

Naval Center for Cost Analysis

REDUCING S-CURVE ALCHEMY: Gold from a New SAR Database



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with Jeff Pincus and Brian Flynn



Overview

- Weapon System Acquisition Reform Act (WSARA)
- Background
- The value of Coefficients of Variance (CVs) and Cost Growth Factors (CGFs)
- Impacts of low CVs and high CGFs
- The new SAR database
- Data organization, transformation, and normalization
- Results: CV Behavior – Conjectures vs Findings

Coefficient of variation is the standard deviation of a distribution divided by its mean.

Cost growth factors are the actual cost of a program divided by the original baseline estimates.



Weapon System Acquisition Reform Act (WSARA)

- WSARA signed into law in May 2009
- Created new sections to 10 USC including 10 USC §2334 which states;
 - ensure that cost estimates are developed based on historical actual cost information that is based on demonstrated contractor and Government performance and that such estimates provide a **high degree of confidence** that the program or subprogram can be completed without the need for significant adjustment to program budgets



Weapon System Acquisition Reform Act (WSARA)

- In April 2013 the Joint Agency Cost Schedule Risk and Uncertainty Handbook (JA CSRUH) was published
 - Provided details on how to conduct uncertainty analyses
 - Prior to this handbook DoD cost analysts had little guidance
 - Every input variable, cost estimating relationship, and factor has uncertainty and uncertainty adjusted results were reminiscent of alchemy



Uncertainty includes risk and opportunity



“Be particularly careful to ensure realistic program baselines-especially when budgets are tight. Further analysis published in this report reinforces prior concerns that excessive optimism or risk tolerance may be particularly acute when programs are initiated during tight budget periods (such as at present), leading to the higher cost growth seen on these programs. We should explicitly recognize this and avoid setting up our successors for large overruns.”

Mr. Frank Kendall Under Secretary of Defense for Acquisition, Technology
and Logistics (AT&L)

Performance of the Defense Acquisition System 2016 Annual Report



Impacts of Low CVs and Inadequate Risk Adjustments

- Results in cost growth by definition
- Results in schedule growth
 - Programs stretch schedule to reduce annual execution cost
- Causes portfolio management problems
 - Cost growth causes reprogramming actions that may damage or delay otherwise healthy programs
 - Cost growth in production across a portfolio results in buy rates at below economic order quantities
- Jeopardizes ability to get needed capabilities to the warfighter
 - Perturbs optimal composition of portfolio
 - Threatens schedules for urgent needs identified by the Joint Requirements Oversight Counsel

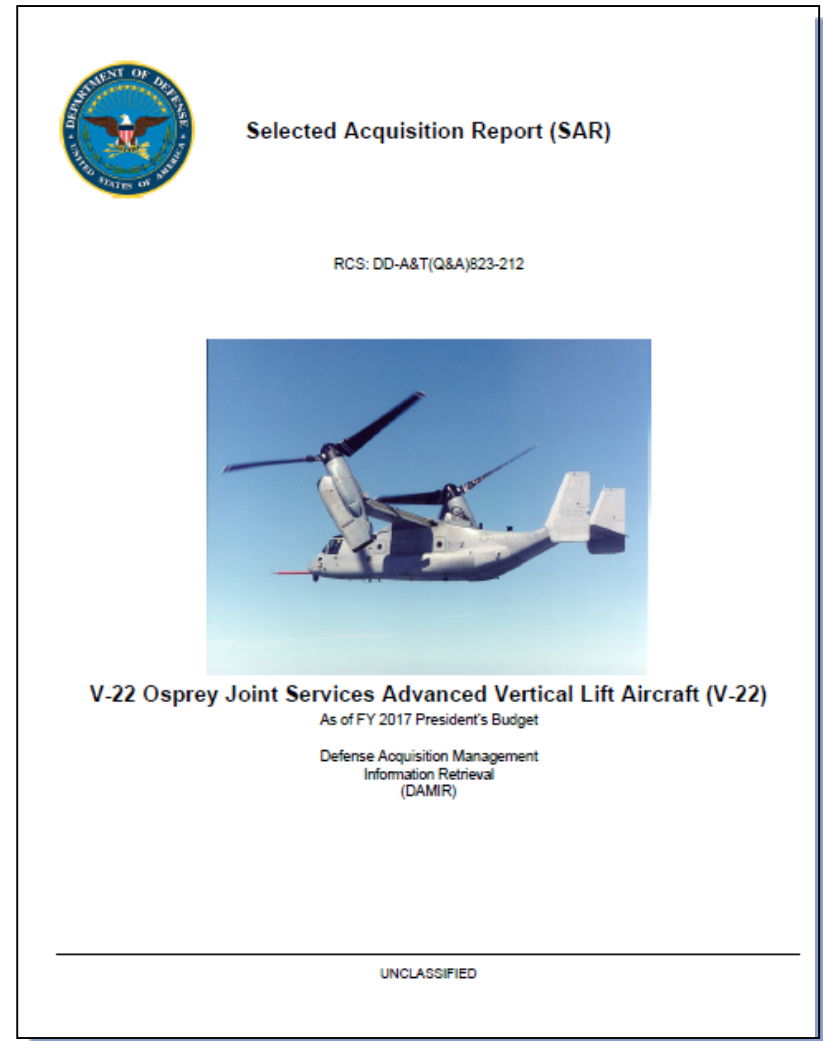


Selected Acquisition Reports (SARs)

- What is a SAR?
 - Standard, comprehensive, summary status reports provided to Congress.
 - Required for Major Defense Acquisition Programs (ACAT I)
 - Includes key cost, schedule, and technical information

Baseline development and production SAR reports are compared to final “at completion” SARs to develop CVs and CGFs.

These baseline SARs are early estimates and are subject to risk and uncertainty. Each CER, input variable, and inflation table used in a cost model has uncertainty.





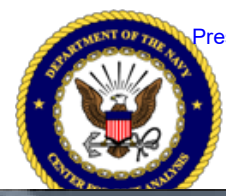
The Value of CVs and CGFs

“That analogous program made avoidable management mistakes.”

“That analogous program had different technical challenges.”

“We did months of research and site visits in the development of our estimate.”

- A manager may make the above arguments but it’s hard to argue with historical CVs and CGFs.
- Programs are subject to the same acquisition pressures and constraints governed by DoD 5000 series.
- Using historical CVs for risk and uncertainty adds realism to cumulative probability distributions (S-curves), helps with independent reviews, and improves risk adjusted estimates.



The New SAR Database

Database Architecture



The New SAR Database

The following tenants shaped the design of the new SAR database:

1. The architecture must **isolate** raw data
2. The architecture must normalize data **separately** from raw data
3. The architecture must maintain an **audit trail** of changes or modification to raw or normalized data
4. Calculation threads must be **separated** from raw and normalized data
5. All normalization and calculation steps must be shown **separately** and **transparently**



Results

- One self-contained, single source, all-inclusive file for data and computations, with a user dashboard
 - Completeness factor
 - Simulate previous years' results
 - Sample size warnings
 - Outlier sensitivity
- Contains a User Guide to help users understand the workings of the model and the analysis
- Thorough documentation that promotes transparency
- Smooth and logical flow of information throughout workbook

The screenshot shows a 'Control Panel' with several adjustable parameters:

- Total Exclusions: 55
- Most Recent SAR year: 2015
- Sample Size Warning: 6
- Outlier Sensitivity: 2σ
- Completeness Sensitivity: 3

A tooltip for 'Sample Size Warning' explains: 'The S-Curve tool will issue a warning message about a too small a sample size (n) if the sample size falls below the listed value.'

Documentation text on the right includes: 'What does this work... This workbook is des... database. As data is... by the S-Curve tool i... Curve tool with new... How does it work?... works us... tistical an... located i... SAR sum... Additiona... This data... calculatio... 2. The raw d... Unique C'

At the bottom, a navigation bar contains tabs: USER_GUIDE, X_Dashboard, Changed Entries (highlighted), Added Entries, and DATA>. Below the navigation bar is a data table with a column labeled 'Gun'.



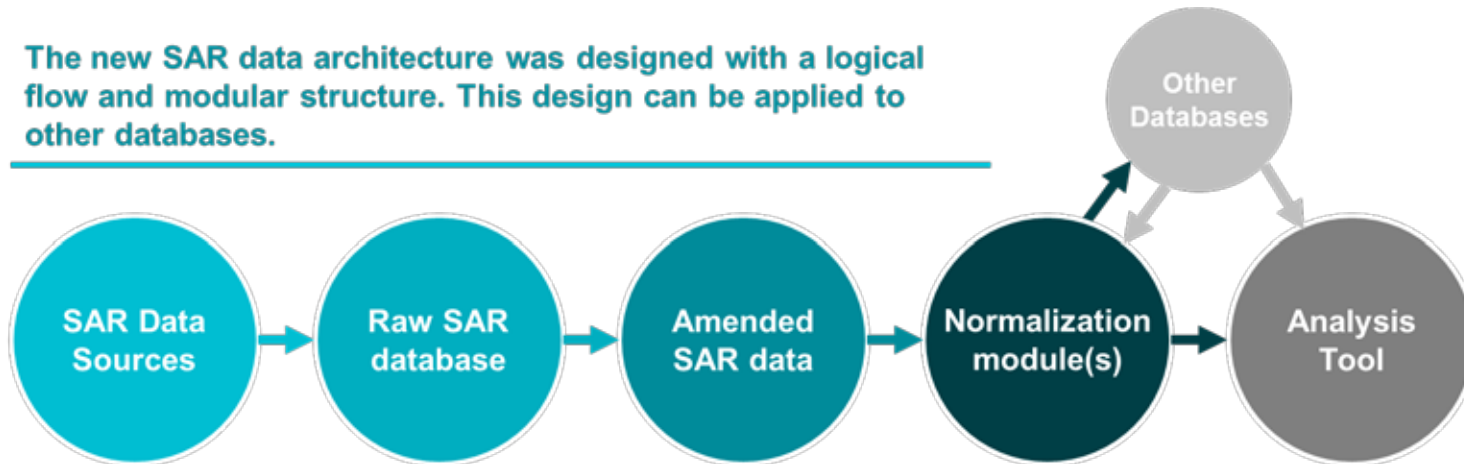
Results

- Review normalized results side-by-side to verify changes
 - Subprogram Breakdown
 - Completeness Factors
 - Interphase growth
 - Milestone Transition Errors
 - Manually altered or eliminated programs
- Developed a powerful new data audit trail with full accountability
 - Who, what, when, where, and why
- Results reflect amended data, but amended data can easily be reverted
- Exclusion Dashboard for a user to customize inputs into calculation threads



Prepared for the Future

The new SAR data architecture was designed with a logical flow and modular structure. This design can be applied to other databases.



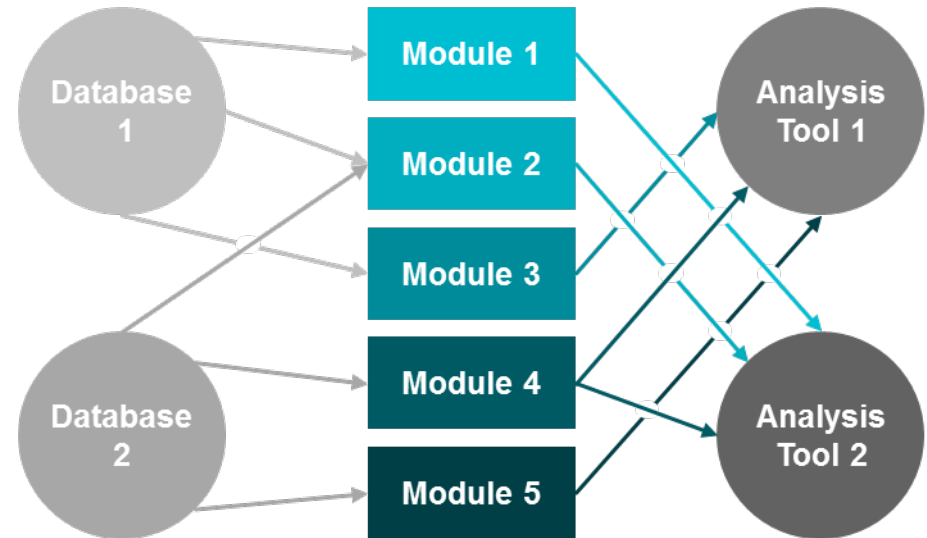
- Normalized data is maintained **separately**
- Calculations are maintained **separately**
- Modules can be turned on and off
 - Users determine what normalization they want
- Future modules can utilize raw data or calculation results without worry of subjective normalization
- Repeatable architecture for other databases



Takeaways

- Data is “**binary**” it either exists or it does not
- What can be done with a single-source of data is **finite**, but what a user can do with data is **infinite**
- A database **must** be single-source
- Need new data? You need a new database
- “Don’t put the cart before the horse”

Normalization modules can utilize different databases. Analysis tools can utilize different normalization modules.





The New SAR Database

Results



Results From the New Database

- Single, authoritative source of raw and normalized SAR data for NCCA
- Increased the accuracy of results due to automation
- More accurate commodity classifications
 - Caveat: we could do with more detail
- Easily updated
- Potential to automate updating



Results From the New Database

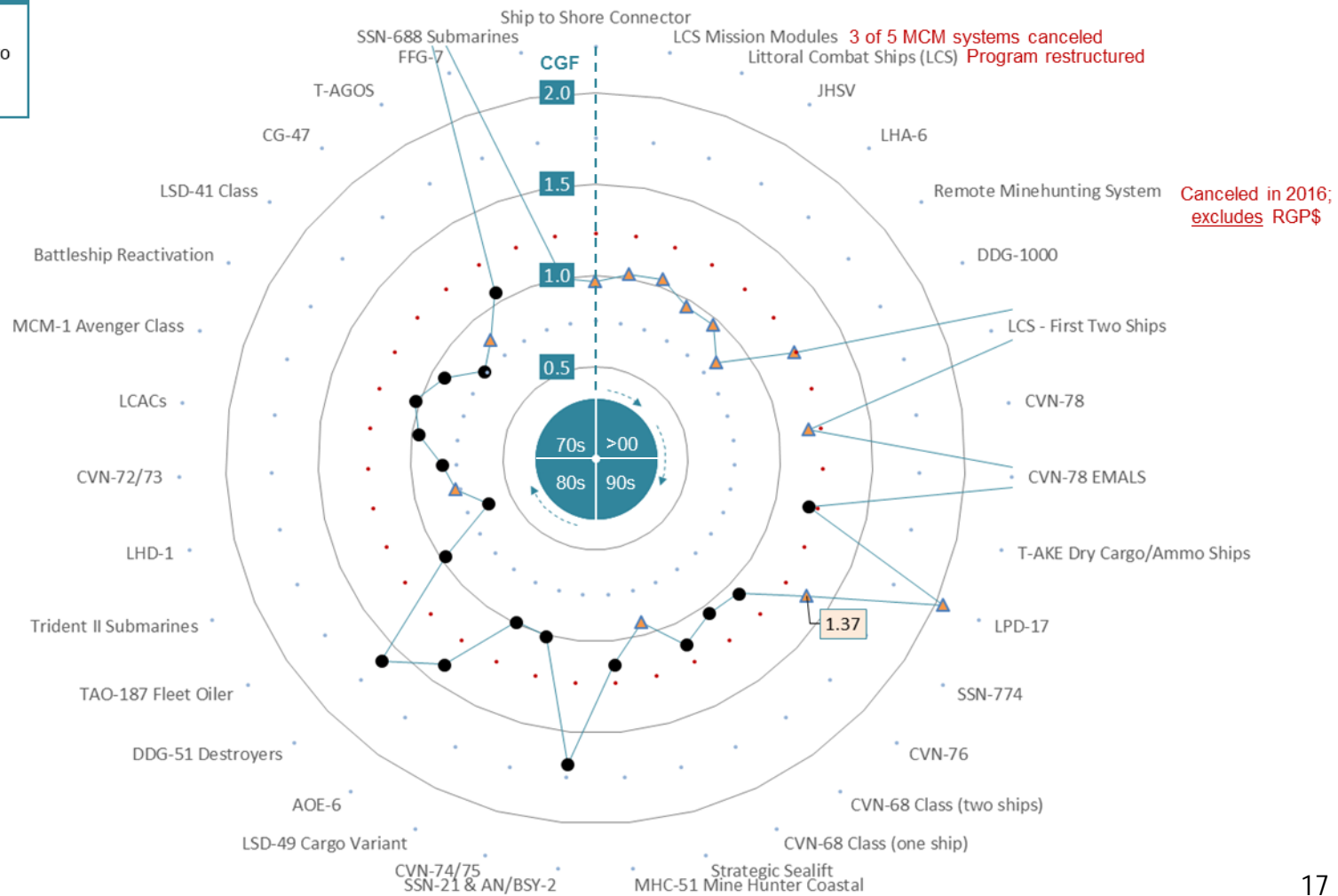
Cost Growth Factors for Naval Sea System Acquisitions

Then-Year\$ CGF's Adjusted for Changes in Quantity [● sample $\mu = 1.23$]

△ Development Estimate (DE) ● Production Estimate (PdE)

Timeline

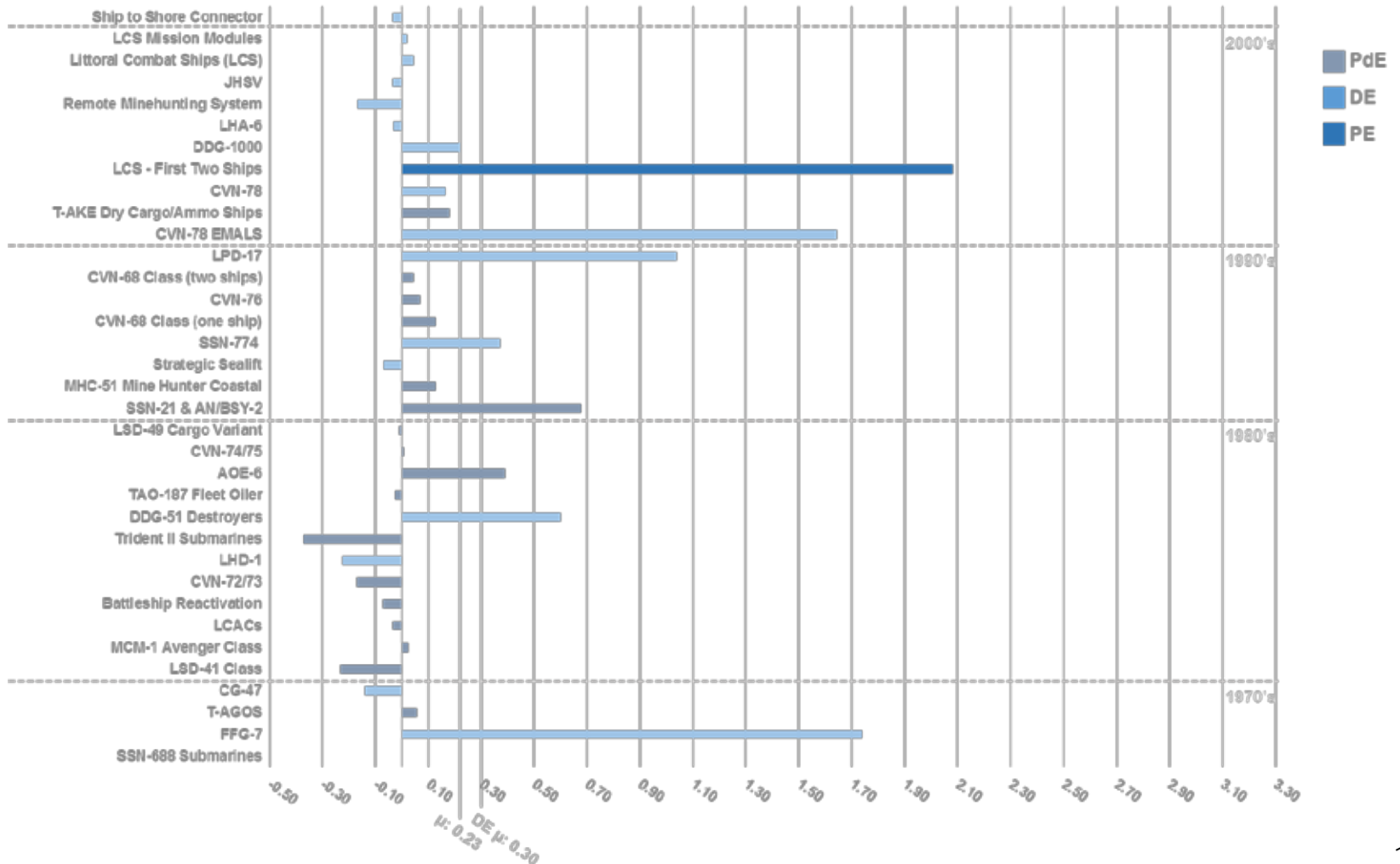
CGFs plotted clockwise according to the date of the BE: newest to oldest





Results From the New Database

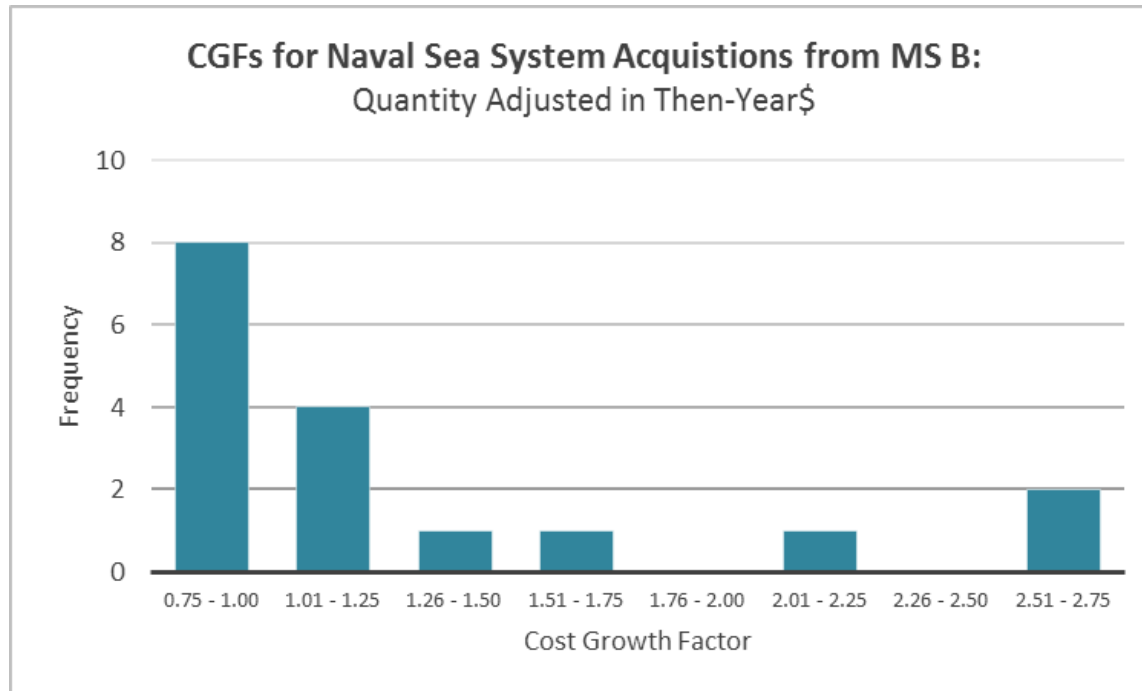
Then-Year\$ CGF's Adjusted for Changed in Quantity





Ship CVs and CGFs Summary

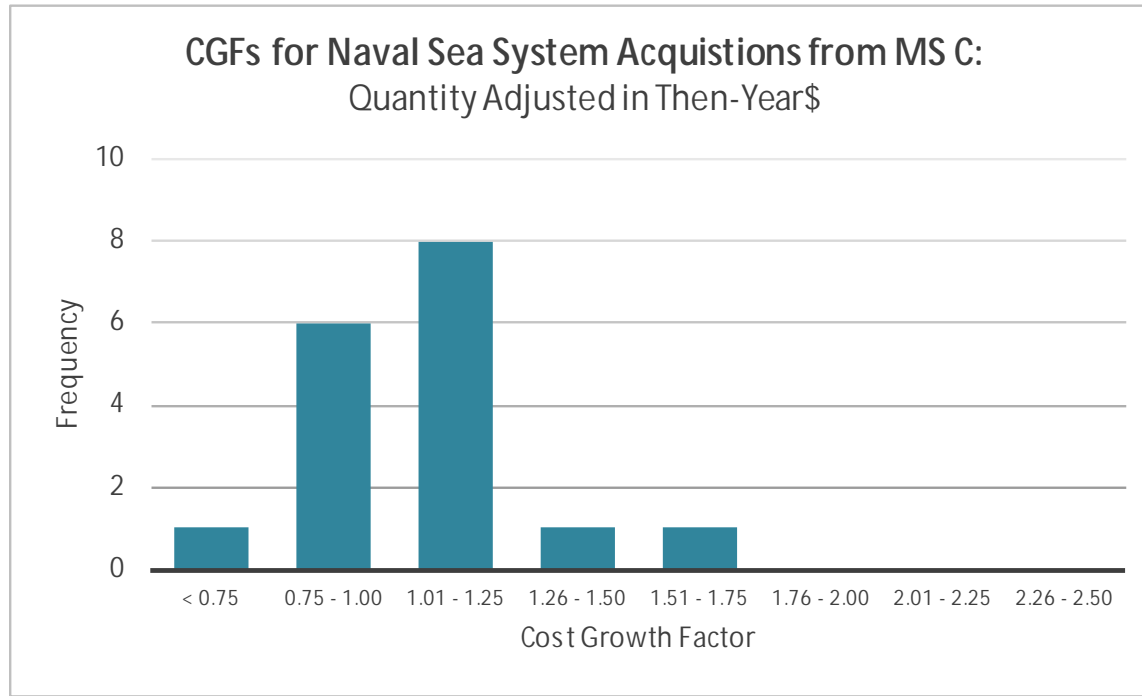
| Cost Growth Factors & CVs for DON Sea System MDAPs at MS B | | | | |
|--|-------------------------------|-------------|---------------------|-------------|
| Statistics | (Without Quantity Adjustment) | | (Quantity Adjusted) | |
| | Base-Year\$ | Then-Year\$ | Base-Year\$ | Then-Year\$ |
| Mean | 1.61 | 1.97 | 1.18 | 1.30 |
| Standard Deviation | 1.11 | 1.54 | 0.38 | 0.61 |
| CV | 69% | 78% | 32% | 47% |





Ship CVs and CGFs Summary

| Cost Growth Factors & CVs for DON Sea System MDAPs at MS C | | | | |
|--|-------------------------------|-------------|---------------------|-------------|
| Statistics | (Without Quantity Adjustment) | | (Quantity Adjusted) | |
| | Base-Year\$ | Then-Year\$ | Base-Year\$ | Then-Year\$ |
| Mean | 1.02 | 0.95 | 1.09 | 1.05 |
| Standard Deviation | 0.28 | 0.27 | 0.14 | 0.23 |
| CV | 28% | 29% | 13% | 22% |





CV Behavior - Conjectures vs Findings

- Consistency
 - Conjecture: CVs from ICEs and cost assessments accord with acquisition experience
 - Finding: CVs appear regularly underestimated by program offices
 - Easy to verify with the new SAR database!
- Tendency to Decline During Acquisition Phase
 - Conjecture: CVs decrease throughout acquisition lifecycle
 - Finding: Strongly supported by evidence
- Platform Homogeneity
 - Conjecture: CV are the same across platform types
 - Finding: Under study



CV Behavior - Conjectures vs Findings

- Tendency to Decrease after Normalization
 - Conjecture: CVs decrease when adjusted for changes in quantity and inflation
 - Finding: Strongly supported by the evidence. Logically, CGFs decrease in value when sources of cost variation are eliminated.
- Invariance of Secular Trend
 - Conjecture: CVs steady long-term
 - Finding: For estimates at Milestone B, results are mixed, and dependent on the inclusion of two key observations. For estimates at Milestone C there's no evidence that CVs have decreased in value.

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Thank you!