



# Expanding the Range of Your Data: A Small Ships Case Study

# Today's Presenter



**Kathleen Hudgins**

Lead Analyst

Ms. Hudgins has over five years of experience as an engineer and analyst supporting federal clients. She is currently a cost analyst for Technomics, where she has supported major US Navy and US Coast Guard acquisition programs through ship lifecycle cost estimates, cost drills, and cost reduction initiatives. Ms. Hudgins earned a Bachelor of Science in Systems Engineering from the University of Virginia.

# Co-Authors



**Robert Nehring (Lead)**

Mr. Nehring is a cost analyst for Technomics, where he has developed many tools, data visualizations, databases, and cost estimates for programs throughout DoD and DHS. He is an ICEAA-Certified Cost Estimator/Analyst who has won many awards, including the ICEAA 2013 Cost Estimator/Analyst of the Year for Technical Achievement and Best Conference Paper at the 2012 SCEA/ISPA Workshop. He also developed the innovative Galaxy Chart concept and many other models and tools throughout his career.



**Elizabeth Koza**

Ms. Koza, a Senior Analyst at Technomics, has sixteen years of experience analyzing and estimating development, production, and operations and support costs of weapons systems. She has developed program life cycle and independent cost estimates that greatly contributed to the success of several acquisition programs. Ms. Koza earned a Bachelor of Science in Mechanical Engineering from the Johns Hopkins University and a Master of Engineering from the University of Maryland in Systems Engineering.



**Anna Irvine**

Ms. Irvine is an ICEAA-Certified Cost Estimator/Analyst (CCE/A) with over eighteen years of experience as a program manager, engineer, and cost analyst performing concept development and feasibility studies for aircraft and aeronautical applications, and conducting analysis of costs for development, production, operating and support for DoD and NASA programs. Ms. Irvine holds an undergraduate degree in Aerospace Engineering and a graduate degree in Applied Mathematics, both from Virginia Tech.

# Abstract Synopsis

- ▶ The Navy's Visibility & Management of Operating and Support Costs (VAMOSOC) database captures O&S data from ships currently in the fleet and inactive/retired ships
- ▶ Estimating the costs of smaller ships based on historical data is challenging as the Navy hasn't built many smaller ships recently
- ▶ Looking to the US Coast Guard (USCG) for data is a logical approach, however the USCG doesn't have a VAMOSOC-like database
- ▶ This paper explores use of USCG O&S data to supplement Navy data for use in estimating O&S costs for smaller ships
- ▶ Topics include the following:
  - Data sources and data collection
  - Data normalization
  - Comparisons of data between the services

# Outline

- ▶ Assumptions and Definitions
- ▶ Naval VAMOSC Overview
- ▶ Motivation for Study
- ▶ USCG O&S Data Sources
- ▶ Data Collection, Normalization, & Storage
- ▶ Data Comparisons
- ▶ Conclusions

# Assumptions and Definitions

## ▶ **OSD CAPE 2014 O&S WBS**

- 1.0 Unit-Level Manpower
- 2.0 Unit Operations
- 3.0 Maintenance
- 4.0 Sustaining Support
- 5.0 Continuing System Improvements
- 6.0 Indirect Support

▶ **Regression:** linear with y intercept=0

▶ **Prediction Interval:** a measure of the uncertainty around an estimate developed using a regression equation

- $\alpha = 0.05$

▶ **Small Ship:** used for the purposes of this brief:

- Lightship weight <5,000 Long Tons
- Steel Hull
- One crew made up of officer and enlisted personnel

# Navy Ship O&S Database – VAMOSOC Overview

- ▶ Naval VAMOSOC (henceforth “VAMOSOC”) provides historical operating & support (O&S) cost data for US Navy & USMC programs



Over 125 cost data providers for 1,200 cost and non-cost data elements



Most ships data from 1984 to present



Data universes for ships, aviation, weapons, personnel, and infrastructure



Costs reported in Navy CES (cost element structure) and Cost Assessment and Program Evaluation (CAPE) 2014 CES

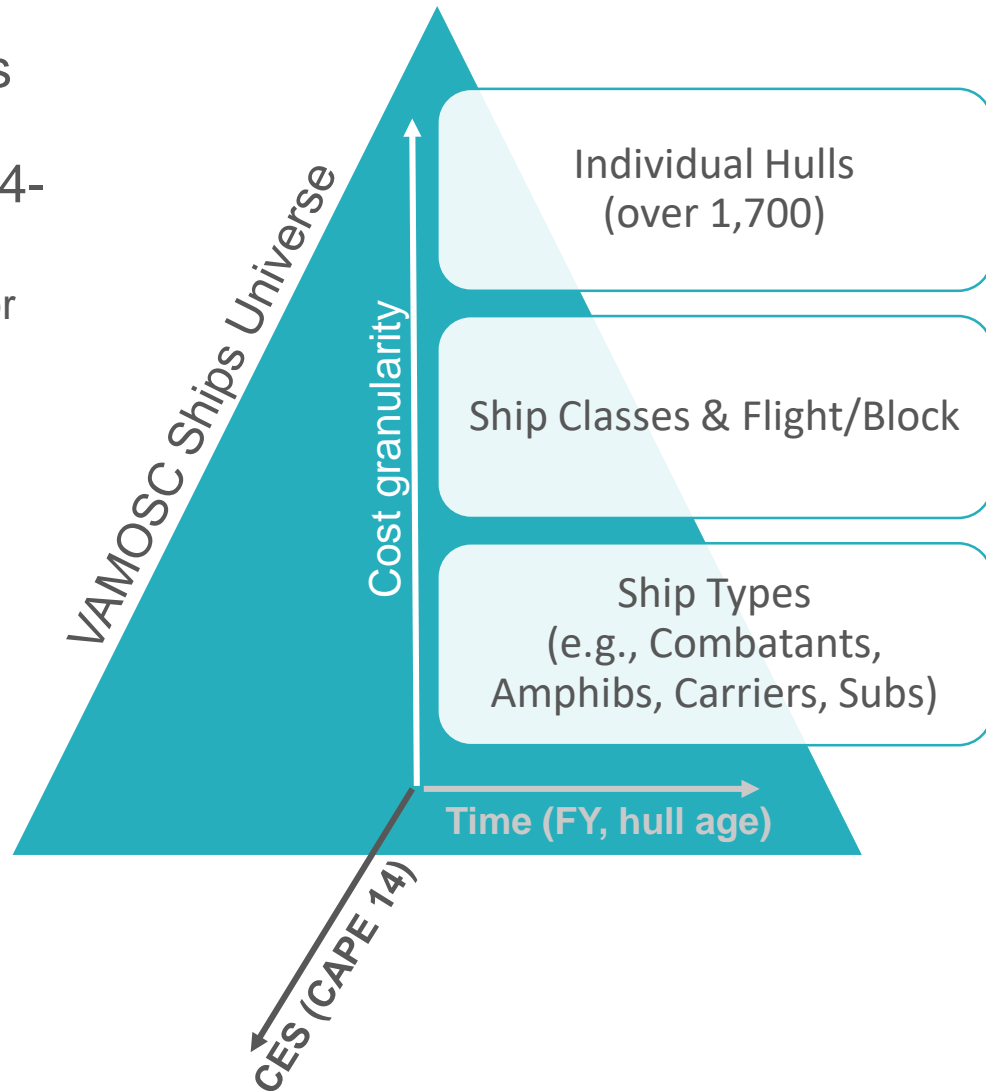


Available to cost community (US government & contractors) via web portal; over 800 registered users currently

- ▶ Maintained by Naval Center for Cost Analysis (NCCA)
  - Similar systems congressionally mandated for each of the DOD components (Navy/USMC, Army, Air Force)
- ▶ VAMOSOC is a **gold standard** in terms of data breadth, depth, and availability, serving as a reputable basis for historical maintenance costs for Navy ship cost studies

# Navy Ship O&S Database – VAMOSC Ship Universe

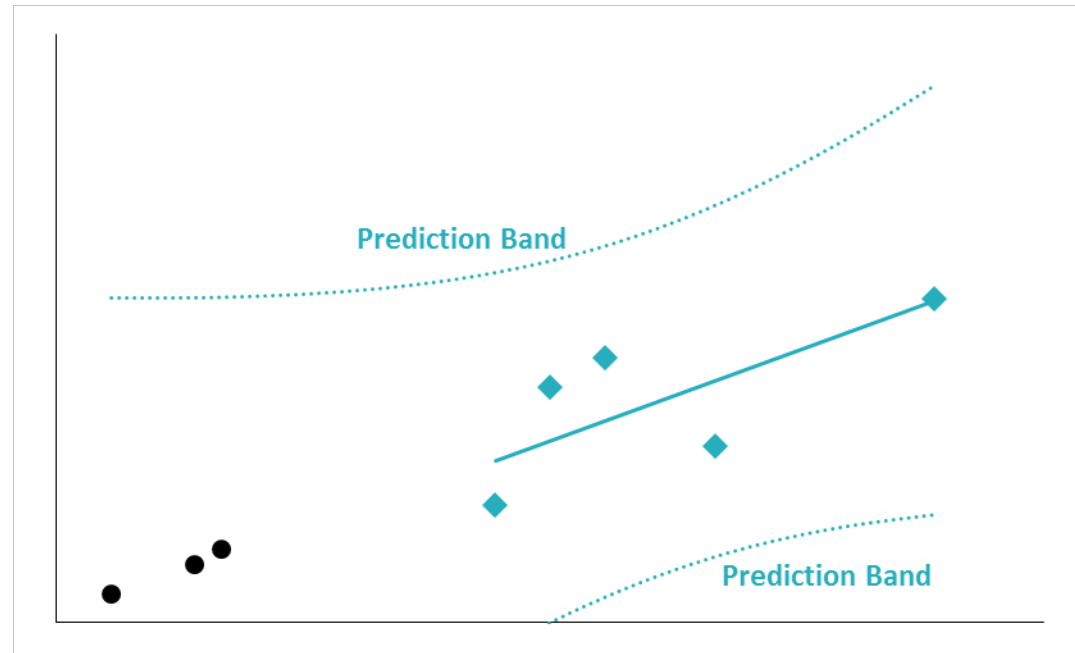
- ▶ Individual Ships Universe contains cost data for active and reserve ships in the Navy fleet, for FY 1984-2016
  - ▶ Cost data available at Class Average or individual hull level
  - ▶ Costs reported by FY and/or hull age, across CAPE 14 CES
- ▶ Non-cost data:
  - ▶ # ships
  - ▶ Percent of FY
  - ▶ Crew size
  - ▶ Maintenance hours
  - ▶ Steaming hours
  - ▶ Hull weight data (not contained in VAMOSC) incorporated for additional data normalization





# Why develop a comprehensive dataset?

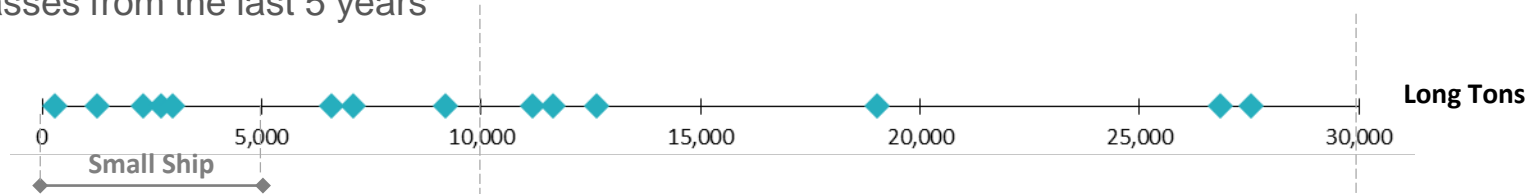
- ▶ Possibility that historical Navy data does not capture unique aspects or trends of Coast Guard maintenance philosophy
- ▶ Supplementing Navy data for estimating small ships leads to **significantly smaller prediction bands** due to additional smaller ship sizes in otherwise-analogous Navy sample ships
  - Expansion of the range of data used in regression is likely to produce much tighter prediction bands, resulting in a more confident estimate.
  - **Focus of this Paper**



# Navy Ship O&S Database – Ship Sizes

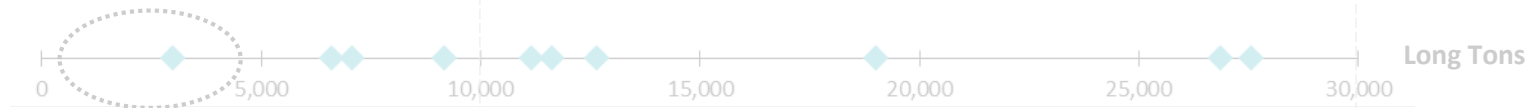
## ▶ Weights of non-nuclear ships in VAMOSC (excluding MSC):

- Active classes from the last 5 years



## ▶ Remove non-analogous points:

- Rotational Crews
- Wood hulls
- Overseas homeports
- Brand new classes (with minimal hulls in service)



## ▶ Add analogous USCG ships:

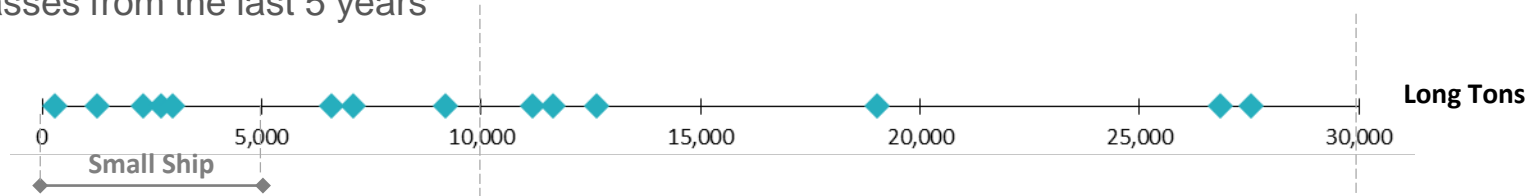
- Similar Size
- Similar Mission



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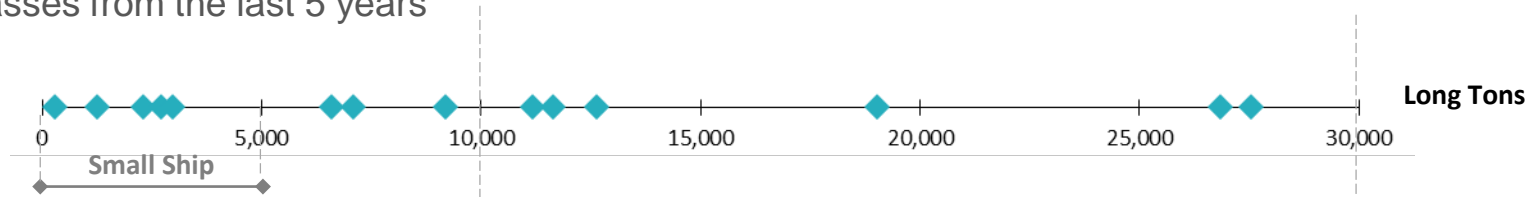
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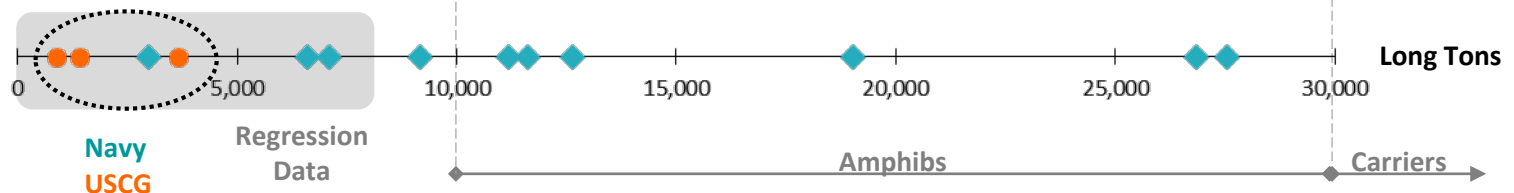
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# Supplemental Data

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Collection, Normalization, Mapping,  
and Storage

# USCG Ship Data Sources

- ▶ USCG is a logical place to supplement data for smaller ships (i.e., ships less than 5,000 Long Tons)
- ▶ However, the USCG doesn't have a robust, comprehensive database like VAMOSC that tracks O&S data
- ▶ Must collect a variety of USCG data sources used for other purposes (i.e., budgeting, logistics, etc.)



**Financial  
Procurement  
Desktop (FPD)**



**Fleet Logistics  
System (FLS)**



**Naval and  
Electronics Supply  
Support System  
(NESSS)**



**In-Service Vessel  
Sustainment (ISVS)  
Program**



**Aviation Logistics  
Management  
Information  
System (ALMIS)**

**Use VAMOSC as a guide to build a similar database for USCG**

# Financial Procurement Desktop (FPD)



▶ Creates and manages simplified procurement documents and maintains accurate accounting records



▶ Includes these functions:

- Ledger management
- Budgeting and funds distribution
- Procurement requests and simplified acquisitions
- Receipt of goods/services
- Interoperability with the USCG Core Accounting System



▶ Provides a simplified view of both funds spent and funds available (i.e., a checkbook)



**Captures expenditures like a statement  
after a swipe of a credit card**

# Fleet Logistics System (FLS)



- ▶ Designed to automate the management of USCG cutter and small boat logistics including:
  - Configuration Management (CM) and integration of maintenance actions
  - Procurement and supply activities
  - Automated Requisition Management (RM)
  - Coast Guard Parts Availability Research Tool (CG-PART)
  - Associated financial transactions



- ▶ Captures labor associated with maintenance (e.g., depot as USCG doesn't distinguish I-level) and hardware modernization

**Captures maintenance and modernization labor**



# Naval and Electronics Supply Support System (NESSS)



▶ Automates the maintenance and logistics management of USCG assets



▶ Used primarily by the USCG Yard and the Surface Forces Logistics Center (SFLC)



▶ Links the functions of:

- Provisioning and cataloging
- Unit configuration
- Supply and inventory control
- Procurement
- Depot-level maintenance property accountability
- Full financial ledger



**Captures parts and repairables cost**

# In-Service Vessel Sustainment (ISVS) Program



- ▶ Includes costs associated with major maintenance and upgrades for vessels to reach or extend their service lives



- ▶ Acquisition, Construction and Improvements (AC&I) Funded (unlike previous systems)



**Captures major maintenance events and modernization costs**

# Aviation Logistics Management Information System (ALMIS)



▶ Enables integrated aircraft operations, logistics, and maintenance support by:

- Collecting data entry from the start of a flight operation
- Recording the flight execution
- Tracking aircrew events and configuration
- Tracking aircraft maintenance requirements
- Tracking aircraft, part replacements
- Collecting aircraft procurement actions and payments



▶ Contains data similar to what was collected for ships through previously mentioned sources for aircraft



**Also captures data for smaller ships**

# Data Collection

## Collected USCG actuals (FY10-FY15) from aforementioned sources

- Data sources unreliable prior to FY10
- Data collected by hull by year
- Ship Types: USCG Long Range Enforcer (LRE), Medium Endurance Cutters (MEC), and Patrol Boats (PB)
- Additional data (Allotment Fund Control (AFC) Code, etc.) collected with most data points



## Ensured data was comprehensive, pulling directly from systems that track operating and maintenance activities

- Crosschecked AFC codes to ensure no gaps existed
- Data experts could not identify additional data sources
  - If additional sources are found, they will be incorporated

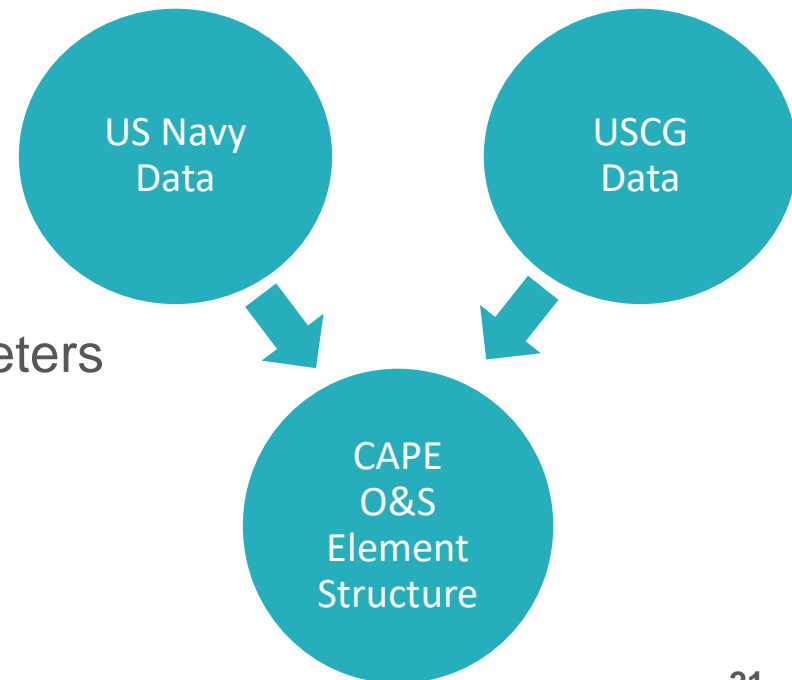


## Mapped each data source independently into CAPE 2014 CES

- Performed at the lowest level possible
- Based on guidance from USCG, VAMOSC Ship Universe Users Guide, and OSD (CAPE) O&S Guide
- All mapping validated by USCG

# Data Normalization

- ▶ Mapped all data to the CAPE 2014 CES ensuring a consistent and comparable data structure
  - VAMOSOC data maps to CAPE O&S Element Structure
  - Mapped USCG Data to CAPE O&S Element Structure
  
- ▶ Utilized the OSD Inflation guidance to normalize all costs to CY16\$ using the appropriate appropriation index.
  - Leverage same inflation guidance as VAMOSOC
  
- ▶ Normalized data by technical parameters
  - Size/weight
  - Fuel Usage
  
- ▶ Normalized data by programmatic parameters
  - Number of hulls in service
  - Technology
  - Time/Age



# Data Mapping

## Raw USCG O&S Data Sources



**FPD**



**FLS**



**NESSS**



**ISVS**



**ALMIS**

CAPE Elements

**1.0 Unit-Level Manpower**



**2.0 Unit Operations**



**3.0 Maintenance**



**4.0 Sustaining Support**



**5.0 Continuing System Improvements**



**6.0 Indirect Support**



# Data Storage and Automation

## ▶ Database created in Microsoft Access

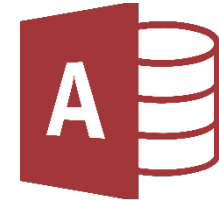
- Microsoft Excel unable to handle volume of data and complex data manipulations and calculations
- Normalized to 3<sup>rd</sup> normal form

## ▶ Raw maintenance data imported

- All manipulations/mapping performed through queries in the database
  - Preserves traceability
  - Documents mappings
  - Forces normalization
  - Allows for easy updates

## ▶ Query Features

- Aggregates data sources
- Maps raw data into CAPE structure
- Rolls up data
- Performs inflation adjustments
- Performs inventory calculations
- Calculates ages
- Phases and filters technical data



**Database designed for easy updates and expansion**

# Data Comparisons

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## US Navy and Coast Guard



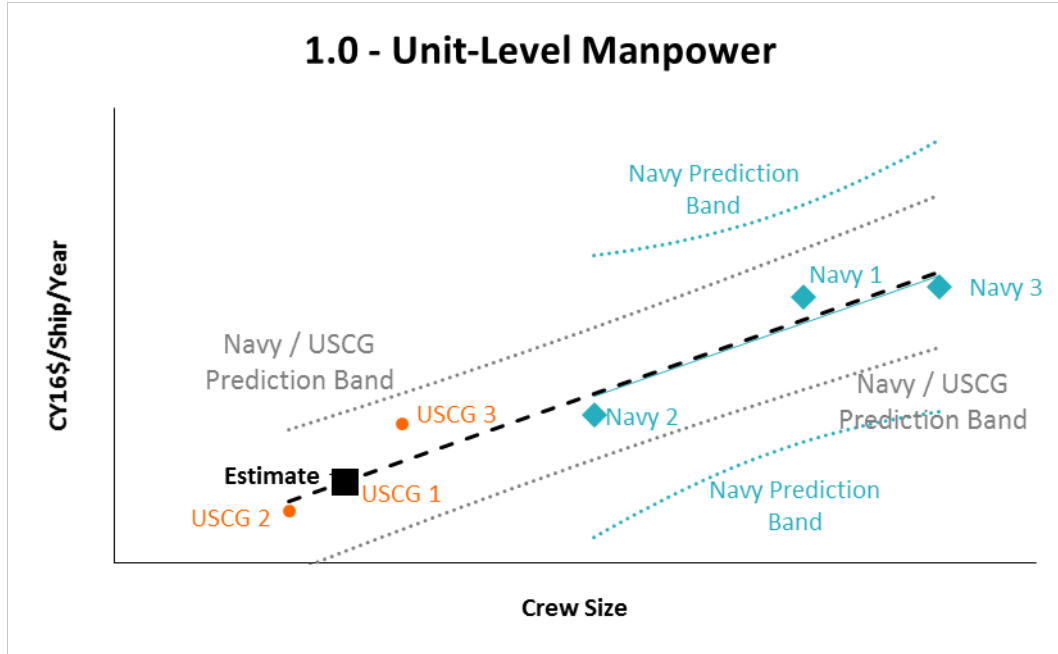
# Data Comparisons - Overview

- ▶ **WBS:** CAPE 2014 CES used to the 1-digit level
  - In practice, analysis and estimates were performed at a more detailed level
    - Kept at a high level for the purposes of this paper
  - CAPE 6.0 (Indirect Costs) not shown – not in Naval VAMOSC
- ▶ **Navy data points:** Active navy combatants with a rich dataset in VAMOSC, with many hulls spanning many years
  - i.e., some of the most analogous and trusted combatants in VAMOSC
  - Utilized class averages with full fiscal years
- ▶ **USCG data points:** USCG vessels with several hulls and several years of data
  - i.e., the best data points in the USCG database
- ▶ **Estimate data point:** small ship with an accordingly sized crew
  - Used for illustration purposes

**Check to see how well the USCG data aligns with Naval VAMOSC**

# Data Comparisons – CAPE 1.0

## ► Cost Estimating Relationship: \$ / Crew Member



**USCG data has little effect on estimate but reduces the prediction interval by ~70% at estimate point**

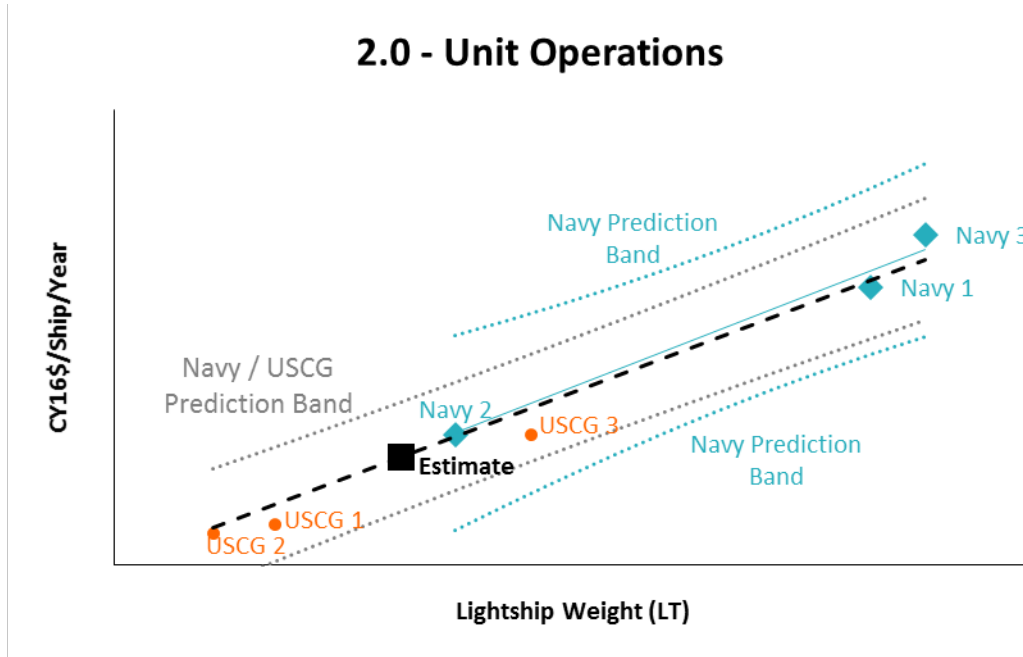
- Supplementing Navy data with USCG data has little effect on regression line
  - Results in good statistics

Stat	Navy / USCG
R <sup>2</sup>	0.99
CV	0.15

- USCG data supplement significantly tightens the prediction bands

# Data Comparisons – CAPE 2.0

## ► Cost Estimating Relationship: \$ / Long Ton



**USCG data has little effect on estimate but reduces the prediction interval by ~50% at estimate point**

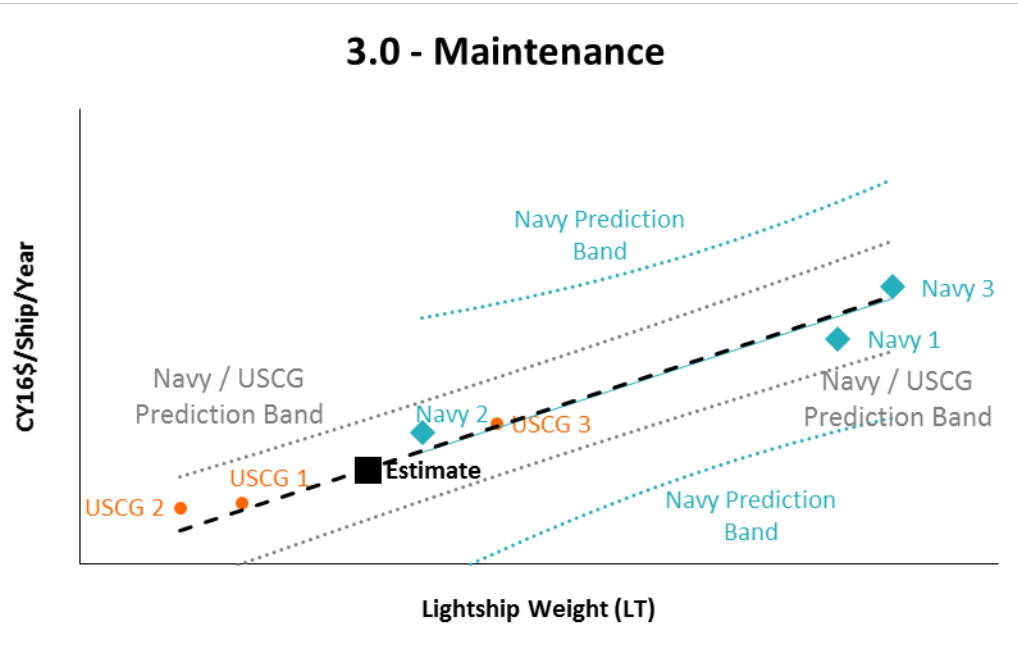
- Supplementing Navy data with USCG data has little effect on regression line
  - Results in good statistics

Stat	Navy / USCG
R <sup>2</sup>	0.99
CV	0.12

- USCG data supplement tightens the prediction bands

# Data Comparisons – CAPE 3.0

## ► Cost Estimating Relationship: \$ / Long Ton



**USCG data has little effect on estimate but reduces the prediction interval by ~65% at estimate point**

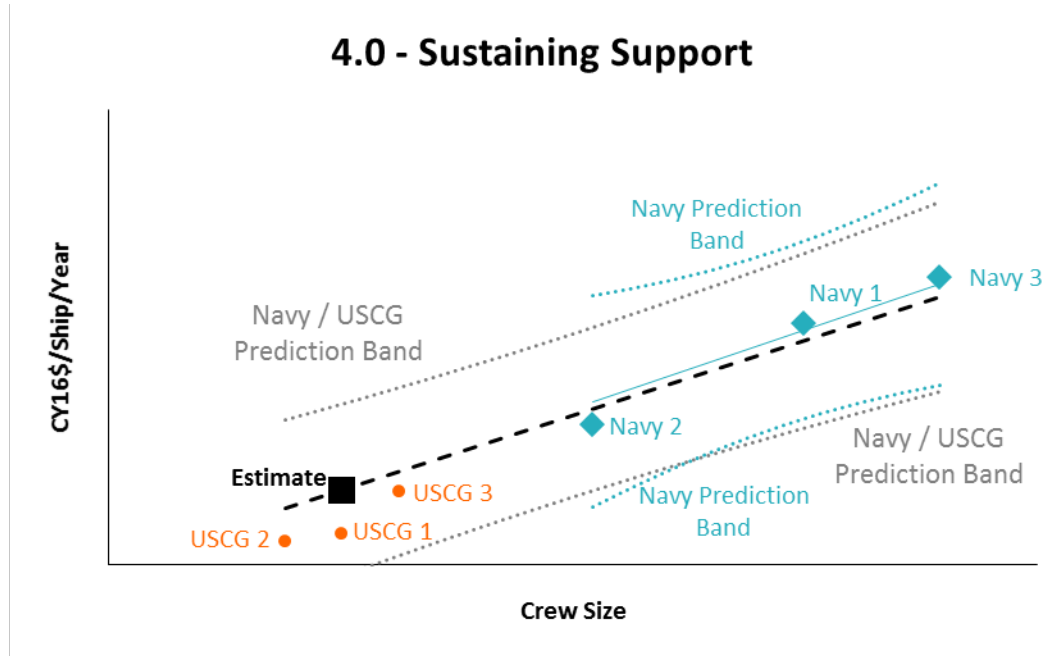
- Supplementing Navy data with USCG data has little effect on regression line
  - Results in good statistics

Stat	Navy / USCG
R <sup>2</sup>	0.99
CV	0.12

- USCG data supplement tightens the prediction bands

# Data Comparisons – CAPE 4.0

## ► Cost Estimating Relationship: \$ / Crew member



**USCG data has little effect on estimate but reduces the prediction interval by ~50% at estimate point**

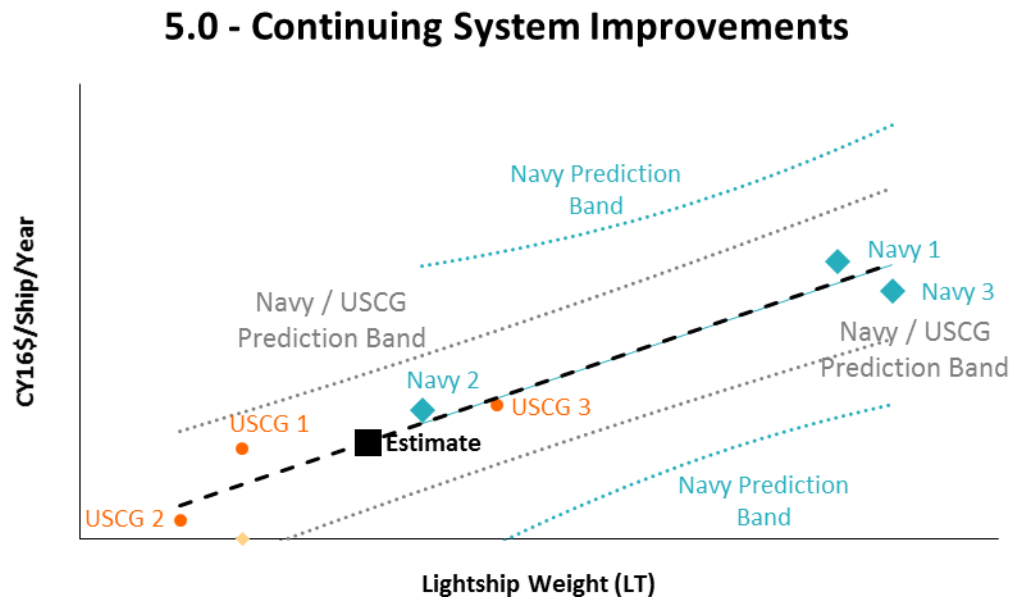
- Supplementing Navy data with USCG data has little effect on regression line
  - Results in good statistics

Stat	Navy / USCG
R <sup>2</sup>	0.97
CV	0.22

- USCG data supplement tightens the prediction bands

# Data Comparisons – CAPE 5.0

## ► Cost Estimating Relationship: \$ / Long Ton



**USCG data has little effect on estimate but reduces the prediction interval by ~60% at estimate point**

- Supplementing Navy data with USCG data has little effect on regression line
  - Results in good statistics

Stat	Navy / USCG
R <sup>2</sup>	0.98
CV	0.16

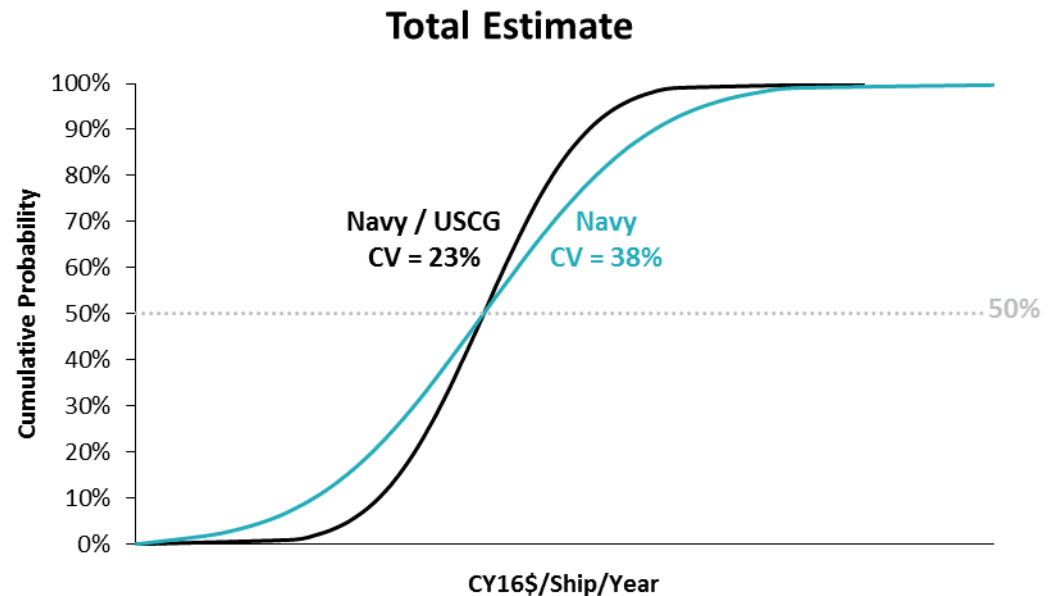
- USCG data supplement tightens the prediction bands

# O&S Cost Estimate Implications

## ▶ Supplementing Navy data with USCG data:

- Results in good statistics
- Has minimal impact on the point estimate
- Has minimal impact on the 50% cumulative probability point
- Significantly reduces the uncertainty around the estimate
  - 38% Coefficient of Variation (CV) reduction

## ▶ Useful in developing an estimate for a smaller ship



# Conclusions & Recommendations

- ▶ USCG O&S Database appears to be credible and comprehensive
  - Data is in line with Naval VAMOSC
  - Can be used to reduce the uncertainty around a Navy estimate
  - Can be used for a USCG estimate
  - Newly available USCG data sources should always be explored
  
- ▶ When estimating O&S costs of smaller ships, USCG ships should be used where applicable
  - Can be used to reduce the uncertainty around an estimate
  
- ▶ Naval VAMOSC & USCG could collaborate for mutual benefit
  - Navy user community could benefit from readily available data
  - USCG could benefit from an easy to access O&S cost database
  - Could also explore supplementing Navy aircraft data with USCG aircraft data





Thank You

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