the ship by signing a contract. This is not the case for a US Navy ship. Per the *FAR*, contracts may be entered into and signed on behalf of the government only by contracting officers (General Services Administration, 2005). Since the US Government does not permit an agent to act on its behalf, it does not have a husbanding agent, but instead, must use a Husbanding Service Provider (King, 2009, January 30).

According to NAVSUP, the HSP coordinates and, in certain cases, provides the delivery of supplies or performance of services. The HSP also assists ships in

[13] The authors used the FISC Sigonella husbanding contract's Statement of Work (SOW) as an example for this research project.

locating sources of supplies or services not priced in the contract, based on best value determination. The provider is paid for the service rendered upon arrival of the ship and, on a separate contract line-item, the subsequent days while the ship is in port or at anchor. The FISC husbanding contract reflects the agreed-upon price for the supplies provided and services rendered to the ship in which the HSP acts as the prime (King, 2009, January 30).

B. Definition of a Husbanding Contract

Two referenced definitions state that the contract is a "non-personal services" type[14] awarded for support of fleet units in foreign ports (Verrastro, 1996, p. 9), and that the contract is awarded to provide services to US Navy and Coast Guard ships making port calls in non-Navy ports (King, 2009, January 30). The husbanding contract is a Firm-fixed-price—Indefinite-delivery Type Contract (FFP-IDTC)[15] used by ship and other operational unit supply officers to place orders of supplies and services by using the CLIN tailored to individual ports and ship categories, ranging from minesweepers to aircraft carriers.

C. COMFISCS' Worldwide Husbanding Contract Coverage

By the direction of the Chief of Naval Operation (CNO), COMFISCS was formally established on August 1, 2006. COMFISCS focuses on global logistics and contracting issues and drives the best practices across the seven FISCs (NAVSUP, 2009a). Table 1 shows each of the seven FISC organizations, which region they support and their operational area of responsibility**.**

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[14] Definition of non-personal services contract, according to *NAVSUP Instruction 4230.37A*, means logistics support services required by a ship (as cited in Verrastro, 1996).

[15] As per *FAR* 16.202-1, FFP-IDTC is a type of contract that may be used to acquire supplies and/or services when the exact times and/or exact quantities of future deliveries are not known at the time of contract award (General Services Administration, 2005).

FISC Organization	Regional Alignment	Operational Alignment
FISC Jacksonville	Navy Region Southeast	4th Fleet
FISC Norfolk	Naval District Washington, Navy Region Mid-Atlantic, Navy Region Midwest	2nd Fleet
FISC Pearl Harbor	Navy Region Hawaii	Supports FISCSD when 3rd Fleet unit are operating in the AOR.
FISC Puget Sound	Navy Region Northwest	Supports FISCSD when 3rd Fleet unit are operating in the AOR.
FISC San Diego	Navy Region Southwest	3rd Fleet
FISC Sigonella	Europe, Africa, Southwest Asia	5th and 6th Fleets
FISC Yokosuka	Japan, Korea, Singapore, Guam	7th Fleet

Table 1. Navy Regions and Operational Areas[16]
(After NAVSUP, 2009a)

The COMFISCS' functional area that aligns with forward logistics is the responsibility of providing husbanding support to operational units deployed in the regional areas covered by COMFISCS. COMFISCS is also charged with providing husbanding support to deployed operational units engaged in the Global War on Terror (Hall & Adams, 2007). According to CAPT Asa Page, former Fleet and Industrial Supply Center (FISC) Norfolk Contracting Director, "COMFISCS' role in

[16] URL https://www.navsup.navy.mil/navsup/ourteam/comfiscs provides detailed area of responsibility for each numbered fleet.

providing husbanding support has expanded in recent years in part because of increased opportunities to standardize husbanding processes while leveraging commercial capabilities" (Hall & Adams, 2007). COMFISCS' mission to better meet the fleet's requirements is the compelling force behind consolidated husbanding contracting, enabling it to be flexible and ready to tackle new task requirements such as Distant Support.

To help facilitate improvements in standardizing the global husbanding-procurement process, FISC Norfolk formed a Process Action Team (PAT) whose members came from key stakeholders such as NAVSUP contracting, COMFISCS, FISCs, CFFC, TYCOMS, Fleet Commanders, and US Coast Guard Representatives (Hall & Adams, 2007). The PAT met with leading members of the husbanding industry and discussed challenges and issues, such as requirement and pricing resolution, improved security measures, cost reporting, and payment-process enhancement (Hall & Adams, 2007).

During the discussions, the team examined the industry's "best practices" to determine what can be applied to achieve the goal. Additionally, the team also held an in-depth comparison of the various FISCs that handle husbanding contracts to see how each supply center supports the ships entering its respective geographic areas of responsibility (Hall & Adams, 2007).

The team discovered an inconsistency in the Navy husbanding support-services contracting across geographic regions. The Navy husbanding contracts vary per region, and range from individual contracts placed on a case-by-case basis just before a port visit, to regional support. These contracts differ from commercial-husbanding contracts, in which port visits are scheduled in advance. Commercial contracts also benefit from agency-like relationships between shipping companies and the husbanding service providers. Consequently, one of the Navy's significant challenges includes frequent changes in port-visit schedules. The ambiguity in scheduling pushes contractors to integrate risk into their prices (Hall & Adams, 2007). The husbanding industry also pointed out that the Navy is not completely benefiting from some of the efficiencies and leveraged buying power of the commercial shipping sector. Based on the feedback received from the industry, CAPT Page stated that the Navy must be able to identify requirements in advance—enabling the husbanding service provider to be more responsive and efficient in meeting the required services and support (Hall & Adams, 2007). These discussions between the PAT and the husbanding industry led to COMFISCS' global husbanding initiatives.

D. COMFISCS' Global Husbanding Initiatives at various FISCs

Of the seven Fleet and Industrial Supply Centers, four are currently engaged in awarding husbanding contracts. These supply centers are FISC San Diego, FISC Norfolk, FISC Sigonella, and FISC Yokosuka. Results of the discussions between PAT and the husbanding industry led to the global husbanding initiatives discussed below:

1. FISC Norfolk

FISC Norfolk developed a contract solicitation for consolidated husbanding services, which will ultimately provide support throughout OCONUS regions. In the past, US Navy and US Coast Guard fleet units requiring husbanding services in the Caribbean and South and Central America had to use one of the 19 different previously awarded contracts with multiple husbanding-services agencies to obtain services for their upcoming port visits. A new, one-time contract is typically written to support units requiring services to areas not covered by these contracts (Hall & Adams, 2007).

FISC Norfolk's solicitation consolidated the areas covered under these 19 contracts, with the ultimate goal to award the contract to one husbanding service provider that would provide services to OCONUS regions and award another contract for CONUS/US Territories. FISC Norfolk's OCONUS consolidated husbanding contract, known as C3MS, will include ports located in Canada, the

Caribbean, Central America, Mexico, and South America (King, 2009, January 30). The OCONUS contract has yet to be awarded.

2. FISC San Diego

Fleet and Industrial Supply Center San Diego (FISCSD) provides logistics, business and support services to fleet, shore and industrial commands of the Navy, Coast Guard and Military Sealift Command and other joint and allied forces. FISCSD delivers combat capability through logistics by teaming with regional partners and customers to provide supply-chain management, procurement, contracting and transportation services, technical and customer support, defense fuel products and worldwide movement of personal property (NAVSUP, 2009c). A single husbanding service provider offers services within CONUS, and two husbanding service providers offer services to units engaged in port visits to Mexico.

FISCSD has adopted a “hands-on” approach to providing husbanding services support to its 3rd Fleet customers. According to Contracting Officer Browley, Director of FISCSD’s Operational Forces Support Contracting Division, “FISCSD acts as a liaison between the ships and agents. Contract personnel forward LOGREQs, prepare LOGREQ response messages, create delivery orders, and assist ship personnel in resolving payment issues” (Hall & Adams, 2007).

Under the COMFISCS global husbanding initiative, FISC Norfolk and FISC San Diego will enter into an Enterprise partnership and will have new areas of responsibility. Under this partnership, FISC Norfolk will handle the Procurement Contracting Officer (PCO) responsibilities while FISCSD will have the responsibilities of an Administrative Contracting Officer (ACO). Once FISC Norfolk awards the new C3MS contract, FISC San Diego will no longer award husbanding contracts (King, 2009, January 30).

3. FISC Sigonella

Established on March 3, 2005, Fleet and Industrial Supply Center Sigonella (FISCSI) is located on Naval Air Station Sigonella, Sicily. FISC Sigonella is providing logistics support services to customers throughout EUCOM (European Command) and CENTCOMAORs (Central Commands' Area of Responsibilities), as well as delivering direct logistical support to Rota, Spain; Gaeta, La Maddalena, Naples, and Sigonella, Italy; Souda Bay, Greece; London, Mildenhall, and St Mawgan, UK; Dubai and Jebel Ali, UAE; Djibouti, and Bahrain (NAVSUP, 2009d).

In the past, different husbanding contractors serviced each country within this region. However, these contracts were later consolidated into five regional contracts: Northern Europe, Black Sea, Mediterranean, Southwest Asia, and Western Africa. In turn, two husbanding contractors—Multinational Logistics Services (MLS) and Inchcape Shipping Services (ISS)—handle these contracts (King, 2009, January 30).

Part of the support that these two husbanding contractors provide is support for operations other than war (OOTW), especially in Africa. FISCSI is developing Expeditionary Logistics Response Teams (ELRT) consisting of pre-selected trained officers, enlisted, and civilian personnel for rapid deployment into under-developed areas to support these OOTW missions.

4. FISC Yokosuka

Fleet and Industrial Supply Center Yokosuka, Japan, is the Western Pacific region's largest Navy logistics command. The FISC Yokosuka (FISCY) enterprise consists of more than 20 detachments, fuel terminals and sites from Diego Garcia in the Indian Ocean to Guam, and from Misawa, Japan, to Sydney, Australia. These dispersed detachments and sites work together as one organizational team, providing logistics support to the Navy, Marine Corps, federal agencies, and other Department of Defense (DoD) activities within the 7th Fleet AOR (NAVSUP, 2009e).

Prior to 2006, the scope of FISCY husbanding contracting was limited to ports in Japan and Korea only. FISCY's role in husbanding contracting increased dramatically upon the disestablishment of Naval Regional Contracting Center Singapore. According to CDR Stephen Armstrong, FISCY Contracting Director, "FISC Yokosuka now provides husbanding contracting support to numerous ports from the International Dateline to Mauritius in the Indian Ocean, and everything in between including Australia and the thousands of islands of Indonesia, the Philippines, Micronesia, and Melanesia" (Hall & Adams, 2007).

Navy and Coast Guard units that require support receive husbanding services from one of the 22 husbanding contracts currently in place. FISCY issues a one-time contract award to support port visits not covered by these contracts. As a result, this type of arrangement increases port-visit costs. To better manage the husbanding services contracts, FISCY initialized the regionalization of husbanding contracts in the 7th Fleet AOR. FISCY's proposed regional contracts will separate the 7th Fleet AOR into four regions. Region 1 will consist of ports in South Asia. Region 2 will include ports in Southeast Asia. Region 3 will cover Australia and the Pacific Islands, while Region 4 will cover ports in East Asia. Additionally, the initiative will establish a husbanding services program manager who will oversee the husbanding-services from a strategic level (Hall & Adams, 2007).

E. Future of Husbanding Service Provider (HSP) Contracts

The NAVSUP brief to RADM Lyden concluded with the discussion on the future of HSP contracts in the areas of ship support, contracts and regions, and cost control (King, 2009, January 30).

Changes discussed for ship support include making the Supply Officer the new Ordering Officer for supplies and services vice the Contracting Officer (KO). Another ship support reform calls for more involvement from the Contracting Officer and the Fleet of real-time visibility of port-visit costs. Additionally, it requires the HSP to collect the port-visit costs data and submit those data via the Web.

Changes in the procurement of husbanding-service contracts call for significantly fewer contracts in the future. Various FISCs are working to consolidate husbanding contracts to regional contracts from port contracts and to coordinate the standardization of contracts throughout the regions. FISC Norfolk is consolidating 19 husbanding contracts into two contracts, the C3MS contract and the CONUS/US territories contract. FISC Yokosuka is currently developing its acquisition strategy to consolidate 26 contracts into four regional contracts based on the C3MS contract structure. FISC Sigonella, on the other hand, has already consolidated its 39 husbanding contracts into five regional contracts. These contracts are currently under the model of a priced-CLIN structure.[17]

Cost-control initiatives include reduced contract administration, better contract oversight, and improved service with reporting port-visit cost via the Web.

F. Husbanding Service Provider Responsibilities

The HSP provides husbanding services to ships visiting the ports. The HSPs' responsibilities start before the arrival of the ship and continue after the ship's departure. They assist in preparing supplies and services prior to the ship's arrival. The HSP also supports any advance party or representatives designated by the ship's SUPPO to coordinate the scheduled port visit.

1. Advance Party

The HSP will assist the advance party sent by the ship to organize the planned port visit. The HSP advance party fee is the same as the "subsequent day" rate[18] for each day of support provided to the advance team (NAVSUP, 2009f).

2. Ship's Logistic Requirements (LOGREQ)

Upon notification of a port visit, the SUPPO submits all services and supplies requested in the ship's LOGREQ and any subsequent LOGREQ changes to the

[17] FISCSI HSP Contract's CLIN structure defined in the Husbanding Contract Statement of Work.

[18] Subsequent-day rate is the husbanding services fee for the succeeding days of supporting the ship during the port visit. The husbanding services fee is broken down into two CLINs, the first-day rate and subsequent-days rate.

HSP via e-mail. The HSP is responsible for coordinating and arranging the husbanding services ordered in the ship's LOGREQ (NAVSUP, 2009f).

3. Initial Boarding

The HSP is responsible to board the ship upon arrival and provide the SUPPO with all the necessary documents[19] pertaining to the required husbanding services. The HSP also coordinates all available local recreational activities and furnishes any other relevant information while in port, such as emergency telephone numbers for police, hospitals, and the fire department (NAVSUP, 2009f).

G. Services Arranged by the Husbanding Service Provider

1. Husbanding Services Fee

The husbanding service fee includes the HSP's regular and overtime labor hours while supporting the ship and may include additional services fees when assisting the ship's advance party. The husbanding fee depends on the ship's class, and is categorized into the management services fee for the first day and succeeding days of the ship's visit (NAVSUP, 2009f).

2. Trash Removal

The HSP is responsible for arranging the trash-removal services requested by the ship during the port visit. The scope of services depends on whether the ship is at anchor or berthed pier side. When the ship is berthed pier side, the trash-removal services cover the positioning of trash containers or garbage trucks within twenty-five (25) meters of the ship, or as required by local port regulation. This may also include positioning of barges alongside the ship. The HSP also ensures the containers or barges are emptied out when full on a continual basis, especially during meal hours and throughout the ship's port visit.

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[19] Document copies of applicable Port Tariffs and current prices for Husbanding Services.

When the ship is at anchor, the HSP is responsible for providing trash-removal services in accordance with the schedule agreed upon by the HSP and the ship's SUPPO. The trash-removal services cover the safe positioning of the barges alongside the ship, the continuous collection by the barge, and ensuring that barges are completely emptied after each collection.

In addition, the HSP is responsible for the safe and expeditious removal of the barges during inclement weather or emergency, as well as ensuring that trash-removal service is in accordance with the host country's environmental laws and regulations (NAVSUP, 2009f).

3. Collection, Holding, and Transfer (CHT)/Sewage Removal

The HSP coordinates and provides all the necessary labor, equipment, and facilities required for Collection, Holding and Transfer (CHT)[20]/sewage removal from the ship during port visit. The collection service commences on the ship's arrival and the price of the service[21] depends on whether the ship is at anchor or berthed pier side. The HSP also ensures that the holding trucks and barges are emptied out, when full, on a continual basis—especially during peak hours and throughout the ship's port visit. Additionally, the HSP ensures that the CHT services are in accordance with the schedule agreed upon by the HSP and the ship's SUPPO (NAVSUP, 2009f).

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[20] CHT is a system onboard the ship designed to accept soil drains from sinks, urinals and waste drains from showers, laundries, and food services galleys.

[21] Price based on CHT pier side by truck, CHT pier side by barge, and CHT at anchorage by barge, each designated by different sub-CLINS in the contract.

4. Yokohama or Comparable-type Fenders

The HSP provides and secures acceptable Yokohama, or comparable-type fenders,[22] to the pier or barge for all classes of ships, as stipulated in the husbanding services contract (NAVSUP, 2009f).

5. Fresh, Potable Water

The HSP supplies all the necessary labor and equipment required for the delivery of fresh, potable water[23] to the ship during the port visit. When available, ships at pier side prefer pipeline-delivery of fresh, potable water. If pipeline-delivery is not available, the HSP coordinates the water delivery by truck, tankers, or barge. The SUPPO pays the HSP for the amount of water ordered by the ship (NAVSUP, 2009f).

6. Pilots, Tug Services, and Line Handlers

The HSP makes arrangements for pilots, tugs, and line-handling services[24] ordered by the ship. Additionally, the HSP verifies with the local port authorities that the services are available at the times and location requested (NAVSUP, 2009f).

7. Water Ferry / Taxi Services

The HSP manages the water-taxi services[25] when ships are anchored. The price for water-taxi services covers the cost for qualified operators, crew members, all insurance, fuel, holiday surcharges, overtime, and other operating expenses, and

[22] Fender refers to the protective and safety device placed between the ship and the pier/barge to cushion against impact.

[23] Potable water is defined as fresh drinking water of a quality not less than that prescribed in the *Current Drinking Water Standards*, as published by the United States Environmental Protection Agency, Office of Water, and shall comply with specifications of the *National Primary and Secondary Drinking Water Regulations.*

[24] Pilot, tugs, and line-handling services are provided by the local port authority or other authorized source; hence, prices are subject to the current tariff rates.

[25] Water taxi service is defined as the ferrying of passengers from ships at anchor to the ferry landing and back.

it applies to each 24-hour period of service delivered. The water-taxi service starts and ends as scheduled by the HSP and the SUPPO. Water taxis are subject to the ship's force protection inspection prior to initial use (NAVSUP, 2009f).

8. Transportation Service

a. Bus Service

The HSP directs the bus services based on the time scheduled by the SUPPO. The service is based on a daily rate and includes cost for one driver, crew, all insurance, fuel, holiday surcharges, overtime, and all other operating expenses. Additionally, the HSP ensures that all bus drivers are familiar with the area, possess a valid driver's license, and can speak English[26] (NAVSUP, 2009f).

b. Vehicle Rental Service

The HSP arranges for vehicle rental services ordered by the ship. The service is based on a daily rate and includes cost for one driver, all insurance, fuel, holiday surcharges, overtime, and all other operating expenses. Additionally, the HSP ensures that all drivers are familiar with the area, possess a valid driver's license, and can speak English (NAVSUP, 2009f).

9. Force Protection Services and Supplies

Force protection[27] services can only be ordered by the ship's Commanding Officer, the ship's SUPPO, or the FISC Contracting Officer. The HSP immediately informs the ship if other than the three mentioned above orders force protection services for the ship (NAVSUP, 2009f).

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[26] In cases in which the driver cannot speak English, the HSP provides a translator.

[27] Force protection is considered a combination of practices and procedures, including the use of specific material, equipment, and personnel, having the objective of improving security to personnel and ships while in port. Force protection services or supplies may be provided by the host nation at no cost or may be billed at the public tariff rate.

10. Camels

The HSP provides camels[28] ordered by the ship. The unit price is based on a daily rate, and includes all costs for mobilization and demobilization, installation and removal. Separate charges for the transportation of camels may apply, if camels are not available in the local area (NAVSUP, 2009f).

11. Landing Barges

The HSP is responsible for providing acceptable landing barges[29] ordered by the ship. The unit price is based on a daily rate, and includes all costs for mobilization and demobilization, installation and removal. Separate charges for the transportation of barges may apply, if barges are not available in the local area (NAVSUP, 2009f).

12. Fleet Landing

The HSP arranges the supplies and services such as tents, chairs, and utilities ordered by the ship for the fleet landing area (NAVSUP, 2009f).

13. Provisions

The HSP coordinates the ship's orders for fuel, Fresh Fruits and Vegetables (FFV), bread, and eggs with other authorized contractors (NAVSUP, 2009f).

14. Oily Waste Removal

The HSP provides all labor and equipment necessary for oily waste[30] collection and removal. The HSP ensures that the oily waste-removal services

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[28] Camels are flat-surface platforms placed alongside the pier and capable of spacing the ship away from the pier or from other ships.

[29] The landing barges are flat-surface barges for positioning at the stern or side of the ship to serve as a loading/unloading platform for water-taxi personnel or cargo; they do not interfere with the operation of the ships' elevators or other equipment.

[30] Oily waste is defined as any liquid petroleum product mixed with wastewater and/or oil in any amount, which if discharged overboard, would cause or show sheen on the water. Any combination of oily waste and gray water is disposed of as oily waste.

comply with the host country's environmental laws and regulations. The ship will pay for the amount, certified and agreed upon by the ship and the contractor, of collected oily waste, measured in cubic meters[31] (NAVSUP, 2009f).

[31] 1 CM=264.2 gallons

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IV. Project Web-based Application

Interviews with subject-matter experts and visits to major stakeholders led the project team to recognize the complexity of various processes in globalizing HSP contracts. The regionalization of HSP contracts demonstrated added effectiveness in providing the required services and increased the efficiency of FISCs' contract team (King, 2009, January 30). Consequently, the follow-on to regionalization may include streamlining the SOW and procedures of all HSP contracts to reflect a single managerial expectation across the regions. In the course of determining the best approach, CLIN standardization may prove to be very instrumental in the pursuit of globalization.

A. Standardization

CLIN standardization benefits stakeholders.[32] As an example, ships' supply officers benefit by easily deciphering cost items on invoices for that port versus other ports. In addition, data repository administrators do not need to reclassify CLIN numbers in the system from one contract to another. Standardization should significantly reduce auditing difficulties for contracting officers and specialists. Husbanding service providers save time in transferring the invoice information into the repository system. More importantly, decision-makers[33] would base their solutions on more accurate operational planning information.

This chapter later describes the relationship of CLINs, sub-CLINs, and unique sub-CLIN types. In a nutshell, unique requirements of various ports may be represented as additional sub-CLIN types rather than as non-contract items (NC). The key to a prescriptive establishment of contract line-item numbers is in examining

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[32] Stakeholders commonly refer to the decision-makers, ship's supply officers, contracting officers, system administrators, and HSPs.

[33] Decision-makers commonly refer to high-level echelons described in the Introduction chapter.

historical requirements, surveying customers for anticipated services, and identifying foreign government fees and levies.

The project website uses the CLIN structure provided in FISCSI HSP contract's SOW. However, sub-CLINs and sub-CLIN types added into the module do not represent the schedule reflected under the contract. Consequently, this paper refers to the Standard Port-visit Cost Forecasting Model (SPCFM) as “the website” or “the module.” The difference between the website and the module reference depends on the purpose of the project during developmental and testing stages versus actual application.

B Standard Port-visit Cost Forecasting Model (SPCFM)

This project mainly focuses on providing a close estimate of future port-visit costs to ships’ supply officers, contracting officers, and major claimant decision-makers. The project team members developed algorithms to minimize the percentage of error between the forecasted cost and the actual cost of the port visit. The SPCFM, during the developmental and testing stages, provides researchers the capability to input and display the port-visit invoices, produce cost reports, and forecast future costs. Since LogSSR and LOGCOP already exist to display repository data and generate reports, these systems render the website’s display and report functions unnecessary during application. Upon operational application and eventual incorporation to an existing system, SPCFM would specifically refer to the estimating functionality of the module instead of to the website.

In the course of developing the website, two requirements presented a unique challenge to the project team: data sources mandating non-disclosure of actual unit prices and selecting the ideal system environment in which to develop the module. The next section of this chapter describes the implementation of information security measures (which addresses the first issue), as well as the Naval Postgraduate School (NPS) IT infrastructure supporting the appropriate applications (which addresses the second requirement).

C. Origin of Data

Invoice data, collected from CRAFT, populate the website's database. The researchers selected two high-frequency, one medium, and two low-frequency ports. The diversity of the selected ports allows a range in the analysis of data. Pseudonyms replaced actual port names to disallow any inadvertent disclosure of the HSP's proprietary data. To minimize the chance of unit price disclosure, an automated database script converted the figures into notional data sets. Results from the data analysis reflect the percentage of differences instead of the actual dollar value of cost. The cost estimate and percentage error renders the display of the actual unit price unnecessary.

D. System Environment

The operating system environment used in developing and maintaining the project website is Windows Server 2003. The NPS network connects the server to the intranet with a static Internet Protocol (IP) address.

In order to run the website, the project requires a Web server, a database, and a server-side programming platform. Due to the short development, testing, and evaluation periods of our research effort, the team members selected the following applications based on the flexibility, scalability, and readily-available documentation of the products:

1. **Apache**. An open-source Hypertext Transfer Protocol (HTTP) server.[34]
2. **MySQL**. An open-source database.[35]
3. **PHP**. A common scripting language used for Web development.[36]

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[34] The Apache Software Foundation. (2009). HTTP Server (Version 2.0) [Software]. Available from http://httpd.apache.org/

[35] Sun Microsystems, Inc. (2009). MySQL Community Server (Version 5.1) [Software]. Available from http://dev.mysql.com/downloads/

[36] The PHP Group. (2009). PHP (Version 5.3) [Software]. Available from http://www.php.net/

E. Implementation of Functions

The current configuration of the website consists of four major functions, namely, administrative tools, portcall invoices, reports, and forecasting. Each function allows the user to collect, input, and analyze data, report the aggregation, forecast the cost of a port visit, and display the intended results. The following paragraphs describe each function and the incorporated features.

1. Administrative Tools

The Tools function allows the user to input each ship's port-visit invoice. In addition, the function also grants the administrator the ability to assign user access. With regard to elaborating the invoice-entry feature, the website allows the user to enter country and port information, the ship name and classification, and specific text fields from the invoice. The Tools also provide the user a method to input the contract line-item numbers (CLINs), sub-CLINs, and the nomenclature of the sub-CLIN types. In demonstrating the standardization of HSP contracts, the website only supports one contract line-item number (CLIN) structure.

As stated in the beginning of this chapter, a single CLIN structure for HSP contracts significantly reduces errors of misclassifying line-item numbers and also reduces the energy exerted by the husbanding agent in selecting the corresponding data fields. A single CLIN structure also increases the reliability of the reports and forecasts used by stakeholders.

Admittedly, various ports have unique port-visit requirements. However, most of these requirements do overlap with other ports in certain aspects. The CLIN organizes the general description of these requirements, and the sub-CLINs capture the requirement classification overlap. Drilling down on specifics, the sub-CLIN type describes the detailed nomenclature of the requirement uniqueness. Figure 5 shows the CLIN structure used in the website and a notional example of information entered.

Contract Line Item Number (CLIN) Structure

CLIN: XX01 – Husbanding Services (First Day)
- Sub-CLIN: AA – Vessel
  - Sub-CLIN Type: Class 1, Unit of Issue (U/I): DY, Unit Price (U/P): $1.00
  - Sub-CLIN Type: Class 2, U/I: DY, U/P: $1.50
  - …

…

CLIN: XX03 – Trash Removal
- Sub-CLIN: AA - At Pierside by Truck
  - …
- Sub-CLIN: AB - At Pierside by Barge
  - …
- Sub-CLIN: AC - At Anchorage by Barge
  - Sub-CLIN Type: Removal by Metric Weight, U/I: MT, U/P: $1.00
  - Sub-CLIN Type: Removal by Volume Weight, U/I: CM, U/P: $1.00
  - Sub-CLIN Type: Removal by Charge Per Trip, U/I: TP, U/P: $1.00
- Sub-CLIN: AD - Other
  - …

… … …

CLIN: XX12 – Force Protection Services and Supplies
- …
- Sub-CLIN: AG - Picket Boat
  - Sub-CLIN Type: Police, U/I: LO, U/P: $1.00
  - Sub-CLIN Type: With pilot and translator, U/I: DY, U/P: $1.00
- Sub-CLIN: AJ - Security Guards
  - Sub-CLIN Type: Services, U/I: HR, U/P: $1.00
- Sub-CLIN: NC - FP Non-Contract
  - Sub-CLIN Type: Security Tower, U/I: LO, U/P: $1.00
  - Sub-CLIN Type: Hire of Under Carriage Security Scanner, U/I: DY, U/P: $1.00

…

Figure 5. Example of the CLIN Structure Used in the Module

The website allows administrators to add or edit CLINs, sub-CLINs, and sub-CLIN types in the representation of an awarded HSP contract's pricing schedule. One method was purposely omitted in the Tools function. The website contains no delete method for the CLIN structure. As different HSP contracts expire, the data set for the expired contract may still be relevant to subsequent contracts. The data set also provides stakeholders the historical pricing data required in awarding future HSP contracts. To maintain the integrity of the data set, the system must keep the link pointers active to the corresponding CLINs. Hence, the researchers rendered the delete method for the CLIN structure fields unusable.

As mentioned earlier, the Tools function also features assignment of user accounts. An administrator may assign new users, edit current account configuration, and delete existing accounts. The user configuration includes the assignment of each user's security level. The security level determines the functions each user may access.

2. Data Security

Due to the sensitivity of the research data, the website is access-protected. Using user identification and the corresponding password, the researchers restricted access to the website to project team members and advisors. An access-level authority further strengthens the security of the website.

The access-level authority allows a user to access functions appropriate to the level assigned by the website administrator. With the current version of the website, administrators may assign one of four access levels. Figure 6 states and defines the access levels used in the website.

Standard Port Cost Forecasting Module – Access Level

Administrator - With an administrator level access, the module allows the user to access all activated functions.

Husbanding Agent - Users, with husbanding agent access level, may add an invoice, add and edit vessel information, and input or modify country and port information. Although not implemented in this module, this access level may also be restricted from accessing the reports and estimate functions, and may only display invoices inputted by the agent's HSP company.

Stakeholder - should be authorized for various stakeholders, with the exception of the HSP, to access the port invoices, reports, and forecasting functions. The stakeholder access restricts from accessing the Administrative Tools function.

Guest - a guest access may be configured to access only invoices, reports, or just the ability to display forecast information. This level of access was not used due to the time constraint in developing the module.

Figure 6. Description of the Four Access Levels Implemented in the Module

The team members created data-security and level-authority functions in the source code to execute the access-protection functionality. In addition, the server firewall and intranet network-security applications extend the external security for the website. All the security features provide a measured assurance that the port-visit invoices were adequately protected during the development of the module and evaluation of the costs data. To display each port-visit invoice, the website allows the user to select the particular ship or port using the portcall function.

3. Display Invoices

The portcall function provides two methods of displaying a particular port-visit invoice. The first method lets the users select the name of the country and port. Upon selection, the date and the vessel name appear in the drop-down menu and identify each port visit. The second method locates the vessel name. After selecting the ship, the drop-down menu identifies the port and the date the ship arrived.

Regardless of the method used, the function displays the same port-visit invoice. Figure 7 shows the services, quantity, and dollar value of each line-item used or purchased. As a reminder, the data shown in Figure 7 reflect fictional information. The total-sum figure at the end of the page aggregates all contract line-items and non-contract line-items acquired during the port visit. The display of port-visit invoices allows the project team members to verify that line-items are accurate. The project team exerted no additional effort to enhance the visual appeal of the display and maintained functionality in its rudimentary state.

The Portcall function provides similar functionality as LogSSR and CRAFT, the invoice repository applications described in previous chapters. For the stated functionality, LogSSR provides users more detailed information selection and aesthetic appearance with finer data arrangement.

Another functionality incorporated in the website allows the user to aggregate the data and present the result in a more useful form for analysis and evaluation.

The next section describes this functionality, which compiles various reporting methods requested by the stakeholders.

Port Apple, CountryAlpha

Invoice/Document Number:	401	
Vessel Name:	ANGUS (CG 1)	Class 2
Arrival Date:	February 21, 2007	
Departure Date:	February 26, 2007	
Number of Days:	5 days	
Inport/Anchorage:	INPORT	
Contract Number:	N49999-01-D-0111	
Contractor Name:	Husbanding Contractor	

LINE NUMBER	DESCRIPTION / TYPE	QTY	UNIT	U/P (USD $)	TOTAL (USD $)
XX01 - Husbanding Services (First Day)					
AA - Vessel	Class 2	1	DY	86.230	86.23
Comment:					
XX18 - ManLift					
NC - Non-Contract Item	ManLifts	2	DY	71.859	143.72
Comment:					
XX24 - Brows					
AA - Port Provided	30-50 FT	6	DY	68.984	413.91
Comment:					
XX26 - Mobile Crane Services					
AA - Crane with Operator	Port Provided	8	HR	66.829	534.63
Comment:					
XX27 - Forklift Services					
AA - Fork Lift	Port provided	8	HR	40.241	321.93
Comment:					
XX28 - Telephone Ser[illegible]					
[illegible] - Landline	[illegible]	5	[illegible]	[illegible]558	[illegible]
[illegible]ment:					
[illegible]					
[illegible]es	Serv[illegible]	[illegible]1	LO	[illegible]	237[illegible]
N[illegible]unication Services & Equip[illegible]ent	Rental of Port Provided Land Lin[illegible]	25	DY	7.904	197.61
Comment:					
XX31 - Port Dues					
AA - Dockage and Wharfage	Fee	6	LO	577.456	3,464.74
Comment:					
XX33 - Miscellaneous, Not Priced in the Contract					
NC - See Comment for Detail	Material by EA	1	EA	186.832	186.83
Comment:					
				TOTAL: USD($)	**37,285.69**

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Figure 7. Screenshot of a Portcall Visit Invoice

4. Generating Reports

The Reports function provides stakeholders the capability to analyze historical invoices and display a valuable representation of the data. As an example, this website features a report segregating each line-item into the appropriate fund code. A user selects the range that allows the aggregation of all invoices between two specified dates. This function also lets the user select the sort priority used in displaying the report. The first priority permits sorting by port, which lists the name of countries and is subdivided by the port names. Each port enumerates the ship types that made port visits and lists the fund codes and aggregated amount of each ship type. The second sorting priority allows the user to sort by ship type, which shows the aggregated amount spent in each port. Figure 8 shows the fund-code report selection screen, while Figure 9 displays the truncated result of the selection.

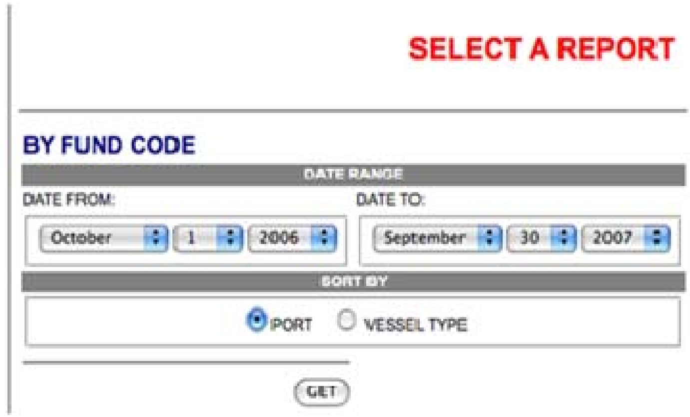

Figure 8. Screenshot of Report Selection

REPORT BY FUND CODE	
From: October 1, 2006 To September 30, 2007 (Sort by Country, Vessel Type)	
CountryAlpha - Port Apple	
CG	
D =	1,189.98
K =	9,652.06
L =	16,098.36
S =	858.71
W =	9,299.75
Y =	186.83
	CG - Total (USD $): 37,285.69
CV	
[illegible]	[illegible]
CountryAlpha - Port Elderberry	
DDG	
D =	1,034.76
K =	38,705.65
L =	18,652.35
S =	804.82
U =	2,100.35
W =	5,767.38
X =	113,986.54
Y =	270.19
	DDG - Total (USD $): 181,322.04
FFG	
D =	2,069.53
K =	65,857.02
L =	46,246.07
S =	916.92
U =	572.43
W =	7,049.33
X =	80,518.96
Y =	540.38
	FFG - Total (USD $): 203,770.63
	CountryAlpha - Port Elderberry :: Total (USD $): 385,092.68
	Grand Total (USD $): 6,175,443.06

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Figure 9. Screenshot of Fund Code Report

While the Reports function provides an exceptional capability for contracting officers and major claimant stakeholders, the development of LOGCOP provides an extensive data set in generating reports. By using LOGCOP, a user may intertwine other reporting categories with the invoice data, which greatly increases the value of the report. In evaluating the module's functionality, the bread-and-butter of the website pertains to the forecast capability that provides an estimate of future port-visit cost.

5. Forecasting

The Estimate function assists the user in determining the future cost of a port visit. As Figure 10 reflects, the user selects the name of the port, the type of vessel making the portcall, whether the vessel will be in port or anchored, and the number of days during the port visit. After selecting the parameters, the module displays the sub-CLIN types used by other vessels of the same type and the cost estimate of each sub-CLIN type. Figure 11 shows the estimate. Some sub-CLIN types should not be included in the estimate, such as CHT removal at anchorage when the user anticipates pulling into port. The user may opt to exclude sub-CLIN types for services not applicable for the estimate.

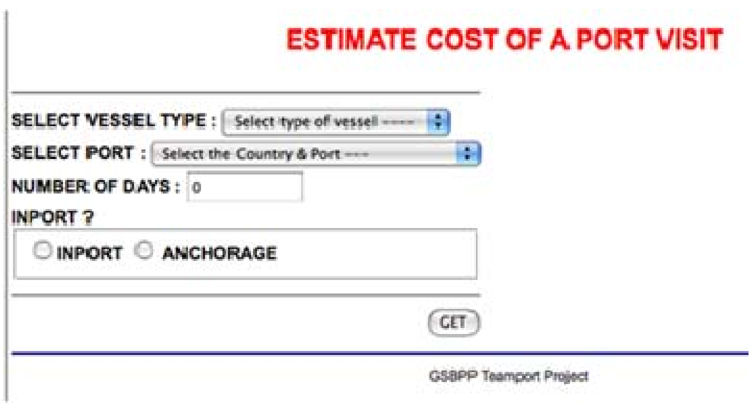

Figure 10. Screenshot of Forecasting Parameters

ESTIMATE COST OF A PORT VISIT

DDG in Port Durian, CountryAlpha for 3 Days (ANCHORED)

LINE NUMBER	DESCRIPTION / TYPE	UNIT	LOWER (USD $)	ESTIMATED COST (USD $)	EXP SMOOTHING (USD $)	UPPER (USD $)	Option
XX01 - Husbanding Services (First Day)							
AA - Vessel	Class 2	DY	215.58	215.58	215.58	215.58	OUT
			215.58	215.58	215.58	215.58	
XX02 - Husbanding Services (Subsequent Days)							
AA - Vessel	Class 2	DY	114.97	114.97	114.97	114.97	OUT
			229.95	229.95	229.95	229.95	
XX03 - Trash Removal							
AB - At Pierside by Barge	Removal by Charge Per Trip	TP	215.58	215.58	215.58	215.58	OUT
			646.73	646.73	646.73	646.73	
AC - At Anchorage by Barge	Removal by Charge Per Trip	TP	215.58	215.58	215.58	215.58	OUT
			646.73	646.73	646.73	646.73	
XX04 - CHT and Sewage Removal							
AB - CHT At Pierside By Barge	Service	GL	1,231.20	1,231.20	1,231.20	1,231.20	OUT
			3,693.60	3,693.60	3,693.60	3,693.60	
AC - CHT At Anchorage By Barge	Service	GL	1,117.20	1,117.20	1,117.20	1,117.20	OUT
			3,351.60	3,351.60	3,351.60	3,351.60	
NC - Other	Rent of Barge	DY	0.00	783.26	100.60	9,457.10	OUT
			0.00	2,349.78	301.81	28,371.30	
XX05 - Fenders							
AA - Fenders Floating Pontoons	One pair per day Port Provided (PT)	DY	0.00	1,164.11	776.07	6,094.51	OUT
			0.00	3,492.33	2,328.22	18,283.52	
XX06 - Fresh, Potable Water							
AB - Anchorage by Barge	[illegible]	GL	360.35	360.35	360.35	360.35	OUT
			1,081.06	1,081.06	[illegible]	1,081.06	
NC - Nor[illegible] Item	[illegible] Water	[illegible]	[illegible]	126.03	[illegible]	126.03	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]							
[illegible] phone	[illegible] Account	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]	
AC - Airtime Charges	Service	LO	[illegible]	287.43	287.43	287.43	OUT
			287.43	287.43	287.43	287.43	
NC - Communication Services & Equipment	Airtime	LO	538.94	538.94	538.94	538.94	OUT
			538.94	538.94	538.94	538.94	
NC - Communication Services & Equipment	Cell phones	DY	80.49	80.49	80.49	80.49	OUT
			241.46	241.46	241.46	241.46	
XX33 - Miscellaneous, Not Priced in the Contract							
NC - See Comment for Detail	Material by load	LO	0.00	408.80	459.89	1,057.97	OUT
			0.00	408.80	459.89	1,057.97	
XX88 - Shore Power							
NC - Non-Contract Items	Hire of Generator for Fleet Landing Power	DY	310.43	310.43	310.43	310.43	OUT
			931.29	931.29	931.29	931.29	
XX89 - Material Handling							
AB - Receiving, Storage, Reporting, & Delivery	Service	PK	24.43	24.43	24.43	24.43	OUT
			24.43	24.43	24.43	24.43	
	TOTAL per day cost: USD($)		19,709.50	23,614.12	45,177.66	65,928.25	
	TOTAL cost for a 3-day port visit: USD($)		43,660.22	53,910.47	73,324.94	128,579.52	

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Figure 11. Screenshot of a Port-visit Cost Estimate

The module generates two types of estimates, namely, t-statistics (Keller, 2009, p. 382) and exponential smoothing (Balakrishan, Render, & Stair, 2007, p. 527). The t-statistics consist of the estimate's lower boundary, the adjusted average of the sub-CLIN type costs, and the higher boundary of the estimate. The lower and higher boundaries reflect the statistical probability, at 95% confidence level, that the actual cost would be between these two numbers. The second forecasting method, called exponential smoothing, represents a type of time-series or moving-average approach that requires a constant, also called alpha (α), by which to weigh the recent data or past period. To determine the optimal constant, the module uses a heuristic algorithm that runs through several iterations in comparing the mean absolute percentage of error (MAPE) of alphas, between 0.01 and 1.00, until the algorithm produces the ideal alpha.

The forecast accuracy depends on the error percentage between the actual and the estimated cost. Accuracy increases as the error percentage decreases. Subsequently, five scenarios also affect the accuracy of the estimate. The list below states the condition of each scenario:

F. Same Vessel Type, Same Port, Same Country

This scenario states that invoices exist in the database for a similar vessel type that pulled into the same port. For example, if DDG19 and DDG20 visited Port Maroon, at Country Zulu in 2007, then DDG21 could forecast an upcoming visit to Port Orange in 2008 by using the invoice data collected from prior DDG visits.

G. Same Vessel Class, Same Port, Same Country

This scenario states that no invoices exist for a similar vessel type. However, invoices for the same vessel class are available in the database for the same port. For example, the Navy classifies DDGs and CGs as Class 2 vessels. DDG19, DDG20, and DDG21 visited Port Maroon, but no CG ever pulled into this port. Using this scenario, CG32 could forecast the ship's upcoming visit by using the same ship class invoices from the three DDGs.

H. Not the Same Vessel Type/Class, Same Port, Same Country

In this scenario, port-visit invoices exist for other vessel types and class only. Using the prior example, three DDGs and one CG visited Port Maroon. The next ship scheduled to visit is an LPD, Class 3 ship. Under this scenario, the LPD predicts the port-visit costs for Port Maroon by using invoices for Class 2 ships.

I. Not the Same Vessel Type/Class, Not the Same Port, Same Country

For this scenario, only invoices from other ports of the same country are available for computation. Continuing with the example, assume that in addition to Port Maroon, Country Zulu has another port called Port Ruby. No ships have ever pulled into Port Ruby before, but DDG22 is set to visit the port. In this scenario, DDG22 uses Port Maroon invoices to produce an estimate of the port-visit costs for Port Ruby.

J. Not the Same Country; Only Invoices from Other Countries are Available

Assume that Country Yankee borders Country Zulu. No ships have ever pulled into any Country Yankee port before. Any ship pulling into port, using algorithms for this scenario, could forecast the port-visit costs using invoices in Country Zulu.

The project team used forecasting algorithms only suitable for the first scenario. As the level of scenario steps up, the level of algorithm sophistication and error rate (the percentage between the actual costs and predicted costs) will likely increase as well. The next chapter describes, in detail, the forecasting methodology the researchers used and explains the steps applied in implementing the algorithms for the first scenario.

V. Forecasting Methodology

The SPFCM forecasting functionality consists of two estimation methods, namely t-statistic and exponential smoothing. This chapter describes each method and the algorithms used to compute the estimated port-visit costs. In addition to describing the methods and algorithms, this chapter also shows the pseudo-code, as applied in the forecasting functionality.

A. Confidence Interval Estimator

T-statistic, as defined by mathematician William S. Gosset, specifies that both population mean and population standard deviation are unknown. The sample standard deviation (*s*) takes the place of the unknown population standard deviation in the formula. The Confidence Interval Estimator of each sub-CLIN type reflects the formula below to include the sample mean ($\bar{x}$), critical value ($t\alpha/2$), and sample size (*n*).

$$\bar{x} \pm t_{a/2} \frac{s}{\sqrt{n}}$$

Equation 1. Confidence Interval

1. Select Parameters

As shown in Figure 10, the user must specify four parameters to execute the forecasting functionality. The user must indicate the type of ship to use and the port to visit in generating the cost estimate. In addition, the user must also indicate the number of days in port or at anchorage, including the arrival and departure days.

2. Get Historical Data

The module employs the parametric values to retrieve the historical information from the database. First, the module creates an array to store invoice headers information such as the number of days in port, ship type and class, and date of arrival. After storing the invoice headers, the module creates a second array to store invoice items such as sub-CLIN type identification key, unit of quantity, unit price, and adjusted price per day. The module also creates a third array to store elements of the CLINs and sub-CLINs for each sub-CLIN type. To refresh the understanding of CLIN elements, Figure 5 shows the relationship of CLINs to sub-CLIN types. Lastly, the module creates keys in the sub-CLIN type array for sum, average, sample size, variation, standard deviation, and confidence level of each type.

3. Critical Values of Student t-distribution ($t_{\alpha/2}$)

The module generates a two-tail test distribution array at 95% confidence level. The array key represents the degree of freedom while the value equates to the t-value. Figure 12, referring to keys and values, reflects the $t_{.025}$ critical values shown in Kellers' book, Appendix B, Table 4.

```
function build_t_distribution_array()
{
//:::Only for 95 percent confidence level//
//:::t_dist[key]=value.  key=degree of freedom, value=t value//
  $array = array(1=>12.706,2=>4.303,3=>3.182,4=>2.776,5=>2.571,
                 6=>2.447,7=>2.365,8=>2.306,9=>2.262,10=>2.228,11=>2.201,
                 12=>2.179,13=>2.16,14=>2.145,15=>2.131,16=>2.12,
                 17=>2.11,18=>2.101,19=>2.093,20=>2.086,21=>2.08,
                 22=>2.074,23=>2.069,24=>2.064,25=>2.06,26=>2.056,
                 27=>2.052,28=>2.048,29=>2.045,30=>2.042,35=>2.03,
                 40=>2.021,45=>2.014,50=>2.009,55=>2.004,60=>2,
                 65=>1.997,70=>1.994,75=>1.992,80=>1.99,85=>1.988,
                 90=>1.987,95=>1.985,100=>1.984,110=>1.982,120=>1.98,
                 130=>1.978,140=>1.977,150=>1.976,160=>1.975,170=>1.974,
                 180=>1.973,190=>1.973,200=>1.972,210=>1.96);

  return($array);
}//end build_t_distribution_array//
```

Figure 12. $t_{.025}$ Critical Values (95% confidence level)

4. Adjust Invoice Item per Day Quantity

Port visits generally vary from one to seven days. Before averaging the sub-CLIN type or invoice items of all applicable invoices, the module adjusts the total quantity to reflect the daily charge for each item on each invoice. The adjustment allows the module to store the variation of a sub-CLIN type in daily quantities rather than managing the total quantity per visit. The module adjusts the quantity depending on the unit of issue and type. One-time charges and charges incurred per visit instead of per day, such as the first-day management fee, per job order, each quantity, and per load, require no adjustment. The module reduces a day from the denominator for daily charges incurred after the arrival date or prior to the departure date, such as managerial fees for subsequent days. Figure 13 shows the pseudo-code for the adjustment method.

```
for each (invoice)
  {
  for each (invoice item)
    {
    if (sub-CLIN type is charged without the arrival or departure date)
      {
      Invoice item's adjusted quantity per day =
        Invoice item's actual quantity / (number of days in port - 1);
      }
    else if (not a one-time charge or charges other than per day)
      {
      Invoice item's adjusted quantity per day =
        Invoice item's actual quantity / number of days in port;
      }
    else
      {
      Invoice item's adjusted quantity per day =
        Invoice item's actual quantity;
      }//end if-else//
    }//end for each -- invoice item//
}//end for each -- invoice//
```

Figure 13. "Adjust Invoice Item per Day Quantity" Pseudo-code

5. Get the Sub-CLIN Type Average ($\bar{x}$)

Since unit prices may vary from one invoice to another, each invoice item stores the adjusted daily price by multiplying the adjusted per day quantity with the item's unit price. The module extracts the sum of all adjusted daily prices with the same sub-CLIN type. The module also computes the sample size of all invoices with charges incurred for the particular sub-CLIN type. A computational representation for sub-CLIN type (XX44AB-services) would reflect the formula below followed by the pseudo-code (Figure 14).

```
Average for XX44AB-services =
( invoice1_XX44AB-services [ adjusted quantity per day * unit price ] +
  invoice2_XX44AB-services [ adjusted quantity per day * unit price ] + . . . +
  invoiceN_XX44AB-services [ adjusted quantity per day * unit price ] )
/ XX44AB-services[sample size]

      for each (sub-CLIN type)
      {
        for each (invoice)
        {
          for each (invoice item)
          {
            if (invoice item type key is the same as iterated sub-CLIN type)
            {
              value = invoice item's adjusted quantity per day *
                invoice item's unit price;

              if (value is not zero)
              {
                Add the value to the sub-CLIN type sum;
                Store the value as the invoice item's actual per day price;
                Add one to the sub-CLIN type sample size;
              }//end if//
            }//end if//
          }//end for each -- invoice item//
        }//end for each -- invoice//

      sub-CLIN type average = sub-CLIN type sum / sub-CLIN type sample size;

      }//end for each -- sub-CLIN type//
```

Figure 14. Sub-CLIN Type Average Pseudo-code

6. Get the Variance and Standard Deviation (s^2 & s)

Using the invoice item array, the module retrieves each invoice item's actual per day price to compute for the sub-CLIN type variance. Figure 15 shows the computational representation of the variance and standard deviation of the sub-CLIN type XX44AB-services and the pseudo-code for getting the sub-CLIN type variance and standard deviation.

```
Variance for XX44AB-services =
[ ( value1 - type average ) ^ 2  + ( value2 - type average ) ^ 2  + . . . +
  ( valuen - type average ) ^ 2 ]
/ ( type sample size - 1 )

Standard deviation for XX44AB-services =
square root of the variance for XX44AB-services
```

```
for each (sub-CLIN type)
{
  for each (invoice)
  {
    for each (invoice item)
    {
      if (invoice item type key is the same as iterated sub-CLIN type)
      {
        Get the invoice item actual per day price stored in the array;
        new value = (invoice item actual per day price - sub-CLIN type average) ^ 2;
        Add new value to the sub-CLIN type variance value holder;
      }//end if//
    }//end for each -- invoice item//
  }//end for each -- invoice//

Sub-CLIN type variance = sub-CLIN type variance value holder /
                                (sub-CLIN type sample size - 1);

Sub-CLIN type standard deviation = square root (sub-CLIN type variance);

}//end for each -- sub-CLIN type//
```

Figure 15. Standard Deviation Pseudo-code

7. Get the Sub-CLIN Type Confidence Interval ($t_{\alpha/2}\frac{s}{\sqrt{n}}$)

To produce the lower and upper boundaries of the estimate for each sub-CLIN type, the module computes for the confidence interval using the critical value from the t-distribution table, the standard deviation, and the sample size of the sub-CLIN type. Figure 16 reflects the pseudo-code to generate the confidence interval and to compute the lower and upper boundaries.

```
for each (sub-CLIN type)
{
  t_value = retrieve the critical value corresponding to the degree of freedom.
            The module computes the degree of freedom as sample size minus one;

  sub-CLIN type confidence level = t_value *
      (sub-CLIN type standard deviation / square root of sub-CLIN type sample size);

  Lower boundary value = sub-CLIN type average - sub-CLIN type confidence level;

  Upper boundary value = sub-CLIN type average + sub-CLIN type confidence level;

}//end for each -- sub-CLIN type//
```

Figure 16. Confidence Level Pseudo-code

The t-statistic estimate in this module differs from the cumulative average used in CRAFT. The module breaks down the computation to the sub-CLIN type level, instead of averaging the total cost of invoices, to accurately capture the charges or fees outside the normal distribution of the sub-CLIN type cost. The module provides the user a 95% chance (based on the historical data) that the sub-CLIN type costs will range between the lower and upper boundaries of the estimate. In measuring the error rate, the module computes the percentage of error between the estimate and actual cost of the sub-CLIN type. A close distance between the actual cost and estimate denotes a low percentage of error.

In addition to the confidence interval estimator, the module also validates the result using another forecasting method called exponential smoothing. The next section describes the methodology used to produce the forecasted costs using this particular time-series model.

B. Exponential Smoothing

Balakrishnan, Render, and Stair (2007) classify exponential smoothing as a type of moving averages model that provides a stable forecast by leveling sudden fluctuations in the costs patterns. The model also applies a smoothing constant, called α, in addition to comparing the previous forecasts for port-visit costs with the actual costs. The smoothing constant reflects a weighted value from 0 to 1, inclusively, that allows more emphasis or weight on recent periods (when α is closer to 1) than on past periods (when α is closer to 0). For SPFCM purposes, the module uses 0.01 as the lowest weighted value. To find the optimum α value between 0.01 and 1, the module iterates through all the invoices in computing the lowest Mean Absolute Percent Error (MAPE). The α that corresponds to the lowest MAPE represents the value used as the smoothing constant in the formula. The formulas below show the exponential smoothing computation to include the MAPE computation:

FORECAST

Forecast for period (t+1) = Forecast for period[t] + α * (Actual value in period[t] - Forecast for period [t])
Forecast for period (t) = Forecast for period[t-1] + α * (Actual value in period[t-1] - Forecast for period [t-1])
Forecast for period (t-1) = Forecast for period[t-2] + α * (Actual value in period[t-2] - Forecast for period [t-2])
. . .
Forecast for period (t-n) = Forecast for period[t-n-1] +
α * (Actual value in period[t-n-1] - Forecast for period [t-n-1])

ERROR

Error(t)=Actual value in period[t]-Forecast for period[t]
Error(t-1)=Actual value in period[t-1]-Forecast for period[t-1]
Error(t-2)=Actual value in period[t-2]-Forecast for period[t-2]
. . .
Error(t-n)=Actual value in period[t-n]-Forecast for period[t-n]

MAPE for Forecast (t + 1)

Error(t)=Absolute value [Error(t)] / Actual value in period [t]
Error(t-1)=Absolute value [Error(t-1)] / Actual value in period [t-1]
Error(t-2)=Absolute value [Error(t-2)] / Actual value in period [t-2]
. . .
Error(t-n)=Absolute value [Error(t-n)] / Actual value in period [t-n]

$$\text{MAPE for Forecast}(t+1) = \frac{[\,\text{Error}(t) + \text{Error}(t-1) + \text{Error}(t-2) + \ldots + \text{Error}(t-n)\,] * 100}{n-1}$$

Equation 2. Formulas used for Exponential Smoothing and Mape Computation

1. Do Exponential Smoothing (Forecast[t+1])

The module retrieves the adjusted per day price stored in the sub-CLIN type array for each key or invoice item. After retrieving the data, the module calls the method that computes for the optimal smoothing constant. The value returned by the method represents α in the exponential smoothing formula. Figure 17 shows the iterative process that generates the forecast for the next sub-CLIN type cost, using the exponential smoothing formula stated above.

```
Call the method that finds the optimal smoothing constant;

For each (invoice)
{
  if (first iteration)
  {
    value = Retrieve the adjusted price for each invoice item;

    holder = value;
  }
  else
  {
    invoice forecast = value + (optimal smoothing constant * (item's adjusted price - value) );

    invoice error = item's adjusted price - invoice forecast;

    invoice MAPE = absolute value ( invoice error / invoice forecast);

    Add the invoice MAPE to the sub-CLIN type MAPE sum;

    value =current invoice forecast;

    holder = current item's adjusted price;
  }//end if-else//
}//end for each -- invoice//

sub-CLIN type MAPE = sub-CLIN type MAPE sum / number of invoices in sub-CLIN type;

sub-CLIN type forecast = last invoice forecast;
```

Figure 17. Exponential Smoothing Pseudo-code

2. Find the Optimal Smoothing Constant (α)

A linear search method forces the module to iterate 100 times through all invoices as the module searches for the α with the lowest MAPE (0.01 to 1 in increments of 0.01). Clearly an inefficient way to conduct the search, this method slows down the process considerably due to the intense demand on the computing system. Therefore, the module employs another method, called a heuristic algorithm, which allows a much faster search for the lowest MAPE value. Using two initial constants, namely the initial α (0.50) and segment (0.25), the module compares the MAPE generated by the two values ([α + segment] and [α - segment]), resets the search using the α of the lower value MAPE, and then divides the segment by half until the segment reaches 0.01. The segmentation allows the search to loop for six iterations (i.e., 0.25, 0.125, 0.625, 0.3125, 0.015625, 0.0078125). Figure 18 below shows an example of a heuristic search for the lowest MAPE, at which the iterated method shows the α that corresponds to the lower MAPE between a higher α and lower α.

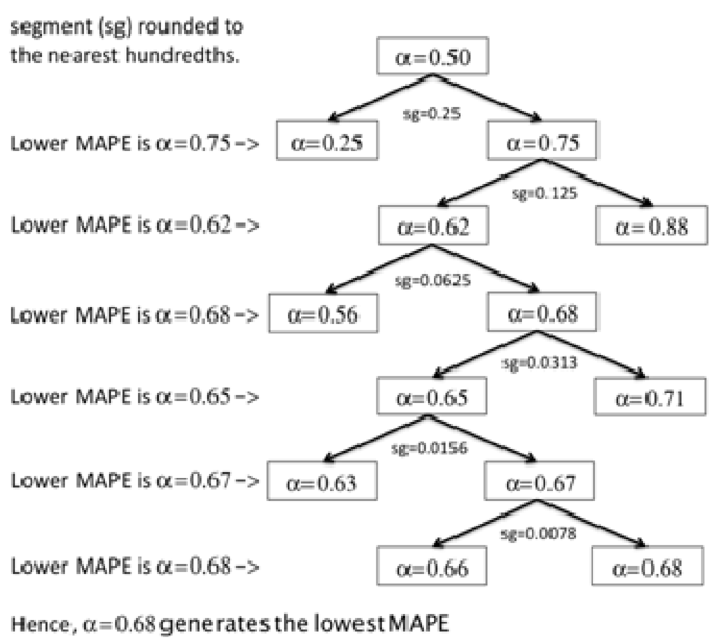

Figure 18. Example of Method Iteration in Search of the Lowest MAPE

Figure 19 reflects the pseudo-code for the optimal smoothing constant, which calls on the heuristic method, shown in Figure 20, to generate a MAPE for a specific α.

```
Initial alpha = 0.5;
Initial segment = 0.25;

while (segment is not less than or equal to 0.01)
{
  upper alpha = alpha + segment;
  Upper alpha cannot exceed 1;
  upper MAPE = Do a heuristic search using the current alpha value;

  lower alpha = alpha - segment;
  lower alpha cannot be less than 0.01;
  lower MAPE = Do a heuristic search using the current alpha value;

  if (upper MAPE is less than lower MAPE )
  {
    lowest possible MAPE = upper MAPE;
    Change the alpha to reflect the value of upper alpha;
   }
   else if (upper MAPE is greater than lower MAPE)
   {
    lowest possible MAPE = lower MAPE;
    Change the alpha to reflect the value of lower alpha;
   }//end if-else//

   if (segment is less than or equal to 0.01)
   {
    Stop the while loop.
   }
   else
   {
    Divide the current segment by 2 and store the value as the new segment;
   }//end if-else//
}//end while//

return the value of optimal smoothing constant;
```

Figure 19. Pseudo-code for Generating the Smoothing Constant

```
for each (sub-CLIN type)
{
 if (first iteration)
 {
   value = Retrieve the adjusted price for each invoice item;
   holder = value;
 }
 else
 {
   temporary price = iterated invoice item's adjusted price;

   temporary forecast = value + (current alpha * (temporary price - value) );

   temporary error = temporary price - temporary forecast;

   temporary MAPE = absolute value ( temporary error / temporary forecast );

   Add the temporary MAPE to the temporary sub-CLIN type MAPE sum;

   value =current temporary forecast;

   holder = current temporary price;
 }//end if-else//

 return MAPE = sub-CLIN type MAPE sum / number of invoices in sub-CLIN type;

}//end for each -- sub-CLIN type//
```

Figure 20. The Heuristic Method Pseudo-code

The module displays the results of estimates, t-statistics and exponential smoothing, as reflected in Figure 11 (shown in previous chapter). The t-statistics method provides a ballpark figure of the actual port-visit costs using the upper and lower limits. Within the limits, a method provides an estimate based on adjusted, per-day costs of the required services. Another method, exponential smoothing, shows whether the estimate represents a close forecast by using the trend of past port visits barring any significant requirements in services or a sudden spike in price or fees (i.e., dockage fee). The two estimates allow the user to analyze the forecasted costs by comparing the deviation between the two forecasting models.

The next chapter discusses the analysis of forecasted port-visit costs for several types of ships and ports. The research analysis compares the two models and shows the module's consistency, or the lack of consistency, in minimizing the error rate as the amount of historical data increase.

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VI. Analysis

To validate the effectiveness of the forecasting module, the researchers conducted the analysis using data from actual invoices and estimates generated by the module. The analysis was conducted using four diverse cases. The cases listed below all operate under the first scenario, described in Chapter IV, and examined combinations of ports, ship types, and classes to compare the actual costs with the forecast and compute the error rate for each visit:

1. The first case examined the port-visit cost data of two ship types, guided missile destroyers (DDG) and guided missile cruisers (CG), anchored at Port Red in country Alpha.
2. The second analysis evaluated two ship types at different ports in the same country. The two ship types consisted of fleet replenishment oilers (TAO) at Port Orange and DDGs at Port Yellow, berthed pier side in country Bravo.
3. The third case involved Class 3 ships, the Landing Transport Dock (LPD), berthing pier side at Port Green in Country Charlie.
4. The last case involved two different classes of ships, a Class 1-submarine (SSN) berthed pier-side at Port Blue and a Class 4–amphibious assault ship (LHD) moored pier-side at Port Indigo in Country Delta.

Using 2006 and 2007 port-visit cost invoices as the base or historical data set, the module forecasted 2008 and, up to a certain extent, 2009 port-visit costs. After generating the estimates, researchers compared the forecast with the actual 2008 and 2009 invoices. For each port visit, the researchers produced an estimate based on the ship's requirements as indicated in the actual invoice. Subsequent to the comparison, project team members input the actual invoice data into the database. However, the team members produced simultaneous estimates in instances when, on the same day, two or more ships entered port.

For example, the module forecasted DDG1 port-visit costs in Port Red, the first DDG entering port in 2008. After generating the estimate, the researchers entered DDG1's actual invoice into the database. The team members repeated the process for all DDG invoices that visited Port Red, DDG2 to DDG8. Consequently, researchers plotted the results of the estimates and the actual, total port-visit costs in terms of percentage.

As the amount of historical data increases, the most common observation noticed in the graphs, in all four cases, reflected a funneling effect of upper and lower boundaries towards the estimated value. In most cases, the actual total costs remained within these boundaries. In a few cases, the sub-CLIN type costs either significantly exceeded the norm or an extenuating circumstance occurred during the visit that required an additional sub-CLIN type. These cases, explained in detail below, deviated from the funneling effect and showed diverging boundaries instead.

The deviations may have occurred due to a new service fee, with no prior historical requirement, or a requirement that substantially exceeded the norm. Two other reasons for deviation may include price changes due to currency exchange rate fluctuation and scheduled rate differences. Since the analysis lacked pricing-schedule documentation, which was proprietary, the researchers could not verify or assess these rate differences. Some reasons for the rate fluctuation may include differences due to holidays, overtime, season, or experience of the person providing the service.

A. Case Analysis

1. Two Ship Types Anchored at Port Red, Country Alpha

a. DDG at Anchor

The historical data points, which would be used as the basis of estimates, consisted of 10 DDG port visits between 2006 and 2007. The estimated data set consisted of 8 DDG port visits in 2008 and 2009. The port visits ranged from two days to seven days. Figure 21 depicts the graph of the estimates and actual port-visit costs.

The graph illustrates the funneling effect discussed earlier in the chapter, showing how the module "learns" as the data set increases. All of the actual port-visit cost data fell within the upper-and lower-limit boundaries. Six out of eight DDG actual port-visit costs came within 5% to 6% of the estimated costs. DDG 4 and DDG 6 actual port-visit costs were 10% and 13% below the estimate, respectively. This is a problem the researchers observed in using percentage as the basis of comparison, since percentage exaggerates the results even if the differences in actual dollar value were minimal.

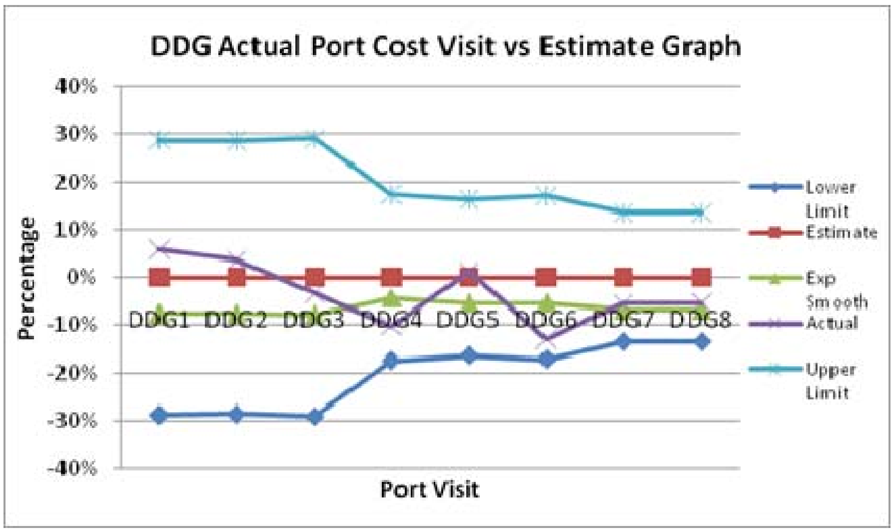

Figure 21. Graph of 2008–2009 DDG Actual Port-visit Costs Compared to the Forecasted Costs, Port Red, Country Alpha

Figure 22 shows the error-rate percentage of the estimate and the exponential smoothing compared to the actual port-visit cost. The calculated average percentage error rate of the estimate and exponential smoothing were both 6%.

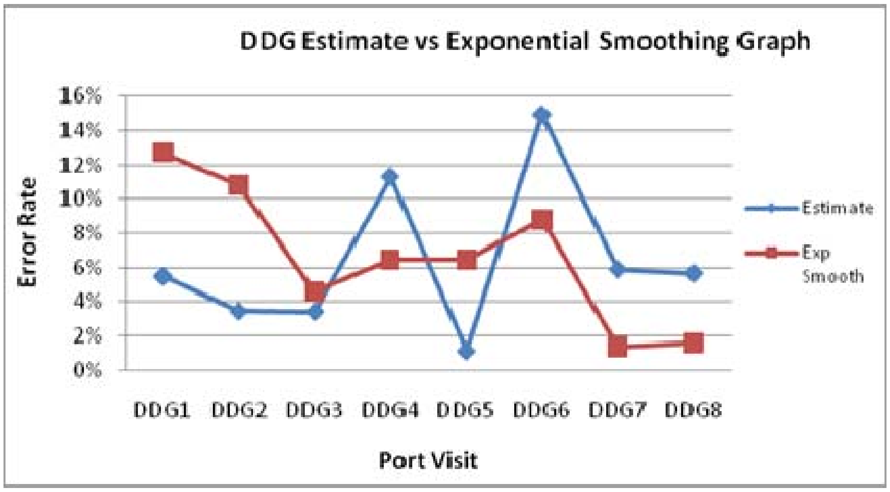

Figure 22. Graph of 2008–2009 DDG Estimate and Exponential Smoothing

b. CG at Anchor

The data utilized for the basis of the estimates was comprised of four ships' invoices during 2006 and 2007. The estimates and actual port-visit costs of the four CGs that visited port Red in 2008 were also plotted and illustrated in a graph (Figure 23).

Again, the graph showed the funneling and diverging effect on the boundaries for the reasons stated above. The boundaries re-converged as soon as the new requirement was entered into the database. The exponential smoothing remained close to the estimated value. However, the actual port-visit costs for CG2, CG3 and CG4 were below the estimated costs. Several factors may have caused this effect. One factor is the fluctuation in exchange rates. The US dollar exchange rate might have been higher compared to Country Alpha's monetary value during those port visits, decreasing the total port-visit costs.

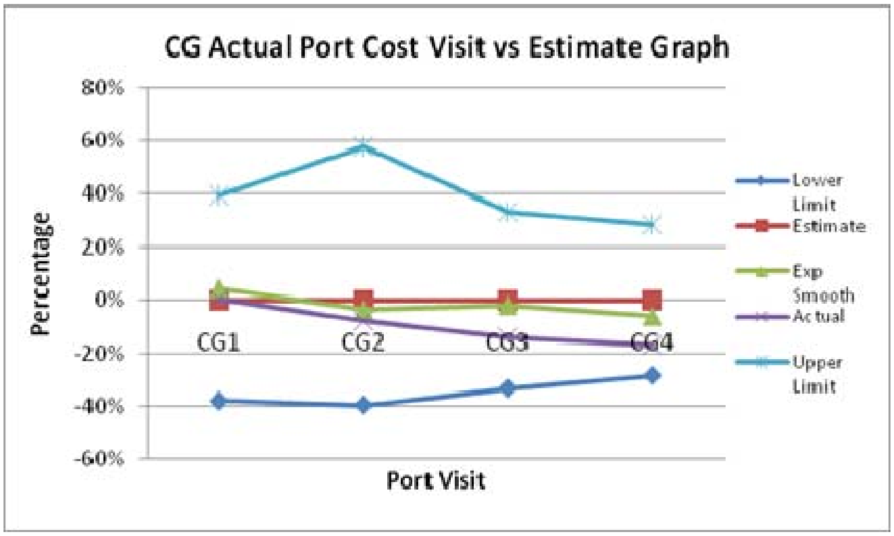

Figure 23. Graph of 2008–2009 CG Actual Port-visit Costs Compared to the Forecasted Costs, Port Red, Country Alpha

The graph in Figure 24 shows the error-rate percentage of the estimate and the exponential smoothing compared to the actual port-visit cost. The calculated average-percentage error rate of the estimate and exponential smoothing were 11% and 9%, respectively.

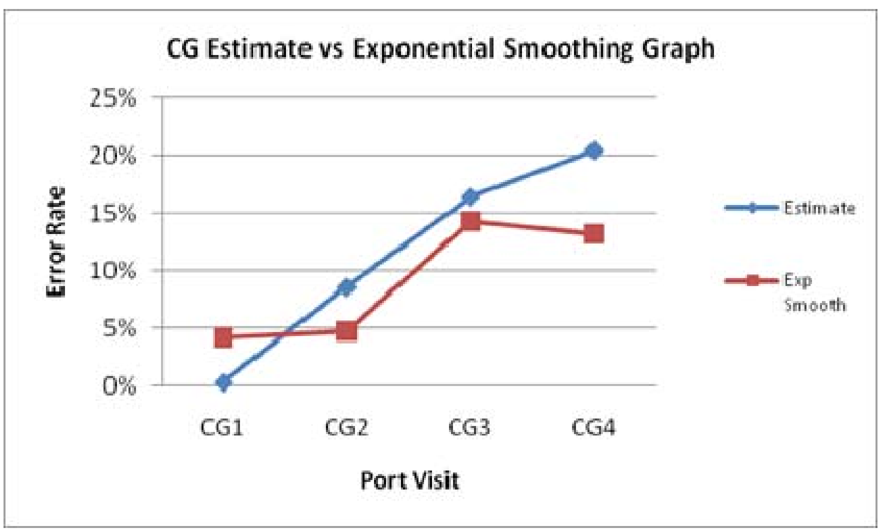

Figure 24. Graph of 2008–2009 CG Estimate and Exponential-smoothing Error Rate

2. Two Ship Types at Different Ports in the Same Country

Case 1 illustrated the module predicting the port-visit costs of two different ship types anchored near a port. Case 2 was conducted to assess if the module could consistently predict the port-visit costs of ships berthing pier side in a port. The second analysis evaluated two ship types. The two ship types consisted of fleet replenishment oilers (TAO) at Port Orange and DDGs at Port Yellow, berthed pier side in Country Bravo.

a. TAO Visiting Pier Side of Port Orange, Country Bravo

Among the types of ships analyzed, TAO port calls in Port Orange presented the most extensive collection of information. The historical data points, which correspond to the basis of estimates, consisted of 42 TAO port visits between 2006 and 2007. Likewise, the estimated data set, represented in Figure 26, also showed an extensive collection of information. The estimated data set consisted of 26 TAO port visits in 2008. Both the historical and the forecasted port visits ranged from two days to several weeks.

The TAO port-visit graph, as shown in Figure 25, reflects the funneling effect of the t-statistic (estimate, upper and lower boundaries). The distance between the upper and lower boundaries decreases as the estimated data set increases. The exponential-smoothing line mostly overlaps the estimate line, especially in later estimations.

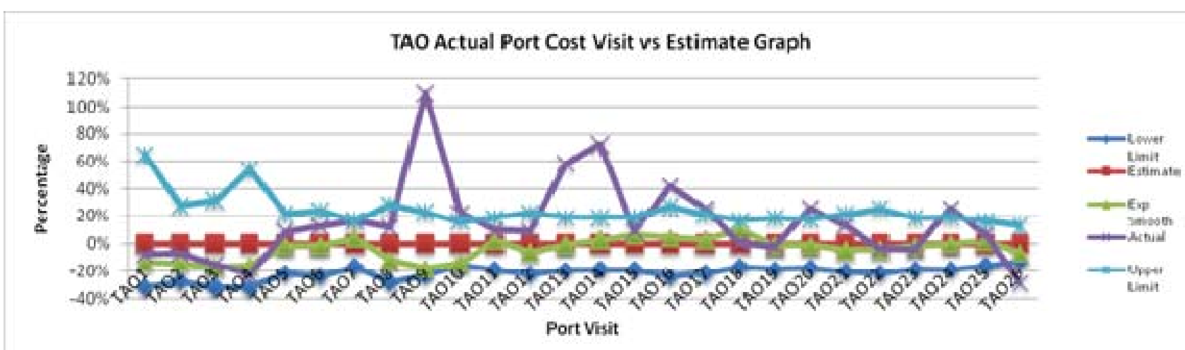

Figure 25. Graph of 2008–2009 TAO Actual Port-visit Costs Compared to the Forecasted Costs, Port Orange, Country Bravo

However, 8 of 26 actual port-visit cost data points exceeded the upper limit, and one was under the lower limit. The first occurrence of an actual port-visit's costs exceeding the upper limit of the estimate happened during TAO9 visit. The invoice included a dockage fee not incurred prior to TAO9 port visit by any other TAO, between 2006 and 2007. As a result, the estimate provided no forecast for that particular sub-CLIN type.

Table 2 shows the port visits incurred significantly higher charges on select services that resulted in actual costs exceeding the forecasted upper-limit boundary. Even though the historical data reflected data points for the specified sub-CLIN type, the charges incurred exceeded the calculated norm for TAOs. As stated earlier in the chapter, the husbanding-contract pricing schedule was not available for research review.

[redacted]

Table 2. List of TAO Port Visits that Incurred Actual Costs beyond Upper Boundary

The last outlier, TAO26, incurred below-norm charges for transportation and force protection sub-CLIN types. The ship stayed in port for several weeks and only requested services under these two CLINs. The dollar value difference between the estimate and the actual costs was not significant. However, the percentage difference reflects a 17% error due to the low dollar-value of the adjusted daily average. Figure 26 illustrates the percentage error rate of the estimate and exponential smoothing from the actual port-visit costs, calculated at 17% and 16%, respectively. It is important to note how the peaks on the line graph matched the peaks (due to actual costs exceeding the upper boundaries) of the graph in Figure 25. Without these peaks or outliers, the averaged error rate of the estimate from the actual port-visit cost was calculated to be 12%.

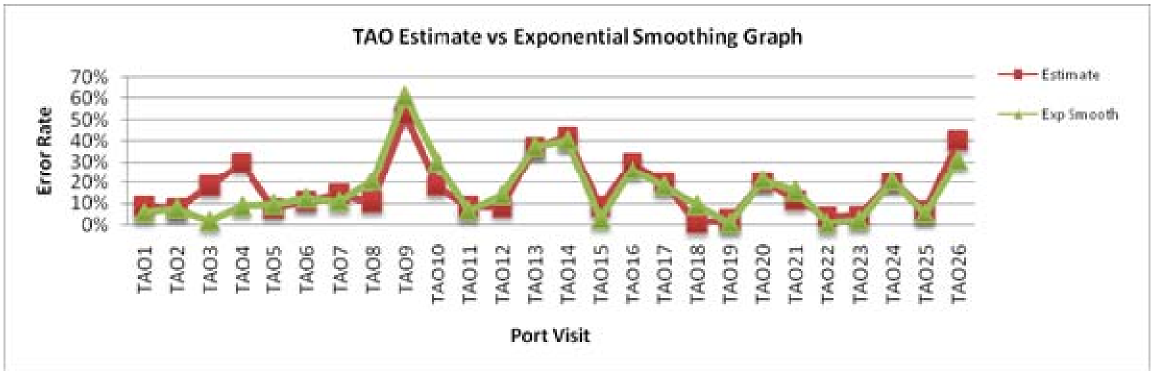

Figure 26. Graph of 2008–2009 TAO Estimate and Exponential-smoothing Error Rate

b. DDG Visiting Pier Side of Port Yellow, Country Bravo

The graph of the actual port-visit cost and estimates for the fourteen DDGs that visited Port Yellow pier side is depicted in Figure 27. The graph shows the funneling and diverging effect of the boundaries discussed earlier. The exponential smoothing mostly overlaps the estimate line. However, 3 out of 14 actual port-visit costs exceeded the upper-limit boundary.

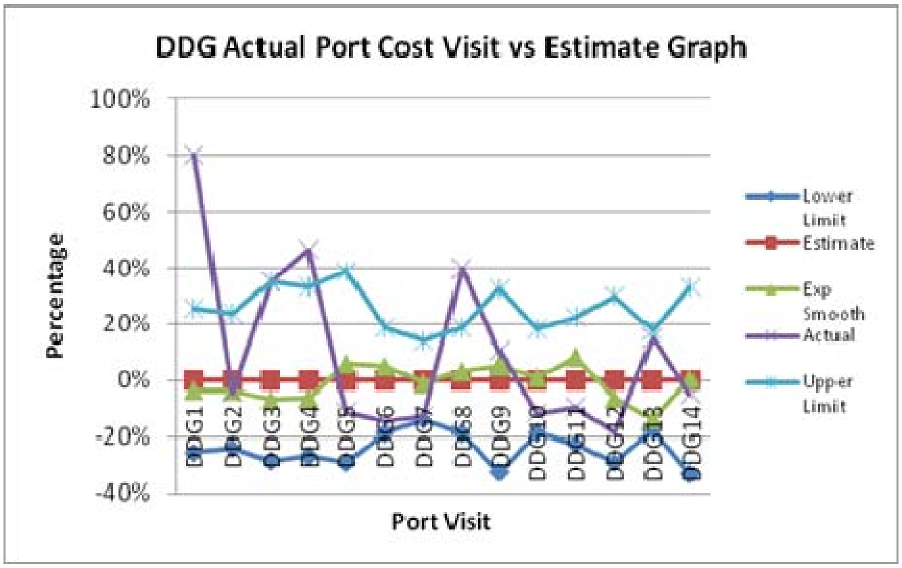

Figure 27. Graph of 2008–2009 DDG Actual Port-visit Costs Compared to the Forecasted Costs, Port Yellow, Country Bravo

The first incidence of an actual port-visit's cost data point exceeding the upper-limit boundary occurred during DDG1's port visit. DDG1 ordered a new requirement, shore power service, which was not required during previous DDG port visits. The cost of this new requirement was substantial enough to cause the actual cost to exceed the upper-limit boundary by 55%. The other occurrence of actual port-visit costs exceeding the boundary happened during the port visits of DDG4 and DDG8. DDG4's increased port-visit cost resulted from the additional oil-boom service requirement and a sudden increase in tug-service cost. Similarly, DDG8's actual port-visit cost exceeded the upper limit due to the increased cost of tug services.

The sudden increase in the cost of the tug's services cannot be explained by simply looking at the invoice, since the unit of issue for the service is per load. Without questioning the HSP on why the sudden increase, the researchers can only conjecture that the increased costs were due to an increased number of tugs used, the increased number of hours or overtime spent, or to seasonal pricing, depending on the time the ship arrived in port (i.e., tides and currents).

Figure 28 shows the percentage error rate of the estimate and exponential smoothing from the actual port-visit costs. The calculated average-percentage error rate of the estimate and exponential smoothing were 18% and 20%, respectively.

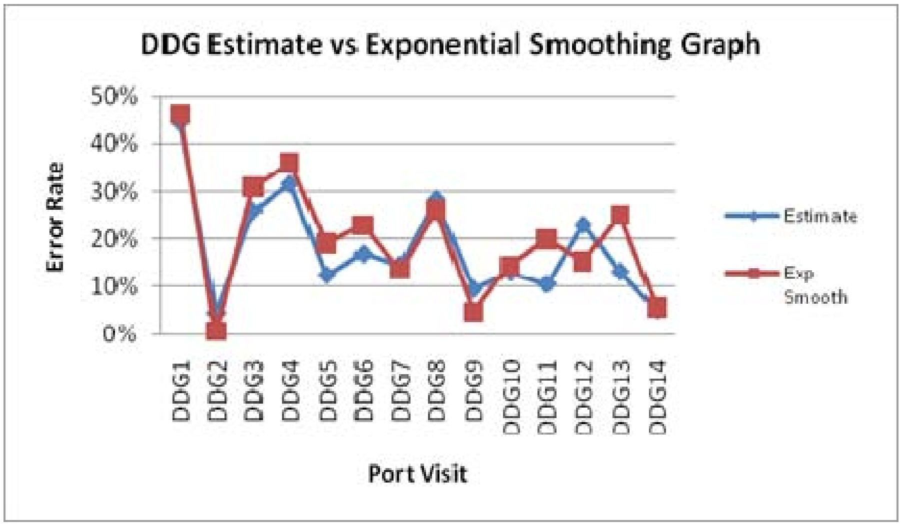

Figure 28. Graph of 2008–2009 DDG Estimate and Exponential-smoothing Error Rate

3. A Different Class of Ship Visiting Pier Side

The previous two cases analyzed the forecasted and actual costs of DDGs, CGs, and TAOs at anchor or moored pier side at various ports in two different countries. All these ships were Class 2 ships. Case 3 differed from the first two cases, since it examined a Landing Transport Dock (LPD), which is a Class 3 ship, berthing pier side at Port Green in Country Charlie.

The historical data points consisted of five LPD port visits between 2006 and 2007. The estimated data points consisted of five LPD port visits in 2008 and plotted in a line graph (Figure 29). The graph shows the same converging and diverging effects of the boundaries, which were commonly observed in the previous graphs. The exponential smoothing overlaps the estimated value line towards the last three estimations. Four out of five actual port-visit costs fell within the upper and lower-limit boundaries of the t-estimate method. The outlier, LPD2, resulted from the ship's requisition of two different types of fuel that previous LPDs have not ordered.

LPD2 might have carried US Marine vehicles during the port visit, requiring the ship to purchase that commodity.

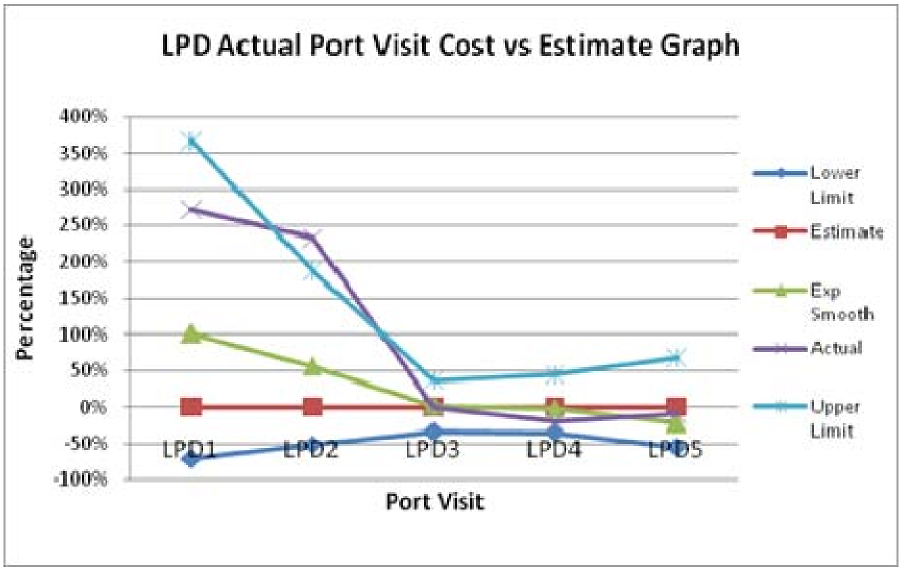

Figure 29. Graph of 2008–2009 LPD Actual Port-visit Costs Compared to the Forecasted Costs, Port Green, Country Charlie

The graph in Figure 30 exhibits the percentage error rate of the estimate and exponential smoothing from the actual port-visit costs. The calculated average error rate of the estimate and exponential smoothing were 35% and 27%, respectively.

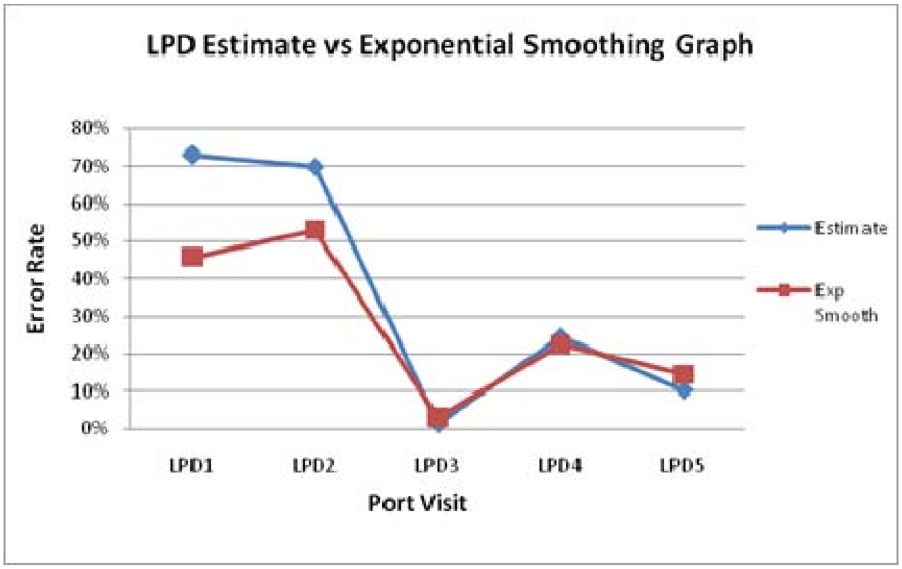

Figure 30. Graph of 2008–2009 DDG Estimate and Exponential-smoothing Error Rate

4. Two Different Classes of Ships Visiting Multiple Ports in the Same Country

Case 4 carried its own unique set of applications. The module-forecasted port-visit costs of various types of ships, whether anchored or moored at different ports and countries. The previous case analyses utilized the robust historical data of port-visit cost invoices from 2006 and 2007 as the baseline to estimate the port-visit costs for ships in 2008 and 2009. However, the estimates conducted in this final case only used two historical data sets to forecast future port-visit costs (i.e., 2008 port-visit costs). What if ships rarely visit a certain port or country? Can the module still provide a port-visit cost estimate using minimal historical data? Case 4 was conducted to assess whether the module will work in this type of situation. For this final case analysis, the researchers examined two different classes of ships: Class 4-amphibious assault ship (LHD) moored pier side at Port Indigo, and a Class 1-submarine (SSN) berthed pier side at Port Blue, in Country Delta.

a. LHD (Class 4 ship) Moored Pier Side at Port Indigo, Country Delta.

The historical data points consisted of two LHD port visits in 2007. The estimated data points consisted of two LHD port visits in 2008 and were plotted in a line graph (Figure 31). Graphically, the upper-limit boundaries for LHD1 and LHD2 were 400% and 600% above the estimate, respectively. This is expected, since the historical data used as the baseline of the estimate function were minimal (i.e., two port-visit cost invoices in 2007). However, the actual port-visit costs were within the upper and lower-limit boundaries of the t-estimate. LHD1's actual port-visit cost was 200% above the estimate due to additional force-protection service requirements, forklift and man-lift services and a huge provisions order. As mentioned earlier, this is the limitation of using percentages vice actual dollar value.

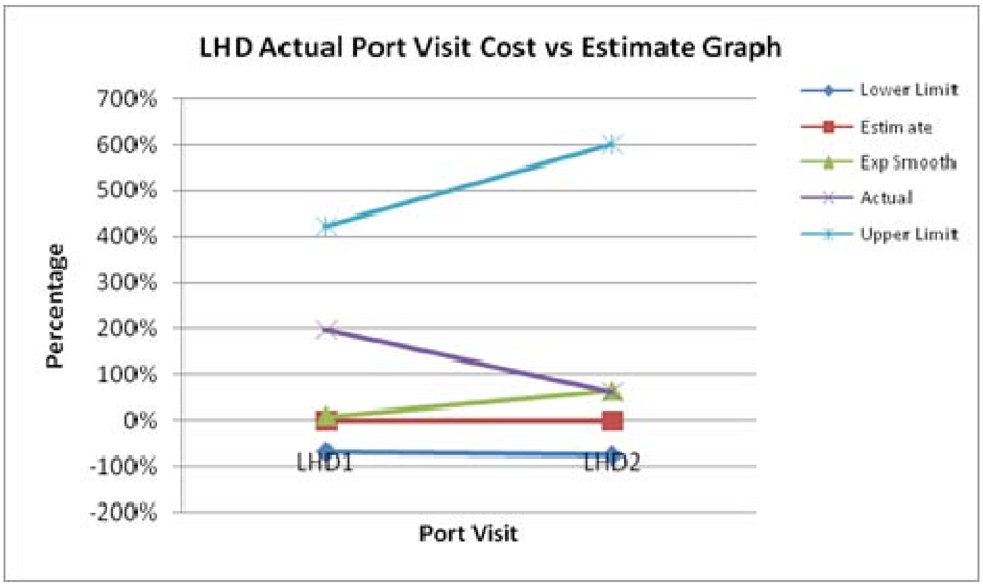

Figure 31. Graph of the Estimates and Actual Port-visit Costs of LHD Visiting Port Indigo, Country Delta

Figure 32 shows the percentage error rate of the estimate and exponential smoothing from the actual port-visit costs. The calculated average-percentage error rate of the estimate and exponential smoothing were 51% and 32%, respectively.

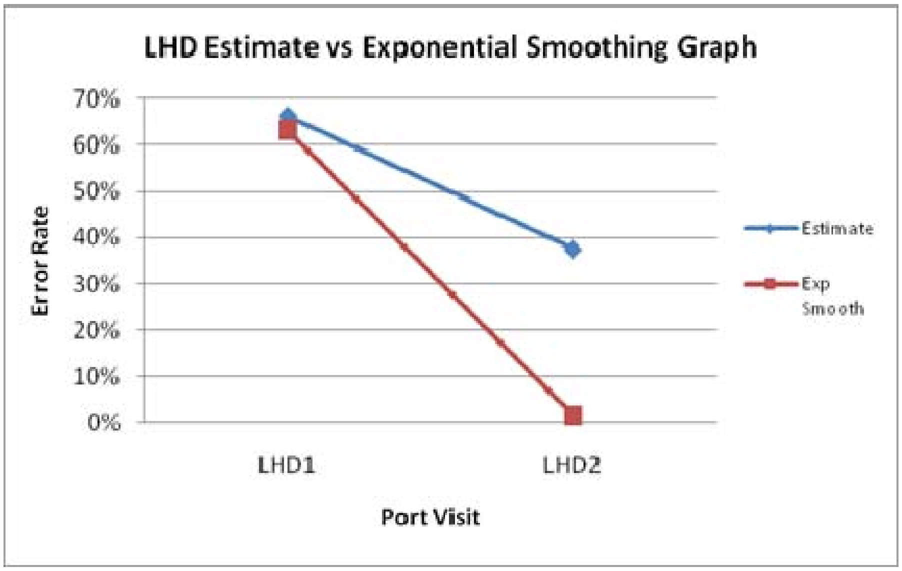

Figure 32. Graph of 2008–2009 DDG Estimate and Exponential-smoothing Error Rate

b. SSN (Class 1 Ship) Moored Pier Side at Port Blue, Country Delta

A similar situation applied to the analysis of submarines. There were only four data sets available, all from SSN port visits during 2007. In this case, the module predicted the port cost of two submarines using the historical data from two previous visits. As graphically illustrated in Figure 33, the analysis produced the same result as that of the LHD. The upper-limit boundaries for SSN1 and SSN2 were 29% and 42% above the estimate, respectively. The exponential smoothing overlaps the estimated cost. This is expected, since the historical data used as the baseline of the estimate function were minimal. However, the actual port-visit costs were within 5% of the forecasted costs and fell within the upper and lower-limit boundaries of the t-estimate.

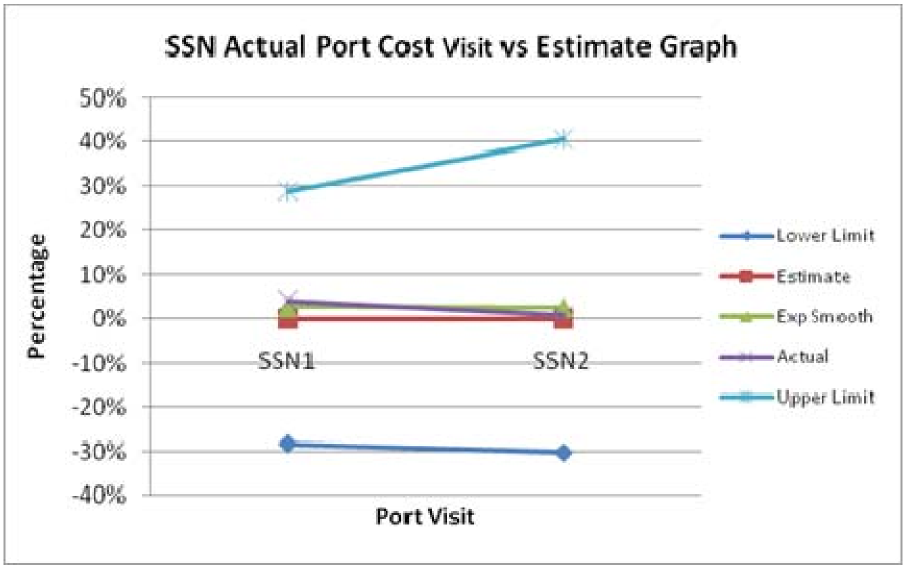

Figure 33. Graph of the Estimates and Actual Port-visit Costs of SSNs Visiting Port Blue, Country Delta

The graph in Figure 34 shows the percentage error rate of the estimate and exponential smoothing from the actual port-visit costs. The calculated average-percentage error rate of the estimate and the exponential smoothing for the actual port-visit costs were 2% and 1%, respectively.

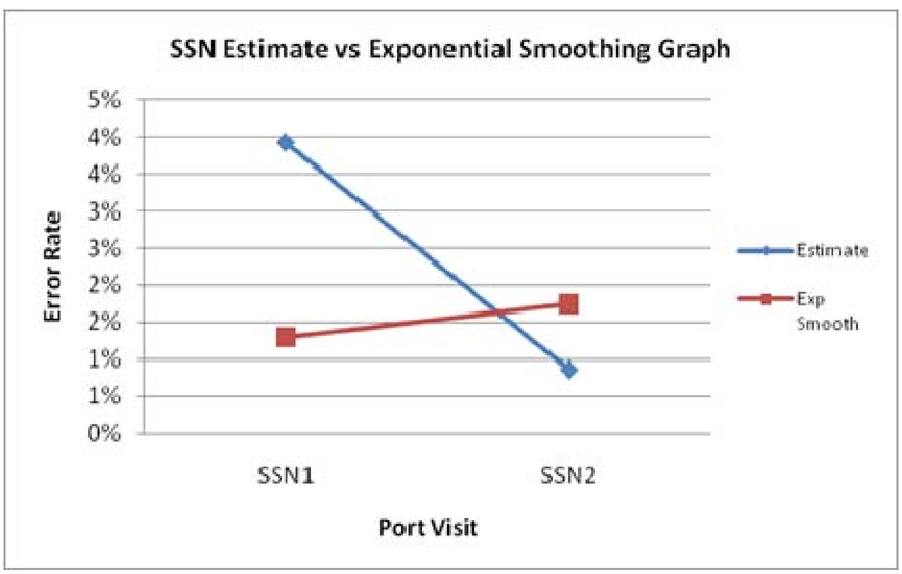

Figure 34. Graph of 2008–2009 SSN Estimate and Exponential-smoothing Error Rate

B. Synthesis

The cases reflect the differences in error rate and limit confidence for both frequency and variability. Low-visit frequency denotes less available historical information with which the module can accurately compute the next port-visit costs. The analysis shows two types of variability. “Price” represents the first variability, while “requirements” marks the second type. Table 3 shows the number of visits that determines the frequency. The table also reflects the error-rate percentages of both forecasting methods and the percentage of visits in which actual costs remained within the confidence limits (between low and high boundaries). The following breakdown shows the scale for frequency and variability:

1. Frequency: Low frequency is 0–15 visits, and high frequency is more than 16 visits in a three-year period.
2. Price Variability: 90% to 100% of actual costs within the limits denotes low price variability. Less than 90% within the limits denotes high price variability.
3. Requirement Variability: Higher than 10% average error rate, for both t-estimate and exponential smoothing, denotes high requirement variability.

As Table 3 reflects, an increase in price and requirement variability corresponds to an increase in error rate and a greater expectation that the actual costs will exceed the confidence level. As stated, visit frequency only affects the accuracy of the forecast and does not necessary affect the movement of the error rate.

CASE	Historical Visits	Forecasted Visits	Error Rate of t-estimate	Error Rate of Exponential Smoothing	Actual Costs Within Limits	Comments
CGs-Port Red in country Alpha	5	4	11%	9%	100%	**Low** Visit Frequency, **Low** Price Variability, **High** Requirement Variability
DDGs-Port Red in country Alpha	11	8	6%	6%	100%	**High** Visit Frequency, **Low** Price Variability, **Low** Requirement Variability
TAOs-Port Orange country Bravo	42	26	17%	16%	70%	**High** Visit Frequency, **High** Price Variability, **High** Requirement Variability
DDGs-Port Yellow country Bravo	12	14	18%	20%	80%	**High** Visit Frequency, **High** Price Variability, **High** Requirement Variability
LPDs-Port Green in Country Charlie	5	5	35%	27%	81%	**Low** Visit Frequency, **High** Price Variability, **High** Requirement Variability
LHDs-Port Indigo Country Delta	2	2	51%	32%	100%	**Low** Visit Frequency, **Low** Price Variability, **High** Requirement Variability
SSNs-Port Indigo Country Delta	2	2	2%	1%	100%	**Low** Visit Frequency, **Low** Price Variability, **Low** Requirement Variability

Table 3. Comparison of Error Rates, Exponential-smoothing vs. Estimate.

Figure 35 presents a different view of the information provided in Table 3. The three-dimensional representation places the results in the axis. The left portion of the cube, the price variability arrow, signifies a higher probability that a port visit will exceed the limits. In all cases, the results with high price variability reflect a lower percentage of staying within the t-estimate boundaries (e.g., TAO, DDG-Port Yellow, and LPD). The upper half of the cube, the requirement variability arrow, denotes high error rates. The results of port visits with high requirement variability reflect high error rates for both forecasting methods.

The Synthesis Cube shows the position of the forecast in relation to the actual costs. Users should expect a high error rate when the actual port-visit costs show high requirement variability compared to the historical data stored in the repository. Also, users should expect the forecast costs to be outside of the t-estimate boundaries when actual prices denote high price variability compared to the historical data. As stated earlier, visit frequency lacks the correlation with both error rate and confidence indicator. However, visit frequency allows the user to gauge the reliability of the forecast results.

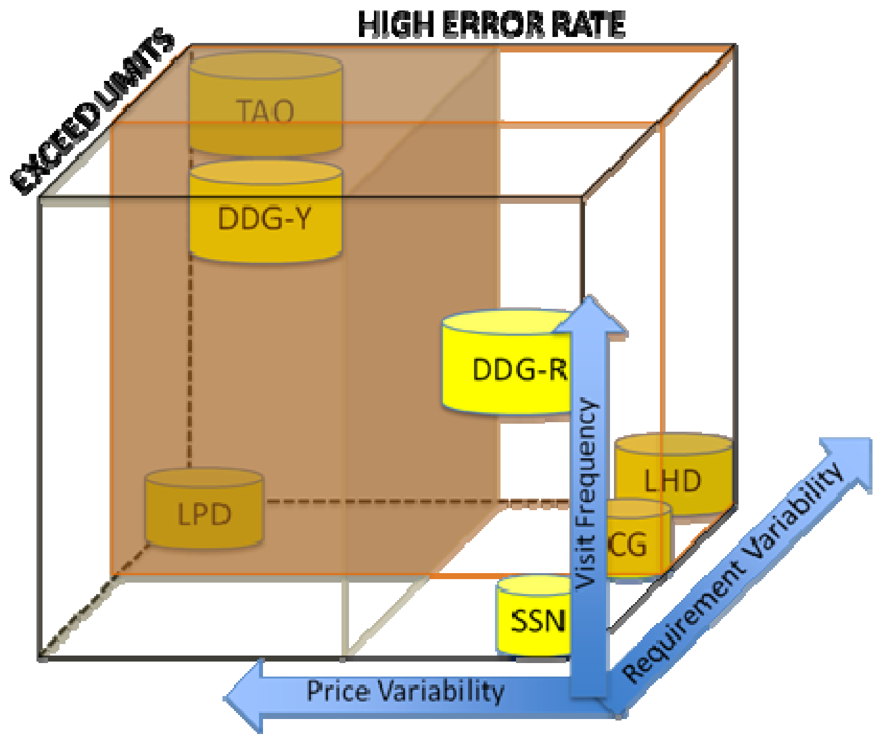

Figure 35. Synthesis Cube of Port-visit Costs

C. Chapter Summary

This chapter discussed the analysis of four cases, under Scenario I algorithms, to validate the effectiveness of the forecasting module. The analysis emphasized the importance of port-visit costs forecasting tools, such as SPCFM, in managing and evaluating costs. These tools provide stakeholders with detailed estimates based on historical data. Among the stakeholders, the SUPPOs and decision-makers benefit the most for this cost-estimating module. From the SUPPO's perspective, the ability to generate a port-visit cost forecast allows him to determine the budgetary impact of the port-visit requirements. In addition, the ability to view costs from previous port visits empowers him to reasonably question noticeable increases in the unit cost of any item in the HSP invoices prior to departure from port. By the same token, the module equips the decision-makers with tools to ascertain the viability of sending ships to ports, mindful of mission needs and funding constraints.

The analysis shows that a standardized CLIN structure increases the accuracy of the estimate. The analysis also captures, through spikes and dips in the graph, the effects of incremental and sudden changes in the husbanding services. Changes in port or ship requirements, with no supporting historical data, decrease the accuracy of the forecast and increase the error rate of both estimating methods. As with other data depository and estimating tools, inaccurate or misleading data results in unusable forecasts.

The project conclusion chapter summarizes the performance of the forecasting model, accounts for the quality of data used in the analysis, and describes the impact of an effective module to users and stakeholders.

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VII. Conclusion

A well-established network-based decision support system can only be effective with accurate and updated stored information. As an enabler to these systems, a stable data repository, including reporting and forecasting capabilities, provides a valuable tool to stakeholders in analyzing requirements and cost trends, assuming that the data collected reflect a true representation of port-visit cost invoices. In addition, the forecasting capabilities allow the same stakeholders to plan port visits based on sound budgetary considerations and to assess the requirements of ships assigned before the actual visits. SPCFM provides stakeholders with these capabilities.

A. SPCFM Performance

SPCFM functionalities allow the user to store and display the invoices, generate different types of reports, and forecast future port-visit costs. Systems currently online, such as LogSSR and CRAFT, have built-in capabilities to perform the data repository function. All of these, including LOGCOP, have display and reporting functions. However, detailed forecasts remain elusive. With the SPCFM, the forecast drills down to the sub-CLIN type level.

The analysis indicates that error rate tolerance may not be the same in every port. Gundemir, Manalang, Metzger, and Pitel (2007, June) stated that ports with low requirement variability and high frequency of visits reflect more accurate cost forecasting (p. 39). The analysis clearly shows that low requirement variability contributes more to the confidence of t-estimate interval, while high frequency contributes to the reliability of the exponential-smoothing results.

Regardless of variability, the number of invoices stored in the database dictates the accuracy of the SPCFM. An accurate result allows users to evaluate the error-rate tolerance of a particular port, using the two forecasting methods embedded in the module. The researchers believe that data quality reinforces the accuracy of results. The saying "garbage in, garbage out" holds credence in the discussion of data collection.

B. Data Quality

True representation of port-visit invoices stems from correct assignment of costs to sub-CLIN types, segregation of sub-CLIN types from consolidated CLIN costs, designation of shared services, and consistency in data entry. Regional husbanding contracts using standard CLIN structure gain a clear advantage over other husbanding contracts that use non-standard CLIN structure. In most cases, data from invoices using standard CLIN structure requires no filtering of line-item designation prior to inclusion into the database.

In cases in which line-item numbers in the invoice differ from the data repository CLINs, the user might designate an item as NC or assign an unrelated sub-CLIN type to the item. The data points would skew the forecast results by either showing a spike or dip in the actual value outside of the t-estimate limits.

In cases in which an item or service does not correspond to a particular sub-CLIN type, the user might inadvertently add that cost to an existing sub-CLIN type, resulting in a consolidated CLIN cost. Hence, the electronic image of the invoice would reflect inaccurate information and distort the aggregate value of the affected sub-CLIN types.

Ships pulling into port at the same time might elect to share transportation or force-protection costs. By not indicating specific sub-CLIN types of the shared costs, the module will not be able to distinguish the shared nature of the services. The forecast would reflect lower-than-expected daily service cost for the ship type and increase the sub-CLIN type error rate.

Consistency in data entry produces more reliable forecasts. Two factors affecting consistency include a well-structured and easy-to-use application, and user training in the proper use of the application. A well-structured application identifies discrepancies in the data-entry process prior to finalizing the invoice submission, while a user-friendly application allows the user to navigate through the functions with relative confidence. Most importantly, training in the proper use of the application prevents unnecessary editing and evaluation of an unreliable data set.

C. Impact to Stakeholders

In applying the SPCFM to the current environment, the module would allow decision-makers to adopt solutions using more accurate operational planning information with clear numerical limits. Ships' supply officers may use the module as a make-or-buy tool in determining the cost advantages of buying services (i.e., potable water, electrical power) instead of producing them, or vice versa. Additionally, other stakeholders such as contracting officers may use the module as a monitoring tool to decrease the burden in auditing invoices and increase contract-performance oversight. Once the standard CLIN structure has been implemented and entered into the data repository, HSPs may not have to spend so much time entering invoice data into the system.

Since LogSSR and LOGCOP implement most of the functionalities of the SPCFM, the module does not need to be used as a fully implemented application. The advantage of the SPCFM allows the system administrators to modularize the forecasting function and embed it into the current system environment. The project's main goal is to provide the stakeholders with an application that increases the current systems' capabilities and a tool to better forecast future port-visit costs. By reducing the error rate to a tolerable limit and confining the actual port-visit costs within the upper and lower boundaries of the estimate, the project team members believe the module achieved the stated goal.

The next chapter discusses recommendations to prevent inclusion of inaccurate and misleading data into the system. It also includes other recommendations that should assist the stakeholders in maintaining the integrity of the data. With proper application, these recommendations will hopefully reduce port-visit costs and increase the ability to project the feasibility of future port visits.

VIII. Recommendations

A. Standardize the CLIN Structure of Husbanding Services Contracts

All HSP contracts must adopt the same structure to properly record, accurately report, and confidently forecast port-visit costs. Regional HSP contracts, such as FISCSI HSP contracts, apply a standardized CLIN structure. Unfortunately, not all HSP contracts share the same CLIN structure. The basis of a successful decision-support system rests on proper classification of identification keys. As stated in an earlier chapter, contracting officers should assign additional sub-CLIN types to unique port requirements rather than classifying the requirements as NC or consolidating them with other similar services.

The lack of standardization clearly has an effect on error rates. If data is not categorized consistently, risk of misclassification greatly increases, especially in ports with a high variability of services. As a result, the forecasting module generates an estimate outside the t-estimate boundaries, thereby decreasing the users' confidence in the forecasts. Effective implementation of decision support systems in the current system environment requires that contracting officers issue contract modifications to reclassify non-standard CLIN structures. For new HSP contracts, the use of the standardized structure should be mandated, and unused identification keys should be proactively assigned for all anticipated services, regardless of utilization frequency. Contracting Officers of existing contracts must recognize the new key assignments to maintain the integrity of the structure.

B. Add a Forecasting Functionality into existing Data Repository Applications

Decision-makers, SUPPOs, and contracting officers need a forecasting tool integrated in the data-repository system. In terms of forecasting the next port-visit costs, ad hoc and Crystal Ball™ reports, and Excel™ spreadsheets are tedious to generate and maintain, and they lack the tailored functionality of an integrated forecasting tool, especially for ships.[37] Integrated estimating capabilities offer users with distinct functionality, sensitive to the HSP contract parameters.

The results of descriptive statistics offer users a frame of reference specific to the data table. However, proper interpretation of the results requires training of all stakeholders. An integrated forecasting module provides useful information to the user without the need for interpretation. Using SPCFM as an example, the forecast shows the user an estimate, a 95% confidence level boundary, a line-item daily cost, and another forecasting method result to compare the estimate. The display provides straightforward and easy-to-understand information.

C. Assign a Lead Office Responsible for Assigning New, Unique CLIN Identifiers

COMFISCS should assign only one office with the responsibility of safeguarding the integrity of the standardized CLIN structure to prevent service type duplication and to maintain the accuracy of the information.

D. Use One Data Repository for All Husbanding Contracts

The existence of multiple applications for invoice data collection adds to the cost of system maintenance, software upgrades, and personnel. In using one data repository, decision-makers reduce costs associated with multiple systems and increase the reliability of data collected. A single repository application allows the system administrators to quickly respond to customer inquiries and, most importantly, increase oversight effectiveness.

To keep systems up-to-date, the use of multiple applications demands upgrades for each system, with allocated overhead costs included in the expense

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[37] Crystal Ball™ software is an Oracle® product, and Excel™ software is a Microsoft® product. These spreadsheet-based applications are primarily used for optimization, data sorting and filtering, graph generating, modeling, forecasting, and simulation.

whether maintenance, personnel, or power usage. Obviously, decreasing the number of repository systems reduces the funding requirements of applications with similar purposes (i.e., collecting and storing HSP invoices).

Data duplication renders the information in multiple non-networked databases unreliable. Data entry corrections must be made in all databases instead of in just one networked database. As a result, the same invoice may reflect different CLINs, service quantity, or amount.

Clearly, a networked database increases the effectiveness of contract-performance oversight. The elimination of redundant applications (not the data back-ups used by the selected repository) increases data quality and renders the system a reliable source of contract performance information.

E. Train HSPs in Data Entry

Current contracts require HSPs to insert the invoices into a data repository system. However, not all are trained in distinguishing the correct service type to use for a particular service charge. Due to description differences in invoices, HSPs assign NC codes even when a more suitable sub-CLIN type is available. Although CLIN standardization addresses some data entry concerns, training for HSPs will provide contracting officers with a baseline of HSP knowledge.

F. Inform the Fleet that the Tool Exists

As with other user-dependent systems, an application that displays historical information, generates reports, and predicts the next requirement may only be useful if users know it exists.

G. Audit and Monitor the Information in the Data Repository

To consistently ensure data quality and reliability, the contracting officer (KO) must conduct periodic audits of invoices stored in the repository. The KO may accomplish this task by randomly selecting a paper copy of an invoice and comparing it with the information stored in the repository as represented by the invoice's electronic image.

IX. Areas for Further Research

A. Expand the Forecasting Model to Include Scenarios II through V

The project Web-based application chapter (Chapter IV) lists five scenarios in computing port-visit costs. These scenarios include: same vessel type, same port, same country; same vessel class, same port, same country; not the same vessel type/class, same port, same country; not the same vessel type/class, not the same port, same country; and not the same country, only invoices from adjacent countries are available. This research project only covers algorithms and analysis addressing cases of the first scenario. As stated in Chapter IV, the algorithm complexity increases as the scenario becomes more complicated. An expanded algorithm base would enhance the capability of the forecasting model to predict port-visit costs under all conditions.

B. Integration of Global Husbanding Services with Network-centric Logistics Systems

Integration of husbanding services management tools into a network-centric logistics system that allows broad access to stakeholders would significantly reduce communication, analytical, and coordination problems currently encountered by supply officers, contracting officers, and contractors. A research paper focusing on this type of implementation should gauge the feasibility of integration considering security-access issues, accountability, and system maintenance.

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Appendix A. Case Data

CG PERCENTAGE PER VISIT				
BASED ON ESTIMATE				
Visit Total	CG1	CG2	CG3	CG4
Lower Limit	-0.38	-0.40	-0.33	-0.28
Estimate	0.00	0.00	0.00	0.00
Exp Smooth	0.04	-0.04	-0.02	-0.06
Actual	0.00	-0.08	-0.14	-0.17
Upper Limit	0.39	0.58	0.33	0.28
BASED ON EXP SMOOTHING				
Visit Total	CG1	CG2	CG3	CG4
Lower Limit	-0.38	-0.40	-0.33	-0.28
Estimate	-0.04	0.04	0.02	0.06
Exp Smooth	0.00	0.00	0.00	0.00
Actual	-0.04	-0.04	-0.12	-0.12
Upper Limit	0.39	0.58	0.33	0.28
BASED ON ACTUAL				
Visit Total	CG1	CG2	CG3	CG4
Estimate	0.00	0.09	0.16	0.20
Exp Smooth	0.04	0.05	0.14	0.13

Table 4. CG Percentage per Visit.

DDG (PORT RED) PERCENTAGE PER VISIT								
BASED ON ESTIMATE								
Visit Total	DDG1	DDG2	DDG3	DDG4	DDG5	DDG6	DDG7	DDG8
Lower Limit	-0.29	-0.29	-0.29	-0.17	-0.16	-0.17	-0.14	-0.14
Estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp Smooth	-0.08	-0.08	-0.08	-0.04	-0.05	-0.05	-0.07	-0.07
Actual	0.06	0.04	-0.03	-0.10	0.01	-0.13	-0.06	-0.05
Upper Limit	0.29	0.29	0.29	0.17	0.16	0.17	0.14	0.14
BASED ON EXP SMOOTHING								
Visit Total	DDG1	DDG2	DDG3	DDG4	DDG5	DDG6	DDG7	DDG8
Lower Limit	-0.29	-0.29	-0.29	-0.17	-0.16	-0.17	-0.14	-0.14
Estimate	0.08	0.08	0.08	0.05	0.06	0.06	0.07	0.07
Exp Smooth	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Actual	0.15	0.12	0.05	-0.06	0.07	-0.08	0.01	0.02
Upper Limit	0.29	0.29	0.29	0.17	0.16	0.17	0.14	0.14
BASED ON ACTUAL								
Visit Total	DDG1	DDG2	DDG3	DDG4	DDG5	DDG6	DDG7	DDG8
Estimate	0.05	0.03	0.03	0.11	0.01	0.15	0.06	0.06
Exp Smooth	0.13	0.11	0.05	0.06	0.06	0.09	0.01	0.02

Table 5. DDG (Port Red) Percentage per Visit.

TAO PERCENTAGE PER VISIT																										
BASED ON ESTIMATE																										
Visit Total	TAO1	TAO2	TAO3	TAO4	TAO5	TAO6	TAO7	TAO8	TAO9	TAO10	TAO11	TAO12	TAO13	TAO14	TAO15	TAO16	TAO17	TAO18	TAO19	TAO20	TAO21	TAO22	TAO23	TAO24	TAO25	TAO26
Lower Limit	-0.32	-0.28	-0.32	-0.32	-0.22	-0.24	-0.17	-0.28	-0.23	-0.16	-0.19	-0.22	-0.19	-0.19	-0.19	-0.24	-0.22	-0.17	-0.19	-0.18	-0.20	-0.22	-0.19	-0.19	-0.16	-0.13
Estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp Smooth	-0.13	-0.14	-0.17	-0.16	-0.02	-0.02	0.04	-0.12	-0.18	-0.14	0.02	-0.06	-0.01	0.03	0.06	0.04	0.03	0.10	-0.01	-0.01	-0.05	-0.04	-0.02	0.00	0.02	-0.06
Actual	-0.08	-0.07	-0.15	-0.23	0.09	0.12	0.17	0.12	1.10	0.23	0.09	0.09	0.58	0.72	0.09	0.42	0.26	0.01	-0.02	0.26	0.13	-0.03	-0.04	0.26	0.07	-0.29
Upper Limit	0.65	0.28	0.32	0.54	0.22	0.24	0.17	0.28	0.23	0.16	0.19	0.22	0.19	0.19	0.19	0.27	0.22	0.17	0.19	0.18	0.21	0.25	0.19	0.19	0.16	0.13
BASED ON EXP SMOOTHING																										
Visit Total	TAO1	TAO2	TAO3	TAO4	TAO5	TAO6	TAO7	TAO8	TAO9	TAO10	TAO11	TAO12	TAO13	TAO14	TAO15	TAO16	TAO17	TAO18	TAO19	TAO20	TAO21	TAO22	TAO23	TAO24	TAO25	TAO26
Lower Limit	-0.21	-0.16	-0.18	-0.19	-0.20	-0.22	-0.20	-0.19	-0.06	-0.02	-0.21	-0.17	-0.19	-0.21	-0.24	-0.27	-0.24	-0.25	-0.18	-0.17	-0.17	-0.18	-0.17	-0.19	-0.18	-0.07
Estimate	0.15	0.17	0.20	0.19	0.02	0.02	-0.04	0.13	0.22	0.17	-0.02	0.07	0.01	-0.03	-0.06	-0.04	-0.03	-0.09	0.01	0.01	0.05	0.04	0.02	0.00	-0.02	0.07
Exp Smooth	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Actual	0.06	0.08	0.02	-0.08	0.10	0.14	0.12	0.27	1.56	0.43	0.07	0.16	0.60	0.68	0.03	0.36	0.22	-0.09	-0.01	0.27	0.19	0.01	-0.02	0.26	0.05	-0.24
Upper Limit	0.90	0.49	0.59	0.83	0.24	0.26	0.12	0.46	0.50	0.35	0.16	0.31	0.20	0.16	0.12	0.22	0.18	0.06	0.20	0.19	0.27	0.31	0.21	0.19	0.14	0.21
BASED ON ACTUAL																										
Visit Total	TAO1	TAO2	TAO3	TAO4	TAO5	TAO6	TAO7	TAO8	TAO9	TAO10	TAO11	TAO12	TAO13	TAO14	TAO15	TAO16	TAO17	TAO18	TAO19	TAO20	TAO21	TAO22	TAO23	TAO24	TAO25	TAO26
Estimate	0.09	0.08	0.18	0.30	0.08	0.11	0.14	0.10	0.52	0.18	0.09	0.08	0.37	0.42	0.09	0.30	0.21	0.01	0.02	0.20	0.12	0.04	0.04	0.21	0.07	0.40
Exp Smooth	0.06	0.08	0.02	0.09	0.09	0.12	0.11	0.21	0.61	0.30	0.07	0.14	0.37	0.40	0.03	0.26	0.18	0.09	0.01	0.21	0.16	0.01	0.02	0.21	0.05	0.31

Table 6. TAO Percentage per Visit.

DDG (PORT YELLOW) PERCENTAGE PER VISIT														
BASED ON ESTIMATE														
Visit Total	DD01	DD02	DD03	DD04	DD05	DD06	DD07	DD08	DD09	DD010	DD011	DD012	DD013	DD014
Lower Limit	-0.26	-0.24	-0.29	-0.27	-0.29	-0.19	-0.14	-0.19	-0.32	-0.19	-0.23	-0.29	-0.18	-0.33
Estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp Smooth	-0.03	-0.04	-0.07	-0.06	0.06	0.05	-0.01	0.03	0.05	0.01	0.08	-0.06	-0.14	0.00
Actual	0.80	-0.04	0.35	0.46	-0.11	-0.14	-0.13	0.40	0.10	-0.12	-0.10	-0.19	0.15	-0.05
Upper Limit	0.26	0.24	0.35	0.33	0.39	0.19	0.14	0.19	0.32	0.18	0.23	0.30	0.18	0.33
BASED ON EXP SMOOTHING														
Visit Total	DD01	DD02	DD03	DD04	DD05	DD06	DD07	DD08	DD09	DD010	DD011	DD012	DD013	DD014
Lower Limit	-0.23	-0.21	-0.23	-0.22	-0.38	-0.23	-0.13	-0.21	-0.36	-0.20	-0.29	-0.24	-0.05	-0.33
Estimate	0.03	0.04	0.07	0.07	-0.06	-0.05	0.01	-0.03	-0.05	-0.01	-0.08	0.07	0.16	0.00
Exp Smooth	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Actual	0.86	-0.01	0.45	0.56	-0.16	-0.19	-0.12	0.35	0.05	-0.13	-0.17	-0.13	0.33	-0.05
Upper Limit	0.30	0.29	0.45	0.42	0.31	0.13	0.15	0.15	0.26	0.17	0.13	0.39	0.36	0.33
BASED ON ACTUAL														
Visit Total	DD01	DD02	DD03	DD04	DD05	DD06	DD07	DD08	DD09	DD010	DD011	DD012	DD013	DD014
Estimate	0.44	0.04	0.26	0.32	0.12	0.17	0.15	0.28	0.09	0.13	0.11	0.23	0.13	0.05
Exp Smooth	0.46	0.01	0.31	0.36	0.19	0.23	0.14	0.26	0.05	0.14	0.20	0.15	0.25	0.06

Table 7. DDG (Port Yellow) Percentage per Visit.

LPD PERCENTAGE PER VISIT					
BASED ON ESTIMATE					
Visit	LPD1	LPD2	LPD3	LPD4	LPD5
Lower Limit	-0.72	-0.52	-0.35	-0.36	-0.56
Estimate	0.00	0.00	0.00	0.00	0.00
Exp Smooth	1.01	0.56	0.02	-0.02	-0.23
Actual	2.72	2.33	-0.01	-0.20	-0.09
Upper Limit	3.66	1.87	0.37	0.44	0.68
BASED ON EXP SMOOTHING					
Visit	LPD1	LPD2	LPD3	LPD4	LPD5
Lower Limit	-0.86	-0.70	-0.36	-0.35	-0.43
Estimate	-0.50	-0.36	-0.02	0.02	0.29
Exp Smooth	0.00	0.00	0.00	0.00	0.00
Actual	0.85	1.13	-0.03	-0.18	0.17
Upper Limit	1.32	0.84	0.35	0.47	1.17
BASED ON ACTUAL					
Visit	LPD1	LPD2	LPD3	LPD4	LPD5
Estimate	0.73	0.70	0.01	0.24	0.10
Exp Smooth	0.46	0.53	0.03	0.22	0.15

Table 8. LPD Percentage per Visit.

LHD PERCENTAGE PER VISIT		
BASED ON ESTIMATE		
Visit	LHD1	LHD2
Lower Limit	-0.69	-0.77
Estimate	0.00	0.00
Exp Smooth	0.09	0.63
Actual	1.96	0.60
Upper Limit	4.22	6.01
BASED ON EXP SMOOTHING		
Visit	LHD1	LHD2
Lower Limit	-0.72	-0.86
Estimate	-0.08	-0.39
Exp Smooth	0.00	0.00
Actual	1.73	-0.02
Upper Limit	3.80	3.30
BASED ON ACTUAL		
Visit	LHD1	LHD2
Estimate	0.66	0.38
Exp Smooth	0.63	0.02

Table 9. LHD Percentage per Visit.

SSN PERCENTAGE PER VISIT		
BASED ON ESTIMATE		
Visit	SSN1	SSN2
Lower Limit	-0.28	-0.30
Estimate	0.00	0.00
Exp Smooth	0.03	0.03
Actual	0.04	0.01
Upper Limit	0.29	0.41
BASED ON EXP SMOOTHING		
Visit	SSN1	SSN2
Lower Limit	-0.30	-0.32
Estimate	-0.03	-0.03
Exp Smooth	0.00	0.00
Actual	0.01	-0.02
Upper Limit	0.25	0.37
BASED ON ACTUAL		
Visit	SSN1	SSN2
Estimate	0.04	0.01
Exp Smooth	0.01	0.02

Table 10. SSN Percentage per Visit.

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- Managing the Services Supply Chain
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- Portfolio Optimization via KVA + RO
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- Software Requirements for OA
- Spiral Development
- Strategy for Defense Acquisition Research
- The Software, Hardware Asset Reuse Enterprise (SHARE) repository

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- Contracting Government Procurement Functions
- Contractors in 21st-century Combat Zone
- Joint Contingency Contracting
- Model for Optimizing Contingency Contracting, Planning and Execution
- Navy Contract Writing Guide
- Past Performance in Source Selection
- Strategic Contingency Contracting
- Transforming DoD Contract Closeout
- USAF Energy Savings Performance Contracts
- USAF IT Commodity Council
- USMC Contingency Contracting

Financial Management

- Acquisitions via Leasing: MPS case
- Budget Scoring
- Budgeting for Capabilities-based Planning
- Capital Budgeting for the DoD
- Energy Saving Contracts/DoD Mobile Assets
- Financing DoD Budget via PPPs
- Lessons from Private Sector Capital Budgeting for DoD Acquisition Budgeting Reform
- PPPs and Government Financing
- ROI of Information Warfare Systems
- Special Termination Liability in MDAPs
- Strategic Sourcing
- Transaction Cost Economics (TCE) to Improve Cost Estimates

Human Resources

- Indefinite Reenlistment
- Individual Augmentation
- Learning Management Systems
- Moral Conduct Waivers and First-tem Attrition
- Retention
- The Navy's Selective Reenlistment Bonus (SRB) Management System
- Tuition Assistance

Logistics Management

- Analysis of LAV Depot Maintenance
- Army LOG MOD
- ASDS Product Support Analysis
- Cold-chain Logistics
- Contractors Supporting Military Operations
- Diffusion/Variability on Vendor Performance Evaluation
- Evolutionary Acquisition
- Lean Six Sigma to Reduce Costs and Improve Readiness

- Naval Aviation Maintenance and Process Improvement (2)
- Optimizing CIWS Lifecycle Support (LCS)
- Outsourcing the Pearl Harbor MK-48 Intermediate Maintenance Activity
- Pallet Management System
- PBL (4)
- Privatization-NOSL/NAWCI
- RFID (6)
- Risk Analysis for Performance-based Logistics
- R-TOC AEGIS Microwave Power Tubes
- Sense-and-Respond Logistics Network
- Strategic Sourcing

Program Management

- Building Collaborative Capacity
- Business Process Reengineering (BPR) for LCS Mission Module Acquisition
- Collaborative IT Tools Leveraging Competence
- Contractor vs. Organic Support
- Knowledge, Responsibilities and Decision Rights in MDAPs
- KVA Applied to AEGIS and SSDS
- Managing the Service Supply Chain
- Measuring Uncertainty in Earned Value
- Organizational Modeling and Simulation
- Public-Private Partnership
- Terminating Your Own Program
- Utilizing Collaborative and Three-dimensional Imaging Technology

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